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Električni rotacijski stroji - 15. del: Nivoji vzdržljivosti na impulzno napetost oblikovno navitih statorskih tuljav pri rotacijskih izmeničnih strojih

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

Drehende elektrische Maschinen - Teil 15: Steh-Stoßspannungspegel von Formspulen im Ständer drehender Wechselstrommaschinen

Machines électriques tournantes - Partie 15: Niveaux de tenue au choc électrique des bobines de stator préformées des machines tournantes à courant alternatif

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TITLE:

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

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CONTENTS

1		
2	FOREWORD	4
3	INTRODUCTION	6
4	1 Scope	7
5	2 Normative references	7
6	3 Terms and definitions	7
7	4 Impulse voltage withstand levels	9
8	4.1 General	9
9	4.2 Impulse withstand levels	9
10	4.3 Enhanced impulse withstand levels	10
11	5 Sample tests	11
12	5.1 General	11
13	5.2 Standard lightning impulse voltage withstand test	11
14	5.3 Steep-front impulse voltage withstand test	12
15	5.4 Power-frequency voltage withstand test	13
16	6 Routine tests	13
17	7 Reporting	13
18	Annex A (informative) Principles involved in the specification of impulse voltage withstand	
19	levels and test procedures	14
20	A.1 Impulse voltage stress of a machine winding	14
21	A.2 Impulse voltage withstand level of a machine winding	14
22	A.3 Indirect proof of impulse voltage withstand levels by sample tests on coils	14
23	Annex B (informative) Testing details	16
24	B.1 Introduction	16
25	B.2 Principal circuit diagrams	16
26	B.2.1 General	16
27	B.2.2 Circuit diagram SLI test	16
28	B.2.3 Circuit diagram SFI test	16
29	B.3 Voltage measurement	17
30	B.4 Practical layout of the test setup	17
31	B.5 Oscillograms of tests on sample coils	19
32	B.5.1 General	19
33	B.5.2 Checking of input wave shape	19
34	B.5.3 Standard lightning impulse	19
35	B.5.4 Steep front impulses	20
36	Annex C (normative) Requirements on sample coils	24
37	C.1 Introduction	24
38	C.2 Requirements for RR and SVPI sample coils	24
39	C.3 Requirements for GVPI sample coils	24
40	Annex D (normative) Routine steep-front impulse testing	26
41	D.1 General	26
42	D.2 Separate stator coils	26
43	D.3 Complete stators	27
44	D.4 Example of the test circuit for routine tests	27
45	Annex E (normative) Procedure for calculation of parameters of lightning impulse voltages	
46	with superimposed overshoot or oscillations	28
47	E.1 Introduction	28

48	E.2	Terms and definitions	28
49	E.3	Basis of the procedure.....	31
50	E.4	Procedure for evaluation of parameters of lightning impulses	31
51	Annex F (informative)	Procedure for manual calculation from graphical waveforms	34
52	Annex G (informative)	Background to the introduction of the test voltage factor for evaluation	
53		of impulses with overshoot	35
54	G.1	Introduction	35
55	G.2	Research and development to provide a solution.....	36
56	G.3	Reference documents.....	38
57	Bibliography	39
58			
59	Figure 1 – Impulse voltage curve.....		8
60	Figure 2 – Full impulse voltage time parameters.....		8
61	Figure B.1 – Standard lightning impulse circuit.....		16
62	Figure B.2 – Steep front impulse circuit		17
63	Figure B.3 – Layout for standard lightning impulse tests: Both connecting leads of the coil		
64	connected to high potential, outside surface coil earthed.....		18
65	Figure B.4 – Layout for steep-front impulse tests: one connecting lead of the coil connected		
66	to high potential, the other lead connected to earth. Coil outside surface earthed.....		18
67	Figure B.5 – Example of test setup steep-front impulse test		19
68	Figure B.6 – Example of standard lightning impulse wave on an undamaged coil		20
69	Figure B.7 – Magnified detail of standard lightning impulse wave as shown in Figure B.6.....		20
70	Figure B.8 – Example of steep front impulse on an undamaged coil		21
71	Figure B.9 – Example of collected steep front impulses undamaged coils (5 negative pulses)21		
72	Figure B.10 – Example of recorded wave of a failing coil.....		22
73	Figure B.11 – Comparison of failing coil with undamaged coil.....		22
74	Figure B.12 – Various break down graphs of five coils of same design		23
75	Figure C.1 – Examples of GVPI slot simulations		25
76	Figure D.1 – Example of the test circuit for routine tests.....		27
77	Figure E.1 – Recorded and base curve showing overshoot and residual curve		29
78	Figure E.2 – Test voltage function		30
79	Figure E.3 – Test voltage curve (addition of base curve and filtered residual curve)		30
80	Figure E.4 – Recorded and test voltage curves		33
81	Figure G.1 – “Effective” test voltage function in IEC 60060-1:1989		35
82	Figure G.2 – Representative experimental points from European experiments and test		
83	voltage function.....		37
84			
85	Table 1 – Standard impulse voltage withstand levels for sample coils used in AC rotating		
86	machines.....		10
87			

