INTERNATIONAL STANDARD

ISO 16811

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Non-destructive testing — Ultrasonic testing — Sensitivity and range setting

Essais non destructifs — Contrôle par ultrasons — Réglage de la sensibilité et de la base de temps

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16811 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 3, *Ultrasonic testing*.

Introduction

This International Standard is based on EN 583-2:2001, *Non-destructive testing — Ultrasonic examination — Part 2: Sensitivity and range setting*.

The following International Standards are linked.

ISO 16810, *Non-destructive testing — Ultrasonic testing — General principles*

ISO 16811, *Non-destructive testing — Ultrasonic testing — Sensitivity and range setting*

ISO 16823, *Non-destructive testing — Ultrasonic testing — Transmission technique*

ISO 16826, *Non-destructive testing — Ultrasonic testing — Examination for discontinuities perpendicular to the surface*

ISO 16827, *Non-destructive testing — Ultrasonic testing — Characterization and sizing of discontinuities*

ISO 16828, *Non-destructive testing — Ultrasonic testing — Time-of-flight diffraction technique as a method for detection and sizing of discontinuities*

Non-destructive testing — Ultrasonic testing — Sensitivity and range setting

1 Scope

This International Standard specifies the general rules for setting the timebase range and sensitivity (i. e. gain adjustment) of a manually operated ultrasonic flaw detector with A-scan display in order that reproducible measurements may be made of the location and echo height of a reflector.

It is applicable to techniques employing a single contact probe with either a single or twin transducers, but excludes the immersion technique and techniques employing more than one probe.

2 Normative references

The following referenced documents are indispensable for the application 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 7963, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 2*

EN 12668-3, *Non-destructive testing — Characterization and verification of ultrasonic examination equipment — Part 3: Combined equipment*

3 General

3.1 Quantities and symbols

A full list of the quantities and symbols used throughout this International Standard is given in Annex A.

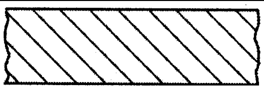
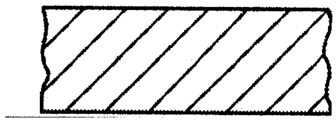
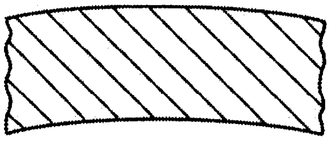
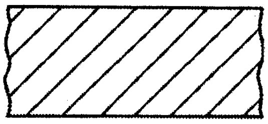
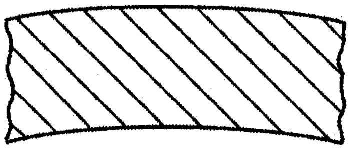
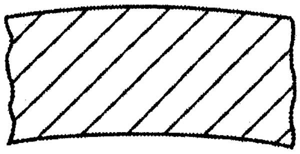
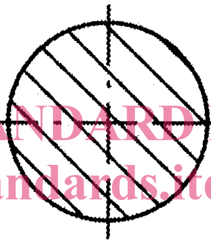
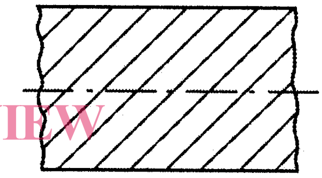
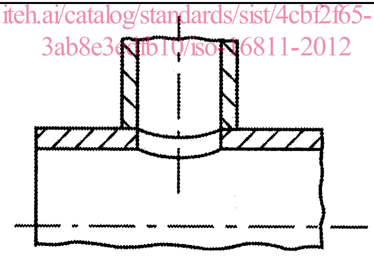
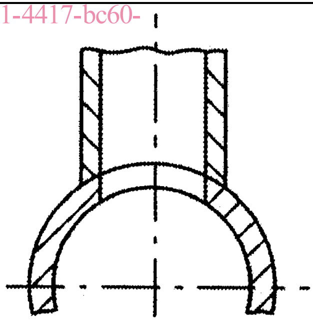
3.2 Test objects, reference blocks and reference reflectors

Requirements for geometrical features of test objects, reference blocks and reference reflectors in general are contained in Annex B.

