Introduction

To Teledyne ICM

TELEDYNE ICM
Everywhereyoulook™

TELEDYNE ICM

Manufacturer specialized in portable
X-ray solutions for Security and Industrial applications

Established in 1993

- Acquired by Teledyne Technologies Corp. in 2016
- 45 people

Worldwide presence

- Headquarter and & production located in Belgium
- Main Offices in North America and China
- Technical Service Centers in strategic locations worldwide to support local customers and users

Innovative and intuitive equipment

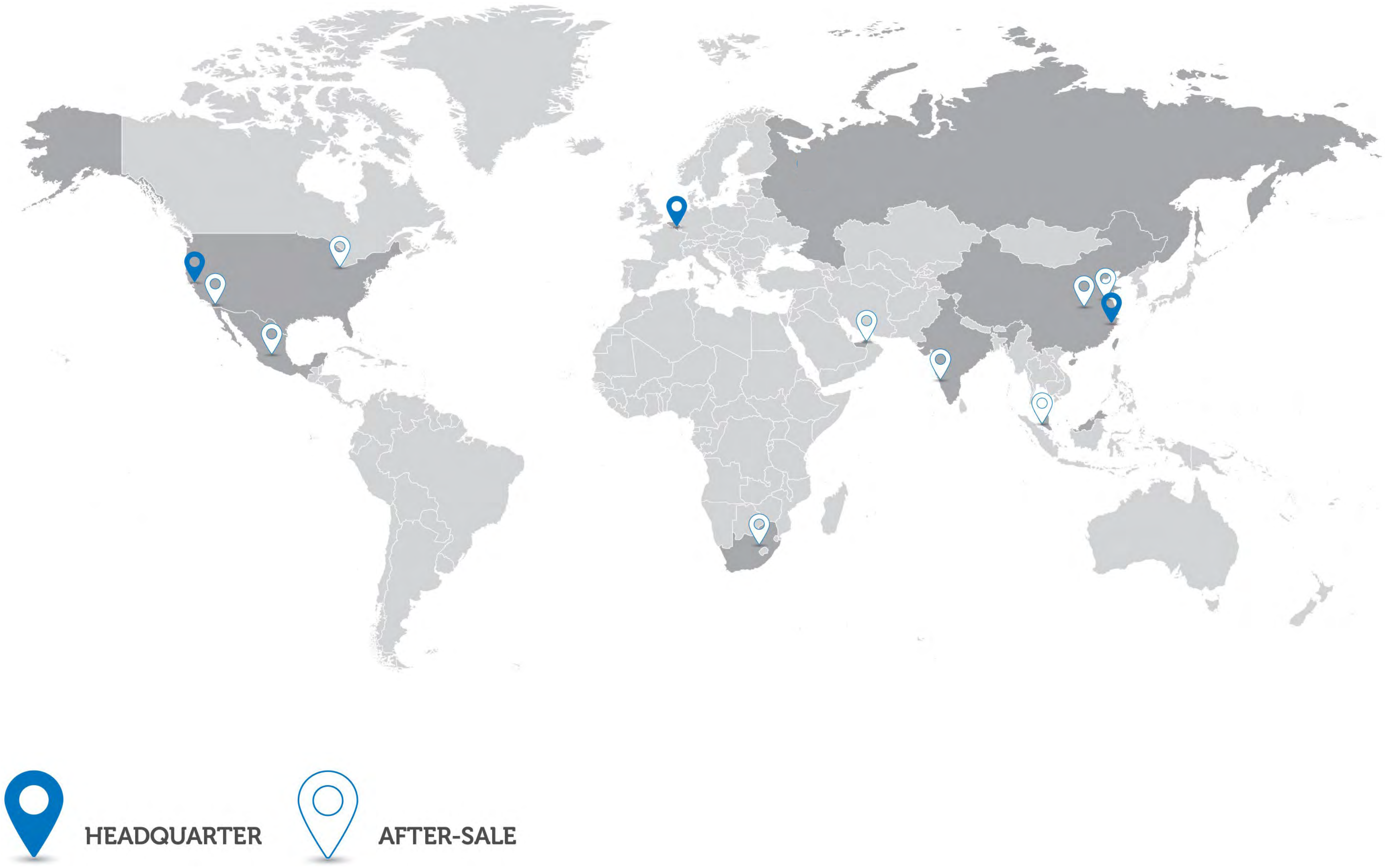
- Portable X-Ray equipment designed, developed and manufactured in house (Belgium)
- 10% of yearly turnover invested in R&D

BUSINESS FIELDS

NDT (Non-Destructive Testing)

Security

Our Offices



HEADQUARTER

TELEDYNE DALSA

TELEDYNE ICM

Our History

Creation

1993

1994-2002

SITEX & SITEX CPBattery

…

FLATSCAN 30

2011

2012

New Offices

CP200D
FLATSCAN 15

2013

TELEDYNE ICM
Everywhereyoulook™

Our History

2014

CP225D

2015

CP300D

iCM

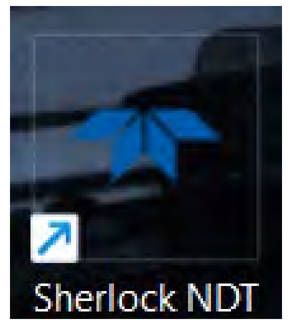
TELEDYNE ICM
Everywhereyoulook™

2016

CPSERIES

2017

Go-Scan 1510
XR / HR



2018

FLATSCAN XS

Our History

2019

Go-Scan 4335
Go-Scan 3025
LiteX

2020

CP300C
Go-Scan C-view

2021

CP200DS
CP300CR
Sherlock SEC

2022

Go-Scan C-View
SEC
TactX & TactXL

2023

CP300DS
CP300DM
Go-Scan 1506
Go-Scan 2023

Our History

And much more
to come

CP300DS

Small Focal Spot Constant Potential Portable X-Ray Generator

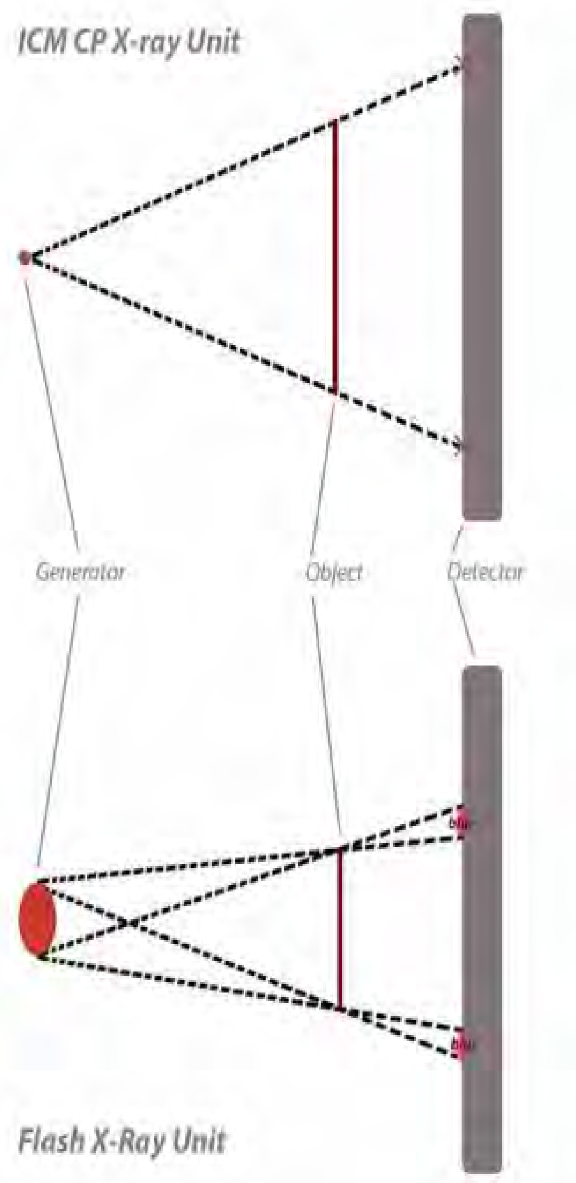
FEATURES

	Unit	SITEX CP300DS
Beam	-	Directional
Power supply	-	Mains
Output voltage range	kV	20 to 300
Tube current range	mA	0.5 to 6
Tube current at full output	mA	3
Maximum power at the anode	W	900
Constant power mode	-	Yes
Working cycle at 30°C (*)	%	100
Steel penetration (**)	mm / in	66 / 2.6
Weight	Kg / lbs	29.6 / 65.25
Overall dimensions	mm / in	Ø 180 x 837 / 7.1 x 33
Leakage dose at 1 m at full output	mSv/h	< 5.0
Optical focal spot according to EN 12543	mm / in	1 / 0.04
Maximum useful angle	°	60 x 30 elliptical
Inherent filtration	mm / in	0.8 / 0.03 (Be window)
Protection class	-	IP65
Operating temperature	°C / F°	-30 to +60 / -22 to +140
Storage temperature	°C / F°	-40 to +70 / -40 to +158

(*) Open air - airstream 5m/sec.
(**) 700 mm FFD, 10 min, AA400, D=2 for CPD

Ideal for Digital Radiography

SMALL FOCAL SPOT



LIGHT WEIGHT

100% DUTY CYCLE

CONSTANT POTENTIAL

WIDE INPUT POWER RANGE

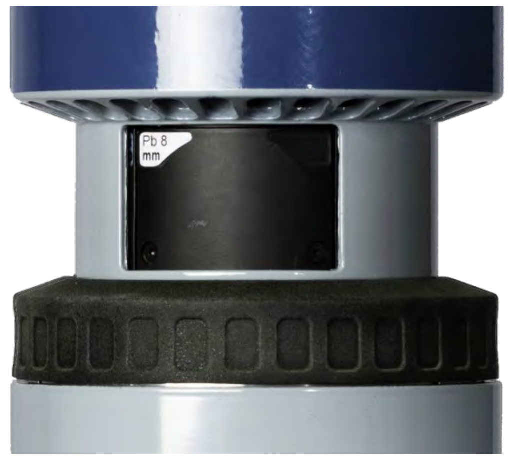
RUGGEDIZED

METAL CERAMIC X-RAY TUBE

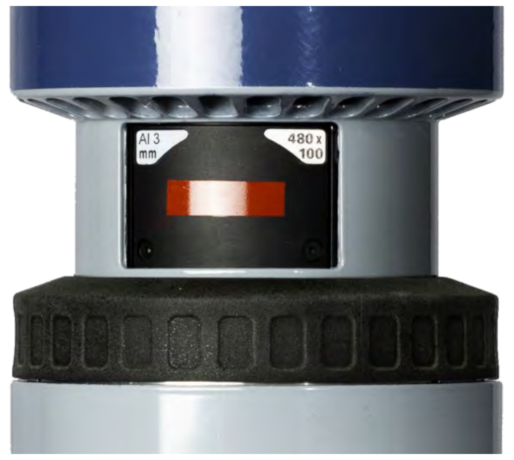
CP Series build-in carrousel

The CP Series generators are equipped with a build-in carrousel spanning five positions. Upon request, any one of these positions can be provided with a specific customized diaphragm.

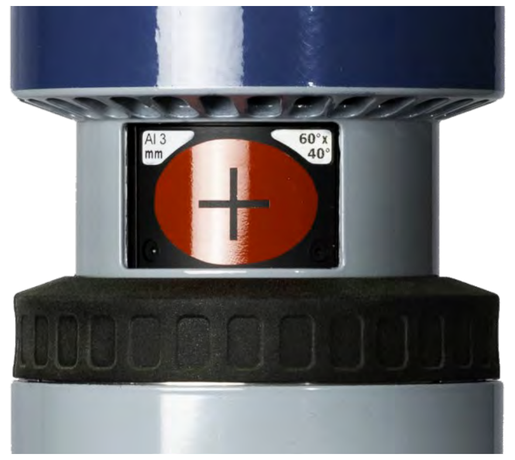
5 output positions



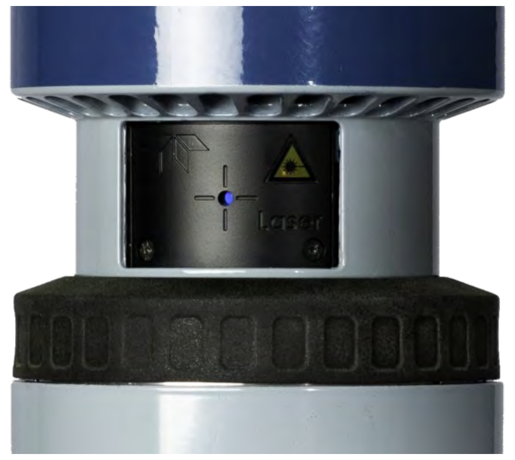
Lead shutter



Custom diaphragm



3 mm Al filter



Laser pointer

0.8 mm Be window

NDT APPLICATIONS EXAMPLES

TELEDYNE ICM
Everywhereyoulook™

Digital Radiography

TELEDYNE ICM
Everywhereyoulook™

Reminder of the important points: standardization

- Three European standards for the application of digital radiography:
  - EN 14784-1: 2005 Non-destructive testing - Scanned industrial radiography with plates - Phosphor images - Part 1: Classification of systems. (draft ISO/DIS 16371-1).
  - EN 14784-2: 2005 Non-destructive testing - Industrial digital radiography with phosphorus image plates - Part 2: General principles of radiographic testing using X-rays and gamma rays of metallic materials .
  - NF EN ISO 17636-2 : 2013 : Non-destructive testing of welded joints - Inspection by radiography - Part 2 : X-ray or gamma-ray techniques using digital detectors.
  - NF EN 12681-2: Foundry - Inspection by radiography - Part 2: Techniques using digital detectors.

- A series of standards dealing with fluoroscopy:
  - EN 13068-3: Non-destructive testing - X-ray inspection - Part 3: General principles for X-ray and gamma-ray inspection of metallic materials

Reminder of the important points: standardization

- ASTM E2007 Standard Guide for Computed Radiography
- ASTM E2339 Standard Practice for Digital Imaging and Communication in Non destructive Evaluation (DICONDE).
- ASTM E2422 Digital Reference Images for Inspection of Aluminum Castings
- ASTM E2445 Practice for Qualification and Long-Term Stability of Computed Radiology Systems
- ASTM E2446 Practice for Classification of Computed Radiology Systems
- ASTM E2597 Practice for Manufacturing Characterization of Digital Detector Arrays
- ASTM E2660 Digital Reference Images for Investment Steel Castings for Aerospace Applications
- ASTM E2669 Digital Reference Images for Titanium Castings
- ASTM E2698 Practice for Radiological Examination Using Digital Detector Arrays
- ASTM E2699 Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for Digital Radiographic (DR) Test Methods

Reminder of the important points: standardization

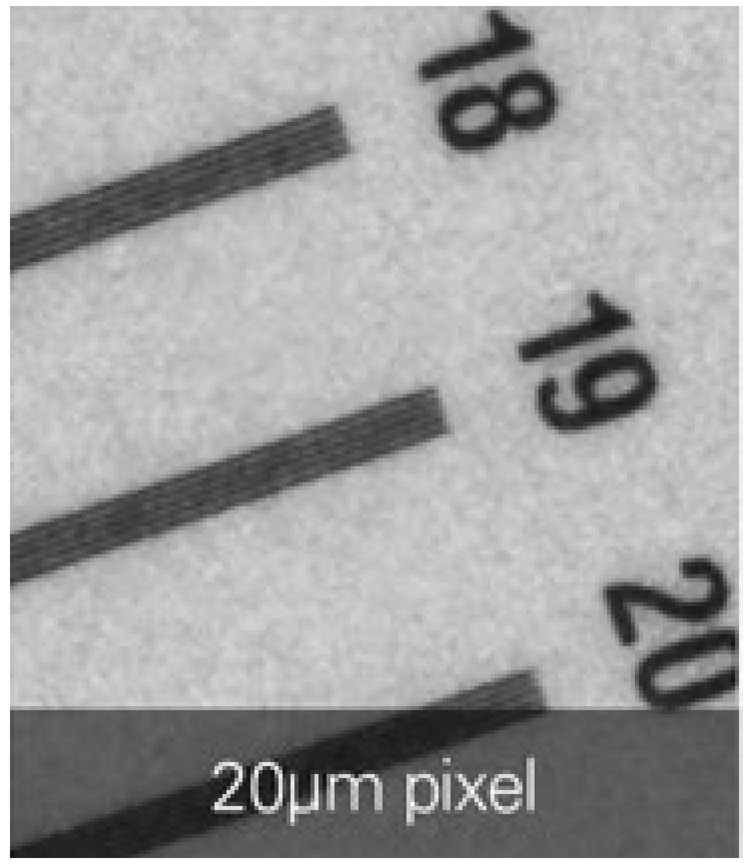
- ASTM E2736 Standard Guide for Digital Detector Array Radiology
- ASTM E2737 Practice for Digital Detector Array Performance Evaluation and Long-Term Stability
- ASTM E2738 Standard Practice for Digital Imaging and Communication Nondestructive Evaluation (DICONDE) for Computed Radiography (CR) Test Methods
- ASTM E2868 Standard Digital Reference Images for Steel Castings up to 2 in. (50.8 mm) in Thickness
- ASTM E2869 Standard Digital Reference Images for Magnesium Castings
- ASTM E 2973 Standard Digital Reference Images for Inspection of Aluminum and Magnesium

