INTERNATIONAL STANDARD

ISO 17636

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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.

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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.

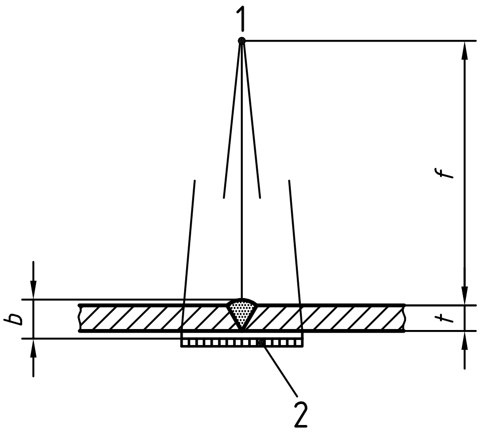
For test arrangements in accordance with Figures 11, 13 and 14, the inclination of the beam shall be kept as small as possible and be such as to prevent superimposition of the two images. The source to object distance, f, shall be kept as small as possible, in accordance with 7.6. The IQI shall be placed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

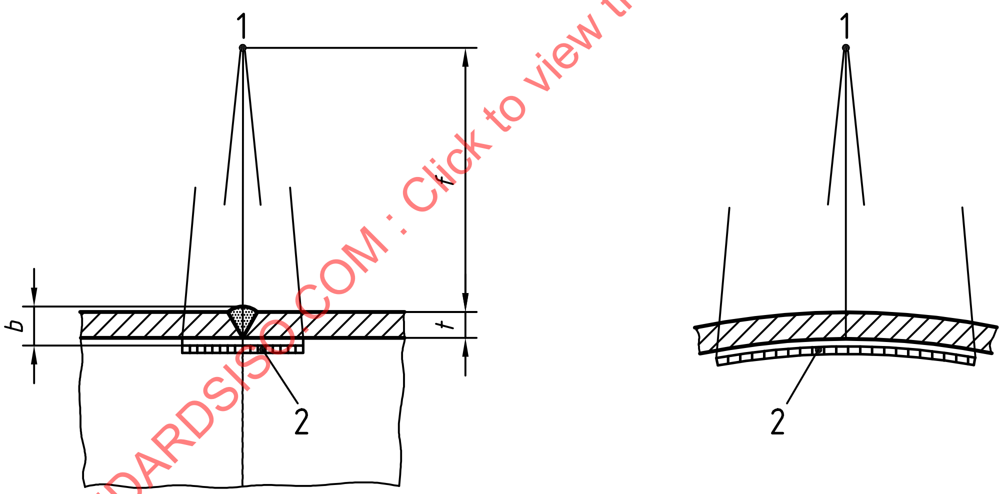
1 radiation source

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.

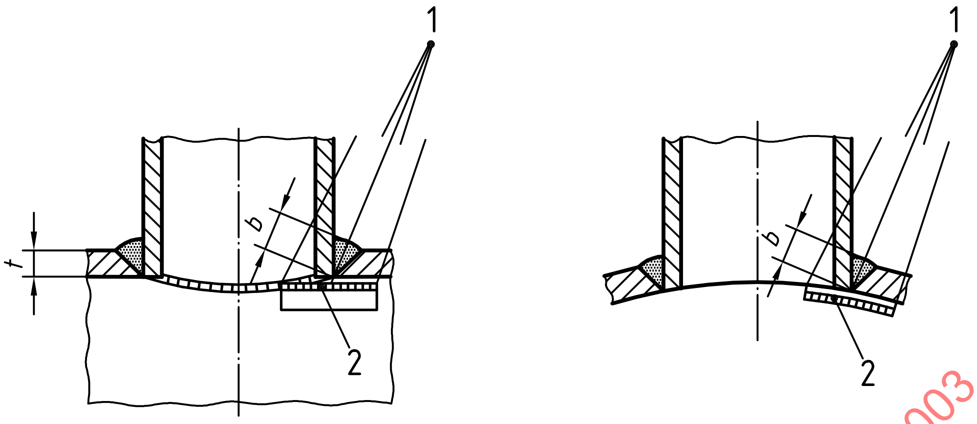


Key

1 radiation source

2 film

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

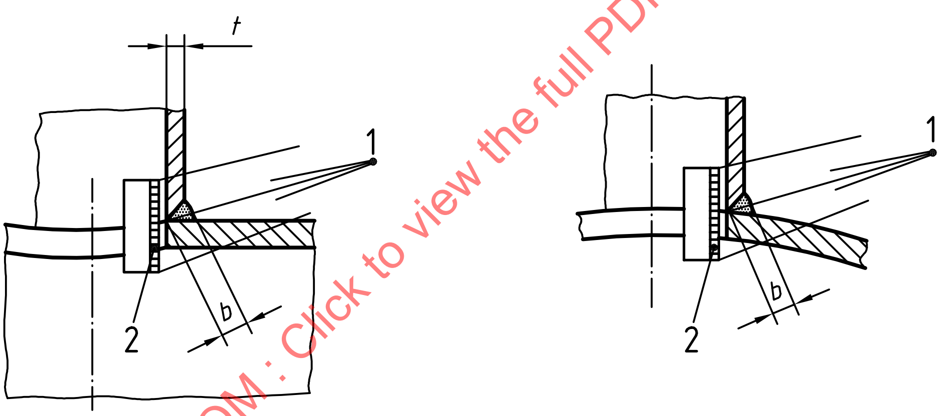


Key

1 radiation source

2 film

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



Key

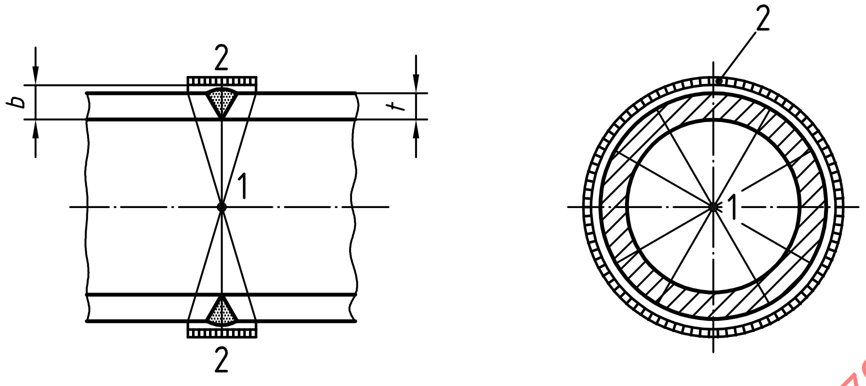
1 radiation source

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.

