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Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces

Peintures et vernis — Anticorrosion des structures en acier par systèmes de peinture — Mesure et critères d'acceptation de l'épaisseur d'un feuil sec sur des surfaces rugueuses

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19840 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 14, *Protective paint systems for steel structures*.

This second edition cancels and replaces the first edition (ISO 19840:2004), which has been technically and editorially revised as follows:

a) the descriptions in 4.2 of the principle of the measurement methods have been improved;

b) a description of eddy current measurement equipment has been introduced (see 5.2.4);

c) Figure 1 has been made language-independent;

d) in line A8 in Annex E, the references to lines A7 and A8 have been corrected to A6 and A7;

e) in line B1 in Annex E, the reference to ISO 8503-1 has been corrected to “the relevant part of ISO 8501”;

f) a Bibliography has been added for the informative references ISO 8501-1 to ISO 8501-4.

Introduction

This International Standard supplements the ISO 12944 series with regard to the measurement and acceptance criteria for the thickness of a dry film. If specified or agreed, the standard can also be used for other applications.

The objective of this International Standard is to achieve uniformity of practice for measuring the dry-film thickness of a coating on a roughened surface. The chosen methods entail the measurement of dry-film thickness using measurement instruments based on the permanent magnet principle and the inductive magnet principle. Instruments using the eddy current principle can be used but their use is normally on non-ferrous metal surfaces.

If a coating is applied to a roughened steel substrate, the measurement of its dry-film thickness is more complicated than for smooth surfaces. Roughened steel substrates include those prepared by abrasive blast-cleaning or abrading.

The effect of surface roughness on the measurement result increases with profile depth, but the result will also depend on the design of the measurement probe and the thickness of the coating.

Annex A, which is informative, is a method based on adjusting the instrument to known thicknesses on a rough surface. In this method, no correction value is used. In this standard, individual readings are used. Annex B describes a method for multiple readings. The methods in Annexes A and B are intended to be used only if specified or agreed.

Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces

1 Scope

This International Standard specifies a procedure for the verification of dry-film thickness against nominal dry-film thickness on rough surfaces, including the adjustment of the instruments used, the definition of inspection areas, sampling plans, measurement methods and acceptance/rejection criteria.

For the purposes of this standard, any specified thickness is taken to be nominal as defined in ISO 12944-5, and the dry-film thickness is the typical thickness above the peaks of the surface profile.

The procedure described in this International Standard is based on the use of instruments of the permanent magnet, electromagnet and eddy current type. Instrument accuracy is verified both at zero and at a known thickness on a smooth surface and adjusted if necessary.

Measurements taken on a coating on a roughened steel substrate will therefore be higher than the actual value above the peaks of the profile. The thickness of the dry film above the peaks of the profile is defined as the instrument reading minus an appropriate correction value.

The dry-film thickness is obtained by using the appropriate correction value applied to readings based on adjustment on a smooth, flat steel surface.

Where individual readings, based on adjustment on a smooth, flat steel surface without the use of correction values, are specified or agreed, it is important to recognize that this method does not conform with this International Standard.

This standard is applicable if the nominal dry-film thickness is 40 µm or greater.

NOTE If the nominal thickness is less than the surface roughness of the substrate, the uncertainty of the measurement will increase.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 8503-1, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces*

ISO 12944-1, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 1: General introduction*

ISO 12944-2, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments*

ISO 12944-3, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 3: Design considerations*

ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation*

ISO 12944-5, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 5: Protective paint systems*

ISO 12944-6, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 6: Laboratory performance test methods*

ISO 12944-7, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 7: Execution and supervision of paint work*

ISO 12944-8, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 8: Development of specifications for new work and maintenance*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
dry-film thickness
DFT
thickness of a coating remaining over the peaks of a rough surface when the coating has hardened

3.2
individual reading
figure displayed by the film thickness instrument

3.3
correction value
allowance for the influence of the abrasive blast-cleaned or otherwise roughened surface on the reading of the film thickness instrument

3.4
individual dry-film thickness
individual reading minus a correction value

3.5
mean dry-film thickness
arithmetic mean of all the individual dry-film thicknesses in the inspection area

3.6
nominal dry-film thickness
NDFT
dry-film thickness specified for each coat or for the whole paint system to achieve the required durability

3.7
inspection area
designated area for which a sampling plan is established and which can be the whole structure or sections of the whole structure

3.8
sampling plan
plan which defines the number of measurements to be taken on an inspection area

3.9
adjustment
process of aligning the readings of a dry-film thickness gauge to known thickness values in order to improve the accuracy of the gauge on a specific surface or within a specific portion of its measurement range

3.10
surface profile
micro-roughness of a surface

NOTE This is generally expressed as the height of the major peaks relative to the major valleys.

[ISO 8503-1:2012]

3.11
maximum dry-film thickness
highest acceptable dry-film thickness above which the performance of the paint or the paint system might be impaired

4 Principle

4.1 General

The thickness of the coating on the prepared steel surface is measured using one of the non-destructive methods described in ISO 2808. The measurement instruments used are adjusted. For the measurement, a sampling plan is laid down as well as an appropriate correction value.

This International Standard also specifies criteria which are used with regard to acceptance or non-acceptance of film thickness values.

4.2 Principle of the applicable measurement methods

4.2.1 Permanent-magnet principle

Instruments of this type produce a static magnetic field. They measure the magnetic field strength between a permanent magnet and a magnetic substrate. The magnetic field strength is related to the coating thickness.

4.2.2 Pull-off permanent-magnet principle

Instruments of this type produce a static magnetic field. They measure the force required to overcome the magnetic attraction between a magnet and a magnetic substrate. This force is related to the coating thickness.