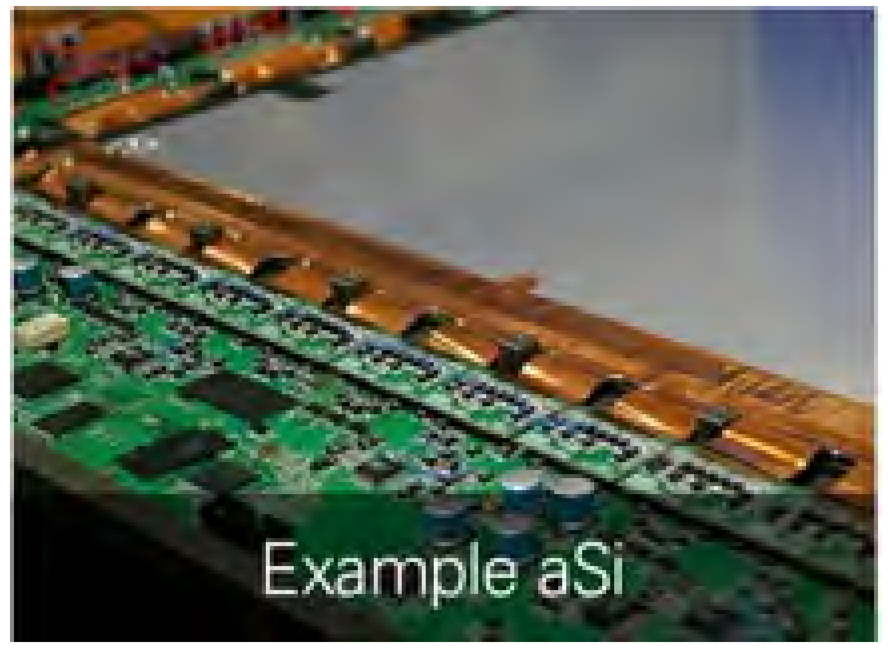
The different families

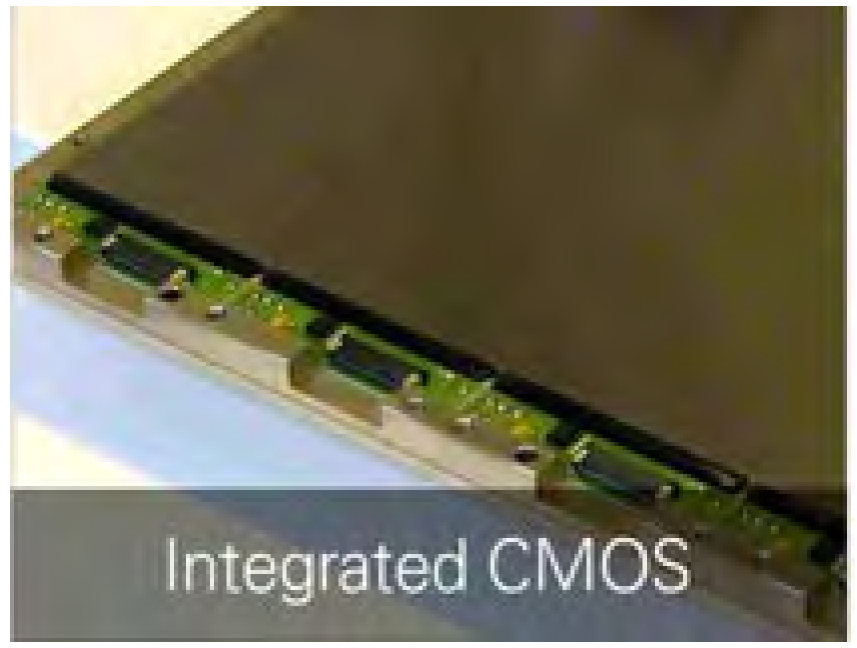
of detectors

CMOS X-Ray Advantages

- Real-time (>90 fps) imaging at full resolution
  - Enabled by high-speed integrated circuits
- High image quality (DQE) at low X-ray dose
  - Enabled by low noise CMOS
- Increased resolving power (MTF)
  - Small CMOS pixel sizes with high fill factor and sensitivity
- No image lag, ghosting, offset drift or other artifacts
  - Enabled by high electron mobility and quality of CMOS process
- Instant and stable start-up time





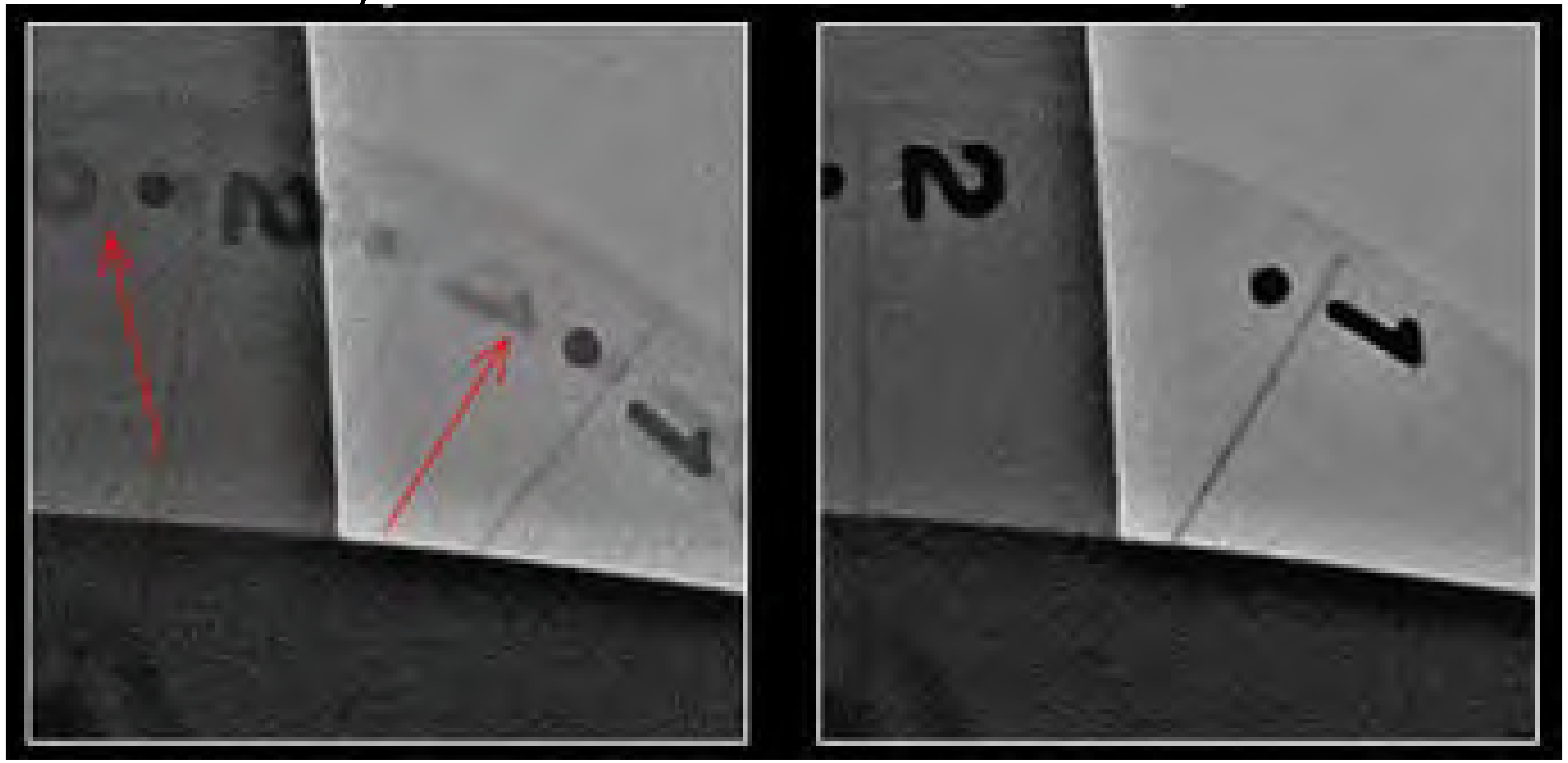


See Clearer

- Absence of image lag & other artifacts

aSi/TFT

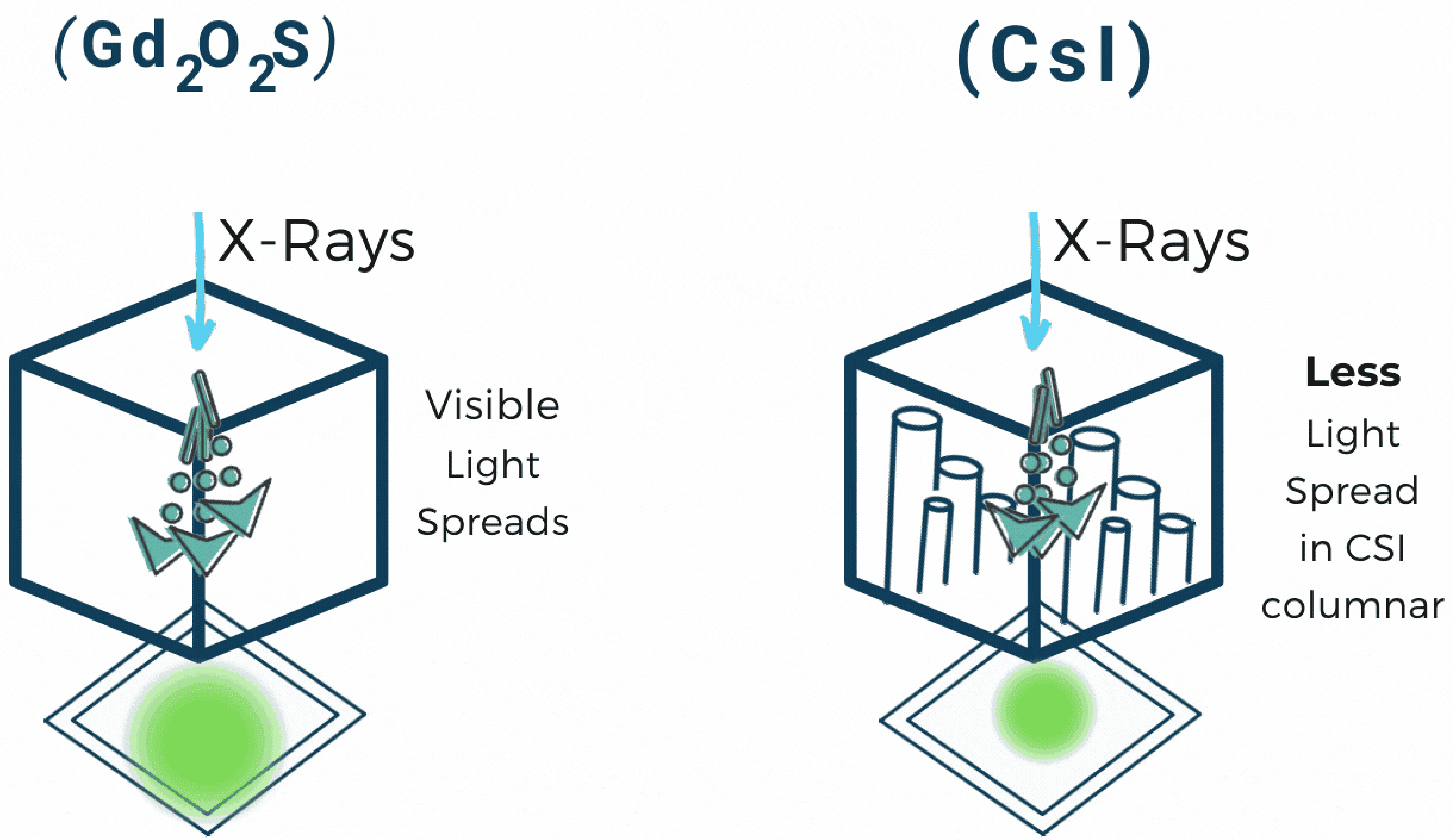
CMOS



~5% first frame lag

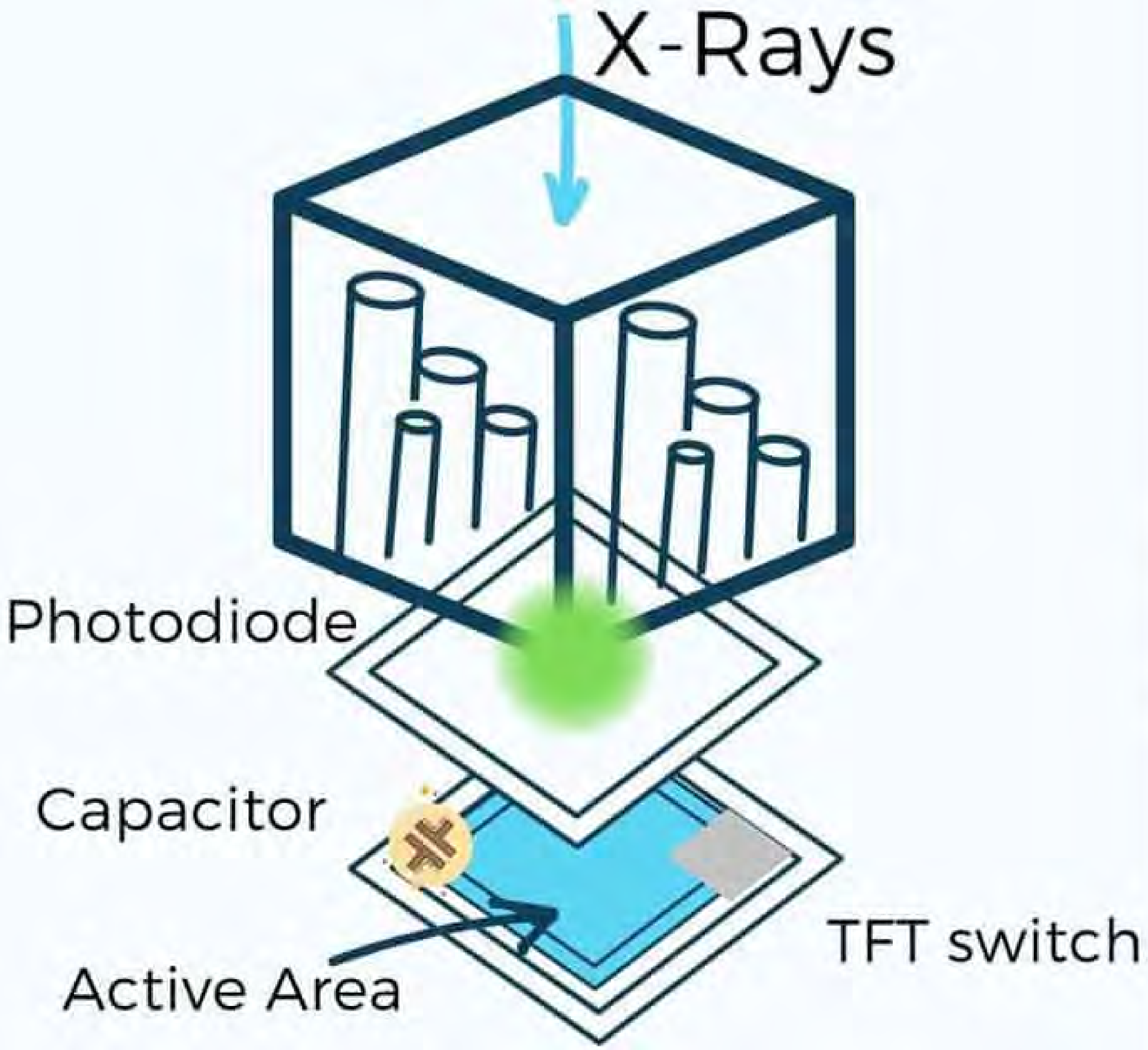
<0.1% first frame lag

Scintillator



aSi

TFT FLAT PANELS



SCINTILLATOR CRYSTAL (CSI)

X-Rays converted to **visible light**

Signal blurred less in CSI (columnar crystal)

