

Non-destructive testing of steel tubes —

Part 10: Radiographic testing of the weld seam of automatic fusion arc welded steel tubes for the detection of imperfections



www.dlsspipeline.com

info@dlsspipe.com

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British Standard

ICS 23.040.10; 25.160.40; 77.040.20

National foreword

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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;
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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 16, an inside back cover 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 July 2000

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ISBN 0 580 34810 5

Amendments issued since publication

Amd. No.	Date	Comments

English version

Non-destructive testing of steel tubes - Part 10: Radiographic testing of the weld seam of automatic fusion arc welded steel tubes for the detection of imperfections

Essais non destructifs des tubes en acier - Partie 10:
Contrôle par radiographie du cordon de soudure pour la
détection des imperfections des tubes en acier soudés à
l'arc immergé sous flux en poudre

Zerstörungsfreie Prüfung von Stahlrohren - Teil 10:
Durchstrahlungsprüfung der Schweißnaht automatisch
lichtbogenschmelzgeschweißter Stahlrohre zum Nachweis
von Fehlern

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of an identical text or by endorsement, at the latest by October 2000, and conflicting national standards shall be withdrawn at the latest by October 2000.

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1 SCOPE

This part of EN 10246 specifies the requirements for radiographic X-ray testing of the longitudinal or helically weld seams of automatic fusion arc-welded steel tubes for the detection of imperfections. The standard specifies acceptance levels and calibration procedures.

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 (including amendments).

EN 444	Non-destructive testing - General principles for radiographic examination of metallic materials by X- and gamma-rays
EN 462-1	Non-destructive testing - Image quality of radiographs - Part 1: Image quality indicators (wire type) - Determination of image quality value
EN 462-2	Non-destructive testing - Image quality of radiographs - Part 2: Image quality indicators (step/hole type) - Determination of image quality value
EN 1330-3	Non-destructive testing - Terminology - Part 3: Terms used in industrial radiographic testing
EN 1435	Non-destructive examination of welds - Radiographic examination of welded joints

3 TERMS AND DEFINITIONS

For the purposes of this part of EN 10246, the terms and definitions given in EN 444, EN 1330-3 and EN 1435 shall apply.

4 GENERAL REQUIREMENTS

4.1 The radiographic inspection covered by this part of EN 10246 is usually carried out on tubes after completion of all the primary production process operations.

4.2 The tubes to be tested shall be sufficiently straight and free from foreign matter as to ensure the validity of the test. The surfaces of the weld seam and adjacent parent metal shall be sufficiently free from 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.

4.3 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 so that its position can be identified on the radiograph.

4.4 Identification symbols, usually in the form of lead letters, shall be placed on each section of the weld beam radiograph so that the images of these symbols appear in the radiograph to ensure unequivocal identification of the section.

4.5 Permanent markings shall be provided on the source side of the tube surface to provide reference points for the accurate relocation of the position of each radiograph. Where the nature of the product and/or its intended service conditions render stamping impossible, other suitable means shall be provided for relocating the radiographs, e.g. by paint marking or by reference to accurate sketches.

4.6 When radiographing a continuous length of weld with separate films, adjacent films shall overlap by at least 10 mm to ensure that no portion of the weld length remains unexamined.

5 METHOD OF TEST

5.1 The weld of longitudinally or helically welded tubes shall be radiographically tested using the X-ray film technique.

By agreement between the purchaser and the manufacturer, the use of radiosopic methods is permitted but only when the manufacturer can demonstrate adequate sensitivity.

5.2 Two image quality classes R1 and R2 are specified:

- Class R1: X-ray examination technique with enhanced sensitivity.
- Class R2: X-ray examination technique with standard sensitivity.

5.3 The films shall be at least fine-grain for image quality class R1 and shall be at least medium-grain for image quality class R2 (see EN 444 and EN 584-1).

