
Determination of the film thickness of coatings using an ultrasonic gage

*Détermination de l'épaisseur du feuil de revêtement par mesurage
ultrasons*

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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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Determination of the film thickness of coatings using an ultrasonic gage

1 Scope

This Technical Specification describes a method for determining the film thickness of coatings on metallic and non-metallic substrates using an ultrasonic gauge.

2 Normative references

The following documents, in whole or in part, are normatively 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*

3 Terms and definitions

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

3.1

ultrasonic wave

acoustic wave having a frequency higher than the range of audibility of the human ear, generally taken as higher than 20 kHz

[SOURCE: EN 1330-4:2010, 3.1.1]

3.2

longitudinal wave

compressional wave

wave in which the particle motion in a material is in the same direction as the propagation of the wave

[SOURCE: EN 1330-4:2010, 2.3.1]

3.3

echo

ultrasonic pulse reflected to the probe

[SOURCE: EN 1330-4:2010, 5.5.2]

3.4

echo height

echo amplitude

height of an *echo* (3.3) indication on the screen

[SOURCE: EN 1330-4:2010, 5.5.5]

3.5

ultrasonic impulse

short-lived ultrasound signal

3.6

ultrasonic sensor

ultrasonic probe

device for sending and receiving *ultrasonic waves* (3.1), mostly based on piezoelectric materials

3.7
acoustic impedance

Z

product of sound velocity and density of a material

3.8
reflection coefficient

ratio of total reflected sound pressure to incident sound pressure at a reflecting surface

[SOURCE: EN 1330-4:2010, 3.4.11]

Note 1 to entry: For a wave the reflection coefficient *R* is calculated from the *acoustic impedances* (3.7) *Z*₁ and *Z*₂ of the bordering media, for which 1 is the medium of the incoming sound:

$$R = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$

For a negative reflection coefficient the *phase* (3.9) of the reflected signal is changed by 180°.

3.9
phase

fraction of a complete wave cycle, expressed as an angle

[SOURCE: EN 1330-4:2010, 2.2.5]

3.10
interface

boundary between two media, in acoustic contact, having different *acoustic impedances* (3.7)

[SOURCE: EN 1330-4:2010, 3.4.1]

3.11
sound path travel time

time needed for the sound path travel distance

[SOURCE: EN 1330-4:2010, 5.6.3]

3.12
couplant
coupling film

medium interposed between the probe and the object under examination to enable the passage of *ultrasonic waves* (3.1) between them

[SOURCE: EN 1330-4:2010, 5.3.2]

3.13
A-scan presentation

display of the ultrasonic signal in which the X-axis represents the time and the Y-axis the amplitude

[SOURCE: EN 1330-4:2010, 5.5.16]

Note 1 to entry: Ultrasonic film thickness measuring devices, besides the numerical values of the obtained film thicknesses, normally display A-scans for checking the echo forms and echo sequences on a screen as well.

3.14 calibration

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with *adjustment of a measuring system* (3.15), often mistakenly called “self-calibration”, nor with verification of calibration.

Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.

[SOURCE: ISO/IEC Guide 99:2007, 2.39]

3.15 adjustment of a measuring system adjustment

set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment and span adjustment (sometimes called “gain adjustment”).

Note 2 to entry: Adjustment of a measuring system should not be confused with *calibration* (3.14), which is a prerequisite for adjustment.

Note 3 to entry: After adjustment of a measuring system, the measuring system normally should be recalibrated.

[SOURCE: ISO/IEC Guide 99:2007, 3.11]

3.16 working standard

standard which is traceable to the national standard

[SOURCE: EN 60731:2007, 3.4.1.2]

4 Principle

The method described in this Technical Specification determines single film thicknesses from the times of flight of an ultrasonic impulse that is partially reflected at the interfaces of the coating system. The strengths and weaknesses of the method are shown by measuring data for the different film-substrate combinations that are relevant in practice.

5 Physical principles of the measuring method and of the application

When measuring the film thickness using ultrasound, longitudinal waves are used because they can be easily generated and can be coupled into a work piece with almost every liquid. As shown in [Figure 1](#), a sensor (6) consists of a piezoelectric disc, for sound generation and for reception, and of a “delay path”. The ultrasonic impulse generated in the sensor first passes the delay path and then spreads through layers 1 to 3 down to the substrate (1) and beyond.

On each interface, a fraction of the impinging ultrasonic wave is reflected as a new ultrasonic impulse, while another fraction passes through. The first reflection occurs in the ultrasonic sensor when the ultrasonic impulse impinges on layer 1 (4).