BRITISH STANDARD

BS EN 60034-15:1996
IEC 34-15: 1995

Rotating electrical machines —

Part 15: Impulse voltage withstand levels of rotating a.c. machines with form-wound stator coils

The European Standard EN 60034-15:1996 has the status of a British Standard

ICS 29.160

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee PEL/2, Rotating electrical machinery, upon which the following bodies were represented:

Association of Consulting Engineers
Association of Electrical Machinery Trades
Association of Manufacturers of Power Generating Systems
Electricity Association
Engineer Surveyors Section of the MSF
Engineering Equipment and Materials Users' Association
ERA Technology Ltd.
Health and Safety Executive
Institution of Incorporated Executive Engineers
Institution of Plant Engineers
Ministry of Defence
Power Generation Contractors' Association (BEAMA Ltd.)
Rotating Electrical Machines Association (BEAMA Ltd.)
United Kingdom Offshore Operators' Association

This British Standard, having been prepared under the direction of the Electrotechnical Sector Board, was published under the authority of the Standards Board and comes into effect on
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Contents

National foreword

This British Standard has been prepared by Technical Committee PEL/2 and is the English language version of EN 60034-15:1996 *Rotating electrical machines — Part 15: Impulse voltage withstand levels of rotating a.c. machines with form-wound stator coils*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 34-15:1995 published by the International Electrotechnical Commission (IEC).

The foreword of the European Standard makes reference to the "date of withdrawal", dow, of the relevant national standard. In this case the relevant national standard is BS 4999-115:1992 which will be withdrawn on 1996-12-01. Certificates and marks will not be awarded after this date with respect to the withdrawn British Standard. However such certificates and marks, already awarded, may continue to apply to production until 2001-12-01.

Cross-references

Publication referred to	Corresponding British Standard
EN 60034-1:1995 (IEC 34-1:1994)	BS EN 60034 *Rotating electrical machines* Part 1:1995 *Rating and performance*
HD 588.1:1991 (IEC 60-1:1989)	BS 923 *Guide on high-voltage testing techniques* Part 1:1990 *General*
EN 60071-1:1995 (IEC 71-1:1993)	BS EN 60071 *Insulation co-ordination* Part 1:1996 *Definitions, principles and rules*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, the EN title page, pages 2 to 8, 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.

Introduction

IEC 71-1 specifies general requirements for the phase-to-earth insulation of equipment in three-phase a.c. systems and states that each apparatus committee is responsible for specifying the insulation levels and test procedures for its equipment, taking into consideration the recommendations of IEC 71-1. The object of this standard is to specify requirements for rotating electrical machines and experience has shown that the values given in this standard meet the insulation requirements for the essential stresses in service under usual operating conditions. An explanation of the principles adopted in preparing these requirements is given in Annex A.

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Descriptors: Rotating electrical machines, alternating current, withstand voltage, impulse voltage test

English version

Rotating electrical machines
Part 15: Impulse voltage withstand levels of rotating a.c. machines with form-wound stator coils

(IEC 34-15:1995)

Machines électriques tournantes
Partie 15: Niveaux de tension de tenue au choc des machines tournantes à courant alternatif à bobines stator préformées
(CEI 34-15:1995)

Drehende elektrische Maschinen
Teil 15: Bemessungsstoßspannungen drehender Wechselstrommaschinen mit Formspulen im Ständer
(IEC 34-15:1995)

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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.

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

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Ref. No. EN 60034-15:1996 E

Foreword

The text of the International Standard IEC 34-15:1995, prepared by IEC TC 2, Rotating machinery, was submitted to the formal vote and was approved by CENELEC as EN 60034-15 on 1995-11-28 without any modification.

This European Standard supersedes HD 53.15 S1:1991.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1996-12-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1996-12-01

For products which have complied with HD 53.15 S1:1991 before 1996-12-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2001-12-01.

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given for information only. In this standard, Annex ZA is normative and Annex A is informative. Annex ZA has been added by CENELEC.

Contents

Introduction

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1 Scope

This part of IEC 34 specifies the rated phase-to-earth impulse voltage withstand levels of rotating a.c. machines having rated voltages from 3 kV to 15 kV inclusive and incorporating form-wound stator coils, together with the test procedures and voltages to be applied to the main and interturn insulation of sample coils to prove the compliance of the machine.

2 Normative references

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

IEC 34-1:1994, *Rotating electrical machines — Part 1: Rating and performance.*

IEC 60-1:1989, *High-voltage test techniques — Part 1: General definitions and test requirements.*

IEC 71-1:1993, *Insulation co-ordination — Part 1: Definitions, principles and rules.*

3 Definitions

For the purpose of this part of IEC 34 the following definitions apply.

