International Standard 2178

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method

Revêtements métalliques non magnétiques sur métal de base magnétique — Mesurage de l'épaisseur du revêtement — Méthode magnétique

Second edition — 1982-08-01

UDC 669.058 : 531.717 : 621.317.49 **Ref. No. ISO 2178-1982 (E)**

Descriptors : metal coatings, non-metallic coatings, vitreous enamels, porcelain enamels, dimensional measurement, magnetic tests, base metal.

Price based on 4 pages

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 2178 was developed by Technical Committee ISO/TC 107, *Metallic and other non-organic coatings*, and was circulated to the member bodies in November 1980.

It has been approved by the member bodies of the following countries :

Australia	Italy	Sweden
Bulgaria	Japan	Switzerland
Czechoslovakia	Netherlands	United Kingdom
France	Poland	USA
Germany, F. R.	Romania	USSR
Hungary	South Africa, Rep. of	
India	Spain	

No member body expressed disapproval of the document.

This second edition cancels and replaces the first edition (i.e. ISO 2178-1972).

Printed in Switzerland

Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method

1 Scope and field of application

This International Standard specifies the method of using coating thickness instruments of the magnetic type for non-destructive measurements of the thickness of non-magnetic coatings (including vitreous and porcelain enamel coatings) on magnetic basis metals.

The method is applicable only for measurements on reasonably flat specimens. In the case of nickel coatings on non-magnetic substrates, the preferred method is that specified in ISO 2361.

2 References

ISO 2064, *Metallic and other non-organic coatings — Definitions and conventions concerning the measurement of thickness.*

ISO 2361, *Electrodeposited nickel coatings on magnetic and non-magnetic substrates — Measurement of coating thickness — Magnetic method.*

3 Principle

Coating thickness instruments of the magnetic type measure either the magnetic attraction between a permanent magnet and the basis metal, as influenced by the presence of the coating, or the reluctance of a magnetic flux path passing through the coating and the basis metal.

4 Factors affecting the measuring accuracy[1)]

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

4.1 Coating thickness

The precision of a measurement changes with coating thickness depending on the instrument design. For thin coatings, the precision is constant, independent of the thickness. For thick coatings, the precision is an approximately constant fraction of the thickness.

4.2 Magnetic properties of the basis metal

Thickness measurements by the magnetic method are affected by variations in the magnetic properties of the basis metal. For practical purposes, magnetic variations in low carbon steels can be considered to be insignificant. To avoid the influences of several, or localized, heat treatments and cold working, the instrument should be calibrated using a calibration standard having a basis metal with the same 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

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

4.4 Edge effects

The method is sensitive to abrupt changes in 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. The effect may extend up to about 20 mm from the discontinuity, depending on the instrument.

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 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.

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

1) For the purpose of this International Standard, the measuring uncertainty is defined as that obtained with an instrument correctly calibrated and used.

4.6 Surface roughness

If the range of a series of measurements, made within the same reference area (see ISO 2064) on a rough surface, substantially exceeds the inherent repeatability of the instrument, the number of measurements required should be increased to at least five.

4.7 Direction of mechanical working of the basis metal

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.

4.8 Residual magnetism

Residual magnetism in the basis metal affects 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 (see 6.7).

4.9 Magnetic fields

Strong magnetic fields, such as those produced by various types of electrical equipment, can seriously interfere with the operation of instruments which employ a stationary magnetic field (see 6.7).

4.10 Foreign particles

The probes of the 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 the surface of the coating. The probe tip should be checked for cleanliness.

4.11 Conductivity of coating

Some magnetic instruments work at frequencies between 200 and 2 000 Hz. At these frequencies, eddy currents produced in thick, highly conductive coatings may interfere with the reading.

4.12 Probe pressure

The poles of the test probe have to be applied at a constant but sufficiently high pressure, such that no deformation of the coating occurs, even if the coating material is soft. Alternatively, soft coatings may be covered with foils, and the thickness of the foils subtracted from the test results. Such considerations are also necessary if measuring the thickness of phosphate coatings.

4.13 Probe orientation

The readings of instruments using the magnetic attraction principle may be affected by the orientation of the magnet in relation to the field of gravity of the earth. Thus, the operation of an instrument probe in a horizontal or upside-down position may require a different calibration, or may be impossible.

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 or by comparing magnetic thickness measurements made on a selection of the test specimens with thickness measurements made by the method specified in the International Standard for the particular coating concerned. For instruments which cannot be calibrated, the deviation from the nominal value shall be determined by comparison with calibration standards and shall be taken into consideration for all measurements.

During use, the calibration of the instrument shall be checked at frequent intervals. Appropriate attention shall be given to the factors listed in clause 4 and to the procedures specified in clause 6.

5.2 Calibration standards

Calibration standards of uniform thickness are available either as shims or foils, or as coated standards.

5.2.1 Calibration foils

NOTE — In this sub-clause, the word "foil" is used to imply a non-magnetic metallic or non-metallic foil or shim.

Because of the difficulty of ensuring adequate contact, foils are not generally recommended for the calibration of instruments using the magnetic attraction principle, but they are suitable for use in some circumstances provided that necessary precautions are taken. They can normally be used for the calibration of other types of instruments.

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

To prevent measurement errors, it is necessary to ensure that intimate contact is established between foil and basis metal. Resilient foils should 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 coatings of known, uniform thickness permanently bonded to a basis metal.

5.3 Verification

5.3.1 The surface roughness and magnetic properties of the basis metal of the calibration standards shall be similar to those