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Non-destructive testing — Ultrasonic testing — Technique of testing claddings produced by welding, rolling and explosion

Essais non destructifs — Essais par ultrasons — Technique d'essai des placages produits par soudage, laminage et explosion

Reference number
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Foreword

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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 WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

ISO 17405 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 138, *Non-destructive testing*, in collaboration with ISO Technical Committee TC 135, *Non-destructive testing*, Subcommittee SC 3, *Ultrasonic testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Non-destructive testing — Ultrasonic testing — Technique of testing claddings produced by welding, rolling and explosion

1 Scope

This International Standard specifies the techniques for manual ultrasonic testing of claddings on steel applied by welding, rolling, and explosion using single-element or dual-element probes.

The test is intended to cover detection of two-dimensional or three-dimensional discontinuities in the cladding and in the region of the interface.

This International Standard does not give acceptance criteria nor define the extent of testing.

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.

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

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

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-4 and the following apply.

3.1
test object
part to be tested

3.2
test surface
areas of the surface of the test object to which probes have to be coupled

4 Ultrasonic test system

4.1 General

The ultrasonic pulse-echo technique is used. For two-dimensional discontinuities parallel to the test surface and three-dimensional discontinuities, straight beam probes (dual-element or single-element) shall be used for testing with longitudinal waves.

For discontinuities with any other orientation, dual-element angle-beam probes for longitudinal waves can be used.

The nominal frequency shall be selected according to the purpose of the test and the characteristics of the materials.

Frequencies from 2 MHz to 6 MHz should be preferred.

The instrument used shall comply with the requirements given in EN 12668-1, and the probes shall comply with the requirements of EN 12668-2

The whole test system shall be checked by the operator periodically as given in EN 12668-3.

4.2 Requirements regarding probes

4.2.1 Single-element straight beam probes for longitudinal waves

A depth zone providing optimum sensitivity is defined (see Annex A) by the size of the transducer used in the probes. The position of this zone should be selected according to the expected position of the discontinuities.

4.2.2 Dual-element straight-beam probes for longitudinal waves

A depth zone providing optimum sensitivity is defined (see Annex A) by the size of the transducers used in the probes and their roof angle. The position of this zone should be selected according to the expected position of the discontinuities.

4.2.3 Dual-element angle-beam probes for longitudinal waves

The beam angle should be between 65° and 80°. The skewing angle, and the shape and size of the transducers, shall be selected so that the depth range for optimum sensitivity (see Annex A) covers the expected position of the discontinuities.

4.2.4 Matching probes to curved surfaces

The distance between the surface and the contact surface of the probe shall not exceed 0,5 mm when the centre of the probe is in contact. To achieve this, a flat probe shall be matched to the curvature of the test object by grinding, using adaptors or other aids if the radius of curvature, R, is within the range

$$R < \frac{A_P^2}{4\ \text{mm}} \tag{1}$$

where

R is the radius of the curvature of the surface, in mm;

A_P is the dimension of the contact surface of the probe in the direction of curvature, in mm, i.e. for testing cylindrical parts in the longitudinal direction, it is the width, and for testing in the circumferential direction, it is the length of the contact surface.

4.3 Additional requirements

4.3.1 Test ranges

There shall be a facility for an expanded time base (“zoom mode”).

4.3.2 Echo width

The echo width visible on the screen shall be taken into account when assessing the suitability for coverage of the selected depth zone. This applies to all types of probes: single-element straight beam probes, dual-element straight beam probes, and dual-element angle-beam probes.

4.4 Instrument settings

4.4.1 Range setting

Range setting of the ultrasonic instrument for accurate localization of discontinuities when using dual-element probes can be carried out using reference blocks (see Reference [2]) as shown in Figure 1 or Figure 2 for example, made of materials that are similar to the test object, or it can be carried out on the test object itself.

