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Non-destructive testing — Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays —

Part 2: Double wall radiographic inspection

Essais non destructifs — Examen radiographique de la corrosion et des dépôts dans les canalisations, par rayons X et rayons gamma —

Partie 2: Examen radiographique double paroi

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 135 *Non-destructive testing*, Subcommittee SC 5 *Radiographic testing*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

A list of all parts in the ISO 20769 series can be found on the ISO website.

Non-destructive testing — Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays —

Part 2: Double wall radiographic inspection

1 Scope

This document specifies fundamental techniques of film and digital 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 document applies to the radiographic examination of pipes in metallic materials for service induced flaws such as corrosion pitting, generalized corrosion and erosion. Besides its conventional meaning, "pipe" as used in this document is understood to cover other cylindrical bodies such as tubes, penstocks, boiler drums and pressure vessels.

Weld inspection for typical welding process induced flaws is not covered, but weld inspection is included for corrosion/erosion type flaws.

The pipes can be insulated or not, and can be assessed where loss of material due, for example, to corrosion or erosion is suspected either internally or externally.

This document covers double wall inspection techniques for detection of wall loss, including double wall single image (DWSI) and double wall double image (DWDI).

Note that the DWDI technique described in this document is often combined with the tangential technique covered in ISO 20769-1.

This document applies to in-service double wall radiographic inspection using industrial radiographic film techniques, computed digital radiography (CR) and digital detector arrays (DDA).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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 17636-2, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors*

ISO 19232-1, *Non-destructive testing — Image quality of radiographs — Part 1: Determination of the image quality value using wire-type image quality indicators*

ISO 19232-5, *Non-destructive testing — Image quality of radiographs — Part 5: Determination of the image unsharpness value using duplex wire-type image quality indicators*

ISO 20769-1, *Non-destructive testing of welds — Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays — Part 1: Tangential radiographic inspection*

EN 14784-1, *Non-destructive testing — Industrial computed radiography with storage phosphor imaging plates — Part 1: Classification of systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20769-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
digital detector array system
DDA system
electronic device converting ionizing or penetrating radiation into a discrete array of analogue signals which are subsequently digitized and transferred to a computer for display as a digital image corresponding to the radiologic energy pattern imparted upon the input region of the device

3.2
double wall double image technique
DWDI
technique where the radiation source is located outside and away from the pipe, with the detector on the opposite side of the pipe and where the radiograph shows details from both the pipe walls on the detector and source sides of the pipe

Note 1 to entry: See Figure 3.

3.3
double wall single image technique
DWSI
technique where the radiation source is located outside the pipe and close to the pipe wall, with the detector on the opposite side of the pipe and where the radiograph shows only detail from the pipe wall on the detector side

Note 1 to entry: See Figure 1.

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

3.5
penetrated thickness
w
thickness of material in the direction of the radiation beam calculated on the basis of the nominal thickness

Note 1 to entry: For double wall radiographic inspection of a pipe, the minimum value for *w* is twice the pipe wall thickness. For multiple wall techniques (pipes in pipe or liners), the penetrated thickness is calculated from the nominal wall thicknesses *t*.

3.6
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

3.7
total effective penetrated thickness
w_{tot}
total equivalent thickness of metallic material in the direction of the radiation beam calculated on the basis of the nominal thickness, with allowance for any liquid or other material present in the pipe and any insulation

4 Classification of radiographic techniques

The double wall radiographic techniques are divided into two classes:

— basic techniques DWA;

— improved techniques DWB.

The basic techniques are intended for double wall radiography of generalized and localized wall loss.

For the basic techniques, DWA, when using Ir 192 sources for pipes with penetrated thicknesses between 15 mm and 35 mm, the sensitivity for detection is high for imperfections, provided their diameters are greater than or equal to 2 mm and the material loss is typically greater than or equal to 5 % of the pipe penetrated thickness, in the absence of liquid or other products in the pipe. When using Se 75, the corresponding detection sensitivity is high for 2 mm diameter or larger imperfections with material loss greater than or equal to 4 % of the pipe penetrated thickness. The detection sensitivity is improved for flaws with larger diameters, whereas the presence of liquid or other products, and external insulation, can reduce the sensitivity for material loss depending on their properties. Different detection sensitivities may apply for penetrated thicknesses less than 15 mm and greater than 35 mm.

The presence of external corrosion product can reduce the techniques sensitivity to corrosion due to the increased radiation attenuation in the product, which can even exceed the reduced attenuation caused by the loss of steel. Build-up of internal solid material (e.g. scale) in pipes can similarly reduce sensitivity to internal degradation.

These techniques can also be used for detection of deposits inside the pipe.

The improved techniques should be used where higher sensitivity is required such as for radiography of fine, localized corrosion pitting.

Further improvements, beyond the improved techniques described herein, 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 concerned parties.

5 General

5.1 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 measures shall be taken to ensure the safety and health of personnel.

5.2 Personnel qualification

Testing shall be carried out by proficient, suitably trained and qualified personnel and, where applicable, shall be supervised by competent personnel nominated by the employer or, by delegation of the employer, the inspection company in charge of testing. To demonstrate appropriate qualification, it is recommended that personnel be certified according to ISO 9712 or an equivalent formalized system. Operating authorization for qualified persons shall be issued by the employer in accordance with a written procedure.

NDT operations, unless otherwise agreed, shall be authorized by a competent and qualified NDT supervisory individual (Level 3 or equivalent) approved by the employer.

The personnel shall prove additional training and qualification in digital industrial radiology if digital detectors are used.

5.3 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.

5.4 Marking

Permanent markings on the object to be examined should 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.

