Designation:B530 –02 Designation: B 530 – 09

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 B 530; 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

1.1This 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.

1.2These instruments measure either the magnetic attraction between a magnet and the coating-substrate combination, or the reluctance of a magnetic flux path passing through the coating and the basis metal. *

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 reluctance gages, 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

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

2. Referenced Documents

2.1

2.1 *ASTM Standards:*[2]

B 487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section

B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals

B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method

B 748 Test Method for Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope

2.2 *ISO International Standard:*

[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 General Test Methods.

Current edition approved Sept. 10, 2002. Published November 2002. Originally published as B530–70. Last previous edition B530–96.on Test Methods.

Current edition approved April 15, 2009. Published June 2009. Originally approved in 1970. Last previous edition approved in 2002 as B 530 – 02.

[2] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[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.

***A Summary of Changes section appears at the end of this 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.

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

~~3.1The 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.~~

~~3.2This method requires that the magnetic properties of the coating and its substrate be the same as those of the calibration standards.~~

~~4.~~

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 B 499 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).

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

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 B 487 or B 748) or coulometric (Test Method B 504) methods that the thickness reading obtained on the test specimen by means of the properly adjusted instrument corresponds to the actual thickness determined by one or both of the above methods.

7.6 Where indicated, the accuracy of the instrument should be checked by rotating the probe in increments of 90° (see 8.7 and 8.8).

7.7 For Type A coatings, the basis metal thickness for the test and the calibration adjustment shall be the same if the critical thickness, defined in 8.3, is not exceeded. When possible, back up the basis metal of the standard, or the test specimen, with a sufficient thickness of similar material to make the readings independent of the basis metal thickness.

7.8 If the curvature of the coating to be measured is such as to preclude calibration adjustment on a flat surface, the curvature of the coated standard shall be the same as that of the test specimen.

8. Factors Affecting the Measuring Accuracy

~~4.1~~

8.1 *Coating Thickness*—Inherent in the method is a measuring uncertainty that, for thin coatings, is constant and independent of the coating thickness; for thicknesses greater than about 50 µm (2 mils), this uncertainty is proportional to the coating thickness.

~~4.2~~8.2 *Magnetic Properties of the Basis Metal* (*Type A coatings only*)—Magnetic thickness measurements are affected by variations in the magnetic properties of the basis metal. For practical purposes, magnetic variations in low-carbon steel can often be considered to be insignificant. To avoid the influences of severe or localized heat treatments and cold working, the instrument should be ~~calibrated~~adjusted using a ~~calibration~~reference standard having a basis metal with the same magnetic properties as that of the test specimen or, preferably and if available, with a sample of the part to be tested before application of the coating.

~~4.3~~8.3 *Basis Metal Thickness* (*Type A coatings only*)—For each instrument, there is a critical thickness of the basis metal above which the measurements will not be affected by an increase in that thickness. Since it depends on the instrument probe (Note 1) and the nature of the basis metal, its value should be determined experimentally, if it is not supplied by the manufacturer.

NOTE 1—The term "instrument probe" also includes the term "magnet."

~~4.4~~

8.4 *Edge Effect*—The method is sensitive to abrupt changes in the surface contour of the test specimen. Therefore, measurements made too near an edge or inside corner will not be valid, unless the instrument is specially ~~calibrated~~adjusted for such a measurement. This also applies to measurements made on geometrically limited areas, such as narrow conductors on printed circuit boards.

~~4.5~~8.5 *Curvature*—Measurements are affected by the curvature of the test specimen. The influence of curvature varies considerably with the make and type of instrument, but always becomes more pronounced as the radius of curvature decreases. Instruments with two-pole probes may also produce different readings, depending on whether the poles are aligned in planes parallel or perpendicular to the axis of a cylindrical surface. A similar effect can occur with a single-pole probe, if the tip is unevenly worn. Measurements made on curved test specimens may not, therefore, be valid unless the instrument is specifically ~~calibrated~~adjusted for such measurements.

~~4.6~~8.6 *Surface Roughness*:

~~4~~8.6.1 Measurements are influenced by the surface topography of the substrate and the coating, and a rough or scratched surface will give individual instrument readings that all vary from point to point. In this case, it is necessary to make many readings at