

INTERNATIONAL STANDARD

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Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of longitudinal imperfections

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Tubes en acier sans soudure et soudés (sauf à l'arc immergé) pour service sous pression — Contrôle par flux de fuite à l'aide de palpeurs magnétiques sur toute la circonférence des tubes d'aciers ferromagnétiques pour la détection des imperfections longitudinales

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Reference number
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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 9402 was prepared by Technical Committee ISO/TC 17, *Steel*.

[ISO 9402:1989](https://standards.iteh.ai/catalog/standards/sist/30e83cbe-e471-4490-a2f5-43c4264bc3eb/iso-9402-1989)

Annex A of this International Standard is for information only.

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Introduction

This International Standard concerns full peripheral magnetic transducer/flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for pressure purposes for the detection of longitudinal imperfections.

Three different acceptance levels are considered (see table 1). The choice between these acceptance levels is within the province of the ISO Technical Committee responsible for the development of the relevant quality standards.

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Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of longitudinal imperfections

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1 Scope

1.1 This International Standard specifies requirements for full peripheral magnetic transducer/flux leakage testing of seamless and welded ferromagnetic steel tubes for pressure purposes, with the exception of submerged arc-welded (SAW) tubes, for the detection of longitudinal imperfections, according to three different acceptance levels (see table 1).

1.2 This International Standard has been prepared with the knowledge that magnetic transducer/flux leakage testing has technical limitations in that the sensitivity of the test is at a maximum at the tube surface adjacent to the magnetic transducer and decreases with increasing tube thickness. As a result this standard recognizes that above certain tube thicknesses for a given acceptance level, it is necessary for the internal notch depth to be increased in excess of that specified for the external notch by an amount to be agreed between purchaser and manufacturer (see annex A).

1.3 This International Standard is applicable to the inspection of tubes with an outside diameter greater than or equal to 9 mm.

2 General requirements

2.1 The magnetic transducer/flux leakage inspection covered by this International Standard is usually carried out on tubes after completion of all the production process operations.

This inspection shall be carried out by suitably trained operators and supervised by competent personnel nominated by the manufacturer. In the case of third-party inspection, this shall be agreed between the purchaser and 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 tube shall be tested using a magnetic transducer/flux leakage technique for the detection of predominantly longitudinal imperfections. See figure 1.

No limits on thickness are specified, but it is emphasized that the effectiveness of the technique decreases with increasing thickness (see 1.2 and annex A).

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

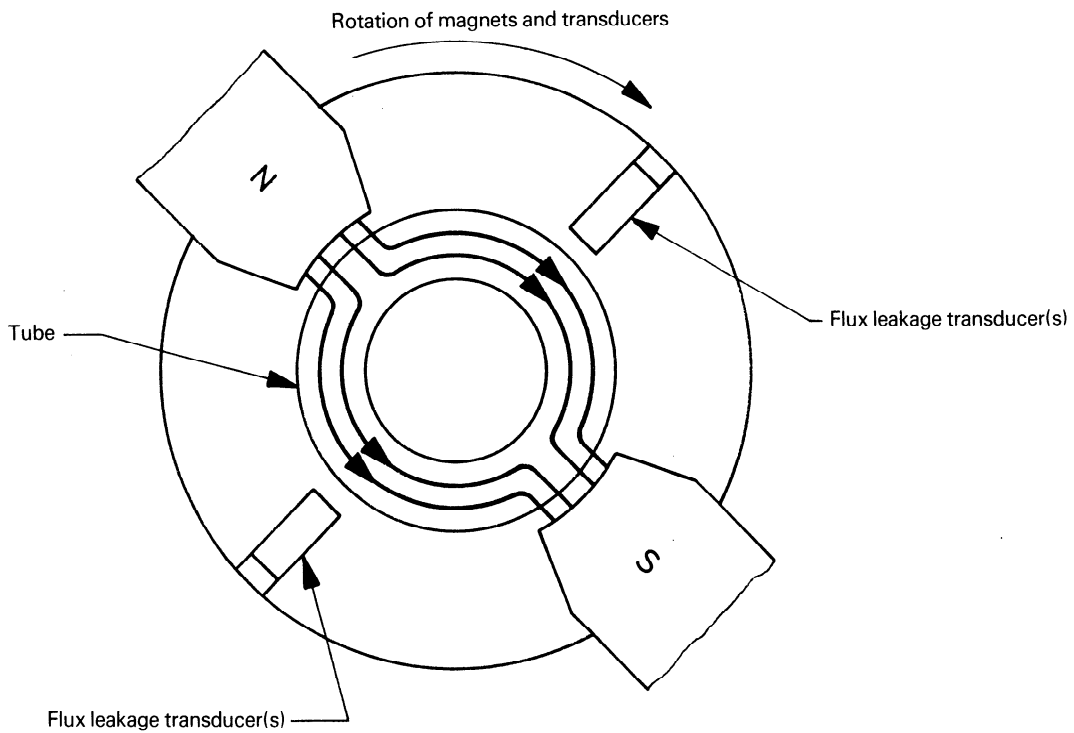
NOTE — It is recognized that there is a short length at both tube ends which may not be able to be tested.

