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Standard Specification for Fully Processed Magnetic Lamination Steel[1]

This standard is issued under the fixed designation A 840; 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 cold-rolled carbon steel coils or strip used in the fully processed condition in magnetic lamination applications.

1.2 This steel is produced to specified maximum core-loss values and is intended primarily for commercial power frequency (50- and 60-Hz) applications in magnetic devices. Desirable core-loss and permeability characteristics are developed during mill processing, so further heat treatment by the purchaser is not necessary for most uses.

1.3 Fully processed magnetic lamination steels are flat-rolled low carbon iron alloys having 1 % maximum silicon and 0.4 % maximum aluminum.

1.4 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]

A 34/A 34M Practice for Sampling and Procurement Testing of Magnetic Materials

A 340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A 343/A 343M Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame

A 664 Practice for Identification of Standard Electrical Steel Grades in ASTM Specifications

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A 719/A 719M Test Method for Lamination Factor of Magnetic Materials

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology A 340.

4. Classification

4.1 The fully processed magnetic lamination steel types described by this specification are as shown in Table 1.

5. Ordering Information

5.1 Orders for material under this specification shall include as much of the following information as necessary to describe the desired material adequately:

5.1.1 ASTM specification number.

5.1.2 Name of material (fully processed magnetic lamination steel).

5.1.3 ASTM core-loss type number.

5.1.4 Thickness, width and length (if in cut lengths instead of coils).

5.1.5 Total weight of ordered item.

5.1.6 Limitations in coil size or lift weights.

5.1.7 *End Use*—The purchaser shall disclose as much pertinent information as possible about the intended application to enable the supplier to provide material characteristics most suitable for specific fabricating practices.

5.1.8 Special requirements or exceptions to the provisions of this specification.

6. Manufacture

6.1 *Melting Practice*:

6.1.1 These fully processed magnetic lamination steels may be made by basic oxygen, electric furnace, or other steelmaking practices.

6.1.2 These steels typically contain less than 0.03 % carbon.

[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.

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TABLE 1 Core-Loss Types[A] and Maximum Core-Loss Values at 15 kG (1.5 T) and 60 Hz[B] for As-Sheared Epstein Specimens[C]

ASTM Core-Loss Type[A]	Strip Thickness,		Maximum Core Loss		Typical Relative Peak Permeability
	in.	(mm)	W/lb	(W/kg)	
47C550	0.0185	(0.47)	5.50	(12.13)	1150
47C600			6.00	(13.23)	1300
64C700	0.025	(0.64)	7.00	(15.43)	1250
64C750			7.50	(16.53)	1400

[A]See Practice A 664.
[B]Maximum core losses at 15 kG (1.5 T) and 50 Hz are 0.79 times maximum core loss at 60 Hz.
[C]One half of the strips cut parallel to and one half of the strips cut perpendicular to the rolling direction.

6.1.3 The addition of silicon, aluminum, manganese, and phosphorus may be used to enhance punchability and improve magnetic properties by increasing electrical resistivity. The alloy additions are usually restricted such that the density of these steels is maintained above 7.825 g/cm^3 (7825 kg/m^3).

6.1.4 Residual elements such as copper, nickel, chromium, molybdenum, and tin should be held as low as practicable.

6.1.5 The producer is not required to report chemical composition of each lot except where a clear need for such information has been shown. In such cases, the analyses to be reported shall be negotiated between the manufacturer and the purchaser.

6.2 *Typical Processing*:

6.2.1 Processing sequence for fully processed magnetic lamination steel comprises hot rolling, pickling, cold rolling, and annealing.

6.2.2 The mill annealing operation is typically nondecarburizing or partially decarburizing, resulting in a finished product that can be prone to magnetic aging depending on the carbon content.

6.2.3 Unless otherwise specified, these steels are supplied with a smooth surface finish in the as-annealed condition. The required surface texture is imparted from the roll surface to the steel surface during cold rolling.

6.3 When changes in the manufacture of the material are believed to exert possible significant effects upon the user's fabricating practices and upon the magnetic performance to be obtained in the specified end use, the manufacturer shall notify the purchaser before shipment is made to provide opportunity to evaluate the effects.