The front intensifying screen, for both image quality class R1 and image quality class R2, shall have a thickness of between 0,02 mm and 0,25 mm. Other thicknesses may be adopted for the back intensifying screen.

In cases where a double film technique is used, both intensifying screens, where used, shall be in the upper thickness range of the front intensifying screen.

5.4 Salt intensifying screens shall not be used.

5.5 The amount of back-scattered or internally scattered X-ray radiation in the film shall be minimized.

Where there is doubt regarding the adequacy of protection from back-scattered X-ray radiation, a characteristic symbol (typically a 1,6 mm thick letter B) shall be attached to the back of the cassette or film holder and a radiograph made in the normal manner. When the image of this symbol appears on the radiograph at a lighter density than the background, it is an indication that protection against back-scattered X-ray radiation is insufficient and it is essential that additional precautions are taken.

5.6 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.

5.7 The diagnostic length shall be such that the increase in penetrated thickness at the ends of the useful length of a radiograph shall not exceed the penetrated thickness at the centre of the radiograph by more than 10 % for image quality class R1 or by more than 20 % for image quality class R2 provided that the conditions specified in 5.11 and clause 8 are not compromised.

5.8 The single wall penetration technique shall be used. If this technique is impractical for dimensional reasons, the use of the double wall penetration technique is permitted by agreement.

5.9 The separation between the film and the weld surface shall be as small as possible.

5.10 The minimum value of the source to specimen distance, f , shall be selected so that the ratio of this distance to the effective dimension of source size d , i.e. f/d , conforms to the values given by the following equations:

for image quality class R1:
$$f/d \geq 15 \left(\frac{b}{mm} \right)^{2/3}$$

for image quality class R2:
$$f/d \geq 7,5 \left(\frac{b}{mm} \right)^{2/3}$$

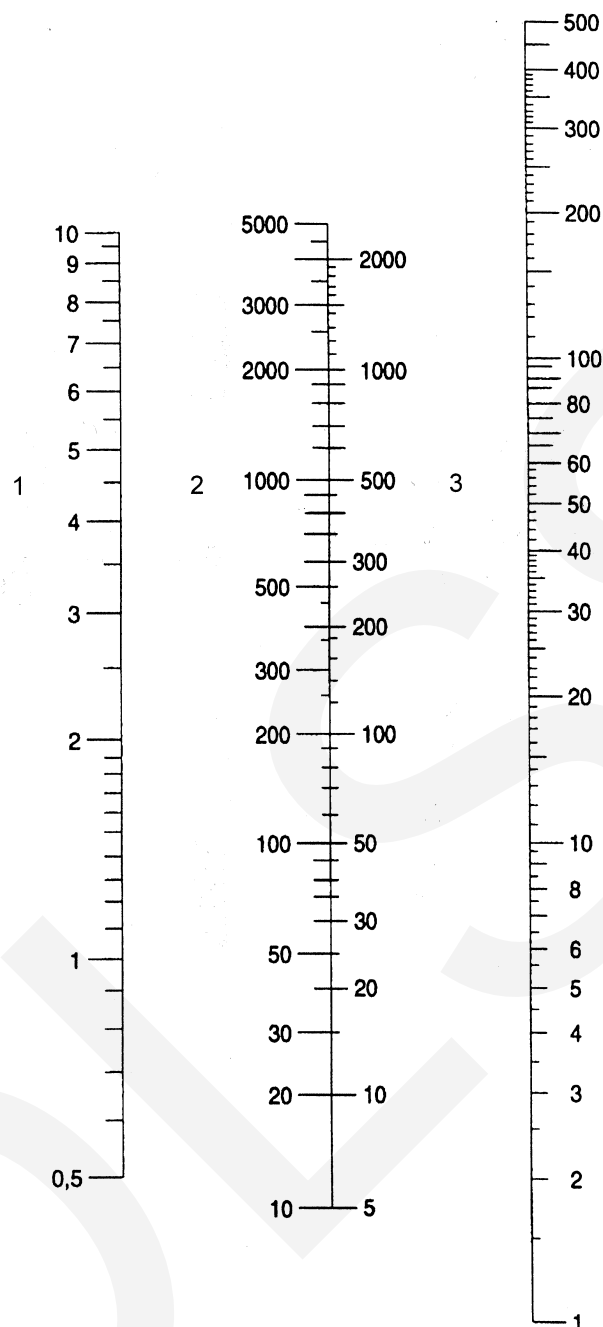
Where:

b is the specimen thickness in the direction of the radiation beam plus separation between the film and the surface remote from the radiation source.

