

**Oförstörande provning – Industriell
datorradiografi med bildplattor med skikt i fosfor
för lagring av bilder –**

Del 1: Klassificering av system

**Non-destructive testing – Industrial computed
radiography with storage phosphor imaging
plates –**

Part 1: Classification of systems

Europastandarden EN 14784-1:2005 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av EN 14784-1:2005.

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

Essais non destructifs - Radiographie industrielle
numérisée avec des plaques-images au phosphore - Partie
1 : Classification des systèmes

Zerstörungsfreie Prüfung - Industrielle Computer-
Radiographie mit Phosphor-Speicherfolien - Teil 1:
Klassifizierung der Systeme

This European Standard was approved by CEN on 1 July 2005.

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Contents

	Page
Foreword.....	3
1 Scope	4
2 Normative references	4
3 Terms and definitions	4
4 Personnel qualification	6
5 CR quality indicators.....	6
6 Procedure for quantitative measurement of image quality parameters	8
7 CR System Classification and Interpretation of Results	15
Annex A (informative) Example for I_{IPx} measurement	18
Annex B (informative) Example of CR test phantom	22
Annex C (informative) Guidance for application of various tests and test methods	25
Bibliography	27

Foreword

This European Standard (EN 14784-1:2005) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by February 2006, and conflicting national standards shall be withdrawn at the latest by February 2006.

EN 14784 comprises a series of European Standards for industrial computed radiography with storage phosphor imaging plates which is made up of the following:

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

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EN 14784-1:2005 (E)

1 Scope

This European Standard specifies fundamental parameters of computed radiography systems with the aim of enabling satisfactory and repeatable results to be obtained economically. The techniques are based both on fundamental theory and test measurements. This document specifies the performance of computed radiography (CR) systems and the measurement of the corresponding 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. It is intended 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 Part 2 of this document. The document relates to the requirements of film radiography defined in EN 584-1 and ISO 11699-1.

This European Standard defines system tests at different levels. More complicated tests are described, which allow the determination of exact system parameters. They can be used to classify the systems of different suppliers and make them comparable for users. These tests are specified as manufacturer tests. Some of them require special tools, which are usually not available in user laboratories. Therefore, simpler user tests are also described, which are designed for a fast test of the quality of CR systems and long term stability.

There are several factors affecting the quality of a CR image including geometrical un-sharpness, signal/noise ratio, scatter and contrast sensitivity. There are several additional factors (e.g. scanning parameters), which affect the accurate reading of images on exposed IPs using an optical scanner.

The quality factors can be determined most accurately by the manufacturer tests as described in this document. 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 the CR Phantom (Annex B). This CR Phantom incorporates many of the basic quality assessment methods and those associated with the correct functioning of a CR system, including the scanner, for reading exposed plates and in correctly erasing IPs for future use of each plate.

The CR System classes in this document do not refer to any particular manufacturers Imaging Plates. A CR system class results from the use of a particular imaging plate together with the exposure conditions – particularly total exposure – the scanner type and the scanning parameters.

2 Normative references

The following referenced documents are indispensable for the application of this European standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 462-5, *Non-destructive testing — Image quality of radiographs — Part 5: Image quality indicators (duplex wire type), determination of image unsharpness value.*

EN 584-1, *Non destructive testing — Industrial radiographic film — Part 1: Classification of film systems for industrial radiography.*

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply:

3.1
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

3.2**computed radiography system class**

particular group of storage phosphor imaging plate systems, which is characterised 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.

3.3**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**signal-to-noise ratio (SNR)**

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

3.5**modulation transfer function (MTF)**

normalised Magnitude of the Fourier-transform (FT) of the differentiated edge spread function (ESF) of the linearised PSL (photo stimulated luminescence) intensity, measured perpendicular to a sharp edge. MTF describes the contrast transmission as a function of the object size. MTF characterises the un-sharpness of the CR system in dependence on the scanning system and IP-type.

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**laser beam jitter**

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

3.8**scanner slippage**

slipping of an IP in a scanner transport system resulting in fluctuation of intensity of horizontal image lines

3.9**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

3.10**gain/amplification**

opto-electrical gain setting of the scanning system

3.11**linearised signal intensity**

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

3.12**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

EN 14784-1:2005 (E)**4 Personnel qualification**

It is assumed that industrial computed radiography is performed by qualified and capable personnel. In order to prove this qualification, it is recommended to certify the personnel according to EN 473 or ISO 9712.

