



Standard Specification for Flat-Rolled Electrical Steels for Magnetic Applications ¹

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1. Scope

1.1 This specification covers general procedures for specifying requirements in the procurement and delivery of flat-rolled electrical steels for magnetic applications. When an applicable individual specification does not exist, this specification enables the user to order a suitable material to be supplied under controlled conditions with respect to magnetic quality, sampling, testing, packaging, and so forth, by specifying certain requirements on the purchase order and citing this specification.

1.2 Individual specifications that are in conformity with this specification are A677, A677M, A683, A683M, A726, A726M, A840, A840M, A876, and A876M.

1.3 The following safety hazards caveat pertains only to the test methods portion, Section 13, of this specification. *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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—For more information on procedures associated with this specification, refer to the following: Test Methods A 341, A 343, A 347, A 348, and A 596, Practice A 664, and Test Methods A 712, A 719, A 720, A 721, A 804, and A 889.

2. Referenced Documents

2.1 ASTM Standards:

- A 34 Practice for Procurement Testing, and Sampling of Magnetic Materials ²
- A 340 Terminology of Symbols and Definitions Relating to Magnetic Testing ²
- A 341 Test Method for Direct-Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods ²

- A 343 Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame ²
- A 347 Test Method for Alternating-Current Magnetic Properties of Materials Using the Dieterly Bridge Method with 25-cm Epstein Frame ²
- A 348 Test Method for Alternating-Current Magnetic Properties of Materials Using the Wattmeter-Ammeter-Voltmeter Method, 100 to 10 000 Hz and 25-cm Epstein Frame ²
- A 596 Test Method for Direct-Current Magnetic Properties of Materials Using the Ballistic Method and Ring Specimens ²
- A 664 Practice for Identification of Standard Electrical and Laminations Steel Grades in ASTM Specifications ²
- A 677 Specification for Nonoriented Electrical Steel, Fully Processed Types ²
- A 677M Specification for Nonoriented Electrical Steel, Fully Processed Types (Metric) ²
- A 683 Specification for Nonoriented Electrical Steel, Semiprocessed Types ²
- A 683M Specification for Nonoriented Electrical Steel, Semiprocessed Types (Metric) ²
- A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment ³
- A 712 Test Method for Electrical Resistivity of Soft Magnetic Alloys ²
- A 717 Test Method for Surface Insulation Resistivity of Single-Strip Specimens ²
- A 719 Test Method for Lamination Factor of Magnetic Materials ²
- A 720 Test Method for Ductility of Nonoriented Electrical Steel ²
- A 721 Test Method for Ductility of Oriented Electrical Steel ²
- A 726 Specification for Cold-Rolled Magnetic Lamination Quality Steel, Semiprocessed Types ²

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² Annual Book of ASTM Standards, Vol 03.04.

³ Annual Book of ASTM Standards, Vol 01.05.

- A 726M Specification for Cold-Rolled Magnetic Lamination Quality Steel, Semiprocessed Types (Metric)²
- A 804 Test Methods for Alternating-Magnetic Properties of Materials at Power Frequencies Using Sheet-Type Test Specimens²
- A 840 Specification for Fully Processed Magnetic Lamination Steel²
- A 840M Specification for Fully Processed Magnetic Lamination Steel (Metric)²
- A 876 Specification for Flat-Rolled, Grain-Oriented, Silicon-Iron, Electrical Steel, Fully Processed Types²
- A 876M Specification for Flat-Rolled, Grain-Oriented, Silicon-Iron, Electrical Steel, Fully Processed Types [Metric]²
- A 889 Test Method for Alternating-Current Magnetic Properties of Materials at Low Inductions Using the Wattmeter-Varmeter-Ammeter-Voltmeter Method and 25-cm Epstein Frame²
- A 937 Test Method for Determining Interlaminar Resistance of Insulating Coatings Using Two Adjacent Test Surfaces²
- A 976 Classification of Insulating Coatings by Composition, Relative Insulating Ability and Application²

3. Terminology

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

4. Ordering Information

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

4.1.1 Specification A 345 or the individual specification number for the specification that shall govern.

4.1.2 Class of electrical steel, whether grain-oriented electrical steel, nonoriented electrical steel, or magnetic lamination steel.

