INTERNATIONAL STANDARD

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

Contrôle non destructif des assemblages soudés — Contrôle par radiographie des assemblages soudés par fusion

Reference number
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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 17636 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*.

This first edition of ISO 17636 cancels and replaces ISO 1106-1:1984, ISO 1106-2:1985 and ISO 1106-3:1984 the technical contents of which are now covered by this document.

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

1 Scope

This International Standard specifies fundamental techniques for radiographic testing of fusion-welded joints in metallic materials. The object is to obtain satisfactory and repeatable results using the most economical methods. The techniques are based on generally recognized practice and fundamental theory of the subject.

This International Standard applies to testing of fusion-welded joints in plates or pipes[1)]. It complies with the basic rules laid down in ISO 5579.

This International Standard does not specify acceptance levels of the indications.

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 2504, *Radiography of welds and viewing conditions for films — Utilization of recommended patterns of image quality indicators (I.Q.I.)*

ISO 5580, *Non-destructive testing — Industrial radiographic illuminators — Minimum requirements*

ISO 11699-1, *Non-destructive testing — Industrial radiographic films — Part 1: Classification of film systems for industrial radiography*

ISO 11699-2, *Non-destructive testing — Industrial radiographic films — Part 2: Control of film processing by means of reference values*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
nominal thickness
t
nominal thickness of the parent material

NOTE Manufacturing tolerances do not have to be taken into account.

1) For the purposes of this International Standard, the term “pipe” applies to “pipe”, “tube”, “penstocks”, “boilers” and “pressure vessels”.

3.2
penetrated thickness
w
thickness of material in the direction of the radiation beam calculated on the basis of the nominal thickness

NOTE For multiple wall techniques, the penetrated thickness is calculated from the nominal thickness.

3.3
object-to-film distance
b
distance between the irradiated side of the test object and the film surface measured along the central axis of the radiation beam

3.4
source size
d
size of the radiation source

3.5
source-to-film distance
SFD
distance between the radiation source and the film measured in the direction of the beam

3.6
source-to-object distance
f
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
nominal external diameter of the pipe

4 Symbols and abbreviations

For the purposes of this document, the symbols and abbreviations given in Table 1 apply.

Table 1 — Symbols and abbreviations

Symbol	Definition
t	nominal thickness
w	penetrated thickness
b	object-to-film distance
d	source size
SFD	source-to-film distance
f	source-to-object distance
D_e	diameter

5 Classification of radiographic techniques

The radiographic techniques are divided into two classes:

— Class A: basic techniques;

— Class B: improved techniques.

The choice of technique shall be specified prior to testing. Class B techniques are used when class A proves to be insufficiently sensitive.

NOTE Better techniques than class B are possible but are not covered by the scope of this International Standard.

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, the condition specified for class A may be used. However, the loss of sensitivity shall be compensated by an increase in minimum density to 3,0 or by use of a higher contrast film system. Because of the better sensitivity compared to class A, the test specimen may be regarded as examined to class B. However, this does not apply if the special SFD reductions as described in 7.6 for test arrangements 7.1.4 and 7.1.5 are used.

6 General

6.1 Protection against ionizing radiation

When using ionizing radiation, local, national or international safety precautions shall be strictly applied.

WARNING — 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 shall be met.

6.2 Surface preparation and stage of manufacture

Where surface imperfections or coatings cause difficulty in detecting defects, the surface shall be ground smooth or the coatings shall be removed. Otherwise, surface preparation is not necessary.

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

6.3 Location of the weld in the radiograph

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

6.4 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.

6.5 Marking

Permanent markings shall be made on the object to be examined, 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.

6.6 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.

6.7 Types and positions of image quality indicators (IQI)

The quality of the image shall be verified by use of an IQI in accordance with ISO 2504.

The IQI used shall preferably be placed on the source side of the test object and in close contact with the surface of the object. The IQI shall be located in a section of uniform thickness characterized by a uniform optical density on the film.

According to the IQI type used, it shall be placed as follows:

a) When using a wire IQI, the wires shall be perpendicular to the weld and its location shall ensure that at least 10 mm of the wire length shows in a section of uniform optical density, which is normally in the parent metal adjacent to the weld. At exposures in accordance with 7.1.6 and 7.1.7 the IQI may be placed with the wires across the pipe axis but they should not project 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.

When making exposures in accordance with 7.1.6 and 7.1.7, the IQIs may be placed on either the source side or the film side. If it is not possible to place the IQIs in accordance with the conditions laid out in a) above, the IQIs shall be placed on the film side and the image quality determined from a comparison exposure with one IQI placed on the source side and one on 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. In this case, reference should be made to Tables A.1 to A.12.

