
Visokonapetostne stikalne in krmilne naprave - 208. del: Metode za kvantifikacijo elektromagnetnih polj v ustaljenem stanju z močjo in frekvenco, ki jih generirajo visokonapetostne VN omrežne stikalne naprave in VN/NN montažne postaje, tako za nazivno napetost nad 1 kV kot do vključno 52 kV

High-voltage switchgear and controlgear - Part 208: Methods to quantify the steady state, power-frequency electromagnetic fields generated by HV switchgear assemblies and HV/LV prefabricated substations, both for rated voltages above 1 kV and up to and including 52 kV

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Appareillage à haute tension - Partie 208: Méthodes de quantification des champs électromagnétiques à fréquence industrielle en régime établi générés par les ensembles d'appareillages ht et les postes préfabriqués ht/BT, à la fois pour les tensions assignées supérieures à 1 kv et inférieures ou égales à 52 kv

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TITLE:

High-voltage switchgear and controlgear - Part 208: Methods to quantify the steady state, power-frequency electromagnetic fields generated by HV switchgear assemblies and HV/LV prefabricated substations, both for rated voltages above 1 kV and up to and including 52 kV

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 208: Methods to quantify the steady state,
power-frequency electromagnetic fields
generated by HV switchgear assemblies
and HV/LV prefabricated substations,
both for rated voltages above 1 kV
and up to and including 52 kV**

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IEC 62271-208 document has been prepared by subcommittee 17C: High-voltage switchgear and controlgear assemblies, of IEC technical committee 17: Switchgear and controlgear.

151 The text of this document is based on the following documents:

Enquiry draft	Report on voting
17C/450/DTR	17C/462/RVC

152 With respect to previous TR, in the current version of this document the Isoline measurement
153 procedure is introduced and compared to the Hot spot one when it is required a measurement
154 for the characterization of a generated electromagnetic field.

155 Full information on the voting for the approval of this document can be found in the report on
156 voting indicated in the above table.

157 This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

158 A list of all the parts in the IEC 62271 series, under the general title *High-voltage switchgear*
159 *and controlgear*, can be found on the IEC website.

160 The committee has decided that the contents of this publication will remain unchanged until
161 the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in
162 the data related to the specific publication. At this date, the publication will be

- 163 • reconfirmed,
- 164 • withdrawn,
- 165 • replaced by a revised edition, or
- 166 • amended.

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168

INTRODUCTION

169 Manufacturers of electricity supply equipment may be asked to provide information about the
170 electromagnetic field characteristics to enable the user to

- 171 • assess the electromagnetic field conditions to assist with planning, installation, operating
172 instructions and service,
- 173 • take measures to meet requirements or regulations on electromagnetic fields,
- 174 • compare different products as far as their level of electromagnetic fields is concerned.

175 The purpose of this document is to describe a methodology for the evaluation (measurement
176 or calculation) of generated electromagnetic fields. In particular, if a measurement is required,
177 Hot spot and Isolines procedures are introduced and described.

178 The electromagnetic field characteristic of the equipment comprises the values of the electric
179 and the magnetic fields around its accessible surfaces.

180 The electromagnetic field characteristic defined in this document refers to a single product as
181 defined in the scope. In real installations, several field sources can superimpose, so the
182 resulting electromagnetic fields on site may differ significantly from the single product
183 characteristics.

184 This document does not define a mandatory test for the products mentioned in the scope.

185 Neither the establishment of limits for the electromagnetic fields generated by equipment, nor
186 the establishment of assessment methods for the human exposure to electromagnetic fields is
187 within the content or intent of this document.

188

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Part 208: Methods to quantify the steady state, power-frequency electromagnetic fields generated by HV switchgear assemblies and HV/LV prefabricated substations, both for rated voltages above 1 kV and up to and including 52 kV

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201 **1 Scope**

202 This part of IEC 62271 gives practical guidance for the evaluation and documentation of the
203 external steady state power-frequency electromagnetic fields which are generated by HV
204 switchgear and controlgear assemblies and prefabricated substations. Basic requirements to
205 measure or calculate the electric and magnetic fields are summarised for assemblies covered
206 by IEC 62271-200 and IEC 62271-201, and for prefabricated substations covered by
207 IEC 62271-202.

208 NOTE 1 The methods described in this document refer to three-phase equipment. However, the methodology can
209 be used correspondingly for any single- or multi-phase equipment covered by this document.

210 This document applies to equipment rated for voltages up to and including 52 kV and power-
211 frequencies from 15 Hz to 60 Hz. The electromagnetic fields which are generated by
212 harmonics or transients are not considered in this document. However, the methods described
213 are equally applicable to the harmonic fields of the power-frequency.

