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

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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UK Vote

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Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

PROJECT NUMBER: IEC 60034-15 ED4	
DATE OF CIRCULATION: 2023-12-15	CLOSING DATE FOR COMMENTS: 2024-03-08
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IEC TC 2 : ROTATING MACHINERY	
SECRETARIAT: United Kingdom	SECRETARY: Mr Charles Whitlock
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

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Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (See [AC/22/2007](#) or [NEW GUIDANCE DOC](#)).

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

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –**Part 15: Impulse voltage withstand levels
of stator coils for rotating AC machines****FOREWORD**

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International Standard IEC 60034-15 has been prepared by IEC technical committee 2: Rotating machinery.

This fourth edition cancels and replaces the third edition published in 2009 and constitutes a technical revision. The principal technical changes are as follows.

- Harmonize the standard test levels with IEEE Std 522.
- Introduce an enhanced surge impulse voltage withstand level.
- Introduce the option to test up to the point of electrical breakdown.
- Improve the evaluation of the recorded impulses in case of oscillations and overshoot.
- Indicate that converted fed machines are excluded from the scope.
- Provide guidance on the execution of impulse tests.

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

FDIS	Report on voting
2/xxxx/FDIS	2/xxxx/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 maintenance result 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 60071-1 specifies general requirements for the phase to earth insulation, phase-to-phase and the longitudinal 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 60071-1.

The object of IEC 60034-15 is to specify these requirements for rotating electrical machines. Experience has shown that the values given in this standard meet the insulation requirements for the essential stresses in service. An explanation of the principles adopted in preparing these requirements is given in Annex A. This standard is neither intended for soft-start machines nor for electronic converter fed machines.

ROTATING ELECTRICAL MACHINES –

Part 15: Impulse voltage withstand levels of stator coils for rotating AC machines

1 Scope

This part of IEC 60034 relates to AC machines incorporating form-wound stator coils that are intended to be connected to a standard grid supply. It specifies the test procedures and voltages to be applied to sample coils, as well as routine tests performed on coils mounted in the stator core.

The stator windings and coils for converter-fed machines are excluded from the scope of this standard.

This IS is not intended for use on complete windings since it is difficult to determine when the turn insulation has failed due to the test.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and requirements*

IEC 60071-1:2019, *Insulation co-ordination – Part 1: Definitions, principles, and rules*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply.

3.1 sample test

test carried out on (sample) coils in new condition which adequately represent the configuration of the finished item to be used in the machine for the purpose of evaluating the manufacturing procedures and processes incorporated in the insulation system

3.2 routine test

test carried out on coils during manufacture

3.3 form-wound stator coil

coil that is preformed to shape, insulated, and substantially completed before insertion into the stator

3.4 impulse voltage

intentionally applied aperiodic transient voltage, which usually rises rapidly to a peak value U_e and then falls more slowly to zero (Figure 1)

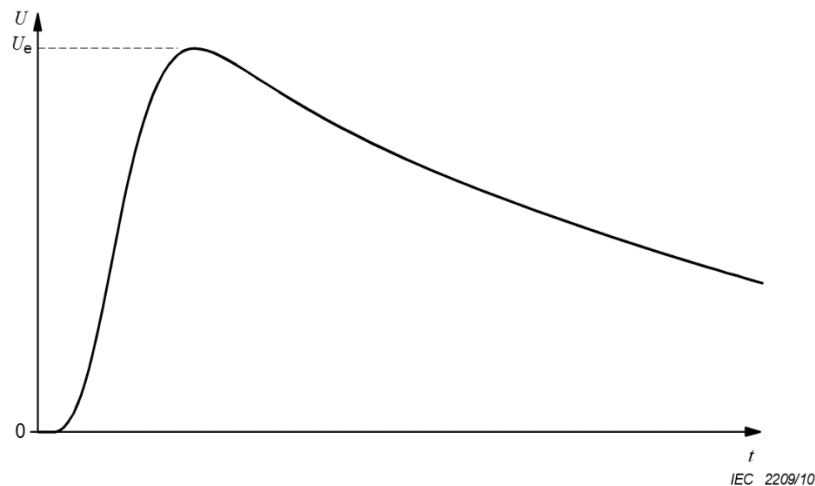


Figure 1 – Impulse voltage curve

3.5

lightning impulse voltage

impulse voltage with a front time T_1 less than 20 μs (see Figure 2)

3.6

full lightning impulse voltage

lightning impulse voltage, which is not interrupted by a disruptive discharge

3.7

overshoot

increase of amplitude of an impulse voltage due to a damped oscillation at the peak caused by the circuit

Note 1 to entry: Such oscillations (frequency range usually 0,1 MHz to 2 MHz) are caused by circuit inductance and sometimes cannot be avoided in large circuits or for inductive test objects.

