



**SLOVENSKI STANDARD**  
**SIST EN 60404-1:2017**  
**01-april-2017**

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**Magnetni materiali - 1. del: Razvrstitev (IEC 60404-1:2016)**

Magnetic materials - Part 1: Classification (IEC 60404-1:2016)

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**Ta slovenski standard je istoveten z: EN 60404-1:2017**

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**ICS:**

29.100.10      Magnetne komponente      Magnetic components

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NORME EUROPÉENNE  
EUROPÄISCHE NORM

**EN 60404-1**

January 2017

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English Version

**Magnetic materials - Part 1: Classification  
(IEC 60404-1:2016)**

Matériaux magnétiques - Partie 1: Classification  
(IEC 60404-1:2016)

Magnetische Werkstoffe - Teil 1: Klassifizierung  
(IEC 60404-1:2016)

This European Standard was approved by CENELEC on 2016-11-28. 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.

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

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**

**EN 60404-1:2017****European foreword**

The text of document 68/533/CDV, future edition 3 of IEC 60404-1, prepared by IEC/TC 68 "Magnetic alloys and steels" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60404-1:2017.

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) 2017-08-28
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-11-28

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

**Endorsement notice**

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## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When 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.cenelec.eu](http://www.cenelec.eu)

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
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) - Chapter 221: Magnetic materials and components	-	-
IEC 60401-3	-	Terms and nomenclature for cores made of magnetically soft ferrites Part 3: Guidelines on the format of data appearing in manufacturers' catalogues of transformer and inductor cores	EN 60401-3	-
IEC 60404-2	-	Magnetic materials - Part 2: Methods of measurement of the magnetic properties of electrical steel sheet and strip by means of an Epstein frame	EN 60404-2	-
IEC 60404-3	-	Magnetic materials - Part 3: Methods of measurement of the magnetic properties of magnetic sheet and strip by means of a single sheet tester	-	-
IEC 60404-4	-	Magnetic materials - Part 4: Methods of measurement of d.c. magnetic properties of iron and steel	EN 60404-4	-
IEC 60404-6	-	Magnetic materials - Part 6: Methods of measurement of the magnetic properties of magnetically soft metallic and powder materials at frequencies in the range 20 Hz to 200 kHz by the use of ring specimens	EN 60404-6	-
IEC 60404-7	-	Magnetic materials - Part 7: Method of measurement of the coercivity of magnetic materials in an open magnetic circuit	-	-

## EN 60404-1:2017

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60404-8-1	-	Magnetic materials - Part 8-1: Specifications for individual materials - Magnetically hard materials	EN 60404-8-1	-
IEC 60404-8-3	-	Magnetic materials - Part 8-3: Specifications for individual materials - Cold-rolled electrical non-alloyed and alloyed steel sheet and strip delivered in the semi-processed state	-	-
IEC 60404-8-4	-	Magnetic materials - Part 8-4: Specifications for individual materials - Cold-rolled non-oriented electrical steel strip and sheet delivered in the fully-processed state	-	-
IEC 60404-8-5	-	Magnetic materials - Part 8: Specifications for individual materials - Section 5: Specification for steel sheet and strip with specified mechanical properties and magnetic permeability	-	-
IEC 60404-8-6	-	Magnetic materials - Part 8-6: Specifications for individual materials - Soft magnetic metallic materials	EN 60404-8-6	-
IEC 60404-8-7	-	Magnetic materials - Part 8-7: Specifications for individual materials - Cold-rolled grain-oriented electrical steel strip and sheet delivered in the fully-processed state	-	-
IEC 60404-8-8	-	Magnetic materials - Part 8: Specifications for individual materials - Section 8: Specification for thin magnetic steel strip for use at medium frequencies	-	-
IEC 60404-8-9	-	Magnetic materials - Part 8: Specification for individual materials - Section 9: Standard specification for sintered soft magnetic materials	-	-
IEC 60404-8-10	-	Magnetic materials - Part 8-10: Specifications for individual materials - Magnetic materials (iron and steel) for use in relays	-	-
IEC 60404-10	-	Magnetic materials - Part 10: Methods of measurement of magnetic properties of electrical steel strip and sheet at medium frequencies	-	-
ISO 4948-1	-	Steels; Classification - Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition	-	-



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# INTERNATIONAL STANDARD

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MAGNETIC MATERIALS –****Part 1: Classification****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.
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International Standard IEC 60404-1 has been prepared by IEC technical committee 68: Magnetic alloys and steels.

