INTERNATIONAL STANDARD

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Non-destructive testing — Ultrasonic testing — Transmission technique

Essais non destructifs — Contrôle par ultrasons — Technique par transmission

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16823 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 3, *Ultrasonic testing*.

Introduction

This International Standard is based on EN 583-3:1997, *Non-destructive testing — Ultrasonic examination — Part 3: Transmission technique*.

The following International Standards 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 — Transmission technique*

ISO 16826, *Non-destructive testing — Ultrasonic testing — Examination 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 — Transmission technique

1 Scope

This International Standard specifies the principles of transmission techniques.

Transmission techniques can be used for:

— detection of imperfections;

— determination of attenuation.

The general principles required for the use of ultrasonic examination of industrial products are described in ISO 16810.

The transmission technique is used for examination of flat products, e.g. plates and sheets.

Further, it is used for examinations e.g.:

— where the shape, dimensions or orientation of possible imperfections are unfavourable for direct reflection;

— in materials with high attenuation;

— in thin products.

2 Normative references

The following referenced documents are indispensable for the application 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 inspection — Vocabulary*

EN 1330-4, *Non-destructive testing — Terminology — Part 4: Terms used in ultrasonic testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577 and EN 1330-4 apply.

4 Principles of the examination

4.1 Basic techniques and set-up

In its simplest application two probes, one emitting and the second receiving, are placed so that the receiving probe receives the sound transmitted through the object. This can be achieved with straight beam probes or angle beam probes, see Table 2, e) to h).

Alternatively, the examination can be carried out using a single probe where the sound is reflected on a surface of an object on the opposite side of the examination object or on the opposite surface of the examination object (back wall), see Table 2, a) to d). See also Table 1.

Table 1 — Techniques and typical set-ups used in transmission technique

wave mode	**continuous waves**	**pulsed waves**
wave type	longitudinal or transverse	longitudinal or transverse
number of transducers	2	1 or 2
angle of incidence	normal	normal or oblique
evalution of	amplitude of transmitted sound	amplitude or time of flight of transmitted pulse or echo

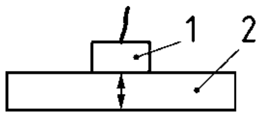
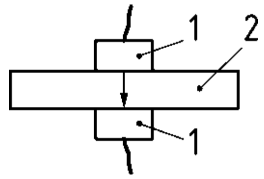
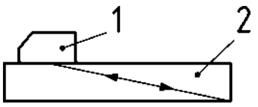
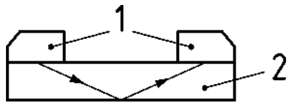
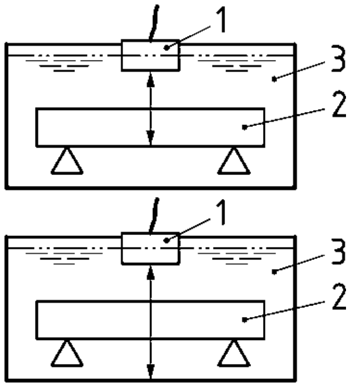
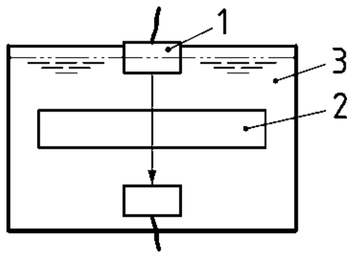
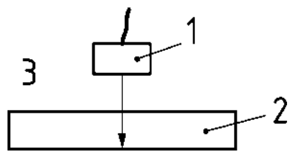
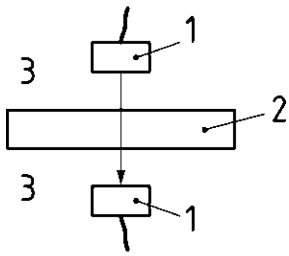
The decrease in amplitude of the transmitted signal can be used to indicate the presence of a discontinuity located in the sound path, or to indicate material attenuation. In addition, the position of the transmitted signal along the timebase of the instrument can be used to indicate material thickness.

Examination can be carried out with either continuous or pulsed ultrasonic waves, except when the technique is used for thickness measurement where only pulsed ultrasonic waves apply.

Straight beam or angle beam probes can be used depending on the scope of the examination.

A probe can be coupled to the product by means of a couplant, a squirter, by immersing the product or by applying a wheel probe.

