BS EN 12668-3:2013

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

Part 3: Combined equipment

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National foreword

This British Standard is the UK implementation of EN 12668-3:2013. It supersedes BS EN 12668-3:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

Zerstörungsfreie Prüfung - Charakterisierung und Verfizierung der Ultraschall-Prüfausrüstung - Teil 3: Komplette Prüfausrüstung

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Foreword

This document (EN 12668-3:2013) 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of an identical text or by endorsement, at the latest by May 2014, and conflicting national standards shall be withdrawn at the latest by May 2014.

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 12668-3:2000.

This European Standard is composed 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* (this document).

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1 Scope

This European Standard describes methods and acceptance criteria for verifying the performance of ultrasonic equipment (i.e. instrument and probe combined as defined in EN 12668-1 and EN 12668-2) by the use of appropriate standard calibration blocks. 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. The methods only apply to pulse echo equipment using A-scan presentation, with gain controls or attenuators calibrated in steps not greater than 2 dB and used essentially in contact testing. These methods are specifically intended for manual testing equipment. For automated testing different tests can be needed to ensure satisfactory performance.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 ISO 2400, *Non-destructive testing - Ultrasonic testing - Specification for calibration block No. 1 (ISO 2400)*

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

3 Description of tests and reporting

3.1 General

The methods described in this European Standard, together with the frequency of checking, are summarized in Table 1.

Compliance with the checks shall be recorded on the ultrasonic test report.

Table 1 — Tests for combined equipment

Subclause	Title	Frequency of checking
3.2.1	Linearity of timebase	Weekly [a]
3.2.2	Linearity of equipment gain	Weekly [a]
3.3.1	Probe index	Daily
3.3.2	Beam angle	Daily
3.4.2	Physical state and external aspects	Daily
3.4.3	Sensitivity and signal-to-noise ratio	Weekly [a]
3.4.4	Pulse duration	Weekly [a]
[a] To simplify the recording of weekly checks it may be more convenient for the user to perform them each time the equipment is used.		

3.2 Ultrasonic instrument checks

3.2.1 Linearity of the timebase

3.2.1.1 General

This check is carried out using a standard calibration block defined in EN ISO 2400 or EN ISO 7963, and a normal-beam compression wave probe or shear wave angle-beam probe. The linearity shall be checked over a range at least equal to that which is to be used in subsequent testing. Where appropriate, due allowance can be made for the fact that a range of 91 mm for compressional waves in steel is equivalent to a range of only 50 mm for shear waves.

3.2.1.2 Procedure

Place the probe on the calibration block in a position where the range to the last backwall or radius echo is equal to or exceeds the range over which the linearity shall be checked. Adjust the timebase so that the first and the sixth backwall echoes coincide with the first and last scale marks respectively. Check the linearity with the four other echoes.

Bring the backwall echoes, in turn, to approximately the same height e.g. 80 % full screen height. The leading edge of each echo should line up with the appropriate graticule line. Check that any deviations from the ideal positions are within the specified tolerance when measured at the same screen height when the first and the sixth echo were positioned.

3.2.1.3 Tolerance

The deviation from linearity shall not exceed ± 2 % of full screen width.

3.2.1.4 Frequency of checking

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

3.2.2 Linearity of equipment gain

3.2.2.1 General

This check monitors the combined result of two characteristics that affect the linearity of the equipment gain, i.e. the linearity of 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 checked with the ultrasonic instrument controls (frequency, range, pulse energy, etc.) switched to positions to be employed in subsequent testing. Variable suppression and swept gain controls shall be switched to “off”.

3.2.2.2 Procedure

Position the probe on a calibration block to obtain a reflected signal from a small reflector e.g. the 5 mm hole in the EN ISO 7963 block.

Adjust the gain to set this signal to 80 % of full screen height 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 (101 %). Restore the gain to its original value and then reduce it by a further 6 dB. Confirm that the signal amplitude falls to approximately 40 % screen height. Successively reduce the signal by three further increments of 6 dB and confirm that the signal amplitude falls respectively to 20 %, 10 % and 5 % screen height.

3.2.2.3 Tolerance

To be acceptable, signal amplitude shall be within the limits given in the following Table 2.

Table 2 — Acceptance limits for gain linearity

Gain dB	**Expected screen height** (%)	**Limits**
+2	101	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 %

3.2.2.4 Logarithmic amplifiers

If the ultrasonic instrument is using a logarithmic amplifier, subclauses 3.2.2.1 to 3.2.2.3 shall be replaced by an overall input/output amplitude accuracy test of the instrument according to manufacturer’s specification. The test shall verify that errors do not exceed ± 1 dB in any 20 dB span and ± 2 dB in any 60 dB span.

