Designation: A342/A342M – 14

Standard Test Methods for Permeability of Weakly 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 U.S. Department of Defense.

1. Scope

1.1 These test methods cover four procedures for determination of the permeability [relative permeability][2] of materials having a permeability not exceeding 6.0.

1.2 The test methods covered are as follows:

1.2.1 *Test Method 1—Fluxmetric Method* is suitable for materials with permeabilities between 1.0 and 4.0. This method permits the user to select the magnetic field strength at which the permeability is to be measured.

1.2.2 *Test Method 2—Permeability of Paramagnetic Materials* has been eliminated as an acceptable method of test.

1.2.3 *Test Method 3—Low Mu Permeability Indicator* is suitable for measuring the permeability of a material as "less than" or "greater than" that of calibrated standard inserts with permeability between 1.01 and 6.0, as designated for use in a Low-Mu Permeability Indicator.[3] In this method, a small volume of specimen is subjected to a local magnetic field that varies in magnitude and direction, so it is not possible to specify the magnetic field strength at which the measurement is made.

1.2.4 *Test Method 4—Flux Distortion* is suitable for materials with permeability between 1.0 and 2.0. In this method, a small volume of specimen is subjected to a local magnetic field that varies in magnitude and direction, so it is not possible to specify the magnetic field strength at which the measurement is made.[4]

1.2.5 *Test Method 5—Vibrating Sample Magnetometry* is suitable for materials with permeability between 1.0 and 4.0. This test method permits the user to select the magnetic field strength at which the permeability is to be measured.

1.3 Materials typically tested by these methods such as austenitic stainless steels may be weakly ferromagnetic. That is, the magnetic permeability is dependent on the magnetic field strength. As a consequence, the results obtained using the different methods may not closely agree with each other. When using Methods 1 and 5, it is imperative to specify the magnetic field strength or range of magnetic field strengths at which the permeabilities have been determined.

1.4 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.

1.5 *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:*[5]

[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, 2014. Published May 2014. Originally approved in 1949. Last previous edition approved in 2012 as A342/A342M–04 (2012). DOI: 10.1520/A0342_A0342M-14.

[2] Test Methods 1 and 5 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] The sole source of supply of the apparatus known to the Committee at this time is the Magnetoscop manufactured by INSTITUT DR. POERSTER GmbH & Co. KG. in Laisen 70, 72766, Reutlingen, Germany. (Probes can be returned for calibration.) If you are aware of alternate 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.

[5] 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.

A34/A34M Practice for Sampling and Procurement Testing of Magnetic Materials
A341/A341M Test Method for Direct Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods

TEST METHOD 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 pair of test coils, one for measuring B in the specimen and one for measuring air flux, plus a variable resistor for precisely canceling the air flux, and a 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 for a short time (approximately 10 seconds) without overheating.

4.2.2 *Test Coil, B_1,* used for measuring magnetic flux density, 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 adjust for exact compensation for the air flux enclosed by coil B_1 in order that the intrinsic induction may be measured directly.

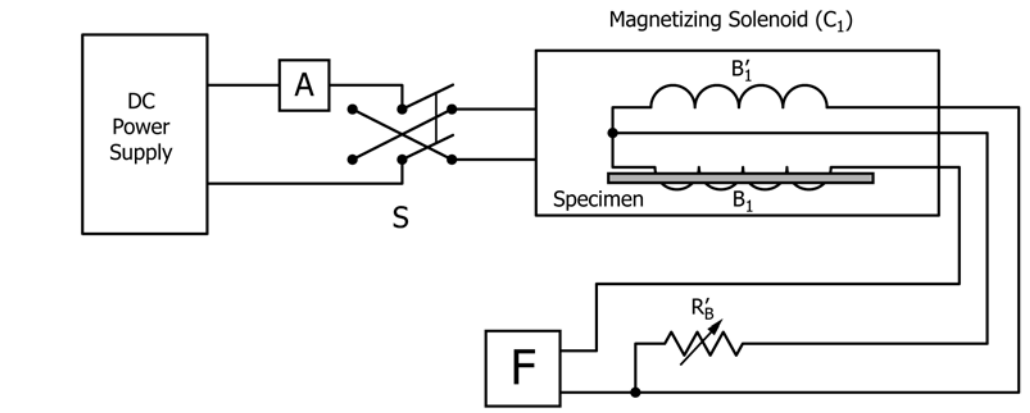
4.2.5 *Electronic Fluxmeter, F*—used to measure magnetic induction. Alternatively, the magnetizing fixture may be connected to a dc hysteresigraph. The combined resistance of the two test coils and the air flux compensating resistor form part of the input resistance of the fluxmeter. The fluxmeter shall be appropriately adjusted to compensate.

