

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Matériaux magnétiques –
Partie 8-6: Spécifications pour matériaux particuliers – Matériaux métalliques
magnétiquement doux**



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Part 8-6: Specifications for individual materials – Soft magnetic metallic materials

Matériaux magnétiques –
Partie 8-6: Spécifications pour matériaux particuliers – Matériaux métalliques magnétiquement doux

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.030

ISBN 978-2-8322-3674-1

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Soft magnetic metallic materials****FOREWORD**

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International Standard IEC 60404-8-6 has been prepared by IEC technical committee 68: Magnetic alloys and steels.

This third edition cancels and replaces the second edition published in 1999 and Amendment 1:2007. This edition constitutes a technical revision.

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

Removal of Table 2b).

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

CDV	Report on voting
68/528/CDV	68/552/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 publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,
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MAGNETIC MATERIALS –

Part 8-6: Specifications for individual materials – Soft magnetic metallic materials

1 Scope

This part of IEC 60404 specifies the general requirements, magnetic properties, geometric characteristics and tolerances as well as inspection procedures for pure iron, silicon-iron, nickel-iron and cobalt-iron. The materials are in the form of bar, billet, sheet, strip or wire. The alloys covered correspond to those defined by classes A, C1, C2, E1 to E4 and F1 to F3 in IEC 60404-1.

Magnetic materials used primarily for relays, iron and steel products, classified only by coercivity, are covered in IEC 60404-8-10. IEC 60404-8-10 is less restrictive in terms of magnetic properties than the irons (class A) and the silicon steels (classes C21 and C22) specified in this standard, but it gives more comprehensive dimensional tolerances.

Non-oriented and oriented silicon steels (C21 and C22) for industrial power frequency applications, classified by specific total loss, are covered in IEC 60404-8-3, IEC 60404-8-4 and IEC 60404-8-7.

Non-oriented and oriented thin magnetic materials for use at medium frequencies, classified by specific total loss, are covered in IEC 60404-8-8.

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2 Normative references

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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 60050-131, *International Electrotechnical Vocabulary – Part 131: Circuit theory*

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

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

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 60404-4, *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 60404-8-3, *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 60404-8-7, *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 60404-8-10, *Magnetic materials – Part 8-10: Specifications for individual materials – Magnetic materials (iron and steel) for use in relays*

IEC 60404-9, *Magnetic materials – Part 9: Methods of determination of the geometrical characteristics of magnetic steel sheet and strip*

IEC 60635, *Toroidal strip-wound cores made of magnetically soft material*

ISO 404, *Steel and steel products – General technical delivery requirements*

ISO 10474, *Steel and steel products – Inspection documents*

<https://standards.iteh.ai/catalog/standards/sist/a19baf6-3804-421b-b7ad-60404-8-6-2016>

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purpose of this document, the terms and definitions given in IEC 60050-121, IEC 60050-131, IEC 60050-221 and the following 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>

3.1.1

bar

solid product of uniform cross-section supplied in straight lengths

Note 1 to entry: The cross-section can be round, square, rectangular or regular polygonal.

Note 2 to entry: Flat: A bar of rectangular cross-section, rolled on the four faces, whose thickness is generally 5 mm or greater and whose width is not greater than 150 mm.

Note 3 to entry: Round: A bar of circular cross-section whose diameter is generally 8 mm or greater.

3.1.2

billet

solid product of uniform cross-section, which may be square, round or rectangular, with a width less than twice the thickness

3.1.3

heat

product of a furnace melt or of a number of melts that are mixed prior to casting

3.1.4

lot

material from the same heat, of the same form, produced at the same time and, if annealed, heat-treated together or sequentially in a continuous furnace

3.1.5

rod

cold-drawn product of uniform rectangular or round cross-section, supplied in straight lengths

3.1.6

sheet and plate

flat-rolled product of uniform cross-section, supplied in coils or cut lengths where the width is over 600 mm

Note 1 to entry: Sheets have a thickness under 5 mm and plates have a thickness over 5 mm.

3.1.7

straightness of long products

greatest distance between the bar and the line joining the two ends of the bar

3.1.8

strip

flat-rolled product of uniform cross-section, supplied in coils or cut lengths where the width is under 600 mm and the thickness under 5 mm

3.1.9

wire

rolled or drawn product of uniform round or rectangular cross-section, supplied in coils

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3.2 Abbreviations for test specimens

Type E.S.: Elongated specimen for test samples, of circular, rectangular or polygonal cross-section, with a length to diameter ratio of at least 5/1, according to IEC 60404-7.

Type L.R.: Laminated rings stamped or etched from flat products (for magnetic head ring, a core with 10 mm outside diameter and 6 mm inside diameter can be used).

Type S.R.: Solid rings or square frames, formed or machined from solid material. The outside diameter of the ring shall be between 30 mm and 50 mm, with an outside/inside diameter ratio from 1,2 to 1,4.

NOTE Types L.R. and S.R. are only applicable to essentially isotropic materials.

Type S.W.: Strip-wound cores as defined by IEC 60635. For dimensional restrictions, see Table 5. The outside diameters of test cores are between 30 mm and 80 mm.

4 Classification

4.1 General

The materials covered by this document are classified according to the main alloying element and the content of this element. The subclassification takes into account the different uses of the alloys.

4.2 Alloy class A (irons)

This material is classified according to the maximum value of coercivity.

4.3 Alloy class C (silicon steels)

Alloy C1, in which the main alloying element is silicon with a content up to approximately 5 %, is classified according to the maximum value of coercivity.