3.3 The maximum width of each individual transducer, measured parallel to the major axis of the tube, shall be 30 mm.

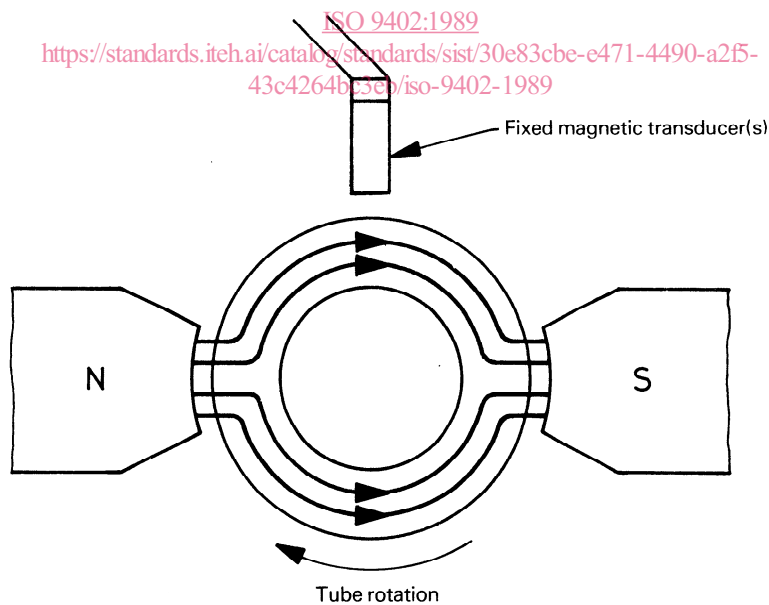
3.4 The equipment for automatic testing shall be capable of differentiating between acceptable and suspect tubes by means of an automatic trigger/alarm level combined with a marking and/or sorting system.

4 Reference standards

4.1 The reference standards defined in this International Standard are convenient standards for calibration of non-



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 a) Rotating magnetic transducer technique (rotating magnets and transducers)
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b) Rotating tube technique [fixed magnets and magnetic transducer(s)]

NOTE — The magnetic transducers used in a) and b) above may take many forms, for example absolute, differential, multidifferential, etc. depending on the equipment used and other factors.

Figure 1 — Simplified diagram of rotating tube/magnetic transducer flux leakage technique

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 magnetic transducer/flux leakage equipment shall be calibrated using a longitudinal reference notch on the outside and inside surfaces, or the outside surface only, (see note below) of a tubular test piece.

Alternatively, a reference hole drilled radially through the full thickness of the test piece may be used for equipment calibration by agreement between purchaser and manufacturer.

