INTERNATIONAL STANDARD

ISO 22825

First edition
2006-07-01

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

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

Reference number
ISO 22825:2006(E)

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Published in Switzerland

Contents

Page

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 CEN/TC 121, *Welding*, 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).

Introduction

Austenitic steel and dissimilar metal welds are widely regarded as very difficult to inspect by ultrasonics. The problems are mainly associated with unfavourable microstructure 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.

Because the austenitic weld metal affects ultrasound propagation, it is necessary to produce a reference block 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 normally the same as for the component being tested.

Since austenitic and dissimilar metal welds present greater challenges for ultrasonic testing than do ferritic ones, ultrasonic testing in all its phases (planning, performance and data evaluation) requires more attention.

This International Standard specifies the approach to be followed when developing procedures for the ultrasonic testing of welds in austenitic steels and nickel-based alloys.

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 http://www.iso.org.

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 austenitic stainless steels;

— welds in nickel-based alloys;

— welds in duplex steels;

— dissimilar metal 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 4).

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

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

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 International Standard, the terms and definitions given in ISO 5577 and ISO 17635 apply.

4 Information required prior to testing

4.1 Items to be defined by specification

Information on the following items is required:

— the purpose and extent of testing;

— examination levels (see Clause 8);

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

— requirements for access, the surface condition (see Clause 10) and temperature;

— whether or not parent metal testing shall be carried out prior to and/or after welding (see Clause 11).

— reference blocks (see Clause 9);

— personnel qualifications (see Clause 5).

— reporting requirements (see Clause 13);

— 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:

— the written testing procedure (see Clause 8);

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

— the joint preparation and dimensions;

— the welding procedure or relevant information on the welding process;

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

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

— reference points and details of coordinate systems for the test object.

5 Personnel

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

In addition to a general knowledge of ultrasonic weld inspection, 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.

If this is not the case, specific training shall 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.

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 longitudinal-wave angled beam probes, which shall be verified on appropriate reference blocks.

7 Range and sensitivity setting

7.1 Range setting

Range setting shall be in accordance with EN 583-2, using an appropriate reference block (see Clause 9).

Reference blocks shall either have sound velocities within ± 5 % of that of the test object, or correction for the velocity differences shall be made. If the test object itself is used for calibration, appropriate reflectors at different known sound path lengths shall be used, as applicable. Range setting shall be carried out prior to each testing.

Checks to confirm these settings shall be performed at least every four hours 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.

NOTE The recheck of range settings can be performed using simple blocks (transfer blocks).

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	The setting shall be corrected before testing is continued.
2	Deviations > 5 % of the range	The setting shall be corrected, and all tests carried out over the previous period shall be repeated.

7.2 Sensitivity setting

7.2.1 Use of 3 mm side-drilled holes

DAC-curves shall be prepared in accordance with EN 583-2. They shall be constructed from the 3 mm side-drilled holes in the weld centreline or in the fusion line of the reference block (see Clause 9).

If the reflectors in the fusion line are used, two DAC-curves shall be constructed:

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.

Sensitivity setting shall be carried out prior to each testing.

Checks to confirm these settings shall be performed at least every four hours 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.

NOTE The recheck of sensitivity settings can be performed using simple blocks (transfer blocks).

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

Table 2 — Sensitivity deviations

1	Deviations $\leqslant$ 4 dB	The setting shall be corrected before testing is continued.
2	Reduction in sensitivity > 4 dB	The setting shall be corrected, and all tests carried out since the last valid check shall be repeated.
3	Increase in sensitivity > 4 dB	The setting shall be corrected, and all indications recorded since the last valid check shall be re-evaluated.

7.2.2 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 (see Clause 9). In that case, specific conditions of sensitivity setting shall be defined.

7.3 Transfer correction

When using appropriate reference blocks, transfer correction is not necessary.

For angled beam shear wave probes, measurement of the transfer differences shall be made between the reference block and the test object at a representative number of locations.

Two identical angled beam shear wave probes are employed as a separate transmitter and receiver in a V-formation to produce a through-transmission signal. The frequency and the angle shall be the same as used for the testing. The probes shall be located on the parent material on the same side of the weld, and directed as for the actual testing.

The transfer correction is given by the gain difference between the through transmission signals of the reference block and the test object.

Table 3 shows the appropriate actions to be taken after performing the measurements.

Table 3 — Transfer corrections

1	Difference 0 dB to 4 dB	No sensitivity correction needed
2	Difference 4 dB to12 dB	The sensitivity setting shall be corrected with the average difference measured
3	Difference > 12 dB	Validity of the reference block and/or the procedure to be re-considered

Where transfer corrections are considered necessary for angled beam probes for longitudinal waves and twin-crystal probes, the required method shall be described in the written procedure.

8 Written testing procedure

The written testing procedure shall include the following information as a minimum:

— the purpose and extent of testing;

— testing techniques;

— examination levels;

NOTE For the testing of austenitic steels, the examination levels are not defined in EN 1714 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.

