IEC 60034-18-21

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Machines électriques tournantes – Partie 18-21: Evaluation fonctionnelle des systèmes d'isolation – Procédures d'essai pour enroulements à fils – Evaluation thermique et classification

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FOREWORD

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International Standard IEC 60034-18-21 has been prepared by IEC technical committee 2: Rotating machinery.

This second edition cancels and replaces the first edition published in 1992, and its amendments 1 (1994) and 2 (1996), and constitutes a technical revision.

The main technical changes with regard to the previous edition can be seen in the introduction of some basic statistical methods in the evaluation of comparative data. Moreover, the standard states a simpler use of different test procedures.

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

FDIS	Report on voting
2/1672/FDIS	2/1682/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- withdrawn,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 comprises several parts, dealing with different types of functional evaluation and special kinds of test procedures for insulation systems of rotating electrial machines. Part IEC 60034-18-1 provides general guidelines for such procedures and qualification principles. The subsequent parts IEC 60034-18-21, IEC 60034-18-22, IEC 60034-18-31, 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.

This part IEC 60034-18-21 deals with the thermal evaluation and classification of insulation systems for wire-wound (usually random wound) windings.

Parts relevant to this document are:

– IEC 60034-18-1: General guidelines
– IEC 60034-18-31: Test procedures for form-wound windings
– IEC 60034-18-41: Qualification and type tests for Type I electrical insulation systems used in rotating electrical machines fed from voltage converters
– IEC 60034-18-42: Qualification and acceptance tests for partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters

ROTATING ELECTRICAL MACHINES –

Part 18-21: Functional evaluation of insulation systems – Test procedures for wire-wound windings – Thermal evaluation and classification

1 Scope

This part of IEC 60034 gives test procedures for the thermal evaluation and classification of insulation systems used or proposed for use in wire-wound alternating current (a.c.) or direct current (d.c.) rotating electrical machines.

The test performance of a candidate insulation system is compared to the test performance of a reference insulation system with proven service experience.

IEC 60034-18-1 describes general testing principles applicable to thermal endurance testing of insulation systems used in rotating electrical machines. The principles of IEC 60034-18-1 are followed unless otherwise stated in IEC 60034-18-21.

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

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

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60216-1, *Electrical insulating materials – Properties of thermal endurance – Part 1: Ageing procedures and evaluation of test results*

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

IEC 60455 (all parts), *Resin based reactive compounds used for electrical insulation*

IEC 60464 (all parts), *Varnishes used for electrical insulation*

IEC 60505, *Evaluation and qualification of electrical insulation systems*

3 General considerations

3.1 Reference insulation system

A reference insulation system shall be tested using the same test procedure as for the candidate system. See 4.3 of IEC 60034-18-1.

3.2 Test procedures

Each thermal endurance test generally consists of a series of cycles, where each cycle comprises a thermal ageing sub-cycle followed by a conditioning sub-cycle and a diagnostic sub-cycle.

There are five different test procedures, according to the type of test object, namely, Procedure 1: Motorette test procedure, Procedure 2: Motor test procedure, Procedure 3: Test procedure for stator windings in slots, Procedure 4: Test procedure for pole windings and Procedure 5: Test procedure for rotor windings in slots and they are described in Clauses 8, 9, 10, 11 and 12. The thermal endurance test procedure uses several cycles, each consisting of:

– a thermal ageing sub-cycle;
– a diagnostic sub-cycle, which includes mechanical and moisture conditioning followed by a diagnostic voltage test, performed in that order.

In addition to the required tests, additional non-destructive informative tests may be used.

4 Test objects and test specimens

4.1 Construction of test objects

It is expected that the various insulating materials or components making up any insulation system to be evaluated by these test procedures will first be screened using company screening procedures. Temperature indices for insulating materials may be used. However, temperature indices of insulating materials cannot be used to classify insulation systems but are to be considered only as indicators for the thermal functional tests for systems. For electrical isolation systems see IEC 60085.

Wherever economics or the size of the machine or both warrant it, an actual machine or machine component should be used as the test object. Usually this means that coils of full cross section, with actual clearances and creepage distances are needed, though a reduced slot length may be adequate.