214 Detailed generic information on requirements and measurements of low-frequency
215 electromagnetic fields is given in IEC 61786.

216 This document covers evaluation under factory or laboratory conditions before installation.
217 The electric and the magnetic fields can be evaluated either by measurements or by
218 calculations.

219 NOTE 2 Where practicable, the methods described in this document can also be used for installations on site.

220 It is not within the scope of this document to specify limit values of electromagnetic fields or
221 methods for the assessment of human exposure.

222 **2 Normative references**

223 The following referenced documents are indispensable for the application of this document.
224 For dated references, only the edition cited applies. For undated references, the latest edition
225 of the referenced document (including any amendments) applies.

226 IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic documents -*
227 *Immunity for industrial environments*

228 IEC 61786, *Measurement of low-frequency magnetic and electric fields with regard to*
229 *exposure of human beings – Special requirements for instruments and guidance for*
230 *measurements*

231 IEC 62110, *Electric and magnetic field levels generated by AC power systems – Measurement*
232 *procedures with regard to public exposure*

233 IEC 62271-200, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed*
234 *switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

235 IEC 62271-201, *High-voltage switchgear and controlgear – Part 201: AC solid-insulation-*
236 *enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52*
237 *kV*

238 IEC 62271-202, *High-voltage switchgear and controlgear – Part 202: AC prefabricated*
239 *substations for rated voltages above 1 kV and up to and including 52 kV*

240 **3 Terms and definitions**

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

242 **3.1**

243 **EMF**

244 abbreviation for the term “electromagnetic field(s)”

245 **3.2**

246 **electric field characteristic**

247 values (RMS) and spatial distribution of the electric field strength (E) expressed in kV/m at
248 rated voltage and frequency around all accessible surfaces of the equipment

249 Note 1 to entry: The electric field characteristic is the resultant of the RMS values of the three orthogonal vector
250 components.

251 **3.3**

252 **magnetic field characteristic**

253 values (RMS) and spatial distribution of the magnetic field strength (H) expressed in A/m or
254 the magnetic flux density (B) expressed in μT , at rated continuous current and frequency
255 around all accessible surfaces of the equipment

256 Note 1 to entry: The magnetic field characteristic is the resultant of the RMS values of the three orthogonal vector
257 components.

258 Note 2 to entry: The terms “resultant electric field” and “resultant magnetic field” are defined in IEC 61786.

259 **3.4**

260 **accessible surfaces**

261 those parts of the walls and roof of prefabricated substations or HV switchgear and
262 controlgear assemblies that can be touched with all covers and doors in closed position in
263 normal service conditions

264 **3.5**

265 **reference surface**

266 **RS**

267 virtual envelope containing the equipment for evaluation purposes

268 **3.6**

269 **measurement surface**

270 **MS**

271 virtual envelope defined outside the reference surface at 20 cm distance for measuring hot
272 spots

273 **3.7**

274 **hot spot**

275 centre of an area of a local maximum of the electric or the magnetic field at the measurement
276 surface

277 **3.8**

278 **EMF characteristic**

279 spatial distribution of the Electric Field characteristic and of the Magnetic Field strength

280
281

Note 1 to entry: The spatial distribution is derived from a measurement or calculation grid.

282 **3.9**
283 **measurement volume**
284 **MV**

285 virtual space in which the electromagnetic background field does not exceed an appropriate
286 level to permit the uninfluenced measurement of the electric and magnetic fields generated by
287 the high-voltage switchgear and controlgear assembly or the prefabricated substations

288 **3.10 measurement plane**

289 horizontal virtual plane on a specific height above floor level on which the measurement
290 points are taken

291 **3.11**
292 **isoline**

293 line of constant electric or magnetic field characteristic on a measurement plane

294 **4 Evaluation requirements**

295 **4.1 General**

296 The EMF characteristic of HV switchgear and controlgear assemblies or HV/LV prefabricated
297 substations is the measured or calculated electric field strength and magnetic flux density
298 around all accessible surfaces under the conditions for evaluation described below. These
299 conditions represent the service, where the loading of the switchgear and controlgear
300 assemblies and, in a substation, of the power transformer is at defined values.

301 As the electric and magnetic fields are dependent on the physical arrangement of incoming
302 and outgoing cables and their loadings, these parameters have to be recorded. The presence
303 of other field sources and shielding or other metallic structures shall be recorded.

304 The recordings shall be carried out in such a way that the loadings, material characteristics,
305 and geometrical configuration (including metric distances) are clearly indicated.

