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Neporušitveno preskušanje - Ugotavljanje značilnosti in overjanje naprav za ultrazvočno preskušanje - 2. del: Preskuševalne glave

Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 2: Probes

Zerstörungsfreie Prüfung - Charakterisierung und Verifizierung der Ultraschall-Prüfausrüstung - Teil 2: Prüfköpfe

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

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EUROPEAN STANDARD

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Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 2: Probes

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 12668-2:2010) has been prepared by 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of an identical text or by endorsement, at the latest by August 2010, and conflicting national standards shall be withdrawn at the latest by August 2010.

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

This document supersedes EN 12668-2:2001.

EN 12668, *Non-destructive testing — Characterization and verification of ultrasonic examination equipment*, consists of the following parts:

— *Part 1: Instruments*

— *Part 2: Probes*

— *Part 3: Combined equipment*

Annex A is normative. Annex B is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard covers probes used for ultrasonic non-destructive examination in the following categories with centre frequencies in the range 0,5 MHz to 15 MHz, focusing and without focusing means:

a) single or dual transducer contact probes generating compressional or shear 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 EN 12668-3.

If parameters in addition to those specified in EN 12668-3 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.

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.

EN 1330-4:2010, *Non-destructive testing — Terminology — Part 4: Terms used in ultrasonic testing*

EN 12668-1, *Non-destructive testing — Characterization and verification of ultrasonic examination equipment — Part 1: Instruments*

EN ISO 7963 [1)], *Non-destructive testing — Ultrasonic testing Specification for calibration block n° 2 (ISO 7963:1985)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-4:2010 and the following apply.

3.1
dead zone
depth of the zone immediately beneath the coupling surface of the work piece, in which it is not possible to detect a given reflector

3.2
focal distance
near field length
point on the acoustical axis where the acoustic pressure is at its maximum

3.3
horizontal plane of a sound beam
<angle-beam probes> plane perpendicular to the vertical plane of the sound beam including the acoustical axis in the material

1) Under preparation.

3.4
operating frequency
f_o
centre frequency
arithmetic mean of upper and lower cut-off frequency

$$f_o = \frac{f_u + f_l}{2} \quad (1)$$

NOTE In the frequency spectrum of an echo the upper and lower cut-off-frequencies are determined at -6 dB compared to the maximum amplitude.

3.5
peak-to-peak amplitude
h
maximum deviation between the largest positive and the largest negative cycles of the pulse

NOTE See Figure 1.

3.6
probe data sheet
sheet containing the information required by this standard

NOTE The data sheet need not necessarily be a test certificate of performance.

3.7
pulse duration
time interval over which the modulus of the unrectified pulse amplitude exceeds 10 % of its maximum amplitude, as shown in Figure 1

3.8
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

3.9
relative bandwidth
Δf_{rel}
ratio of the difference between the upper and lower cut-off frequencies f_u and f_l and the centre frequency f_o

$$\Delta f_{rel} = [(f_u - f_l)/f_o] \times 100\ \%$$

NOTE The relative bandwidth is expressed in percent (%).

3.10
squint angle for straight-beam probes
δ
deviation between the axis of the beam and a perpendicular to the coupling surface at the emission point

NOTE 1 See Figure 2.

<angle-beam probes> angle between the sides of the probe housing and the measured beam axis, projected onto the plane of the probe face

NOTE 2 See Figure 3.

3.11
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 inspected component both lie

4 General requirements for compliance

An ultrasonic probe complies with this standard if it satisfies the following conditions:

a) the probe shall comply with Clause 7;

b) either a declaration of conformity, issued by a manufacturer operating a certified quality management system, or issued by an organization operating an accredited test laboratory shall be available;

NOTE It is recommended that the certification is carried out in accordance with EN ISO 9001, or that the accreditation is carried out in accordance with EN ISO/IEC 17025.

c) the probe shall be clearly marked to identify the manufacturer, and carry a unique serial number, showing operating frequency, transducer size, angle, or a permanent reference number from which this information can be traced;

d) a technical specification (data sheet) for the appropriate type and series of probe which defines the performance criteria in accordance with Clause 5 shall be available.

The quality of probes will be assured in one of the following ways:

e) by issuing a declaration of conformity based on statistical analysis where a number of identical probes are manufactured under a quality management system. The manufacturer shall supply a data sheet which includes the values of the specified parameters with tolerances;

f) by issuing a declaration of conformity quoting the results of measurements made on each probe.

5 Technical specification for probes

Table 1 gives the list of information to be reported in a data sheet for all probes within the scope of this standard (I = Information, M = Measurement, C = Calculation). The data sheet shall also contain information concerning the ultrasonic instrument used for the test, its settings and coupling conditions, etc.

The operating temperature range of the probe, and any special conditions for storage or protection during transport shall also be stated in the data sheet.

For probes intended for use at elevated temperatures, the manufacturer shall provide information on the maximum operating temperature in relation to the time of use, and the effect of temperature on the sensitivity and on the beam angle.

