BS EN 3718:2012

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Aerospace series — Test method for metallic materials — Ultrasonic inspection of tubes

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee ACE/61/-/5, Non - Destructive Testing of Metallic Materials for Aerospace Purposes.

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

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EN 3718

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English Version

Aerospace series - Test method for metallic materials - Ultrasonic inspection of tubes

Série aérospatiale - Méthode d'essai applicable aux matériaux métalliques - Contrôle par ultrasons des tubes

Luft- und Raumfahrt - Prüfverfahren für metallische Werkstoffe - Ultraschallprüfung von Rohren

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 3718:2012) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

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of an identical text or by endorsement, at the latest by September 2012, and conflicting national standards shall be withdrawn at the latest by September 2012.

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1 Scope

This European Standard specifies the requirements for ultrasonic inspection of tubes in metallic materials with an external diameter ≥ 5 mm.

For other cases, the use of this standard is by agreement between the manufacturer and the purchaser.

The purpose of the ultrasonic inspection is the detection of defects within the wall thickness and at the outer and inner surfaces of the tube. The method will detect two dimensional defects in the longitudinal and circumferential directions perpendicular to the tube wall. Where inspection for other types of defects is required, this requirements should be stated on the order.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 2078, *Aerospace series — Metallic materials — Manufacturing schedule, inspection schedule, inspection and test report — Definition, general principles, preparation and approval*

EN 4050-1, *Aerospace series — Test method for metallic materials — Ultrasonic inspection of bars, plates, forging stock and forgings — Part 1: General requirements* [1)]

EN 4179, *Aerospace series — Qualification and approval of personnel for non-destructive testing*

ISO 7963, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 2*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 4050-1 apply.

4 Short description of the procedure

The inspection shall be carried out using ultrasonic test equipment, which emits ultrasonic signals passing through a liquid coupling medium obliquely into the tube under test and which receives and evaluates the reflected (or transmitted) signals. The tubes shall be inspected automatically and completely i.e. the relative movement of probe and tube under test shall be accomplished with the aid of a manipulator. The corresponding signal amplitudes from the ultrasonic test equipment shall be plotted as a function of the location, e.g. amplitude scans or C-scans.

5 Equipment requirements

5.1 Calibration blocks

Calibration blocks as per ISO 7963 or equivalent standards shall be used to check the proper function and characteristics of the ultrasonic test unit and probes. The method of checking the equipment and requirements concerning the calibration blocks shall be agreed between the manufacturer and the purchaser.

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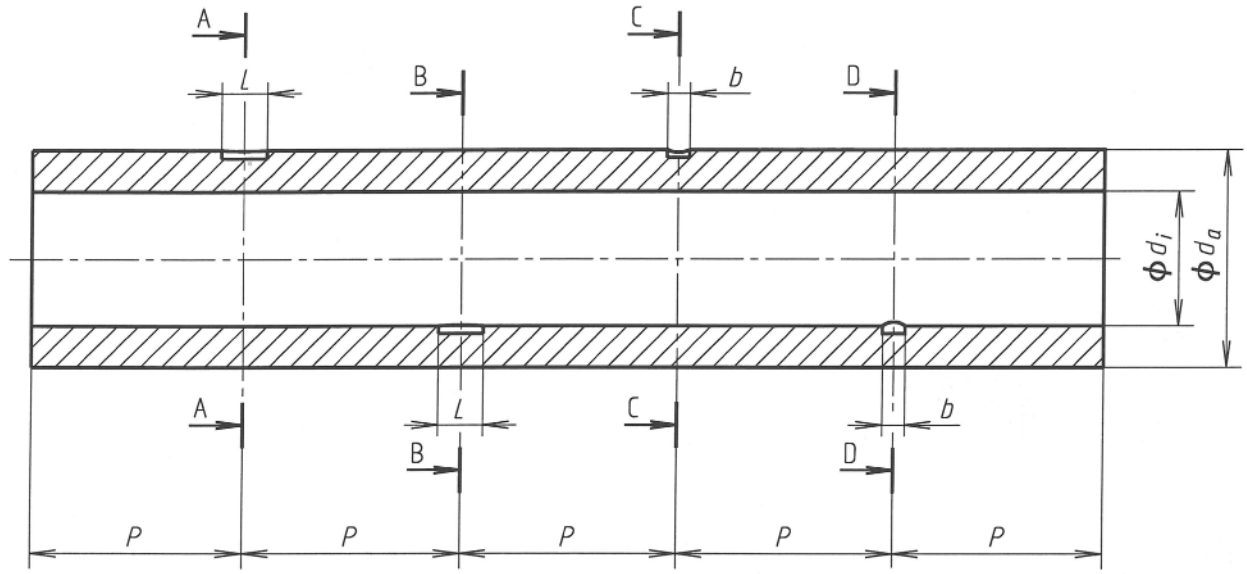
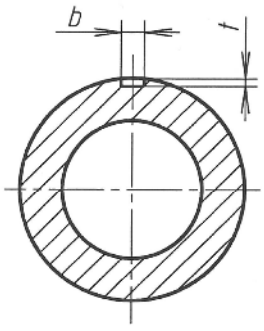
1) Published as ASD-STAN Prestandard at the date of publication of this standard (www.asd-stan.org).

