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

Part 1: Tangential radiographic inspection

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

Partie 1: Examen radiographique tangentiel

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Foreword

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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).

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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 1: Tangential 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 steel pipes 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 the tangential inspection technique for detection and through-wall sizing of wall loss, including with the source:

a) on the pipe centre line; and

b) offset from pipe centre line by the pipe radius.

ISO 20769-2 covers double wall radiography, and note that the double wall double image technique is often combined with tangential radiography with the source on the pipe centre line.

This document applies to tangential radiographic inspection using industrial radiographic film techniques, computed 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 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 16371-1, *Non-destructive testing — Industrial computed radiography with storage phosphor imaging plates — Part 1: Classification of systems*

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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
actual wall thickness
t_{act}
real thickness of the pipe wall which can differ from the nominal thickness

3.2
axial coverage
L_d
<on the detector> total axial extent of the evaluated section of the pipe radiograph measured on the *detector* (3.8)

3.3
axial coverage
L_p
<on the pipe central axis> total axial extent of the evaluated section of the pipe radiograph measured along the central axis of the pipe

3.4
basic spatial resolution
$SR_b^{detector}$
<digital detector> smallest geometrical detail, which can be resolved in a digital image at a magnification equal to 1; corresponds to half of the measured image unsharpness in a digital image; corresponds to the effective *pixel size* (3.19) of the magnified image; and is determined from the smallest number of the duplex wire pair, which is not separable by visual inspection or from the smallest number of the duplex wire pair with less than 20 % modulation depth in a linearized profile

Note 1 to entry: For this measurement, the duplex wire IQI is placed directly on the digital *detector* (3.8) array or imaging plate.

Note 2 to entry: The measurements of $SR_b^{detector}$ and unsharpness are described in ISO 19232-5. and ASTM E2002[17].

3.5
basic spatial resolution
SR_b^{image}
<digital image> smallest geometrical detail, which can be resolved in a digital image at a magnification >1; corresponds to half of the measured image unsharpness in a digital image; corresponds to the effective *pixel size* (3.19) of the magnified image; and is determined from the smallest number of the duplex wire pair, which is not separable by visual inspection or from the smallest number of the duplex wire pair with less than 20 % modulation depth in a linearized profile

Note 1 to entry: The measurements of SR_b^{image} and unsharpness are described in ISO 19232-5. and ASTM E2002[17].

3.6
comparator
C
reference object of defined dimension c and material for dimensional calibration of a radiographic image

3.7
computed radiography
CR
complete system comprising a *storage phosphor imaging plate (IP)* (3.23) and a corresponding read-out unit (scanner or reader), which converts the information from the IP into a digital image and the control software of the read-out unit

3.8
detector
D
detection device, consisting of a NDT film system (see ISO 11699-1) or a digital radiography system using a CR system or a DDA system

Note 1 to entry: Film systems and IPs can be used as flexible and curved detectors or in planar cassettes.

3.9
digital detector array
DDA
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 and the control software

3.10
imaged comparator dimension
c'
dimension of the *comparator* (3.6) measured on the *detector* (3.8)

3.11
imaged outside diameter
D_e'
nominal outside diameter of the pipe measured on the detector

3.12
maximum penetrated thickness
w_{max}
maximum thickness of material for a pipe which occurs for a tangent to the inner pipe surface

3.13
measured wall thickness
t_{meas}
thickness of the pipe wall as measured on the radiograph or digital image

3.14
nominal wall thickness
t
thickness of the pipe wall as given by the manufacturer, neglecting the manufacturing tolerances

3.15
normalized signal-to-noise ratio
SNR_N
ratio of signal-to-noise, normalized by the *basic spatial resolution, SR_b^{image}*, (3.5) as measured directly in the digital image and/or calculated from the measured $SNR_{measured}$, by:

$$SNR_N = SNR_{measured} \frac{88{,}6\ \mu m}{SR_b}$$

Note 1 to entry: SR_b^{image} can be substituted by $SR_b^{detector}$ (3.4) at magnification equal to 1.

