BS EN ISO 10893-3:2011

BSI Standards Publication

Non-destructive testing of steel tubes

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 (ISO 10893-3:2011)

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National foreword

This British Standard is the UK implementation of EN ISO 10893-3:2011. It supersedes BS EN 10246-4:2000 and BS EN 10246-5:2000, which are withdrawn.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.

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ISBN 978 0 580 59031 3

ICS 23.040.10; 77.040.20; 77.140.75

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2011.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 10893-3

April 2011

ICS 23.040.10; 77.040.20; 77.140.75

Supersedes EN 10246-4:1999, EN 10246-5:1999

English Version

Non-destructive testing of steel tubes - 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 (ISO 10893-3:2011)

Essais non destructifs des tubes en acier - Partie 3: Contrôle automatisé par flux de fuite sur toute la circonférence des tubes en acier ferromagnétique sans soudure et soudés (sauf à l'arc immergé sous flux en poudre) pour la détection des imperfections longitudinales et/ou transversales (ISO 10893-3:2011)

Zerstörungsfreie Prüfung von Stahlrohren - Teil 3: Automatisierte Streuflussprüfung nahtloser und geschweißter (ausgenommen unterpulvergeschweißter) ferromagnetischer Stahlrohre über den gesamten Rohrumfang zum Nachweis von Unvollkommenheiten in Längs- und/oder Querrichtung (ISO 10893-3:2011)

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Foreword

This document (EN ISO 10893-3:2011) 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 10893-3:2011 has been approved by CEN as a EN ISO 10893-3:2011 without any modification.

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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.

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ISO 10893-3 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 9402:1989 and ISO 9598:1989, 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 hydraulic 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 10893-3:2011(E)**

Non-destructive testing of steel tubes —

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

1 Scope

This part of ISO 10893 specifies requirements for automated full peripheral magnetic flux leakage testing of seamless and welded ferromagnetic steel tubes, with the exception of submerged arc-welded (SAW) tubes, for the detection of imperfections.

Unless otherwise specified in the purchase order, this part of ISO 10893 is applicable to the detection of predominantly longitudinal imperfections.

This part of ISO 10893 is applicable to the inspection of tubes with an outside diameter equal to or greater than 10 mm.

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

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*

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 11484 and the following apply.

3.1
reference standard
standard for the calibration of non-destructive testing equipment (e.g. drill holes, notches and 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
tube
hollow long 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 after welding can be further processed, either hot or cold, into its final dimensions

3.7
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)

3.8
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 standard or agreed on by the purchaser and manufacturer, this peripheral magnetic flux leakage inspection shall be carried out on tubes after completion of all the primary production process operations (rolling, heat treating, cold and hot working, sizing, primary straightening, etc.).

4.2 The tubes being tested 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 inspection shall be carried out by 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 between the purchaser and manufacturer.

The operating authorization issued by the employer shall be according to a written procedure. 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

