IEC 60404-8-4

Edition 3.0 2013-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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 60404-8-4:2013

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MAGNETIC MATERIALS –

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

FOREWORD

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International Standard IEC 60404-8-4 has been prepared by IEC technical committee 68: Magnetic alloys and steels, in collaboration with ISO technical committee 17: Steel.

This third edition cancels and replaces the second edition published in 1998. It constitutes a technical revision.

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

- Deletion of the dates for all normative references (see Clause 2);
- Introduction of the new grades M210-35A 5 and M230-50A 5 (see Table 1).

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

CDV	Report on voting
68/436/CDV	68/450/RVC

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

This publication 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.

MAGNETIC MATERIALS –

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

1 Scope

This part of IEC 60404 defines the grades of cold-rolled non-oriented electrical steel strip and sheet in nominal thicknesses of 0,35 mm, 0,50 mm, 0,65 mm and 1,00 mm. In particular, it specifies general requirements, the magnetic properties, geometric characteristics and tolerances, and technological characteristics, as well as the inspection procedure.

This standard gives in Table 2 the magnetic properties of cold-rolled non-oriented electrical steel strip and sheet of nominal thickness 0,47 mm for use at 60 Hz only.

This standard applies to materials supplied in the fully annealed condition intended for the construction of magnetic circuits. It does not apply to semi-processed material.

These magnetic materials correspond to class C.21 of IEC 60404-1.

2 Normative references

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.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

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

IEC 60404-13, *Magnetic materials – Part 13: Methods of measurement of density, resistivity and stacking factor of electrical steel sheet and strip*

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

ISO 7799, *Metallic materials – Sheet and strip 3 mm thick or less – Reverse bend test*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions relating to magnetic properties given in IEC 60050-121 and IEC 60050-221 and the following apply.

3.1
edge camber
greatest distance between a longitudinal edge of the sheet and the line joining the two extremities of the measured length of this edge

3.2
flatness
property of a sheet or a length of strip which is characterized by the wave factor, i.e. by the relation of the height of the wave to its length

3.3
number of bends
number of alternate bends possible before the appearance in the base metal of the first crack visible to the naked eye

Note 1 to entry: The number of bends constitutes an indication of the ductility of the material.

3.4
internal stresses
deviation from the shearing line due to internal stresses

4 Classification

The grades covered by this standard are classified according to the value of maximum specific total loss in watts per kilogram at 1,5 T and according to the nominal thickness of the material (0,35 mm, 0,47 mm, 0,50 mm, 0,65 mm and 1,00 mm).

5 Designation

The steel name comprises the following in the order given:

a) the letter M for electrical steel;
b) one hundred times the specified value of the maximum specific total loss, in watts per kilogram, at 1,5 T and 50 Hz for the materials given in Table 1 and at 1,5 T and 60 Hz for the materials given in Table 2 and corresponding to the nominal product thickness;
c) one hundred times the nominal thickness of the material, in millimetres;
d) the characteristic letter A for cold-rolled non-oriented electrical strip or sheet supplied in the fully processed state;
e) one tenth of the frequency at which the maximum specific total loss is specified, i.e. 5 or 6.

EXAMPLE M250-35A 5 for cold-rolled non-oriented electrical steel strip or sheet with a maximum specific total loss of 2,50 W/kg at 1,5 T and 50 Hz, a nominal thickness of 0,35 mm, supplied in the fully-processed state.

NOTE The corresponding steel numbers used in the European standard are given in Annex B.

6 General requirements

6.1 Production process

The production process of the steel and its chemical composition are left to the discretion of the manufacturer.

6.2 Form of supply

The material is supplied in coils in the case of strip and in bundles in the case of sheets.

The mass of coils or bundles of sheets shall be agreed at the time of ordering.

The recommended value for the internal diameter of coils is 508 mm or 610 mm.

Strip shall be of constant width and wound in such a manner that the side faces of the coil are substantially flat.

Coils shall be sufficiently tightly wound in order that they do not collapse under their own weight.

