IEC 60404-8-11

Edition 1.0 2018-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Magnetic materials –
Part 8-11: Specifications for individual materials – Fe-based amorphous strip delivered in the semi-processed state

Matériaux magnétiques –
Partie 8-11: Spécifications pour matériaux particuliers – Bandes en alliage amorphe à base de fer livrées à l'état semi-fini

IEC 60404-8-11:2018-03(en-fr)

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MAGNETIC MATERIALS –

Part 8-11: Specifications for individual materials – Fe-based amorphous strip delivered in the semi-processed state

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The text of this International Standard is based on the following documents:

CDV	Report on voting
68/571/CDV	68/585A/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.

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INTRODUCTION

Fe-based amorphous strip is regarded as a promising material to reduce energy loss in transformer cores and, consequently, to help mitigate global warming.

The Fe-based amorphous strip is produced by a rapidly-solidifying, direct-casting process. The strip is intended primarily for the construction of wound cores of transformers for commercial power frequency (50 Hz and 60 Hz) applications.

After appropriate heat treatment, the strip exhibits a significantly lower value of specific total loss in comparison with grain-oriented electrical steel strip for the same applications. It is associated with low hysteresis loss due to low magnetic anisotropy and with low eddy current loss due to high resistivity and reduced thickness.

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MAGNETIC MATERIALS –

Part 8-11: Specifications for individual materials – Fe-based amorphous strip delivered in the semi-processed state

1 Scope

This part of IEC 60404 defines the grades of Fe-based amorphous strip delivered in the semi-processed state, i.e. without final heat treatment, of nominal thickness 0,025 mm. Other nominal thicknesses in the range from 0,020 mm to 0,030 mm can be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order. In particular, it gives general requirements, magnetic properties, geometric characteristics, tolerances and technological characteristics, as well as inspection procedures.

This document applies to the rapidly-solidified Fe-based amorphous strip supplied in coils with as-cast edges and intended for the construction of magnetic circuits.

The grades are grouped into two classes:

– conventional grades;
– high permeability grades.

They correspond to Class I1 of IEC 60404-1.

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

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

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

IEC 60404-16, *Magnetic materials – Part 16: Methods of measurement of the magnetic properties of Fe-based amorphous strip by means of a single sheet tester*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-121, IEC 60050-221, IEC 60404-9, and the following apply.

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- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
strip tear ductility
ductility which is characterized by a ductility code that is classified by the number of brittle spots when a strip of a length corresponding to two times the casting roll circumference is torn in a direction parallel to the casting direction

Note 1 to entry: The ductility code is specified in Table 4.

3.2
casting roll
spinning chilled roll on which molten alloy is ejected and a rapidly-solidified strip is produced

3.3
brittle spots
areas of strip which show the following brittleness when being torn through: shatter, fracture, diverting the path or direction of the tear by approximately 6 mm or more, or a piece of the material comes free from the strip

4 Classification

The grades covered by this document are classified according to the value of maximum specific total loss in watts per kilogram at a peak magnetic polarization of 1,3 T and 50 Hz, according to the value of minimum stacking factor and according to the nominal thickness of the strip in mm.

5 Designation

The material name comprises the following in the order given:

a) the letters “AM” for Fe-based amorphous material;

b) one hundred times the specified value of maximum specific total loss at a peak magnetic polarization of 1,3 T and 50 Hz, in watts per kilogram;

c) one thousand times the nominal thickness of the strip, in millimetres;

d) the characteristic letter;
   - “S” for conventional grades;
   - “P” for high permeability grades;

e) one tenth of the frequency 50 Hz, i.e. “5”;

f) one hundred times the specified value of the minimum stacking factor.

EXAMPLE: AM10-25S5-84 for Fe-based amorphous strip of conventional grade with a maximum specific total loss at 1,3 T of 0,10 W/kg at 50 Hz, a nominal thickness of 0,025 mm and a minimum stacking factor of 0,84, supplied in the semi-processed state.

6 General requirements

6.1 Production process

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

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6.2 Form of supply

The strip is supplied in coil. It shall be a single-ply coil made by a continuous single strip wound on a spool hub, or a multi-ply coil made by a number of strips simultaneously wound on a spool hub.

