
Železniške naprave - Stabilne naprave električne vleke - Električna varnost, ozemljitev in povratni tokokrog - 3. del: Medsebojno vplivanje med izmeničnimi in enosmernimi sistemi vleke

Railway applications - Fixed installations - Electrical safety, earthing and the return circuit
- Part 3: Mutual Interaction of AC and DC traction systems

Bahnanwendungen - Ortsfeste Anlagen - Elektrische Sicherheit, Erdung und Rückleitung
- Teil 3: Gegenseitige Beeinflussung von Wechselstrom- und Gleichstrombahnen

Applications ferroviaires - Installations fixes - Sécurité électrique, mise à la terre et circuit
de retour - Partie 3: Interactions mutuelles entre systèmes de traction en courant
alternatif et en courant continu

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Sicherheit, Erdung und Rückleitung - Teil 3: Gegenseitige
Beeinflussung von Wechselstrom- und Gleichstrombahnen

This draft European Standard is submitted to CENELEC members for enquiry.
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It has been drawn up by CLC/SC 9XC.

If this draft becomes a European Standard, CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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50 European foreword

51 This document (prEN 50122-3:2020) has been prepared by CLC/SC 9XC “Electric supply and earthing systems for public transport equipment and ancillary apparatus (Fixed installations)”.

53 This document is currently submitted to the Enquiry.

54 The following dates are proposed:

- latest date by which the existence of this document has to be announced at national level (doa) dor + 6 months
- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) dor + 12 months
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) dor + 36 months (to be confirmed or modified when voting)

55 This document will supersede EN 50122-3:2010 and all of its amendments and corrigenda (if any).

56 prEN 50122-3:2020 includes the following significant technical changes with respect to EN 50122-3:2010:

57 — harmonization with EN 50122-1:2020.

58 This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

60 For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

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61 **1 Scope**

62 This document specifies requirements for the protective provisions relating to electrical safety in fixed installa-
63 tions, when it is reasonably likely that hazardous voltages or currents will arise for people or equipment, as a
64 result of the mutual interaction of AC and DC electric power supply traction systems.

65 It also applies to all aspects of fixed installations that are necessary to ensure electrical safety during mainte-
66 nance work within electric power supply traction systems.

67 The mutual interaction can be of any of the following kinds:

- 68 — parallel running of AC and DC electric traction power supply systems;
- 69 — crossing of AC and DC electric traction power supply systems;
- 70 — shared use of tracks, buildings or other structures;
- 71 — system separation sections between AC and DC electric power supply traction systems.

72 The scope is limited to basic frequency voltages and currents and their superposition. This document does not
73 cover radiated interferences.

74 This document applies to all new lines, extensions and to all major revisions to existing lines for the following
75 electric power supply traction systems:

- 76 a) railways;
- 77 b) guided mass transport systems such as:
 - 78 1) tramways,
 - 79 2) elevated and underground railways,
 - 80 3) mountain railways,
 - 81 4) trolleybus systems, and
 - 82 5) magnetically levitated systems, which use a contact line system;

83 c) material transportation systems.

84 The document does not apply to:

- 85 d) electric traction power supply systems in underground mines;
- 86 e) cranes, transportable platforms and similar transportation equipment on rails, temporary structures (e.g.
87 exhibition structures) in so far as these are not supplied directly or via transformers from the contact line
88 system and are not endangered by the traction power supply system for railways;
- 89 f) suspended cable cars;
- 90 g) funicular railways;
- 91 h) procedures or rules for maintenance.

92 The rules given in this document can also be applied to mutual interaction with non-electrified tracks, if haz-
93 arduous voltages or currents can arise from AC or DC electric traction power supply systems.

94 2 Normative references

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

98 prEN 50122-1:2020, *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit*
99 *- Part 1: Protective provisions against electric shock*

100 prEN 50122-2:2020, *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit*
101 *- Part 2: Provisions against the effects of stray currents caused by DC traction systems*

102 3 Terms and definitions

103 For the purposes of this document, the terms and definitions given in prEN 50122-1:2020 apply.

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

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

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

107 4 Hazards and adverse effects

108 4.1 General

109 The different requirements specified in prEN 50122-1 and prEN 50122-2, concerning connections to the return
110 circuit of the AC railway, and connections to the return circuit of the DC railway, shall be harmonized in order
111 to avoid risks of hazardous voltages and stray currents.

112 Such hazards and risks shall be considered from the start of the planning of any installation which includes
113 both AC and DC railways. Suitable measures shall be specified for limiting the voltages to the levels given in
114 this document, while limiting the damaging effects of stray currents in accordance with EN 50122-2.

