CarestreamNDT

WHITE PAPER

Looking forward while standing on the shoulders of titans

A retrospective analysis on the evolution of industrial radiography technology.

INTRODUCTION

At Carestream NDT we want to share not only our technological developments and product portfolio, but also the knowledge and practical experience that our staff obtains by working shoulder-to-shoulder with customers like you. We aim to share this knowledge and experience in a straightforward fashion so that our readers may find practical applications in their everyday activities.

This series is directed but not limited to NDE professionals in the following industries: Oil & Gas, Nuclear, Construction, Foundry and Castings, Energy Generation, Aerospace, Transportation, Automotive, Military and Defense, Agriculture, Art Restoration & Museum Artifacts, and NDE Services Companies.

CarestreamNDT

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Introduction

Radiography has long served as an essential nondestructive testing (NDT) inspection modality in many industries and in very diverse set of operational stages, from initial manufacturing to structural health and operational condition monitoring processes. The initial fifty years of radiographic imaging were characterized by films with high contrast and covering power. **Digital technologies were introduced during the past thirty years and are gradually becoming more prevalent.** Computed radiography (CR) was the first to be introduced, followed by digital detector array (DDA) radiography.

Despite the extensive training available for NDT radiography, there is a significant lack of information regarding how the technologies associated with NDT imaging processes work. Radiographers all over the world are eager for trustworthy technical information to understand what aspects merit consideration when selecting specific NDT imaging technology solutions. **This white paper aims to provide, following a historic perspective, a summarized description of each radiography technology solution, highlighting not only their respective role in an NDT imaging ecosystem but also their associated trade-offs.**

But before we begin our exploration through the evolution of industrial radiography technology, first let's get our terms right!.

Table 1, which was obtained from Section D of ASTM E1316, proposes a series of fundamental terminology related to film radiography, that is independent of whether Gamma- or X-radiologic testing is performed. The terms are listed in alphabetical order:

Term	Definition
analog image	An image produced by a continuously variable physical process (for example, exposure of film).
characteristic curve	The plot of density versus log of exposure or of relative exposure. (Also called the D-log E curve or the H and D curve.)
densitometer	A device for measuring the optical density of radiograph film.
film contrast	Also called gradient: a quantitative expression of the slope or steepness of the characteristic curve of a film; that property of a radiographic film material which is related to the magnitude of the density difference resulting from a given difference of the logarithmic exposure dose.
film density	The quantitative measure of diffuse optical light transmission (optical density, blackening) through a developed film. $$D = \log(I_0/I)$$ where: D = optical density, I0 = light intensity incident on the film, and I = light intensity transmitted.

Term	Definition
film speed	A numerical value expressing the response of an image receptor to the energy of penetrating radiation under specified conditions.
fog	A general term used to denote any increase in optical density of a processed photographic emulsion caused by anything other than direct action of the image forming radiation and due to one or more of the following: (a) aging—deterioration, before or after exposure, or both, resulting from a recording medium that has been stored for too long a period of time, or other improper conditions. (b) base—the minimum uniform density inherent in a processed emulsion without prior exposure. (c) chemical—resulting from unwanted reactions during chemical processing. (d) dichroic—characterized by the production of colloidal silver within the developed sensitive layer. (e) exposure—arising from any unwanted exposure of an emulsion to ionizing radiation or light at any time between manufacture and final fixing. (f) oxidation—caused by exposure to air during developing. (g) photographic—arising solely from the properties of an emulsion and the processing conditions, for example, the total effect of inherent fog and chemical fog. (h) threshold—the minimum uniform density inherent in a processed emulsion without prior exposure.
graininess	The visual impression of irregularity of silver deposit in a processed film.
step-wedge comparison film	A processed film with defined discrete optical density steps, used to characterize the optical density on a radiograph.