Table 2 — Possible configurations for transmission technique

	One probe	Two probes
Straight beam contact	 **a)**	 **e)**
Angle beam contact	 **b)**	 **f)**
Total immersion	 **c)**	 **g)**
Local immersion (squirter)	 **d)**	 **h)**

Key
1 probe
2 object
3 water

4.2 Capability of detection of imperfections

When used for the detection of imperfections, any imperfection (or group of imperfections) shall intercept a significant proportion (i.e. 25 % to 50 %) of the cross-sectional area of the ultrasonic beam before an unambiguous change in signal amplitude is observed. This technique can only be used for detecting imperfections or groups of imperfections which are relatively large compared to the ultrasonic beam area, e.g. laminations in plate material.

Within the limitations mentioned above, the technique provides positive proof of the absence of an imperfection at any position along the sound path. However, it does not indicate the position in depth of a detected imperfection.

4.3 Requirements for geometry and access

The technique requires that the geometry of the object under examination and access to its surfaces allow the transmitting and receiving probes to be so positioned that their beam axes are coincident, either with or without intermediate reflection from a surface of the object.

4.4 Effects of variations in coupling, angulation and alignment of probe

The technique is particularly sensitive to variations in probe coupling and misangulation due to surface irregularities, since these factors also cause a marked reduction in transmitted signal amplitude. To improve the uniformity of coupling immersion or squirter scanning is most frequently used. Dressing of the surface to improve coupling uniformity can be necessary, especially for contact scanning.

When using separate transmitting and receiving probes and/or a reflecting object on the opposite side of the object to be examined their positions in relation to each other are also critical, and wherever possible they should be maintained in alignment by permanent orientation.

5 Examination technique

5.1 General

The technique described under this clause refers to the detection of imperfections, and where applicable their size determination, and to the measurement of sound attenuation in the material.

5.2 Sensitivity setting

The test sensitivity shall be set on either a reference block of the same relevant dimensions, surface finish and similar ultrasonic properties as the object to be examined or on an area of the latter known to be free from imperfections and of known or previously determined attenuation in accordance with 5.5. The probes shall be maintained in alignment in ultrasonic contact with the block or object and the gain adjusted to set the transmitted signal to a specified level. For manual examination a level of 80 % full screen height is recommended.

5.3 Scanning

Scanning shall be carried out in accordance with the requirements of the applicable test procedure, at all times keeping the probes in correct alignment to each other and to the object under examination.

5.4 Evaluation of imperfections

The evaluation of imperfections shall be done in accordance with the relevant International Standard. For imperfections whose transmitted signal amplitude during scanning is reduced to below the evaluation level, the evaluation criteria and requirements can be summarized as follows:

a) confirm that the reduction in signal amplitude is not due to loss of coupling or to a normal geometrical feature of the object;

b) measure the maximum reduction in transmitted signal amplitude. When the zone causing the signal reduction to fall below the evaluation level is smaller than the beam width, it is possible to relate the reduction in amplitude to the area of an imperfection, perpendicular to the ultrasonic beam, placed at a given depth;

c) determine as accurately as possible the volume of the object through which the ultrasonic beam is being attenuated;

d) determine if an imperfection is continuous or intermittent;

e) if either a complete or a partial loss of the transmitted signal amplitude is observed, due to a single large imperfection, the extent of the imperfection may be plotted by noting those positions of the sound beam at which the transmitted signal amplitude has fallen by a given value (most frequently 6 dB) below its value in a zone of the object free of imperfections.

5.5 Determination of attenuation coefficient

5.5.1 General

The energy loss, usually called attenuation, is normally expressed as an attenuation coefficient determined in dB per metre of sound path in the examination object.

The value depends on the type of wave, i.e. longitudinal, transverse and on the ultrasonic frequency etc..

Two techniques for determining the attenuation coefficient are described in the 5.5.2 and 5.5.3.

5.5.2 Comparative technique using a reference block

This technique is based on determining the difference in amplitude between 2 echoes. The first echo is that transmitted through a sample of material whose attenuation coefficient, α_1, is to be determined. The second echo is that transmitted through a sample whose attenuation coefficient, α_2, is known.

It is important to use the same determination conditions: ultrasonic probes, equipment and settings for each amplitude determination and coupling medium, and the samples shall be of the same thickness and surface finish.