PHOTODIODES (aSi)

Convert **visible light** to **electrical signal**

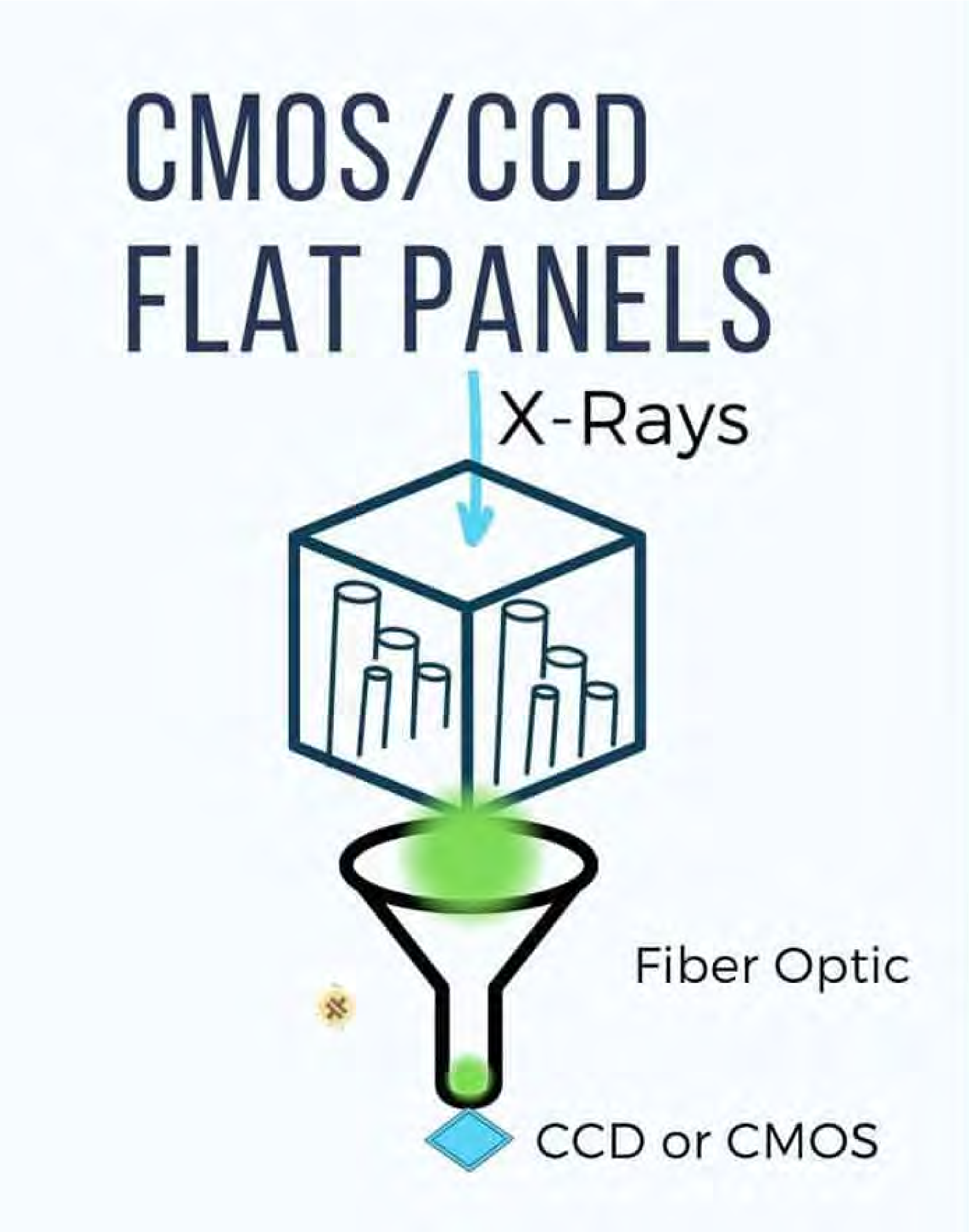
READOUT ELECTRONICS (TFT OR TFD ARRAY)

Amplify **electrical signal** and convert to **digital signal**

Active Area collects charge stored in **Capacitor**

TFT used as a gate to determine when to send charge

CMOS



SCINTILLATOR CRYSTAL

(CSI, GD)

X-Rays converted to **visible light**

FIBER OPTICS

Tunnel **visible light** to **smaller size**

READOUT ELECTRONICS

(CCD/CMOS ARRAY)

Convert **visible light** to **electrical signal,** then **digital signal**

CCD/CMOS are fast, but small

Scanning, format

and archiving of digital data

TELEDYNE ICM
Everywhereyoulook™

Dynamics

- Dynamic range is the ability of a sensor to differentiate between different levels of grey.
- It is defined by the ratio between the value of the highest gray level on the noise. For example, a system of 65536 gray levels with a noise of about 200 (+/-2 standard deviations): the dynamic range is about 300.
- The fact of having a sensor with a great dynamic range makes it possible to spread the gray levels to the maximum.
- High dynamic range facilitates the detection of foundry defects which are often of low contrast.
- The higher the coding (e.g. 16bits), the more faithful the digitization and the greater the dynamics.
- Digital radiography systems have a very high dynamic range compared to silver film (dynamic range about 100).

Standard DICONDE (ASTM E 2339)

- This is the standard for . dcm (DICONDE).
- This standard comes from the medical sector and is defined by the ASTM E 2339 standard (which defines the list of data fields and their content).
- It associates the image and the control information (metadata). For radiography, that is to say the reference of the part, the shooting parameters, the IQIs used, etc.
- It allows to secure the data to limit frauds (disadvantage of digital technologies with falsifications of the images).

Image processing

Acquisition processing (DR system)

CORRECTION OF DEFECTIVE PIXELS

- Some pixels do not light up when exposed to radiation.
- The pre-processing consists of an interpolation with the neighboring pixels.
- It is necessary to have the updated mapping of the defective pixels.

FLATTENING CORRECTION

- Goal: reduce the lack of homogeneity.
- Correction performed with the white image (image with maximum grey levels without saturation) and the black image (image without X-rays).

IMAGE INTEGRATION

- Goal: reduce noise by averaging images.
- May slow down the speed of control (search for a compromise).

Handling of digital radiograms & interpretation

Digital magnification

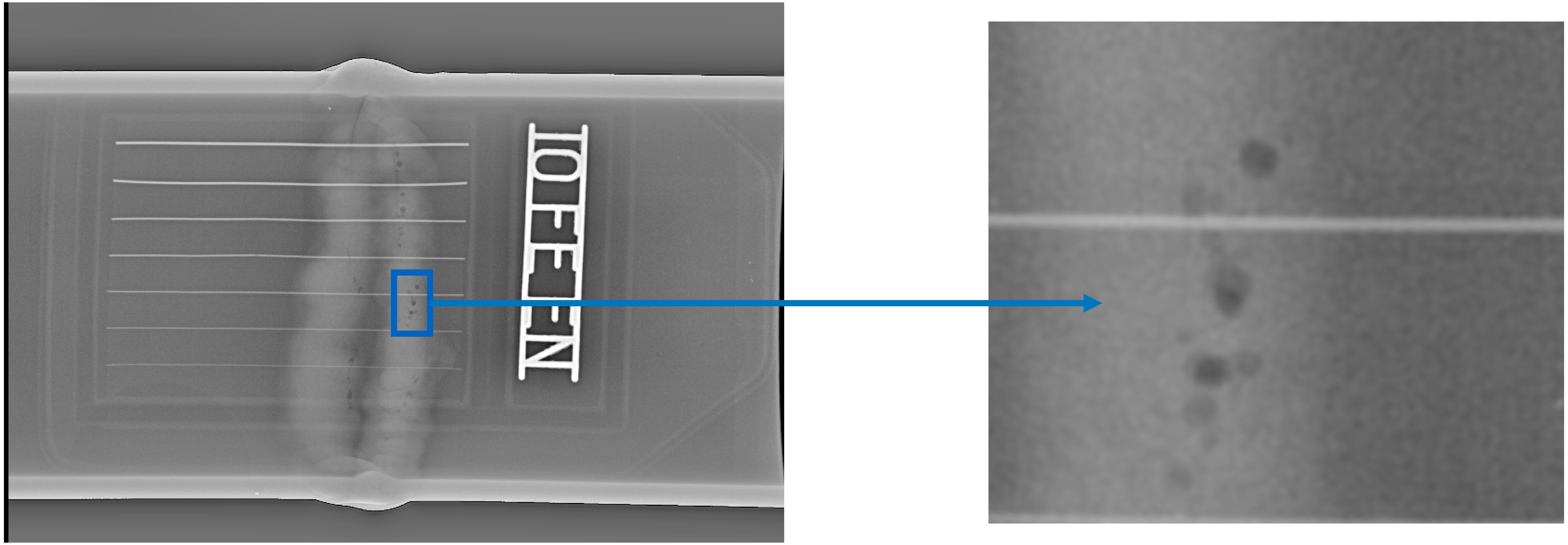
Digital filtration

Contrast and brightness improvement

Interpretation

requires the use of a screen with a high resolution (about 3 million pixels)

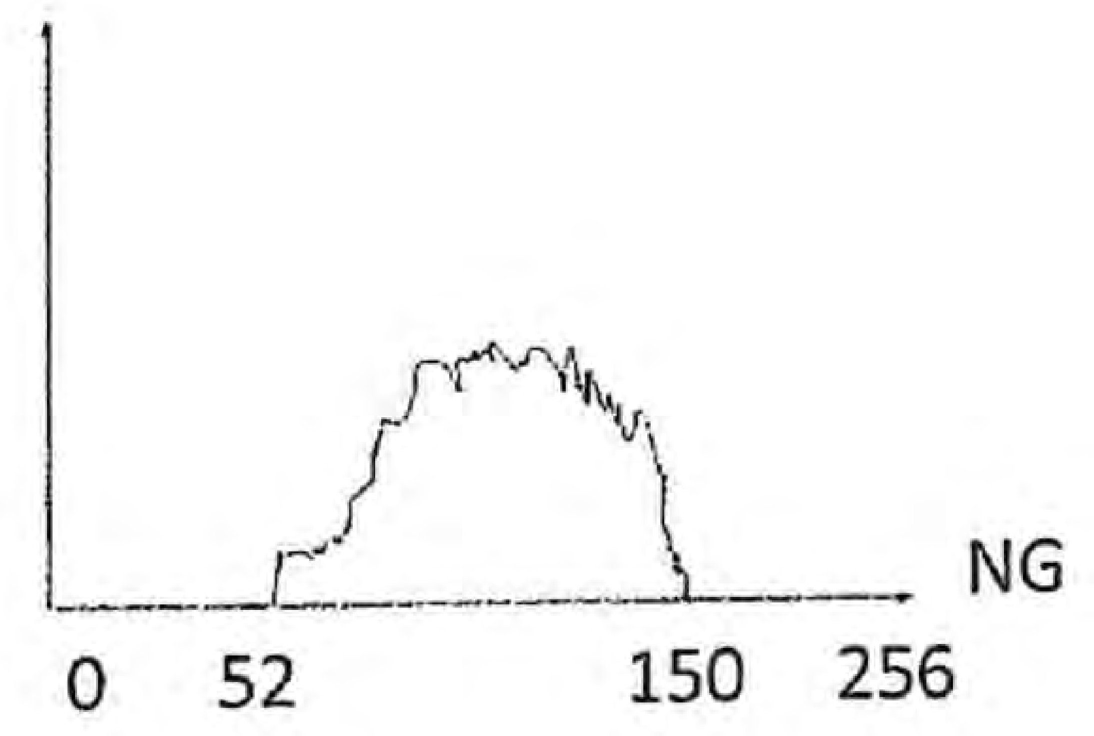
Image magnification

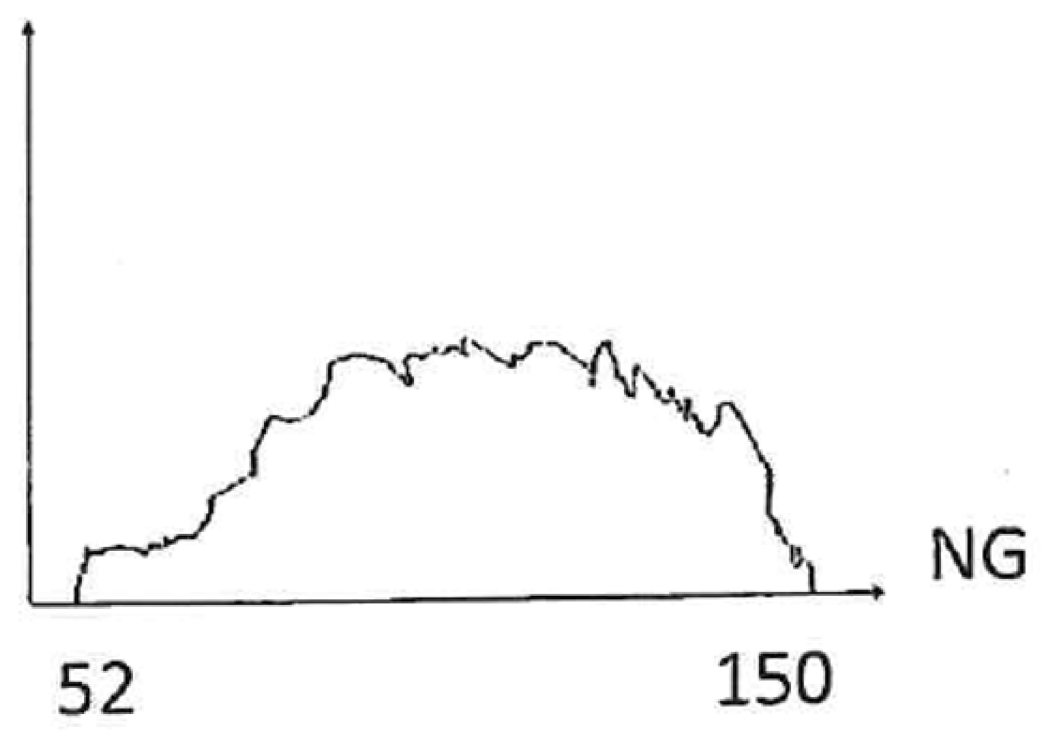


Importance of the image resolution

Contrast and brightness improvement (1/2)

Refocusing the gray level range allows to see the information better. As you can see with the two diagrams below.





The **first one** shows a grayscale histogram with **no adjustment**. Not all of the available grayscale range is used.

On the **second one** (after processing), the histogram is **dilated** and more data feels **exploitable**. In this case, the detection of defects is facilitated.