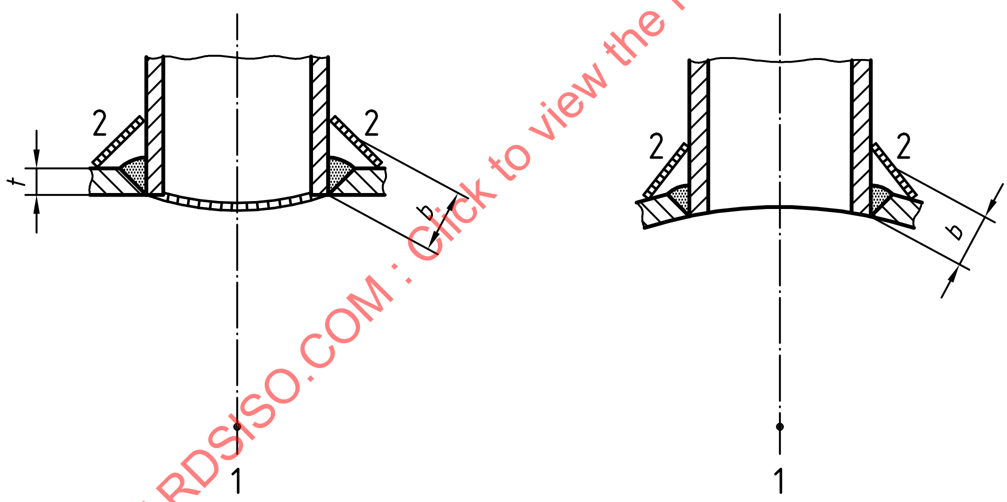


Key

1 radiation source

2 film

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

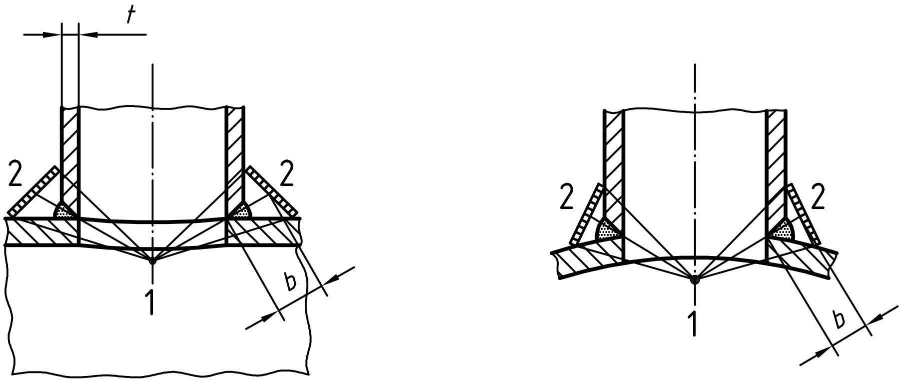


Key

1 radiation source

2 film

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



Key

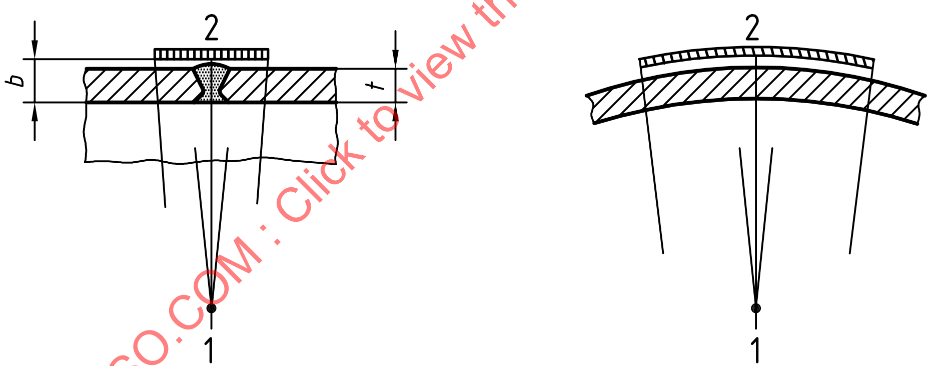
1 radiation source

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.

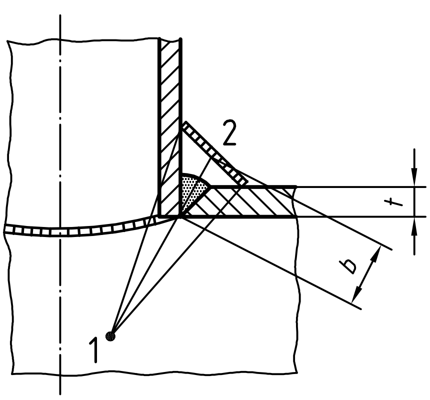


Key

1 radiation source

2 film

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

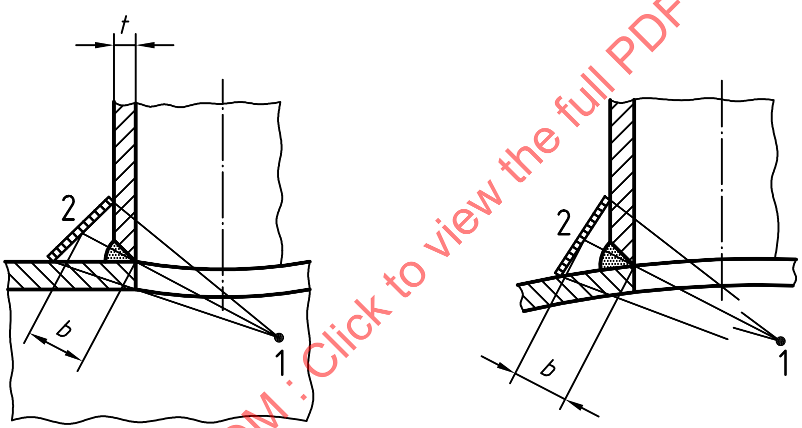


Key

1 radiation source

2 film

Figure 9 — Test arrangement for single-wall penetration of curved object (set-in weld)



