INTERNATIONAL STANDARD

ISO 2808

Fourth edition
2007-02-01

Paints and varnishes — Determination of film thickness

Peintures et vernis — Détermination de l'épaisseur du feuil

Reference number
ISO 2808:2007(E)

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Published in Switzerland

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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 2808 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This fourth edition cancels and replaces the third edition (ISO 2808:1997), which has been technically revised. The main changes are as follows:

a) The structure of the standard has been changed into four main clauses:

   1) determination of wet-film thickness;

   2) determination of dry-film thickness;

   3) determination of the thickness of uncured powder layers; and

   4) measurement of film thickness on rough surfaces.

b) Methods using photothermal, radiological and acoustic techniques have been added.

c) The split-beam method has been deleted as such instruments are no longer manufactured.

Introduction

Measurement of film thickness depends on the following steps:

a) calibration of the measurement instrument, typically performed by the manufacturer or by any qualified laboratory;

b) verification of the instrument (an accuracy check performed by the user at regular intervals, typically before each series of measurements);

c) subsequent adjustment, if necessary, of the instrument so that the thickness readings it gives match those of a specimen of known thickness. For a dry-film thickness gauge this would mean zeroing it on the uncoated surface, using devices of known thickness such as shims, or using a coated specimen of known film thickness;

d) measurement.

Paints and varnishes — Determination of film thickness

1 Scope

This International Standard describes a number of methods that are applicable to the measurement of the thickness of coatings applied to a substrate. Methods for determining wet-film thickness, dry-film thickness and the film thickness of uncured powder layers are described. Reference is made to individual standards where these exist. Otherwise the method is described in detail.

An overview on the methods is given in Annex A, in which the field of application, existing standards and the precision are specified for the individual methods.

This International Standard also defines terms concerning the determination of film thickness.

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 463, *Geometrical Product Specifications (GPS) — Dimensional measuring equipment — Design and metrological characteristics of mechanical dial gauges*

ISO 3611, *Micrometer callipers for external measurement*

ISO 4618:2006, *Paints and varnishes — Terms and definitions*

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 and the following apply.

3.1
substrate
surface to which a coating material is applied or is to be applied

[ISO 4618:2006]

3.2
coating
continuous layer formed from a single or multiple application of a coating material to a substrate

[ISO 4618:2006]

3.3
film thickness
distance between the surface of the film and the surface of the substrate

3.4
wet-film thickness
thickness of a freshly applied wet coating material, measured immediately after application

3.5
dry-film thickness
thickness of a coating remaining on the surface when the coating has hardened

3.6
thickness of uncured powder layer
thickness of a freshly applied coating material in powder form, measured immediately after application and before stoving

3.7
relevant surface area[1)]
part of an article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance

3.8
test area[1)]
representative part of the relevant surface area within which an agreed number of single measurements is made as a spot-check

3.9
measurement area[1)]
area over which a single measurement is made

3.10
minimum local film thickness[1)]
lowest value of the local film thickness found on the relevant surface area of a particular test specimen

3.11
maximum local film thickness[1)]
highest value of the local film thickness found on the relevant surface area of a particular test specimen

3.12
mean film thickness[1)]
arithmetic mean of all the individual dry-film thicknesses in the test area or the result of a gravimetric determination of the thickness

3.13
calibration
controlled and documented process of measuring traceable calibration standards and verifying that the results are within the stated accuracy of the measurement instrument

NOTE Initial calibration is typically performed by the instrument manufacturer or by a qualified laboratory in a controlled environment using a documented process. This initial calibration will normally be verified by the user at regular intervals. The standards used in the calibration are such that the combined uncertainties of the resultant measurement are less than the stated accuracy of the instrument.

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1) Measurement of this property is only required for the extended evaluation of film thickness measurements; see Clause 8 (test report), items k) and l).

3.14
verification
accuracy check performed by the user using reference standards

3.15
reference standard
specimen of known thickness against which a user can verify the accuracy of the measurement instrument

NOTE Reference standards may be coated thickness standards, or shims. If agreed to by the contracting parties, a part of the test specimen may be used as a thickness standard for a particular job.

3.16
adjustment
act of aligning the measurement instrument's thickness readings to match those of a reference standard

NOTE Most electronic measurement instruments can be adjusted on a thickness standard or on a shim, where the thickness of the coating or of the shim is known.

3.17
accuracy
consistency between a measured value and the true value of the thickness standard

4 Determination of wet-film thickness

4.1 General

Annex A gives an overview of the methods used for the determination of wet-film thickness.

4.2 Mechanical methods

4.2.1 Principle

In all mechanical methods the substrate surface is contacted by part of the measurement instrument through the coating, and the surface of the coating is contacted simultaneously (see Figure 1) or subsequently (see Figures 2 and 3) by another part of the instrument. The wet-film thickness is the height difference between these two points of contact, which can be read directly.