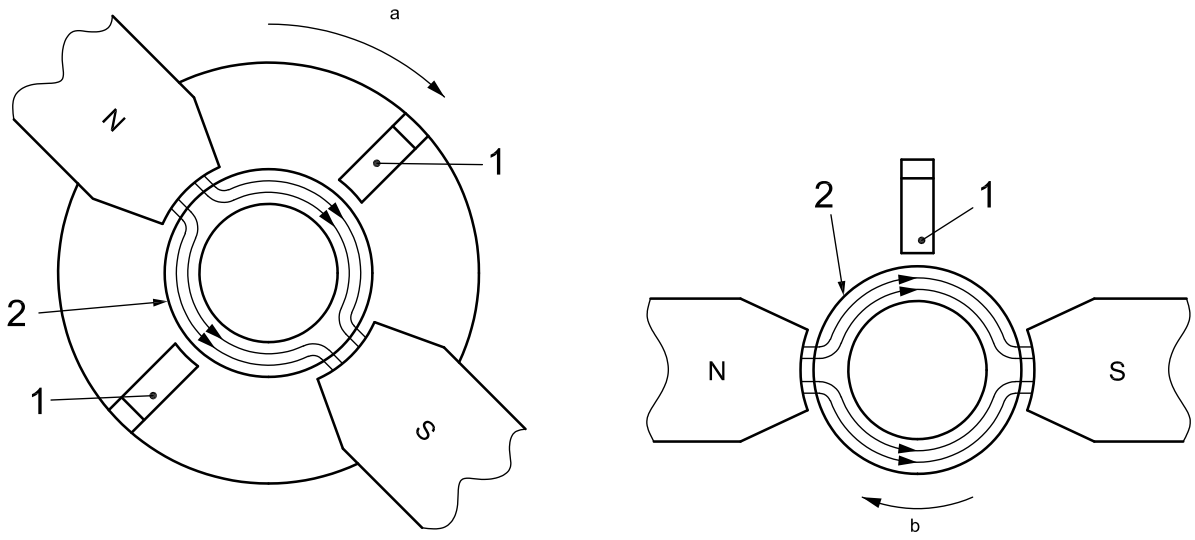
5.1 The tubes shall be tested using the magnetic flux leakage technique for the detection of predominantly longitudinal imperfections (see Figure 1) and/or, by agreement, predominantly transverse imperfections (see Figure 2). No limits on thickness are specified; indications on the limits of the method are reported in Annex A.

It is recognized that there can 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 standards.

5.2 During testing, the tube and the transducer(s) shall be moved relative to each other such that the whole of the tube surface is scanned. The relative speed during testing shall not vary by more than ±10 %.

5.3 The maximum width of each individual transducer, measured parallel to the major axis of defects being detected, shall be 30 mm.

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



a) Rotating magnetic transducer technique — Linear movement of the tube

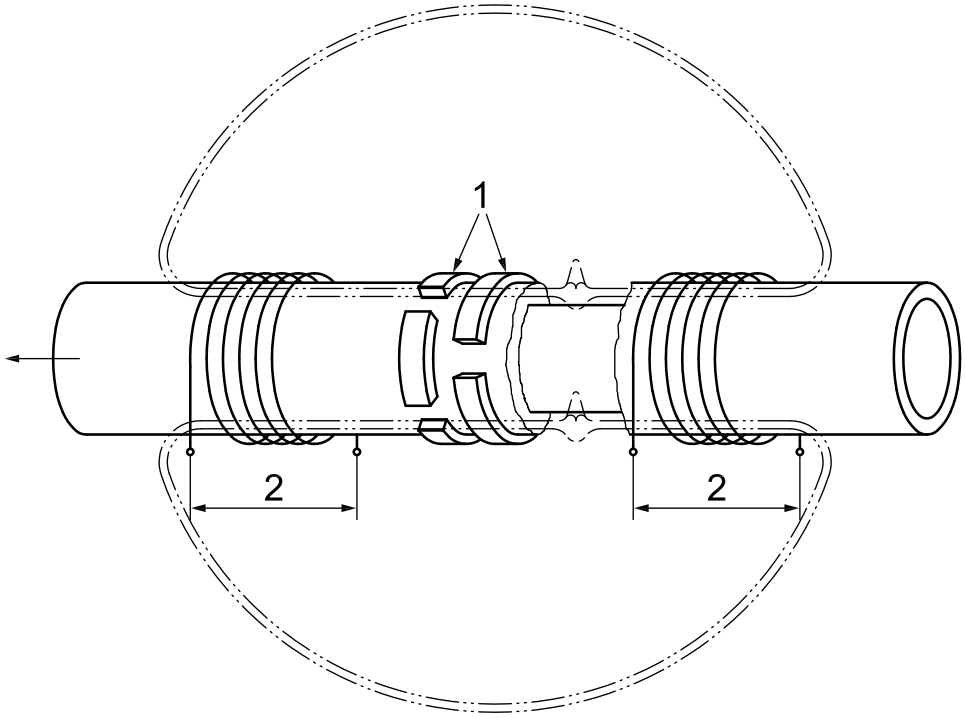
b) Fixed magnetic transducer technique — Linear and rotary movement of the tube

Key

1 flux leakage transducers
2 tube
N north pole
S south pole

[a] Direction of probe rotation.
[b] Direction of tube rotation.