5.2 Reference specimens

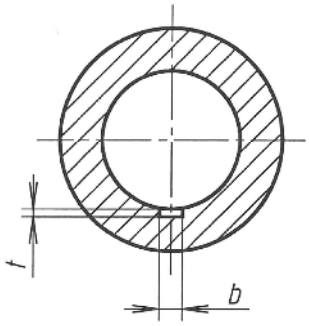
A reference specimen shall be fabricated from a tube consisting of the same material, having the same nominal diameter, wall thickness, surface condition and heat treatment condition as the tubes to be inspected. The selected length of the reference specimen shall be such that it can be tested in the test system described below. The reference specimen shall not have any defects or other irregularities that can produce indications or interfere with the detection of the reference notches. Four reference notches of the same dimensions (depth, width, length) as shown in Figure 1 shall be introduced in each tube. The depth, width and length of the notches are defined in Table 1 and subdivided into classes.



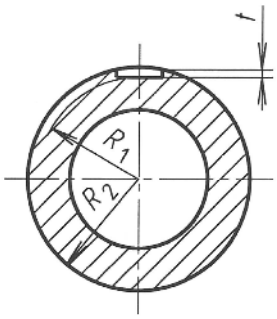
A-A
Longitudinal defects



B.B
Longitudinal defects

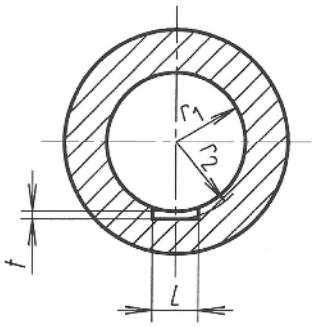


C-C
Circumferential defects



$$R_2 = R_1 + t \qquad R_2 = \frac{d_a}{2}$$

D-D
Circumferential defects



$$r_2 = r_1 + t \qquad r_2 = \frac{d_i}{2}$$

t = Depth
b = Widht
L = Length
d_i = Internal diameter
d_a = External diameter
$P \geq 20$ mm

Figure 1 — Reference specimen with four notches in longitudinal and circumferential direction on the inner and outer surface of the tube wall

Table 1 — Reference notch dimensions

Dimensions in millimetres

Class	Depth	Length	Width
5	0,05	1,5	0,10
4	0,05	3,0	0,10
3	0,08	3,0	0,10
2	0,10	3,0	0,10
1	5 % of *a* [a]	6,0	0,10

[a] *a* is wall thickness in millimetres.

The reference notches shall be rectangular for notches in the longitudinal direction and shall have the shape of a ring segment in the circumferential direction and edge radii ≤ 0,13 mm. The depth of the notch shall correspond to a mean value, measured from the tube surface to the respective penetration depth of the notch. Notch dimensions shall comply with the values specified in Table 1 to within ± 15 %.

The notch depth shall be measured from the circular surface to the deepest penetration of the notch. Measurements may be made by replication or by a destructive method on a duplicate notch which has identical ultrasonic response (amplitude within 90 % to 110 % of the reference notch amplitude).

In order to have access to notches lying inside the reference specimen, a window may be cut into the opposite tube wall to provide access to the notch. The window shall not be so large as to interfere with the ultrasonic responses from the notch.

Each reference specimen shall be identified. The serial number and EN 3718 shall be permanently marked on the reference specimen and the following information shall either be marked on the specimen or maintained in a log book: alloy, heat treatment condition, diameter, wall thickness, size and location of reference notches.