Test objects may be actual machines, machine components or models.

Test models shall contain all the essential elements employed in the windings they simulate and shall be considered only as close approximations. Insulation thicknesses, creepage distances and, where necessary, discharge protection appropriate for the intended maximum rated voltage and equipment standards or practice shall be used.

For large and high-voltage machines, test models representing a part of a coil or bar may be used, when ageing specific for that part is investigated, provided that representative factors of influence can be applied to the test specimens.

The systems compared shall have arrangements consistent with those to be used in machines.

NOTE It is recognized that markedly different values of test life may be obtained for the same insulating materials, depending on insulation thicknesses and creepage distances.

Test specimens simulating parts of a coil or winding may be used for evaluation, if stresses acting on these parts in service can be reproduced reliably in the test.

Particular types of models have been used successfully in some countries and examples of these are illustrated in Annexes A and B.

The manufacturer should make certain that the materials proposed for use in the new insulation system can be handled without deterioration of properties in the intended manufacturing processes.

4.2 Verification of effects of minor changes in insulation systems

A minor change is described in IEC 60034-18-1. An example of a minor change in a wire-wound insulation system may include purchasing a key component material from a new supplier without changing the material specification. If thermal ageing evaluation is appropriate to evaluate a minor change to a service-proven insulation system, it is acceptable to use one temperature to age one test object consisting of no fewer than the recommended number of test specimens.

Reduced evaluation should be performed using an ageing temperature cycle within the range of known thermal endurance data for the service-proven system.

4.3 Number of test specimens

Tests should be conducted using no fewer than five test specimens per ageing temperature, per insulation system. This is the minimum recommended number for statistical confidence.

4.4 Quality control

Each insulating material intended to be used in preparation of test objects should be subjected to separate tests to establish uniformity before it is used in assembly.

Each test specimen shall be subjected to the quality control tests of the normal or intended production process.

To eliminate defective test objects, they should be qualified first by visual examination and then by over-voltage tests consistent with the machine or coil tests in the manufacturing facility, or as described in the appropriate subclauses for diagnostic tests, whichever voltage test is greater.

NOTE When appropriate additional screening (or qualifying) tests may be used, including the following:

- insulation resistance measurement;
- loss tangent and capacitance measurement;
- partial discharge inception voltage measurement;
- balance of phase currents while running;
- repetitive surge;
- leakage current;
- high-voltage test.

Any widely deviating test object should be discarded or inspected to determine the reason for the deviation and appropriate allowances should be made for the deviations.

4.5 Initial diagnostic tests

Each completed test object shall be subjected to all of the diagnostic tests selected to be used in the thermal functional test before starting the first thermal ageing sub-cycle, to establish that each test specimen is capable of passing the selected diagnostic tests.

5 Test procedures

5.1 General principles of diagnostic tests

In many cases, experience has indicated that the best diagnostic evaluation of a thermally degraded and thus usually brittle insulation system is obtained by exposure to mechanical stress, thus producing cracks in the mechanically stressed parts, then exposure to moisture and finally application of the test voltage.

In other cases, mechanical stress, moisture exposure and application of voltage may not be the best diagnostic tests and may be replaced by selected dielectric tests (e.g., measurement of partial discharge or loss tangent) to check the condition of the insulation after each thermal ageing sub-cycle.

The test procedure consists of several ageing tests, performed at different ageing temperatures. At each temperature, the test life of the insulation system is determined. Based on these test life values, the life at the class temperature is estimated relative to that of the reference system at its class temperature.

Each ageing test is performed in cycles, each cycle consisting of a thermal ageing sub-cycle and a diagnostic sub-cycle. The diagnostic sub-cycle may include mechanical and moisture conditioning procedures, followed by a diagnostic voltage test and other diagnostic tests.

5.2 Ageing temperatures and sub-cycle lengths

It is recommended that the tests be carried out on the number of specimens indicated in subsequent subclauses of this standard for at least three different ageing temperatures.

The intended thermal class (or class temperature) of the candidate insulation system as well as the known class of the reference system shall be selected from Table 1, which is a subset of the thermal classes defined in IEC 60085 and IEC 60505.

