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Non-destructive testing - Characterization and verification of ultrasonic test equipment - Part 2: Probes (ISO/DIS 22232-2:2018)

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Essais non destructifs - Caractérisation et vérification de l'appareillage de contrôle par ultrasons - Partie 2: Traducteurs (ISO/DIS 22232-2:2018)

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Non-destructive testing — Characterization and verification of ultrasonic test equipment —

Part 2: Probes

Essais non destructifs — Caractérisation et vérification de l'appareillage de contrôle par ultrasons — Partie 2: Traducteurs

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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 documents 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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 135 *Non-destructive testing*, SC 3 *Ultrasonic testing*.

ISO 22232 consists of the following parts, under the general title *Non-destructive testing — Characterization and verification of ultrasonic test equipment*:

— Part 1: Instruments;

— Part 2: Probes;

— Part 3: Combined equipment.

Non-destructive testing — Characterization and verification of ultrasonic test equipment —

Part 2: Probes

1 Scope

This document covers probes used for non-destructive ultrasonic testing in the following categories with centre frequencies in the range 0,5 MHz to 15 MHz, focusing or without focusing means:

a) single- or dual-transducer contact probes generating longitudinal or transverse waves;

b) single-transducer immersion probes.

Where material-dependent ultrasonic values are specified in this document they are based on steels having a sound velocity of (5 920 ± 50) m/s for longitudinal waves, and (3 255 ± 30) m/s for transverse waves.

Periodic tests for probes are not included in this document. Routine tests for the verification of probes using on-site methods are given in ISO 22232-3.

If parameters in addition to those specified in ISO 22232-3 are to be verified during the probe's life time, as agreed upon by the contracting parties, the methods of verification for these additional parameters should be selected from those given in this document.

Ultrasonic phased array probes are not included in this document, see ISO 18563-2.

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 7963, *Non-destructive testing — Ultrasonic testing --- Specification for calibration block No. 2*

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

ISO/IEC 17050-1:2004, *Conformity assessment — Supplier's declaration of conformity — Part 1: General requirements*

3 Terms and definitions

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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
horizontal plane of a sound beam
<angle-beam probes> plane perpendicular to the vertical plane of the sound beam including the beam axis in the material

3.2
peak-to-peak amplitude
h
maximum deviation between the largest positive and the largest negative amplitudes of the pulse

Note 1 to entry: See Figure 1.

3.3
probe data sheet
document giving manufacturer's technical specifications of the same type of probes

Note 1 to entry: The data sheet need not necessarily be a test certificate of performance.

3.4
probe test report
document showing compliance with this document giving the measured values of the required parameters of one specific probe, including test equipment and conditions

3.5
reference side
reference side is the right side of an angle-beam probe looking in the direction of the beam, unless otherwise specified by the manufacturer

3.6
squint angle for straight-beam probes
δ
deviation between the axis of the beam and the line perpendicular to the coupling surface at the emission point

Note 1 to entry: See Figure 2.

3.7
vertical plane of a sound beam
<angle-beam probes> plane in which the sound beam axis in the probe wedge and the sound beam axis in the test object both lie

3.8
Wear allowance
Maximum wear of the probe contact surface which does not affect the performance of the probe, typically expressed in millimetres

4 Symbols

Table 1 — Symbols

Symbol	Unit	Meaning
L	us	Pulse duration
h	%	Peak-to-peak amplitude
f_0	Hz	Centre frequency
f_u	Hz	Upper frequency limit at -3 dB
f_l	Hz	Lower frequency limit at -3 dB
Δf	Hz	Frequency bandwidth in each frequency range

Table 1 *(continued)*

Symbol	Unit	Meaning
Δf_{rel}	Hz	Relative bandwidth
S	dB	Pulse echo sensitivity
N_0	mm	Near field length
F_D	mm	Focal distance
F_L	mm	Length of focal zone at -6 dB using a reflector or -3 dB using a hydrophone
Z_P	mm	Focal point
W_x	mm	Focal width on X-axis
W_y	mm	Focal width on Y-axis
Ω_X	mm	Angle of beam divergence in X direction
Ω_Y	mm	Angle of beam divergence in Y direction
X	mm	Probe index point
α	°	Beam angle
δ	°	Squint angle
CT	dB	Cross talk

5 General requirements of conformity

An ultrasonic probe complies with this document if it fulfils all of the following requirements:

a) the probe shall comply with Clause 8;

b) a declaration of conformity according to ISO 17050-1 shall be available;

c) the ultrasonic probe shall be clearly marked to identify the manufacturer, and carry a unique serial number or show a permanent reference number from which information can be traced to the data sheet and probe test report;

d) the probe data sheet corresponding to the ultrasonic probe shall be available, which defines the performance criteria for the items given in Clause 6;

e) a probe test report shall be delivered together with the probe, which includes at least the test results given in Clause 6.

