



SLOVENSKI STANDARD

SIST EN 12668-1:2001

01-maj-2001

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Non-destructive testing - Characterization and verification of ultrasonic examination 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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Ta slovenski standard je istoveten z: EN 12668-1:2000

ICS:

19.100 Neporušitveno preskušanje Non-destructive testing

SIST EN 12668-1:2001

en

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 12668-1

May 2000

ICS 19.100

English version

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This European Standard was approved by CEN on 13 April 2000.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

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Foreword

This European Standard 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of an identical text or by endorsement, at the latest by November 2000, and conflicting national standards shall be withdrawn at the latest by November 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This standard consists of the following parts :

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

EN 12668-2, Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 2 : Probes

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

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1 Scope

This 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 twin transducer 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 automatic systems but then other tests can be needed to ensure satisfactory performance.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 1330-4:2000, *Non-destructive testing - Terminology - Part 4 : Terms used in ultrasonic testing*.

EN 12668-3:2000, *Non-destructive testing - Characterization and verification of ultrasonic examination equipment – Part 3 : Combined equipment*.

EN ISO 9001, *Quality systems - Model for quality assurance in design/development, production, installation and servicing (ISO 9001:1994)*.

EN ISO 9002, *Quality systems - Model for quality assurance in production, installation and servicing (ISO 9002:1994)*.

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For the purposes of this standard the definitions given in EN 1330-4:2000 apply, together with the following definitions.

3.1

amplifier frequency response

variation of the gain of an amplifier versus frequency

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

3.3

cross-talk damping during transmission

defines the amount of energy transfer from the transmitter output to the receiver input during the transmission pulse, with the ultrasonic instrument set for twin probe working (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 analog to digital converter

3.7**dynamic range**

ratio of the amplitude of the largest signal to the smallest signal which a ultrasonic instrument can display. The smallest signal may be limited by noise in the system, the largest by the saturation of the amplifier or by the maximum attenuation which can be introduced to bring a large signal onto the screen

3.8**equivalent input noise**

a 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**

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

3.10**fall time of proportional output**

the 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**

the 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**

the 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, e.g. 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**

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

3.19**monitor threshold**

the 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
a 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
the 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
the time interval that it takes the proportional gate output to rise from 10 % to 90 % of its peak value
- 3.29**
temporal resolution
the 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
the 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

"continued"

Table 1 - Symbols (concluded)

Symbol	Unit	Meaning
n_{in}	V/\sqrt{Hz}	Noise per root bandwidth for receiver input
R_t	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
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_t	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 the following conditions :

- the ultrasonic instrument shall comply with clause 7 ;
- either a declaration of conformity, issued by an organisation certified in accordance with EN ISO 9001 or EN ISO 9002 ; or a certificate issued by an organisation accredited according to the EN 45000-series ; or a test report issued by an organisation performing in house calibration ;
- the ultrasonic instrument is clearly marked to identify the manufacturer, type and series, and carries a unique serial number marked on both the chassis and the case ;
- there is available a users instruction manual for the particular type and series of the ultrasonic instrument ;
- there is available a manufacturer's technical specification for the appropriate type and series of ultrasonic instrument which defines the performance criteria in accordance with clause 6.

NOTE This specification can form part of the ultrasonic instrument instruction manual or can be separate from it, but it shall 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 a particular model of ultrasonic instrument shall contain, as a minimum, the information listed in 6.2 to 6.5. Values obtained from the tests described in clause 7 shall be quoted as nominal values, 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 probe 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) the percentage 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 ;
- k) signal monitor outputs provided, i.e., go/no-go and/or proportional and, where applicable, output response time, linearity, maximum current drive capability and stability of proportional output(s). The hysteresis and accuracy of the threshold of any go/no-go gate together with the hold time of any switched output.

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 directions ;
- c) if any form of suppression, not controllable by the operator, is built into the equipment ;
- d) time-base velocity and delay ranges, and linearity of time base.

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 Amplifier 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) 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) equivalent 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), the form of the correction and the influence of any DAC controls.

For instruments with logarithmic amplifiers, see annex A.

6.6 Digital ultrasonic instruments

In addition to the information given above in 6.1 to 6.4 details should be supplied on the principles of :

- a) the analog to digital conversion ;
- b) the number of pixels used to display the A-scan ;
- c) the data output and storage facilities ;
- d) the printer output ;
- e) the calibration storage facilities ;
- f) the display and recall facilities ;
- g) the automatic calibration ;
- h) the type of 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

To meet the performance requirements of this standard an ultrasonic instrument shall be verified using the two groups of tests described below :

Group 1 : tests to be performed by the manufacturer (or his agent) on a representative sample of the ultrasonic instruments produced. A high level of electronic measuring equipment is required for these tests ;

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) ;
- 2) by the manufacturer, the owner, or a laboratory, at twelve months intervals to verify the performance of the ultrasonic instrument during its lifetime ;
- 3) following the repair of the ultrasonic instrument.

Only basic electronic measurement equipment is required for the tests in group 2.

By agreement between the parties involved these tests may be supplemented with additional tests from group 1.

A third group of tests for the complete system (ultrasonic instrument and probe combined) are given in EN 12668-3:2000. During their lifetime these are performed at regular intervals on site. Table 2 summarises the tests performed on ultrasonic instruments.

For ultrasonic instruments marketed before the introduction of this standard, continuing fitness for purpose shall be demonstrated by performing the group 2 (periodic) tests every twelve months.

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

Manufacturer's tests are group 1 tests together with group 2 tests.

Zero point periodic tests and repair tests are group 2 tests.