

This document is a preview generated by EVS

Magnetic materials - Part 1: Classification

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 60404-1:2017 sisaldb Euroopa standardi EN 60404-1:2017 ingliskeelset teksti.	This Estonian standard EVS-EN 60404-1:2017 consists of the English text of the European standard EN 60404-1:2017.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 27.01.2017.	Date of Availability of the European standard is 27.01.2017.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile [standardiosakond@evs.ee](mailto:standardiosakond@evs.ee).

ICS 29.030

Standardite reproduutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:  
Koduleht [www.evs.ee](http://www.evs.ee); telefon 605 5050; e-post [info@evs.ee](mailto:info@evs.ee)

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:

Homepage [www.evs.ee](http://www.evs.ee); phone +372 605 5050; e-mail [info@evs.ee](mailto:info@evs.ee)

EUROPEAN STANDARD  
NORME EUROPÉENNE  
EUROPÄISCHE NORM

EN 60404-1

January 2017

ICS 29.030

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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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

## 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

The text of the International Standard IEC 60404-1:2016 was approved by CENELEC as a European Standard without any modification.

## 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	-	-

<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	-	-

## CONTENTS

FOREWORD .....	4
1 Scope .....	6
2 Normative references .....	6
3 Terms and definitions .....	7
4 Magnetically soft materials (coercivity $\leq 1$ 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 .....	27
4.8.1 Class H1 – Soft ferrites.....	27
4.8.2 Class H2 – Magnetically soft sintered materials .....	29
4.8.3 Class H3 – Powder composites .....	29
4.9 Class I – Amorphous soft magnetic materials .....	30
4.9.1 General .....	30
4.9.2 Class I1 – Iron-based amorphous alloys .....	30
4.9.3 Class I2 – Cobalt-based amorphous alloys .....	31
4.9.4 Class I3 – Nickel-based amorphous alloys .....	32
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.....	33
4.10.4	Basis of subclassification.....	33
4.10.5	Available forms .....	33
4.10.6	Physical characteristics .....	33
4.10.7	Main applications.....	34
5	Magnetically hard materials (coercivity > 1 kA/m) .....	34
5.1	Class Q – Magnetostrictive alloys – Rare earth iron alloys (Class Q1) .....	34
5.1.1	Reference document.....	34
5.1.2	Chemical composition.....	34
5.1.3	Basis of subclassification.....	34
5.1.4	Available forms .....	34
5.1.5	Physical characteristics .....	34
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 .....	36
5.2.4	Class R6 – Chromium-iron-cobalt (CrFeCo) alloys .....	37
5.2.5	Class R7 – Rare earth-iron-boron (REFeB) alloys .....	38
5.3	Class S – Magnetically hard ceramics – Hard ferrites (Class S1) .....	39
5.3.1	Reference document.....	39
5.3.2	Chemical composition and manufacturing method .....	39
5.3.3	Basis of subclassification.....	39
5.3.4	Available forms .....	39
5.3.5	Physical characteristics .....	40
5.3.6	Main applications.....	40
5.4	Class T – Other magnetically hard materials – Martensitic steels (Class T1) .....	40
5.4.1	Reference document.....	40
5.4.2	Composition .....	40
5.4.3	Basis of subclassification.....	40
5.4.4	Available forms .....	40
5.4.5	Physical characteristics .....	40
5.4.6	Main applications.....	41
5.5	Class U – Bonded magnetically hard materials.....	41
5.5.1	General .....	41
5.5.2	Class U1 – Bonded aluminium-nickel-cobalt-iron-titanium (AlNiCo) magnets .....	41
5.5.3	Class U2 – Bonded rare earth-cobalt (RECo) magnets .....	42
5.5.4	Class U3 – Bonded neodymium-iron-boron (REFeB) magnets .....	42
5.5.5	Class U4 – Bonded hard ferrite magnets.....	43
5.5.6	Class U5 – Bonded rare earth-iron-nitrogen magnets.....	44