



BSI Standards Publication

Non-destructive testing — Ultrasonic thickness determination

National foreword

This British Standard is the UK implementation of EN ISO 16809:2025. It is identical to ISO 16809:2025. It supersedes BS EN ISO 16809:2019, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/46/3, Ultrasonic Testing.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Date	Text affected
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par ultrasons (ISO 16809:2025)

Zerstörungsfreie Prüfung - Dickenbestimmung mit
Ultraschall (ISO 16809:2025)

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

This document (EN ISO 16809:2025) has been prepared by Technical Committee ISO/TC 135 "Non-destructive testing " in collaboration with Technical Committee CEN/TC 138 "Non-destructive testing" the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2025, and conflicting national standards shall be withdrawn at the latest by December 2025.

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Endorsement notice

The text of ISO 16809:2025 has been approved by CEN as EN ISO 16809:2025 without any modification.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 3, *Ultrasonic testing*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 138, *Non-destructive testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 16809:2017), which has been technically revised.

The main changes are as follows:

- terminology in the document has been modified, changing "measurement" to "determination";
- terminology has been aligned with ISO 16831;
- ultrasonic instruments with A-scan presentation that conform with ISO 22232-1 can be used to determine wall thicknesses;
- all figures have been improved.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Non-destructive testing — Ultrasonic thickness determination

1 Scope

This document specifies principles for determination of the thickness of metallic and non-metallic materials using the contact technique or immersion technique, based on measurement of the time of flight of ultrasonic pulses only.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

ISO 16831, *Non-destructive testing — Ultrasonic testing — Characterization and verification of ultrasonic equipment for the determination of thickness*

ISO 22232-1, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 1: Instruments*

ISO 22232-2, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 2: Probes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Modes of determination

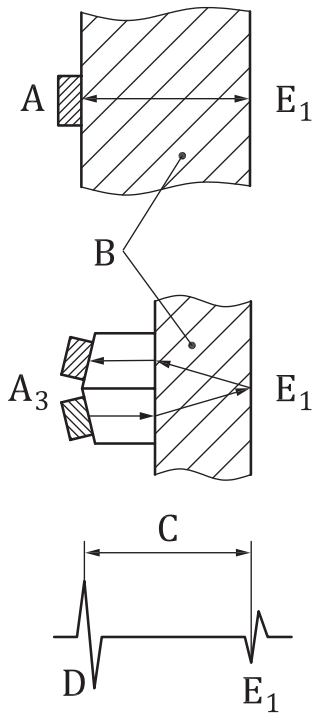
The thickness of a test object is determined by accurately measuring the time required for a short ultrasonic pulse generated by a transducer to travel through the thickness of the material once, twice or several times.

The material thickness is calculated by multiplying the known sound velocity of the material of the test object with the measured time of flight and dividing by the number of times the pulse transits the material wall.

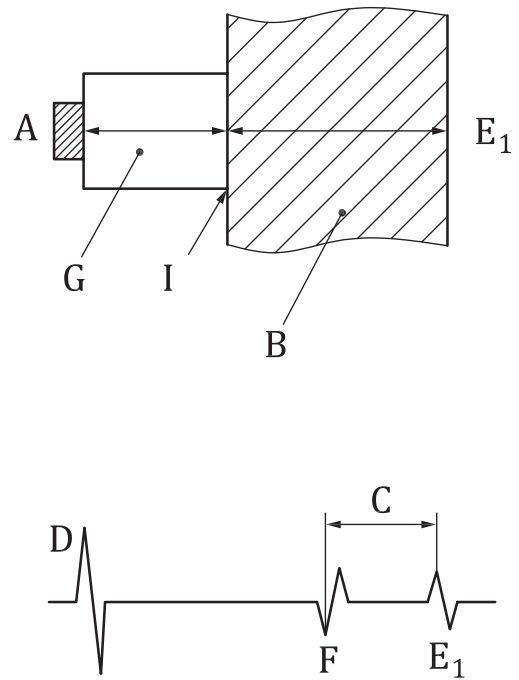
This principle can be accomplished by applying one of the following modes (see [Figure 1](#)).

- a) Mode 1: measure the time of flight from an initial excitation pulse to a first returning echo, minus a zero-point correction to account for the thickness of the probe's wear plate or delay path and the couplant layer (single-echo mode).
- b) Mode 2: measure the time of flight from the end of a delay line to the first back wall echo (single-echo delay line mode).
- c) Mode 3: measure the time of flight between back wall echoes (multiple-echo mode).

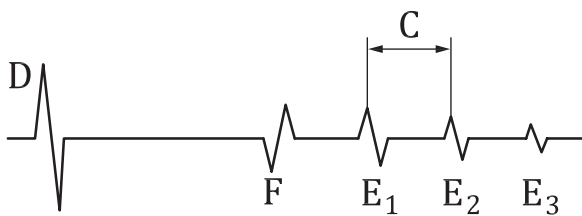
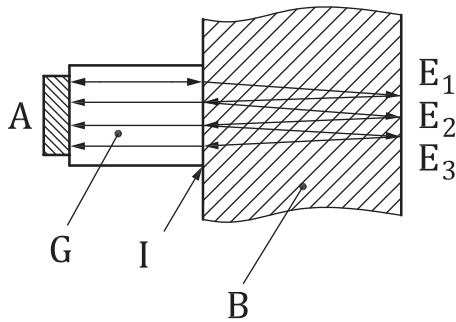
- d) Mode 4: measure the time of flight for a pulse travelling from the transmitter to a receiver in contact with the back wall (through-transmission mode).



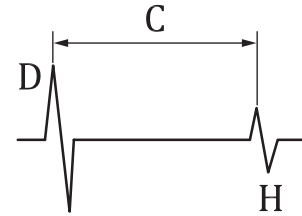
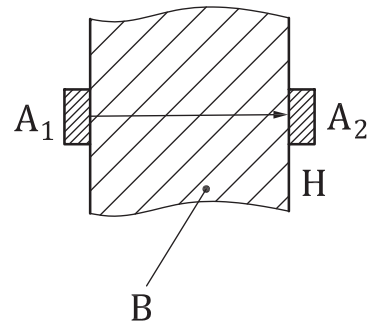
a) Mode 1



b) Mode 2



c) Mode 3



d) Mode 4

Key

A transmit/receive probe
 A₁ transmit probe
 A₂ receive probe

D transmitter pulse indication
 E₁ to E₃ back wall echoes
 F interface echo

A ₃	dual-transducer probe	G	delay path
B	test object	H	received pulse
C	time of flight	I	interface

NOTE The interface echo is typically not visible for mode 1.

Figure 1 — Modes of determination

5 General requirements

5.1 Ultrasonic instruments

The ultrasonic instrument shall fulfil the requirements of ISO 16831 or ISO 22232-1, depending on the type of instrument. The following types of ultrasonic instruments shall be used to perform thickness determination:

- dedicated ultrasonic instruments for the determination of thickness with only numerical display showing the determined thickness value;
- dedicated ultrasonic instruments for the determination of thickness with numerical display showing the determined thickness value and A-scan presentation;
- ultrasonic instruments not limited to thickness determination but designed primarily for the detection of discontinuities with A-scan presentation. The operator reads the position of a signal on the time base of the display, or this type of ultrasonic instrument can also include a gate and numerical display showing the determined thickness value.

See [6.4](#) for the selection of ultrasonic instrument.

5.2 Probes

The probe(s) shall initially be in accordance with ISO 22232-2. The following types of probes shall be used (these are generally longitudinal wave straight-beam probes):

- dual-transducer probes;
- single-transducer probes.

See [6.3](#) for the selection of probe.

5.3 Couplant

- Acoustic contact between the probe(s) and the test object shall be provided, normally by application of a fluid or gel.
- The couplant shall not have any adverse effect on the test object, the equipment or represent a health hazard to the operator.
- The couplant shall be chosen to suit the surface conditions and the irregularities of the surface to ensure adequate coupling.
- Different coupling media can be used, but their type shall be compatible with the materials to be tested. Examples are:
 - water, possibly containing an agent, e.g. wetting, anti-freeze, corrosion inhibitor;
 - contact paste;
 - oil;

- grease;
 - cellulosic paste containing water.
- e) The characteristics of the coupling medium shall remain constant throughout the verification, the setting operations and the testing.
- f) The coupling medium shall be suitable for the temperature range in which it will be used.
- g) After testing is completed, the coupling medium shall be removed if its presence will adversely affect subsequent operations or use of the test object.

For the use of the couplant in special test conditions, see [6.5](#).

5.4 Reference blocks

- a) The equipment shall be set using one or more samples or reference blocks representative of the test object, i.e. having comparable dimensions, material and structure.
- b) The thicknesses of the blocks or the steps should cover the range of thickness to be determined.
- c) The thickness or the sound velocity, or both, of the reference blocks shall be known.

5.5 Test objects

- a) The test object shall allow for ultrasonic wave propagation.
- b) There shall be free access to each individual area to be tested.
- c) The surface of the area to be tested shall be free of all dirt, grease, lint, scale, welding flux and spatter, oil or other extraneous matter that can interfere with the testing.
- d) If the surface is coated, the coating shall have good adhesion to the material. Otherwise it shall be removed.
- e) When testing through coating, its thickness and sound velocity need to be known unless mode 3 is used.

For further details, see [6.1](#) and [Clause 8](#).

5.6 Qualification of test personnel

- a) An operator performing ultrasonic thickness determination according to this document shall have a basic knowledge of the physics of ultrasound, and a detailed understanding and training related to ultrasonic thickness determination.
- b) In addition, the operator shall have knowledge of the product and material to be tested.
- c) It is recommended that personnel is qualified in accordance with ISO 9712 or equivalent.

6 Application of the techniques

6.1 Surface condition and surface preparation

Using the pulse-echo technique means that the ultrasonic pulse needs to pass the test surface between test object and the probe at least twice: when entering the object and when leaving it.

Therefore, a clean and even contact area with at least twice the probe's diameter is preferred. Poor contact will result in loss of energy, distortion of signals and sound path.

- a) To enable sound propagation all loose parts and non-adherent coatings shall be removed by brushing or grinding.

- b) Attached layers, like colour coating, plating, enamels, may stay on the object, but only a few ultrasonic instruments are able to exclude these layers from the thickness determination.
- c) Very often, thickness determination needs to be done on corroded surfaces, e.g. storage tanks and pipelines.

To increase the accuracy in this case, the test surface should be ground within an area at least two times the probe's diameter.

This area should be cleaned from corrosion products.

When grinding, care should be taken not to reduce the thickness below the minimum acceptable value.

6.2 Technique

6.2.1 General

The task of ultrasonic thickness determination can be separated into two application areas:

- determination during manufacture;
- determination of residual wall thickness in service.

Each area has its own special conditions which require special techniques.

Using knowledge of the material, geometry and approximate thickness to be determined and the required accuracy, the most suitable test equipment and mode shall be selected as follows ([Annex D](#) gives guidance):

- a) depending on the thickness and the material, frequencies from 100 kHz with through-transmission technique on highly attenuative materials up to 50 MHz on thin metal sheets shall be used;
- b) if dual-transducer probes are used, then compensation for V-path error is required;
- c) on curved test objects, the diameter of the probe contact area shall be significantly smaller than the diameter of the test object.

The accuracy of the thickness determination depends on how accurate the time of flight can be measured, on the measurement mode for the time difference (zero crossing, flank-to-flank, peak-to-peak), on the mode of determination (with multiple echoes, mode 3, the accuracy is higher than with modes 1 and 2), and on the frequencies which can be used (higher frequencies provide higher accuracy than lower frequencies because of the more accurate time measurement).

- d) Ultrasonic thickness determination is often required over an area of the test object. Where this is the case, consideration shall be given to the spacing between testing locations.
- e) Such spacing shall be even and the use of a grid is recommended.
- f) The grid size shall be selected to give a balance between the confidence in the results, detection of local thickness variations and the work content involved.

To determine the thickness ultrasonically means measuring the time of flight and then calculating the thickness assuming a constant sound velocity (see [Clause 7](#)).

If the sound velocity is not constant within the path the ultrasonic pulse has travelled, the accuracy of the determination will be severely affected.

6.2.2 Determination during manufacture

6.2.2.1 Modes 1, 2 and 3

- a) Where the pulse-echo mode is used, the flow charts in [Figures D.1](#) and [D.2](#) give guidance on the selection of the best technique and equipment.

- b) Thickness determination on clean parallel surfaces may be carried out with simple ultrasonic instruments for thickness determination with numerical display [type [5.1 a\)](#)].
- c) On composite materials which generate echoes in addition to the back wall echo, it is recommended that ultrasonic instruments with A-scan presentation [type [5.1 b\)](#) or [5.1 c\)](#)] be used to select the correct echo for the thickness determination.

6.2.2.2 Mode 4

If the material is highly attenuative and large thicknesses need to be tested, no pulse-echo technique can be used, i.e. only through-transmission (mode 4) is applicable.

- a) Two probes on opposite sides of the test object shall then be used.
- b) The ultrasonic instrument therefore shall allow for operation with separate transmitter and receiver (TR mode).
- c) In most cases, the frequency shall be lower than 1 MHz.
- d) Special low-frequency ultrasonic instruments from type c) in [5.1](#) with low-frequency probes shall be used.

6.2.3 Determination of residual wall thickness in service

During in-service testing, thickness determinations need to be taken on materials that are subject to corrosion or erosion. The surfaces can be rough and contain pitting or other imperfections (see [Annex A](#)) which are areas of low reflectivity.

- a) For these applications, the use of dual-transducer probes and ultrasonic instruments with A-scan presentation is recommended.
- b) The sensitivity shall be set manually to detect the poor reflecting areas.
- c) Where it is necessary to take a lot of thickness determinations, the readings shall be values with the information on the location of the test position. Data logging software can therefore be applied.
- d) With in-service testing, the environmental conditions are very important. Equipment can be needed which can withstand high temperatures and harsh environments or has special electrical shielding.

The flowcharts in [Figures D.3](#) and [D.4](#) give guidance on thickness determination in-service.

6.3 Selection of probe

Having chosen a suitable testing technique according to [6.2](#), i.e. a general decision for a probe type (single- or dual-transducer) has been made, there are other parameters that need to be considered when matching the probe to the test conditions.

Wide-band probes offer a shorter pulse than narrow-band probes, thus giving a suited flank or peak for the time-of-flight measurement, giving a better resolution when testing thin sheets or coatings.

Additionally, a wide frequency band always gives a stable echo even when attenuating materials need to be tested.

- a) Probe size and frequency shall be chosen to cover the thickness range by a narrow sound beam to get an echo from a well-defined area.
- b) For dual-transducer probes the focal range shall cover the expected thickness range.
- c) When determining small thicknesses:
 - 1) a delay path shall be used;