NOTE: These relationships are presented graphically in Figure 1.

5.11 Exposure conditions shall be such that the density of the radiograph of the sound weld metal in the area under examination is not less than 2,0 for image quality class R1 and not less than 1,7 for image quality class R2.

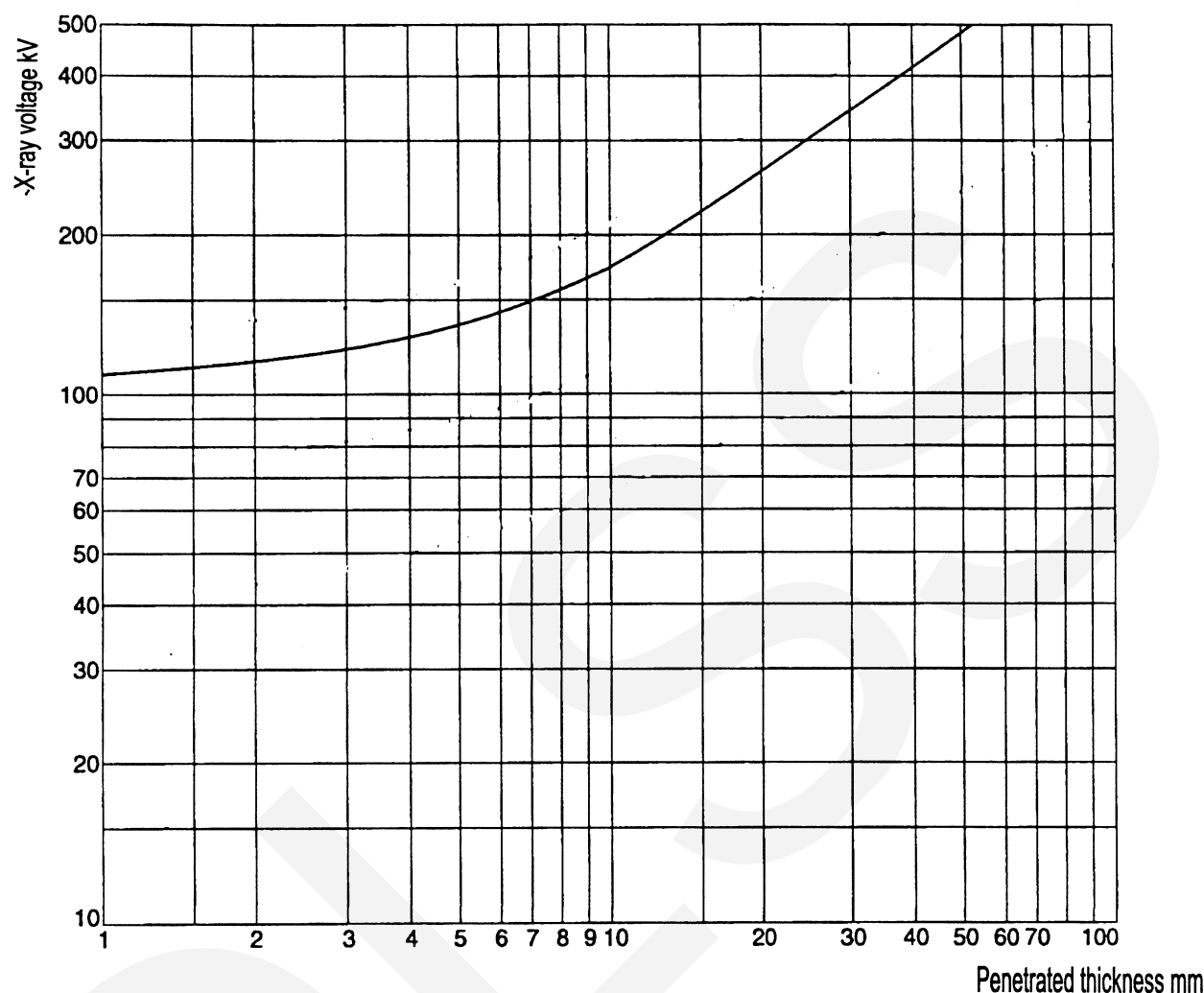
5.12 To maintain sufficient sensitivity, the X-ray tube voltage shall not exceed the maximum values given in Figure 2.