3.3 Categories of test objects

The requirements for range and sensitivity setting will depend on the geometrical form of the test object. Five categories of test objects are defined in Table 1.

Table 1 — Categories of test objects

Class	Feature	Section in x-direction	section in y-direction
1	Plane parallel surfaces (e. g. plate/sheet)		
2	Parallel, uniaxially curved surfaces (e. g. tubes)		
3	Parallel surfaces curved in more than one direction (e. g. dished ends)		
4	Solid material of circular cross section (e. g. rods and bars)		
5	Complex shapes (e. g. nozzles, sockets)		

3.4 Contouring of probes

Contouring of the probe shoe, for geometry categories 2 to 5, may be necessary to avoid probe rocking, i.e. to ensure good, uniform, acoustic contact and a constant beam angle in the test object. Contouring is only possible with probes having a hard plastic stand-off (normally twin-transducer straight beam probes or angle beam probes with wedges).

The following conditions for the different geometric categories exist (see Table 1 and Figure 1):

— category 1: No probe contouring necessary for scanning in either x- or y-direction;

— categories 2 and 4: scanning in x-direction: Probe face longitudinally curved, scanning in y-direction: Probe face transversely curved;

— categories 3 and 5: scanning in either x- or y-direction: Probe face longitudinally and transversely curved.

The use of contoured probes necessitates setting the range and sensitivity on reference blocks contoured similar to the test object, or the application of mathematical correction factors.

When using equations (1) or (2), problems due to low energy transmission or beam misalignment are avoided.

3.4.1 Longitudinally curved probes

3.4.1.1 Convex scanning surface

For scanning on convex surfaces the probe face shall be contoured when the diameter of the test object, D_{obj}, is below ten times the length of the probe shoe, l_{ps}, (see Figure 1):

$$D_{obj} < 10 l_{ps} \quad (1)$$

3.4.1.2 Concave scanning surface

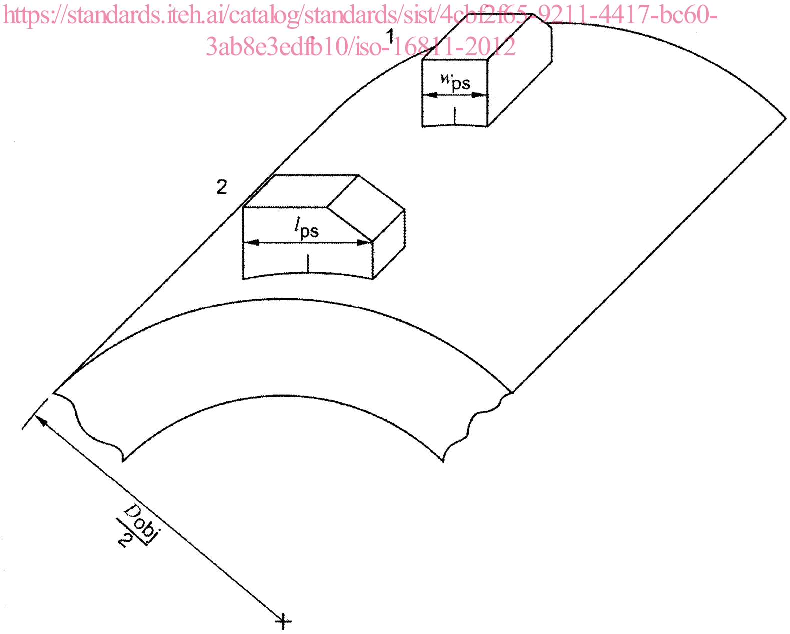
On a concave scanning surface the probe face shall always be contoured, unless adequate coupling can be achieved due to very large radii of curvature.