Alloys C2, in which the main alloying element is silicon with a content up to approximately 5 %, are classified according to the shape of the hysteresis loop and the minimum amplitude permeability in an AC measurement (50 Hz or 60 Hz) with a L.R. specimen made of material with a thickness of 0,35 mm; the measuring point is $\hat{H} = 1,6$ A/m.

4.4 Alloy class E (nickel-iron alloys)

These alloys are classified according to the shape of the hysteresis loop and the minimum amplitude permeability in an AC measurement (50 Hz or 60 Hz), under sine flux conditions, with a S.W. specimen made of material with a thickness of 0,10 mm.

4.5 Alloy class F (cobalt-iron alloys)

These alloys are classified according to the shape of the hysteresis loop and to the maximum value of coercivity.

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5 Designation

The conventional designation of the materials comprises the following in the order given:

- a) the letter for the alloy class: A, C, E or F (see Table 1);
- b) the number according to the content of the main alloying element (see Table 1);
- c) for alloy classes C, E and F, the number 1 or 2 according to the shape of the hysteresis loop:
 - 1) = round (non-oriented)
 - 2) = rectangular (oriented by texture or by thermomagnetic treatment);
- d) a dash;
- e) depending on the alloy class, either the maximum value for the coercivity in amperes per metre or the peak value of the minimum permeability divided by 1 000 for a given magnetic field strength ($\hat{H} = 0,4$ A/m or 1,6 A/m) and a given thickness measured with a certain test specimen (see above under classification).

EXAMPLE:

E31-10: nickel-iron with 40 % to 51 % weight of nickel, a round hysteresis loop, and a minimum amplitude permeability of 10 000 at the peak value of the magnetic field strength \hat{H} of 0,4 A/m at 50 Hz or 60 Hz for a strip-wound core made of a sheet with a thickness of 0,10 mm.

6 General requirements

6.1 Chemical composition and production process

The typical composition of each of the alloy classes covered by this document is given in Table 1.

The actual composition and production process are left to the discretion of the manufacturer, unless otherwise agreed between the manufacturer and purchaser, and specified in the order.

6.2 Delivery condition

6.2.1 General

The materials covered by this standard may be delivered in the hot-finished, cold-worked or annealed condition. The condition required shall be specified in the order.

6.2.2 Form of supply

Coils shall be of constant width and wound in such a manner that the edges are superimposed in a regular manner and the side faces of the coil are substantially flat. Coils shall be sufficiently tightly wound that they do not collapse under their own weight.

Coils can occasionally present welds or interleaves resulting from the removal of defective zones, subject to prior agreement between the parties. The value of the additional thickness due to the weld is subject to special agreement. If necessary, the marking of welds or interleaves may form the subject of a special agreement. For coils containing repair welds or interleaves, each part of the strip shall be of the same quality material.

The edges of parts welded together shall not be so much out of alignment as to affect the further processing of the material.

The mass of coils shall be agreed upon at the time of ordering.

6.2.3 Surface condition

The surface condition of sheets or strips shall be uniform, clean, and free from grease and rust.

Isolated imperfections such as scratches, blisters, etc. may be tolerated if the thickness remains within the tolerance limits and the manufacture or performance of the final product is not affected.

The nature of the surface condition will depend on the final treatment. For material in the hot-finished condition, the material exhibits a hot mill scale.

7 Technical requirements

7.1 Magnetic properties

Unless otherwise required by the order, the magnetic properties shall be determined for each lot of material on a representative sample taken from the lot and heat-treated in accordance with the recommendations of the manufacturer or as specified by the purchaser. Acceptance testing of sheets and strips shall be carried out by AC measurement of laminated rings (type L.R.) or strip-wound cores (type S.W.), or by DC measurement of either solid rings (type S.R.), laminated rings (type L.R.) or elongated specimens (type E.S.).

The properties shall meet the magnetic requirements specified in Tables 2 to 4 for the alloy, the magnetic grade and the thickness specified in the order. For intermediate thicknesses not given in the tables, the values for the next thicker group shall apply. It is not necessary to measure all of the properties. The required magnetic properties and test conditions shall be agreed between manufacturer and purchaser.

7.2 Geometric characteristics and tolerances

7.2.1 Flat products: sheet, plate and strip

7.2.1.1 Thickness

The thickness of cold-rolled sheet and strip shall not vary by more than the tolerances indicated in Table 6.

7.2.1.2 Width

The width of strip shall not vary by more than the tolerances indicated in Table 7.

7.2.1.3 Flatness

The wave factor, expressed as a percentage, shall not exceed 2 % and flatness shall be as agreed between manufacturer and purchaser.

7.2.1.4 Edge camber

The edge camber shall be as agreed between the manufacturer and the purchaser.

7.2.2 Cold-worked bar, rod and wire

The diameter, width and thickness tolerances shall be as specified in Table 8.

7.2.3 Hot-finished bar

Tolerances shall be as agreed between the manufacturer and the purchaser.

8 Inspection and testing

8.1 General

The materials defined by this standard are generally ordered with inspection in accordance with ISO 404. The purchaser shall specify, when ordering, the properties for which the verification shall be made, the type of inspection and the related document (see ISO 10474).

In the case of an order without inspection, as a dispensation from ISO 404, the manufacturer and the purchaser shall agree which property shall be certified, for example the maximum coercivity of the delivered material.

Each acceptance unit shall comprise not more than 23 t of the same grade and the same nominal dimensions. Different acceptance units can be adopted by special agreement.

For products supplied in coil form, each coil shall constitute an acceptance unit.

When the products are delivered in the form of slit coils, the test results applying to the parent unit of acceptance shall apply.

Except by special agreement, the same rules apply to the characteristics which are specifically specified.