This third edition cancels and replaces the second edition published in 2000 and constitutes a technical revision.

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

- a) Removal of all tables and values describing typical properties of the material to be consistent with the aim of the document to be a classification and not a specification.
- b) Enlargement of the Ni content for the classes E1 and E3.
- c) Enlargement of the Co content for the classes F3.
- d) Addition of a new class: U5 bonded rare earth-iron-nitrogen magnets.

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

CDV	Report on voting
68/533/CDV	68/555/RVC

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

A bilingual version of this publication may be issued at a later date.

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## MAGNETIC MATERIALS –

### Part 1: Classification

#### 1 Scope

This part of IEC 60404 is intended to classify commercially available magnetic materials.

The term "magnetic materials" denotes substances where the application requires the existence of ferromagnetic or ferrimagnetic properties.

In this document, the classification of magnetic materials is based upon the generally recognized existence of two main groups of products:

- soft magnetic materials (coercivity  $\leq 1\,000$  A/m);
- hard magnetic materials (coercivity  $> 1\,000$  A/m).

Within these main groups, the classification when appropriate recognizes the following characteristics:

- the main alloying element and the metallurgical state and physical properties of the material;
- when possible and convenient, the relationship between these characteristics is identified.

A classification by specific areas of application cannot be applied to all materials because different materials can very often be used for the same application depending on the characteristics required.

#### 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 60401-3, *Terms and nomenclature for cores made of magnetically soft ferrites – Part 3: Guidelines on the format of data appearing in manufacturers catalogues of transformer and inductor cores*

IEC 60404-2, *Magnetic materials – Part 2: Methods of measurement of the magnetic properties of electrical steel sheet and strip by means of an Epstein frame*

IEC 60404-3, *Magnetic materials – Part 3: Methods of measurement of the magnetic properties of magnetic sheet and strip by means of a single sheet tester*

IEC 60404-4, *Magnetic materials – Part 4: Methods of measurement of d.c. magnetic properties of iron and steel*

IEC 60404-6, *Magnetic materials – Part 6: Methods of measurement of the magnetic properties of magnetically soft metallic and powder materials at frequencies in the range 20 Hz to 200 kHz by the use of ring specimens*

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

IEC 60404-8-1, *Magnetic materials – Part 8-1: Specifications for individual materials – Magnetically hard materials*

IEC 60404-8-3, *Magnetic materials – Part 8-3: Specifications for individual materials – Cold-rolled electrical non-alloyed and alloyed steel sheet and strip delivered in the semi-processed state*

IEC 60404-8-4, *Magnetic materials – Part 8-4: Specifications for individual materials – Cold-rolled non-oriented electrical steel strip and sheet delivered in the fully-processed state*

IEC 60404-8-5, *Magnetic materials – Part 8: Specifications for individual materials – Section Five: Specification for steel sheet and strip with specified mechanical properties and magnetic permeability*

IEC 60404-8-6, *Magnetic materials – Part 8-6: Specifications for individual materials – Soft magnetic metallic materials*

IEC 60404-8-7, *Magnetic materials – Part 8-7: Specifications for individual materials – Cold-rolled grain-oriented electrical steel strip and sheet delivered in the fully processed state*

IEC 60404-8-8, *Magnetic materials – Part 8: Specifications for individual materials – Section 8: Specification for thin magnetic steel strip for use at medium frequencies*

IEC 60404-8-9, *Magnetic materials – Part 8: Specifications for individual materials – Section 9: Standard specification for sintered soft magnetic materials*

IEC 60404-8-10, *Magnetic materials – Part 8-10: Specifications for individual materials – Magnetic materials (iron and steel) for use in relays*

IEC 60404-10, *Magnetic materials. Part 10: Methods of measurement of magnetic properties of magnetic sheet and strip at medium frequencies*

ISO 4948-1, *Steels – Classification – Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-121, IEC 60050-151, IEC 60050-221 and in the product standards of the IEC 60404-8 series 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 Magnetically soft materials (coercivity $\leq 1$ kA/m)

### 4.1 Class A – Irons

#### 4.1.1 Reference documents

These materials are covered by IEC 60404-8-6 and IEC 60404-8-10.