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.



S - Current Reversing Switch
A - Ammeter and Current Range Network
F - Electronic Fluxmeter
C_1 - Magnetizing Solenoid
B_1 - Test Coil
B'_1 - Compensating Coil
R'_B - Air Flux Compensating Resistor

FIG. 1 Circuit Diagram for Method No. 1

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 (from $+H_m$ to $-H_m$) 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;
Γ_m = $4\pi \times 10^{-7}$ H/m; and
H = magnetic field strength, A/m.

9. Precision and Bias of Test Method 1

9.1 The precision and bias of this test method have not been established by interlaboratory study.

9.2 The measured permeability will be less than the true value due to the demagnetizing field, which depends on the specimen dimensional ratio. This leads not only to an overestimation of the magnetic field strength but also reduces the flux linkages in the B-coil. Provided the specimen and coil dimensional ratios are as specified in 4.2.2 and 5.1, the largest negative error in $\mu - 1$ as a result of demagnetizing effects[6,7] will be –3 % for $\mu - 1 < 0.5$.

TEST METHOD 3, LOW-MU PERMEABILITY INDICATOR METHOD OF TEST

10. Significance and Use of Test Method 3

10.1 The Low-Mu Permeability Indicator, schematically shown in Fig. 2, is suitable for determining if the permeability of low permeability materials (relative μ of 6.0 or less) is greater than or less than that of the standard insert employed at the time of the test.

10.2 The instrument is portable and suitable for use in the shop, field, and laboratory.

10.3 The instrument is suitable to test all forms and shapes including parts, provided a suitable flat surface is available on the specimen. The material under test is that which is at the surface and is against or is in immediate proximity to the permanent bar magnet.

10.4 This test method provides test values (generally stated as "permeability is less than") suitable for specification purposes. It was originally created to comply with now obsolete Specification MIL – I – 17214B.

11. Apparatus

11.1 *Permanent Bar Magnet*—The center of the permanent bar magnet is attached to one end of a movable arm having a fulcrum in the center and a counterbalance at the opposite end, thus permitting the permanent magnet to move in one plane in both directions.

[6] Chen, D.-X., and Li, B.-Z., "On the Error of Measurement of Feebly Magnetic Material in Regard to Demagnetizing Field," *Acta Metall. Sinica*, Vol. 19, pp. 217–224, Oct. 1983 (in Chinese).

[7] Chen, D.-X., Brug, J. A., and Goldfarb, R. B., "Demagnetizing Factors for Cylinders," *IEEE Trans. Magn.*, Vol. 27, 1991, pp. 3601–3619.

