BRITISH STANDARD

BS EN 14784-2:2005

# 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

The European Standard EN 14784-2:2005 has the status of a British Standard

ICS 19.100





British Standards

# National foreword

This British Standard is the official English language version of EN 14784-2:2005.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

**Cross-references**

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**Summary of pages**

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 16, an inside back cover and a back cover.

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# EN 14784-2

August 2005

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English version

# 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

Essais non destructifs - Radiographie industrielle numérisée avec plaques-images au phosphore - Partie 2 : Principes généraux de l'essai radioscopique, à l'aide de rayons X et gamma, des matériaux métalliques

Zerstörungsfreie Prüfung - Industrielle Computer-Radiographie mit Phosphor-Speicherfolien - Teil 2: Grundlagen für die Prüfung von metallischen Werkstoffen mit Röntgen- und Gammastrahlen

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

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Ref. No. EN 14784-2:2005: E

# Contents

# Foreword

This European Standard (EN 14784-2:2005) 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.

# 1 Scope

This European Standard specifies fundamental techniques of computed radiography with the aim of enabling satisfactory and repeatable results to be obtained economically. The techniques are based on the fundamental theory of the subject and tests measurements. This document specifies the general rules for industrial computed X- and gamma radiography for flaw detection purposes, using storage phosphor imaging plates (IP). It is based on the general principles for radiographic examination of metallic materials on the basis of films (EN 444 and ISO 5579). The basic set-up of radiation source, detector and the corresponding geometry shall be applied in agreement with EN 444 and ISO 5579 and the corresponding product standards as e.g. EN 1435 for welding and EN 12681 for foundry. It does not lay down acceptance criteria of the imperfections.

# 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 462-1, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality Indicators (wire type) — Determination of image quality value.*

EN 462-2, *Non-destructive testing — Image quality of radiographs — Part 2: Image quality indicators (step/hole type) — Determination of image quality value.*

EN 462-3, *Non-destructive testing — Image quality of radiographs — Part 3: Image quality classes for ferrous metals.*

EN 462-4, *Non-destructive testing — Image quality of radiographs — Part 4: Experimental evaluation of image quality values and image quality tables.*

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

EN 14784-1:2005; *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 European Standard, the following terms and definitions apply.

**3.1**
**storage phosphor imaging plate systems**
complete system of a storage phosphor imaging plate (IP) and a corresponding read out unit (scanner or reader), which converts the information of the IP into a digital image

**3.2**
**nominal thickness**
$t$
nominal thickness of the material in the region under examination. Manufacturing tolerances do not have to be taken into account

**3.3**
**penetrated thickness**
$w$
thickness of material in the direction of the radiation beam calculated on basis of the nominal thickness.

For multiple wall techniques the penetrated thickness is calculated from the nominal thickness.

**3.4**
**object-to-detector distance**
*b*
distance between the radiation side of the test object and the detector surface measured along the central axis of the radiation beam

**3.5**
**source size**
*d*
size of the source of radiation

**3.6**
**source-to-detector distance (SDD)**
distance between the source of radiation and the detector measured in the direction of the beam

**3.7**
**source-to-object distance**
*f*
distance between the source of radiation and the source side of the test object measured along the central axis of the radiation beam

## 4 Personnel qualification

The examination should be carried out by qualified and capable personnel. In order to prove this qualification, it is recommended to certify the personnel in accordance with EN 473 or ISO 9712.

## 5 Classification of computed radiographic techniques

Computed radiographic techniques are subdivided into two classes:

— Class A: basic technique;

— Class B: improved technique.

Class B technique will be used when class A may be insufficiently sensitive.

Better techniques, compared with class B, are possible and may be agreed between the contracting parties by specification of all appropriate test parameters.

The choice of radiographic technique shall be agreed between the parties concerned.

Due to image parameters such as SNR, un-sharpness and sensitivity to scattered radiation and hardening differences exist between film radiographs and computed radiographs.

Nevertheless, the perception of flaws using film radiography or computed radiography is comparable by using class A and class B techniques, respectively. The perceptibility shall be proven by the use of IQIs according to EN 462-1, EN 462-2 and EN 462-5.

