SLOVENSKI STANDARD
SIST EN 16407-2:2014

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Neporušitvene preiskave - Radiografski pregled korozije in nanosov v ceveh z rentgenskimi in gama žarki - 2. del: Radiografski pregled preko dveh sten

Non-destructive testing - Radiographic inspection of corrosion and deposits in pipes by X - and gamma rays - Part 2: Double Wall radiographic inspection

Zerstörungsfreie Prüfung - Durchstrahlungsprüfung auf Korrosion und Ablagerungen in Rohren mit Röntgen- und Gammastrahlen - Teil 2: Doppelwand Durchstrahlungsprüfung

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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ICS:

19.100	Neporušitveno preskušanje	Non-destructive testing
23.040.01	Deli cevovodov in cevovodi na splošno	Pipeline components and pipelines in general

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English Version

Non-destructive testing - Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays - Part 2: Double wall radiographic inspection

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COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 16407-2:2014) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2014, and conflicting national standards shall be withdrawn at the latest by July 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

EN 16407 consists of the following parts, under the general title *Non-destructive testing — Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays:*

— *Part 1: Tangential radiographic inspection*;

— *Part 2: Double wall radiographic inspection*.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard 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 European Standard 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 standard should be 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 may 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 part of EN 16407 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 part of EN 16407 is often combined with the tangential technique covered in EN 16407-1.

This European Standard 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

EN ISO 17636-2:2013, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2:2013)*

EN 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 19232-1)*

EN 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 19232-5)*

3 Terms and definitions

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

3.1
basic spatial resolution of a digital detector
$SR_b^{detector}$
half of the measured detector unsharpness in a digital image which corresponds to the effective pixel size and indicates the smallest geometrical detail, which can be resolved with a digital detector at magnification equal to one

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

Note 2 to entry: The measurement of unsharpness is described in EN ISO 19232-5, see also ASTM E2736 [18] and ASTM E1000 [16].

3.2
computed radiography
CR
storage phosphor imaging plate system
complete system comprising a storage phosphor imaging plate (IP) and a corresponding read-out unit (scanner or reader), which converts the information from the IP into a digital image

3.3
detector
D
radiographic image detector consisting of a NDT film system (see EN ISO 11699-1) or a digital radiography system using an imaging plate system (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.

3.4
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

3.5
DWDI
double wall double image technique
technique where the radiation source is located outside the pipe 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.

3.6
DWSI
double wall single image technique
technique where the radiation source is located outside the pipe 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.

3.7
nominal wall thickness
t
thickness of the pipe material only where manufacturing tolerances do not have to be taken into account

3.8
normalized signal-to-noise ratio
SNR_N
signal-to-noise ratio, SNR, normalized by the basic spatial resolution, SR_b, as measured directly in the digital image and/or calculated from the measured SNR, $SNR_{measured}$, by:

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

3.9
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

3.10
outside diameter
D_e
nominal outside diameter of the pipe

3.11
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, the penetrated thickness is calculated from the nominal wall thickness t.

3.12
pipe centre to detector distance
PDD
distance between the pipe centre and the detector

3.13
pixel size
geometrical centre-to-centre distance between adjacent pixels in a row (horizontal pitch) or column (vertical pitch) of the scanned image

[SOURCE: EN 14096-2:2003, 3.2]

3.14
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

3.15
source size
d
size of the radiation source

[SOURCE: EN 12679:1999, 2.1]

3.16
source-to-detector distance
SDD
distance between the source of radiation and the detector measured in the direction of the beam

3.17
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

3.18
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

3.19
storage phosphor imaging plate
IP
photostimulable luminescent material capable of storing a latent radiographic image of a material being examined and, upon stimulation by a source of red light of appropriate wavelength, generates luminescence proportional to radiation absorbed

3.20
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 will be high for imperfections, provided their diameters are ≥ 2 mm and the material loss is typically ≥ 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 will be high for 2 mm diameter or larger imperfections with material loss ≥ 4 % of the pipe penetrated thickness. The detection sensitivity will be improved for flaws with larger diameters, whereas the presence of liquid or other products, and external insulation, may reduce the sensitivity for material loss depending on their properties. Different detection sensitivities may apply for penetrated thicknesses < 15 mm and > 35 mm.

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 legal requirements shall be applied. Local or national or international safety precautions when using ionising radiation shall be strictly applied.

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 EN 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 being 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 will appear on each film or detector. If the radiographs will be 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 EN 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), the IQIs will be placed on the detector side and 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 IQI's 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 EN 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 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.

Technique 6.1.2 is normally used for larger diameter pipes. Technique 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.