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ISO 10893-7

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Non-destructive testing of steel tubes —

Part 7:
Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections

Essais non destructifs des tubes en acier —

Partie 7: Contrôle radiographique numérique du cordon de soudure des tubes en acier soudés pour la détection des imperfections

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10893-7 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 19, *Technical delivery conditions for steel tubes for pressure purposes*.

ISO 10893 consists of the following parts, under the general title *Non-destructive testing of steel tubes*:

— *Part 1: Automated electromagnetic testing of seamless and welded (except submerged arc-welded) steel tubes for the verification of hydraulic leaktightness*

— *Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections*

— *Part 3: Automated full peripheral flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections*

— *Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

— *Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

— *Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

— *Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections*

— *Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes*

— *Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 12: Automated full peripheral ultrasonic thickness testing of seamless and welded (except submerged arc-welded) steel tubes*

Introduction

Digital radiography has been used for the testing of longitudinal weld seams in submerged arc-welded steel tubes for some years. Digital radiography can be automated, and is considered to be more environmentally friendly than film-based radiographic techniques.

Digital radiography maintains the levels of security and availability afforded by X-ray film testing, which have been in place for many years. Images can be made available in a fraction of the time previously taken by film-based techniques, and usually at a lower exposure level and increased detector unsharpness when compared to film.

The storage and handling of digital images maintain the same levels of integrity available from film-based techniques, yet gain all the benefits associated with comprehensive data storage and retrieval systems.

Imaging systems are constantly under development, and an important aspect of this part of ISO 10893 is to qualify the use of those alternative systems currently available. This part of ISO 10893 describes the steps required to deliver these benefits.

Non-destructive testing of steel tubes —

Part 7:
Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections

1 Scope

This part of ISO 10893 specifies the requirements for digital radiographic X-ray testing by either computed radiography (CR) or radiography with digital detector arrays (DDA) of the longitudinal or helical weld seams of automatic fusion arc-welded steel tubes for the detection of imperfections. This part of ISO 10893 specifies acceptance levels and calibration procedures.

This part of ISO 10893 can also be applicable to the testing of circular hollow sections.

2 Normative references

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

ISO 5576, *Non-destructive testing — Industrial X-ray and gamma-ray radiology — Vocabulary*

ISO 9712, *Non-destructive testing — Qualification and certification of personnel*

ISO 11484, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

ISO 17636, *Non-destructive testing of welds — Radiographic testing of fusion-welded joints*

ISO 19232-1, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality indicators (wire type) — Determination of image quality value*

ISO 19232-2, *Non-destructive testing — Image quality of radiographs — Part 2: Image quality indicators (step/hole type) — Determination of image quality value*

ISO 19232-5, *Non-destructive testing — Image quality of radiographs — Part 5: Image quality indicators (duplex wire type) — Determination of image unsharpness value*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5576 and ISO 11484 and the following apply.

3.1
tube
hollow long product open at both ends, of any cross-sectional shape

3.2
welded tube
tube made by forming a hollow profile from a flat product and welding adjacent edges together, and which after welding can be further processed, either hot or cold, into its final dimensions

3.3
manufacturer
organization that manufactures products in accordance with the relevant standard(s) and declares the compliance of the delivered products with all applicable provisions of the relevant standard(s)

3.4
agreement
contractual arrangement between the manufacturer and purchaser at the time of enquiry and order

4 General requirements

4.1 Unless otherwise specified by the product standard or agreed on by the purchaser and manufacturer, a radiographic inspection inspection shall be carried out on welded tubes after completion of all the primary manufacturing process operations (rolling, heat treating, cold and hot working, sizing and primary straightening, etc.).

4.2 This inspection shall be carried out by trained operators qualified in accordance with ISO 9712, ISO 11484 or equivalent. Competent personnel, nominated by the manufacturer, shall supervise all inspection. In the case of third-party inspection, this shall be agreed on between the purchaser and manufacturer.

The operating authorization issued by the employer shall be according to a written procedure. Non-destructive testing (NDT) operations shall be authorized by a level 3 NDT individual approved by the employer.

NOTE The definition of levels 1, 2 and 3 can be found in appropriate standards, e.g. ISO 9712 and ISO 11484.

4.3 The tubes under test shall be sufficiently straight and free of foreign matter as to ensure the validity of the test. The surfaces of the weld seam and adjacent parent metal shall be sufficiently free of such foreign matter and surface irregularities which would interfere with the interpretation of the radiographs.

Surface grinding is permitted in order to achieve an acceptable surface finish.

4.4 In cases where the weld reinforcement is removed, markers, usually in the form of lead arrows, shall be placed on each side of the weld such that its position can be identified on the radiographic image. Alternatively, an integrated automatic positioning system may be used to identify the position of the weld.

4.5 Identification symbols, usually in the form of lead letters, shall be placed on each section of the weld seam radiograph such that the projection of these symbols appears in each radiographic image to ensure unequivocal identification of the section. Alternatively, an integrated automatic positioning system may be used to identify the position of each radiographic image along the pipe weld.

4.6 Markings shall be displayed on the recorded radiographic images to provide reference points for the accurate relocation of the position of each radiograph. Alternatively, the automated measured image position may be displayed on the digital image viewing screen by software for accurate position relocation.

4.7 When carrying out radiography on a continuous length of a weld, the pipe or pipe wall shall pass between the X-ray tube and detector at a speed which is sufficient to allow accurate defect detection, or the pipe shall move in start-stop mode and digital radiographs shall be taken when the pipe is not moving.

