BS EN ISO 10893-8:2011

BSI Standards Publication

Non-destructive testing of steel tubes

Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections (ISO 10893-8:2011)

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National foreword

This British Standard is the UK implementation of EN ISO 10893-8:2011. It supersedes BS EN 10246-14:2000, BS EN 10246-16:2000, and BS EN 10246-17:2000, which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/110, Steel Tubes, and Iron and Steel Fittings.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Zerstörungsfreie Prüfung von Stahlrohren - Teil 8: Automatisierte Ultraschallprüfung nahtloser und geschweißter Stahlrohre zum Nachweis von Dopplungen (ISO 10893-8:2011)

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Foreword

This document (EN ISO 10893-8:2011) has been prepared by Technical Committee ISO/TC 17 "Steel" in collaboration with Technical Committee ECISS/TC 110 “Steel tubes, and iron and steel fittings” the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2011, and conflicting national standards shall be withdrawn at the latest by October 2011.

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The text of ISO 10893-8:2011 has been approved by CEN as a EN ISO 10893-8:2011 without any modification.

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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.

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ISO 10893-8 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 19, *Technical delivery conditions for steel tubes for pressure purposes*.

This first edition cancels and replaces ISO 10124:1994, ISO 11496:1993 and ISO 13663:1995, which have been technically revised.

ISO 10893 consists of the following parts, under the general title *Non-destructive testing of steel tubes*:

— *Part 1: Automated electromagnetic testing of seamless and welded (except submerged arc-welded) steel tubes for the verification of leaktightness*

— *Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections*

— *Part 3: Automated full peripheral flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections*

— *Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

— *Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

— *Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

— *Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections*

— *Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes*

— *Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 12: Automated full peripheral ultrasonic thickness testing of seamless and welded (except submerged arc-welded) steel tubes*

INTERNATIONAL STANDARD **ISO 10893-8:2011(E)**

Non-destructive testing of steel tubes —

Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections

1 Scope

This part of ISO 10893 specifies requirements for automated ultrasonic testing for the detection of laminar imperfections

a) in the pipe body (full peripheral testing) of seamless and welded, except submerged arc-welded (SAW), steel tubes, or

b) in the area adjacent to the weld seam of welded steel tubes, and optionally

c) at the ends (full peripheral testing) of seamless and welded tubes.

This part of ISO 10893 can also be applicable to the testing of circular hollow sections.

NOTE For welded tubes, see ISO 10893-9 for an alternative test method for the detection of laminar imperfections in steel strip/plate prior to tube forming.

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 10893-6, *Non-destructive testing of steel tubes — Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

ISO 10893-7, *Non-destructive testing of steel tubes — Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

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 and ISO 11484 and the following apply.

3.1
reference standard
standard for the calibration of non-destructive testing equipment (e.g. drill holes, notches, recesses)

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

3.3
reference sample
sample (e.g. segment of tube, plate or strip) containing the reference standard(s)

NOTE Only the term “reference tube” is used in this part of ISO 10893, also covering the term “reference sample”.

3.4
laminar imperfection
imperfection located in the wall thickness and generally parallel to the pipe surfaces

NOTE Its extension can be calculated by measuring its outlined area on the external surface.

3.5
tube
hollow long product open at both ends, of any cross-sectional shape

3.6
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

3.7
welded tube
tube made by forming a hollow profile from a flat product and welding adjacent edges together, and which after welding can be further processed, either hot or cold, into its final dimensions

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 the product standard or agreed on by the purchaser and manufacturer, an ultrasonic testing shall be carried out on tubes after completion of all the primary production process operations (rolling, heat treating, cold and hot working, sizing and primary straightening, etc.).

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

4.3 This test 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 on by the purchaser and manufacturer.

The operating authorization issued by the employer shall be according to a written procedure. Non-destructive testing (NDT) operations shall be authorized by a level 3 NDT individual approved by the employer.

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

5 Test method

5.1 General

5.1.1 As specified in the product standard, the test shall be executed using an ultrasonic pulse echo technique for the detection of laminar imperfections in accordance with 5.2 or 5.3 and/or 5.4. The ultrasound shall be transmitted in the direction normal to the tube surface.

