



SLOVENSKI STANDARD
oSIST prEN IEC 60404-8-1:2023
01-marec-2023

Magnetni materiali - 8-1. del: Specifikacije za posamezne materiale - Trdomagnetni materiali

Magnetic materials - Part 8-1: Specifications for individual materials - Magnetically hard materials

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Matériaux magnétiques - Partie 8-1: Spécifications pour matériaux particuliers - Matériaux magnétiquement durs

<https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02-162392010000/sist-pr-en-iec-60404-8-1-2023>

Ta slovenski standard je istoveten z: prEN IEC 60404-8-1:2023

ICS:

17.220.20	Merjenje električnih in magnetnih veličin	Measurement of electrical and magnetic quantities
29.030	Magnetni materiali	Magnetic materials

oSIST prEN IEC 60404-8-1:2023 **en**



PROJECT NUMBER: IEC 60404-8-1 ED4	
DATE OF CIRCULATION: 2023-01-20	CLOSING DATE FOR VOTING: 2023-04-14
SUPERSEDES DOCUMENTS: 68/714/CD, 68/726/CC	

IEC TC 68 : MAGNETIC ALLOYS AND STEELS	
SECRETARIAT: Germany	SECRETARY: Mr Richard Daniel Knobloch
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: <input type="checkbox"/> Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: <input type="checkbox"/> EMC <input type="checkbox"/> ENVIRONMENT <input checked="" type="checkbox"/> QUALITY ASSURANCE <input type="checkbox"/> SAFETY	
<input checked="" type="checkbox"/> SUBMITTED FOR CENELEC PARALLEL VOTING	<input type="checkbox"/> NOT SUBMITTED FOR CENELEC PARALLEL VOTING
Attention IEC-CENELEC parallel voting	
The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.	
The CENELEC members are invited to vote through the CENELEC online voting system.	

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of

- any relevant patent rights of which they are aware and to provide supporting documentation,
- any relevant "in some countries" clauses to be included should this proposal proceed. Recipients are reminded that the enquiry stage is the final stage for submitting "in some countries" clauses. See AC/22/2007.

TITLE:

Magnetic materials - Part 8-1: Specifications for individual materials - Magnetically hard materials

PROPOSED STABILITY DATE: 2028

NOTE FROM TC/SC OFFICERS:

The high degree of consensus achieved with the third CD suggested to proceed to this CDV document. The substantial new issues introduced in this projected fourth edition of IEC standard 60404-8-1 are:

Copyright © 2022 International Electrotechnical Commission, IEC. All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.

- . Recently developed anisotropic REFeB hot deformed magnets and anisotropic HDDR REFeB bonded magnets;
- High energy Ca-La-Co ferrites stabilized by La and Co substitution;
- New and high- performance grades of REFeB and RE₂Co₁₇ sintered magnets and REFeN bonded magnets.

The comments received from National Committees at the circulation of the 3rd CD, 68/714/CD, were discussed by the PL and the Project Team and resulted in this CDV.

National Committees are invited to send their comments and vote on this document.

iTeh STANDARD PREVIEW (standards.iteh.ai)

[oSIST prEN IEC 60404-8-1:2023](https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02-d2bdf929f93b/osist-pren-iec-60404-8-1-2023)

<https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02-d2bdf929f93b/osist-pren-iec-60404-8-1-2023>