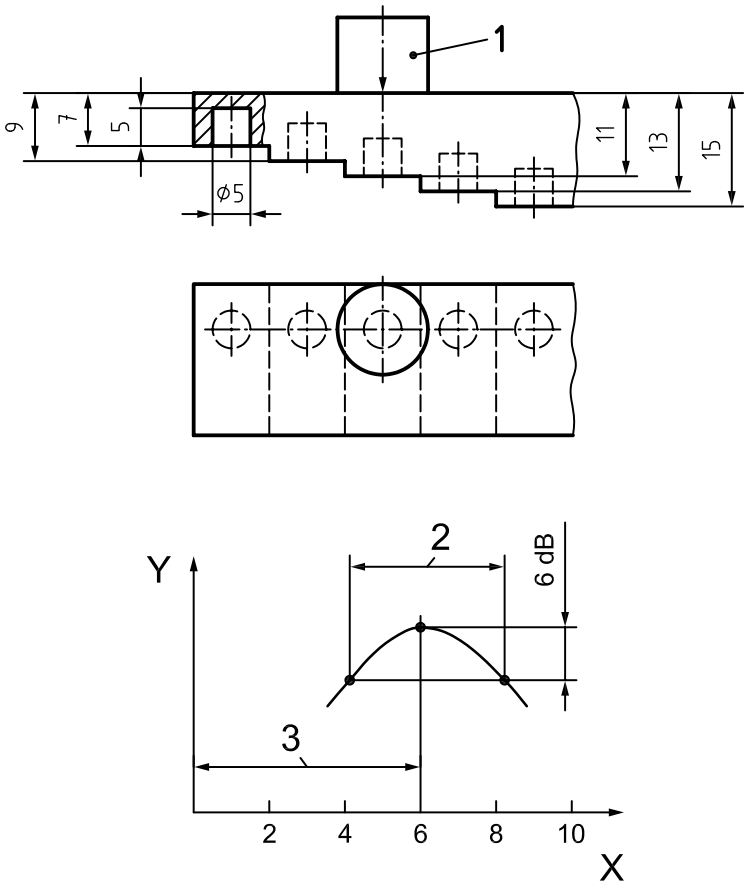
In the case of a dual-element straight-beam probe, the probe can, for example, be placed on the various steps of a stepped wedge calibration block. The front edge of the associated echo shall be set on the appropriate marks on the screen by adjusting the zero shift and the sweep (velocity). When dual-element angle-beam probes are used on a reference block as shown in Figure 2, for example, the shortened projected distances (distance between the front edge of the probe and the projection of the reflection point on the test surface) shall be lined up with the appropriate marks on the screen. In this manner, it is possible to read the position of a reflection point directly on the screen, i.e. for the setting with shortened projected distances as well as with depth positions.

NOTE 1 It is recommended to mark the range of any discontinuities to be detected on the screen according to their depth position (normally corresponding to the thickness of the cladding).

When straight beam probes are used, the range of the ultrasonic instrument can be calibrated using multiple echo series from a plane-parallel steel plate of known thickness and sound velocity (e.g. calibration block No. 1 according to ISO 2400).

NOTE 2 Since when dual-element angle-beam probes are used for longitudinal waves, transverse waves are also generated, care has to be taken to ensure that no erroneous indications of transverse waves are used during the setting procedure. In any case, these indications have a considerable larger time-of-flight than those of longitudinal waves.

Dimensions in millimetres



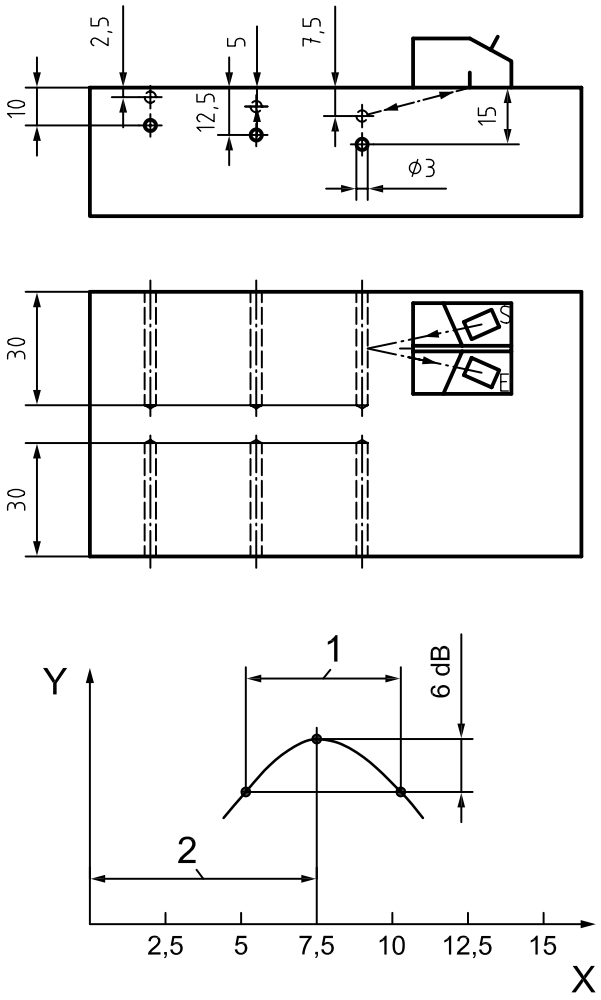
Key

1 probe
2 focal range
3 focal depth
X reflector depth
Y echo height

NOTE When reference blocks are used, all dimensions not specified should be selected so that the measurement or setting is not impaired by echoes from the geometry of the test block.

