



Designation: **A838 – 02 (Reapproved 2013) A838 – 18**

Standard Specification for Free-Machining Ferritic Stainless Soft Magnetic Alloy Bar for Relay Applications¹

This standard is issued under the fixed designation A838; 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 free-machining ferritic stainless soft magnetic alloy produced or supplied expressly in cold-finished bar form for use in magnetic cores and other parts requiring a high permeability, low-coercivity stainless steel.

1.1.1 This specification does not cover either cast parts or parts produced by powder metallurgy techniques.

1.2 Two specific alloy types are covered. The primary constituents are shown in **Table 1**. These types have corrosion resistance similar to AISI Type 430F and Type 430F, Specification **A582/A582M**.

1.3 This specification covers only these alloy types supplied in cold-finished bars in cross-sectional shapes such as rounds, squares, hexagons, and octagons with diameters (diagonals) greater than or equal to ~~0.250 in. (6.35 mm)~~ 6.35 mm (0.250 in.) and less than or equal to ~~1.625 in. (41.28 mm)~~ 41.5 mm (1.63 in.).²

1.4 Certain cold-finished round bar products are capable of being supplied mill annealed to required magnetic properties such as low coercivity. The size range that can be mill annealed is from ~~0.250 to 1.625 in. (6.35 to 41.28 mm)~~ 6.35 to 41.5 mm (0.250 to 1.63 in.). Other products of these alloys cannot be mill annealed to produce equivalently low coercivity; hence, the final machined parts should be heat treated as recommended by the producer.

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 conversions to SI-customary (cgs-emu and inch-pound) units which are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and 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:*³

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

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

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

A582/A582M Specification for Free-Machining Stainless Steel Bars

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 Hysteresis-graphs

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 Other product forms can be supplied to the chemistries listed in this specification; however, all other requirements shall be subject to negotiation between the producer and the user.

³ 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.

TABLE 1 Alloy Types

Alloy Type	Nominal Composition, Weight Percent				
	Carbon	Chromium	Silicon	Sulfur	Iron
1	0.05	17.5	0.50	0.30	balance
2	0.05	17.5	1.25	0.30	balance

[E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Inert Gas Fusion Techniques](#)

2.2 *Other Standard:*

[IEC Publication 60404-7 Methods of Measurement of the Coercivity of Magnetic Materials in an Open Magnetic Circuit](#)⁴

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology [A340](#).

4. Classification

4.1 Two specific alloy types are covered:

4.2 *Grades, Alloy Type 1*—The standard grades of this alloy type are distinguished by the as-supplied condition, ~~coercivity~~, coercive field strength, and nominal mechanical hardness and are listed in [Table 2](#).

4.3 *Grades, Alloy Type 2*—The standard grades of this alloy type are distinguished by the as-supplied condition, ~~coercivity~~, coercive field strength, and nominal mechanical hardness and are listed in [Table 3](#).

5. Ordering Information

5.1 Purchase orders for material under this specification shall include the following information to adequately describe the desired product:

5.1.1 Reference to this specification and year of issue/revision.

5.1.2 Alloy type and grade (Section 4),

5.1.3 Form and condition,

5.1.4 Dimensions and tolerances (Section 9),

5.1.5 Quantity (weight or number of pieces),

5.1.6 Magnetic property requirements if other than shown in this specification.

5.1.7 Certification of analysis or magnetic quality evaluation, or both, if needed,

5.1.8 Marking and packaging, and

5.1.9 Exceptions to the specification or special requirements.

6. Chemical Composition

6.1 The material shall conform to the requirements prescribed in [Table 4](#).

6.2 Determination of metallic constituents shall be by a method acceptable to both the producer and the user. Analysis of carbon, nitrogen, sulfur, and oxygen shall be done in accordance with Test Methods [E1019](#).

7. Form and Condition

7.1 *Cold Finished Bars*—Cold drawn; cold drawn and centerless ground; cold drawn and precision ground; mill annealed and centerless ground; mill annealed and precision ground.

