SLOVENSKI STANDARD
oSIST prEN 16407-2:2012

01-junij-2012

Neporušitveno preskušanje - Radiografski pregled korozije in nanosov v ceveh z rentgenskimi in gama žarki - 2. del: Double Wall radiografski pregled

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

Ta slovenski standard je istoveten z: **prEN 16407-2**

ICS:

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

oSIST prEN 16407-2:2012 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 16407-2

March 2012

ICS

English Version

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

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

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 138.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. prEN 16407-2:2012: E

Contents

Page

Foreword 4

1 Scope 5

2 Normative references 5

3 Terms and definitions 6

4 Classification of radiographic techniques 7

5 General 8
5.1 Protection against ionizing radiation 8
5.2 Personnel qualification 8
5.3 Surface preparation 8
5.4 Identification of radiographs 8
5.5 Marking 8
5.6 Overlap of films or digital images 8
5.7 Types and positions of image quality indicators (IQI) 9
5.7.1 Single wire IQI 9
5.7.2 Duplex wire IQI (digital radiographs) 9

6 Recommended techniques for making radiographs 9
6.1 Test arrangements 9
6.1.1 General 9
6.1.2 Double wall single image (DWSI) 9
6.1.3 Double wall double image (DWDI) 11
6.1.4 Alignment of beam and film/detector 13
6.2 Choice of radiation source 13
6.3 Film systems and screens 14
6.4 Screens and shielding for imaging plates (computed radiography only) 16
6.5 Reduction of scattered radiation 18
6.5.1 Filters and collimators 18
6.5.2 Interception of back scattered radiation 18
6.6 Source-to-detector distance 19
6.6.1 Double wall single image 19
6.6.2 Double wall double image 19
6.7 Axial coverage and overlap 19
6.8 Circumference coverage 20
6.8.1 DWSI 20
6.8.2 DWDI 21
6.9 Operation of computed radiography equipment 21

7 Radiograph/digital image sensitivity, quality and evaluation 22
7.1 Minimum image quality values 22
7.1.1 Wire image quality indicators 22
7.1.2 Duplex wire IQIs (digital radiographs) 22
7.1.3 Minimum normalised signal to noise ratio (digital radiographs) 22
7.2 Density of film radiographs 23
7.3 Film processing 23
7.4 Film viewing conditions 23

8 Measurement of differences in penetrated thickness 23
8.1 Principle of technique 23
8.2 Measurement of attenuation coefficient 24
8.3 Source and detector positioning 24
8.4 Image grey level profiles 24

8.5 Validation 24
8.6 Key Points 24

9 Digital Image recording, storage, processing and viewing 25
9.1 Digital image recording and storage 25
9.2 Image processing for digital radiographs 25
9.3 Monitor viewing conditions 25

10 Test report 26

Annex A (normative) **Minimum image quality values** 28

Annex B (informative) **Penetrated thickness measurements : Image grey level profiles** 30

Bibliography 32

Foreword

This document (prEN 16407-2:2012) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

prEN 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

1 Scope

This part 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 standard applies to the radiographic examination of pipes in metallic materials for service induced flaws such as corrosion pitting, generalised 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 this standard 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 2, is often combined with the tangential technique covered in Part 1 of this standard.

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

For the basic techniques described in this standard, the probability of detection should be high for corrosion type flaws with through wall extents of typically ≥ 5% of the pipe wall thickness, provided the circumferential and axial extents of the flaws are about 10mm or larger.

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 12679:1999, *Non-destructive testing — Determination of the size of industrial radiographic sources — Radiographic method*

EN 14096-2:2003, *Non-destructive testing - Qualification of radiographic film digitisation systems - Part 2: Minimum requirements*

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

EN 25580:1992, *Non-destructive testing - Industrial radiographic illuminators - Minimum requirements*

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

FprEN ISO 17636–2:2012, *Non-destructive testing of welds — Radiographic examination of welded joints — Part 2: X- and gamma-ray techniques with digital detectors*

prEN ISO 19232–1:2011, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality indicators (wire type) - Determination of image quality value*

prEN ISO 19232–2:2011, *Non-destructive testing — Image quality of radiographs — Part 2: Image quality indicators (step/hole type) — Determination of image quality value*

prEN ISO 19232–4:2011, *Non-destructive testing — Image quality of radiographs — Part 4: Experimental evaluation of image quality values and image quality tables*

prEN ISO 19232–5:2011, *Non-destructive testing — Image quality of radiographs — Part 5: Image quality indicators (duplex wire type) - Determination of image unsharpness value*

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

3 Terms and definitions

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

3.1
DWSI
double wall single image technique. The radiation source is located outside the pipe close to the pipe wall, with the detector on the opposite side of the pipe. The radiograph shows only detail from the pipe wall on the detector side. See Figure 1.

3.2
DWDI
double wall double image technique. The radiation source is located outside the pipe and away from the pipe, with the detector on the opposite side of the pipe. The radiograph shows details from both the pipe walls on the detector and source sides of the pipe. See Figure 2.

