FINAL DRAFT
International
Standard

ISO/FDIS 16826

Non-destructive testing — Ultrasonic testing — Testing for discontinuities perpendicular to the surface

Essais non destructifs — Contrôle par ultrasons — Contrôle des discontinuités perpendiculaires à la surface

ISO/TC **135**/SC **3**

Secretariat: **DIN**

Voting begins on:
2024-12-04

Voting terminates on:
2025-01-29

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/FDIS 16826:2024(en)

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Foreword

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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 second edition cancels and replaces the first edition (ISO 16826:2012), which has been technically revised.

The main changes are as follows:

— revised figures and formulas;

— editorial revisions.

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.

Introduction

The following documents on ultrasonic testing are linked:

ISO 16810, *Non-destructive testing — Ultrasonic testing — General principles*

ISO 16811, *Non-destructive testing — Ultrasonic testing — Sensitivity and range setting*

ISO 16823, *Non-destructive testing — Ultrasonic testing — Through-transmission technique*

ISO 16826, *Non-destructive testing — Ultrasonic testing — Testing for discontinuities perpendicular to the surface*

ISO 16827, *Non-destructive testing — Ultrasonic testing — Characterization and sizing of discontinuities*

ISO 16828, *Non-destructive testing — Ultrasonic testing — Time-of-flight diffraction technique as a method for detection and sizing of discontinuities*

Non-destructive testing — Ultrasonic testing — Testing for discontinuities perpendicular to the surface

1 Scope

This document specifies principles for the tandem technique and the longitudinal-longitudinal-transverse wave (LLT) technique for detection of discontinuities perpendicular to the surface or almost perpendicular to the surface.

The general principles for ultrasonic testing of industrial products are described in ISO 16810.

The tandem or LLT techniques can be used for the detection of embedded planar discontinuities.

This document gives guidelines for the testing of metallic materials with a thickness between 40 mm and 500 mm with parallel or concentric surfaces.

The procedures provided in this document can be used for testing of other materials or smaller thickness if special measures are taken according to a written testing procedure.

Phased array techniques can also be applied for the tandem technique and the LLT technique, but additional steps or verifications can be needed.

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 16810, *Non-destructive testing — Ultrasonic testing — General principles*

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 Test equipment and test personnel

The requirements of ISO 16810 on test equipment and test personnel shall be applied unless stated otherwise.

5 Tandem technique

5.1 General

a) The testing normally shall be carried out using two similar 45° angle-beam transverse wave probes, one probe operating as transmitter and the other probe as receiver.

b) For wall thicknesses larger than 160 mm, different transducer sizes for the transmitter probe and the receiver probe should be used to ensure approximately the same beam dimensions in the test zone.

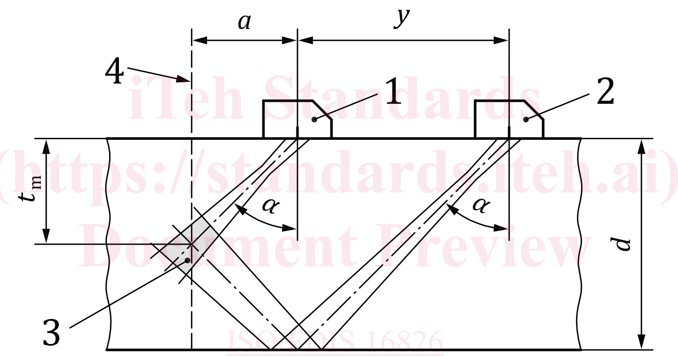
c) The use of beam angles other than 45° may be necessary to comply with particular geometrical conditions of the test object and/or the orientation of the expected discontinuity.

d) Beam angles that give rise to mode conversion shall be avoided.

NOTE For a test object with parallel surfaces, the use of transverse wave probes with a beam angle of 60° results in the beam impinging on the reference line at 30°, which can result in mode conversion on a discontinuity in steel test objects.

e) The probes shall be located in a line with their beam axes in the same direction.

The sound beam from the rear probe will, after reflection from the opposite surface, intersect the sound beam from the front probe, as shown in Figure 1. The area of intersection of the beams is the test zone. The intersection of the beam axes is the centre of the test zone, located at the reference line.



Key

1	front probe	d	material thickness
2	rear probe	t_m	depth of the intersection of the beam axes
3	test zone	y	probe distance
4	reference line	α	beam angle
a	projected distance		

Figure 1 — Basic principle of tandem technique

When testing objects with plane parallel surfaces, the distance between the probes can be determined using Formula (1):

$$y = 2(d - t_m)\tan\alpha \quad (1)$$

For 45° beam angles Formula (2) can be used:

$$y = 2(d - t_m) \quad (2)$$

where

- d is the material thickness;
- t_m is the depth of the intersection of the beam axes;
- α is the beam angle.

5.2 Probe movement

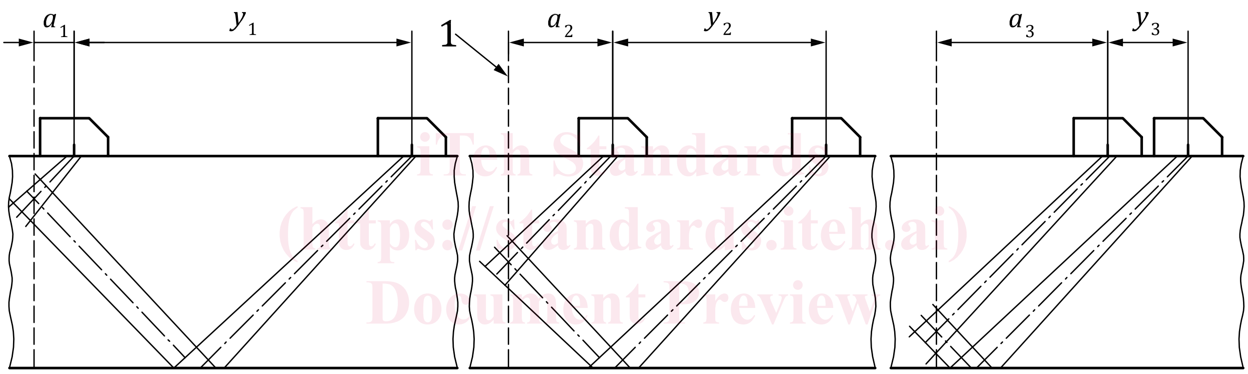
Probe movement (scanning) shall be performed in either of the following ways:

a) both probes shall be moved along the surface with a fixed probe distance (y).

In this way only one test zone is covered at a time, and the scanning shall be repeated with different probe distances until the complete test volume has been tested;

b) both probes shall be moved simultaneously but in opposite directions (forward and backward respectively), such that the sum of their distances from the reference line [a + (a + y)] remains constant, thereby scanning the full thickness of the test object in one continuous movement, as shown in Figure 2.

For example, the reference line can be the vertical weld axis.



Key

1 reference line

a_1, a_2, a_3 projected distance

y_1, y_2, y_3 probe distance

Figure 2 — Probes at different distances for test zones at different depths (schematic)

5.3 Time base setting

All relevant echoes will appear at the same sound path distance, which corresponds to the sound path for full skip for probes with the beams in opposite directions. Therefore, the setting of the time base is not critical. However, the echo of the signal along this path should be located at a specified position, e.g. at 80 % of full screen width, and indications in the vicinity of this specified position should be also displayed/recorded.

5.4 Sensitivity setting

The setting of sensitivity shall be performed using one of the following reflector types:

a) the opposite surface, where the back-wall echo is used;

b) disc-shaped reflectors perpendicular to the scanning surface (e.g. flat-bottomed holes), which shall be located at the intersection of the beam axes;

c) side-drilled holes located at the intersection of the beam axes and at the borders of the test zones.

5.5 Determination of test zones

Because of beam divergence, the shape of the test zone is not exactly a square or a rectangle and the dimensions of the test zone vary depending on the depth of the test zone.

a) To ensure that the sensitivity throughout the thickness does not fall below a certain level, a sufficient number of test zones shall be used to cover the thickness of the test object taking the beam divergence into account.

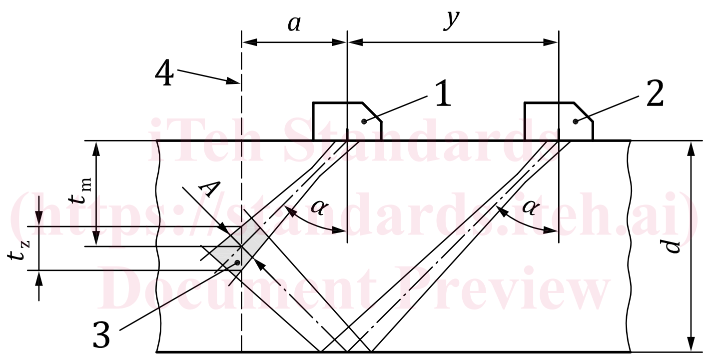
b) The probes shall be selected to ensure suitable beam characteristics, especially in the area near the test surface due to the near field length of the front probe.

The test zone near the opposite surface can require that the transducers for both beams are mounted in a single probe housing.

The test zones at the surfaces may be tested using a single probe with pulse-echo technique to detect corner reflections.

c) The height of the test zone (t_z) is defined as the height of the test zone at the reference line through the intersection point of the beam axes, see Figure 3.

d) The height of the test zones shall be selected so that the sensitivity at the edges of the test zones is not more than 6 dB below the sensitivity in the intersection point of the beam axes.



Key

1	front probe	t_m	depth of the intersection of the beam axes
2	rear probe	t_z	height of test zone
3	test zone	α	beam angle
4	reference line	a	projected distance
A	beam dimension of front probe	y	probe distance
d	material thickness		

Figure 3 — Height of test zone

e) The height of each test zone (t_z) shall be determined by using a reference block with reflectors at different depths or approximated using Formula (3), based on the dimension A of the direct beam in the test zone (6 dB drop), see Figure 3:

$$t_z = \frac{A}{\sin\alpha} \approx \frac{\lambda \cdot t_m}{D_{\text{eff}} \cdot \sin\alpha \cdot \cos\alpha} \qquad (3)$$

For 45° beam angles Formula (4) can be used:

$$t_z \approx \frac{2 \cdot \lambda \cdot t_m}{D_{\text{eff}}} \qquad (4)$$