3.16
outside diameter
D_e
nominal outer diameter of the pipe as given by the manufacturer, neglecting the manufacturing tolerances

3.17
pipe centre to detector distance
PDD
distance between the pipe centre and the *detector* (3.8)

3.18
pixel size
geometrical centre-to-centre distance between adjacent pixels in a row (horizontal pitch) or column (vertical pitch) of the scanned image

[SOURCE: ISO 14096-2:2005, 3.2]

3.19
signal-to-noise ratio
SNR
ratio of mean value of the linearized grey values to the standard deviation of the linearized grey values (noise) in a given region of interest in a digital image

3.20
source size
d
size of the radiation source

[SOURCE: ISO 16371-2:2017, 3.15]

3.21
source-to-detector distance
SDD
distance between the source of radiation and the *detector* (3.8) measured in the direction of the beam

3.22
source-to-pipe centre distance
SPD
distance between the source of radiation and the pipe centre (pipe axis) measured in the direction of the beam

3.23
storage phosphor imaging plate
IP
photostimulable luminescent material capable of storing a latent radiographic image of a material being examined and which, upon stimulation by a source of red light of appropriate wavelength, generates luminescence proportional to radiation absorbed

4 Classification of radiographic techniques

The tangential radiographic techniques are divided into two classes:

— class TA, basic techniques;

— class TB, improved techniques.

The basic techniques, class TA, are intended for tangential radiography of generalized wall loss, such as that due to erosion or large-scale corrosion.

The improved techniques, class TB, should be used for the more demanding tangential radiography of localized corrosion pitting flaws, which require higher sensitivity for detection and sizing.

Further technique improvements beyond TB 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

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

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 should 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.

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 will appear on each film or detector. If the radiographs are 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 or step hole IQIs

For tangential radiography, single wire or step hole IQIs are not applicable.

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 7.1.3 and Annex A). The duplex wire IQI shall be placed adjacent to 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