4.1.3 Whether semi- or fully processed.

4.1.4 Core loss type number or standard grade designation. If an individual specification is not cited, the limiting value of the core loss or other magnetic property that shall control, as well as all applicable test conditions and test methods, shall be stated on the order.

4.1.5 Surface coating type.

4.1.6 Thickness, width, and length, if in cut lengths instead of coils, for the ordered item.

4.1.7 Total weight of ordered item.

4.1.8 Limitations on coil size or lift weight.

4.1.9 End use. Whenever possible, state a single end use for the desired material. For instance, specify whether it is for punched or stamped laminations, sheared laminations, wound cores, formed cores, welded lamination cores, adhesive-bonded cores, and so forth. This will help the supplier to provide material with the most desirable physical characteristics for the user's fabricating practices.

4.1.10 Exceptions to the cited specification or a statement of special requirements.

5. Materials and Manufacture

5.1 Normally, these electrical steels are composed principally of iron with relatively small amounts of alloying elements such as silicon and aluminum. Other chemical elements are either in residual amounts or added in small amounts to improve fabrication. The manufacturer shall provide on request a statement of nominal chemistry being supplied.

5.2 The chemical composition and the method of manufacture shall not be unduly prescribed. Any restriction on the conditions of manufacture shall be negotiated between the manufacturer and the purchaser.

5.3 When changes in the manufacture of successive shipments of material because of changing technology are believed to increase the likelihood of adverse effects upon magnetic or fabrication performance in the specified end use, the manufacturer shall notify the purchaser before shipment is made so that he can be afforded an opportunity to evaluate the effects.

6. Magnetic Properties

6.1 Electrical steels are normally purchased to specified maximum core-loss requirements. The purchaser shall make clear to the supplier the limiting values of core loss required for the ordered material. The grain direction of the test specimen, whether as sheared or given a specific anneal, the test induction and frequency, the test method, and other information pertinent to the proper qualification of the material shall be specified.

6.2 When the desired end use imposes definite limits on other magnetic properties such as specific power exciting, permeability, coercive force, and so forth, the purchaser is responsible for so specifying on the order. The purchaser shall also state whether specific tests are required for these other properties or whether the specified characteristics are for informational purposes only.

7. Electrical Properties

7.1 Electrical steels are normally provided with an electrical resistivity appropriate to the core-loss limit and the specified end use. If the electrical resistivity must be restricted, the limiting value shall be negotiated with the supplier.

7.2 The surface insulation ability inherent in the processing of electrical steels for magnetic applications may differ widely with the class of electrical steel and the intended end use. Several types of applied coatings are available to attain different levels of insulation ability as needed for critical applications. These inherent and applied coating types C-0, C-2, C-3, C-4, C-4AS, C-5, C5-AS, and C-6 are described and characterized in Classification A 976. If the inherent mill-processed surface lacks sufficient insulating ability for the user's purposes, the purchaser shall specify the applied coating type to be used, whether tests shall be made by Test Method A 717 or Test Method A 937, any special test conditions under these test methods, and any limiting value of the insulation ability.

8. Mechanical Properties

8.1 Requirements for ductility, lamination factor, tensile or yield strength, and so forth that differ from those inherent in the usual product meeting the magnetic requirements should be

specified. Any limiting value(s), the test method(s), and test conditions that apply should be specified also.

9. Dimensions and Permissible Variations

9.1 *Thickness*—Electrical steels are normally supplied in certain standardized decimal thicknesses for the various classes of electrical steel covered by the individual specifications listed in 1.2. The specified thickness should be one of the standardized decimal thicknesses whenever possible. Where the requirements of the end use indicate thicknesses that are lighter or heavier than those commonly offered, the manufacturer should be consulted by the purchaser and a thickness agreeable to both (and agreement on the corresponding effects on the magnetic requirements) should be negotiated.

9.2 *Thickness Variations*—The thickness supplied shall be as close as possible to the ordered decimal thickness. The variations with respect to the ordered thickness may differ appreciably with the class of electrical steel to be provided and the mill equipment normally used for its manufacture. The specified thickness tolerances should be no more stringent than required for satisfactory fabrication of the desired end product. The tolerances given in the individual specifications represent normal commercial tolerances. For further details or requirements more stringent than the normal ones, the manufacturer should be consulted.