3.1
random sample test

test carried out on coils which adequately represent the configuration of the finished item to be used in the machine, for the purpose of evaluating the basic design, type of materials, manufacturing procedures and processes incorporated in the insulation system

3.2
routine test

test carried out on all coils of the machine

3.3
form-wound stator coil

coil which is preformed to shape before insertion into the stator

4 Impulse voltage withstand levels

Rated impulse voltage withstand levels for rated voltages from 3 kV to 15 kV shall be obtained by application of the formulae given in notes 2 and 4 of Table 1, the values obtained being rounded off to the nearest whole number. Table 1 gives the rated impulse voltage withstand levels for some common rated voltages, together with the corresponding rated power-frequency withstand voltage (r.m.s.) according to IEC 34-1.

5 Tests

5.1 Random sample tests

5.1.1 *General*

These tests are carried out as an indirect proof as explained in **A.3.2** of Annex A. The test coils shall be fully processed, including corona protection, if provided, and shall be either embedded in slots or fitted with the slot portion wrapped in earthed conducting tape or foil. The number of sample coils shall be two, unless agreed otherwise between the manufacturer and the purchaser.

All tested coils shall fulfil the requirements given below and, in the case of a failure, investigations shall be carried out to determine the cause.

5.1.2 *Impulse test of the interturn insulation*

5.1.2.1 The impulse test of the interturn insulation shall be carried out by applying a voltage between the two terminals of the sample coils.

5.1.2.2 The interturn test voltage shall be generated by the damped oscillatory discharge of a capacitor. The number of capacitor discharges shall be five, unless agreed otherwise between the manufacturer and the purchaser. The front time of the first voltage peak shall be 0,2 µs with a tolerance of + 0,3 µs/– 0,1 µs.

5.1.2.3 The voltage peak between the terminals of the sample coil shall have the values given in Table 1, column 3, as appropriate, or the values obtained by application of the formula in note 4 of Table 1 and rounded off to the nearest whole number.

Table 1 — Rated insulation levels for rotating machines

1 **Rated voltage**	2 **Rated lightning impulse withstand voltage (peak) (see notes 1 and 2)**	3 **Rated steep-front impulse withstand voltage (peak) (see notes 3 and 4)**	4 **Rated power-frequency withstand voltage (r.m.s.) according to IEC 34-1**
U_N	U_P	U_P'	$2\ U_N + 1$
kV	kV	kV	kV
3	17	11	7
3,3	18	12	7,6
4	21	14	9,0
6	29	19	13
6,6	31	20	14,2
10	45	29	21
11	49	32	23
13,2	58	38	27,4
13,8	60	39	28,6
15	65	42	31

NOTE 1 The levels in column 2 are based on a standard lightning impulse having a front time of 1,2 µs and a time to half-value of 50 µs as specified in IEC 60-1.

NOTE 2 The levels in column 2 are obtained by application of the formula:

$U_P = 4\ U_N + 5$ kV

where

U_P is the rated lightning impulse withstand voltage (peak);

U_N is the rated voltage.

NOTE 3 The levels in column 3 are based on an impulse having a front time of 0,2 µs.

NOTE 4 The levels in column 3 are obtained by application of the formula:

$U_P' = 0{,}65\ U_P$.

where

U_P' is the rated steep-front impulse withstand voltage (peak).

NOTE 5 The levels in columns 2 and 3 have been deemed appropriate by taking into consideration both the average characteristics of machines and "usual" operating conditions.

The above-mentioned levels, therefore, may not be adequate for "special" operating conditions (e.g. interrupted start, or direct connection to overhead lines). In such cases the windings should either be designed to withstand other impulse levels or be protected in an appropriate way.

5.1.3 *Impulse test of the main insulation*

The impulse withstand level of the main insulation is tested by applying either a power-frequency voltage (see **5.1.3.1**) or an impulse voltage (see **5.1.3.2**).

5.1.3.1 *Power-frequency voltage test*

The rated power-frequency withstand voltage ($2\ U_N + 1$ kV) shall be applied for 1 min between coil terminals and earth. The applied voltage shall then be increased at the rate of 1 kV/s up to 2 ($2\ U_N + 1$ kV), and then immediately be reduced at a rate of at least 1 kV/s to zero. There shall be no failure during the sequence. The corresponding impulse withstand level of the main insulation and the overhang corona protection are then considered to fulfil at least the requirements of Table 1.

NOTE 1 The rated impulse levels in Table 1, columns 2 and 3, are lower than the peak value $2\sqrt{2}$ ($2\ U_N + 1$ kV) derived from this test, because the impulse level of a machine is determined by the interturn voltage due to longitudinal voltage distribution (see **A.1.1** and **A.1.2**). The purpose of the higher a.c. test level is to produce a voltage gradient in the region just beyond the slot exit as near as possible to that obtained by the impulse test.

NOTE 2 In some countries, it is common practice to apply a d.c. test voltage instead of the power-frequency voltage specified above. This is permitted by this standard when agreed between the manufacturer and the purchaser. The d.c. voltage level shall be included in such an agreement and should be at least as high as 1,7 times the 1 min power-frequency test voltage, in accordance with clause **17** of IEC 34-1,1994.

