Performance evaluation of a Computed Radiography system

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Abstract
Computed radiography (CR) standards have been formalized and published in Europe and in the US. The CR system classification is defined in those standards by

- minimum normalized signal-to-noise ratio (SNR_N), and
- maximum basic spatial resolution (SR_b).

Both the signal-to-noise ratio (SNR) and the contrast sensitivity of a CR system depend on the dose (exposure time and conditions) at the detector. Because of their wide dynamic range, the same storage phosphor imaging plate can qualify for all six CR system classes. The exposure characteristics from 30 to 450 kV, the contrast sensitivity, and the spatial resolution of the KODAK INDUSTREX CR Digital System have been thoroughly evaluated. This paper will present some of the factors that determine the system's spatial resolution performance.
Keywords: Computed radiography, INDUSTREX CR Digital System, standardization, spatial resolution

1. Computed Radiography (CR) standards

Computed Radiography (CR) standards have been formalized and published in Europe and in the US:

- E2007 Guide for Computed Radiology
- E2445 Practice for Qualification of CR systems
- E2446 Practice for Classification of CR systems
- EN 14784-1 Classification of systems
- EN 14784-2 General principles

The CR system classification is defined in these standards by:

- minimum normalized signal-to-noise ratio (SNR_N)
- maximum basic spatial resolution (SR_b).

Table 1. Limiting values in CR standards

Minimum SNR_N	ASTM E2446	EN 14784-1
43	IP III/Y	IP 6/Y
52	IP II/Y	IP 5/Y
65	IP I/Y	IP 4/Y
78		IP 3/Y
117		IP 2/Y
130	IP Special/Y	IP 1/Y

Y is the maximum basic spatial resolution (SR_b).

Both the signal-to-noise ratio (SNR) and the contrast sensitivity of a CR system depend on the dose (exposure time and conditions) at the detector. Because of their wide dynamic range, the same phosphor imaging plate can qualify for all CR system classes. The exposure characteristics from 30 to 450 kV, the contrast sensitivity, and the spatial resolution of the KODAK INDUSTREX CR Digital System have been thoroughly evaluated.

2 Basic spatial resolution

The basic spatial resolution SR_b shall be determined using the EN 462-5 (E2002) duplex-wire gage. This duplex-wire is intended to provide a means for measuring total image unsharpness as independently as practicable from the imaging system contrast sensitivity limitations. The first unresolved wire pair, which is projected with a dip between the wires of less than 20%, shall be taken. SRb corresponds to one half of the measured unsharpness. Due to the step increments of the duplex-wire gage, both the GP and the HR imaging plate round off to the same maximum basic spatial resolution of 100µm.

3 Converging line pair quality indicator

According to EN 14784-1, converging line pair quality indicators can be used in both manufacturer and end user tests. Accordingly, a converging line pair quality indicator is contained in the CR phantom. Data obtained with such a quality indicator indicates that the HR imaging plate has a higher sharpness.

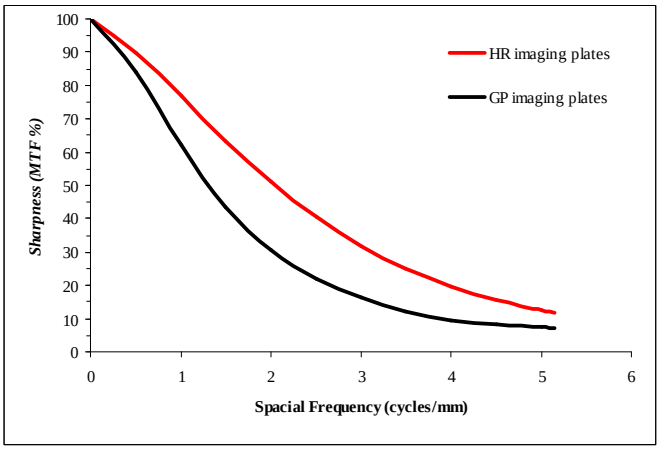
Table 2. Basic spatial resolution

	Converging line pair (line pairs/mm)		Duplex-wire gage element number		max SR_b (µm)
	scan	subscan	scan	subscan	
GP	6	5,5	#11	#10	100
HR	7	6	#11	#10	100

4 Presampling MTF

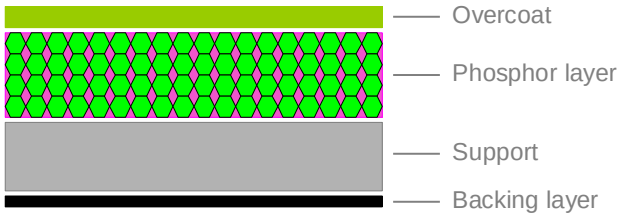
It is customary to characterize the spatial resolution of imaging systems using the modulation transfer function (MTF). The presampling MTF describes the system response up to, but not including, the stage of sampling. The figure below shows the presampling MTF curves for both imaging plates, and highlights the improved sharpness of the HR imaging plate.