Key

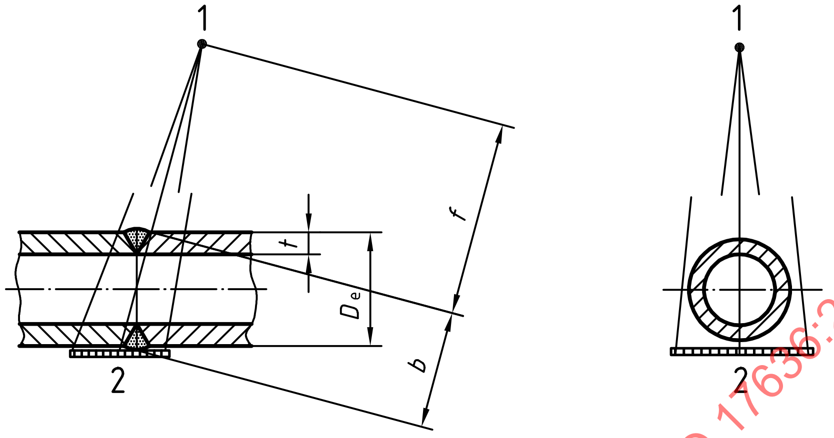
1 radiation source

2 film

Figure 10 — Test arrangement for single-wall penetration of curved objects (set-on weld)

7.1.6 Elliptical technique

See Figure 11.



Key

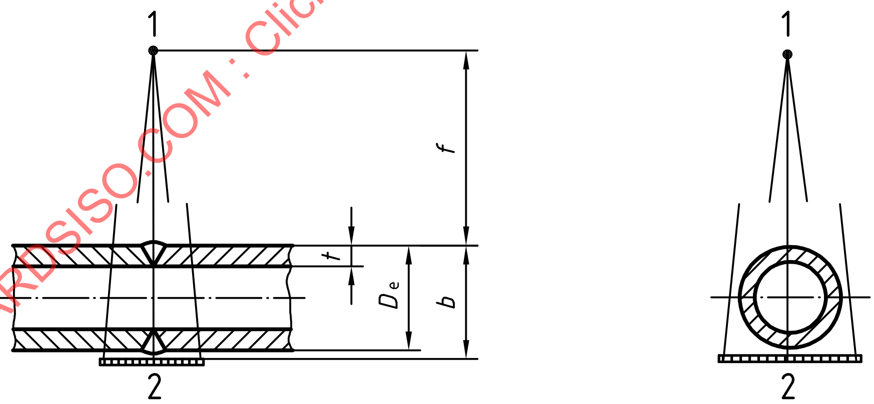
1 radiation source

2 film

Figure 11 — Test arrangement for double-wall penetration double image of curved objects for evaluation of both walls (source and film outside of the test object)

7.1.7 Perpendicular technique

See Figure 12.



Key

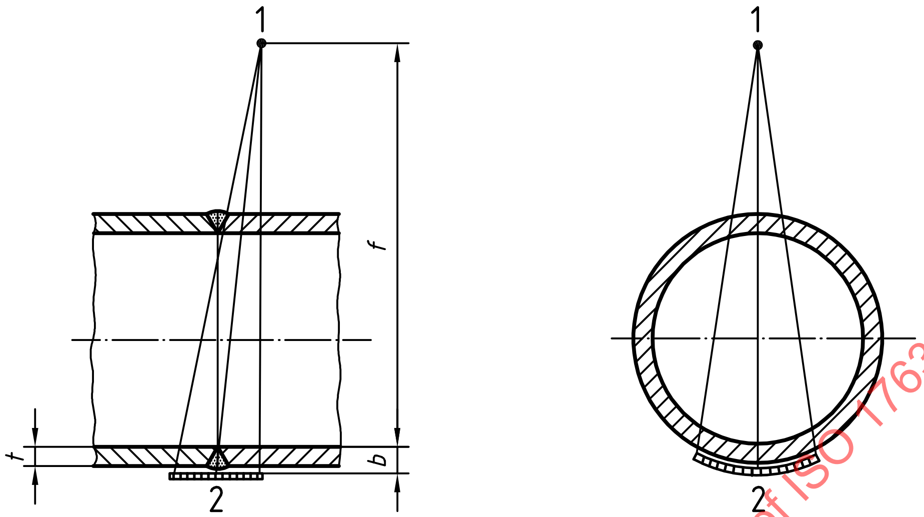
1 radiation source

2 film

Figure 12 — Test arrangement for double-wall penetration double image of curved objects for evaluation of both walls (source and film outside of the test object)

7.1.8 Radiation source located outside the object and film on the other side

See Figures 13 to 18.

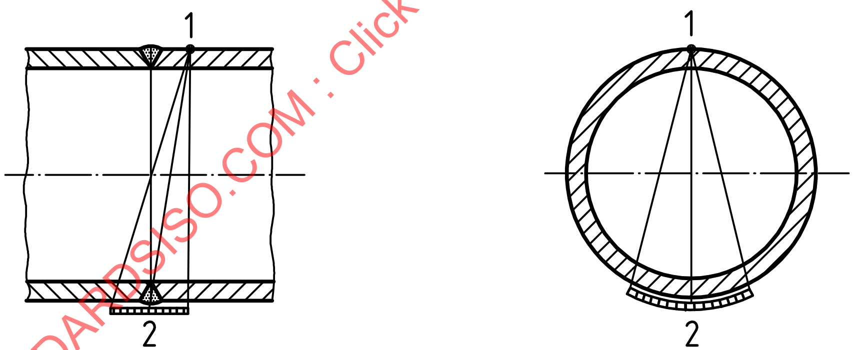


Key

1 radiation source

2 film

Figure 13 — Test arrangement for double-wall penetration single image of curved objects for evaluation of the wall next to the film with the IQI placed close to the film