5.1.2 For testing in accordance with 5.2 or 5.3, the relative speed of movement during testing shall not vary by more than ±10 %. For determining the extent of the laminated suspect area, adjacent suspect areas separated by less than the smaller of the two minor axes of the laminations shall be considered as one lamination. There may be a short length at both tube ends which cannot be tested in the case of testing in accordance with 5.2 or 5.3.

Any untested ends shall be dealt with in accordance with the requirements of the appropriate product standards (see also 5.4).

5.1.3 The ultrasonic test frequency that shall be applied shall be in the range of 2 MHz to 10 MHz.

5.1.4 The suggested maximum width of each transducer, or each active aperture when using phased array transducers, should be 25 mm measured in any direction. However, manufacturers may use larger transducers providing their capability for detecting the adopted reference standard; on request, this capability shall be demonstrated.

5.1.5 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.

5.1.6 Where manual ultrasonic testing is required, this shall be carried out in accordance with Annex A.

NOTE For wall thicknesses less than 5 mm, where difficulties can occur in detecting and sizing laminar imperfections using this method of test, an alternative method of test can be agreed on by the manufacturer and purchaser.

5.2 Full peripheral testing of seamless and welded (except SAW) tubes

During testing, the tubes and the transducer assembly shall be moved relative to each other such that the tube surface is scanned in order to detect laminar imperfections with a size equal to or greater than the relevant minimum lamination size, B_{min}, with a circumferential dimension, C_{min}, calculated as given in Table 1.

Table 1 — Acceptance levels and minimum size that shall be detected and maximum acceptable size of laminar imperfections in full peripheral testing

Acceptance level	Minimum individual size of laminar imperfections that shall be considered		Maximum acceptable area of laminar imperfections		
	Individual area	Circumferential or transversal dimension	Individual area	Sum of individual areas $\geqslant B_{min}$ to $\leqslant B_{max}$[a] in percentage of tube surface	
				Per any metre of tube length	Average per metre of tube length (entire tube)
	B_{min}[a]	C_{min}	B_{max}[a]		
	mm^2	mm	mm^2	max.	max.
U0	160	6	160	Not applicable	Not applicable
U1	160 + $\pi D/4$[b]	9	160 + πD[b]	1	0,5
U2	160 + $\pi D/2$[b]	12	160 + 2 πD[b]	2	1
U3	160 + πD[b]	15	160 + 4 πD[b]	4	2

[a] B_{min} and B_{max} shall, when calculating as the product of the length and circumferential dimensions, be rounded up to the next 10 mm^2.

[b] D = specified outside diameter of the tube, in millimetres.

5.3 Testing of welded steel tubes in the area adjacent to the weld seam

During testing, the tube and/or the probe assembly shall be moved relative to each other such that at least a 15 mm wide band on either side of the weld, as close as possible to the parent metal/weld interface at the external surface, is 100 % ultrasonically tested for the detection of laminar imperfections, in order to detect the relevant minimum imperfection length, L_{min} (parallel to the weld), as given in Table 2.

Table 2 — Acceptance levels and minimum size that shall be detected and maximum acceptable size of laminar imperfections when testing the area adjacent to the weld

Acceptance level	Minimum individual size of laminar imperfections that shall be considered	Maximum acceptable size of laminar imperfections		
		Individual dimensions		Number[a] per metre tube length, where $L_{min} \leqslant L \leqslant L_{max}$ and $E \leqslant E_{max}$
	Length	Length	Area (product of length and width)	
	L_{min}	L_{max}	E_{max}	
	mm	mm	mm^2	
U1	10	20	250	3
U2	20	40	500	4
U3	30	60	1 000	5

[a] Only laminar imperfections exceeding 6 mm in width (C_{min}) shall be considered.

5.4 Full peripheral testing of the ends of seamless and welded tubes

5.4.1 When end testing has been agreed on by the purchaser and manufacturer, the tube end zone at both tube ends shall be tested.