3.2.2.5 Frequency of checking

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

3.3 Probe checks

3.3.1 Probe index point

3.3.1.1 General

This check applies only to angle beam probes. The probe index point can be checked on the standard EN ISO 2400 or EN ISO 7963 calibration block each of which has a cylindrical reflector (quadrant).

The probe index point shall be checked prior to checking the beam angle.

3.3.1.2 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 should 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 checks and defect plotting.

3.3.1.3 Tolerance

Tolerance will depend on application, but for plotting of defects it is recommended that the probe index point position is known to within ± 1 mm.

3.3.1.4 Frequency of checking

This 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 check shall be carried out at least every few hours; otherwise, a daily check shall be performed for probes to be used during that day.

3.3.2 Beam angle

3.3.2.1 General

The reference blocks defined in EN ISO 2400 or EN ISO 7963 provide a means of rapidly checking the beam angle. If a higher accuracy is needed, the angle shall be determined using one of the methods described in EN 12668-2.

3.3.2.2 Procedure

Place the probe on the calibration block and establish 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 deviation between measured and nominal angle shall be recorded.

3.3.2.3 Tolerance

Using the method previously described it is possible to measure the beam angle to an accuracy of approximately ± 1,5°. Unless the probe history is known, previously marked probe angles should not be regarded as accurate, especially on 70° or higher angle beam probes, or on worn probes. It is recommended

that the newly measured angle be marked on the probe and recorded for future reference during the subsequent probe checks and/or defect plotting applications.

Tolerances will depend on the application but for some procedures it is recommended that the angle is within ± 2°.

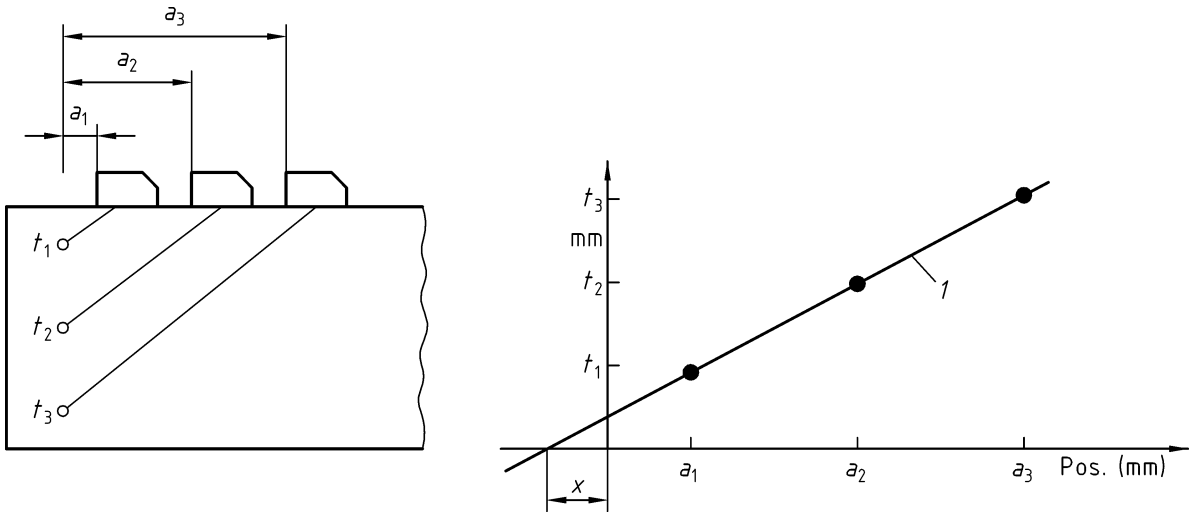
3.3.2.4 Frequency of checking

Frequency of checking 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 check shall be carried out at least every few hours; otherwise, a daily check shall be performed for probes to be used during that day.

3.3.3 Index point and beam angle simultaneously

This method requires the use of a reference block containing at least 3 and preferably 4 or more side-drilled holes at different depths.

The direct echo from each hole is maximized in turn and the reduced projection distance (a) from the centre of the hole to the front face of the probe is measured in each case. By plotting these distances against the depth position of the holes (t) on a scale drawing of a section through the reference block and, drawing a straight line through the points, both the probe index and beam angle can be determined simultaneously (see Figure 1).



