

This is a preview of "S+ IEC 60404-1 Ed. 3...". Click here to purchase the full version from the ANSI store.



Edition 3.0 2016-10

REDLINE VERSION



Magnetic materials – Part 1: Classification

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.030

ISBN 978-2-8322-3714-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
1 General	
1 Scope and object	7
2 Normative references	7
3 Terms and definitions	9
4 Magnetically soft materials (coercivity ≤ 1 kA/m).....	9
4.1 Class A – Irons	9
4.1.1 General Reference documents.....	9
4.1.2 Chemical composition.....	9
4.1.3 Basis of subclassification.....	9
4.1.4 Available forms.....	9
4.1.5 Physical characteristics	10
4.1.6 Main applications.....	10
4.2 Class B – Low carbon mild steels.....	10
4.2.1 Class B1 – Bulk material.....	10
4.2.2 Class B2 – Flat material.....	11
4.3 Class C – Silicon steels	12
4.3.1 Class C1 – Bulk material	12
4.3.2 Class C2 – Flat material	13
4.4 Class D – Other steels	20
4.4.1 Class D1 – Bulk material	20
4.4.2 Class D2 – Flat material	22
4.4.3 Class D3 – Stainless steels	23
4.5 Class E – Nickel-iron alloys	24
4.5.1 Class E1 – Nickel content 72 70 % to 83 85 %.....	24
4.5.2 Class E2 – Nickel content 54 % to 68 %	26
4.5.3 Class E3 – Nickel content 45 40 % to 50 51 %.....	27
4.5.4 Class E4 – Nickel content 35 % to 40 %	29
4.5.5 Class E5 – Nickel content 29 % to 33 %	30
4.6 Class F – Iron-cobalt alloys.....	31
4.6.1 Class F1 – Cobalt content 47 % to 50 %	31
4.6.2 Class F2 – Cobalt content 35 %.....	32
4.6.3 Class F3 – Cobalt content 23 % to 27 30 %.....	33
4.7 Class G – Other alloys	34
4.7.1 Class G1 – Aluminium-iron alloys	34
4.7.2 Class G2 – Aluminium-silicon-iron alloys	35
4.8 Class H – Magnetically soft materials made by powder metallurgical techniques	35
4.8.1 Class H1 – Soft ferrites.....	35
4.8.2 Class H2 – Magnetically soft sintered materials	37
4.8.3 Class H3 – Powder composites	39
4.9 Class I – Amorphous soft magnetic materials.....	40
4.9.1 General	40
4.9.2 Class I1 – Iron-based amorphous alloys	40
4.9.3 Class I2 – Cobalt-based amorphous alloys	41
4.9.4 Class I3 – Nickel-based amorphous alloys.....	42

4.10	Class J – Nano-crystalline soft magnetic materials.....	43
4.10.1	Reference document.....	43
4.10.2	Production process.....	43
4.10.3	Chemical composition.....	43
4.10.4	Basis of subclassification.....	43
4.10.5	Available forms.....	43
4.10.6	Physical characteristics.....	43
4.10.7	Main applications.....	44
5	Magnetically hard materials (coercivity > 1 kA/m).....	44
5.1	Class Q – Magnetostrictive alloys – Rare earth iron alloys (Class Q1).....	44
5.1.1	General Reference documents.....	44
5.1.2	Chemical composition.....	44
5.1.3	Basis of subclassification.....	44
5.1.4	Available forms.....	44
5.1.5	Physical characteristics.....	44
5.1.6	Main applications.....	45
5.2	Class R – Magnetically hard alloys.....	45
5.2.1	Class R1 – Aluminium-nickel-cobalt-iron-titanium (AlNiCo) alloys.....	45
5.2.2	Class R3 – Iron-cobalt-vanadium-chromium (FeCoVCr) alloys.....	46
5.2.3	Class R5 – Rare earth cobalt (RECo) alloys.....	47
5.2.4	Class R6 – Chromium-iron-cobalt (CrFeCo) alloys.....	48
5.2.5	Class R7 – Rare earth-iron-boron (REFeB) alloys.....	49
5.3	Class S – Magnetically hard ceramics – Hard ferrites (Class S1).....	50
5.3.1	General Reference document.....	50
5.3.2	Chemical composition and manufacturing method.....	50
5.3.3	Basis of subclassification.....	51
5.3.4	Available forms.....	51
5.3.5	Physical characteristics.....	51
5.3.6	Main applications.....	51
5.4	Class T – Other magnetically hard materials – Martensitic steels (Class T1).....	51
5.4.1	General Reference document.....	51
5.4.2	Composition.....	51
5.4.3	Basis of subclassification.....	51
5.4.4	Available forms.....	52
5.4.5	Physical characteristics.....	52
5.4.6	Main applications.....	52
5.5	Class U – Bonded magnetically hard materials.....	52
5.5.1	General	52
5.5.2	Class U1 – Bonded aluminium-nickel-cobalt-iron-titanium (AlNiCo) magnets.....	53
5.5.3	Class U2 – Bonded rare earth-cobalt (RECo) magnets.....	53
5.5.4	Class U3 – Bonded neodymium-iron-boron (REFeB) magnets.....	54
5.5.5	Class U4 – Bonded hard ferrites magnets.....	55
5.5.6	Class U5 – Bonded rare earth-iron-nitrogen magnets.....	56

