02-18-2024

Title: Comparative Analysis of Spatial Resolution: Pacific NDT's Film Size Digital Detectors in Accordance with ASME BPVC V. 2023 (Table T-276)

Introduction:

Digital Radiography (DR) has revolutionized the field of non-destructive testing (NDT) by offering superior image quality, enhanced efficiency, and improved workflow compared to traditional film-based radiography. This technical white paper explores the wide range of “film size” digital detectors offered by Pacific NDT & compares spatial resolution based on ASME Section V using IQI A Pack.

Quick Overview: How DR works?

Digital radiography (DR) works by capturing X-ray images using digital detectors, which convert X-ray photons into electronic signals. Here's a quick summary on how the process typically works:

X-ray Generation:

- The process begins with the generation of X-rays by an X-ray tube. These X-rays pass through the object being inspected, such as a weld, casting, or component.

Interaction with Object:

- As the X-rays pass through the object, they are attenuated or absorbed to varying degrees based on the density and composition of the materials they encounter. This results in the formation of a pattern of X-ray attenuation within the object.

X-ray Detection:

- Digital radiography systems use digital detectors, such as flat-panel detectors (FPDs) or Bendable Panel Detectors (BPDs) to capture the attenuated X-rays after they pass through the object.
- The detectors are composed of a scintillator material, which converts X-ray photons into visible light, and a photosensitive array, which converts the visible light into electronic signals.

Signal Conversion:

- The electronic signals generated by the detectors are then converted into digital data by analog-to-digital converters (ADCs). This process digitizes the X-ray image, converting it into a matrix of pixels with varying levels of brightness corresponding to the X-ray attenuation within the object.

Image Processing:

- The digital X-ray image is processed and enhanced using image processing algorithms to improve clarity, contrast, and resolution.
- Image processing techniques may include noise reduction, edge enhancement, and dynamic range adjustment to optimize image quality.

Image Display and Analysis:

- The processed digital X-ray image is displayed on a computer monitor or other display device, allowing inspectors to visualize and analyze the image in real-time.
- Advanced image analysis software may be used to perform measurements, annotations, and defect detection to evaluate the integrity of the object being inspected.

Data Storage and Retrieval:

- The digital X-ray images are stored electronically in a digital format, allowing for easy retrieval and archival.
- Digital radiography systems may utilize Picture Archiving and Communication Systems (PACS) for centralized storage, management, and distribution of X-ray images across networks.

Scope of Work:

In this paper, we analyze 3 high resolution detectors that are currently offered by Pacific NDT for weld inspection.

1. PiX Pikena: X Ray Inspection System | PiX Pikena - Pacific NDT
2. PiX 411: Portable X Ray Machine | Portable X-Ray Solutions - PiX 411 (pacificndt.com)
3. PiX 410C: https://pacificndt.com/solutions/pix-410c/

*Please note 410C is a “bendable” detector. We call this category of detectors: BPD (Bendable Panel Detectors). A separate article will be published performing comparison of the rigid/flat vs bendable/curved detectors.

Table below shows the technical specs of all 3 digital detectors under study here:

Specifications	PIKENA	410C	411
Pixel Pitch (µm)	76	99	127
Active Area (in)	3.8 x 9.1	3.8 x 9.8	3.8 x 11.5
A/D Conversion (bits)	16	16	16
Conversion Screen*	Gadox	Gadox	Gadox
Product Weight (lbs)	4.5	3.1**	6.2

*Gadox variants of all products were compared since they are most commonly used in NDT.

