Designation: A342/A342M – 04(Reapproved 2012)

Standard Test Methods for Permeability of Feebly Magnetic Materials[1]

This standard is issued under the fixed designation A342/A342M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 These test methods cover three procedures for determination of the permeability [relative permeability][2] of materials having a permeability not exceeding 4.0.

1.2 The test methods covered are as follows:

1.2.1 *Test Method 1* is suitable for materials with permeabilities between 1.0 and 4.0.

1.2.2 *Test Method 2* is suitable for measuring the permeability of paramagnetic materials having a permeability less than 1.05.

1.2.3 *Test Method 3* is a suitable means of measuring the permeability of a material as "less than" or "greater than" that of calibrated standard inserts designated for use in a Low-Mu Permeability Indicator.[3]

1.3 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 except for the sections concerning calculations where there are separate sections for the respective unit systems. 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.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

A341/A341M Test Method for Direct Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods

TEST METHOD NO. 1, FLUXMETRIC METHOD

3. Significance and Use of Test Method 1

3.1 This test method is suitable for specification acceptance, design purposes, service evaluation, regulatory statutes, manufacturing control, and research and development.

3.2 Because of the restrictions on the specimen shape and size, this test method is most often used to evaluate semifinished product before fabrication of parts.

4. Apparatus

4.1 *Power Supply*—A source of dc current for the electrical circuit shown in Fig. 1. Electronic power supplies are preferable although the use of storage batteries is permitted.

4.2 *Test Fixture*—A test fixture consisting of a magnetizing solenoid with a set of test coils mounted midway between the ends of the solenoid for measuring magnetic induction and an air flux balancing resistor, fluxmeter, and associated circuitry conforming to the following requirements:

4.2.1 *Magnetizing Solenoid, C_1,* having a minimum length of 30 cm [300 mm] and a ratio of length to equivalent diameter of four or more. The magnetizing winding shall be uniformly wound and be capable of producing a uniform field of at least 300 Oe [24 kA/m] over the length of the test specimen without overheating.

[1] These test methods are under the jurisdiction of ASTM Committee A06 on Magnetic Properties and are the direct responsibility of Subcommittee A06.01 on Test Methods.

Current edition approved May 1, 2012. Published July 2012. Originally approved in 1949. Last previous edition approved in 2004 as A342/A342M–04. DOI: 10.1520/A0342_A0342M-04R12.

[2] Test Methods 1 and 2 actually measure magnetic susceptibility. The permeability (μ) [relative permeability (μ_r)] is related to the susceptibility (κ) by the equations:

$$\mu = 1 + 4\pi\kappa \text{ (cgs-emu)}$$
$$\mu_r = 1 + \kappa \text{ (SI)}$$

The term permeability has been retained in these test methods because of its widespread commercial and technological usage.

[3] The sole source of supply of the apparatus known to the committee at this time is Low-Mu Permeability Indicator, manufactured by Severn Engineering Co., Inc., 555 Stage Rd., Suite 1A, Auburn, AL 36830, http://www.severnengineering.com. (Indicators can be returned for recalibration.) If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[4] 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.

