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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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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

1.1 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. For autocatalytic nickel coating, see Section 7.

1.2 These 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.

1.3 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 for Type A coatings, and up to 25 µm for Type B coatings. For reluctance gages, the effective ranges are much greater, and measurements up to 1 mm 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 *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:*

B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[2]

2.2 *ISO International Standard:*

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

3. Significance and Use

3.1 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.

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

4. Factors Affecting the Measuring Accuracy

4.1 *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, this uncertainty is proportional to the coating thickness.

4.2 *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 using a calibration 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 *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 *Edge Effect*—The method is sensitive to abrupt changes

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[2] *Annual Book of ASTM Standards*, Vol 02.05.

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

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 for such a measurement. This also applies to measurements made on geometrically limited areas, such as narrow conductors on printed circuit boards.

4.5 *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 for such measurements.

4.6 *Surface Roughness*:

4.6.1 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 different positions to obtain an average value that is representative of the mean coating thickness.

4.6.2 If the basis metal is magnetic and rough, it may also be necessary to check the zero of the instrument at several positions on a sample of the uncoated rough substrate.

4.6.3 If the roughness of the substrate surface is small, relative to the coating thickness, its effect will probably be negligible.

4.7 *Direction of Mechanical Working of the Basis Metal* (*Type A coatings only*)—Measurements made by an instrument having a two-pole probe or an unevenly worn single-pole probe may be influenced by the direction in which the magnetic basis metal has been subjected to mechanical working, such as rolling. The reading may change with the orientation of the probe on the surface.

4.8 *Residual Magnetism* (*Type A coatings only*)—Residual magnetism in the basis metal affects the measurements made by instruments that employ a stationary magnetic field. Its influence on measurements made by reluctance instruments employing an alternating magnetic field is much smaller.

4.9 *Stray Magnetic Field*—Strong stray magnetic fields, such as those produced by various types of electrical equipment, can seriously interfere with the operation of magnetic thickness instruments.

4.10 *Foreign Particles*—The probes of magnetic instruments of all types must make physical contact with the test surface and are, therefore, sensitive to foreign material that prevents intimate contact between the probe and the coating surface. Both the test surface and the instrument probe should be kept free of foreign material.

4.11 *Magnetic Properties of the Coating*—Magnetic thickness measurements are affected by variations in the magnetic properties to the coating. These properties depend on the conditions under which the deposit is produced, the type and composition of the coating, and its stress. The magnetic properties of multiple-layer nickel coatings will also depend on the relative thickness of each of the layers.

4.11.1 A heat treatment at 400°C for 30 min will equalize the magnetic permeability of dull (Watts) nickel coatings of the same composition. Bright nickel deposits may or may not have the same magnetic properties after heat treatment.

4.12 *Nickel Coatings on the Back of the Substrate* (*Type B coatings only*)—Nickel coatings on the back of the substrate can affect the measurements, depending on the thickness of the substrate.

4.13 *Pressure*—Instrument readings are sensitive to the pressure with which the probe is applied to the test specimen. No deformation of the coating or probe should be allowed. Errors that sometimes are encountered with the use of manual probes can be avoided by employing spring-loaded probes that exert a relatively constant pressure.

4.14 *Probe Orientation*—Instrument readings may be sensitive to the orientation of the magnet in relation to the field of gravity of the earth. Thus, the operation of an instrument in a horizontal or upside-down position may require a different calibration, or may be impossible.

5. Calibration of Instruments

5.1 Before use, each instrument shall be calibrated in accordance with the instructions of the manufacturer, employing suitable thickness standards. During use, the calibration shall be checked at regular intervals, at least once a day. Attention shall be given to the factors listed in Section 4 and to the procedures in Section 6.

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

5.3 The substrate and the coating of the standard shall have the same magnetic properties as those of the test specimen (see 4.2, 4.3, 4.12 and section 4.12.1).

5.3.1 To assure the similarity of the magnetic properties of the nickel deposit and for Type A coatings the steel substrate, calibration standards shall be produced 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.

5.3.2 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 coulometric or microscopical method that the thickness reading obtained on the test specimen by means of the properly calibrated instrument corresponds to the actual thickness determined by one or both of the above methods.

5.4 Where indicated, the calibration of the instrument should be checked by rotating the probe in increments of 90° (see 4.7 and 4.8).

5.5 For Type A coatings, the basis metal thickness for the test and the calibration shall be the same if the critical thickness, defined in 4.3, is not exceeded. When possible, back