
**Non-destructive testing —
Characterization and verification of
ultrasonic test equipment —**

**Part 1:
Instruments**

*Essais non destructifs — Caractérisation et vérification de
l'appareillage de contrôle par ultrasons —*

Partie 1: Appareils

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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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 138, *Non-destructive testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 22232 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 test equipment —

Part 1: Instruments

1 Scope

This document specifies methods and acceptance criteria within the frequency range of 0,5 MHz to 15 MHz, for assessing the electrical performance of digital ultrasonic instruments for pulse operation using A-scan display, for manual ultrasonic non-destructive testing with single- or dual-transducer probes. This document is also applicable for multi-channel instruments. This document can partly be applicable to ultrasonic instruments in automated systems, but other tests can be needed to ensure satisfactory performance.

This document excludes ultrasonic instruments for continuous waves.

This document also excludes ultrasonic phased array instruments, see e.g. ISO 18563-1. If a phased array instrument has dedicated connectors for single- or dual-transducer probes this document is applicable for these channels.

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/IEC 17050-1, *Conformity assessment — Supplier's declaration of conformity — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577 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 <http://www.electropedia.org/>

3.1

analogue 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

3.2

cross talk during transmission

amount of signal transfer from the transmitter output to the receiver input during the transmission pulse, with the ultrasonic instrument set for separate transmitter-receiver operation (dual-transducer probe)

3.3
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 technique, because of saturation by the transmitter pulse

3.4
digital output

output from the ultrasonic instrument which gives a low or high value depending if a signal is below or above a monitor gate threshold

3.5
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

3.6
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

3.7
external attenuator

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

3.8
fall time

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

3.9
switched monitor gate signal hold time

time for which the switched output from a monitor gate remains above 50 % of its maximum output following a signal in the monitor gate which is above the threshold

3.10
hold time

<analogue output> time for which the *analogue output* (3.1) is above 50 % of its maximum output following a signal in the monitor gate

3.11
linearity of analogue output

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

3.12
mid-gain position

ultrasonic instrument gain setting which is half way between the maximum and minimum gains

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.

Note 1 to entry: Mid-gain position is measured in decibels.

3.13
receiver input impedance

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

3.14
response time

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

3.15**temporal resolution**

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

3.16**switching hysteresis**

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

4 Symbols

| Symbol | Unit | Meaning |
|--------------------|------------------------|---|
| A_o, A_n | dB | Attenuator settings used during tests |
| C_{\max} | pF | Parallel capacity of receiver at the maximum gain |
| C_{\min} | pF | Parallel capacity of receiver at the minimum gain |
| D_S | dB | Cross talk during transmission |
| Δf_g | Hz | Frequency bandwidth measured at the proportional gate output |
| f_{go} | Hz | Centre frequency measured at the proportional gate output |
| f_{gu} | Hz | Upper frequency limit at -3 dB, measured at the proportional gate output |
| f_{gl} | Hz | Lower frequency limit at -3 dB, measured at the proportional gate output |
| $f_{g\max}$ | Hz | Frequency with the maximum amplitude in the frequency spectrum measured at the proportional gate output |
| f_0 | 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 |
| G_D | dB | Dynamic range |
| I_{\max} | A | Amplitude of the maximum current that can be driven by the proportional gate output |
| N | — | Number of measurements taken |
| n_{ein} | nV/ $\sqrt{\text{Hz}}$ | Equivalent input noise |
| R_l | Ω | Termination resistor |
| R_{\max} | Ω | Input resistance of receiver at the maximum gain |
| R_{\min} | Ω | Input resistance of receiver at the minimum gain |
| S | dB | Attenuator setting |
| ΔT | s | Time increment |
| t_A | s | Temporal resolution |
| t_d | s | Pulse duration |
| T_{final} | s | Time to the end of a distance-amplitude curve |
| T_0 | s | Time to the start of a distance-amplitude curve |
| t_m | s | Measured rise time |
| t_r | s | Transmitter pulse rise time from an amplitude of 10 % to 90 % of the peak amplitude |
| t_s | s | Oscilloscope rise time |
| V_E | V | Input voltage at the receiver |
| V_{ein} | V | Equivalent input noise voltage |
| 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 |

| Symbol | Unit | Meaning |
|----------|----------|--|
| V_o | V | Proportional gate output voltage with no load resistor |
| V_{50} | V | Voltage amplitude of the transmitter pulse with a 50 Ω loading of the transmitter |
| V_{75} | Ω | 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 analogue output |

