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Non-conductive coatings on non-magnetic basis metals — Measurement of coating thickness — Eddy current method

Revêtements non conducteurs sur métal de base non magnétique — Mesurage de l'épaisseur — Méthode des courants de Foucault

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2360 was developed by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings*, and was circulated to the member bodies in November 1980.

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No member body expressed disapproval of the document.

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Non-conductive coatings on non-magnetic basis metals — Measurement of coating thickness — Eddy current method

1 Scope and field of application

This International Standard specifies the method of using eddy current instruments for non-destructive measurements of the thickness of non-conductive coatings on non-magnetic basis metals.

The method is applicable for measurements of the thickness of most oxide coatings produced by anodizing, but it is not applicable to all conversion coatings, some of which are too thin to be measured by this method (see clause 7).

Although, theoretically, the method can be used for measurements of the thickness of coatings on magnetic basis metals, its use for this application is not recommended. In such cases, the magnetic method specified in ISO 2178 should be used.

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2 Reference

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method.*

3 Principle

Eddy current instruments work on the principle that a high frequency electromagnetic field generated in the probe system of the instrument will produce eddy currents in a conductor upon which the probe is placed, and that the amplitude and phase of these currents is a function of the thickness of a non-conductive coating present between the conductor and the probe.

4 Factors affecting the measuring accuracy

The following factors may affect the accuracy of measurements of coating thickness.

4.1 Coating thickness

A measuring uncertainty is inherent in the method. For thin coatings, this measuring uncertainty (in absolute terms) is constant, independent of the coating thickness, and, for a single measurement, is at least 0,5 µm. For coatings thicker than about 25 µm, this uncertainty is an approximately constant fraction of the coating thickness.

If measuring coatings of thickness 5 µm or less, it is advisable to take the average of several readings.

It may be impossible to obtain the accuracy requirement specified in clause 7 with coatings of thickness less than 3 µm.

4.2 Electrical properties of the basis metal

Measurements using eddy current instruments can be affected by the electrical conductivity of the basis metal, which is a function of the composition and heat treatment of the material. The influence of electrical conductivity on the measurement varies considerably with the make and type of instrument.

4.3 Basis metal thickness

For each instrument, there is a critical thickness of basis metal above which measurements will not be affected by an increase in thickness. Since this thickness depends on both the measuring frequency of the probe system and the electrical conductivity of the basis metal, its value should be determined experimentally, unless it is specified by the manufacturer.

In general, for a given measuring frequency, the higher the conductivity of the basis metal, the smaller is its critical thickness. For a given basis metal, the higher the measuring frequency, the smaller is the critical thickness of the basis metal.

4.4 Edge effects

Eddy current instruments are 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 calibrated for such measurements.

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. Measurements made on curved test specimens will not, therefore, be valid unless the instrument is specifically calibrated for such measurements.

4.6 Surface roughness

Measurements are influenced by the surface topography of the basis metal and of the coating. Rough surfaces can cause both systematic and random errors. The latter can be reduced by making a greater number of measurements, each measurement being made at a different location.

If the basis metal is rough, it is also necessary to check the zero of the instrument at several positions on a sample of the uncoated, rough, basis metal. If no similar uncoated basis metal is available, the coating on the test specimen shall be stripped with a solution which does not attack the basis metal.

4.7 Foreign particles

The probes of eddy current instruments have to make physical contact with the test surface because these instruments are sensitive to foreign material that prevents intimate contact between the probe and surface of the coating. The probe tip should be checked for ceanliness.

4.8 Probe pressure

The pressure with which the probe is applied to the test specimen affects the instrument readings and shall therefore be maintained constant. This can be achieved by the use of a suitable jig.

4.9 Positioning of the probe

Tilting of the instrument probe will change the instrument response; hence the probe should always be perpendicular to the test surface at the point of measurement. This can be achieved by the use of a suitable jig.

