



SLOVENSKI STANDARD
oSIST prEN IEC 62044-3:2023

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Jedra iz mehkomagnetnih materialov - Merilne metode - 3. del: Magnetne lastnosti pri močnem vzburjanju

Cores made of soft magnetic materials - Measuring methods - Part 3: Magnetic properties at high excitation level

Kerne aus weichmagnetischen Materialien - Messverfahren - Teil 3: Messungen der magnetischen Eigenschaften im Leistungsapplikationsbereich

Noyaux en matériaux magnétiques doux - Méthodes de mesure - Partie 3: Propriétés magnétiques à niveau élevé d'excitation

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29.100.10	Magnetne komponente	Magnetic components

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TITLE:

Coresh made of soft magnetic materials - Measuring methods - Part 3: Magnetic properties at high excitation level

PROPOSED STABILITY DATE: 2028

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**CORES MADE OF SOFT MAGNETIC MATERIALS –
MEASURING METHODS –**
Part 3: Magnetic properties at high excitation level

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IEC 62044-3 has been prepared by IEC technical committee 51: Magnetic components, ferrite and magnetic powder materials. It is an International Standard.

This second edition cancels and replaces the first edition published in 2000. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) addition of Annex F and Annex G.

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

FDIS	Report on voting
51/xxxx/FDIS	51/xxxx/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

163 The language used for the development of this International Standard is English.

164 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
165 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at
166 https://www.iec.ch/members_experts/refdocs. The main document types developed by IEC are
167 described in greater detail at <https://www.iec.ch/standardsdev/publications>.

168 IEC 62044, presented under the general title *Cores made of soft magnetic materials –*
169 *Measuring methods*, will include the following parts:

170 Part 1: Generic specification

171 Part 2: Magnetic properties at low excitation level

172 Part 3: Magnetic properties at high excitation level

173 The committee has decided that the contents of this document will remain unchanged until the stability
174 date indicated on the IEC website under webstore.iec.ch in the data related to the specific document.
175 At this date, the document will be

- 176 • reconfirmed,
- 177 • withdrawn,
- 178 • replaced by a revised edition, or
- 179 • amended.

180

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CORES MADE OF SOFT MAGNETIC MATERIALS – MEASURING METHODS –

Part 3: Magnetic properties at high excitation level

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187 **1 Scope**

188 This part of IEC 62044 specifies measuring methods for power loss and amplitude permeability
189 of magnetic cores forming the closed magnetic circuits intended for use at high excitation levels
190 in inductors, chokes, transformers and similar devices for power electronics applications.

191 The methods given in this document can cover the measurement of magnetic properties for
192 frequencies ranging practically from d.c. to 10 MHz, and even possibly higher, for the
193 calorimetric and reflection methods. The applicability of the individual methods to specific
194 frequency ranges is dependent on the level of accuracy that is to be obtained.

195 The methods in this standard are basically the most suitable for sine-wave excitations. Other
196 periodic waveforms can also be used; however, adequate accuracy can only be obtained if the
197 measuring circuitry and instruments used are able to handle and process the amplitudes and
198 phases of the signals involved within the frequency spectrum corresponding to the given
199 magnetic flux density and field strength waveforms with only slightly degraded accuracy.

200 NOTE It can be necessary for some magnetically soft metallic materials to follow specific general principles,
201 customary for these materials, related to the preparation of specimens and prescribed calculations. These principles
202 are formulated in IEC 60404-8-6.

203 **2 Normative references**

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

208 IEC 60205, *Calculation of the effective parameters of magnetic piece parts*

209 IEC 60401-3:2015, *Ferrite materials – Guide on the format of data appearing in manufacturers’
210 catalogues of transformer and inductor cores*

211 IEC 61332:2016, *Soft ferrite material classification*

212 IEC 62044-1:2002, *Cores made of soft magnetic materials - Measuring methods - Part 1:
213 Generic specification*

214 **3 Terms, definitions and symbols**

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

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

- 218 – IEC Electropedia: available at <https://www.electropedia.org/>
- 219 – ISO Online browsing platform: available at <https://www.iso.org/obp>

220

221 3.1 Definitions

222 3.1.1

223 (effective) amplitude permeability

224 amplitude permeability: μ_a , effective amplitude permeability: μ_{ea}

225 magnetic permeability obtained from the peak value of the effective magnetic flux density, \hat{B}_e ,
226 and the peak value of the effective magnetic field strength, \hat{H}_e , at the stated value of either,
227 when the magnetic flux density and magnetic field vary periodically with time and with an
228 average of zero, and the material is initially in a specified neutralized state

