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Endorsed by American  
Electroplaters' Society  
Endorsed by National  
Association of Metal Finishers

# Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals<sup>1</sup>

This standard is issued under the fixed designation B499; 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 ( $\epsilon$ ) 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 This test method covers the use of magnetic instruments for the nondestructive measurement of the thickness of nonmagnetic coatings over ferrous or other magnetic base metals. It is intended to supplement manufacturers' instructions for the operation of the instruments and is not intended to replace them.

NOTE 1—Autocatalytically deposited nickel-phosphorus alloys containing more than 8% phosphorus are sufficiently nonmagnetic to be measured by this test method, as long as the measurement is made prior to any heat treatment.

1.2 These instruments measure either the magnetic attraction between a magnet and the basis metal, as influenced by the presence of the coating (categorized as “magnetic pull-off”), or the change in magnetic-flux density within the probe (categorized as “electronic”). These instruments cannot distinguish the thickness of individual layers. They can only measure the cumulative thickness of all layers beneath the probe down to the base metal.

1.3 Measurements made in accordance with this test method will be in compliance with the requirements of ISO International Standard 2178 as printed in 1982.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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*:<sup>2</sup>

**B530 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates**

2.2 *International Standard*:

**ISO 2178 Non-Magnetic Coatings on Magnetic Substrate—Measurement of Coating Thickness—Magnetic Method**<sup>3</sup>

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard*:

3.1.1 *accuracy, n*—the measure of the magnitude of error between the result of a measurement and the true thickness of the item being measured.

3.1.2 *adjustment, n*—the physical act of aligning a instrument's thickness readings to match those of a known thickness sample (removal of bias), in order to improve the accuracy of the instrument on a specific surface or within a specific portion of its measurement range. An adjustment will affect the outcome of subsequent readings.

3.1.3 *calibration, n*—the high-level, controlled and documented process of obtaining measurements on traceable calibration standards over the full operating range of the instrument, then making the necessary instrument adjustments (as required) to correct any out-of-tolerance conditions.

3.1.3.1 *Discussion*—Calibration of coating thickness instruments is performed by the equipment manufacturer, an authorized agent, or by an authorized, trained calibration laboratory in a controlled environment using a documented process. The outcome of the calibration process is to restore/realign the instrument to meet/exceed the manufacturer's stated accuracy.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.10 on Test Methods.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

\*A Summary of Changes section appears at the end of this standard

3.1.4 *reference standard, n*—a specimen of known thickness used to verify the accuracy of a coating thickness measuring instrument.

3.1.5 *verification of accuracy, n*—obtaining measurements on a reference standard prior to instrument use for the purpose of determining the ability of the coating thickness instrument to produce reliable values, compared to the combined instrument manufacturer’s stated accuracy and the stated accuracy of the reference standard.

## 4. Summary of Test Method

4.1 Magnetic pull-off instruments employ an attraction principle and a stationary magnetic field. These mechanical instruments measure the force required to pull a permanent magnet from a coated magnetic metal substrate. The magnetic force of attraction to the substrate beneath the coating is opposed by a spring or coil. Tension is applied to the spring/coil until the magnetic attraction to the magnetic substrate is overcome. The instrument must be placed directly on the coated surface to obtain a measurement. The force holding the permanent magnet to the magnetic base is inversely proportional to the thickness of the coating layer(s) between the magnet and the magnetic base. For example, a thin coating applied to a ferrous substrate will require greater spring tension to pull the magnet off than will a thicker coating, since the magnet is closer to the ferrous substrate with the thinner coating. This inverse relationship is reflected on the nonlinear instrument scale.

4.2 Electronic instruments measure a change in magnetic flux density within the probe to produce a coating thickness measurement. The instrument probe must be placed directly (in a perpendicular position) on the coated surface to obtain a measurement. These instruments determine the effect on the magnetic field generated by the probe due to the proximity to the substrate.

## 5. Significance and Use

5.1 The thickness of a coating is often critical to its performance. For most nonferrous coatings on steel, the magnetic method is reliable for measuring coating thickness nondestructively and is suitable for specification acceptance testing and SPC/SQC applications.

5.2 This test method should not be used to determine the thickness of electrodeposited nickel coatings on steel. Test Method **B530** is suitable for that determination.

## 6. Apparatus

6.1 *Coating Thickness Instrument*, based on magnetic principles, commercially available, suitable to measure coating thickness accurately.

6.2 *Coating Thickness Standards*, with assigned values traceable to a National Metrology Institution. They may be coated or plated steel plates, or may be foils or shims of flat, non-metallic sheet (typically polyester).

## 7. Calibration and Standardization

7.1 Calibration of coating thickness instruments is performed by the equipment manufacturer, an authorized agent, or

by an authorized, trained calibration laboratory in a controlled environment using a documented process. A Certificate of Calibration showing traceability to a National Metrology Institution can be issued. There is no standard time interval for re-calibration, nor is one absolutely required, but a calibration interval can be established based on experience and the work environment. A one-year calibration interval is a typical frequency suggested by many instrument manufacturers.

7.2 Before use, each instrument’s calibration accuracy shall be verified in accordance with the instructions of the manufacturer, employing suitable thickness standards and, if necessary, any deficiencies found shall be corrected.

7.3 During use, calibration accuracy shall be verified at frequent intervals, at least once a day. Attention shall be given to the factors listed in Section 8 and to the procedures described in Section 9.

7.4 Coating thickness standards of known thickness are available either as shims or foils or as coated specimens.

### 7.4.1 Foils:

NOTE 2—In the following paragraphs, the use of the word “foil” will imply a nonmagnetic metallic or nonmetallic foil or shim.

7.4.1.1 Because of the difficulty of ensuring adequate contact, foils are generally not recommended for the calibration, verification of accuracy, and adjustment of magnetic pull-off instruments but they are suitable in some circumstances provided the necessary precautions are taken. They can normally be used with other types of instruments.

7.4.1.2 Foils are advantageous on curved surfaces and are more readily available than coated standards. To prevent measurement errors it is necessary to ensure that intimate contact is established between foil and substrate. Resilient foils should be avoided to prevent indentation errors. Only nonferrous metal foils should be used for thicknesses less than 15  $\mu\text{m}$  (0.6 mil). Foils are subject to wear and indentation and, therefore, should be replaced frequently. Worn foils shall not be used.

7.4.2 *Coated Standards*— These calibration standards consist of nonconductive coatings of known, uniform thickness permanently bonded to the substrate material.

7.4.3 The coating thickness of the standards used shall bracket the user’s highest and lowest coating thickness measurement requirement. Standards suitable for many applications of the test method are commercially available and may be used provided the certified values are traceable to a National Metrology Institution.

7.5 In some cases the calibration of the instrument should be checked by rotating the probe in increments of 90° (see 8.1.8 and 8.1.9).

7.6 The basis-metal thickness for the test and the calibration adjustment shall be the same if the critical thickness, defined in 8.1.3, is not exceeded. It is often possible to back up the basis metal of the standard or of the test specimen with a sufficient thickness of similar material to make the readings independent of the basis-metal thickness.

7.7 If the curvature of the coating to be measured is such as to preclude calibration adjustment on a flat surface, the