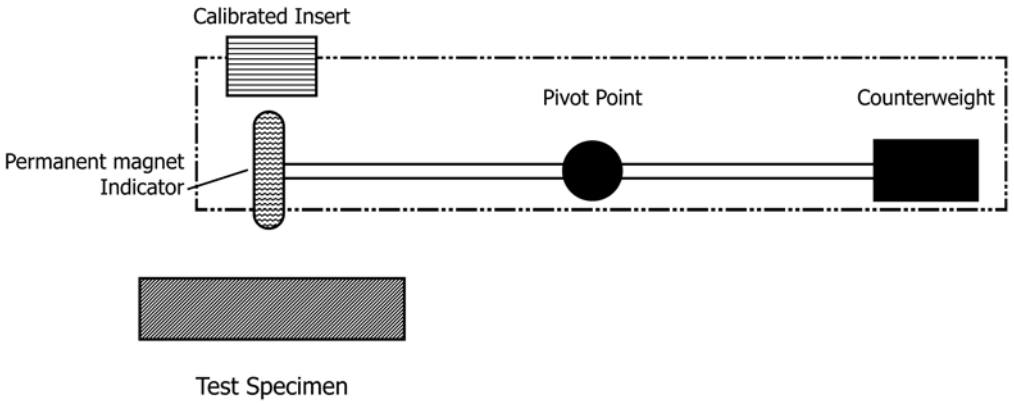


FIG. 2 Schematic Illustration of Low Permeability Indicator

11.2 *Inserts*—The standard inserts are weakly magnetic materials of known permeability values as calibrated by the manufacturer of the indicator against their established standards. They are available with relative permeability ranging from 1.01 to 6.0.

11.3 *Interferences*—Bringing another magnet in contact with the indicator permanent bar magnet will disturb the calibration of the indicator to such an extent that it must be returned to the manufacturer for recalibration. Avoid contacting the indicator with strongly magnetic materials such as steel, cast iron, ferritic, or martensitic stainless steels.

12. Test Specimen

12.1 The test specimen or material to be tested is recommended to have a minimum area of 1 cm^2 [100 mm^2] and a minimum thickness of 0.3 cm [3 mm] (the specimen may be laminated). Test specimens having a volume in excess of the minimum value implied above may be in any form, shape, or condition (for example, castings, forgings, bars, weld beads, and so forth). The indicator may be placed on any location on the specimen to be tested provided that the surface is suitably flat and in full contact with the permanent bar magnet. The indicator is capable of detecting surface permeability differences, if present, of large objects.

13. Procedure

13.1 Screw into the top of the case a calibrated insert of known permeability. The permanent magnet is attached to the insert by a force dependent upon the insert's designated permeability value. Place the end of the permanent magnet projecting from the hole in the bottom of the indicator in contact with the material being tested. Move the indicator away in a direction normal to the contact surface. If the material being tested has a permeability higher than that of the insert, the permanent magnet will break contact first with the insert as the indicator is moved away. However, if the permeability of the material being tested is lower than that of the insert, the permanent magnet will break contact first with the test material as the indicator is moved away. By interchanging inserts, it is possible to bracket the permeability of the material under test.

14. Precision and Bias of Test Method 3

14.1 The precision and bias of this test method have not been established by interlaboratory study.

14.2 The manufacturer of the Low-Mu Permeability Indicator determines the permeability of the calibrated inserts. The standards used in calibrating the inserts were measured by the National Institute of Standards and Technology using Test Method A341/A341M. No significant changes were observed between 1952 and 1976. Measurements were made in a magnetic field strength of 100 Oe [8 kA/m] at 25°C.

14.3 Calibrated inserts are claimed by the manufacturer to have a bias of ±1 % or less at the low range and within ±5 % at the high range relative to the standards.

TEST METHOD 4, FLUX DISTORTION METHOD OF TEST

15. Significance and Use of Test Method 4

15.1 The Flux Distortion Method of Test, schematically shown in Fig. 3, is suitable for determining the permeability of low permeability materials (relative permeability between 1.0

