

Rotating electrical machines —

Part 18: Functional evaluation of insulation systems —

Section 21: Test procedures for wire-wound windings — Thermal evaluation and classification

The European Standard EN 60034-18-21:1994 with the incorporation of amendments A1:1996 and A2:1996 has the status of a British Standard

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Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national committees of the following countries:

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National foreword

This British Standard has been prepared under the direction of the Electrotechnical Sector Board and is the English language version of EN 60034-81-21:1994, *Rotating electrical machines. Part 18: Functional evaluation of insulation systems. Section 21: Test procedures for wire-wound windings — Thermal evaluation and classification*, including amendments A1:1996 and A2:1996 published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 34-18-21:1992, including amendments 1:1996 and 2:1996 published by the International Electrotechnical Commission (IEC).

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 30, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

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

(includes amendments A1:1996 and A2:1996)
(IEC 34-18-21:1992 + A1:1996 and A2:1996)

Machines électriques tournantes
Partie 18: Evaluation fonctionnelle des
systèmes d'isolation
Section 21: Procédures d'essai pour
enroulements à fils — Evaluation thermique et
classification
(inclut les amendements A1:1996 et A2:1996)
(CEI 34-18-21:1992 + A1:1996 et A2:1996)

Drehende elektrische Maschinen
Teil 18: Funktionelle Bewertung von
Isoliersystemen für drehende elektrische
Maschinen
Hauptabschnitt 21: Prüfverfahren für
Runddraht- Wicklungen — Thermische
Bewertung und Klassifizierung
(enthält Änderungen A1:1996 und A2:1996)
IEC 34-18-21:1992 + A1:1996 und A2:1996)

This European Standard was approved by CENELEC on 1993-12-08; amendments A1 and A2 were approved by CENELEC on 1996-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 34-18-21:1992 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as a European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 60034-18-21 on 8 December 1993.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-03-15
- latest date of withdrawal of conflicting national standards (dow) 1995-03-15

For products which have complied with the relevant national standard before 1995-03-15, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2000-03-15.

Annexes designated “normative” are part of the body of the standard,

Annexes designated “informative” are given only for information.

In this standard, Annex A, Annex B and Annex C are informative and Annex ZA is normative.

Foreword to amendment A1

The text of amendment 1:1994 to the International Standard IEC 34-18-21:1992, prepared by SC 2J, Classification of insulation systems for rotating machinery, of IEC TC 2, Rotating machinery, was submitted to the formal vote and was approved by CENELEC as amendment A1 to EN 60034-18-21:1994 on 1996-10-01 without any modification.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1997-09-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1997-09-01

For products which have complied with EN 60034-18-21:1994 before 1997-09-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2002-09-01.

Foreword to amendment A2

The text of document 2J/51/fDIS, future amendment 2 to IEC 34-18-21:1992, prepared by SC 2J, Classification of insulation systems for rotating machinery, of IEC TC 2, Rotating machinery, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A2 to EN 60034-18-21:1994 on 1996-10-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1997-09-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1997-09-01

For products which have complied with EN 60034-18-21:1994 and its amendment A1:1996 before 1997-09-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2002-09-01.

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Introduction

Section 1 of IEC 34-18 presents general principles for the evaluation and classification of insulation systems used in rotating electrical machines.

This section of IEC 34-18 deals with the thermal evaluation and classification of insulation systems for wire-wound (usually random wound) windings. Several standard test procedures are given for various types of wire-wound windings and testing techniques.

This section belongs to Part 18 of a series of publications dealing with the functional evaluation of insulation systems for rotating electrical machines, the other parts being:

- *Section 1: General guidelines.* (IEC 34-18-1)
- *Section 31: Test procedures for form-wound windings.* (IEC 34-18-31)

1 Scope

This section of IEC 34-18 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 procedures are comparative in that the performance of a candidate insulation system is compared to that of a reference insulation system with proven service experience.

Section 21 shall be used in conjunction with Section 1.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this section of IEC 34-18. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this section of IEC 34-18 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 34-1:1983, *Rotating electrical machines — Part 1: Rating and performance.*

IEC 455, *Specification for solventless polymerisable resinous compounds used for electrical insulation.*

IEC 464, *Specification for insulating varnishes containing solvent.*

IEC 34-18-1:1991, *Rotating electrical machines — Part 18: Functional evaluation of insulation systems — Section 1: General guidelines.*

3 General considerations

3.1 Relationship to Section 1

Section 1 describes general testing principles applicable to thermal endurance testing of insulation systems in rotating machines. Unless the procedures of this part indicate otherwise, the principles of Section 1 shall be followed.

3.2 Standard procedures

Five standard procedures are specified in clauses 4 through 8. Procedure 1 can be considered of general applicability to both a.c. and d.c. applications and to both stators and armatures. However, the user of this standard may select that test procedure which most closely corresponds to the type and size of the windings to be tested and classified, taking into account facilities and past experience.

3.3 Reference insulation system

A reference insulation system shall be tested using the same test procedure as for the candidate system. See 4.2 of Section 1.

The thermal class temperatures of the two systems shall not differ by more than 50 K.

3.4 Test objects

3.4.1 Construction of test objects

Tests for the selection of materials according to 5.2.1 of section 1 may be performed, as appropriate.

Test objects may be actual machines, machine components or models. The components and models should embody all the essential elements.

Insulation thickness, creepage distances and discharge protection where required shall be appropriate for the intended maximum rated voltage and equipment standards or practice. 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 can 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 Annex A and Annex 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.

3.4.2 Quality assurance tests

To eliminate defective test objects, they should be qualified first, as per 5.2.3 of Section 1, 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 object should be discarded or inspected to determine the reason for the deviation and appropriate allowances should be made for the deviations.