5 Equipment

The following digital imaging methods can be used in replacement of radiographic film:

a) computed radiography (CR) with storage phosphor imaging plates (e.g. EN 14784-1 and EN 14784-2);

b) radiology with digital detector arrays (e.g. ASTM E2597);

c) digital radioscopy with image integration (e.g. EN 13068-1, EN 13068-2 and EN 13068-3).

6 Test method

6.1 The weld seam shall be tested by a digital radiographic technique, corresponding to 5 a) to 5 c).

6.2 Two image quality classes, A and B, conforming to ISO 17636, shall be specified as:

— class A: radiographic examination technique with standard sensitivity;

— class B: radiographic technique with enhanced sensitivity.

NOTE Image quality class A is used for most applications. Image quality class B is intended for applications where increased sensitivity is required to reveal all the imperfections being detected.

The required image quality class should be stated in the relevant product standard.

6.3 The digital image displayed shall meet the required quality class A or B.

6.4 The beam of radiation shall be directed at the centre of the section of the weld seam under examination and shall be normal to the tube surface at that point.

6.5 The diagnostic length shall be such that the increase in penetrated thickness at the ends of the useful length of the sensitive detector input screen shall not exceed the penetrated thickness at the centre of the detector by more than 10 % for image quality class B or by more than 20 % for image quality class A, provided the specific requirements of 6.9 and Clause 7 are satisfied.

6.6 The single wall penetration technique shall be used. When the single wall technique is impracticable for dimensional reasons, the use of the double wall penetration technique may be used, by agreement, if the required sensitivities can be shown to be achievable.

6.7 The separation between the detector and the weld surface shall be as small as possible for contact technique (no magnification).

The minimum value of the source-to-weld distance, f, shall be selected such that the ratio of this distance to the effective focal spot size, d, i.e. f/d, conforms to the values given by the following formulae (contact technique):

for image quality class A:

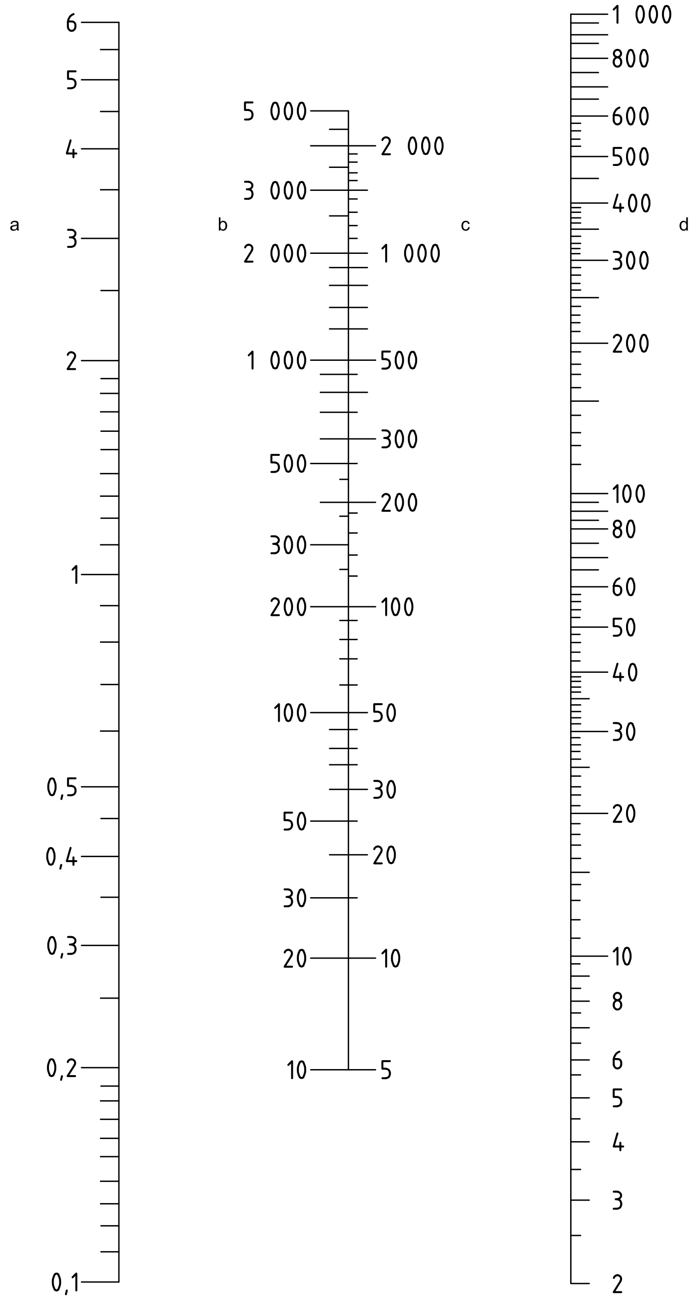
$$\frac{f}{d} \geqslant 7{,}5 \times b^{2/3} \tag{1}$$

for image quality class B:

$$\frac{f}{d} \geqslant 15 \times b^{2/3} \tag{2}$$

where b is the distance between the source side of the weld and the sensitive surface of the detector, in millimetres.

NOTE These relationships are presented graphically in Figure 1.



a Effective focal spot size, d, in millimetres.

b Minimum source to weld distance, f, for class B, in millimetres.

c Minimum source to weld distance, f, for class A, in millimetres.

d Weld-to-detector distance, b, in millimetres.