Table 1: Basic Film Radiography Terms - Reprinted, with permission, from ASTM E1316-25b, Standard Terminology for Nondestructive Examinations, copyright ASTM International. A copy of the complete standard may be obtained from https://store.astm.org/e1316-25b.html

Table 2 was also obtained from Section D of ASTM E1316 and integrates basic terminology associated with computed and digital radiography. The terms are also irrespective of whether Gamma- or X-rays testing is performed and are listed in alphabetical order:

Term	Definition
amorphous silicon (a-Si) detector	An amorphous silicon (a-Si) radiation detector consists of a glass substrate with an array of photodiodes and thin film transistors; the photodiodes are illuminated by light photons emitted from a scintillator which is irradiated by X rays or gamma rays, and is in intimate contact with the photodiode array.
analog to digital converter (a/d)	A device that changes an analog signal to a digital representation of the signal.

Term	Definition
bad pixel	A DDA pixel that does not conform to a specified performance. *Bad pixel criteria may include, but are not limited to, non-responding, over-responding, under-responding, noisy, non- uniform, non-persistent, or bad neighborhood; non-persistent bad pixels may have flickering or poor lag performance.*
computed radiography (CR)	A two step radiographic imaging process; first, a storage phosphor imaging plate (IP) is exposed by penetrating radiation; second, the luminescence from the IP's photostimulable luminescent phosphor is stimulated, detected, digitized, and displayed on an image display monitor.
computed tomography (CT)	A nondestructive examination technique that captures radiographic projections of an object at various rotational angles, which are mathematically reconstructed to produce a three-dimensional volume data set or one or more two-dimensional cross-sectional images, where each voxel value represents the attenuation coefficient of the incident radiation at a specific location within the object.
Digital Imaging and Communication for Nondestructive Evaluation (DICONDE)	A vendor-neutral digital data storage and transmission protocol that defines the organization of NDT image data and associated metadata in a standard electronic format. *DICONDE is based on and inherits from the universally adopted medical standard, DICOM, which facilitates the interoperability of imaging equipment through data storage and network communication protocols.*
digital	The representation of data or physical quantities in the form of discrete codes, such as numerical characters, rather than a continuous stream.
digital image	An image composed of discrete pixels each of which is characterized by a digitally represented luminance level.
digital detector array (DDA)	An electronic device that converts ionizing or penetrating radiation into a discrete array of analog signals that are subsequently digitized and transferred to a computer for display as a digital image corresponding to the radiologic energy pattern imparted upon the input region of the device.
digital radiography	All radiography methods whereby images are in a digital format — for example CR, CT, DDA, and digitized film.
frame	The data resulting from a single readout period of a digital detector system. *An image can be made up of a single or multiple frames.*
frame averaging	A method of noise reduction in which multiple single frame images are combined pixel-by-pixel to form a single averaged image.
frame rate	The number of frames acquired per unit time for an imaging system. *Typically reported as the number of frames per second.*

Term	Definition
image data file	A digital file containing radiological image and text information.
image processing	A method whereby digital image data is transformed through a mathematical function.
noise	The data present in a radiological measurement that is not directly correlated with the degree of radiation attenuation by the object being examined.
pixel	The smallest addressable element in an electronic image.
pixel size	The length and width of a pixel.
pixel value (PV)	The numeric value of a pixel in a digital image.
recording medium	A film or detector that converts radiation into a visible image.
scintillators	A detector that converts ionizing radiation to light.
signal	The data present in a radiological measurement that is directly correlated with the degree of radiation attenuation by the object being examined.

Table 2: Basic Computed and Digital Radiography Terms - Reprinted, with permission, from ASTM E1316-25b, Standard Terminology for Nondestructive Examinations, copyright ASTM International. A copy of the complete standard may be obtained from https://store.astm.org/e1316-25b.html

For our readers interested in expanding or reinforcing their knowledge on NDE and radiography terms, a series of five white papers is available in this subject at:

https://www.carestream.com/en/us/nondestructive-testing-ndt-solutions/ndt-white-papers

Figure 1: Carestram NDT's Series of White Papers on Radiography-related terms.

RT 101 – How Does Film Radiography Work?

Film technology has worked well for decades because it takes advantage of an electron intensification process obtained through the use of lead screens. This is especially true at higher energy and dose levels. **Film remains relevant today in industrial radiography,** even though it is almost completely gone from medical radiology and consumer photography.