Where the IQIs are placed at the film side, the letter “F” shall be placed near the IQI and this shall be recorded in the test report.

If steps have been taken to guarantee that radiographs of 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. However, the extent of image quality verification should be specified prior to testing.

For pipe diameters, D_e, $\geqslant$ 200 mm and 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 of the whole circumference.

6.8 Evaluation of image quality

Exposed films shall be viewed in accordance with ISO 5580.

The image of the IQI on the radiograph shall be tested and the number of the smallest wire or hole which can be discerned shall be determined. The image of a wire is acceptable 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 and 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 recorded on the radiographic examination report. The type of IQI used shall also be clearly stated.

6.9 Minimum image quality values

Tables A.1 to A.12 show the minimum quality values for ferrous materials. Users of this International Standard should verify if these values can be used for other materials in accordance with EN 462-4.

6.10 Personnel qualification

Non-destructive testing and the evaluation of results for final acceptance of welds shall be performed by qualified and capable personnel. It is recommended that personnel be qualified in accordance with ISO 9712 or an equivalent standard at an appropriate level in the relevant industry sector.

7 Recommended techniques for making radiographs

7.1 Test arrangements

7.1.1 General

The radiographic techniques in accordance with 7.1.2 to 7.1.9 are recommended.

The elliptical technique (double wall/double image) in accordance with 7.1.6 should not be used for external diameters $D_e > 100$ mm, wall thicknesses $t > 8$ mm and weld widths $> D_e/4$. 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 $D_e \leqslant 100$ mm, the perpendicular technique in accordance with 7.1.7 may be used (see Figure 12). In this case, three exposures 120° or 60° apart are required.

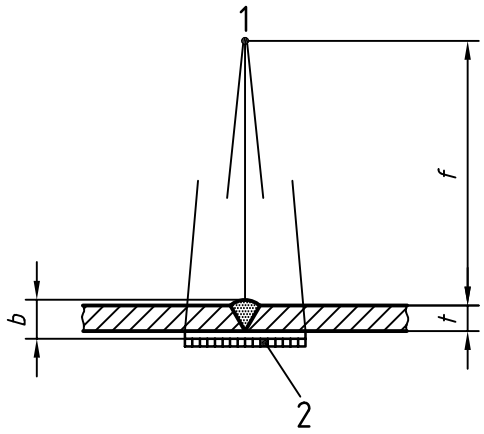
For test arrangements in accordance with Figures 11, 13 and 14, the inclination of the beam shall be kept as small as possible and be such as to prevent superimposition of the two images. The source to object distance, f, shall be kept as small as possible, in accordance with 7.6. The IQI shall be placed close to the film with a lead letter "F".

Other radiographic techniques may be used, when the geometry of the piece or differences in material thickness do not permit use of one of the techniques listed in 7.1.2 to 7.1.9. Multi-film techniques shall not be used to reduce exposure times on uniform sections.

NOTE The minimum number of radiographs necessary to obtain an acceptable radiographic coverage of the total circumference of a butt weld in pipe is shown in Annex B.

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

See Figure 1.



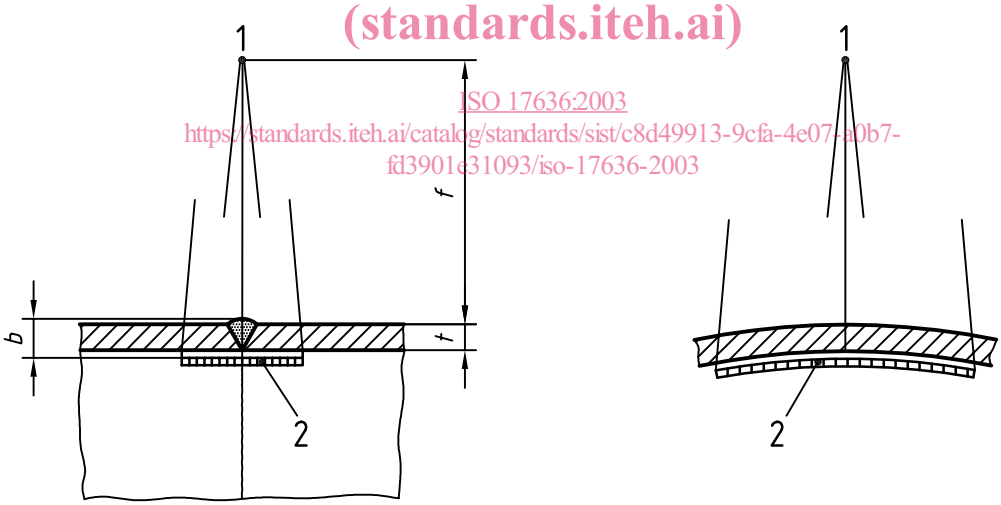
Key

1 radiation source
2 film

Figure 1 — Test arrangement for plane walls and single-wall penetration
(see Clause 3 for *f*, *b*, *t*)

