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Neporušitveno preskušanje - Ugotavljanje značilnosti in overjanje naprav za ultrazvočno preskušanje - 1. del: Aparati

Non-destructive testing - Characterization and verification of ultrasonic testing equipment - Part 1: Instruments

Zerstörungsfreie Prüfung - Charakterisierung und Verifizierung der Ultraschall-Prüfausrüstung - Teil 1: Prüfgeräte

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

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Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 1: Instruments

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Foreword

This document (EN 12668-1:2010) 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of an identical text or by endorsement, at the latest by August 2010, and conflicting national standards shall be withdrawn at the latest by August 2010.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 12668-1:2000.

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*

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 specifies methods and acceptance criteria for assessing the electrical performance of analogue and digital ultrasonic instruments for pulse operation using A-scan display, employed for manual ultrasonic non-destructive examination with single or dual-element probes operating within the centre frequency range 0,5 MHz to 15 MHz. Ultrasonic instruments for continuous waves are not included in this standard. This standard may partly be applicable to ultrasonic instruments in automated systems but then other tests can be needed to ensure satisfactory performance.

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 12668-3, *Non-destructive testing — Characterization and verification of ultrasonic examination equipment — Part 3: Combined equipment*

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
amplifier frequency response
variation of the gain of an amplifier versus frequency

NOTE It is usually specified by a plot of gain (normalized to the peak gain value) versus frequency.

3.2
amplifier bandwidth
width of the frequency spectrum between the high and low cut-off frequencies

NOTE This standard uses as limits the points at which the gain is 3 dB below the peak value.

3.3
cross-talk during transmission
amount of energy transfer from the transmitter output to the receiver input during the transmission pulse, with the ultrasonic instrument set for dual-element probe (separate transmitter and receiver)

3.4
calibrated dB-switch
device controlling the overall gain of the ultrasonic instrument calibrated in decibels

3.5
dead time after transmitter pulse
time interval following the start of the transmitter pulse during which the amplifier is unable to respond to incoming signals, when using the pulse echo method, because of saturation by the transmitter pulse

3.6
digitisation sampling error
error introduced into the displayed amplitude of an input signal by the periodic nature of measurements taken by an analogue-to-digital converter

3.7
dynamic range
ratio of the amplitude of the largest signal to the smallest signal which an ultrasonic instrument can display

3.8
equivalent input noise
measure of the electronic noise level observed on the ultrasonic instrument screen, and defined by the input signal level, measured at the receiver input terminals, that would give the same level on the screen if the amplifier itself were noiseless

3.9
external attenuator
standard attenuator calibrated to a traceable source used to test the ultrasonic instrument

3.10
fall time of proportional output
time it takes the proportional gate output to fall from 90 % to 10 % of its peak value

3.11
frequency response of proportional gate output
measure of how the amplitude of the proportional gate output varies with input signal frequency

3.12
hold time of switched outputs
time for which the switched output from a monitor gate will remain above 50 % of its maximum output following a signal in the monitor gate which is above the threshold

3.13
hold time of proportional output
time for which the proportional output is above 90 % of its peak output following a signal in the monitor gate

3.14
linearity of proportional output
measure of how close the voltage output from the proportional gate is to being directly proportional to the input signal amplitude

3.15
linearity of time base
measure of how close the horizontal graticule reading on the ultrasonic instrument screen is to being directly proportional to the time-of-flight of an echo

3.16
linearity of vertical display
measure of how close the vertical graticule reading of a signal on the ultrasonic instrument screen is to being directly proportional to the input signal amplitude

3.17
mid gain position
ultrasonic instrument gain setting which is half way between the maximum and minimum gains, measured in decibels

EXAMPLE For an ultrasonic instrument with a maximum gain of 100 dB and a minimum gain of 0 dB, the mid gain position would be 50 dB.

