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Standard Guide for Measuring Power Frequency Magnetic Properties of Flat-Rolled Electrical Steels Using Small Single Sheet Testers[1]

This standard is issued under the fixed designation A1036; 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 guide covers procedures for interpreting the specific core loss and peak permeability determined using small single-sheet test systems. It is limited to single-sheet test systems that require a test specimen or coupon be cut from the material being tested and are designed such that the entire width of that test specimen is magnetized during testing.

1.2 This guide is primarily intended for measurements of the magnetic properties of flat-rolled electrical steels at frequencies of 50 Hz or 60 Hz under sinusoidal flux conditions.

1.3 This guide includes procedures to provide correlation with the 25-cm Epstein test method (Test Method A343/A343M).

1.4 The range of magnetic flux densities is governed by the properties of the test specimens and the instruments and test power source. Nonoriented electrical steels may be tested at magnetic flux densities up to about 16-kG [1.6T] for core loss. The maximum magnetic field strength for peak permeability testing is limited by the current carrying capacity of the magnetizing winding and the test power source. Single sheet testers are typically capable of testing at magnetic field strengths up to 50 Oe [4000 A/m] or more.

1.5 Within this guide, a small single sheet tester (small SST) is defined as a magnetic tester designed to test flat, rectangular sheet-type specimens. Typical specimens for these testers are square (or nearly so). The design of the small SST test fixture may be small enough to accommodate specimens about 5 by 5 cm or may be large enough to accommodate specimens about 36 by 36 cm. Specimens for a particular SST must be appropriate for the particular test fixture.

1.6 This guide covers two alternative test methods: Method 1 and Method 2.

1.6.1 Method 1 is an extension of Method 1 of Test Method A804/A804M, which describes a test fixture having two windings that encircle the test specimen and two low-reluctance, low-core loss ferromagnetic yokes that serve as flux return paths. The dimensions of the test fixture for Method 1 are not fixed but rather may be designed and built for any nominal specimen dimension within the limits given in 1.5. The power loss in this case is determined by measuring the average value of the product of primary current and induced secondary voltage.

1.6.2 Method 2 covers the use of a small single sheet tester, which employs a magnetizing winding, a magnetic flux sensing winding, and a magnetic field strength detector. The power loss in this case is determined by measuring the average value of the product of induced secondary voltage and magnetic field strength.

1.6.3 The calibration method described in the annex of this guide applies to both test methods.

1.7 The values and equations stated in customary (cgs-emu and inch-pound) or SI units are to be regarded separately as standard. Within this standard, SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this standard.

1.8 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

[1] This guide is under the jurisdiction of ASTM Committee A06 on Magnetic Properties and is the direct responsibility of Subcommittee A06.01 on Test Methods.

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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.

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
A677 Specification for Nonoriented Electrical Steel Fully Processed Types
A683/A683M Specification for Nonoriented Electrical Steel, Semiprocessed Types
A726 Specification for Cold-Rolled Magnetic Lamination Quality Steel, Semiprocessed Types
A804/A804M Test Methods for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Sheet-Type Test Specimens
A840/A840M Specification for Fully Processed Magnetic Lamination Steel

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—The definitions of terms, symbols, and conversion factors relating to magnetic testing found in Terminology A340 are used in the methods in this guide.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *sheet specimen*—a rectangular specimen comprised of a single piece of material or paralleled multiple strips of material arranged in a single layer.

3.2.2 *small single sheet tester*—a magnetic tester designed to determine the magnetic properties of small rectangular sheet-type specimens.

4. Significance and Use

4.1 *Materials Evaluation*—Small single sheet testers were developed to supplement the testing of Epstein specimens for various applications. They are especially appropriate for determining the magnetic properties of samples when insufficient material is available for preparation of an Epstein specimen. Although the small specimen size is attractive, the precision of the small sheet testers is not expected to be as good as that of the test method Test Method A343/A343M. Small sheet testers are frequently used to measure the properties of both fully processed and semiprocessed nonoriented and magnetic lamination steels. Specimens of semiprocessed steels are normally subjected to an appropriate quality development anneal prior to testing. Small sheet testers may also be used to evaluate oriented electrical steels in either the as sheared or stress-relief annealed condition.

5. Apparatus

5.1 *Test Method 1*—The apparatus for Test Method 1 includes a test fixture having two windings that encircle the test specimen (a magnetizing winding and a flux-sensing secondary winding) and two low-reluctance, low-core loss ferromagnetic yokes that serve as flux return paths. Such a test fixture may be constructed by following the instructions given in Annex A1 of Test Method A804/A804M. The test power and instrumentation for this method are described as Test Method 1 in Test Method A804/A804M. The primary difference between the tests covered by this guide and Test Method 1 of Test Method A804/A804M are the dimensions of the yokes and the limitation to the use of double-yoke test fixtures. When selecting test instrumentation and test power source components for Method 1, the devices selected for use with small single-sheet test fixtures must have appropriate ranges for these smaller test fixtures.

5.2 *Test Method 2*—Test systems for Method 2 are supplied as complete test systems: test fixture, test power source, and complete instrumentation.

6. Procedure

6.1 *Determine Correction Factors*—Following the procedures given in Annex A1, determine correction factors for the grades of material that will be evaluated at the magnetic flux densities at which tests will be performed. The samples used to determine the correction factors must be typical of the material that will be evaluated since correction factors vary with class of material, chemical composition, thickness, heat treatment, grain direction, magnetic flux density, and other physical properties.

6.2 *Prepare the Test Specimen*—The type of test fixture and its dimensions govern the dimensions of permissible test specimens. The minimum length of a specimen shall be no less than the outside dimension of the distance between pole faces of the test fixture. The amount of projection of the specimen beyond the pole faces of fixture is not critical but should be no longer than necessary for convenient loading and unloading of the specimen. For maximum accuracy, the specimen width should, as nearly as practicable, be the maximum that can be accommodated by the opening of the test coil. As a minimum, it is recommended that the specimen width be at least one half of the maximum width that can be accommodated by the test coil.

6.2.1 Specimens with length and width appropriate for the small single sheet tester shall be cut by a suitable method. The specimens shall be as rectangular as practicable. Excessive burr and mechanical distortion must be avoided when preparing the test specimens. Specimens may be subjected to any desired heat treatment.

6.3 *Make Initial Determinations*—Depending upon the test equipment used, the appropriate measured values of length, width, thickness, or mass, or combinations thereof, of the specimen must be determined prior to conducting magnetic tests. These measured values are needed to set up the instrument for conducting tests. When mass is required, it shall be determined using a balance capable of measuring the specimen mass with an uncertainty less than 0.1 %. The length or width of the specimen shall be measured by any suitable method with an uncertainty less than 0.1 %.

6.3.1 *Cross-sectional Area*—The preferred method of determining cross-sectional area is the mass-density method. Some test systems may require that the width and thickness of the specimen be entered into the test instrument and others may require that the cross-sectional area be entered. The cross-sectional area is determined using the following equation:

$$A = m/(l\delta) \quad (1)$$