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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)

ICS: 87.040

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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.

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

## 1 Scope

The 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 individual 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,
- hard (cannot be scribed/drilled) or too soft and/or elastic substrates,
- too low visual contrast between the coating and sûbstrate,
- film thicknesses that are larger than the depthof field of the measuring microscope.


## 2 Normative references

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

ISO 4618:2014, Paints and varnishes - Termsand definitions

## 3 Terms and definitions

For the purposes of this documento 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 <br> coating

layer formed from a single or multiple application of a coating material to a substrate
[SOURCE: ISO 4618:2014, 2.50.1]
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.
[SOURCE: ISO 4618:2014, 2.54]

## 3.4 <br> individual coat <br> part of a coating system

## 3.5 <br> total film thickness <br> distance between the surface of the coating and surface of the substrate

## 3.6 <br> individual film thickness

distance between the surface of an individual coat and the surface of the coat (substrate) underneath

## 3.7 <br> dry-film thickness

thickness of a coating remaining on the surface when the coating has hardened
[SOURCE: ISO 2808:2007, 3.5]

## 3.8 <br> 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 cribe or as a conical bore hole.

## 3.9

wedge-cut image
microscopic image of a wedge cut

### 3.10

## adhesive failure

detachment of a coating from the substrate caused by external forces
Note 1 to entry: The substrate can be another coating beneath or the basic material.
[SOURCE: ISO/DTR 19402:2015, 3.3]

### 3.11 <br> cohesion failure

loss of cohesion within a coating caused by external forces
[SOURCE: ISO/DTR 19402:2015, 3.4]

## 4 Principle

A wedge cut with a known flank angle is made in the coating using a scribing 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 standard can be made using a scribing tool (method A) or a drilling tool (method B).

Figure 1 shows a wedge cut according to method A in the cross section. The basis section $l$ 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.


Key
1
Coating
Substrate
Lower contrast mark (intersection from the substrate to the coating)
Upper contrast mark
Wedge-cut basis
dry-film thickness
Wedge-cut angle
Figure 1 - Wedge cut according to method A (single eoat/cross section)

The film thickness is determined according to Formula 1:

$$
\begin{equation*}
t_{\mathrm{d}}=l \cdot \tan \alpha \tag{1}
\end{equation*}
$$

where
$t_{\mathrm{d}} \quad$ is the dry-film thickness, in micrometres
$l \quad$ is the wedge-cut base (microseope reading), in micrometres
$\tan \alpha \quad$ 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

- 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 A.9).

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

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

- the wedge-cut factor $\tan \alpha$,
- the dry-film thickness measuring range (= scale measuring range $\times \tan \alpha$ ),
- the absolute dry-film thickness resolution $\Delta_{\mathrm{a}}(=$ scale division $\times \tan \alpha)$,
- the relative dry-film thickness resolution $\Delta_{\mathrm{r}}\left(=\left(\Delta_{\mathrm{a}} / t_{\mathrm{d}}\right) \times 100 ; t_{\mathrm{d}}=\right.$ 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 $0,02 \mathrm{~mm}$ and that the wedge-cut tool is sufficiently dimensioned.

Table 1 - - Numerical data on the wedge-cut method

| Wedge-cut angle $\alpha \quad{ }^{\circ}$ | 5,7 | 14,0 |
| :--- | :---: | :---: |
| Wedge-cut factor tan $\alpha$ | 0,10 | 0,25 |
| Film thickness measuring range $\mu \mathrm{m}$ | up to 200 | up to 500 |
| Absolute film thickness resolution $\Delta_{a} \mu \mathrm{~m}$ | 2 | 5 |
| Relative film thickness resolution $\Delta_{\mathrm{r}} \%$ | $200 / t_{\mathrm{d}}$ | $500 / t_{\mathrm{d}}$ |

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.


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

In the case of coating systems, the individual film thicknesses can be determined in a similar manner:
Figure 3 shows the wedge-cut scribe (method A) for a 2 -coat system. The individual dry-film thicknesses $t_{\mathrm{d} 1}$ and $t_{\mathrm{d} 2}$ are then calculated from the microscope readings $l_{1}$ and $l_{2}$ with Formula 1 for $t_{\mathrm{d} 1}=l_{1} \cdot \tan \alpha$ and $t_{\mathrm{d} 2}=l_{2} \cdot \tan \alpha$.


Key

1
2
3
$l_{i}$
$t_{\mathrm{d} i}$
$\alpha$

Single coat 1
Single coat 2
Substrate
Wedge-cut basis associated with $t_{\mathrm{d} i}(i=1,2)$
Dry-film thickness of the individual coat $i(i=1,2)$
Wedge-cut angle
Figure 3 - Wedge cut according to method A (2-coat system / cross section)

6 Apparatus

### 6.1 Method A

6.1.1 Wedge-cut scribing device, as shownschematically in Figure 4, with the following features:
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 scribingodeyices that are equipped with support wheels instead of the support bolts.
6.1.1.2 The device shall be adjusted so that, when placed on an even surface, the stylus axis 8 is oriented vertically to this surface.

a) Side view

b) Front view

Key
1
2
3
4
5
6

7
8

> Direction of load
> Direction of scribing
> Support bolts
> Coating
> Substrate
> Wedge-cut stylus
> Metal block
> Stylus axis

Figure 4 - Wedge-cut scribing device
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.


| Key |  |
| :--- | :--- |
| 1 | Shaft |
| 2 | Cutting edge |
| 3 | Stylus axis |
| $\alpha$ | Wedge-cut angle |

Figure 5 - - Wedge-cut stylus

### 6.2 Method B

6.2.1 Wedge-cut drilling device, as shown schematically in Figure 6, 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.


| Key |  |
| :--- | :--- |
| 1 | Direction of load |
| 2 | Drill axis |
| 3 | Rotational movement |
| 4 | Drilling spindle with chuck |
| 5 | Drilling spindle guide |
| 6 | Support |
| 7 | Coating |
| 8 | Substrate |
| 9 | Wedge-cut drill bit |
| 10 | Housing |

Figure 6 - - Wédge-cut drilling device
6.2.2 Wedge-cut drill bit, made fron hard metal with a form according to Figure 7, with indication of the wedge-cut factor and/or the wedge-cut angle.