5.3 Ultrasonic test equipment

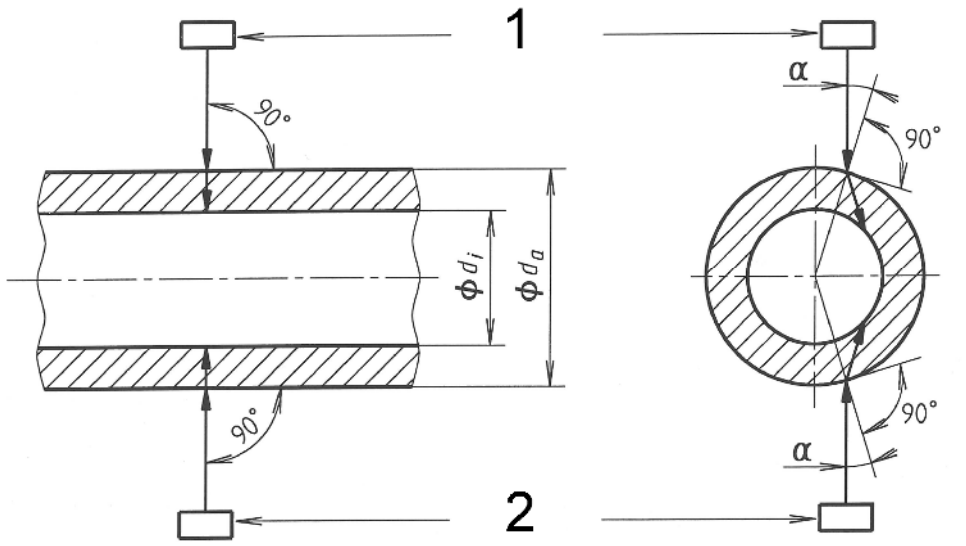
The ultrasonic test equipment shall be of the pulse echo type with appropriate signal outputs for registration of the measuring values.

5.4 Probes and probe arrangement

In view of the geometry of the defects anticipated, the use of spherical or cylindrical focused probes as determined by the specified notch dimensions is recommended.

For the ultrasonic echo inspection to detect defects running primarily in the longitudinal or circumferential direction of the tube, identical probes shall be used to achieve oblique incidence on both sides of the tube. The probes shall be sufficiently far apart to ensure that they will not influence one another. It is also possible to use just one probe on one side, although it is then necessary to inspect from the other side in a subsequent run.

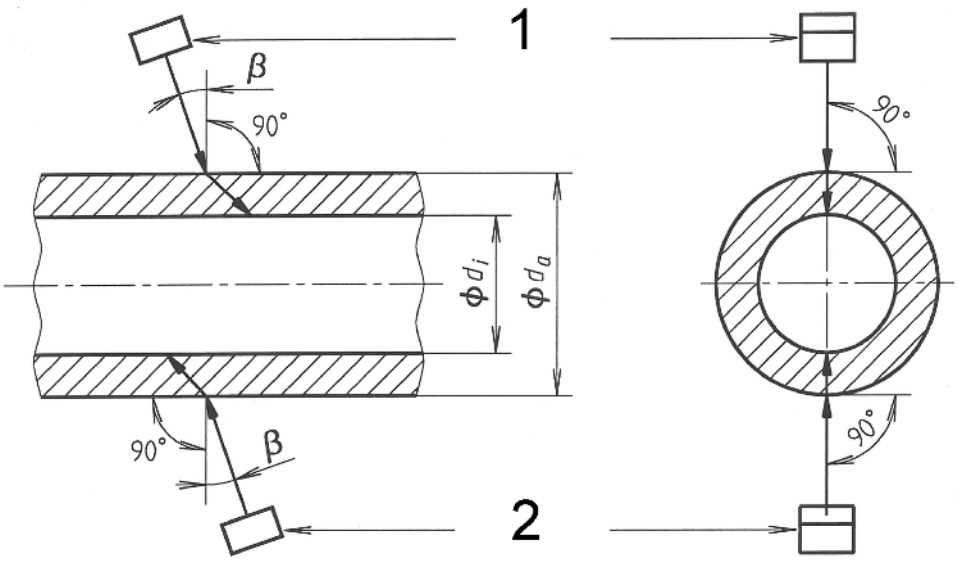
For example, the inspection of steel tube may be carried out by using 45° transverse waves. In this case the angle of incidence in water is approximatively 17° for detection of defects in longitudinal tube direction (see Figure 2), and approximatively 19° for detection of defects in circumferential tube direction (see Figure 3).



