INTERNATIONAL STANDARD

ISO 12710

First edition
2002-09-15

Non-destructive testing — Ultrasonic inspection — Evaluating electronic characteristics of ultrasonic test instruments

Essais non destructifs — Contrôle aux ultrasons — Évaluation des caractéristiques électroniques des instruments d'essai aux ultrasons

Reference number
ISO 12710:2002(E)

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Printed in Switzerland

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12710 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 3, *Acoustical methods*.

Introduction

In ultrasonic non-destructive testing, pulse/echo signals are used to detect and evaluate imperfections or flaws inside a structural material. The pulse/echo ultrasonic signals are generated by various types of electronic instruments.

This International Standard describes a set of procedures for the measurement of performance characteristics in an ultrasonic test instrument that has a display screen. The procedures are used for ultrasonic test instruments operating in a nominal frequency range from 100 kHz to 25 MHz, although the procedures are also applicable to measurements on instruments utilizing higher-frequency components. The recommended techniques are designed to use commercially-available instrumentation. An ultrasonic test instrument that cannot be completely described as a combination of the electronic sections discussed in this practice can be partially evaluated. Each portion of the ultrasonic test instrument that is evaluated should fit the description for the corresponding section.

Implementation of these practices may require more detailed procedural instruction. Competence in the use of the electronic instrumentation specified is a prerequisite for effective use of these procedures. Careful selection of the specific measurements to be made is recommended. If the related parameter is not relevant to the intended application, its measurement may be unnecessary; e.g., vertical linearity may be irrelevant for an application using a single-level flaw alarm, while horizontal linearity might be required only for accurate flaw-depth or thickness measurement from the instrument display.

No minimum interval between instrument evaluations is recommended or implied. The accuracy of each measurement is dependent upon the combined accuracy of each of the electronic measuring instruments (which should be described in the specifications and calibrations for these instruments) and the precision associated with reading the values of each part of the system. It is assumed that the precision of measuring the vertical and horizontal values from the screen of the ultrasonic test instrument is ± 1 mm.

Specifically, this International Standard intends to provide techniques and procedures to achieve the following objectives:

a) To measure performance characteristics of components of ultrasonic test instruments.

b) To check and ensure consistent performance of such components during the life span of the instrument.

c) To select and specify characteristics necessary for proper overall performance of the instrument.

d) To achieve interchangeability with similar components or similar overall instruments for same type inspections.

e) To provide a base for the correlation and comparison of performance results from different instruments and testing sources.

NOTE These procedures are not intended to preclude the use or application of ultrasonic test equipment for which some or all of the measurement techniques of this document are not applicable. Additionally, it is not intended, nor is it applicable, as a specification defining the performance of ultrasonic test systems. If such performance criteria are required, they must be agreed upon by the using parties.

Non-destructive testing — Ultrasonic inspection — Evaluating electronic characteristics of ultrasonic test instruments

1 Scope

1.1 This International Standard establishes the procedures for measuring performance characteristics of components of pulse-echo ultrasonic non-destructive testing instruments including both analog and digital type instruments with screen displays. The aim is to establish uniformity of evaluation techniques, to form a basis for data correlation and for interpretation of results obtained from different laboratories and at different times. Note that this International Standard establishes no acceptance criteria; such criteria should be specified by user parties.

The usual components of ultrasonic non-destructive testing instruments and the performance characteristics for which procedures for measuring these characteristics are included and listed in 1.2 to 1.6.

1.2 Power supply section:

— line regulation

— battery discharge time

— battery charge time

1.3 Pulser section:

— pulse shape

— pulse amplitude

— pulse rise time

— pulse length

— pulse frequency spectrum

1.4 Receiver section:

— vertical linearity

— frequency response

— noise and sensitivity

— dB controls

1.5 Time base section:

— horizontal linearity

— clock (pulse repetition rate)

1.6 Gate section/alarm section:

— delay and width

— resolution

— alarm level

— gain uniformity

— analog output

— back-echo gate linearity

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60050-111, *International Electrotechnical Vocabulary — Chapter 111: Physics and chemistry*

3 Terms, definitions and symbols

For the purposes of this International Standard the terms, definitions and symbols listed in IEC 60050-111 as well as the following apply.

