BRITISH STANDARD

BS EN
10246-7:2005

Non-destructive testing of steel tubes —

Part 7: Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc welded) tubes for the detection of longitudinal imperfections

The European Standard EN 10246-7:2005 has the status of a British Standard

ICS 23.040.10; 77.040.20

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 10246-7:2005. It supersedes BS EN 10246-7:1996 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee ISE/73, Steel for pressure purposes, to Subcommittee ISE/73/1, Steel tubes for pressure purposes, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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English Version

Non-destructive testing of steel tubes - Part 7: Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc welded) tubes for the detection of longitudinal imperfections

Essais non destructifs des tubes en acier - Partie 7 : Contrôle automatique par ultrasons sur toute la circonférence des tubes en acier sans soudure et soudés (sauf à l'arc immergé sous flux en poudre) pour la détection des imperfections longitudinales

Zerstörungsfreie Prüfung von Stahlrohren - Teil 7: Automatische Ultraschallprüfung nahtloser und geschweißter (ausgenommen unterpulvergeschweißter) Stahlrohre über den gesamten Rohrumfang zum Nachweis von Längsfehlern

This European Standard was approved by CEN on 26 August 2005.

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Foreword

This European Standard (EN 10246-7:2005) has been prepared by Technical Committee ECISS/TC 29 “Steel tubes and fittings for steel tubes”, 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of an identical text or by endorsement, at the latest by April 2006, and conflicting national standards shall be withdrawn at the latest by April 2006.

This European Standard supersedes EN 10246-7:1996.

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1 Scope

This part of EN 10246 specifies the requirements for automatic full peripheral ultrasonic shear wave (including phased array technique) and Lamb wave testing of seamless and welded steel tubes, with the exception of submerged arc-weld (SAW) tubes, for the detection of longitudinal imperfections. This European Standard specifies acceptance levels and calibration procedures.

This part of EN 10246 is applicable to the inspection of tubes with an outside diameter > 10 mm, and with an outside diameter-to-thickness ratio ≥ 5.

For tubes with an outside diameter-to-thickness ratio < 5, one of the options specified in Annex B shall be used by agreement between purchaser and manufacturer.

The European Standard EN 10246 ”Non-destructive testing of steel tubes" comprises the parts shown in Annex A.

2 General requirements

2.1 The ultrasonic inspection covered by this Part of EN 10246 is usually carried out on tubes after completion of all the primary production process operations.

The inspection shall be carried out by suitably trained, qualified and competent personnel approved by the manufacturer.

2.2 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 could interfere with the validity of the test.

3 Method of test

3.1 The tubes shall be tested using an ultrasonic shear wave or Lamb wave technique for the detection of predominantly longitudinal imperfections.

3.2 During testing, the tubes and the transducer assembly shall be moved relative to each other so that the whole of the tube length is scanned.

It is recognised 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 standards (see also Annex C).

The relative speed of movement during testing shall not vary by more than ± 10%.

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

3.4 The ultrasonic test frequency to be applied 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 Lamb waves, depending upon the thickness and surface finish of the tube to be tested.

3.5 The maximum width of each individual transducer, measured parallel to the major axis of the tube, shall be 25 mm for shear waves and 35 mm for Lamb waves.

For U1 and U2 category tubes with an outside diameter equal to or less than 50mm, the width of any one shear wave transducer is normally restricted to a maximum of 12,5 mm (see also 4.3).

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

3.7 Where manual ultrasonic testing of untested tube ends and/or local suspect areas is required, this shall be carried out in accordance with Annex C.

4 Reference standards

4.1 General

4.1.1 The reference standards defined in this Part of EN 10246 are convenient for the calibration of non-destructive testing equipment. The dimensions of the reference notches should not be construed as the minimum size of imperfection detectable by such equipment.

4.1.2 The ultrasonic equipment shall be calibrated using a longitudinal reference notch on the outside and inside surfaces of a reference tube.

However, the internal notch shall not be used when the tube internal diameter is less than 20 mm, unless otherwise agreed between purchaser and manufacturer.

