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Non-destructive testing of welds — Ultrasonic testing — Testing of welds in austenitic steels and nickel-based alloys

Contrôle non destructif des assemblages soudés — Contrôle par ultrasons — Contrôle des soudures en aciers austénitiques et en alliages à base nickel

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Foreword

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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 22825 was prepared by the European Committee for Standardization (CEN) Technical Committee TC 121, *Welding*, Sub-committee SC 5, *Testing of welds*, in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 22825:2006), which has been technically revised.

The main changes are the addition of annexes on:

— compression wave angle beam techniques;

— stainless steel calibration blocks for range setting;

— examples of reference blocks.

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.

Introduction

Welds in austenitic steel components and dissimilar metal welds are widely regarded as very difficult to inspect by ultrasound. The problems are mainly associated with unfavourable structure and grain size, as well as with different material properties which result in inhomogeneous and anisotropic mechanical and acoustic properties that contrast with the relatively homogeneous and isotropic behaviour in low-alloy steel welds.

Austenitic weld metal and other coarse-grained, anisotropic materials can significantly affect ultrasound propagation. In addition, beam distortion, unexpected reflections and wave mode conversions on the fusion line and/or columnar grains can occur. Therefore it can be difficult and sometimes impossible for ultrasonic waves to penetrate the weld metal.

Ultrasonic testing of these metals may require techniques that differ from conventional techniques. These special techniques often include the use of dual-element probes designed for refracted compression (longitudinal) waves or creeping waves rather than for conventional shear waves.

In addition, it is necessary to produce representative reference blocks with welds in order to develop a testing procedure, set a preliminary sensitivity level, assess the procedure and demonstrate effectiveness before a definitive procedure is written. Material, weld preparation and welding procedure, as well as the geometry and surface condition of reference blocks are the same as for the component being tested.

Non-destructive testing of welds — Ultrasonic testing — Testing of welds in austenitic steels and nickel-based alloys

1 Scope

This International Standard specifies the approach to be followed when developing procedures for the ultrasonic testing of the following welds:

— welds in stainless steels;

— welds in nickel-based alloys;

— welds in duplex steels;

— dissimilar metal welds;

— austenitic welds.

The purposes of the testing can be very different, e.g.:

— for the assessment of quality level (manufacturing);

— for the detection of specific indications induced in service.

Acceptance levels are not included in this International Standard, but can be applied in accordance with the scope of the testing (see Clause 5).

The requirements of this International Standard are applicable to both manual and mechanized testing.

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

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

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

ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

EN 473, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

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 ISO 5577, ISO 17635 and the following apply.

3.1
dual-element probe
ultrasonic probe in which the transmit and receive transducers are separate and are electrically and acoustically isolated from each other

3.2
focal distance
⟨dual element probes⟩ distance between probe and focal point on the acoustical axis where the acoustic pressure is at its maximum

3.3
focal curve
⟨dual element probes⟩ curve, representing the relationship between sound path and sensitivity of a probe on a specified material containing specified reflectors

4 Information required prior to testing

4.1 Items to be defined by specification

Information on the following items is required:

a) material type and grade;

b) purpose and extent of testing, including testing for transverse indications, if required;

c) testing levels (see Clause 10);

d) manufacturing or operation stage at which the testing shall be carried out;

e) requirements for access, the surface condition (see 11.2) and temperature;

f) whether or not parent metal testing shall be carried out prior to and/or after welding (see 11.3);

g) reference blocks (see Clauses 6 and 7);

h) personnel qualifications (see Clause 5);

i) reporting requirements (see Clause 12);

j) acceptance criteria and/or recording level.

4.2 Specific information required by the operator prior to testing

Before any testing of a welded joint, the operator shall have access to all the information as specified in 4.1, together with the following additional information:

a) the written testing procedure (see Clause 9);

b) type(s) of parent material and product form (i.e. cast, forged, rolled);

c) the joint preparation and dimensions;

d) the welding procedure or relevant information on the welding process;

e) the time of the inspection with regard to any post-weld heat treatment;

f) the result of any parent metal testing carried out prior to and/or after welding;

g) reference points and details of co-ordinate systems for the test object.

5 Personnel

Personnel performing testing in accordance with this International Standard shall be qualified to an appropriate level in accordance with ISO 9712 or EN 473 or equivalent in the relevant industrial sector.

In addition to a general knowledge of ultrasonic weld testing, the operators shall be familiar with and have practical experience in testing problems specifically associated with the type of materials and weld joints to be tested. Specific training and examination of personnel should be performed on representative pieces (duplex, austenitic, stainless steel) containing welds and using dual-element longitudinal wave probes. This training and the examination results should be documented.

If this is not the case, specific training and examination should be performed with the finalized ultrasonic testing procedures and selected ultrasonic testing equipment on representative samples containing natural or artificial reflectors similar to those expected. This training and the examination results should be documented.