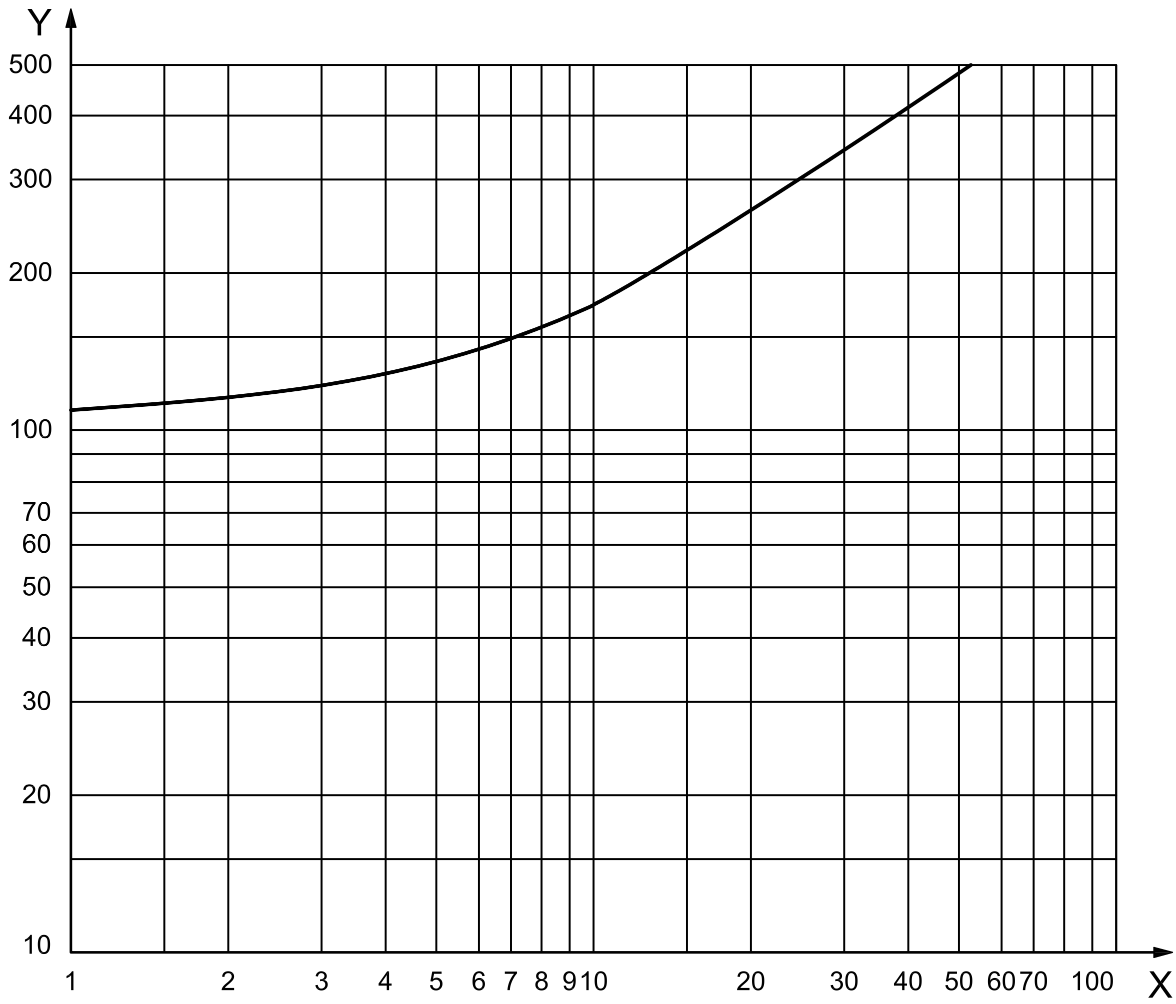
Figure 1 — Nomogram for determination of minimum source-to-weld distance, f, in relation to weld-to-detector distance, b, and the effective focal spot size, d

6.8 An obstacle to the implementation of DDA systems is the large (> 50 µm) pixel size of the array compared to the small grain size in film (which leads to film having very high spatial resolution).

It can, therefore, not be possible to achieve the required geometric resolution with a setup typically used for film radiography. This difficulty may be circumvented by using geometric magnification to achieve the required geometric resolution or by making use of the compensation principle [increasing the signal-to-noise ratio (SNR) in the image] described in 7.1. Any combination of these measures is allowed.

6.9 Exposure conditions, including X-ray tube voltage, shall achieve the image quality indicator (IQI) requirements in Clause 7. Image contrast and brightness may be adjusted as required for digital image viewing.

6.10 To maintain sufficient contrast sensitivity, the X-ray tube voltage should not exceed the maximum values given in Figure 2. A voltage above the values shown is allowed, as long as the minimum sensitivity is obtained.



Key

X penetrated thickness, mm

Y X-ray voltage, kV

Figure 2 — Maximum X-ray voltage for X-ray devices up to 500 kV **as a function of penetrated thickness**

7 Image quality

7.1 The image quality shall be determined by the use of IQIs of the type specified in ISO 19232-1, ISO 19232-2 and ISO 19232-5, and agreed on between the purchaser and manufacturer. The appropriate IQI shall be placed on the source side of the weld on the base material adjacent to the weld. In the case of a wire type IQI, at least 10 mm of the wires shall be visible on the parent material (see Figures 3 and 4).