Strip can occasionally exhibit welds or interleaves resulting from the removal of defective zones, subject to prior agreement between the parties. If necessary, marking of welds or interleaves may be agreed at the time of ordering.

For coils containing welds or interleaves, each part of the strip shall be of the same grade.

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

Sheets which make up each bundle shall be stacked so that the side faces are substantially flat, and approximately perpendicular to the top face.

6.3 Delivery condition

The material may be supplied either without insulation or with insulation on one or both sides. If the material is supplied with insulation, the nature of the insulation, its properties, and the stacking factor and their verification shall be agreed at the time of ordering.

6.4 Surface condition

The surfaces shall be smooth and clean, free from grease and rust[1]. Dispersed defects such as scratches, blisters, cracks, etc. are permitted if they are within the limits of thickness tolerances, and if they are not detrimental to the correct use of the supplied material.

When an insulation coating is present on the surface of the material, it shall be sufficiently adherent so that it does not become detached during cutting operations. During the alternating bend test (see 8.4.4.2), the coating shall not become detached after a bend of 90°. If the coating becomes detached during the test, the piece from which the sample was taken shall be subjected to a shearing test. During this test, it shall not be admissible for large pieces of the coating to become detached. However, some slight chipping of this coating at the sheared edges shall be tolerated.

6.5 Suitability for cutting

The material shall be able to be cut or punched without causing premature wear of tools; it shall be able to be cut at any point and into the usual shapes, thus ensuring accurate working with the correct cutting tools. If there are special requirements with regard to a suitability test for cutting or punching, these shall be established by agreement between the manufacturer and the purchaser.

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1 This should not be confused with some coloration of the insulation coating inherent to the manufacturing process.

7 Technical requirements

7.1 Magnetic properties

7.1.1 General

The properties defined in 7.1.2 to 7.1.4 are applicable to products in the delivery conditions defined in 6.3. For coated products, the mass of the insulation coating shall be taken into account.

7.1.2 Magnetic polarization

The minimum specified values of magnetic polarization for magnetic field strengths H of 2 500 A/m, 5 000 A/m and 10 000 A/m (expressed as a peak value) shall be as given in Table 1.

The magnetic polarization shall be determined in an alternating magnetic field at 50 Hz or 60 Hz.

Table 1 – Technological properties and magnetic properties measured by the Epstein method (1 of 2)

Steel name	Nominal thickness	Maximum specific total loss at 1,5 T W/kg		Minimum magnetic polarization [a] in an alternating magnetic field for a magnetic field strength T			Maximum anisotropy of loss	Minimum stacking factor	Minimum number of bends	Conventional density [c]
	mm	at 50 Hz	at 60 Hz [b]	2 500 A/m	5 000 A/m	10 000 A/m	%			kg/dm^3
M210-35A 5		2,10	2,65	1,49	1,60	1,70	±17		2	7,60
M230-35A 5		2,30	2,90	1,49	1,60	1,70	±17		2	7,60
M235-35A 5		2,35	2,97	1,49	1,60	1,70	±17		2	7,60
M250-35A 5		2,50	3,14	1,49	1,60	1,70	±17		2	7,60
M270-35A 5	0,35	2,70	3,36	1,49	1,60	1,70	±17	0,95	2	7,65
M300-35A 5		3,00	3,74	1,49	1,60	1,70	±17		3	7,65
M330-35A 5		3,30	4,12	1,49	1,60	1,70	±17		3	7,65
M360-35A 5		3,60	4,55	1,49	1,60	1,70	±17		3	7,65
M230-50A 5		2,30	2,95	1,49	1,60	1,70	±17		2	7,60
M250-50A 5		2,50	3,21	1,49	1,60	1,70	±17		2	7,60
M270-50A 5		2,70	3,47	1,49	1,60	1,70	±17		2	7,60
M290-50A 5		2,90	3,71	1,49	1,60	1,70	±17		2	7,60
M310-50A 5		3,10	3,95	1,49	1,60	1,70	±14		3	7,65
M330-50A 5		3,30	4,20	1,49	1,60	1,70	±14		3	7,65
M350-50A 5		3,50	4,45	1,50	1,60	1,70	±12		5	7,65
M400-50A 5	0,50	4,00	5,10	1,53	1,63	1,73	±12	0,96	5	7,70
M470-50A 5		4,70	5,90	1,54	1,64	1,74	±10		10	7,70
M530-50A 5		5,30	6,66	1,56	1,65	1,75	±10		10	7,70
M600-50A 5		6,00	7,53	1,57	1,66	1,76	±10		10	7,75
M700-50A 5		7,00	8,79	1,60	1,69	1,77	±10		10	7,80
M800-50A 5		8,00	10,06	1,60	1,70	1,78	±10		10	7,80
M940-50A 5		9,40	11,84	1,62	1,72	1,81	±8		10	7,85
M1000-50A 5		10,00	12,60	1,62	1,72	1,81	±8		10	7,85

