International Standard

ISO 16811

Non-destructive testing — Ultrasonic testing — Sensitivity and range setting

Essais non destructifs — Contrôle par ultrasons — Réglage de la sensibilité et de la base de temps

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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 16811:2012), which has been technically revised.

The main changes are as follows:

— normative references have been updated;

— Annex A and Annex B from the prior edition have been moved to the main text;

— document has been editorially revised.

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 standards 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 — Sensitivity and range setting

1 Scope

This document specifies the general rules for setting the time-base range and sensitivity (i.e. gain adjustment) of a manually operated ultrasonic instrument with A-scan display in order that reproducible determinations can be made of the location and echo height of a reflector.

This document is applicable to contact techniques employing a single probe with either a single transducer or dual transducers. This document does not apply to the immersion technique and techniques employing more than one probe.

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 2400, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 1*[1)]

ISO 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

ISO 7963, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 2*[1)]

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

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*

ISO 22232-3, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 3: Combined equipment*

3 Terms and definitions

For the purpose 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 Quantities and symbols

A full list of the quantities and symbols used throughout this document is given in Table 1.

1) In the next revision of the standard, the term "calibration block" is intended to be replaced by the term "standard block".

Table 1 — Quantities and symbols

Symbol	Quantity	Unit
A	Normalized distance in DGS diagram	
A'	Probe coordinate	mm
a	Projected sound path length	mm
a'	Reduced projected sound path length	mm
α	Beam angle in steel	°
α_r	Beam angle in a non-alloy steel reference block	°
α_d	Incident angle (beam angle in delay block or wedge)	°
α_t	Beam angle in test object	°
β	Angle of incidence	°
c_r	Sound velocity in reference block	m/s
c_t	Velocity of transverse waves in test object	m/s
c_d	Velocity of longitudinal waves in delay block or wedge	m/s
D_{obj}	Outer diameter of test object or curvature of scanning surface	mm
d	Wall thickness	mm
D_{eff}	Effective transducer size	mm
D_f	Equivalent reflector diameter	mm
D_{SSH}	Diameter of spherical-shaped reflector	mm
D_{DSR}	Diameter of disc-shaped reflector	mm
D_{ps}	Diameter of probe shoe	mm
D_{SDH}	Diameter of side-drilled hole	mm
e_1 to e_7	Reference block dimensions	mm
g	Depth of contour on probe contact surface	mm
G	Normalized diameter of disc-shaped reflector in DGS-Diagram	
λ	Wavelength	mm
ΔH_u	Difference between the echo height from a reference reflector and the echo height from a discontinuity	dB
l_{ps}	Length of probe shoe	mm
l_d	Length of delay path	mm
Δl_{ps}	Length of contoured probe face	mm
N_{eff}	Effective near field length	mm
P_r	Reference point at s_{max}	
P_j	Reference point at s_j	
q	Coordinate of reflector	mm
s	Sound path length (single trip)	mm
s_d	Equivalent sound path distance in the delay block	
s_j	Sound path length of reference reflector	mm
s_{max}	Maximum sound path length	mm
s_u	Sound path length associated with evaluated signal	mm
s_v	Acoustic equivalent to delay path in test object	mm
t	Depth coordinate of reflector	mm
V	Gain in DGS diagram	dB
V_j	Basic gain	dB
V_r	Recording gain	dB
V_t	Gain for determining ΔV_t	dB

Table 1 *(continued)*

Symbol	Quantity	Unit
V_u	Indication gain	dB
ΔV	Gain difference	dB
$\Delta V_\sim$	Correction for ΔV_t	dB
ΔV_k	Gain correction for cylindrical reflector surface	dB
ΔV_s	Gain difference associated with sound path length	dB
ΔV_t	Transfer correction (average)	dB
$V_{t,r}$	Gain for back wall echo on reference block	dB
$V_{t,t}$	Gain for back wall echo on test object	dB
ΔV_u	Difference between indication gain and recording gain	dB
w_{ps}	Width of probe shoe	mm
Δw_{ps}	Width of contouring of the probe face	mm
x	Distance between probe index point and front edge of probe, for an uncontoured probe	mm
Δx	Probe index shift	mm

5 Qualification of personnel

a) The testing shall be performed by personnel qualified in accordance with ISO 9712.

b) The requirements for qualification of test personnel shall be specified in the product standards and/or other applicable documents.

6 Test equipment

6.1 Instrument

The ultrasonic instrument shall fulfil the requirements of ISO 22232-1.

6.2 Probes

6.2.1 General

The probe(s) shall initially fulfil the requirements of ISO 22232-2.

6.2.2 Probe selection

The choice of the probe depends on the purpose of the testing and the requirements of the referencing standard or specification. It depends on:

— the material thickness, shape and surface condition of the test object;

— the type and metallurgical condition of the material to be tested;

— the type, position and orientation of discontinuities to be detected and assessed.

The probe parameters listed in 6.2.3, 6.2.4 and 6.2.5 shall be considered in relation to the characteristics of the test object stated above.

6.2.3 Frequency and dimensions of transducer

The frequency and dimensions of a transducer determine the shape of the sound beam (near field and beam divergence).

a) The selection shall assure that the characteristics of the beam are the optimum for the testing by a compromise between the following:

   1) the near-field length which shall remain, whenever possible, smaller than the thickness of the test object.