When the source side is inaccessible, the IQIs may be placed on the detector side of the object. In these circumstances a letter “F” shall be placed near the IQIs and this procedural change shall be recorded in the test report. Detector-side positions typically show 1 or 2 more wires, or holes, than if the same IQI was on the source side. Customers may ask for a trial exposure to be carried out on a sample piece of pipe, with IQIs placed on both source and detector sides as a comparison.

When the tubes under inspection have the same dimensions and grade, it is sufficient to use the IQI only every 4 h, or twice a shift, to check image sensitivity. When carrying out the sensitivity checks, though, the IQI shall be placed on the source side.

The parameters used with the trial exposures (settings of X-ray source, detector and geometry) shall not be changed for the subsequent images acquired with detector-side IQIs. For stable systems and processes, such as automated testing systems using DDAs, it is sufficient to prove the image quality once per shift as long as tube dimension, tube material and testing parameters remain unchanged. In this case, the image quality proof should be performed only with source side IQIs.

By usage of the duplex wire IQI, conforming to ISO 19232-5, the image unsharpness, U_g, shall be measured.

The read-out unsharpness, U_g, value for the duplex wire IQI is the smallest wire pair element number (largest wire diameter) with a dip separation below 20 %, measured with a profile plot across the duplex wire in the digital image.

The duplex wire IQI should be positioned at an approximately 5° angle towards the pixel orientation in order to avoid aliasing effects.

The basic spatial resolution, SR_b, of the detector which is fixed by the construction and hardware parameters shall be determined by placing the duplex wire IQI directly in front of the detector. In this case, SR_b is given by:

$$SR_b = 0{,}5\ U_g \quad (3)$$

Compensation principle

If both IQI sensitivities of Tables 1 and 2 (wire or hole and duplex wire IQI) cannot be achieved by the detector system used, an increase in single wire visibility can compensate too high unsharpness values.

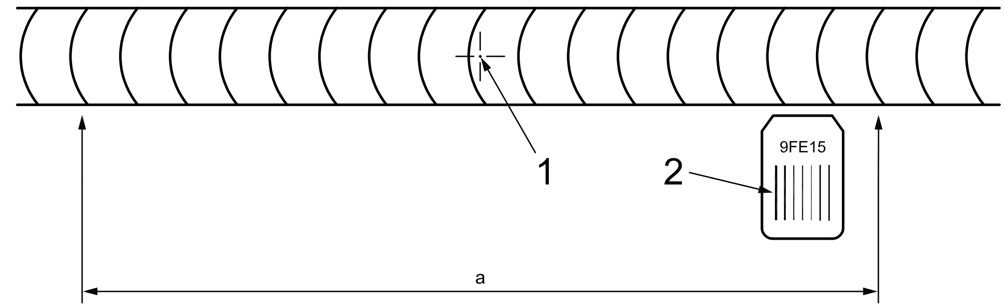
EXAMPLE For 10 mm wall thickness, class B; it is necessary to use wire number W14 and duplex D11. If D11 cannot be reached, compensation is possible: two steps down from D11 to D9, but increasing two steps up from W14 to W16.

The contrast sensitivity for digital detectors depends on the integration time and tube current (mA) used for the acquisition of the radiographic images for a given distance and tube voltage, so the single wire visibility can be increased by an increased exposure time and mA setting.

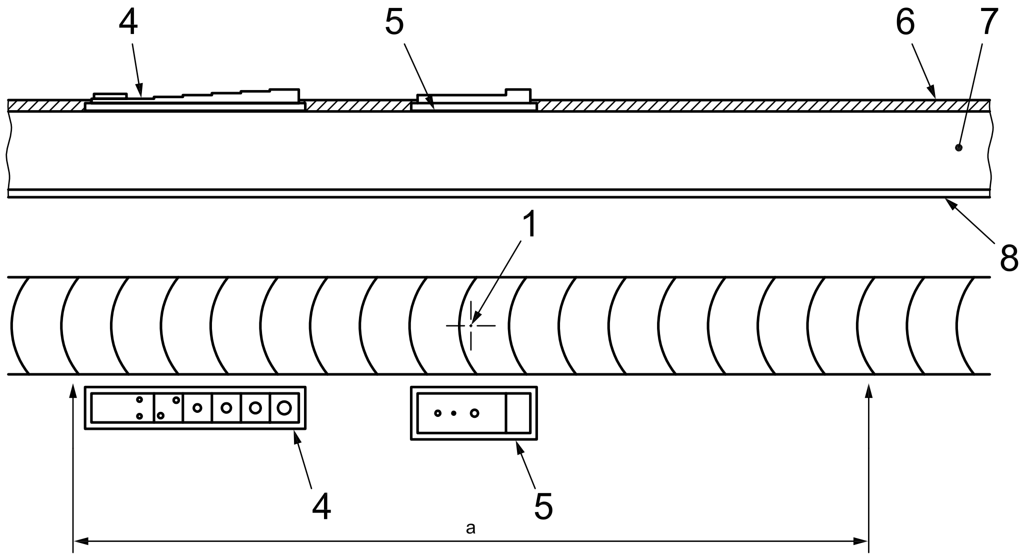
7.2 The two image quality classes are defined in Tables 1 and 2. The minimum normalized SNR_{norm} in the base material should be > 70 for testing class A and > 100 for testing class B. The normalized SNR_{norm} shall be calculated from the measured SNR in the image at base material adjacent to the welding seam and normalized by the basic spatial resolution of the detector system:

