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Edition 2.0 2010-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Machines électriques tournantes –
Partie 18-1: Evaluation fonctionnelle des systèmes d'isolation – Principes directeurs généraux

IEC 60034-18-1:2010

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ROTATING ELECTRICAL MACHINES –

Part 18-1: Functional evaluation of insulation systems – General guidelines

FOREWORD

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International Standard IEC 60034-18-1 has been prepared by IEC technical committee 2: Rotating machinery.

This second edition cancels and replaces the first edition, published in 1992, and its amendment 1 published in 1996, and constitutes a technical revision.

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

– provides general guidelines for functional evaluation of different types of windings as before but beyond that for electrical evaluation of windings which are electrically stressed by converter-supply;
– is now focused on general guidelines with all technical details of procedures and qualification principles moved to the subsequent parts;

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– details additional general aspects of functional evaluation, particularly the statistical procedure for comparison between reference and candidate insulation systems and the evaluation of minor component or manufacturing changes;
– contains a new acceptance test for verifying the expected production quality level of the insulation systems;
– restricts the classification of insulation systems as a result of the functional evaluation to thermal classification. Other kinds of classifications (classes) of insulation systems no longer exist.

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

FDIS	Report on voting
2/1583/FDIS	2/1592/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 list 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.

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INTRODUCTION

IEC 60034-18 comprises several parts, dealing with different types of functional evaluation and special kinds of test procedures for insulation systems of rotating electrial machines. IEC 60034-18-1 provides general guidelines for such procedures and qualification principles, whereas the subsequent parts IEC 60034-18-21, IEC 60034-18-22, IEC 60034-18-31, IEC 60034-18-32, IEC 60034-18-33, IEC 60034-18-34, IEC 60034-18-41 and IEC 60034-18-42 give detailed procedures for the various types of windings. Beyond that, part IEC 60034-18-41 and IEC 60034-18-42 contain special test procedures for electrical evaluation of windings electrically stressed by converter-supply.

The following standards provide the basis and background for the development of the previous standards:

IEC 60505 establishes the basis for estimating the ageing of electrical insulation systems under conditions of either electrical, thermal, mechanical, environmental stresses or combinations of these (multifactor stresses). It specifies the general principles and procedures that should be followed defining functional test and evaluation procedures.

The IEC 60216 series deals with the determination of thermal endurance properties of single insulating materials. On the assumption, that the Arrhenius equations describe the rate of thermal ageing, test procedures and analyzing instructions for getting characteristic parameters like the “Temperature index” (TI), the “Halving interval” (HIC) and the “Relative thermal endurance index” (RTE) are given. For all these parameters selected properties and accepted end-point-criteria are specified. Consequently, a material may be assigned with more than one temperature index, derived from the measurement of different properties and the use of different end-point criteria.

IEC 60085 deals with thermal evaluation of insulation systems used in electrical equipment. In particular, thermal classes of insulation systems are defined and designations are given, such as 130 (B), 155 (F) and 180 (H) for use in rotating machines belonging to IEC 60034-1. In the past, materials for insulation systems were often selected solely on the basis of thermal endurance of individual materials performed according to the IEC 60216 series. However, IEC 60085 recognizes that such selection may be used only for screening materials prior to further functional evaluation of a new insulation system which is not service-proven. Evaluation is performed on the basis of a comparison with a service-proven reference insulation system. Service experience is the preferred basis for assessing the thermal endurance of an insulation system.

IEC 62539 defines statistical methods to analyse times to breakdown and breakdown voltage data obtained from electrical testing of solid insulation materials, for the purposes of characterization of the system and comparison with other insulation systems. The methods of analysis are described for the Weibull-distribution but other distributions are also presented.

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ROTATING ELECTRICAL MACHINES –

Part 18-1: Functional evaluation of insulation systems – General guidelines

1 Scope

This part of IEC 60034 deals with the general guidelines for functional evaluation of electrical insulation systems, used or proposed to be used in rotating electrical machines within the scope of IEC 60034-1, in order to qualify them.