5.4.2 During testing, the tubes and the probe assembly shall be moved relative to each other such that the circumference of the tube ends is scanned from the outside surface, or the inside surface where appropriate, over a length of approximately 25 mm or 2 T (T = specified tube thickness, in millimetres), whichever is the greater, with a maximum of 50 mm, from the point where the outside surface meets the face or bevel.

In the case of submerged arc-welded tubes, when the weld reinforcement precludes a test for laminar imperfections close to and over the reinforcement, a zone 25 mm on either side of the weld reinforcement shall not be tested unless by agreement between the purchaser and the manufacturer; the reinforcement shall be removed to permit the conduct of a full peripheral test.

6 Reference tube

6.1 General

6.1.1 The reference standards defined in this part of ISO 10893 are convenient standards for the calibration of non-destructive testing equipment. The dimensions of these standards should not be construed as the minimum size of imperfections detectable by such equipment.

6.1.2 The ultrasonic equipment shall be calibrated either electronically using any tube [see 7.1 a)] or with a reference standard comprising a flat-bottomed circular, square or rectangular recess (see Figure 1) machined into the inner surface of a reference tube (or reference sample), with the exception that for acceptance level U0 (see 5.2 and Table 1), only the flat-bottomed circular recess shall be used [see 7.1 b)].

The flat-bottomed circular recess shall be used as the primary means of establishing the test sensitivity. When using one of the other types of reference standard, the test sensitivity shall be adjusted such that it is equivalent to that obtained when using the flat-bottomed circular recess.

6.1.3 The reference recess shall be obtained by machining, spark erosion or other appropriate methods.

NOTE The bottom or the bottom corners of the recess can be rounded.

6.1.4 The reference tubes shall have the same nominal diameter and thickness, same surface finish, heat treatment and delivery conditions (e.g. as-rolled, normalized, quenched and tempered) as the tubes being tested and shall have similar acoustic properties (e.g. sound velocity and attenuation coefficient).

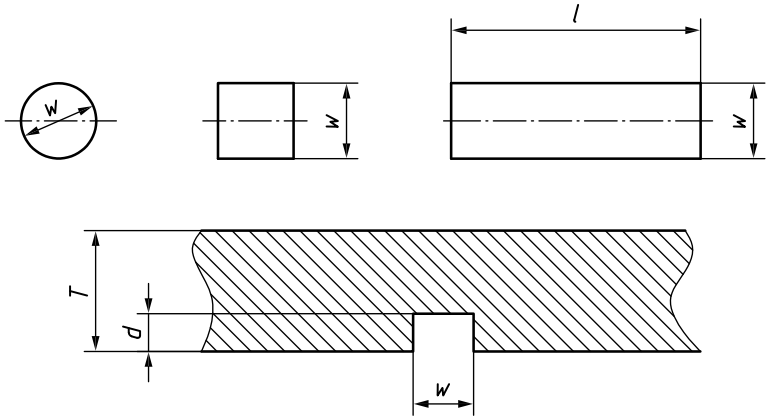
6.2 Dimensions of reference standards

The dimensions of the recess reference standards (see Figure 1) shall be as follows:

a) width or diameter w: 6 mm $^{+0,6}_{0}$ mm;

b) depth d: $T/4 \leqslant d \leqslant T/2$, with a maximum of 25 mm;

c) length l: $\geqslant$ 6 mm, with a maximum of 25 mm.



Key

d depth of recess

l length of rectangular recess

T specified wall thickness

w width or diameter of recess

Figure 1 — Reference standard recess forms

6.3 Verification of reference standards

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

7 Equipment calibration and checking

7.1 At the start of each test cycle, the equipment shall be calibrated statically either without a reference standard in accordance with 7.1 a) or using a reference standard in accordance with 7.1 b).

a) Calibration without a reference standard: with the probe assembly positioned on the tube under test, the full amplitude of the first back wall echo minus 6 dB shall be used to activate their respective trigger/alarm level of the equipment.

   The test sensitivity may be established with distance amplitude correction (DAC) curves as supplied by the transducer manufacturer or DAC curves as prepared by the tube manufacturer using, in both cases, the 6 mm flat-bottomed hole curve.

