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Non-destructive testing of steel tubes — Automated ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for verification of hydraulic leak-tightness

Essais non destructifs des tubes en acier — Contrôle automatisé par ultrasons pour vérification de l'étanchéité hydraulique des tubes en acier sans soudure et soudés (sauf à l'arc immergé)

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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 10332 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 19, *Technical delivery conditions for steel tubes for pressure purposes*.

This second edition cancels and replaces the first edition (ISO 10332:1994), which has been technically revised.

Non-destructive testing of steel tubes — Automated ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for verification of hydraulic leak-tightness

1 Scope

This International Standard specifies requirements for automated ultrasonic shear-wave (generated by single element probes or the phased-array technique) testing of seamless and welded (except submerged arc-welded) steel tubes, for verification of hydraulic leak-tightness.

The testing technique is applied for the detection of predominantly longitudinal imperfections.

Where applicable, Lamb-wave testing may be applied at the discretion of the manufacturer.

This International Standard is applicable to the inspection of tubes with an outside diameter greater than or equal to 10 mm, and with an outside diameter-to-thickness ratio greater than or equal to 5.

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

ISO 11484, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577, ISO 11484 and the following apply.

3.1
reference standard
standard for the calibration of non-destructive testing equipment

EXAMPLE Drill hole(s), notch(es), recess(es).

3.2
reference tube
tube or length of tube containing the reference standard(s)

3.3
reference sample
sample containing the reference standard(s)

EXAMPLE Segment of tube/plate/strip.

NOTE Only the term “reference tube” is used in this International Standard; it also covers “reference samples”.

3.4
tube
long hollow product, open at both ends, of any cross-sectional shape

3.5
seamless tube
tube made by piercing a solid product to obtain a tube hollow, which is further processed, either hot or cold, into its final dimensions

3.6
welded tube
tube made by forming a hollow profile from a flat product and welding adjacent edges together and which may be further processed, either hot or cold, into its final dimensions

3.7
submerged arc welded tube (*SAW*)
tube made by forming, either hot or cold, a hollow profile from strip or plate and welding the adjacent edges together, without pressure, by addition of filler metal

NOTE 1 The adjacent edges and the filler metal are heated to welding temperature by an arc generated by the resistance to the passage of an electric current. The arc generated and the molten metal are protected from atmospheric contamination by the presence of a layer of flux.

NOTE 2 The tubes may have one or two longitudinal seam welds (*SAWL*) or one helical seam weld (*SAWH*) with at least one pass on the inside of the tube and at least one pass on the outside of the tube.

3.8
manufacturer
organization that manufactures products in accordance with the relevant standard(s) and declares the compliance of the delivered products with all applicable provisions of the relevant standard(s)

3.9
agreement
contractual arrangement between the manufacturer and purchaser at the time of enquiry and order

4 General requirements

4.1 Unless otherwise specified by product standards or agreed between the purchaser and manufacturer, the ultrasonic testing shall be carried out on tubes after completion of all the primary production-process operations, such as rolling, heat treating, cold and hot working, sizing, straightening, etc.

4.2 The tubes to be tested shall be sufficiently straight to ensure the validity of the test. The surfaces shall be sufficiently free from foreign matter which would interfere with the validity of the test.

4.3 This inspection shall be carried out by suitable trained operators qualified in accordance with ISO 9712, ISO 11484 or equivalent and supervised by competent personnel nominated by the manufacturer. In the case of third-party inspection, this shall be agreed between the purchaser and the manufacturer.

The operating authorization issued by the employer shall be in accordance with a written procedure. Non-destructive testing operations shall be authorized by a Level 3 non-destructive testing individual approved by the employer.

NOTE The definition of Levels 1, 2 and 3 can be found in appropriate standards, e.g. ISO 9712 and ISO 11484.

5 Method of test

5.1 The tubes shall be tested by using an ultrasonic shear-wave technique or Lamb-wave technique, if applicable, for the detection of predominantly longitudinal imperfections.

5.2 During testing, the tubes and the transducer assembly shall be moved relative to each other so that the whole of the tube surface is scanned, with coverage calculated on the dimension of the transducer(s). The relative speed of movement during testing shall not vary by more than 10 %. It is recognized that there may be a short length at both tube ends which cannot be tested. Any untested ends shall be dealt with in accordance with the requirements of the appropriate product standard (see also Annex A).

In the case of electro-welded (EW) tubes, excluding welded stretch-reduced tubes, by agreement between the purchaser and manufacturer, verification of hydraulic leak-tightness of the weld zone only is permitted. In this case, the transducer assembly shall be correctly aligned with the weld seam so that the whole length of the weld seam is scanned.

5.3 During testing, the tubes shall be scanned in two opposing directions of beam travel, unless otherwise agreed between the purchaser and manufacturer.

5.4 For the detection of longitudinal imperfections, the maximum width of each individual transducer measured parallel to the major axis of the tube, shall be 25 mm.

When using the Lamb-wave technique or phased-array technique, the maximum length of the transducer/active aperture shall be limited to 35 mm.

5.5 The ultrasonic test frequency of transducers to be used shall be in the range of 1 MHz to 15 MHz for shear-wave technique and in the range of 0,3 MHz to 1 MHz for the Lamb-wave technique, depending on the product condition and properties, the thickness, and the surface finishing of tubes under examination.

