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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) steel tubes for the detection of longitudinal imperfections

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

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

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CEN

European Committee for Standardization
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Foreword

This European Standard 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publication of an identical text or by endorsement, at the latest by September 1996, and conflicting standards shall be withdrawn at the latest by September 1996.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

Contents

1 Scope

This Part of EN 10246 specifies the requirements for automatic full peripheral ultrasonic shear wave testing of seamless and welded steel tubes, with the exception of submerged arc-weld (SAW) tubes, for the detection of longitudinal imperfections according to six different acceptance levels (see Table 1 and associated notes).

This Part of EN 10246 is applicable to the inspection of tubes with an outside diameter greater than 10 mm, and with an outside diameter-to-thickness ratio equal to or greater than five.

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

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.

This inspection shall be carried out by suitably trained, qualified and competent NDT 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 would interfere with the validity of the test.

3 Method of test

3.1 The tubes shall be tested using an ultrasonic shear 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 surface is scanned. The chosen relative speed of movement during testing shall not vary by more than ± 10 %.

NOTE 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 standards (see also Annex C).

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 dependent 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 U1 and U2 category tubes with an outside diameter equal to or less than 50 mm, the width of any one transducer is normally restricted to a maximum of 12,5 mm (see also **5.3**).

3.6 The equipment shall be capable of classifying tubes as either acceptable or suspect by means of an automatic trigger/alarm 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 The reference standards defined in this Part of EN 10246 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 imperfection detectable by such equipment.

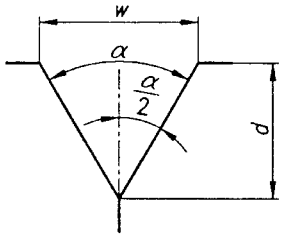
4.2 The ultrasonic equipment shall be calibrated using a longitudinal reference notch on the outside and inside surfaces, or the outside surface only of a tubular test piece. The internal notch shall not be used when the tube internal diameter is less than 20 mm, unless otherwise agreed between purchaser and manufacturer.

4.3 The test piece shall have the same specified diameter, thickness, surface finish and heat treated condition as the tube to be tested, and shall have similar acoustic properties (for example velocity, attenuation coefficient, etc).

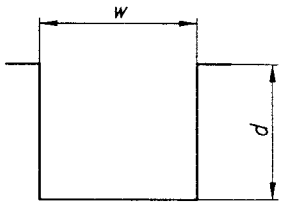
4.4 The external and internal notches shall be sufficiently separated from the extremities of the test piece and from each other (when both are used), so that clearly distinguishable signal indications are obtained.

4.5 The reference notch or notches shall lie parallel to the major axis of the test piece.

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.



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



'N' type notch

Key :
$\alpha = 60\,°$;
w = width;
d = depth.

Figure 1 — Reference notch forms

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

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

5 Dimensions of reference notches

The dimensions of the reference notches shall be as follows:

5.1 Width, w (see Figure 1). The width of the reference notch shall be 1,0 mm max.

5.2 Depth, d (see Figure 1).

5.2.1 ***Reference notch depth.*** The reference notch depth shall be as given in Table 1.

Table 1 — Acceptance level designation and corresponding reference notch depth

Acceptance level	Notch depth in % of the specified thickness (see note 1)
U1 (see note 2)	3
U2 (see note 3)	5
U3	10
U4	12,5
U5	15
U6	20

NOTE 1 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.

NOTE 2 Acceptance level U1 is not applicable to welded tubes.

NOTE 3 For welded tubes, acceptance level U2 can be used as an alternative to or in combination with U3 by agreement between purchaser and manufacturer.

5.2.2 ***Minimum notch depth***

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	Typical tube condition
A	0,1 mm	Cold-finished and machined tubes
B	0,2 mm	
C	0,3 mm	All other conditions
D	0,5 mm	

NOTE 1 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.

NOTE 2 Sub-categories A and B do not apply to welded tubes.

5.2.3 ***Maximum notch depth***

The maximum notch depth for all acceptance levels and sub-categories shall be 1,5 mm, with exception that in the case of tubes with a thickness in excess of 50 mm, the maximum notch depth, may be extended to 3,0 mm unless otherwise agreed.

5.3 Tolerance on 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.

5.4 Length

The length of the reference notch or notches shall be at least twice the width of the transducers, with the following exception:

for 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).

