SLOVENSKI STANDARD
oSIST prEN 12681-2:2016

01-maj-2016

Livarstvo - Radiografsko preskušanje - 2. del: Tehnike z digitalnimi detektorji

Founding - Radiographic testing - Part 2: Techniques with digital detectors

Gießereiwesen - Durchstrahlungsprüfung - Teil 2: Technik mit Digitaldetektoren

Fonderie - Contrôle par radiographie - Partie 2 : Techniques à l'aide de détecteurs numériques

Ta slovenski standard je istoveten z: prEN 12681-2

ICS:

77.040.20	Neporušitveno preskušanje kovin	Non-destructive testing of metals

oSIST prEN 12681-2:2016 en,fr,de

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 12681-2

March 2016

ICS 77.040.20

English Version

Founding - Radiographic testing - Part 2: Techniques with digital detectors

Fonderie - Contrôle par radiographie - Partie 2 : Techniques à l'aide de détecteurs numériques

Gießereiwesen - Durchstrahlungsprüfung - Teil 2: Technik mit Digitaldetektoren

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 190.

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.

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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.

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

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Ref. No. prEN 12681-2:2016 E

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European foreword

This document (prEN 12681-2:2016) has been prepared by Technical Committee CEN/TC 190 “Foundry Technology”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 10 “Inner defects” to revise and to split the following standard:

EN 12681:2003, *Founding — Radiographic testing*

into:

— prEN 12681-1, *Founding — Radiographic testing — Part 1: Film techniques (replacement for* EN 12681:2003*)*

— prEN 12681-2, *Founding — Radiographic testing — Part 2: Techniques with digital detectors (new issue and part of* EN 12681:2003*)*

Introduction

Radiography can be used to detect internal discontinuities in a casting. The discontinuities can be gas holes, non-metallic inclusions, shrinkage, cracks, inserts or chills or inclusions that have lower or higher densities than the parent metal. This European Standard gives acceptance criteria through severity levels.

1 Scope

This European Standard gives specific procedures for industrial X-ray and gamma radiography for discontinuity detection purposes, using NDT (Non-destructive testing) digital X-ray image detectors. This part of EN 12681 specifies the requirements for digital radiographic testing by either computed radiography (CR) or radiography with digital detector arrays (DDA) of castings.

Digital detectors provide a digital grey value image which can be viewed and evaluated using a computer.

NOTE This part of EN 12681 complies with EN 14784–2 for CR. Some clauses and annexes are taken from EN ISO 17636-2.

This part of EN 12681 specifies the recommended procedure for detector selection and radiographic practice. Selection of computer, software, monitor, printer and viewing conditions are important but are not the main focus of this standard. The procedure specified in this standard provides the minimum requirements for radiographic practice which permit exposure and acquisition of digital radiographs with equivalent sensitivity for detection of imperfections as film radiography, as specified in Part 1 of this standard.

This standard does not consider radiographic or radioscopic fitness for purpose testing as applied for specific castings based on manufacturer’s internal requirements and procedures.

The requirements on image quality in class A and B testing of Annex A consider the good workmanship quality for general casting applications as also required in Part 1 of this standard for film radiography.

The classes A_A and B_A reflect the quality requirements of current automated and semi-automated radiographic inspection systems with DDAs (computer based flaw recognition or visual inspection) and mini or micro focus tubes (spot size ≤ 1 mm) with reduced requirements to the unsharpness, but unchanged requirements to contrast sensitivity as also required in Part 1 of this standard for film radiography.

The specified procedures are applicable to castings produced by any casting process, especially for steel, cast irons, aluminium, cobalt, copper, magnesium, nickel, titanium, zinc and any alloys of them.

This part of this European Standard does not apply to:

— the testing of welded joints (see EN ISO 17636-2);

— film radiography (see prEN 12681-1);

— real time testing with radioscopy.

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

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

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

EN ISO 9712, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012)*

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

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

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)*

ISO 5576, *Non-destructive testing — Industrial X-ray and gamma-ray radiology — Vocabulary*

ISO 16371-1:2011, *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 5576 and EN ISO 17636-2 and the following apply.