~~Table 1 – Ranges of chemical composition.....~~

~~Table 2 – Ranges of specified values for magnetic properties.....~~

~~Table 3 – Ranges of typical values of magnetic and mechanical properties.....~~

~~Table 4 – Ranges of specified values of maximum specific total loss.....~~

This is a preview of "S+ IEC 60404-1 Ed. 3...". Click here to purchase the full version from the ANSI store.

Table 5	Ranges of specified values for magnetic and electric properties
Table 6	Ranges of specified values of maximum specific total loss
Table 7	Ranges of specified values of maximum specific total loss
Table 8	Ranges of typical values of maximum specific loss
Table 9	Specified values of maximum specific total loss
Table 10	Typical values of mechanical and magnetic properties for the thickness of 0,50 mm
Table 11	Typical values of magnetic properties
Table 12	Typical ranges of magnetic and mechanical properties
Table 13	Typical ranges of mechanical properties
Table 14	Ranges of specified values of mechanical and magnetic characteristics of hot-rolled products
Table 15	Ranges of specified values of mechanical and magnetic characteristics of cold-rolled products
Table 16	Ranges of chemical composition
Table 17	Typical magnetic properties of materials in the fully processed state
Table 18	Specified magnetic properties of material with a round hysteresis loop
Table 19	Typical magnetic properties of material with a flat hysteresis loop
Table 20	Typical magnetic properties of material with a rectangular hysteresis loop
Table 21	Typical magnetic properties of material with a round hysteresis loop
Table 22	Typical magnetic properties of material with a flat hysteresis loop
Table 23	Specified magnetic properties of material with a round hysteresis loop
Table 24	Typical magnetic properties of material with a flat hysteresis loop
Table 25	Typical magnetic properties of material with a rectangular hysteresis loop
Table 26	Specified magnetic properties of materials in the fully processed state
Table 27	Typical magnetic properties
Table 28	Ranges of specified magnetic properties of material with a round hysteresis loop
Table 29	Typical magnetic properties of material with a rectangular hysteresis loop
Table 30	Specified magnetic properties
Table 31	Specified magnetic properties
Table 32	Typical properties for Mn-Zn ferrites
Table 33	Typical properties for Ni-Zn ferrites
Table 34	Ranges of specified properties
Table 35	Typical physical and magnetic properties
Table 36	Typical physical and magnetic properties
Table 37	Typical physical and magnetic properties
Table 38	Typical physical properties
Table 39	Ranges of specified magnetic properties
Table 40	Specified values of magnetic properties
Table 41	Ranges of specified magnetic properties and density of sintered material
Table 42	Ranges of specified magnetic properties
Table 43	Ranges of specified magnetic properties and density for anisotropic RE-FeB alloys
Table 44	Ranges of specified values of magnetic properties
Table 45	Typical magnetic properties
Table 46	Specified values of magnetic properties
Table 47	Specified values of magnetic properties
Table 48	Ranges of typical physical and magnetic properties
Table 49	Ranges of specified magnetic properties

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.
- 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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

DISCLAIMER

This Redline version is not an official IEC Standard and is intended only to provide the user with an indication of what changes have been made to the previous version. Only the current version of the standard is to be considered the official document.

