Designation: A596/A596M – 21

Standard Test Method for Direct-Current Magnetic Properties of Materials Using the Point by Point (Ballistic) Method and Ring Specimens[1]

This standard is issued under the fixed designation A596/A596M; 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 test method covers dc testing for the determination of basic magnetic properties of materials in the form of ring, toroidal, link, double-lapped Epstein cores, or other standard shapes which may be cut, stamped, machined, or ground from cast, compacted, sintered, forged, or rolled materials. It includes tests for determination of the normal magnetization curve and hysteresis loop taken under conditions of steep wavefront reversals of the direct-current magnetic field strength.

1.2 This test method shall be used in conjunction with Practice A34/A34M.

1.3 This test method is suitable for a testing range from very low magnetic field strength up to 200 or more Oe [15.9 or more kA/m]. The lower limit is determined by integrator sensitivity and the upper limit by heat generation in the magnetizing winding. Special techniques and short duration testing may extend the upper limit of magnetic field strength.

1.4 Testing under this test method is inherently more accurate than other methods. When specified dimensional or shape requirements are observed, the measurements are a good approximation to absolute properties. Test accuracy available is primarily limited by the accuracy of instrumentation. In most cases, equivalent results may be obtained using Test Method A773/A773M or the test methods of IEC Publication 60404-4.

1.5 This test method permits a choice of test specimen to permit measurement of properties in any desired direction relative to the direction of crystallographic orientation without interference from external yoke systems.

1.6 The symbols and abbreviated definitions used in this test method appear in Fig. 1 and Sections 5, 6, 9, and 10. For the official definitions see Terminology A340.

1.7 **Warning—**Mercury has been designated by EPA and many state agencies as a hazardous material that can cause central nervous system, kidney, and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury-containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website (http://www.epa.gov/mercury/faq.htm) for additional information. Users should be aware that selling mercury or mercury-containing products, or both, in your state may be prohibited by state law.

1.8 The values stated in either customary (cgs-emu and inch-pound) units or SI units are to be regarded separately as standard. Within this test method, the SI units are shown in brackets except for the sections concerning calculations where there are separate sections for the respective unit systems. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this method.

1.9 *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.*

1.10 *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]

A34/A34M Practice for Sampling and Procurement Testing of Magnetic Materials

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A341/A341M Test Method for Direct Current Magnetic

[1] This test method 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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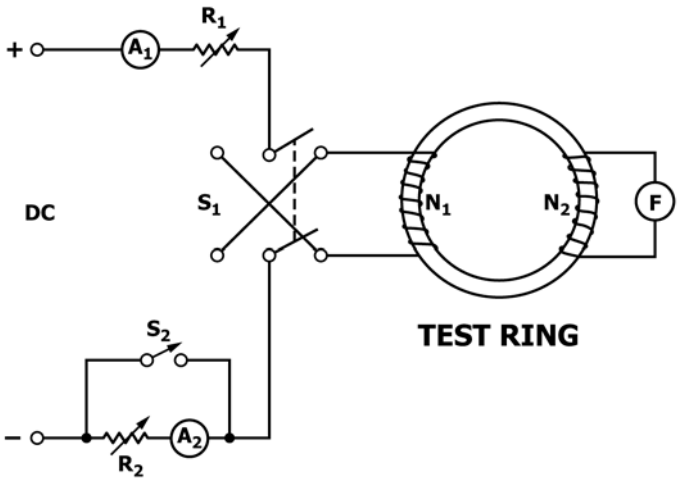
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



NOTE 1—
A_1—Multirange ammeter, main-magnetizing current circuit
A_2—Multirange ammeter, hysteresis-current circuit
N_1—Magnetizing (primary) winding
N_2—Flux-sensing (secondary) winding
F—Electronic integrator
R_1—Main current control rheostat
R_2—Hysteresis current control rheostat
S_1—Reversing switch
S_2—Shunting switch for hysteresis current control rheostat

FIG. 1 Basic Circuit Using Ring-Type Cores

Properties of Soft Magnetic Materials Using D-C Permeameters and the Point by Point (Ballistic) Test Methods

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

A773/A773M Test Method for Direct Current Magnetic Properties of Low Coercivity Magnetic Materials Using Hysteresigraphs

2.2 *IEC Standard:*[3]

Publication 60404-4 Ed. 2.2, Magnetic Materials—Part 4: Methods of Measurement of the D-C Magnetic Properties of Magnetically Soft Materials, IEC, 2008

3. Significance and Use

3.1 Test methods using suitable ring-type specimens[4] are the preferred methods of determining the basic magnetic properties of a material caused by the absence of demagnetizing effects and are well suited for specification acceptance, service evaluation, and research and development.

3.2 Provided the test specimen is representative of the bulk material as is usually the case for thin strip and wire, this test is also suitable for design purposes.

3.3 When the test specimen is not necessarily representative of the bulk material such as a ring machined from a large forging or casting, the results of this test method may not be an accurate indicator of the magnetic properties of the bulk material. In such instances, the test results when viewed in context of past performance history will be useful for judging the suitability of the current material for the intended application.

4. Interferences

4.1 This test method has several important requirements. Unless adequate inside diameter to outside diameter ratios are maintained in the test specimens, the magnetic field strength will be excessively nonuniform throughout the test specimen and the measured parameters cannot be represented as material properties.

4.2 The basic quality of materials having directionally sensitive properties cannot be tested satisfactorily with rings or laminations. With them it is necessary to use Epstein specimens cut with their lengths in the direction of specific interest or to use long link-shaped or spirally wound toroidal core test specimens whose long dimensions are similarly located. The acceptable minimum width of strip used in such test specimens is also sensitive to the material under test. At present, it is believed that the grain-oriented silicon steels should have a strip width of at least 3 cm [30 mm].

4.3 Unless ring specimens are large in diameter, it is difficult to provide a sufficient number of primary turns needed to reach the highest magnetic field strength. In general, magnetic materials tend to have nonuniform properties throughout the body of the test specimen; for this reason, uniformly distributed test windings and uniform specimen cross-sectional area are highly desirable to suppress nonuniform behavior to a tolerable degree.

5. Apparatus

5.1 The apparatus shall consist of as many of the components described in 5.2 – 5.10 as are required to perform the desired test. The basic circuit is shown in Fig. 1.

5.2 *Balance and Scales:*

5.2.1 The balance used to weigh the test specimen shall be capable of weighing to an accuracy of better than ±0.1 % of the specimen mass.

5.2.2 The micrometer, caliper, or other length-measuring device used in the determination of magnetic path length and cross-sectional area shall be capable of measuring to an accuracy of better than ±0.1 % of the measured values.

5.3 *dc Power Supply*—The preferred source of dc current is a high-quality linear power supply of either unipolar or bipolar operation. The power supply must exhibit high stability and very low ripple to achieve the most accurate results. Programmable bipolar operational amplifier power supplies have proven to be very satisfactory for this type of testing. Other stable sources of dc current such as storage batteries are permitted.

5.4 *Main-Current-Control Rheostat R_1*—When nonprogrammable sources of dc current such as storage batteries are used, rheostats must be used to control the current. These rheostats must have sufficient power rating and heat-dissipating capability to handle the largest test current without undesirable

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Lloyd, M. G., "Errors in Magnetic Testing with Ring Specimens," *Technical News Bulletin*, National Institute for Standards and Technology, Vol 5, 1909, p. 435 (S108).