Key

1 slope = beam angle

x distance between probe index point and front face

Figure 1 — Simultaneous determination of probe index point and beam angle

3.4 System checks: Probe, cable and ultrasonic instrument combined

3.4.1 Measurement of base values

Initially the user shall establish base values for the signal-to-noise ratio and the pulse duration using the methods given in 3.4.2 and 3.4.3. These shall either be measured for the actual probe and ultrasonic instrument to be used for subsequent testing or for each combination of probe type and ultrasonic instrument type to be used. During these initial base measurements the relevant ultrasonic instrument controls, e.g. frequency, pulse energy, suppression/reject, pulse repetition frequency, shall be the same as those to be used

for subsequent checks. The type of test block and cable type and length used for these initial base measurements shall also be the same as those used for subsequent checks. The ultrasonic instrument and probe used for these base measurements shall comply with EN 12668-1 and EN 12668-2. These values are to be used as base values against which the measured values will be compared.

3.4.2 Physical state and external aspects

3.4.2.1 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 face of the probe for physical damage or wear. If the probe is assembled from separate components, check that the components are assembled correctly. Check for instability of electrical contact.

3.4.2.2 Frequency of checking

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

3.4.3 Sensitivity and signal-to-noise ratio

3.4.3.1 General

The objective of these checks is to provide the operator with a simple method which will allow a deterioration in the performance of the combined equipment to be identified. These checks are only intended to be applied to monitor the continuing performance of a fixed combination of equipment that has been previously shown to operate satisfactorily.

The measured signal-to-noise ratio is compared with base values established by the user for the type of ultrasonic instrument and probe. A simple method for checking sensitivity is given but is not intended as a method of defining inspection sensitivity which should be set according to the requirements of the examination and the testing standard being applied.

The EN ISO 2400 calibration block, using the small diameter hole, or the EN ISO 7963 block, using the 5 mm diameter hole, are suitable.

The sensitivity shall be checked with the relevant ultrasonic instrument controls, e.g. frequency, pulse, energy suppression/reject, pulse repetition frequency, range setting, set to the positions used during the base measurements.

Uncalibrated gain controls shall be set at maximum or at previously determined positions. The type and length of cable used shall be the same as that used during the base measurements. The same ultrasonic instrument setting shall be used as for the subsequent testing.

3.4.3.2 Procedure

Place the probe on the chosen calibration block and adjust its position to maximize the signal from the side-drilled hole to be used as a sensitivity check. Adjust the calibrated control (dB) to set this signal to 20 % of screen height and note the setting of the gain control. Remove the probe from the test block and wipe the probe face dry of couplant. Then place the probe on its side. Using the calibrated control, increase the gain until the overall system noise at the same range as the target hole reaches 20 % of screen height, and note the new setting of the gain control.

The first gain measurement noted provides a check on the sensitivity of the probe and ultrasonic instrument, and the difference between the first and second measurements (dB) gives the signal-to-noise ratio. In each case, check these parameters at the particular range selected for the base measurements.

3.4.3.3 Tolerance

The sensitivity and signal-to-noise ratio shall be within 6 dB of the base measurements, made by the user, for this type of probe and ultrasonic instrument.

3.4.3.4 Frequency of checking

The check shall be carried at least once per week for the probes to be used during that week.

3.4.4 Pulse duration

3.4.4.1 General

This check on the probe and ultrasonic instrument combination, which is similar to that described in EN 12668-2, measures the effect on the displayed signal of pulse shaping, matching, amplifier bandwidth, built-in suppression and smoothing circuits. The measured pulse duration is compared with base value established by the user for the type of ultrasonic instrument and probe.

The pulse duration check requires only the display on the calibrated timebase, of the reflected signal from the radius in the EN ISO 2400 or EN ISO 7963 calibration block for shear wave probes, or a backwall echo for compressional wave probes.

The check should be made with the relevant ultrasonic instrument controls e.g. frequency, pulse energy, suppression/reject, pulse repetition frequency, range setting, set to the positions used during the base measurements. The type and length of cable used shall be the same as that used during the base measurements. Where practical the same ultrasonic instrument settings and cable should be used for the subsequent testing.

3.4.4.2 Procedure

Having calibrated the timebase to an appropriate setting to measure the pulse duration, adjust the amplitude of the reflected signal to 100 % of screen height. Measure the width of the signal in millimetres at 10 % screen height.

If desired, the measurement in millimetres can be converted to microseconds.

3.4.4.3 Tolerance

The pulse duration shall not be greater than 1,5 times the base measurement, made by the user with the same instrument setting, for this type of probe and ultrasonic instrument.

3.4.4.4 Frequency of checking

The check shall be carried at least once per week for the probes to be used that week. For shear wave probes the measurement can be performed in conjunction with the check on probe index point (see 3.3.1).

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