

© Copyright SEK Svensk Elstandard. Reproduction in any form without permission is prohibited.

Magnetiska material – Del 8-1: Specifikationer för enskilda material – Hårdmagnetiska material

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

Som svensk standard gäller europastandarden EN IEC 60404-8-1:2023. Den svenska standarden innehåller den officiella engelska språkversionen av EN IEC 60404-8-1:2023.

Nationellt förord

Europastandarden EN IEC 60404-8-1:2023

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 60404-8-1, Fourth edition, 2023 - Magnetic materials – Part 8-1: Specifications for individual materials – Magnetically hard materials**

utarbetad inom International Electrotechnical Commission, IEC.

Tidigare fastställd svensk standard SS-EN 60404-8-1, utg 1:2015 med eventuella tillägg, ändringar och rättelser gäller ej fr o m 2026-10-25

ICS 17.220.20; 29.030.00

Denna standard är fastställd av SEK Svensk Elstandard, som också kan lämna upplysningar om **sakinnehållet** i standarden.
Postadress: Box 1284, 164 29 KISTA
Telefon: 08 - 444 14 00.
E-post: sek@elstandard.se. Internet: www.elstandard.se

Standarder underlättar utvecklingen och höjer elsäkerheten

Det finns många fördelar med att ha gemensamma tekniska regler för bl a mätning, säkerhet och provning och för utförande, skötsel och dokumentation av elprodukter och elanläggningar.

Genom att utforma sådana standarder blir säkerhetsfordringar tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

SEK är Sveriges röst i standardiseringsarbetet inom elområdet

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

Stora delar av arbetet sker internationellt

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

Var med och påverka!

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

SEK Svensk Elstandard

Box 1284
164 29 Kista
Tel 08-444 14 00
www.elstandard.se

English Version

Magnetic materials - Part 8-1: Specifications for individual materials - Permanent magnet (magnetically hard) materials (IEC 60404-8-1:2023)

Matériaux magnétiques - Partie 8-1: Spécifications pour matériaux particuliers - Matériaux (magnétiques durs) pour aimants permanents (IEC 60404-8-1:2023)

Magnetische Werkstoffe - Teil 8-1: Anforderungen an einzelne Werkstoffe - Hartmagnetische Werkstoffe (Dauermagnete) (IEC 60404-8-1:2023)

This European Standard was approved by CENELEC on 2023-10-25. 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.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 68/732/CDV, future edition 4 of IEC 60404-8-1, prepared by IEC/TC 68 "Magnetic alloys and steels" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60404-8-1:2023.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2024-07-25
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2026-10-25

This document supersedes EN 60404-8-1:2015 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60404-8-1:2023 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standard indicated:

IEC 60404-1:2016 NOTE Approved as EN 60404-1:2017 (not modified)

IEC 60404-7:2019 NOTE Approved as EN IEC 60404-7:2020 (not modified)

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cencenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
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 60404-5	2015	Magnetic materials - Part 5: Permanent magnet (magnetically hard) materials - Methods of measurement of magnetic properties	EN 60404-5	2015

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Magnetic materials –

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

Matériaux magnétiques –

Partie 8-1: Spécifications pour matériaux particuliers – Matériaux (magnétiques durs) pour aimants permanents

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 17.220.20, 29.030

ISBN 978-2-8322-7503-0

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	8
4 Types of materials and their applications.....	9
5 Classification.....	9
5.1 General.....	9
5.2 Principal magnetic properties.....	10
5.3 Additional magnetic properties.....	10
6 Chemical composition.....	11
7 Densities	11
8 Designation	11
9 Mode of shipment and dimensions.....	11
10 Testing	12
10.1 Extent of testing.....	12
10.2 Testing methods	12
11 Grounds for rejection.....	12
12 Description of tables of standard properties.....	12
12.1 Magnetically hard alloys	12
12.1.1 Aluminium-nickel-cobalt-iron-titanium alloys (AlNiCo).....	12
12.1.2 Chromium-iron-cobalt alloys (CrFeCo).....	13
12.1.3 Iron-cobalt-vanadium-chromium alloys (FeCoVCr)	14
12.1.4 Rare earth-cobalt alloys (RECo)	14
12.1.5 Rare earth-iron-boron sintered and hot deformed magnets (REFeB).....	15
12.2 Magnetically hard ceramics (magnetically hard ferrites)	16
12.2.1 Chemical composition.....	16
12.2.2 Manufacturing method	17
12.2.3 Sub-classification	17
12.2.4 Magnetic properties and densities.....	17
12.2.5 Dimensional tolerances	17
12.3 Bonded magnetically hard materials (Bonded magnets).....	17
12.3.1 General	17
12.3.2 Magnet materials.....	17
12.3.3 Manufacturing method	18
12.3.4 Sub-classification	18
12.3.5 Magnetic properties and densities	20
12.3.6 Dimensional tolerances	20
13 Irreversible demagnetization behaviour	20
13.1 General.....	20
13.2 General definition of demagnetization field strength H_D	20
13.3 Simplified definition of demagnetization field strength H_D	21
14 Tables 10 to 25.....	23