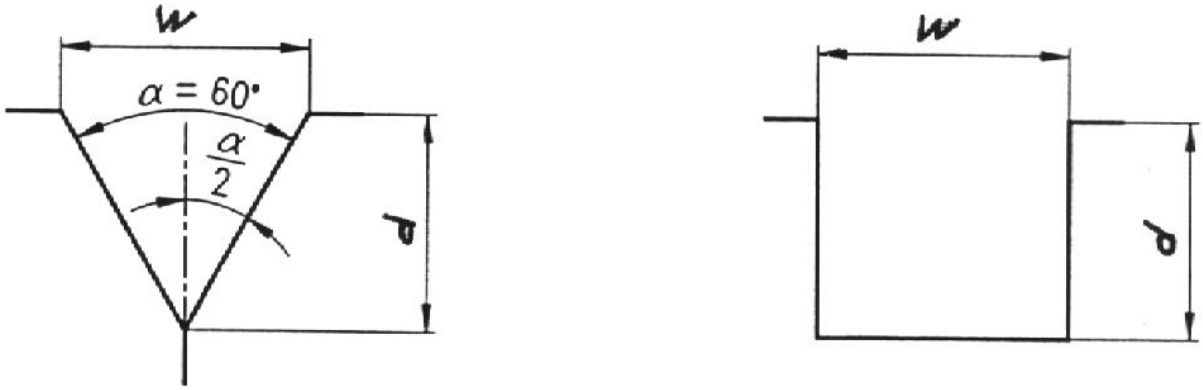
4.1.3 The reference tube shall have the same specified diameter, thickness, surface finish and heat treatment conditions as the tube to be tested, and shall have similar acoustic properties (for example velocity, attenuation coefficient).

4.1.4 In order to obtain clearly distinguishable signal indications, the notch(es) shall be sufficiently separated from the ends of the reference tube and, when both notches are used, from each other.

4.2 Types of reference notches

4.2.1 The reference notch or notches shall lie parallel to the major axis of the reference tube.

The reference notch or notches shall be of the "N" type except that the "V" type notch may be used at the discretion of the manufacturer when the specified notch depth is less than or equal to 0,5 mm (see figure 1). In the case of the "N" type notch, the sides shall be nominally parallel and the bottom shall be nominally square to the sides.



a) "V" type notch (only to be used when d ≤ 0,5 mm)

b) ”N” type notch

Key

w = width

d = depth

α = 60°

Figure 1 - **Reference notch forms**

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

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

4.3 Dimensions of reference notches

4.3.1 Width, w (see figure 1)

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

4.3.2 Depth, d (see figure 1)

The depth of the reference notch shall be as given in table 1.

Table 1 — Acceptance level design and corresponding reference notch depth

Acceptance level	Notch depth in % of the specified thickness [a]
U1 [b]	3
U2 [c]	5
U3	10
U4	12,5
U5	15
U6	20

a The values of notch depth specified in this table are the same, for the corresponding categories, in all European Standards concerning non-destructive testing of steel tubes where reference is made to different acceptance levels. It should, however, be kept in mind that although the reference standards are identical, the various test methods involved can give different test results. Accordingly the acceptance level designation prefix U (ultrasonic) has been adopted to avoid any inferred direct equivalence with other test methods.

b Acceptance level U1 is not applicable to as-welded or hot stretch reduced welded tubes.

c For welded tubes, acceptance level U2 can be used as an alternative to or in combination with U3 by agreement between purchaser and manufacturer.

4.3.2.1 The minimum notch depth is related to the type of tube used for a particular application and is denoted by a sub-category as given in table 2, unless otherwise agreed between purchaser and manufacturer.

Table 2 — Minimum notch depth categories

Sub-category	Minimum notch depth in mm[a]	Typical tube condition
A [b]	0,1	Cold-finished or machined tubes
B [b]	0,2	
C	0,3	All other conditions
D	0,5	

a The minimum notch depth that can be used is related to specific tube manufacturing methods where the surface finish plays a dominant role in the minimum notch depth that can be adopted for ultrasonic equipment calibration in order to achieve an acceptable signal/noise ratio.

b Sub-categories A and B do not apply to as-welded or hot stretch reduced welded tubes.

4.3.2.2 The maximum depth of the notch for all acceptance levels and sub-categories shall be 1,5 mm, except for tubes with a wall thickness greater than 50 mm for which it can be increased to 3 mm unless otherwise agreed.

4.3.3 Tolerance on notch depth

The tolerance on depth shall be ± 15 % of reference notch depth or ± 0,05 mm. whichever is the larger, with the exception that when the notch depth is less than 0,2 mm, the tolerance on the depth shall be ± 0,03 mm.