5 CR quality indicators**5.1 Description of CR quality indicators for user and manufacturer tests****5.1.1 General**

The following is a description of CR quality indicators, which will be identified by reference to this document.

5.1.2 Contrast sensitivity quality indicator

The description of the selected contrast sensitivity targets corresponds to ASTM E1647-98a (see for details Annex B.4).

5.1.3 Duplex wire quality indicator

The description of the duplex wire quality indicator corresponds to 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).

5.1.4 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 recognisable line pairs. It shall cover a range from 1,5 to 20 line pairs per mm (lp/mm). Two quality indicators shall be used, one in direction of the scanned lines and the other one in the perpendicular direction.

5.1.5 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 direction of the scanned lines and the other in the perpendicular direction. The scaling shall be at least in mm.

5.1.6 T-target

This CR quality indicator consists of a thin plate of brass or copper ($\leq 0,5$ 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 (see Figure B.1).

5.1.7 Scanner slipping quality indicator

It consists of a homogenous strip of aluminium of 0,5 mm thickness. It has a shape of a rectangle (see Figure B.1) and shall be aligned perpendicular and parallel respectively to the direction of the scanned lines.

5.1.8 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 Al-plate (0,5 mm to 1,0 mm) above the IP. The exposure shall be made with low energy radiation (50 keV to 100 keV).

Another type is the shading quality indicator of the CR-test phantom (see Annex B).

5.1.9 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; (see Annex B.3). Honeycomb material may also be used.

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. Annex C gives a 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 Annex 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 optimised 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 mAs) 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 5.1.2 to 5.1.9 and 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 5.1.2 to 5.1.8 (alignment by 5.1.9) or the CR phantom shall be radiographed and the results examined at any interval agreed between the contracting parties. For periodical control, ensure that the agreed quality values of the tests 6.3.2, 6.3.3, and 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 linearised condition;
- b) read-out the imaging plate 5 minutes after exposure;
- c) set the linearised read-out intensity of this measurement as reference (100 %);

EN 14784-1:2005 (E)

- d) always expose the imaging plate with the same X-ray parameters (kV, mA*s, 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, 1h, 2h, 4h, etc. up to 128 h or depending on the application;
- f) plot the linearised read-out intensity (grey value) versus time between exposure and read-out of the imaging plate.

The fading effect has 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.

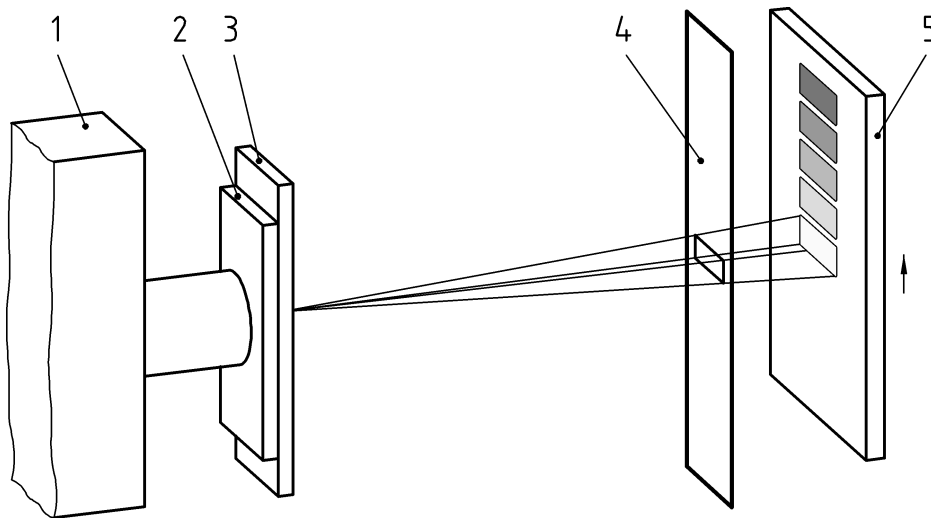
6 Procedure for quantitative measurement of image quality parameters

6.1 Measurement of the normalized Signal-to-Noise Ratio

6.1.1 Step Exposure Method (manufacturer test)

6.1.1.1 General

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 (Figure 1) and algorithm corresponds to EN 584-1 and ISO 11699-1.



Key

- 1 X-ray tube
- 2 Cu-Filter
- 3 Collimator
- 4 Diaphragm
- 5 IP in a cassette

Figure 1 — Scheme of experimental arrangement for the step exposure method

For measurement of the SNR, the following steps are taken (see also EN 584-1).