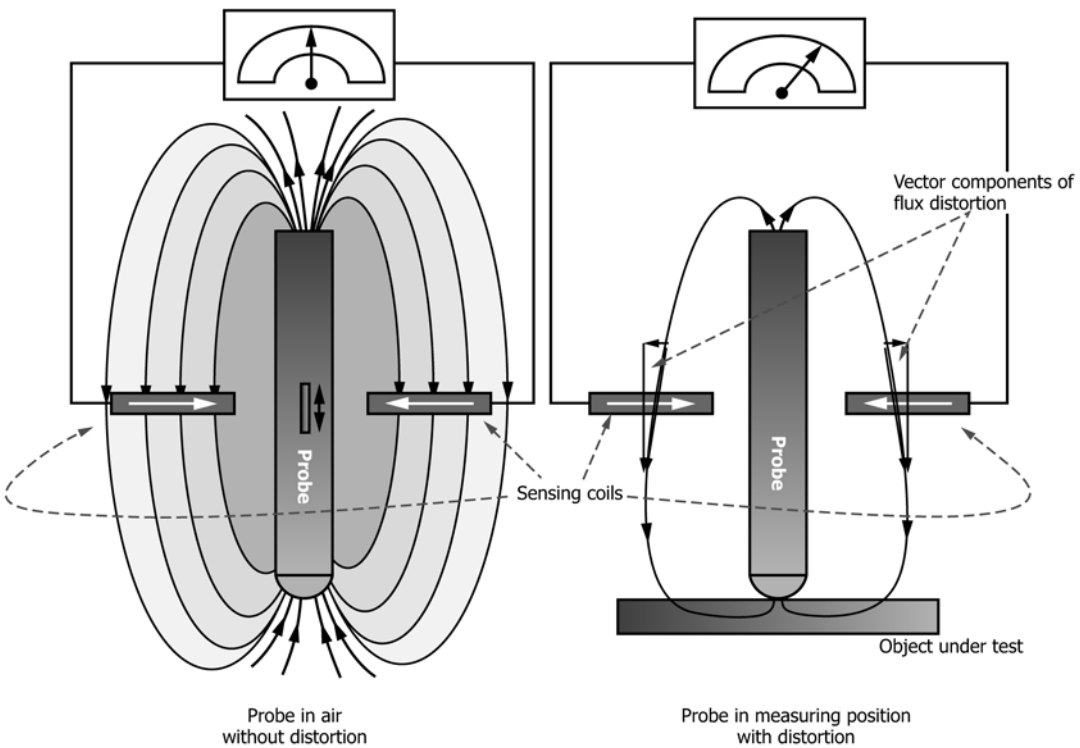


FIG. 3 Schematic Illustration of Flux Distortion Method Method 4

and 2.0) with resolution up to 0.00001. When the instrument with probe is calibrated against standards with known permeability values as determined by the manufacturer of the indicator against their established standards or national standards, the measured values of permeability can be made traceable to national standards.

15.2 The commercially available electronic instruments for performing this test are portable and suitable for use in the shop, field, and laboratory.

15.3 This test method is suitable to test all forms and shapes including finished parts, provided a suitable flat or nearly flat surface is available on the specimen. The material under test is that which is at the surface and is against, or is in immediate proximity to, the probe.

15.4 This test method is suitable for specification acceptance, design purposes, service evaluation, regulatory statutes, manufacturing control, and research and development. Relative test values allow for comparison of permeability between parts of the same physical geometry.

16. Apparatus

16.1 *Electronic Measuring Instrument*—An electronic instrument contains the hardware and software required to measure the distortion of magnetic flux around a permanent magnet within the permeability probe, caused by the presence of the specimen under test. Such instruments are available from commercial manufacturers.

16.2 *Permeability Probe*—A suitable probe, matched to the particular brand of instrument being used, is required. There is a variety of probes to cover the various ranges of permeability and magnetic field strength. Suitable probes are available from commercial manufacturers.

16.3 *Interferences*—Exposure of the probe to strong magnetic fields will permanently change its characteristics. The measurement is sensitive to temperature and nearby magnetic influences such as the stray field of a permanent magnet, of an electromagnetic device, or proximity to a ferromagnetic object. Significant magnetic field gradients near the test location will affect the measurement accuracy.

17. Test Specimen

17.1 The size and shape of the test specimen or material to be tested is critical, and for absolute measurements the specimen size and shape must be as specified by the instrument manufacturer. Generally, materials to be measured with permeability probes should be >0.3 in. [>8 mm] thick, the flat test area where the probe will be placed should have diameter >0.8 in. [>20 mm] and curved surfaces should have radius of curvature >1.6 in. [>40 mm]. When testing specimens with dimensions smaller than these approximate limits, the instrument will indicate permeability different than the actual value.

