

Non-destructive testing of steel tubes —

**Part 2: Automatic eddy current testing of
seamless and welded (except submerged
arc welded) austenitic and
austenitic-ferritic steel tubes for
verification of hydraulic leak-tightness**



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The European Standard EN 10246-2:2000 has the status of a
British Standard

ICS 23.040.10; 77.040.20

National foreword

This British Standard is the official English language version of EN 10246-2:2000.

This British Standard contains elements of BS 3889, *Non-destructive testing of pipes and tubes — Part 2A: Automatic eddy current testing of wrought steel tubes*. A complete list of the parts of EN 10246 is given in annex A of this standard. When all relevant parts have been published BS 3889-2A:1986 will be withdrawn.

The UK participation in its preparation was entrusted by Technical Committee ISE/73, Steels 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 European committee any enquiries on the interpretation, or proposals for change, and keep the 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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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 13 and a back cover.

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This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 June 2000

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ISBN 0 580 34175 5

Amendments issued since publication

Amd. No.	Date	Comments

English version

Non-destructive testing of steel tubes – Part 2: Automatic eddy current testing of seamless and welded (except submerged arc-welded) austenitic and austenitic-ferritic steel tubes for verification of hydraulic leak-tightness

Essais non destructifs sur des tubes en acier – Partie 2:
Contrôle automatique par courants de Foucault des tubes
en aciers austénitiques et austéno-ferritiques sans soudure et
soudés (sauf à l'arc immergé sous flux en poudre) pour
vérification de l'étanchéité hydraulique

Zerstörungsfreie Prüfung von Stahlrohren – Teil 2:
Automatische Wirbelstromprüfung nahtloser und
geschweißter (ausgenommen unterpulvergeschweißter)
austenitischer und austenitisch-ferritischer Stahlrohre zum
Nachweis der Dichtheit

This European Standard was approved by CEN on 25 December 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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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 August 2000, and conflicting national standards shall be withdrawn at the latest by August 2000.

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 eddy current testing of seamless and welded austenitic and austenitic-ferritic steel tubes with the exception of submerged arc-welded (SAW) tubes for verification of hydraulic leak-tightness. The standard specifies acceptance levels, calibration procedures and gives guidance on the limitations of the tests.

This part of EN 10246 is applicable to the inspection of tubes with an outside diameter equal to or greater than 4 mm.

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

2 NORMATIVE REFERENCES

This European Standard 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 these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 20286-2	ISO system of limits and fits - Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts (ISO 286-2:1988)
EN ISO1127	Stainless steel tubes - Dimensions, tolerances and conventional masses per unit length (ISO 1127:1992)
ISO 235	Parallel shank jobber and stub series drills and Morse taper shank drills

3 GENERAL REQUIREMENTS

3.1 The eddy current 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 for verification of hydraulic leak-tightness by eddy current testing using one of the following techniques:

- a) concentric coil (see figure 1);
- b) segment coil(s) (see figure 2);
- c) rotating tube/pancake coil (see figure 3).

It is recognized that under normal production conditions there may, as with hydraulic pressure testing, be a short length at both tube ends which cannot be tested.

NOTE: For guidelines on the limitation of eddy current test methods, see Annex B.

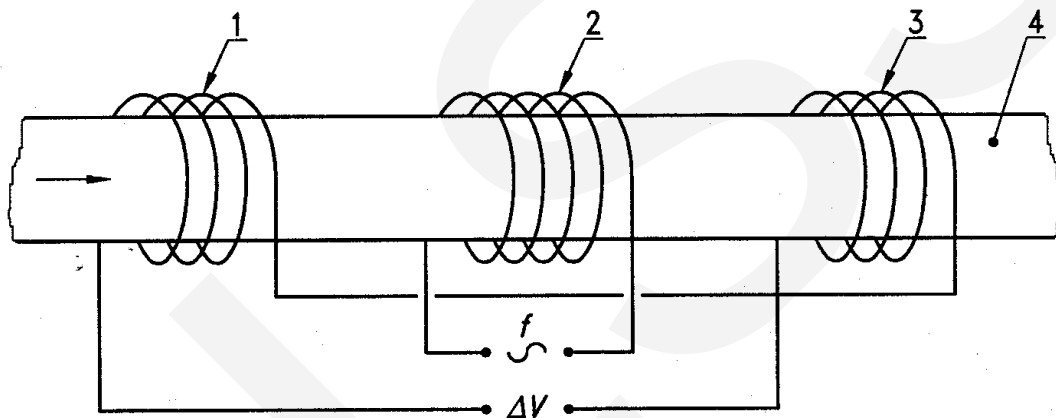
4.2 When testing tubes using the concentric coil technique, the maximum outside diameter of the tube to be tested is restricted to 180 mm.