6.1.1.2 The IP, with a front and back screen from lead of 0,1 mm thickness in the typical exposure cassette, shall be positioned in front of an X-ray tube with tungsten anode. Make the exposures with an 8 mm copper filter at the X-ray tube and the kilo voltage set such that the half value layer in copper is 3,5 mm. The kilo voltage setting will be approximately 220 kV.

6.1.1.3 Determine the required exact kilo voltage setting by making an exposure (or an exposure rate) measurement with the detector placed at a distance of at least 750 mm from the tube target and an 8-mm copper filter at the tube. Then make a second measurement with a total of 11,5 mm of copper at the tube. These filters should be made of 99,9 % pure copper.

6.1.1.4 Calculate the ratio of the first and second readings. If this ratio is not 2, adjust the kilo voltage up or down and repeat the measurements until a ratio of 2 (within 5 %) is obtained. Record the setting of the kilo voltage for use with the further IP tests.

6.1.1.5 The sensitive layer of the IP shall face the X-ray source. For gamma radiography with Ir-192, the measurements shall be carried out with 0,3 mm lead screens in front and behind the IP. Also 8 mm Cu shall be used for pre-filtering (see Figure 1).

6.1.1.6 The scanner shall read with a dynamic of ≥ 12 Bit and operate at its highest spatial resolution - or a spatial resolution for which the classification shall be carried out. Background and anti-shading correction may be used before the analysis of data, if it relates to the standard measurement procedure for all measurements. In this case the procedure shall be carried out and documented for all gain and latitude ranges and all read-out pixel sizes if any of these parameters change the SNR-analysis.

6.1.1.7 IPs are exposed in a similar way to film radiography and under the conditions described: intensity and a noise (σ_{PSL}) or SNR over dose curve shall be measured. It is especially important that the exposure of the IP for the SNR measurements be spatially uniform. Any non-uniformities in X-ray transmission of the cassette front, or defects in the Pb foil or in the phosphor itself could influence the SNR measurement. No major scratches or dust shall be visible in the measurement area. Therefore exercise considerable care in selection and placement of the aperture, and selection and maintenance of the cassette, the lead screens and the phosphor screen. To achieve a uniform region of interest on to the IP, the following standard protocol is recommended. Other approaches may be used as long as a uniform exposure is created. At least 12 areas (test areas) of $\geq 400 \text{ mm}^2$ are evenly exposed on the same IP over the full working range of dose. Due to the different construction principles of scanners, the measurement shall be performed for all possible pixel sizes. The digital read-out intensity values (grey values) shall be calibrated in such a way, that they are linear in relation to the radiation dose that corresponds to the photo stimulated luminescence (PSL) intensity of the exposed IPs. These calibrated grey values shall be used for the calculation of the SNR. In order to get a reliable result at least six measurements shall be made on different samples, and the results are to be averaged for each of the 12 or more dose levels measured.

6.1.1.8 The signal intensity I_{meas} and standard deviation σ_{PSL} shall be computed from a region without shading or artifacts. Sample SNR values shall be taken in different regions of the image area under test to ensure that SNR values are within 10% stable. The size of the ROI used to measure the mean intensity and the noise shall be at least 20 by 55 pixels and it should be an area ROI. An example technique for assuring reliable signal to noise measurements is described below. This can be achieved using a commonly available image-processing tool. The signal and noise shall be calculated from a data set of 1100 values or more per exposed area. The data set is subdivided into 55 groups or more with 20 values per group. For each group with index i , the value I_{meas_i} is calculated as mean of the unfiltered group values and the value σ_{PSL_i} is calculated from the same group values. An increased number of groups yields a better (lower) uncertainty of the result. Due to the filtering effect of this grouping procedure, the σ_{PSL_i} -values are corrected by the following equation:

$$\sigma_{\text{PSL}_i\text{,corr}} = 1,0179 \cdot \sigma_{\text{PSL}_i} \quad (1)$$

NOTE The values σ_{PSL_i} are multiplied with 1,0179 to correct for the following median unbiased estimation. Assume k is the number of consecutive observations within a group and C is the critical value of the chi-square distribution for $\alpha = 0,5$ with $k-1$ degrees of freedom. In case of 20 observations the values σ_{PSL_i} shall be multiplied with 1,0179 for statistical