5.5 Overlap of films or digital images

When radiographing an area with two or more films or separate detectors, the films or detectors 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 appears on each film or detector. If the radiographs is taken sequentially, the high-density marker shall be visible on each of the radiographs.

5.6 Types and positions of image quality indicators (IQI)

5.6.1 Single wire IQI

The quality of image shall be verified by use of IQIs in accordance with ISO 19232-1.

For DWDI, the single wire IQI used shall be placed preferably on the source side of the test object at the centre of the area of interest. The IQI shall be in close contact with the surface of the object. If the IQIs cannot be placed in accordance with the above conditions (insulated pipes), they shall be placed on the detector side. The image quality shall be determined at least once from a comparison exposure with one IQI placed at the source side and one at the detector side under the same conditions.

For DWSI, the single wire IQI used shall be placed on the detector side of the test object at the centre of the area of interest. If possible, the IQI shall be in close contact with the surface of the object. However, if this is not possible due for example to the presence of insulation, the IQI shall be in contact with the film/detector.

For both DWDI and DWSI, the wire IQIs shall be aligned across the pipe, with their long axis angled at a few degrees (2° to 5°) to the orthogonal to the pipe axis. The IQI location should be in a section of uniform thickness, near to the pipe centre line.

For DWDI, where the IQIs are placed at the detector side, the letter “F” shall be placed near the IQI and it shall be noted in the test report.

The extent of image quality verification for repeat exposures of closely similar objects under identical conditions shall be subject to agreement between the contracting parties.

5.6.2 Duplex wire IQI (digital radiographs)

IQIs in accordance with ISO 19232-5 should be used for measurement of the basic spatial resolution of the CR/DDA system in a reference radiograph (see 7.1.2 and Annex C). The duplex wire IQI shall be placed on the source side of the imaging plate or detector array and positioned a few degrees tilted (2° to 5°) to the digital rows or columns of the digital image.

6 Recommended techniques for making radiographs

6.1 Test arrangements

6.1.1 General

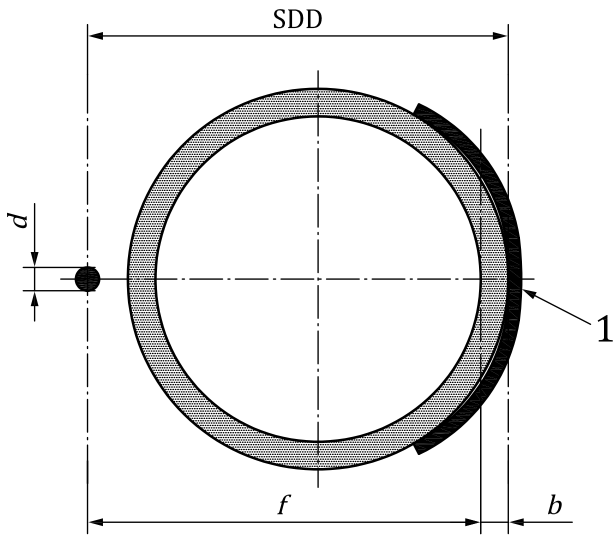
Normally, radiographic techniques in accordance with 6.1.2 and 6.1.3 shall be used.

The technique presented in 6.1.2 is normally used for larger diameter pipes. The technique presented in 6.1.3 is generally used for smaller diameter pipes (less than typically about 150 mm outside diameter).

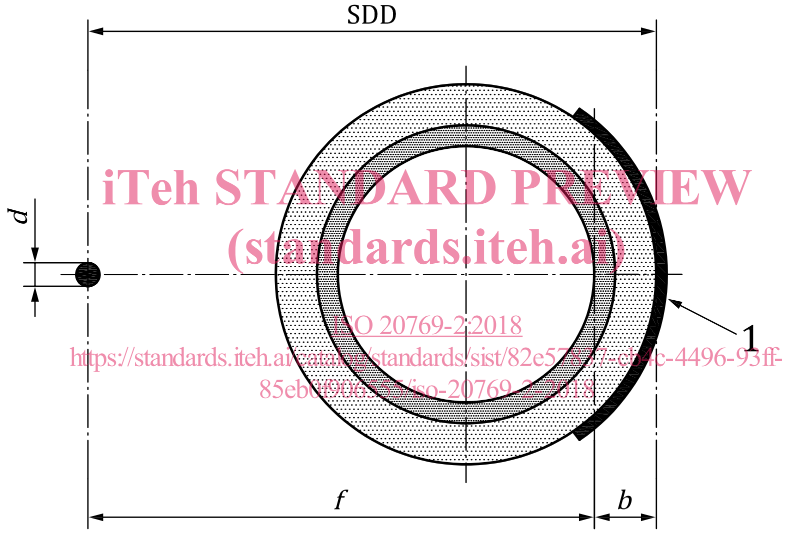
For both techniques, the film or digital detector shall be placed as close to the pipe as possible.

6.1.2 Double wall single image (DWSI)

For this arrangement with curved detectors or film, the source is located near to the pipe and with the film/detector on the opposite side, as shown in Figure 1 a) (without insulation) and Figure 1 b) (with insulation). The relevant distances for determination of source to detector distance, SDD (see 6.6), are also shown.



a) Non-insulated pipe



b) Insulated pipe

Key

1 detector

Figure 1 — Test arrangement for double wall single image radiography (DWSI) using a curved detector

Note that the wall loss can be located on either the inner diameter, outer diameter or both surfaces of the pipe wall adjacent to the detector. Wall loss on the source side of the pipe is not imaged.

For rigid planar detectors, DWSI can also be applied as shown in Figure 2 a) and Figure 2 b). Although, with this arrangement, a smaller fraction of the pipe circumference can be inspected at each position.