5.1.3.2 *Impulse voltage test*

5.1.3.2.1 The impulse test of the main insulation shall be carried out by applying a voltage between the coil terminals and earth.

5.1.3.2.2 The main insulation test voltage shall be generated by an impulse generator applying an impulse voltage with a front time of 1,2 µs as specified in IEC 60-1. The number of impulses shall be five, unless otherwise agreed between the manufacturer and the purchaser.

5.1.3.2.3 The voltage peaks between the coil terminals and earth shall be 100 % of the values given in Table 1, column 2, or 100 % of the values obtained by application of the formula $U_p = 4\ U_N + 5$ kV (see clause **4**) and rounded off to the nearest whole number.

5.2 Routine tests

Routine tests shall be carried out for all coils after insertion in the stator core, but before the connections have been made.

Due to the various technologies involved (e.g. resin-rich insulation, vacuum-pressure insulation), no general requirements can be specified for the test values.

NOTE The manufacturer is responsible for using values sufficient to make it certain that the coils are free from defects after he inserts them in the stator core and before the connections have been made.

Annex A (informative) Principles involved in the specification of impulse voltage withstand levels and test procedures

A.1 Impulse voltage stress of a machine winding

A.1.1 When a steep voltage surge occurs between one machine terminal and earth, the corresponding phase cannot "suddenly" (i.e. during the impulse rise-time) adopt the same potential on all its points. Hence, two types of voltage arise in the winding: the voltage between the copper and earth (transverse voltage) and the voltage along the copper (longitudinal voltage).

A.1.2 Whilst the transverse voltage stresses the main wall insulation, the longitudinal voltage also stresses the interturn insulation. The highest voltage components of both kinds normally appear on the first or entrance coil of the winding.

A.1.3 In practice, voltage surges can be of various shapes and may even extend to wave-front times down to about 0,1 μs.

A.2 Impulse withstand level of a machine winding

A.2.1 A machine winding should have a defined impulse withstand level within the system of insulation co-ordination.

A.2.2 Impulse withstand levels specified in column 2 of Table 1 are based on the formula $U_P = 4\ U_N + 5$ kV (see clause **4**).

For convenience the values in column 2 are adopted as a guideline for the transverse voltage on the machine for reasons given in **A.3.2.2**.

A.2.3 Impulse withstand levels specified in column 3 of Table 1 are based on the formula $U_P' = 0{,}65\ U_P$.

For convenience the values in column 3 are adopted as a guideline for the longitudinal voltage on the entrance coil for the reasons given in **A.3.2.3**.

A.3 Proof of impulse voltage withstand levels

A.3.1 It is not recommended that an impulse test should be carried out on a complete machine, because, in this case, any interturn failure is very difficult to detect with the present state of knowledge. The impulse voltage withstand levels can therefore only be proved indirectly by random sample tests on individual coils.

A.3.2 *Indirect proof by random sample test on coils*

A.3.2.1 The impulse voltage withstand level of a complete machine winding can be proved indirectly by tests on a sample coil, based on the principle that the sample coil during this random sample test should be stressed, as near as practicable, in the same manner as that coil (or those coils) within the complete winding with the maximum stresses between turns and/or to earth, i.e. normally the entrance coil of the winding.

A.3.2.2 The peak value of the transverse voltage (between copper and earth) appearing on the entrance coil (and therefore on the sample coil for the random sample test) is equal to the peak value of the impulse voltage on the complete winding. This peak value can be higher than the power-frequency routine test peak voltage $\sqrt{2}\ (2\ U_N + 1\ \text{kV})$ but generally not higher than the figure derived from the test in **5.1.3.1**.

A.3.2.3 The peak value of the longitudinal voltage appearing on the entrance coil varies widely due, at least, to the following factors:

— rise time t_s of the voltage impulse;

— copper length of the entrance coil;

— number and arrangement of the turns.

The actual value may be investigated by applying a "model impulse voltage" with, for example, a few hundred volts peak on the terminal of the complete machine.

Corresponding investigations have been made in several countries and results have been published, but, as expected, no simple law has been found for pre-calculating this peak value from a given machine configuration.

It is considered, therefore, that the three factors mentioned above are too complicated to be used as a basis for practical specifications.

Annex ZA (normative)
Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 34-1 (mod)	1994	*Rotating electrical machines Part 1: Rating and performance*	EN 60034-1[a] + corr. April	1995 1995
IEC 60-1	1989	*High-voltage test techniques Part 1: General definitions and test requirements*	HD 588.1 S1	1991
IEC 71-1	1993	*Insulation co-ordination Part 1: Definitions, principles and rules*	EN 60071-1	1995

[a] EN 60034-1 includes the corrigendum December 1994 to IEC 34-1.

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List of references

See national foreword.

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