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## Magnetic materials – Part 1: Classification

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ICS 29.030

ISBN 978-2-8322-3714-4

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### MAGNETIC MATERIALS –

#### Part 1: Classification

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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

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- withdrawn,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

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## MAGNETIC MATERIALS –

### Part 1: Classification

#### ~~1~~ **General**

#### **1** ~~Scope and object~~

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:~~1998~~, *International Electrotechnical Vocabulary – Part 121: Electromagnetism*

IEC 60050-151:~~1978~~, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*

IEC 60050-221:~~1990~~, *International Electrotechnical Vocabulary – Chapter 221: Magnetic materials and components*

~~IEC 60401:1993, Ferrite materials – Guide on the format of data appearing in manufacturers catalogues of transformer and inductor cores~~

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 (all parts), Magnetic materials~~

IEC 60404-2:~~1996~~, *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:~~1992~~, *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:~~1995~~, *Magnetic materials – Part 4: Methods of measurement of d.c. magnetic properties of iron and steel*

IEC 60404-6:~~1986~~, *Magnetic materials – Part 6: Methods of measurement of the magnetic properties of ~~isotropic nickel-iron soft magnetic alloys, types E1, E3 and E4~~ 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:~~1982~~, *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 – ~~Standard specifications for~~ Magnetically hard materials*

~~IEC 60404-8-2:1998, Magnetic materials – Part 8-2: Specifications for individual materials – Cold-rolled electrical alloyed steel sheet and strip delivered in the semi-processed state~~

IEC 60404-8-3:~~1998~~, *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:~~1998~~, *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:~~1989~~, *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:~~1999~~, *Magnetic materials – Part 8-6: Specifications for individual materials – Soft magnetic metallic materials*

IEC 60404-8-7:~~1998~~, *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:~~1991~~, *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:~~1994~~, *Magnetic materials – Part 8: Specifications for individual materials – Section 9: Standard specifications for sintered soft magnetic materials*

IEC 60404-8-10:~~1994~~, *Magnetic materials – Part 8-10: Specifications for individual materials – ~~Specification for~~ Magnetic materials (iron and steel) for use in relays*

IEC 60404-10:~~1988~~, *Magnetic materials. Part 10: Methods of measurement of magnetic properties of magnetic ~~steel~~ sheet and strip at medium frequencies*

ISO 4948-1:~~1982~~, *Steels – Classification – Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*



# INTERNATIONAL STANDARD

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**Magnetic materials –  
Part 1: Classification**

**Matériaux magnétiques –  
Partie 1: Classification**





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# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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**Magnetic materials –  
Part 1: Classification**

**Matériaux magnétiques –  
Partie 1: Classification**

INTERNATIONAL  
ELECTROTECHNICAL  
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ICS 29.030

ISBN 978-2-8322-5157-7

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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 bilingual version (2017-12) corresponds to the monolingual English version, published in 2016-10.

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.

The French version of this standard has not been voted upon.

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.

## 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*

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

### MATÉRIAUX MAGNÉTIQUES –

#### Partie 1: Classification

#### AVANT-PROPOS

- 1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
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La Norme internationale IEC 60404-1 a été établie par le comité d'études 68 de l'IEC: Matériaux magnétiques tels qu'alliages et aciers.

La présente version bilingue (2017-12) correspond à la version anglaise monolingue publiée en 2016-10.

Cette troisième édition annule et remplace la deuxième édition parue en 2000, dont elle constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) Suppression de l'ensemble des tableaux et valeurs décrivant les propriétés types du matériau dans un souci de cohérence avec l'objectif du document visant à établir une classification et non une spécification.
- b) Augmentation de la teneur en Ni pour les classes E1 et E3.
- c) Augmentation de la teneur en Co pour les classes F3.
- d) Ajout d'une nouvelle classe: classe U5 – aimants agglomérés terres rares-fer-azote.

Le texte anglais de cette norme est issu des documents 68/533/CDV et 68/555/RVC.

Le rapport de vote 68/555/RVC donne toute information sur le vote ayant abouti à l'approbation de cette norme.

La version française de cette norme n'a pas été soumise au vote.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60404, publiées sous le titre général *Matériaux magnétiques*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "<http://webstore.iec.ch>" dans les données relatives à la publication recherchée. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

# MATÉRIAUX MAGNÉTIQUES –

## Partie 1: Classification

### 1 Domaine d'application

La présente partie de l'IEC 60404 a pour objet la classification des matériaux magnétiques disponibles commercialement.

Le terme "matériaux magnétiques" décrit les substances dont l'application exige l'existence de propriétés ferromagnétiques ou ferrimagnétiques.