1	FOREWORD.....	5
2	INTRODUCTION.....	7
3	1 Scope	8
4	2 Normative references	8
5	3 Terms and definitions.....	8
6	4 Types of materials and their applications	9
7	5 Classification	9
8	5.1 General	9
9	5.2 Principal magnetic properties	10
10	5.3 Additional magnetic properties	10
11	6 Chemical composition	11
12	7 Densities.....	11
13	8 Designation.....	11
14	9 Mode of shipment and dimensions	11
15	10 Testing.....	12
16	10.1 Extent of testing	12
17	10.2 Testing methods	12
18	11 Grounds for rejection	12
19	12 Description of tables of standard properties	12
20	12.1 Magnetically hard alloys.....	12
21	12.1.1 Aluminium-nickel-cobalt-iron-titanium alloys (AlNiCo).....	12
22	12.1.2 Chromium-iron-cobalt alloys (CrFeCo).....	13
23	12.1.3 Iron-cobalt-vanadium-chromium alloys (FeCoVCr)	14
24	12.1.4 Rare earth-cobalt alloys (RECo).....	14
25	12.1.5 Rare earth-iron-boron sintered and hot deformed magnets (REFeB).....	15
26	12.2 Magnetically hard ceramics (magnetically hard ferrites)	16
27	12.2.1 Chemical composition.....	16
28	12.2.2 Manufacturing method	17
29	12.2.3 Sub-classification.....	17
30	12.2.4 Magnetic properties and densities	17
31	12.2.5 Dimensional tolerances.....	17
32	12.3 Bonded magnetically hard materials (Bonded magnets).....	17
33	12.3.1 General.....	17
34	12.3.2 Magnet materials	17
35	12.3.3 Manufacturing method	18
36	12.3.4 Sub-classification	18
37	12.3.5 Magnetic properties and densities.....	20
38	12.3.6 Dimensional tolerances.....	20
39	13 Irreversible demagnetization behaviour	20
40	13.1 General	20
41	13.2 General definition of demagnetization field strength H_D	20
42	13.3 Simplified definition of demagnetization field strength H_D	21
43	14 Tables 10 to 25	23
44	Annex A (informative) Physical data and mechanical reference values of AlNiCo, CrFeCo, FeCoVCr, SmCo, NdFeB, hard ferrite and SmFeN bonded magnets	42
46	Annex B (informative) Grain boundary diffusion process for REFeB sintered magnets	45
47	Annex C (informative) Cerium-iron-boron sintered magnets (CeFeB)	46

48	Bibliography.....	47
49		
50	Figure 1 – Graphic representation of $B(H)$ and $J(H)$ demagnetization and recoil curves.....	21
51	Figure 2 – Simplified evaluation of $B(H)$ and $J(H)$ demagnetization and recoil curves.....	22
52	Figure B.1 – Example of coercivity gain of GBD processed sintered REFeB magnets in	
53	dependence of the distance to the magnet surface.....	45
54	Figure C.1 – Manufacturing flow chart of CeFeB sintered magnets.....	46
55		
56	Table 1 – Classification of permanent magnet (magnetically hard) materials.....	9
57	Table 2 – Magnetic properties — Symbols and units.....	10
58	Table 3 – Additional magnetic properties — Symbols and units.....	10
59	Table 4 – Chemical compositions of AlNiCo alloys (% mass fraction) – for information	
60	purposes only.....	12
61	Table 5 – Chemical compositions of CrFeCo alloys (% mass fraction) – for information	
62	purposes only.....	13
63	Table 6 – Chemical compositions of FeCoVCr alloys (% mass fraction) – for	
64	information purposes only.....	14
65	Table 7 – Chemical compositions of RECo alloys (% mass fraction) – for information	
66	purposes only.....	15
67	Table 8 – Chemical compositions of REFeB sintered and hot deformed magnets (%	
68	mass fraction) – for information purposes only.....	16
69	Table 9 – Chemical compositions of REFeN alloys for bonded magnet (% mass	
70	fraction) – for information purposes only.....	18
71	Table 10 – Magnetic properties and densities of AlNiCo magnets.....	24
72	Table 11 – Magnetic properties and densities of CrFeCo and FeCoVCr magnets.....	25
73	Table 12 – Magnetic properties and densities of RECo sintered magnets.....	26
74	Table 13 – Magnetic properties and densities of REFeB sintered magnets.....	28
75	Table 14 – Magnetic properties and densities of REFeB hot deformed magnets.....	30
76	Table 15 – Magnetic properties and densities of hard ferrites.....	31
77	Table 16 – Magnetic properties and densities of isotropic AlNiCo bonded magnets.....	32
78	Table 17 – Magnetic properties and densities of isotropic and anisotropic RECo	
79	bonded magnets.....	33
80	Table 18 – Magnetic properties and densities of isotropic REFeB bonded magnets.....	34
81	Table 19 – Magnetic properties and densities of anisotropic REFeB bonded magnets.....	35
82	Table 20 – Magnetic properties and densities of isotropic and anisotropic hard ferrite	
83	bonded magnets.....	36
84	Table 21 – Magnetic properties and densities of isotropic and anisotropic REFeN	
85	bonded magnets.....	37
86	Table 22 – Dimensional tolerances (as cast or as sintered) of AlNiCo magnets.....	39
87	Table 23 – Dimensional tolerances of cold rolled strips of FeCoVCr and CrFeCo	
88	magnets with a maximum thickness of 6 mm and maximum width of 125 mm.....	40
89	Table 24 – Dimensional tolerances of the diameter of cold drawn wires and bars of	
90	FeCoVCr and CrFeCo magnets.....	40
91	Table 25 – Dimensional tolerances on hard ferrites.....	41
92	Table A.1 – Physical data and mechanical reference values of AlNiCo, CrFeCo,	
93	FeCoVCr, SmCo, NdFeB, hard ferrite and SmFeN bonded magnets.....	43

