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Standard Specification for Low-Carbon Magnetic Iron[1]

This standard is issued under the fixed designation A848; 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 requirements for wrought low-carbon iron having a carbon content of 0.015 % or less with the remainder of the analysis being substantially iron.

1.1.1 Two alloy types are covered: Type 1 is a low-phosphorous grade and Type 2 contains a phosphorous addition to improve machinability.

1.2 This specification also covers alloys supplied by a producer or converter in the form and condition suitable for fabrication into parts which will be subsequently heat treated to create the desired magnetic characteristics. It covers alloys supplied in the form of forging billets, hot-rolled products, and cold-finished bar, wire, and strip.

1.3 This specification does not cover iron powders capable of being processed into magnetic components.

1.4 This specification does not cover flat-rolled, low-carbon electrical steels.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A34/A34M Practice for Sampling and Procurement Testing of Magnetic Materials

A341/A341M Test Method for Direct Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods

A596/A596M Test Method for Direct-Current Magnetic Properties of Materials Using the Ballistic Method and Ring Specimens

A773/A773M Test Method for Direct Current Magnetic Properties of Low Coercivity Magnetic Materials Using Hysteresigraphs

2.2 *Other:*

IEC Publication 60404-7 Ed. 1 Method of Measurement of the Coercivity of Magnetic Materials in an Open Magnetic Circuit[3]

3. Ordering Information

3.1 Orders to this specification shall include as much of the following information as is required to describe the desired material:

3.1.1 ASTM specification number and alloy type.

3.1.2 *Dimensions and Tolerances*—The tolerances are to be mutually agreed upon between the user and the producer.

3.1.3 Quantity (weight or number of pieces).

3.1.4 Form and condition.

3.1.5 Magnetic property requirements if they are other than stated herein.

3.1.6 Certification of chemical analysis or magnetic property evaluation, or both.

3.1.7 Marking and packaging.

3.1.8 *End Use*—Whenever possible, the user should specify whether the product will be machined, blanked into flat pieces, blanked and formed, or deep drawn to shape. This information will help the producer provide the most suitable product for the user's fabrication practice.

3.1.9 Exceptions to this specification or special requirements.

4. Chemical Composition

4.1 Alloys supplied to this specification shall conform to the requirements in Table 1. Three of the elements listed in Table 1, namely vanadium, titanium, and aluminum, are not required but may be added to suppress magnetic aging. If present, they must be analyzed and reported.

5. Form and Condition

5.1 These two alloys are capable of being produced in a wide variety of forms and conditions for fabrication into magnetic components. The desired form and condition shall be

[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.

[3] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

TABLE 1 Chemical Requirements (Weight Percent)

	Alloy Type 1	Alloy Type 2
Carbon, max	0.020	0.020
Manganese, max	0.35	0.35
Silicon, max	0.15	0.15
Phosphorous	0.030 max	0.10/0.18
Sulfur, max	0.025	0.025
Chromium, max	0.20	0.20
Nickel, max	0.15	0.15
Vanadium, max	0.10	0.10
Titanium, max	0.10	0.10
Aluminum, max	0.10	0.10
Iron	balance	balance

discussed with the producer to assure receiving the correct product. Available forms and conditions are:

5.1.1 *Forging Billet*—Hot worked and surface conditioned by grinding.

5.1.2 *Hot-Rolled Product*—Hot rolled; hot rolled and acid cleaned; hot rolled and annealed; hot rolled, annealed, and acid cleaned; hot rolled and mechanically cleaned; mechanical properties as specified.

5.1.3 *Cold-Finished Bars*—Cold drawn, centerless ground, mechanical properties as specified; or relay condition.

5.1.3.1 *Relay condition* applies to 1 in. (25.4 mm) round and less in diameter and certain shapes supplied in the cold-worked condition having up to 25 % reduction in area and capable of meeting Class 2 magnetic property requirements as defined in 6.5.

5.1.4 *Strip*—Cold rolled, cold rolled and annealed, deep draw quality, mechanical properties as specified; or relay condition.

5.1.4.1 *Relay condition* applies to cold-rolled strip 0.020 to 0.200 in. (0.51 to 5.1 mm) thick having up to 25 % reduction in thickness and capable of meeting Class 2 magnetic property requirements as defined in 6.5.

5.1.4.2 Ordering information for strip must include edge condition and mechanical property requirements.

5.1.5 *Wire*—Cold drawn, annealed, mechanical properties as specified or relay condition.

5.1.5.1 *Relay condition* applies to cold-drawn wire when capable of being supplied having up to 25 % reduction in area and capable of meeting Class 2 magnetic property requirements as defined in 6.5.

6. Magnetic Property Requirements

6.1 *Density*—The density for test purposes is 7.86 g/cm^3 (7860 kg/m^3).