6 Equipment

The equipment used for testing shall fulfil the requirements of EN 12668-1 and EN 12668-2. The verification of the combined equipment shall be done in accordance with EN 12668-3, with the exception of dual-element compression wave angle beam probes, which can be verified on appropriate reference blocks other than the blocks mentioned in EN 12668-3.

Focal curves shall be available for the dual-element probes to be used, determined on a material representative of the material to be tested.

7 Range setting for compression waves

Range setting shall be carried out on appropriate calibration blocks, e.g. on blocks which are designed to be similar to block No. 2 (see ISO 7963) as shown in Annex B. The dimension of at least one of the radii of the block used shall be close to the focal distance of the probes.

The index point of each probe shall be marked on the probe's side, after having optimized the echo amplitude on the radius closest to its focal distance. Since echo optimization can be difficult for high-angle probes and creeping wave probes, the shear wave component may be used for optimization instead. In that case, the calibration methodology shall be included in the test procedure.

Optimization of the echoes shall be done on the two radii separately, and by iteration until the signals from the smaller and the larger radius are on their correct positions.

Alternatively, the time base may be set with the aid of a single-element straight beam probe on the width of the calibration block, and subsequent zero point adjustment with the angle probe placed on the calibration block, on the radius which is closest to the probe's focal distance.

Range setting shall be carried out prior to each testing. 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 whenever changes in the equivalent settings are suspected.

If deviations are found during these checks, corrective actions shall be carried out as specified in Table 1.

Table 1 — Range deviations

1	Deviations ≤5 % of the range	No correction is needed, test can be continued
2	Deviations >5 % of the range	The setting shall be corrected and all tests carried out over the previous period shall be repeated

8 Sensitivity setting

8.1 General

Sensitivity setting shall be performed on a reference block with a weld. Annex C shows examples for reference blocks. The wall thickness of the reference block shall be similar to the wall thickness of the component to be tested within 10 % or 3 mm, whichever is the larger.

Reference reflectors may be side-drilled holes in the weld centre and/or on the fusion line. Alternatively, flat-bottomed holes on the fusion line may be used, having the flat bottom in the plane of the fusion line (weld bevel). Surface notches shall be used as references for near-surface defects. See Figures C.1, C.2, and C.3.

Zone coverage related to wall thickness shall be established on the basis of the focal curves as shown in A.6 when dual-element probes are used. Zone overlap shall be documented in the procedure.

Setting of sensitivity shall be carried out prior to each testing in accordance with this International Standard.

The gap, g, between test surface and bottom of the probe shoe shall not be greater than 0,5 mm.

For cylindrical or spherical surfaces, this requirement can be checked with Equation (1):

$$g = \frac{a^2}{D} \tag{1}$$

where

D is the diameter, in millimetres, of the component;

a is the dimension, in millimetres, of the probe shoe in the direction of testing.

If a value for g larger than 0,5 mm results from Equation (1), the probe shoe shall be adapted to the surface, and the sensitivity and range shall be set accordingly.

Checks to confirm these settings shall be performed at least every 4 h and on completion of testing. Checks shall also be carried out if a system parameter is changed or if changes in the equivalent settings are suspected.

If deviations are found during these checks, corrective actions shall be carried out as specified in Table 2.

Table 2 — Sensitivity deviations

1	Deviations ≤2 dB	No correction is needed, test can be continued
2	Deviations between 2 dB and 4 dB	The setting shall be corrected before testing is continued
3	Reduction in sensitivity >4 dB	The setting shall be corrected and all tests carried out since the last valid test shall be repeated
4	Increase in sensitivity >4 dB	The setting shall be corrected and all indications recorded since the last valid test shall be re-evaluated

8.2 Use of side-drilled holes

If the reflectors in the fusion line are used, sensitivity settings shall be performed:

a) by establishing the echo height with the sound beam passing through the parent material only;

b) by establishing the echo height with the sound beam passing through the weld metal.

If the reflectors in the weld centreline are used, sensitivity setting may be performed from one side only, with the exception of dissimilar metal welds (where the acoustic properties of the parent metal are different on one side compared to the other).

Side-drilled hole diameter shall be typically 3 mm.

8.3 Use of other reference reflectors

Where specific discontinuities are to be detected and/or in a particular limited zone of the weld, other types and dimensions of reference reflectors may be used. In that case, specific conditions of sensitivity setting shall be defined.

In pipe weld inspection, flat-bottomed holes and notches are typically used as reference reflectors. An example for a pipeline girth weld is given in Figure C.2.

The position of the flat-bottomed hole shall be determined from a macro-section of the austenitic weld, positioned accordingly in the reference block and machined to position the flat bottom at the fusion line.

9 Test procedure and ultrasonic techniques

9.1 Development of the test procedure

The development of a procedure shall follow the main steps as mentioned in the flowchart shown in Figure 1.

