Designation: ~~A901 – 12~~ A901 – 19

Standard Specification for Amorphous Magnetic Core Alloys, Semi-Processed Types[1]

This standard is issued under the fixed designation A901; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the general requirements to which flat-cast, amorphous, semi-processed, iron-base magnetic core alloys must conform.

1.2 These alloys are produced by a rapid-quenching, direct-casting process, resulting in metals with noncrystalline (amorphous) structure. The metallic alloys are made to meet specified maximum core-loss values and are intended primarily for commercial power frequency (50- and 60-Hz) applications in magnetic devices. Desirable core-loss and permeability characteristics are developed by further heat treatment in a magnetic field by the user. The heat treatment typically consists of heating the material to a temperature of 320 to 420°C in a dry, inert atmosphere for 5 to 10 min, although soak times of up to 2 h may be used for large transformer cores. A magnetic field may be required during annealing as designated by the producer. Exact optimum annealing conditions depend on the processing of the material and the size and shape of the device.

1.3 Some of these alloys are sensitive to mechanical stress. Care must be exercised in minimizing any stresses on the material in its final application, otherwise, its magnetic properties will be significantly impaired.

1.4 This specification is developed to aid in the purchase of transformer grade amorphous strip. It provides the chemical, physical, and magnetic parameters and procedures for quality control tests.

1.5 The values stated in ~~customary (cgs-emu and inch-pound)~~ SI units are to be regarded as standard. The values given in parentheses are ~~mathematical~~numerical conversions to ~~SI~~ customary (cgs and inch-pound) units which are provided for information only and are not considered standard.

~~NOTE 1—For more information on procedures associated with this specification, refer to the following: Practices A34/A34M, A664, A700, and B490; Test Methods A370 and A773/A773M.~~

1.6 *This standard does not purport to address the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A34/A34M Practice for Sampling and Procurement Testing of Magnetic Materials
A340 Terminology of Symbols and Definitions Relating to Magnetic Testing
~~A370 Test Methods and Definitions for Mechanical Testing of Steel Products~~
~~A664 Practice for Identification of Standard Electrical Steel Grades in ASTM Specifications~~
~~A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment~~
A712 Test Method for Electrical Resistivity of Soft Magnetic Alloys
A773/A773M Test Method for Direct Current Magnetic Properties of Low Coercivity Magnetic Materials Using Hysteresigraphs

[1] This specification is under the jurisdiction of ASTM Committee A06 on Magnetic Properties and is the direct responsibility of Subcommittee A06.02 on Material Specifications.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

A900/A900M Test Method for Lamination Factor of Amorphous Magnetic Strip
A912/A912M Test Method for Alternating-Current Magnetic Properties of Amorphous Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method with Toroidal Specimens
~~B490~~A932/A932M ~~Practice for Micrometer Bend Test for Ductility of Electrodeposits~~Test Method for Alternating-Current Magnetic Properties of Amorphous Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method with Sheet Specimens
C693 Test Method for Density of Glass by Buoyancy
D3455 Test Methods for Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology A340.

4. Classification

4.1 The classification of iron-based amorphous alloys conforming to this material specification are given in Table 1 and Table 2.

4.2 The material name in Table 1 and Table 2 comprises the following in the order given.
4.2.1 The letter AM for amorphous magnetic material,
4.2.2 The two-digit number following AM indicating one hundred times the specific value of maximum specific core loss at 1.3 T (13 000 G) magnetic flux density level at 60 Hz in watts per kilogram (watts per pound),
4.2.3 The two-digit number following maximum specific core loss designation indicating one thousand times the nominal thickness of the strip in millimetres,
4.2.4 The alphabet letters, S and P, following strip thickness for conventional and high permeability grade, respectively,
4.2.5 The single digit number following grade designation being one-tenth of the measuring frequency, and
4.2.6 The last two-digit number indicating one-hundred times the specified value of the minimum lamination factor.

5. Ordering Information

5.1 Order for materials conforming to the specification shall indicate the following information:
5.1.1 Reference to this specification and year of issue revision.
5.1.2 Reference to material name.
5.1.3 Depending upon the desired end use, other magnetic properties such as specific exciting power, saturation magnetic flux density, residual flux density and coercive field strength may need to be specified. The user is responsible for specifying the limits on magnetic properties. The user also states whether and what specific tests are required.

6. Dimensions

6.1 *Width*—Tolerances on nominal as-cast strip width shall be ~~±0.65%~~±0.65 % of the specified purchase width.

6.2 *Thickness*—The nominal thickness shall be ~~0.001 in. (0.025 mm)~~0.025 mm (0.001 in.) as measured by a ~~0.25-in. (6.35-mm)~~ 6.35 mm (0.25-in.) diameter anvil micrometer. The nominal thickness may vary ~~±0.0002 in. (±0.005 mm),~~±0.005 mm (±0.0002 in.), but the maximum thickness variation across the width shall be within ±10 % of the mean thickness, or as agreed upon between the user and the producer. Alternatively, the nominal thickness may be determined by Eq 1:

$$d = m/\rho_m \cdot b \cdot l \quad (1)$$

where:

d = average calculated thickness of the test specimen in metres,
m = mass of the specimen in kilograms,
b = width of the specimen in metres,
l = length of the specimen in metres, and
ρ_m = conventional density of the specimen in kilogram per cubic metre.