229 Note 1 to entry: This definition differs from that of IEC 60050 [221-03-07].

230 Note 2 to entry: Two amplitude permeabilities are in common use, namely:

231 – that in which the peak values apply to the actual waveforms of the magnetic flux density and field strength,

232 – that in which the peak values apply to the fundamental components of waveforms of the magnetic flux density
233 and the field

234 Note 3 to entry: The magnetic flux density and the field strength and, consequently, the amplitude permeability may
235 even be quasi-static quantities, provided the core is cyclically magnetized and no excursion of the B-H curve appears.

236 3.1.2

237 maximum (effective) amplitude permeability

238 $\mu_{ea \max}$

239 maximum value of the (effective) amplitude permeability when the amplitude of excitation (\hat{B}_e
240 or \hat{H}_e) is varied

241 3.1.3

242 excitation

243 either magnetic flux density or field strength for which the waveform and amplitude both remain
244 within the specified tolerance

245 Note 1 to entry: When the magnetic flux density (field strength) mode of excitation is chosen, the resultant waveform
246 of field strength (magnetic flux density) may be distorted with respect to the excitation waveform due to the non-
247 linear behaviour of the magnetic material.

248 3.1.4

249 high excitation level

250 excitation at which the permeability depends on excitation amplitude (particularly at low
251 frequencies) and/or at which the power loss results in a noticeable temperature rise (particularly
252 at high frequencies)

253 3.1.5

254 exciting winding

255 winding of measuring coil to which the exciting voltage is applied or through which the exciting
256 current is flowing

257 3.1.6

258 voltage sensing winding

259 unloaded winding of a measuring coil across which the electromotive force induced by the
260 excitation may be determined

261 3.1.7

262 measuring winding

263 winding, usually secondary, loaded or unloaded, which can be used for measurement apart
264 from the exciting and/or voltage sensing winding

265 **3.1.8**
 266 **power loss**
 267 power absorbed by the core

268 **3.2 Symbols**

269 All the formulae in this standard use basic SI units. When multiples or sub-multiples are used,
 270 the appropriate power of 10 shall be introduced.

271 A_e effective cross-sectional area of the core
 272 \hat{B}_e peak value of the effective magnetic flux density in the core
 273 f frequency
 274 \hat{H}_e peak value of the effective magnetic field strength in the core
 275 l_e effective magnetic path length of the core
 276 L inductance
 277 i instantaneous value of the current
 278 I current
 279 N number of turns of winding of the measuring coil
 280 P power loss in the core
 281 Q_c quality factor of the core for a given frequency
 282 R resistance
 283 t time
 284 T temperature
 285 u instantaneous value of the voltage
 286 U voltage
 287 V_e effective volume of the core
 288 δ relative error, deviation, etc.
 289 Δ absolute error, deviation, etc.
 290 μ_{ea} (effective) amplitude permeability
 291 μ_0 magnetic constant : approximately $4\pi \times 10^{-7}$ H/m
 292 π the number 3,14159...
 293 φ phase shift
 294 ω angular frequency = $2\pi f$

295 NOTE 1 Additional subscript, upper script, etc. gives a more specific meaning to the given symbol.

296 NOTE 2 Symbols which are used sporadically are defined in the place where they appear in the text.

297 NOTE 3 Effective parameters, such as effective magnetic path length, l_e , effective cross-sectional area, A_e , and
 298 effective volume of the core, V_e , are calculated in accordance with IEC 60205.

299 NOTE 4 In the further text of this standard, the terms magnetic flux density and field strength stand for the shortened
 300 terms magnetic flux density and magnetic field strength.

301

302 4 General precautions for measurements at high excitation level

303 4.1 General statements

304 4.1.1 Relation to practice

305 The measuring conditions, methods and procedures shall be chosen in such a way that the
306 measured results are suitable for predicting the performance of the core under practical
307 circumstances. This does not imply that all these stipulations, especially those related to the
308 excitation waveforms, have to correspond to terms encountered in practice.

309 4.1.2 Core effective parameters and material properties

310 Since the core is in general of non-uniform cross-section and generally has non-uniformly
311 distributed windings along the core path, the measurement does not yield the amplitude
312 permeability and the power loss of the material, but the effective values of these parameters
313 appropriate to the effective magnetic flux density \hat{B}_e and the effective field strength \hat{H}_e in the
314 core.