Figure 1 — Simplified diagram of magnetic flux leakage techniques for the detection of longitudinal imperfections



Key

1 staggered array of transducers

2 power supply (d.c.)

NOTE The magnetic transducers can take different forms, for example absolute and differential, depending on the equipment used and other factors. The means of introducing magnetic flux in a direction parallel to the major axis of the tube can be achieved by methods other than that shown in this figure.

Figure 2 — Simplified diagram of magnetic flux leakage technique for the detection of transverse imperfections

6 Reference tube

6.1 General

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

6.1.2 Each single probe of the magnetic flux leakage equipment shall be calibrated using a reference notch on the outside surface or notches on outside and inside surfaces of a reference tube.

Alternatively, a circular reference hole drilled radially through the full thickness of the reference tube may be used for equipment calibration by agreement between the purchaser and the manufacturer. In this case, the maximum diameter of the reference hole for a specific acceptance level shall be agreed on and the manufacturer shall demonstrate that the test sensitivity achieved using the reference hole and the equipment settings is essentially equivalent to that obtained when using the specified external reference notch and the agreed internal reference notch depth.

NOTE The diameter of the holes can be specified based on factors involving intended service or other appropriate criteria. Typical holes diameter range is from 0,80 mm to 3,20 mm.

The internal surface of the reference tube may be dressed or machined prior to the preparation of the internal notch. The internal notch should not be used when the tube internal diameter is less than 20 mm, unless otherwise agreed on between the purchaser and the manufacturer or when the tube thickness is greater than 20 mm since, due to technical limitations given in Annex A, the test at the tube bore is not adequate even after applying the maximum ratios given in Table A.1.

6.1.3 The reference tubes shall have the same specified diameter and thickness, same surface finish and delivery condition (e.g. as-rolled, normalized, quenched and tempered) and similar steel grade as the tubes being tested. For specified wall thickness exceeding 10 mm, the wall thickness of the reference tubes may be greater than the specified wall thickness of the pipe under inspection provided the notch depth is calculated on the specified wall thickness of the pipe being inspected. The manufacturer shall demonstrate, on request, the effectiveness of the adopted solution.

6.1.4 The external and the eventual internal notches and the reference hole shall be sufficiently separated from the ends of the reference tube and from each other (when both notches are used), such that clearly distinguishable signals are obtained.

6.2 Reference notches

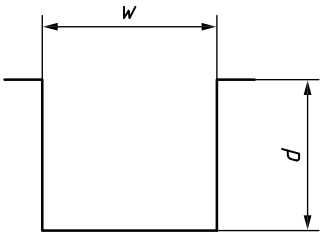
6.2.1 General

a) The reference notch(es) shall be of the “N” type (see Figure 3) and shall lie parallel to the major axis of the tube; when transverse imperfection detection has been agreed on between the purchaser and manufacturer, the reference notch(es) shall lie transversally to the major axis of the tube (see Figure 4).

b) The sides shall be nominally parallel and the bottom shall be nominally square to the sides;

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

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



Key

w width
d depth

Figure 3 — “N” type notch

a) External partial circumferential notch **b) Internal partial circumferential notch**

Key

d depth

Figure 4 — Possible transverse notch forms

6.2.2 Dimensions of the reference notch

a) Width, *w* (see Figure 3)

The width of the reference notch shall not be greater than the depth of the reference notch depth or 1 mm whichever is greater.

b) Depth, *d* (see Figures 3 and 4)

The depth of the external reference notch shall be as given in Table 1 with the following limitations:

— minimum notch depth: 0,30 mm for acceptance levels F2 and F3; 0,50 mm for acceptance levels F4 and F5;

— maximum notch depth: 1,5 mm.

The internal notch depth shall be subject to agreement between the purchaser and manufacturer (see Annex A) but under no circumstance shall be less than the specified external notch depth or greater than that applying the maximum ratios given in Table A.1. The maximum internal notch depth shall be 3,0 mm.