6.2 *Test Specimen*—Whenever possible, test specimen size and shape shall conform to Practice A34/A34M. Shapes such as ring laminations, solid rings, Epstein specimens, or straight lengths having a uniform cross section are preferred. If, however, it is impossible to prepare a preferred test specimen shape from the product, specimen shape and size shall be mutually agreed upon by the user and the producer.

6.3 *Heat Treatment*—It is recommended that the user specify the desired heat treatment method to be applied to the test specimens.

6.3.1 When relay condition is specified, the test specimen shall be heat treated in a dry forming gas atmosphere (5 to 15 % hydrogen in nitrogen with a dew point less than −40°C) at a temperature of 845°C for 1 h at temperature and cooled at a rate from 55 to 100°C/h to 500°C and cooled at any rate thereafter.

6.3.2 If relay condition is not specified and no heat-treating procedure is specified by the user, the producer is free to choose a heat treatment procedure. Refer to Appendix X3 for heat treatment recommendations.

6.4 *Test Method*—Magnetic testing shall be conducted in accordance with Test Methods A341/A341M, A596/A596M, or A773/A773M or by use of a coercimeter. Under this specification only the coercive field strength (H_c) must be measured.

6.5 *Requirements*—The coercive field strength (H_c) measured from a maximum magnetic flux density of 15 kG (1.5 T) or higher must meet the maximum values listed in Table 2 when the test specimen is heat treated in accordance with 6.3.1.

6.5.1 When a coercimeter is used, the supplier must be able to demonstrate that the flux density in the test specimen reaches at least 15 kG (1.5 T) during the magnetization cycle. In addition, the test equipment and method should conform to those specified in IEC Publication 60404-7.

7. Packaging and Marking

7.1 Packaging shall be subject to agreement between the producer and the user.

7.2 Material furnished under this specification shall be identified by the name or symbol of the producer, by alloy type, melt number, and material size. Each lot applied on a given order must be identified and packaged separately.

8. Investigation of Claim

8.1 Where any order fails to meet the requirements of this specification, disposition of the material so designated shall be subject to agreement between the user and the producer.

9. Keywords

9.1 coercive field strength; magnetic iron; relay steel

TABLE 2 Direct Current Coercive Field Strength Requirements

Class 1	0.75 Oe (60 A/m)
Class 2 (Relay Condition)	1.0 Oe (80 A/m)
Class 3	1.5 Oe (120 A/m)

APPENDIXES

(Nonmandatory Information)

X1. TYPICAL MAGNETIC PROPERTIES

X1.1 Typical magnetic properties of these alloys are shown in Fig. X1.1, Fig. X1.2, and Fig. X1.3 and are listed in Table X1.1. There is no statistically significant difference in magnetic properties between Type 1 and Type 2 alloys for a given product size, condition, and heat treatment. The data provided are for information only and are not requirements in this specification.

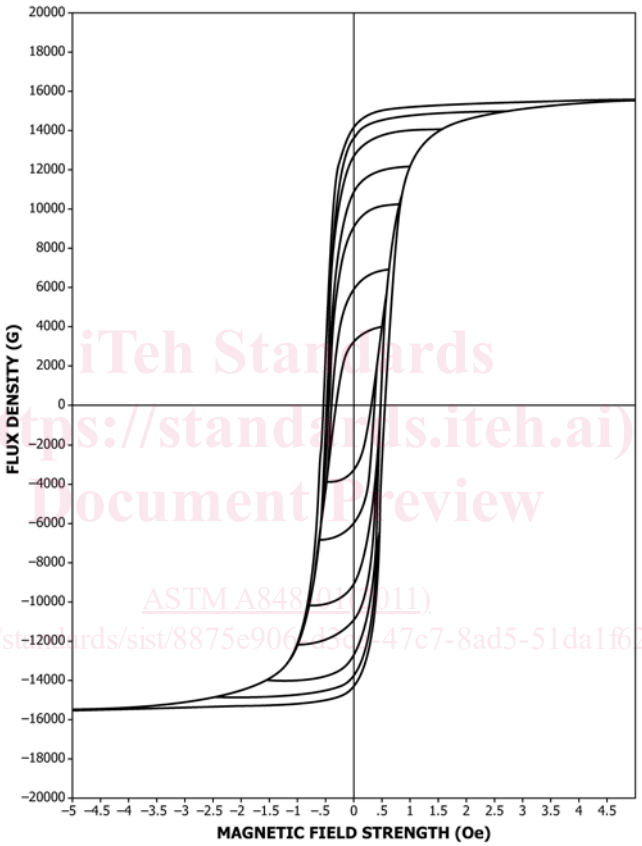

FIG. X1.1 Direct Current Hysteresis Loops for Specimen of Low-Carbon Magnetic Iron Exhibiting Class 1 Behavior. Coercive Field Strength is 0.534 Oe (42.5 A/m)