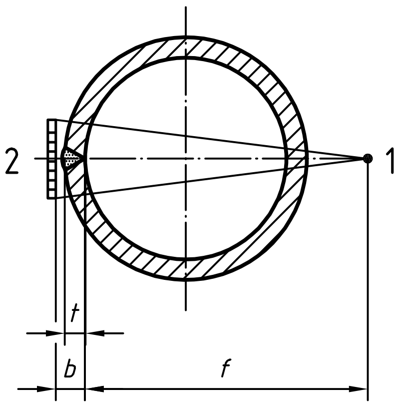


Key

1 radiation source

2 film

Figure 14 — Test arrangement for double-wall penetration single image

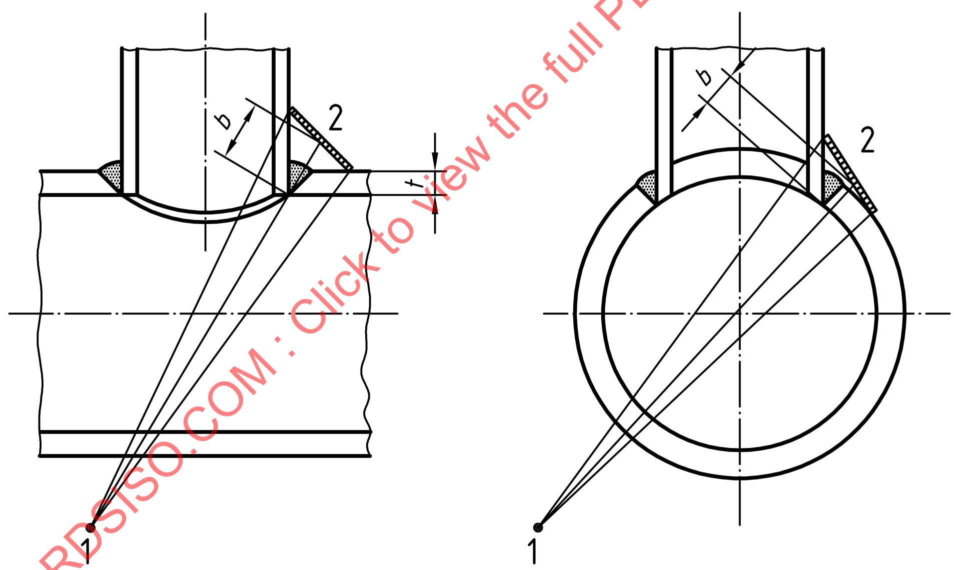


Key

1 radiation source

2 film

Figure 15 — Test arrangement for double-wall penetration single image of longitudinal welds

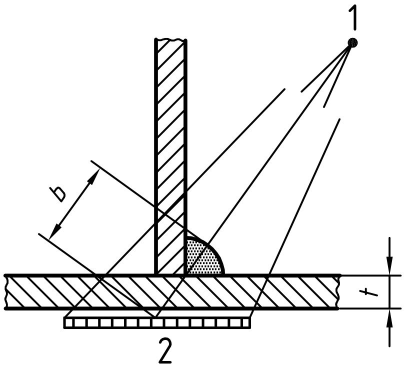


Key

1 radiation source

2 film

Figure 16 — Test arrangement for double-wall penetration single image of curved objects for evaluation of the wall next to the film

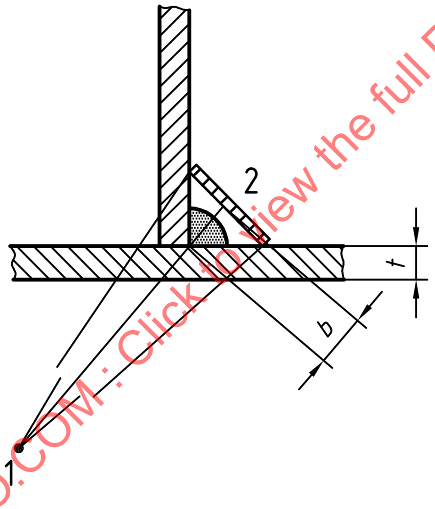


Key

1 radiation source

2 film

Figure 17 — Test arrangement for penetration of fillet welds



Key

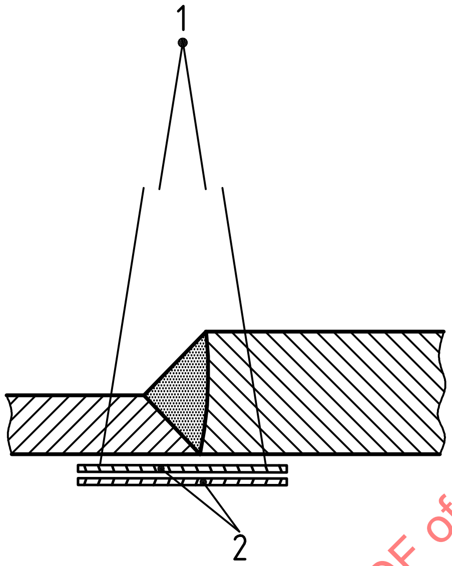
1 radiation source

2 film

Figure 18 — Test arrangement for penetration of fillet welds

7.1.9 Technique for different material thicknesses

See Figure 19.