Dans le présent document, la classification des matériaux magnétiques est basée sur l'existence généralement reconnue de deux groupes principaux de produits:

- les matériaux magnétiques doux (coercitivité  $\leq 1\ 000$  A/m);
- les matériaux magnétiques durs (coercitivité  $> 1\ 000$  A/m).

A l'intérieur de ces groupes principaux, la classification reconnaît lorsque cela est approprié les caractéristiques suivantes:

- l'élément d'alliage principal et l'état métallurgique et les propriétés physiques du matériau;
- lorsque cela est possible et réalisable pratiquement, la relation entre ces caractéristiques est identifiée.

Une classification selon les domaines spécifiques d'application ne peut être appliquée à tous les matériaux, car différents matériaux peuvent bien souvent être utilisés pour la même application en fonction des caractéristiques exigées.

### 2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-121, *Vocabulaire électrotechnique international – Partie 121: Electromagnétisme*

IEC 60050-151, *Vocabulaire électrotechnique international – Partie 151: Dispositifs électriques et magnétiques*

IEC 60050-221, *Vocabulaire électrotechnique international – Chapitre 221: Matériaux et composants magnétiques*

IEC 60401-3, *Termes et nomenclature pour noyaux en matériaux ferrites magnétiquement doux – Partie 3: Lignes directrices relatives au format des données figurant dans les catalogues des fabricants de noyaux pour transformateurs et inductances*

IEC 60404-2, *Matériaux magnétiques – Partie 2: Méthodes de mesure des propriétés magnétiques des tôles et bandes magnétiques en acier au moyen d'un cadre Epstein*

IEC 60404-3, *Matériaux magnétiques – Partie 3: Méthodes de mesure des caractéristiques magnétiques des tôles et feuillards magnétiques à l'aide de l'essai sur tôle unique*

IEC 60404-4, *Matériaux magnétiques – Partie 4: Méthodes de mesure en courant continu des propriétés magnétiques du fer et de l'acier*

IEC 60404-6, *Matériaux magnétiques – Partie 6: Méthodes de mesure des propriétés magnétiques des matériaux métalliques et des matériaux en poudre magnétiquement doux, aux fréquences comprises entre 20 Hz et 100 kHz, sur des éprouvettes en forme de tore*

IEC 60404-7, *Matériaux magnétiques – Partie 7: Méthode de mesure du champ coercitif des matériaux magnétiques en circuit magnétique ouvert*

IEC 60404-8-1, *Matériaux magnétiques – Partie 8-1: Spécifications pour matériaux particuliers – Matériaux magnétiquement durs*

IEC 60404-8-3, *Matériaux magnétiques – Partie 8-3: Spécifications pour matériaux particuliers – Tôles et bandes magnétiques en acier non allié et en acier allié, laminées à froid, livrées à l'état semi-fini*

IEC 60404-8-4, *Matériaux magnétiques – Partie 8-4: Spécifications pour matériaux particuliers – Bandes et tôles magnétiques en acier à grains non orientés, laminées à froid et livrées à l'état fini*

IEC 60404-8-5, *Matériaux magnétiques – Partie 8: Spécifications pour matériaux particuliers – Section cinq – Spécification des tôles en acier à caractéristiques mécaniques et perméabilité magnétique garanties*

IEC 60404-8-6, *Matériaux magnétiques – Partie 8-6: Spécifications pour matériaux particuliers – Matériaux métalliques magnétiquement doux*

IEC 60404-8-7, *Matériaux magnétiques – Partie 8-7: Spécifications pour matériaux particuliers – Bandes et tôles magnétiques en acier à grains orientés, laminées à froid et livrées à l'état fini*

IEC 60404-8-8, *Matériaux magnétiques – Partie 8: Spécifications pour matériaux particuliers – Section 8: Spécification des tôles magnétiques extra-minces en acier pour utilisation à moyennes fréquences*

IEC 60404-8-9, *Matériaux magnétiques – Partie 8: Spécifications pour matériaux particuliers – Section 9: Spécification des matériaux magnétiques doux frittés*

IEC 60404-8-10, *Matériaux magnétiques – Partie 8-10: Spécifications pour matériaux particuliers – Matériaux magnétiques (fer et acier) pour relais*

IEC 60404-10, *Magnetic materials – Part 10: Methods of measurement of magnetic properties of magnetic sheet and strip at medium frequencies (disponible en anglais seulement)*

ISO 4948-1, *Aciers – Classification – Partie 1: Classification en aciers alliés et aciers non alliés basée sur la composition chimique*