94 Table C.1 – Chemical compositions of CeFeB sintered magnets (% mass fraction).....46
95
96

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[oSIST prEN IEC 60404-8-1:2023](https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02-d2bdf929f93b/osist-pren-iec-60404-8-1-2023)

<https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02-d2bdf929f93b/osist-pren-iec-60404-8-1-2023>

97

INTERNATIONAL ELECTROTECHNICAL COMMISSION

98

99

100

101

102

103

104

105

MAGNETIC MATERIALS –**Part 8-1: Specifications for individual materials –
Permanent magnet (magnetically hard) materials****FOREWORD**

- 106 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising
107 all national electrotechnical committees (IEC National Committees). The object of IEC is to promote
108 international co-operation on all questions concerning standardization in the electrical and electronic fields. To
109 this end and in addition to other activities, IEC publishes International Standards, Technical Specifications,
110 Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC
111 Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested
112 in the subject dealt with may participate in this preparatory work. International, governmental and non-
113 governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely
114 with the International Organization for Standardization (ISO) in accordance with conditions determined by
115 agreement between the two organizations.
- 116 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international
117 consensus of opinion on the relevant subjects since each technical committee has representation from all
118 interested IEC National Committees.
- 119 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National
120 Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC
121 Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any
122 misinterpretation by any end user.
- 123 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications
124 transparently to the maximum extent possible in their national and regional publications. Any divergence
125 between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in
126 the latter. <https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02->
- 127 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity
128 assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any
129 services carried out by independent certification bodies.
- 130 6) All users should ensure that they have the latest edition of this publication.
- 131 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and
132 members of its technical committees and IEC National Committees for any personal injury, property damage or
133 other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and
134 expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC
135 Publications.
- 136 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is
137 indispensable for the correct application of this publication.
- 138 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of
139 patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

140 IEC 60404-8-1 has been prepared by IEC technical committee 68: Magnetic alloys and steels.
141 It is an International Standard.

142 This fourth edition cancels and replaces the third edition published in 2015. This edition
143 constitutes a technical revision.

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

- 146 a) recently developed anisotropic REFeB hot deformed magnets and anisotropic HDDR
147 REFeB bonded magnets are included;
- 148 b) high energy Ca-La-Co ferrites stabilized by La and Co substitution are included;

149 c) new and high-performance grades of REFeB and RE₂Co₁₇ sintered magnets and isotropic
150 REFeN bonded magnets are added.

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

FDIS	Report on voting
68/XX/FDIS	68/XX/RVD

152 Full information on the voting for the approval can be found in the report on voting indicated in
153 the above table.
154

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

156 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
157 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement,
158 available at www.iec.ch/members_experts/refdocs. The main document types developed by
159 IEC are described in greater detail at <http://www.iec.ch/standardsdev/publications>.

160 A list of all parts in the IEC 60404 series, published under the general title *Magnetic materials*,
161 can be found on the IEC website.

162 The committee has decided that the contents of this publication will remain unchanged until
163 the stability date indicated on the IEC web site under webstore.iec.ch in the data related to
164 the specific publication. At this date, the publication will be

- 165 • reconfirmed,
- 166 • withdrawn,
- 167 • replaced by a revised edition, or
- 168 • amended.

