BS EN 16392-2:2014

BSI Standards Publication

Non-destructive testing — Characterisation and verification of ultrasonic phased array equipment

Part 2: Probes

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Non-destructive testing - Characterisation and verification of ultrasonic phased array equipment - Part 2: Probes

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

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

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Foreword

This document (EN 16392-2:2014) 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of an identical text or by endorsement, at the latest by September 2014 and conflicting national standards shall be withdrawn at the latest by September 2014.

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.

EN 16392 consists of the following parts, under the general title *Non-destructive testing — Characterisation and verification of ultrasonic phased array equipment:*

— *Part 2: Probes;*

and

prEN ISO 18563

— *Part 1: Instruments;*

— *Part 3: Combined systems.*

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard covers linear phased array probes used for ultrasonic non-destructive testing in contact technique (with or without a wedge) or in immersion technique, with centre frequencies in the range 0,5 MHz – 10 MHz.

This European Standard specifies the characterisation tests that have to be done at the end of the fabrication of a phased array probe. It defines both methodology and acceptance criteria.

This document does not describe methods and acceptance criteria to characterise the performance of an ultrasonic phased array instrument or the performance of a combined system. These are described in prEN ISO 18563-1 and in prEN ISO 18563-3.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 16018, *Non-destructive testing - Terminology - Terms used in ultrasonic testing with phased arrays*

EN 1330-2, *Non-destructive testing - Terminology - Part 2: Terms common to the non-destructive testing methods.*

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

EN ISO 2400, *Non-destructive testing - Ultrasonic testing - Specification for calibration block No. 1 (ISO 2400:2012)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-2, EN 1330-4, EN 16018 and the following apply.

3.1
phased array probe data sheet
document describing the general characteristics of the same type of phased array probes

3.2
phased array probe certificate
document showing compliance with this European Standard giving the measured values of the required parameters of one specific phased array probe

4 General requirements for compliance

An ultrasonic phased array probe complies with this document if it satisfies the following conditions:

a) the probe shall comply with Clause 7;

b) a declaration of conformity is issued:

1) either based on the results of statistical analysis by a manufacturer operating a certified quality management system or by an organisation operating an accredited test laboratory;

2) or based on measurements of every probe. Probe manufacturers shall then provide the measurement results.

   Manufacturers shall state which method is used.

c) the probe body shall show:

   1) a unique serial number;

   2) the centre frequency;

   3) the number of elements;

   4) the pitch;

   5) the position of the first and last element;

   6) reference, if applicable.

If this information cannot be given on the probe body, then at least a unique serial number and a reference to identify the probe shall be used.

d) a technical specification for the probe is available, which defines the performance criteria in accordance with Clause 5.

5 Technical specification for phased array probes

The technical specifications of phased array probes required by this document shall be listed in a data sheet.

Table 1 shows the information which shall be supplied by the manufacturer in the probe data sheet (M = Measurement, OI = Other information). The probe data sheet shall also contain information concerning the ultrasonic phased array instrument used for the test and its settings, the coupling conditions etc.

Table 1 – Technical information to be given in the probe data sheet

Information required	Information type [a]	Comments
Probe supplier	OI	
Identification	OI	Serial number, reference if applicable and other information engraved on the probe
Probe type	OI	
Probe dimensions	OI	Outer dimensions
Shape and dimensions of the transducer	OI	Array surface dimensions and geometry, array dicing and position of element number 1
Pitch, space between elements and element dimensions	OI	Element dimensions (length and width)
Type of connector	OI	Commercial name, size, number of pins etc.
Wiring order	M	Pin assignment of the connector
Cable	OI	Cable length, outer diameter and material if specific request
Dimensions and material of integrated wedge	OI	Only valid for contact probes with integrated wedge
Centre frequency, bandwidth and pulse width	M	See 7.3
Relative pulse-echo sensitivity	M	See 7.4.
Probe sensitivity	M	See 7.5
Inter-element cross-talk	OI	Minimum value of the inter-element cross-talk, see 7.6
Maximum allowable squint angle	OI	Maximum value of the squint angle, with indication of the plane of reference
Environmental conditions	OI	For example temperature range, humidity, sealing, pressure
Equipment and setting used for characterization tests	OI	For example test instruments, test blocks, measurement setup
Special conditions	OI	For example for storage, for protection during transportation
Physical aspects	OI	For example casing material, aspect, see 7.2
[a] Information to be given for each transducer except if contrary indications are given in observation.		

Table 2 – Optional technical information to be shown in the probe data sheet

Optional information	Comments
General drawing and tolerances	
Inter-element cross-talk	Measured cross-talk value corresponding to the probe – See 7.6
Squint angle	Measured squint angle value, with indication of the plane of reference

6 Test equipment

6.1 Electronic equipment

The measurement equipment used for the tests specified in Clause 7 shall be stated on the probe data sheet, conformity of this equipment must be checked periodically.

Testing shall be carried out with the probe cables and matching devices specified on the probe data sheet.

In addition to the ultrasonic phased array instrumentation or laboratory pulser-receiver, the following equipment or its equivalent is essential to test phased array probes in accordance with this document:

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

b) a frequency spectrum analyser with a minimum bandwidth of 100 MHz, or an oscilloscope/digitiser performing Fast Fourier Transform (FFT).

