INTERNATIONAL STANDARD

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Non-destructive testing of welds — Radiographic testing —

Part 1: X- and gamma-ray techniques with film

Contrôle non destructif des assemblages soudés — Contrôle par radiographie —

Partie 1: Techniques par rayons X ou gamma à l'aide de film

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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 17636-1 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition, together with ISO 17636-2, cancels and replaces ISO 17636:2003, of which it constitutes a technical revision.

ISO 17636 consists of the following parts, under the general title *Non-destructive testing of welds — Radiographic testing*:

— *Part 1: X- and gamma-ray techniques with film*

— *Part 2: X- and gamma-ray techniques with digital detectors*

The main changes are that:

— the normative references have been updated;

— the document has been divided into two parts — this part of ISO 17636 applies to radiographic testing with films;

— X-ray devices up to 1 000 kV have been included;

— the text has been editorially revised.

Requests for official interpretations of any aspect of this part of ISO 17636 should be directed to the Secretariat of ISO/TC 44/SC 5 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

Introduction

This International 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, inspection of fusion welded joints with industrial radiographic films.

Non-destructive testing of welds — Radiographic testing —

Part 1:
X- and gamma-ray techniques with film

1 Scope

This part of ISO 17636 specifies techniques of radiographic examination of fusion welded joints in metallic materials using industrial radiographic film techniques.

This part of ISO 17636 applies to the joints of plates and pipes. Besides its conventional meaning, “pipe” as used in this International Standard covers other cylindrical bodies such as tubes, penstocks, boiler drums, and pressure vessels.

NOTE This part of ISO 17636 complies with ISO 5579.[1]

This part of ISO 17636 does not specify acceptance levels for any of the indications found on the radiographs.

If contracting parties apply lower test criteria, it is possible that the quality achieved is significantly lower than when this part of ISO 17636 is strictly applied.

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

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

ISO 11699-1, *Non-destructive testing — Industrial radiographic film — 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*

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 19232-4, *Non-destructive testing — Image quality of radiographs — Part 4: Experimental evaluation of image quality values and image quality tables*

EN 12543 (all parts), *Non-destructive testing — Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing*

EN 12679, *Non-destructive testing — Determination of the size of industrial radiographic sources — Radiographic method*

3 Terms and definitions

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

3.1
nominal thickness
t
nominal thickness of the parent material only where manufacturing tolerances do not have to be taken into account

3.2
penetration thickness change
Δt
change of penetrated thickness relative to the nominal thickness due to beam angle

3.3
penetrated thickness
w
thickness of material in the direction of the radiation beam calculated on the basis of the nominal thicknesses of all penetrated walls

3.4
object-to-film distance
b
distance between the radiation side of the radiographed part of the test object and the film surface measured along the central axis of the radiation beam

3.5
source size
d
size of the radiation source or focal spot size

NOTE See EN 12679 or EN 12543.

3.6
source-to-film distance
SFD
SDD
distance between the source of radiation and the film measured in the direction of the beam

NOTE SFD = $f + b$

where

f source-to-object distance

b object-to-film distance

3.7
source-to-object distance
f
distance between the source of radiation and the source side of the test object measured along the central axis of the radiation beam

3.8
external diameter
D_e
nominal external diameter of the pipe

4 Symbols and abbreviated terms

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

Table 1 — Symbols and terms

Symbol	Term
b	object-to-film distance
b'	object-to-film distance perpendicular to test object
D_e	external diameter
d	source size
f	source-to-object distance
f'	source-to-object distance perpendicular to test object
f_{min}	minimum source-to-object distance
t	nominal thickness
Δt	penetration thickness change
w	penetrated thickness
F	film
IQI	image quality indicator
S	radiation source
SFD SDD	source-to-film distance

5 Classification of radiographic techniques

The radiographic techniques are divided into two classes:

— Class A: basic techniques;

— Class B: improved techniques.

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

Better techniques compared to class B are possible and may be agreed between the contracting parties by specification of all appropriate test parameters.

The choice of radiographic technique shall be agreed between the contracting parties.