$$SNR_{norm} = SNR \times 88{,}6\ \mu m / SR_b \quad (4)$$

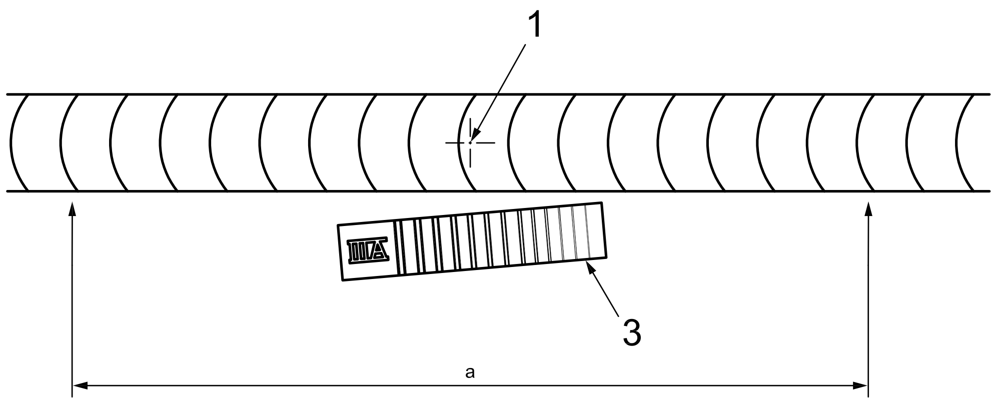
NOTE For details of SNR measurement, see, for example, EN 14784-1, ASTM E2446 or ASTM E2597. IQI quality for larger wall thicknesses is available in ISO 17636.



a) Wire type



b) Plaque and step/hole types



c) Duplex type — For use with wire or step/hole type

Key

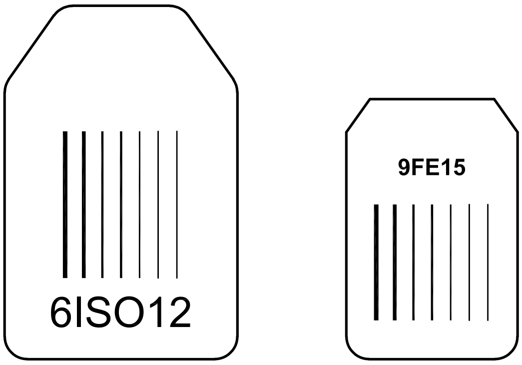
1 centre of beam
2 wire type IQI, thinnest wire away from the centre of the beam
3 duplex type IQI, approx. 5° tilted
4 step/hole type IQI, thinnest step away from the centre of the beam
5 plaque type IQI, with shim stock
6 outer weld reinforcement
7 tube wall
8 inner weld reinforcement

[a] Mapped weld length (DDA) or image plate length (CR).

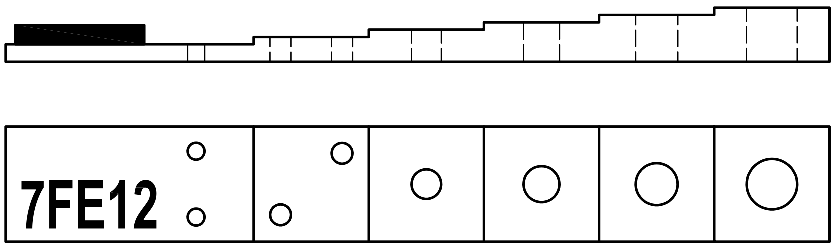
Figure 3 — Positioning of IQIs — Basic requirements

7.3 For the double wall penetration technique, the image quality value for use shall be taken as that corresponding to twice the specified wall thickness.

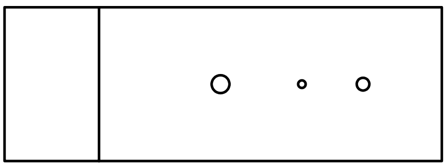
7.4 Where available, the performance of the digital system should also be measured, using representative quality indicators (RQIs). RQIs should be of the same dimensions and grade as the tubes under inspection. RQIs containing actual or simulated linear defects, such as lack of penetration, lack of fusion and cracks, are advised in order to ensure digital set-up is capable of meeting inspection specifications.



