IEC 60404-8-1

Edition 4.0 2023-09

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

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/...71d/iec-60404-8-1-2023-ed4

IEC 60404-8-1:2023-09(en-fr)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2023 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 60404-8-1:2023
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-60404-8-1-2023-ed4

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, …). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

IEC 60404-8-1

Edition 4.0 2023-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Magnetic materials –

iTeh STANDARD PREVIEW
(standards.iteh.ai)

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

IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-

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.

® Registered trademark of the International Electrotechnical Commission
Marque déposée de la Commission Electrotechnique Internationale

CONTENTS

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-96f132fba71d/iec-60404-8-1-2023-ed4

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/6449a70b5-91ee-4330-aa03-9671521ba71d/iec-60404-8-1-2023-ed4

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-967132f6a71d/iec-60404-8-1-2023-ed4

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 RE_2Co_{17} 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.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-967132f6a71d/iec-60404-8-1-2023-ed4

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.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-967132f6a71d/iec-60404-8-1-2023-ed4

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

IEC STANDARD PREVIEW
(standards.iteh.ai)

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 60404-8-1:2023
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-967132f6a71d/iec-60404-8-1-2023-ed4

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*

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 terminology databases for use in standardization at the following addresses:

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

4 Types of materials and their applications

Permanent magnet materials, also designated as magnetically hard materials, are classified in IEC 60404-1:2016 [1][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 [1].

5 Classification

iTeh STANDARD PREVIEW
(standards.iteh.ai)

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.

IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/iec/96713226a71d/iec-60404-8-1-2023-ed4

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.

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

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 Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19, Table 20 and Table 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.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

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.

https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-

For the method of measurement of the coercivity up to 160 kA/m of magnetic materials in an open magnetic circuit. The application of IEC 60404-7 [2] is indispensable.

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 [3] or a pulsed field magnet (PFM) [4].

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
Curie temperature	T_c	°C

The values given in Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19, Table 20 and Table 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 [2] and IEC TR 62517 [5]. The temperature stability of rare earth sintered magnets is described in more detail in IEC TR 62518 [6].

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 Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19, Table 20 and Table 21 for information purposes only. The density values can be used for mass and volume calculations.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

8 Designation

Permanent magnet materials can be identified by brief designations and by alpha-numeric symbols (code numbers, see Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19, Table 20 and Table 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 [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 (Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19, Table 20 and Table 21 give specified minimum values of some magnetic properties), non-compliant physical dimensions and dimensional tolerances (Table 22, Table 23, Table 24 and Table 25).

iTeh STANDARD PREVIEW

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

(standards.iteh.ai)

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

IEC 60404-8-1:2023 ED4
https://standards.iteh.ai/catalog/standards/sist/449a70b5-91ce-418b-aa63-
-8-1-2023-ed4

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.

The best performances of AlNiCo magnets are achieved with columnar or single crystal structure materials. The magnetic field applied during the heat treatment has to be parallel to the columnar axis.

12.1.1.3 Sub-classification

Isotropic AlNiCo cast or sintered magnets (R1-0-x)

where x = 1, 2, 3

Anisotropic AlNiCo cast magnets (R1-1-x)

where x = 1, …, 7

Anisotropic AlNiCo sintered magnets (R1-1-x)

where x = 10, …,13

12.1.1.4 Magnetic properties and densities

The magnetic properties and densities are given in Table 10 (see also 5.2, 5.3 and Clause 7).

12.1.1.5 Dimensional tolerances

Values of the dimensional tolerances (as cast or as sintered) of AlNiCo magnets are given in Table 22.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

12.1.2 Chromium-iron-cobalt alloys (CrFeCo)

12.1.2.1 Chemical composition

Permanent magnet materials based on chromium-iron-cobalt alloys, referred to as CrFeCo, have compositions within the ranges given in Table 5 (values in percentage mass fraction).

Table 5 – Chemical compositions of CrFeCo alloys (% mass fraction) – for information purposes only

	Cr	Co	Other elements e.g. Si, Ti, Mo, Al, V	Fe
CrFeCo	25 to 35	7 to 25	0,1 to 3	balance

12.1.2.2 Manufacturing method

The CrFeCo alloys can be manufactured by casting, followed by hot and cold rolling or drawing to produce strips or wires, respectively. Parts are made from this material by stamping, turning or drilling. Subsequent to the shaping, a heat treatment has to be provided to obtain the permanent magnet properties. The magnets can also be formed by a powder metallurgical process. The magnetic performance of the cast as well as sintered material can be increased in a preferred direction by applying a magnetic field during heat treatment.

12.1.2.3 Sub-classification

Isotropic CrFeCo cast or sintered magnets (R6-0-x)

where x = 1, 2

Anisotropic CrFeCo cast or sintered magnets (R6-1-x)

where x = 1, …, 4