Contrast and brightness improvement (2/2)

Raw image

Edited image

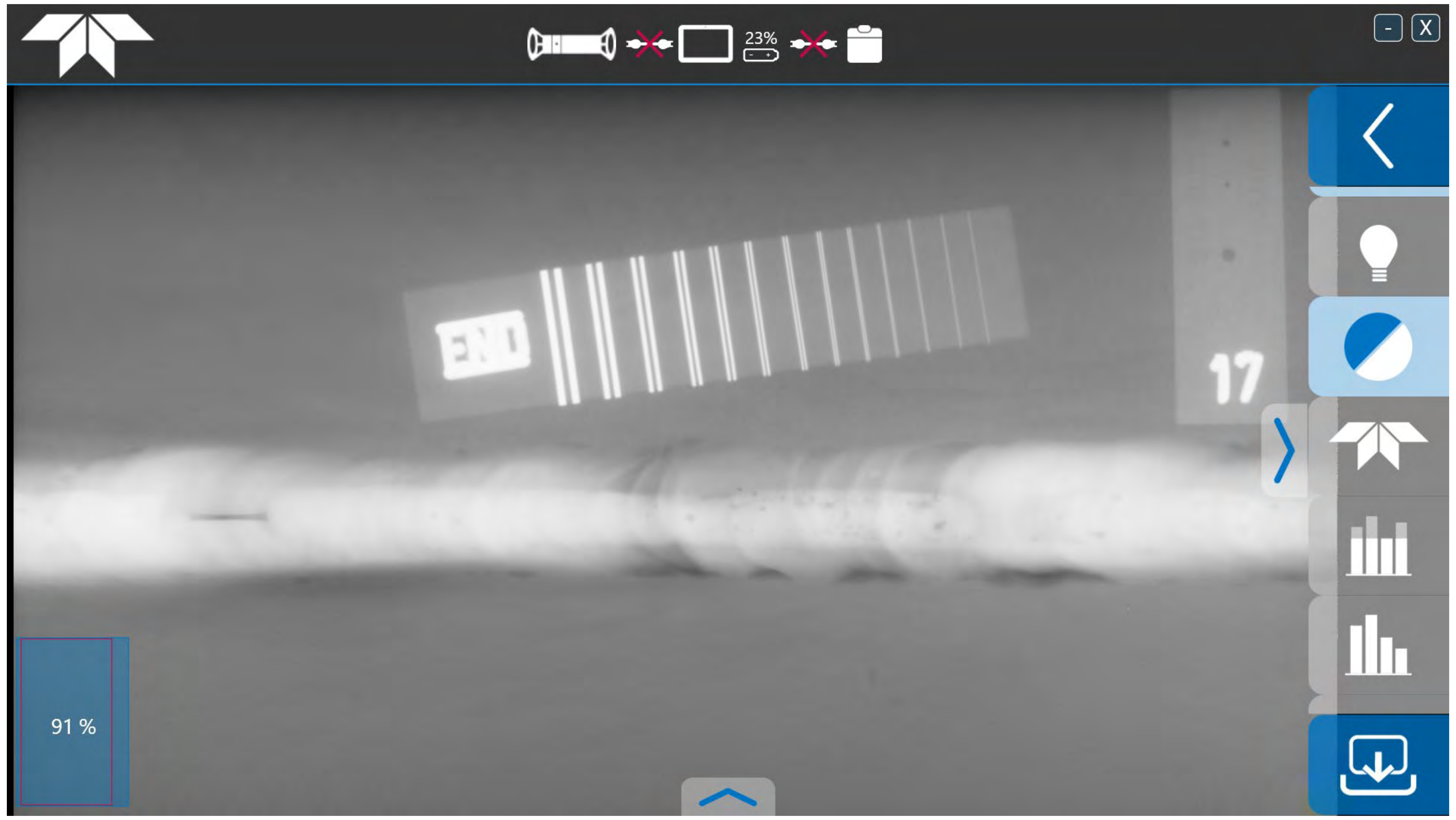
Digital filtration

- To improve the visual quality of the image, we must eliminate the effects of noise (parasites) by subjecting it to a treatment called filtering.
- A filter is a mathematical transformation (called a *convolution product)* that allows, for each pixel of the area to which it applies, to modify its value according to the values of the neighboring pixels, affected by coefficients.
- The filter is represented by an array (matrix), characterized by its dimensions and coefficients, whose center corresponds to the pixel concerned. The coefficients of the array determine the properties of the filter.
- Among these systems, we distinguish: low-pass filters (smoothing), high-pass filters (sharpening), complex filters (FFT).

Complex filtration

TELEDYNE FILTER

- Filter that analyzes the spatial spectrum of gray levels.
- It allows to observe several areas with different levels of gray and reinforce the contours.



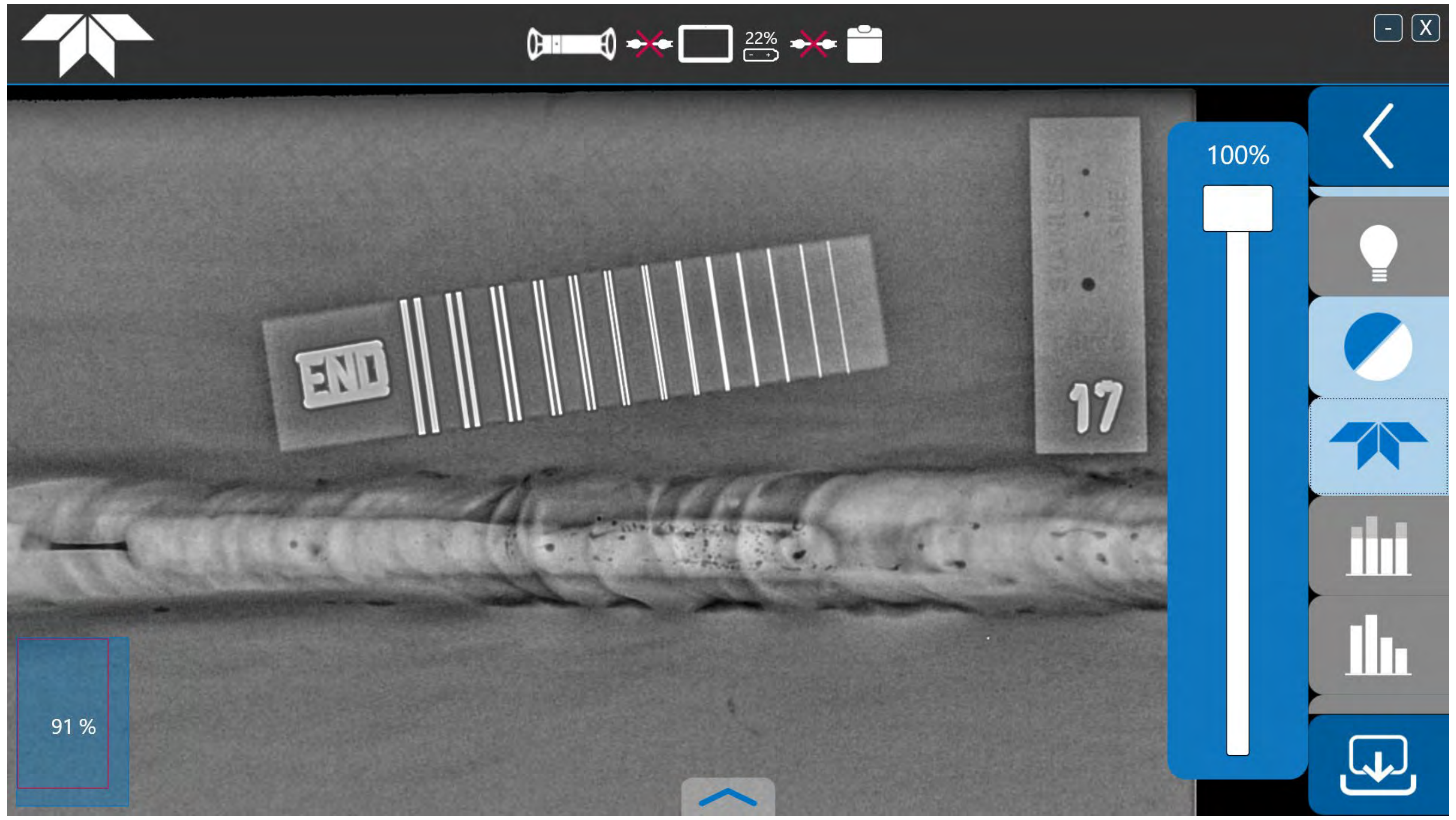


Image quality

Image quality

- EN 1330-3 defines the term image quality as the characteristic of a radiographic image that determines the degree of detail.
- The knowledge of this characteristic allows to estimate at best the aptitude of a radiographic control process to detect indications of predetermined size (notion of smallest detectable indication).
- The main factors influencing this characteristic are:
  - The thickness of the material passed through
  - The nature of the material
  - The energy of the radiation used
  - The technique used
  - The detection system

Image Quality Indicators (IQI)

DEFINITION

- It is a standardized feature device used to determine the conventional quality of a radiographic image.
- The IQI can in no way be used to evaluate the size of the defects encountered, nor can it be used to set acceptance limits for parts subjected to radiographic inspection.

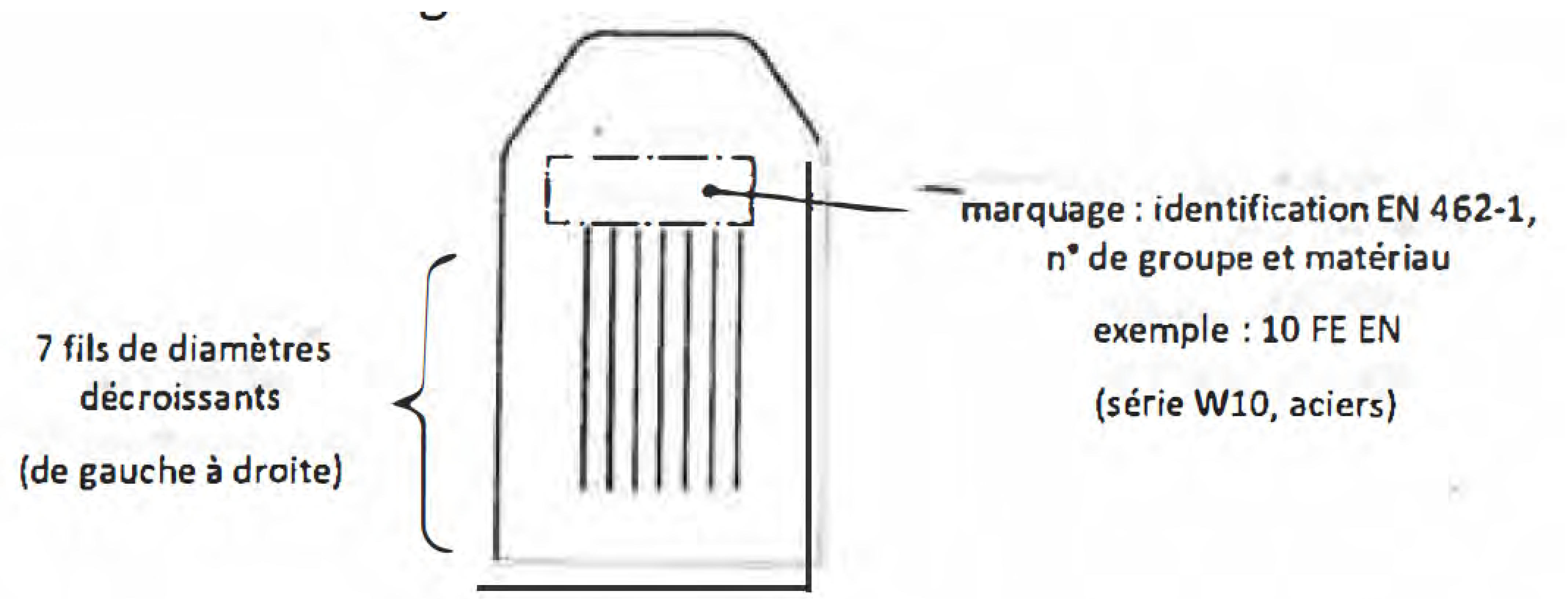
DIFFERENT TYPE OF IQI'S

IQI's are made of 4 different materials (copper, steel, titanium and aluminium) to cover a maximum of material types.

- IQI with wires ⇒ standard NF-EN ISO 19232-1
- IQI with holes ⇒ standard NF-EN ISO 19232-2
- IQI Duplex ⇒ standard NF-EN ISO 19232-5 to measure spatial resolution pair of Tungsten-Platinumalloy wires (Used in digital radiography only)

Wire IQI according to NF-EN ISO 19232-1 (1/3)

- Wire IQIs according to EN ISO 19232-1 are used to estimate the image quality.
- The IQI system is based on the use of 19 wires of Z!0.05 to 3.2mm, divided into 4 groups (4 IQI) consisting of 7 wires (with overlapping diameters between the groups).
- There are IQIs for 4 families of alloys: steels, aluminum alloys, copper alloys and titanium alloys.



Wire IQI according to NF-EN ISO 19232-1 (2/3)

- By default, the IQI is placed on the side of the part that is on the side of the radiation source. If this is not possible, the letter "F" must be placed visibly next to the IQI marking.
- The determination of the image quality index shall be made under the radiogram reading conditions specified in EN 25580 (for silver radiography). The wire number corresponding to the smallest clearly visible wire on the radiogram shall be taken as the image quality index.
- The image of a wire is considered visible if a continuous length of at least 10 mm can be seen in a region of uniform optical density.

Wire IQI according to NF-EN ISO 19232-1 (3/3)

Plage d'indicateur de qualité d'image				Fil	
W1	W6	W10	W13	N° fil	Diamètre nominal du fil (mm)
X				W1	3.20
X				W2	2.50
X				W3	2.00
X				W4	1.60
X				W5	1.25
X	X			W6	1.00
X	X			W7	0.80
	X			W8	0.63
	X			W9	0.50
	X	X		W10	0.40
	X	X		W11	0.32
	X	X		W12	0.25
		X	X	W13	0.20
		X	X	W14	0.16
		X	X	W15	0.125
		X	X	W16	0.100
			X	W17	0.080
			X	W18	0.063
			X	W19	0.050

Radiographic technique Class A/B single wall IQI source side

Minimum IQI values for testing class A				
Nominal thickness *t* mm				IQI value[a]
		to	1,2	W 18
above	1,2	to	2,0	W 17
above	2,0	to	3,5	W 16
above	3,5	to	5,0	W 15
above	5,0	to	7	W 14
above	7	to	10	W 13
above	10	to	15	W 12
above	15	to	25	W 11
above	25	to	32	W 10
above	32	to	40	W 9
above	40	to	55	W 8
above	55	to	85	W 7
above	85	to	150	W 6
above	150	to	250	W 5
above	250			W 4

[a] For exceptions when using gamma ray sources, see 6.9.

Minimum IQI values for testing class B				
Nominal thickness *t* mm				IQI value[a]
		to	1,5	W 19
above	1,5	to	2,5	W 18
above	2,5	to	4	W 17
above	4	to	6	W 16
above	6	to	8	W 15
above	8	to	12	W 14
above	12	to	20	W 13
above	20	to	30	W 12
above	30	to	35	W 11
above	35	to	45	W 10
above	45	to	65	W 9
above	65	to	120	W 8
above	120	to	200	W 7
above	200	to	350	W 6
above	350			W 5

[a] For exceptions when using gamma ray sources, see 6.9.

Radiographic technique Class A/B DWDI IQI source side

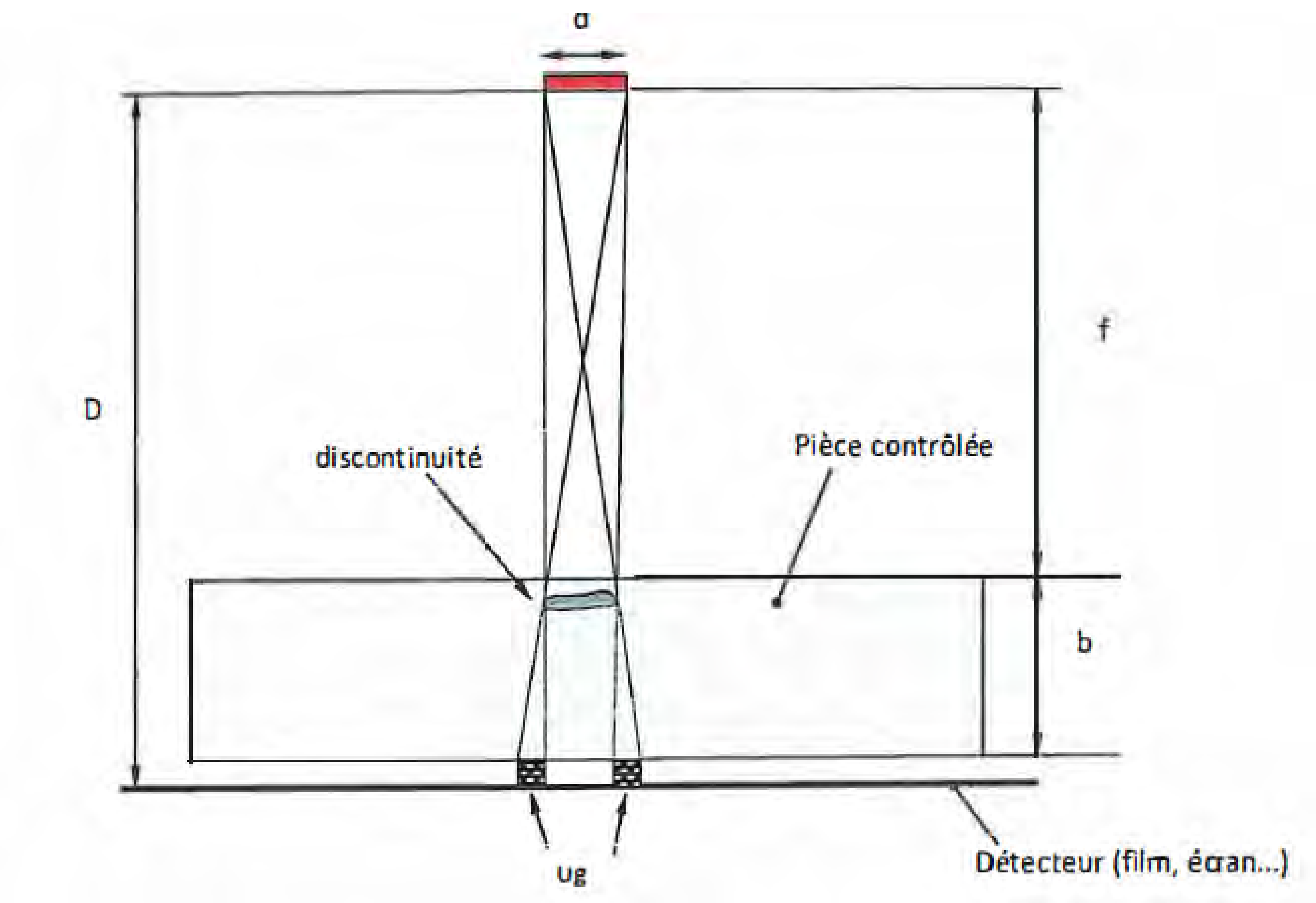
Minimum IQI values for testing class A				
Penetrated thickness *w* mm				IQI value[a]
		to	1,2	W 18
above	1,2	to	2	W 17
above	2	to	3,5	W 16
above	3,5	to	5	W 15
above	5	to	7	W 14
above	7	to	12	W 13
above	12	to	18	W 12
above	18	to	30	W 11
above	30	to	40	W 10
above	40	to	50	W 9
above	50	to	60	W 8
above	60	to	85	W 7
above	85	to	120	W 6
above	120	to	220	W 5
above	220	to	380	W 4
above	380			W 3

[a] For exceptions when using gamma ray sources, see 6.9.