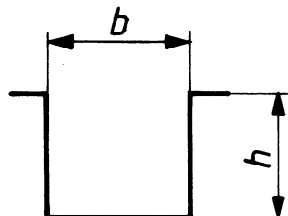
In this case the diameter of the drill required to produce the reference hole for a specific acceptance level shall also be agreed upon and the manufacturer shall demonstrate to the satisfaction of the purchaser that the test sensitivity achieved using the reference hole and the equipment settings, for example signal rate filtering, etc., is essentially equivalent to that obtained when using the specified external reference notch and the agreed internal reference notch depth.

NOTE — The internal notch should not be used when the tube internal diameter is less than 15 mm, unless otherwise agreed between purchaser and manufacturer, or when the tube thickness is greater than 20 mm since, due to the technical limitations given in annex A, the test at the tube bore is not adequate even after applying the maximum ratios given in table 2.

4.3 The test piece shall have the same nominal diameter, thickness and surface finish as the tube to be tested and shall have similar electromagnetic properties.

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

4.5 The reference notch or notches shall be of the "N" type (see figure 2) 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.



$b = \text{width}$ $h = \text{depth}$

Figure 2 — "N"-type notch

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.

4.7 The diameter of the reference hole, when used, shall be verified and shall not exceed the specified drill diameter by more than 0,2 mm.

5 Dimensions of reference notches

The dimensions of the reference notches shall be as follows.

5.1 Width, b (see figure 2)

Not greater than the reference notch depth.

5.2 Depth, h (see figure 2)

5.2.1 External notch depth

As given in table 1 :

Table 1

Acceptance level	External notch depth in % of the specified thickness
L 2	5
L 3	10
L 4	12,5

NOTE — The values of external 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 a 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.

5.2.2 Internal notch depth

The internal notch depth shall be subject to agreement between purchaser and manufacturer (see annex A for guidance) but in no circumstances shall be less than the specified external notch depth or greater than that when applying the maximum ratios given in table A.1.

5.2.3 Minimum notch depth

The minimum notch depth shall be 0,3 mm for L 2 category tubes and 0,5 mm for L 3 and L 4 category tubes.

5.2.4 Maximum notch depth

The maximum external notch depth shall be 1,5 mm and the maximum internal notch depth shall be 3 mm.

5.2.5 Tolerance on depth, h

$\pm 15\%$ of reference notch depth or $\pm 0,05$ mm, whichever is the larger.

5.3 Length

The reference notch or notches shall be of a convenient length selected by the manufacturer for calibration and checking purposes.

5.4 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, to the satisfaction of the purchaser, clearly identifiable signals from the reference standard(s). The full amplitude of these signals shall be used to set the 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.

6.3 The calibration of the equipment shall be checked at regular intervals during the production testing of tubes of the same 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 h 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 h maximum period may be extended by agreement between purchaser and manufacturer.

6.4 The equipment shall be recalibrated following any system adjustments or whenever the specified nominal tube diameter, thickness, or grade of steel is 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.

Retesting shall not be necessary even after a drop in test sensitivity of more than 3 dB since the previous calibration, provided that suitable recordings from individually identifiable tubes are available which permit accurate classification into suspect and acceptable categories.

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 retested 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 report

When specified, the manufacturer shall submit to the purchaser a test report that includes, at least, the following information :

- a) reference to this International Standard;
- b) date of test report;
- c) acceptance level;
- d) statement of conformity;
- e) material designation by grade and size;
- f) type and details of inspection technique;
- g) description of the reference standard.

Annex A (informative)

Guidance notes on limitations of the magnetic transducer/flux leakage technique

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

As a result, above certain tube thicknesses, it is necessary for the internal notch depth to be increased in excess of that specified for the external notch depth by an amount to be agreed between purchaser and manufacturer, dependent on for example the type of equipment in use and the surface condition of the tube to be tested etc., but generally in accordance with table A.1.

Table A.1

Tube thickness δ mm	Maximum ratio of	Internal notch depth External notch depth
	L 2	L 3/L 4
$\delta < 12$	2,0 ¹⁾	1,2
$12 < \delta \leq 15$	2,5	1,5
$15 < \delta \leq 20$	3,0	2,0
1) Minimum internal notch depth : 0,4 mm.		