Table 1 – Thermal classes

Thermal class rating	Thermal class °C
105 (A)	105
120 (E)	120
130 (B)	130
155 (F)	155
180 (H)	180
200 (N)	200

NOTE The thermal classes 105 (A), 120 (E) and 200 (N) in Table 1 are nowadays seldom used in rotating electrical machines and are not found in IEC 60034-1.

Table 2 lists the suggested ageing temperatures and corresponding periods of exposure in each thermal ageing sub-cycle for insulation systems of the various thermal classes. Time and temperature may be adjusted to make the best use of facilities and staff but comparisons shall take such variations into consideration.

The lowest ageing temperature should be selected such as to produce the mean test life of about 5 000 h and the highest temperature should produce a mean test life of at least 100 h. This is generally accomplished by choosing the lowest ageing temperature to correspond to an exposure period of 28 to 35 days or longer.

In addition, at least two higher ageing temperatures should be selected, separated by intervals of 20 K or more. Intervals of less than 20 K may be suitable when tests are made at more than four ageing temperatures. The highest temperature shall provide a mean test life of at least 100 h.

To minimize the uncertainty introduced by extrapolation the lowest test temperature should not exceed by more than 25 K the temperature to which the results will be extrapolated.

If the intended thermal class for the candidate insulation system differs from the known class of the reference system, different ageing temperatures and sub-cycle lengths are to be selected in an appropriate manner.

Where the candidate insulation system represents a minor change from a classified system, 4.2 may be followed.

It is recommended that the lengths of ageing sub-cycles for the intended class temperature be selected so as to give a mean life of about 10 cycles for each ageing temperature.

Table 2 – Recommended temperatures and ageing sub-cycle exposure periods

Anticipated thermal class	**105**		**120**		**130**		**155**		**180**		**200**		**Days per ageing sub-cycle**
$T_1 < T_A \le T_2$	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	
Suggested range for ageing temperature (T_A) °C	170	180	185	195	195	205	220	230	245	255	265	275	1 – 2
	160	170	175	185	185	195	210	220	235	245	255	265	2 – 3
	150	160	165	175	175	185	200	210	225	235	245	255	4 – 6
	140	150	155	165	165	175	190	200	215	225	235	245	7 – 10
	130	140	145	155	155	165	180	190	205	215	225	235	14 – 21
	120	130	135	145	145	155	170	180	195	205	215	225	28 – 35
	110	120	125	135	135	145	160	170	185	195	205	215	45 – 60

NOTE This Table 2 is designed to give flexibility to laboratories to choose ageing times and temperatures in such a way as to optimize the use of their manpower and facilities. It accommodates the ideal situation (based on 10 K rule) that allows for doubling the ageing time for every 10 K decrease in ageing temperature (e.g. 1, 2, 4, 8, 16, 32, and 64 days of ageing). It allows the ageing to be performed in multiples of one week at the lower ageing temperatures (e.g. 1, 2, 4, 7, 14, 28 and 49 days of ageing). It also allows the ageing to be performed in such a way as to maximize the 5-day working week. This has the main benefit, that always starting an ageing sub-cycle on a Friday and the diagnostic tests on a Monday (e.g. 3, 10, 17, 31 and 59 days of ageing) is possible.

5.3 Methods of heating

Despite some evident disadvantages, ovens have been shown by experience to be a convenient and economical method of providing thermal ageing. Ovens with forced convection shall be used. The oven method subjects all the parts of the insulation system to the full ageing temperature, while in actual service a large proportion of the insulation may operate at considerably lower temperatures than the hot-spot temperature. Also, the products of decomposition are likely to remain near the insulation during oven ageing whereas they may be carried away by ventilation in actual operation. Ageing temperatures shall be controlled and held constant within ± 2 K up to 180 °C inclusive and ± 3 K from 180 °C to 300 °C.

The use of ovens for heating is not mandatory. A more direct means which more closely simulates service conditions may be used when appropriate, such as:

– direct heating by electric current;
– starting and reversing duty (motor test);