

Non-destructive testing of welds — Radiographic testing of welded joints

The European Standard EN 1435:1997, with the incorporation of amendments A1:2002 and A2:2003, has the status of a British Standard

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National foreword

This British Standard is the English language version of EN 1435:1997, including amendments A1:2002 and A2:2003. It supersedes BS 2600-1:1983, BS 2600-2:1973, BS 2910:1986 and BS 7257:1989, which are withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by **A1** **A1**.

As agreed by CEN/TC 121/SC 5 resolution 134/2000 and in accordance with amendment A1:2002, the term “examination” has been replaced by “testing” throughout the document.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing, which has the responsibility to:

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- 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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English version

Non-destructive testing of welds — Radiographic testing of welded joints

(includes amendments A1:2002 and A2:2003)

Contrôle non destructif des assemblages
soudés —
Contrôle par radiographie des assemblages
soudés
(inclut les amendements A1:2002 et A2:2003)

Zerstörungsfreie Prüfung von
Schweißverbindungen —
Durchstrahlungsprüfung von
Schmelzschweißungen
(enthält Änderungen A1:2002 und A2:2003)

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Foreword

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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of an identical text or by endorsement, at the latest by February 1998, and conflicting national standards shall be withdrawn at the latest by February 1998.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

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Foreword to amendment A1

This document EN 1435:1997/A1:2002 has been prepared by Technical Committee CEN/TC 121, Welding, the Secretariat of which is held by DS.

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Annex A and Annex B are normative.

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Foreword to amendment A2

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1 Scope

This European Standard specifies fundamental techniques of radiography with the object of enabling satisfactory and repeatable results to be obtained economically. The techniques are based on generally recognized practice and fundamental theory of the subject.

This standard applies to the radiographic testing of fusion welded joints in metallic materials.

It applies to the joints of plates or pipes. Besides its conventional meaning, “pipe” as used in this standard should be understood to cover other cylindrical bodies such as tubes, penstocks, boiler drums and pressure vessels. This standard complies with EN 444.

This standard does not specify acceptance levels of the indications.

If lower test criteria $\boxed{A_1}$ are permitted by specification $\boxed{A_1}$, the quality achieved may be significantly lower than when this standard is strictly applied.

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 444, *Non-destructive testing — General principles for the radiographic examination of metallic materials using X- and gamma-rays.*

EN 462-1, *Non-destructive testing — Image quality of radiographs — Part 1: Concepts, image quality indicators (wire type), determination of image quality value.*

EN 462-2, *Non-destructive testing — Image quality of radiographs — Part 2: Concepts, image quality indicators (step/hole type), determination of image quality value.*

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 473, *Qualification and certification of non-destructive personnel — General principles.*

EN 584-1, *Non-destructive testing — Industrial radiographic film — Part 1: Classification of film systems for industrial radiography.*

EN 584-2, *Non-destructive testing — Industrial radiographic film — Part 2: Control of film processing by means of reference value.*

EN 25580, *Non-destructive testing — Industrial radiographic illuminators — Minimum requirements.* (ISO 5580:1985)

3 Definitions

For the purpose of this standard, the following definitions apply.

3.1

nominal thickness, t

the nominal thickness of the parent material only. Manufacturing tolerances do not have to be taken into account

3.2

penetrated thickness, w

the thickness of material in the direction of the radiation beam calculated on the basis of the nominal thickness

for multiple wall techniques the penetrated thickness is calculated from the nominal thickness.

3.3**object-to-film distance, b**

the distance between the radiation side of the test object and the film surface measured along the central axis of the radiation beam

3.4**source size, d**

the size of the radiation source

3.5**source-to-film distance (SFD)**

the distance between the radiation source and the film measured in the direction of the beam

3.6**source-to-object distance, f**

the distance between the radiation source and the source side of the test object measured along the central axis of the radiation beam

3.7**diameter, D_e**

the nominal external diameter of the pipe

4 Classification of radiographic techniques

The radiographic techniques are divided into two classes:

- class A: basic techniques;
- class B: improved techniques.

Class B techniques will be used when class A might be insufficiently sensitive.