Films designed specifically for industrial applications were produced starting in the early 1940's. As the silver halide grains were made smaller and the coated layer was made thinner, the films became photographically slower. Table 3 provides an overview of Carestream film types and their classification according to three different standards prevalent in different geographic regions.

Carestream NDT Film Product	Film Speed	USA Classification ASTM E1815	World / Europe Classification ISO 11699-1 / EN 584-1	Japan Classification JIS K7627
INDUSTREX DR50 Film	50	Special	C1	T1
INDUSTREX M100 Film	100	Class I	C2	T1
INDUSTREX MX125 Film	125	Class I	C3	T2
INDUSTREX T200 Film	200	Class I	C4	T2
INDUSTREX AA400 Film	400	Class II	C5	T3

Table 3: Portfolio of Carestream NDT Film Products, from White [1].

Each time the film speed doubled, the exposure required to achieve the same density was halved. Slower films have improved sharpness and graininess. Film has a light-sensitive emulsion coated on both sides of the blue-tinted 7-mil polyethylene terephthalate (PET) support. Industrex films can be used with direct X-rays and gamma rays and with lead intensifying screens. Class III films can also be used in conjunction with fluorescent or flourometallic screens. Table 4 provides the film system classification parameters from ASTM E1815.

System Class				Minimum gradient at:		Minimum gradient-noise ratio at:	Maximum granularity at:
World ISO 11699-1	Europe EN 584-1	USA ASTM E1815	Japan JIS K7627	D=2 above D_0	D=4 above D_0	D=2 above D_0	D=4 above D_0
				G_2	G_4	G_2/σ_D	σ_D
C1	C1	Special	T1	4.5	7.5	300	0.018
C2	C2	Class I	T2	4.3	7.4	230	0.020
C3	C3			4.3	6.8	180	0.023
C4	C4			4.1	6.8	150	0.028
C5	C5	Class II	T3	3.8	6.4	120	0.032
C6	C6	Class III	T4	3.5	5.0	100	0.039
		Class W-A	Class W-A	3.8	5.7	135	0.027
		Class W-B	Class W-B	3.5	5.0	110	0.032
		Class W-C	Class W-C	< 3.5	< 5.0	80	0.039

Table 4: Comparison of Film System Classification Parameters, from White [1].

Figure 2 presents the characteristic curves for the Industrex film family at specific ISO exposure conditions and M43 chemistry and processing conditions. The film systems exhibit very high contrast to achieve maximized density.

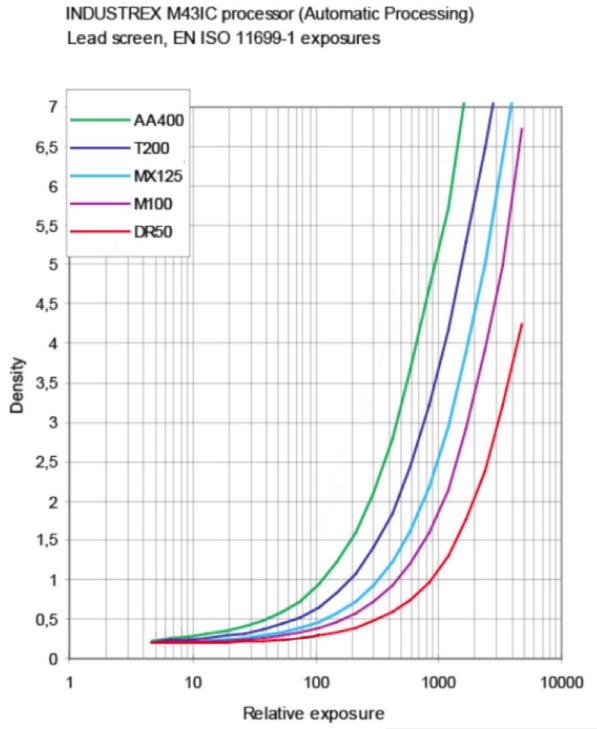


Figure 2: Density versus Log Exposure Curves for Carestream NDT's film products, updated and adapted from White [1].

