Non-destructive testing of welds —
Radiographic testing —

Part 2:
X- and gamma-ray techniques with digital detectors

Contrôle non destructif des assemblages soudés — Contrôle par radiographie —

Partie 2: Techniques par rayons X ou gamma à l'aide de détecteurs numériques
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 17636-2 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 44, Welding and allied processes, Subcommittee SC 5, Testing and inspection of welds in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition, together with ISO 17636-1, cancels and replaces ISO 17636:2003, of which it constitutes a technical revision.

ISO 17636 consists of the following parts, under the general title Non-destructive testing of welds — Radiographic testing:

— Part 1: X- and gamma-ray techniques with film
— Part 2: X- and gamma-ray techniques with digital detectors

The main changes are that:

— the normative references have been updated;
— the document has been divided into two parts — this part of ISO 17636 is applicable to radiographic testing with digital detectors;
— X-ray devices up to 1 000 kV have been included;
— Annex C on determination of basic spatial resolution has been added;
— Annex D on determination of minimum grey values for CR practice has been introduced;
— Annex E with general remarks on grey values has been added;
— the text has been editorially revised.

Requests for official interpretations of any aspect of this part of ISO 17636 should be directed to the Secretariat of ISO/TC 44/SC 5 via your national standards body. A complete listing of these bodies can be found at www.iso.org.
Introduction

This International Standard specifies fundamental techniques of 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, inspection of fusion welded joints with digital radiographic detectors.

Digital detectors provide a digital grey value image which can be viewed and evaluated with a computer only. The practice describes 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 part of ISO 17636.

The procedure specified in this part of ISO 17636 provides the minimum requirements and practice which permits exposure and acquisition of digital radiographs with equivalent sensitivity for detection of imperfections as film radiography, specified in ISO 17636-1.
Non-destructive testing of welds — Radiographic testing —

Part 2:
X- and gamma-ray techniques with digital detectors

1 Scope

This part of ISO 17636 specifies fundamental techniques of 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 part of ISO 17636 applies to the digital radiographic examination of fusion welded joints in metallic materials. It applies to the joints of plates and pipes. Besides its conventional meaning, “pipe”, as used in this International Standard, covers other cylindrical bodies such as tubes, penstocks, boiler drums, and pressure vessels.

NOTE This part of ISO 17636 complies with EN 14784-2.[6]

This part of ISO 17636 specifies the requirements for digital radiographic X- and gamma-ray testing by either computed radiography (CR) or radiography with digital detector arrays (DDA) of the welded joints of metallic plates and tubes for the detection of imperfections.

Digital detectors provide a digital grey value (GV) image which can be viewed and evaluated using a computer. This part of ISO 17636 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 part of ISO 17636. The procedure specified in this part of ISO 17636 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 ISO 17636-1.

This part of ISO 17636 does not specify acceptance levels for any of the indications found on the digital radiographs.

If contracting parties apply lower test criteria, it is possible that the quality achieved is significantly lower than when this part of ISO 17636 is strictly applied.

2 Normative references

The following referenced documents are indispensable for the application 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 5576, Non-destructive testing — Industrial X-ray and gamma-ray radiology — Vocabulary

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

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 the following apply.

3.1 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

3.2 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 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).

3.3 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

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

NOTE 1 After scanning of the exposed imaging plate, the inhomogeneities appear as overlaid fixed pattern noise in the digital image.

NOTE 2 This noise limits the maximum achievable image quality of digital CR images and can be compared with the graininess in film images.
3.5 structure noise of digital detector array
structure noise of DDA
structure due to different properties of detector elements (pixels)

NOTE 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.

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

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

3.7 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 This is typically interchangeable with the terms linearized pixel value, and linearized detector signal.

3.8 basic spatial resolution of a digital detector
SR_{detect}^{b}
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 For this measurement, the duplex wire IQI is placed directly on the digital detector array or imaging plate.

NOTE 2 The measurement of unsharpness is described in ISO 19232-5, see also ASTM E2736\cite{13} and ASTM E1000.\cite{8}

3.9 basic spatial resolution of a digital image
SR_{image}^{b}
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 For this measurement, the duplex wire IQI is placed directly on the object (source side).

NOTE 2 The measurement of unsharpness is described in ISO 19232-5, see also ASTM E2736,\cite{13} and ASTM E1000.\cite{8}

3.10 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
3.11 normalized signal-to-noise ratio
\( \text{SNR}_N \)

Signal-to-noise ratio, SNR, normalized by the basic spatial resolution, \( \text{SR}_b \), as measured directly in the digital image and/or calculated from the measured SNR, \( \text{SNR}_{\text{measured}} \), by

\[
\text{SNR}_N = \frac{\text{SNR}_{\text{measured}}}{\text{SR}_b}
\]

3.12 contrast-to-noise ratio
\( \text{CNR} \)

Ratio of the difference of the mean signal levels between two image areas to the averaged standard deviation of the signal levels.

NOTE 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.

3.13 normalized contrast-to-noise ratio
\( \text{CNR}_N \)

Contrast-to-noise ratio, CNR, normalized by the basic spatial resolution, \( \text{SR}_b \), as measured directly in the digital image and/or calculated from the measured CNR, i.e.

\[
\text{CNR}_N = \frac{\text{CNR}}{\text{SR}_b}
\]

3.14 aliasing

Artifacts that appear in an image when the spatial frequency of the input is higher than the output is capable of reproducing.

NOTE Aliasing often appears as jagged or stepped sections in a line or as moiré patterns.

3.15 cluster kernel pixel
\( \text{CKP} \)

Bad pixel which does not have five or more good neighborhood pixels.


3.16 nominal thickness
\( \text{t} \)

Thickness of the parent material only where manufacturing tolerances do not have to be taken into account.

3.17 penetration thickness change
\( \Delta t \)

Change of penetrated thickness relative to the nominal thickness due to beam angle.

3.18 penetrated thickness
\( \text{w} \)

Thickness of material in the direction of the radiation beam calculated on the basis of the nominal thicknesses of all penetrated walls.
3.19 **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

3.20 **source size**

d
size of the radiation source or focal spot size

NOTE See EN 12679 or EN 12543.

3.21 **source-to-detector distance**

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

NOTE $SDD = f + b$

where

$f$ source-to-object distance

$b$ object-to-detector distance

3.22 **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

3.23 **external diameter**

$D_e$
nominal external diameter of the pipe

3.24 **geometric magnification**

$v$
ratio of source-to-detector distance $SDD$ to source-to-object distance, $f$

### 4 Symbols and abbreviated terms

For the purposes of this standard, the symbols given in Table 1 apply.

<table>
<thead>
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<th>Symbol</th>
<th>Term</th>
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<tr>
<td>$b$</td>
<td>object-to-detector distance</td>
</tr>
<tr>
<td>$b'$</td>
<td>object-to-detector distance perpendicular to test object</td>
</tr>
<tr>
<td>$d$</td>
<td>source size, focal spot size</td>
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<tr>
<td>$D_e$</td>
<td>external diameter</td>
</tr>
<tr>
<td>$f$</td>
<td>source-to-object distance</td>
</tr>
<tr>
<td>$f'$</td>
<td>source-to-object distance perpendicular to test object</td>
</tr>
<tr>
<td>SNR</td>
<td>signal-to-noise ratio</td>
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