9.2 Content of the procedure

A procedure shall be written and shall include the following information as a minimum:

a) the purpose and extent of testing;

b) testing techniques;

c) testing levels;

NOTE For the testing of austenitic steels, the testing levels are not defined in ISO 17640 as for ferritic steels. However, it is important to set them to take into account the required probability of detection in each area under consideration.

d) personnel qualification/training requirements;

e) equipment requirements;

f) probe for each zone or part of the bevel;

g) reference blocks;

h) test blocks, if applicable;

i) the setting of equipment;

j) available access and surface conditions;

k) scanning directions and probe positions;

l) the testing of parent material;

m) the evaluation of indications;

n) acceptance levels and/or recording levels;

o) reporting requirements;

p) environmental and safety issues.

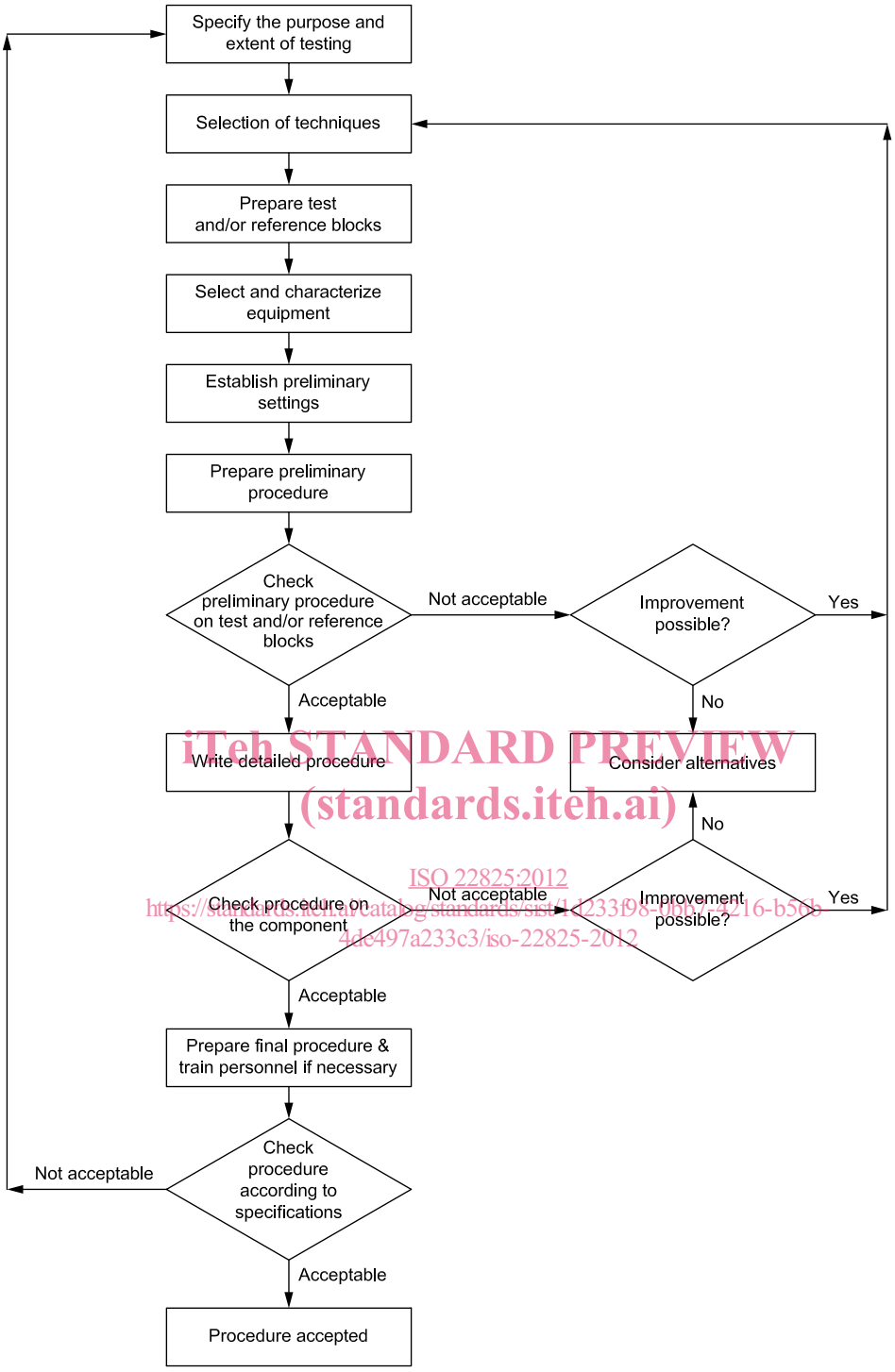

Figure 1 — Steps necessary when producing a written ultrasonic procedure

9.3 Selection of ultrasonic technique(s)

The technique(s) to be used shall be selected on the basis of initial test measurements on relevant test samples (see Annex C). Such measurements shall include transfer measurements on the parent metal (using shear waves), exploratory measurements to get an impression of the noise level in the weld (using shear and compression waves), and measurements on artificial reflectors through the weld metal (to get an impression of the achievable signal-to-noise ratios in different parts of the weld).