Minimum IQI values for testing class B				
Penetrated thickness *w* mm				IQI value[a]
		to	1,5	W 19
above	1,5	to	2,5	W 18
above	2,5	to	4	W 17
above	4	to	6	W 16
above	6	to	8	W 15
above	8	to	15	W 14
above	15	to	25	W 13
above	25	to	38	W 12
above	38	to	45	W 11
above	45	to	55	W 10
above	55	to	70	W 9
above	70	to	100	W 8
above	100	to	170	W 7
above	170	to	250	W 6
above	250			W 5

[a] For exceptions when using gamma ray sources, see 6.9

Geometric unsharpness (1/3)



Geometric unsharpness (2/3)

On a :

$$\frac{u_g}{d} = \frac{b}{f}$$

or $f = D - b$

donc

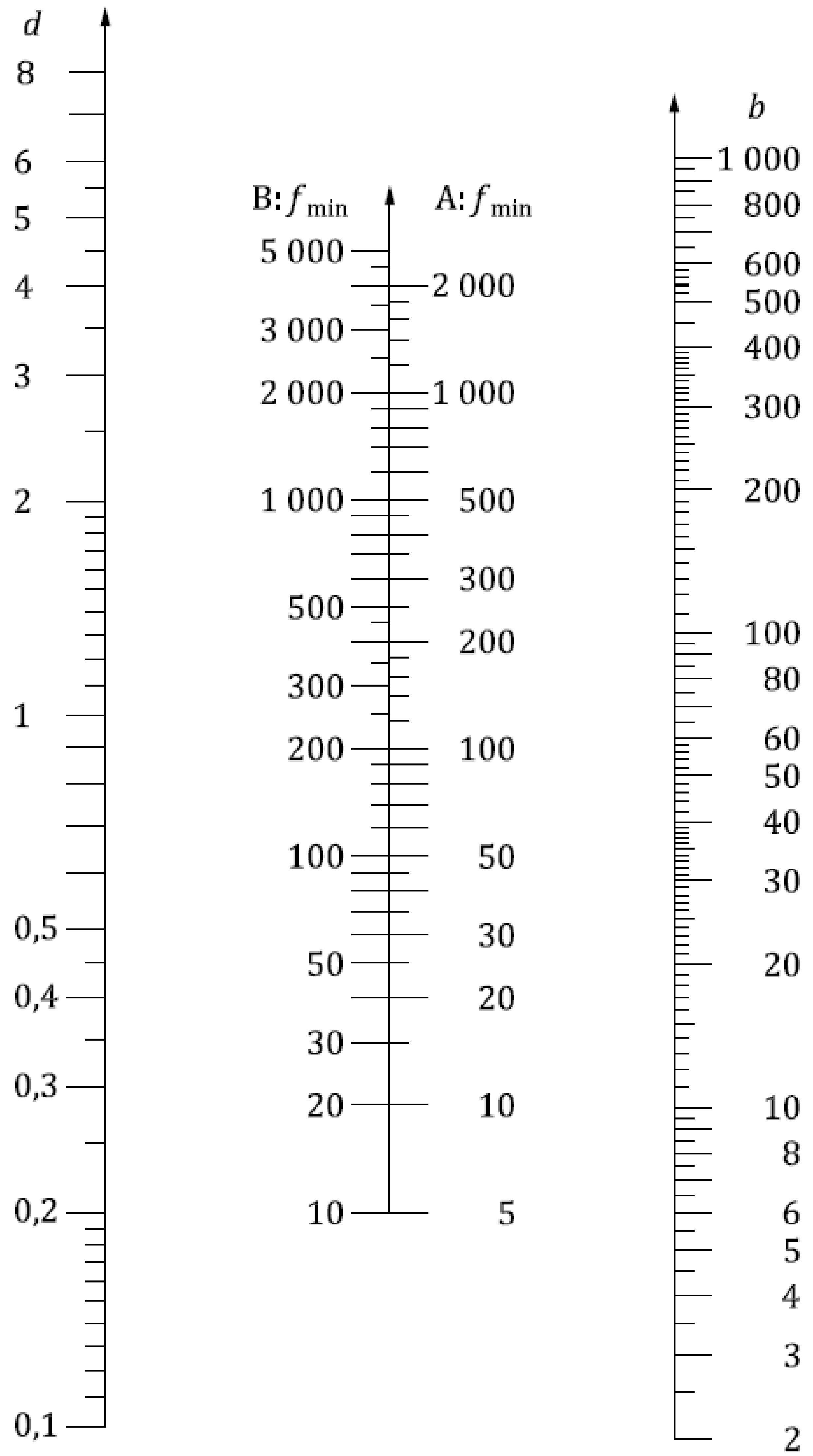
$$\boxed{u_g = \frac{d \times b}{D - b}}$$

et

$$\boxed{D = \frac{d \times b}{u_g} + b}$$

- d: characteristic dimension of the X-ray source (or y) in mm
- b: maximum thickness of the part to be checked in mm
- D: source-to-film distance in mm
- f: source-to-workpiece distance in mm
- Ug: geometric unsharpness in mm

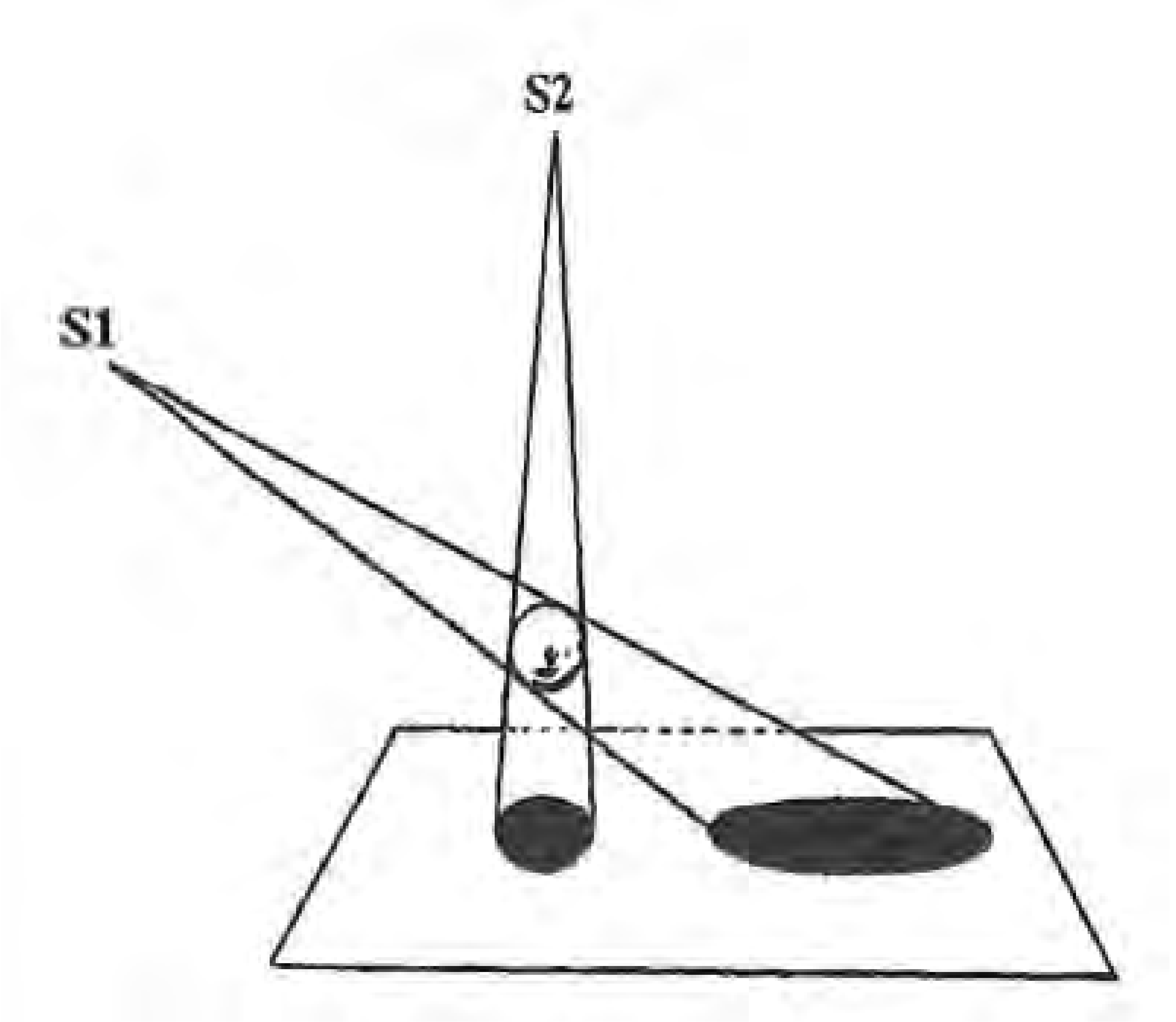
Geometric unsharpness (3/3)



Key

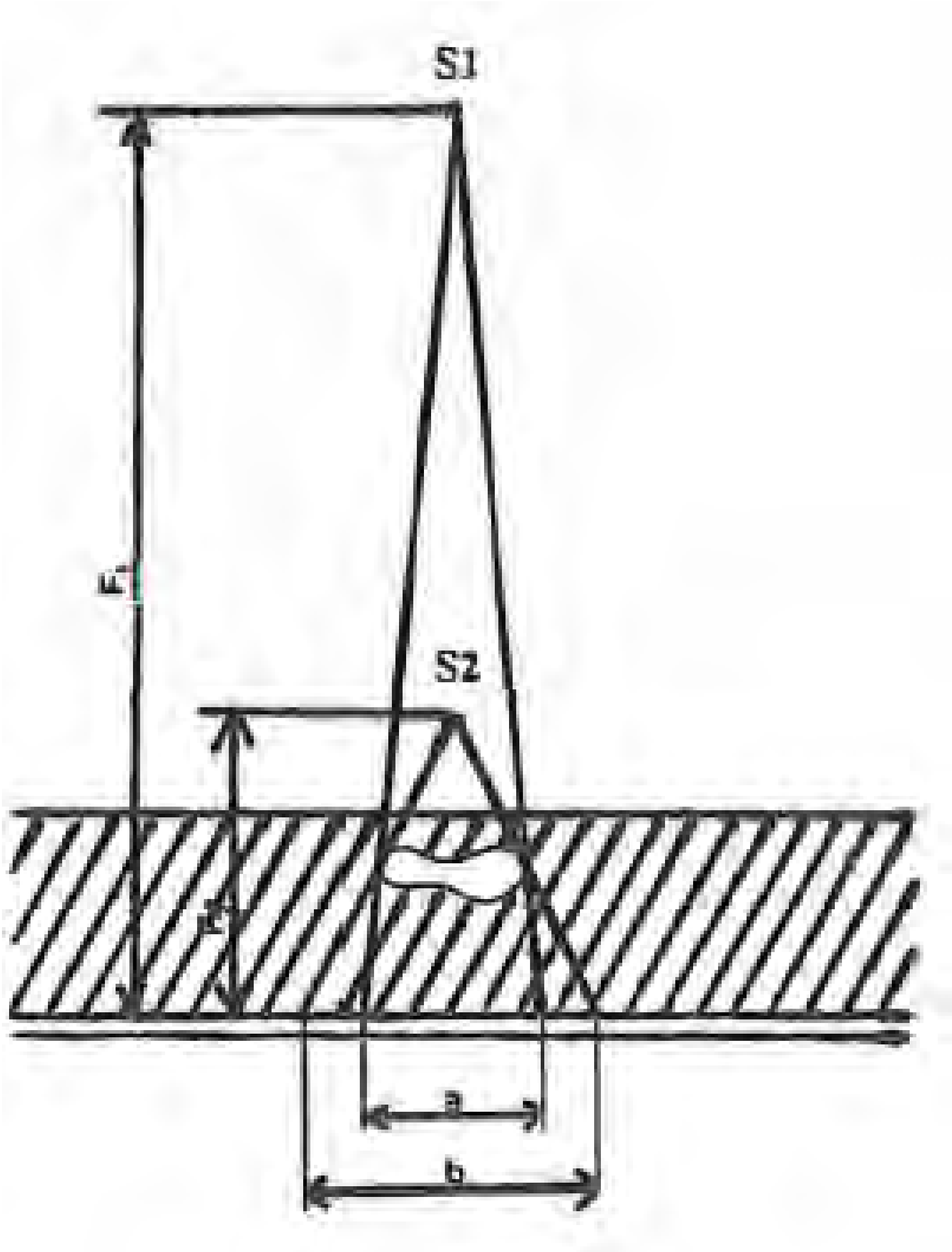
*f*min in mm	minimum source-to-object distance,
d	source size, in mm
b	object-to-film distance, in mm
A	testing class A
B	testing class B

Distortion

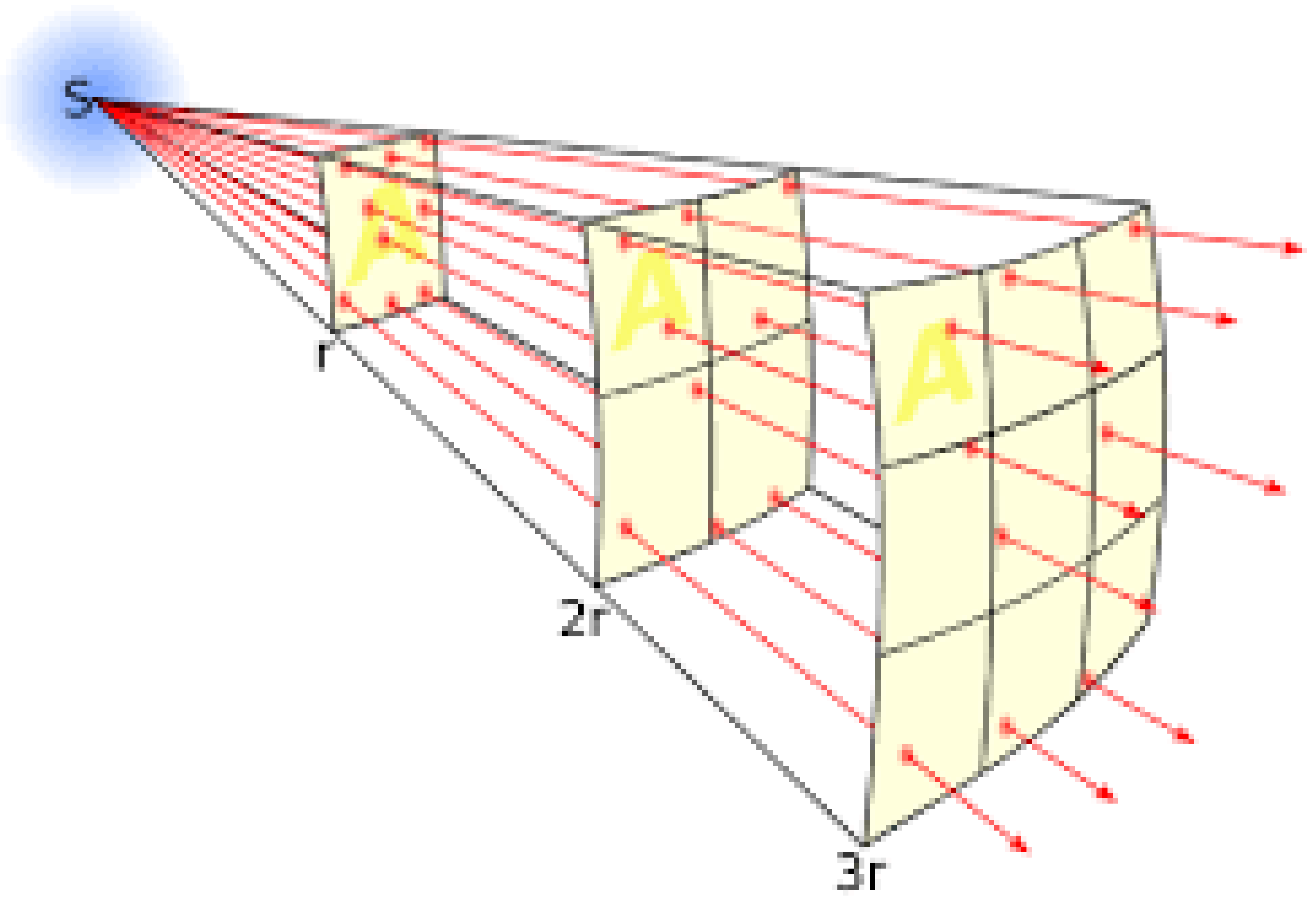


Expansion

For this reason, the object should be placed as far away as possible from the source.



