EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 10246-14

November 1999

ICS 23.040.10; 77.040.20

English version

Non-destructive testing of steel tubes - Part 14: Automatic ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of laminar imperfections

Essais non destructifs des tubes en acier - Partie 14: Contrôle automatique par ultrasons des tubes pour la détection des dédoublures des tubes en acier sans soudure et soudés (sauf à l'arc immergé sous flux en poudre)

Zerstörungsfreie Prüfung von Stahlrohren - Teil 14: Automatische Ultraschallprüfung nahtloser und geschweißter (ausgenommen unterpulvergeschweißter) Stahlrohre zum Nachweis von Dopplungen

This European Standard was approved by CEN on 6 October 1999.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 10246-14:1999 E

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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of an identical text or by endorsement, at the latest by May 2000, and conflicting national standards shall be withdrawn at the latest by May 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association. This European Standard is considered to be a supporting standard to those application and product standards which in themselves support an essential safety requirement of a New Approach Directive and which make reference to this European Standard.

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

1   Scope

This Part of EN 10246 specifies requirements for automatic ultrasonic testing of seamless and welded steel tubes, with the exception of submerged arc welded (SAW) tubes, for the detection of laminar imperfections. The standard specifies acceptance levels and calibration procedures.

> NOTE : An alternative test method for the detection of laminar imperfections in steel strip/plate prior to tube forming of welded tubes, is given in EN 10246-15.

This Part of EN 10246 is applicable to the inspection of tubes with an outside diameter greater than 30 mm. No lower limit of wall thickness is specified but see note in 4.1.

European Standard EN 10246 "Non-destructive testing of steel tubes" comprises the Parts shown in annex A.

2   Normative references

This Part of EN 10246 incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of those publications apply to this Part of EN 10246 only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 10246-15   Non-destructive testing of steel tubes - Part 15: Automatic ultrasonic testing of strip/plate used in the manufacture of welded steel tubes for the detection of laminar imperfections.

3   General requirements

3.1 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.

3.2   The tubes to be tested shall be sufficiently straight and free from foreign matter as to ensure the validity of the test.

4   Method of test

4.1   The tubes shall be tested using an ultrasonic pulse echo technique for the detection of laminar imperfections. The ultrasound shall be transmitted in the direction normal to the tube surface.

> NOTE: For wall thicknesses less than 5 mm, where difficulties may occur in detecting and sizing laminar imperfections using this method of test, an alternative method of test may be agreed between manufacturer and purchaser

4.2   During testing, the tubes and the transducer assembly shall be moved relative to each other so 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) calculated as given in table 1. The relative speed of movement during testing shall not vary by more than + 10 %.

It is recognized that there may be a short length at both tube ends which cannot be tested. Any untested ends shall be dealt with in accordance with the requirements of the appropriate product standards.

Table 1: Acceptance level designation and minimum size of laminar imperfections to be detected

Acceptance level	Minimum individual lamination area to considered B_{min} [1] mm^2	Circumferential dimension C mm
UO	165	12 and above
U1	$165 + \pi D/4$ [2]	between 6 and 12
U2	$165 + \pi D/2$ [2]	between 9 and 15
U3	$165 + \pi D$ [2]	between 12 and 20

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

[2] D = Specified outside diameter of the tube in mm

4.3   The maximum width of each individual transducer, measured parallel to the major axis of the tube, shall be 30 mm. The ultrasonic test frequency shall be 2 to 10 MHz.

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

5   Reference standards

5.1   General

5.1.1 The reference standards defined in this Part of EN 10246 are convenient standards for 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.

5.1.2. The ultrasonic equipment shall be calibrated either electronically using a tubular test piece (see 6.1.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 tubular test piece, with the exception that for acceptance level U0, only the flat bottomed circular recess shall be used (see 6.1.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.

5.1.3 The test piece shall be of the same specified diameter, thickness and surface finish as the tube to be tested and shall have similar acoustic properties (e.g. velocity, attenuation coefficient).

5.2 Dimensions of reference standard

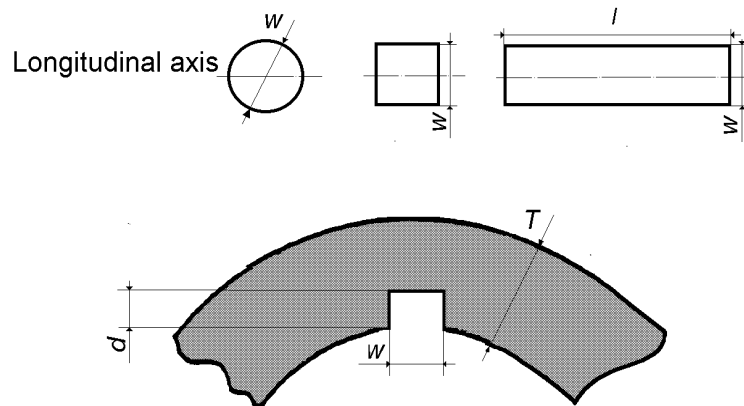**5.2.1** The dimensions of the rectangular recess reference standard (see figure 1) shall be as follows:

a) width, w: 6 mm $^{+10}_{\ 0}$ %;

b) length, l: 6 mm min.;

c) depth, d: $T/4 < d < T/2$, with a maximum of 10 mm.