This Redline version provides you with a quick and easy way to compare all the changes between this standard and its previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

This is a preview of "S+ IEC 60404-1 Ed. 3...". [Click here to purchase the full version from the ANSI store.](#)

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.

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

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*

This is a preview of "S+ IEC 60404-1 Ed. 3...". Click here to purchase the full version from the ANSI store.

~~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

NORME INTERNATIONALE

**Magnetic materials –
Part 1: Classification**

**Matériaux magnétiques –
Partie 1: Classification**





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2016 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 Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

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 also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

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: csc@iec.ch.

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.

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

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 aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

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



INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Magnetic materials –
Part 1: Classification**

**Matériaux magnétiques –
Partie 1: Classification**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.030

ISBN 978-2-8322-5157-7

**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.**

CONTENTS

FOREWORD.....	4
1 Scope.....	6
2 Normative references	6
3 Terms and definitions	7
4 Magnetically soft materials (coercivity ≤ 1 kA/m).....	8
4.1 Class A – Irons	8
4.1.1 Reference documents.....	8
4.1.2 Chemical composition.....	8
4.1.3 Basis of subclassification.....	8
4.1.4 Available forms.....	8
4.1.5 Physical characteristics	8
4.1.6 Main applications.....	8
4.2 Class B – Low carbon mild steels.....	9
4.2.1 Class B1 – Bulk material.....	9
4.2.2 Class B2 – Flat material.....	9
4.3 Class C – Silicon steels	10
4.3.1 Class C1 – Bulk material	10
4.3.2 Class C2 – Flat material	11
4.4 Class D – Other steels	16
4.4.1 Class D1 – Bulk material	16
4.4.2 Class D2 – Flat material	18
4.4.3 Class D3 – Stainless steels	18
4.5 Class E – Nickel-iron alloys	19
4.5.1 Class E1 – Nickel content 70 % to 85 %	19
4.5.2 Class E2 – Nickel content 54 % to 68 %	20
4.5.3 Class E3 – Nickel content 40 % to 51 %	21
4.5.4 Class E4 – Nickel content 35 % to 40 %	22
4.5.5 Class E5 – Nickel content 29 % to 33 %	23
4.6 Class F – Iron-cobalt alloys.....	24
4.6.1 Class F1 – Cobalt content 47 % to 50 %	24
4.6.2 Class F2 – Cobalt content 35 %.....	24
4.6.3 Class F3 – Cobalt content 23 % to 30 %	25
4.7 Class G – Other alloys	26
4.7.1 Class G1 – Aluminium-iron alloys	26
4.7.2 Class G2 – Aluminium-silicon-iron alloys	27
4.8 Class H – Magnetically soft materials made by powder metallurgical techniques	28
4.8.1 Class H1 – Soft ferrites.....	28
4.8.2 Class H2 – Magnetically soft sintered materials	29
4.8.3 Class H3 – Powder composites	30
4.9 Class I – Amorphous soft magnetic materials.....	30
4.9.1 General	30
4.9.2 Class I1 – Iron-based amorphous alloys	31
4.9.3 Class I2 – Cobalt-based amorphous alloys	32
4.9.4 Class I3 – Nickel-based amorphous alloys.....	33
4.10 Class J – Nano-crystalline soft magnetic materials.....	33
4.10.1 Reference document.....	33

4.10.2	Production process	33
4.10.3	Chemical composition	34
4.10.4	Basis of subclassification	34
4.10.5	Available forms	34
4.10.6	Physical characteristics	34
4.10.7	Main applications	34
5	Magnetically hard materials (coercivity > 1 kA/m)	35
5.1	Class Q – Magnetostrictive alloys – Rare earth iron alloys (Class Q1)	35
5.1.1	Reference document	35
5.1.2	Chemical composition	35
5.1.3	Basis of subclassification	35
5.1.4	Available forms	35
5.1.5	Physical characteristics	35
5.1.6	Main applications	35
5.2	Class R – Magnetically hard alloys	35
5.2.1	Class R1 – Aluminium-nickel-cobalt-iron-titanium (AlNiCo) alloys	35
5.2.2	Class R3 – Iron-cobalt-vanadium-chromium (FeCoVCr) alloys	36
5.2.3	Class R5 – Rare earth cobalt (RECo) alloys	37
5.2.4	Class R6 – Chromium-iron-cobalt (CrFeCo) alloys	38
5.2.5	Class R7 – Rare earth-iron-boron (REFeB) alloys	39
5.3	Class S – Magnetically hard ceramics – Hard ferrites (Class S1)	40
5.3.1	Reference document	40
5.3.2	Chemical composition and manufacturing method	40
5.3.3	Basis of subclassification	40
5.3.4	Available forms	40
5.3.5	Physical characteristics	41
5.3.6	Main applications	41
5.4	Class T – Other magnetically hard materials – Martensitic steels (Class T1)	41
5.4.1	Reference document	41
5.4.2	Composition	41
5.4.3	Basis of subclassification	41
5.4.4	Available forms	41
5.4.5	Physical characteristics	41
5.4.6	Main applications	42
5.5	Class U – Bonded magnetically hard materials	42
5.5.1	General	42
5.5.2	Class U1 – Bonded aluminium-nickel-cobalt-iron-titanium (AlNiCo) magnets	42
5.5.3	Class U2 – Bonded rare earth-cobalt (RECo) magnets	43
5.5.4	Class U3 – Bonded neodymium-iron-boron (REFeB) magnets	43
5.5.5	Class U4 – Bonded hard ferrite magnets	44
5.5.6	Class U5 – Bonded rare earth-iron-nitrogen magnets	45

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.
- 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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

This is a preview of "S+ IEC 60404-1 Ed. 3...". [Click here to purchase the full version from the ANSI store.](#)

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*

This is a preview of "S+ IEC 60404-1 Ed. 3...". [Click here to purchase the full version from the ANSI store.](#)

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*

SOMMAIRE

AVANT-PROPOS	48
1 Domaine d'application	50
2 Références normatives	50
3 Termes et définitions	52
4 Matériaux magnétiques doux (coercitivité ≤ 1 kA/m)	52
4.1 Classe A – Fers	52
4.1.1 Documents de référence	52
4.1.2 Composition chimique	52
4.1.3 Base de sous-classification	52
4.1.4 Formes disponibles	52
4.1.5 Caractéristiques physiques	53
4.1.6 Applications principales	53
4.2 Classe B – Aciers doux à faible teneur en carbone	53
4.2.1 Classe B1 – Produits massifs	53
4.2.2 Classe B2 – Produits plats	54
4.3 Classe C – Aciers au silicium	55
4.3.1 Classe C1 – Produits massifs	55
4.3.2 Classe C2 – Produits plats	56
4.4 Classe D – Autres types d'aciers	61
4.4.1 Classe D1 – Produits massifs	61
4.4.2 Classe D2 – Produits plats	63
4.4.3 Classe D3 – Aciers inoxydables	64
4.5 Classe E – Alliages fer-nickel	65
4.5.1 Classe E1 – Teneur en nickel comprise entre 70 % et 85 %	65
4.5.2 Classe E2 – Teneur en nickel comprise entre 54 % et 68 %	66
4.5.3 Classe E3 – Teneur en nickel comprise entre 40 % et 51 %	67
4.5.4 Classe E4 – Teneur en nickel comprise entre 35 % et 40 %	68
4.5.5 Classe E5 – Teneur en nickel comprise entre 29 % et 33 %	69
4.6 Classe F – Alliages fer-cobalt	70
4.6.1 Classe F1 – Teneur en cobalt entre 47 % et 50 %	70
4.6.2 Classe F2 – Teneur en cobalt de 35 %	71
4.6.3 Classe F3 – Teneur en cobalt entre 23 % et 30 %	71
4.7 Classe G – Autres alliages	72
4.7.1 Classe G1 – Alliages fer-aluminium	72
4.7.2 Classe G2 – Alliages fer-aluminium-silicium	73
4.8 Classe H – Matériaux magnétiques doux obtenus par les techniques de métallurgie des poudres	74
4.8.1 Classe H1 – Ferrites doux	74
4.8.2 Classe H2 – Matériaux magnétiques doux frittés	75
4.8.3 Classe H3 – Poudres composites	76
4.9 Classe I – Matériaux magnétiques doux amorphes	77
4.9.1 Généralités	77
4.9.2 Classe I.1 – Alliages amorphes à base fer	77
4.9.3 Classe I2 – Alliages amorphes à base cobalt	78
4.9.4 Classe I3 – Alliages amorphes à base nickel	79
4.10 Classe J – Matériaux magnétiques doux nanocristallins	80
4.10.1 Document de référence	80

4.10.2	Procédé de production.....	80
4.10.3	Composition chimique.....	80
4.10.4	Base de sous-classification.....	80
4.10.5	Formes disponibles.....	80
4.10.6	Caractéristiques physiques.....	80
4.10.7	Applications principales.....	81
5	Matériaux magnétiques durs (coercitivité > 1 kA/m).....	81
5.1	Classe Q – Alliages magnétostrictifs – Alliages fer-terres rares (classe Q1).....	81
5.1.1	Document de référence.....	81
5.1.2	Composition chimique.....	81
5.1.3	Base de sous-classification.....	81
5.1.4	Formes disponibles.....	81
5.1.5	Caractéristiques physiques.....	81
5.1.6	Applications principales.....	82
5.2	Classe R – Alliages magnétiques durs.....	82
5.2.1	Classe R1 – Alliages aluminium-nickel-cobalt-fer-titane (AlNiCo).....	82
5.2.2	Classe R3 – Alliages fer-cobalt-vanadium-chrome (FeCoVCr).....	83
5.2.3	Classe R5 – Alliages terres rares-cobalt (RECo).....	84
5.2.4	Classe R6 – Alliages chrome-fer-cobalt (CrFeCo).....	85
5.2.5	Classe R7 – Alliages terres rares-fer-bore (REFeB).....	86
5.3	Classe S – Céramiques magnétiques dures – Ferrites durs (classe S1).....	87
5.3.1	Document de référence.....	87
5.3.2	Composition chimique et procédé de fabrication.....	87
5.3.3	Base de sous-classification.....	87
5.3.4	Formes disponibles.....	87
5.3.5	Caractéristiques physiques.....	88
5.3.6	Applications principales.....	88
5.4	Classe T – Autres matériaux magnétiques durs – Aciers martensitiques (classe T1).....	88
5.4.1	Document de référence.....	88
5.4.2	Composition.....	88
5.4.3	Base de sous-classification.....	88
5.4.4	Formes disponibles.....	88
5.4.5	Caractéristiques physiques.....	88
5.4.6	Applications principales.....	89
5.5	Classe U – Matériaux magnétiques durs agglomérés.....	89
5.5.1	Généralités.....	89
5.5.2	Classe U1 – Aimants agglomérés aluminium-nickel-cobalt-fer-titane (AlNiCo).....	89
5.5.3	Classe U2 – Aimants agglomérés terres rares-cobalt (RECo).....	90
5.5.4	Classe U3 – Aimants agglomérés néodyme-fer-bore (REFeB).....	90
5.5.5	Classe U4 – Aimants agglomérés de ferrites durs.....	91
5.5.6	Classe U5 – Aimants agglomérés terres rares-fer-azote.....	92

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.
- 2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
- 3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
- 4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
- 5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
- 6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
- 7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
- 8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
- 9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

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.

MATERIAUX MAGNETIQUES –

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*

This is a preview of "S+ IEC 60404-1 Ed. 3...". [Click here to purchase the full version from the ANSI store.](#)

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*