— personnel qualification/training requirements;

— equipment requirements;

— reference blocks;

— the setting of equipment;

— available access and surface conditions;

— scanning directions and probe positions;

— the testing of parent material;

— the evaluation of indications;

— acceptance levels and/or recording levels;

— reporting requirements;

— environmental and safety issues.

A written testing procedure may be produced by following the flowchart shown in Annex A.

9 Reference blocks

The blocks shall be produced as closely as possible from the same grade of material and the same geometry as the test object. Each block produced shall contain a weld made in accordance with the welding procedure employed on the test object.

It shall be noted that parameters such as heat input, deposition rate and the number of weld runs have a great impact on the ultrasonic properties of welds.

A thickness difference between the block and the test object of up to ± 25 % is acceptable.

The surface condition of these blocks shall be representative of the test object.

The reference blocks shall contain 3 mm diameter side-drilled holes for establishing a distance amplitude correction curve. These holes shall be positioned in the parent material, the fusion zone (between the parent material and the weld) and in the weld body.

In addition, two rectangular notches, minimum 20 mm in length, shall be placed to represent surface-breaking discontinuities on both the inner and outer surfaces. The depth of these notches is dependent on the weld thickness to be tested. Table 4 shows the depth of the notches required in relation to the weld thickness to be tested.

Table 4 — Depth of notch

Weld thickness mm	8 up to 20	20 up to 40	40 or more
Depth of notch mm	1,5	2	3

A typical design for such blocks is shown in Annex B.

Other types and sizes of reference reflectors may also be used depending on their application, e.g. in-service inspection, for transverse cracking.

10 Surface condition

The surface shall be free from any irregularities that may interfere with the ultrasonic testing. Waviness of the scanning surface and other local variations in surface contour shall not result in a gap between the probe and the scanning surface of greater than 0,5 mm.

Where necessary, light grinding may be carried out to ensure a smooth surface finish.

The 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.

In order to obtain optimum testing, the weld reinforcement should be ground flush with the parent metal.

11 Parent metal 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. in previous tests during the fabrication process) that the angled probe testing of the weld will not be influenced by the presence of the discontinuities.

Where discontinuities are found, their influence on the proposed testing of the weld shall be assessed and, if necessary, the technique adjusted correspondingly. When satisfactory coverage by ultrasonic testing is seriously affected, other testing methods (e.g. radiography) shall be considered.

For applications where a high degree of reproducibility is required, it may be necessary to perform a measurement of the attenuation of the parent material using the same type of angled probes as will be used for the testing of the weld.

12 Testing of weld

12.1 General

The testing of the weld and heat affected zone shall be carried out in accordance with a written testing procedure, containing details of the extent of coverage, scanning surfaces, probe types and angles, etc. (see Clause 8).

For some austenitic materials, it may be possible to use standard, or low frequency, shear wave probes depending on the ultrasonic properties of the parent material and weld metal. For many other austenitic materials, it will be necessary to use longitudinal wave angled beam probes. The limitations of these probes shall be taken into account, e.g. they should only be used up to a maximum range equal to the half skip distance due to the different wave modes produced on reflection.

For many applications, dual element probes or creeping wave probes are used for the detection and sizing of discontinuities. Scanning from both sides of the weld is highly recommended.

12.2 Indication sizing

For testing during manufacture, the measurement of the length of an indication is normally sufficient. For in-service inspection where service-induced discontinuities can be present, the sizing will, in many cases, require a measurement of both the length and the height of the indication.

For measurement of the length of an indication, the following techniques are available:

— a 6 dB drop from maximum;

— the fixed amplitude level technique;

— the use of focusing probes.

For the measurement of the height of the indication, techniques may be developed during the preparation of the procedure as described in the flowchart shown in Annex A.

12.3 Evaluation of indications

Evaluation of indications is based on several parameters. It may include the use of the following techniques and parameters:

— welding techniques;

— the measurement of echo amplitude;

— the measurement of the length and height of the indication;

— characterization (planar or non-planar);

— the location in the weld;

— directional reflectivity;

— echodynamic pattern.

The evaluation process involves considering all the parameters in order to arrive at a conclusion.

13 Test report

13.1 General data

The test report shall include a reference to this International Standard and give, as a minimum, the following information:

— identification of the object under testing:

— the material and product form;

— dimensions;

— the location or identification of the weld tested;

— a sketch showing geometrical configuration (if necessary);

— a reference to the welding procedure and stage of heat treatment (if any);

— the state of manufacture;

— surface conditions;

— the temperature of the object, if outside the range 0°C to 40°C;

— contract requirements e. g. specifications, guidelines, special agreements, etc;

— the place and date of testing;

— identification of testing organizations and identification, certification and signature of the operator.

13.2 Information related to equipment

The test report shall include the following information related to equipment:

— the manufacturer and type of ultrasonic instrument with identification number;

— the manufacturer, type, nominal frequency and actual angle of probes used with identification number;

— the identification of reference blocks used with a sketch;

— the couplant medium.