3.1
wall thickness
t
thickness as measured on the casting

3.2
nominal wall thickness
t_n
thickness as specified on the drawing

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

3.4
source size
d
size of the radiation source or focal spot size

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.20]

3.5
object-to-detector distance
b
largest (maximum) distance between the radiation side of the radiographed part of the test object and the sensitive layer of the detector along the central axis of the radiation beam

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.19]

3.6
source-to-object distance
f
distance between the source of radiation and the source side of the test object, most distant from the detector, measured along the central axis of the radiation beam

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.22]

3.7
source-to-detector distance
SDD
distance between the source of radiation and the detector, measured in the direction of the beam

Note 1 to entry: SDD = $f + b$

where

f source-to-object distance

b object-to-detector distance

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.21]

3.8
geometric magnification
v
ratio of source-to-detector distance SDD to source-to-object distance f

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.24]

3.9
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

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.1]

3.10
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

Note 1 to entry: When performing computed radiography, an IP is used in lieu of a film. When establishing techniques related to source size or focal geometries, the IP is referred to as a detector, i.e. source-to-detector distance (SDD).

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.2]

3.11
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

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.3]

3.12
structure noise of imaging plate (IP)
structure noise of IP
structure due to inhomogeneities in the sensitive layer (graininess) and surface of an imaging plate

Note 1 to entry: After scanning of the exposed imaging plate the inhomogeneities appear as overlaid fixed pattern noise in the digital image.

Note 2 to entry: This noise limits the maximum achievable image quality of digital CR images and can be compared with the graininess in film images.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.4]

3.13
structure noise of digital detector array (DDA)
structure noise of DDA
structure due to different properties of detector elements (pixels)

Note 1 to entry: After read out of the exposed uncalibrated DDA, the inhomogeneities of the DDA appear as overlaid fixed pattern noise in the digital image. Therefore, all DDAs require after read-out a software based calibration (software and guidelines are provided by the manufacturer). A suitable calibration procedure reduces the structure noise.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.5]

3.14
grey value
GV
numeric value of a pixel in a digital image

Note 1 to entry: This is typically interchangeable with the terms pixel value, detector response, analogue-to-digital unit, and detector signal.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.6]

3.15
linearized grey value
GV_{lin}
numeric value of a pixel which is directly proportional to the detector exposure dose, having a value of zero if the detector was not exposed

Note 1 to entry: This is typically interchangeable with the terms linearized pixel value, and linearized detector signal.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.7]

3.16
basic spatial resolution of a digital detector
$SR_b^{detector}$
corresponds to half of the measured detector unsharpness in a digital image and 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 according EN ISO 19232-5 is placed directly on the digital detector array or imaging plate. The measurement of unsharpness is described in EN ISO 19232-5, see also ASTM E 2736 and ASTM E 1000.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.8]

3.17
basic spatial resolution of a digital image
SR_b^{image}
corresponds to half of the measured image unsharpness in a digital image and corresponds to the effective pixel size and indicates the smallest geometrical detail, which can be resolved in a digital image

Note 1 to entry: For this measurement, the duplex wire IQI is placed directly on the object (source side).

Note 2 to entry: The measurement of unsharpness is described in EN ISO 19232-5, see also ASTM E 2736, and ASTM E 1000.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.9]

3.18
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

Note 1 to entry: The region of interest shall contain at least 1100 pixels.

