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Reciprocating internal combustion engine driven alternating current generating sets —

Part 3: Alternating current generators for generating sets

*Groupes électrogènes à courant alternatif entraînés par moteurs alternatifs à combustion interne —
Partie 3: Alternateurs pour groupes électrogènes*

ICS: 27.020; 29.160.40; 29.160.20

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65 Foreword

66 ISO (the International Organization for Standardization) is a worldwide federation of national standards
67 bodies (ISO member bodies). The work of preparing International Standards is normally carried out
68 through ISO technical committees. Each member body interested in a subject for which a technical
69 committee has been established has the right to be represented on that committee. International
70 organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO
71 collaborates closely with the International Electrotechnical Commission (IEC) on all matters of
72 electrotechnical standardization.

73 The procedures used to develop this document and those intended for its further maintenance are
74 described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the
75 different types of ISO documents shall be noted. This document was drafted in accordance with the
76 editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

77 Attention is drawn to the possibility that some of the elements of this document can be the subject of
78 patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any
79 patent rights identified during the development of the document will be in the Introduction and/or on
80 the ISO list of patent declarations received (see www.iso.org/patents).

81 Any trade name used in this document is information given for the convenience of users and does not
82 constitute an endorsement.

83 For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and
84 expressions related to conformity assessment, as well as information about ISO's adherence to the World
85 Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see
86 www.iso.org/iso/foreword.html.

87 This document was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, together
88 with IEC/TC 2, *Rotating electrical machines*, by merging this document with IEC 60034-22:2009.

89 This third edition cancels and replaces the second edition (ISO 8528-3:2005), which has been revised.

90 The main changes compared to the previous edition are as follows:

- 91 — clause 9 updated with requirements for isochronous operation and grid parallel operation;
- 92 — requirements for asynchronous generators integrated in clause 10;
- 93 — new power rating “GPO” introduced for grid parallel operation;
- 94 — revision of operating limits;
- 95 — new clauses added for specifying “bearings” and “maintenance”;
- 96 — new Annex B describing voltage and frequency range for grid parallel operation.
- 97 — elimination of identification markings BR and PR;

98 A list of all parts in the ISO 8528 series can be found on the ISO website.

99 Any feedback or questions on this document shall be directed to the user's national standards body. A
100 complete listing of these bodies can be found at www.iso.org/members.html.

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102 Reciprocating internal combustion engine driven alternating 103 current generating sets —

104 Part 3: Alternating current generators for generating sets

105 1 Scope

106 This document specifies the principal characteristics of alternating current (a.c.) generators under the
107 control of their excitation control system when used for reciprocating internal combustion (RIC) engine
108 driven generating set applications and supplements the requirements given in IEC 60034-1. It covers the
109 use of such a.c. generators for land and marine applications, excluding generating sets used on aircraft or
110 to propel land vehicles and locomotives.

111 NOTE 1 For some specific applications (e.g. essential hospital supplies, high-rise buildings, operation parallel
112 with the grid), supplementary requirements can be necessary. The provisions of this document can be regarded as
113 the basis for establishing any supplementary requirements.

114 NOTE 2 Attention is drawn to the need to take note of additional regulations or requirements imposed by
115 various regulatory bodies. Such regulations or requirements can form the subject of agreement between the a.c.
116 generator manufacturer and the generating set manufacturer when conditions of use of the product invoke such
117 requirements.

118 NOTE 3 Examples of regulatory authorities:

- 119 — classification societies, for generating sets used on ships and offshore installations;
- 120 — government agencies;
- 121 — inspection agencies, local utilities, etc.

122 For a.c. generating sets driven by other reciprocating-type prime movers (e.g. steam engines) the
123 provisions of this document can be used as basis for establishing these requirements.

