IEC 60034-18-32

Edition 2.0 2022-01
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

Rotating electrical machines –
Part 18-32: Functional evaluation of insulation systems (Type II) –
Electrical endurance qualification procedures for form-wound windings

IEC 60034-18-32:2022-01 CMV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.160.01

ISBN 978-2-8322-4022-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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This commented version (CMV) of the official standard IEC 60034-18-32:2022 edition 2.0 allows the user to identify the changes made to the previous IEC 60034-18-32:2010 edition 1.0. Futhermore, comments from IEC TC 2 experts are provided to explain the reasons of the most relevant changes.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 60034-18-32 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

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

a) Title modified.
b) Simplification of clauses.
c) Reduction in the number of test procedures.
d) Inclusion of full bars and coils as test objects.
e) A new clause dealing with failures and failure criteria.

The text of this International Standard is based on the following documents:

Draft	Report on voting
2/2068/FDIS	2/2075/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

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.

INTRODUCTION

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

This document deals exclusively with insulation systems for form-wound windings (Type II) and concentrates on electrical functional evaluation.

In IEC 60034-18-42, tests are described for qualification of Type II insulation systems in voltage-source converter operation. These insulation systems are generally used in rotating machines which have form-wound windings, mostly rated above 700 V r.m.s. The two standards IEC 60034-18-41 and IEC 60034-18-42 separate the systems into those which are not expected to experience partial discharge activity within specified conditions in their service lives (Type I), and those which are expected to experience and withstand partial discharge activity in any part of the insulation system throughout their service lives (Type II).

ROTATING ELECTRICAL MACHINES –

Part 18-32: Functional evaluation of insulation systems (Type II) – ~~Test~~ Electrical endurance qualification procedures for form-wound windings ~~– Evaluation by electrical endurance~~

1 Scope

This part of IEC 60034-18 describes ~~test~~ qualification 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 energized with sinusoidal power frequency voltage. The test procedures for the main wall insulation 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.~~ If no reference system is available, the diagram in Annex A is available for use. The qualification procedures of inverter duty insulation system for form-wound windings can be found in IEC 60034-18-42 or IEC 60034-18-41. A new and informative test procedure for the stress control system is introduced and defined in Annex B. **2**

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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*

IEC TS 60034-18-33:2010, *Rotating electrical machines – Part 18-33: Functional evaluation of insulation systems – Test procedures for form-wound windings – Multifactor evaluation by endurance under simultaneous thermal and electrical stresses*

IEC 60034-18-41, *Rotating electrical machines – Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters – Qualification and quality control tests*

IEC 60034-18-42:2017, *Rotating electrical machines – Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters – Qualification tests*
IEC 60034-18-42:2017/AMD1:2020

IEC 60034-27-1, *Rotating electrical machines – Part 27-1: Off-line partial discharge measurements on the winding insulation*

IEC 60034-27-3, *Rotating electrical machines – Part 27-3: Dielectric dissipation factor measurement on stator winding insulation of rotating electrical machines*

IEC 60216-4-1, *Electrical insulating materials – Thermal endurance properties – Part 4-1: Ageing ovens – Single-chamber ovens*

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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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~~ strand insulation
electrical insulation that covers each conductor in coils/bars

3.3
~~interturn~~ turn 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~~

~~**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~~

3.4
conductive slot coating
conductive paint or tape layer in intimate contact with the mainwall insulation in the slot portion of the coil side, often called semi-conductive coating

Note 1 to entry: The purpose is to prevent partial discharge from occurring between the coil/bar and the stator core.

3.5
stress control coating
paint or tape on the surface of the mainwall insulation that extends beyond the conductive slot coating in high-voltage stator bars and coils

Note 1 to entry: The purpose of the coating is to prevent surface discharges near the slot exit or in the end winding area.

3.6
stress control system
generic name for the combination of the conductive slot coating and stress control coating in high-voltage stator bars and coils 3

3.7
confidence interval
range of values so defined that there is a specified probability that the value of a parameter (voltage, stress or time) lies within it

3.8
test temperature
temperature of the outer surface of the bar/coil at the straight part of the bar/coil measured with an appropriate selected and placed sensor

4 General considerations

4.1 Relationship to IEC 60034-18-1

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

4.2 Selection and designation of test procedures

One or more of the procedures in this document 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

Following test procedures are described:

- Mainwall insulation
- Turn insulation only with the main insulation test
- Conductive slot coating (Annex B)
- Stress control coating (Annex B)
- Mainwall insulation, where voltage level and/or life time differs from the reference system

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, information such as "different insulation thickness at same electrical field stress levels by obtaining equal or similar breakdown time" should be provided showing the correlation between electrical lifetime and electrical stress for the different insulation thicknesses. If no reference insulation system is available the diagram in Annex A shall be used as criterion.

4.4 Test procedures ~~(IEC 61251)~~

4.4.1 General

Electrical ageing tests are usually performed at fixed voltage levels until failure (mainwall insulation) or in combination with elevated temperature until signs of deterioration occur (conductive slot coating system). Statistical evaluation of the results of testing should be performed according to IEC 62539.

4.4.2 Electrical ageing of the mainwall insulation

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.~~

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 overvoltage arising from switching surges or inverter supply. The ability of the mainwall insulation to withstand transient overvoltage from converter supplies may be demonstrated by the system's performance using IEC 60034-18-42.

This document describes ~~voltage~~ electrical ageing of the mainwall insulation, carried out at power frequency or ~~at a frequency up to 10 times greater~~ higher. In order to keep acceleration of ageing in a linear progression, a maximum of 10 times of the power frequencies is appropriate. Latest experiences with the application of IEC 60034-18-42 show that a frequency of up to 1 000 Hz can be used as well. Care shall be taken that the dielectric losses do not increase the temperature of the insulation beyond the service temperature to avoid additional thermal ageing effects. (IEC TS 60034-18-33:2010, Table 1).

4.4.3 Electrical ageing of the stress control system

In order to allow a full qualification of the entire insulation system Annex B describes methods to qualify the conductive slot coating and stress control coating. 5

4.4.4 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.~~

In normal direct-on-line operation of rotating machines the turn insulation is subjected to a stress significantly below the partial discharge inception voltage. Continuous electrical ageing is then not taking place and turn insulation qualification is therefore excluded from this document. Withstand against transient overvoltage should be tested according to IEC 60034-15.

In converter fed or other types of special operation the turn insulation may continuously be subjected to a stress above the partial discharge inception voltage. Electrical ageing should then be performed according to IEC 60034-18-42. **6**

4.5 Extent of tests

4.5.1 Full evaluation of the mainwall insulation

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~~ from the reference ~~and candidate systems~~ system according to IEC 60034-18-1.

4.5.2 Reduced evaluation of the mainwall insulation

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~~ used in 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 5.2). 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 significant effect on the insulation system. It is the responsibility of the manufacturer to justify the use of the reduced qualification procedure~~

4.5.3 Evaluation of the stress control system

Annex B defines tests and criteria to evaluate conductive slot coating and stress control coating.