3.19
normalised signal-to-noise ratio
SNR_N
SNR, normalised by the basic spatial resolution SR_b^{image} as measured directly in the digital image and/or calculated from measured $SNR_{measured}$

Note 1 to entry: $SNR_N = SNR_{measured} \times (88{,}6\ \mu m / SR_b^{image})$

3.20
contrast-to-noise ratio
CNR
ratio of the difference of the mean signal levels between two image areas to the averaged standard deviation of the signal levels

Note 1 to entry: The contrast-to-noise ratio describes a component of image quality and depends approximately on the product of radiographic attenuation coefficient and SNR. In addition to adequate CNR, it is also necessary for a digital radiograph to possess adequate unsharpness or basic spatial resolution to resolve desired features of interest.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.12]

3.21
normalised contrast-to-noise ratio
CNR_N
CNR, normalised by the basic spatial resolution SR_b^{image} as measured directly in the digital image and/or calculated from measured CNR

Note 1 to entry: $CNR_N = CNR \times (88{,}6\ \mu m / SR_b^{image})$

3.22
aliasing
artefacts that appear in an image when the spatial frequency of the input is higher than the output is capable of reproducing

Note 1 to entry: Aliasing often appears as jagged or stepped sections in a line or as moiré patterns.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.14]

3.23
cluster kernel pixels
CKP
bad pixels which do not have five or more good neighbourhood pixels

Note 1 to entry: See ASTM E 2597 for details on bad pixels and CKP.

[SOURCE: EN ISO 17636-2:2013, 01, definition 3.15

3.24
inherent unsharpness
$\boldsymbol{u_\mathrm{i}}$
unsharpness of the detector system, excluding any geometric unsharpness, measured from the digital image with a duplex wire IQI adjacent to the detector

Note 1 to entry: $u_\mathrm{i} = 2 \times \mathrm{SR_b}^{\mathrm{detector}}$

3.25
image unsharpness
$\boldsymbol{u_\mathrm{im}}$
unsharpness measured in the digital image at the object plane with a duplex wire IQI at this plane too

3.26
total image unsharpness
$\boldsymbol{u_\mathrm{T}}$
including geometric and inherent unsharpness, measured in the digital image at the detector plane with a duplex wire IQI at the object plane

Note 1 to entry: u_T is calculated by $u_T = \sqrt{u_G^2 + u_i^2}$

3.27
geometric unsharpness
$\boldsymbol{u_\mathrm{G}}$
unsharpness measured in the digital image at the detector plane with a duplex wire IQI at the object plane with a high resolution detector excluding the inherent detector unsharpness

Note 1 to entry: u_G is calculated by $u_G = \frac{b}{f} \cdot d$

4 Symbols and abbreviations

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

Table 1 — Symbols and abbreviations

Symbol or abbreviation	Term	Clause, Figure
w	penetrated thickness	Clause 3.3
t	wall thickness	Clause 3.1
t_{n}	nominal wall thickness	Clause 3.2
b	object-to-detector distance	Clause 3.5
d	source size	Clause 3.4
f	source-to-object distance	Clause 3.6
f_{min}	minimum source-to-object distance	Clause 11.1
S	source of radiation	Figures 1 to 12
D	radiographic detector	Clause 12.4, Figures 1 to 12
SDD	source-to-detector distance	Clause 3.7
v	geometric magnification	Clause 3.8
CR	computed radiography	Clause 3.9
IP	storage phosphor imaging plate	Clause 3.10
DDA	digital detector array system	Clause 3.11
GV	grey value	Clause 3.14
$\mathrm{GV_{lin}}$	linearized grey value	Clause 3.15
IQI	image quality indicator	Clause 16
$\mathrm{SR_b^{detector}}$	basic spatial resolution of a digital detector	Clause 3.16
$\mathrm{SR_b^{image}}$	basic spatial resolution of a digital image	Clause 3.17
SNR	signal-to-noise ratio	Clause 3.18
$\mathrm{SNR_N}$	normalised signal-to-noise ratio	Clause 3.19
CNR	contrast-to-noise ratio	Clause 3.20
$\mathrm{CNR_N}$	normalised contrast-to-noise ratio	Clause 3.21
u_{G}	geometric unsharpness	Clause 3.27
CKP	cluster kernel pixel	Clause 3.23
u_{i}	inherent unsharpness.	Clause 3.24
u_{im}	image unsharpness	Clause 3.25
u_{T}	total image unsharpness	Clause 3.26