Table 2 summarises the tests to be performed on ultrasonic probes.

Table 2 — List of tests for ultrasonic probes

Title of test	Manufacturer's tests
	Sub-clause
Physical aspects	8.1
Pulse shape, amplitude and duration	8.2
Pulse spectrum and bandwidth	8.3
Pulse echo sensitivity	8.4
Distance-amplitude curve	8.5
Beam parameters for immersion probes	8.6
Axial profile – focal distance and length of the focal zone	8.6.2.2
Transverse profile – focal width	8.6.2.3
Transverse profile – beam divergence	8.6.2.4
Beam profile by scanning means – focal distance and focal length	8.6.3.2

Table 2 *(continued)*

Title of test	Manufacturer's tests
	Sub-clause
Beam profile by scanning means – focal width and beam divergence	8.6.3.3
Beam parameters for contact, straight-beam single-transducer probes	8.7
Beam divergence and side lobes	8.7.2
Squint angle and offset	8.7.3
Focal distance (near field length)	8.7.4
Focal width	8.7.5
Length of focal zone	8.7.6
Beam parameters for angle-beam single-transducer contact probes	8.8
Index point	8.8.2
Beam angle and beam divergence	8.8.3
Squint angle and offset	8.8.4
Focal distance (near field length)	8.8.5
Focal width	8.8.6
Length of focal zone	8.8.7
Beam parameters for contact, straight beam dual-element probes	8.9
Cross-talk	8.9.2
Distance to sensitivity maximum (focal distance)	8.9.4
Lateral sensitivity range (focal width)	8.9.6
Beam parameters for contact angle-beam, dual-element probes	8.10
Cross-talk	8.10.2
Index point	8.10.3
Beam angle and profile	8.10.4
Distance to sensitivity maximum (focal distance)	8.10.6
Axial sensitivity range (length of focal zone)	8.10.7
Lateral sensitivity range (focal width)	8.10.8

6 Technical information for probes

6.1 General

The test conditions and the equipment used for the evaluation of the probe parameters have to be listed (see Table 3).

6.2 Probe data sheet

The probe data sheet gives the list of information to be reported for all probes within the scope of this document (see Table 3).

6.3 Probe test report

The probe test report gives the measured values of the required parameters of one specific probe and other information from the probe data sheet (see Table 3).

The probe test report shall include the unique serial number or the permanent reference number to provide a uniquely assignment between the specific probe and the probe test report.

Table 3 — List of information to be given in a probe data sheet and probe test report

Information to be given	Probe data sheet	Probe test report	Comment
Manufacturer's name	I	I	—
Probe type	I	I	—
Probe serial number	-	I	—
Probe housing dimensions	I	I	—
Probe weight	I	I	—
Type of connectors	I	I	—
Connectors interchangeability	I	I	Only for dual-transducer probes
Cross talk	I	M	Only for dual-transducer probes
Transducer material	I	I	—
Shape and size of transducer	I	I	—
Roof angle of transducers	I	I	Only for dual-transducer probes
Wedge material	I	I	Only for angle-beam probes
Wedge delay	I	I	Only for angle-beam probes, for measurement see Annex D
Delay line material	I	I	Only for straight-beam probes
Delay line delay	I	I	Only for straight-beam probes, for measurement see Annex D
Protection layer material	I	I	—
Wear allowance	I	I	—
Pulse shape	I	M	—
Pulse spectrum	I	M	—
Centre frequency	I	M	—
Bandwidth	I	M	—
Pulse duration	I	M	—
Pulse-echo sensitivity	I	M	—
Beam angle	I	M	Only for angle-beam probes
Angles of divergence	I	I	—
Probe index point	I	I	Only for angle-beam probes Alternatively the distance between the probe index point and the front of the probe can be given.
Type of focus	I	I	—
Focal distance or near field length	I	I	—
Width of focal zone	I	I	Only for focusing probes
Length of focal zone	I	I	Only for focusing probes
Operating temperature range	I	I	—
Storage temperature range	I	I	—
DAC	I	-	—
I = Information; M = Measurement			

7 Test equipment

7.1 Electronic equipment

The ultrasonic instrument (or laboratory pulser/receiver) used for the tests specified in Clause 8 shall be of the type designated on the probe data sheet, and shall comply with ISO 22232-1 as applicable.

Where more than one type of ultrasonic instrument is designated the tests shall be repeated with each of the additional designated types.

Testing shall be carried out with the probe cables and electrical matching devices specified on the probe data sheet for use with the particular type of ultrasonic instrument.