Early radiography films were manufactured using photographic emulsions comprising polydisperse, polymorphic silver halide grains. These grains required additional chemical addenda and a high iodide content to produce an effect called "infectious development" to produce a film with high contrast. Because of the dispersity in grain surface area and surface chemical reactivity, it was difficult to chemically sensitize these grains uniformly, resulting in higher-than-desirable development process sensitivity, silver fog, and film granularity. Some modern films utilize tabular silver halide microcrystals because they are more efficiently spectrally and chemically sensitized and result in less silver content. The tabular grains exhibited a browner tone, less crossover, and required higher spectral dye levels. Figure 3 presents scanning electron micrographs of tabular silver halide grains for two emulsion types at two magnification levels. The silver bromo iodide tabular grains contained a small amount of iodide.

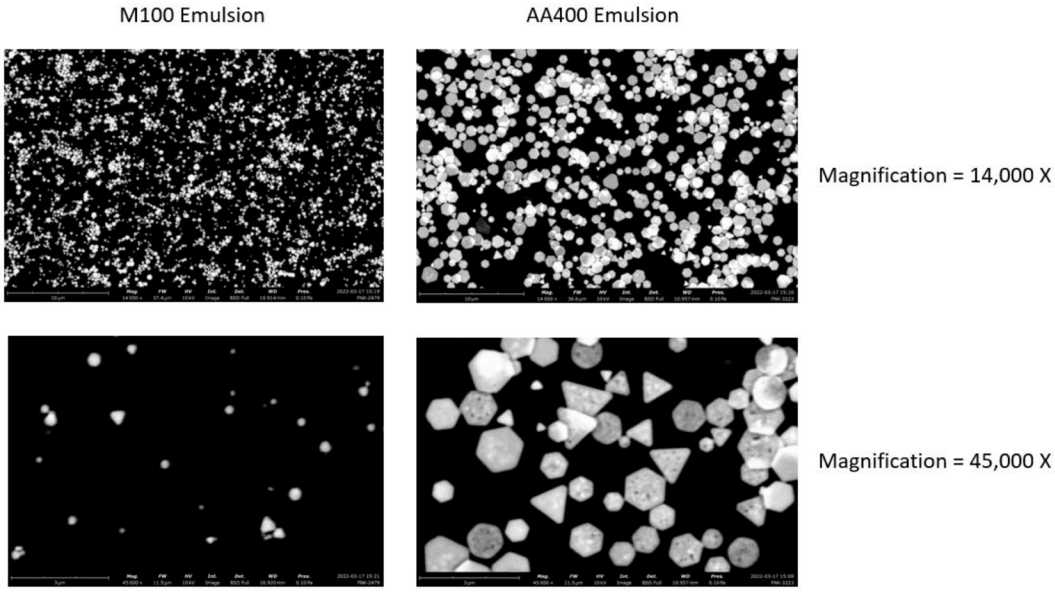


Figure 3: Silver Halide Grain Size Comparison, from White [1].

Silver crystals are precipitated in gelatin according to the following chemical reaction between Silver Nitrate and Sodium Bromide:

$$AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$$

The excess salts are washed from the emulsion after precipitation, and the crystals are chemically and spectrally sensitized. **The crystals have imperfections that give them useful properties; dislocations in the crystal lattice trap electrons as part of latent image formation.** When the film is exposed, two to three silver development centers must be formed for each crystal to form filamentary metallic silver at the time of development. The silver halide is reduced to metallic silver by a developing agent such as hydroquinone or ascorbic acid. Figure 4 presents a micrograph of filamentary silver as present in the developed film.

Figure 4: Developed Filamentary Silver, from White [1].

The formation of filamentary silver is the basis of the image and results in the optical density that is viewed on the lightbox. The developed density is proportional to the exposure that the film receives.