Key

1 radiation source

2 film

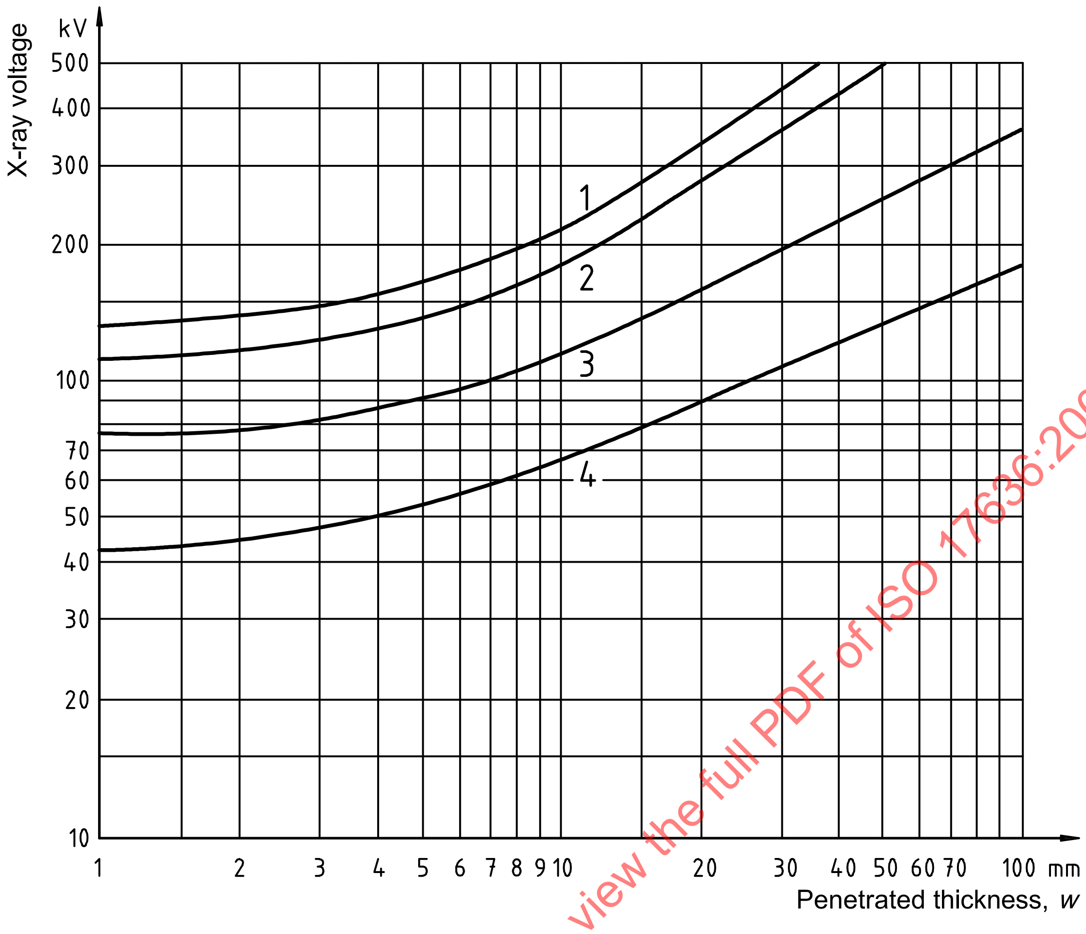
Figure 19 — Multi-film technique

7.2 Choice of tube voltage and radiation source

7.2.1 X-ray devices up to 500 kV

To maintain good flaw sensitivity, the X-ray tube voltage should be as low as possible. The maximum values of tube voltage versus thickness are given in Figure 20.

For some applications where there is a thickness change across the area of object being radiographed, a modified technique with a slightly higher voltage may be used, but it should be noted that an excessively high tube voltage will lead to a loss of defect detection sensitivity. For steel the increment shall not be more than 50 kV, for titanium not more than 40 kV and for aluminium not more than 30 kV.



Key

1 copper/nickel and alloys

2 steel

3 titanium and alloys

4 aluminium and alloys

Figure 20 — Maximum X-ray voltage for X-ray devices up to 500 kV as a function of penetrated thickness and material

7.2.2 Other radiation sources

The permitted penetrated thickness ranges for gamma ray sources and X-ray equipment above 1 MeV are given in Table 2.

NOTE A reduction in the value for Ir 192 to 10 mm and for Se 75 to 5 mm may be specified.

On thin steel specimens, gamma rays from Se 75, Ir 192 and Co 60 will not produce radiographs having as good a defect detection sensitivity as X-rays used with the appropriate techniques and parameters. However, there are advantages in handling and accessibility of gamma ray sources over X-ray equipment. Table 2 gives a range of thicknesses for which each of these gamma ray sources may be used when the use of X-rays is difficult.

For certain applications wider wall thickness ranges may be permitted, if sufficient image quality can be achieved.

In cases where radiographs are produced using gamma rays, the travel time to position the source shall not exceed 10 % of the total exposure time.

Table 2 — Penetrated thickness range for gamma ray sources and X-ray equipment with energy 1 MeV and above for steel, copper and nickel base alloys

Radiation source	Penetrated thickness, w mm	
	Test class A	Test class B
Tm 170	$w \leqslant 5$	$w \leqslant 5$
Yb 169 [a]	$1 \leqslant w \leqslant \leqslant 15$	$2 \leqslant w \leqslant 12$
Se 75 [b]	$10 \leqslant w \leqslant 40$	$14 \leqslant w \leqslant 40$
Ir 192	$20 \leqslant w \leqslant 100$	$20 \leqslant w \leqslant 90$
Co 60	$40 \leqslant w \leqslant 200$	$60 \leqslant w \leqslant 150$
X-ray equipment with energy from 1 MeV to 4 MeV	$30 \leqslant w \leqslant 200$	$50 \leqslant w \leqslant 180$
X-ray equipment with energy from 4 MeV to 12 MeV	$w \geqslant 50$	$w \geqslant 80$
X-ray equipment with energy above 12 MeV	$w \geqslant 80$	$w \geqslant 100$

a For aluminium and titanium, the penetrated material thickness is $10 \text{ mm} < w < 70 \text{ mm}$ for class A and $25 \text{ mm} < w < 55 \text{ mm}$ for class B.

b For aluminium and titanium, the penetrated material thickness is 35 mm u w u 120 mm for class A.

7.3 Film systems and screens

For radiographic testing, film system classes shall be used in accordance with ISO 11699-1.

For different radiation sources, the minimum film system classes are given in Tables 3 and 4.

When using metal screens, good contact between films and screens is required. This may be achieved either by using vacuum-packed films or by applying pressure.

For different radiation sources, Tables 3 and 4 show the recommended screen materials and thicknesses.

NOTE Other screen thicknesses may be used provided the required image quality is achieved.

Table 3 — Film system classes and metal screens for the radiography of steels, copper and nickel based alloys

Radiation source	Penetrated thickness w	Film system class[a] Class A	Film system class[a] Class B	Type and thickness of metal screens Class A	Type and thickness of metal screens Class B
X-ray potentials $\leqslant$ 100 kV		C 5	C 3	None or up to 0,03 mm front and back screens of lead	
X-ray potentials $>$ 100 kV to 150 kV				Up to 0,15 mm front and back screens of lead	
X-ray potentials $>$ 150 kV to 250 kV			C 4	0,02 mm to 0,15 mm front and back screens of lead	
Yb 169 Tm 170	$w < 5$ mm	C 5	C 3	None or up to 0,03 mm front and back screens of lead	
	$w \geqslant 5$ mm		C 4	0,02 mm to 0,15 mm front and back screens of lead	
X-ray potentials $>$ 250 kV to 500 kV	$w \leqslant 50$ mm	C 5	C 4	0,02 mm to 0,2 mm front and back screens of lead	
	$w > 50$ mm		C 5	0,1 mm to 0,2 mm and front screens of lead[b] 0,02 mm to 0,2 mm back screens of lead	
Se 75		C 5	C 4	0,1 mm to 0,2 mm front and back screens of lead	
Ir 192		C 5	C 4	0,02 mm to 0,2 mm front screens of lead[b]	0,1 mm to 0,2 mm front screens of lead[b]
				0,02 mm to 0,2 mm back screens of lead	
Co 60	$w \leqslant 100$ mm	C 5	C 4	0,25 mm to 0,7 mm front and back screens of steel or copper[c]	
	$w > 100$ mm		C 5		
X-ray equipment with energy from 1 MeV to 4 MeV	$w \leqslant 100$ mm	C 5	C 3	0,25 mm to 0,7 mm front and back screens of steel or copper [c]	
	$w > 100$ mm		C 5		
X-ray equipment with energy from 4 MeV to 12 MeV	$w \leqslant 100$ mm	C 4	C 4	Up to 1 mm front screen of copper, steel or tantalum[d].	
	100 mm < $w \leqslant 300$ mm	C 5			
	$w > 300$ mm		C 5	Back screen of copper or steel up to 1 mm and tantalum up to 0,5 mm [d]	
X-ray equipment with energy above 12 MeV	$w \leqslant 100$ mm	C 4	—	Up to 1 mm front screen of tantalum [e] No back screen	
	100 mm $< w \leqslant 300$ mm	C 5	C 4		
	$w > 300$ mm		C 5	Up to 1 mm front screen of tantalum [e] Up to 0,5 mm back screen of tantalum	

[a] Better film system classes may also be used.