NOTE Probe leads more than about 2 m long could have significant effect on probe performance.

In addition to the ultrasonic instrument or laboratory pulser/receiver the items of equipment essential to assess probes in accordance with this document are as follows:

a) an oscilloscope with a minimum bandwith of 100 MHz;

b) a frequency spectrum analyser with a minimum bandwith of 100 MHz, or an oscilloscope/digitiser or computer capable of performing Discrete Fourier Transforms (DFT).

The following additional equipment is optional:

c) For contact probes only:

   1) an electromagnetic-acoustic probe (EMA) and receiver;

   2) a plotter to plot directivity diagrams;

d) For immersion probes only:

   1) a hydrophone receiver with an active diameter less than two times the central ultrasonic wavelength of the probe under test but not less than 0,5 mm. The bandwidth of the hydrophone and the amplifier shall cover the bandwidth of the probe under test.

7.2 Test blocks and other equipment

The following test blocks shall be used to carry out the specified range of tests, for contact probes only:

a) Hemicylindrical blocks with different radii (R) in the range from 12 mm to 200 mm. Steps of $R\sqrt{2}$ are recommended. Steel quality shall be as defined in ISO 7963. The length of each block shall be equal to or larger than its radius, up to a maximum length of 100 mm. An example is shown in Figure 4;

b) blocks with parallel faces and different thicknesses in the range from 12 mm to 200 mm. Steel quality shall be as defined in ISO 7963. The length and witdh of each block shall be equal to or larger than its thickness, up to a maximum thickness of 100 mm.;

c) steel blocks with parallel faces and side-drilled holes of 3 mm diameter as shown in Figure 5 or Figure 6. The dimensions of the blocks shall meet the following requirements:

   1) length, l, height, h, and width, w, shall be such that the sides of the blocks shall not interfere with the ultrasonic beam;

   2) depth positions of the holes, d_1, d_2, etc., shall be such that at least three holes shall fall outside the near field;

   3) the distance between the holes, s, shall be such that the amplitude profile across the holes shows an amplitude drop of at least 26 dB between two adjacent holes;

   4) the steel quality is as defined in ISO 7963.

d) the steel blocks with inclined faces with a notch as shown in Figure 7, and steel blocks with hemispheric holes as in Figure 8. Steel quality shall be as defined in ISO 7963. These blocks are used to measure the beam divergence in the vertical and horizontal plane respectively;

e) an alternative steel block to measure index point, beam angle and beam divergence for angle-beam probes as given in Annex B;

f) a ruler;

g) feeler gauges starting at 0,05 mm.

NOTE Not all blocks are required if only special kinds of probes are to be checked, e.g. blocks to measure the index point and beam angle are not necessary if only straight-beam probes have to be measured.

For testing immersion probes the following reflectors and additional equipment shall be used:

h) a steel ball or rod with a hemispheric ended smooth reflective surface. For each frequency range the diameter of ball or rod to be used is given in Table 4.

Table 4 — Steel ball (rod) diameters for different frequencies

Probe centre frequency MHz	**Diameter d of ball or rod** mm
$3 < f \leq 15$	$d \leq 3$
$0{,}5 \leq f \leq 3$	$3 \leq d \leq 5$

i) a large plane and flat reflector target. The target's lateral size shall be at least ten times wider than the beam diameter of the probe under test at the end of focal zone, as defined in 8.6.2.2.

The thickness of the reflector shall be at least five times the wavelength calculated using the sound velocity of the material used and the centre frequency of the probe under test.

j) an immersion tank equipped with a manual or automated scanning mechanism with five free axes:

— three linear axes X, Y, Z;

— two angular axes θ and ψ;

k) automated recording means: If the amplitudes of ultrasonic signals are recorded automatically, then it is the responsibility of the manufacturer to ensure that the system has sufficient accuracy. In particular, consideration shall be given to the effects of the system bandwidth, spatial resolution, data processing and data storage on the accuracy of the results.

Typical setups to measure the sound beam of immersion probes are shown in Figures 14, 15 and 16.

The scanning mechanism used with the immersion tank should be able to maintain alignment between the target and the probe in the X and Y directions, i.e. within ± 0,1 mm for 100 mm distance in the Z direction.

The temperature of the water in the immersion tank should be maintained at room temperature and shall not deviate for more than ± 2 °C during the beam characterization of immersion probes described in 7.6.

The water temperature shall be reported in the probe data sheet.

Care shall be taken about the influence of sound attenuation in water, which, at high frequencies, causes a downshift of the echo frequency when using broad-band probes.

Table 5 shows the relation between frequency downshift and water path.