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

Part 3: Combined equipment

Essais non destructifs — Caractérisation et vérification de l'appareillage de contrôle par ultrasons — Partie 3: Equipement complet

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 135 *Non-destructive testing*, SC 3 *Ultrasonic testing*.

ISO 22232 consists of the following parts, under the general title *Non-destructive testing — Characterization and verification of ultrasonic test equipment*:

— *Part 1: Instruments;*

— *Part 2: Probes;*

— *Part 3: Combined equipment.*

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

Part 3:
Combined equipment

1 Scope

This document describes methods, tolerances and acceptance criteria for verifying the performance of combined ultrasonic test equipment (i.e. instrument, probes and cables connected) by the use of appropriate standard calibration blocks.

These methods are specifically intended for manual test equipment, i.e. digital ultrasonic instruments according to ISO 22232-1 for manual ultrasonic non-destructive testing with single or dual-element probes according to ISO 22232-2. This document is applicable for multi-channel instruments also. For automated test equipment different tests can be needed to ensure satisfactory performance.

These methods are not intended to prove the suitability of the equipment for particular applications. The methods described are suitable for the use by operators working under site or shop floor conditions.

Ultrasonic instruments for continuous waves are not included in this document.

Ultrasonic phased array systems are not included in this document, see e. g. ISO 18563-3. If a phased array instrument is used in combination with single or dual-element probes this document is applicable for this combination.

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

ISO 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

ISO 7963, *Non-destructive testing — Ultrasonic testing --- Specification for calibration block No. 2*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 22232-1, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 1: Instruments*

ISO 22232-2, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 2: Probes*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 5577 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 General requirements for conformity

The ultrasonic instrument and probe used shall comply with ISO 22232-1 and ISO 22232-2 respectively.

When all tests are successful, the combined equipment is considered to conform to this document.

The result of the tests shall be reported on a test report.

The tests described in this document, together with the frequency of testing, are summarized in Table 1.

Table 1 — Tests to be performed

Subclause	Title	Frequency of testing
6.3	Vertical linearity	Weekly[a]
6.4.2 / 6.4.4	Probe index point	Daily
6.4.3 / 6.4.4	Beam angle	Daily
6.2	Physical state and external aspects	Daily
6.5	Sensitivity and signal-to-noise ratio	Weekly[a]
6.6	Pulse duration	Weekly[a]

[a] To simplify the recording of weekly tests it may be more convenient for the user to perform them each time the equipment is used.

Non-compliance with the requirements in this document shall result in replacement, repair and/or verification according to ISO 22232-1 Group 2 tests or to ISO 22232-2 for the affected component.

5 Personnel qualification

Personnel performing the verifications in accordance with this document shall be qualified to an appropriate level in ultrasonic testing in accordance with ISO 9712 or equivalent.

6 Description of tests and reporting

6.1 Baseline measurements of characteristic values

For each set of combined equipment (instrument, cables and probe) base values have to be determined and reported. The later measured values are to be compared against the base values.

For all systems, initially the user shall establish base values for the sensitivity, the signal-to-noise ratio and the pulse duration using the methods given in 6.3.2, resp. 6.6.2. These shall either be measured for the actual probe and instrument to be used for subsequent testing or for each combination of probe type and instrument type to be used.

For angle-beam probes initially the user shall establish base values for the probe index point (6.4.2.2) and beam angle (6.4.3.2), unless these values are available for new probes.

During the baseline measurements the relevant parameters of the instrument controls, e.g. frequency, pulse energy, suppression/reject, pulse repetition frequency, shall be the same as those to be used for subsequent tests.

The type of test block, cable type and cable length used for these baseline measurements shall also be the same as those used for subsequent tests.

For the measurement of base values it is assumed that the probes, cables and instrument are in proper condition, especially for used parts.

6.2 Physical state and external aspects

6.2.1 Procedure

Visually inspect the outside of the ultrasonic instrument, probes, cable and calibration block for physical damage or wear which could influence the system's current operation or future reliability. In particular inspect the probe contact surface for physical damage or wear. If the probe is assembled from separate components, test that the components are assembled correctly. Test for instability of electrical contacts.

6.2.2 Acceptance criterion

Any damage or wear which could influence the system's current operation or future reliability, e. g. instability of electrical contact shall result in replacement, repair and/or verification according to Group 2 tests of ISO 22232-1 or to ISO 22232-2 for the affected component.

6.2.3 Frequency of testing

The equipment shall be tested once per day for equipment to be used during that day.

6.3 Vertical linearity

6.3.1 General

This test monitors the combined result of two characteristics that affect the linearity of the equipment gain, i.e. the linearity of the amplifier and the accuracy of the calibrated gain control. Any standard calibration block can be used for this test, preferably in conjunction with the probe that will be used in subsequent testing.

The linearity shall be tested with the ultrasonic instrument controls (frequency, range, pulse energy) switched to positions to be employed in subsequent testing. Variable suppression and swept gain controls shall be switched to "off".

6.3.2 Procedure

The ratio method discloses only non-linearity that occurs in the instrument circuitry between the gain controls being used to set the amplitudes and the display.