Key

- 1 d = Source d (mm)
- 2 f R1 = Minimum source to specimen distance f for class R1 (mm)
- 3 f R2 = Minimum source to specimen distance f for class R2 (mm)
- 4 b = Specimen to film distance b (mm)

Figure 1 - Nomogram for determination of minimum source-to-specimen distance f in relation to specimen-to-film distance b and the source size d



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

6 IMAGE QUALITY

6.1 The image quality shall be determined by the use of a mild steel image quality indicator (IQI) of the type specified in EN 462-1 and EN 462-2, and agreed between the purchaser and the manufacturer. This IQI shall be placed on the surface facing the source of radiation, either adjacent to the weld or, in the case of wire type IQIs, across the weld. The IQI shall only be placed on the film side when the surface facing the radiation source is inaccessible. In these circumstances a letter "F" shall be placed near the IQI and this procedural change recorded in the test report.

NOTE: For further details, refer to EN 462-3, EN 462-4 and EN 1435.

6.2 The two image quality classes specified in this part of EN 10246 are defined in Table 1.

Table 1 - Image quality classes

Specified Wall thickness T (mm)	Required visibility							
	Image quality class R1				Image quality class R2			
	Hole		Wire		Hole		Wire	
	number	diameter mm	number	diameter mm	number	diameter mm	number	diameter mm
$T \leq 4,5$	H5	0,32	W15	0,125	H6	0,40	W14	0,16
$4,5 < T \leq 10$	H6	0,40	W14	0,16	H7	0,50	W13	0,20
$10 < T \leq 16$	H7	0,50	W13	0,20	H8	0,63	W12	0,25
$16 < T \leq 25$	H8	0,63	W12	0,25	H9	0,80	W11	0,32
$25 < T \leq 32$	H9	0,80	W11	0,32	H10	1,00	W10	0,40
$32 < T \leq 40$	H10	1,00	W10	0,40	H11	1,25	W9	0,50
$40 < T \leq 50$	H11	1,25	W9	0,50	H12	1,60	W8	0,63

6.3 For double wall penetration technique the image quality value to be used shall be taken as that corresponding to twice the specified wall thickness.

7 PROCESSING OF FILM

The radiographs shall be free from imperfections due to processing or other defects that could interfere with interpretation.

8 VIEWING CONDITIONS FOR RADIOGRAPHS

The minimum luminance of the illuminated radiograph shall be 30 cd/m² for densities less than or equal to 2,5 and 10 cd/m² for densities greater than 2,5.

9 ACCEPTANCE LIMITS

The following acceptance limits are applicable to radiographic examination of the weld seam unless alternative requirements are specified in the product standards.

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

9.2 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 12 T of weld length, whichever is the smaller, shall not exceed 6,0 mm or 0,5 T , whichever is the smaller, where the separation between individual inclusions is less than 4 T .

9.3 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 12 T of weld length, whichever is the smaller, shall not exceed 12,0 mm where the separation between individual inclusions is less than 4 T .

