SLOVENSKI STANDARD
oSIST prEN ISO 18563-3:2023

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Neporušitveno preskušanje - Ugotavljanje značilnosti in preverjanje ultrazvočne opreme faznih sistemov - 3. del: Kombinirani sistemi (ISO/DIS 18563-3:2023)

Non-destructive testing - Characterization and verification of ultrasonic phased array equipment - Part 3: Complete systems (ISO/DIS 18563-3:2023)

Zerstörungsfreie Prüfung - Charakterisierung und Verifizierung der Ultraschall-Prüfausrüstung mit phasengesteuerten Arrays - Teil 3: Vollständige Prüfsysteme (ISO/DIS 18563-3:2023)

Essais non destructifs - Caractérisation et vérification de l'appareillage ultrasonore multiélément - Partie 3: Système complet (ISO/DIS 18563-3:2023)

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

Part 3:
Complete systems

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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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 18563:2015), which has been technically revised.

The main changes compared to the previous edition are as follows:

— integration of matrix array probes;

— deletion of group 1 and 2 tests;

— addition of a chapter dealing with the use of imaging for complete system verification (9.4.3) as a simplification for a more functional standard (characterisation of beams moved to Annex A);

— addition of signal processing techniques using arrays (e.g. TFM) in the scope.

A list of all parts in the ISO 18563 series can be found on the ISO website.

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.

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

Part 3: Complete systems

1 Scope

This document addresses ultrasonic test systems implementing array probes, for contact technique (with or without wedge) or for immersion technique, with centre frequencies in the range of 0,5 MHz–10 MHz.

It provides methods and acceptance criteria for determining the compliance of the combined equipment (i.e. instrument, probe, wedge and cables connected). Its purpose is for the verification of the correct operation of the system prior to testing or verification of the absence of degradation of the system.

The methods are not intended to prove the suitability of the system for particular applications but are intended to prove the capability of the complete system (used for an application) to operate correctly according to the settings used. Tests can be performed on individual ultrasonic beams (for phased array technique, see 9.4.4) or on resulting images (for phased array technique and total focusing technique, see 9.4.3).

The tests can be limited to the functions that are intended to be used for a certain application.

This document does not cover the calibration of the system for a specific application and the characterization and verification of the mechanical scanning equipment. It is intended that these items will be covered by the test operating procedure.

This document does not address the configurations of probes using the tandem technique.

The characterization of beams, as recommended for dead elements or for more in-depth knowledge of the beams, is presented in Annex A. It is not applicable for signal processing technology using arrays.

NOTE Unless stated otherwise, in this document 'TFM' and 'TFM technique' refer to the total focusing technique as defined in ISO 23243, and to related techniques, see for example ISO 23865 and ISO 23243.

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

ISO 18563-1, *Non-destructive testing — Characterization and verification of ultrasonic phased array equipment — Part 1: Instruments*

ISO 18563-2, *Non-destructive testing — Characterization and verification of ultrasonic phased array equipment — Part 2: Probes*

ISO 19675, *Non-destructive testing — Ultrasonic testing — Specification for a calibration block for phased array testing (PAUT)*

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

ISO 23243, *Non-destructive testing — Ultrasonic testing with arrays — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577, ISO 23243 and the following apply.

ISO and IEC maintain terminological 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/

3.1
combined equipment
connected set including the instrument, the array probe (with wedge if applicable) and connecting cables, including adapters

[SOURCE: ISO 23243:2020. Modified – array and wedge added]

3.2
complete system
combined equipment including the settings for a given mode of operation

Note 1 to entry: Settings are specific values or ranges of values, e.g. electronic scanning or steering range.

3.3
reference system
complete system including an instrument according to ISO 18563-1 and a probe initially according to ISO 18563-2, on which all of the applicable tests defined in Clause 9 of this document have been performed successfully

3.4
identical system
complete system in which instruments, probes, wedges, connecting cables and the settings for a given mode of operation are identical to those of the reference system

Note 1 to entry: components are identical if from the same manufacturer and the same model

3.5
system record sheet
document for reporting the results for a complete system which enables a comparison with the values obtained from the reference system

4 Symbols

For the purposes of this document, the symbols given in Table 1 apply.

Table 1 — Symbols

Symbol	Unit	Definitions
λ	mm	Wavelength
ΔS_{el}	dB	Relative sensitivity of an element

Table 1 *(continued)*

Symbol	Unit	Definitions
a_i	mm	*Contact technique*: reduced projected sound path length *Immersion technique*: distance between the orthogonal projection of the axis of the side-drilled hole on the test surface and the centre of the probe surface
A_{el}	V or % FSH	Amplitude of one elementary signal
A_{max}	V or % FSH	Maximum value of the amplitudes of all elementary signals
A_{ref}	V or % FSH	Median value of the amplitudes of all elementary signals
A_{min}	V or % FSH	Minimum value of the amplitudes of all elementary signals, excluding the dead elements
D_{CM}	mm	Distance between the centre of a side-drilled hole and the point of maximum amplitude of the indication of this hole
D	mm	Diagonal of the active aperture
$(X_M; Z_M)$	mm; mm	Coordinate of the position of maximum amplitude of an indication
G_{ref}	dB	Reference gain
N	mm	Near-field length associated with the active aperture
Θ	°	Angle of refraction
p	mm	Pitch
X	mm	Distance between the probe front surface and the probe index point

5 General requirements for conformity

5.1 General

All following tests shall be performed with an instrument that complies with ISO 18563-1 and an array that initially complied with ISO 18563-2.