4.2.3 Magnetic-induction principle

Instruments of this type use an electronic probe to generate a magnetic field with either a permanent magnet (with a Hall sensor) or an electromagnet (with an electromagnetic induction coil). They produce a coating thickness measurement by measuring the change in magnetic field strength within their probes due to the proximity of the magnetic substrate. The magnetic field strength is related to the coating thickness.

NOTE Other methods using a similar principle are available.

4.2.4 Eddy current principle

Instruments of this type — mainly used on non-magnetic metal substrates — produce a varying high-frequency magnetic field. They measure the magnetic field strength produced by eddy currents caused by the probe in a conductive substrate. The magnetic field strength is related to the coating thickness.

5 Apparatus and materials

5.1 General

All instruments for measuring dry-film thicknesses will give variable values within very small areas on roughened surfaces due to the influence of the surface roughness and the variations inherent in the method(s) used to apply the paint.

The type of measurement equipment and material shall be specified or agreed between the interested parties before the measurements commence.

5.2 Measurement equipment using a magnetic field

5.2.1 Electromagnet

Instruments using this principle may be equipped with either a single- or twin-pole probe.

This equipment may incorporate a statistical capability. This enables the minimum, maximum, mean and standard deviation to be calculated.

When using a twin-poled instrument, it is recommended that the instrument be moved to positions 90°, 180° and 270° from the original position where the first reading was made, for example the instrument is pivoted around the first point of measurement. The mean value of the four readings taken should be determined and represents the dry-film thickness at the particular spot. In this case, the arithmetic mean value of the four readings is used in place of an individual reading.

5.2.2 Permanent magnet

Instruments of this type incorporate a permanent magnet with one or more poles in the form of hemispherical contacts which are placed on the coated surface.

When using a twin-poled instrument, it is recommended that the instrument be moved to positions 90°, 180° and 270° from the original position where the first reading was made, for example the instrument is pivoted around the first point of measurement. The mean value of the four readings taken should be determined and represents the dry-film thickness at the particular spot. In this case, the arithmetic mean value of the four readings is used in place of an individual reading.

5.2.3 Magnetic pull-off

This type of instrument most commonly incorporates a permanent magnet to which is attached a spring. Various forms of the instrument are available, including a simple pencil type, a spring balance type and another type to which tension is applied by turning a calibrated circular dial until the magnet and attached spring detach from the coated surface.

Instruments as described in 5.2.2 and 5.2.3 have a fixed scale graduation and should only be used when a lower level of accuracy can be accepted. They can only be adjusted at one particular point on the scale, and this adjustment will have a limited effect on calibration over the full range.

5.2.4 Eddy current

This type of instrument commonly utilizes an electromagnet to produce a magnetic field. The strength of the magnetic field is related to the coating thickness. These instruments are mainly used to measure the thickness of coatings on non-magnetic (i.e. non-ferrous) metal substrates.

5.3 Materials

5.3.1 Foils/shims

Foils/shims with verified thickness with assigned values traceable to recognized standards and with thicknesses above the dry-film thickness to be measured are preferred.

The use of other foils/shims is permitted provided they are verified by a traceable method.

Care should be taken to ensure that foils/shims are in good condition before they are used. Foils/shims will wear more quickly when used on roughened surfaces.

5.3.2 Uncoated test plates

Use an uncoated, smooth, flat, visually clean, square, rectangular or circular steel test plate free of mill scale and at least 3 mm thick and with a minimum side or diameter of 25 mm.

5.3.3 Pre-coated test plates

Use certified, smooth, flat, visually clean pre-coated steel test plates with assigned values traceable to recognized standards and with coating thicknesses near to the expected dry-film thickness to be measured. The dimensions shall be at least equal to those specified in 5.3.2.

6 Procedure

6.1 Sampling plan

The sampling plan defines the number of measurements to be taken in an inspection area. If the structure has not been divided into individual inspection areas, the whole structure is considered as the inspection area for measuring the dry-film thickness.

NOTE Inspection areas will normally be defined in the project specification (see also ISO 12944-7 and ISO 12944-8).

The procedures for areas requiring special consideration, such as welds, edges, corners, fixtures, areas with observed defects, shall be agreed by the interested parties. For more details, see Annex C.

The minimum number of randomly taken measurements to be taken for verifying the dry-film thickness on inspection areas is given in Table 1. The number of measurements given is generally considered as being representative for inspection areas for the purposes of this International Standard. This number shall be increased for inspection areas having a difficult configuration with regard to paint application or measurement or limitations in accessibility (difficult areas). Each difficult area, e.g. stiffeners, brackets, supports, attached piping, shall have additional random measurements taken appropriate to its area in accordance with Table 1, over and above the random measurements in the inspection area.

Table 1 — Sampling plan

Area/length of inspection area m^2 or m	Minimum number of measurements	Maximum number of measurements allowed to be repeated (see 6.3)
up to 1	5	1
above 1 to 3	10	2
above 3 to 10	15	3
above 10 to 30	20	4
above 30 to 100	30	6
above 100[a]	add 10 for every additional 100 m^2 or 100 m or part thereof	20 % of the minimum number of measurements

[a] Areas above 1 000 m^2 or m should be divided into smaller inspection areas.

6.2 Adjustment of the instrument

Before use, it shall be ascertained that the instrument is in good working condition and correctly adjusted. Verification shall then be carried out on uncoated test plates (5.3.2) at zero and with verified foils/shims (5.3.1) above and below the specified dry-film thickness. Pre-coated test plates (5.3.3) may be used instead of verified foils/shims.