315 For the measurement of the amplitude permeability and the power loss of the material, the core
316 shall have a ring or toroidal shape in which the ratio of outer to inner diameter should not be
317 greater than 1,4 and should have windings distributed uniformly, close to the core, of inductive
318 coupling coefficient practically equal to unity.

319 4.1.3 Reproducibility of the magnetic state

320 To obliterate various remanence and time effects in the core material, the measurement shall
321 be made at a well-defined and reproducible magnetic state.

322 Any measurement under specified excitation, unless otherwise stated, is to be made at the time
323 $t_m = t_c + \Delta t$ after the magnetic conditioning start; t_c is the time period within which the magnetic
324 conditioning is completed and, whereupon, the specified excitation is set; Δt is the time period
325 during which the core is kept stable under the excitation being set.

326 4.2 Measuring coil

327 4.2.1 General

328 Normally, a measuring coil will be used, but in principle any coaxial line, cavity or other suitable
329 device providing the necessary interaction between the magnetic material and the
330 electromagnetic signal, may also be used.

331 For measurement on toroid using coils, the turns of the measuring coil shall be distributed in
332 such a way as to keep both the stray capacitance and the stray field as low as necessary for
333 sufficiently accurate measurement.

334 For measurements on cores which assemble around a coil, the shape of the measuring coil
335 shall correspond to that of the coils used for normal application of the core and its influence on
336 the variation of the inductance to be measured shall be negligible.

337 Unless otherwise specified, the test coil complete with coil former or encapsulation, or both,
338 shall be positioned coaxial to the limb which it embraces, and the side of the coil at which the
339 start of the winding is located shall be lightly pressed into contact with the core at one end of
340 this limb as follows:

341 - for a symmetrical core, the coil assembly shall contact the core at either one end or the other;

342 - for a core that is symmetrical except for an air-gap, the coil assembly shall make end contact
343 to that half of the core that contains the least proportion of the air-gap.

344 One of the coil faces shall be marked so as to define its orientation. The coil shall be kept in
345 the defined position during the whole measurement in order to obtain the maximum
346 reproducibility of the measurement.

347 **4.2.2 Number of turns**

348 The number of turns shall be specified for each winding in relation to the measuring conditions,
349 the equipment used and the accuracy to be obtained. The windings shall be wound as close to
350 the core as possible, to make the coupling (magnetic flux linkage) coefficients between the
351 measuring coil windings and the core and between the windings of measuring coil, as close to
352 100 % as possible.

353 The resistance, self-capacitance and inter-winding capacitance of windings should be as low
354 as possible to make the related errors negligible.

355 In the case of ring or toroidal cores, the turns shall be distributed evenly around the core
356 circumference.

357 The connectors, primarily of exciting winding, should consist of insulated strands, if this is
358 necessary for measurements at high frequencies.

359 When winding a sharp-edge core, care should be taken to ensure that the wire insulation is not
360 ruptured and, in the case of stranded wire, strands are not broken.

361

362 **4.2.3 Single winding and double winding** © 62044-3:2023

363 The use of a single winding both for excitation and voltage sensing is recommended if

- 364 – the coupling between the exciting winding and the voltage sensing winding is so reduced
365 that it results in a non-negligible error in the determination of the measuring magnetic flux
366 density B in the core;
- 367 – the inter-winding capacitance is too high;
- 368 – there is no measuring circuitry contra-indication against the direct connection of the exciting
369 winding to input(s) of measuring instruments.

370 NOTE 1 When single winding is used, it is recommended that its resistance be made as low as possible to make the
371 winding ohmic power loss negligible compared to the power loss in the core.

372 The use of separate exciting and voltage sensing windings (double winding) is recommended
373 if, for whatever reason, the exciting winding should be galvanically separated from the voltage
374 and the current measuring instruments, for example, to avoid a floating or d.c. connection to
375 their inputs.

376 NOTE 2 When the exciting and voltage sensing windings are used, it is critical to make their magnetic coupling
377 coefficient as close to 100 % as possible.

378 NOTE 3 The voltage needed for calculation of the magnetic flux density in the core is typically measured across a
379 voltage sensing winding that is separate from the current-carrying (exciting) winding. When measuring core losses,
380 ohmic losses in the voltage sensing winding do not affect the calculation, but ohmic losses in the current-carrying
381 (exciting) winding must be excluded from the core loss calculation.

382 NOTE 4 The use of two windings is recommended at more than 200 kHz.