Inverse-square law



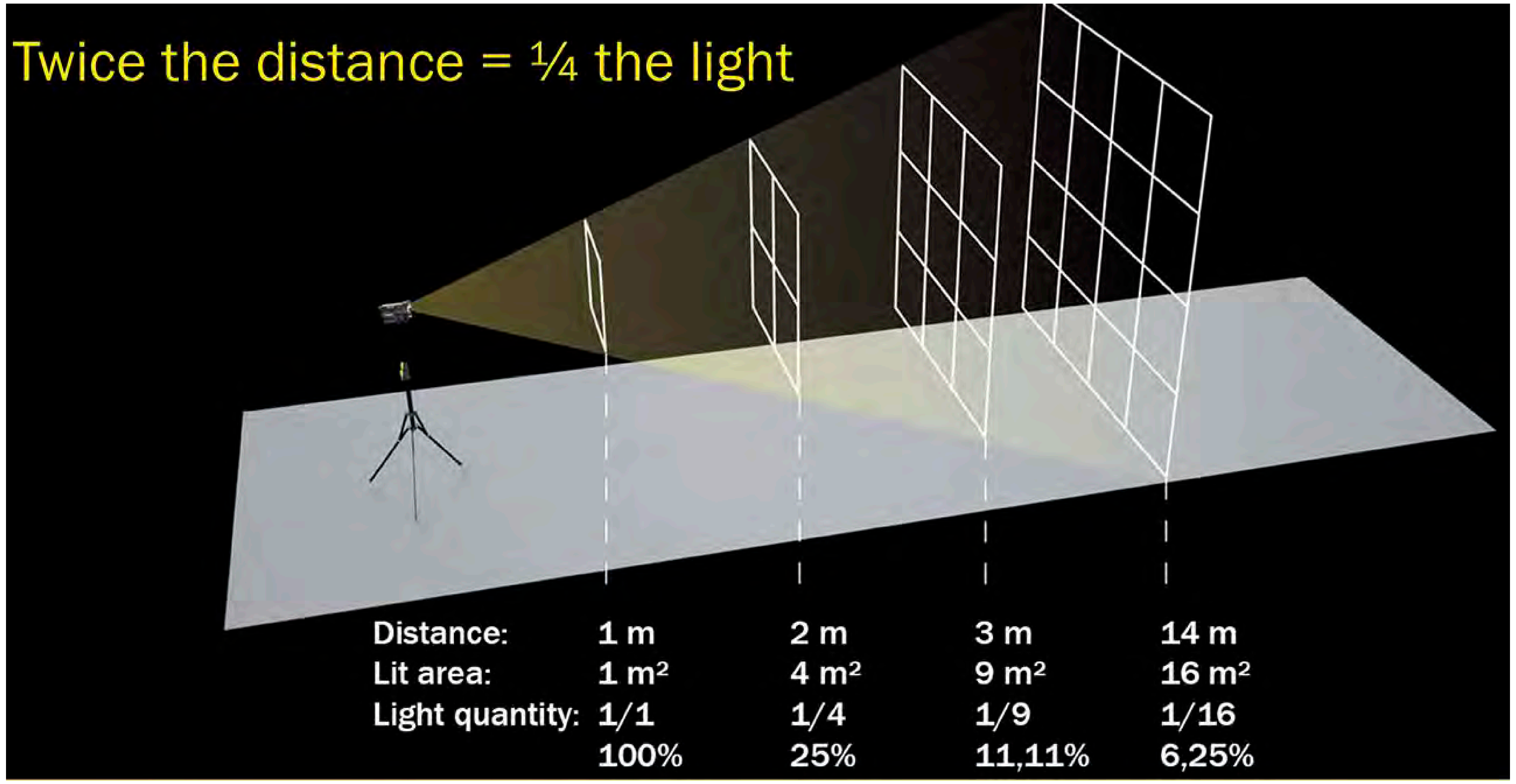


Image quality factors

in Digital Radiography

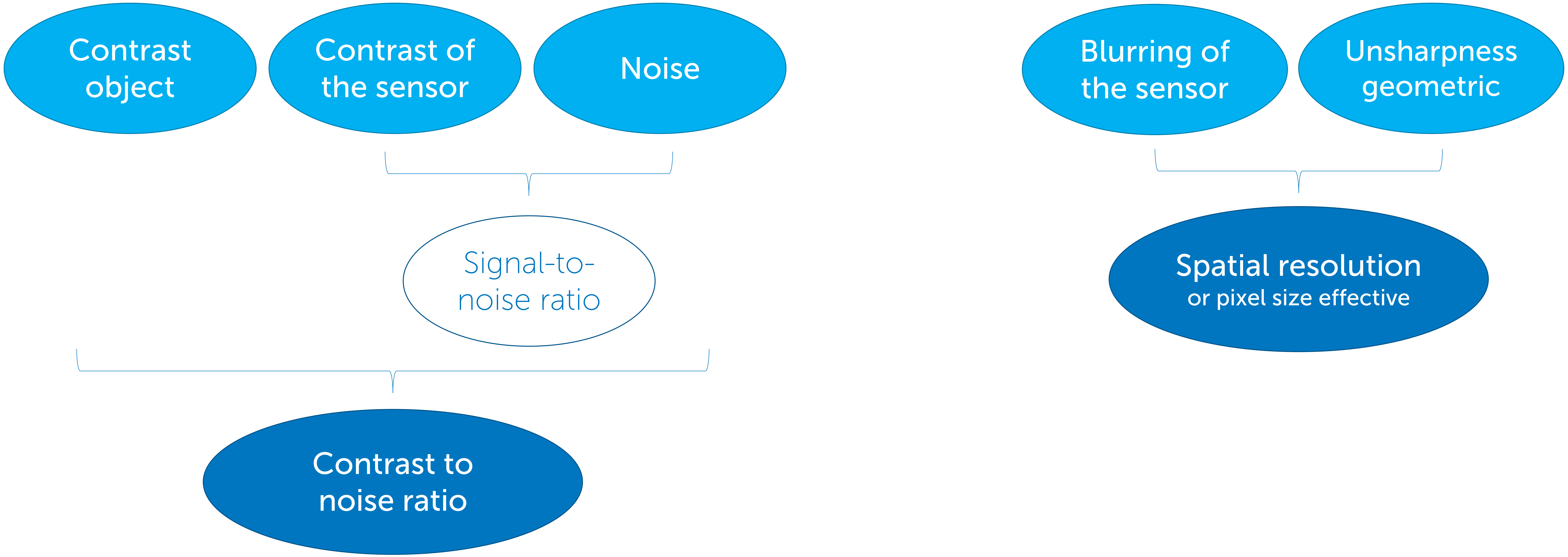
TELEDYNE ICM
Everywhereyoulook™

Image quality in Digital Radiography

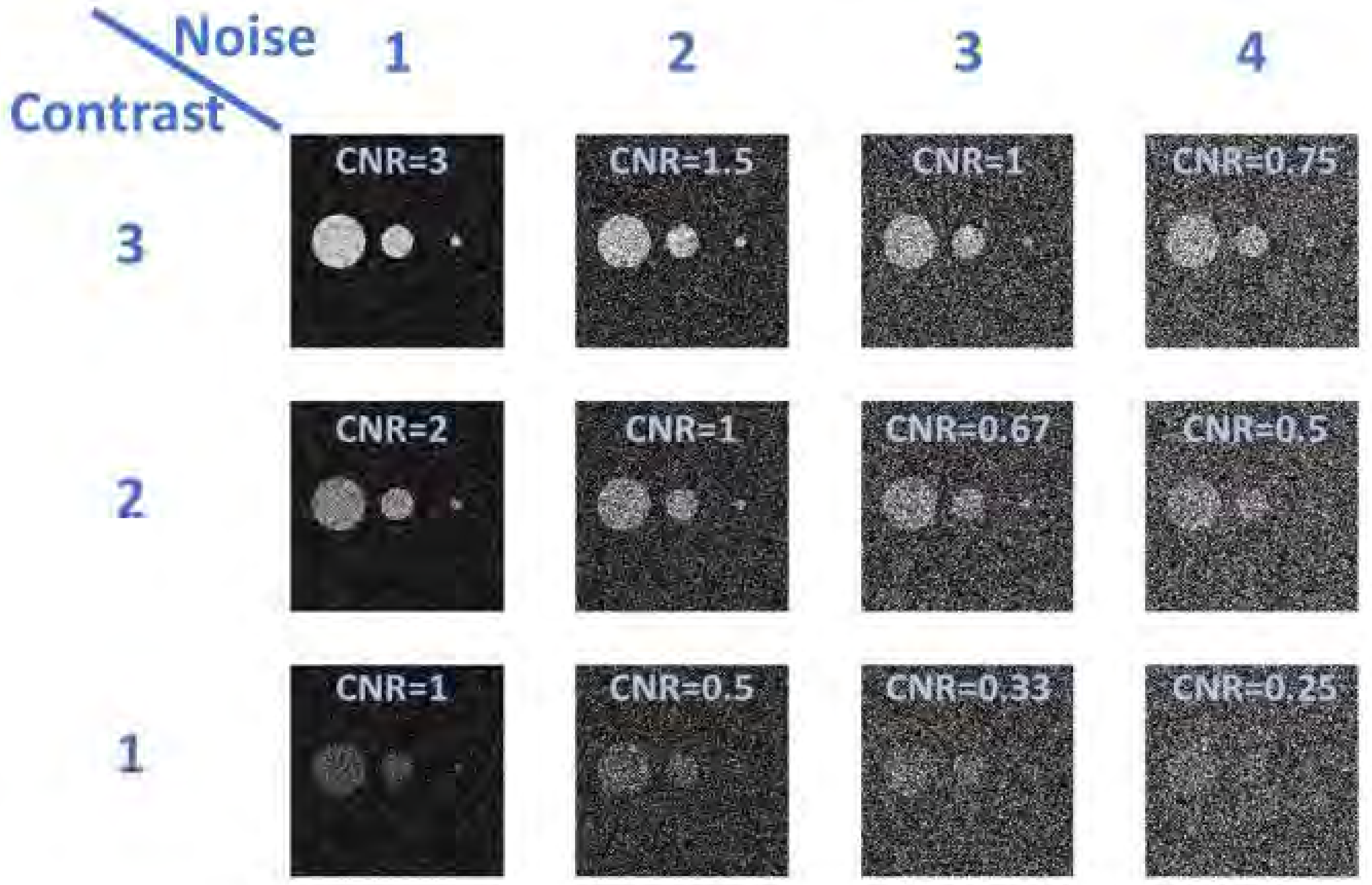
A digital radiographic image depends on two main image quality parameters:

- The ratio of contrast to noise which is the smallest detectable difference in the thickness of a material (signal-to-noise ratio).
- The spatial resolution which depends on the geometric unsharpness (projection unsharpness) and the detector unsharpness resulting from the spatial resolution of the scanner. The geometric unsharpness is only dependent on the shooting conditions and is detailed in the following plates.

Image quality parameters in Digital Radiography



Contrast to noise ratio



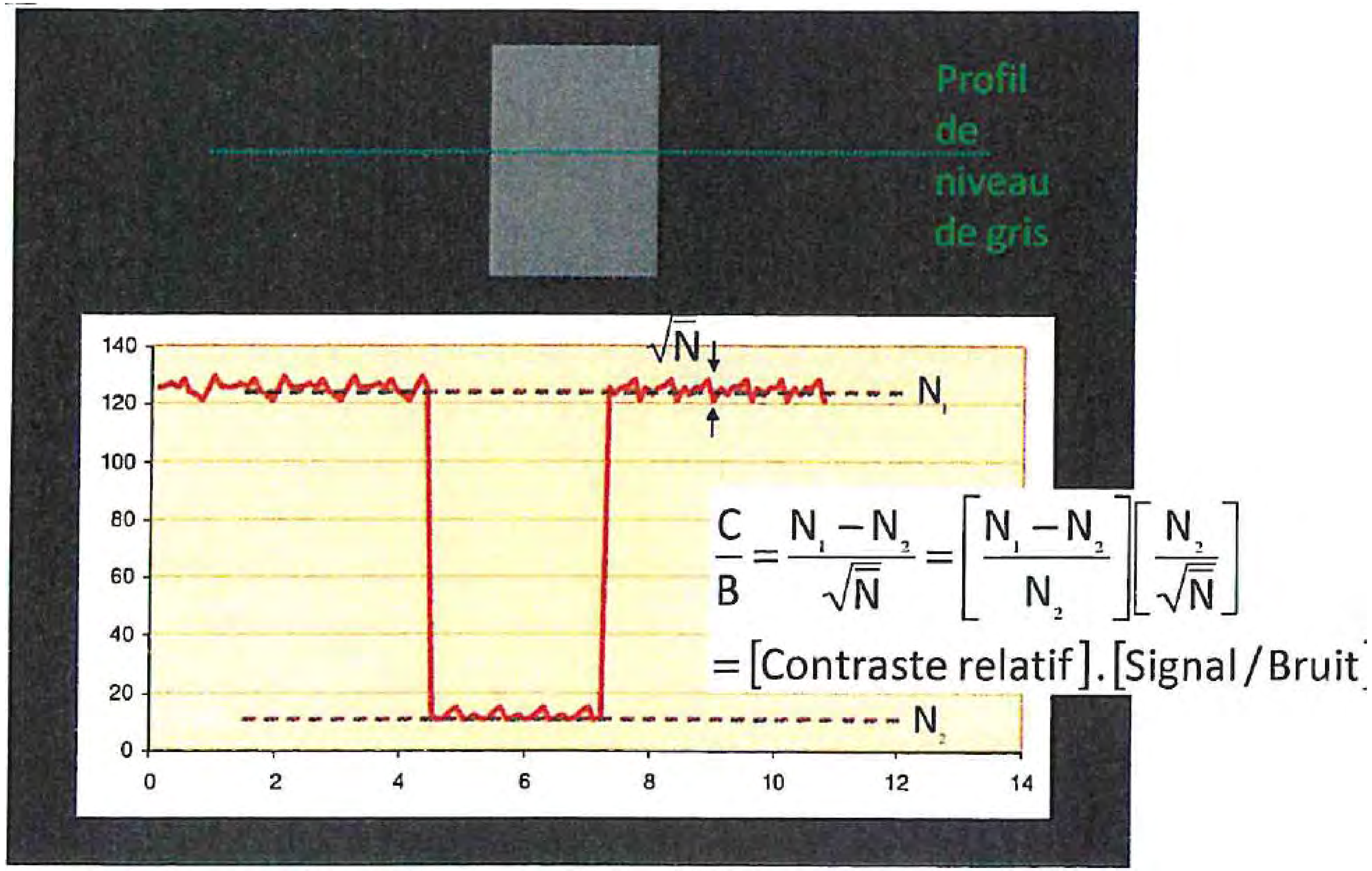
Contrast to noise ratio (CNR) (1/2)

The contrast to noise ratio (CNR) can therefore be defined as follows:

$$SNR = \frac{\text{Avg pixel values in Signal ROI}}{\text{Std Background ROI}}$$

$$CNR = \frac{\text{Avg Signal ROI} - \text{Avg Background ROI}}{\text{Std Background ROI}}$$