115 Additional adverse effects are possible, for example:

116 — thermal overload of conductors, screens and sheaths;

117 — thermal overload of transformers due to magnetic saturation of the cores;

118 — restriction of operation because of possible effects on the safety and correct functioning of signalling sys-
119 tems;

120 — restriction of operation because of malfunction of the communication system.

121 These effects should be considered in accordance with the appropriate standards.

122 4.2 Electrical safety of persons

123 Where AC and DC voltages are present together the limits for touch voltage given in Clause 7 apply in addition
124 to the limits given in prEN 50122-1:2020, Clause 9.

125 5 Types of mutual interaction to be considered

126 5.1 General

127 Coupling describes the physical process of transmission of energy from a source to a susceptible device.

128 The following types of coupling shall be considered:

129 a) galvanic (conductive) coupling;

130 b) non-galvanic coupling;

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131 1) inductive coupling;

132 2) capacitive coupling.

133 Galvanic coupling dominates at low frequencies, when circuit impedances are low. The effects of galvanic
134 coupling are conductive voltages and currents.

135 The effects of inductive coupling are induced voltages and hence currents. These voltages and currents de-
136 pend *inter alia* on the distances, length, inducing current conductor arrangement and frequency.

137 The effects of capacitive coupling are influenced voltages into galvanically separated parts or conductors. The
138 influenced voltages depend *inter alia* on the voltage of the influencing system and the distance. Currents re-
139 sulting from capacitive coupling are also depending on the frequency.

140 NOTE As far as the capacitive and inductive coupling are concerned, general experience is that only the influence of
141 the AC railway to the DC railway is significant.

142 5.2 Galvanic coupling**143 5.2.1 AC and DC return circuits not directly connected**

144 A mutual interaction between the return circuits is possible by currents through earth caused by the rail poten-
145 tial of both AC and DC railways, for example return currents flowing through the return conductors, earthing
146 installations of traction power supply substations and cable screens.

147 In case a conductive parallel path to the return circuit exists in the influenced system, various effects are
148 possible. In case a vehicle forms part of the parallel path, return current of the influencing railway system can
149 flow through the propulsion system of the traction unit. The same effects are possible when the return current
150 of the influencing system flows, for example, through the auto-transformer and substation transformer of an
151 auto-transformer system or through booster transformers or other devices.

152 An electric shock with combined voltages can occur when parts of the return circuits or conductive parts which
153 are connected to the return circuits by voltage limiting devices are located in the overhead contact line zone
154 of the other railway system, see 8.2.2.

155 5.2.2 AC and DC return circuits directly connected or common

156 In addition to the effects described in 5.2.1 current exchange will be increased where AC and DC return circuits
157 are directly connected or common.

158 EXAMPLE Direct connections can be railway level crossings, common tracks, system separation sections, etc.

159 Currents flowing between the AC railway and the DC railway can create mutual interaction between the return
160 circuits.

161 Both return circuits are at the same potential at the location of the connection. A short-circuit within the AC
162 system can cause a peak voltage on conductive structures connected to the return circuit of the DC railway.
163 The same effects apply for conductive structures connected to it directly or via a voltage limiting device (VLD).
164 The voltage across the voltage limiting device can trip the device without a fault on the DC side.

165 The connection of the return circuit of the DC railway to the earthed return circuit of the AC railway increases
166 the danger of stray current corrosion.

167 For requirements for fixed installations see 8.3.

168 5.3 Non-galvanic coupling**169 5.3.1 Inductive coupling**

170 An AC voltage can be induced on a DC contact line system and on the DC system's return circuit. This effect
171 needs to be considered in case the DC railway is within the zone of mutual interaction.

172 Consequently an AC voltage can occur within the DC substation at the busbars versus earth (i.e. at the rectifier
173 or in the feeder cubicles).

174 Interaction can occur in terms of impermissible touch voltages. See Clause 7.

175 Perpendicular crossings do not result in inductive effects in the DC system.

176 5.3.2 Capacitive coupling

177 Within small distances an AC voltage can be influenced on a DC contact line system when it is isolated with a
178 disconnecter or circuit-breaker open. The possibility shall be considered that the flash-over voltage of the
179 insulators or of the surge arrestors can be reached.

180 Distance depends *inter alia* on geometry and voltage.

181 An AC voltage can occur within the DC substation at the DC busbars versus earth, i.e. in the feeder cubicles.

182 Interaction can occur in terms of impermissible touch voltages. See Clause 7.

183 6 Zone of mutual interaction

184 6.1 General

185 The AC railway affects the DC railway and vice-versa by galvanic, inductive and/or capacitive coupling (see
186 Clause 5). The zone of mutual interaction indicates a distance and a length of parallelism between an AC
187 railway and a DC railway (see Annex A). The limits of zone of mutual interaction are based on the limits of the
188 touch voltage given in Clause 7.