3.5 Verification of diagnostic tests

A preliminary ageing test according to 5.3.4 of Section 1, to check the feasibility of the diagnostic sub-cycle, may be performed.

3.6 Thermal ageing test procedure

The test procedure consists of several ageing tests, performed at different ageing temperatures. At each temperature, the test life of the insulation systems tested 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 a mechanical test, a moisture test, a voltage test and other diagnostic tests.

3.7 Ageing temperatures and sub-cycle lengths

The considerations and procedures of 5.3.2 of Section 1 should be observed and followed.

For the normal procedure, the number of ageing temperatures shall be at least three.

Where the candidate insulation system represents a minor change from a classified system, 5.3.2.2 of Section 1 may be followed.

Ageing temperatures and lengths of ageing subcycles should be selected from Table 2 of Section 1.

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.

The lowest ageing temperature should be selected such as to produce the log mean test life of about 5 000 h or more. 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 10 K may be used when tests are made at more than three ageing temperatures.

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.

4 Procedure 1: Motorette test procedure

4.1 General

4.1.1 Procedure 1

This procedure, using “motorette” type models as test objects, shall be referred to as IEC 34-18-21, Procedure 1.

4.1.2 General features

This thermal endurance test procedure consists of several cycles. Each cycle consists of:

- a thermal ageing sub-cycle;
- a diagnostic sub-cycle which includes a mechanical test, a moisture test with test-specimen cooling and a voltage test, performed in that order.

4.2 Test objects

4.2.1 Construction of test objects

The test object in this procedure, designated motorette, models the insulation system to be tested.

The motorette shall be made to embody all of the essential elements and should be as nearly as possible representative of a complete winding insulation system. The motorette simulates a wire-wound winding of a slotted structure.

An example of a motorette used to test wire-wound winding insulation is described in Annex A.

4.2.2 Number of test objects

At least 10 motorettes should be tested at each ageing temperature, for each insulation system.

4.2.3 Quality assurance tests

Before the first thermal ageing sub-cycle is started, the following quality assurance tests shall be performed:

- visual inspection of the test objects;
- voltage tests according to IEC 34-1;

- 400 V a.c. conductor-to-conductor test with 50 mA circuit breaker to detect failure.

4.2.4 Initial diagnostic tests

Each completed test object shall be subjected to the diagnostic tests of 4.4, before starting the first thermal ageing sub-cycle.

4.3 Thermal ageing sub-cycle

4.3.1 Ageing temperatures and sub-cycle lengths

The procedures given in 3.7 shall be followed.

4.3.2 Means of heating

Ageing ovens according to 5.3.3 of Section 1 shall be used.

4.3.3 Ageing procedure

The motorettes shall be loaded directly into the hot ageing oven at the beginning of the ageing sub-cycle, and removed from the oven directly to room temperature air at the end of the sub-cycle.

In order to diminish the effects of differences in actual ageing temperatures between individual motorettes, the locations of the motorettes in the ageing oven should be randomized in successive heat ageing sub-cycles.

4.4 Diagnostic sub-cycle

4.4.1 Mechanical test

Following each sub-cycle of thermal ageing, after cooling to room temperature, each motorette is subjected to mechanical stress on a shake table for a period of 1 h.

The motorettes are mounted so that the motion occurs at right angles to the plane of the coils so that the coil ends are excited to vibrate as they would under radial end-winding forces in an actual motor. This vibration test is made at room temperature and without any applied voltage.

The preferred amplitude of the vibration corresponds to an acceleration of 1,5 g (0,2 mm peak-to-peak amplitude at 60 Hz or 0,3 mm at 50 Hz). If the principle of service-related stresses (see 5.5.1 of Section 1) leads to a larger vibration amplitude, it shall be used and reported.

4.4.2 Moisture test

A moisture test of at least 48 h duration shall be performed, according to 5.5.2 of Section 1. Visible moisture droplets, without puddles, shall be present on the windings during the moisture test. The motorettes shall be at approximately room temperature, in the 15 °C to 35 °C range. The actual motorette temperatures shall be reported. No voltage is applied to the test objects during this test. See Annex C for examples of equipment for such tests.

The principle of cooled test objects shall be used. See clause C.2 of Annex C.

4.4.3 Voltage test

In order to check the condition of the test specimens and determine when the end of test life has been reached, power-frequency voltage is applied after each successive exposure to moisture, as follows:

The test voltage to be used to frame and between coils should correspond to the upper limit of the voltage range for which that insulation system is intended. A voltage other than 660 V may be employed in order, for example, to permit the use of much test data taken at 600 V. Other test voltages may be used for end-point determination based on test experience as long as these voltages are maintained consistently for both the reference and the candidate systems. Deviations from values given in Table 1 shall be reported.

The voltages are applied for a period of 10 min while the test specimens are still in the equipment for moisture test, wet with moisture. The applied voltage is held successively, each time for 10 min using appropriate circuitry, first between the parallel wound conductors, then from coil to coil, and finally from all coils to frame. It is suggested that surge protectors be included in the test circuit to eliminate unintended high-voltage spikes.

Based on experience, one of the most significant factors in the testing of motorettes is the characteristics of the circuit breakers used to detect failure. See clause A.3 of Annex A.

Table 1 — Test voltages in procedure 1

Rated voltage in service	Recommended power-frequency voltage for testing ($V_{r.m.s.}$)		
	To frame	Between coils	Between conductors ^a
110 – 400	400	400	110 ± 10
401 – 660	660	660	110 ± 10
661 – 1 000	Under consideration	Under consideration	Under consideration

^a Range of acceptable voltage; however, the value chosen should be used consistently.