5.5 Verification

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

6 Equipment calibration and checking

6.1 The equipment shall be adjusted to consistently produce, (for example, from three consecutive passes of the test piece through the equipment), clearly identifiable signals from both the external and internal reference notches or from the external reference notch when this alone is used (see **4.2**). These signals shall be used to set the trigger/alarm level(s) of the equipment.

Where a single trigger/alarm level is used, the transducer(s) shall be adjusted so that the signals from the internal and external reference notches are as near equal as possible and the full 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.

6.2 During calibration, the relative speed of movement between the test piece and the transducer assembly shall be the same as that to be used during the production test, except that semi-dynamic calibration may be used when dynamic calibration is impractical. In this case, any necessary adjustment to sensitivity shall be made to allow for differences in signal magnitude between semi-dynamic and dynamic calibration.

6.3 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 test piece through the inspection equipment.

The frequency of checking the calibration shall be at least every 4 hours or once every 10 production tubes tested, whichever is the longer time period, but also whenever, there is an equipment operator change-over and at the start and end of the production run.

NOTE In cases where a production testing run is continuous from one shift period to the next, the 4 hour maximum period may be extended by agreement between purchaser and manufacturer.

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

6.5 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.

Retesting shall not be necessary even after a drop in test sensitivity of more than 3 dB but less than 6 dB since the previous equipment calibration, provided that suitable recordings from individually identifiable tubes are available which permit accurate classification as either suspect or acceptable.

7 Acceptance

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

7.2 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.

7.3 If on 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.

7.4 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 explored by dressing using an acceptable 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 to the satisfaction of the purchaser that all the suspect area has been removed.

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

8 Test reporting

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

a) reference to this Part of EN 10246;

b) date of test;

c) acceptance level and sub-category;

d) statement of conformity;

e) product designation by grade and size;

f) type and details of inspection technique;

g) description of the reference standard.

Annex A (informative)
Table of Parts of EN 10246 *Non-destructive testing of steel tubes*

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

Annex B (normative)
Testing of tubes having an outside diameter-to-thickness ratio less than five

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

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

Table B.1 — Ratios

Tube outside diameter / Tube thickness	Internal reference notch depth / External reference notch depth
≥ 5,00	1,0
< 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.2 When the ratio of the outside diameter to the thickness of the tube is less than five but greater than or equal to three, a mode-transformed compression wave adaption 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.

Annex C (normative)
Manual ultrasonic testing of untested ends/suspect areas

C.1 Untested tube ends

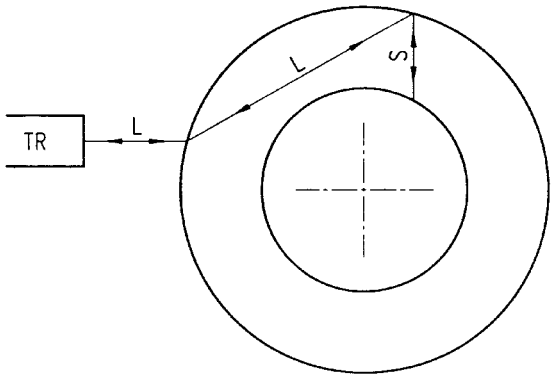
When specified by the relevant product standard, tube end zones which cannot be tested by the automatic ultrasonic equipment shall be subjected to a manual/semi-automatic ultrasonic test around the full periphery of the tube, from the ultimate tube ends and over the length of the original untested zone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

C.2 Local suspect areas

Where appropriate, local areas on the tube deemed suspect by the automatic ultrasonic equipment shall be subjected to a manual ultrasonic test using the same ultrasonic shear 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** below, so that the whole of the local suspect area is scanned.



Key :
TR = single transceiver transducer or twin separate transmitting and receiving transducers;
L = compression wave;
S = shear wave.

Figure B.1 — Mode transformed compression wave adaptation of shear wave testing

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.

C.3.1 The scanning speed over the tube surface shall not exceed 150 mm/s.

C.3.2 Scanning shall be carried out in both circumferential directions of ultrasonic beam travel.

C.3.3 The 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.

C.3.4 The 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.

C.3.5 The ultrasonic angle in steel used during manual ultrasonic testing shall be nominally the same as that used during the original automatic test.

C.3.6 The ultrasonic transducer type to be used during manual ultrasonic testing shall be of the contact, gap-scan or immersion type. Means shall be provided to ensure that the transducer is held at the correct altitude in relation to the tube surface e.g. for contact type transducers, the “wear-face” at the front face of the transducer shall be profiled to the radius of curvature of the tube under test.