7. Magnetic Properties

7.1 Core losses are guaranteed and shall conform to the limits given in Table 1.

7.2 Permeability depends on alloy composition and processing. Relative peak permeability is a dimensionless quantity which is the same in all unit systems. Typical relative peak permeability values are found in Table 1.

7.3 Note that fully processed electrical steels do not normally need a user anneal. Therefore, care must be taken to minimize fabrication strain, as magnetic properties can be adversely affected. Examples of such strain are roller leveling and improper slitting practices.

8. Mechanical Requirements

8.1 *Lamination Factor*—The lamination factor shall be as high as practicable. It is higher in the thicker gauge and when the surface is smooth, uncoated, and without significant amounts of oxide. Lamination factors determined in accordance with Test Method A 719/A 719M at 50 psi (345 MPa) are typically in the range from 95 to 98 %.

8.2 *Hardness*—Typical hardness for this steel is between 45 to 75 HRB. Specific hardness requirements shall be negotiated between the steel producer and user.

9. Dimensions and Permissible Variations

9.1 *Thickness*—Specified thickness should be one of the common thicknesses as follows:

Thickness, in.	(mm)
0.0185	(0.47)
0.025	(0.64)

9.2 *Thickness Variations*—The average thickness of the material supplied shall be as close as possible to the ordered thickness. Measurements made with a contacting micrometer at points no closer than ⅜ in. (10 mm) from the edge of a sheet or coil of specified width shall not differ from the specified thickness by more than the value (which include taper) shown in Table 2.

9.3 *Taper*—The rolling of flat rolled coils inherently produces an edge which is thinner than the rest of the coil width. This characteristic is termed tapered edge or feather or gamma and occurs primarily within 1 or 2 in. (25 or 50 mm) from the as-rolled edge of the material. The thickness variation involved in edge taper sometimes is the major portion of the total overall thickness variation permitted in 9.2. It may be expected that in the case of edge slit coils, the following limits on the differences in thickness measured within the first 2 in. (50 mm) or less from either edge of the ordered width will apply:

Ordered Thickness,		Maximum Taper,	
in.	(mm)	in.	(mm)
0.0185	0.47	0.0012	0.030
0.025	0.64	0.0014	0.036

TABLE 2 Thickness Tolerances, Cold-Rolled Sheet, Fully Processed Magnetic Lamination Steel for Specified Width 2 to 60 in. (50 to 1520 mm) Inclusive[A]

Specified Thickness		Thickness Tolerance, Over and Under	
in.	(mm)	in.	(mm)
Over 0.019 to 0.039, incl	(over 0.48 to 0.99 incl)	0.003	(0.08)
Over 0.014 to 0.019, incl	(over 0.36 to 0.48 incl)	0.002	(0.05)

[A]Thickness is measured at any point across the width not less than ⅜ in. (10 mm) from a side edge.

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More restricted taper tolerances or tolerances on mill edge coils shall be negotiated between the manufacturer and the purchaser.

9.4 *Width Tolerances*—Maximum deviations from the ordered width shall be as shown in Table 3.

9.5 *Camber*—Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straight edge. The camber tolerances are shown in Table 4.

10. Workmanship and Finish

10.1 *Flatness*—Adequately defining the degree of flatness necessary for the general application of fully processed magnetic lamination steel is extremely difficult; therefore, no specific limits for flatness have been established.

10.1.1 It is intended that flatness shall be suitable for the intended application and consequently the purchaser should inform the producer of any requirements for a degree of flatness greater than that resulting from usual commercial practices.

10.1.2 Commercial practices recognize that sharp, short waves and buckles are objectionable.

10.1.3 Procedures for judging the degree of critical flatness necessary shall be subject to negotiation between purchaser and manufacturer.

10.2 *Surface Imperfections*—The surface shall be reasonably clean and essentially free of manufacturing defects such as holes, blisters, slivers, indentations, and so forth which would interfere with its effective use in the intended application.

11. Sampling

11.1 Test samples for magnetic properties shall be taken in a manner to assure representative sampling of the test lot. For quality control purposes, a test lot comprises one heat, and it is usual practice to sample one coil from a cast or heat. Frequency of sampling shall be subject to negotiation.