4.2.2 Field of application

The mechanical principle is suitable for all film-substrate combinations. The substrate has to be flat in at least one direction in the area where the measurement is conducted. Curvature of the surface in a single plane is permissible (e.g. internal or external surface of pipes).

4.2.3 General

Classification as a destructive or non-destructive method depends on:

a) the rheological properties of the coating material;

b) the nature of the wetting contact between the contact surfaces of the measurement instrument and the coating material;

c) whether the thickness measurements will make the coating unsuitable for the purpose for which it is intended.

Since the possibility of pigment particles remaining between the gauge and the substrate cannot be excluded, all mechanical methods contain a systematic error: the film thickness displayed is smaller than the actual wet-film thickness by at least the mean diameter of the pigment particles.

In the case of a wheel gauge (method 1B, see 4.2.5), the wheel has to be wetted by the coating material. If not, this represents a further source of systematic error which can result in exaggerated readings and is a function of:

— the surface tension and the rheological properties of the coating material;

— the material of the wheel gauge;

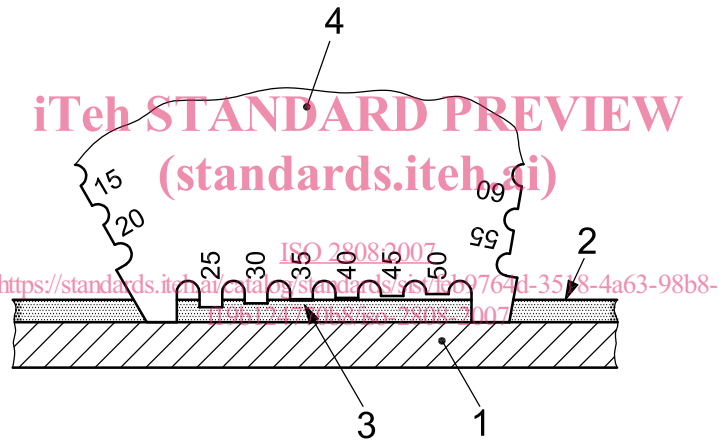
— the speed at which the wheel is turned.

4.2.4 Method 1A — Comb gauge

4.2.4.1 Description of instrument

A comb gauge is a flat plate made of a corrosion-resistant material with teeth along its edges (see Figure 1). The reference teeth at the corners of the plate define a baseline along which the inner teeth are arranged to give a graduated series of gaps. Each tooth is labelled with the assigned gap value.

With commercially available comb gauges the maximum thickness which can be measured is typically 2 000 µm and the smallest increment is typically 5 µm.



Key

1 substrate
2 coating
3 point of wetting contact
4 comb gauge

Figure 1 — Example of a comb gauge

4.2.4.2 Procedure

Ensure that the teeth are clean and not worn or damaged. Place the comb gauge onto the flat specimen surface such that the teeth are normal to the plane of the surface. Allow sufficient time for the coating to wet the teeth prior to removing the gauge.

In the case of specimens curved in a single plane, the comb gauge shall be placed in position parallel to the axis of curvature.

The result of the thickness measurement depends on the time of measurement. The thickness should therefore be measured as soon as possible after application.

Note the greatest gap reading of the tooth wetted by the coating material as the wet-film thickness.

4.2.5 Method 1B — Wheel gauge

4.2.5.1 Description of instrument

A wheel gauge consists of a wheel, made of hardened and corrosion-resistant steel, with three projecting rims (see Figure 2).

Two rims are ground to the same diameter and are configured concentrically to the wheel axle. The third rim has a smaller diameter and is eccentrically ground. One of the outer rims has a scale from which the respective projection of the concentric rims relative to the eccentric rim can be read.

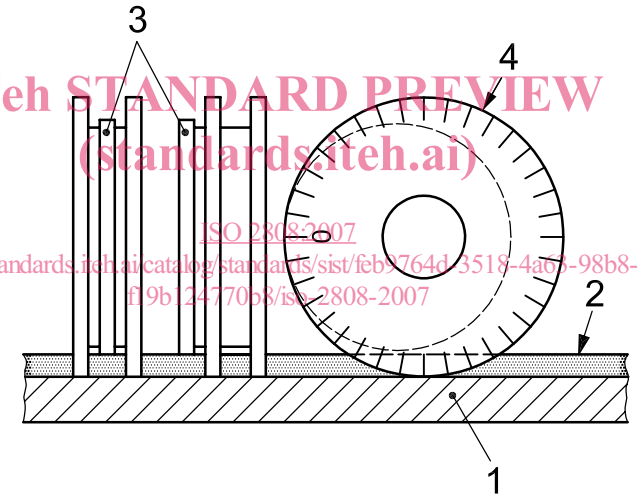
Two versions are available:

— version 1 has the eccentric rim located between the concentric rims;

— version 2 has the eccentric rim located outside the concentric rims and closely adjacent to one of them.