9.4 Individual undercuts of any length having a maximum depth of 0,4 mm are 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 are acceptable provided that there are not more than two such undercuts in any 300 mm of the weld length, and all such undercuts are dressed out.

9.5 Any undercuts exceeding the above limits shall be repaired, or the corresponding area shall be cropped off or the pipe rejected.

9.6 Any undercuts on the inside and outside welds of any length and depth which are coincident in the longitudinal direction are not acceptable.

NOTE: For information the criteria specified in 9.2 and 9.3 are shown diagrammatically in Annex B.

10 CLASSIFICATION OF INDICATIONS

All indications found on the radiograph shall be classified as weld imperfections or defects as defined below:

10.1 Imperfections are discontinuities in the weld seam detectable by the radiographic testing method described in this part of EN 10246. 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 the tubes.

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

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 product standard:

a) The suspect area shall be dressed by a suitable method. After checking that the remaining thickness is within tolerance, the suspect area shall be retested by either the magnetic particle or liquid penetrant testing method to ensure that each defect giving rise to the original indications has been completely removed. The tube shall then be deemed to have passed the test.

Should the removal of the defect reduce the wall thickness below the specified limit, 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 EN 10246.

b) Crop off the suspect area. The manufacturer shall ensure that all the suspect area has been cropped off.

c) The tube shall be deemed not to have passed the test.

12 TEST REPORTING

When specified, the manufacturer shall provide the purchaser with, 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) any deviation - by agreement or otherwise - from the procedures specified;

g) the image quality class.

ANNEX A (informative)

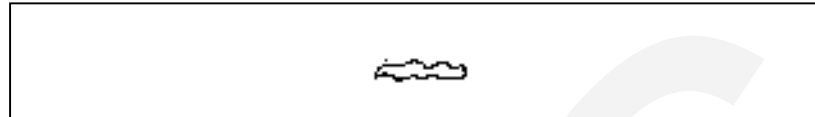
Table of parts of EN 10246 - Non-destructive testing of steel tubes

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 (informative)

Examples of distribution of imperfections

← Weld length 150 mm or 12 T whichever is smaller →



Example 1: one 12,0 mm imperfection



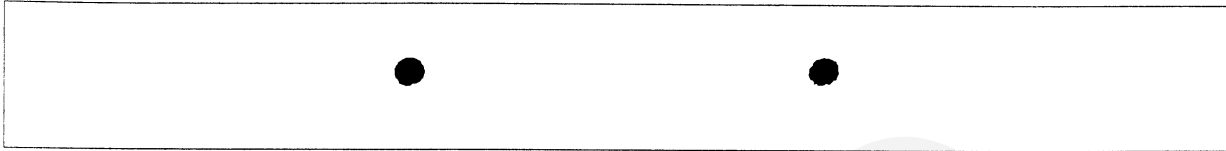
Example 2: two 6,0 mm imperfections



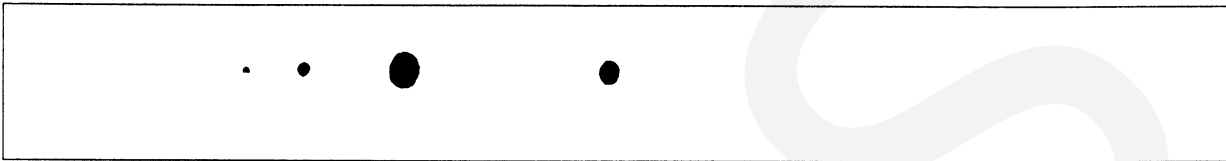
Example 3: three 4,0 mm imperfections

Figure B.1 - Example of maximum distribution patterns of indicated elongated slag imperfections

