Designation: A 345 – 04

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

This standard is issued under the fixed designation A 345; 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 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 Specifications A 677/A 677M, A 683/A 683M, A 726, A 840, and A 876.

NOTE 1—For more information on procedures associated with this specification, refer to the following: Test Methods A 341/A 341M, A 343/A 343M, A 348/A 348M, A 596/A 596M, A 712, A 719/A 719M, A 720/A 720M, A 721/A 721M, A 773/A 773M, A 804/A 804M, A 889/A 889M, A 937/A 937M, A 971, and Practice A 664.

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.*

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 341/A 341M Test Method for Direct-Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods

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 348/A 348M 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

A 596/A 596M Test Method for Direct-Current Magnetic Properties of Materials Using the Ballistic Method and Ring Specimens

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

A 677/A 677M Specification for Nonoriented Electrical Steel, Fully Processed Types

A 683/A 683M Specification for Nonoriented Electrical Steel, Semiprocessed Types

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

A 712 Test Method for Electrical Resistivity of Soft Magnetic Alloys

A 717/A 717M Test Method for Surface Insulation Resistivity of Single-Strip Specimens

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

A 720/A 720M Test Method for Ductility of Nonoriented Electrical Steel

A 721/A 721M Test Method for Ductility of Oriented Electrical Steel

A 726 Specification for Cold-Rolled Magnetic Lamination Quality Steel, Semiprocessed Types

A 773/A 773M Test Method for dc Magnetic Properties of Materials Using Ring and Permeameter Procedures with dc Electronic Hysteresigraphs

A 804/A 804M Test Methods for Alternating-Magnetic Properties of Materials at Power Frequencies Using Sheet-Type Test Specimens

A 840 Specification for Fully Processed Magnetic Lamination Steel

[1] This specification is under the jurisdiction of ASTM Committee A06 on Magnetic Properties and is the direct responsibility of Subcommittee A06.02 on Materials 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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A 876 Specification for Flat-Rolled, Grain-Oriented, Silicon-Iron, Electrical Steel, Fully Processed Types
A 889/A 889M Test Method for Alternating-Current Magnetic Properties of Materials at Low Inductions Using the Wattmeter-Varmeter-Ammeter-Voltmeter Method and 25-cm (250-mm) Epstein Frame
A 937/A 937M Test Method for Determining Interlaminar Resistance of Insulating Coatings Using Two Adjacent Test Surfaces
A 971 Test Method for Measuring Edge Taper and Crown of Flat-Rolled Electrical Steel Coils
A 976 Classification of Insulating Coatings by Composition, Relative Insulating Ability and Application

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 Insulation 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 producer 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 producer 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 producer and the user.

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 producer shall notify the user 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 graded and purchased to specified maximum core–loss requirements. The user shall make clear to the producer 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 exciting power, relative permeability, coercive field strength, and so forth, the user is responsible for so specifying on the order. The user shall also state whether specific tests are required for these other properties or whether the specified characteristics are for informational purposes only.

6.3 The user may request statistical monitoring of product quality by the producer. If mutually agreed upon, any deviation from established product quality limits shall be promptly reported to the user prior to shipment even though the steel being provided conforms in all other respects to the specification.

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 producer.

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 user shall specify the applied coating type to be used, whether tests shall be made by Test Method A 717/A 717M or Test Method A 937/A 937M, 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.

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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 producer should be consulted by the user 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 producer 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 producer 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 producer 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 producer 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 user shall inform the producer 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 user and the producer.

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 insultation coatings should be thin and tightly adherent.

11. Sampling

11.1 The producer shall assign a number to each test lot for identification. The test lot shall conform to the requirements of Practice A 34/A 34M unless otherwise agreed between the user and the producer.

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/A 34M 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/A 34M 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 producer in compliance with the requirements of Practice A 34/A 34M.

14. Test Report

14.1 The producer shall submit to the user, 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 user. 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 user 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

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user'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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