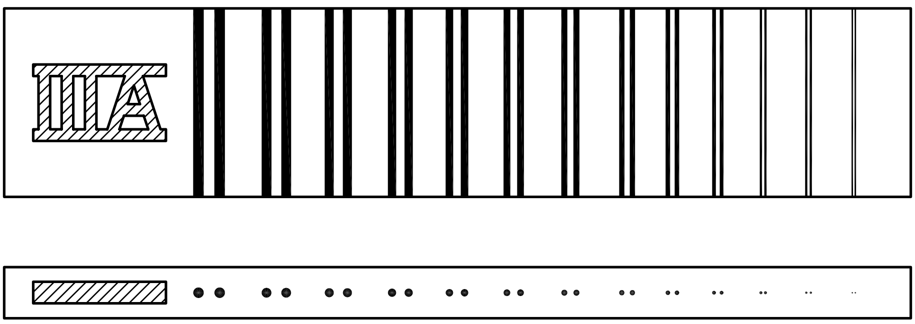
a) Wire type



b) Step/hole type



c) Plaque type



d) Duplex type

Figure 4 — Types of image quality indicator

Table 1 — Single wall techniques — Class A

Dimensions in millimetres

Specified wall thickness T	Wire number Diameter	Specified wall thickness T	Hole number Diameter	Specified wall thickness T	Duplex IQI[ab] Unsharpness	 Wire diameter and spacing
$T \leqslant 1{,}2$	W18 0,063	$T \leqslant 2$	H3 0,20	$T \leqslant 2$	D11 0,16	0,080
$1{,}2 < T \leqslant 2$	W17 0,08	$2 < T \leqslant 3{,}5$	H4 0,25	$2 < T \leqslant 5$	D10 0,20	0,100
$2 < T \leqslant 3{,}5$	W16 0,10	$3{,}5 < T \leqslant 6$	H5 0,32	$5 < T \leqslant 10$	D9 0,26	0,130
$3{,}5 < T \leqslant 5$	W15 0,13	$6 < T \leqslant 10$	H6 0,40	$10 < T \leqslant 25$	D8 0,32	0,160
$5 < T \leqslant 7$	W14 0,16	$10 < T \leqslant 15$	H7 0,50	$25 < T \leqslant 55$	D7 0,40	0,200
$7 < T \leqslant 10$	W13 0,20	$15 < T \leqslant 24$	H8 0,64	$55 < T$	D6 0,50	0,250
$10 < T \leqslant 15$	W12 0,25	$24 < T \leqslant 30$	H9 0,80			
$15 < T \leqslant 25$	W11 0,32	$30 < T \leqslant 40$	H10 1,00			
$25 < T \leqslant 32$	W10 0,40	$40 < T \leqslant 60$	H11 1,25			
$32 < T \leqslant 40$	W9 0,50	$60 < T$	H12 1,60			
$40 < T \leqslant 55$	W8 0,63					
$55 < T$	W7 0,80					

[a] Duplex IQI should be used in conjunction with either a wire or step/hole IQI.

[b] Duplex IQI should be examined using a profile display; the smallest wires which have a dip separation below 20 % between the wire pair determine the unsharpness.

Table 2 — Single wall techniques — Class B

Dimensions in millimetres

Specified wall thickness T	Wire number Diameter	Specified wall thickness T	Hole number Diameter	Specified wall thickness T	Duplex IQI[ab] Unsharpness	Duplex IQI[ab] Wire diameter and spacing
$T \leqslant 1{,}5$	W19 0,05	$T \leqslant 2{,}5$	H2 0,16	$T \leqslant 1{,}5$	D13+ < 0,10	< 0,05
$1{,}5 < T \leqslant 2{,}5$	W18 0,063	$2{,}5 < T \leqslant 4$	H3 0,20	$1{,}5 < T \leqslant 4$	D13 0,10	0,05
$2{,}5 < T \leqslant 4$	W17 0,08	$4 < T \leqslant 8$	H4 0,25	$4 < T \leqslant 8$	D12 0,13	0,065
$4 < T \leqslant 6$	W16 0,10	$8 < T \leqslant 12$	H5 0,32	$8 < T \leqslant 12$	D11 0,16	0,080
$6 < T \leqslant 8$	W15 0,13	$12 < T \leqslant 20$	H6 0,40	$12 < T \leqslant 40$	D10 0,20	0,100
$8 < T \leqslant 12$	W14 0,16	$20 < T \leqslant 30$	H7 0,50	$40 < T$	D9 0,26	0,130
$12 < T \leqslant 20$	W13 0,20	$30 < T \leqslant 40$	H8 0,64			
$20 < T \leqslant 30$	W12 0,25	$40 < T \leqslant 60$	H9 0,80			
$30 < T \leqslant 35$	W11 0,32	$60 < T$	H10 1,00			
$35 < T \leqslant 45$	W10 0,40					
$45 < T \leqslant 65$	W9 0,50					
$65 < T$	W8 0,63					

NOTE “D13+” is achieved if the duplex wire pair D13 is resolved with a dip > 20 %.

[a] Duplex IQI should be used in conjunction with either a wire or step/hole IQI.

[b] Duplex IQI should be examined using a profile display; the smallest wires which have a dip separation below 20 % between the wire pair determine the unsharpness.

8 Image processing

8.1 The digital data of the radiographic detector shall be evaluated proportional to the radiation dose. This shall be the prerequisite for correct measurements of SNR for evaluation of image quality. For optimal image display, contrast and brightness should be interactively adjustable. Optional filter functions, profile plots and the SNR tool should be integrated into the software for image display and evaluation.

8.2 Further means of image processing applied on the stored raw data (e.g. high pass filtering for image display) shall be documented, repeatable and agreed on by the purchaser and manufacturer.

9 Classification of indications

9.1 All indications found on the radiograph shall be classified as weld imperfections or defects, as described in 9.2 and 9.3.

9.2 Imperfections are discontinuities in the weld seam detectable by the radiographic testing method described in this part of ISO 10893. Imperfections with a size and/or population density that are within the specified acceptance limits are considered to have no practical implications on the intended use of the tubes.

9.3 Defects are imperfections with a size and/or population density greater than the specified acceptance limits. Defects are considered to adversely affect or limit the intended use of the tubes.

10 Acceptance limits

10.1 Acceptance limits are applicable to radiographic examination of the weld seam and specified in 10.2 to 10.6, unless alternative requirements are specified in the product standards.

10.2 Cracks, incomplete penetration and lack of fusion are not acceptable.

10.3 Individual circular slag inclusions and gas pockets up to 3,0 mm or $T/3$ in diameter (T = specified wall thickness), whichever is the smaller, are acceptable.

