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Electrodeposited nickel coatings on magnetic and non-magnetic substrates — Measurement of coating thickness — Magnetic method

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

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 2361 was drawn up by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings*.

It was approved in October 1971 by the Member Bodies of the following countries :

Austria	Ireland	Sweden
Egypt, Arab Rep. of	Italy	Switzerland
France	Korea, Rep. of	Thailand
Germany	New Zealand	United Kingdom
Hungary	Romania	U.S.A.
India	South Africa, Rep. of	U.S.S.R.

No Member Body expressed disapproval of the document.

Electrodeposited nickel coatings on magnetic and non-magnetic substrates – Measurement of coating thickness – Magnetic method

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the use of magnetic instruments for non-destructive measurement of the thickness of an electrodeposited nickel coating on either a magnetic or non-magnetic substrate.

It does not apply to autocatalytic (electroless) nickel coatings.

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 substrate.

This International Standard deals with two types of coating-substrate combinations which can be encountered :

A : nickel coatings on a magnetic substrate;

B : nickel coatings on a non-magnetic substrate.

The effective measuring ranges of instruments using the principle of magnetic attraction are up to 50 μm for type A, and up to 25 μm for type B coatings.

For reluctance gauges, the effective ranges are much greater, and measurements up to 1 mm, or more, can be made on both types of coatings.

2 FACTORS AFFECTING THE MEASURING ACCURACY

The following factors may affect the accuracy of a coating thickness measurement :

2.1 Coating thickness

Inherent in the method is a measuring uncertainty.

For thin coatings, this uncertainty is constant and independent of the coating thickness.

For greater thicknesses this uncertainty is proportional to the coating thickness.

2.2 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 among low carbon steels can be considered to be insignificant.

2.3 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 the thickness of the basis metal. Since it depends on the instrument probe¹⁾ and the nature of the basis metal, its value shall be determined experimentally, if not specified by the manufacturer.

2.4 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 specifically calibrated for such a measurement.

This also applies to measurements on geometrically limited areas, such as the narrow conductors on printed circuit boards.

2.5 Curvature

The 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, if 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. Therefore, measurements made on curved specimens will not be valid unless the instrument is specifically calibrated for such a measurement.

1) In this International Standard, the term "instrument probe" also includes the term "magnet".

2.6 Surface roughness

The measurements are influenced by the surface topography of the substrate and of the coating. Therefore, it is necessary, on a rough surface, to make a greater number of measurements at different positions to obtain a mean value that is representative of the average coating thickness.

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, basis metal.

2.7 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 changing with the orientation of the probe on the surface.

2.8 Residual magnetism (Type A coatings only)

Residual magnetism in the basis metal affects the measurements made by instruments which employ a stationary magnetic field. Its influence on measurements made by reluctance instruments employing an alternating magnetic field is much smaller.

2.9 Stray magnetic fields

Strong magnetic fields, such as those produced by various types of electrical equipment can seriously interfere with the operation of magnetic thickness measuring instruments.

2.10 Foreign particles

The probes of magnetic instruments shall make physical contact with the test surface and are, therefore, sensitive to foreign material that prevents intimate contact between the probe and the surface of the coating.

2.11 Magnetic properties of the coating

Magnetic thickness measurements are affected by variations in the magnetic properties of the coating. These properties depend on the conditions under which the deposit is made, the type and composition of the coating, and its stress conditions¹⁾. The magnetic properties of multiple layer nickel coatings will also depend on the relative thickness of each of the layers.

2.12 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.

2.13 Pressure

The pressure with which the probe is applied to the test specimen affects the instrument readings and shall therefore be maintained constant.

2.14 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.

3 CALIBRATION OF INSTRUMENTS

3.1 General

Before use, each instrument shall be calibrated in accordance with the instructions of the manufacturer, employing suitable thickness standards.

During use, the calibration should be checked after a warm-up period at regular intervals, at least once a day. Attention shall be given to the factors listed in section 2 and to procedures described in section 4.

3.2 Calibration standards

The calibration standards shall be coated standards obtained by electroplating nickel adherently onto a substrate.

3.3 Verification

3.3.1 The substrate and the coating of the standards shall have the same magnetic properties as those of the test specimen (see 2.2 and 2.11).

To confirm the similarity of the magnetic properties of the substrates a comparison of the readings obtained with the bare basis metal of the standard and that of the test specimen is recommended.

In the same manner, the similarity of the magnetic properties of the coating of the test specimen with that of the standard can be established, by verifying, with the

1) A heat treatment at 400 °C for 30 min will equalize the magnetic permeability of dull (sulphur-free or nearly sulphur-free) nickel coatings of the same composition. Bright nickel deposits may or may not have the same magnetic properties after heat treatment. This treatment may damage the article.

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.

3.3.2 In some cases, the calibration of the instrument should be checked by rotating the probe in increments of 90° . (See 2.7 and 2.8.)

3.3.3 For type A coatings, the basis metal thickness for the test and calibration shall be the same, if the critical thickness, defined in 2.3, is not exceeded. When possible, back up the basis metal of the standard, or the test specimen, with a sufficient thickness of similar material in order to make the readings independent of the basis metal thickness.

3.3.4 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 shall be the same as that of the test specimen.

4 MEASURING PROCEDURE

Each instrument shall be operated in accordance with the instructions of the manufacturer. Appropriate attention shall be given to the factors listed in section 2.

The calibration of the instrument shall be checked after a warm-up period, at the test site, each time the instrument is put into service, and at regular intervals during use, at least once a day, to assure proper performance.

The following precautions shall be observed :

4.1 Basis metal thickness (Type A coatings only)

Check whether the basis metal thickness exceeds the critical thickness. If not, either use the back-up method mentioned in 3.3.3, or make sure that the calibration has been made on a standard having the same thickness and magnetic properties as the test specimen.

4.2 Edge effects

Readings shall not be made close to an edge, hole, inside corner, etc., of a specimen, unless the validity of the calibration for such a measurement has been demonstrated.

4.3 Curvature

Readings shall not be made on a curved surface of a specimen, unless the validity of the calibration for such a measurement has been demonstrated.

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.

Instruments of the attractive-force type are sensitive to vibrations, and readings that are obviously too high shall be rejected.

4.5 Direction of mechanical working (Type A coatings only)

If the direction of mechanical working has a pronounced effect on the reading, the measurement on the test specimen shall be made with the probe in the same orientation as that used during calibration. If this is impossible, four measurements shall be made in various orientations by rotating the probe in increments of 90° .

4.6 Residual magnetism (Type A coatings only)

When residual magnetism is present in the basis metal, it is necessary, when using two-pole instruments employing a stationary magnetic field, to make measurements in two orientations differing by 180° . It may also be necessary to demagnetize the test specimen to get valid results. (See 2.7 and 2.8.)

4.7 Surface cleanliness

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

4.8 Techniques

The readings obtained may depend on the technique of the operator. For example, the pressure applied to a probe, or the rate of applying a balancing force to a magnet, will vary from one individual to another. Such effects can be reduced or minimized either by having the instrument calibrated by the same operator who will make the measurement, or by using constant pressure probes.

4.9 Positioning of the probe

The instrument probe shall be placed perpendicularly to the specimen surface at the point of measurement.

5 MEASURING ACCURACY

The instrument, its calibration and its operation shall be such that the coating thickness can be determined within $\pm 10\%$ or $\pm 1\ \mu\text{m}$, whichever is greater, of its true thickness.

If it is not practical to meet the accuracy requirements, allowance shall be made for less reliable measurements, and the contracting parties shall agree on the acceptability of this test method and of the less reliable measurements.

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