18. Procedure

18.1 Best results are obtained when the probe is in a fixed location and the specimen is moved into contact with the probe.

18.2 *Absolute Measurements:*

18.2.1 Identify a location on the test piece which meets the dimensional requirements stated by the instrument manufacturer.

18.2.2 Connect a suitable probe to the instrument, as recommended by the instrument manufacturer.

18.2.3 Calibrate the instrument/probe against a calibration standard per manufacturer recommendations.

18.2.4 Place the test piece in contact with the probe and record the display reading.

18.3 *Comparative Measurements:*

18.3.1 Identify a location on the test piece.

18.3.2 Calibrate the instrument/probe against the reference object to which the comparison will be made.

18.3.3 Place the test piece in contact with the probe and record the display reading.

19. Precision and Bias

19.1 The precision and bias of this test method have not been established by interlaboratory study.

19.2 The manufacturer of the instrument determines the permeability of the calibration standards. Standards with permeability traceable back to national standards are available.

19.3 One manufacturer states an absolute accuracy of permeability measurement of better than ±5 % of the actual value.

TEST METHOD 5, VIBRATING SAMPLE MAGNETOMETER METHOD OF TEST

20. Significance and Use of Test Method 5

20.1 The vibrating sample magnetometer (VSM), schematically shown in Fig. 4, is well suited for determining the properties of weakly magnetic materials. It is sensitive enough to measure the magnetization of a paramagnet, and can apply

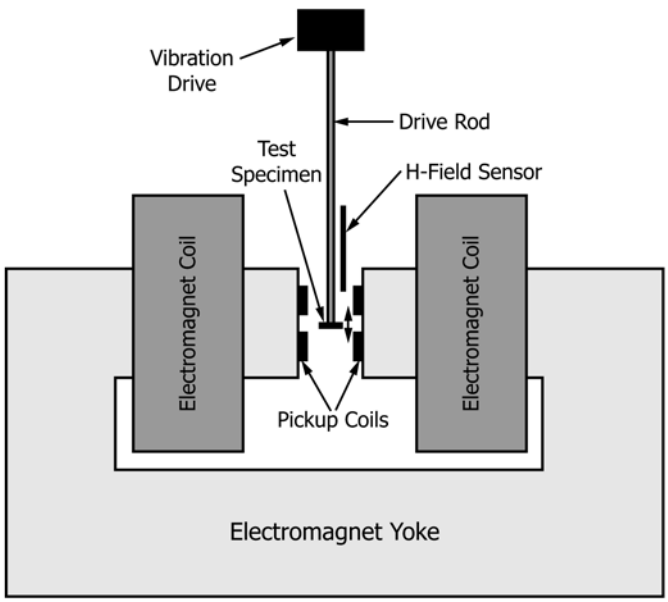


FIG. 4 Schematic Illustration of Vibrating Sample Magnetometer (VSM) Method 5

fields over a large enough range to separate and measure paramagnetism and weak ferromagnetism when they co-exist.

20.2 This method is suitable for any material that can be prepared in the form of a small disk or cube of known volume. The values of constant (field independent) permeability as low as 1.001 may be determined with an uncertainty of ±0.0001. There is no theoretical upper limit to the measurable permeability, but in practice ferromagnetic behavior quickly masks paramagnetic behavior.

20.3 Because specimens for vibrating sample magnetometry are typically small disks less than 1 cm [0.01 m] in diameter and require fabrication into a specific shape, due care in specimen preparation is necessary to prevent the preparation procedures from affecting the test results.

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

21. Apparatus

21.1 Any VSM capable of measuring a magnetic moment of 10^{-3} emu [10^{-6} Am^2] with an uncertainty of ±2 %, and capable of applying a known magnetic field strength of at least ±5000 Oe [±400 kA/m] can be used. Almost all VSM instruments can meet these conditions. Commercial VSM instruments are available from a number of makers. Home-made instruments also exist in various university and company laboratories.