The sum of the diameters of all such permitted individual imperfections in any 150 mm or $12T$ of weld length, whichever is the smaller, shall not exceed 6,0 mm or $0{,}5T$, whichever is the smaller, where the separation between individual inclusions is less than $4T$.

10.4 Individual elongated slag inclusions up to 12,0 mm or T in length, whichever is the smaller, or up to 1,5 mm in width are acceptable.

The accumulated length of such permitted individual imperfections in any 150 mm or $12T$ of weld length, whichever is the smaller, shall not exceed 12,0 mm where the separation between individual inclusions is less than $4T$.

NOTE For information, the criteria specified in 10.3 and 10.4 are shown diagrammatically in Annex A.

10.5 Individual undercuts of any length having a maximum depth of 0,4 mm and not encroaching on the minimum wall thickness shall be acceptable.

Individual undercuts of a maximum length of $T/2$ having a maximum depth of 0,5 mm and not exceeding 10 % of the specified wall thickness shall be acceptable, provided there are not more than two such undercuts in any 300 mm of the weld length, and all such undercuts are dressed out.

10.6 Undercuts on the inside and outside welds, which are coincident in the longitudinal direction, shall not be acceptable.

11 Acceptance

11.1 Any tubes not showing indications in excess of that permitted by the corresponding acceptance limits shall be deemed to have passed the test.

11.2 Any tubes showing indications in excess of that permitted by the corresponding acceptance limits shall be deemed suspect.

11.3 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 removed by dressing. Complete removal of the defect shall be verified by either liquid penetrant or magnetic particle testing, and the dressed area shall be retested by radiography. The remaining wall thickness shall be measured by an appropriate technique to verify compliance with the specified tolerances;

b) the suspect area shall be repaired by welding carried out to an approved welding procedure. The repaired area shall then be subject to radiographic examination in accordance with the requirements of this part of ISO 10893 and the product standard;

c) the suspect area shall be cropped off. The remaining length of the tube shall be measured to verify conformance to the specified tolerances;

d) the tube shall be rejected.

12 Image storage and display

The original images shall be stored in full resolution as delivered by the detector system. Only image processing connected with the detector calibration [e.g. off-set correction, gain calibration for detector equalization and bad pixel correction (see ASTM E2597) to provide artefact-free detector images] shall be applied before storage of these raw data.

The display for image evaluation should fulfil the following minimum requirements:

— minimal brightness of 250 cd/m^2;

— display of minimal 256 shades of grey;

— minimum displayable light intensity ratio of 1:250;

— display of minimal 1 000 $\times$ 1 000 pixels of a size $<$ 0,30 mm.

The image evaluation shall be carried out in a dimly lit room. The monitor setup shall be verified with a suitable test image.

13 Test report

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

a) reference to this part of ISO 10893, i.e. ISO 10893-7;

b) statement of conformity;

c) any deviation, by agreement or otherwise, from the procedures specified;

d) product designation by steel grade and size;

e) radiation source, type and effective focal spot size and equipment used, tube voltage and current;

f) detector and software used for image acquisition and display;

g) time of exposure per image, date of last detector calibration;

h) geometrical set-up, magnification and source-to-pipe distance;

i) types and positions of IQI;

j) IQI readings and minimum SNR at base material;

k) the image quality class achieved;

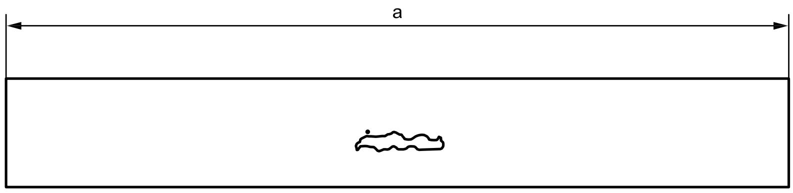
l) file name and storage location of raw data acquired;

m) date of exposure and report;

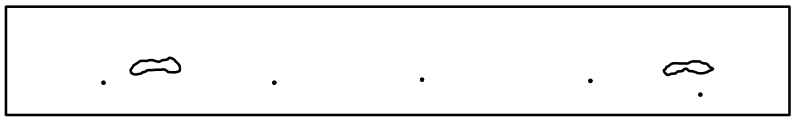
n) operator identification and name, certification and signature of the responsible persons.

Annex A
(informative)

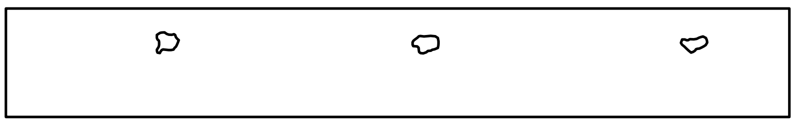
Examples of distribution of imperfections



a) Example 1: one 12,0 mm **imperfection**



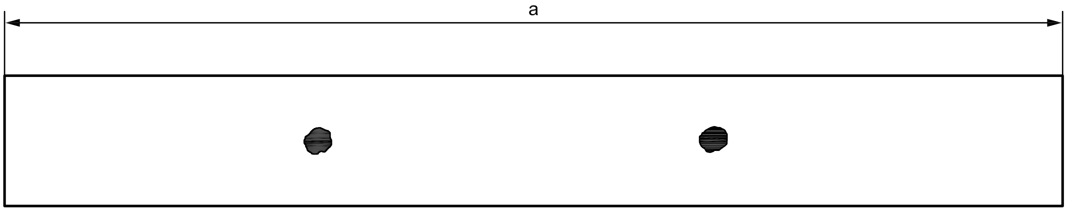
b) Example 2: two 6,0 mm **imperfections**