Key

1 Probe 1
2 Probe 2

Figure 2 — Oblique incidence on both sides to detect defects in longitudinal direction of the tube $\alpha = 17°$



Key

1 Probe 1
2 Probe 2

Figure 3 — Oblique incidence on both sides to detect defects in circumferential direction of the tube $\beta = 19°$

5.5 Coupling

A liquid couplant such as water, oil or glycerine shall be used for conduction of the ultrasonic longitudinal waves between the probes and the tube wall.

Wetting or anti-corrosion agents may be added to the couplant, provided that the surface conditions of the tube is not impaired. Bubbles are not allowed in order to avoid any disturbance of the transmission of sound.

Sound coupling may be achieved by immersion of the probe and tube. Coupling is also possible by having a local stream of fluid between the two, whilst ensuring that the flow is not turbulent (squirter technique).

5.6 Manipulator

Using a manipulator, the helix and rotational speed shall be such that two return signals are recorded from the reference notch. The two signals shall not be more than 6 dB lower than the maximum indication of the reference notch. See Figure 4.

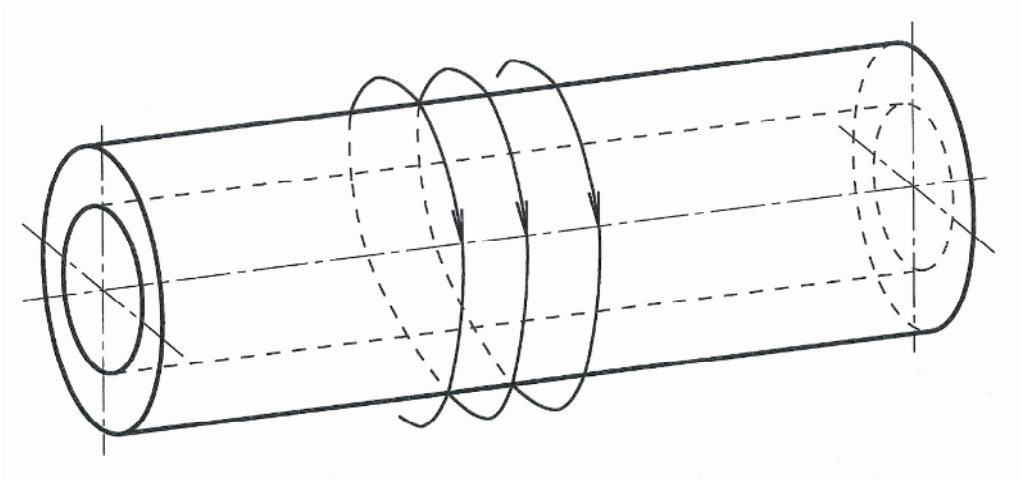


Figure 4 — Test trace in the case of helical movement

5.7 Evaluation and recording unit

The ultrasonic signals of interest received by the ultrasonic apparatus, shall be gated out and their amplitudes registered by a recorder plotting them as a function of the respective location on the tube. Evaluation and recording is also possible by using a computer and a plotter for producing amplitude scans or C-scans.

5.8 Detection sensitivity of the equipment

The inspection equipment and the procedure for the respective type of defect primarily to be found (see description of reference specimen in 5.2) shall fulfil the following requirements with regard to detection sensitivity:

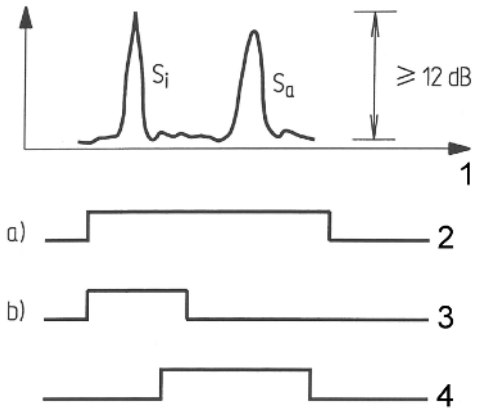
— indication of the corresponding notch of the reference specimen for the respective tube type with a signal-to-noise ratio of at least 12 dB (with reference to faultless condition). In the case of external defects, indications shall be based on a one-skip-distance arrangement;

— complete separation time-wise of the evaluation signal from any other signal (e.g. surface signal);

— demonstration of reproducibility by means of plots.

One procedure is normally required for each main type of defect, however the following simplifications are possible:

— if the signal indications of the reference notches in longitudinal (or circumferential) tube direction fulfil the above-mentioned criteria on the inside and outside and do not differ by more than 10 %, the tubes may be simultaneously inspected for internal and external defects in longitudinal (and circumferential) direction of the tube. In this case, the entire time range of the signal from the inner and outer notch shall be gated in one or two channels (see Figure 5) and evaluated on the basis of the one channel threshold level.