[b] Ready packed films with a front screen up to 0,03 mm may be used if an additional lead screen of 0,1 mm is placed between the object and the film.

[c] In class A, 0,5 mm to 2,0 mm screens of lead may also be used.

[d] In class A, 0,5 mm to 1 mm screens of lead may also be used.

[e] Tungsten screens may also be used.

Table 4 — Film system classes and intensifying screens for aluminium and titanium

Radiation source	Film system class[a]		Type and thickness of intensifying screens
	Class A	Class B	
X-ray potentials ⩽ 150 kV			None or up to 0,03 mm front and up to 0,15 mm back screens of lead
X-ray potentials > 150 kV to 250 kV			0,02 mm to 0,15 mm front and back screens of lead
X-ray potentials > 250 kV to 500 kV	C 5	C 3	0,1 mm to 0,2 mm front and back screens of lead
Yb 169			0,02 mm to 0,15 mm front and back screens of lead
Se 75			0,2 mm front[b] and 0,1 mm to 0,2 mm back screens of lead

a Better film system classes may also be used.

b Instead of 0,2 mm lead, a 0,1 mm screen with an additional filter of 0,1 mm may be used.

7.4 Alignment of beam

The radiation beam shall be directed to the centre of the area being examined and should be perpendicular to the object surface at that point, except when it can be demonstrated that certain imperfections are best revealed by a different alignment of the beam. In this case, an appropriate alignment of the beam may be permitted.

7.5 Reduction of scattered radiation

7.5.1 Filters and collimators

In order to reduce the effect of back-scattered radiation, direct radiation shall be collimated as much as possible to the section being tested.

With Ir 192 and Co 60 radiation sources or in the case of edge scatter, a sheet of lead can be used as a low-energy scattered radiation filter between the object and the cassette. The thickness of this sheet shall be between 0,5 mm and 2 mm in accordance with the penetrated thickness.

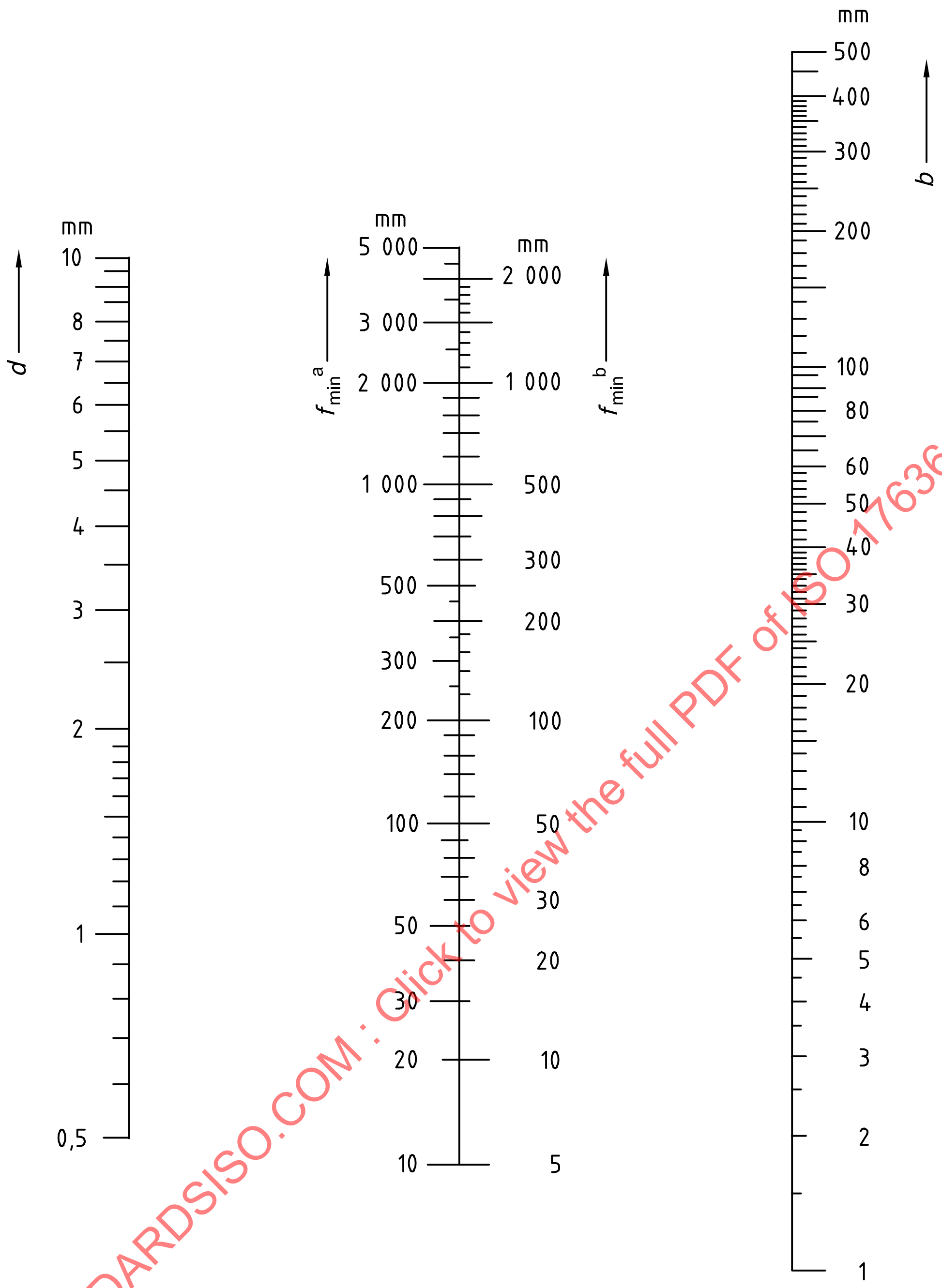
7.5.2 Interception of back-scattered radiation

If necessary, the film shall be shielded from back-scattered radiation by an adequate thickness of lead at least 1 mm, or of tin at least 1,5 mm, placed behind the film-screen combination.