      NOTE It is possible to detect discontinuities in the near field, but their characterization is less accurate and less reproducible than in the far field.

   2) the beam width, which shall be sufficiently small within the test volume furthest from the probe to maintain an adequate detection level;

   3) the beam divergence, which shall be sufficiently large to detect planar discontinuities that are unfavourably orientated.

b) Apart from the above considerations, the selection of frequency shall take into account the influence of the sound attenuation in the material and the reflectivity of discontinuities.

The higher the frequency, the greater the test resolution, but the sound waves are more attenuated (or the spurious signals due to the structure are greater) than with lower frequencies.

The choice of frequency thus represents a compromise between these two factors.

Most ultrasonic tests are performed at frequencies between 1 MHz and 10 MHz.

6.2.4 Dead zone

The choice of the probe shall take into account the influence of the dead zone in relation to the test volume.

6.2.5 Damping

The probe selection shall also include consideration of the damping which influences the axial resolution as well as the frequency spectrum.

6.2.6 Focusing probes

Focusing probes are mainly used for the detection of small discontinuities and for sizing reflectors.

Their advantages in relation to non-focused single-transducer probes are an increased lateral resolution and a higher signal-to-noise ratio than with non-focussing probes.

a) Their sound beams shall be described by the focal distance, the focal zone and the width of the focal zone.

b) The sensitivity setting shall be carried out by using reference reflectors.

6.3 Coupling media

a) 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

b) The characteristics of the coupling medium shall remain constant throughout the verification, the setting operations and the testing.

c) If the constancy of the characteristics cannot be guaranteed between setting and testing, a transfer correction may be applied.

One method for determining the necessary correction is described in 12.5.

d) The coupling medium shall be suitable for the temperature range in which it will be used.

e) After testing is completed, the coupling medium shall be removed if its presence will adversely affect subsequent operations or use of the test object.

6.4 Standard blocks

The blocks used for setting up the ultrasonic test equipment shall be in accordance with those specified in ISO 2400 and ISO 7963.

The stability of test equipment and setting can be verified by using the blocks given in ISO 2400 and ISO 7963.

6.5 Reference blocks

a) When amplitudes of echoes from the test object are compared with echoes from a reference block, certain requirements relating to the material, surface condition, geometry and temperature of the block shall be observed.

b) Where possible, the reference blocks shall be made from a material with acoustic properties which are within a specified range with respect to the material to be tested and shall have a surface condition comparable to that of the test object.

c) If these characteristics are not the same, a transfer correction shall be applied.

A method for determining the necessary correction is described in 12.5.

d) The geometrical conditions of the reference blocks and the test object shall be considered.

For further details, see Clause 8.

e) The geometry of the reference blocks, its dimensions, and the position of any reflectors, shall be indicated on a case by case basis in the specific standards and specifications.

f) The position and number of reflectors shall relate to the scanning of the entire test volume.

g) The most commonly used reflectors are:

1) large planar reflectors, compared to the beam width, perpendicular to the beam axis (e.g. back wall);

2) flat-bottomed holes;

3) side-drilled holes;

4) grooves or notches of various cross-sections

h) When reference blocks are submerged, e.g. for immersion testing, the influence of water in the holes shall be considered or the ends of the holes shall be plugged.

i) The consequences of temperature differences between test object, probes, and reference blocks shall be considered and compared to the requirements for the accuracy of the test.

j) If necessary, the reference blocks shall be maintained within the specified temperature range during the testing.

6.6 Specific test blocks

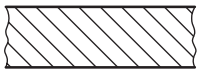
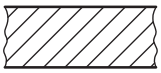
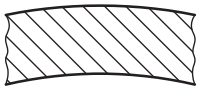
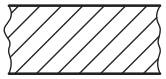
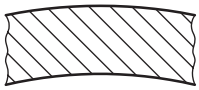
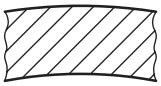
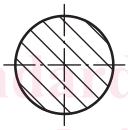
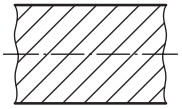
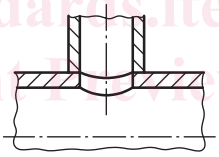
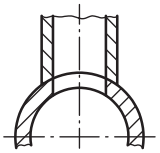
In certain cases, specific blocks, e.g. with identified natural discontinuities, can be used to optimise the test technique and to check the stability of the test sensitivity.

7 Categories of test objects

The requirements for range and sensitivity setting will depend on the geometrical form of the test object.

Five categories of test objects are specified in Table 2.

Table 2 — Categories of test objects

Category	Feature	Section in *x*-direction	Section in *y*-direction
1	Plane parallel surfaces (e.g. plate/ sheet)		
2	Parallel, uniaxially curved surfaces (e.g. tubes)		
3	Parallel surfaces curved in more than one direction (e.g. dished ends)		
4	Solid material of circular cross section (e.g. rods and bars)		
5	Complex shapes (e.g. nozzles, sockets)		

8 Test objects, reference blocks and reference reflectors

Requirements for geometrical features of test objects, reference blocks and reference reflectors in general are contained in Table 3 and Table 4.