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

Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments[1]

This standard is issued under the fixed designation B244; 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 eddy-current instruments for the nondestructive measurement of the thickness of a nonconductive coating on a nonmagnetic basis metal. It is intended to supplement manufacturers' instructions for the operation of the instruments and is not intended to replace them.

1.2 This test method is particularly useful for measuring the thickness of an anodic coating on aluminum alloys. Chemical conversion coatings are too thin to be measured by this test method.

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

1.4 *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:*[2]

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

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.

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 Instruments complying with this test method measure coating thickness by the use of eddy currents. A probe is placed directly on the coated surface in a perpendicular position and electronic circuitry is used to convert a reference signal into a coating thickness measurement.

[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.

4.2 The instrument probe coil is energized by alternating current that induces eddy currents in the metal substrate. The eddy currents in turn create a secondary magnetic field within the substrate. The characteristics of this secondary field are dependent upon the distance between the probe and the basis metal. This distance (gap) is measured by the instrument probe and shown on the instrument display as the thickness (microns or mils) of the intervening coating.

5. Significance and Use

5.1 The thickness of a coating is often critical to its performance. This eddy-current method is nondestructive and is suitable for measuring the thickness of anodic coatings on aluminum, as well as the thickness of most nonconductive coatings on nonmagnetic basis metals.

5.2 This test method requires that the conductivity of the substrate be the same in the reference standard used for calibration adjustment and in the coated article to be measured.

6. Apparatus

6.1 *Coating Thickness Instrument ,* based on eddy current 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 aluminum 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:*

7.4.1.1 Foils used for accuracy verification and adjustment of eddy-current instruments are generally made of plastic. They are advantageous for adjustments on curved surfaces, and are more readily available than coated standards.

7.4.1.2 To prevent measurement errors, it is necessary to ensure that intimate contact is established between foil and substrate. Resilient foils should be avoided if possible. Foils are subject to indentation and should, therefore, be replaced frequently.

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 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 of the test specimen with a sufficient thickness of similar material to make the readings independent of the basis metal thickness. A way to determine if the basis metal thickness exceeds the critical thickness is to make measurements before and after backing up the basis metal with similar metal at least 3 mm (120 mils) thick. If there is no difference between the readings, the critical thickness is exceeded.

7.6 If the test specimen is soft and thin, it is subject to indentation by the probe. Because of this, and despite the use of special probes or fixtures, measurements on such specimens are sometimes impossible to make.

7.7 If the curvature of the test specimen to be measured is such as to preclude calibration adjustment on a flat surface, the curvature of the coated standard or of the substrate on which the foil is placed shall be the same as that of the test specimen.

8. Factors Affecting the Measuring Accuracy

8.1 Inherent in the test method is a measuring uncertainty that, for thin coatings, is constant and independent of the coating thickness, and, for a single measurement, not less than 0.5 μm (0.02 mil); for thicknesses greater than about 25 μm (1 mil), this uncertainty is proportional to the coating thickness.

8.2 *Electrical Properties of the Basis Metal*—Eddy-current measurements are affected by the electrical conductivity of the basis metal, which itself is often affected by heat treatments.

8.3 *Basis-Metal Thickness*—For each measurement, there is a critical thickness of the basis metal above which the measurements will not be affected by an increase in that thickness. Its value should be determined experimentally, if not supplied by the manufacturer of the measuring instrument, since it depends on both the measuring frequency of the probe system and the electrical conductivity of the basis metal.

8.3.1 *General Rule*—For a given measuring frequency, the higher the conductivity of the basis metal, the smaller its critical thickness. For a given basis metal, the higher the measuring frequency, the smaller the critical thickness of the basis metal.

8.4 *Edge Effect*—This test 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 specifically adjusted for such a measurement.

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.

8.6 *Surface Roughness:*

8.6.1 1 Measurements are influenced by the surface topography of the substrate and the coating, and a rough surface will give individual instrument readings that will 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. If the basis metal is rough it may also be necessary to check, and adjust if necessary, the zero of the instrument at several positions on a sample of the uncoated rough substrate. If the roughness of the substrate surface is small, relative to the coating thickness, its effect will probably be negligible.

8.6.2 If the basis metal is rough it may also be necessary to check, and adjust if necessary, the zero of the instrument at several positions on a sample of the uncoated rough substrate. If the roughness of the substrate surface is small, relative to the coating thickness, its effect will probably be negligible.

8.7 *Foreign Particles*—The probes of eddy-current instruments 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 instrument probe should be kept free of foreign material.

8.8 *Pressure*—The pressure with which the probe is applied to the test specimen affects the instrument readings, and should, therefore, be kept constant.

8.9 *Number of Readings*—The precision of the measurements can be improved by increasing the number of readings in accordance with statistical principles.

9. Procedure

9.1 Operate each instrument in accordance with the instructions of the manufacturer. Give appropriate attention to the factors listed in Section 8.

9.2 Verify the accuracy of the instrument at the test site each time the instrument is put into service and at frequent intervals during use to assure proper performance.

9.3 Many instruments can be adjusted in order to improve their accuracy on a specific surface or within a specific portion of its measurement range. The effects of properties of the substrate (composition, shape, roughness, edge effects, electrical properties) and coating (composition, mass, surface roughness), as well as ambient and surface temperatures, may require adjustments to be made to the instrument. Follow the manufacturer's instructions.

9.4 Observe the following precautions:

9.4.1 *Basis Metal Thickness*—Check whether the basis metal thickness exceeds the critical thickness. If not, either use the back-up method in 7.5, or make sure that the calibration adjustment has been made on a reference standard having the same thickness and electrical properties as the test specimen.

9.4.2 *Edge Effects*—Do not make readings close to an edge, hole, inside corner, etc., of a specimen, unless the validity of the calibration adjustment for such a measurement has been demonstrated.

9.4.3 *Curvature*—Do not make readings on a curved surface of a specimen unless the validity of the calibration adjustment for such a measurement has been demonstrated.

9.4.4 *Number of Readings*—Because of normal instrument variability, it is necessary to make several readings at each position. Local variations in coating thickness may also require that a number of measurements be made in any given area; this applies particularly to a rough surface (see 8.9).

9.4.5 *Surface Cleanliness*—Before making measurements, clean any foreign matter such as dirt, grease, and corrosion products from the surface without removing any coating material.

10. Accuracy

10.1 The instrument, its calibration, and its operation shall be such that the coating thickness can be determined within 10 % or 1 μm, whichever is greater, of the true thickness.

11. Report

11.1 The report shall include the following information:

11.1.1 Type of instrument used including manufacturer, model number, principle of operation, and date of calibration,

11.1.2 Size and description of test specimen,

11.1.3 Whether special jigs were used,

11.1.4 Type of coating thickness standard and/or reference standard and the method used for accuracy verification and any calibration adjustment

11.1.5 The number of measurements taken and the value of each measurement,

11.1.6 Operator identification, and

11.1.7 Date.

NOTE 1—Although, theoretically, this test method can be used for measuring nonconductive coatings on a magnetic basis metal, its use for coatings below 25 μm (1 mil) is not recommended, and the magnetic method outlined in Test Method B499 shall be used.

12. Precision and Bias

12.1 The precision of this test method is being determined.

13. Keywords

13.1 coating thickness; coatings; eddy current; nonconductive coatings; thickness; thickness testing; nondestructive thickness; anodic coatings