
**Non-destructive testing of welds —
Ultrasonic testing of welded joints**

*Contrôle non destructif des assemblages soudés — Contrôle par
ultrasons des assemblages soudés*

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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 17640 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*.

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Introduction

This International Standard describes general methods for ultrasonic testing, using standard criteria, of the most commonly used welded joints. It specifies requirements for equipment, surface preparation, inspection performance and reporting. The parameters specified, in particular those for the probes, are compatible with the requirements of EN 1712 and EN 1713, and are suitable for use with other acceptance criteria standards. The inspection techniques are suitable for the detection of weld imperfections specified in typical weld acceptance standards. The methods used for ultrasonic assessment of indications and acceptance criteria shall be specified, for example by reference to application standards.

Requests for official interpretations of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 5 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

NOTE If the acceptance criteria require a more precise determination of the height and nature of the defect, e.g. when fitness-for-purpose criteria are applied, this may necessitate the use of techniques outside the scope of this International Standard.

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Non-destructive testing of welds — Ultrasonic testing of welded joints

1 Scope

This International Standard specifies methods for manual ultrasonic testing of fusion-welded joints in metallic materials, greater than or equal to 8 mm thick, which exhibit low ultrasonic attenuation (especially that due to scatter). This International Standard is primarily intended for full penetration welded joints where both the welded and parent materials are ferritic.

This International Standard specifies four testing levels (A, B, C and D) (see Clause 11), each corresponding to a different probability of detection of imperfections. Rules for the selection of testing levels A, B and C are given in Annex A.

This International Standard may be used for assessment of indications, for acceptance purposes, by either of the following methods:

- a) evaluation based primarily on length and echo amplitude of the signal indication;
- b) evaluation based on characterization and sizing of the indication by probe movement methods.

The techniques described in this International Standard may be specified, for example in an application standard, for use with:

- materials other than those stated,
- partial-penetration welds,
- automated equipment.

In each case, the technique should be verified as having adequate sensitivity.

NOTE Where material-dependent ultrasonic values are specified in this International Standard, they are based on steels having an ultrasonic sound velocity of $(5\,920 \pm 50)$ m/s for longitudinal waves, and $(3\,255 \pm 30)$ m/s for transverse waves. This is to be taken into account when testing materials with a different velocity.

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

ISO 10375, *Non-destructive testing — Ultrasonic inspection — Characterization of search unit and sound field*

ISO 12715, *Ultrasonic non-destructive testing — Reference blocks and test procedures for the characterization of contact search unit beam profiles*

ISO 17635, *Non-destructive testing of welds — General rules for fusion welds in metallic materials*

EN 583-1, *Non-destructive testing — Ultrasonic examination — Part 1: General principles*

EN 583-2, *Non-destructive testing — Ultrasonic examination — Part 2: Sensitivity and range setting*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17635 and ISO 5577 apply.

4 Symbols and abbreviated terms

The symbols and abbreviated terms used in this International Standard are given in Table 1.

Table 1 — Symbols and abbreviated terms

Symbol	Term	Unit
t	Thickness of parent material (at the thinnest point)	mm
D_{DSR}	Diameter of a disc-shaped reflector	mm
D_{SDH}	Diameter of a side-drilled hole	mm
l	Indication length	mm
h	Extension of an indication in the depth direction	mm
x	Position of an indication in the longitudinal direction	mm
y	Position of an indication in the transverse direction	mm
z	Position of an indication in the depth direction	mm
l_z	Projected length of the indication in the z-direction	mm
l_x	Projected length of the indication in the x-direction	mm
l_y	Projected length of the indication in the y-direction	mm
p	Full skip distance	mm

5 Information requirements

5.1 Information required prior to testing

Prior to testing, the following items shall be specified (where applicable):

- method for setting the reference level;
- manufacturing and operation stage(s) at which testing is to be carried out;
- testing level;
- acceptance levels;
- method to be used for evaluation of indications;
- qualification of personnel;

- extent of testing for transverse indications;
- requirements for tandem testing;
- parent material testing prior to and/or after welding;
- requirements for written test procedures.

5.2 Additional pre-test information

Prior to testing, the operator shall have access to the following information:

- written test procedure, if required (see 5.3);
- type(s) of parent material and product form (i.e. cast, forged, rolled);
- manufacturing or operation stage, including any heat treatment, at which testing is to be carried out;
- time and extent of any post-weld heat treatment;
- joint preparation and dimensions;
- requirements for surface conditions;
- welding procedure or relevant information on the welding process;
- reporting requirements;
- acceptance levels;
- extent of testing, including requirements for transverse indications, if relevant;
- testing level;
- personnel qualification level;
- procedures for corrective actions when unacceptable indications are revealed.

