Designation: B530 – 09 (Reapproved 2021)

Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates[1]

This standard is issued under the fixed designation B530; 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 This test method covers the use of magnetic instruments for the nondestructive measurement of the thickness of an electrodeposited nickel coating on either a magnetic or nonmagnetic substrate. It is intended to supplement manufacturers' instructions for the operation of the instruments and is not intended to replace them.

1.2 These instruments measure either the magnetic attraction between a magnet and the coating-substrate combination (categorized as "magnetic pull-off"), or the change in magnetic flux density within the probe (categorized as "electronic").

1.3 For this test method, there are two types of coating-substrate combinations that can be encountered: Type A, nickel coatings on a magnetic substrate, and Type B, nickel coatings on a nonmagnetic substrate.

1.4 The effective measuring ranges of instruments using the principle of magnetic attraction are up to 50 µm (2 mils) for Type A coatings, and up to 25 µm (1 mil) for Type B coatings. For gages based on change in magnetic flux density principles, the effective ranges are much greater, and measurements up to 1 mm (40 mils) or more, can be made on both types of coatings.

1.5 Measurements made in accordance with this test method will be in compliance with the requirements of ISO Standard 2361 as printed in 1982.

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

1.7 *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.*

1.8 *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]

B487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section

B499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals

B504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method

B748 Test Method for Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope

2.2 *ISO International Standard:*

ISO 2361 Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates—Measurement of Coating Thickness—Magnetic Method[3]

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.

[1] 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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[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.

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

3.1.2 *adjustment, n*—the physical act of aligning an 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.

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 are mechanical instruments that measure the force required to pull a permanent magnet from magnetic material. The magnetic force of attraction to the magnetic coating or coating-substrate combination is opposed by a spring or coil. Tension is applied to the spring/coil until the magnetic attraction to the material 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 material is inversely proportional to the thickness of the coating layer(s) between the magnet and the magnetic material. For example, a thin nickel layer applied to a nonmagnetic substrate will require less spring tension to pull the magnet off than will a thicker nickel layer, since the thinner coating has weaker magnetic strength.

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. This magnetic method is suitable for measuring nondestructively the thickness of some nickel coatings and for specification acceptance.

5.2 This method requires that the magnetic properties of the coating and its substrate be the same as those of the reference standards used for the calibration adjustment of the instrument.

5.3 This method should not be used to determine the thickness of autocatalytically deposited nickel-phosphorus alloys containing more than 8 % phosphorus on steel. Those coatings are sufficiently nonmagnetic for Test Method B499 to be suitable for that determination, as long as the measurement is made prior to any heat treatment.

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 Reference standards shall be coated standards obtained by electroplating nickel adherently onto a substrate. The coating thickness of the reference standards shall bracket the user's highest and lowest coating thickness measurement requirement.

7.5 The substrate and the coating of the standard shall have the same magnetic properties as those of the test specimen (see 8.2, 8.3, 8.11 and 8.12).

7.5.1 To assure the similarity of the magnetic properties of the nickel deposit and for Type A coatings on steel substrate, reference standards shall be produced and measured by another suitable test method, such as cross sectioning or the coulometric test method from a specimen produced under identical conditions as the test specimen to be measured. To confirm the similarity of the magnetic properties of the substrate to those of the standards, a comparison of the readings obtained with the bare basis metal of the standard to that of the test specimen is recommended.

7.5.2 In the same manner, the similarity of the magnetic properties of the coating of the test specimen to that of the standard can be established by verifying with the cross sectioning (Test Methods B487 or B748) or coulometric (Test