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

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

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

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29.030	Magnetni materiali	Magnetic materials

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68/732/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

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: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC ☐ ENVIRONMENT ☒ QUALITY ASSURANCE ☐ SAFETY

☒ SUBMITTED FOR CENELEC PARALLEL VOTING	☐ 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:

- . 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, where 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.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MAGNETIC MATERIALS –

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

FOREWORD

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

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

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

a) recently developed anisotropic REFeB hot deformed magnets and anisotropic HDDR REFeB bonded magnets are included;

b) high energy Ca-La-Co ferrites stabilized by La and Co substitution are included;

c) new and high-performance grades of REFeB and RE_2Co_{17} sintered magnets and isotropic REFeN bonded magnets are added.

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

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

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

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

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

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

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This document includes the recently developed REFeB hot deformed magnets, anisotropic HDDR REFeB bonded magnets and high energy Ca-La-Co ferrites which have become established in permanent magnet applications. New and high-performance materials of REFeB and RE_2Co_{17} sintered magnets and isotropic and anisotropic REFeN bonded magnets are added to each Table with new codes. Almost all materials added to this document have been used for various motors to save energy and contribute to the prevention of global warming.

MAGNETIC MATERIALS –

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

1 Scope

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

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

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

2 Normative references

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

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

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

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

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

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

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

3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Types of materials and their applications

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

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

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

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

5 Classification

5.1 General

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

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

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

5.2 Principal magnetic properties

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

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

Minimum values of magnetic properties at ambient temperature of (23 ± 5) °C, determined after magnetization to saturation, are given in Tables 10 to 21.

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

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

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

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

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

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

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

5.3 Additional magnetic properties

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

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 $\alpha(J_s)$]	$\alpha(B_r)$	%/°C
Temperature coefficient of the coercivity relating to the magnetic polarization	$\alpha(H_{cJ})$	%/°C

[1] Numbers in square brackets refer to the Bibliography.

Curie temperature	T_c	°C

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

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

6 Chemical composition

The composition ranges for the different material groups are given for information purposes 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.

7 Densities

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

8 Designation

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

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

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

9 Mode of shipment and dimensions

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

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

10 Testing

10.1 Extent of testing

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

10.2 Testing methods

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

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

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

11 Grounds for rejection

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

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

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

12 Description of tables of standard properties

12.1 Magnetically hard alloys

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

12.1.1.1 Chemical composition

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

Table 4 – Chemical compositions of AlNiCo alloys (% mass fraction) – for information 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

12.1.1.2 Manufacturing methods

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