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

Part 1: Instruments

Essais non destructifs — Caractérisation et vérification de l'appareillage de contrôle par ultrasons en multiéléments — Partie 1: Appareils

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Contents

Page

Foreword ..... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Symbols and abbreviated terms **2**

5 General requirements of conformity **3**

6 Manufacturer's technical specification for phased array ultrasonic phased array instruments **3**

7 Performance requirements for ultrasonic phased array instruments **7**

8 Group 1 tests **9**
8.1 Equipment required for group 1 tests 9
8.2 Battery operated phased array instruments 10
8.2.1 Operating time 10
8.2.2 Stability against voltage variations 10
8.3 Stability tests 11
8.3.1 Stability after warm-up time 11
8.3.2 Stability against temperature 11
8.4 Display 12
8.4.1 General 12
8.4.2 Time base deviation 12
8.4.3 Highest digitized frequency 12
8.4.4 Screen refresh rate for A-scan presentations 13
8.5 Transmitter 13
8.5.1 Pulse repetition frequency 13
8.5.2 Output impedance 14
8.5.3 Time delay resolution 14
8.6 Receiver 15
8.6.1 Cross-talk between receivers 15
8.6.2 Dead time after the transmitter pulse 15
8.6.3 Dynamic range and maximum input voltage 16
8.6.4 Receiver input impedance 17
8.6.5 Time-corrected gain 17
8.6.6 Temporal resolution 18
8.6.7 Time delay resolution 19
8.6.8 Linearity of vertical display over the extreme frequency ranges of the instrument 19
8.7 Monitor gate 20
8.7.1 General 20
8.7.2 Linearity of monitor gate amplitude 20
8.7.3 Linearity of monitor gate time-of-flight 21
8.7.4 Monitor gates with analogue outputs 21
8.8 Summation 23
8.8.1 General 23
8.8.2 Procedure 23
8.8.3 Acceptance criteria 24

9 Group 2 tests **24**
9.1 Equipment required for group 2 tests 24
9.2 Visual inspection 24
9.2.1 Procedure 24
9.2.2 Acceptance criteria 24
9.3 Transmitter pulse parameters 24

9.3.1 General 24
9.3.2 Transmitter voltage, rise time, and duration 24
9.3.3 Linearity of time delays 25
9.4 Receiver 26
9.4.1 General 26
9.4.2 Frequency response 26
9.4.3 Channel gain variation 27
9.4.4 Equivalent input noise 28
9.4.5 Gain linearity 28
9.4.6 Linearity of vertical display 29
9.4.7 Linearity of time delays 30
10 Figures 31
Bibliography 39

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).

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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 WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

ISO 18563-1 was prepared by the European Committee for Standardization (CEN), Technical Committee CEN/TC 138, *Non-destructive testing*, in collaboration with ISO/TC 135, *Non-destructive testing*, Subcommittee SC 3 *Ultrasonic testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 18563 consists of the following parts, under the general title *Non-destructive testing — Characterization and verification of ultrasonic phased array equipment*:

— *Part 1: Instruments*

— *Part 3: Combined systems*

An additional part on *Probes* is planned.

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

Part 1: Instruments

1 Scope

This part of ISO 18563 identifies the functional characteristics of a multichannel ultrasonic phased array instrument used for phased array probes and provides methods for their measurement and verification.

This part of ISO 18563 can partly be applicable to ultrasonic phased array instruments in automated systems, but then, other tests might be needed to ensure satisfactory performance. When the phased array instrument is a part of an automated system, the acceptance criteria can be modified by agreement between the parties involved.

This part of ISO 18563 gives the extent of the verification and defines acceptance criteria within a frequency range of 0,5 MHz to 10 MHz.

The evaluation of these characteristics permits a well-defined description of the ultrasonic phased array instrument and comparability of instruments.

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.

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

EN 1330-4, *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 16018, *Non-destructive testing — Terminology — Terms used in ultrasonic testing with phased arrays*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-4, EN 12668-1, EN 16018, and the following apply.

3.1
maximum number of channels that can be simultaneously activated
maximum number of transmitting and/or receiving channels which can be used for one shot

3.2
parallel phased array instrument
phased array instrument featuring a *maximum number of channels that can be simultaneously activated* (3.1) equal to the number of channels in the instrument

EXAMPLE In a type 64/64 (or 64//), the number of channels that can be simultaneously activated is 64 and the number of channels of the instrument is 64.

3.3
multiplexed phased array instrument
phased array instrument featuring a *maximum number of channels that can be simultaneously activated* (3.1) smaller than the number of channels in the instrument and which are controlled by an internal multiplexing device

EXAMPLE In a type 16/64 multiplexed instrument, the number of channels that can be simultaneously activated is 16 and the number of channels available is 64. See Figure 1.