3.8

front time

T_1

virtual parameter for the impulse voltage to rise from 0 % to 100 % and defined as 1,67 times the interval T between the instants when the impulse is 30 % and 90 % of the peak value of the voltage curve (point A and B, Figure 2)

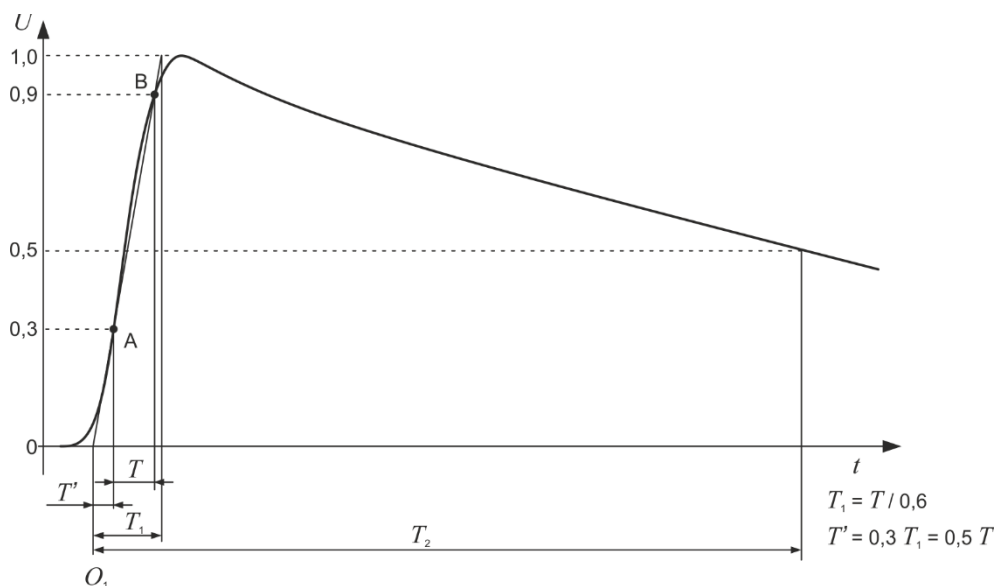


Figure 2 – Full impulse voltage time parameters

Note 1 to entry: This front time definition is applicable to both the standard lightning impulse as well as to the steep front impulse as described in this standard.

Note 2 to entry: In this standard exclusively the term “front time” is used. This quantity should not be confused with the term “rise time” that is used in other documents, but usually defined as being the time between the 10 % and 90 % value of the pulse final magnitude.

3.9

virtual origin

O_1

instant preceding that corresponding to point A, of the voltage curve (see Figure 2) by a time $0,3 T_1$

3.10

time to half-value

T_2

virtual parameter defined as the time interval between the virtual origin, O_1 , and the instant when the voltage curve has decreased to half the peak voltage value U_e (see Figure 2)

3.11

standard lightning impulse (SLI)

lightning impulse with a front time of $1,2 \mu\text{s} \pm 0,36 \mu\text{s}$, a time-to-half-value of $50 \mu\text{s} \pm 10 \mu\text{s}$ and a voltage value of the impulse voltage $U_e = U_p$ with a tolerance of $\pm 3 \%$ as specified in IEC 60060-1

3.12

steep-front impulse (SFLI)

lightning impulse with a front time of $0,2 \mu\text{s} \pm 0,1 \mu\text{s}$ and a voltage value of the impulse voltage $U_e = U'_p$ with a tolerance of $\pm 3 \%$

4 Impulse voltage withstand levels

4.1 General

Impulse voltage withstand levels are defined to test the insulation between the conductors and the earthed outside surface of the coil as well as to test the insulation that is stressed when a voltage is applied across both terminals of the coil. As the steep-front voltage of the pulses proceeds through the coil windings, turn by turn they stress the interturn insulation between the strands as well as the main insulation of the coil. Based on experience of laboratory tests, it is assumed that when a steep-front voltage impulse across the terminals of a single coil is applied with a voltage level that is around 70 % of the standard lightning withstand voltage for the main insulation, the actual situation for the entry (first) coil of a complete stator winding is approximated. Since there does not exist a simple general method to determine the actual voltage stress in a winding of a certain design (see Annex A

107 for further explanation), no distinct test levels for the individual interturn insulation itself are given in
108 this standard.

