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## Standard Specification for FLAT-ROLLED, GRAIN-ORIENTED, SILICON IRON, ELECTRICAL STEEL, FULLY PROCESSED TYPES 23G048, 27G053, 30G058, AND 35G066<sup>1</sup>

This standard is issued under the fixed designation A 665; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification covers detailed requirements to which specified grades of flat-rolled, grain-oriented, fully processed electrical steels shall conform. These steels are used primarily in transformer cores operating near 15 kG at commercial power frequencies (50 and 60 Hz).

1.2 These grain-oriented electrical steels are low-carbon, silicon-iron alloys with a silicon content of approximately 3.15 % in which the low core loss and high permeability in the direction of rolling have been achieved by appropriate metallurgical processing.

NOTE 1—A complete metric companion to Specification A 665 has been developed—A 665 M; therefore, no metric equivalents are shown in this specification.

### 2. Applicable Documents

#### 2.1 *ASTM Standards:*

A 34 Practice for Procurement Testing, and Sampling of Magnetic Materials<sup>2</sup>

A 340 Definition of Terms, Symbols, and Conversion Factors Relating to Magnetic Testing<sup>2</sup>

A 343 Test Methods for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame<sup>2</sup>

A 700 Practices for Packaging, Marking, and Loading Methods for Domestic Shipment<sup>3</sup>

A 717 Test Method for Surface Insulation Resistivity of Single-Strip Specimens<sup>2</sup>

A 718 Test Method for Surface Insulation of Multi-Strip Specimens<sup>2</sup>

A 719 Test Method for Lamination Factor of Magnetic Materials<sup>2</sup>

A 721 Test Method for Ductility of Oriented Electrical Sheet Steel<sup>2</sup>

### 3. Terminology

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

### 4. Classification

4.1 The ASTM core loss type designations for the electrical steels covered by this specification are listed in Table 1.

### 5. Condition

5.1 The grain-oriented electrical steels specified herein may be purchased in one of the following conditions (which are combinations of material form and surface type or treatment) as desired for the expected end use:

5.1.1 *Condition NF*—An annealed coil form having an inorganic surface coating, AISI Type C-2, developed during the high-temperature coil anneal. This material is not flattened and so exhibits appreciable coil curvature. The principal application is in spirally wound or formed cores where the strip curvature is not detrimental to fabricating procedures or device performance.

<sup>1</sup> This specification is under the jurisdiction of Committee A-6 on Magnetic Properties and is the direct responsibility of Subcommittee A06.12 on Materials Specifications.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 03.04.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.01, 01.03, 01.04, and 01.05.

5.1.2 *Condition F2*—Thermally flattened sheet or coiled strip, otherwise the same as the NF condition. The principal application is in flat sheared laminations for stacked cores in small sizes where the surface insulation resistance of the inherent C-2 coating is adequate.

5.1.3 *Condition F5*—Thermally flattened sheet or coiled strip, otherwise the same as the F2 condition but with an inorganic coating, AISI Type C-5, applied over the inherent C-2 coating to provide extra surface insulation resistance. The principal application is in flat sheared laminations for cores of power transformers.

5.1.4 *Condition PQ*—Thermally flattened sheet or coiled strip (sometimes called “punching quality”) with the inherent C-2 coating removed and an inorganic coating, AISI Type C-5 applied for insulative purposes. The principal application is in flat stamped laminations for small stacked cores with only moderate surface insulation requirements.

## 6. Ordering Information

6.1 Orders for material under this specification shall include such of the following information as is required to adequately describe the desired material:

- 6.1.1 ASTM specification number,
- 6.1.2 ASTM core loss type designation (Table 1),
- 6.1.3 Material condition (form and surface type) designation (5.1),
- 6.1.4 Ductility class (when required),
- 6.1.5 Sheet or strip width,
- 6.1.6 Length (only when cut lengths are specified),
- 6.1.7 Total weight of each ordered item,
- 6.1.8 Limitations on lift weight,
- 6.1.9 Limitations on coil size requirements,
- 6.1.10 End use (whenever practicable, the purchaser should specify whether the ordered material will be made into flat-sheared laminations, flat-stamped laminations, wound cores, bonded wound cores, formed lamination cores, welded lamination cores, etc. This will help the supplier to provide the most suitable material for the user's fabricating practices), and
- 6.1.11 Exception to the specification or special requirements.

## 7. Materials and Manufacture

7.1 Normally, these steels contain from 3.0 to 3.3 % silicon and the balance iron with residual

elements at a minimum. When requested, the manufacturer shall provide a statement of chemical composition typical of the material being supplied.

7.2 These electrical steels may be made by the open-hearth, basic-oxygen, or electric-furnace process.

7.3 When changes in the manufacture of successive shipments of the material are believed to increase the likelihood of adverse effects upon the magnetic performance or fabrication for 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.

## 8. Magnetic Properties

### 8.1 Core Loss:

8.1.1 Maximum permissible specific core losses at 15kG, 50 and 60 Hz, are guaranteed and are listed in Table 1 for the ASTM core-loss types. The sampling, specimen preparation, and testing practices that are described herein must be followed when conformity to these guarantees is being checked.

8.1.2 Material that conforms to both the core loss and thickness limits of this specification shall be identified by this specification number and the appropriate core loss type designation.

8.2 *Permeability*—The permeability at all inductions shall be as high as practicable. The quality control of these grades is normally based on a measurement of relative peak permeability,  $\mu_p$ , at a peak a-c magnetizing force,  $H_z$ , of 10 Oersteds. For the specified grades, the value of relative  $\mu_p$  at 10 Oersteds is commonly above 1800.

8.2.1 Relative peak permeability is a dimensionless quantity which is the same in all unit systems.

## 9. Surface Insulation Characteristics

9.1 The surfaces produced in each of the material conditions of 5.1 normally have different levels of insulation quality. For specimens as sheared from the coated material, the typical (not minimum) insulation characteristics as measured by Methods A 717 and A 718 are approximately as shown in Table 2.

9.2 When insulative characteristics substantially different than those listed in Table 2 are necessary, the specific requirements and the pro-