#### 4.1.2 Chemical composition

The basic constituent of these materials is pure iron, and they are often referred to as "commercially pure" or "magnetically soft" irons. The material also contains unavoidable impurities that may affect magnetic properties. The amount of impurities that adversely affect the remanence, coercivity, saturation, magnetic polarization and stability of the magnetic properties are limited to produce the required magnetic properties for the proposed application. For information the most significant impurities when they are present in these materials are carbon (up to 0,03 %), silicon (up to 0,1 %), manganese (up to 0,2 %), phosphorus (up to 0,015 %), sulphur (up to 0,03 %), aluminium (up to 0,08 %), titanium (up to 0,1 %) and vanadium (up to 0,1 %).

NOTE For improved free machining capability, the amount of phosphorus and sulphur can be higher than indicated above.

#### 4.1.3 Basis of subclassification

The recommended subclassification is based on coercivity values.

#### 4.1.4 Available forms

These materials are available in a wide variety of forms. They may be supplied as slabs, billets, ingots or forgings; as hot-rolled bar in rectangular and square cross-sections; as hot-rolled wire rod in round, hexagonal and octagonal cross-sections; in cold-rolled and drawn forms as bar and wire; as hot- or cold-rolled sheet and strip.

#### 4.1.5 Physical characteristics

In addition to the values of coercivity, a more complete definition of these materials can be based on the following characteristics:

- magnetic: saturation magnetic polarization, magnetic polarization at various values of magnetic field strength (from which permeability can be derived), stability of characteristics with time;
- mechanical: hardness, suitability for punching operations, free machining capability, deep drawing properties, tensile strength;
- metallurgical state: hot- or cold-worked, forged, deep drawn, fully processed state, i.e. final annealed.

NOTE For material not delivered in the fully processed state, subclassification is based on the coercivity measured after heat treatment according to the requirements of the product standard or the recommendations of the manufacturer.

Ranges of specified values for the above-mentioned magnetic characteristics in the fully processed state are given in the corresponding product specifications.

#### 4.1.6 Main applications

The main applications are in DC relays, loudspeakers, electromagnets, magnetic clutches, brakes, parts for magnetic circuits in instruments and control apparatus, as well as for pole pieces and other DC parts for generators and motors.

## 4.2 Class B – Low carbon mild steels

### 4.2.1 Class B1 – Bulk material

#### 4.2.1.1 Reference document

Some of these materials are covered by IEC 60404-8-10.

#### 4.2.1.2 Chemical composition

The basic constituent of these materials is iron containing unavoidable impurities, together with a low level of other elements which may arise from additions necessitated during the manufacturing process. The amount of alloying elements is limited to that of a non-alloy steel as defined in ISO 4948-1, in particular silicon is less than 0,5 %.

#### 4.2.1.3 Basis of subclassification

The recommended subclassification is based on the coercivity.

#### 4.2.1.4 Available forms

These materials are normally supplied in the form of castings or forgings in a final heat-treated condition or partially machined to drawings supplied by the user or as bar, wire rod or wire in the hot-rolled, cold-rolled or cold-drawn condition.

#### 4.2.1.5 Physical characteristics

In addition to the coercivity a more complete definition of these materials can be based on the following properties:

- magnetic: magnetic polarization at various values of magnetic field strength;
- mechanical: yield strength (or 0,2 % proof stress) elongation ( $L_0 = 5 d_0$ ), freedom from defects;
- metallurgical state: hot- or cold-worked, annealed to produce required magnetic characteristics.

Mechanical and non-destructive tests are made in accordance with the appropriate ISO standards. Coercivity shall be measured in accordance with IEC 60404-7, other magnetic properties in accordance with IEC 60404-4.

Ranges of typical values of magnetic and mechanical properties are given in the corresponding product specification.

#### 4.2.1.6 Main applications

The materials are used for large DC magnets where no mechanical strength is required, for example, in deflection magnets in elementary particle physics and for relay applications.

## 4.2.2 Class B2 – Flat material

### 4.2.2.1 Reference documents

These materials are covered by IEC 60404-8-3, IEC 60404-8-4 and IEC 60404-8-10.

### 4.2.2.2 Chemical composition

The basic constituent of these materials is iron containing unavoidable impurities, together with a low level of other elements which may arise from additions necessitated during the manufacturing process. The amount of alloying elements is limited to that of non-alloy steel as