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(JPMA/JSA)

**Testing methods for paints—
Part 1: General rule—Section 7:
Determination of film thickness**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Paint Manufacturers Association (JPMA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS K 5600-1-7:1999** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

JIS K 5600 series consists of the following 9 parts under the general title “*Testing methods for paints*”:

Part 1: General rule

Part 2: Characteristics and stability of paints

Part 3: Film formability

Part 4: Visual characteristics of film

Part 5: Mechanical property of film

Part 6: Chemical property of film

Part 7: Long-period performance of film

Part 8: Evaluation of degradation of paint coatings

Part 9: Coating powders

JIS K 5600-1 consists of the following 8 parts under the title of “*Testing methods for paints—Part 1: General rule*”:

Section 1: General test methods (conditions and methods)

Section 2: Sampling

Section 3: Examination and preparation of samples for testing

Section 4: Standard panels for testing

Section 5: Coating of test panel (brush application)

Section 6: Temperatures and humidities for conditioning and testing

Section 7: Determination of film thickness

Section 8: Reference sample

Testing methods for paints— Part 1: General rule— Section 7: Determination of film thickness

Introduction

This Japanese Industrial Standard has been prepared based on the fourth edition of **ISO 2808** published in 2007 with some modifications of the technical contents.

The portions given dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with the explanations is given in Annex JA.

1 Scope

This 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.

NOTE 1 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.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 2808:2007 *Paints and varnishes—Determination of film thickness* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7502 *Micrometer callipers*

JIS B 7503 *Mechanical dial gauges*

JIS G 3141 *Cold-reduced carbon steel sheet and strip*

JIS K 5500 *Glossary of terms for coating materials*

JIS R 6252 *Abrasive papers*

JIS R 6253 *Waterproof abrasive papers*

- ISO 2811-1 *Paints and varnishes—Determination of density—Part 1: Pyknometer method*
- ISO 2811-2 *Paints and varnishes—Determination of density—Part 2: Immersed body (plummet) method*
- ISO 2811-3 *Paints and varnishes—Determination of density—Part 3: Oscillation method*
- ISO 2811-4 *Paints and varnishes—Determination of density—Part 4: Pressure cup method*
- ISO 8130-2 *Coating powders—Part 2: Determination of density by gas comparison pyknometer (referee method)*
- ISO 8130-3 *Coating powders—Part 3: Determination of density by liquid displacement pyknometer*
- 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 19840 *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*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS K 5500**, and the following apply.

3.1 substrate

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

3.2 test panel

substrate whose surface has been prepared before coating application

3.3 test piece

substrate prepared to an appropriate size for a test after coating application

3.4 coating

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

3.5 film thickness

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

3.6 wet-film thickness

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

3.7 dry-film thickness

thickness of a coating remaining on the surface when the coating has hardened

3.8 thickness of uncured powder layer

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

3.9 relevant surface area

part of an article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance

3.10 test area

representative part of the relevant surface area within which an agreed number of single measurements is made as a spot-check

3.11 measurement area

area over which a single measurement is made

3.12 minimum local film thickness

lowest value of the local film thickness found on the relevant surface area of a particular test specimen

3.13 maximum local film thickness

highest value of the local film thickness found on the relevant surface area of a particular test specimen

3.14 mean film thickness

arithmetic mean of all the individual dry-film thicknesses in the test area or the result of a gravimetric determination of the thickness

3.15 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 1 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.

NOTE 2 Initial calibration is typically performed by the instrument manufacturer or by a qualified laboratory in a controlled environment using a documented process.

3.16 verification

accuracy check performed by the user using reference standards

3.17 reference standard

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

NOTE 1 If agreed to by the contracting parties, a part of the test specimen may be used as a thickness standard for a particular job.

NOTE 2 Reference standards may be coated thickness standards, or shims.

3.18 adjustment

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

3.19 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.

This Standard specifies mechanical (comb gauge and wheel gauge) and gravimetric methods (by difference in mass).

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, to be selected from Table A.1 according to the following properties of the substrate and coating. The substrate has to be flat in at least one direction in the area where the measurement is conducted, therefore is inapplicable to round shape. Curvature of the surface in a single plane is permissible (e.g. internal or external surface of pipes).