21.2 It is important to note that a VSM measures the magnetic moment (m) and not the magnetic flux (φ).

22. Test Specimens

22.1 The VSM is an open magnetic circuit device, but the demagnetizing correction (a characteristic uncertainty in such systems) is negligible when the magnetization levels are very small.

22.2 The specimen shall be prepared in the form of a disk with diameter-to-thickness ratio of five or greater. A metal specimen will normally be made by machining from a larger block, and in this case steps should be taken to minimize surface deformation and local heating, either of which may affect the magnetic properties. Use of a sharp tool bit, taking light cuts, and using a cooling fluid are recommended.

22.3 The specimen volume should be as large as practical, to maximize the measured signal. The maximum specimen diameter or mass will be limited by the structure of the VSM. A further constraint on the specimen diameter is the fact that the VSM must be calibrated with a specimen of known mass or volume, known saturation magnetization, a diameter equal to that of the specimen to be measured, and with a diameter-to-thickness ratio of no less than that of the specimen to be measured. The specimen diameter must be matched to that of the calibration standard.

22.4 The specimen volume must be determined to an uncertainty of ±2 %, either by direct measurement of its dimensions or by measuring the mass and converting to volume using the known density.

23. Procedure

23.1 Since low levels of magnetization will be measured, the specimen and the specimen holder must be carefully cleaned of any strongly magnetic contamination prior to measurement.

23.2 Commercial VSM instruments are computer controlled, usually with custom software. Home-made instruments will have written instructions, or an experienced operator, or both. In any case, the specimen disk is mounted in the VSM specimen holder, and magnetic moment is measured in a properly calibrated VSM at uniformly spaced values of applied magnetic field strength from a maximum of at least 5000 Oe [400 kA/m] to an equal negative magnetic field strength, and then in similar steps back to the maximum positive magnetic field strength. A total of at least 20 data pairs (magnetic moment and magnetic field strength) should be recorded.

23.3 A background run with no specimen in the specimen holder shall be made to see if a measurable background signal is present. If present, this signal is recorded and subtracted from the measured data. Note that the background signal from a polymer specimen holder will likely be negative, since polymers are typically diamagnetic.

23.4 The data points shall be plotted as magnetization per unit volume M versus applied magnetic field strength H.

24. Calculations

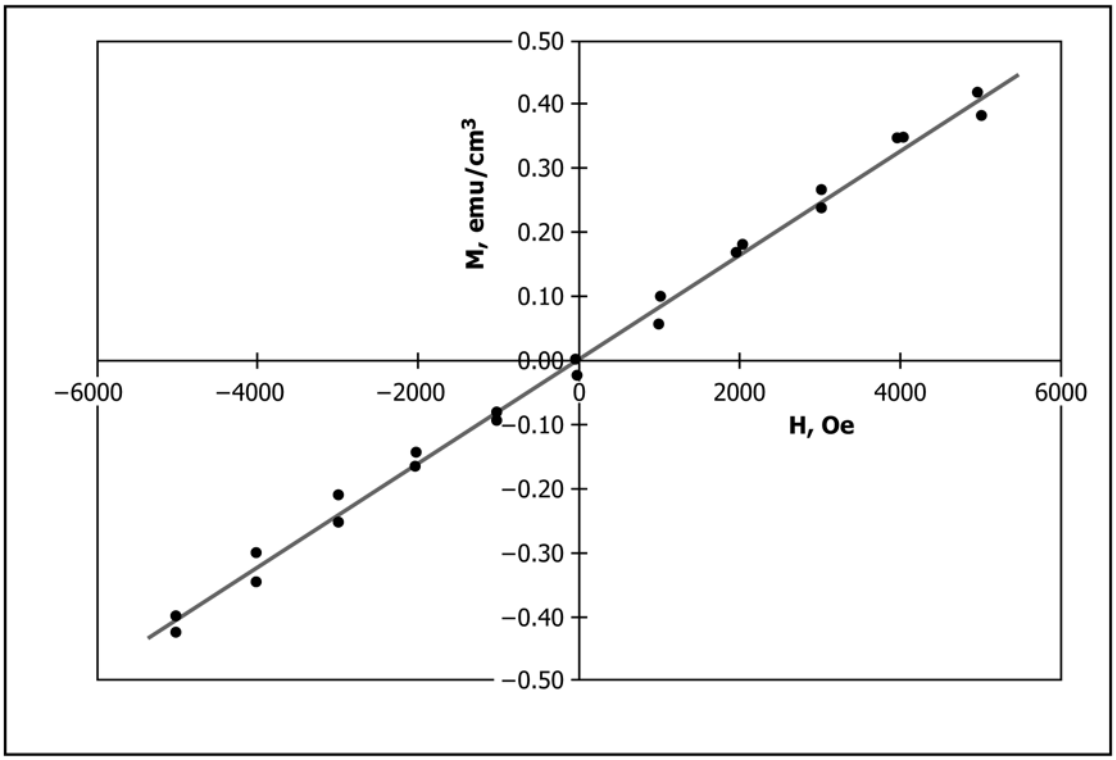
24.1 Generally one of two forms of behavior will be observed from the M versus H plot.