3.4.2 Transversely curved probes

3.4.2.1 Convex scanning surface

For scanning on convex surfaces the probe face shall be contoured when the diameter of the test object, D_{obj}, is below ten times the width of the probe shoe, w_{ps}, (see Figure 1):

$$D_{obj} < 10 w_{ps} \quad (2)$$



Key

1 Transversely curved
2 Longitudinally curved

Figure 1 — Length, l_{ps}, and width, w_{ps}, of probe shoe in direction of curvature of the test object

3.4.2.2 Concave scanning surface

On a concave scanning surface the probe face shall always be contoured, unless adequate coupling can be achieved due to very large radii of curvature

3.4.3 Concave scanning surface

The probe face shall fulfil the requirements of 3.4.1 and 3.4.2.

4 Determination of probe index and beam angle

4.1 General

For straight beam probes there is no requirement to measure probe index and beam angle as it is assumed that the probe index is in the centre of the probe face and the angle of refraction is zero degrees.

When using angle probes, these parameters shall be measured in order that the position of a reflector in the test object can be determined in relation to the probe position. The techniques and reference blocks employed depend on the contouring of the probe face.

Measured beam angles depend on the sound velocity of the reference block used. If the block is not made of non-alloy steel its velocity shall be determined and recorded.

4.2 Flat probes

4.2.1 Calibration block technique

Probe index and beam angle shall be determined using Calibration Block No. 1 or Calibration Block No. 2 according to the specifications given in ISO 2400 or ISO 7963 respectively, depending on the size of the probe.

4.2.2 Reference block technique

An alternative technique using a reference block containing at least 3 side-drilled holes as given in EN 12668-3 may be used.

4.3 Probes curved longitudinally

4.3.1 Mechanical determination

Before contouring the probe face, the probe index and beam angle shall be measured as described in 4.2.1.

The incident angle at the probe face (α_d) shall be calculated from the measured beam angle (α) and a line, originating from the probe index and parallel to the incident beam, shall be marked on the side of the probe, as shown in Figure 2.

The incident angle is given by equation 3:

$$\alpha_d = \arcsin\left(\frac{c_d}{c_t}\sin\alpha\right) \tag{3}$$

where

c_d is the longitudinal wave velocity in the probe wedge (normally 2730 m/s for acrylic glass)

c_t is the transverse wave velocity in the test object (3255 m/s ± 15 m/s for non-alloy steel).

After contouring, the probe index will have moved along the marked line, and its new position can be measured by mechanical means directly on the probe housing, as shown in Figure 2.

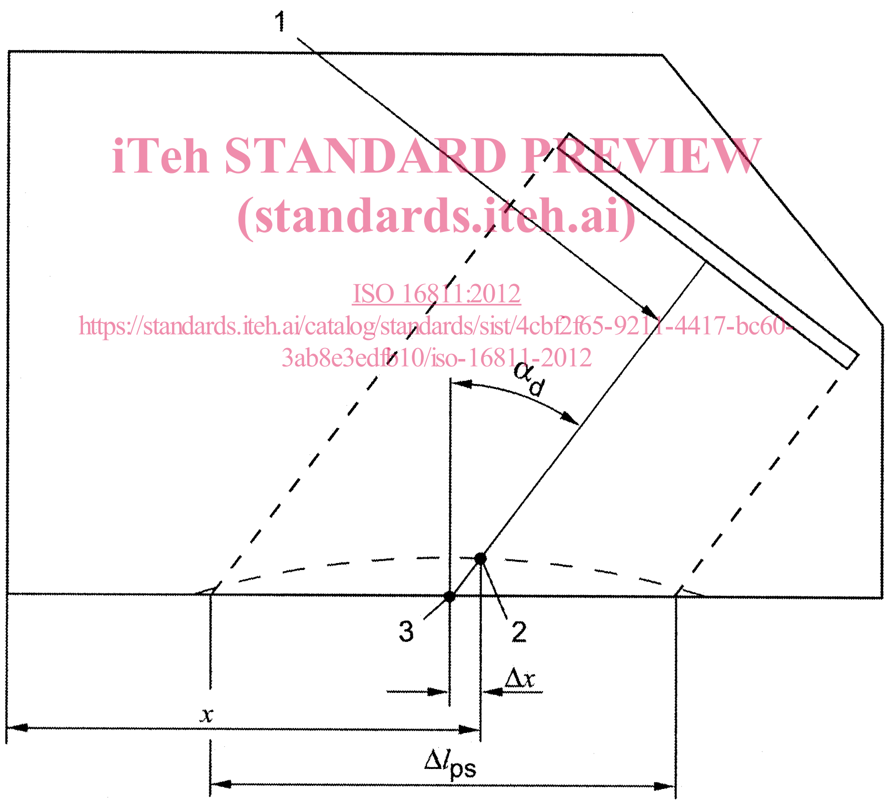
The beam angle shall be determined by maximizing the echo from a side-drilled hole satisfying the conditions given in annex B. The beam angle may then be measured directly on the test object, on the reference block, or on a scale drawing. See Figure 3.