NOTE Visual testing in accordance with ISO 17637 may be specified prior to any ultrasonic testing. In this case, the result shall also be made available.

5.3 Written test procedure

This International Standard will normally satisfy the need for a written test procedure. Where additional written procedures are required, they shall be specified prior to testing, for example by reference to an application standard.

6 Requirements for personnel and equipment

6.1 Personnel qualifications

Ultrasonic testing of welds and the evaluation of results for final acceptance shall be performed by qualified and capable personnel. It is recommended that personnel are qualified in accordance with ISO 9712 or an equivalent standard at an appropriate level in the relevant industry sector.

6.2 Equipment

All ultrasonic testing equipment shall comply with the requirements of ISO 10375 and ISO 12715.

6.3 Probe parameters

6.3.1 Test frequency

The test frequency shall be within the range 2 MHz to 5 MHz, and selected to comply with the specified acceptance levels.

For the initial test, when the evaluation is carried out according to acceptance levels based on length and amplitude, e.g. EN 1712, the test frequency shall be as low as possible within the above range. Higher test frequencies may be used to improve range resolution, if necessary, when using standards for acceptance levels based on characterization of imperfections, e.g. EN 1713.

NOTE Test frequencies of approximately 1 MHz may be used for testing of long sound paths where the material shows above-average attenuation.

6.3.2 Angles of incidence

When testing is carried out with transverse waves and techniques that require the ultrasonic beam to be reflected from an opposite surface, care shall be taken to ensure that the incident angle of the beam, with the opposite reflecting surface, is not less than 35° and preferably not greater than 70°. Where more than one probe angle is used, at least one of the angle probes used shall conform with this requirement. One of the probe angles used shall ensure that the weld fusion faces are tested at, or as near as possible to, normal incidence. When the use of two or more probe angles is specified, the difference between the nominal beam angles shall be 10° or greater.

Angles of incidence at the probe and opposite reflecting surface, when curved, may be determined by drawing a sectional view of the weld or in accordance with the methods given in EN 583-2. Where angles of incidence cannot be determined as specified by this International Standard, the test report shall contain a comprehensive description of the scans used and the extent of any incomplete coverage caused together with an explanation of the difficulties encountered.

6.3.3 Adaptation of probes to curved scanning surfaces

The gap between test surface and bottom of the probe shoe shall not be greater than 0,5 mm. For cylindrical or spherical surfaces, this requirement will normally be met when $D \geq (a^2/2)$, where D is the diameter, in millimetres, of the component and a is the dimension, in millimetres, of the probe shoe in the direction of testing.

If this requirement cannot be met, the probe shoe shall be adapted to the surface and the sensitivity and range shall be set accordingly.

6.3.4 Coupling media

The coupling media shall be in accordance with EN 583-1.

7 Test volume

The test volume (see Figure 1) is defined as the zone which includes the weld and parent material for at least 10 mm on each side of the weld, or the width of the heat-affected zone, whichever is greater.

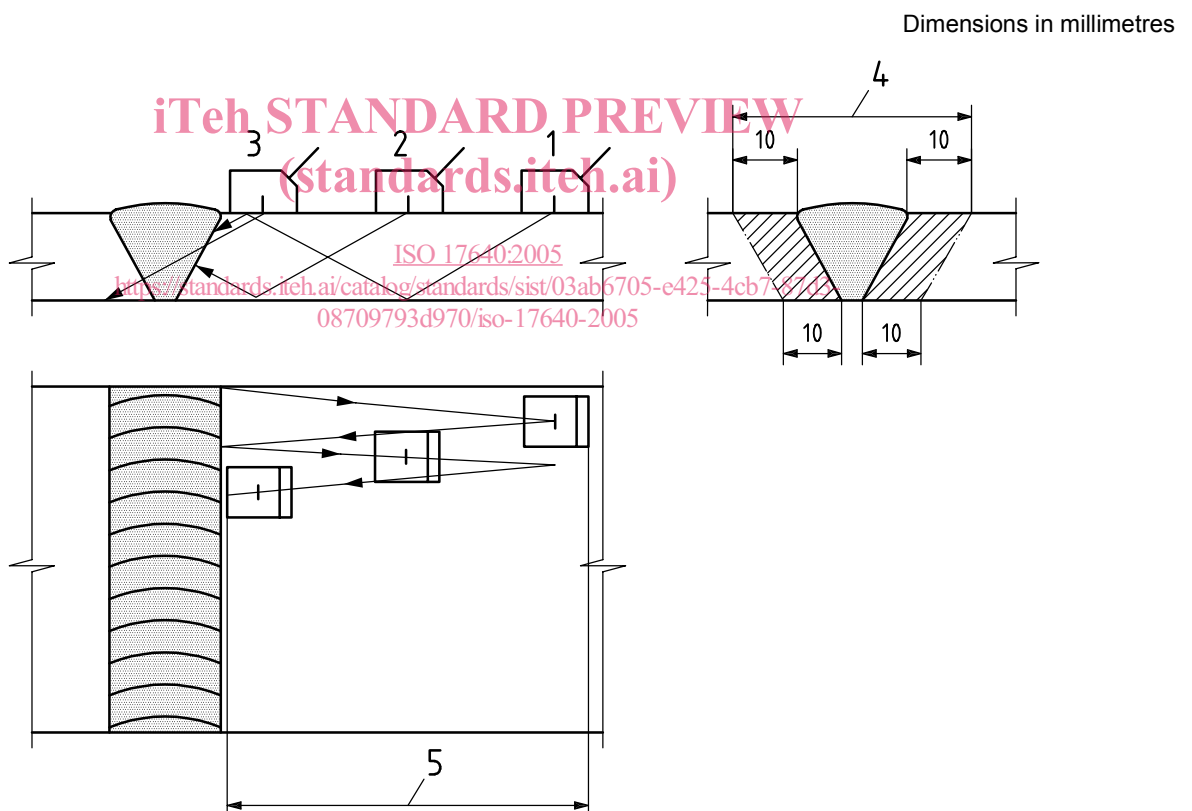
In all cases, scanning shall cover the whole test volume. If individual sections of this volume cannot be covered in at least one scanning direction, or if the angles of incidence with the opposite surface do not meet the requirements of 6.3.2, alternative or supplementary ultrasonic techniques or other non-destructive methods shall be specified. This may require removal of the weld reinforcement.