306 The EMF characteristic shall be evaluated for the conditions that would result in the highest
307 levels of electric and magnetic fields in normal, undisturbed service. These conditions include
308 the highest currents and largest loops realistically possible through the assembly working at
309 maximum capacity. EMF caused by switching operations, including interruption of fault
310 currents, or other transient phenomena is deemed to be incidental and shall not be
311 considered.

312 Electric field strength and magnetic flux density shall be recorded as the resultant of the RMS
313 values of the three orthogonal vector components.

314 The evaluation shall be carried out at the rated frequency of the equipment.

315 However, in the frequency range from 15 Hz up to and including 60 Hz the actual value of
316 frequency does not significantly affect the levels of generated E fields for any given values of
317 voltage. Therefore, evaluation at any frequency up to and including 60 Hz is considered valid.

318 Similarly, the difference in attenuation of B fields by metallic enclosures at 50 Hz and 60 Hz
319 can be ignored for the purpose of this document. Therefore, evaluation at 50 Hz is considered
320 applicable also for 60 Hz and vice versa.

321 In the power-frequency range covered by this document the electric and magnetic fields may
322 be treated separately. When selecting the conditions to obtain the highest level of electric and
323 magnetic fields as realistically as possible in undisturbed service, the following subclauses
324 should be considered.

325 **4.2 Methods of evaluation**

326 The EMF characteristic may be evaluated by measurement or by calculation.

327 4.3 Evaluation of electric fields**328 4.3.1 HV assemblies**

329 The equipment shall be evaluated at the rated voltage of the HV switchgear and controlgear
330 assemblies.

331 Only if the evaluation cannot be carried out at rated voltage, the results shall be extrapolated
332 to the rated value. Since the electric field strength is a linear function of the voltage, the field
333 strengths for different high voltages may be extrapolated linearly.

334 4.3.2 HV/LV prefabricated substations

335 The equipment shall be evaluated at the rated high voltage of the HV/LV power
336 transformer(s).

337 Only if the evaluation cannot be carried out at rated voltage, the results shall be extrapolated
338 to the rated value. Since the electric field strength is a linear function of the voltage, the field
339 strengths for different high voltages may be extrapolated linearly.

340 4.4 Evaluation of magnetic fields**341 4.4.1 HV assemblies**

342 To evaluate the HV assembly magnetic field, use the rated continuous current given on the
343 switchgear nameplate. The HV circuit shall be selected to form the widest possible current
344 loop between the incoming and outgoing functional units (panels) of the switchgear and
345 controlgear assemblies to obtain the maximum magnetic field by using the smallest number of
346 circuits, taking into account their rated continuous current. An example is shown in Figure 1.

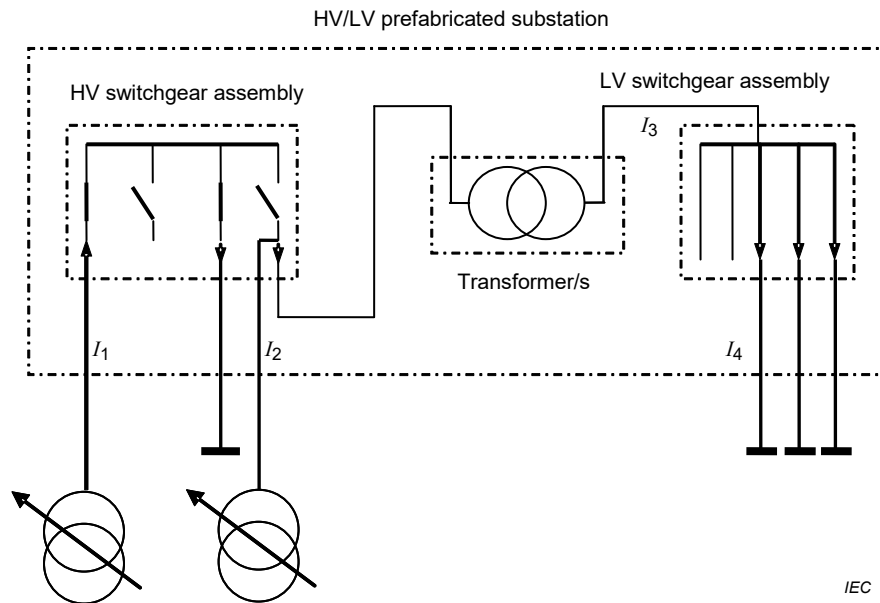
347 If the evaluation cannot be carried out at the rated continuous current the results shall be
348 extrapolated to the rated value. Any saturation effect will be less pronounced at lower
349 currents, therefore extrapolation from lower to higher values of current is allowed since it can
350 only result in an overestimate of the B field.