The tests can be limited to the functions that are intended to be used for a certain application, e.g. used channels of the instrument or used part of the array or specific settings for a given mode of operation.

When all required tests have been successfully conducted, the complete system is considered to conform to this document and may be used as a reference system.

5.2 Reference system

a) The tests to be performed prior to the first use of a complete system are described in Table 4.

The results of the measurements made on the reference system are the base values.

b) A system record sheet of these base values shall be created.

5.3 Identical system

a) When an identical system is created, and/or when using other channels of the instrument and duplicating the settings, or after a maintenance operation, the same tests shall be performed again.

b) The results of the measurements made on the identical system shall be recorded in the system record sheet and compared against the base values.

5.4 Periodic check

a) For a periodic check of correct operation of the system, the same tests shall be performed.

b) The frequency of checking of the complete system shall be specified in the procedure, e. g. before starting and at the end of the non-destructive testing or daily.

c) The system record sheet shall be updated after each periodic check.

6 Qualification of test personnel

Personnel performing the verifications in accordance with this document shall be qualified to an appropriate level in ultrasonic testing in accordance with ISO 9712 or equivalent.

In addition to general knowledge of ultrasonic testing, the operators shall be familiar with, and have practical experience in, the use of ultrasonic phased arrays or TFM techniques.

7 Modes of operation for phased array techniques

This clause is not applicable for signal processing techniques using arrays, e.g. TFM.

This clause is applicable for phased array techniques based on beams by using a set of delay laws for multiple array elements during transmission and/or reception.

Depending on the application, the following options of the phased array technique may be used:

— number of active apertures (one or multiple);

— number of shots or delay laws (one or multiple) per active aperture;

— type of delay law (beam steering, beam focusing or combined setting).

The six most common modes of operation for phased array techniques are defined in Table 2.

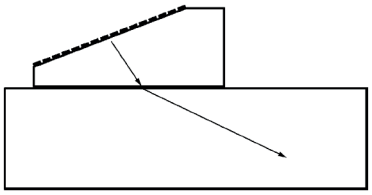
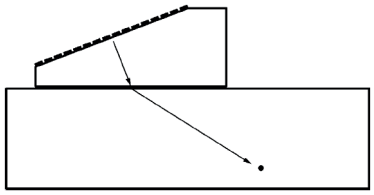
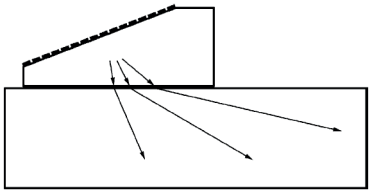
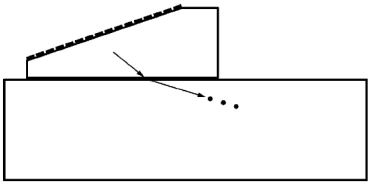
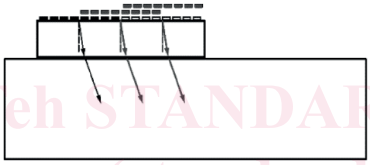
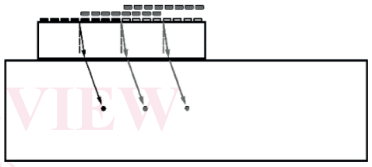
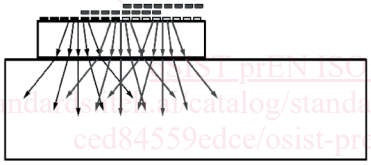
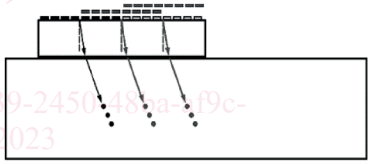
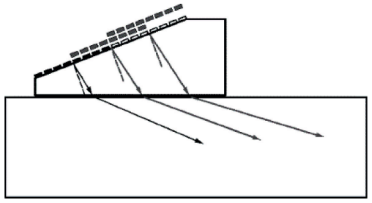
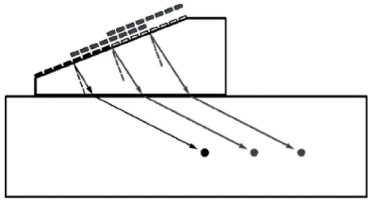
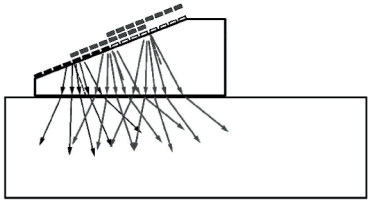
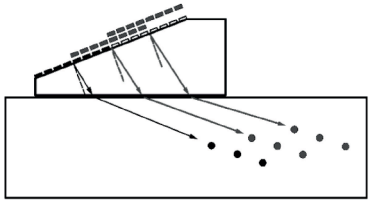
Examples of modes of operation for phased array techniques are illustrated in Table 3.