TABLE 2 Grades for Alloy Type 1

Grade	As-Supplied Condition
1	mill annealed
2	mill annealed
3	unannealed, cold drawn

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

TABLE 3 Grades for Alloy Type 2

Grade	As-Supplied Condition
1	mill annealed
2	unannealed, cold drawn

8. Magnetic Property Requirements

8.1 *General*—Material supplied under terms of this specification shall be tested using either ring, permeameter, or coercimeter test methods. Only the coercive field strength (H_{ccB}) is subject to specification. Since coercimeters saturate the test specimen before measurement of the coercive field strength, two different sets of coercive field strength requirements, one for ring and permeameter testing and one for coercimeter testing, are given. Unless specified in the purchase order, coercimeter testing shall be the standard test method.

8.2 *Test Specimen*—Test specimen size and shape shall be in accordance with the requirements listed in Practice A34/A34M. If tests on heat-treated specimens are requested, all machining operations shall be performed before heat treatment. The cross-sectional area of all specimen types shall be determined by measurement with a micrometer or calipers.

8.3 *Magnetic Test Specimen Heat Treatment*—When specified on the purchase order, the annealed magnetic properties (also referred to as the magnetic capability) rather than the as-supplied magnetic properties shall be determined. The heat treatment to be used to assess the magnetic capability should be specified by the user. If not, the following heat treatment procedure (full anneal) shall be used.

8.3.1 *Atmosphere*—High vacuum or very dry hydrogen (dew point less than -60°C).

8.3.2 *Soak Temperature* (Alloy Type 1)— $815 \pm 25^{\circ}\text{C}$.

8.3.3 *Soak Temperature* (Alloy Type 2)— $850 \pm 25^{\circ}\text{C}$.

8.3.4 *Soak Time*—2-h minimum.

8.3.5 *Cooling*—Furnace cool (50 to 100°C/h) to 400°C then cool to room temperature at any convenient rate.

8.4 *dc Ring and Permeameter Testing:*

8.4.1 Either ring or permeameter test methods may be used. For ring testing, a link-type specimen with its long edge parallel to the bar axis is preferred. Testing of ring or link specimens shall be in accordance with Test Methods A596/A596M or A773/A773M. Testing of bar specimens on a permeameter shall be in accordance with either Test Methods A341/A341M or A773/A773M.

8.4.2 *Requirements*—The coercive field strength, when measured from a maximum magnetic flux density of 10.0 kG (1.00 T), 1.0 T (10 kG), shall meet the requirements listed in Table 5. Full-anneal requirements refer to specimens heat treated in accordance with 8.3.

8.5 *Coercimeter Testing:*

8.5.1 Coercimeter testing is permitted provided it can be demonstrated that the maximum magnetic flux density induced in the specimen exceeds 13 kG (1.30 T), 1.3 T (13 kG) and that the equipment and procedures used satisfy the requirements of IEC Publication 60404-7.

8.5.2 Any machining before testing shall be done with due care, and only enough material shall be removed to permit insertion of the test specimen into the coercimeter.

8.5.3 *Requirements*—The coercive field strength shall meet the requirements listed in Table 6. Full-anneal requirements refer to specimens heat treated in accordance with 8.3.

9. Dimensions and Tolerances

9.1 Dimensions and tolerances shall be as mutually agreed upon between the user and the producer.

10. Certification

10.1 When specified in the purchase order or contract, the user shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of test results shall be furnished.

11. Packaging and Package Marking

11.1 Packaging and package marking shall be subject to agreement between the user and the producer.

11.2 Material furnished under this specification shall be identified by the name or symbol of the producer, by alloy type and grade, or producer's brand name, or a combination thereof, heat number, and material size. Each heat supplied on a given order must be identified separately and packaged separately.

12. Keywords

12.1 coercive field strength; coercivity; ferritic stainless steel; free-machining; relay