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 60034-18-21, *Rotating electrical machines – Part 18-21: Functional evaluation of insulation systems – Test procedures for wire-wound windings – Thermal evaluation and classification*

IEC 60034-18-22, *Rotating electrical machines – Part 18-22: Functional evaluation of insulation systems – Test procedures for wire-wound windings – Classification of changes and insulation component substitutions*

IEC 60034-18-31, *Rotating electrical machines – Part 18-31: Functional evaluation of insulation systems – Test procedures for form-wound windings – Thermal evaluation and classification of insulation systems used in machines up to and including 50 MVA and 15 kV*

IEC 60034-18-32, *Rotating electrical machines – Part 18-32: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation of electrical endurance of insulation systems used in machines up to and including 50 MVA and 15 kV*

IEC 60034-18-33, *Rotating electrical machines – Part 18-33: Functional evaluation of insulation systems – Test procedures for form-wound windings – Multifactor functional evaluation – Endurance under combined thermal and electrical stresses of insulation systems used in machines up to and including 50 MVA and 15 kV*

IEC 60034-18-34, *Rotating electrical machines – Part 18-34: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation of thermomechanical endurance of insulation systems*

IEC 60034-18-41, *Rotating electrical machines – Part 18-41: Qualification and type tests for Type I electrical insulation systems used in rotating electrical machines fed from voltage converters*

IEC/TS 60034-18-42, *Rotating electrical machines – Part 18-42: Qualification and acceptance tests for partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters*

IEC 60085, *Thermal evaluation and designation of electrical insulation*

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IEC 60216 (all parts), *Electrical insulating materials – Properties of thermal endurance*

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 60505:2004, *Evaluation and qualification of electrical insulation systems*

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
class temperature
temperature for which the insulation system is suitable, as defined by the thermal class in IEC 60085 and as used in IEC 60505

3.1.2
insulation system
insulating structure containing one or more electrical insulating materials applied over conducting parts employed in rotating electrical machines

[IEC 60505:2004, 3.1.1, modified]

NOTE 1 There may be several insulation components within the windings, each being designed for different stresses in service, i.e. turn insulation, slot insulation and end-winding insulation. Different criteria may be applied to the various components within the overall system.

NOTE 2 There may be more than one insulation system in a particular type of machine. These insulation systems may have different thermal classes (e.g. stator and rotor windings).

3.1.3
candidate insulation system
insulation system being tested to determine its capability with respect to ageing factors

[IEC 60050-411, Amendment 1:2007, 411-39-26, modified]

3.1.4
reference insulation system
insulation system whose performance has been established by satisfactory service experience

[IEC 60050-411, Amendment 1:2007, 411-39-27]

3.1.5
coil
one or more turns of insulated conductors connected in series and surrounded by common insulation, arranged to link or produce magnetic flux

[IEC 60050-411:1996, 411-38-03, modified]

3.1.6
bar
either of two parts which, after placed in their slots and when connected together, will form the complete form-wound coil (see 3.1.8) and which comprise a coil side and an appropriate end winding

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[IEC 60050-411:1996, 411-38-05, modified]

NOTE Large a.c. machines commonly use bars, and usually, though not always, they form single-turn coils in a two-layer winding.

3.1.7
wire-wound winding
winding which is wound with one or several insulated conductors and in which the individual conductors occupy random positions in the coil side

NOTE It is usually random-wound with round conductors.

[IEC 60050-411:1996, 411-38-13, modified]

3.1.8
form-wound winding
winding consisting of coils or bars which are preformed to shape, insulated and substantially completed before they are inserted into their final places

NOTE Coils or bars are usually wound with rectangular conductors.

[IEC 60050-411:1996, 411-38-11, modified]

3.2 Terms relating to the objects being tested

3.2.1
test object
unit being tested

NOTE 1 It may be an actual machine or part thereof or a special test model (see 3.2.3 and 3.2.4) which can be subjected to functional tests.

NOTE 2 A test object may contain more than one test specimen (see 3.2.2).

3.2.2
test specimen

individual component within a test object which can be used to generate one piece of test data (e.g. time to failure)

NOTE A test specimen may contain more than one insulation component (e.g. turn insulation and conductor to earth insulation), any one of which can provide that piece of data.