The major components of a film system are the film, the processor, the lightbox, and a densitometer. **Film advantages include excellent sensitivity due to electron intensification and high image resolution.**

Film's main advantages are that it is available in multiple speeds, has sharp contrast, is simple to use, thin, light, and can be cut to size. Film disadvantages include less contrast sensitivity relative to digital, approaching technology obsolescence, higher cost, limited exposure latitude, and an analog image.

Initiating the Immersion into the Digital Realm – How Does Computed Radiography Work?

Computed Radiography, or CR, was invented by George Luckey at Eastman Kodak in 1975. It is a transitional technology between the analog world of film and the electronics realm. Early system development was performed during the late 1980's and early 1990's and was focused on hardware (lasers, optics), digital computing electronics, and imaging plate (IP) development.

CR gained momentum in the early 2000's, with initial systems and the introduction of standards. In the late 2000's, key developments were the introduction of 25 µm pixel size, image processing, and imaging plate noise reduction. **Portability of CR systems followed with the introduction of readers that were less than 35 lbs.** CR has been successfully implemented in industrial radiography during the last decade; however, it has declined in medical radiology and has been replaced by DDA's, digital tomography, and computed tomography.

Figure 5 presents a schematic of the CR imaging process. **The system includes a phosphor imaging plate, a reader (a red laser that provides the energy for phosphors to emit blue light), a photomultiplier tube (which collects the light and amplifies the voltage), an analog-to-digital converter (digitizes the voltage), a computer (assimilates the digital image), suitable imaging processing software, and a monitor (image viewing).** The system may contain a printer for hard copy output or an image archive for searchable electronic storage.

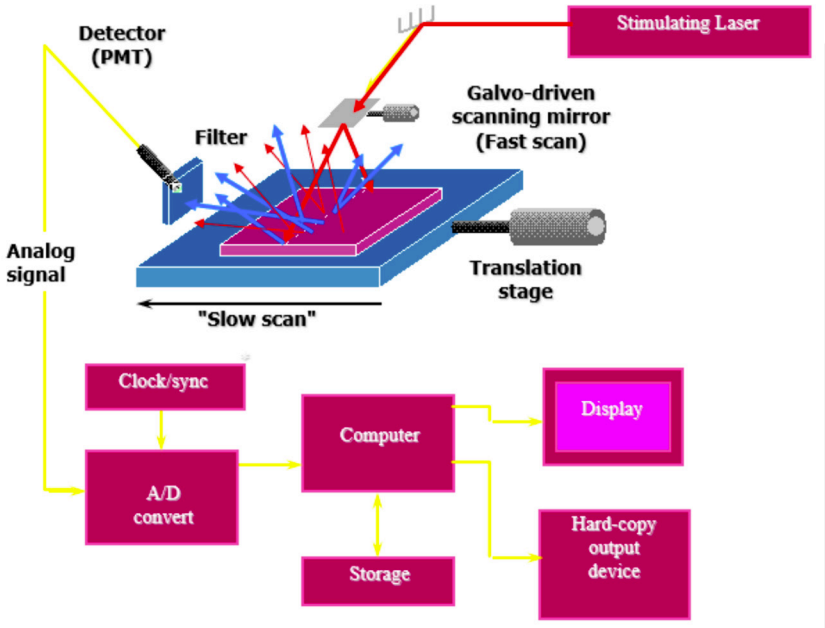


Figure 5: Computed Radiography Image Process, from White [1].

CR has many similarities with film; the same radiation sources are used, cassettes hold the detector, radiation generates a latent image, both produce an image with a similar appearance, and both require a series of processing steps. Film requires chemical processing and CR requires electronic processing. However, film benefits from lead intensifying screens, and because it is utilized only once, it is less susceptible to image artifacts. Film is viewed on a lightbox, whereby only the intensity of the lightbox can be adjusted. Digital images are viewed on a monitor as part of a system; the brightness and contrast can be adjusted, and image processing can be applied to improve the image quality.

Although both film and imaging plates function as detectors of radiation, they utilize different technologies to capture the image. A side view photograph of an imaging plate is presented in Figure 6. The overcoat protects the phosphors from the environmental elements; the phosphor is in the imaging layer, the support provides dimensional stability, and the backing layer provides halation and curl control.