88
89
90
91
92
93
94
95
96
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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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127 International Standard IEC 60034-15 has been prepared by IEC technical committee 2: Rotating
128 machinery.

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

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

137

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

FDIS	Report on voting
2/xxxx/FDIS	2/xxxx/RVD

- 139
140 Full information on the voting for the approval of this standard can be found in the report on voting
141 indicated in the above table.
- 142 This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.
- 143 NOTE A table of cross-references of all IEC TC 2 publications can be found on the IEC TC 2 dashboard on the IEC
144 website.
- 145 The committee has decided that the contents of this publication will remain unchanged until the
146 maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data
147 related to the specific publication. At this date, the publication will be
- 148 • reconfirmed,
 - 149 • withdrawn,
 - 150 • replaced by a revised edition, or
 - 151 • amended.
- 152

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153

INTRODUCTION

154 IEC 60071-1 specifies general requirements for the phase to earth insulation, phase-to-phase and
155 the longitudinal insulation of equipment in three phase a.c. systems and states that each apparatus
156 committee is responsible for specifying the insulation levels and test procedures for its equipment,
157 taking into consideration the recommendations of IEC 60071-1.

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

163

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ROTATING ELECTRICAL MACHINES –

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

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171 **1 Scope**

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

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

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

179 **2 Normative references**

180 The following documents are referred to in the text in such a way that some or all of their content
181 constitutes requirements of this document. For dated references, only the edition cited applies. For
182 undated references, the latest edition of the referenced document (including any amendments)
183 applies.

184 IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and requirements*

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

186 **3 Terms and definitions**

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

188 **3.1**

189 **sample test**

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

193 **3.2**

194 **routine test**

195 test carried out on coils during manufacture

196 **3.3**

197 **form-wound stator coil**

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

199 **3.4**

200 **impulse voltage**

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

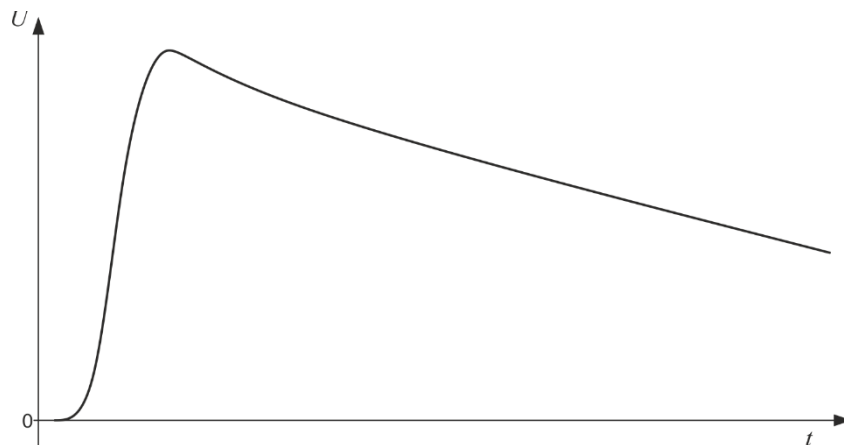


Figure 1 – Impulse voltage curve

203

204

205

206 3.5

207 lightning impulse voltage

208 impulse voltage with a front time T_1 less than $20 \mu\text{s}$ (see Figure 2)