Table 1 — List of information to be given in a data sheet

Information to be given	Category of probe															
	Contact														Immersion	
	Straight beam					Angle beam									Straight	
	Compressional				Shear	Compressional				Shear					Compressional	
	Single		Double		Single	Single		Double		Single		Double			Single	
	non-f.	focus.	non-f.	focus.	non-f.	non-f.	focus.	non-f.	focus.	non-f.	focus.	non-f.	focus.		non-f.	focus.
Manufacturer's name	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I
Type of probe	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I
Weight and size of probe	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I
Type of connectors	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I
TR connectors interchangeable?			I	I				I	I			I	I			
Material of transducers	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I
Shape and size of transducers	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I
Material of wedge, delay	I	I	I	I		I	I	I	I	I	I	I	I			
Material of wear plate	I															
Wear allowance	I	I	I	I		I	I	I	I	I	I	I	I			

I = Information;
M = Measurement;
C = Calculation.

continued

Table 1 *(continued)*

Parameters to be measured or calculated	Category of probe															
	Contact													Immersion		
	Straight beam					Angle beam								Straight		
	Compressional				Shear	Compressional				Shear				Compressional		
	Single		Double		Single	Single		Double		Single		Double		Single		
	non-f.	focus.	non-f.	focus.	non-f.	non-f.	focus.	non-f.	focus.	non-f.	focus.	non-f.	focus.	non-f.	focus.	
Cross talk damping			M	M				M	M			M	M			
Pulse shape (time and frequency)	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Centre frequency, band width	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Pulse-echo sensitivity	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	
Distance-amplitude curve	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	
Impedance, static capacitance	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	

I = Information;
M = Measurement;
C = Calculation;
M,C = Measurement or calculation.

continued

Table 1 *(end)*

Parameters to be measured or calculated	Category of probe														
	Contact													Immersion	
	Straight beam					Angle beam								Straight	
	Compressional				Shear	Compressional				Shear				Compressional	
	Single		Double		Single	Single		Double		Single		Double		Single	
	non-f.	focus.	non-f.	focus.	non-f.	non-f.	focus.	non-f.	focus.	non-f.	focus.	non-f.	focus.	non-f.	focus.
Probe index						M	M	M	M	M	M	M	M		
Beam angle						M	M	M	M	M	M	M	M		
Angles of divergence	M				M	M				M				M	
Beam axis offset	M	M	M	M	M	M	M	M	M	M	M	M	M		
Squint angle	M	M	M	M	M	M	M	M	M	M	M	M	M		
Focal distance, near field	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C	M,C
Focal width	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Focal length	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Physical aspects	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M

I = Information;
M = Measurement;
C = Calculation;
M,C = Measurement or calculation;
Non-f. = Non-focusing.

6 Test equipment

6.1 Electronic equipment

The ultrasonic instrument (or laboratory pulser/receiver) used for the tests specified in Clause 7 shall be of the type designated on the probe data sheet, and shall comply with EN 12268-1 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 standard 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);

c) an impedance analyser.

The following additional equipment is optional:

d) For contact probes only:

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

   2) a plotter to plot directivity diagrams;

e) For immersion probes only:

   1) 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 amplifier should be higher than the bandwidth of the probe under test.

6.2 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) semi-cylinders with different radii (R) in the range from 12 mm to 200 mm. Steps of $R\sqrt{2}$ are recommended. Steel quality is as defined in EN ISO 7963. The thickness of each block shall be equal to or larger than its radius, up to a maximum thickness of 100 mm;

b) steel blocks with parallel faces and side-drilled holes of 3 mm diameter as shown in Figure 4. 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) depths 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) steel quality is as defined in EN ISO 7963.

c) steel blocks with inclined faces with a notch as shown in Figure 5, and steel blocks with hemispherical holes as in Figure 6. Steel quality is as defined in EN ISO 7963. These blocks are used to measure the beam divergence in the vertical and horizontal plane respectively;

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

e) ruler;

f) 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:

g) a steel ball or semi-spherical ended rod with smooth reflective surface. For each frequency range the diameter of ball or rod to be used is given in Table 2.

Table 2 — Steel ball (rod) diameters for different frequencies

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

h) a large plane and flat reflector target. The target's lateral size shall be at least ten times wider than the diameter of the beam of the probe under test at the end of focal zone, as defined in 7.7.2.2.

Thickness is at least five times the wavelength of the probe under test, calculated using the velocity of ultrasound in the material of the target.

i) immersion tank equipped with a manual or automatic scanning bridge with five free axes:

— three linear axes X, Y, Z;

— two angular axes Θ and Ψ;

j) automatic 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 set-ups to measure the sound beam of immersion probes are shown in Figures 15, 16 and 17.

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 shall be maintained at (20 ± 2) °C during the beam characterization of immersion transducers described in 7.7.

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 broadband probes.

Table 3 shows the relation between frequency downshift and water path.

Table 3 — Frequency downshift in percent of centre frequency f_0 depending on total water path length, for relative bandwidths (b.w.) 50 % and 100 %

f_0	b.w.	Total water path mm															
MHz	%	10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400
5	50	0	0	0	0	0	0	1	1	1	1	1	2	2	2	3	3
	100	0	1	1	1	2	2	2	3	3	3	5	6	7	9	10	11
10	50	0	1	1	1	2	2	2	3	3	3	5	6	7	9	10	11
	100	1	3	4	5	6	7	8	9	10	11	16	21	24	28	31	34
15	50	1	1	2	3	4	4	5	6	6	7	10	13	15	18	20	23
	100	3	6	8	10	13	15	17	19	21	23	30	37	42	47	50	54
20	50	1	3	4	5	6	7	8	9	10	11	16	21	24	28	31	34
	100	5	10	13	17	21	24	27	29	32	34	44	51	56	61	64	67
25	50	2	4	6	7	9	11	12	14	15	17	23	29	34	38	41	45
	100	7	14	20	24	29	33	36	39	42	45	55	62	67	70	74	76
30	50	3	6	8	10	13	15	17	19	21	23	30	37	42	47	50	54
	100	10	19	26	32	37	41	45	48	51	54	64	70	74	78	80	82