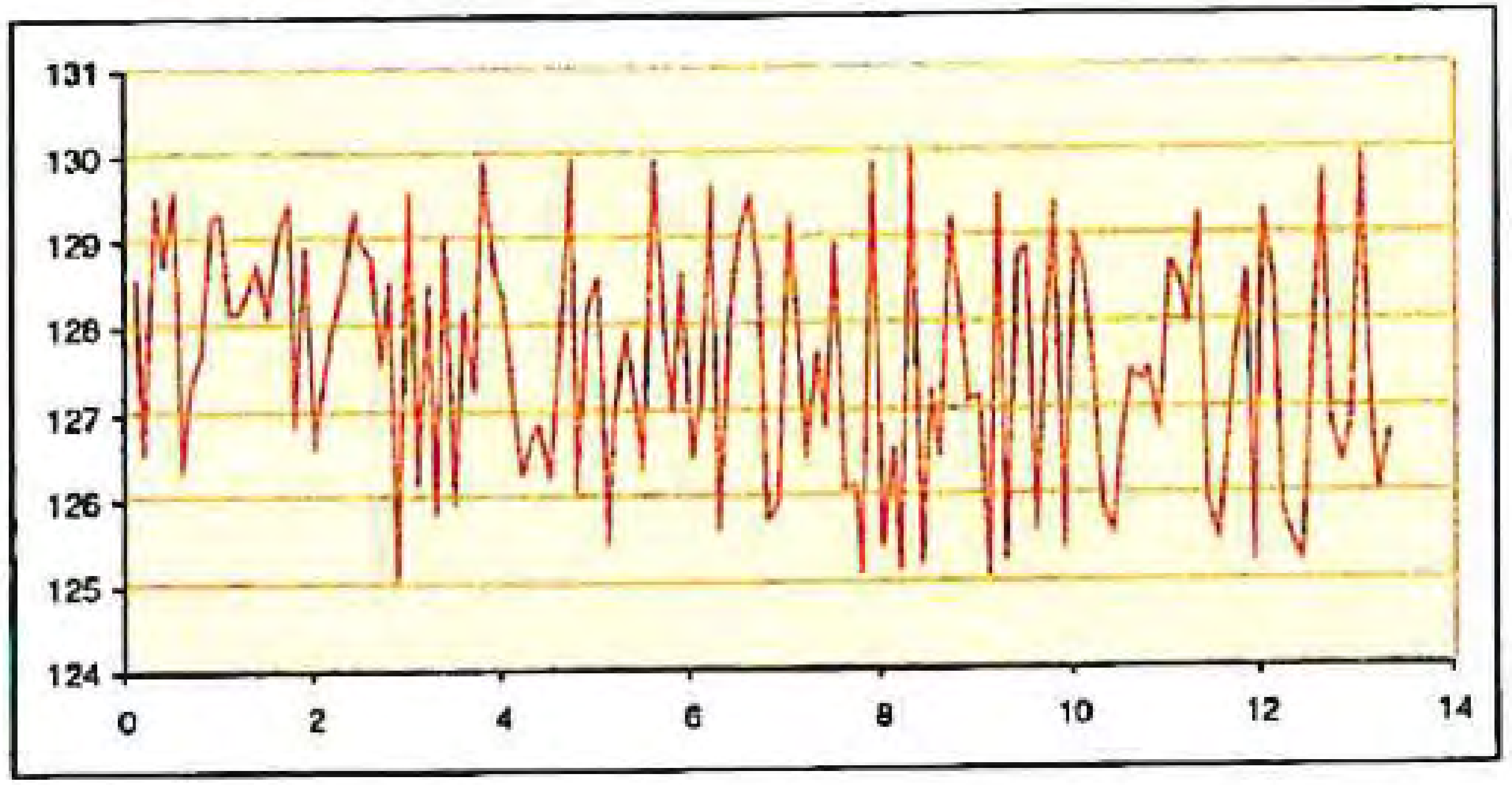
Contrast to noise ratio (CNR) (2/2)



Signal-to-noise ratio (SNR) (1/3)

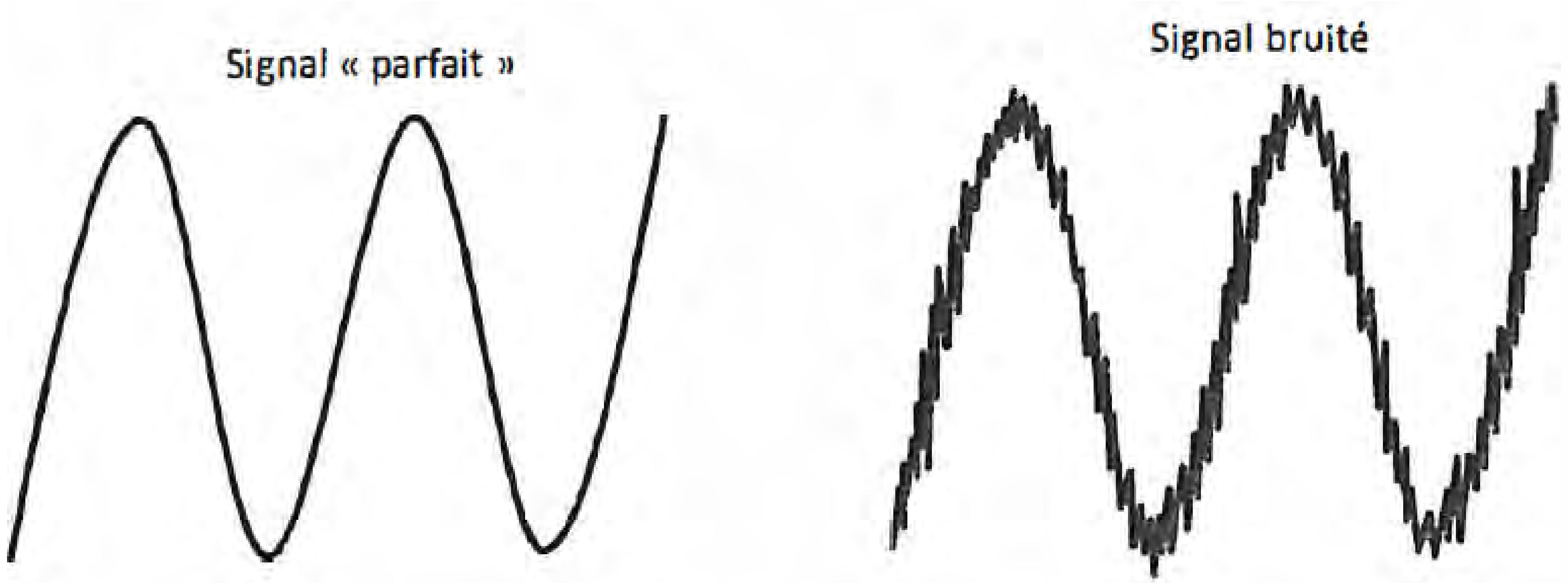
CAUSES

- Scattered radiation
- Wear and tear of the sensor (sensitive screen)
- Quantification noise (sampling quality...)
- Environment at the time of acquisition
- Sensor quality...



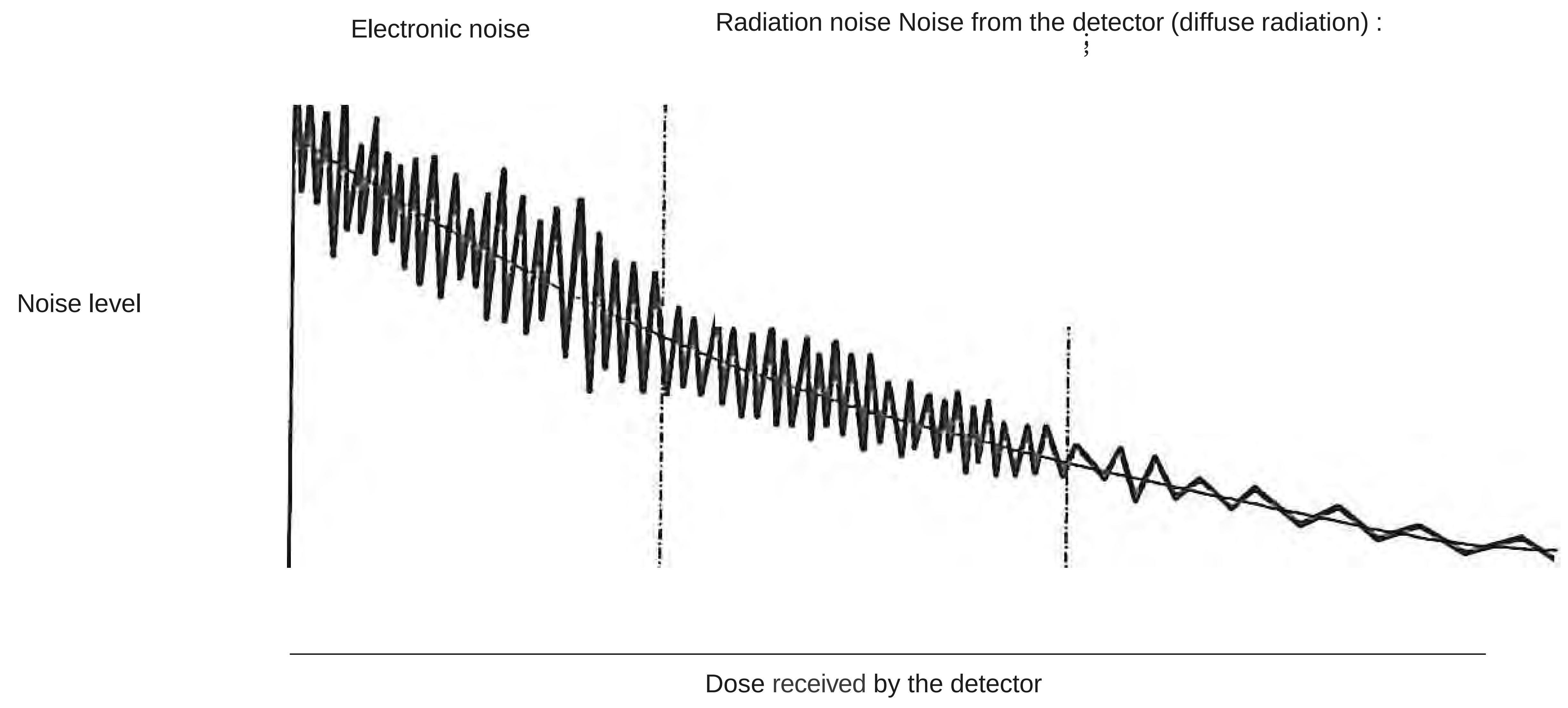
Signal-to-noise ratio (SNR) (2/3)

Electronic noise is a parasitic signal whose amplitude and frequency vary randomly, causing local distortions of the signal. Thus, the noise of an image designates the pixels of the image whose intensity is very different from those of the neighboring pixels.



Signal-to-noise ratio (SNR) (3/3)

The signal-to-noise ratio depends on the amount of radiation (dose) and the properties of the digital radiography system.



Noise level decreases with increasing dose

SNR_N values (CR and DDA) of Fe, Cu and nickel-based alloys

Radiation source	Penetrated material thickness w mm	Minimum SNR_N[c] Testing class A	Minimum SNR_N[c] Testing class B	Type and thickness of metal-front screens mm
X-ray potentials ≤ 50 kV		100	150	None
X-ray potentials[d] 50 kV < U ≤ 150 kV		70	120	0 to 0,1 (Pb)
X-ray potentials[d] 150 kV < U ≤ 250 kV		70	100	0 to 0,1 (Pb)
X-ray potentials[d] 250 kV < U ≤ 1 000 kV	w ≤ 50	70	100	0 to 0,3 (Pb)
	w > 50	70	70	0 to 0,3 (Pb)
Yb 169[d] Tm 170[d]	w ≤ 5	70	120	0 to 0,1 (Pb)
	w > 5	70	100	0 to 0,1 (Pb)
Ir 192[d], Se 75[d]	w ≤ 50	70	100	0 to 0,3 (Pb)
	w > 50	70	70	0,1 to 0,4 (Pb)
Co 60[a,b] X-ray potentials[a,b] 1MV < U ≤ 5 MV	w ≤ 100	70	100	0,3 to 0,8 (Fe or Cu) + 0,6 to 2 (Pb)
	w > 100	70	70	0,3 to 0,8 (Fe or Cu) + 0,6 to 2 (Pb)
X-ray potentials[a, b] > 5 MV	w ≤ 100	70	100	0,6 to 4 (Fe, Cu or Pb)
	w > 100	70	70	0,6 to 4 (Fe, Cu or Pb)

a In the case of multiple screens (Fe+Pb), the steel screen shall be located between the IP and the lead screen.

b Instead of Fe or Fe+Pb, copper, tantalum or tungsten screens may be used if the image quality can be proven.

c If the SNRN is measured in the HAZ/parent material, these values shall be multiplied by 1,4. No multiplication is required if the weld cap and root are flush with the parent material or if sufficient SNRN is measured in the centre of the weld.

d Pb screens may be replaced completely or partially by Fe or Cu screens. The equivalent thickness for Fe or Cu is three

SNR_N values (CR and DDA) of aluminium and titanium

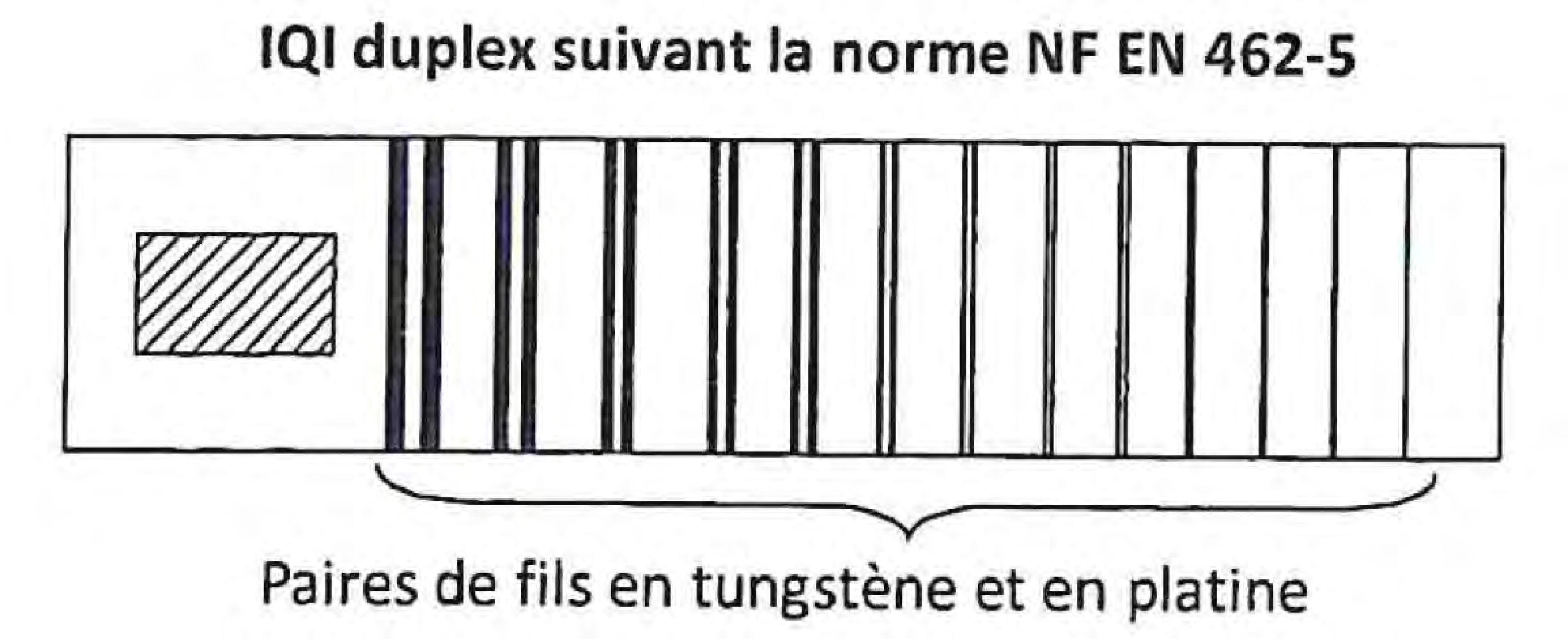
Radiation source	Minimum SNR_N[b]		Type and thickness of metal-front screens
	Testing class A	Testing class B	mm
X-ray potentials $U \leq 150$ kV	70	120	≤ 0,03 (Pb)
X-ray potentials 150 kV < $U \leq 500$ kV	70	100	≤ 0,2 (Pb)[a]
Yb 169, Tm 170	70	100	≤ 0,2 (Pb)[a]
Se 75	70	100	≤ 0,3 (Pb)[a]

a Instead of 0,2 mm lead, a 0,1 mm screen with an additional filter of 0,1 mm may be used outside of the cassette.

b If the SNRN is measured in the HAZ/parent material, these values shall be multiplied by 1,4. No multiplication is required if the weld cap and root are flush with the parent material or if sufficient SNRN is measured in the centre of the weld.