4.3 When testing tubes using the segment coil technique, the maximum outside diameter of the tube to be tested is limited to:

- 219,1 mm for 2 x 180° coils;
- 508,0 mm for 4 x 100° coils.

4.4 When testing tubes using the rotating tube/pancake coil technique, the tube and pancake coil(s) shall be moved relative to each other so that the whole of the tube surface is scanned. There is no restriction on the maximum outside diameter using this technique.

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



1 = secondary coil 1

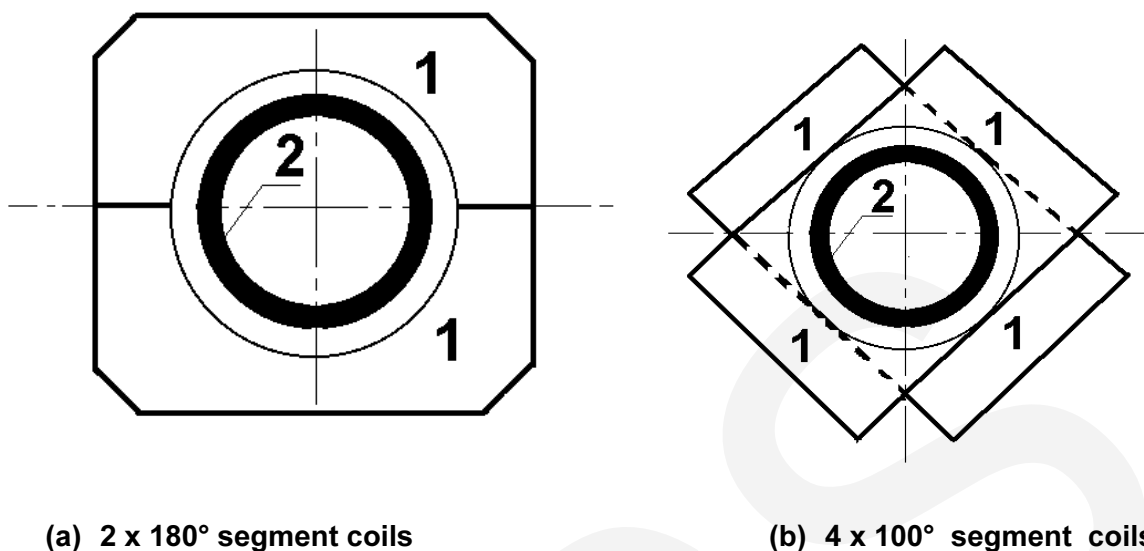
2 = primary coil

3 = secondary coil 2

4 = Tube

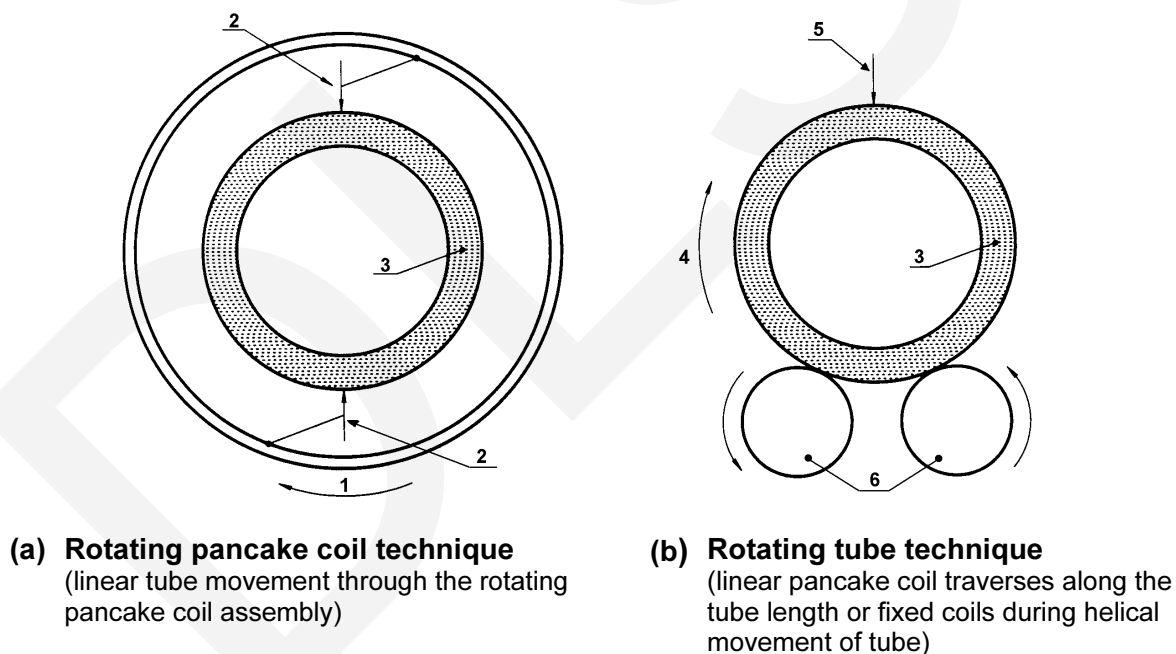
NOTE: The above diagram is a simplified form of a multi-coil arrangement which may contain, for example, split primary coils, twin differential coil, a calibrator coil.