Figure 1 — Reference block for dual-element straight beam probes with representation of the focal zone

Dimensions in millimetres



Key

1 focal range
2 focal depth
X reflector depth
Y echo height

NOTE When reference blocks are used, all unspecified dimensions should be selected so that the placing of the probe on the test surface and the measurement or adjustment is not affected by shape echoes.

Figure 2 — Reference block for dual-element angle-beam probes showing the focal zone

4.4.2 Sensitivity setting

For sensitivity setting, it is recommended to choose reference reflectors (type and size) according to the expected discontinuities.

A reference block with a cladding of the same type as that to be tested shall be used for setting the sensitivity. The thickness of the cladding, the surface preparation, and the shape of the test surface shall be the same as those of the object to be tested (see Clause 5). If the probes have to be matched to curved test surfaces, the reference blocks used shall also have test surfaces on which the probe fits, as specified in 4.2.3.

For the detection of volumetric discontinuities, side-drilled holes of e.g. 3 mm diameter and 30 mm length in the parent metal at the interface with the cladding can be used for sensitivity setting (see Figure 3).

In the case of claddings produced by welding, one hole shall be made perpendicular to the direction of welding and one parallel to this direction. In the case of double or multi-pass welded claddings, it might be necessary to use further holes between the individual passes.

For the detection of planar discontinuities parallel to the test surface, it is recommended to use flat-bottomed holes for sensitivity setting with straight beam probes (single-element or dual-element).

For the detection of planar discontinuities perpendicular to the test surface, it is recommended to use notches for sensitivity setting with angle-beam probes.

Positions 1, 2, and 3 in Figure 3 show how the reference reflector echo shall be generated for setting the test sensitivity of the instrument. It is recommended that the echo height should be set to 40 % of the screen height.

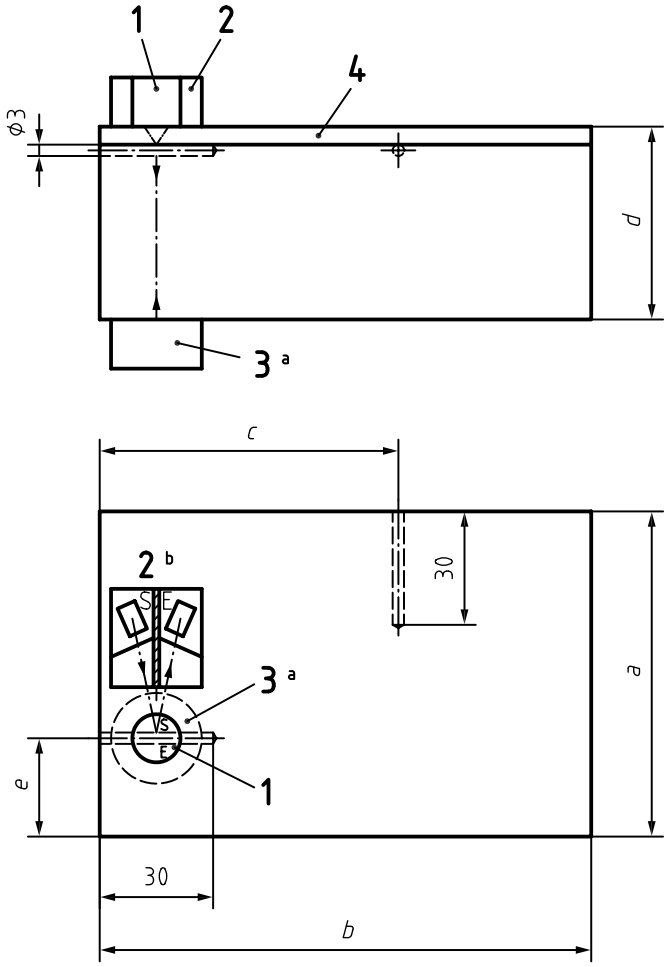
When straight beam probes are used, only reference blocks of the same or larger wall thickness as the test object shall be used. If these thicknesses are different, the corresponding difference of sensitivity can be compensated.

Note the gain required to set an indication to 40 % of the screen height for positions 1 (dual-element straight beam probe), 2 (dual-element angle-beam probe), and 3 (straight beam probe).

For all probes, the height of the noise shall be determined by moving the probe over a representative area of the surface of the test object. While this is done, the instrument gain shall be set so that the noise peaks produce indications up to 40 % of the screen height, when the probe is continuously moved (resulting from the structure of the material and the roughness and undulations of the contact surface) over the area where indications from discontinuities are expected.

There shall be at least 6 dB separation between the echo height that has to be indicated and the height of the noise. If necessary, the test surface should be machined to achieve this and/or other probes should be used.

Dimensions in millimetres



Key

1 position 1
2 position 2
3 position 3
4 cladding
a TR straight beam probe.
b TR angle-beam probe.