A1 Better techniques compared to class B are possible and may be defined by specification of all appropriate test parameters. **A1**

The choice of radiographic technique shall be **A1** defined by specification. **A1**

If, for technical reasons, it is not possible to meet one of the conditions specified for class B, such as type of radiation source or the source-to-object distance, f , it may be **A1** defined by specification **A1** that the condition selected may be that specified for class A. The loss of sensitivity shall be compensated by an increase of minimum density to 3,0 or by the choice of a higher contrast film system. Because of the better sensitivity compared to class A, the test specimen may be regarded as tested within class B. This does not apply if the special SFD reductions as described in 6.6 for test arrangements 6.1.4 and 6.1.5 are used.

5 General

5.1 Protection against ionizing radiation

WARNING NOTICE. Exposure of any part of the human body to X-rays or gamma-rays can be highly injurious to health. Wherever X-ray equipment or radioactive sources are in use, appropriate legal requirements must be applied.

Local or national or international safety precautions when using ionizing radiation shall be strictly applied.

5.2 Surface preparation and stage of manufacture

In general, surface preparation is not necessary, but where surface imperfections or coatings might cause difficulty in detecting defects, the surface shall be ground smooth or the coatings shall be removed.

Unless otherwise specified, radiography shall be carried out after the final stage of manufacture, e.g. after grinding or heat treatment.

5.3 Location of the weld in the radiograph

Where the radiograph does not show the weld, high-density markers shall be placed on either side of the weld.

5.4 Identification of radiographs

Symbols shall be affixed to each section of the object being radiographed. The images of these symbols shall appear in the radiograph outside the region of interest where possible and shall ensure unambiguous identification of the section.

5.5 Marking

Permanent markings on the object to be tested shall be made in order to accurately locate the position of each radiograph.

Where the nature of the material and/or its service conditions do not permit permanent marking, the location may be recorded by means of accurate sketches.

5.6 Overlap of films

When radiographing an area with two or more separate films, the films shall overlap sufficiently to ensure that the complete region of interest is radiographed. This shall be verified by a high-density marker on the surface of the object which will appear on each film.

5.7 Types and positions of image quality indicators (IQI)

The quality of image shall be verified by use of IQI in accordance with EN 462-1 or EN 462-2.

The IQI used shall be placed preferably on the source side of the test object at the centre of the area of interest on the parent metal beside the weld. The IQI shall be in close contact with the surface of the object.

Its location shall be made in a section of uniform thickness characterized by a uniform optical density on the film.

According to the IQI type used, two cases shall be considered.

- a) When using a wire IQI, the wires shall be directed perpendicular to the weld and its location shall ensure that at least 10 mm of the wire length will show in a section of uniform optical density, which is normally in the parent metal adjacent to the weld. At exposures in accordance with 6.1.6 and 6.1.7, the IQI can be placed with the wires across to the pipe axis, and they should not be projected into the image of the weld.
- b) When using a step/hole IQI, it shall be placed in such a way that the hole number required is placed close to the weld.

At exposures in accordance with 6.1.6 and 6.1.7, the IQI type used can be placed either on the source or on the film side. If the IQIs cannot be placed in accordance with the above conditions, the IQIs will be placed on the film side and the image quality shall be determined at least once from comparison exposure with one IQI placed at the source side and one at the film side under the same conditions.

For double-wall exposures, when the IQI is placed on the film side, the above test is not necessary and in this case reference should be made to the tables of correspondence given in Annex B.

Where the IQIs are placed at the film side, the letter "F" shall be placed near the IQI and it shall be noted in the test report.

If steps have been taken to guarantee that radiographs or similar test objects and regions are produced with identical exposure and processing techniques, and no differences in the image quality value are likely, the image quality need not be verified for every radiograph, the extent of image quality verification being subject to A_1 specification A_1 .

For exposures of pipes with diameter 200 mm and above with the source centrally located, at least three IQIs should be placed equally spaced at the circumference. The film(s) showing IQI images are then considered representative for the whole circumference.

5.8 Evaluation of image quality

The films shall be viewed in accordance with EN 25580.

From the testing of the image of the IQI on the radiograph, the number of the smallest wire or hole which can be discerned is determined. The image of a wire is accepted if a continuous length of at least 10 mm is clearly visible in a section of uniform optical density. In the case of the step/hole type IQI, if there are two holes of the same diameter, both shall be discernible in order that the step be considered as visible.

The image quality obtained shall be indicated on the test report of the radiographic test. In each case, the type of indicator used shall be clearly stated, as shown on the IQI.

5.9 Minimum image quality values

Table B.1 to Table B.12 in Annex B show the minimum quality values for ferrous materials. For other materials these requirements or corresponding requirements may be $\langle A_1 \rangle$ defined by specification $\langle A_1 \rangle$. The requirements shall be determined in accordance with EN 462-4.