Figure 7 provides a comparison of phosphor imaging plates to film. Phosphor plates have imaging layers that are much thicker compared to film. Industrial film is generally fabricated duplitized; this means that it has thin layers of silver halide crystals on both sides of the support. The imaging plates, in contrast to film, have thick layers that are only on one side of the support. The support used for plates is thicker to provide additional dimensional stability.

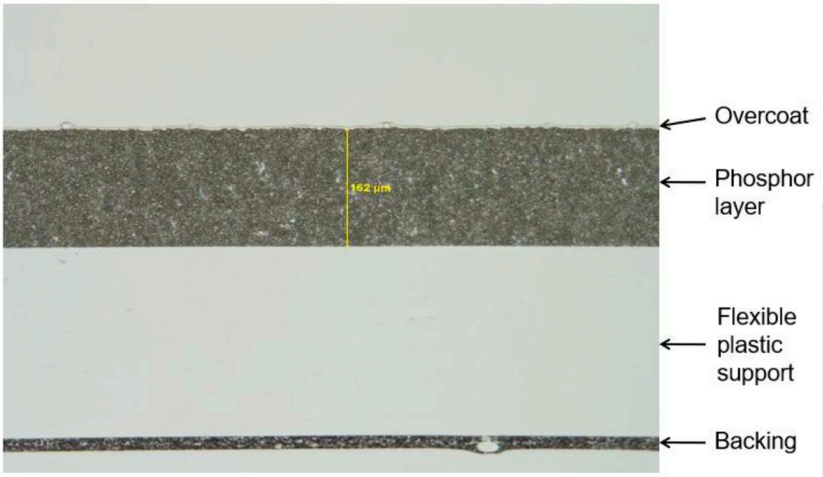


Figure 6: Cross Section of a CR Imaging Plate, from White [1].

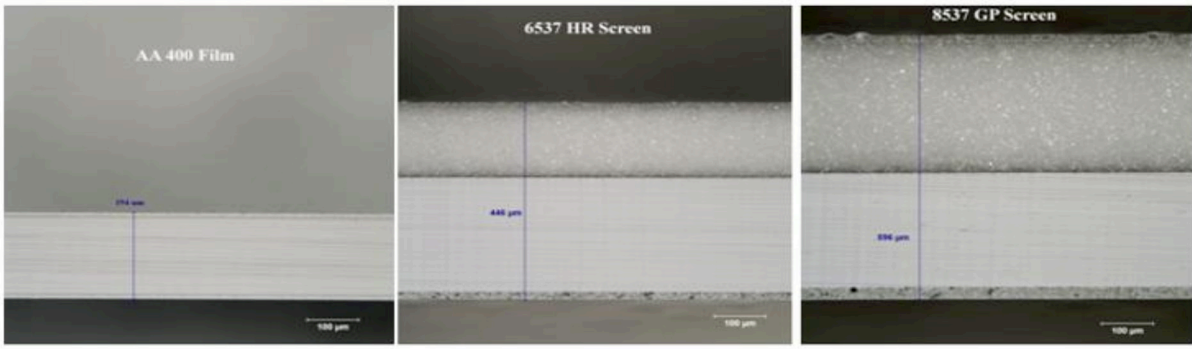


Figure 7: Cross-sectional Comparison of Film and Imaging Plate Technology, from White [1].

Figure 8 demonstrates the particle size difference between silver halide crystals and phosphors. The phosphors are much larger and are much more polydisperse, meaning there is a much greater range of sizes for the phosphors.

The process by which computed radiography phosphors glow with blue light is called Photostimulable Luminescence (PSL). When radiation attenuates through an object, electrons are excited in the imaging plate phosphors. A portion of electrons de-excite immediately, and others become trapped at crystal defect sites. Metastable electrons are excited to a higher energy state by red light upon scanning. When electrons fall back to lower energy levels, the Europium atoms release blue light. Blue light is the basis of the image and is proportional to the dose.

