

Australian Standard[®]

Non-destructive testing—Computerized radiography

Part 1: Systems



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- Australian Aerospace Non-Destructive Testing Committee
 - Australian Industry Group
 - Australian Institute for Non-Destructive Testing
 - Australian Nuclear Science & Technology Organisation
 - Australian Pipeline Industry Association
 - Bureau of Steel Manufacturers of Australia
 - Engineers Australia
 - Metals Trade Industry Association
 - National Association of Testing Authorities Australia
 - New Zealand Non-Destructive Testing Association
 - NSW WorkCover Authority
 - Victorian WorkCover Authority
 - Welding Technology Institute of Australia
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Non-destructive testing—Computerized radiography

Part 1: Systems

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MT-007, Non-destructive Testing of Metals and Materials. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to ensure that the parameters of computed radiography systems are achieved.

In the preparation of this Standard cognizance was taken of the following Standards:

EN

- 14784 Non-destructive testing—Industrial computed radiography with storage phosphor imaging plates
- 14784-1 Part 1: Classification of systems
- 14784-2 Part 2: General principles for testing of metallic materials using X-rays and gamma rays

This Standard is one of a series of Standards covering the range radiography as follows:

AS

- 2168 Non-destructive testing—Computerized radiography
- 2168.1 Part 1: Systems (this Standard)
- 2168.2 Part 2: Testing of metallic materials using X-rays and gamma rays
- 2177 Non-destructive testing—Radiography of welded butt joints in metal
- 2314 Radiography of metals—Image quality indicators (IQI) and recommendations for their use
- 3507 Non-destructive testing
- 3507.1 Part 1: Guide to radiography for ferrous castings
- 3507.2 Part 2: Radiography determination of quality of ferrous castings
- 4749 Non-destructive testing—Terminology of and abbreviations for fusion weld imperfections as revealed by radiography

The term ‘informative’ has been used in this Standard to define the application of the appendix to which it applies. An ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard

Non-destructive testing—Computerized radiography

Part 1: Systems

1 SCOPE

This Standard specifies the performance of computed radiography (CR) systems and the measurement of the parameters for the system scanner and storage phosphor imaging plate (IP). It describes the classification of these systems in combination with specified metal screens for industrial radiography to ensure that the quality of images (as far as this is influenced by the scanner-IP system) is in conformity with the requirements of AS 2168.2.

Manufacturers tests are described, which allow the determination of exact system parameters. Simpler user tests are also described, which are designed for a fast test of the quality of CR systems and long term stability.

The classifications can be determined accurately by the manufacturer tests as described in this Standard. Individual test targets, which are recommended for practical user tests, are described for quality assurance. These tests can be carried out either separately or by the use of a CR Phantom (see Appendix B).

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1929	Non-destructive testing—Glossary of terms
2168	Non-destructive testing—Computerized radiography
2168.2	Part 2: testing of metallic materials using X-rays and gamma rays
2177	Non-destructive testing—Radiography of welded butt joints in metal
3669	Non-destructive testing—Qualification and approval of personnel—Aerospace
3998	Non-destructive testing—Qualification and certification of personnel
ASTM	
E1647	Standard practice for determining contrast sensitivity in radioscopy
EN	
462	Non-destructive testing—Image quality of radiographs
462-5	Part 5: Image quality indicators (duplex wire type), determination of image unsharpness value
584	Non-destructive testing—Industrial radiography film
584-1	Part 1: Classification of film systems for industrial radiography

3 DEFINITIONS

For the purpose of this Standard, the following definitions and those in AS 1929 apply.

3.1 Aliasing

Pre-sampled high spatial frequency signals beyond the Nyquist frequency (given by the pixel distance) reflected back into the image at lower spatial frequencies.

3.2 Basic spatial resolution

Read-out value of un-sharpness measured with duplex wire IQI according to EN 462-5 divided by 2 as effective pixel size of CR system.

3.3 CEN speed S_{CEN}

Defines the speed of CR systems and is calculated from the reciprocal dose value, measured in Grays, which is necessary to obtain a specified minimum SNR of a CR system.

3.4 Computed radiography system (CR system)

Complete system of a storage phosphor imaging plate (IP) and corresponding read-out unit (scanner or reader) and system software, which converts the information of the IP into a digital image.