13.3 Information related to testing technique

The test report shall include the following information related to testing technique:

— testing level(s) and a reference to the written procedure;

— the extent of testing;

— the location of the scanning areas;

— reference points and details of the coordinate system;

— identification of probe positions;

— the time base range;

— the method and values used for sensitivity setting (gain setting for reference levels and values used for transfer corrections);

— reference levels;

— the result of the parent material testing;

— the standard for acceptance and/or recording levels;

— deviations from this International Standard, or contract requirements;

— any factors which have prevented the testing from being carried out as intended.

13.4 Results of the testing

The test report shall include a tabular summary (or sketches) providing the following information for recorded indications:

— coordinates of the indication with details of associated probes and corresponding probe positions;

— the maximum echo amplitude and information, if required, on the type and height of indication;

— lengths of indications;

— results of the evaluation in accordance with specified acceptance and/or recording levels.

Annex A
(informative)

Development of a written procedure

The flowchart in Figure A.1 shows the steps necessary when producing a written ultrasonic procedure.

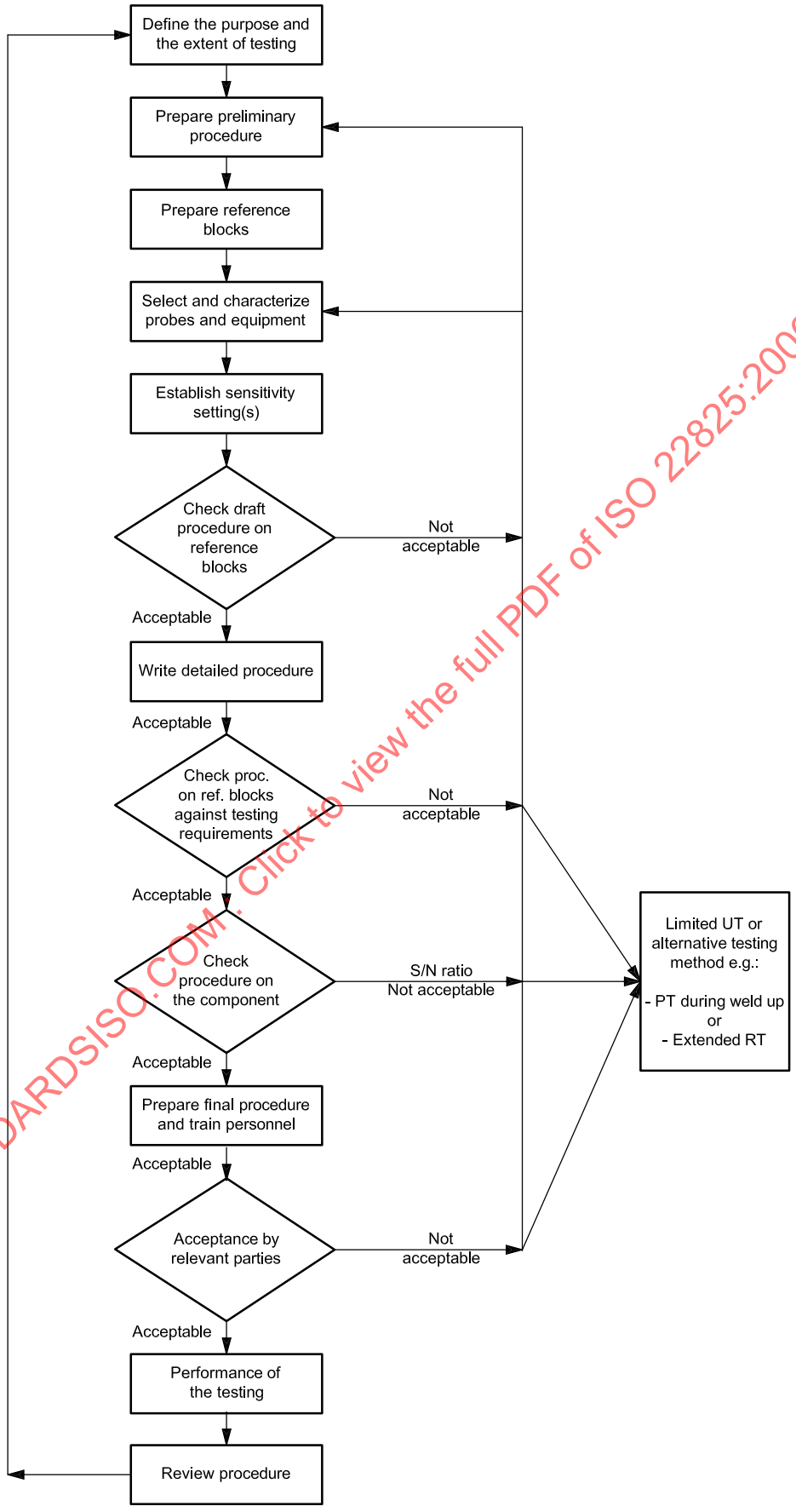

Figure A.1