Figure 1. Presampling MTF for the GP and HR imaging plates



5 Imaging plate layer characteristics and resolution

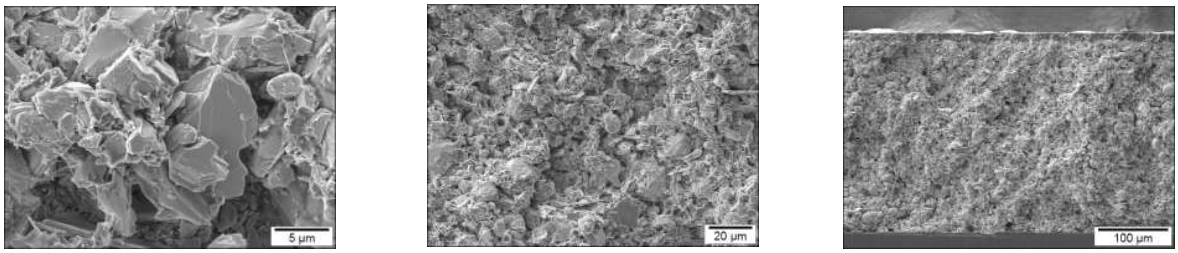
Figure 2. Imaging plates structure



To improve the resolution of an imaging plate, one generally wants

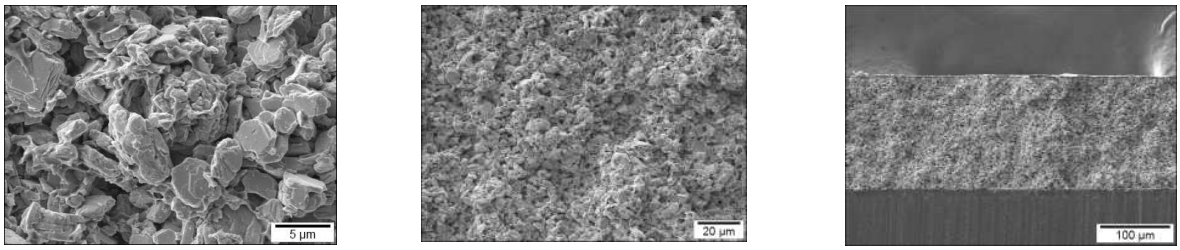
- smaller, smoother phosphor particles without defects
- better packing of phosphor particles
- thinner phosphor layer.

Figure 3. Electron micrographs of the GP imaging plate



The improved sharpness of the HR imaging plate comes from smaller phosphor particles and a thinner layer.

Figure 4. Electron micrographs of the HR imaging plate



When used with the INDUSTREX ACR2000 Digital System, both the GP and the HR imaging plate can meet requirements for the highest system class IP I/100 (EN 14784-1) and class IP Special/100 (ASTM E2446) with the same maximum basic spatial resolution of 100µm. Converging line pair quality indicator and presampling MTF data as well as practical assessments indicate that the HR plate has indeed improved sharpness.

6 Using ASTM E2422 Digital Reference Images with the INDUSTREX Digital Viewing software

ASTM Committee E07 on Nondestructive Testing has sanctioned an industry study to develop a set of digital reference images. ASTM E2422 - Standard Digital Reference Images for Inspection of Aluminum Castings – was published in 2006. ASTM has granted Kodak special permission to use one ASTM E2422 image. The INDUSTREX Digital Viewing software allows the user to put production and reference images side-by-side to gauge the degree or severity of the discontinuity.
ASTM is currently working on other digital reference standards. The corresponding reference for steel castings will be the next available, in late 2007 or sometime in 2008.

7 Further reading

- How to Evaluate the Radiographic Performance Envelope of a Computed Radiography System. S.A. Mango, ASNT Digital Imaging VIII, July 25, 2005.
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