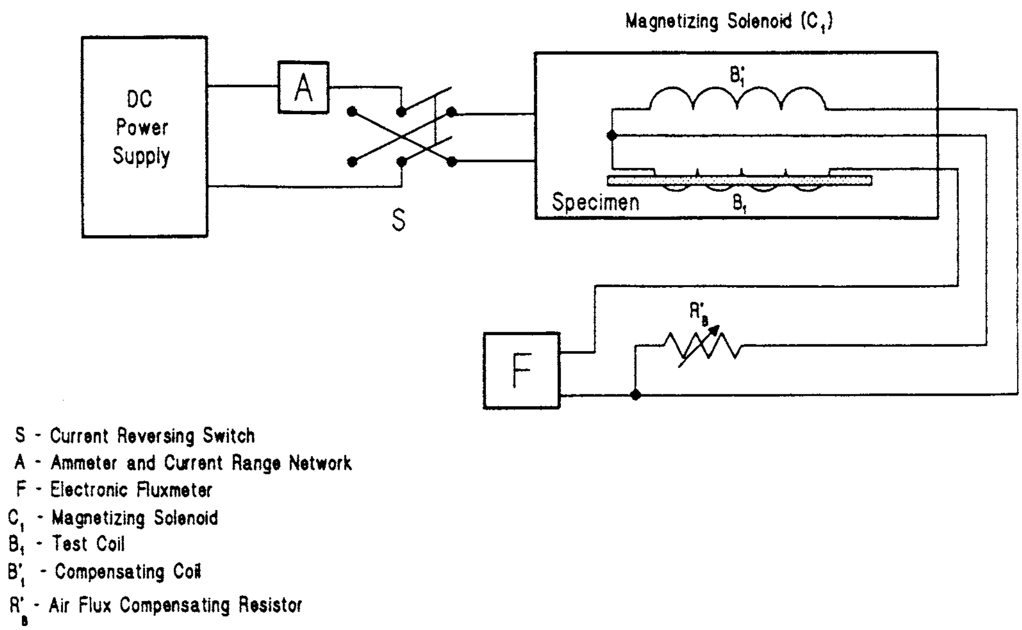

FIG. 1 Circuit Diagram for Method No. 1

4.2.2 *Test Coil, B_1*, used for measuring induction, shall have a cross-sectional area not greater than ten times that of the test specimen. The test coil should have sufficient turns (>1000) to provide adequate resolution and should be no longer than 20 % of the test specimen length.

4.2.3 *Compensating Coil, B'_1*, of the same length, cross-sectional area, and number of turns as coil B_1 and connected to it in series opposition.

4.2.4 *Air Flux Compensating Resistor, R'_B*—This resistor is used in conjunction with coil B'_1 of Fig. 1 to help it compensate for the air flux enclosed by coil B_1 in order that the intrinsic induction may be measured directly.

4.2.5 *Electronic Fluxmeter, F*—used to measure magnetic induction. Alternatively, the magnetizing fixture may be connected to a dc hysteresigraph.

4.2.6 *Magnetic Field Strength Sensor (optional)*—If the magnetic field strength cannot be accurately determined from the magnetizing current, then either a Hall effect sensor or H-coil connected to the fluxmeter shall be used.

5. Test Specimens

5.1 The test specimens shall consist of straight bars, rods, wires, or strips of uniform cross section. Multiple pieces of the same test lot may be used to increase the specimen cross-sectional area when needed. The cross-sectional area shall be not less than 0.2 cm^2 [20 mm^2]. The length shall be not less than 10 cm [100 mm] and the ratio of length to diameter or equivalent diameter (that is, the diameter of a circle having an area equal to the cross-sectional area of the specimen) shall be as follows:

Permeability	Dimensional Ratio
Under 1.5	10 or greater
1.5 to 2.0, incl.	15 or greater
2.0 to 4.0	30 or greater

5.2 This test method can be used with smaller dimension-ratio test specimens when used for comparing to similar specimens for quality control purposes.

6. Procedure

6.1 Measure the thickness and width or diameter of the test specimens and calculate the cross-sectional area in square centimetres [square millimetres].

6.2 Before inserting the test specimen in the solenoid, obtain an exact balance to nullify the effect of air flux in coil B_1 by reversing the highest magnetizing current to be used in the test and adjusting the compensating resistor to obtain the minimum output from the flux sensing coils.

6.3 Place the test specimen in position in coil B_1, adjust the magnetic field strength to the desired test value, then reverse the magnetizing current and record the fluxmeter reading. Optionally, the B versus H curve can be recorded on a hysteresigraph.

7. Calculation (Customary Units)

7.1 Convert the fluxmeter reading to intrinsic induction B_i and calculate the permeability as follows:

$$\mu = 1 + \frac{B_i}{H} \quad (1)$$

where:

μ = permeability of the test specimen;
B_i = intrinsic induction of the test specimen, G; and
H = magnetic field strength, Oe.

8. Calculation (SI Units)

8.1 The output from the fluxmeter is the magnetic polarization J. The relative permeability is calculated as follows:

$$\mu_r = 1 + \frac{J}{\Gamma_m H} \quad (2)$$

where:

μ_r = relative permeability of the test specimen;
J = magnetic polarization, T;