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Rotating electrical machines –

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

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

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
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International Standard IEC 34-15 has been prepared by IEC technical committee 2: Rotating machinery.

This second edition cancels and replaces the first edition published in 1990 and constitutes a technical revision.

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

DIS	Reports on voting
2(CO)577	2(CO)587A 2(CO)587B

Full information on the voting for the approval of this standard can be found in the reports on voting indicated in the above table.

Annex A is for information only.

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.

ROTATING ELECTRICAL MACHINES –

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

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.

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

NOTES

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.

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.

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

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).

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.

5.1.3.2 *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.