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Standard Specification for Cold-Rolled Magnetic Lamination Quality Steel, Semiprocessed Types[1]

This standard is issued under the fixed designation A726; 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 sheet steel used for magnetic applications. These products, commonly called "cold-rolled magnetic lamination steel" (CRML) are usually intended for applications in which the stamped laminations or assembled core structures for electrical equipment are annealed to develop the desired core loss and permeability characteristics.

1.2 By using appropriate lamination annealing practices, the user can optimize magnetic properties for the various types.

1.3 Non-guaranteed core-loss types, usually made to controlled chemical compositions, are available but are not covered by this specification.

1.4 Higher quality core-loss types are made to controlled chemical compositions and are usually given a critical reduction on a temper-mill to yield specified magnetic properties after a suitable lamination anneal. These products, typically called semiprocessed lamination steel, are classified by the ASTM Code Letter D in accordance with Practice A664.

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]

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A343/A343M Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A664 Practice for Identification of Standard Electrical Steel Grades in ASTM Specifications

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

E18 Test Methods for Rockwell Hardness of Metallic Materials

E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *cold-rolled sheet*—sheet manufactured from hot-rolled descaled coils by cold reducing to the desired thickness, generally followed by annealing to recrystallize the grain structure. In the case of magnetic lamination steels, particularly semiprocessed lamination steels, temper rolling is used after annealing to enhance flatness and optimize magnetic properties during the user's lamination anneal.

3.1.2 *magnetic lamination steels*—specialty cold-rolled carbon sheet steel melted to controlled levels of carbon with additions of manganese, phosphorus, silicon, and aluminum. Residual elements are generally held as low as possible. The appropriate chemical composition combined with controlled mill processing results in a carbon sheet steel having mechanical properties and magnetic properties (after a quality development anneal) desired for electrical applications.

3.2 Other terms and symbols used in this specification are defined in Terminology A340.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information, as required, to describe the required material adequately:

4.1.1 ASTM specification number and date of issue.

4.1.2 Core-loss type number.

[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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4.1.3 Finish (indicate typical profilometer range, as required) (see 10.2).

4.1.4 Specify not oiled or oiled, as required (see 10.4).

4.1.5 Dimensions (nominal thickness and coil width) and tolerances, if not standard (see 9.1).

4.1.6 Coil size (must include limitations on inside diameter and maximum weight).

4.1.7 Application (scroll slit for hermetic motors, and so forth).

4.1.8 Special requirements (indicate hardness range, magnetic limitations, and so forth).

4.1.9 Cast or heat analysis and magnetic test report (request if required).

NOTE 1—A typical description is as follows: Cold-Rolled Sheet, Magnetic Lamination Steel, ASTM A726 64D480, Surface Roughness 50- to 80-µin. (1.3- to 2.0-µm) arithmetic average (R_A), Not Oiled, 0.025 by 49 in. (0.64 by 1245 mm) by coil, 24-in. (610-mm) inside diameter, 20 000 lb (9000 kg) maximum, for fractional horsepower motors.

5. Materials and Manufacture

5.1 *Melting Practice*—These steels are typically made by the basic-oxygen or electric-furnace process.

5.2 *Typical Rolling and Annealing*—The processing sequence for magnetic lamination steel comprises hot rolling, pickling, cold rolling, annealing, and temper rolling.

5.2.1 Magnetic lamination steels (all types) are cold reduced to thickness. The non-guaranteed core-loss type product can also be sold in the as-annealed condition or after a temper mill pass to flatten and to impart the required surface texture (surface roughness). Magnetic lamination steels are usually temper rolled after box or continuous annealing to enhance magnetic property development during the user's lamination anneal. In addition, the temper pass is used to improve sheet flatness and punchability and to obtain the required surface texture. Special emphasis may be placed on high extensions (2 to 10 %) during the temper roll after annealing.

5.2.2 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 producer shall notify the user before shipment is made so that user has an opportunity to evaluate the effects.

6. Chemical Composition

6.1 Magnetic lamination steels have low-carbon contents. For the non-guaranteed core-loss type, the carbon content is less than 0.06 %. For higher quality core-loss types, the carbon content is typically less than 0.04 % and may be reduced to less than 0.02 % by means of vacuum degassing, argon stirring, or other steel refining practices when such low-carbon contents are required to facilitate decarburizing during annealing. Some magnetic lamination steels are produced to carbon contents less than 0.005 %. In these steels, decarburization during annealing may not be required.

6.2 Magnetic lamination steels may have manganese, phosphorus, silicon, and aluminum added to enhance punchability and to improve magnetic characteristics by increasing electrical resistivity. Other elements in small controlled amounts may be used in the manufacture of these steels. In the past, the alloy additions to magnetic lamination steels have been restricted such that the density of the steel was maintained above 7.825 g/cm^3 (7825 kg/m^3). However, higher quality core-loss type magnetic lamination steels may have alloy contents with density values less than 7.825 g/cm^3 (7825 kg/m^3) and subsequent testing for magnetic properties shall be in accordance with the procedure of Test Method A343/A343M (see Section 12).

6.3 Residual elements found in steels are generally held as low as practical.

7. Magnetic Properties

7.1 The magnetic properties of these steels are optimized when the stamped laminations or assembled core structures are annealed to reduce the carbon content to 0.005 % or less. To avoid sticking of laminations and assure adequate decarburization, the annealing temperature should be in the range from 1350 to 1500°F (730 to 845°C). Time at temperature will vary with lamination dimensions, charge size, surface finish, and annealing furnace characteristics. A partially combusted natural gas atmosphere with suitable dew point is often used. Also, some users of lamination steels use a hydrogen-nitrogen gas mixture with a suitable dew point. For steel containing manganese, silicon, and aluminum, annealing conditions shall be such that subsurface oxidation of these elements is minimized.

7.2 Core losses of higher quality core-loss types are guaranteed and shall conform to the limits given in Table 1. Relative peak permeability is a dimensionless quantity which is the same in all unit systems. The typical values of relative peak permeability for higher quality core-loss types are given in Appendix X1.

8. Mechanical Properties

8.1 Hardness in the finished product depends on chemical composition and mill processing. For the mill process annealed and temper rolled condition, hardness values typically range from Rockwell 45 to 85 HRB.

8.2 Specific ranges of hardness are subject to negotiation and should be specified on the order.

8.3 Rockwell hardness measurements are normally determined by a superficial test (R30T and R15T) and converted to a B scale value in accordance with Test Methods E18 and Tables E140.

8.4 When mechanical tests are required, test specimens shall be prepared and mechanical tests conducted in accordance with Test Methods and Definitions A370.

9. Dimensions and Permissible Variations

9.1 Tolerances for thickness, width, and camber applicable to magnetic lamination steels are shown in Table 2, Table 3, and Table 4.

9.2 *Thickness Variations*—The average thickness of the material supplied shall be as close as possible to the order thickness. Measurements made with a contacting micrometer

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