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

Gießereiwesen - Durchstrahlungsprüfung - Teil 2: Techniken mit digitalen Detektoren

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

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Gießereiwesen - Durchstrahlungsprüfung - Teil 2: Techniken mit digitalen Detektoren

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European foreword

This document (EN 12681-2:2026) has been prepared by Technical Committee CEN/TC 190 “Foundry technology”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by May 2027, and conflicting national standards shall be withdrawn at the latest by May 2027.

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

This document supersedes EN 12681-2:2017.

The significant technical changes with respect to EN 12681-2:2017 are given in Annex K (see Table K.1).

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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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 document gives acceptance criteria through severity levels.

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1 Scope

This document 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 the EN 12681 series 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 the EN 12681 series complies with EN ISO 16371-2 for CR. Some clauses and annexes are taken from EN ISO 17636-2.

This part of the EN 12681 series 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 document. The procedure specified in this document provides the minimum requirements for radiographic practice which permit exposure and acquisition of digital images with equivalent sensitivity for detection of imperfections as film radiography, as specified in EN 12681-1.

This document 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 testing class A and B testing of Annex A consider the good workmanship quality for general casting applications as also required in EN 12681-1 for film radiography.

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The testing classes A_A and B_A reflect the quality requirements of current automated and semi-automated radiographic testing systems with DDAs and computer- or operator-based image evaluation, 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 EN 12681-1 for film radiography.

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

This document does not apply to:

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

— film radiography (see EN 12681-1);

— real time testing with radioscopy (see EN 13068-1; radioscopy with image intensifiers).

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.

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

EN ISO 17636-2:2022, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2:2022, Corrected version 2023-02)*

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)*

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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 and basic spatial resolution value using duplex wire-type image quality indicators (ISO 19232-5)*

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

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.

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

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

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

3.1
wall thickness
t
thickness as measured on the casting

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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 17636-2:2022, 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, measured along the central axis of the radiation beam

[SOURCE: EN ISO 17636-2:2022, 3.19]

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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 17636-2:2022, 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 is the source-to-object distance;

b is the object-to-detector distance

[SOURCE: EN ISO 17636-2:2022, 3.21]

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

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[SOURCE: EN ISO 17636-2:2022, 3.24]

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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 17636-2:2022, 3.1]

3.10
storage phosphor imaging plate
IP
photostimulable luminescent material capable of storing a latent radiographic image of a material being tested 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 17636-2:2022, 3.2]

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3.11
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

[SOURCE: EN ISO 17636-2:2022, 3.3]

3.12
structure noise of imaging plate
structure noise of IP
local sensitivity variations due to inhomogeneities in the sensitive layer (structure, 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 17636-2:2022, 3.4]

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

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Note 1 to entry: After read out of the exposed uncorrected 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 correction procedure (software and guidelines are provided by the manufacturer). A suitable correction procedure reduces the structure noise.

Note 2 to entry: The image correction is also called “calibration” in other documents.

[SOURCE: EN ISO 17636-2:2022, 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*.

Note 2 to entry: For further information, see Annex H.

[SOURCE: EN ISO 17636-2:2022, 3.6]

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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 17636-2:2022, 3.7, modified – "GV_{lin}"has been added.]

3.16
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 E 2736-17 (2022) and ASTM E 1000-24.

[SOURCE: EN ISO 17636-2:2022, 3.8]

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3.17
basic spatial resolution of a digital image
SR_b^{image}
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half of the measured image unsharpness in a digital image, which 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 2736-17 (2022), and ASTM E 1000-24.

[SOURCE: EN ISO 17636-2:2022, 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 1 100 pixels.

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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

Note 1 to entry: $SNR_N = SNR \cdot c / SR_b^{image}$; c = 0,088 6 mm.

Note 2 to entry: SR_b^{image} is used for images with magnification.

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: Signal levels are measured in *grey values* or *linearized grey values*.

Note 2 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 17636-2:2022, 3.12]

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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

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Note 1 to entry: $CNR_N = CNR \cdot c / SR_b^{image}$; c = 0,088 6 mm.

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 17636-2:2022, 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/E 2597M-22 for details on bad pixels and CKP.

[SOURCE: EN ISO 17636-2:2022, 3.15]

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3.24
inherent unsharpness
u_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: $u_i = 2 \cdot SR_b^{detector}$

3.25
image unsharpness
u_{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
u_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 the following formula:

$$u_T = \sqrt{u_G^2 + u_i^2}$$

3.27
geometric unsharpness
u_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

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Note 1 to entry: u_G is calculated by the following formula:

$$u_G = \frac{b}{f} \cdot d$$

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviations apply:

w	penetrated thickness
t	wall thickness
t_n	nominal wall thickness
b	object-to-detector distance
d	source size
f	source-to-object distance
f_{min}	minimum source-to-object distance
S	source of radiation
D	radiographic detector
SDD	source-to-detector distance

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v	geometric magnification
CR	computed radiography
IP	storage phosphor imaging plate
DDA	digital detector array system
D_d	diagonal size of the detector area
GV	grey value
GV_{lin}	linearized grey value
IQI	image quality indicator
$SR_b^{detector}$	basic spatial resolution of a digital detector
SR_b^{image}	basic spatial resolution of a digital image
SNR	signal-to-noise ratio
SNR_N	normalized signal-to-noise ratio
CNR	contrast-to-noise ratio
CNR_N	normalized contrast-to-noise ratio
u_G	geometric unsharpness
CKP	cluster kernel pixel
u_d	inherent detector unsharpness.
u_{im}	image unsharpness
u_T	total image unsharpness

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5 Classification of radiographic techniques and compensation principles

5.1 Classification

The radiographic techniques for film replacement are divided into two testing classes:

— Testing class A: basic techniques;

— Testing class B: improved techniques.

The techniques for automated DDA based testing are divided into two testing classes:

— Testing class A_A: basic automated techniques;

— Testing class B_A: improved automated technique.

NOTE Automated DDA based techniques are used in industry for fast testing of castings mainly in serial production. These automated techniques are not considered as film replacement technique.

It is recommended to perform the testing according to testing class A or A_A, if not otherwise specified in the order, testing class B or B_A techniques are used when testing class A or A_A are insufficiently sensitive. This document does not cover fitness for purpose testing with IQI requirements different from Table A.1 to Table A.3.

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