5.2.2 The dimensions of the circular and square recess reference standard shall be as follows (see figure 1):

a) width or diameter, w: 6 mm $^{+10}_{\ 0}$ %;

b) depth, d: $T/4 < d < T/2$, with a maximum of 10 mm.

5.3 Verification of reference standard

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

l = length of rectangular recess w = width or diameter of recess

d = depth of recess T = specified wall thickness

Figure 1: Reference recess forms (reference standards)

6 Equipment calibration and checking

6.1 The equipment shall be calibrated statically either without reference standard in accordance with 6.1.a or using a reference standard in accordance with 6.1.b.

By agreement between the purchaser and manufacturer, the equipment may also be checked dynamically to prove that at the inspection pitch and pulse repetition frequency selected, the equipment will detect the relevant minimum lamination size B_{min} as given in table 1.

a) Calibration without reference standard

With the transducer assembly positioned on the test piece, the full amplitude of the first back wall echo minus 6 dB shall be used to set the trigger/alarm level of the equipment.

The test sensitivity may also be established with DAC[1] curves as supplied by the transducer manufacturer or with DAC curves as prepared by the tube manufacturer using, in both cases, the 6 mm flat bottom hole curve.

At the commencement of the production test run, the manufacturer shall demonstrate that at the set sensitivity, the equipment will detect under static conditions the reference standard as given in 5.1.2. 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 transducer assembly centrally located over the reference standard, the full signal amplitude of the signal obtained from the reference standard shall be used to set the trigger/alarm level of the equipment.

6.2 During production testing, the relative rotational and/or translational speeds and pulse repetition frequency shall be chosen in order to detect the relevant minimum lamination size (B_{min}) with the circumferential dimension (C) as given in table 1 by producing a trigger/alarm condition.

6.3 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.

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

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 check shall be retested after the equipment has been recalibrated.

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.

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.

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[1] DAC = distance amplitude correction

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

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

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 a manual ultrasonic compression wave method according to annex B or by a suitable automatic or semi-automatic 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} given in table 2 are not exceeded.

Table 2: Acceptance limits

Acceptance level	Maximum individual lamination area to be considered B_{max} [1) mm^2	Maximum cumulative area of laminations $> B_{min}$ [1) to $< B_{max}$ [1)	
		Value per m of tube length below % max.	Mean value per m of tube length for entire tube % max.
U0	165	N/A [3)	N/A [3)
U1	$165 + \pi D$ [2)	1	0,5
U2	$165 + 2\pi D$ [2)	2	1
U3	$165 + 4\pi D$ [2)	4	2

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

2) D = Specified outside diameter of tube in mm.

3) N/A = not applicable.

NOTE: 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.

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.

8 Test reporting

When specified, the manufacturer shall submit to the purchaser a test report containing 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 standard, if used;

h) equipment calibration method used.

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.	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 arc-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 the 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)

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

B.1 General

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

In cases of dispute 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 tubes.

B.2 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 bottom hole located at the same depth as the imperfection.

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

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

This method requires that the ultrasonic probe is passed over the laminated suspect area in two directions, transverse (X) and longitudinal (Y). The suspect location shall be 100 % scanned as described in 7.4.a). During the transverse scan, the positions X1 and X2 shall be determined, where, over the greatest transverse extent, the magnitude of the intermediate reflection equals half the related maximum value (6 dB difference in signal level). If this value is less than the minimum allowable width to be considered, no further explorations shall be done. Similarly, during the longitudinal scan, the positions Y1 and Y2 are determined. The distances between point X1 and X2 and Y1 and Y2 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.

B.3 Surface condition

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

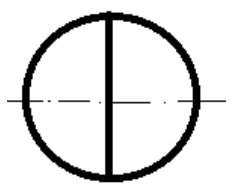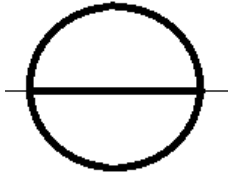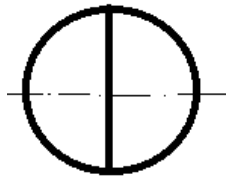### B.4 Test equipment requirements

B.4.1 The ultrasonic probe shall be guided over the tube either manually or by mechanical means. The ultrasound shall be transmitted in the direction normal to the tube surface.

B.4.2 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 so that the ultrasonic signals from the laminated suspect area to be evaluated are between 20 % and 80 % of the usable height of the screen display.

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

B.4.3 If twin crystal probes are used for manual determination of the size of the laminated suspect area, the details given in table B.1 shall be noted.

Table B.1

Probe-to-lamination distance	Type of twin crystal probe	Plane of acoustic separation
≤ 20 mm	either – Nominal frequency: 4 MHz – Transducer angle: approx. 5° – Transducer size: 8 to 12,5 mm – Focal depth: approx. 10 to 12 mm	At right angles to PRD [1]
	or – Nominal frequency: 4 MHz – Transducer angle: approx. 0° – Transducer size: 18 to 20 mm – Focal depth: approx. 10 to 12 mm	Parallel to PRD [1]
> 20 mm	– Nominal frequency: 4 MHz – Transducer angle: approx. 0° – Transducer size: 18 to 20 mm – Focal depth: approx. 25 to 60 mm	At right angles to PRD [1]
1) PRD = Principal rolling direction		