3.18
monitor gate
section of the time-base on the A-scan display in which the amplitude is compared to a threshold and/or converted to an analogue output

3.19
monitor threshold
minimum signal amplitude that will operate the monitor gate output

3.20
noise of proportional output
measure of the noise on the proportional output

3.21
proportional output
output from the ultrasonic instrument which gives a d.c. voltage nominally proportional to the amplitude of the largest received signal within a monitor gate

3.22
pulse duration
time interval during which the modulus of the amplitude of a pulse is 10 % or more of its peak amplitude

3.23
pulse repetition frequency
frequency at which the transmission pulse is triggered

3.24
pulse rise time
time taken for the amplitude of the leading edge of a pulse to rise from 10 % to 90 % of its peak value

3.25
pulse reverberation
secondary maximum in the transmitter pulse waveform after the intended output

3.26
receiver input impedance
characterisation of the internal impedance of the receiver as a parallel resistance and capacitance

3.27
response time of digital ultrasonic instruments
time over which a signal has to be detected by a digital ultrasonic instrument before it is displayed at 90 % of its peak amplitude

3.28
rise time of proportional output
time interval that it takes the proportional gate output to rise from 10 % to 90 % of its peak value

3.29
temporal resolution
minimum time interval over which two pulses are resolved by a drop in amplitude of 6 dB

3.30
time-dependent gain
TDG
time-dependent or swept-gain function fitted to some ultrasonic instruments to correct for the distance-related reduction in reflected amplitude

3.31
short pulse
unrectified pulse which has fewer than 1,5 cycles in the time interval over which the pulse amplitude exceeds half its maximum peak amplitude

3.32
suppression
preferential rejection of signals near the baseline of the screen, deliberately introduced to remove grass and noise or to steepen the trailing edges of larger echoes

3.33
switching hysteresis
difference in amplitude between the signal which turns on and turns off a monitor gate

4 Symbols

Table 1 — Symbols

Symbol	Unit	Meaning
A_o, A_n	dB	Attenuator settings used during tests
C_{max}	pF	Parallel capacity of receiver at maximum gain
C_{min}	pF	Parallel capacity of receiver at minimum gain
D_S	dB	Cross-talk damping during transmission
Δf_g	Hz	Frequency bandwidth measured at proportional gate output
f_{go}	Hz	Centre frequency measured at proportional gate output
f_{gu}	Hz	Upper frequency limit at - 3 dB, measured at proportional gate output
f_{gl}	Hz	Lower frequency limit at - 3 dB, measured at proportional gate output
f_{gmax}	Hz	Frequency with the maximum amplitude in the frequency spectrum measured at proportional gate output
f_o	Hz	Centre frequency
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
Δf	Hz	Frequency bandwidth
I_{max}	A	Amplitude of the maximum current that can be driven by the proportional gate output
N		Number of measurements taken
n_{in}	$V/\sqrt{Hz}$	Noise per root bandwidth for receiver input
R_l	Ω	Termination resistor
R_{max}	Ω	Input resistance of receiver at maximum gain
R_{min}	Ω	Input resistance of receiver at minimum gain
S	dB	Attenuator setting
ΔT	s	Time increment

Table 1 *(continued)*

Symbol	Unit	Meaning
t_d	s	Pulse duration
T_{final}	s	Time to the end of distance amplitude curve
T_o	s	Time to the start of distance amplitude curve
t_r	s	Transmitter pulse rise time from an amplitude of 10 % to 90 % of peak amplitude
t_{A1}, t_{A2}	s	Temporal resolution
V_E	V	Input voltage at the receiver
V_{ein}	V	Receiver input equivalent noise
V_{in}	V	Input voltage
V_l	V	Proportional gate output voltage with load resistor
V_{max}	V	Maximum input voltage of the receiver
V_{min}	V	Minimum input voltage of the receiver
V_o	V	Proportional gate output voltage with no load resistor
V_r	V	Voltage amplitude of the ringing after the transmitter pulse
V_{50}	V	Voltage amplitude of the transmitter pulse with a 50 Ω loading of the transmitter
V_{75}	V	Voltage amplitude of the transmitter pulse with a 75 Ω loading of the transmitter
Z_o	Ω	Output impedance of transmitter
Z_A	Ω	Output impedance of proportional output

5 General requirements for compliance

An ultrasonic instrument complies with this standard if it satisfies all of the following conditions:

a) the ultrasonic instrument 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 1 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 ultrasonic instrument shall be clearly marked to identify the manufacturer, type and series, and carry a unique serial number marked on both the chassis and the case;

d) a user's instruction manual for the particular type and series of the ultrasonic instrument shall be available;

e) a manufacturer's technical specification for the appropriate type and series of ultrasonic instrument which defines the performance criteria in accordance with Clause 6 shall be available.

NOTE 2 This specification can form part of the ultrasonic instrument instruction manual or can be separate from it, but it will state the type and series of the ultrasonic instrument to which it applies. The manufacturer's technical specification does not in itself constitute the certificate of measured values required in b).