Alternatively, the beam angle may be determined by calculation on the basis of the sound path length measured on the reference block by mechanical means, using equation (4). This may be accomplished together with the range setting as described in 5.4.4.

$$\alpha = \arccos\left\{\frac{\left[(D_{SDH}/2)^2 + s^2 - t^2 + sD_{SDH} + tD_{Obj}\right]}{D_{Obj}\left[s + (D_{SDH}/2)\right]}\right\} \quad (4)$$

The symbols used in this equation are illustrated in Figure 3.

The radius of curvature of the surface used for the calibration shall be within ± 10 % of that of the test object.



Key

1 Marked line for index shift
2 Index point after contouring
3 Index point before contouring

Figure 2 — Determination of index shift for longitudinally curved probes

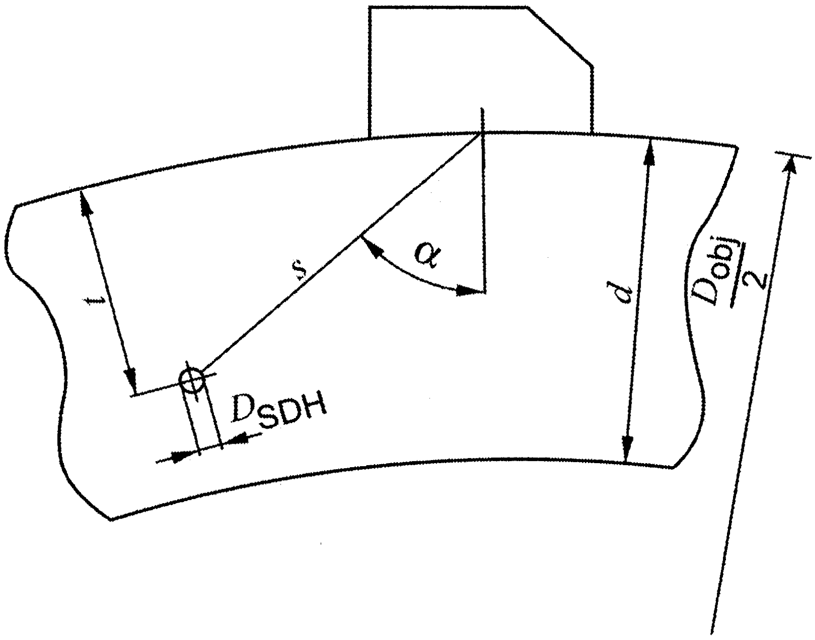


Figure 3 — Determination of beam angle *α* for a longitudinally contoured probe

4.3.2 Reference Block Technique

This is similar to that referenced in 4.2.2, except that the test block shall have a radius of curvature within ± 10% of that of the test object.