3.3
nominal thickness
t
nominal thickness of the parent material only where manufacturing tolerances do not have to be taken into account

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
outside diameter
D_e
nominal outside diameter of the pipe

3.6
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 thickness.

3.7
pipe centre to detector distance
PDD
distance between the pipe centre and the detector

3.8
source size
d
size of the radiation source

[SOURCE: EN 12679:1999, 2.1]

3.9
source-to-detector distance
SDD
distance between the source of radiation and the detector measured in the direction of the beam

3.10
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

3.11
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

3.12
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 gaseous product present in the pipe

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]

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 generalised and localised wall loss.

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

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 must be applied. Local or national or international safety precautions when using ionizing 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 prEN ISO 9712 or an equivalent formalised system. Operating authorisation for qualified person shall be issued by the employer in accordance with a written procedure.

NDT operations, unless otherwise agreed, shall be authorised 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 Surface preparation

In general, surface preparation is not necessary, but where surface imperfections or coatings might cause difficulty in detecting flaws or significant errors in thickness measurements, the surface shall be ground smooth or the coatings shall be removed.

5.4 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.

5.5 Marking

Permanent markings on the object to be examined shall 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.

5.6 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.

5.7 Types and positions of image quality indicators (IQI)

5.7.1 Single wire IQI

The quality of image shall be verified by use of IQIs in accordance with prEN ISO 19232-1:2011.

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 film/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 (2º - 5º) to the orthogonal to the pipe axis. The IQI location shall 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.

5.7.2 Duplex wire IQI (digital radiographs)

IQIs in accordance with prEN ISO 19232-5:2011 should be used for measurement of the basic spatial resolution of the CR/DR system (see 7.1.2), as applied to the radiography of the test object (same scanner/imaging plate and user settings such as pixel size). The duplex wire IQI shall be positioned a few degrees tilted (2º - 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

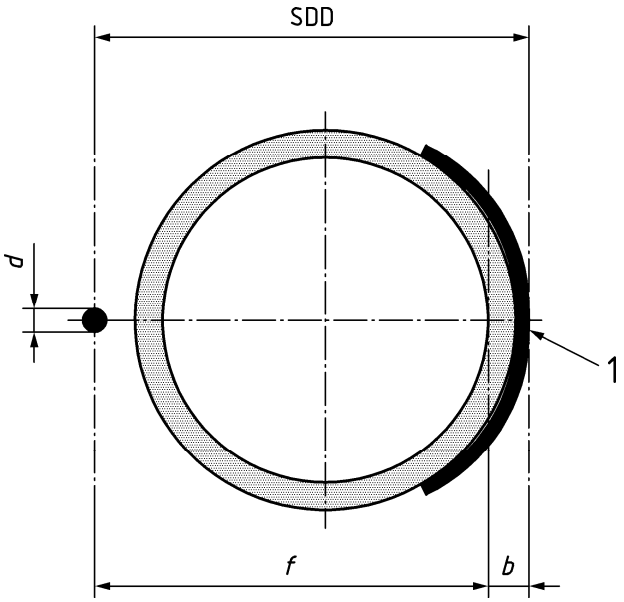
Normally radiographic techniques in accordance with 6.1.2 and 6.1.3 shall be used.

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).

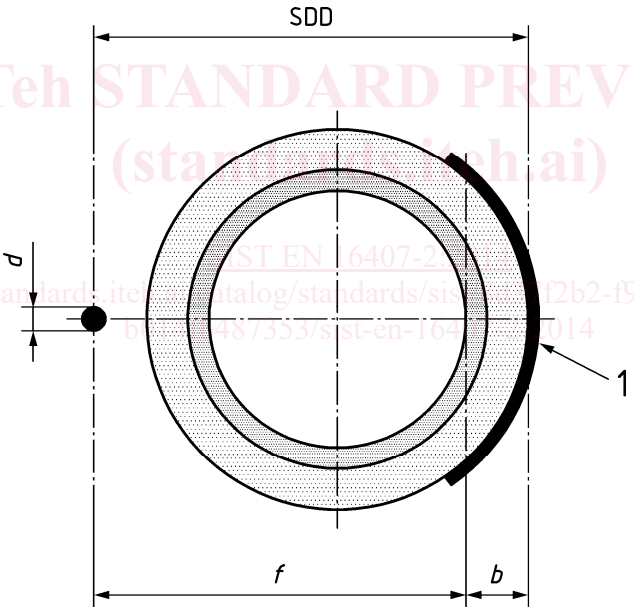
For both techniques, the film or digital detector shall be placed as close to the pipe as possible.

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 1a) (without insulation) and Figure 1b) (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 or outer diameter surface of the pipe wall adjacent to the film/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 2a) and Figure 2b), although with this arrangement a smaller fraction of the pipe circumference can be inspected at each position.