NOTE Unlike version 1, the design of version 2 allows parallax-free reading of the wet-film thickness.

With commercially available wheel gauges, the maximum thickness which can be measured is typically 1 500 µm and the smallest increment is typically 2 µm.



Key

1 substrate
2 coating
3 eccentric rim
4 wheel gauge

Figure 2 — Example of a wheel gauge

4.2.5.2 Procedure

Grip the wheel gauge with the thumb and index finger by the wheel axle and press the concentric rims onto the surface at the point of the largest reading on the scale.

In the case of specimens curved in a single plane, the axis of curvature and the wheel gauge axle shall be parallel.

Roll the wheel gauge in one direction, lift it from the surface and read off the highest scale reading at which the eccentric rim is still wetted by the coating material. Clean the gauge and repeat in the other direction.

Calculate the wet-film thickness as the arithmetic mean of these readings.

The result of the thickness measurement depends on the time of measurement. The thickness should therefore be measured as soon as possible after application.

To minimize the effect of surface tension on the result, observe how the paint wets the eccentric rim and record the scale reading at the first point of contact. This is only possible with version 2 of the wheel gauge.

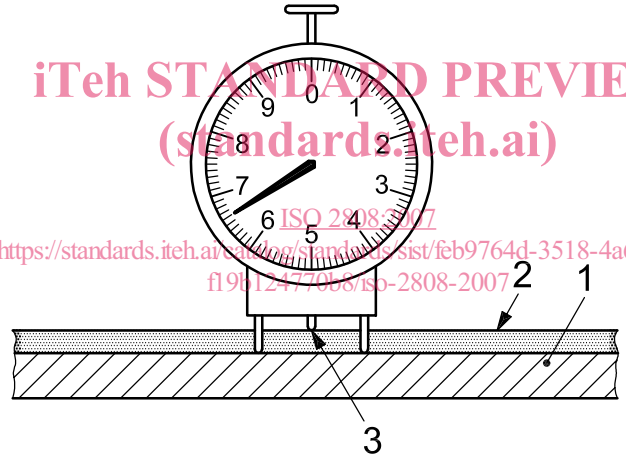
4.2.6 Method 1C — Dial gauge

4.2.6.1 Instrument and reference standards

4.2.6.1.1 **Dial gauge** (see Figure 3)

Mechanical dial gauges conforming to the requirements of ISO 463 and electronic dial gauges are typically capable of measuring to an accuracy of 5 µm (mechanical dial gauge) or 1 µm (electronic dial gauge), or better. The gauge can have an analogue or digital display.

The underside of the dial gauge has two contact pins of equal length located equidistant from the movable plunger and in a straight line with it. An adjusting screw is used to make fine adjustments to the position of the plunger in its guideway.



Key

1 substrate
2 coating
3 plunger

Figure 3 — Example of a dial gauge

4.2.6.1.2 Reference standard for zeroing the gauge

A flat reference plate is required for zeroing the gauge. The reference plate shall consist of a flat glass plate whose flatness tolerance does not exceed 1 µm (see also ISO 1101 [1]).

4.2.6.2 Procedure

Zero the dial gauge on the reference plate with the measuring tip adjusted so that it is just touching the plate.

Screw the plunger back from the zeroing position. Place the contact pins of the dial gauge on the specimen so that they are normal to the surface of the substrate and carefully screw the plunger down until the measuring tip is just touching the coating material.

The result of the thickness measurement depends on the time of measurement. The thickness should therefore be measured as soon as possible after application.

Read the wet-film thickness directly from the gauge.

4.3 Gravimetric method

4.3.1 Principle

A coating is applied and the thickness is determined by dividing the mass of the coating by its density and by the coated surface area.

The wet-film thickness, t_w, in micrometres, is calculated from the equation

$$t_w = \frac{m - m_0}{A \cdot \rho} \quad (1)$$

where

m_0 is the mass of the uncoated specimen, in grams;

m is the mass of the coated specimen, in grams;

A is the coated surface area, in square metres;

ρ is the density of the liquid coating material applied, in grams per millilitre.

NOTE The density of the liquid coating material applied can be determined in accordance with ISO 2811-1, ISO 2811-2, ISO 2811-3 or ISO 2811-4.

4.3.2 Field of application

The gravimetric principle is generally applicable, provided that the amount of highly volatile substances in the liquid coating material is low.

4.3.3 General

Determination using the gravimetric principle yields the mean value of the wet-film thickness over the entire coated surface area. With spray application in particular, the reverse side of the specimen shall be masked to prevent measurement errors resulting from partial coating of the reverse (overspray). Any masking of the reverse side shall be removed before weighing the coated specimen.

4.3.4 Method 2 — By difference in mass

4.3.4.1 Apparatus

Required are scales capable of weighing up to 500 g to the nearest 1 mg.

4.3.4.2 Procedure

Weigh the specimen first uncoated and then coated and calculate the wet-film thickness using Equation (1).