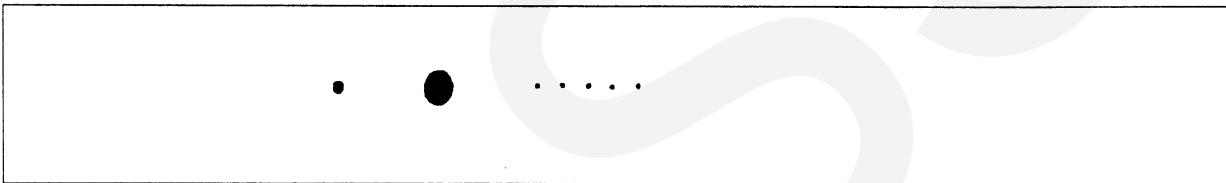
← Weld length 150 mm or 12 *T* whichever is smaller →



Example 1: two 3,0 mm imperfections



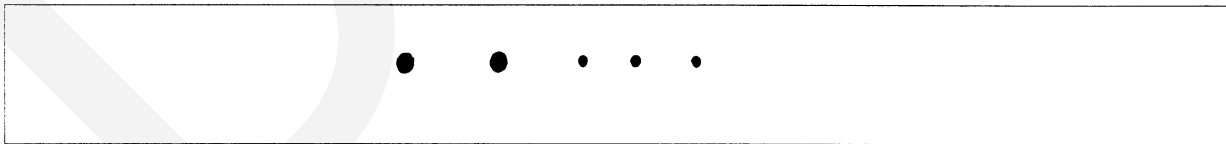
Example 2: one 3,0 mm, one 1,5 mm, one 1,0 mm and one 0,5 mm imperfections



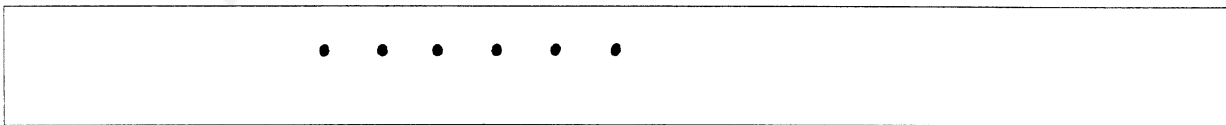
Example 3: one 3,0 mm, one 1,0 mm and four 0,5 mm imperfections



Example 4: four 1,5 mm imperfections

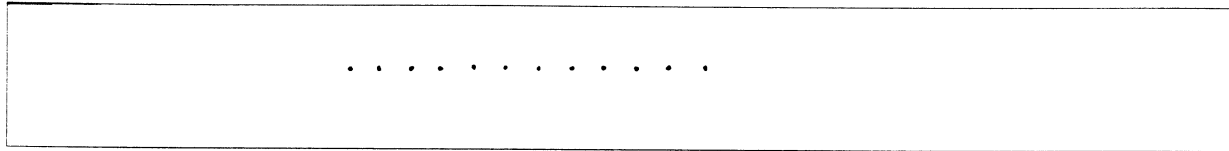


Example 5: two 1,5 mm, three 1,0 mm imperfections

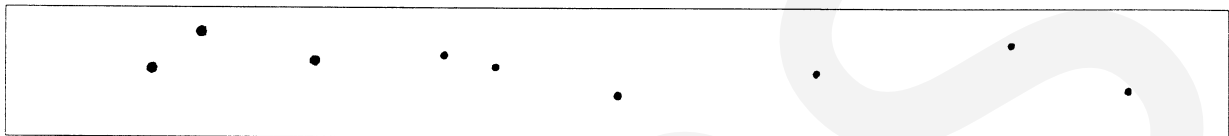


Example 6: six 1,0 mm imperfections

← Weld length 150 mm or 12 T whichever is smaller →



Example 7: twelve 0,5 mm imperfections



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

Figure B.2 - Example of maximum distribution patterns of gas pocket type imperfections

Bibliography

- EN 462-3 Non-destructive testing - Image quality of radiographs - Part 3: Image quality classes for ferrous metals
- EN 462-4 Non-destructive testing - Image quality of radiographs - Part 4: Experimental evaluation of image quality values and image quality tables
- EN 584-1 Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography

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