Key

1 Time
2 One channel
3 Channel 1
4 Channel 2

Figure 5 — Gating of signals S_i (inner notch) and S_a (outer notch)

6 Preparation for inspection

6.1 Check of tubing surface

The inner and outer surfaces of the tubes shall be clean and free from damage, dirt, grease, paint and any other surface contamination which might affect the interpretation of the inspection results. Neither the metal nor its final surface condition shall be impaired by the surface cleaning and pretreatment procedures carried out prior to the ultrasonic inspection. The inner surface shall be dry to avoid false indications from fluid droplets. Tubes shall be plugged. The mean depth of surface roughness R_a shall not exceed 2,5 µm.

6.2 Instrument calibration

Using the reference specimen as per 5.2, the test equipment shall be set to a certain indication value with reference to the respective reference notch(es) subsequent to completion of the time adjustment (path adjustment). Adjustment shall be carried out under dynamic conditions; one plot of a reference specimen shall be kept to document the correct adjustment.

The helical scan pitch and rotational speed shall be such that the respective reference notch always produces at least two indications on two adjacent traces. The two signals shall not be more than 6 dB lower than the maximum indication of the reference notch. For tubes with a wall thickness < 1,5 mm the focus shall be in the tube wall.

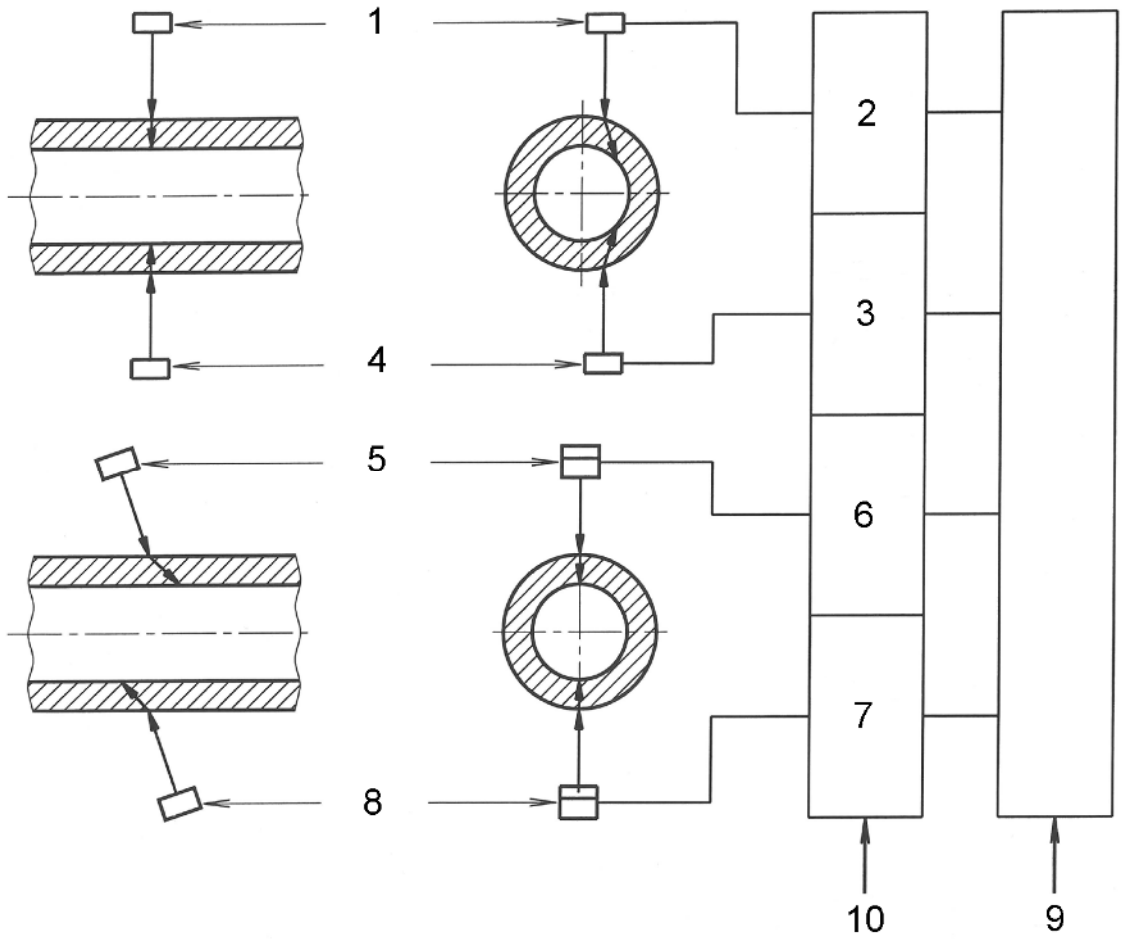
Water path shall be adjusted so that the focal spot of the source beam lies at the middle of the wall thickness of the tube during calibration and inspection.