189 If a zone of mutual interaction exists the requirements given in this document shall be fulfilled.

190 In general no generic values can be given for the zone of mutual interference. An assessment based on local
191 circumstances has to be made. However when the distance between both AC and DC railways is less than
192 50 m a zone of mutual interaction is assumed. Distances in excess of 50 m are dealt with in 6.2 and 6.3.

193 NOTE For information on analysis and assessment of zone of mutual interaction, see Annex C.

194 6.2 AC

195 In case of an AC railway influencing a DC railway the zone of mutual interaction is based on voltages coupled
196 galvanically and inductively into the affected system. In this Subclause effects of capacitive coupling are neg-
197 ligible.

198 For planning purposes the zone of mutual interaction has to be investigated either by calculation or by the
199 following procedure.

200 Where the following preconditions apply the limit of the distance between AC and DC railway is 1 000 m:

201 — double track line, where only the four running rails of the AC railway are used for the return circuit;

202 — the inducing current is 500 A per overhead contact line (1 000 A in total);

203 — the length of parallelism between AC and DC railway is 4 km;

204 — the soil resistivity is 100 Ωm ;

205 — the rated frequency is 50 Hz;

206 — the affected system is insulated versus earth along its entire length and connected to earth at one end
207 only;

208 — screening effects of other parallel metallic objects have not been taken into account.

209 Where other preconditions apply the dimension of the zone of mutual interaction shall be calculated.

210 A method for the calculation is given in Annex A.

211 NOTE The example above is based on a 35 V limit for AC with a time duration longer than 300 s.

212 In case a DC railway is within the zone of mutual interaction of an AC railway, the level of voltages or currents
213 coupled into the DC system is not necessarily too high; in this case further analysis of the situation shall be
214 carried out.

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215 **6.3 DC**

216 For the effects of DC railway systems on AC railway systems the dimension of the zone of mutual interaction
217 can be neglected due to the steep voltage gradient in the soil, caused by the insulated rails.

218 However if the possibility of a voltage transfer exists, either permanently or temporary, due to a galvanic con-
219 nection towards conductive or partly conductive parts, the zone of mutual interaction is given by the dimensions
220 of those parts. In this case the level of voltages or currents coupled into the AC system is not necessarily too
221 high; further analysis of the situation shall be carried out.

222 **7 Touch voltage limits for the combination of alternating and direct voltages**223 **7.1 General**

224 The limits given in 7.2 to 7.6 are based on touch voltage only and shall not be exceeded. Other effects with
225 respect to electrical installations are not taken into account.

226 Limits for electrical installations cannot be given in a generic way and should be addressed separately if nec-
227 essary, depending on the sensitivity of the affected installations.

228 Where either an alternating or a direct voltage is present the touch voltage limits given in prEN 50122-1 apply.

229 The direct and the alternating components of a combined voltage $u(t)$ for time duration in excess of 1 s are
230 calculated as follows:

$$231 \quad U_{dc} = \frac{1}{T} \cdot \int_a^{a+T} u(t) \cdot dt \quad (1)$$

$$232 \quad U_{ac} = \sqrt{\frac{1}{T} \cdot \int_a^{a+T} (u(t) - U_{dc})^2 \cdot dt} \quad (2)$$

233 where

T = 1 s;

t is the time;

$u(t)$ is the combined voltage;

U_{dc} is the direct component of combined voltage;

U_{ac} is the alternating component of combined voltage.

234 NOTE 1 Formula (1) gives the moving average value of the direct component, and Formula (2) gives the moving r.m.s.
235 value of the alternating component.

236 Only for short-duration phenomena ≤ 1 s the following definitions for alternating voltage and direct voltage are
237 used:

238 — U_{dc} is defined as that part of the combined voltage that is caused by the DC system;

239 — U_{ac} is defined as that part of the combined voltage that is caused by the AC system.