7. Material Requirements

7.1 Amorphous magnetic core alloys are composed principally of iron with small amounts of alloying elements such as boron and silicon. Other chemical elements are in residual amounts or can be added to improve fabrication or the physical or magnetic properties. The chemistry is left to the discretion of the producer. The producer shall provide, on request, a statement of the nominal chemistry being supplied. ~~The nominal composition for one particular alloy, in weight percent, is: iron 92.3, silicon 5.2, and boron 2.5.~~

8. Sampling

8.1 A continuously cast strip in one coil without breaks will constitute one test lot. In practice, this may represent quantities up to ~~2200 lb (1000 kg),~~1000 kg (2200 lb), depending on the width of the strip.

8.2 Test samples normally shall be taken from both ends of the continuous strip of each test lot. Other sample frequencies may be used as agreed upon by the producer and the user.

8.3 For small coils, less than ~~100 lb (45 kg),~~45 kg (100 lb), and for coils containing splices, the test lot shall be as agreed upon between the producer and the user.

9. Physical and Mechanical Property Requirements

9.1 *Density*—The density shall be provided by the producer to a precision of ~~±0.05 g/cm~~±50 kg/m^3 ~~(±50 kg/m~~(±0.05 g/cm^3) as measured by Test Method C693.

TABLE 1 Magnetic and Physical Properties of the Conventional Grades of Fe-based Amorphous Strip

Material Name	Nominal Thickness	Maximum Specific Core Loss at 1.3 T (13 000 G) W/kg (W/lb)		Maximum Specific Core Loss at 1.4 T (14 000 G) W/kg (W/lb)		Minimum Magnetic Flux Density B at *H* = 80 A/m (1.0 Oe)	Minimum Lamination Factor
	mm (in.)	50 Hz	60 Hz	50 Hz	60 Hz	T (G)	
AM11-25S6-90	0.025 (0.001)	0.08 (0.036)	0.11 (0.050)	0.11 (0.050)	0.14 (0.064)	1.35 (13 500)	0.90
AM11-25S6-88							0.88
AM11-25S6-86							0.86
AM11-25S6-84							0.84
AM13-25S6-90	0.025 (0.01)	0.10 (0.045)	0.13 (0.059)	0.13 (0.059)	0.17 (0.077)	1.35 (13 500)	0.90
AM13-25S6-88							0.88
AM13-25S6-86							0.86
AM13-25S6-84							0.84
AM15-25S6-90	0.025 (0.001)	0.12 (0.055)	0.15 (0.068)	0.16 (0.073)	0.20 (0.091)	1.35 (13 500)	0.90
AM15-25S6-88							0.88
AM15-25S6-86							0.86
AM15-25S6-84							0.84

TABLE 2 Magnetic and Physical Properties of the High Permeability Grades of Fe-based Amorphous Strip

Material Name	Nominal Thickness	Maximum Specific Core Loss at 1.3 T (13 000 G) W/kg (W/lb)		Maximum Specific Core Loss at 1.4 T (14 000 G) W/kg (W/lb)		Minimum Magnetic Flux Density B at *H* = 80 A/m (1.0 Oe)	Minimum Lamination Factor
	mm (in.)	50 Hz	60 Hz	50 Hz	60 Hz	T (G)	
AM11-25P6-90	0.025 (0.001)	0.08 (0.036)	0.11 (0.050)	0.11 (0.050)	0.14 (0.064)	1.50 (15 000)	0.90
AM11-25P6-88							0.88
AM11-25P6-86							0.86
AM11-25P6-84							0.84
AM13-25P6-90	0.025 (0.01)	0.10 (0.045)	0.13 (0.059)	0.13 (0.059)	0.17 (0.077)	1.50 (15 000)	0.90
AM13-25P6-88							0.88
AM13-25P6-86							0.86
AM13-25P6-84							0.84
AM15-25P6-90	0.025 (0.001)	0.12 (0.055)	0.15 (0.068)	0.16 (0.073)	0.20 (0.091)	1.50 (15 000)	0.90
AM15-25P6-88							0.88
AM15-25P6-86							0.86
AM15-25P6-84							0.84

9.2 *Ductility*—Strip bend ductility, with free solidification surface facing inward, shall be such that a minimum 1-m (39.4 in.) length of ribbon may be passed 180° around a ~~0.125-in. (3-mm)~~3-mm (0.125-in.) polished steel rod without cracking or fracture. Alternatively, the acceptable number of brittle spots shall be determined by agreement between the producer and the user. Further information is found in Appendix X3.

9.3 *Thermal Expansion*—The nominal coefficient of thermal expansion shall be reported for the temperature range 40 to ~~400°C.~~ 400°C (104 o 752°F).

9.4 *Thermal Conductivity*—The average value measured across the width shall be reported for temperatures of 25, 100, and ~~400°C.~~ 400°C (77, 212, and 572°F). These values of thermal conductivity of the material shall not differ from the published values by more than 20 %.

9.5 *Electrical Resistivity*—The electrical resistivity shall be reported as measured by Test Method A712.

9.6 *Lamination Factor*—The minimum lamination factor of ~~as-cast material shall be 81.5 % as~~ each grade of as-cast material measured in accordance with Test Method A900/A900M is given in Table 1 and Table 2. The lamination factor for coated material shall be as agreed between the producer and the user.

9.7 *Surface*—The strip surface and edges shall have no wrinkles, dimples, cracks, folds, flakes, or other injurious imperfections that would make the material unsuitable for the fabrication of transformer cores.

9.8 *Edge*—The strip edge shall have no slivers with a maximum dimension exceeding ~~0.12 in. (3.0 mm).~~3.0 mm (0.12 in.).

9.9 *Holes*—The strip shall have no holes exceeding ~~0.2 in. (5 mm).~~5 mm (0.2 in.). Maximum hole frequency, visible against a light source, shall not be more than five per ~~inch (25 mm)~~ 25 mm (1 in.) of strip length.