T_m the measured rise time

T_r the actual rise time of the instrumentation

T_s the oscilloscope rise time

4 Abbreviations

ASTM	American Society for Testing and Materials
DAC/EDAC	distance amplitude correction/electronic distance-amplitude compensation
EN	European Norme (European Standard)
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JIS	Japanese Industrial Standard
PRF	pulse repetition frequency
RF	radio frequency

5 Summary of procedure

5.1 Performance measurements

The electronic performance of each section is measured by identifying that portion of the electrical circuit of the instrument which comprises the section, applying the recommended stimulus or load or both, and performing the required measurements using commercially available electronic test equipment. These data are then summarized in tabular or graphical form as performance-related values which can be compared with corresponding values of other ultrasonic test instruments or of values for the same instrument obtained earlier (see clause 12 for a suggested reporting format).

5.2 Ultrasonic test Instruments and Interactions

5.2.1 Power supply section

The power supply section is that portion of the total instrument circuitry which supplies the regulated DC voltages required to power all other sections of the ultrasonic test instrument, including the high voltage (i.e pulser) circuitry.

5.2.2 Pulser section

The pulser section is that portion of the total instrument circuitry that generates the electrical pulse used to energize the search unit. The pulser section may also include the pulse-shape modification controls such as pulse length, damping or tuning controls.

5.2.3 Receiver section

The receiver section is that portion of the total instrument circuitry that amplifies, or modifies or both, the radio frequency (RF) pulses received from the search unit. This includes the RF amplifiers, detectors, video amplifiers, suppression and filtering circuits, and the cathode ray tube vertical deflection circuits. Some instruments may not contain all of these circuits.

NOTE For EDAC operation, reject or threshold, although part of the receiver section, should be turned off while making measurements unless otherwise specified by the user.

5.2.4 Time base section

The time base section provides the linear horizontal sweep or baseline. It includes the horizontal deflection circuit and the clock and delay circuits which control PRF and positioning of signals on the baseline.

5.2.5 Gate/alarm section

This section monitors the signals in the receiver section to detect the presence or absence of significant indications. The gate may include attenuator or gain controls. This section is considered separate from the receiver section for the purposes of this International Standard. The alarm signal may be audible, or a mark on voltage or current sensitive paper or some combination of these. It also may be a voltage proportional to the amplitude.

6 Apparatus

6.1 Ultrasonic test Instrument, being any electronic instrument comprised of a power supply, pulser, clock, receiver and a sweep display section to generate, receive and display electrical signals related to ultrasonic waves for examination purposes.

NOTE Some ultrasonic test instruments do not include a screen display. Some sections of this International Standard may not apply to these instruments, or may be applicable only with modifications. Such modifications should be made only by personnel competent in electronics.

6.2 Voltmeter, being any instrument capable of measuring the AC line voltage and DC battery voltage required as described in 7.1 or 7.2.

6.3 Variable transformer, such as an autotransformer or other device capable of supplying variable AC power to the ultrasonic test instrument over the full range specified by the manufacturer.

6.4 Pulser load, consisting of a 50 ohm non-inductive resistor, preferably mounted in a shielded coaxial assembly, unless otherwise requested by the using parties. The resistor shall be able to withstand the maximum peak pulser voltage. It is recommended that the complex impedance of the resistor be checked at frequencies from 100 kHz to 25 MHz in order to ensure that the magnitude is 50 ohms ± 2 ohms, and that the phase angle is less than ± 5°.

NOTE Other impedances may be used if specified.

6.5 Spectrum analyser, of any type (with probe assembly if required) that is capable of analysing the electrical pulse from the pulser module and displaying the frequency components of the pulse as described in 8.3. A recording of the display (photograph or chart recorder) shall be included in the report.

6.6 Oscilloscope probe, being a 100 × or 50 × wide band high input impedance (⩾ 10 kΩ) attenuating probe to reduce the pulse amplitude, as delivered to the oscilloscope and the spectrum analyser, to a level that i) will not harm the equipment and ii) will allow for frequency and time analysis without significantly altering the pulse shape. The probe output impedance shall match the input impedance of the measurement instrument. (If the impedance is high, a terminating resistance may be required at the input to match the output impedance of the probe.) The frequency bandwidth shall be at least as wide as that of the instruments to be measured. The probe shall be able to withstand the pulser output voltage.