   The manufacturer shall demonstrate that at the set sensitivity, the equipment detects under static conditions the reference standard as given in 6.1.2 and Figure 1. If this is not the case, the necessary adjustment in sensitivity shall be made prior to the testing of production tubes.

b) Calibration using a reference standard: under static conditions, with the transducer or each transducer of a probe assembly centrally located over the reference standard, the full signal amplitude of the signal obtained from the reference standard shall be used to activate their respective trigger/alarm level of the equipment.

7.2 During production testing, the relative rotational and/or translational speeds and pulse repetition frequency shall be chosen to provide full surface coverage of the zone of the tube under test.

7.3 The calibration of the equipment shall be checked at regular intervals during the production testing of tubes of the same nominal diameter, thickness and grade.

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

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

7.5 If, on checking during production testing, the calibration requirements are not satisfied, even after increasing the test sensitivity by up to 3 dB to allow for system drift, all tubes tested since the previous equipment check shall be retested after the equipment has been recalibrated, provided suitable records of the concerned tubes are available.

8 Acceptance

8.1 General

8.1.1 Any tube producing signals lower than the trigger/alarm level shall be deemed to have passed this test.

8.1.2 Any tube producing signals equal to or greater than the trigger/alarm level shall be designated suspect or, at the discretion of the manufacturer, may be retested. If, after two consecutive retests, all signals are lower than the trigger/alarm level, the tube shall be deemed to have passed this test; otherwise, the tube shall be designated as suspect.

For tube end testing, this condition only applies when the circumferential length of imperfection exceeds 6 mm, which shall be detected, if applicable, by the half-amplitude method.

If applicable, the evaluation may be based on DAC curves.

8.1.3 Suspect tubes shall be dealt with as specified in 8.2.

8.2 Procedure for suspect tubes

8.2.1 Test in accordance with 5.2

One or more of the following actions shall be taken subject to the requirements of the product standard:

a) the suspect area shall be explored by a manual ultrasonic compression wave technique according to Annex A or by a suitable automated or semi-automated system, to establish the extent of the laminar imperfections. The tube shall be deemed to have passed this test if the lamination size, B_{max}, and the total summed area of laminations greater than B_{min} and less than B_{max} (see Table 1) are not exceeded;

b) the suspect area shall be cropped off;

c) the tube shall be deemed not to have passed this test.

8.2.2 Test in accordance with 5.3

One or more of the following actions shall be taken subject to the requirements of the product standard:

a) the suspect area shall be explored by a manual ultrasonic compression wave technique according to Annex A or by a suitable automated or semi-automated system to establish the extent of the laminar imperfections. The tube shall be deemed to have passed this test if the laminar imperfection size (E_{max}, L_{max}) and the maximum population density, as given in Table 2, are not exceeded;

b) in the case of spiral or longitudinal submerged arc-welded tubes, and by agreement between the purchaser and manufacturer, the weld seam in the vicinity of laminar imperfections exceeding the relevant acceptance limits given in Table 2 may be subjected to radiographic testing in accordance with ISO 10893-6 or ISO 10893-7 to disclose the presence of imperfections in or at the extremities of the weld seam which possibly escaped detection during ultrasonic weld seam testing due to the presence of such laminar imperfections;

c) the suspect area shall be cropped off;

d) the tube shall be deemed not to have passed this test.

8.2.3 Test in accordance with 5.4

The manufacturer may either reject the tube or crop off the suspect area. In the latter case, the manufacturer shall ensure that all the suspect area has been removed and shall submit the end zone of the remaining length to a repeat test as specified in 5.4.

9 Test report

When specified, the manufacturer shall submit to the purchaser a test report including at least the following information:

a) reference to this part of ISO 10893, i.e. ISO 10893-8;

b) statement of conformity;

c) any deviation, by agreement or otherwise, from the procedures specified;

d) product designation by steel grade and size;

e) type and details of test technique(s);

f) equipment calibration method used;

g) description of the reference standard acceptance level;

h) date of test;

i) operator identification.