3.5 Computed radiography system class

Particular group of storage phosphor imaging plate systems, which is characterized by a SNR (Signal-to-Noise Ratio) range shown in Table 1 and by a certain basic spatial resolution value (e.g. derived from duplex wire IQI) in a specified exposure range.

3.6 CR phantom

Device containing an arrangement of test targets to evaluate the quality of a CR system, as well as monitoring the quality of the chosen system.

3.7 Gain/amplification

Opto-electrical gain setting of the scanning system.

3.8 Laser beam jitter

Lack of smooth movement of the plate laser-scanning device, causing lines in the image consisting of a series of steps.

3.9 Linearized signal intensity

Numerical signal value of a picture element (pixel) of the digital image, which is proportional to the radiation dose. The linearized signal intensity is zero, if the radiation dose is zero.

3.10 Modulation transfer function (MTF)

MTF describes the contrast transmission as a function of the object size. MTF characterizes the un-sharpness of the CR system is dependent on the scanning system and IP-type.

3.11 Scanner slippage

IP slippage in a scanner transport system resulting in fluctuation of intensity of horizontal image lines.

3.12 Signal-to-noise ratio (SNR)

Quotient of mean value of the linearized signal intensity and standard deviation of the noise at this signal intensity. The SNR depends on the radiation dose and the CR system properties.

4 PERSONNEL QUALIFICATION AND VISION REQUIREMENTS

4.1 Personnel qualifications

Radiographic testing interpretation, evaluation for compliance, and report shall be made by personnel having qualification and experience for their job function acceptable to the testing body, the manufacturer and where required by the purchaser.

Operators shall have the qualification detailed below or shall carry out their duties under the supervision of persons responsible for the performance of the test.

Qualifications acceptable for the radiographic testing of welds or metallic materials include the following:

- (a) Certification by the Australian Institute for Non-Destructive Testing (AINDT) Certification Board in accordance with AS 3998 or approval in accordance with AS 3669 in radiographic testing.
- (b) Equivalent qualifications.

4.2 Vision requirements

The personnel shall provide documented evidence of satisfactory vision in accordance with AS 3998 or AS 3669.

Subsequent to certification, the tests of visual acuity shall be carried out annually and be verified by the employer or the responsible agency.

5 CR QUALITY INDICATORS

5.1 General

5.1.1 Contrast sensitivity quality indicator

The contrast sensitivity quality indicators are in accordance with ASTM E1647.

NOTE: For further guidance on contrast sensitivity quality indicators refer to Appendix B, Paragraph B4.

5.1.2 Duplex wire quality indicator

The duplex wire quality indicator shall be in accordance with EN 462-5. The IQI shall be positioned at a 5° angle to the direction of the scanned lines (fast scan direction) or the perpendicular direction (slow scan direction).

5.1.3 Converging line pair quality indicator

The target consist of 5 converging strips of lead (0.03 mm thickness) which can be used for spatial resolution test by reading the limit of recognizable line pairs. It shall cover a range from 1.5 to 20 line pairs per millimetre (lp/mm). Two quality indicators shall be used, one in the direction of the scanned lines and the other one in the perpendicular direction.

5.1.4 Linearity quality indicators

Rulers of high absorbing materials are located on the perimeter of the scanned range. Two quality indicators shall be used, one in the direction of the scanned lines and the other in the perpendicular direction. The scaling shall be in millimetres.

5.1.5 T-target

This CR quality indicator consists of a thin plate of brass or copper (≤ 0.5 mm thick) with sharp edges. This plate is manufactured in a T-shape with 5 mm wide segments. The T should have a size of at least 50 mm $\times$ 70 mm. It shall be aligned perpendicular and parallel respectively to the direction of the scanned lines.

NOTE: For further guidance on the location and alignment of CR quality indicators refer to Appendix B, Paragraph B1.

5.1.6 Scanner slipping quality indicator

This indicator consists of an homogenous rectangle strip of aluminium of 0.5 mm thickness. It shall be aligned perpendicular and parallel respectively to the direction of the scanned lines.

5.1.7 *Shading quality indicator*

Different shading quality indicators may be used.

One type is based on the homogeneous exposure of an imaging plate (IP) with a thin Aluminium plate (0.5 mm to 1.0 mm). The exposure shall be made with low energy radiation (50 keV to 100 keV).

NOTE: Another type is the shading quality indicator of the CR-test phantom, see Appendix B.