5 General requirements of conformity

An ultrasonic instrument complies with this document if it fulfils all of the following requirements:

- the ultrasonic instrument shall comply with [Clause 7](#) within the frequency range of 0,5 MHz to 15 MHz;
- a declaration of conformity according to ISO/IEC 17050-1 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);
- the ultrasonic instrument shall be clearly marked to identify the manufacturer, and carry a unique serial number or show a permanent reference number from which information can be traced to the data sheet;
- a manufacturer's technical specification corresponding to the ultrasonic instrument shall be available, which defines the performance criteria in accordance with [Clause 6](#).

6 Manufacturer's technical specification for ultrasonic instruments

The manufacturer's technical specification for an ultrasonic instrument shall contain, as a minimum, the information listed in [Table 1](#). 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.

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 shall be described and the version of any software installed shall be quoted.

Table 1 — 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 | — |
| Battery operational time | M | At fully charged new batteries |
| Number and type of batteries | OI | — |
| Stability against temperature | M | — |
| Key | | |
| M measurement | | |
| OI other information | | |

Table 1 (continued)

| Information | Type of information | Remarks |
|---|---------------------|--|
| 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 instrument performance outside of the specification | OI | — |
| Pulse repetition frequencies (PRFs) | M | Minimum and maximum values |
| Maximum power consumption | OI | W |
| Protection grade | OI | — |
| Environment | OI | For example: restriction of hazardous substances (RoHS), explosive atmosphere (ATEX), vibration, humidity |
| Multi-channel configuration | OI | Number of channels controlled simultaneously (parallel operation) and number of available channels (multiplexed operation) |
| 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 range | OI | — |
| List of available views | OI | — |
| Screen refresh rate for A-scan presentations | OI | — |
| Maximum digitization frequency without processing | OI | — |
| Digitization frequency with processing | OI | For example: interpolation |
| Digitizer vertical resolution | OI | In bits |
| Highest digitized frequency | OI | — |
| Time base deviation | M | — |
| Response time | M | — |
| 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) |
| Key | | |
| M measurement | | |
| OI other information | | |

Table 1 (continued)

| Information | Type of information | Remarks |
|--|---------------------|--|
| Available power supply for external devices | OI | Voltage, power |
| Synchronization input/output | OI | — |
| Transmitter | | |
| Shape of transmitter pulse and, where applicable, polarity | OI | i.e. rectangular, unipolar, bipolar, arbitrary pulse |
| Transmitter voltage, pulse rise time, fall time and duration | M | — |
| Output impedance | M | — |
| Possibility to apply different voltages on each channel | OI | — |
| Maximum power available per transmitter | OI | — |
| Receiver | | |
| Characteristics of the gain control, i.e. range in decibels, value of increments | OI | — |
| Characteristics of the logarithmic amplifier | OI | — |
| Input voltage at full screen height (FSH) | OI | — |
| Maximum input voltage | M | V_{\max} measured in 8.9.4.1 |
| Linearity of vertical display | M | — |
| Frequency response | M | — |
| Dead time after transmitter pulse | M | — |
| Equivalent input noise | M | $\frac{nV}{\sqrt{Hz}}$ |
| Dynamic range | M | — |
| Input impedance | M | — |
| Time-corrected gain (TCG) | M | — |
| Possibility to apply different gain values on each channel | OI | — |
| Cross talk between transmitter and receiver | M | — |
| Gain linearity | M | — |
| Data acquisition | | |
| Transfer rate between the instruments and the external storage unit | OI | Including type of interface |
| 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 | — |
| Gates | | |
| Number of gates | OI | — |
| Threshold operation | OI | For example: coincidence or anti-coincidence |
| Measurement mode | OI | For example: threshold, max amplitude, zero crossing |
| Key | | |
| M measurement | | |
| OI other information | | |