11.2 Test samples shall be obtained after final mill heat treatment or other operation which is the final operation to have significant influence on the magnetic properties.

11.3 The full-width coil selected to be tested shall be sampled in accordance with Practice A 34/A 34M.

12. Specimen Preparation

12.1 The Epstein test specimen shall be in the as-sheared condition with one half of the test strips sheared parallel to rolling and one half transverse to the rolling direction, in accordance with Practice A 34/A 34M.

12.2 Care should be practiced to exclude any bent, twisted, dented, highly burred, or improperly sheared strips from the test specimen.

13. Test Methods

13.1 The required tests for core loss to determine the core-loss grade and other magnetic tests, when made, shall be in accordance with the procedure of Test Method A 343/A 343M.

13.2 The assumed density for test purposes varies according to the amounts of silicon and aluminum present in the steel. The factor percent silicon plus 1.7 multiplied by percent aluminum, from the density equation $\delta = 7.865 - 0.065$ (% Si + 1.7 × % Al), as determined for the median or aim silicon and aluminum of the melt, shall determine the assumed density to be used (Practice A 34/A 34M) as follows:

(% Si + 1.7 × % Al)	Assumed Test Density, g/cm^3	(kg/m^3)
0.00–0.65	7.85	7850
0.66–1.40	7.80	7800
1.41–2.15	7.75	7750

14. Rejection and Rehearing

14.1 Material that fails to conform to the requirements of this specification may be rejected by the purchaser. The rejection shall be reported to the producer promptly and in writing. The rejected material shall be set aside, adequately protected and correctly identified.

14.2 The producer may make claim for a rehearing. In this event, the purchaser shall make samples that are representative of the rejected material available to the producer for evaluation.

15. Certification

15.1 The manufacturer shall submit to the purchaser with the shipment or as promptly as possible after shipment, a certified report of the average core-loss values or any other required test values, for each test lot, to show that the material conforms to this specification.

15.2 The test methods and applicable test conditions, including the test density, shall be clearly stated.

15.3 The test report shall carry the lot identification, purchaser order number, and other information that is deemed necessary to identify the test results with the proper shipment and shipping lot.

TABLE 3 Width Tolerances, Cold-Rolled Sheet, Fully Processed Magnetic Lamination Steel[A]

Specified Width		Width Tolerances			
		Over		Under	
in.	(mm)	in.	(mm)	in.	(mm)
2 to 6, incl	(50 to 150, incl)	0.008	(0.20)	0.008	(0.20)
Over 6 to 9, incl	(over 150 to 230, incl)	0.016	(0.41)	0.016	(0.41)
Over 9 to 12, incl	(over 230 to 300, incl)	0.032	(0.81)	0.032	(0.81)
Over 12 to 30, incl	(over 300 to 760, incl)	0.125	(3.2)	0	0
Over 30 to 48, incl	(over 760 to 1220, incl)	0.188	(4.8)	0	0
Over 48 to 60, incl	(over 1220 to 1520, incl)	0.250	(6.4)	0	0

[A]Width tolerances for 2 to 12 in. (50 to 300 mm) inclusive apply to widths produced by slitting from wider sheet coils.

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TABLE 4 Camber Tolerances, Cold-Rolled Sheet, Fully Processed Magnetic Lamination Steel[A,B]

Coil Width		Camber Tolerance	
in.	(mm)		
2 to 12, incl	(50 to 300, incl)	¼ in. to any 8 ft	(6.4 mm to any 2.4 m)
Over 12 to 60, incl	(over 300 to 1250, incl)	1 in. to any 20 ft	(25 mm to any 6.1 m)

[A]Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straight edge.
[B]The tolerance of 2- to 12-in. (50- to 300-mm) inclusive widths applies to those coils slit from wider sheet coils.

16. Packaging and Package Marking

16.1 Unless otherwise specified, the steel shall be packaged and loaded in accordance with Practices A 700.

16.2 As a minimum requirement, the material shall be identified by having the manufacturer's order number and material identification legibly shown on the tag attached to each coil or shipping unit.

17. Keywords

17.1 carbon steel sheet; cold-rolled lamination steel; cold-rolled magnetic lamination steel; fully processed; lamination steel; magnetic lamination steel

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