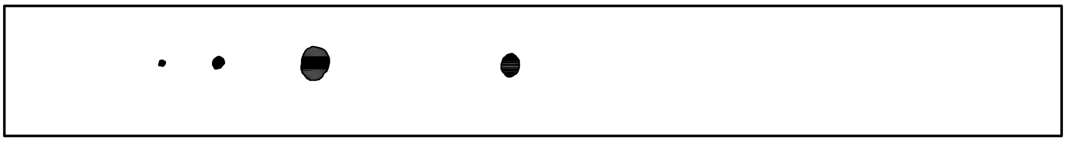
c) Example 3: three 4,0 mm **imperfections**

[a] Weld length 150 mm or 12T (T = specified wall thickness), whichever is the smaller.

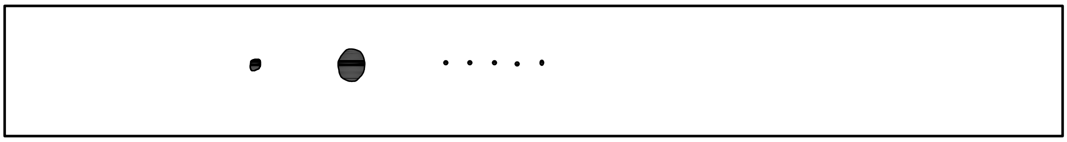
Figure A.1 — Example of maximum distribution patterns of indicated elongated slag imperfections for specified wall thickness above 12 mm



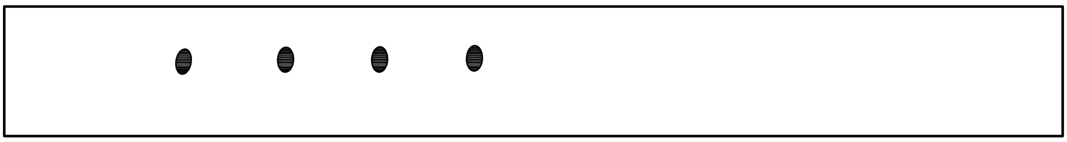
a) Example 1: two 3,0 mm **imperfections**



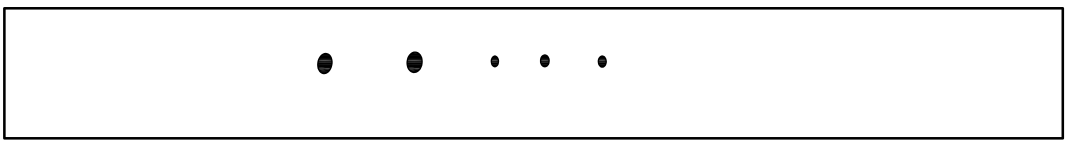
b) Example 2: one 3,0 mm**, one** 1,5 mm**, one** 1,0 mm **and one** 0,5 mm **imperfections**



c) Example 3: one 3,0 mm**, one** 1,0 mm **and five** 0,5 mm **imperfections**

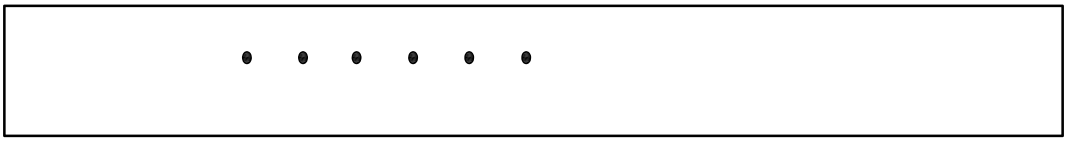


d) Example 4: four 1,5 mm **imperfections**

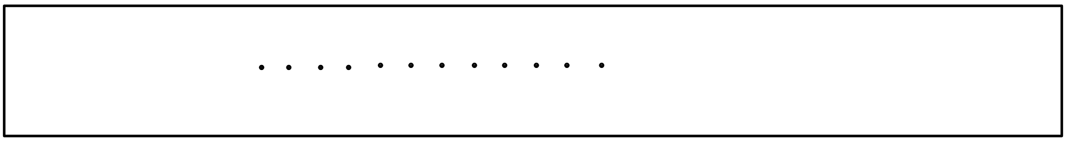


e) Example 5: two 1,5 mm**, three** 1,0 mm **imperfections**

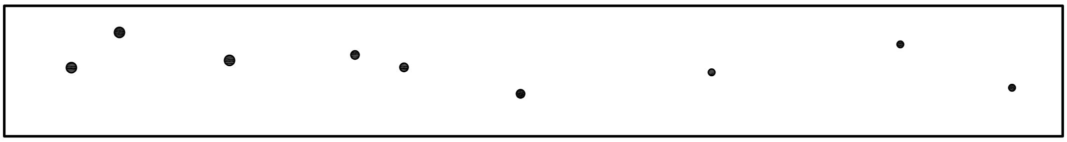
Figure A.2 (*continued*)



f) Example 6: six 1,0 mm **imperfections**



g) Example 7: twelve 0,5 mm **imperfections**



h) Example 8: three 1,0 mm**, six** 0,5 mm **imperfections (scattered)**

[a] Weld length 150 mm or $12T$ (T = specified wall thickness), whichever is the smaller.

Figure A.2 — Examples of maximum distribution patterns of gas pocket type imperfections for specified wall thickness above 9 mm

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