4.3.4 Notch length

The length of the reference notch or notches shall be twice the width of the transducers but not more than 50 mm, with the following exception:

— U1 and U2 category tubes with an outside diameter less than or equal to 50 mm and where the width of any one transducer exceeds 12,5 mm, the length of the reference notch or notches shall not exceed 12,5 mm (at full depth).

4.4 Verification

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

5 Equipment calibration and checking

5.1 The equipment, independent of the applied type of waves, 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 notches (see 4.2). The full amplitude of these signals shall be used to set the trigger/alarm level(s) of the equipment.

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 separate trigger/alarm levels are used for internal and external reference notches, the full signal amplitude from each notch 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 examined.

5.2 During calibration check, the relative speed of movement between the reference tube and the transducer assembly shall be the same as that to be used during the production test. Semi-dynamic calibration checking may be used. When requested, the manufacturer shall demonstrate that the semi-dynamic calibration check gives the same results as the dynamic calibration check.

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

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

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

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

6 Acceptance

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

6.2 Any tube producing signals equal to or greater than the trigger/alarm level shall be designated suspect or, at the manufacturer's option, may be retested as specified above.

6.3 If upon retesting no signal is obtained equal to or greater than the trigger/alarm level, the tube shall be deemed to have passed this test.

Tubes giving signals equal to or greater than the trigger/alarm level shall be designated suspect.

6.4 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 by a suitable method. After checking that the remaining thickness is within tolerance, the tube shall be tested as previously specified. If no signals are obtained equal to or greater than the trigger/alarm level, the tube shall be deemed to have passed this test. The suspect area may be retested by other non-destructive techniques and test methods, by agreement between purchaser and manufacturer to agreed acceptance levels.

b) The suspect area shall be cropped off. The manufacturer shall ensure that all the suspect area has been removed.

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

7 Test reporting

When specified, the manufacturer shall provide the purchaser a test report with, at least, the following information:

a) reference to this part of EN 10246;

b) date of test report;

c) acceptance level;

d) statement of conformity;

e) product designation by grade and size;

f) type and details of inspection technique;

g) description of the reference tube;

h) operator identification.

Annex A
(informative)
Parts of EN 10246 and corresponding ISO standards

Table A1 — Table of parts of EN 10246 - Non-destructive testing of steel tubes

Purpose of test	Title of part	Part No.	ISO Reference
Leak Tightness	Automatic electromagnetic testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for verification of hydraulic leak-tightness.	1	9302
	Automatic eddy current testing of seamless and welded (except submerged arc-welded) austenitic and austenitic-ferritic steel tubes for verification of hydraulic leak-tightness.	2	
Longitudinal and/or Transverse Imperfections	Automatic eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections	3	9304
	Automatic full peripheral magnetic transducer/flux leakage testing of seamless ferromagnetic steel tubes for the detection of transverse imperfections.	4	9598
	Automatic full peripheral magnetic transducer/flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal imperfections.	5	9402
	Automatic full peripheral ultrasonic testing of seamless steel tubes for the detection of transverse imperfections.	6	9305
	Automatic full peripheral ultrasonic testing of seamless and welded (except submerged are-welded) steel tubes for the detection of longitudinal imperfections.	7	9303
	Automatic ultrasonic testing of the weld seam of electric welded steel tubes for the detection of longitudinal imperfections.	8	9764
	Automatic ultrasonic testing of the weld seam of submerged arc welded steel tubes for the detection of longitudinal and/or transverse imperfections.	9	9765
	Radiographic testing of the weld seam of automatic fusion arc welded steel tubes for the detection of imperfections.	10	12096
Surface Imperfections	Liquid penetrant testing of seamless and welded steel tubes for the detection of surface imperfections.	11	12095
	Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections.	12	13665
Thickness	Automatic full peripheral ultrasonic thickness testing of seamless and welded (except submerged arc-welded) steel tubes.	13	10543
Laminar Imperfections	Automatic ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of laminar imperfections.	14	10124
	Automatic ultrasonic testing of strip/plate used in the manufacture of welded steel tubes for the detection of laminar imperfections.	15	12094
	Automatic ultrasonic testing of the areas adjacent to the weld seam of welded steel tubes for the detection of laminar imperfections.	16	13663
	Ultrasonic testing of tube ends of seamless and welded steel tubes for the detection of laminar imperfections.	17	11496
	Magnetic particle inspection of the tube ends of seamless and welded ferromagnetic steel tubes for the detection of laminar imperfections.	18	13664

Annex B
(normative)

Testing of tubes having an outside diameter-to-thickness ratio less than 5

B.1 When the ratio of the outside diameter to the thickness of the tube is less than 5, either clause B.2 or clause B.3 shall be applied by agreement between purchaser and manufacturer.