109 While performing impulse tests, overshoot and /or oscillations can occur. See Annex E for information
110 on dealing with this situation.

111 **4.2 Impulse withstand levels**

112 The impulse withstand levels for a specific rated voltage shall be calculated in accordance with the
113 following formulae:

114 For the standard lightning impulse (SLI) withstand level between the conductors and the earthed
115 outside surface of the main wall insulation:

$$U_P = 5 \frac{\sqrt{2}}{\sqrt{3}} U_N \text{ kV with a minimum of 8 kV} \quad (1)$$

116

117 For the steep-front impulse (SFLI) withstand level across the terminals of the coil with one terminal
118 connected to the earth.:

$$U'_P = 3,5 \frac{\sqrt{2}}{\sqrt{3}} U_N \text{ kV with a minimum of 5,6 kV} \quad (2)$$

119 With the SFLI, the outside surface of the main wall insulation should preferably be directly connected
120 to earth.

121 Table 1 gives the impulse voltage withstand levels for some common rated voltages rounded to one
122 decimal.

123 Without any particular indication a stator winding is considered to be able to withstand the levels
124 defined in this standard category. These levels are considered as those not being surpassed by the
125 voltage excursions occurring in a direct-on-line application of a stator winding on a normal grid.

126 NOTE This level is in line with the level as defined in IEEE Std 522

Table 1 – Standard impulse voltage withstand levels for sample coils used in AC rotating machines

Rated voltage (RMS value)	Rated SLI voltage withstand level (see NOTE 1)	Rated SFLI voltage withstand level (see NOTE 2)
U_N	U_P	U'_P
kV	kV	kV
2,3	9,4	6,6
3	12,2	8,6
3,3	13,5	9,4
4	16,3	11,4
6	24,5	17,1
6,6	26,9	18,9
10	40,8	28,6
11	44,9	31,4
13,2	53,9	37,7
13,8	56,3	39,4
15	61,2	42,9
18	73,5	51,4
22	89,8	62,9

NOTE 1 The levels in Column 2 are based on a standard lightning impulse (SLI) having a voltage value of the impulse voltage U_P with a tolerance of $\pm 3\%$.

NOTE 2 The levels in Column 3 are based on a steep-front lightning impulse (SFLI) having a front time of $(0,2 \pm 0,1) \mu s$ and a voltage value of the impulse voltage U'_P with a tolerance of $\pm 3\%$.

4.3 Enhanced impulse withstand levels

A user can request for an enhanced impulse withstand level, for instance, when special operation conditions occur (such as very frequent switching or aborted starts), a specific grid layout is present (for instance feeding by overhead lines) or other special circumstances are present. This might lead to an enhanced winding insulation design to be implemented.

In this case an enhanced impulse voltage withstand capability is specified where the standard levels as found in the previous clause are increased by a default value of 15 kV (for the SLI) and 11 kV (for the SFLI). The resulting test voltage shall be limited to twice the standard voltage values as defined in Clause 4.2. Application of these test levels are subject on the explicit agreement between user and manufacturer. Upon agreement a deviation from the default increase is allowed.

NOTE With the default increase as stated here the SLI voltage values are within the middle of the LI ranges as specified in IEC 60071-1. The SFLI test level increase is again 70 % of the SLI level.

5 Sample tests

5.1 General

Sample tests are carried out as an indirect proof of compliance as explained in Clause A.3. The test coils are selected from the entire set of coils produced for a certain stator winding. In case of global impregnated systems, the selected (green) coils shall be embedded in adequate slot simulations and subsequently processed (impregnated and cured), preferably together with the stator concerned.

The test coils shall have completed their manufacturing process, including the application of corona protection layer and stress grading if applicable and including all diagnostic tests and measurements that are performed during normal coil production. Processed (impregnated and cured) sample coils related to global impregnated systems shall be tested without dismounting them from their slot simulations. Other sample coils, in case of single coil production, shall be either embedded in earthed slots or fitted with the slot portion wrapped in earthed conducting tape or foil. Annex C gives further requirements for the sample coils.

In all cases special attention is required for the connection leads. The length of the leads shall be sufficient to prevent flash over during the impulse tests. This implies that in some cases the coils to be tested have to be provided with connection leads with an increased length (for instance in case of global impregnation sample coils). As an alternative the connection leads could be extended which