The presence of back-scattered radiation shall be checked for each new test arrangement by a lead letter B (with a minimum height of 10 mm and a minimum thickness of 1,5 mm) placed immediately behind each cassette. If the image of this symbol records as a lighter image on the radiograph, it shall be rejected. If the symbol is darker or invisible, the radiograph is acceptable and demonstrates good protection against scattered radiation.

7.6 Source-to-object distance

The minimum source-to-object distance, f_{min}, depends on the source size d and on the object-to-film distance, b.



a Class B.

b Class A.

Figure 21 — Nomogram for the determination of minimum source-to-object distance, f_{min}, in relation to object-to-film distance, b, and the source size, d.

The source-to-object distance, f, shall be chosen, where practicable, so that the ratio f/d is in accordance with equations 1 and 2:

For class A:

$$f/d \geqslant 7{,}5 \left(\frac{b}{\text{mm}}\right)^{2/3} \tag{1}$$

For class B:

$$f/d \geqslant 15 \left(\frac{b}{\text{mm}}\right)^{2/3} \tag{2}$$

b is given in millimetres (mm).

If the distance $b < 1{,}2\ t$, the dimension b in Equations (1) and (2) and Figure 21 shall be replaced by the nominal thickness t.

For the determination of the source-to-object distance, f_{min}, the nomogram in Figure 21 may be used. The nomogram is based on equations (1) and (2).

In class A, if planar imperfections are to be detected, the minimum distance f_{min} shall be the same as for class B in order to reduce the geometric unsharpness by a factor of 2.

For critical technical applications in crack-sensitive materials, more sensitive radiographic techniques than class B shall be used.

When using the elliptical technique described in 7.1.6 or the perpendicular technique described in 7.1.7, b shall be replaced by the external diameter, D_{e}, of the pipe in Equations (1) and (2) and in Figure 21.

When the source is outside the object and the film on the other side (technique described in 7.1.8 as double-wall penetration/single image), the source-to-object distance is determined only by the wall thickness.

If the radiation source can be placed inside the object to be radiographed (techniques shown in 7.1.4 and 7.1.5) to achieve a more suitable direction of testing and when a double-wall technique (see 7.1.6 to 7.1.8) is avoided, this method should be preferred. The reduction in minimum source-to-object distance should not be greater than 20 %. When the source is located centrally inside the object and the film outside (technique shown in 7.1.4) and provided that the IQI requirements are met, this percentage may be increased. However, the reduction in minimum source-to-object distance shall be no greater than 50 %.

7.7 Maximum area for a single exposure

The number of radiographs for complete testing of flat welds (see Figures 1 and 15) and of curved welds with the radiation source arranged off-centre (see Figures 2 to 4 and 8 to 16) should be specified.

The ratio of the penetrated thickness at the outer edge of an evaluated area of uniform thickness to that at the beam centre shall not be more than 1,1 for class B and 1,2 for class A.

The densities resulting from any variation of penetrated thickness should not be lower than those indicated in 7.8 and not higher than those allowed by the available illuminator, provided suitable masking is possible.

The size of the area to be examined includes the weld and the heat-affected zones. In general, about 10 mm of parent metal should also be tested on each side of the weld.

The recommended number of radiographs for acceptable testing of a circumferential butt weld is given in Annex B.

7.8 Density of radiograph

Exposure conditions should be such that the minimum optical density of the radiograph in the area examined is in accordance with Table 5.

Table 5 — Optical density of the radiographs

Class	Optical density[a]
A	$\geqslant$ 2,0[b]
B	$\geqslant$ 2,3[c]

[a] A measuring tolerance of ± 0,1 is permitted.

[b] May be reduced to 1,5 if specified, e.g. in an application standard.

[c] May be reduced to 2,0.if specified, e.g. in an application standard.

High optical densities can be used where the viewing light is sufficiently bright in accordance with 7.10.

In order to avoid unduly high fog densities arising from film ageing, development or temperature, the fog density shall be checked periodically on a non-exposed sample taken from the films being used, and handled and processed under the same conditions as the actual radiograph. The fog density shall not exceed 0,3. Fog density here is defined as the total density (emulsion and base) of a processed, unexposed film.

When using a multi-film technique with interpretation of single films, the optical density of each film shall be in accordance with Table 5.

If double film viewing is requested, the optical density of one single film shall be no lower than 1,3.

7.9 Processing

Films should be processed in accordance with the conditions recommended by the film and chemical manufacturer in order to obtain the selected film system class. Particular attention shall be paid to temperature, developing time and washing time. The film processing shall be controlled regularly in accordance with ISO 11699-2. The radiographs should be free from defects due to processing or other causes that would interfere with interpretation.

7.10 Film viewing conditions

The radiographs should be examined in a darkened room on an area of the viewing screen with an adjustable luminance in accordance with ISO 5580. The viewing screen should be masked to the area of interest.

8 Test report

For each exposure, or set of exposures, a test report shall be prepared giving information on the radiographic technique used, and on any other special circumstances which would allow a better understanding of the results.

The test report shall include at least the following information:

a) name of the testing body;

b) object examined;

c) material;

d) heat treatment;

e) geometry of the weld;

f) material thickness;

g) welding process;

h) specification of test including requirements for acceptance;

i) radiographic technique and class, required IQI sensitivity in accordance with this International Standard;

j) test arrangement in accordance with 7.1;

k) system of marking used;

l) film position plan;

m) radiation source, type and size of focal spot and identification of equipment used;

n) film, screens and filters;

o) used tube voltage and current or source activity;

p) time of exposure and source-to-film distance;

q) processing technique: manual/automatic;

r) type and position of image quality indicators;

s) results of test including data on film density, reading of IQI;

t) any deviation from this International Standard, by special agreement;

u) name, reference to certificate and signature of the responsible person(s);

v) date(s) of exposure and test report.

Annex A
(normative)

Minimum image quality values for ferrous materials[2)]

A.1 Single-wall technique; IQI on source side

See Tables A.1 and A.2.

Table A.1 — Wire IQI

Image quality class A				
Nominal thickness t mm				IQI value[a]
		≤	1,2	W 18
>	1,2	≤	2	W 17
>	2	≤	3,5	W 16
>	3,5	≤	5	W 15
>	5	≤	7	W 14
>	7	≤	10	W 13
>	10	≤	15	W 12
>	15	≤	25	W 11
>	25	≤	32	W 10
>	32	≤	40	W 9
>	40	≤	55	W 8
>	55	≤	85	W 7
>	85	≤	150	W 6
>	150	≤	250	W 5
>	250			W 4

[a] When using Ir 192 sources, IQI values lower than listed values can be accepted as follows:

10 mm to 24 mm: up to 2 values

above 24 mm to 30 mm: up to 1 value.