If it is not possible for technical reasons to meet one of the conditions specified for the class B, such as the type of radiation source or the source-to-object distance f, it may be agreed between the contracting parties that the condition selected may be that specified for class A. The loss of sensitivity shall be compensated for, by doubling the required minimum exposure time with the goal to increase the minimum SNR by a factor of 1.4 (additional to the SNR required from the plate-scanner classes given by Tables 2 to 3). Because of the resulting improved sensitivity compared to class A, the test sections may be regarded as examined within class B.

NOTE This applies only to those IP-scanner systems whose SNR is not limited by the in-homogeneity of the phosphor layer or the scanner dynamic at the required minimum exposure time (see clause 7.9).

# 6 General

## 6.1 Protection against ionising radiation

**WARNING — Exposure of any part of the human body to X-rays or gamma-rays can be highly injurious to health. Wherever X-ray equipment or radioactive sources are in use, appropriate legal requirements must be applied.**

Local or national or international safety precautions when using ionizing radiation shall be strictly applied.

## 6.2 Surface preparation and stage of manufacture

In general, surface preparation is not necessary, but where surface imperfections or coatings might cause difficulty in detecting defects, the surface shall be ground smooth or the coatings shall be removed.

Unless otherwise specified computed radiography shall be carried out after the final stage of manufacture, e.g. after grinding or heat treatment.

## 6.3 Identification of radiographs

Symbols shall be affixed to each section of the object being radiographed. The images of these symbols shall appear in the radiograph outside the region of interest where possible and shall ensure unequivocal identification of the section.

## 6.4 Marking

Permanent markings on the object to be examined shall be made in order to locate accurately the position of each radiograph.

Where the natures of the material and/or its service conditions do not permit permanent marking, the location may be recorded by means of accurate sketches or photographs.

## 6.5 Overlap of phosphor imaging plates

When radiographing an area with two or more separate phosphor imaging plates (IP), the IPs shall overlap sufficiently to ensure that the complete region of interest is radiographed. This shall be verified by a high-density marker on the surface of the object that will appear on each image.

## 6.6 Image quality indicators

The quality of image shall be verified by use of IQIs, in accordance with the specific application of the following European Standards - EN 462-1 for the contrast resolution and EN 462-5 for measurement of un-sharpness. Therefore, two IQIs are always required on each image. The minimum IQI-values in dependence on wall thickness and geometry are defined by EN 462-3. This document may be applied to non-ferrous metals if appropriate IQIs are used. In specific application cases minimum IQI-values may be specified in accordance with EN 462-4. IQIs of the step-hole type (e.g. EN 462 2) should not be applied because the wire IQIs are more suitable to encourage the operator to compensate for limited sharpness with increased contrast. This compensation can be achieved either by reduction of the source voltage or by longer exposure time to increase the SNR of the computed radiograph.