The mass of the coils shall be agreed between the manufacturer and the purchaser at the time of enquiry and order.

The recommended value for the internal diameter of spool hubs is approximately 406 mm. The outside diameter of coils should be at least 600 mm and should not exceed 1 120 mm.

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

Irregular deviations from flatness and/or the size and the number of voids or openings in the coil shall be agreed between the manufacturer and the purchaser at the time of enquiry and order.

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

In the case of multi-ply coils, strips may exhibit single-ply joints if agreed between the manufacturer and the purchaser at the time of enquiry and order. The shape of strip ends at the joint may be agreed between the manufacturer and the purchaser at the time of enquiry and order.

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

6.3 Delivery condition

Fe-based amorphous strip is usually supplied without an insulating coating. An oxide layer is formed naturally on the strip surface during the manufacture of the strip.

6.4 Surface condition

The surfaces shall be smooth and clean, free from grease and rust. No continuous indication of oxide shall be visible along the surfaces or edges of the strip.

The surfaces and edges shall have no wrinkles, dimples, cracks, folds, flakes or other defects that would make the strip unsuitable for the fabrication of wound cores. Dispersed imperfections such as minor rusts, slight coloration, small pinholes, shallow dimples, etc. are permitted if they are not detrimental to the correct use of the supplied strip.

The strip shall have no needle-like holes exceeding 7,0 mm in length. The strip shall have no more than eight needle-like holes aligned in the direction of casting of the strip in any 25 mm long segment.

The strip edge shall have no slivers, nicks or feathers with a maximum dimension exceeding 4,0 mm.

6.5 Suitability for cutting

The strip shall be suitable for cutting straight at any point when appropriate cutting tools are used.

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7 Technical requirements

7.1 Magnetic properties

7.1.1 Reference condition

The properties defined in 7.1.2 and 7.1.3 shall apply only to test specimens in the reference condition which is obtained by the following magnetic annealing.

The test specimens shall be subjected to magnetic annealing in a DC magnetic field directed parallel to the direction of casting, at least 1 600 A/m in strength and at a temperature in accordance with the specification of the manufacturer.

The magnetic annealing shall be maintained for 2 h at the temperature and maintained until the temperature falls to 200 °C.

NOTE 1 The magnetic annealing releases stress and induces magnetic anisotropy in the casting direction.

NOTE 2 As a general guideline, the temperature for the magnetic annealing is below the onset of the crystallization temperature, which can be determined by differential scanning calorimetry (DSC) at a heating rate of 20 K/min, between 140 °C and 170 °C.

The test specimen shall be kept flat during the magnetic annealing. The atmosphere of the magnetic annealing shall be dry and inert.

A quick magnetic annealing may be performed at a higher temperature and for a shorter time than the above treatments by agreement between the manufacturer and the purchaser at the time of enquiry and order.

NOTE 3 In the case of a quick magnetic annealing, the magnetic properties of the test specimen can be poorer than in the case of the reference condition.

7.1.2 Magnetic polarization

The specified minimum values of peak magnetic polarization for a peak magnetic field strength of 80 A/m at 50 Hz or 60 Hz shall be as given in Table 1 and Table 2.

7.1.3 Specific total loss

The specified values of maximum specific total loss at 1,3 T and 1,4 T shall be as given in Table 1 and Table 2 at 50 Hz.

NOTE Annex A gives non-specified values of maximum specific total loss at 1,5 T.

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Table 1 – Technological properties and magnetic properties of the conventional grades of Fe-based amorphous strip

Material name	Nominal thickness	Maximum specific total loss at 1,3 T[a] W/kg		Maximum specific total loss at 1,4 T[a] W/kg		Minimum magnetic polarization for H = 80 A/m[a, b]	Minimum stacking factor	Conventional density[c]
	mm	50 Hz	60 Hz[d]	50 Hz	60 Hz[d]	T		kg/dm^3
AM08-25S5-90	0,025	0,08	0,11	0,11	0,14	1,35	0,90	7,20
AM08-25S5-88							0,88	
AM08-25S5-86							0,86	
AM08-25S5-84							0,84	
AM10-25S5-90	0,025	0,10	0,13	0,13	0,17	1,35	0,90	7,20
AM10-25S5-88							0,88	
AM10-25S5-86							0,86	
AM10-25S5-84							0,84	
AM12-25S5-90	0,025	0,12	0,15	0,16	0,20	1,35	0,90	7,20
AM12-25S5-88							0,88	
AM12-25S5-86							0,86	
AM12-25S5-84							0,84	
AM16-25S5-90	0,025	0,16	0,20	0,21	0,26	1,35	0,90	7,20
AM16-25S5-88							0,88	
AM16-25S5-86							0,86	
AM16-25S5-84							0,84	

[a] These values are valid only for test specimens in the reference condition (see 7.1.1).

