Designation: D 1186 – 93

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[1]

This standard is issued under the fixed designation D 1186; 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 the nondestructive measurement of the dry film thickness of nonmagnetic coatings applied over a ferrous base material using commercially available test instruments. The test methods cover the use of instruments based on magnetic measuring principles only. Test Method A provides for the measurement of films using magnetic pull-off gages and Test Method B provides for the measurement of films using magnetic flux gages.

1.2 These test methods are not applicable to coatings that will be readily deformable under the load of the measuring instruments, as the instrument probe must be placed directly on the coating surface to take a reading.

1.3 *This standard does not purport to address all of the safety problems, 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:*

D 609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products[2]

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[2]

D 1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[2]

D 3980 Practice for Interlaboratory Testing of Paint and Related Materials[2]

2.2 *Steel Structures Painting Council Standard:*

SSPC-PA2 Measurement of Dry Paint Thickness with Magnetic Gages[3]

TEST METHOD A—MAGNETIC PULL-OFF GAGES

3. Summary of Test Method

3.1 Instruments complying with this test method measure thickness by using a spring calibrated to determine the force required to pull a permanent magnet from a ferrous base coated with a nonmagnetic film. The instrument must be placed directly on the coating surface to take a reading.

3.2 The attractive force of the magnet to the substrate varies inversely with the thickness of the applied film. The spring tension required to overcome the attraction of the magnet to the substrate is shown on the instrument scale as the distance (in mils or micrometres) between the magnet and the substrate.

3.3 It should be recognized that the accuracy of the measurements can be influenced when measurements are made closer than 1 in. (25 mm) to an edge.

4. Significance and Use

4.1 After calibrating the instrument using shims of known thickness and either a bare part of the metal object or metal of the same kind, the instrument magnet (or metal foot) is placed in contact with the coated metal in the manner described in 12.1. The results of many test methods applicable to coatings are markedly affected by the film thickness of the dry film, some examples being adhesion, flexibility, and hardness to name a few. To be able to compare results obtained by different operators, it is essential to measure film thickness closely.

4.2 Most protective and high performance coatings are applied to meet a requirement or a specification for the dry-film thickness of each coat, or for the complete system, or both. Coatings must be applied within certain minimum and maximum thickness tolerances in order that they can fulfill their intended function. In addition to potential performance deficiencies, it is uneconomical to apply more material than

[1] These test methods are under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

Current edition approved Oct. 15, 1993. Published December 1993. Originally published as D 1186 – 51. Last previous edition D 1186 – 87.

[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] Available from Steel Structures Painting Council, 4516 Henry St., Pittsburgh, PA 15213.

necessary when coating large areas such as metal structures and coils. This test method is used to measure film thickness of coatings on ferrous metals.

5. Apparatus

5.1 *Permanent Magnet*, small, either attached directly to a coil spring ("pencil" gage)[4] or to a horizontal lever arm which is attached to a helical spring ("banana" gage).[5] Increasing force is applied to the magnet by extending the coil spring in the first case or turning a graduated dial that coils the helical spring in the second. The readings obtained are shown directly on the instrument scale or converted by reference to a calibration curve.

5.2 *Nonmagnetic Thickness Shims or Polished Metal Certification Calibration Standards*[6]—Shims with assigned values traceable to National Standards are available, but when shims are used that are not traceable to National Standards, the thickness must be measured to the nearest 0.1 mil (2.5 µm) using a micrometer as described in Procedure D in Test Method D 1005.

6. Test Specimens

6.1 When this test method is used in the field, the specimen is the coated structure or article on which the thickness is to be evaluated.

6.2 For laboratory use, apply the materials to be tested to panels of the composition and surface conditions on which it is desired to determine the thickness.

NOTE 1—Applicable test panel description and surface preparation methods are given in Practice D 609.

NOTE 2—Coatings should be applied in accordance with Practices D 823 or as agreed upon between the purchaser and the seller.

7. Calibration of Apparatus

7.1 Calibrate the instrument in an area free of stray magnetic fields, such as power lines, generators, or welding equipment. There shall be no vibration apparent on the test piece when the instrument is being calibrated.

7.2 Use a bare section of the substrate after the specified surface preparation has been accomplished. If an uncoated section of the substrate is not available, uncoated test panels similar to the type on which the specified surface preparation has been performed may be used.

7.3 Select calibration shims in the expected thickness range to be measured. For example, if a coating is approximately 3 mils (75 µm) in thickness, calibrate the instrument at 3 mils. Then check the calibration, using shims of both a lesser and greater thickness, to determine the thickness range over which the instrument is calibrated. The limits of this range are set at the points where the gage no longer registers the shim thickness within the manufacturer's stated accuracy (for example, ±15 %).

7.4 Lay a calibration shim on the bare, uncoated substrate and bring the instrument magnet in direct contact with the shim. Remove the magnet from the shim by slowly rotating the dial scale ring clockwise (for helical spring-type instruments) or lifting the entire instrument housing (for coil spring-type instruments). Hold the shim so that it will not flex during calibration, causing the magnet to lift prematurely. Observe the thickness shown on the instrument scale at the moment when the magnet breaks contact with the surface.

7.5 If the instrument scale reading does not agree with the shim thickness, calibration is required. This can be accomplished by physical calibration or by drafting a calibration curve. A calibration curve involves plotting a graph with the actual gage reading on one axis and the shim reading on the other. For physical calibration, consult the manufacturer's instructions.

NOTE 3—Instruments based on the scale dial ring/helical spring can be calibrated and used in any position, while those based on the coil spring must be calibrated and used in the vertical position only.

8. Calibration of Apparatus—Polished Metal Calibration Standards

8.1 Follow 7.1, 7.2, and 7.3.

8.2 Place the gage directly on the calibration standard. If the instrument scale reading does not agree with the shim thickness, calibration is required as in 7.5.

8.3 After the gage is calibrated, take ten readings on the bare, prepared substrate. Record the mean of these readings. This is a correction for variations of magnetic attraction due to the roughness of the substrate.

8.4 Subtract the value obtained in 8.3 when measuring the coating thickness to obtain the corrected thickness of the paint.

NOTE 4—More information on this calibration test method is described in SSPC-PA 2.

9. Procedure

9.1 Use the instrument only after it has been calibrated in accordance with Section 7 or 8.

9.2 Assure that the coating is dry prior to use of the instrument.

9.3 Inspect the magnet tip and surface to be measured to assure that they are clean. Adherent magnetic filings or other surface contaminants will affect gage readings.

9.4 Take readings in locations free of vibration, electrical, or magnetic fields.

9.5 If thickness readings are found to be outside the calibration range established in 7.3, repeat the calibration procedure in the appropriate range. Check the calibration before, during, and after each use to ensure that the instrument continues to read properly. If the instrument is found to be out of adjustment, remeasure the thicknesses taken since the last satisfactory calibration check was made.

9.6 Take a sufficient number of readings to characterize the surface.

9.6.1 For laboratory measurements, a recommended minimum is three for a 3 by 6-in. (75 by 150-mm) panel and more in proportion to size.

9.6.2 For field measurements, a recommended minimum is five determinations at random for every 100 ft^2 (10 m^2) of

[4] Apparatus of the "pencil" (coil spring) type found to be typical are shown in Table 1.

[5] Apparatus of the "banana" (helical spring) type found to be typical are shown in Table 1.

[6] Polished metal standards for this purpose are available from U.S. Department of Commerce, National Institute of Standards and Technology, Standard Reference Material Program, Building 202, Room 204, Gaithersburg, MD 20899.