4.2.3 General

In film thickness measurement, 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 Method 1A—Comb gauge

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 .

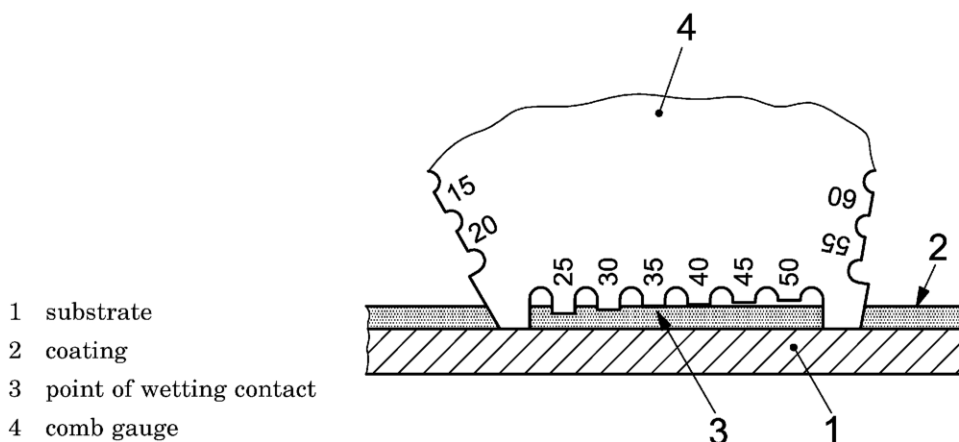


Figure 1 Example of a comb gauge

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 Wheel gauge

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.

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 .

In the case of a wheel gauge, the rim 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 rim is turned.

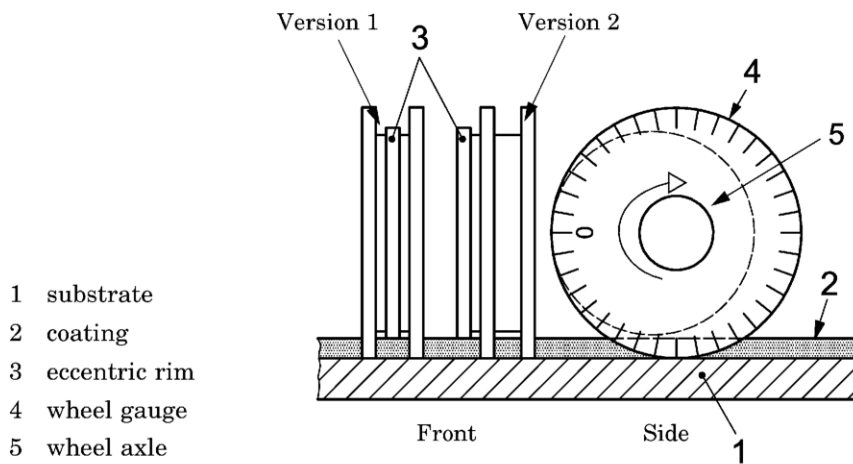


Figure 2 Example of a wheel gauge

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.

- b) 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.
- c) Clean the gauge and repeat in the other direction.
- d) 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.

4.3 Gravimetric method

4.3.1 Principle

A coating is applied and the thickness, t_w (μm), is determined by dividing the mass of the coating by its density and by the coated surface area.

$$t_w = \frac{m - m_0}{A \times \rho} \dots\dots\dots (1)$$

where, m_0 : the mass of the uncoated specimen, in grams;
 m : the mass of the coated specimen, in grams;
 A : the coated surface area, in square metres;
 ρ : the density of the liquid coating material applied, in grams per millilitre.

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.**

NOTE : Conversion to film thickness $\text{ml}/\text{M}^2 = 1 \mu\text{m}$ ($\text{ml} = 1 \times 10^{-6} \text{M}^3$, $1 \times 10^{-6} \text{M}^3/\text{M}^2 = 10^{-6} \text{M} = 1 \mu\text{m}$)

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).

5 Determination of dry-film thickness

5.1 General

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

This Standard specifies mechanical, gravimetric, optical, magnetic, radiological, and acoustic methods.