124 2 Normative references

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

128 ISO 281, *Rolling bearings — Dynamic load ratings and rating life*

129 ISO 8528-1, *Reciprocating internal combustion engine driven alternating current generating sets — Part 1:
130 Application, ratings and performance*

131 IEC 60034-1, *Rotating electrical machines — Part 1: Rating and performance*

132 IEC 60034-5, *Rotating electrical machines — Part 5: Degrees of protection provided by the integral design
133 of rotating machines (IP code) — Classification*

134 IEC 60034-6, *Rotating electrical machines — Part 6: Methods of cooling (IC code)*

135 IEC 60034-7, *Rotating electrical machines — Part 7: Classification of types of construction, mounting
136 arrangements and terminal box position (IM code)*

137 IEC 60050 (all parts), *International Electrotechnical Vocabulary*

138 CISPR 11, *Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics —*
139 *Limits and methods of measurement*

140 3 Terms and definitions

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

142 ISO and IEC maintain terminological databases for use in standardization at the following addresses:

143 — ISO Online browsing platform: available at <https://www.iso.org/obp>

144 — IEC Electropedia: available at <http://www.electropedia.org/>

145 NOTE 1: This document uses suffix “r” for “rated” whereas in IEC standards the suffix “N” is used.

146 NOTE 2: Voltage terms relate to an a.c. generator running at constant (rated) speed under the control of the normal
147 excitation and voltage control system.

148 3.1

149 **rated output**

150 **rated apparent power**

151 S_r

152 product of the rated rms voltage, the rated rms current and a constant m

153 Note 1 to entry: Where

154 $m = 1$ for single-phase;

155 $m = \sqrt{2}$ for two-phase;

156 $m = \sqrt{3}$ for three-phase.

157 Note 2 to entry: $\sqrt{2}$ is applicable only when the a.c. generator is specifically designed in two-phase, an angle of 90°
158 electrical between the two poles.

159 Note 3 to entry: S_r is expressed in volt-amperes (VA) or its multiples.

160 3.2

161 **rated active power**

162 P_r

163 product of the rated rms voltage, the in-phase component of the rated rms current and a constant m

164 Note 1 to entry: Where

165 $m = 1$ for single-phase;

166 $m = \sqrt{2}$ for two-phase;

167 $m = \sqrt{3}$ for three-phase.

168 Note 2 to entry: $\sqrt{2}$ is applicable only when the a.c. generator is specifically designed in two-phase, an angle of 90°
169 electrical between the two poles.

170 Note 3 to entry: P_r is expressed in watts (W) or its decimal multiples.

171 **3.3**
 172 **rated power factor**
 173 $\cos \varphi_r$
 174 ratio of the rated active power (3.2) to the rated output (3.1)

$$175 \quad \cos \varphi_r = \frac{P_r}{S_r}$$

176 **3.4**
 177 **rated reactive power**
 178 Q_r
 179 geometrical difference of the rated output (3.1) and the rated active power (3.2)

$$180 \quad Q_r = \sqrt{S_r^2 - P_r^2}$$

181 Note to entry: Q_r is expressed in volt-amperes reactive (var) or its decimal multiples.

182 **3.5**
 183 **rated speed of generator rotation**

184 n_r
 185 speed of rotation necessary for voltage generation at rated frequency

186 For a synchronous generator, the rated speed of generator rotation is given by

$$187 \quad n_r = 60 \frac{f_r}{p}$$

188 Note 1 to entry: Where

p is the number of pole pairs;

f_r is the rated frequency (according to load requirements), expressed in (Hz).

189 For an asynchronous generator the rated speed of generator rotation is given by

$$190 \quad n_r = 60 \frac{f_r}{p} (1 - s_r)$$

191 Note 2 to entry: Where

p is the number of pole pairs;

f_r is the rated frequency (according to load requirements) expressed in (Hz);

s_r is the rated slip (3.6).

192 Note 3 to entry: n_r is expressed in (min^{-1}).

193 Note 4 to entry: Since the slip of an asynchronous generator is always negative, the rated speed (3.5) is above the
 194 synchronous speed.

