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METRIC

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Standard Specification for Nonoriented Electrical Steel, Fully Processed Types (Metric) [1]

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1. Scope

1.1 This specification covers the detailed requirements to which flat-rolled nonoriented fully processed electrical steel shall conform.

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 additional heat treatment by the purchaser is not usually necessary.

1.3 These nonoriented fully processed electrical steels are low-carbon, silicon-iron, or silicon-aluminum-iron alloys containing up to about 3.5 % silicon and a small amount of aluminum.

NOTE 1—This specification is the metric companion of Specification A 677.

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 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 664 Practice for Identification of Standard Electrical- and Lamination-Steel Grades in ASTM Specifications [2]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment [3]

A 717/A 717M 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 937 Test Method for Determining Interlaminar Resistance of Insulating Coatings Using Two Adjacent Test Surfaces[2]

A 976 Classification of Insulating Coatings by Composition, Relative Insulating Ability and Application[2]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials [4]

3. Terminology

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

4. Classification

4.1 The nonoriented electrical 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 Core-loss type number.

5.1.3 Surface coating type.

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 *Typical Melting and Casting*:

6.1.1 These fully processed electrical steels may be made by basic-oxygen, electric-furnace, or other steelmaking practice.

[1] This specification is under the jurisdiction of ASTM Committee A-6 on Magnetic Properties and is the direct responsibility of Subcommittee A06.02 on Material Specifications.

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[2] *Annual Book of ASTM Standards*, Vol 03.04.

[3] *Annual Book of ASTM Standards*, Vol 01.05.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

TABLE 1 Core-Loss Types [A] and Maximum Core Losses [B] at 15 T for As-Sheared Epstein Specimens [C]

0.36-mm Thickness			0.47-mm Thickness			0.64-mm Thickness		
Core-Loss Type	Maximum Core Loss, W/kg		Core-Loss Type	Maximum Core Loss, W/kg		Core-Loss Type	Maximum Core Loss, W/kg	
	60 Hz	50 Hz		60 Hz	50 Hz		60 Hz	50 Hz
36F320M	3.20	2.53	...	...	...	...	...	...
36F342M	3.42	2.70	47F364M	3.64	2.87	64F441M	4.41	3.48
36F364M	3.64	2.87	47F397M	3.97	3.13	64F463M	4.63	3.66
36F386M	3.86	3.05	47F419M	4.19	3.31	64F496M	4.96	3.92
36F408M	4.08	3.22	47F441M	4.41	3.48	64F518M	5.18	4.09
36F430M	4.30	3.40	47F463M	4.63	3.66	64F551M	5.51	4.35
36F452M	4.52	3.57	47F529M	5.29	4.18	64F606M	6.06	4.79
...	...	...	47F617M	6.17	4.88	64F705M	7.05	5.57
...	...	...	47F882M	8.82	6.97	64F1102M	11.02	8.71
...	...	...	47F992M	9.92	7.84	64F1213M	12.13	9.58

[A] See Practice A 664.
[B] The test density shall be the correct ASTM assumed density (in accordance with 14.2) for the chemistry used by the producer to meet the property requirements of the specification.
[C] One half of strips cut parallel to the steel rolling direction, one half of strips cut perpendicular to the steel rolling direction.

6.1.2 These electrical steels are characterized by low carbon, usually less than 0.020 %. The principal alloying element is commonly silicon, but aluminum up to about 0.6 % is sometimes used instead of or in addition to silicon, depending on mill-processing practice for the desired magnetic grade. Individual producers will often have different silicon or aluminum contents for a particular grade because of intrinsic mill-processing procedures.

6.1.3 Sulfur content is typically less than 0.025 % and is usually lowest in the numbered types representing lowest core loss. Manganese is typically present in amounts between 0.10 and 0.40 %. Phosphorus, copper, nickel, chromium, molybdenum, antimony, and tin are usually present only in residual amounts except in the higher numbered core-loss types in which phosphorus up to 0.15 % and tin or antimony up to 0.10 % may be present.

6.1.4 The producer is not required to report chemical composition of each lot except when 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 Rolling and Annealing*—The processing sequence for fully processed nonoriented electrical steel comprises hot rolling, annealing, pickling, cold rolling, and decarburizing annealing.

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 so the purchaser has an opportunity to evaluate the effects.

7. Magnetic Properties

7.1 *Specific Core Loss*—Each core-loss type of electrical steel is identified by a maximum core-loss limit established for each thickness as shown in Table 1.

7.2 *Permeability*—The permeability at all inductions shall be as high as possible, consistent with the required core-loss limits that govern the grade. Typical relative peak permeability (μp) values are given in Appendix X1.

7.3 *Specific Exciting Power*—The rms exciting power required for the excitation of a particular type of electrical steel is frequently useful to the user. Ranges of typical values of specific exciting power are given in Appendix X1.

7.4 *Magnetic Aging*—Although steel sold to this specification is considered non-aging, the maximum core loss values of Table 1 are based on tests of freshly sheared specimens. The guarantee of magnetic properties after an aging treatment is subject to negotiation between the purchaser and the producer. The definition of aging coefficient and the aging treatments usually specified are given in Terminology A 340.

8. Surface Insulation Characteristics

8.1 Unless otherwise specified, fully processed nonoriented electrical steels are supplied with a smooth surface finish and a thin, tightly adherent surface oxide (Coating Type C-0 in Classification A 976) which has sufficient insulating ability for most small cores.

8.2 *Applied Coatings*:

8.2.1 Several types of thin, tightly adherent applied coatings (Coatings Types C-3, C-4, C-5, and C-6 in Classification A 976) with higher levels of insulating ability are available on fully processed nonoriented electrical steels. If an applied coating is needed, the purchaser shall specify the coating type.

8.2.2 If the insulating ability of the applied coating is unusually critical to the application, the purchaser shall specify not only the coating type, but also the test method (either Test Method A 717/A 717M or Test Method A 937) and test conditions to be used to evaluate the insulating ability of the coating, as well as the corresponding minimum value of insulating ability.

8.2.3 A thinner-than-usual applied coating may be preferred when the core-fabricating practice involves welding or die casting. In such cases, the coating type shall be suffixed with the letter "A."

9. Mechanical Requirements

9.1 *Lamination Factor*—The lamination factor shall be as high as practicable. It is greatest for thicker gages and when the surface is smooth, uncoated, and without significant amounts of oxide. Lamination factors can be determined using Test Method A 719. Typical values of lamination factor are given in Appendix X1.

9.2 *Ductility*—The material shall be as ductile as possible.