The technique can employ either one probe acting as both transmitter and receiver, or two separate transmitting and receiving probes positioned on opposite faces of the sample. Either the first transmitted echo, or any subsequent multiple echo may be used.

The attenuation coefficient (α_1) in the material to be determined is given by:

$$\alpha_1 = \alpha_2 + \frac{20 \log\left(\frac{A_1}{A_2}\right)}{B} \quad \text{dB/m} \tag{1}$$

or equivalent

$$\alpha_1 = \alpha_2 + \left(\frac{V_2 - V_1}{B}\right) \quad \text{dB/m} \tag{2}$$

where:

α_1 is the attenuation coefficient of the object to be determined;

α_2 is the known attenuation coefficient of the reference sample;

B is the total sound path length in the examination object (m);

A_1 is the signal amplitude in the object to be determined;

A_2 is the signal amplitude in the reference sample with known attenuation coefficient;

V_1 is the amplification in decibel for signal amplitude A_1;

V_2 is the amplification in decibel for signal amplitude A_2.

5.5.3 Direct immersion technique

This technique is based on comparing the amplitude of one echo (A_m) of a series of multiple echoes, from within a sample of material to be determined, with the amplitude of a subsequent echo (A_n) within the same series, see Figure 1.

The technique can employ any of the probe configurations described under 5.5.2, but the following additional requirements apply:

a) the sound path of the echoes used for the measurement shall be longer than three near field lengths. Equations (3) and (4) apply for non focusing probes;

b) allowance should be made for the loss each time the pulse is reflected at a material water interface.

The attenuation coefficient (α) is given by:

$$\alpha = \frac{20\log\left(\frac{A_m}{A_n}\right) + 20\log\left(\frac{B_m}{B_n}\right) + 40(n-m)\log(R)}{2(n-m)d} \quad \text{dB/m} \tag{3}$$

or equivalent

$$\alpha = \frac{(V_n - V_m) + 20\log\left(\frac{B_m}{B_n}\right) + 40(n-m)\log(R)}{2(n-m)d} \quad \text{dB/m} \tag{4}$$

where:

α is the attenuation coefficient in the test object;

$B_m = 2[g + md(c_s/c_w)]$ is the equivalent water path of the mth echo;

$B_n = 2[g + nd(c_s/c_w)]$ is the equivalent water path of the nth echo;

c_s is the longitudinal sound velocity in the test object (m/s);

c_w is the sound velocity in water (1480 m/s);

d is the thickness of the test object (m);

g is the water delay between probe and test object (m);

m, n are the numbers of evaluated echoes ($n > m$);

A_m is the amplitude of mth echo;

A_n is the amplitude of nth echo;

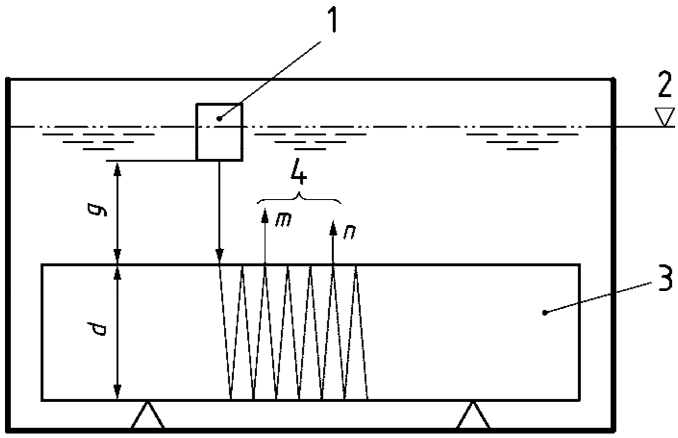
$R = \left|\frac{Z_s - Z_w}{Z_s + Z_w}\right|$ is the modulus of reflection coefficient water/sample, resp. sample/water;

V_m is the amplification in decibel for the amplitude A_m of the mth echo (dB);

V_n is the amplification in decibel for the amplitude A_n of the nth echo (dB);

Z_s is the acoustical impedance of the test object (Pa·s/m);

Z_w is the acoustical impedance of water (1,480 x 10^6 Pa·s/m).



Key

1	probe	*d*	thickness of test object
2	water level	*g*	water delay between probe and test object
3	examination object	*m*, *n*	numbers of evaluated echoes

Figure 1 — Measurement of attenuation by direct technique

ICS 19.100

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