

Magnetic materials —

Part 8: Specifications for individual materials —

Section 8.1: Magnetically hard materials

ICS 29.030

National foreword

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

Magnetic materials –

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MAGNETIC MATERIALS –

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

FOREWORD

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

This second edition cancels and replaces the first edition published in 1986, amendment 1 (1991) and amendment 2 (1992), and constitutes a technical revision.

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

FDIS	Report on voting
68/230/FDIS	68/232/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annex A is for information only.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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- withdrawn;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

MAGNETIC MATERIALS –

Part 8-1: Specifications for individual materials – 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 magnetically hard materials (permanent magnets).

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

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

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60404. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60404 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050-121:1998, *International Electrotechnical Vocabulary (IEV) – Part 121: Electro-magnetism*

IEC 60050(221):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 221: Magnetic materials and components*

IEC 60404-1:2000, *Magnetic materials – Part 1: Classification*

IEC 60404-5:1993, *Magnetic materials – Part 5: Permanent magnet (magnetically hard) materials – Methods of measurement of magnetic properties*

IEC 60404-7:1982, *Magnetic materials – Part 7: Method of measurement of the coercivity of magnetic materials in an open magnetic circuit*

3 Types of materials and their applications

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

Permanent magnets have a coercivity of magnetic polarization >1 kA/m. After being magnetized to saturation they produce a material-dependent specific magnetic energy, which can be used in static or dynamic magnetic circuit applications.

Permanent magnetic 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. Magnet materials are indispensable in office equipment and computer hardware, automobiles, 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 magnetic materials are described in more detail in clauses R, S and U of IEC 60404-1.

4 Classification

Compared to the preceding edition of IEC 60404-8-1 (1986), this revised edition uses a new classification of permanent magnetic materials for technical applications. This classification is given in table 8. The materials are regrouped according to their metallurgical relationships.

The permanent magnetic materials are identified by the following principal magnetic properties.

4.1 Principal magnetic properties

Table 1 – Magnetic properties – Symbols and units

Term number in IEC 60050(121) and/or IEC 60050(221)	Magnetic properties	Symbol	Unit
– 221-04-05	Maximum value of (BH) product	$(BH)_{\max}$	kJ/m^3
121-12-67 221-02-38	Remanence	B_r	mT
121-12-69 221-02-36	Coercivity relating to the magnetic flux density	H_{cB}	kA/m
121-12-69 221-02-36	Coercivity relating to the magnetic polarization	H_{cJ}	kA/m

Minimum values at room temperatures of magnetic properties, determined after magnetization to saturation, are given in tables 9 to 17.

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 from 1 cm^3 to 200 cm^3 and with dimensions in three directions of the coordinate axes of at least 8 mm.

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

NOTE 1 For more details on size limits for measurements, see IEC 60404-5.

NOTE 2 For reasons connected with the manufacturing methods, smaller values of the magnetic properties may be obtained if the dimensional conditions mentioned above are not satisfied.

4.2 Additional magnetic properties

Table 2 – Additional magnetic properties – Symbols and units

Term number in IEC 60050(121) or IEC 60050(221)	Magnetic properties	Symbol	Unit
221-03-16	Recoil permeability	μ_{rec}	–
	Temperature coefficient of the remanence (it corresponds to the temperature coefficient of the magnetic saturation $\alpha(J_s)$)	$\alpha(B_r)$	%/°C
	Temperature coefficient of the coercivity of magnetic polarization	$\alpha(H_{cJ})$	%/°C
121-12-51	Curie temperature	T_C	°C

The values given in tables 9 to 17 are typical values. They are mean values published in the literature and are given as an indication 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 magnetically hard materials to magnetic saturation is defined in IEC 60404-5 and IEC 60404-7.

5 Chemical composition

The composition ranges for the different material groups are given for information purposes under 11.1.1.1 and 11.2.1.

6 Densities

Density values are given in tables 9 to 17 for information purposes only. The density values can be used for mass and volume calculations.

7 Designation

Magnetically hard materials can be identified by brief designations and by alpha-numeric symbols (code numbers) (see tables 9 to 17). 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 maximum value of the (BH) product in kilojoules per cubic metre (kJ/m^3) and the number after the oblique stroke denotes one tenth of the coercivity H_{cJ} in kiloamperes per metre (kA/m). Magnetically hard materials with a binder (mostly organic, see 11.3) are denoted by a suffixed “p” to the brief designation.

EXAMPLE For the grade AlNiCo 12/6 of table 9, the integer 12 is obtained from its minimum value $(BH)_{\text{max}}$ of 11,6 kJ/m^3 , and the integer 6 from one-tenth of its minimum value of H_{cJ} , i.e. $1/10$ 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 magnetically hard material. The first number designates the kind of material in the respective class, see table 8. 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.

8 Mode of shipment and dimensions

The materials mentioned in this specification may be delivered either magnetized or not magnetized and may be mounted in magnetic circuits.

The dimensions of the magnets have to be agreed upon when ordering.

9 Testing

9.1 Extent of testing

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

9.2 Testing methods

The testing methods shall be agreed upon between supplier and purchaser.

The minimum magnetic values of magnets 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 4.1, the details of the test should be agreed upon between the supplier and the purchaser.

10 Grounds for rejection

Grounds for rejection include inferior magnetic quality (tables 9 to 17 give specified minimum values of some magnetic properties), physical dimensions and dimensional tolerances (tables 18 to 21).

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.

11 Description of tables of standard properties

11.1 Magnetically hard alloys

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

11.1.1.1 Chemical composition

Permanent magnets based on aluminium-nickel-cobalt-iron-titanium, referred to as AlNiCo, form a broad spectrum of component-rich alloys in the following composition ranges (values in weight percentage):