209 3.6

210 full lightning impulse voltage

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

212 3.7

213 overshoot

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

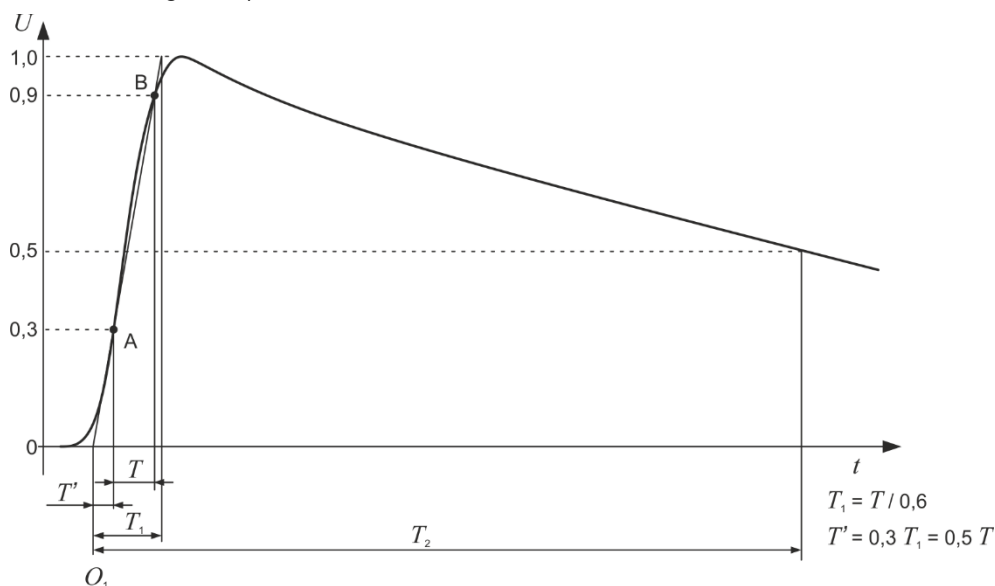
216 Note 1 to entry: Such oscillations (frequency range usually 0,1 MHz to 2 MHz) are caused by circuit inductance and
217 sometimes cannot be avoided in large circuits or for inductive test objects.

218 3.8

219 front time

220 T_1

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



224

225

Figure 2 – Full impulse voltage time parameters

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

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

231 3.9 232 virtual origin

233 O_1

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

235 3.10 236 time to half-value

237 T_2

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

240 3.11 241 standard lightning impulse (SLI)

242 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
243 voltage value of the impulse voltage U_p with a tolerance of $\pm 3 \%$ as specified in IEC 60060-1

244 3.12 245 steep-front impulse (SFI)

246 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'_p
247 with a tolerance of $\pm 3 \%$

248 3.13 249 slot simulation / slot model

250 a rigid, metal fixture to mimic the actual stator slot with at least the same length as the stator core
251 and the same width as the slots in the stator core

252 Note 1 to entry: The slot simulation is not necessarily built up from sheets of electrical core sheet material.

253 4 Impulse voltage withstand levels

254 4.1 General

255 Impulse voltage withstand levels are defined to test the insulation between the conductors and the
256 earthed outside surface of the coil as well as to test the insulation that is stressed when a voltage is
257 applied across both terminals of the coil. As the steep-front voltage of the pulses proceeds through
258 the coil windings, turn by turn they stress the interturn insulation between the strands as well as the
259 main insulation of the coil. Based on experience of laboratory tests, it is assumed that when a steep-
260 front voltage impulse across the terminals of a single coil is applied with a voltage level that is around
261 70 % of the standard lightning withstand voltage for the main insulation, the actual situation for the
262 entry (first) coil of a complete stator winding is approximated. Since there does not exist a simple
263 general method to determine the actual voltage stress in a winding of a certain design (see Annex A
264 for further explanation), no distinct test levels for the individual interturn insulation itself are given in
265 this standard.

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

268 4.2 Impulse withstand levels

269 The impulse withstand levels for a specific rated voltage shall be calculated in accordance with the
270 following formulae.

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

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

273

274 For the steep-front impulse (SFI) withstand level across the terminals of the coil with one terminal
275 connected to the earth:

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

276 With the SFI, the outside surface of the main wall insulation should preferably be directly connected
277 to earth.

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

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

283 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**

284

285

Rated voltage (RMS value)	Rated SLI voltage withstand level (see NOTE 1)	Rated SFI 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 (SFI) having a front time of $(0,2 \pm 0,1) \mu\text{s}$ and a voltage value of the impulse voltage U'_P with a tolerance of $\pm 3\%$.

286

287 4.3 Enhanced impulse withstand levels

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

292 In this case an enhanced impulse voltage withstand capability is specified where the standard levels
293 as found in the previous clause are increased by a default value of 15 kV (for the SLI) and 11 kV (for
294 the SFI). The resulting test voltage shall be limited to twice the standard voltage values as defined in
295 Clause 4.2. Formulae (3) and (4) give the calculation of the levels to be applied. Application of these
296 test levels are subject on the explicit agreement between user and manufacturer. Upon agreement a
297 deviation from the default increase is allowed.