Table 1 (2 of 2)

Steel name	Nominal thickness	Maximum specific total loss at 1,5 T		Minimum magnetic polarization [a] in an alternating magnetic field for a magnetic field strength			Maximum anisotropy of loss	Minimum stacking factor	Minimum number of bends	Conventional density [c]
		W/kg		T						
	mm	at 50 Hz	at 60 Hz [b]	2 500 A/m	5 000 A/m	10 000 A/m	%			kg/dm^3
M310-65A 5		3,10	4,08	1,49	1,60	1,70	±15		2	7,60
M330-65A 5		3,30	4,30	1,49	1,60	1,70	±15		2	7,60
M350-65A 5		3,50	4,57	1,49	1,60	1,70	±14		2	7,60
M400-65A 5		4,00	5,20	1,52	1,62	1,72	±14		2	7,65
M470-65A 5	0,65	4,70	6,13	1,53	1,63	1,73	±12	0,97	5	7,65
M530-65A 5		5,30	6,84	1,54	1,64	1,74	±12		5	7,70
M600-65A 5		6,00	7,71	1,56	1,66	1,76	±10		10	7,75
M700-65A 5		7,00	8,98	1,57	1,67	1,76	±10		10	7,75
M800-65A 5		8,00	10,26	1,60	1,70	1,78	±10		10	7,80
M1000-65A 5		10,00	12,77	1,61	1,71	1,80	±10		10	7,80
M600-100A 5		6,00	8,14	1,53	1,63	1,72	±10		2	7,60
M700-100A 5		7,00	9,38	1,54	1,64	1,73	±8		3	7,65
M800-100A 5	1,00	8,00	10,70	1,56	1,66	1,75	±6	0,98	5	7,70
M1000-100A 5		10,00	13,39	1,58	1,68	1,76	±6		10	7,80
M1300-100A 5		13,00	17,34	1,60	1,70	1,78	±6		10	7,80

[a] It has been common practice for many years to give values of magnetic flux density. In fact, the Epstein frame is used to determine magnetic polarization (intrinsic flux density) which is defined as follows:

$$J = B - \mu_0 H$$

where
J is the magnetic polarization;
B is the magnetic flux density;
μ_0 is the magnetic constant: $4\pi \times 10^{-7}$ H m^{-1};
H is the magnetic field strength;

in accordance with IEC 60050-121.

[b] Only for information.

[c] Other values may be agreed between the manufacturer and the purchaser, see Annex C.

Table 2 – Technological properties and magnetic properties measured by the Epstein method for strip and sheet of nominal thickness 0,47 mm for use at 60 Hz only