5.10 Personnel qualification

Personnel performing non-destructive testing in accordance with this standard shall be qualified in accordance with EN 473, or equivalent, to an appropriate level in the relevant industrial sector.

6 Recommended techniques for making radiographs

6.1 Test arrangements

6.1.1 General

Normally, radiographic techniques in accordance with 6.1.2, 6.1.3, 6.1.4, 6.1.5, 6.1.6, 6.1.7, 6.1.8 and 6.1.9 shall be used.

The elliptical technique (double wall/double image) in accordance with Figure 11 should not be used for external diameter $D_e > 100$ mm, wall thickness $t > 8$ mm and weld width $> D_e/4$. Two 90° displaced images are sufficient if $t/D_e < 0,12$. The distance between the two weld images shall be about one weld width.

When it is difficult to carry out an elliptic test at $D_e \leq 100$ mm, the perpendicular technique in accordance with 6.1.7 may be used (see Figure 12). In this case, three exposures 120° or 60° apart are required.

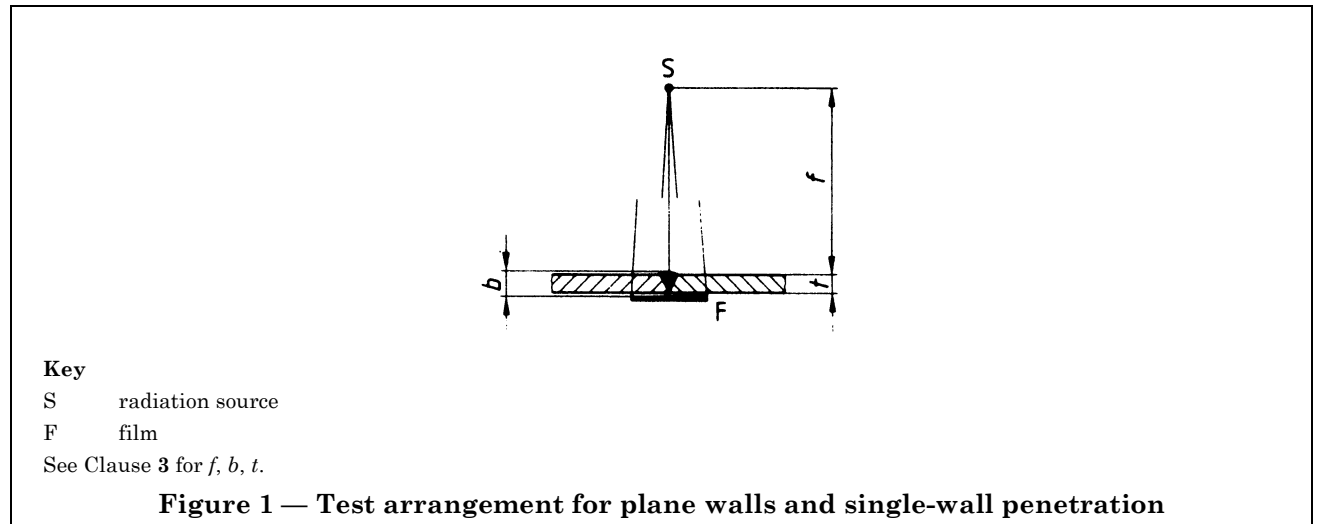
For test arrangements in accordance with Figure 11, Figure 13 and Figure 14, the inclination of the beam shall be kept as small as possible and be such as to prevent superimposition of the two images. The source-to-object distance, f , shall be kept as small as possible, in accordance with 6.6. The IQI shall be placed close to the film with a lead letter "F".

Other radiographic techniques may be $\langle A_1 \rangle$ specified, $\langle A_1 \rangle$ e.g. for reasons like geometry of the $\langle A_1 \rangle$ test object $\langle A_1 \rangle$ or differences in material thickness. In 6.1.9 an example of such a case is presented. Multi-film techniques shall not be used to reduce exposure times on uniform sections.

NOTE In Annex A the minimum number of radiographs necessary is given in order to obtain an acceptable radiographic coverage of the total circumference of a butt weld in pipe.

6.1.2 Radiation source located in front of the object and with the film at the opposite side

See Figure 1.



6.1.3 Radiation source located outside the object and with the film inside

See Figure 2, Figure 3 and Figure 4.