Figure 1 - Simplified diagram of the concentric coil technique



1 = segment coil 2 = tube

Figure 2 - Simplified diagram of the segment coil technique



1 = pancake coil rotation 2 = pancake coil 3 = tube 4 = tube rotation
5 = fixed pancake coil 6 = turning rolls

NOTE: The pancake coils in a) and b) may have different forms, e.g. single-coils, multiple coils of different configurations, depending on the equipment used and other factors.

Figure 3 - Simplified diagram of the rotating tube/pancake coil technique (helical scan)

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 testing equipment shall be calibrated using a reference standard machined into a tubular test piece. The test piece shall be of the same specified diameter, thickness and surface finish as the tube to be tested and shall have similar electromagnetic properties.

NOTE: In special cases, for example testing hot tubes, a modified calibration procedure can be used by agreement.

5.1.3 The reference standards for the various techniques shall be as follows:

- a) a reference hole or holes as defined in 5.2 when using the concentric coil technique;
- b) a reference hole or holes as defined in 5.3 when using the segment coil technique;
- c) a reference notch as defined in 5.4 when using the rotating tube/pancake coil technique.

5.1.4 The reference holes defined in clauses 5.2 and 5.3 shall meet the requirements of table 1.

The diameter of the reference hole or reference holes shall be verified and shall not exceed the specified drill diameter by more than 10 %.

Table 1: Drill to be used for producing the reference hole as a function of the tube diameter

Outside diameter of tube, $D^{1)}$ mm	Drill diameter ²⁾ mm
$D \leq 25$	1,2
$25 < D \leq 45$	1,7
$45 < D \leq 65$	2,2
$65 < D \leq 140$	2,7
$140 < D \leq 180$	3,2
$180 < D^{3)}$	3,2
¹⁾ See EN ISO 1127 ²⁾ Tolerances in accordance with ISO 235 (jobber series) and EN 20286-2 (h8) ³⁾ This applies only to the segment coil technique.	

5.2 Concentric coil technique

When using the concentric coil technique, the test piece shall contain three circular holes, drilled radially through the full thickness of the test piece. The three holes shall be circumferentially displaced 120° from each other, and shall be sufficiently separated longitudinally and from the ends of the test piece so that clearly distinguishable signal indications are obtained.

Alternatively, only one hole shall be drilled through the full thickness of the test piece and during calibration and calibration checking, the test piece shall be passed through the equipment with the hole positioned at 0° , 90° , 180° and 270° .

5.3 Segment coil technique

When using the segment coil technique, the test piece shall contain three circular holes, drilled radially through the full thickness of the test piece. The three holes shall be displaced as follows:

- 180° segment coils: 0° , $+90^\circ$ and -90° from the centre of the coil;
- 100° segment coils: 0° , $+45^\circ$ and -45° from the centre of the coil.

The holes shall be sufficiently separated longitudinally and from the ends of the test piece that clearly distinguishable signal indications are obtained.

Alternatively, only one hole shall be drilled through the full thickness of the test piece and during calibration and calibration checking the test piece shall be passed through the equipment with the hole positioned at 0° , $+90^\circ$ and -90° for the 180° segment coil and at 0° , $+45^\circ$ and -45° for the 100° segment coil.

5.4 Rotating tube/pancake coil technique

5.4.1 When using the rotating tube/pancake-coil technique, the test piece shall contain a longitudinal reference notch on the external surface.

5.4.2 The reference notch shall be sufficiently separated from the ends of the test piece that clearly distinguishable signal indications are obtained.

5.4.3 The reference notch shall be of the 'N' type (see figure 4) and shall lie parallel to the major axis of the tube. The sides shall be nominally parallel and the bottom shall be nominally square to the sides.