Independent of the applied type of waves, internal and external notch shall be verified

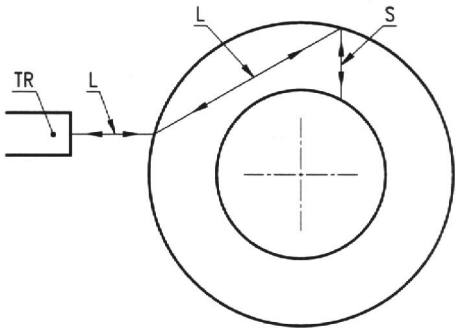
NOTE Testing of tubes with ratio values < 3 is not covered by this European Standard. Test techniques for such special cases may be subject of agreement between purchaser and manufacturer.

B.2 When the ratio of the outside diameter to the thickness of the tube is less than 5 but greater than or equal to 4, the internal notch depth shall be increased in relation to the external notch depth as given in table B.1.

Table B1 — Ratios

$\frac{\text{Tube outside diameter}}{\text{Tube thickness}}$	$\frac{\text{Internal reference notch depth}}{\text{External reference notch depth}}$
(≥ 5,00)	(1)
< 5,00 ≥ 4,75	1,6
< 4,75 ≥ 4,50	1,9
< 4,50 ≥ 4,25	2,2
< 4,25 ≥ 4,00	2,5

B.3 When the ratio of the outside diameter to the thickness of the tube is less than 5 but greater than or equal to 3, a mode-transformed compression wave adaptation of shear wave testing shall be used, as shown in figure B.1. In this case, the ratio of internal to external notch depth shall be by agreement between purchaser and manufacturer, but in no circumstances be less than 1,0 or greater than the relevant ratios given in table B.1.



Key

TR Transceiver or double transducer probe

L Compression wave

S Shear wave

Figure B1 — Immersion testing using compression wave to transverse wave conversion mode

Annex C
(normative)

Manual/semi-automatic ultrasonic testing of untested ends/suspect areas

C.1 Untested tube ends

When specified by the relevant product standard, tube end zones which cannot be tested by the automatic ultrasonic equipment shall be subjected to a manual/semi-automatic ultrasonic test around the full periphery of the tube, from the ultimate tube ends and over the length of the original untested zone plus 10 %.

The manual/semi-automatic ultrasonic test shall be carried out so that the whole surface of the untested end is scanned with a 10 % overlap of adjacent scanning paths, with reference to the ultrasonic transducer width used, measured in the direction parallel to the major axis of the tube.

The manual/semi-automatic ultrasonic test shall be carried out using the ultrasonic shear wave technique or Lamb wave technique, test sensitivity (reference notch depth) and general test parameters, as used during the original automatic test on the main tube length, with the restrictions given in **C.3**.

C.2 Local suspect areas

Where appropriate, local areas on the tube deemed suspect by the automatic ultrasonic equipment shall be subjected to a test by manual ultrasonic shear wave technique or Lamb wave technique, test sensitivity (reference notch depth) and general test parameters, as used during the original automatic test, with the restrictions given in **C.3**, so that the whole of the local suspect area is scanned.

C.3 Manual ultrasonic test restrictions

The following restrictions apply to the application of a manual ultrasonic test to untested end zones and/or local suspect areas.

a) Beam angle in steel used for manual ultrasonic testing with shear waves shall be nominally the same as that used during the original automatic test.

b) Scanning shall be carried out in both circumferential directions of ultrasonic beam travel.

c) Scanning speed over the tube surface shall not exceed 150 mm/s.

d) Ultrasonic transducer type to be used during manual ultrasonic testing with shear waves shall be of the contact, gap-scan or immersion type. Means shall be provided to ensure that the probe is held at the correct distance in relation to the tube surface e.g. for contact type transducers, the "wear-face" at the front face of the probe shall be fitted to the radius of curvature of the tube under test.

e) Width of the transducer, measured parallel to the major axis of the tube, used in the manual ultrasonic test shall not exceed that used during the original automatic test.

f) Nominal ultrasonic test frequency of the transducer used in manual testing shall not vary from that used during the original automatic test by more than ± 1 MHz. Where Lamb waves have been used in the original automatic test, the frequency of shear wave transducers, if used for manual testing, shall be in the range of 4 MHz to 5 MHz.

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