Alternative or supplementary techniques may require testing using dual-element angle beam probes, creeping wave probes and additional ultrasonic techniques. Other non-destructive methods may include liquid penetrant, magnetic particle and radiographic testing. In selecting alternative or supplementary methods, due consideration should be given to the type of weld and probable orientation of any imperfections to be detected.

8 Preparation of scanning surfaces

The width of the scanning surfaces should be sufficient to enable full coverage of the test volume by scanning from one surface (see Figure 1). The width of the scanning surfaces may be smaller if full coverage of the test volume can be achieved by scanning from both the upper and the lower surfaces of the joint.

The scanning surfaces shall be even and free from foreign matter likely to interfere with probe coupling (e.g. rust, loose scale, weld spatter, notches, grooves). The maximum permitted gap between the probe and the scanning surface from which the evaluation of indications is to be carried out shall be 0,5 mm. Any unevenness in the test surface which exceeds 0,5 mm shall be dressed in order to ensure these requirements.



Key

- 1 angle probe position 1
- 2 angle probe position 2
- 3 angle probe position 3
- 4 width of test volume
- 5 scanning surface

Figure 1 — Example of test volume to be covered when scanning for longitudinal indications

Scanning surfaces and surfaces from which the sound beam is reflected may be assumed to be satisfactory if the surface roughness, R_a , is not greater than 6,3 μm for machined surfaces, or not greater than 12,5 μm for shot-blasted surfaces.

Local variations in surface contour, e.g. along the edge of the weld, which result in a gap beneath the probe of up to 1 mm, are only permitted if at least one additional probe angle is employed from the affected side at the weld. This additional scanning is necessary to compensate for the reduced weld coverage that occurs with such a gap.

9 Parent material testing

The parent material in the scanning zone area shall be tested with straight beam probes prior to or after welding, unless it can be demonstrated (e.g. by previous testing during the fabrication process) that testing of the weld using an angle probe will not be influenced by the presence of imperfections or high attenuation in the parent material.

If imperfections are found in the parent material, their influence on the subsequent weld testing using an angle probe shall be assessed and, if necessary, the weld testing techniques shall be adjusted. When ultrasonic testing of the weld is seriously affected by the presence of imperfections in the parent material, other test methods (e.g. radiography) shall be considered.

10 Range and sensitivity setting

10.1 General

The range and sensitivity shall be set prior to each test in accordance with this International Standard and EN 583-2. Checks to confirm these settings shall be performed at least every 4 h and on completion of testing. Checks shall also be carried out whenever a system parameter is changed or changes in the equivalent settings are suspected.

If deviations in range or sensitivity are found during these checks, corrections shall be made in accordance with Table 2.

Table 2 — Sensitivity and range corrections

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

10.2 Reference level

The reference level for sizing of imperfections shall be set using one of the following methods:

- Method 1: The reference level is set using a distance-amplitude-corrected curve (DAC curve) for a side-drilled hole of diameter $D_{SDH} = 3$ mm.