6.2 Tests block and other equipment

Phased array probes can be used in contact technique (with or without a wedge) or in immersion technique. Depending on this, the performance tests shall be carried out under corresponding conditions:

a) Contact technique with wedge (integrated or not integrated);

   A block of the same material as the wedge and proper dimensions so that the total ultrasonic path is the same for each element shall be used;

   If the wedge can be removed, the test shall preferably be performed without the wedge.

b) Contact technique without wedge;

   A block of the material to be tested shall be used so that the total ultrasonic path is the same for each element. If no material is specified a block of steel grade according to EN ISO 2400 shall be used.

c) Immersion technique.

   Performance tests shall be carried out in immersion fluid using a defined reflector at a specified distance, which has to be reported in the data sheet. If no fluid is specified water shall be used.

   Details of the test block (geometry, material, reflector type, shape and position, speed of sound) shall be stated in the probe data sheet or probe certificate.

7 Performance tests for phased array probes

7.1 General

Measurements shall be performed at the probe connector once the probe is completely assembled.

It should be noted that acceptance criteria are only valid under the conditions defined for the considered probe.

7.2 Physical aspects

7.2.1 Method

Visually inspect the outside of the probe for correct identification and assembly and for physical damage. For contact probes measure the flatness of the contact surface of the probe.

7.2.2 Acceptance criterion

For flat faced probes, over the whole probe face the gap shall not be larger than 0,05 mm.

7.3 Frequency, bandwidth and pulse duration

7.3.1 General

Measurements shall be done on each element of the probe.

7.3.2 Method

Measurements are performed in transmit-receive mode according to 6.2.

The transmitter pulse shall be a negative square pulse, the duration of which is equal to half the period corresponding to the nominal probe frequency.

The echo of the reflector shall be placed in a time window, the duration of which is at least twice the duration of the echo pulse measured at -20 dB of the signal amplitude.

The frequency spectrum shall be determined on the signal in the used time window.

The frequencies intersecting the spectrum at -6 dB of the maximum amplitude of the spectrum shall be determined.

From the upper and lower frequencies thus obtained, respectively named, f_u, and, f_l, the centre frequency ,f_0, is calculated as follows:

$$f_0 = \frac{f_u + f_l}{2} \tag{1}$$

the bandwidth is defined as follows:

$$\Delta f = f_u - f_l \tag{2}$$

And the relative bandwidth is calculated in %, as:

$$\Delta f_{rel} = \left(\Delta f / f_0\right) \times 100 \tag{3}$$

7.3.3 Acceptance criteria

Values obtained for the frequency, bandwidth and pulse duration, are the values for each element.

The centre frequency shall be within ± 10 % of the frequency stated in the data sheet.

The -6 dB bandwidth shall be equal to or larger than the bandwidth stated in the data sheet.

The pulse duration shall be smaller or equal to the value stated in the data sheet.

7.4 Relative pulse-echo sensitivity variation

7.4.1 General

Measurements shall be done on each element.

7.4.2 Method

The measurement is performed under the same conditions as those for 7.3.

The amplitude in volts V_{el} of the reference echo of each element shall be measured and recorded. The arithmetic mean value V_{av} of the V_{el} amplitudes shall be calculated and recorded.

Relative pulse-echo sensitivity variation S_{el} of each element shall be calculated as follows:

$$S_{el} = 20 \lg \frac{V_{el}}{V_{av}} \tag{4}$$

7.4.3 Acceptance criterion

The relative pulse-echo sensitivity variation S_{el} over all the elements shall be within ± 3dB.

7.5 Probe sensitivity

7.5.1 General

Measurements shall be done to compare probes of the same type.

7.5.2 Method

The measurement is performed under conditions as that for 7.3.

The reference excitation signal amplitude V_{ref} is measured with one channel of an instrument considering one element connected.

The signal is considered as the reference excitation signal used for all elements.

The average element sensitivity (arithmetic mean) V_{av} over all elements shall be calculated (see 7.4.2).

The probe sensitivity ΔS_{pr} shall be calculated as follows:

$$\Delta S_{pr} = 20 \lg \frac{V_{av}}{V_{ref}} \tag{5}$$

7.5.3 Acceptance criterion

The probe sensitivity ΔS_{pr} shall be within ± 3 dB of the manufacturer's specification.

7.6 Inter-element cross-talk

7.6.1 General

The inter-element cross-talk shall be determined on two locations for an array with up to 64 elements and on four locations for an array with more than 64 elements.

7.6.2 Method

The inter-element cross-talk is measured by exciting one element selected randomly and measuring the signal received on the adjacent elements. A network analyser can be used for a direct measurement.

When the measurements are performed using an oscilloscope, the excitation signal should be a sine burst of the nominal frequency with a duration of at least 6 periods.

The cross-talk shall be measured by connecting an oscilloscope to an adjacent element. In case of a contact probe, the probe's matching face shall be in contact with a test block, in case of an immersion probe the probe shall be immersed. The setup shall be chosen in a way that the measurement is not influenced by reflections from the test block or from the immersion tank.

Inter-element cross-talk Δ_{ct} is calculated as follows:

$$\Delta_{ct} = 20 \lg \frac{V_{exc}}{V_{rec}} \tag{6}$$

Where

V_{rec} is the voltage received by an adjacent element

V_{exc} is the voltage of the excitation burst

7.6.3 Acceptance criterion

The inter-element cross-talk shall be at least 25 dB.

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