24.2 *Case 1*—The data points can be completely represented by a single straight line passing through the origin as in Fig. 5. In this case the specimen is paramagnetic, the slope of the line is the magnetic susceptibility (κ) and the permeability (μ) is given by:

$$\mu = 4\pi\kappa + 1 \tag{3}$$

The result may be reported as the numerical value of the permeability determined by A342/A342M Test Method 5 over the magnetic field strength range actually used. Paramagnetic behavior of engineering materials is not usually temperature dependent, so temperature need not be controlled or reported so long as the test temperature conforms to the requirements of Practice A34/A34M.

24.3 *Case 2*—The data points above some minimum positive and negative field strength can be completely represented by straight lines intercepting the magnetization axis at equal and opposite (positive and negative) values, respectively, as illustrated in Fig. 6. In this case the magnetic behavior consists of a paramagnetic component, with magnetic susceptibility κ, given by the average of the slopes of the two straight-line portions of the graph, and the corresponding permeability given by Eq 3, and a ferromagnetic component whose saturation magnetization M_s in emu/cm^3 [T] is given by the average of the absolute values of the two intercepts. The result may be reported as the permeability determined by A342/A342M Test Method 5 over the magnetic field strength range corresponding to the upper and lower limits of the linear portion of the data,



NOTE 1—The data shown correspond to a cgs-emu susceptibility of about 0.00008 or a permeability of about 1.001.