169

170

171

INTRODUCTION

172 This document includes the recently developed REFeB hot deformed magnets, anisotropic
173 HDDR REFeB bonded magnets and high energy Ca-La-Co ferrites which have become
174 established in permanent magnet applications. New and high-performance materials of
175 REFeB and RE₂Co₁₇ sintered magnets and isotropic and anisotropic REFeN bonded magnets
176 are added to each Table with new codes. Almost all materials added to this document have
177 been used for various motors to save energy and contribute to the prevention of global
178 warming.

179

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[oSIST prEN IEC 60404-8-1:2023](https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02-d2bdf929f93b/osist-pren-iec-60404-8-1-2023)

<https://standards.iteh.ai/catalog/standards/sist/96c70383-aaf6-49a0-bf02-d2bdf929f93b/osist-pren-iec-60404-8-1-2023>

MAGNETIC MATERIALS –

Part 8-1: Specifications for individual materials – Permanent magnet (magnetically hard) materials

180
181
182
183
184
185
186

187 **1 Scope**

188 This part of IEC 60404 specifies minimum values for the principal magnetic properties of,
189 and dimensional tolerances for, technically important permanent magnet (magnetically hard)
190 materials.

191 For information purposes only, this document provides values for the densities of the
192 materials and the ranges of their chemical compositions.

193 NOTE Some additional physical data and mechanical reference values concerning the magnetic materials are
194 given in Table A.1 for information and comparison purposes.

195 **2 Normative references**

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

200 IEC 60050-121, *International Electrotechnical Vocabulary – Part 121: Electromagnetism*

201 IEC 60050-151, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic*
202 *devices*

203 IEC 60050-221, *International Electrotechnical Vocabulary – Chapter 221: Magnetic materials*
204 *and components*

205 IEC 60404-1, *Magnetic materials – Part 1: Classification*

206 IEC 60404-5, *Magnetic materials – Part 5: Permanent magnet (magnetically hard) materials –*
207 *Methods of measurement of magnetic properties*

208 IEC 60404-7, *Magnetic materials – Part 7: Method of measurement of the coercivity (up to*
209 *160 kA/m) of magnetic materials in an open magnetic circuit*

210 **3 Terms and definitions**

211 For the purposes of this document, the terms and definitions given in IEC 60050-121,
212 IEC 60050-151 and IEC 60050-221 apply.

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

- 214 • IEC Electropedia: available at <http://www.electropedia.org/>
215 • ISO Online browsing platform: available at <http://www.iso.org/obp>

216

217 4 Types of materials and their applications

218 Permanent magnet materials, also designated as magnetically hard materials, are classified
219 in IEC 60404-1 as Class R (magnetically hard alloys), Class S (magnetically hard ceramics)
220 and Class U (bonded magnetically hard materials).

221 Permanent magnet materials have a coercivity relating to the magnetic polarization greater
222 than 1 kA/m. After being magnetized to saturation they provide a material-dependent
223 specific magnetic energy, which can be used in static or dynamic magnetic circuit
224 applications.

225 Permanent magnet materials are used in nearly every area of daily life. They perform
226 coupling, modulating, or regulating functions in equipment and devices based on
227 electromagnetic principles, for example in measuring instruments, motors, generators and
228 loudspeakers. Permanent magnet materials are indispensable in office equipment and
229 computer hardware, automobiles including traction motors for Hybrid Electric Vehicles (HEV)
230 and Electric Vehicles (EV), entertainment electronics, telecommunications, household
231 appliances and medical instruments, as well as in mechanical engineering as holding
232 devices, clamping plates, etc.

233 Further possible and typical applications for the commercially available permanent magnet
234 materials are described in more detail in 5.2 (Class R), 5.3 (Class S) and in 5.5
235 (Class U) of IEC 60404-1.

236 5 Classification

237 5.1 General

238 The classification of permanent magnet materials for technical applications is given in Table
239 1. The materials are grouped according to their metallurgical relationships and their
240 processes.