4.10 Deformation of test specimens

Test specimens with soft coatings or thin test specimens may be deformed by the probe. Valid measurements on such test specimens may be impossible or may be accomplished only with the use of special probes or fixtures.

4.11 Temperature of the probe

Because a large change in the temperature affects the characteristics of the probe, it should be used under approximately the same temperature conditions as those used for calibration.

5 Calibration of instruments

5.1 General

Before use, each instrument shall be calibrated in accordance with the manufacturer's instructions, using suitable calibration standards, giving appropriate attention to the factors listed in clause 4 and to the procedures described in clause 6.

5.2 Calibration standards

Calibration standards of known thickness are available either as foils or as coated standards.

5.2.1 Calibration foils

5.2.1.1 Calibration foils used for the calibration of eddy current instruments are generally made of suitable plastic materials.

They are advantageous for calibration on curved surfaces and are more readily available than coated standards.

5.2.1.2 To prevent measurement errors, it is necessary to ensure that intimate contact is established between the foil and the substrate. Resilient foils shall be avoided, if possible.

Calibration foils are subject to indentation and shall, therefore, be replaced frequently.

5.2.2 Coated standards

Coated standards consist of non-conductive coatings of known, uniform thickness permanently bonded to a substrate.

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5.3 Verification

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5.3.1 The electrical properties of the basis metal of the calibration standards shall be similar to those of the basis metal of the test specimen. To confirm their suitability, a comparison of the readings obtained with the basis metal of the uncoated calibration standard and that of the test specimen is recommended.

5.3.2 If the basis metal thickness exceeds the critical thickness, as defined in 4.3, the thickness measurement is not affected by the thickness of the basis metal. If the critical thickness is not exceeded, the thickness of the basis metal for the test and for the calibration shall be the same, whenever possible. If this is impossible, back up the calibration standard or the test specimen with a sufficient thickness of metal of similar electrical properties to make the readings independent of the basis metal thickness. This cannot be done if the basis metal is coated on both sides, or if there is any gap between the basis metal and the back-up metal.

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

6 Procedure

6.1 General

Operate each instrument in accordance with the manufacturer's instructions, giving appropriate attention to the factors listed in clause 4.

Check the calibration of the instrument at the test site, each time the instrument is put into service, and at frequent intervals during use (at least once per hour) to ensure proper performance.

The following precautions shall be observed.

6.2 Basis metal thickness

Check whether the basis metal thickness exceeds the critical thickness. If not, either use the back-up method described in 5.3.2 or make sure that the calibration has been carried out on a calibration standard having the same thickness and electrical properties as the test specimen.

6.3 Edge effects

Do not make measurements close to an edge, hole, inside corner, etc. of a test specimen, unless the validity of the calibration for such measurements has been demonstrated.[1)]

6.4 Curvature

Do not make measurements on a curved surface of a test specimen, unless the validity of the calibration for such measurements has been demonstrated.

6.5 Number of readings

Because of normal instrument variability, it is necessary to take 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 if the surface is rough.

6.6 Surface cleanliness

Before making measurements, remove any foreign matter, such as dirt, grease and corrosion products, from the surface, without removing any coating material.

7 Accuracy requirements

The instrument, its calibration, and its operation shall be such that the coating thickness can be determined to within 10 % of its true thickness. If measuring coating thicknesses of less than 5 µm, it is advisable to take the mean of several readings. It may be impossible to obtain this accuracy with coatings of thickness less than 3 µm.

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1) A simple **edge effect check**, to assess the effect of the proximity of an edge, may be made using a clean uncoated sample of the basis metal as follows.

Place the probe on the sample, well away from the edge, and adjust the instrument to read zero. Progressively bring the probe towards the edge and note where a change of the instrument reading occurs. Measure the distance from the probe to the edge.

The instrument may be used without correction provided that the probe is farther from the edge than the distance measured above. If the probe is used closer to the edge, special calibration correction is required. If necessary, refer to the manufacturer's instructions.

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