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

c) Length

Unless otherwise specified by product standard or agreed between purchaser and manufacturer, the length of the reference notch(es) shall be greater than the width of each individual transducer. In any case, the length of reference notch shall not exceed 50 mm.

In case of detection of transverse imperfections, the minimum length of circumferential notch(es) (see Figure 4) shall be 25 mm.

6.2.3 Verification of reference standards

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

Table 1 — Acceptance levels and corresponding external reference notch depth

Acceptance level	Notch depth of the specified thickness %
F2	5 % (min 0,30 mm)
F3	10 % (min 0,30 mm)
F4	12,5 % (min 0,50 mm)
F5	15 % (min 0,50 mm)

NOTE The values of notch depth specified in this table are the same for the corresponding categories, in all International Standards concerning non-destructive testing of steel tubes where reference is made to different acceptance levels. Although the reference standards are identical, the various test methods involved can give different test results. Accordingly, the acceptance level designation prefix F (flux leakage) has been adopted to avoid any inferred direct equivalence with other test methods.

7 Equipment calibration and checking

7.1 At the start of each inspection cycle, the equipment shall be calibrated to produce consistently (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 their respective trigger alarm of the equipment.

7.2 During the calibration check, the relative speed of movement between the reference tube and the transducer assembly shall be the same as that used during the production test.

7.3 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 test equipment.

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 production.

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

7.5 If, on checking during production testing, the calibration requirements are not satisfied, all tubes tested since the previous acceptable equipment calibration shall be retested after the equipment has been recalibrated.

8 Acceptance

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

8.2 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.

8.3 For suspect tubes, one or more of the following actions shall be taken subject to the requirements of the product standard.

a) The suspect area shall be dressed or explored using a suitable method. After checking that the remaining thickness is within tolerance, the tube shall be retested as previously specified. If no signals are obtained equal to or greater than trigger/alarm level, the tube shall be deemed to have passed this test.

   By agreement between the purchaser and manufacturer, the suspect area may be retested by other non-destructive techniques and test methods to agreed acceptance levels.

b) The suspect area shall be cropped off.

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

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 10893-3;

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 inspection 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)

Limitations of magnetic flux leakage test method

A.1 General

When using this method, the inspected products shall be magnetically saturated inserting them in an external strong magnetic field; the aim of this saturation is to cause flux leakage/flux diversion from imperfections.

During the magnetic flux leakage testing of tubes, the sensitivity of the test is at maximum at the tube surface adjacent to the magnetic transducer and decreases with increasing tube thickness due to effective diminishing flux diversion from imperfection at the tube bore surface in relation to that at the external surface. The signal response from internal surface imperfection may thus be smaller than that from an external imperfection of the same size.

As a result, it may be necessary for the internal notch depth to be increased in excess of that specified for the external notch depth by an amount agreed on by the purchaser and the manufacturer, being dependent, for example on the type of equipment in use and the surface condition of the tube being tested. For that reason, Table A.1 is generally applied.

Table A.1 — Maximum ratio of internal notch depth and external notch depth with respect to tube thickness

Specified wall thickness T mm	**Maximum ratio of internal notch depth/external notch depth**	
	F2	F3/F4/F5
$8 < T \leqslant 12$	2,0	1,2
$12 < T \leqslant 15$	2,5	1,5
$15 < T \leqslant 20$	3,0	2,0
NOTE Minimum internal notch depth: 0,4 mm.		

A.2 Fixed or rotating magnetic transducer

These test techniques use one or more magnetic transducers to describe a helical path over the tube surface. For this reason, these techniques detect longitudinal imperfections with a minimum length dependant on the width of the transducer and the inspection helical pitch. It is recognized that transverse imperfections are normally not detectable.

A.3 Multiple transducers technique

This test technique uses multiple fixed magnetic transducers surrounding the tube during its linear movement. For this reason the technique detects predominantly transverse imperfections having a minimum length dependant on the circumferential dimension of the transducer. It is recognized that longitudinal imperfections are normally not detectable unless they have a significant transverse component (oblique).

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