5.2 Mechanical methods

5.2.1 Principle

A micrometer or dial gauge (see **5.2.4**) is used to measure the film thickness as the difference between the total thickness (substrate + film) and the substrate thickness. There are two ways of determining the film thickness:

- a) **Measurements are made before and after coating removal (destructive)**
The total thickness is first measured in a defined measurement area and then, after the coating has been removed in the measurement area, the substrate thickness is measured.
- b) **Measurements are made before and after coating application (non-destructive)**
The substrate thickness is first measured and then the total thickness is measured in the same measurement area after coating.

The film thickness is calculated from the difference between the two readings.

A micrometer or dial gauge shall be used in measurements before and after coating application. A depth gauge (see **5.2.5**) or a profilometer (see **5.2.6**) shall be used in measurements before and after coating material.

The coating on a test piece, when removed, shall be scraped in its part by a knife or cutter to reach the substrate so that a ledge can be created. When the substrate is soft, the coating shall be removed by solvent.

5.2.2 Field of application

The mechanical principle is basically suitable for all film-substrate combinations. Where mechanical gauging is used, the substrate and coating shall be hard enough to prevent the reading from being falsified as a result of the measuring tip creating an indentation. The micrometer or dial gauge (**5.2.4**) is also suitable for measuring the film thickness of cylindrical specimens of circular cross-section (e.g. wires, pipes). The profilometer (**5.2.6**) is recognized as the referee method in the event of disputes.

5.2.3 General

In the “coating application” variant, a template with labelled holes is used to ensure that the determination of the substrate thickness and total thickness is carried out at exactly the same points.

NOTE 1 The “coating application” variant is preferred in the case of plastic substrates since in most cases the substrate cannot be exposed without causing damage.

In the “coating removal” variant, the measurement areas shall be circled and labelled. The coating shall be carefully and completely removed in the measurement areas without damaging the substrate mechanically or chemically.

The substrate may be partly masked using adhesive tape before coating in order to obtain well-defined steps from one layer to the next. In the case of the depth gauge and profilometer (**5.2.5** and **5.2.6**), the coating which is not removed in the region of the measurement area shall remain undamaged. In the case of the profilometer (**5.2.6**), the shoulder between the substrate and the film surface shall be sufficiently well defined.

With hard substrates (e.g. glass) the coating can be removed mechanically, but with less hard substrates (e.g. steel) the coating shall be removed chemically using a solvent or paint remover.

NOTE 2 In the case of less hard substrate materials such as steel, the film can be cut through with a core drill of 10 mm diameter and the disc of coating thus formed removed with a solvent or paint remover.

All surfaces (coating, substrate, reverse side of specimen) which are contacted or gauged shall be clean and free from film residues.

5.2.4 Method 4A—By difference in thickness

5.2.4.1 Description of instrument

5.2.4.1.1 Micrometer, as specified in JIS B 7502.

Version 1—Fixed to a stand A micrometer head (see JIS B 7502) with a plane measuring face is clamped to a rigid stand with a flat baseplate such that its height can be adjusted. The measuring face shall be aligned parallel to the top of the baseplate.

Version 2—Hand-held Use outside micrometer (see JIS B 7502).

NOTE : The usual term for this kind of instrument is an outside micrometer, although it is also known as micrometer callipers for external use (see Figure 3). The measuring faces of the spindle and the anvil shall be plane and parallel to each other.

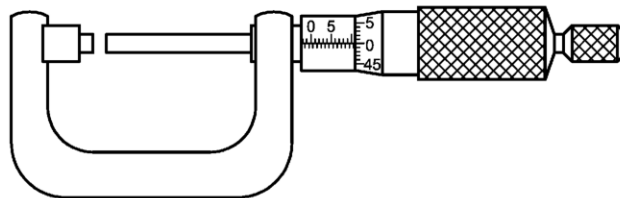


Figure 3 Outside micrometer

5.2.4.1.2 Dial gauge

Mechanical dial gauges shall conform to the requirements of JIS B 7503. The shape of the measuring tip shall be selected as a function of the hardness of the coating material whose thickness is to be measured (spherical for hard materials, plane for soft materials).