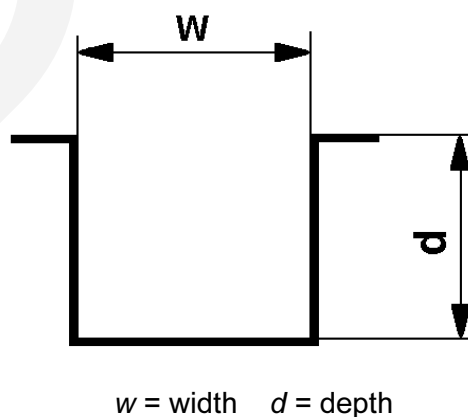


Figure 4 – 'N' type notch

5.4.4 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.

5.4.5 The dimensions of the notch shall be as follows:

a) width w (see figure 4):

the width of the reference notch shall not be greater than the depth of the reference notch depth;

b) depth d (see figure 4):

the depth of the reference notch shall be 12,5 % of the specified thickness with the following limitations:

- minimum notch depth: 0,5 mm;
- maximum notch depth: 1,5 mm;

c) tolerance on notch depth:

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

d) length:

the length of the reference notch shall be at least twice the width of each individual transducer, with a maximum of 50 mm.

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

6 EQUIPMENT CALIBRATION AND CHECKING

6.1 The equipment shall be calibrated to produce consistently, (e.g. from three consecutive passes of the test piece through the equipment), clearly identifiable signals from the reference standard. These signals shall be used to set the trigger/alarm level(s) of the equipment as follows.

a) When using multiple reference holes in the test piece (concentric coil and segment coil techniques), the full amplitude obtained from the reference hole giving the smallest signal shall be used to set trigger/alarm level of the equipment.

b) When using a single reference hole, the test piece shall be passed through the inspection equipment with the reference hole, on successive runs, positioned as specified in 5.2 and 5.3 and the full amplitude obtained from the reference hole run giving the smallest signal shall be used to set trigger/alarm level of the equipment.

c) When using the reference notch (rotating tube/pancake coil technique), the full signal amplitude shall be used to set the trigger/alarm level of the equipment.

After calibration, using single or multiple reference hole (see a) and b) above), and before the production run, the sensitivity shall be increased by:

- + 4 dB for seamless tubes;
- + 6 dB for welded tubes.

6.2 During the calibration check, the relative speed of movement between the test piece and the test coil shall be the same as that to be used during production testing. The same equipment settings, e.g. frequency, sensitivity, phase discrimination, rate filtering, magnetic saturation, shall be employed.

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 by passing the test piece through the test equipment.

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.

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 dressed or explored by using a suitable method. After checking that the remaining thickness is within tolerance, the tube shall be retested as previously specified. If no signal is 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 methods with agreed acceptance levels, by agreement between the purchaser and manufacturer.

- b) Unless otherwise agreed between the purchaser and manufacturer, each suspect tube shall be subjected to a hydraulic leak-tightness test to verify the tightness in accordance with the relevant product standard.
- c) The suspect area shall be cropped off. The manufacturer shall ensure that all the suspect area has been removed.
- d) 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) statement of conformity;
- d) product designation by grade and size;
- e) type and details of inspection technique;
- f) description of the reference standard.

ANNEX A (informative)

Table A.1: 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 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 automatic fusion 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 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 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 **(informative)**

Guidelines notes on the limitations associated with the eddy current test methods

B.1 General

It should be noted that during the eddy current testing of tubes, the test sensitivity is at its maximum on the tube surface adjacent to the test coil and decreases with increasing distance from the test coil. The signal response from a subsurface or internal surface imperfection is thus smaller than that from an external imperfection of the same size. The capability of the test equipment to detect subsurface imperfections is determined by various factors, but predominantly by the thickness of the tube under test and the eddy current excitation frequency.

The excitation frequency applied to the test coil determines the extent to which the induced eddy current penetrates into the tube wall. The higher the excitation frequency the lower the penetration and conversely the lower the excitation frequency the greater the penetration; particular account should be taken of the tube physical parameters (e.g. conductivity, permeability).

B.2 Concentric coil/segment coil techniques

These techniques are preferred as they can detect short longitudinal imperfections and transverse imperfections, both of which break, or lie below, the surface adjacent to the test coil.

The minimum length of the longitudinal imperfections which is detectable is principally determined by the search coil arrangement and by the rate of changes of section along the length of the imperfections.

B.3 Pancake coil technique

This test technique utilizes one or more pancake coils to describe a helical path over the tube surface. For this reason the technique detects longitudinal imperfections having a minimum length dependent on the width of the test coil and the inspection helical pitch. It is recognized that transverse imperfection are not normally detectable

Since the excitation frequency is significant higher than that using concentric coils, only imperfections which break the surface adjacent to the test coil are detectable.

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