# 7 Recommended techniques for making computed radiographs

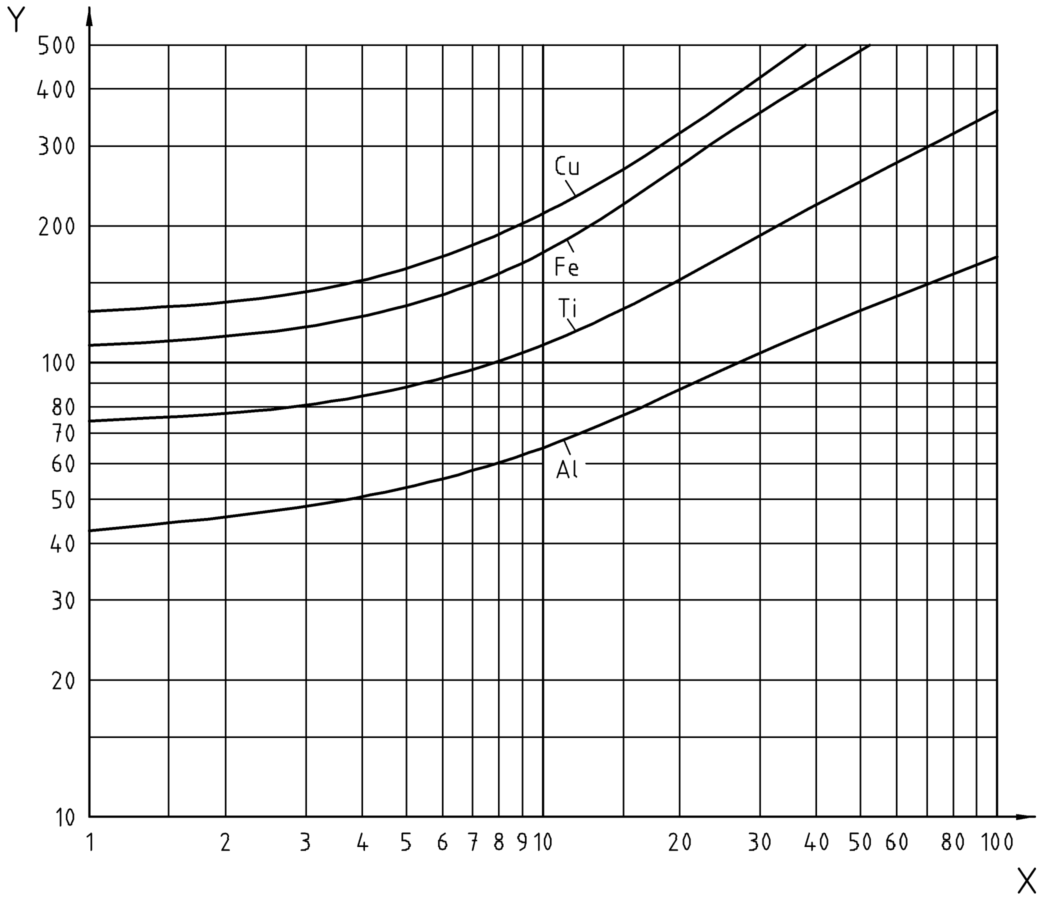
## 7.1 Test arrangements

Test arrangements shall be determined from the specific application standards for film radiography as e.g. EN 1435 and EN 12681.

## 7.2 Choice of X-ray tube voltage and radiation source

### 7.2.1 X-ray equipment

To maintain good flaw detection sensitivity, the X-ray tube voltage should be as low as possible. The maximum values of tube voltage versus thickness are given in Figure 1.




**Key**

X penetrated thickness $w$, in millimetres

Y X-ray voltage, in kilovolts

**Figure 1 — Maximum X-ray voltage for X-ray devices up to 500 kV as function of penetrated wall thickness**

### 7.2.2 Other radiation sources

The permitted penetrated thickness ranges for gamma ray sources and X-ray equipment above 1 MeV are given in Table 1.

By agreement of the contracting parties the value for Ir 192 may be reduced furthermore to 10 mm and for Se 75 to 5 mm penetrated wall thickness.

On thin specimens, gamma rays from Ir-192 and Co-60 will not produce computed radiographs having as good a defect detection sensitivity as X-rays used with appropriate technique parameters. However, because of the advantages of gamma ray sources in handling and accessibility, Table 1 gives a range of thickness for which each of these gamma ray sources may be used when the use of X-rays is not practicable.

For certain applications wider wall thickness ranges may be permitted if sufficient image quality can be achieved.

In cases where radiographs are produced using gamma rays, the travel time to position the source shall not exceed 10 % of the total exposure time.

**Table 1 — Penetrated thickness range for gamma ray sources and X-ray equipment with energy from 1 MeV and above for steel, copper and nickel-base alloys**

| Radiation source | Penetrated thickness $w$ mm | |
|---|---|---|
| | Test class A | Test class B |
| Tm 170 | $w \leq 5$ | $w \leq 5$ |
| Yb 169 [a] | $1 \leq w \leq 15$ | $2 \leq w \leq 12$ |
| Se 75 [b] | $10 \leq w \leq 40$ | $14 \leq w \leq 40$ |
| Ir 192 | $20 \leq w \leq 100$ | $20 \leq w \leq 90$ |
| Co 60 | $40 \leq w \leq 200$ | $60 \leq w \leq 150$ |
| X-ray equipment with energy 1 to 4 MeV | $30 \leq w \leq 200$ | $50 \leq w \leq 180$ |
| X-ray equipment with energy 4 to12 MeV | $50 \leq w$ | $80 \leq w$ |
| X-ray equipment with energy > 12 MeV | $80 \leq w$ | $100 \leq w$ |

[a] For aluminium and titanium the penetrated material thickness is $10 \leq w \leq 70$ for class A and $25 \leq w \leq 55$ for class B.