**Weight of 410C is without the control box connected via a rugged cable to the BPD (Bendable Panel Detector)

X-Ray Techniques:

1. Tube Used: Comet 225kV

2. Focal Spot: 5.5 mm

3. Technique Used: 210 kV, 2mA, 24 seconds

4. SID: 24" (approx)

5. Object to be imaged: 24” diameter pipe, 3/8” thickness , double wall exposure

6. Image Quality Requirement: ASTM IQI A pack, required wire is the 6th wire (screenshot below showing the required standard)

Table T-276
IQI Selection

Nominal Single-Wall Material Thickness Range, in. (mm)	IQI					
	Source Side			Film Side		
	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire
≤0.25 (≤6.4)	12	2T	5	10	2T	4
>0.25 through 0.375 (>6.4 through 9.5)	15	2T	6	12	2T	5
>0.375 through 0.50 (>9.5 through 12.7)	17	2T	7	15	2T	6
>0.50 through 0.75 (>12.7 through 19.0)	20	2T	8	17	2T	7
>0.75 through 1.00 (>19.0 through 25.4)	25	2T	9	20	2T	8
>1.00 through 1.50 (>25.4 through 38.1)	30	2T	10	25	2T	9
>1.50 through 2.00 (>38.1 through 50.8)	35	2T	11	30	2T	10
>2.00 through 2.50 (>50.8 through 63.5)	40	2T	12	35	2T	11
>2.50 through 4.00 (>63.5 through 101.6)	50	2T	13	40	2T	12
>4.00 through 6.00 (>101.6 through 152.4)	60	2T	14	50	2T	13
>6.00 through 8.00 (>152.4 through 203.2)	80	2T	16	60	2T	14
>8.00 through 10.00 (>203.2 through 254.0)	100	2T	17	80	2T	16
>10.00 through 12.00 (>254.0 through 304.8)	120	2T	18	100	2T	17
>12.00 through 16.00 (>304.8 through 406.4)	160	2T	20	120	2T	18
>16.00 through 20.00 (>406.4 through 508.0)	200	2T	21	160	2T	20

GENERAL NOTE: It is recognized that the required hole-type designation or wire-type essential wire in this table may not achieve an IQI sensitivity level of 2-2T. This is intentional.

According to Article 2 ASME BPVC.V 2023s, Table T-276, for nominal single wall material thickness of >0.375 through 0.50 (in), the required wire type essential wire on “film side” is 6.

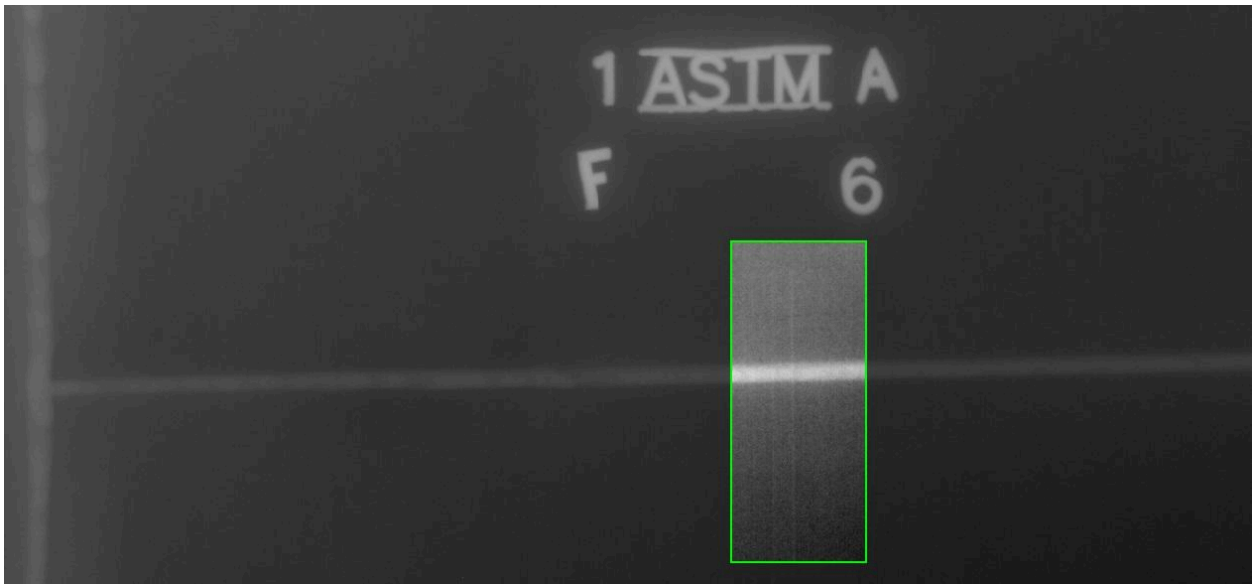
ASTM Image Quality Indicator (IQI) Type A wire provides information about the resolution and image quality of radiographic images. Specifically, it helps assess the ability of the radiographic system to distinguish between adjacent details or defects of specified sizes. The IQI Type A wire typically consists of a set of wires of varying thicknesses arranged in a step-wedge pattern.