241 **Table 1 – Classification of permanent magnet (magnetically hard) materials**

Group	Principal constituents	Class
Magnetically hard alloys (R)	Aluminium-nickel-cobalt-iron-titanium (AlNiCo) alloys	R1
	Chromium-iron-cobalt (CrFeCo) alloys	R6
	Iron-cobalt-vanadium-chromium (FeCoVCr) alloys	R3
	Rare earth-cobalt (RECo) alloys	R5
	Rare earth-iron-boron (REFeB) sintered magnets	R7
	Rare earth-iron-boron (REFeB) hot deformed magnets	R8
Magnetically hard ceramics (S)	Hard ferrites ($MO \cdot nFe_2O_3$; M = Ba, Sr and Ca, and $n = 4,5$ to $6,5$)	S1
Bonded magnetically hard materials (U)	Bonded aluminium-nickel-cobalt-iron-titanium (AlNiCo) magnets	U1
	Bonded rare earth-cobalt (RECo) magnets	U2
	Bonded rare earth-iron-boron (REFeB) magnets	U3
	Bonded hard ferrite magnets	U4
	Bonded rare earth-iron-nitrogen (REFeN) magnets	U5

242

243 The permanent magnet materials are identified by the principal magnetic properties given in
244 5.2.

245 5.2 Principal magnetic properties

246 Symbols and units of magnetic properties of permanent magnet materials are given in Table 2.

247 **Table 2 – Magnetic properties – Symbols and units**

Magnetic properties	Symbol	Unit
Maximum value of (BH) product	$(BH)_{\max}$	kJ/m^3
Remanent flux density	B_r	mT
Coercivity relating to the magnetic flux density	H_{cB}	kA/m
Coercivity relating to the magnetic polarization	H_{cJ}	kA/m

248
249 Minimum values of magnetic properties **at ambient temperature of $(23 \pm 5) ^\circ\text{C}$** , determined after
250 magnetization to saturation, are given in Tables 10 to 21.

251 The specified values of magnetic properties are valid only for magnets having a cross
252 section invariable along the axis of magnetization, with a volume of at least $0,125 \text{ cm}^3$ and
253 with dimensions in the three directions of the coordinate axes of at least 5 mm.

254 For anisotropic materials, they are valid only along the one preferred direction.

255 For more details on size limits for measurements, see IEC 60404-5.

256 For reasons connected with the manufacturing methods, lower values of the magnetic
257 properties may be obtained if the dimensional conditions mentioned above are not satisfied.

258 For the method of measurement of the coercivity up to 160 kA/m of magnetic materials in an
259 open magnetic circuit, see IEC 60404-7.

260 The measurement of magnetic properties shall be made using the method specified in IEC
261 60404-5.

262 NOTE For measurement of $H_{cJ} \geq 1,600 \text{ kA/m}$, saturation effects in the pole pieces can lead to significant
263 measurement errors (see IEC 60404-5). In such case, the measurement can be carried out with open magnetic
264 circuits using a superconducting magnet [1]¹ or a pulsed field magnet (PFM) [2].

265 5.3 Additional magnetic properties

266 Symbols and units of additional magnetic properties of permanent magnet materials are given
267 in Table 3.

268 **Table 3 – Additional magnetic properties – Symbols and units**

Magnetic properties	Symbol	Unit
Relative recoil permeability	μ_{rec}	—
Temperature coefficient of the remanent flux density [it corresponds to the temperature coefficient of the magnetic saturation $\alpha(J_s)$]	$\alpha(B_r)$	$\%/^\circ\text{C}$
Temperature coefficient of the coercivity relating to the magnetic polarization	$\alpha(H_{cJ})$	$\%/^\circ\text{C}$

¹ Numbers in square brackets refer to the Bibliography.

Curie temperature	T_c	°C
-------------------	-------	----

269

270 The values given in Tables 10 to 21 are specified minimum values and some typical
271 values. The typical values are mean values published in the literature and are given for
272 information purposes only and are not guaranteed. The temperature range for the
273 temperature coefficients in the tables is generally from 20 °C to 100 °C, but this does not
274 preclude the use of these materials outside this temperature range.

275 The magnetic field strength necessary for magnetizing permanent magnet materials to
276 magnetic saturation is defined in IEC 60404-5, IEC 60404-7 and IEC TR 62517 [3]. The
277 temperature stability of rare earth sintered magnets is described in more detail in IEC TR
278 62518 [4].