Annex A
(normative)

Procedure for the determination of the size of laminar imperfections by manual ultrasonic testing

A.1 General

This annex covers the procedure for manual ultrasonic pulse echo scanning of tubes for the determination of the extent of laminated suspect areas found by automated/semi-automated testing for the detection of laminar imperfections.

In cases of arbitration between the manufacturer and the purchaser or his representative regarding the extent and frequency of detected laminar imperfections, this procedure shall be used. This procedure determines the details of the sizing method to establish the extent and frequency of laminar imperfections in steel tubes.

A.2 Surface condition

The surface of the tube shall be sufficiently free of foreign matter as to ensure the validity of the test.

A.3 Test equipment requirements

A.3.1 The ultrasonic probe shall be guided over the tube surface either manually or by mechanical means. The ultrasound shall be transmitted in the direction normal to the tube surface.

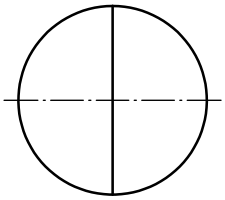
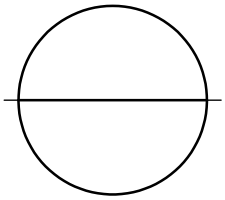
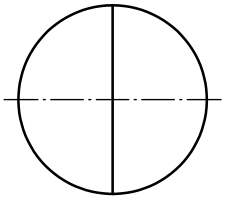
A.3.2 One of the following two types of ultrasonic testing equipment shall be used.

a) Equipment with a screen display and gain control, adjustable in 2 dB steps. The gain control shall be adjusted such that the ultrasonic signals from the laminated suspect area under evaluation are between 20 % and 80 % of the usable height of the screen display.

b) Equipment without a screen display where automated signal amplitude measurement/assessment facilities are used. The amplitude measuring unit shall be capable of signal amplitude assessment steps not exceeding 2 dB.

A.3.3 If dual transducer probes are used for manual determination of the size of the laminated suspect area, examples of details given in Table A.1 shall be noted.

Table A.1 — Examples of details for the use of dual transducer probes

Probe-to-lamination distance	Type of dual transducer probe[a]	Plane of acoustic separation[b]
⩽ 20 mm	Either — Nominal frequency: 4 MHz to 5 MHz — Roof angle: approximately 0° or 5° — Transducer size: 8 mm to 15 mm — Focal distance: 10 mm to 12 mm	At right angles to PRD 
	or — Nominal frequency: 4 MHz — Roof angle: approximately 0° or 5° — Transducer size: 18 mm to 20 mm — Focal distance: 10 mm to 15 mm	Parallel to PRD 
> 20 mm	— Nominal frequency: 4 MHz — Roof angle: approximately 0° or 5° — Transducer size: 15 mm to 25 mm — Focal distance: 20 mm to 60 mm	At right angles to PRD 

[a] Probe with circular or rectangular transducers may be used.

[b] PRD: principal rolling direction.

A.4 Test procedure

Laminar imperfections shall be located by comparing the amplitude of the imperfection echo with the amplitude of the echo of a 6 mm flat-bottomed hole used during calibration.

Only those imperfections giving an echo at least equivalent in amplitude to that obtained with the 6 mm flat-bottomed hole shall be considered.

In order to determine the extent of laminar imperfections which should be considered, the method of measuring the half-amplitude value shall be used.

This method requires that the ultrasonic probe be passed over the laminated suspect area in a transverse direction (for the determination of dimension C) and longitudinal direction (for the determination of dimension L). The suspect location shall be 100 % scanned. During the transverse scan, the positions C_1 and C_2 shall be determined where, over the greatest circumferential extent, the magnitude of the intermediate reflection equals half of the related maximum value (6 dB difference in signal level). If this value is less than the minimum allowable width, C_{min}, which should be considered (see Table 1), no further explorations shall be carried out. Similarly, during the longitudinal scan, the positions L_1 and L_2 shall be determined (see Table 2). The distances between points C_1 and C_2 and L_1 and L_2 are defined as the maximum width and length dimensions, respectively. The product of these dimensions is defined as the area of the equivalent laminar imperfection.

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