Imaging plates are segmented based upon their resolution capability. The higher the resolution, the lower the signal-to-noise ratio (SNR), and vice versa. Overall dose level impacts the image quality the most. Scatter is an important consideration for CR and must be controlled by incorporating lead screens.

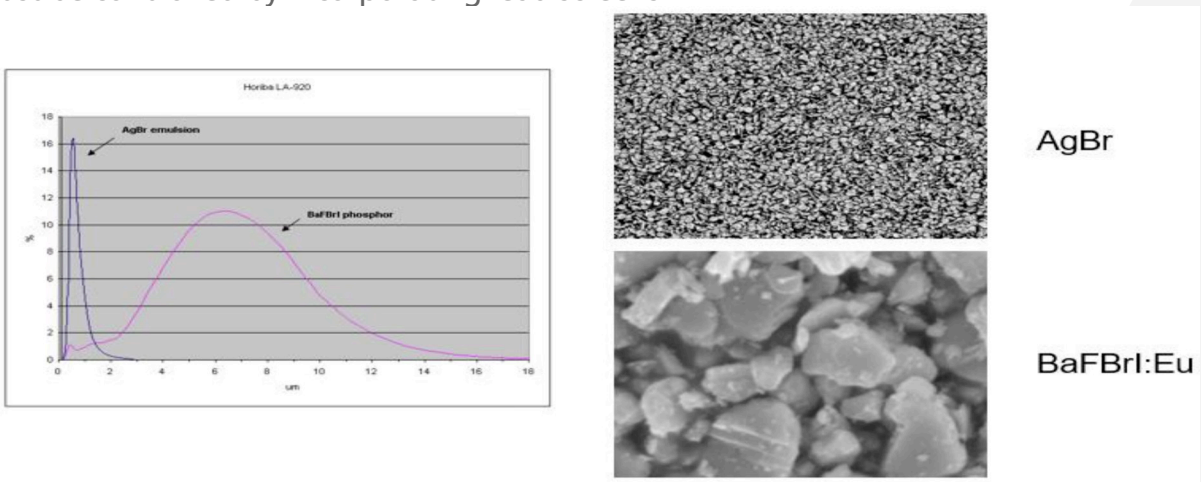
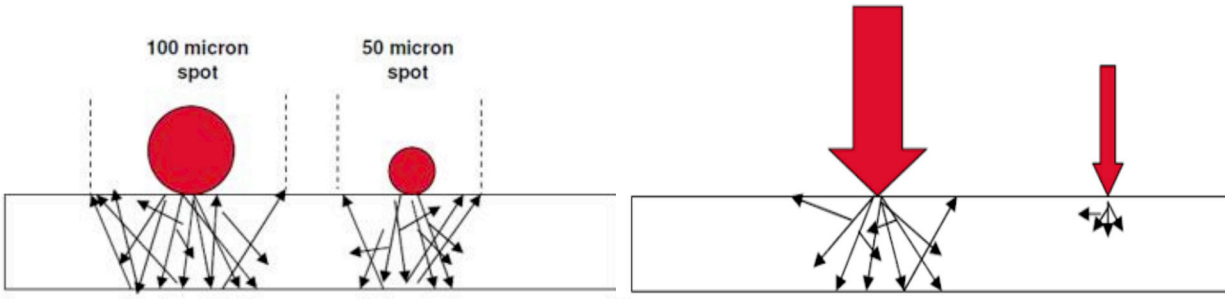


Figure 8: Particle size distribution of silver halide crystals versus phosphor crystals., from Brian White's Presentation "Imaging Plate Design and Use for Radiographic Nondestructive Evaluation" ASNT XVI Digital Imaging Conference, [4]

Figure 9a demonstrates the impact of laser spot size on the imaging layer. The larger the spot, more red light penetrates the imaging layer, resulting in worse resolution and improved SNR. The smaller the spot, the better the resolution, and the SNR is degraded.