Spatial resolution

- The notion of resolution in general is related to the ability to distinguish two elements from each other.
- For non-destructive testing, it is the ability to discern two indications of close discontinuities, "Distance separating two details that can be differentiated on an image in the case of industrial radiography" (NF EN 1330-3).
- To determine this distance, a duplex IQI is used, consisting of a set of wire pairs of increasing diameter and spacing.



(the spacing between the wires is equal to their diameter, from 0.05 to 0.8mm)

Maximum image unsharpness class A

Testing class A: Duplex wire ISO 19232-5		
Penetrated thickness w [a] mm	Minimum IQI value and maximum unsharpness (ISO 19232-5)[b,c] mm	Maximum basic spatial resolution (equivalent to wire thickness and spacing)[b,c] $SR_b^{detector}$ mm
$w \le 1{,}0$	D 13 0,10	0,05
$1{,}0 < w \le 1{,}5$	D 12 0,125	0,063
$1{,}5 < w \le 2$	D 11 0,16	0,08
$2 < w \le 5$	D 10 0,20	0,10
$5 < w \le 10$	D 9 0,26	0,13
$10 < w \le 25$	D 8 0,32	0,16
$25 < w \le 55$	D 7 0,40	0,20
$55 < w \le 150$	D 6 0,50	0,25
$150 < w \le 250$	D 5 0,64	0,32
$w > 250$	D 4 0,80	0,4

a For double-wall technique, single-image, the nominal thickness, t, shall be used instead of the penetrated thickness, w.

b The IQI reading for system selection (see Annex C) applies for contact radiography. If the geometric magnification technique (see 7.7) is used, the IQI reading shall be performed in the corresponding reference radiographs.

c If magnification, v, is > 1,2, then SRbimage shall be used instead of SRbdetector.

Maximum image unsharpness class B

Testing class B: Duplex wire ISO 19232-5		
Penetrated thickness w^{a} mm	Minimum IQI value and maximum unsharpness (ISO 19232-5)[b,c] mm	Maximum basic spatial resolution (equivalent to wire thickness and spacing)[b,c] $SR_b^{detector}$ mm
$w \leq 1,5$	D 14 (D 13+)[d] 0,08	0,04
$1,5 < w \leq 4$	D 13 0,10	0,05
$4 < w \leq 8$	D 12 0,125	0,063
$8 < w \leq 12$	D 11 0,16	0,08
$12 < w \leq 40$	D 10 0,20	0,10
$40 < w \leq 120$	D 9 0,26	0,13
$120 < w \leq 200$	D 8 0,32	0,16
$w > 200$	D 7 0,40	0,20

a For double-wall technique, single-image, the nominal thickness, t, shall be used instead of the penetrated thickness, w.

b The IQI reading for system selection (see Annex C) applies for contact radiography. If the geometric magnification technique (see 7.7) is used, the IQI reading shall be performed in the corresponding reference radiographs.

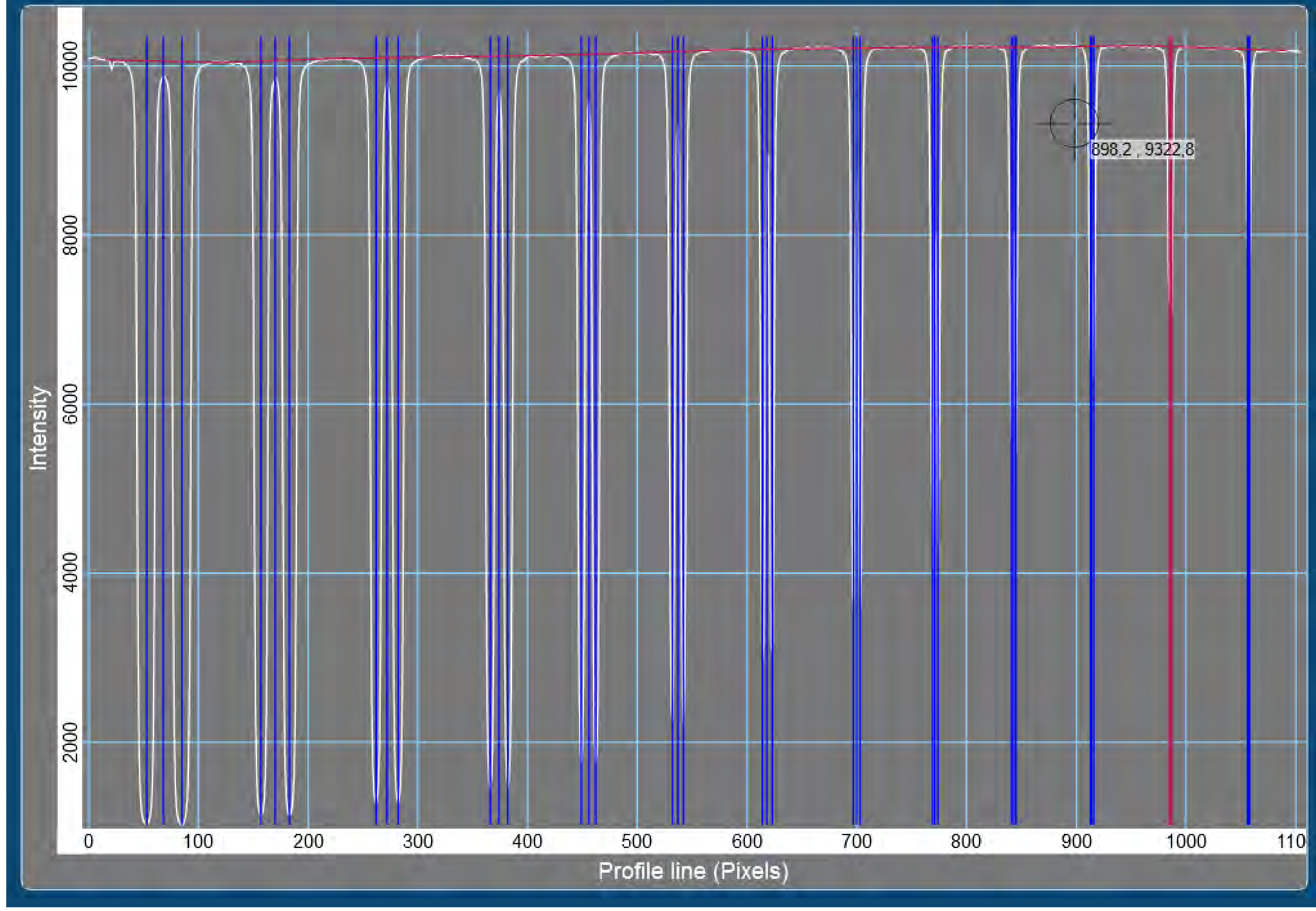
c If magnification, v, is > 1,2, then SRbimage shall be used instead of SRbdetector.

d D 13+ is achieved if the duplex wire pair D 13 is resolved with a dip larger than 20 %.

NOTE The duplex wire IQIs can be used effectively with tube voltages up to 600 kV. The wire pairs > 13 can be used effectively at tube voltages lower than 225 kV. When using source voltages in the megavolt range, it can be possible that the results will not be completely satisfactory. SRbdetector values can be determined but it will be difficult to measure SRbimage values.

Example of BSR determination with the IQI Duplex

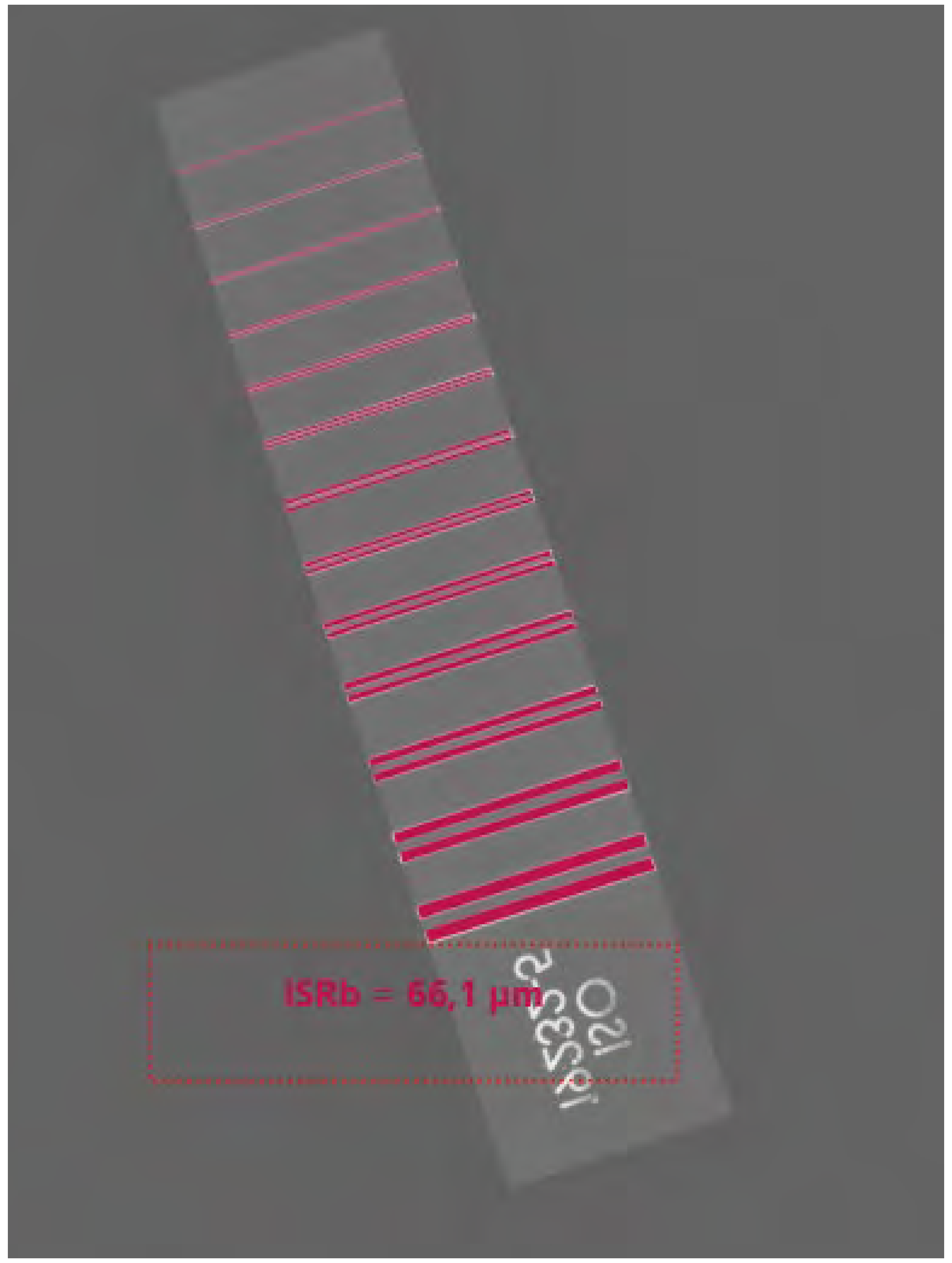
iSRb computation



Wire pair	Spatial resolution (µm)	Modulation dip (%)
D1	800	97,7
D2	630	98,0
D3	500	96,6
D4	400	95,4
D5	320	93,5
D6	250	89,5
D7	200	83,0
D8	160	76,6
D9	130	62,4
D10	100	53,5
D11	80	35,4
D12	63	11,1
D13	50	2,0

iSRb = 66,1 µm
SRb = 63 µm

iSRb

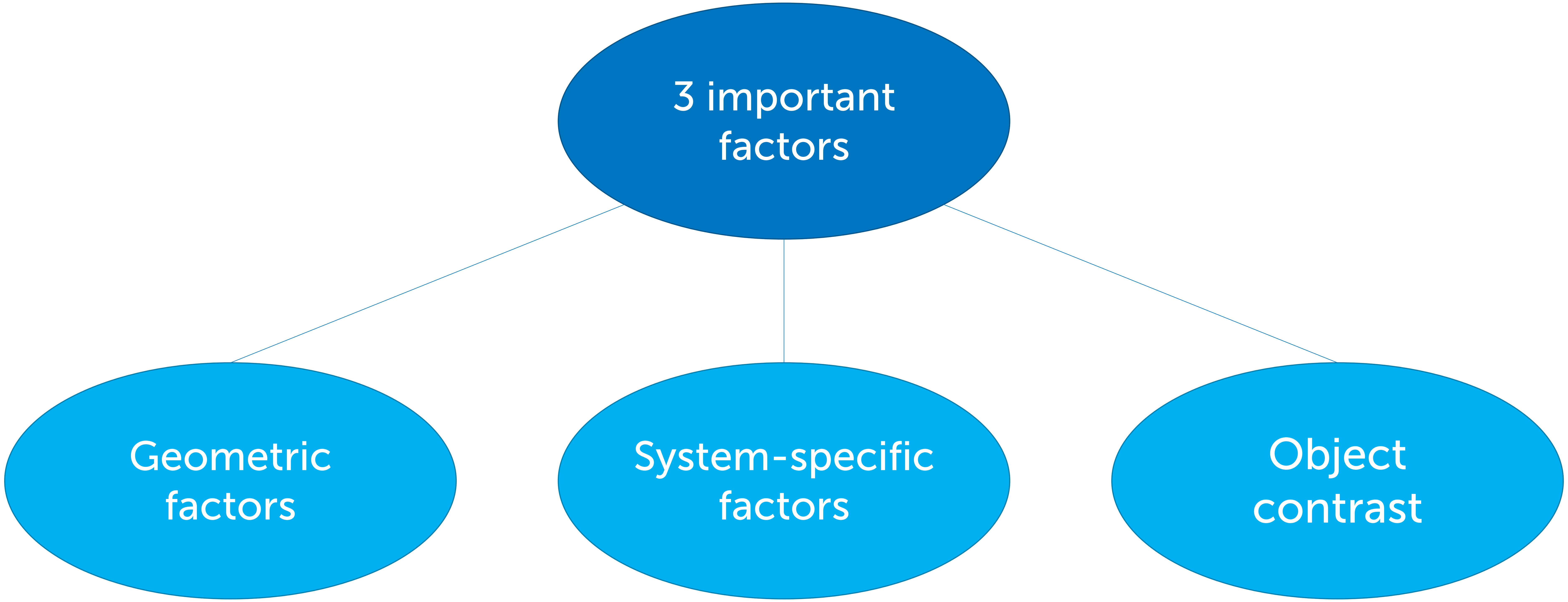


Compensation principle

- If the two IQI sensitivities (differential sensitivity by single-wire or hole-and-step IQIs on the one hand, and spatial resolution of the detector by duplex wire IQIs on the other hand) indicated in Tables A.1 to A.4 cannot be achieved by the detection system and exposure conditions used, an increase in visibility in the single-wire IQI or in the visibility of the holes and steps shall compensate for too high unsharpness index values (or too high SRb_{image} or SRbddetector values).

- For example, if the required values of D12 and W16 (for 5 mm thickness, class B - Tables A.2 and A.4) are not achieved at the same time for a given detector configuration, then the values of D11 and W17 give equivalent detection sensitivity. Compensation shall be limited to a maximum increase of two individual wires for two pairs of unresolved duplex wires. If the required imperfection detection sensitivity can be obtained for a specific application, by agreement between the contracting parties, the compensation may be extended to a maximum of three individual wires for three pairs of unresolved duplex wires.

Factors affecting image quality (1/4)



Factors affecting image quality (2/4)

GEOMETRIC FACTORS

- Geometric blurring (firing conditions and radiation source characteristics)
- Geometry and position of the discontinuity in the part
- Distortion
- Diffusion unsharpness
- Kinetic unsharpness

SYSTEM-SPECIFIC FACTORS

- Size of the pixels composing the detector
- Image integration
- Signal-to-noise ratio (SNR)
- Spatial resolution

Factors affecting image quality (3/4)

OBJECT CONTRAST

- Radiation energy
- Object (nature, geometry)
- Type of defect and orientation
- Filtration (radiation quality)
- Scattered radiation

Factors affecting image quality (4/4)

RADIOGRAPHIC TECHNIQUE

- Position of the object between the detector and the source,
- Reduction of scattered and backscattered radiation (filtration and anterior protection / blocking screen),
- Lowest possible generator voltage for the thickness traversed (increased contrast).

CHOICE OF THE ACQUISITION PARAMETERS OF THE DETECTOR

Thanks!

For more information, please visit www.teledyneicm.com

Maximilian Salomon | Sales Engineer
Phone: +46 (0)31 748 52 56
maximilian.salomon@kontrollmetod.se

Kontrollmetod

Call US:

+32 475 60 15 74

Email US:

Abdallah.rady@teledyne.com

Follow US: