# INTERNATIONAL STANDARD

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# Paints and varnishes — Wedge-cut method for determination of film thickness (scribe and drill method)

Peintures et vernis — Détermination de l'épaisseur par la méthode d'entaille en coin (Méthode de rayer et de forage)

# iTeh STANDARD PREVIEW (standards.iteh.ai)

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# Foreword

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The committee responsible for this document is ISO/TC 35, Paints and varnishes, Subcommittee SC 9, General test methods for paints and varnishes.

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# Paints and varnishes — Wedge-cut method for determination of film thickness (scribe and drill method)

# 1 Scope

This International Standard specifies a destructive method for determination of the dry film thickness, in which damage to the coat caused in a definite manner is evaluated microscopically. The method is suitable for almost all coat-substrate combinations and also allows determination of the single film thicknesses of coating systems.

The method cannot be applied or can only be applied with restrictions in case of

- too soft and/or elastic coatings (no recognizable scribe or drill hole can be observed),
- hard (cannot be scribed/drilled) or too soft and/or elastic substrates,
- too low visual contrast between the coating and substrate, and
- film thicknesses that are larger than the depth of field of the measuring microscope.

# 2 Normative references STANDARD PREVIEW

The following documents, in whole or in part care hormative) y referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4618, Paints and varnishes — Terms and definitions Scool of Science 19399-2016

# 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

[SOURCE: ISO 4618:2014, 2.244]

# 3.2

#### coating

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

[SOURCE: ISO 4618:2014, 2.50.1]

#### 3.3

#### coating system

combination of all coats of coating materials which are to be applied or which have been applied to a substrate

Note 1 to entry: The actual coating system can be characterized by the number of coats involved.

Note 2 to entry: See also *coating* (3.2).

[SOURCE: ISO 4618:2014, 2.54]

# 3.4

single coat

part of a coating system

### 3.5

# total film thickness

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

# 3.6

# single film thickness

distance between the surface of a single coat and the surface of the coat (substrate) underneath

# 3.7

# dry-film thickness

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

[SOURCE: ISO 2808:2007, 3.5]

# 3.8

# wedge cut

damage to the coating system caused mechanically under the specified angle to the surface and extending into the substrate

Note 1 to entry: The wedge cut can be implemented as a linear scribe or as a conical bore hole.

# 3.9

wedge-cut image nicroscopic image of a wedge cut

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### 3.10

# adhesive failure

<u>ISO 19399:2016</u>

detachment of a coating from the substrate caused by external forces 3d5a-43d8-906d-

Note 1 to entry: The substrate can be another coating beneath or the basic material.

# 3.11

# cohesion failure

loss of cohesion within a coating caused by external forces

# 4 Principle

A wedge cut with a known flank angle is made in the coating using a scribing or drilling tool. The film thickness is calculated from the width of the flank projection of the wedge cut obtained with the measuring microscope.

# 5 Wedge-cut principle

The wedge cut for determination of the film thickness according to this International Standard can be made using a scribing tool (method A) or a drilling tool (method B).

<u>Figure 1</u> shows a wedge cut according to method A in the cross section. The basis length, *l*, is the projection of the wedge-cut flank within the coating and is measured with a microscope between the upper and lower contrast mark in micrometres.



#### Кеу

- 1 coating
- 2 substrate
- 3 lower contrast mark (intersection from the substrate to the coating)
- 4 upper contrast mark
- *l* wedge-cut basis
- *t*d dry-film thickness
- $\alpha$  wedge-cut angle

# Figure 1 — Wedge cut according to method A (single coat/cross section)

# The film thickness is determined according to Formula (1):

 $t_{\rm d} = l \cdot \tan \alpha$ 

where

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### <u>ISO 19399:2016</u>

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- $t_{\rm d}$  is the dry-film thickness, in micrometres;
- *l* is the wedge-cut base (microscope reading), in micrometres;

 $\tan \alpha$  is the wedge-cut factor of the wedge-cut tool used.

NOTE 1 Instruments are available where the microscope reading is indicated in "number of scale divisions" and the wedge-cut factor in "micrometres per scale division".

NOTE 2 Instruments are available where the microscope reading (in micrometres) for calculating the film thickness is divided by a divisor assigned to the wedge-cut tool.

The film thickness measuring range is as follows:

- determined by the wedge-cut angle, the dimensions of the wedge-cut tool and the scale measuring range of the microscope;
- limited by the depth of field of the measuring microscope (see <u>A.9</u>).

The resolution of the dry-film thickness measurement is determined by the wedge-cut angle and the scale division of the measuring microscope.

EXAMPLE For the usual wedge-cut angles  $\alpha = 5,7^{\circ}$  and  $\alpha = 14,0^{\circ}$ , the following is indicated in <u>Table 1</u>:

- the wedge-cut factor  $\tan \alpha$ ;
- the dry-film thickness measuring range (= scale measuring range × tan α);
- the absolute dry-film thickness resolution  $\Delta_a$  (= scale division × tan  $\alpha$ );

(1)

— the relative dry-film thickness resolution  $\Delta_r$  (= ( $\Delta_a/t_d$ ) × 100;  $t_d$  = dry-film thickness).

In the above, it is assumed that the measuring microscope has a scale measuring range of 2 mm, as well as a scale division of 0,02 mm and that the wedge-cut tool is sufficiently dimensioned.

Wedge-cut angle $\alpha$	0	5,7	14,0
Wedge-cut factor tan $\alpha$		0,10	0,25
Film thickness measuring range		up to 200	up to 500
Absolute film thickness resolution $\Delta_a$	μm	2	5
Relative film thickness resolution $\Delta_r$	%	200/t <sub>d</sub>	500/t <sub>d</sub>

Table 1 — Numerical data on the wedge-cut method

Figure 2 shows a wedge cut according to method B in the cross section (I) and the associated wedge-cut image (II) visible through the microscope. Here, the section *l* to be measured with the microscope is the distance between the concentric circles.



#### Кеу

- 1 cross section
- 2 wedge-cut image
- I coating
- II substrate
- *l* wedge-cut basis
- *t*d dry-film thickness
- $\alpha$  wedge-cut angle

# Figure 2 — Wedge cut according to method B (single coat)

In the case of coating systems, the single film thicknesses can be determined in a similar manner.

Figure 3 shows the wedge-cut scribe (method A) for a 2-coat system. The single dry-film thicknesses  $t_{d1}$  and  $t_{d2}$  are then calculated from the microscope readings  $l_1$  and  $l_2$  with Formula (1) for  $t_{d1} = l_1 \cdot \tan \alpha$  and  $t_{d2} = l_2 \cdot \tan \alpha$ .



### Key

- single coat 1 1
- 2 single coat 2
- 3 substrate
- li wedge-cut basis associated with  $t_{di}$  (*i* = 1, 2)
- dry-film thickness of the single coat i (i = 1, 2) t<sub>di</sub>
- wedge-cut angle α

#### Figure 3 — Wedge cut according to method A (2-coat system/cross section)

#### **iTeh STANDARD PREVIEW** Apparatus 6

# (standards.iteh.ai)

# 6.1 Method A

#### ISO 19399:2016

6.1.1 Wedge-cut scribing device, as shown schematically in Figure 4, with the following features. 3cb69603e65c/iso-19399-2016

**6.1.1.1** The stylus 6 is fastened interchangeably in the metal block 7 and protrudes as far out as the support bolts 3.

NOTE There are wedge-cut scribing devices that are equipped with support wheels instead of the support bolts.

The device shall be adjusted so that, when placed on an even surface, the stylus axis 8 is 6.1.1.2 oriented vertically to this surface.



**6.1.2** Wedge-cut stylus, made from hard metal with a form according to Figure 5, with indication of the wedge-cut factor and/or the wedge-cut angle.



#### Кеу

- 1 shaft
- 2 cutting edge

3 stylus axis

 $\alpha$  wedge-cut angle



# 6.2 Method B

**6.2.1** Wedge-cut drilling device, as shown schematically in <u>Figure 6</u>, with the following features.

**6.2.1.1** The rotational movement of the drill bit 9 fastened interchangeably in the drilling spindle 4 (see Figure 6) may be generated manually or by an electromotive drive.

**6.2.1.2** The device shall be adjusted so that, when placed on an even surface, the drill axis 2 is oriented vertically to this surface.



**6.2.2** Wedge-cut drill bit, made from hard metal with a form according to Figure 7, with indication of the wedge-cut factor and/or the wedge-cut angle.



Key

- 1 coupling
- 2 shaft
- 3 drill head

4 cutting edge

5 drill axis

 $\alpha$  wedge-cut angle

# Figure 7 — Wedge-cut drill

# 6.3 Measuring microscope

Measuring microscope, with illumination device and with

- a minimum of 40x magnification,
- a measuring range of minimum 2 mm, and
- a scale division of maximum 0,02 mm.

NOTE 1 Standard wedge-cut devices are equipped with an integral measuring microscope and an integral illumination device.

NOTE 2 Instead of a conventional measuring microscope, a video microscope can be used and the wedge-cut image evaluated digitally.

# 7 Test specimens

The specimens shall exhibit a planar area, which is at least twice as big as the base plane of the wedge-cut device.

NOTE 1 Clamping devices are available for wedge-cut drilling devices (method B), which also enable measurements on specimens with a very small planar area (typical dimensions: 15 mm × 15 mm). Specimens with complex geometry (e.g. profiles) can also be fastened with these devices for measuring the dry-film thickness of such specimens.

NOTE 2 Under certain boundary conditions, film thickness determinations on curved specimens are also possible (see <u>Annex C</u>). (standards.iteh.ai)

# 8 Procedure

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# 8.1 Sample preparation

A laminar contrast marking should preferably be applied to the coating in the area in which the wedge-cut is to be made, so as to make the microscopic measurement easier.

A black permanent felt-tip pen is normally used for bright coatings. A white or silver-coloured paint felttip pen may be used for dark specimens. In this case, the marking coat shall be applied thinly and shall be fully hardened before making the wedge cut. It shall be ensured that the solvent in the felt-tip pen does not attack the coating.

### 8.2 Number of determinations

For each determination of the dry-film thickness, three wedge-cut scribes or wedge-cut drills, respectively, shall be applied on the test panel. The wedge-cut basis, *l*, shall be measured for each cut or each drill at two different test points.

# 8.3 Method A (wedge-cut scribe)

**8.3.1** Insert the wedge-cut stylus (6.1.2) for the intended measuring range according to 6.1.1.1 into the wedge-cut scribing device (6.1.1) and fix.

**8.3.2** Place the scribing device on the coating and pull with a speed of about 10 mm/s over a section of minimum 10 mm (see Key 2 in Figure 4). When doing so, press down the scribing device so that a scribe is made down into the substrate.