3.4
time resolution of the phased array instrument
inverse of the maximum digitization frequency without processing

4 Symbols and abbreviated terms

Table 1 — Symbols and abbreviations

Symbol	Unit	Meaning
A_{min}	%	Minimum amplitudes measured on a screen
A_{max}	%	Maximum amplitudes measured on a screen
A_0, A_n	dB	Attenuator settings used during tests
CT	dB	Cross-talk
f_0	Hz	Centre frequency for each frequency range
f_u	Hz	Upper frequency limit at −3 dB
f_l	Hz	Lower frequency limit at −3 dB
f_{max}	Hz	Frequency with the maximum amplitude in the frequency spectrum
f_h	Hz	Highest digitized frequency
Δf	Hz	Frequency bandwidth in each frequency range
f_{RR}	Hz	Screen refresh rate
FSH		Full screen height
ΔG	dB	Channel gain variation
G_D	dB	Input signal dynamic range
G_i	dB	Instrument gain on channel *i*
H_R	%	Reference screen height
I_{max}	A	Amplitude of the maximum current that can be driven by the proportional gate output
N_{in}	$\frac{V}{\sqrt{Hz}}$	Noise per root bandwidth for receiver input
R_A, R_B, R_l	Ω	Termination resistors
S	dB	Attenuator setting
Δt	s	Time increment
t	s	Time delay
t_0	s	Time to the start of distance amplitude curve
t_1	s	Dead time
t_d	s	Pulse duration
t_{final}	s	Time to the end of distance amplitude curve

Table 1 *(continued)*

Symbol	Unit	Meaning
t_r	s	Transmitter pulse rise time from an amplitude of 10 % to 90 % of peak amplitude
$t_{Target\ 0}$, $t_{Target\ i}$, t_{Pi}, $t_{P\ 0}$, t_{difi}, t_{dif}	s	Transmitter or receiver time delay
t_{A1}, t_{A2}	s	Temporal resolution
V_A, V_B	V	Pulse voltage amplitudes
V_{ein}	V	Receiver equivalent input noise
V_{in}	V	Input voltage when measuring the receiver equivalent input noise
V_l	V	Output voltage modified when measuring the output impedance of the analogue gate
V_{min}	V	Minimum input voltage of the receiver
V_{max}	V	Maximum input voltage of the receiver
V_O	V	Output voltage to get an indication at 80 % of FSH when measuring the output impedance of the analogue gate
V_{50}	V	Voltage amplitude of the 50 Ω loaded transmitter pulse
Z_0	Ω	Output impedance of transmitter
Z_A	Ω	Output impedance of proportional output

5 General requirements of conformity

An ultrasonic phased array instrument complies with this part of ISO 18563 if it fulfils all of the following requirements:

a) the ultrasonic phased array instrument shall comply with Clause 7;

b) a declaration of conformity shall be available, issued by either the manufacturer operating a certified quality management system (e.g. in accordance with ISO 9001) or by an organization operating an accredited test laboratory (e.g. in accordance with ISO/IEC 17025);

c) the ultrasonic phased array instrument shall carry a unique serial number;

d) manufacturer‘s technical specification corresponding to the instrument, which defines the performance criteria in accordance with Clause 6, shall be available.

6 Manufacturer’s technical specification for phased array ultrasonic phased array instruments

The manufacturer’s technical specification relative to a specific model of an ultrasonic phased array instrument shall contain, as a minimum, the information listed in Table 2. This table specifies the information which shall be supplied by the manufacturer in the instrument’s technical specification (M = Measurement, OI = Other information). The values obtained from the tests described in Clause 7 shall be established as nominal values, with tolerances given as indicated.

Table 2 — Technical characteristics to be shown in the instrument's technical specification

Information	Type of information	Remarks
General features		
Size	OI	Width (mm) × Height (mm) × Depth (mm)
Weight	OI	At an operational stage including all batteries
Type(s) of power supply	OI	
Type(s) of instrument sockets	OI	Including the wiring diagram
Battery operational time	M	At fully charged new batteries
Number and type of batteries	OI	
Stability against temperature	M	
Stability after warm-up time	M	
Stability against voltage variations	M	
Temperature and voltage (mains and/or batteries) ranges in which the instrument operates in accordance with the technical specification (operation and storage)	OI	When a warm-up time is necessary, its duration shall be stated
Form of indication given when a low battery voltage takes the ultrasonic phased array instrument performance outside of specification	OI	
Pulse repetition frequencies (PRFs)	M	Minimum and maximum values
Maximum power consumption	OI	VA (volt-amps)
Protection grade	OI	
Environment	OI	For example: restriction of hazardous substances (RoHS), explosive atmosphere (ATEX), vibration, humidity
Multichannel configuration	OI	Number of channels controlled simultaneously and number of available channels
Extension of the number of channels by interconnection of instruments	OI	
Available measurement units	OI	For example: mm, inches, %, dB, V
Display		
Screen size and resolution	OI	
Range of sound velocities	OI	
Time base delay and depth	OI	
List of available views	OI	
Screen refresh rate for A-scan presentations	M	
Maximum digitization frequency without processing	OI	
Digitization frequency with processing	OI	For example: interpolation
Digitizer vertical resolution	OI	In bits
Highest digitized frequency	M	
Time base error	M	

M Measurement.