5.6 The equipment shall be capable of classifying tubes as either acceptable or suspect by means of an automated trigger/alarm level combined with a marking and/or sorting system.

6 Reference tube

6.1 General

6.1.1 The reference standards defined in this International Standard are convenient for the calibration of non-destructive testing equipment. The dimensions of these standards should not be construed as the minimum size of imperfection detectable by such equipment.

6.1.2 The ultrasonic equipment shall be calibrated using a longitudinal reference notch on the outside and inside surfaces or a reference hole drilled radially through the full thickness of a reference tube. The internal notch shall not be used when the internal diameter of the tube is less than 15 mm, unless otherwise agreed between the purchaser and the manufacturer.

6.1.3 The reference tubes shall have the same nominal diameter and thickness and the same surface finish and delivery condition (e.g. as-rolled, normalized, quenched and tempered) as the tubes to be tested, and shall have similar acoustic properties (for example, sound velocity, attenuation coefficient).

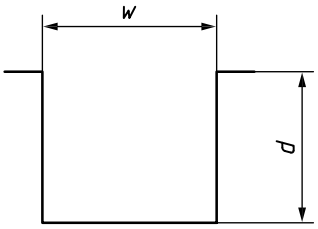
6.1.4 In order to obtain clearly distinguishable signals, the reference standard(s) shall be sufficiently separated from the ends of the reference tubes and from each other.

6.2 Types of reference notches

6.2.1 The reference notches shall lie parallel to the major axis of the reference tube.

The reference notches shall be of the “N” type (see Figure 1). The sides of the notch shall be nominally parallel and the bottom shall be nominally square to the sides.

It is recognized that the bottom or the bottom corners of the notch may be rounded.



Key

w width

d depth

Figure 1 — Reference notch forms (“N” type notch)

6.2.2 The reference notch shall be formed by machining, spark erosion or other methods.

6.3 Dimensions of reference notches

6.3.1 Width, w

The width of the reference notch (see Figure 1) shall not be greater than 1,0 mm.

6.3.2 Depth, d

The depth of the reference notch (see Figure 1) shall be 12,5 % of the specified thickness with the following limitations:

— minimum notch depth: 0,5 mm;

— maximum notch depth: 1,5 mm.

The tolerance on notch depth shall be ±15 % of the nominal reference notch depth.

6.3.3 Notch length

Unless otherwise specified by the product standard or agreed between the purchaser and the manufacturer, the length of the reference notch(es) shall be greater than the width of the single transducer or the active aperture of the phased-array transducer, with a maximum of 50 mm.

6.4 Reference hole

The reference hole shall be drilled through the wall, perpendicular to the surface of the tube; for welded pipe, it shall be drilled at the centre of the weld.

The diameter of the reference holes related to the outside diameter of the tube shall not exceed the requirements of Table 1. The holes shall be formed by machining, spark erosion or other methods.

Table 1 — Specified tube diameter related to the diameter of the reference holes

Specified outside diameter of the tube D mm	Maximum hole diameter acceptance level mm
$10 \leqslant D \leqslant 26{,}9$	1,20
$26{,}9 < D \leqslant 48{,}3$	1,70
$48{,}3 < D \leqslant 63{,}5$	2,20
$63{,}5 < D \leqslant 114{,}3$	2,70
$114{,}3 < D$	3,20

6.5 Verification of the reference standards

The reference standard dimensions and shape shall be verified by a suitable technique.

The diameter of the reference hole(s) (see Table 1), when used, shall be verified and shall not exceed the value reported in Table 1; the reference notch dimensions and shape shall be verified by a suitable technique.

7 Equipment calibration and checking

7.1 General

At the start of each testing cycle, the equipment shall be calibrated to consistently produce (e.g. from three consecutive passes of the reference tube through the equipment) clearly identifiable signals from the reference standard(s). These signals shall be used to activate the respective trigger alarm of the equipment.

7.2 Adjustment of the trigger/alarm level

7.2.1 Where a single trigger/alarm level is used, the transducers shall be adjusted so that the signals from the internal and external reference notches are equal, as far as possible; and the full signal amplitude of the lesser of the two signals shall be used to set the trigger/alarm level of the equipment.

Where a reference hole is applied, the signal from the inner and outer side of the reference hole shall be used in accordance in the same manner as for reference notches.

7.2.2 Where separate trigger/alarm levels are used for the signals from internal and external reference notches, the full amplitude from each signal shall be used to set the relevant trigger/alarm level of the equipment. The position and width of the gates shall be adjusted in such a way that the entire wall thickness of the tube is tested.

Where a reference hole is applied, the signal from the inner and outer side of the reference hole shall be used in accordance in the same manner as for reference notches.

7.3 Calibration check and re-calibration

7.3.1 The calibration of the equipment shall be checked at regular intervals during the production testing of tubes of the same specified diameter, thickness and grade, by passing the reference tube through the testing equipment.

The checking frequency for calibration shall be at least every 4 h, but also whenever there is an equipment operator change-over and at the start and end of the production run.

7.3.2 The equipment shall be recalibrated if any of the parameters which were used during the initial calibration are changed.