If, for technical or industrial reasons, it is not possible to meet one of the conditions specified for class B, such as the type of radiation source or the source-to-object distance, f, it may be agreed by contracting parties 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 selection of a better film system class with a minimum density of 2,6. The other conditions for class B remain unchanged, especially the image quality achieved (see Tables B.1 to

B.12). Because of the better sensitivity compared to class A, the test specimen may be regarded as being examined to class B. 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 preparations and requirements

6.1 Protection against ionizing radiation

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 applied.

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

6.2 Surface preparation and stage of manufacture

In general, surface preparation is not necessary, but where surface imperfections or coatings can 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.

6.3 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.

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 on the object to be examined shall be made in order to accurately locate the position of each radiograph (e.g. zero point, direction, identification, measure).

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 or photographs.

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 is to appear on each film.

6.7 Types and positions of image quality indicators

The quality of image shall be verified by use of image quality indicators (IQIs) in accordance with ISO 19232-1 or ISO 19232-2.

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 identification numbers and, when used, the lead letter F, shall not be in the area of interest, except when geometric configuration makes it impractical. 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, cases a) and b) 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 shows in a section of uniform optical density, which is normally in the parent metal adjacent to the weld. For exposures in accordance with 7.1.6 and 7.1.7, the IQI can be placed with the wires across 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 way that the hole number required is placed close to the weld.

For exposures in accordance with 7.1.6 and 7.1.7, 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 are 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. In this case, refer to the correspondence tables (Tables B.3 to B.12).

Where the IQIs are placed on the film side, the letter F shall be placed near the IQI and it shall be stated 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. The extent of image quality verification should be subject to agreement between the contracting parties.

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.

6.8 Evaluation of image quality

The films shall be viewed in accordance with ISO 5580.

From the examination 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 IQI value obtained shall be indicated on the test report of the radiographic examination. In each case the type of indicator used shall be clearly stated, as shown on the IQI.

6.9 Minimum image quality values

Tables B.1 to B.12 show the minimum quality values for metallic materials. For other materials these requirements or corresponding requirements may be agreed upon by contracting parties. The requirements shall be determined in accordance with ISO 19232-4.

In the case where Ir 192 or Se 75 sources are used, IQI values worse than the ones listed in Tables B.1 to B.12 may be accepted by agreement of contracting parties as follows:

Double wall, double image techniques, both class A and B ($w = 2t$):

— 10 mm < $w \leq$ 25 mm: 1 wire or step hole value less for Ir 192;

— 5 mm < $w \leq$ 12 mm: 1 wire or step hole value less for Se 75.

Single wall single image and double wall single image techniques, class A:

— 10 mm < $w \leq$ 24 mm: 2 wire or step hole values less for Ir 192;

— 24 mm < $w \leq$ 30 mm: 1 wire or step hole value less for Ir 192;

— 5 mm < $w \leq$ 24 mm: 1 wire or step hole value less for Se 75.

Single wall single image and double wall single image techniques, class B:

— 10 mm < $w \leq$ 40 mm: 1 wire or step hole value less for Ir 192;

— 5 mm < $w \leq$ 20 mm: 1 wire or step hole value less for Se 75.

6.10 Personnel qualification

Personnel performing non-destructive examination in accordance with this part of ISO 17636 shall be qualified in accordance with ISO 9712 or equivalent to an appropriate level in the relevant industrial sector.

7 Recommended techniques for making radiographs

NOTE Unless otherwise explained, definitions of the symbols used in Figures 1 to 21 can be found in Clause 4.

7.1 Test arrangements

7.1.1 General

Normally radiographic techniques in accordance with 7.1.2 to 7.1.9 shall be used.

X-ray film shall be placed as close to the object as possible.

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

When it is difficult to carry out an elliptical examination at $D_e \leq$ 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 for the technique shown in Figure 13, in accordance with 7.6. The IQI shall be placed close to the film with a lead letter F.

Other radiographic techniques may be agreed by the contracting parties when it is useful, e.g. for reasons such as the geometry of the piece or differences in material thickness. In 7.1.9 an example of such a case is presented. Multi-film techniques shall not be used to reduce exposure times on uniform sections. Additionally, thickness compensation with the same material may be applied.