OI Other information.

Table 2 *(continued)*

Information	Type of information	Remarks
Inputs/outputs		
Signal unrectified output (i.e. radio frequency, RF) and/or rectified available on the output socket	OI	
Number and characteristics of logic and analogue control outputs	OI	Including the wiring diagram
Number and characteristics of encoder inputs	OI	Including the wiring diagram
Power input	OI	AC, DC, voltage range, power (W)
Available power supply for external devices	OI	Voltage, power
Synchronization input/output	OI	
Beam forming		
Maximum number of channels active simultaneously	OI	
Maximum number of delay laws	OI	
Summation	M	
Transmitter		
Number of transmitters available simultaneously	OI	
Shape of transmitter pulse and where applicable, polarity	OI	i.e. rectangular, unipolar, bipolar, arbitrary pulse
Transmitter voltage, rise time, fall time and duration	M	
Output impedance	M	
Maximum time delay	OI	
Time delay resolution	M	
Linearity of time delays	M	
Possibility to apply different voltages on each channel	OI	
Maximum power available per transmitter	OI	
Receiver		
Number of receivers available simultaneously	OI	
Characteristics of the gain control, i.e. range in decibels, value of increments	OI	
Characteristics of the logarithmic amplifier	OI	
Input voltage at FSH	OI	
Maximum input voltage	M	
Linearity of vertical display	M	

M Measurement.

OI Other information.

Table 2 *(continued)*

Information	Type of information	Remarks
Linearity of the vertical display over the extreme frequency ranges of the instrument	M	
Frequency response	M	
Dead time after transmitter pulse	M	
Equivalent input noise	M	$\frac{V}{\sqrt{Hz}}$
Dynamic range	M	
Input impedance	M	
Maximum time delay	OI	
Time delay resolution	M	
Time-corrected gain (TCG)	M	
Possibility to apply different gain values on each channel	OI	
Cross-talk between receivers	M	
Linearity of time delays	M	
Gain linearity	M	
Channel gain variation	M	
Data acquisition		
Transfer rate between the external storage unit and the instrument (type of link)	OI	
Maximum number of A-scans stored per second	OI	A-scan characteristics shall be stated
Maximum number of C-scans stored per second	OI	C-scan characteristics shall be stated
Maximum number of samples per A-scan	OI	
Storage capacity	OI	Mbytes
Gates		
Number of gates	OI	
Threshold operation	OI	For example: coincidence or anticoincidence
Measurement mode	OI	For example: threshold, max, zero crossing
Synchronisation of gates	OI	For example: transmission pulse, first echo
Characteristics of gates	OI	Threshold, position, duration
Resolution of measurements	OI	
Trigger of warnings	OI	For example: number of sequences before an alarm
Linearity of monitor gate amplitude	M	
Time-of-flight of the monitor gate	M	
Impedance of analogue output	M	
Linearity of analogue output	M	

M Measurement.

OI Other information.

Table 2 *(continued)*

Information	Type of information	Remarks
Influence of the measurement signal position in the analogue gate output	M	
Rise, fall, and hold time of analogue gate output	M	
Signal processing		
Processing features	OI	For example: averaging, Fast Fourier Transform (FFT), rectification, envelope, compression, dimensional measurements
M Measurement. OI Other information.		

7 Performance requirements for ultrasonic phased array instruments

In order to fulfil the requirements of this part of ISO 18563, ultrasonic phased array instruments shall be verified with the following two groups of tests:

— Group 1: Tests to be performed by the manufacturer (or his agent) on a representative sample of the ultrasonic phased array instruments. High level measurement instruments are required for these tests.

— Group 2: Tests to be performed on every ultrasonic phased array instrument:

a) by the manufacturer (or his agent) prior to the supply of the ultrasonic phased array instrument (zero point tests);

b) by the manufacturer, the owner, or a laboratory, at 12-month intervals, to verify the performance of the ultrasonic phased array instrument during its lifetime;

c) following the repair of the ultrasonic phased array instrument.

Only basic electronic measurement instruments are needed for group 2 tests. By agreement between the parties involved, these tests may be supplemented with additional tests from group 1.

A third group of tests for the combined system (ultrasonic phased array instrument and connected probes) are specified in ISO 18563-3. During their lifetime, these are performed at regular intervals on site.

For ultrasonic phased array instruments marketed before the introduction of this part of ISO 18563, continuing fitness for purpose shall be demonstrated by performing the group 2 (periodic) tests every 12 months.

Following repair, all parameters which might have been influenced by the repair shall be checked using the appropriate group 1 or group 2 tests.

Table 3 contains the tests to be performed on ultrasonic phased array instruments.