Table 2 — Definition of modes of operation for phased array techniques

Modes	Number of active apertures	Number of delay laws per active aperture	Identical or different set of delay laws for each aperture	Array orientation	Resulting beam(s)
Mode 1	One	One	Not applicable (only one aperture)	Not relevant	One beam
Mode 2	One	Multiple	Not applicable (only one aperture)	Not relevant	Multiple beams from one active aperture
Mode 3	Multiple	One	Identical	Array parallel to the test surface	One beam from each active aperture, all beams are identical
Mode 4	Multiple	Multiple	Identical	Array parallel to the test surface	Multiple beams from each active aperture, beams are identical for all active apertures
Mode 5	Multiple	One	Identical	Array not parallel to the test surface	One beam from each active aperture, beams are different for each active aperture
			Different	Not relevant	
Mode 6	Multiple	Multiple	Identical	Array not parallel to the test surface	Multiple beams from each active aperture, beams are different for each active aperture
			Different	Not relevant	

Considering these different modes of operation and their resulting beams, the number of beams or images to be tested is described in Table 4.

Table 3 — Examples of modes of operation for phased array techniques

Modes	Examples	
Mode 1	 a) Beam steering	 b) Beam focusing on one point
Mode 2	 a) Electronic sectorial scanning	 b) Focusing on several points
Mode 3	 a) Electronic linear scanning with constant delay path	 b) Electronic linear scanning with focusing
Mode 4	 a) Electronic sectorial scanning together with electronic linear scanning	 b) Focusing on several points together with electronic linear scanning
Mode 5	 a) Electronic linear scanning with varying delay path	 b) Electronic linear scanning with focusing or combined electronic scanning
Mode 6	 a) Electronic sectorial scanning together with electronic linear scanning	 b) Focusing on several points together with electronic linear scanning

NOTE 1 For simplicity, only the beam centre lines are indicated. An arrow indicates the beam direction, dots indicate focal points.

NOTE 2 The medium between the array and the test object may be a fluid (immersion) or a solid (e.g. wedge).

8 Equipment required for tests

The equipment required for the tests of the complete system includes:

a) suitable reference block(s);

b) measurement devices for the length to ±0,5 mm and for the angle to ±1°.

9 Tests to be performed

9.1 General

a) Before performing the tests, the equipment settings shall be made according to the array and wedge that are in use for the application.

b) For applications where only a part of the array is used, the tests can be limited to this part. In that case the results of the tested parts of the array shall be recorded on the system record sheet.

Table 3 describes the various tests to be conducted on a complete system based on the different modes of operation for phased array techniques.

The last column of Table 3 describes the various tests to be conducted on a complete system in case of signal processing techniques using arrays. For conciseness it is named TFM mode.

For tests where Table 3 indicates that it is required to verify at least three beams, apertures or presentations, this means at least the median and both extreme situations shall be verified.

For the phased array technique, tests can be performed either on individual ultrasonic beams or on resulting images, if applicable.

For the total focusing technique, tests can only be performed on resulting images, because no individual ultrasonic beams are available.

Table 4 — Tests to be performed

Items	Test and clause	Mode 1	Mode 2 Example a	Mode 2 Example b	Mode 3	Mode 4	Mode 5	Mode 6	TFM mode
Visual inspection	Visual inspection of the equipment 9.2	Required							
Elements and channels	Channel assignment 9.3.2	Required for used channels							
	Relative sensitivity of elements, reference amplitude and dead elements 9.3.3	Required for used channels							
Correct operation [c]	Amplification system 9.4.2	Required for used channels							
	Using imaging [a] 9.4.3	Not applicable	S-scan presentation	Not applicable	L-scan presentation	At least one L-scan or S-scan presentation	L-scan or S-scan presentation	At least three L-scan or S-scan presentations [b]	TFM image
	Angle of refraction and probe index point measurements [a] 9.4.4	Used beam	At least 3 beams [b]		At least three apertures [b]	At least the three following beams: first shot of first aperture, last shot of last aperture and median shot of median aperture	At least three apertures: extreme and median positions	— at least three apertures [b], and — for each of these apertures, three beams [b]	Not applicable
	Skew angle 9.4.5								
	Characterization of sound beams Annex A	Optional							Not applicable
Other verifications	Squint angle 9.5.1	Required							
	Grating lobes 9.5.2	Optional							

[a] Verification of correct operation is either done by using imaging (9.4.3) or by measuring angle of refraction and probe index point (9.4.4).

[b] Verifications shall be done for extreme and median positions or apertures or beams.

[c] For matrix array probes generating beams with skew angles, the verifications shall be performed in the extreme and median deflection planes