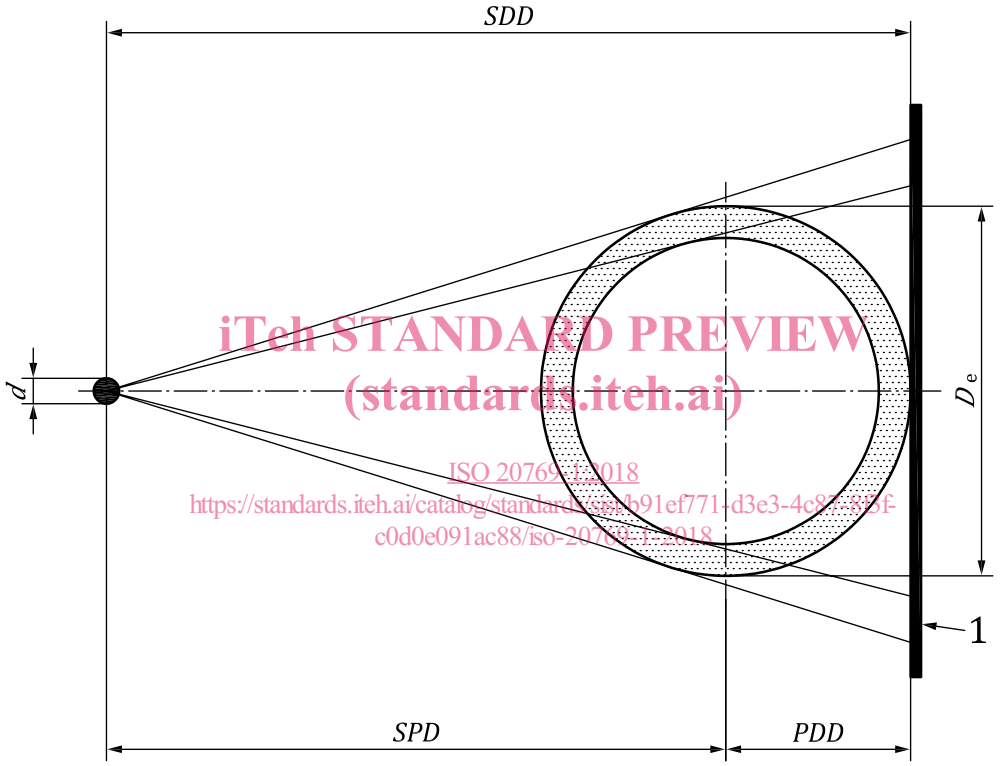
6.1 Test arrangements

6.1.1 General

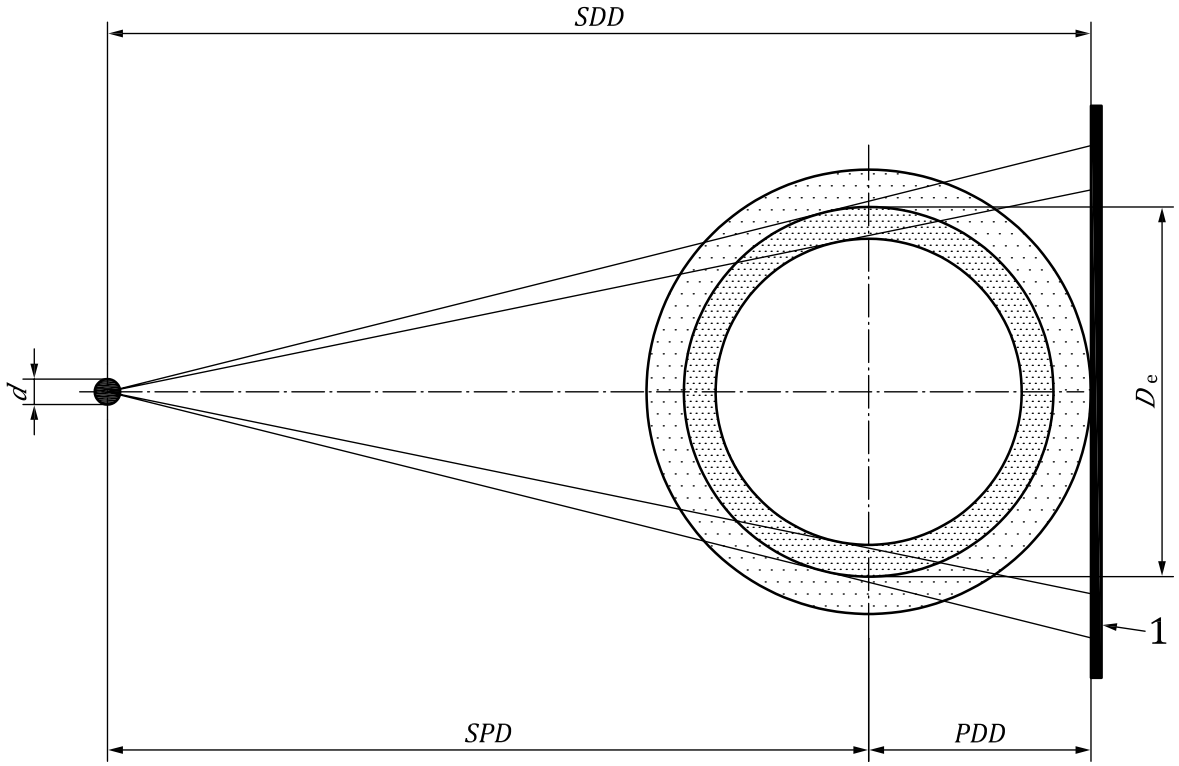
Normally, radiographic techniques in accordance with 6.1.2 and 6.1.3 shall be used. For both techniques, the film or digital detector shall be placed as close to the pipe as possible.

6.1.2 Radiation source located on the pipe centre line

For this arrangement, the source is located in front of the pipe and with the film/detector at the opposite side, as shown in Figure 1. The pipe can be non-insulated [Figure 1 a)] or insulated [Figure 1 b)].



a) Non-insulated pipe



b) Insulated pipe

Key

1 detector, *D*

Figure 1 — Test arrangement and distances for tangential radiography with the source on the pipe centre line

Note that the wall loss can be located on either the inner diameter, outer diameter or both surfaces of the pipe.

6.1.3 Radiation source located offset from the pipe centre line

For this arrangement, the radiation source is located in front of the pipe and with the film/detector at the opposite side, as shown in Figure 2 a) (non-insulated pipe) and Figure 2 b) (insulated pipe).