NOTE More than one probe may be needed to match the various test instruments used.

6.7 Function generator, capable of producing an internally or externally triggered single-cycle sine wave or five cycles of a sine wave, the frequency of which is variable over the range of the frequency capabilities of the ultrasonic test instrument to be measured. The frequency read-out shall be accurate to 1 %. Square or rectangular waves in single or burst mode shall be provided. The generator shall be capable of being triggered from a signal derived from the instrument clock to provide wave trains coherent with the display. An adjustable delay of at least 10 μs is required.

NOTE A free running (i.e. non-triggered) single-cycle sine wave may not be used for receiver evaluation.

6.8 Electronic gate, with a variable delay and width and triggerable from either the ultrasonic test instrument pulser section output pulse or the clock section logic signal. The gate step output (i.e. the output that represents the location of the gate) shall be sufficient to trigger the function generator.

NOTE Some function generators incorporate the gate delay and width functions, in which case an electronic gate will not be needed.

6.9 Calibrated oscilloscope, capable of displaying all portions of the pulser output with sufficient time base expansion, triggering capability and frequency response to enable measurement of the pulse rise time, amplitude and length, as well as fulfilling the requirements of other measurements.

6.10 Calibrated attenuator, capable of providing a measuring range of 60 dB in 1 dB steps with an accuracy of ± 0,5 dB and having a frequency bandwidth at least as great as the highest frequency of interest. Most attenuators have a nominal input and output impedance of 50 ohms, but other impedances may be specified. Proper termination rules shall be observed. An impedance matching probe shall be used to protect the attenuator if it is to be used to reduce pulse output.

6.11 Terminators, used to match the impedances of instruments and cables used (see 6.4); they shall be of a non-inductive, feed-through style.

6.12 Cables, coaxial, with maximum length of 2 m and a 50 ohm characteristic impedance. Other lengths and impedances may be used if authorized, but lengths shall be kept as short as possible in order to minimize the effects of cable capacitance on measurements.

6.13 Search unit, of the desired type, size and frequency required for the procedures selected for 6.15, 7.1.1, 7.2.1, 7.2.1.2, 10.2 or 10.3.

6.14 Immersion tank, (optional) consisting of an ultrasonic immersion system that will enable continuous variations of the distance between the search unit and a reflector over a water path range that will provide a time range comparable to the end use of the ultrasonic test instrument. A distance (position) scale of precision needed for the procedure described in 10.2 shall be incorporated.

6.15 Reference block, of any suitable material, containing certain features, such as flat-bottom holes, side-drilled holes, wedges, flat steps of different thickness or hemi-steps, which can be used to provide ultrasonic echo signals.

6.16 Camera or recorder, such as a screen camera or display recorder, suitable for measuring pulse characteristics, and useful in making other measurements.

7 Power-supply section measurements

7.1 AC-powered instrument line regulation

7.1.1 Connect the variable transformer (6.3), the voltmeter (6.2) and a search unit (6.13) that matches the nominal frequency of the instrument, to the ultrasonic test instrument (6.1) as shown in Figure 1. Although Figure 1 shows an immersion set-up, the evaluation may be performed by either the contact or the immersion method. The primary requirement is that the signal from the reference reflector does not vary due to coupling or position variations during the evaluation. Contact tests may require clamping of the search unit to the reference block. A block with permanently bonded search unit(s) is quite helpful.

7.1.2 Adjust the variable transformer for 100 % nominal line voltage and obtain a 50 % full-scale indication from the reference block (6.15). Decrease the variable transformer output voltage until the reference reflector indication changes its amplitude, width or horizontal position by 10 %.

NOTE Damage may result from going, in either direction, beyond the manufacturer's line voltage specification.

7.1.3 The ultrasonic test instrument display may turn off before any significant signal change is noted.

7.1.4 Increase the variable transformer output voltage(s) at which the 10 % change or turn-off occurs. The upper limit will usually be the manufacturer's specification. These are the input voltage limits.

7.2 Battery-powered instruments

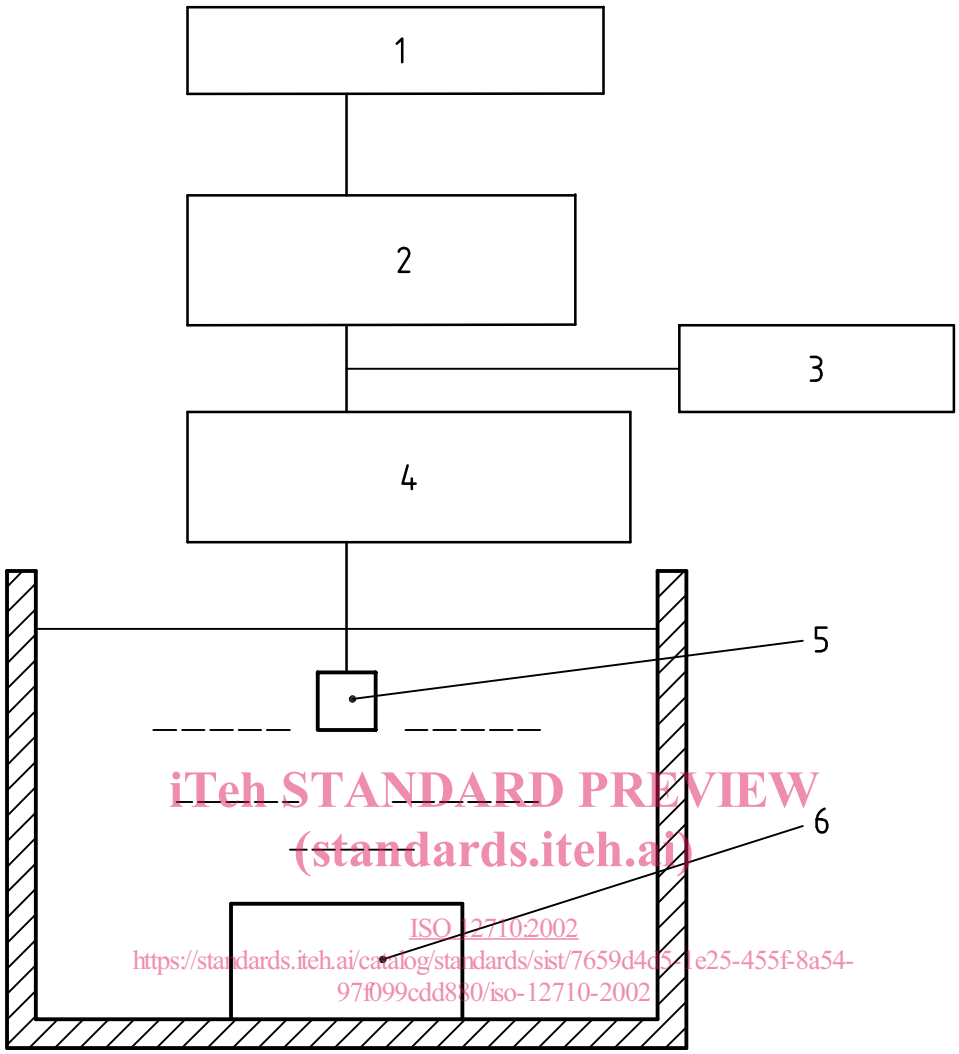
7.2.1 Discharge time

7.2.1.1 With the battery in the fully-charged condition, connect a search unit (6.13) to the instrument and obtain a 50 % full-scale indication from a suitable reference block (6.15). This evaluation may be performed by either the contact or the immersion method. The primary requirement is that the signal from the reference reflector does not vary due to coupling or position changes during the battery discharge time period.

7.2.1.2 Instrument controls that affect power drain, such as PRF, display brightness, sweep range, etc., shall be set to the maximum levels corresponding to good examination practices in order to provide the maximum practical power supply loading condition.

7.2.1.3 At time intervals $\leqslant$ 15 min, record the amplitude of the signal from the reference block and plot these values versus time as shown in Figure 2 until the signal amplitude, horizontal sweep length or position changes 10 % or until the instrument display turns off. The discharge time is the time required for a change of the stated amount or until the display turns off, whichever occurs first. Record this value.

7.2.1.4 The data recording may be minimized by making an initial reading and then beginning the periodic measurements at a later time near the anticipated discharge time.



Key

1 Line voltage
2 Variable transformer
3 Voltmeter
4 Ultrasonic test instrument
5 Search unit
6 Reference block

Figure 1 — Set-up for voltage regulation measurements