The adjustment of the overall system prior to and after tube inspection shall be checked at intervals as agreed between manufacturer and purchaser, using the corresponding reference specimen. Deviations on the plots shall not exceed 10 %; if they do the tube inspection, carried out in this workshift, shall be repeated.

7 Inspection procedure

The tubes shall be inspected under identical conditions to those applied during instrument calibration. Identical conditions shall include all instrument settings, mechanical motions, probe arrangement and position relative to the tube, liquid coupling and any other factors that affect the performance of the inspection.

The inspection shall be carried out in one direction, either with oblique incidence on both sides as illustrated in Figure 2 and Figure 3, or with oblique incidence from one side with additional run with oblique incidence from the opposite side. Figure 6 shows an example of a complete tube inspection in one run: the simplified procedure of inspecting for internal and external defects simultaneously as outlined in 5.8.



Key

1 Probe 1
2 Channel 1
3 Channel 2
4 Probe 2
5 Probe 3
6 Channel 3
7 Channel 4
8 Probe 4
9 Evaluation and recording unit
10 Ultrasonic equipment

Figure 6 — Example of a tube inspection: Inspection in one run simultaneously for internal and external defects in longitudinal and circumferential tube directions, rigid mechanical coupling of the four probes to one another

8 Evaluation

Signal indications ≥ 50 % (6 dB) of the maximum value of the corresponding reference notch (see 5.2) shall be marked on the plots. By using C-scans, this will be achieved automatically when the threshold level has been attained.

— Sections of the tube showing no indications on any channels are satisfactory;

— Sections of the tube showing indications on one or more channels on consecutive circumferential scans are defective;

— Sections of the tube showing indications on only one circumferential scan on one or more channels will require investigations while varying the angle of incidence. If the indication is confirmed the tube shall be recorded as defective.

Tubes inspected in the appropriate way and not revealing any faulty areas shall be regarded as satisfactory.

Any reworking, where permitted by the material standard shall be carried out with great care to ensure that acceptance is not impeded by changes with respect to material standard, such as unacceptable changes in wall thickness, ovality, final surface condition, length, etc.

9 Written instruction

An inspection schedule shall be prepared in accordance with the requirements of EN 2078. The schedule shall identify the type of ultrasonic equipment, method(s) of test, ultrasonic test reference, search unit type, style, and frequency, search unit qualification, fixturing, method of reporting indications and all other instructions that pertain to the actual test. Procedures shall be detailed sufficiently that another investigator qualified as in Clause 10 could duplicate the test and obtain equivalent information.

10 Qualification and approval of personnel

Ultrasonic testing of tubes as per this standard shall only be carried out and supervised by personnel qualified and approved in accordance with EN 4179.

11 Inspection and test report

An inspection report shall be prepared in accordance with EN 2078. In addition to the requirements of EN 2078 the report shall contain:

— tube: Manufacturer, type, material standard number, dimensions, charge, serial number;

— date of inspection: Date, previous working step, first inspection or repetition inspection;

— instrument calibration: Reference specimen, reference notch, plots of testing the reference notches before and after the tube inspection;

— ultrasonic test equipment: Manufacturer, type, serial number and settings like inspection range, gate position and range, pulse repetition frequency, test frequency (range) sensitivity, suppression, filter, mode (pulse-echo, double crystal, through transmission technique) and any other relevant information;

— manipulator: Manufacturer, type, serial number and settings like axial advance and rotational speed;

— probe: Manufacturer, type, serial number and characteristic data, e.g. nominal frequency, transducer dimensions, focusing (type of focusing, focus length and diameter), delay path;

— sound incidence: Probe arrangement, incidence angle, type of coupling;

— evaluation and recording unit: Scale, threshold level, channel designation;

— inspection notes: Marking of faulty areas on the plots, note of a possible additional inspection and its result, signature of inspection personnel and supervision;

— name of inspector.

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BSI Group Headquarters

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