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353 **Key**

- 354 I_1 = HV assembly highest loop current
 355 I_2 = HV/LV loop (HV side) current
 356 I_3 = HV/LV loop (LV side) highest current
 357 I_4 = HV/LV (LV outgoing) highest current

358 **Figure 1 – Example of test circuits configuration to obtain the maximum external**
 359 **magnetic field of a HV assembly and/or a prefabricated substation**

360

361 **4.4.2 HV/LV prefabricated substations**

362 For the HV assembly, 4.4.1 applies.

363 The LV switchgear and controlgear assembly and the power transformer shall be loaded with
 364 the highest continuous current derived from the rated power of the prefabricated substation
 365 and the highest LV rated current of the corresponding power transformer for a given LV level.
 366 The circuit shall be configured to form the highest concentration of currents to obtain the
 367 maximum magnetic field. This can be achieved by using the smallest number of circuits,
 368 choosing those located closest to the enclosure of the prefabricated substation and taking into
 369 account their rated continuous currents. An example is shown in Figure 1.

370 NOTE: See 5.5 of IEC 62271-202:2022 for further information about the different rated currents

371 If the evaluation cannot be carried out at the rated power for a given LV level, the results shall
 372 be extrapolated to the rated value. Any saturation effect will be less pronounced at lower
 373 currents, therefore extrapolation from lower to higher values of current is allowed since it can
 374 only result in an overestimate of the B field.

375 The extrapolation of magnetic field values is not permitted if the currents on the HV and LV
 376 sides of the prefabricated substation vary independently.

377 **5 Measurements**378 **5.1 General**

379 At power-frequency the electric and magnetic field are independent from each other. Hence,
 380 magnetic flux density and electric field strength characteristic need not be recorded
 381 simultaneously.

382 The electric field characteristic of the equipment is independent of the load current.

383 The magnetic field characteristic of the equipment is independent of the voltage.

384 NOTE General guidance on measurement procedures for electric and magnetic fields can also be found in
385 IEC 62110 and IEC 61786.

386 5.2 Measuring instruments

387 Instruments for measuring electric and magnetic fields shall meet the requirements of
388 specification and calibration given by IEC 61786. The calibration report shall be traceable to
389 national or International Standards. These instruments should be used in appropriate
390 conditions, in particular with regard to

- 391 • electromagnetic immunity according to IEC 61000-6-2,
- 392 • immunity of power-frequency electric field on magnetic field measurement,
- 393 • temperature and humidity ranges as recommended by the instrument manufacturer.

394 A three-axis instrument measures RMS values of resultant field F_r . A single-axis instrument
395 may be used to obtain F_r by measuring F_x , F_y , and F_z , using Equation (1), where F_x , F_y and F_z
396 are RMS values of the orthogonal three-axis components of electric or magnetic field.

$$397 \quad F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \quad (1)$$

398 The use of a three-axis instrument with three concentric sensors is preferred. However, if a
399 single-axis instrument is used, special attention should be paid to the orientation of the sensor
400 along three orthogonal directions. The orientation of the sensor shall be changed without
401 moving the position of its centre.

402 In the case of non-concentric sensors, the locations and orientations of the sensors that are
403 contained within the housings of field meters shall be clearly indicated on the instrument or in
404 the instruction manual.

405 During the evaluation of the magnetic field generated by HV assemblies and HV/LV
406 prefabricated substations, the distance between the field source and the measuring
407 instrument is relatively short (in comparison to other AC power equipment like overhead
408 lines). In general, the measurements will be carried out in non-uniform fields. In case of the
409 magnetic field measurement, it is necessary to consider the ratio of distance (d_{sc}) from the
410 field source and sensor radius (a). For measurements with a three-axis instrument, a
411 minimum ratio of 4 is considered suitable.

412 For example, when using a probe with radius 5 cm the minimum distance to the field source
413 would be 20 cm considering a ratio of 4. More information about this topic can be found in IEC
414 61786.

415 5.3 Measurement procedures

416 If measurement procedures are used, one of the following methods shall be used: a) Hot spot
417 measurement procedure b) Isoline measurement procedure.

418 5.3.1 General

419 To consider equipment of all kinds of shape, a virtual envelope containing the equipment is
420 defined as the reference surface (RS); see Figure 2. The purpose of the RS is to integrate
421 irregularities and to eliminate abrupt changes in the measurement surface (MS). The MS is
422 defined outside the RS at 20 cm distance.

423 NOTE A measurement distance between 0,10 m and 0,20 m corresponds to the distance from the centre of a
424 person's body to an accessible surface when a person is leaning against it. Taking into account the practical sizes
425 of field probes and the necessary clearance to avoid direct contact of the probe with the accessible surface, 0,20 m
426 IS considered the minimum measurement distance. Some national regulations as well as IEC 62110 take this
427 distance as their basis.