[b] For aluminium and titanium the penetrated material thickness is $35 \leq w \leq 120$ for class A.

## 7.3 Phosphor imaging plate-scanner systems and screens

For computed radiographic examination, IP-scanner system classes shall be used corresponding to the definitions given in EN 14784-1:2005. The IP system classes are defined in EN 14784-1 by the minimum SNR-values ($SNR_{IPx}$) which are given in Table 1 of EN 14784-1:2005.

For different radiation sources and wall thickness ranges, the minimum IP-system classes are given in Tables 2 and 3. These Tables show the recommended screen materials and metal thickness. When using lead screens, good contact between IP and screens is required.

Other screen thicknesses and materials may also be applied if described in the specification provided the required image quality is achieved.

**Table 2 — IP-system classes and metal screens for the computed radiography of steel, copper- and nickel based alloys**

| Radiation source | Penetrated wall thickness $w$ in mm | IP system class[a] | | Type and minimum thickness in mm of metal screen | |
|---|---|---|---|---|---|
| | | A | B | Front | Back |
| X-ray < 50 kV | | 4 | 2 | None | None |
| X-ray 50 kV to 150 kV | | 5 | 3 | Pb 0,1 | Pb 0,1 |
| X-ray > 150 kV to 250 kV | | 5 | 4 | Pb 0,1 | Pb 0,1 |
| X-ray > 250 kV to 350 kV | $w < 50$ | 5 | 4 | Pb 0,2 | Pb 0,2 |
| | $w > 50$ | 5 | 5 | Pb 0,3 | Pb 0,3 |
| X-ray > 350 kV to 450 kV | $w < 50$ | 5 | 4 | Pb 0,3 | Pb 0,3 |
| | $w > 50$ | 5 | 5 | Pb 0,3 | Pb 0,3 |
| Yb 169, Tm 170 | $w < 5$ | 5 | 3 | Pb 0,1 | Pb 0,1 |
| | $w > 5$ | 5 | 4 | Pb 0,1 | Pb 0,1 |
| Ir 192, Se 75 | $w < 50$ | 5 | 4 | Pb 0,3 | Pb 0,3 |
| | $w > 50$ | 5 | 5 | Pb 0,4 | Pb 0,4 |
| Co 60[b] | $w < 100$ | 5 | 4 | Fe 0,5+Pb 1,5 | Fe 0,5+Pb 1,0 |
| | $w > 100$ | 5 | 5 | Fe 0,5+Pb 2,0 | Fe 0,5+Pb 1,0 |
| X-ray > 1 MV[b] | $w < 100$ | 5 | 4 | Fe 0,5+Pb 1,5 | Fe 0,5+Pb 1,0 |
| | $w > 100$ | 5 | 5 | Fe 0,5+Pb 2,0 | Fe 0,5+Pb 1,0 |

[a] Better IP-system classes may also be used.

[b] In case of multiple screens (Fe+Pb) the steel screen shall be located between the IP and the lead screen. Instead of Fe or Fe+Pb also copper, tantalum or tungsten screens may be used if the image quality can be proven.

**Table 3 — IP system classes and metal screens for aluminium and titanium**

| Radiation source | | IP-system class[a] | | Type and minimum thickness, in mm, of front and back screens |
|---|---|---|---|---|
| | | Class A | Class B | |
| X-ray | < 50 kV | IP 5 | IP 3 | 0 |
| X-ray | 50 kV to 150 kV | | | 0 |
| X-ray | > 150 kV to 250 kV | | | Pb 0,02 |
| X-ray | > 250 kV | | | Pb 0,1 |
| Yb 169, Tm 170 | | | | Pb 0,02 |
| Se 75 | | | | Pb 0,1 |

[a] Better IP-system classes may be also used.