When included in a radiographic image, the wire pattern allows inspectors to evaluate the resolution capabilities of the radiographic system by visually determining the smallest wire that is clearly distinguishable. This assessment helps ensure that the radiographic images meet the required quality standards for flaw detection and characterization.

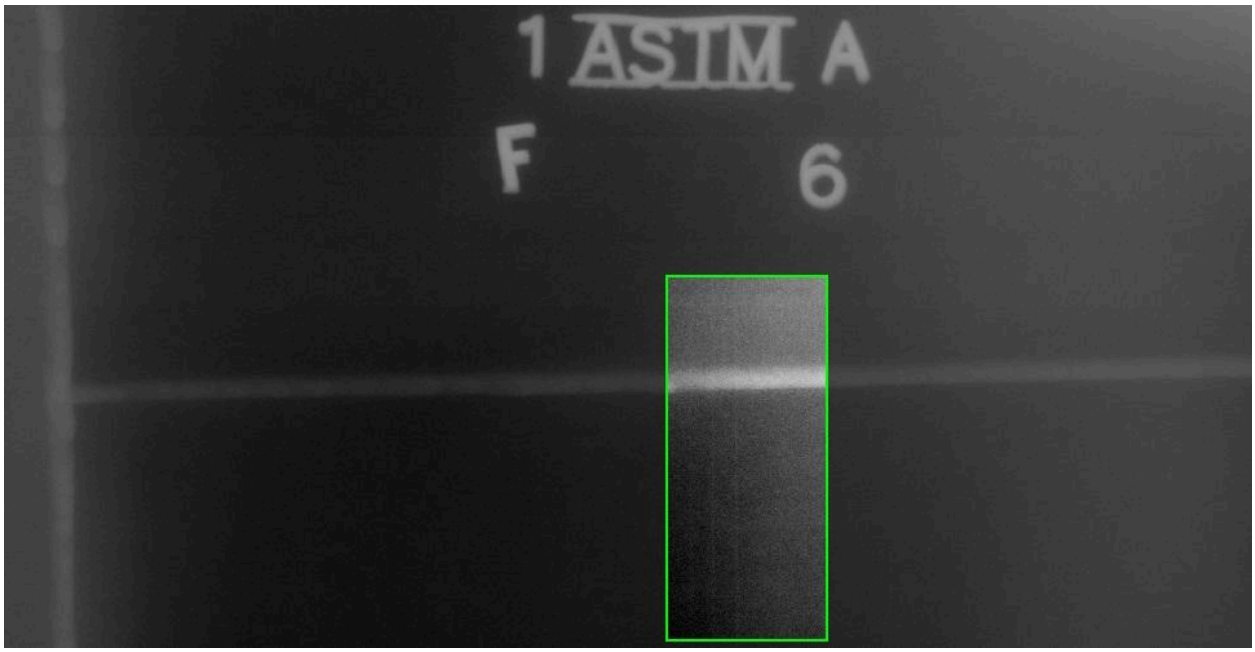
Detector Placement - Image below shows the convenient detector placement due to its size and weight.

Image Quality Results:

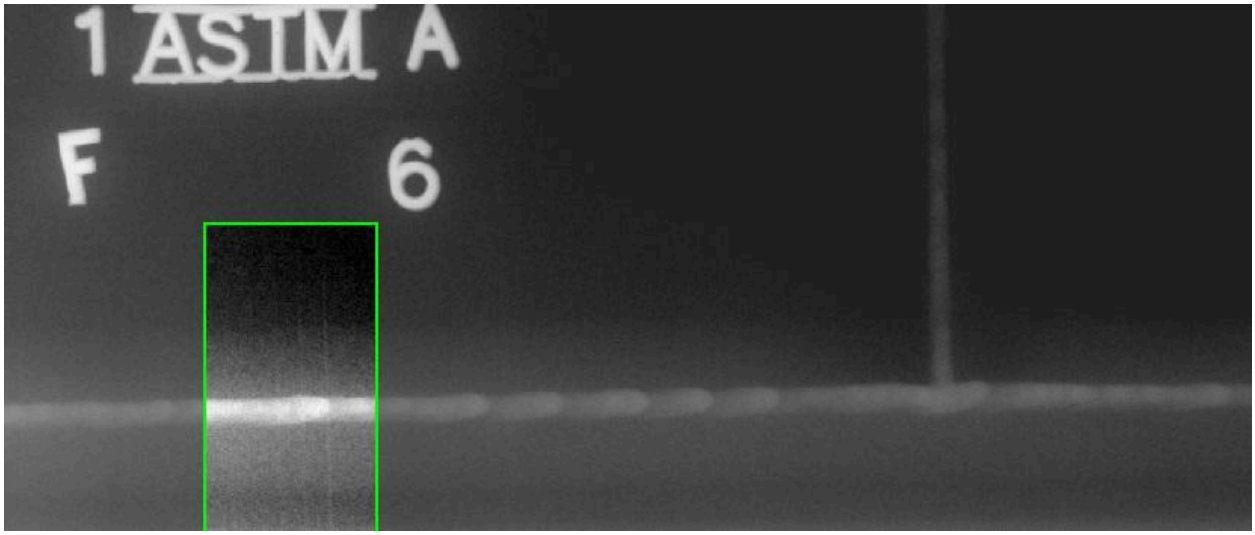
1. PiX Pikena (image below)– Wire 6 and 5 were clearly visible.



2. PiX 411 (image below) - Wire 6 and 5 were visible



3. PiX 410C (image below) - Wire 5 & 6 were visible



Conclusion:

Small form factor “film size” digital detectors offered by Pacific NDT are a suitable replacement to the cumbersome film-based radiography. They provide faster image acquisition, enhanced image quality, improved workflow efficiency, and easier data storage and retrieval.

Pacific’s DR systems provide tremendous benefits in terms of saving time and money.

With significantly reduced exposure duration and radiation, our detectors meet stringent image quality standards while minimizing risk. Seamlessly integrated with PiX Acquisition Software, Pacific's Digital Detectors ensure swift and seamless digital image capture.

Digital radiography continues to evolve as a powerful tool for non-destructive testing, offering unparalleled image quality, efficiency, and versatility across a wide range of industries. As technology continues to advance, digital radiography is poised to play an increasingly critical role in ensuring the integrity and safety of critical infrastructure and components.

For further inquiries or to learn more about our digital radiography solutions, please contact us at Sales@pacificndt.com

Comments:

a. All products were tested in wired mode. However, all 3 are capable of working in wireless mode.
b. All detectors used single frame capture to make sure test conditions were uniform. We expect improved results with multi frame capture.
c. Image Quality Comparison was performed on Raw Diconde data.
d. Pacific NDT provides rugged armor & mounting kits for all its detectors to allow easy mounting of digital detectors on curved surfaces.
e. Pacific NDT's bendable detector comes with an auto lock mechanism that stops the detector from being beyond its range. Currently, the system can be used on pipes with diameter 6" and greater making it an ideal choice for boiler pipelines and large cylindrical pipe inspections.

Future Work (planned in 2024):

- Perform real world image quality comparison between BPD (bendable panel detectors) and CR (Computed Radiography imaging plates HR & GP).
- Advancements in Detector Technology: Explore emerging trends in digital detector technology, such as different sizes of BPDs, their limitations as well as benefits in field use, perform comparison studies on CMOS vs CsI vs Gadox detectors for aerospace use at low kV etc.
- Artificial Intelligence (AI) Integration: Discuss the initial results of integration of Pacific NDTs AI algorithms for automated defect detection, image analysis, and predictive maintenance in digital radiography systems.