Table A.2 — Step/hole IQI

Image quality class A				
Nominal thickness t mm				IQI value[a]
		≤	2	H 3
>	2,0	≤	3,5	H 4
>	3,5	≤	6	H 5
>	6	≤	10	H 6
>	10	≤	15	H 7
>	15	≤	24	H 8
>	24	≤	30	H 9
>	30	≤	40	H 10
>	40	≤	60	H 11
>	60	≤	100	H 12
>	100	≤	150	H 13
>	150	≤	200	H 14
>	200	≤	250	H 15
>	250	≤	320	H 16
>	320	≤	400	H 17
>	400			H 18

[a] When using Ir 192 sources, IQI values lower than listed values can be accepted as follows:

10 mm to 24 mm: up to 2 values

above 24 mm to 30 mm: up to 1 value.

2) These values may be useable for other materials but should be verified in accordance with EN 462-4.

A.2 Single-wall technique; IQI on source side

See Tables A.3 and A.4.

Table A.3 — Wire IQI

Image quality class B				
Nominal thickness t mm				IQI value[a]
		⩽	1,5	W 19
>	1,5	⩽	2,5	W 18
>	2,5	⩽	4	W 17
>	4	⩽	6	W 16
>	6	⩽	8	W 15
>	8	⩽	12	W 14
>	12	⩽	20	W 13
>	20	⩽	30	W 12
>	30	⩽	35	W 11
>	35	⩽	45	W 10
>	45	⩽	65	W 9
>	65	⩽	120	W 8
>	120	⩽	200	W 7
>	200	⩽	350	W 6
>	350			W 5

a When using Ir 192 sources, IQI values lower than listed values can be accepted as follows:

12 mm to 40 mm: up to 1 value.

Table A.4 — Step/hole IQI

Image quality class B				
Nominal thickness t mm				IQI value[a]
		⩽	2,5	H 2
>	2,5	⩽	4	H 3
>	4	⩽	8	H 4
>	8	⩽	12	H 5
>	12	⩽	20	H 6
>	20	⩽	30	H 7
>	30	⩽	40	H 8
>	40	⩽	60	H 9
>	60	⩽	80	H 10
>	80	⩽	100	H 11
>	100	⩽	150	H 12
>	150	⩽	200	H 13
>	200	⩽	250	H 14

a When using Ir 192 sources, IQI values lower than listed values can be accepted as follows:

12 mm to 40 mm: up to 1 value.

A.3 Double-wall technique; double image; IQI on source side

See Tables A.5 and A.6.

Table A.5 — Wire IQI

Image quality class A				
Penetrated thickness w mm				IQI value
		⩽	1,2	W 18
>	1,2	⩽	2	W 17
>	2	⩽	3,5	W 16
>	3,5	⩽	5	W 15
>	5	⩽	7	W 14
>	7	⩽	12	W 13
>	12	⩽	18	W 12
>	18	⩽	30	W 11
>	30	⩽	40	W 10
>	40	⩽	50	W 9
>	50	⩽	60	W 8
>	60	⩽	85	W 7
>	85	⩽	120	W 6
>	120	⩽	220	W 5
>	220	⩽	380	W 4
>	380			W 3

Table A.6 — Step/hole IQI

Image quality class A				
Penetrated thickness w mm				IQI value[a]
		⩽	1	H 3
>	1	⩽	2	H 4
>	2	⩽	3,5	H 5
>	3,5	⩽	5,5	H 6
>	5,5	⩽	10	H 7
>	10	⩽	19	H 8
>	19	⩽	35	H 9

[a] When using Ir 192 sources, IQI values lower than listed values can be accepted as follows:

up to 3,5 mm: up to 2 values

above 3,5 mm to 10 mm: up to 1 value.

A.4 Double-wall technique; double image; IQI on source side

See Tables A.7 and A.8.

Table A.7 — Wire IQI

Image quality class B				
Penetrated thickness w mm				IQI value[a]
		⩽	1,5	W 19
>	1,5	⩽	2,5	W 18
>	2,5	⩽	4	W 17
>	4	⩽	6	W 16
>	6	⩽	8	W 15
>	8	⩽	15	W 14
>	15	⩽	25	W 13
>	25	⩽	38	W 12
>	38	⩽	45	W 11
>	45	⩽	55	W 10
>	55	⩽	70	W 9
>	70	⩽	100	W 8
>	100	⩽	170	W 7
>	170	⩽	250	W 6
>	250			W 5

Table A.8 — Step/hole IQI

Image quality class B				
Penetrated thickness w mm				IQI value[a]
		⩽	1	H 2
>	1	⩽	2,5	H 3
>	2,5	⩽	4	H 4
>	4	⩽	6	H 5
>	6	⩽	11	H 6
>	11	⩽	20	H 7
>	20	⩽	35	H 8

[a] When using Ir 192 sources, IQI values lower than listed values can be accepted as follows:

4 mm to 11 mm: up to 1 value.

A.5 Double-wall technique; single or double image; IQI on film side

See Tables A.9 and A.10.

Table A.9 — Wire IQI

Image quality class A				
Penetrated thickness w mm				IQI value
		⩽	1,2	W 18
>	1,2	⩽	2	W 17
>	2	⩽	3,5	W 16
>	3,5	⩽	5	W 15
>	5	⩽	10	W 14
>	10	⩽	15	W 13
>	15	⩽	22	W 12
>	22	⩽	38	W 11
>	38	⩽	48	W 10
>	48	⩽	60	W 9
>	60	⩽	85	W 8
>	85	⩽	125	W 7
>	125	⩽	225	W 6
>	225	⩽	375	W 5
>	375			W 4

Table A.10 — Step/hole IQI

Image quality class A				
Penetrated thickness w mm				IQI value[a]
		⩽	2	H 3
>	2	⩽	5	H 4
>	5	⩽	9	H 5
>	9	⩽	14	H 6
>	14	⩽	22	H 7
>	22	⩽	36	H 8
>	36	⩽	50	H 9
>	50	⩽	80	H 10

[a] When using Ir 192 sources, IQI values lower than listed values can be accepted as follows:

5 mm to 9 mm: up to 2 values

above 9 mm to 22 mm: up to 1 value.