

# High Contrast (Spatial) Resolution Testing for Computed Radiography

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## Introduction

Computed radiography is used to replace all films except in the case of mammography. Performing quality assurance on computed radiography will reduce levels of radiation doses to the patient while improving the quality of each image taken. The quality control program should include the following tests at a minimum: phosphor plate dark noise, system linearity, receptor reproducibility, phosphor plate throughput, laser beam function, spatial resolution, wire mesh test, low contrast sensitivity, distance accuracy measurements, and accuracy/thoroughness of erasure cycle.<sup>1</sup> Spatial resolution testing of computed radiography tests the central and peripheral limiting resolution for each image, plate size, and plate type.

Film-based processing requires a dark room and cannot be displayed for ease of viewing for the patient and radiologist. Due to improved technology, filmless based technology arose in the field of x-ray systems. Previously, image spatial resolution in filmless technology was one of the main limitations. The image spatial resolution problems were corrected using microfocus x-ray tube technology but that would then degrade the field of view characteristics. Computed radiography was the solution to many of the problems with filmless technology. Computed radiography was developed in the early 1980s and includes improved spatial resolution over the previous filmless technology. Computed radiography when compared to film-based processing has an exceptional use of digital format storage, displayed images for ease of viewing, improved image quality due to diagnostics of system, improved efficiency, and can be archived for future use.

## Theory

Computed radiography is made up of photostimulable storage phosphors (PSPs). These PSPs hold absorbed x-ray energy in the crystal lattices. When exposed to either heat or light, the phosphor reemits the absorbed energy especially with intense visible light. Various PSPs used in computed radiography include BaFI:Eu<sup>+2</sup>, BaFCl:Eu<sup>+2</sup>, BaFBr:Eu<sup>+2</sup>, and Eu<sup>2+</sup> as an activator. Many of the x-rays that are absorbed are excited and recombine to make Eu<sup>3+</sup> or are captured by the F-centers. These trapped electrons may move back to the different electron holes due to heat processes being undertaken. The theory of the computed radiography release of the latent image is that a HeNe laser is used to discharge the image from the storage phosphor plate. The released light should be approximately proportional to the intensity of the x-ray energy that is absorbed within the phosphor.

Spatial resolution means the ability to see the small detail in the patient or object. The limiting spatial resolution is the determination of the smallest object that can be resolved by the imaging system.<sup>2</sup> According to Bushberg, the limiting resolution of digital radiography is 0.17 mm due to the limitation of the size of detector elements. The spatial resolution of the imaging system is determined mathematically by the point spread function of the imaging system.<sup>5</sup>

## Testing Standards

To test for high contrast (spatial) resolution, the medical physicist must first place a high contrast square wave resolution test pattern near parallel or near perpendicular to the x and y directions in the center and one corner of the cassette size.

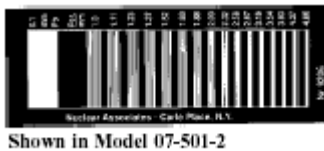
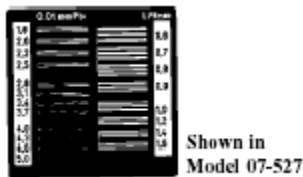


Fig 1. Spatial Resolution test patterns for Computed Radiography.<sup>3</sup>

The cassette must then be exposed to a relatively low beam energy (~60 kVp), @ 180 cm SID, and with a mAs to deliver approximately 5 mR to reduce the quantum mottle. The CR computer will need to be setup to process the cassette using a sensitivity readout/processing algorithm and finally the cassette can be processed.



Fig. 2. FCR 5000 Computed Radiography Image Reader

Once the cassette is processed, the medical physicist can use the computer workstation to view the digital image and adjust the window/level to the appropriate setting for the best viewing.

The observed resolution is determined in the x and y axis directions by recording the smallest pattern that can be seen on the test pattern. This resolution test examines the high contrast resolution or spatial resolution which should be less than 10% poorer than the indicated manufacturer's specifications for the vertical and horizontal directions or else corrective action is needed.<sup>1</sup> There are various tools available for the everyday quality assurance testing done by medical physicists and the high contrast square wave resolution test pattern can have a range of 0.5 to 10 lp/mm.

## Results

Example of application of spatial resolution testing:

One example of spatial resolution testing was performed on a FCR 5000 using a Fuji FCR 5000 Plate Reader and a PACS workstation. The limiting spatial resolution for the FCR 5000 was determined to be as follows:

Image Plate Size (Inches)	Sampling Pitch (Pixels per mm)	Limiting Resolution (lp/mm)	Observed Resolution	
			x-axis	y-axis
8 x 10	10	5	3.5	5
10 x 12	6.7	3.3	3.15	3.15
14 x 17	5	2.5	2.5	2.5

When applying the ACR/AAPM standard of less than 10% poorer than the indicated manufacturer's specifications for both the horizontal and vertical directions, this FCR 5000 machine does not pass for the x-axis direction on the image plate 8 x 10 because it

is more than 10% less than 5 lp/mm. All of the rest pass with less than the 10% difference.

## **Discussion**

The quality control program is a vital portion of everyday CR operation and imaging. The standards provided by the American College of Radiology have allowed the medical physicist to perform these quality assurance tests with ease and provide accurate results. The high contrast (spatial) resolution testing is well outlined to set limits on the limiting resolution for the horizontal and vertical directions that will provide the best results for that CR equipment. The high contrast square wave resolution pattern provides an effortless way of testing for the spatial resolution of the CR equipment. Using this tool for quality assurance will help the medical physicist determine the need for corrective actions hopefully at an early stage in the degradation of the resolution of the equipment.

Some of the downfalls of using the line pair test to measure the limiting spatial resolution of the computed radiography is that at times there can be a misalignment error and it is not always an accurate representation of the computed radiography machine. The misalignment error is due to the misalignment of the pattern with the pixel matrix causing one solid shade of gray in the readout perpendicular direction. The pixels end up being only half covered by the lead and then half are not covered at the limiting resolution causing the short segment of the image corresponding to the limiting resolution to be the same shade of gray. The main downfall is that the line-pair test pattern does not always accurately represent the limiting resolution of the computed radiography machine due to the discrete frequencies of the line-pair test pattern. When the image must be leveled and displayed in the zoom position this can cause misinterpretations or inaccuracies in the observed resolution.

Spatial resolution testing is critical due to necessity of the high image quality. It is important in digital x-ray systems to determine the optimal balance of pixel size and noise.

## **Conclusion**

Spatial resolution testing of CR equipment can aid in determining any problems with the equipment instead of the technician adjusting other parameters to obtain a better image. Therefore, spatial resolution testing can help to reduce the overall levels of radiation doses while verifying that the quality of image taken will be exceptional. Spatial resolution testing of computed tomography (CT) equipment tests the central and peripheral limiting resolution for each image, plate size, and plate type. It is very important that all of the quality assurance tests are performed on a regular basis to help avoid any misrepresentations or misinterpretations of the image provided to the radiologist.

1. AAPM Report No. 74, Quality Control in Diagnostic Radiology, Report of Task Group # 12, Diagnostic X-ray Imaging Committee, July 2002.
2. Bushberg, The Essential Physics of Medical Imaging. "Introduction to Medical Imaging pp. 1-15.
3. Cardinal Health Website, Radiation Management Services.  
[www.cardinal.com/rms](http://www.cardinal.com/rms)
4. Computed Radiography Image Reader Performance, DXI Imaging Laboratory, Spring 2004.
5. DXII Chapter Notes – Chapter 1 and Chapter 6.