7.1.3 Radiation source located outside the object and film inside

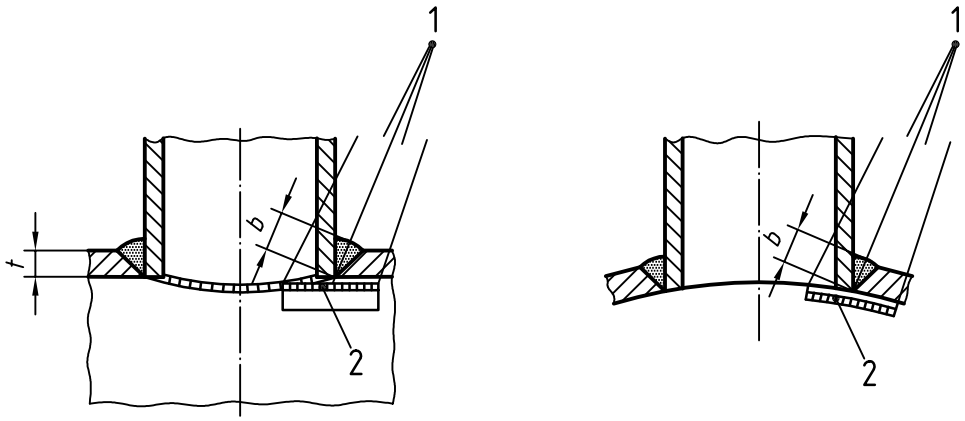
See Figures 2 to 4.



Key

1 radiation source
2 film

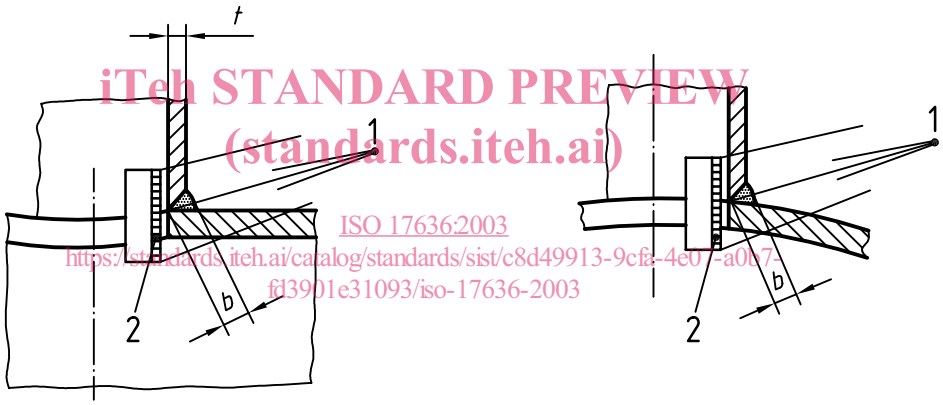
Figure 2 — Test arrangement for single-wall penetration of curved objects



Key

1 radiation source
2 film

Figure 3 — Test arrangement for single-wall penetration of curved objects (set-in weld)



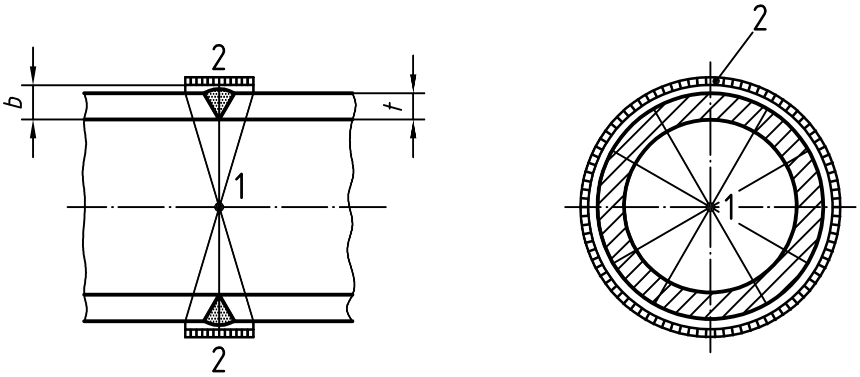
Key

1 radiation source
2 film

Figure 4 — Test arrangement for single-wall penetration of curved objects (set-on weld)

7.1.4 Radiation source centrally located inside the object and with the film outside

See Figures 5 to 7.