6 Manufacturer's technical specification for ultrasonic instruments

6.1 General

The manufacturer's technical specification for an ultrasonic instrument shall contain, as a minimum, the information listed in 6.2 to 6.5. The actual values quoted for the parameters listed in this clause shall be the results obtained from the tests described in Clause 7, with tolerances given as indicated.

6.2 General attributes

The following shall be detailed:

a) size;

b) weight (at an operational stage);

c) type(s) of power supply;

d) type(s) of instrument sockets;

e) battery operational time (as new, at maximum power consumption);

f) temperature and voltage (mains and/or battery) ranges, in which operation complies with the technical specification. If a warm-up period is necessary, the duration of this shall be stated;

g) form of indication given when a low battery voltage takes the ultrasonic instrument performance outside of specification;

h) absolute change in amplitude and time base position of a nominally constant signal over the battery voltage range during its normal discharge and recharge cycle;

i) pulse repetition frequencies (PRFs) (switched positions and/or variable ranges);

j) unrectified (i.e. radio frequency, RF) and/or rectified signal output available via socket.

6.3 Display

The following shall be detailed:

a) dimensions of display graticule area;

b) number of major and minor subdivisions in vertical and horizontal instrument;

c) range of sound velocities and delay ranges;

d) linearity.

6.4 Transmitter

The following shall be detailed:

a) shape of transmitter pulse (i.e. square wave, uni-directional or bi-directional) and, where applicable, polarity;

b) at each pulse energy setting and pulse repetition frequency, with the output loaded with a 50 Ω non-reactive resistor:

   1) transmitter pulse voltage (peak-to-peak);

   2) pulse rise time;

   3) pulse duration (for square wave the range over which the pulse duration can be set);

   4) effective output impedance (with tolerance);

   5) pulse fall time (for square wave only);

   6) pulse reverberation amplitude;

   7) frequency spectrum plot.

6.5 Receiver and attenuator

The following shall be detailed:

a) characteristics of calibrated attenuator (sometimes called "gain control"), i.e. dB range, step-size, accuracy;

b) characteristics of any uncalibrated variable gain, i.e. decibel range;

c) vertical linearity measured with respect to the screen graticule;

d) centre frequency and bandwidth (between - 3 dB points) of each band setting (give tolerances). The effect (if any) of the attenuator setting;

e) dead time after transmitter pulse, including the effects of pulse energy, damping, attenuator/gain control and frequency band setting;

f) input equivalent noise (microvolts (μV)) at all frequency settings;

g) minimum input voltage for 10 % screen height over all specified frequency ranges;

h) dynamic range of the ultrasonic instrument over all the specified frequency ranges;

i) receiver input impedance of the ultrasonic instrument over all the specified frequency ranges;

j) details of any distance amplitude correction (DAC) function including the dynamic range, the maximum correction slope (in decibels per microsecond (dB/μs)), the form of the correction and the influence of any DAC controls.

For instruments with logarithmic amplifiers, see Annex A.

6.6 Monitor output

a) go/no-go;

b) proportional;

c) output response time;

d) linearity;

e) accuracy of the threshold;

f) hysteresis;

g) hold time;

h) maximum current drive capability.

If applicable, additional information on monitor output should be given.

6.7 Additional information

If applicable in addition to the information given above in 6.1 to 6.6 details should be supplied on the principles of:

a) analogue-to-digital conversion;

b) number of pixels used to display the A-scan;

c) data output and storage facilities;

d) printer output;

e) calibration storage facilities;

f) display and recall facilities;

g) automatic calibration;

h) type of display (e.g. cathode ray tube, liquid crystal display) and its response time.

Where applicable, these details should also include sampling rates used, effect of pulse repetition frequency or display range on the sampling rate and response time. In addition, the principles of any algorithm used to process data for display should be described and the version of any software installed shall be quoted.

7 Performance requirements for ultrasonic instruments

The ultrasonic instrument shall be subjected to all the tests described below. The test results shall meet or exceed the stated requirement in every case. The results shall be recorded and stored for verification.

a) Group 1: tests to be performed at manufacture on a representative sample of the ultrasonic instruments produced;

b) Group 2: tests to be performed on every ultrasonic instrument:

   1) by the manufacturer, or his agent, prior to the supply of the ultrasonic instrument (zero point test);