5.1.8 *Central beam alignment quality indicator (BAM-snail)*

The alignment quality indicator consists of a roll (1.5 mm to 2.0 mm thick) of thin lead foil separated by a spacer of 0.1 mm to 0.2 mm of low absorbing material. Honeycomb material may also be used.

NOTE: For guidance on central beam alignment refer to Appendix B, Paragraph B3.

5.2 Application procedures for CR quality indicators

5.2.1 *General*

The CR quality indicators are designed for fast evaluation of the quality of a CR system as well as for a periodical quality control.

NOTE: Appendix C gives guidance for application of various tests and test methods.

5.2.2 *Exposure of CR quality indicators (user test)*

The CR quality indicators should be positioned in a special arrangement as described in Appendix B in the CR phantom. The CR quality indicators can be applied separately or all together in the CR phantom. The selected set of CR quality indicators or the CR phantom is placed on the cassette, which contains an Imaging Plate. The radiation source is set at a distance of 1 metre and the beam is aligned with the centre of the plate. Above a radiation energy of 100 keV a lead screen of 0.1 mm shall be applied between CR quality indicators or CR phantom and the IP to reduce scattered radiation. Test exposures are made and the radiation and CR system functions are optimized and the final image to be evaluated is agreed.

The exposure time and the parameter setting of the CR scanning unit determine the image quality as well as the type of imaging plate. These values and the type of IP have to be documented and agreed as well as the radiation energy (keV, gamma-source type), dose (e.g. in milliamps) and quality (pre-filters, tube type and tube window).

NOTE: High exposure time and low gain setting yield high contrast resolution and SNR. Furthermore, the contrast sensitivity is higher for large pixel size setting (high un-sharpness) than for small pixel size setting (low un-sharpness).

5.2.3 *Initial assessment of CR quality indicators (user test)*

For initial quality assessment, examine the radiographic image(s) of the CR phantom or the separated quality indicators on the monitor (or hard copy) for the features described in Clause 5.1.2 to Clause 5.1.8, and Clauses 6.3.2, 6.3.3, 6.4.1 to 6.4.7. The results can provide the basis of agreement between the contracting parties.

5.2.4 *Periodical control (user test)*

The CR quality indicators of Clause 5.1.2 to Clause 5.1.8 (alignment by Clause 5.1.9) or the CR phantom shall be radiographed and the results examined. The examination interval is the subject of agreement between the contracting parties. For periodical control, ensure that the agreed quality values of the tests Clause 6.3.2, Clause 6.3.3, and Clause 6.4.1 to 6.4.7 are achieved.

5.3 Imaging plate fading

The intensity of the stored image in the imaging plate will decrease over time. This effect is known as ‘image fading’. The measurement of fading characteristics shall be done by performing the following steps:

- (a) Expose a plate homogeneously using typical exposure conditions. For documentation the following parameters shall be recorded: kV, SDD, pre-filter and plate material and thickness. The exposed image shall have an intensity between 70% and 90% of the maximum possible intensity of the CR-reader at lowest gain and under linearized condition.
- (b) Read-out the imaging plate 5 minutes after exposure.
- (c) Set the linearized read-out intensity of this measurement as reference (100%).
- (d) Always expose the imaging plate with the same X-ray parameters (kV, mAs, distance).
- (e) Change the time between exposure and read-out. The time interval between exposure and readout will be doubled for every measurement; steps are 15 min, 30 min, 1 h, 2 h, 4 h, and so on up to 128 h or depending on the application.
- (f) Plot the linearized read-out intensity (grey value) versus time between exposure and read-out of the imaging plate.

The fading effect needs to be considered to ensure correct exposure conditions.

To enable reproducible test results it is important to consider fading effects, which influence the required exposure time. The time between exposure and read-out for all tests shall correspond to the typical application of the CR system.

6 PROCEDURE FOR QUANTITATIVE MEASUREMENT OF IMAGE QUALITY PARAMETERS

6.1 Measurement of the normalized Signal-to-Noise Ratio (SNR)

6.1.1 *Step Exposure Method (manufacturer test)*

CR System evaluation depends on the combined properties of the phosphor imaging plate (IP) type, the scanner used and the selected scan parameters. Therefore, all measurements shall be performed with the same IP type, scanner and scan parameters and documented. The applied test equipment (see Figure 1).