[b] Magnetic polarization (intrinsic flux density) is defined as follows in accordance with IEC 60050-121:

$J = B - \mu_0 H$

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.

NOTE The difference between B and J at 80 A/m is equal to 0,000 1 T.

[c] Other values may be agreed between the manufacturer and the purchaser at the time of enquiry and order.

[d] Only for information.

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Table 2 – Technological properties and magnetic properties of the high permeability grades of Fe-based amorphous strip

Material name	Nominal thickness	Maximum specific total loss at 1,3 T[a] W/kg		Maximum specific total loss at 1,4 T[a] W/kg		Minimum magnetic polarization for H = 80 A/m[a, b]	Minimum stacking factor	Conventional density[c]
	mm	50 Hz	60 Hz[d]	50 Hz	60 Hz[d]	T		kg/dm^3
AM08-25P5-90	0,025	0,08	0,11	0,11	0,14	1,50	0,90	7,35
AM08-25P5-88							0,88	
AM08-25P5-86							0,86	
AM08-25P5-84							0,84	
AM10-25P5-90	0,025	0,10	0,13	0,13	0,17	1,50	0,90	7,35
AM10-25P5-88							0,88	
AM10-25P5-86							0,86	
AM10-25P5-84							0,84	
AM12-25P5-90	0,025	0,12	0,15	0,16	0,20	1,50	0,90	7,35
AM12-25P5-88							0,88	
AM12-25P5-86							0,86	
AM12-25P5-84							0,84	
AM16-25P5-90	0,025	0,16	0,20	0,21	0,26	1,50	0,90	7,35
AM16-25P5-88							0,88	
AM16-25P5-86							0,86	
AM16-25P5-84							0,84	

[a] These values are valid only for test specimens in the reference condition (see 7.1.1).

[b] Magnetic polarization (intrinsic flux density) is defined as follows in accordance with IEC 60050-121:

$J = B - \mu_0 H$

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.

NOTE The difference between B and J at 80 A/m is equal to 0,000 1 T.

[c] Other values may be agreed between the manufacturer and the purchaser at the time of enquiry and order.

[d] Only for information.

7.2 Geometrical characteristics and tolerances

7.2.1 Thickness

The nominal thickness of the strip is 0,025 mm. Other nominal thicknesses may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

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 length of strip in the direction parallel to the casting direction;

– the difference in thickness in the direction perpendicular to the casting direction

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At any point, the allowable tolerance on the nominal thickness within the same acceptance unit shall not exceed ± 0,002 mm.

The difference in thickness in a length of strip of 2 m in the direction parallel to the casting direction shall not exceed ± 0,002 5 mm.

The difference in thickness in the direction perpendicular to the casting direction shall not exceed ± 0,002 5 mm.

7.2.2 Width

The available nominal widths are 142,2 mm, 170,2 mm and 213,4 mm. Other nominal widths may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

The tolerances of Table 3 shall apply. For other nominal widths, the tolerance may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

Table 3 – Tolerances on the nominal width of Fe-based amorphous strip

Nominal width mm	Tolerance mm
142,2	± 1,0
170,2	± 1,1
213,4	± 1,4

7.2.3 Length

The determination of the length does not apply to the strip supplied in a coil.

7.2.4 Edge camber

A requirement concerning edge camber may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

7.2.5 Edge wave (wave factor)

A requirement concerning edge wave (wave factor) may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

7.2.6 Residual curvature

A requirement concerning residual curvature may be specified by agreement between the manufacturer and the purchaser at the time of enquiry and order.

7.2.7 Burr height

The determination of burr height does not apply to as-cast edges of the strip.

7.3 Technological characteristics

7.3.1 Density

The density of Fe-based amorphous material is not specified.

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