FIG. 5 Method 5 (VSM) – Data Plot for Case 1 (Paramagnetic) Behavior

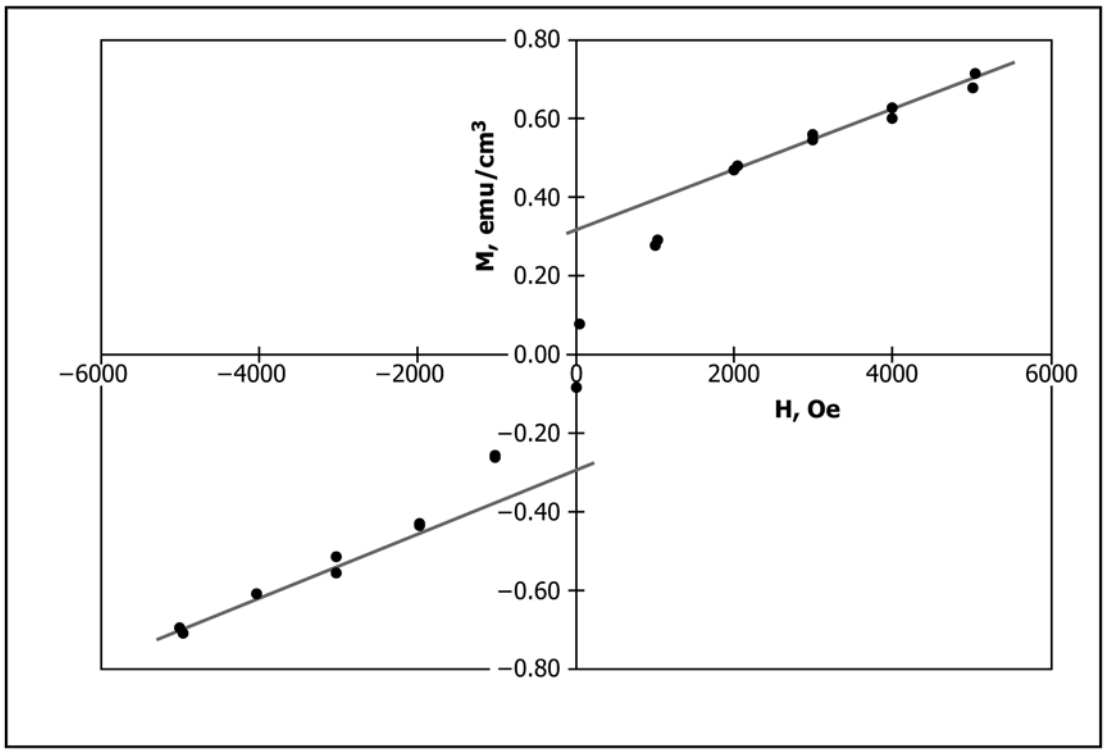


FIG. 6 Method 5 (VSM) – Data Plot for Case 2 (Ferromagnetic) Behavior

plus a ferromagnetic component with saturation magnetization M_s. If more detailed information about the properties of the ferromagnetic component is needed, additional data points may be taken in the low-field region, the paramagnetic component regarded as a background correction to be subtracted, and the ferromagnetic hysteresis loop constructed as a plot of M versus

H. From this plot the remanence and coercive field strength may be obtained. Note that the coercive field strength will be the intrinsic coercive field strength H_{ci} since the loop is plotted as *M* versus *H*, not *B* versus *H*.

24.4 *Case 3*—If the data plots do not match either Case 1 or Case 2, some more complicated magnetic structure may be involved. In this case the results should be reported in the form of the graph of *M* versus *H* with the notation that the data were acquired using A342/A342M Test Method 5.

25. Precision and Bias

25.1 The precision and bias of this test method have not been established by interlaboratory study.

25.2 Because this method measures susceptibility and then calculates permeability, the usual notion of a percentage or fractional error in the permeability does not apply. The magnetic susceptibility determined from the slope of the *M* versus *H* plot will be accurate to two significant digits under the conditions specified in these test methods. The permeability will then be uncertain by one digit in the fourth decimal place.

26. Keywords

26.1 magnetic balances; magnetic probes; magnetic susceptibility; NDE; nondestructive evaluations; paramagnetics; permeability; permeameters; vibrating sample magnetometers

APPENDIX

(Nonmandatory Information)

X1. WEAKLY MAGNETIC MATERIALS

X1.1 Weakly magnetic materials may be paramagnetic, meaning that they develop magnetization linearly proportional to the applied magnetic field. In this case, the magnetic susceptibility and also permeability are constant and independent of magnetic field strength. Weakly magnetic materials may also be ferromagnetic or ferrimagnetic with small values of saturation magnetization and with susceptibility and permeability dependent on magnetic field strength. This usually results from the presence of a small volume fraction of a ferro- or ferri- magnetic phase or region. This may arise due to strain induced transformations such as occur in austenitic stainless steels, chemical segregation arising from solidification, alloy depleted regions due to precipitation or oxidation, or the presence of exogeneous ferromagnetic particles such as iron powder. Both types of weak magnetism may be present in the same specimens. Other magnetic structures that can produce behavior that can be described as weakly magnetic are known to exist, but they are rarely encountered in common engineering materials.

X1.2 Because some materials such as austenitic stainless steels have a ferromagnetic component with a relatively high coercivity, the prior magnetic history of the material may influence the test results since with relatively low applied magnetic fields, one might be working on a minor hysteresis loop. For this reason, it is recommended that a minimum magnetic field strength of 500 Oe [40 kA/m] be used to ensure reproducible test results when testing austenitic stainless steels.