## 7.4 System un-sharpness

Computed radiography systems shall provide sufficient image quality for a certain probability of detection of material in-homogeneities. Table 4 defines the required maximum un-sharpness (duplex wire IQI-value) and pixel size of the scanner depending on radiation energy and wall thickness.

The system un-sharpness has to be proven for all exposures by the duplex wire IQI perceptibility (EN 462-5).

**Table 4 — Required spatial system resolution in dependence on energy and wall thickness**

| Radiation source | Wall thickness | Class IPA | | Class IPB | |
|---|---|---|---|---|---|
| | *w* in mm | Max. pixel[a] size µm | Double wire IQI number[b] | Max. pixel[a] size µm | Double wire IQI number[b] |
| X-ray $U_p \leq 50$ kV | $w < 4$ | 40 | > 13[c] | 30 | >> 13[d] |
| | $4 \leq w$ | 60 | 13 | 40 | > 13[c] |
| X-ray 50 kV < $U_p \leq 150$ kV | $w < 4$ | 60 | 13 | 30 | >> 13[d] |
| | $4 \leq w < 12$ | 70 | 12 | 40 | > 13[c] |
| | $w \geq 12$ | 85 | 11 | 60 | 13 |
| X-ray 150 kV < $U_p \leq 250$ kV | $w < 4$ | 60 | 13 | 30 | >> 13[d] |
| | $4 \leq w < 12$ | 70 | 12 | 40 | > 13[c] |
| | $w \geq 12$ | 85 | 11 | 60 | 13[c] |
| X-ray 250 kV < $U_p \leq 350$ kV | $12 \leq w < 50$ | 110 | 10 | 70 | 12 |
| | $w \geq 50$ | 125 | 9 | 110 | 10 |
| X-ray 350 kV < $U_p < 450$ kV | $w < 50$ | 125 | 9 | 85 | 11 |
| | $w \geq 50$ | 160 | 8 | 110 | 10 |
| Yb 169, Tm 170 | | 85 | 11 | 60 | 13 |
| Se 75, Ir 192 | $w < 40$ | 160 | 8 | 110 | 10 |
| | $w \geq 40$ | 200 | 7 | 125 | 9 |
| Co 60 | | 250 | 6 | 200 | 7 |
| X-ray $U_p > 1$ MeV | | 250 | 6 | 200 | 7 |

a If magnification technique is used, double wire IQI readout is required only.

b The given IQI numbers indicate the readout value of the first unresolved wire pair corresponding to EN 462-5.

c The symbol "> 13" requires the 13th wire pair to be resolved with a dip separation larger than 20 % (see Figure 3 of EN 14784-1:2005).

d The symbol ">> 13" requires the 13th wire pair to be resolved with a dip separation larger than 50 %.

$U_P$ = tube voltage.

## 7.5 Alignment of beam

The beam of radiation shall be directed to the centre of the area being inspected and should be normal to the object surface at that point, except when it can be demonstrated that certain flaws are best revealed by a different alignment of the beam.

Other ways of radiographing may be performed as defined in the specification.

## 7.6 Reduction of scattered radiation

### 7.6.1 Filters and collimators

In order to reduce the effect of back-scattered radiation, direct radiation shall be collimated as much as possible to the section under examination.

With Se 75, Ir 192 and Co 60 radiation sources, or in case of edge scatter, a sheet of lead can be used as a filter of low energy scattered radiation between the object and the cassette. The thickness of this sheet is 0,5 mm to 2 mm in accordance with the penetrated thickness.

### 7.6.2 Interception of back scattered radiation

If necessary, the IP shall be shielded from back-scattered radiation by an adequate thickness of lead at least 1 mm, or of tin of at least 1,5 mm, placed behind the IP-screen combination.

The presence of back-scattered radiation shall be checked for each new test arrangement by a lead letter B (with a height of minimum 10 mm and a thickness of minimum 1,5 mm) placed immediately behind each cassette. If the image of this symbol records as an image with less intensity than the background on the radiograph, it shall be rejected. If the symbol is projected with higher intensity or invisible the radiograph is acceptable and demonstrates good protection against scattered radiation.

## 7.7 Source-to-object distance

The minimum source-to-object distance $f_{\mathrm{min}}$ depends on the source size $d$ and on the object-to-detector (IP) distance $b$.

The distance $f$, shall, where practicable, be chosen so that the ratio of this distance to the source size $d$, i.e. $f/d$, is not below the values given by the following equations:

For class A: $f/d \geq 7{,}5\ (b)^{2/3}$. (1)

For class B: $f/d \geq 15\ (b)^{2/3}$. (2)

$b$ is given in millimetre (mm).

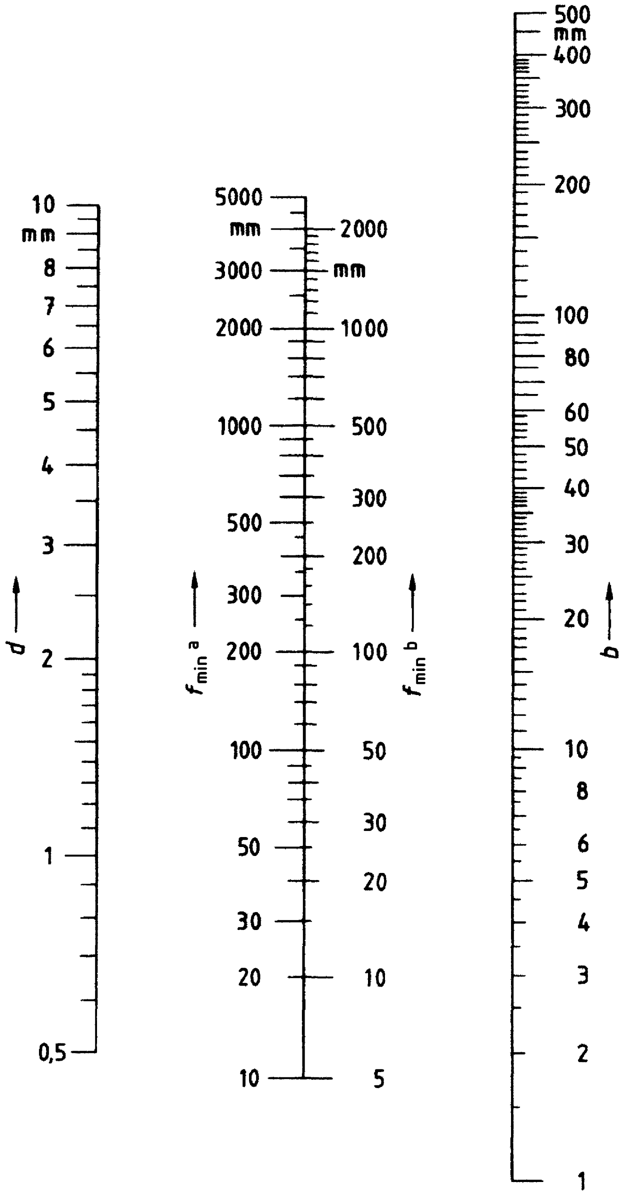
If the distance $b$ < 1,2 t the dimension $b$ in equations (1) and (2) and Figure 2 shall be replaced by the nominal thickness $t$.

For determination of the source-to-object distance, $f_{\mathrm{min}}$, the nomogram in Figure 2 may be used.

The nomogram is based on equations (1) and (2).

In class A, if planar imperfections have to be detected the minimum distance $f_{\mathrm{min}}$ shall be the same as for class B in order to reduce the geometric un-sharpness by a factor of 2.

In critical technical applications of crack-sensitive materials more sensitive radiographic techniques than class B shall be used.




**Key**

a minimum source to object distance for class B

b minimum source to object distance for class A

**Figure 2 — Nomogram for determination of minimum source-to-object distance $f_{min}$ in relation to the object-IP distance and the source size**

## 7.8 Maximum area for a single exposure

The ratio of the penetrated thickness at the outer edge of an evaluated area of uniform thickness to that at the centre beam shall not be more than 1,1 for class B and 1,2 for class A.

The read-out intensities resulting from any variation of penetrated thickness should not be lower than those indicated in 7.9.

### 7.9 Minimum read-out intensity of computed radiographs

Each CR image shall have better or equal SNR than those defined by the system classes mentioned in Tables 2 and 3. As SNR values are not measured regularly, the minimum SNR values are guaranteed by the use of minimum read-out intensities $I_{IPx}$, where x represents the IP class. These read-out intensities are analogous to the use of minimum optical densities in film radiography. The definition of minimum read-out intensity is derived from measurements of the particular CR system (see EN 14784-1) and they are provided by the manufacturer.

Each acquired computed radiograph shall be verified in accordance to Table 5. To be classified as class A or class B, readings should be equal or exceed the required values.

NOTE The same IP-scanner system may be used for different applications, which have to satisfy different IP-scanner system classes. This results in different minimum read-out intensities and usually in different exposure times.

**Table 5 — Read-out intensity of computed radiographs**

| Testing class | Minimum Read-out intensity[a] for system class x | Minimum SNR |
|---|---|---|
| A | $0,81 \cdot I_{Ipx}{}^{b}$ | $0,9 \cdot SNR_{Ipx}{}^{b}$ |
| B | $1,0 \cdot I_{Ipx}{}^{b}$ | $1,0 \cdot SNR_{Ipx}{}^{b}$ |

[a] A measuring tolerance of ± 5 % is permitted.

[b] Value may be reduced by special agreement of contracting parties.

High intensities may be used with advantage if the IP-scanner system does not already limit the SNR.

In order to avoid unduly high background intensities arising from exposure by natural radiation, IPs shall always be erased before use if the last erasure was more than two weeks ago. If IPs are used for high-energy application or gamma radiography, they shall be checked for sufficient erasure by a test read out, after erasure.

If $I_{IPx}$-values are not available, the achieved testing class can be determined from the IQI-read out values in accordance with EN 462-3 or EN 462-4. No image processing is allowed apart from linear brightness and contrast adjustment.

### 7.10 Monitor and film viewing conditions

The computed radiographs shall be examined in a darkened room on a monitor or a printed film hardcopy - with a resolution better or equal to the requirements of Table 4, on a light box corresponding to EN 25580.

The monitor shall have a luminance of $\geq 100$ cd/m$^2$ and a resolution of $\geq 1280 \times 1024$ pixel with a pixel size 150 µm to 300 µm. The graphic board shall provide $\geq 256$ grey levels. The software shall provide images, which are always visualised with 256 grey levels. The ratio for displayable luminance ($L_{max}/L_{min}$) shall be $\geq$ 100:1.

## 8 Test report

For each computed radiograph, or set of computed radiographs, a test report shall be made giving information on the radiographic technique used, and on any other special circumstances which would allow a better understanding of the results.

Details concerning form and contents should be specified in special application standards or be agreed on by the contracting parties. If inspection is carried out exclusively to this guideline then the test report shall contain at least the following information:

a) name of the test house;

b) number of test report;

c) object under test;

d) material tested;

e) stage of manufacture;

f) nominal thickness;

g) radiographic technique and class;

h) system of marking used;

i) IP position plan, if required;

j) radiation source, type and size of focal spot and equipment used;

k) selected IP systems, screens and filters;

l) tube voltage and current or source activity;

m) time of exposure and source-to-detector distance;

n) type and position of image quality indicators;

o) reading of IQIs and/or minimum read-out intensity;

p) conformity with this document;

q) any deviation from agreed standards and this document;

r) name, certification and signature of the responsible person(s);

s) date of exposure and report;

t) reference to this document.

# Bibliography

[1] EN 444, *Non-destructive testing — General principles for radiographic examination of metallic materials X- and gamma-rays.*

[2] EN 473, *Non destructive testing — Qualification and certification of NDT personnel — General principles.*

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

[4] EN 1435, *Non–destructive examination of welds — Radiographic examination of welded joints.*

[5] EN 12681, *Founding — Radiographic examination.*

[6] ISO 5579, *Non-destructive testing — Radiographic examination of metallic materials by X- and gamma-rays — Basic rules.*

[7] ISO 9712, *Non-destructive testing — Qualification and certification of personnel*.

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