195 **3.6**
196 **rated slip**

197 s_r
198 difference between the synchronous speed and the rated speed (3.5) of the rotor divided by the
199 synchronous speed, when the generating set is operated at its rated active power (3.2)

200
$$s_r = \frac{60 \frac{f_r}{p} - n_r}{60 \frac{f_r}{p}}$$

201 Note to entry: s_r is only relevant to an asynchronous generator.

202 **3.7**
203 **rated voltage**

204 U_r
205 line-to-line voltage at the terminals of the a.c. generator at rated frequency and at rated output (3.1)

206 Note 1 to entry: Rated voltage (3.7) is the voltage assigned by the a.c. generator manufacturer for operating and
207 performance characteristics.

208 Note 2 to entry: U_r is expressed in volts (V) or its decimal multiples.

209 **3.8**
210 **no-load voltage**

211 U_0
212 line-to-line voltage at the terminals of the a.c. generator at rated frequency and no-load

213 Note to entry: U_0 is expressed in volts (V) or its decimal multiples.

214 **3.9**
215 **operating voltage**

216 U_c
217 value of the voltage under normal conditions at a given instant and given point of the system

218 [SOURCE: IEC 60050-601:1985, 601-01-22]

219 Note 1 to entry: U_c is expressed in volts (V) or its decimal multiples.

220 Note 2 to entry: This value can be expected, estimated or measured.

221 **3.10**
222 **range of voltage setting**

223 ΔU_s
224 range of possible upward and downward adjustment of voltage at a.c. generator terminals at rated
225 frequency, for all loads between no-load and rated output (3.1)

226
$$\Delta U_s = |\Delta U_{s,up}| + |\Delta U_{s,do}|$$

227 with

228 a) The upward range of voltage setting

229
$$\Delta U_{s,up} = \frac{U_{s,up} - U_r}{U_r} \cdot 100 \%$$

230 Note 1 to entry: $U_{s,up}$ is the upward adjustable limit for voltage settings, expressed in volts (V) or its decimal
231 multiples.

232 b) The downward range of voltage setting

$$233 \quad \Delta U_{s,do} = \frac{U_{s,do} - U_r}{U_r} \cdot 100 \%$$

234 Note 2 to entry: $U_{s,do}$ is the downward adjustable limit for voltage settings, expressed in volts (V) or its decimal
235 multiples.

236 Note 3 to entry: ΔU_s is expressed as a percentage of rated voltage (3.7).

237 Note 4 to entry: Special controllable excitation equipment can provide a range of voltage adjustment for
238 asynchronous generators.

239 3.11

240 steady-state voltage tolerance band

241 ΔU

242 agreed voltage band about the steady-state voltage that the voltage can reach within a given voltage
243 recovery time (3.14) after a specified sudden increase or decrease of load.

244 Note to entry: ΔU is expressed as a percentage of rated voltage (3.7).

245 3.12

246 steady-state voltage regulation

247 ΔU_{st}

248 change in steady-state voltage for all load changes between no-load (3.8) and rated output (3.1),
249 considering the influence of temperature but ignoring the effect of quadrature current compensation
250 voltage droop

$$251 \quad \Delta U_{st} = \frac{U_{st,max} - U_{st,min}}{U_r} \cdot 100 \%$$

252 Note 1 to entry: Where

$U_{st,max}$ is the maximum steady-state voltage deviation, expressed in volts (V) or its decimal multiples;

$U_{st,min}$ is the minimum steady-state voltage deviation, expressed in volts (V) or its decimal multiples.

253 Note 2 to entry: The initial set voltage is usually rated voltage (3.7) but can be anywhere within the range of voltage
254 setting (3.10).

255 Note 3 to entry: ΔU_{st} is expressed as a percentage of rated voltage (3.7).

256 3.13

257 transient voltage regulation

258 δU_{dyn}

259 maximum voltage change following a sudden change of load

260 a) with load increase

261 maximum transient voltage drop

262 δU_{dyn}^-

263 maximum voltage drop, when the a.c. generator, driven at rated speed (3.5) and at rated voltage