9.3 *Width Limitations*—Maximum widths that are available are limited by the width capability of the rolling and other steel-processing equipment used for the manufacture of the various classes of electrical steels. Narrower than economic widths are usually provided as subwidths slit from a more economic width. Tolerances on the ordered width are dependent on the limitations imposed by the equipment required for the ordered width. The individual specifications or the supplier should be consulted for the normal tolerances that can be provided.

9.4 *Cut Lengths*—Material to be supplied as sheets or blanks is generally obtained by shearing from coils. The tolerances normally available may be determined by consulting the individual specifications or the manufacturer of the desired material.

9.5 *Camber*—In cut lengths or coiled strip, the tolerance for the deviation of a side edge from a true straight line touching both ends of the side over a specified length may be determined by consulting the individual specifications or the manufacturer of the desired material.

10. Workmanship and Finish

10.1 *Flatness*:

10.1.1 Adequately defining a limiting degree of flatness of electrical steels for commercial purposes is extremely difficult. Therefore, no specific limits or qualifications for flatness evaluation are generally accepted. It is recognized that sharp waves and buckles are objectionable and that they should be minimized in the delivered material to an extent that will ensure that it is suitable for fabrication of the intended end product.

10.1.2 The purchaser shall inform the supplier of any requirements for a degree of flatness more critical than that provided by the usual commercial manufacturing practices.

Procedures for evaluating the required degree of flatness shall be negotiated between the purchaser and the supplier.

10.2 *Surface Defects*—The surface shall be reasonably free of loose dust 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. Surface oxide and core plate coatings should be thin and tightly adherent.

11. Sampling

11.1 The manufacturer shall assign a number to each test lot for identification. The test lot shall conform to the requirements of Practice A 34 unless otherwise agreed between the purchaser and the supplier.

11.2 Samples shall be obtained from full width coils after the final mill heat treatment or the final operation that may have a significant influence on the magnetic properties of the steel.

12. Specimen Preparation

12.1 The required samples shall be made into specimens suitable for magnetic, electrical, or mechanical tests as required by Practice A 34 or by the test method cited in the individual specification or the purchase order. Care should be practiced to eliminate any bent, twisted, dented, highly burred, or improperly prepared pieces from the test specimen.

13. Test Methods

13.1 The required tests to determine the core-loss grade, and other tests, when required, shall be in accordance with the test methods of Practice A 34 or as designated in the individual specification or the purchase order.

13.2 The density of the material will vary according to the chemical composition of the material to be supplied. The proper test density shall be determined and used in the testing by the supplier in compliance with the requirements of Practice A 34.

14. Test Report

14.1 The producer or supplier shall submit to the purchaser, at the time of shipment or as promptly as possible thereafter, a certified report of the measured core loss value(s) or other required test value(s) to show that the material conforms to the individual specification or the purchase order. The test methods and applicable test conditions, including the test density, shall be clearly stated. The test report shall also carry the lot identification, purchase order number, and other information that is deemed necessary to identify the test results with the proper shipment and item.

15. Rejection and Rehearing

15.1 Material that fails to conform to the requirements of the purchase order or the individual 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.

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

16. Marking

16.1 Each package of coils or lift of cut lengths shall have firmly attached to it, outside its wrappings, a tag showing the purchaser's order number, grade designation, thickness, width (and length if in sheet form), weight, and test lot number. In addition, each wide coil shall have the specification number, grade designation, coating or surface type designation, thickness, width, and test lot number marked on the outer surface of the coil itself. In a package of narrow coils, each narrow coil in the package shall be tagged with the specification number,

grade designation, coating or surface type designation, thickness, width, and test lot number.

17. Packaging

17.1 Methods of packaging, loading, and shipping, unless otherwise specified, shall correspond to Practices A 700.

18. Keywords

18.1 electrical steel; fully processed; grain-oriented electrical steel; identification; magnetic lamination steel; nonoriented electrical steel; semiprocessed

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