Steel name	Nominal thickness	Maximum specific total loss at 1,5 T W/kg		Minimum magnetic polarization [a] in an alternating magnetic field for a magnetic field strength T			Maximum anisotropy of loss	Minimum stacking factor	Minimum number of bends	Conventional density [c]
	mm	at 50 Hz [b]	at 60 Hz	2 500 A/m	5 000 A/m	10 000 A/m	%			kg/dm^3
M370-47A 6	0,47	2,92	3,70	1,49	1,60	1,70	±18	0,96	2	7,65
M380-47A 6		3,00	3,80	1,49	1,60	1,70	±14		3	7,65
M408-47A 6		3,22	4,08	1,49	1,60	1,70	±14		3	7,65
M419-47A 6		3,31	4,19	1,49	1,60	1,70	±14		3	7,70
M452-47A 6		3,57	4,52	1,50	1,60	1,70	±14		5	7,70
M507-47A 6		4,01	5,07	1,51	1,61	1,71	±14		5	7,70
M638-47A 6		5,04	6,38	1,54	1,64	1,74	±12		10	7,75
M836-47A 6		6,60	8,36	1,58	1,68	1,77	±12		10	7,80
M990-47A 6		7,82	9,90	1,58	1,68	1,77	±12		10	7,80

[a] It has been common practice for many years to give values of magnetic flux density. In fact the Epstein frame is used to determine magnetic polarization (intrinsic flux density) which is defined as follows:

$$J = B - \mu_0 H$$

where
J is the magnetic polarization;
B is the magnetic flux density;
μ_0 is the magnetic constant: $4\pi \times 10^{-7}$ H m^{-1};
H is the magnetic field strength;

in accordance with IEC 60050-121.

[b] Only for information.

[c] Other values may be agreed between the manufacturer and the purchaser, see Annex C.

7.1.3 Specific total loss

The specified values of maximum specific total loss at 50 Hz shall be as given in Table 1. They apply:

– for the nominal thicknesses 0,35 mm, 0,50 mm and 0,65 mm to aged or non-aged test pieces (see 8.3.1);
– for the nominal thickness 1,00 mm to non-aged test pieces.

Table 2 gives the specified values of maximum specific total loss at 60 Hz for products of 0,47 mm nominal thickness.

In certain cases, the specified value of maximum specific total loss can be made the subject of agreement for longitudinal test pieces only or for transverse test pieces only.

The values of the specific total loss are specified for a magnetic polarization of 1,5 T.

The test shall be made in an alternating magnetic field at 50 Hz or at 60 Hz.

NOTE Annex A gives non-specified values of the maximum specific total loss for a magnetic polarization of 1,0 T at 50 Hz.

7.1.4 Anisotropy of loss

The maximum permitted values of the anisotropy of loss at a polarization of 1,5 T shall be as specified in Tables 1 and 2.

A requirement concerning the declaration of the measured value of the anisotropy of loss may be specified by agreement when ordering.

7.2 Geometrical characteristics and tolerances

7.2.1 Thickness

The nominal thicknesses of the material are 0,35 mm, 0,50 mm, 0,65 mm and 1,00 mm.

The nominal thickness of 0,47 mm for use at 60 Hz only is also given in Table 2.

For thickness tolerance, a distinction is made between

– the allowable tolerance on the nominal thickness within the same acceptance unit;
– the difference in thickness in a sheet or in a length of strip in a direction parallel to the direction of rolling;
– the difference in thickness in a direction perpendicular to the direction of rolling. This tolerance applies only to materials with a width greater than 150 mm.

The allowable tolerance on the nominal thickness within the same acceptance unit shall be ± 8 % of the nominal value for the nominal thicknesses 0,35 mm, 0,47 mm and 0,50 mm, and ± 6 % of the nominal value for the nominal thicknesses 0,65 mm and 1,00 mm. The additional thickness due to welds, with respect to the measured thickness of the steel strip or sheet, shall not exceed 0,10 mm.

The difference in thickness in a sheet or in a length of strip (see 8.3.2) in a direction parallel to the direction of rolling shall not exceed 8 % for nominal thicknesses 0,35 mm, 0,47 mm and 0,50 mm, and 6 % for nominal thicknesses 0,65 mm and 1,00 mm.

The difference in thickness in a direction perpendicular to the direction of rolling shall not exceed 0,020 mm for nominal thicknesses of 0,35 mm, 0,47 mm and 0,50 mm, and 0,030 mm