279 6 Chemical composition

280 The composition ranges for the different material groups are given for information purposes
281 only under 12.1.1.1, 12.1.2.1, 12.1.3.1, 12.1.4.1, 12.1.5.1, 12.2.1 and 12.3.2.

282 7 Densities

283 Density values are given in Tables 10 to 21 for information purposes only. The density
284 values can be used for mass and volume calculations.

285 8 Designation

286 Permanent magnet materials can be identified by brief designations and by alpha-numeric
287 symbols (code numbers, see Tables 10 to 21). In so far as chemical symbols are used in
288 the brief designation, they indicate main constituents. The number before the oblique stroke
289 in the brief designation denotes the specified minimum value of the $(BH)_{\max}$ expressed in
290 kilojoules per cubic metre (kJ/m^3) and the number after the oblique stroke denotes one tenth
291 of the specified minimum value of the H_{cJ} expressed in kiloamperes per metre (kA/m).
292 Permanent magnet materials with a binder (mostly organic, see 12.3.1) are denoted by a
293 suffixed “p” to the brief designation.

294 EXAMPLE For the grade AlNiCo 12/6 of Table 10, the integer 12 is obtained from its minimum value $(BH)_{\max}$ of
295 $11,6 \text{ kJ/m}^3$, and the integer 6 from one-tenth of its minimum value of H_{cJ} i.e. one-tenth of $55 \text{ kA/m} = 5,5 \text{ kA/m}$ on
296 rounding up or down to the nearest integer. If rounding down would give the integer zero, the number containing
297 the first rounded non-zero decimal is maintained.

298 The code numbers are derived from the classification system used in IEC 60404-1. The
299 letter in the code number means the class of the permanent magnet material. The first
300 number designates the kind of material in the respective class, see Table 10. A ‘0’ in the
301 second position means that the material is magnetically isotropic, a “1”, that the material is
302 magnetically anisotropic. The number in the third position denotes the different grades.

303 9 Mode of shipment and dimensions

304 The materials described in this document may be delivered either magnetized or
305 unmagnetized and may be mounted in magnetic circuits.

306 The dimensions of the magnets have to be agreed upon between the supplier and the
307 purchaser when ordering.

308 10 Testing

309 10.1 Extent of testing

310 The extent of testing shall be agreed upon between the supplier and the purchaser.

311 10.2 Testing methods

312 The minimum values of the magnetic properties of permanent magnet materials having
313 suitable shape and appropriate dimensions shall be tested according to IEC 60404-5.

314 If the shape and dimensions do not correspond to the requirement of 5.2, the details of the
315 test should be agreed upon between the supplier and the purchaser.

316 The other testing methods may be agreed upon between the supplier and the purchaser.

317 11 Grounds for rejection

318 Grounds for rejection include inferior magnetic quality (Tables 10 to 21 give specified
319 minimum values of some magnetic properties), physical dimensions and dimensional
320 tolerances (Tables 22 to 25).

321 External and internal mechanical imperfections may be considered a cause for rejection, if
322 these are deleterious to handling and application.

323 The purchaser's notification of rejection to the supplier shall be accompanied by samples of
324 the rejected consignment.

325 12 Description of tables of standard properties

326 12.1 Magnetically hard alloys

327 12.1.1 Aluminium-nickel-cobalt-iron-titanium alloys (AlNiCo)

328 12.1.1.1 Chemical composition

329 Permanent magnet materials based on aluminium-nickel-cobalt-iron-titanium alloys, referred
330 to as AlNiCo, form a broad spectrum of component-rich alloys in the composition ranges
331 given in Table 4 (values in percentage mass fraction).

332 **Table 4 – Chemical compositions of AlNiCo alloys (% mass fraction) – for information**
333 **purposes only**

	Al	Ni	Co	Cu	Ti	Nb	Si	Fe
AlNiCo	8 to 13	13 to 28	5 to 42	2 to 6	0 to 9	0 to 3	0 to 0,8	balance

334

335 12.1.1.2 Manufacturing methods

336 AlNiCo magnets are formed by casting or by a powder metallurgical process. The magnetic
337 performance of alloys with a Co content higher than 20 % mass fraction can be
338 increased in a preferred direction by applying a magnetic field during heat treatment. By this
339 procedure a magnetic anisotropy is generated in the material.