Annex A (informative) Physical data and mechanical reference values of AlNiCo, CrFeCo, FeCoVCr, SmCo, NdFeB, hard ferrite and SmFeN bonded magnets	43
Annex B (informative) Grain boundary diffusion (GBD) process for REFeB sintered magnets.....	45
Annex C (informative) Cerium-iron-boron sintered magnets (CeFeB)	46
Bibliography.....	47
Figure 1 – Graphic representation of $B(H)$ and $J(H)$ demagnetization and recoil curves	21
Figure 2 – Simplified evaluation of $B(H)$ and $J(H)$ demagnetization and recoil curves	23
Figure B.1 – Example of coercivity gain of GBD processed sintered REFeB magnets in dependence of the distance to the magnet surface	45
Figure C.1 – Manufacturing flow chart of CeFeB sintered magnets	46
Table 1 – Classification of permanent magnet (magnetically hard) materials	9
Table 2 – Magnetic properties – Symbols and units	10
Table 3 – Additional magnetic properties – Symbols and units	10
Table 4 – Chemical compositions of AlNiCo alloys (% mass fraction) – for information purposes only	12
Table 5 – Chemical compositions of CrFeCo alloys (% mass fraction) – for information purposes only	13
Table 6 – Chemical compositions of FeCoVCr alloys (% mass fraction) – for information purposes only	14
Table 7 – Chemical compositions of RECo alloys (% mass fraction) – for information purposes only	15
Table 8 – Chemical compositions of REFeB sintered and hot deformed magnets (% mass fraction) – for information purposes only	16
Table 9 – Chemical compositions of REFeN alloys for bonded magnet (% mass fraction) – for information purposes only	18
Table 10 – Magnetic properties and densities of AlNiCo magnets	24
Table 11 – Magnetic properties and densities of CrFeCo and FeCoVCr magnets	25
Table 12 – Magnetic properties and densities of RECo sintered magnets.....	26
Table 13 – Magnetic properties and densities of REFeB sintered magnets.....	28
Table 14 – Magnetic properties and densities of REFeB hot deformed magnets.....	30
Table 15 – Magnetic properties and densities of hard ferrites.....	31
Table 16 – Magnetic properties and densities of isotropic AlNiCo bonded magnets.....	33
Table 17 – Magnetic properties and densities of isotropic and anisotropic RECo bonded magnets	34
Table 18 – Magnetic properties and densities of isotropic REFeB bonded magnets.....	35
Table 19 – Magnetic properties and densities of anisotropic REFeB bonded magnets.....	37
Table 20 – Magnetic properties and densities of isotropic and anisotropic hard ferrite bonded magnets	38
Table 21 – Magnetic properties and densities of isotropic and anisotropic REFeN bonded magnets	39
Table 22 – Dimensional tolerances (as cast or as sintered) of AlNiCo magnets.....	40
Table 23 – Dimensional tolerances of cold rolled strips of FeCoVCr and CrFeCo magnets with a maximum thickness of 6 mm and maximum width of 125 mm.....	40

Table 24 – Dimensional tolerances of the diameter of cold drawn wires and bars of FeCoVCr and CrFeCo magnets..... 41

Table 25 – Dimensional tolerances on hard ferrites..... 42

Table A.1 – Physical data and mechanical reference values of AlNiCo, CrFeCo, FeCoVCr, SmCo, NdFeB, hard ferrite and SmFeN bonded magnets 44

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

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 RE₂Co₁₇ sintered magnets and isotropic REFeN bonded magnets are added.

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

Draft	Report on voting
68/732/CDV	68/742/RVC

Full information on the voting for its 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 www.iec.ch/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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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 (IEV) - Part 121: Electromagnetism*

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) - Part 151: Electrical and magnetic devices*

IEC 60050-221, *International Electrotechnical Vocabulary (IEV) - Part 221: Magnetic materials and components*

IEC 60404-5:2015, *Magnetic materials - Part 5: Permanent magnet (magnetically hard) materials - Methods of measurement of magnetic properties*