3.2.3
formette
special test model used for the evaluation of the insulation systems for form-wound windings

[IEC 60050-411, Amendment 1:2007, 411-53-64]

3.2.4
motorette
special test model used for the evaluation of the insulation systems for wire-wound (random-wound) windings

[IEC 60050-411, Amendment 1:2007, 411-53-65]

3.3 Terms relating to factors of influence and ageing factors

3.3.1
factor of influence
stress imposed by conditions of operation, environment or test that may affect ageing or life of an insulation system

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3.3.2
ageing factor
factor of influence that causes ageing

NOTE In the winding of an electrical machine, different factors of influence or ageing factors can be dominant in different parts (e.g. turn insulation and end-winding insulation). Therefore, different criteria may be used to assess those parts of the insulation. It can also be appropriate to apply different procedures of functional evaluation to these parts.

3.4 Terms relating to testing and evaluation

3.4.1
diagnostic factor
variable or fixed stress applied to an insulation component of a test specimen in order to establish its condition after ageing without significantly adding to the ageing

[IEC 60505:2004, 3.3.7, modified]

3.4.2
functional test
comparative test in which the candidate and the reference insulation systems are exposed to ageing and diagnostic factors in order to qualify the candidate system

3.4.3
endurance test
test in which the insulation system of a test object is exposed to one or more ageing factors related to service conditions and where changes in specific properties are evaluated by diagnostic tests

3.4.4
diagnostic test
test in which the insulation system of a test object is exposed to one or more diagnostic factors in order to discern its condition through measurements or proof tests and to determine when the end-point criterion has been reached

3.4.5
end-point criterion
selected value of a characteristic of a test object indicating the end of its test life or arbitrarily chosen for the purpose of the comparison of insulation systems

3.4.6
end-point
end of a test as defined by the end-point criterion

3.4.7
classification
set of actions leading to determination of the thermal class of an insulation system

4 General aspects of functional evaluation

4.1 Introductory remarks

All functional tests given in the IEC 60034-18 series are comparative. The performance of a candidate system is compared with that of a reference system when both are subjected to equivalent test conditions with respect to test objects, methods of ageing and diagnostic tests.

At the end of every functional test, the functional evaluation shall be made. This means it is necessary to compare the diagnostic data obtained from the candidate and the reference system, usually to compare the mean times to failure.

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If the data from the candidate system is no worse than from the reference system, the candidate system is considered to be qualified. This is true if the 90 % confidence interval of that percentile of the used probability distribution which represents the mean value falls above or within that obtained from the reference system (see IEC 60493-1 and IEC 62539).

The large differences found in rotating electrical machine windings, in terms of size, voltage and operating conditions, necessitate the use of different procedures for functional evaluation to evaluate various types of windings. These procedures can also be of different complexity, the simplest being based on a single ageing factor (e.g. thermal or electrical).

The procedures for functional evaluation will permit comparisons and allow qualification of candidate insulation systems. However, they cannot completely determine the merits of any particular insulation system. Such information can be obtained in general only from extended service experience.

4.2 Effects of ageing factors

All ageing factors, i.e. thermal, electrical, environmental and mechanical, affect the life of all types of machines but the significance of each factor varies with the type of machine and the expected duty. In some cases, one of these ageing factors is considered to be dominant.

In other cases, several ageing factors may be acting significantly. These different conditions have to be considered in choosing the appropriate functional test according to this standard.

Insulation of small or medium low-voltage line-fed machines is degraded primarily by temperature and environment, with electrical and mechanical stresses being of less importance.

Medium to large machines, using form-wound windings, are also affected by temperature and environment but, in addition, the electrical and mechanical stresses can be important ageing factors.

Very large machines, which generally utilize form-wound (with bars) windings and which can operate in a special environment such as hydrogen, are normally most affected by mechanical stresses or electrical stresses, or both. Temperature and environment can be less significant ageing factors.

The winding insulation of small, medium, large and very large converter fed machines may be substantially electrically stressed (see IEC 60034-18-41 and IEC 60034-8-42).

4.3 Reference/candidate insulation system

An insulation system qualifies to be used as a reference insulation system if its performance has been established by satisfactory service experience. This means:

– it has shown successful operation over suitably long periods of time at operating conditions characteristic of the rating (or class) and in typical applications of that insulation system;
– its service experience is based on a sufficient number of machines.

A reference insulation system shall be tested together with the candidate system using the same test procedure and the same test equipment, preferably in the same laboratory.

If it is necessary to verify results in another laboratory it can be found that the test-life values differ if the conditions in the original test are not duplicated precisely. However, a comparison of results between qualified laboratories should show the same relative performance between candidate and reference systems.

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