Position the probe on a calibration block to obtain a reflected signal from a small reflector, e.g. the 5 mm hole in calibration block no. 2 according to ISO 7963.

Adjust the gain to set this signal to 80 % of full screen height (FSH) and note the value of the calibrated gain control (dB). Then increase the gain by 2 dB and confirm that the signal rises to more than full screen height (100 %). Reset the gain to its original value and then reduce it by 6 dB. Confirm that the signal amplitude falls to approximately 40 % of FSH. Successively reduce the signal by three further increments of 6 dB and confirm that the signal amplitude falls respectively to 20 %, 10 % and 5 % of FSH.

For equipment capable of measuring signal amplitudes with a gate above 100 % of FSH, e.g. displayed as a value, the vertical linearity shall be tested up to the maximum possible amplitude value.

Adjust the gain to set the signal to 80 % of the maximum gate amplitude value as a reference value. Decrease the gain in steps of 6 dB and confirm that the signal amplitude falls to approximately half and quarter of the reference amplitude value, if applicable.

6.3.3 Acceptance criteria

To be acceptable, the signal amplitude on the display shall be within the limits given in Table 2. When a gate is used the signal amplitude value shall be within the limits given in Table 3.

Table 2 — Acceptance criteria for vertical display linearity

Gain dB	Expected screen height (% of FSH)	Limits (% of FSH)
+2	100	not less than 95
0	80	(reference line)
−6	40	37 to 43
−12	20	17 to 23
−18	10	8 to 12
−24	5	visible, below 8

Table 3 — Acceptance criteria for vertical gate linearity

Gain dB	Expected gate amplitude value (% of maximum value)	Limits (% of maximum value)
+2	100	not less than 95
0	80	(reference value)
−6	40	37 to 43
−12	20	17 to 23
−18	10	8 to 12
−24	5	below 8

6.3.4 Frequency of testing

The test shall be carried at least once per week for ultrasonic instruments to be used during that week.

6.4 Tests for angle-beam probes

6.4.1 General

The probe index point and the beam angle can be determined separately as described in 6.4.2 and 6.4.3 or simultaneously as described in 6.4.4.

6.4.2 Probe index point

6.4.2.1 General

The probe index point can be tested on calibration blocks according to ISO 2400 or ISO 7963.

The probe index point shall be verified prior to the determination of the beam angle.

6.4.2.2 Procedure

Position the probe on the appropriate side of the block to obtain a reflection from the quadrant. Move the probe backwards and forwards to maximize the amplitude of the reflected signal, taking care to move the probe parallel to the block sides.

When the amplitude is at maximum, the true probe index point will correspond to the engraved line on the block which marks the geometrical centre of the quadrant.

The probe index point measurement shall be repeatable to within ± 1 mm. If the measured position differs from the existing mark by more than 1 mm the new position shall be marked on the probe sides, and recorded, and shall be used in subsequent probe tests and plotting of discontinuities.

6.4.2.3 Frequency of testing

The frequency of testing will depend on the rate of probe wear due to usage and to the roughness of the scanning surface. When a probe is in continuous use, the test shall be carried out at least every few hours; otherwise, a daily test shall be performed for probes to be used during that day.

6.4.3 Beam angle

6.4.3.1 General

The reference blocks defined in ISO 2400 or ISO 7963 provide a means for rapidly testing the beam angle. If a higher accuracy is needed, the angle shall be determined using one of the methods described in ISO 22232-2.

6.4.3.2 Procedure

Place the probe on the calibration block and generate a signal from the selected hole. Move the probe backwards and forwards to maximize the signal from the hole. When the signal is at its maximum amplitude, the beam angle can be read from the engraved scale on the calibration block at a point directly below the measured probe index point. The measured angle shall be recorded.

Using this method it is possible to measure the beam angle to approximately ± 1,5°.

6.4.3.3 Acceptance criterion

The measured beam angle has to be within ± 2° of the nominal beam angle.

6.4.3.4 Frequency of testing

The frequency of testing will depend on the rate of probe wear due to usage and the roughness of the scanning surface. When a probe is in continuous use, the test shall be carried out at least every few hours; otherwise, a daily test shall be performed for probes to be used during that day.

6.4.4 Simultaneous determination of probe index point and beam angle

6.4.4.1 General

This method requires the use of a reference block containing at least 3 side-drilled holes at different depth positions.

6.4.4.2 Procedure

The direct echo amplitude from each hole is maximized in turn and the reduced projection distance a_i between the orthogonal projection of the axis of the hole and the front of the probe is measured (with a ruler) in each case. By plotting these distances against the depth positions of the holes d_i on a scale drawing of a section through the reference block, and drawing a straight line through the points, both the probe index and the beam angle can be determined simultaneously (see Figure 1). The position of the probe index point position corresponds to the distance X in Figure 1 and the angle of refraction, Θ, can be calculated using Formula (1):

$$\theta = Arctan\left(\frac{a_i - a_1}{d_i - d_1}\right) \quad (1)$$

The probe index point measurement shall be repeatable to within ± 1 mm. If the measured position differs from the existing mark by more than 1 mm the new position shall be marked on the probe sides, and recorded, and shall be used in subsequent probe tests and plotting of discontinuities.