4.4 Probes curved transversely

4.4.1 Mechanical determination

Before contouring the probe face the probe index and beam angle shall be measured as described in 4.2.

After contouring, either

i) a line representing the incident beam, originating from the probe index, shall be marked on the side of the probe. The new position of the probe index shall be measured on the side of the probe as shown in Figure 4;

ii) the shift in probe index position (Δx) shall be calculated using equation 5:

$$\Delta x = g \tan(\alpha_d) \tag{5}$$

The symbols in this equation are illustrated in Figure 4.

For acrylic glass wedges (c_d=2730 m/s) and non-alloy steel test objects (c_t=3255 m/s) the shift in the probe index position (Δx), for the three most commonly used beam angles, shall be read from Figure 5 in relation to the depth of contouring (g).

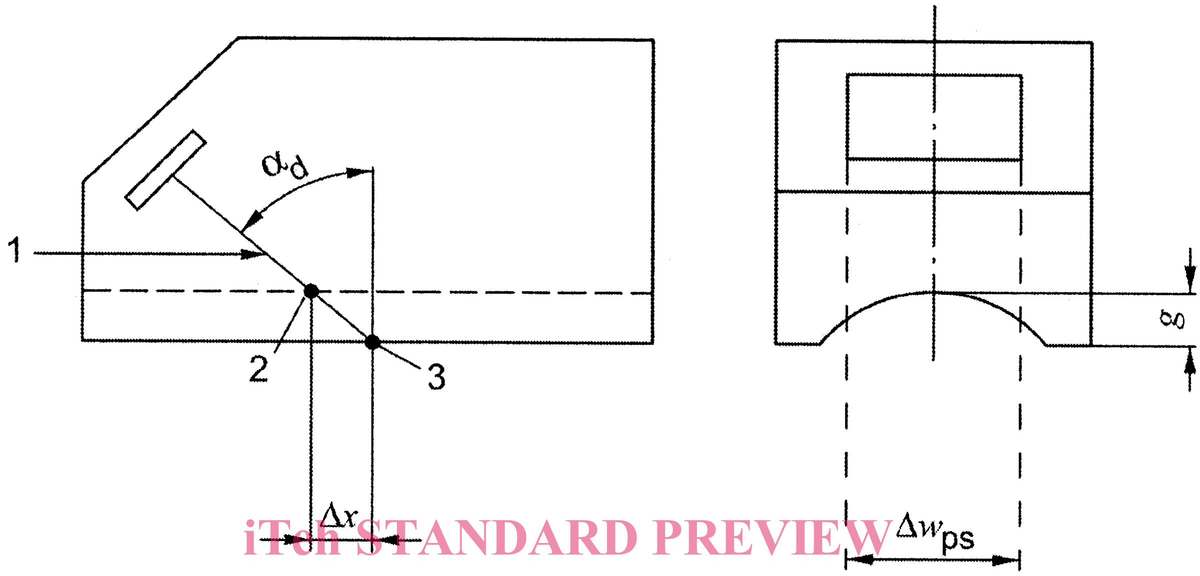
The beam angle should not change during contouring.

However, if it is not known, or there is any variation in the depth of contouring along the length of the probe, it shall be measured on a suitably contoured reference block using a side drilled hole satisfying the conditions given in Annex B. The beam angle shall be determined by:

iii) drawing a straight line between the hole and the probe index on a scale drawing; or

iv) calculation using, for example, equation (6) for the setup illustrated in Figure 6.

$$\alpha = \arctan\left[\frac{A' + x - q}{t}\right]$$



Key

1 Marked line for index shift
2 Index point after contouring
3 Index point before contouring

Figure 4 — Determination of index shift for transversely curved probes

4.4.2 Reference block technique

This technique is similar to that referenced in 4.2.2 except that the test block shall be curved transversely in relation to the probe, and shall have a radius of curvature not exceeding 10 % greater, or 30 % lower, than that of the test object.