240 NOTE 2 Further information on combined voltages is given in Annex B.

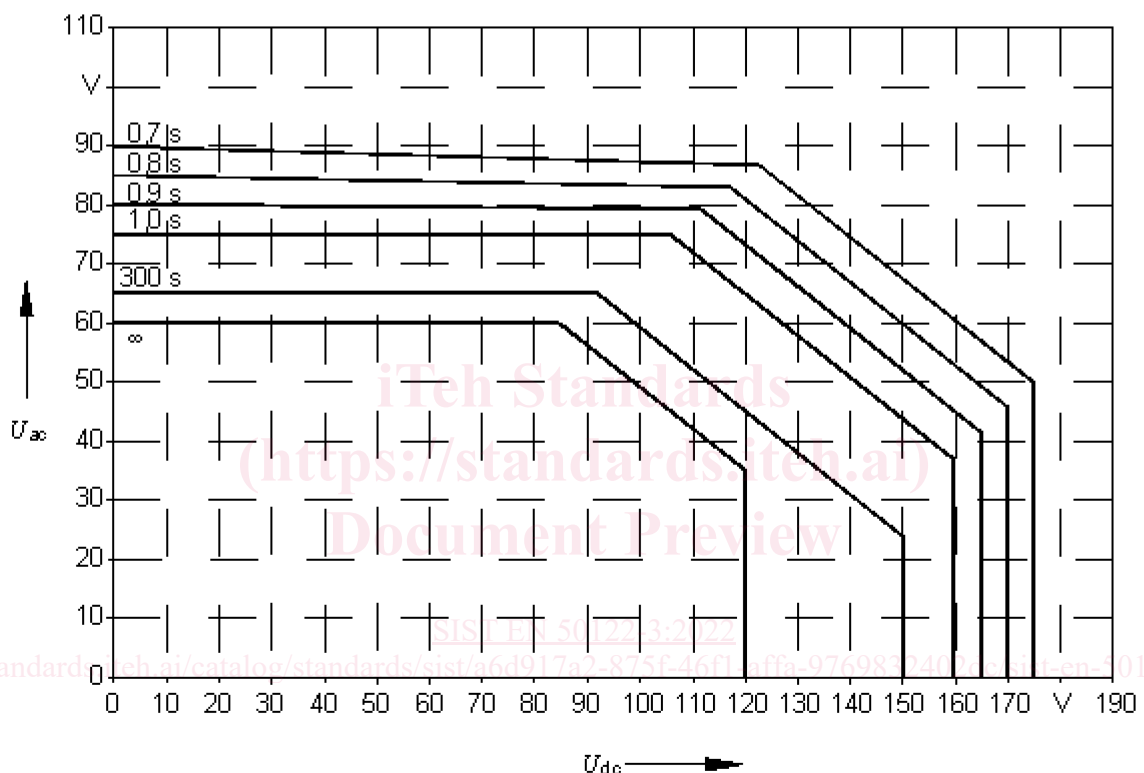
241 NOTE 3 Long-term conditions are associated with operation conditions and short-term conditions are associated with
242 fault conditions or for example switching operations.

243 **7.2 Touch voltage limits for long-term conditions**

244 The following approach shall be used to check whether the combined voltage is permissible:

- 245 1) the alternating part of the combined voltage shall not exceed the maximum permissible alternating body
246 voltage as given in prEN 50122-1:2020, Table 7 for the applicable duration;
- 247 2) the direct part of the combined voltage shall not exceed the maximum permissible direct body voltage as
248 given in prEN 50122-1:2020, Table 9 for the applicable duration;
- 249 3) the combined voltage is permissible if it is within the envelope as given for the applicable duration in
250 Figure 1;
- 251 4) for time durations in excess of 1 s the combined peak value (see explanation in Annex B) shall be less
252 than $2 \times \sqrt{2}$ times the maximum permissible alternating body voltage as given in prEN 50122-1:2020, Ta-
253 ble 7 for the applicable duration irrespective of frequency content.

254 EXAMPLE Assuming the maximum permissible direct touch voltage of 120 V being present in the DC system the
255 alternating voltage limit is 35 V, see Figure 1. Assuming the maximum permissible alternating touch voltage of 60 V being
256 present in the AC system the direct voltage limit is 85 V, see Figure 1.



257

258 The curves given in the graph are based on the r.m.s. values as given in prEN 50122-1.

259 **Figure 1 — Maximum permissible combined effective touch voltages**
260 **(excluding workshops and similar locations) for long-term conditions**

261 7.3 AC system short-term conditions and DC system long-term conditions

262 The following approach shall be used to check whether the combined voltage is permissible:

- 263 1) the short-duration alternating part of the combined voltage shall not exceed the maximum permissible
264 alternating touch voltage as given in prEN 50122-1:2020, Table 8 for the applicable duration;
- 265 2) the direct part of the combined voltage shall not exceed the maximum permissible direct touch voltage as
266 given in prEN 50122-1:2020, Table 10 for the applicable duration;
- 267 3) the combined voltage is permissible if it is within the envelope as given for the applicable durations in
268 Figure 2.