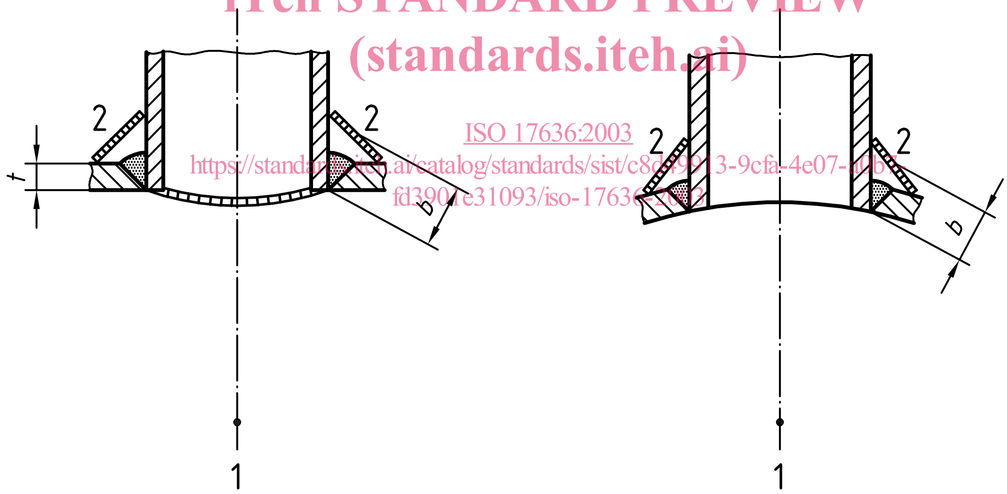


Key

1 radiation source

2 film

Figure 5 — Test arrangement for single-wall penetration of curved objects

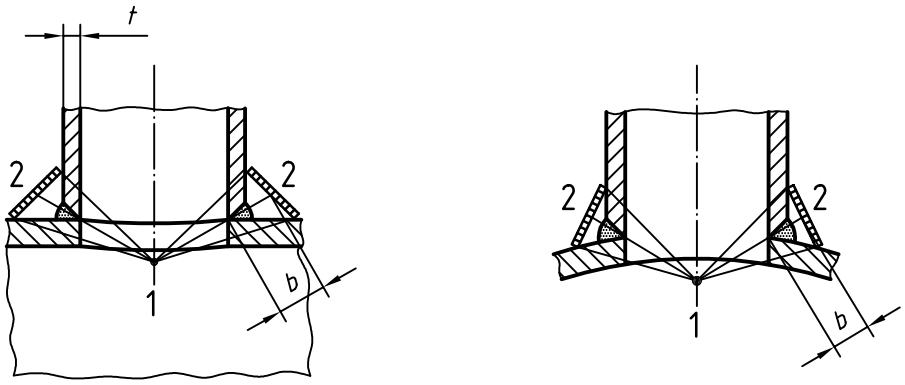


Key

1 radiation source

2 film

Figure 6 — Test arrangement for single-wall penetration of curved objects (set-in weld)



Key

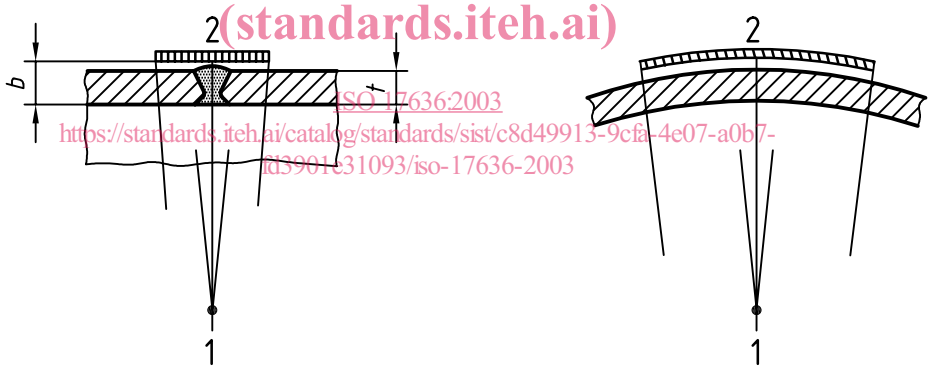
1 radiation source

2 film

Figure 7 — Test arrangement for single-wall penetration of curved objects (set-on weld)

7.1.5 Radiation source located off-centre inside the object and film outside

See Figures 8 to 10.



Key

1 radiation source

2 film

Figure 8 — Test arrangement for single-wall penetration of curved objects