NOTE Dimensions *a*, *b*, *c*, *d*, and *e* should be selected so that in each case, the probe can be coupled to the test object without difficulty and that echoes from the geometry of the block do not affect the gain setting.

Figure 3 — Sensitivity setting on a cladded adjustment reference block

5 Preparation of the test object

If it is required to detect discontinuities occurring at a particular stage of fabrication by means of this test, the test shall only be carried out when that stage has been reached.

The size of the test area shall be defined before the test.

The surface of the cladding should be prepared in the region of the test area so as to provide an adequate contact surface for the probes. The surface condition shall be such that the requirements regarding the signal-to-noise ratio given in 4.4.2 are fulfilled.

6 Test procedure

6.1 General

When selecting the test technique (probes, coupling area, and method of moving the probes), account shall be taken of the typical types and orientations discontinuities with the type of cladding concerned.

6.2 Movement of probe

When moving a dual-element straight beam probe, it shall be swivelled to ensure maximum indication heights.

Where the motion is along parallel lines when an area has to be scanned, a maximum distance between the lines should be chosen such that the echo height of the reference reflectors as shown in Figure 3 drops by no more than 6 dB compared with the maximum. For straight beam probes, this will usually be the case when the distance is half the dimension of the probe's contact surface, and for dual-element angle-beam probes, this means a distance of 10 mm.

6.3 Checking the instrument setting

The setting of the instrument shall be checked at regular intervals during the test, at least at intervals of 4 h of work.

If deviations are found during these checks, the corrections given in Table 1 shall be carried out.

Table 1 — Sensitivity and range corrections

Sensitivity		
1	Deviations ≤4 dB	Setting shall be corrected before the testing is continued.
2	Reduction of sensitivity >4 dB	Setting shall be corrected and all testing carried out with the equipment over the previous period shall be repeated.
3	Increase in sensitivity >4 dB	Setting shall be corrected and all recorded indications shall be re-examined.
Range		
1	Deviations ≤2 % of the range	Setting shall be corrected before testing is continued.
2	Deviations >2 % of the range	Setting shall be corrected and testing carried out with the equipment over the previous period shall be repeated.

6.4 Recording levels

Unless the conditions of delivery or acceptance stipulate the recording levels, it is recommended to use the echo heights of the reference reflectors specified in Clause 4 as recording levels.

The recording level for discontinuities oriented perpendicularly to the surface shall be agreed upon for each case separately. A possible choice for the recording level in such a case is given in Annex A.

7 Test report

The test report shall give the following information for each test:

a) a reference to this International Standard (i.e. ISO 17405:2014);

b) general information on test:

   1) name of operator;

2) date of testing;

3) test instrument;

4) probes;

5) instrument gain;

6) reference blocks used;

7) test object (type of cladding, parent, and clad material);

8) type of test (object of test);

9) condition of test surface;

10) extent of testing;

11) instrument gain (gain in dB) to produce an indication at 40 % of the screen height for the reference reflector echo and for the recording sensitivity used in the test;

12) difference of the echo heights to the noise level to be recorded, in dB;

c) information on the detected discontinuities:

1) positions of detected discontinuities in a reproducible coordinate system specified for the test object;

2) depth position and echo height of discontinuities (referred to the echo height of the reference reflector) of any signals to be recorded;

3) lengths and widths of discontinuities to be recorded using the 6 dB-drop technique;

4) typical indications that cannot be avoided during the test (e.g. because of the surface condition or the dimensions of the test object).

Annex A
(informative)

Determination of focal zone

If it is not specified by the manufacturer of the probe, the depth range giving optimum test sensitivity, the so-called focal zone, can be determined for dual-element straight beam probes with a reference block with flat-bottomed holes, which can also be used for the location of discontinuities as described in 4.4.1.

Figure 1 shows the probe and the recommended reference block for flat surfaces. The height of the echo from the various flat-bottomed holes can be plotted in a diagram against depth. From this, both the focal distance and the focal zone can be read off. The points at which the echo height has dropped by 6 dB are used for determining the focal zone. If the focal zone has not been specified by the manufacturer with dual-element angle-beam probes, a reference block as shown in Figure 2 with side-drilled holes parallel to the surface and perpendicular to the probe axis can be used. The echoes of the side-drilled holes at various depths can be used for determining the focal distance and also the focal zone.

If the probes have to be matched to the curvature of the surface and the position of the focal zone has to be known for the test, it shall be determined on reference blocks as shown in Figure 1 or Figure 2 with a surface of similar curvature.

Bibliography

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

[2] EN 1330-2, *Non-destructive testing — Terminology — Part 2: Terms common to the non-destructive testing methods*

ICS 19.100

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