Figure 9b demonstrates the impact of laser intensity on the imaging layer. The larger the intensity, the more red light penetrates the imaging layer, resulting in worse resolution and improved SNR. The smaller the intensity, the better the resolution, and the SNR is degraded.



a. Effect of Laser Spot Size **b. Effect of Laser Beam Intensity**

Figure 9: Visualization of the effect of Computed radiography process variables over industrial computed radiography imaging plates, adapted from White [2]

The photomultiplier tube (PMT) detects blue light and converts it into a voltage. The voltage is then amplified and sent through an analog-to-digital converter. Figure 10 demonstrates the impact of voltage amplification on the measured pixel intensity. The higher the amplification, the higher the pixel intensity for a given exposure level.

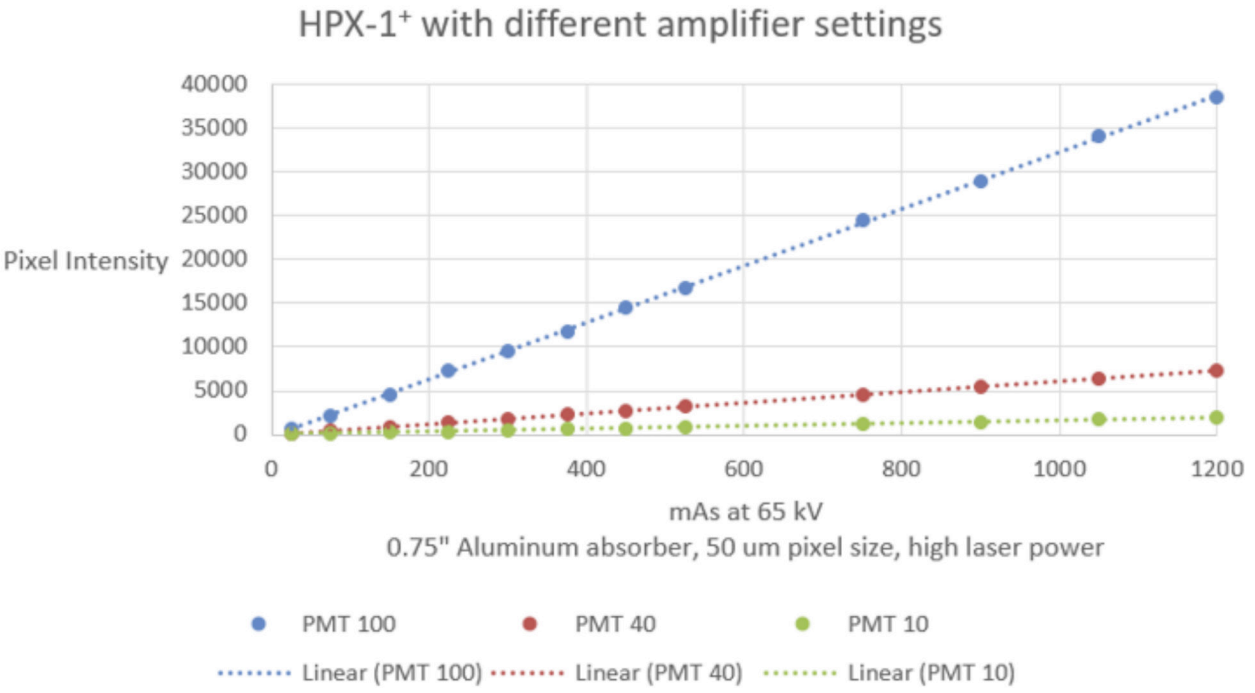


Figure 10: Impact of Photo-Multiplier Tube (PMT) setting on grey value, adapted from White [1]

As mentioned above, the pixel size is determined by the sampling rate of the scanner. Smaller pixel sizes result in improved resolution and degraded SNR. Larger pixel sizes result in worse resolution and improved SNR.

The major components of a CR system are the IP, the reader (laser, PMT, optics), the computer, the monitor, and the imaging software. CR advantages include digital images, digital metadata, contrast sensitivity, high-resolution options, reusable IP's, portable, thin, light, and IP's can be cut to size. CR disadvantages are imaging noise, IP artifacts, and the technology requires prominent levels of training and commitment.

Diving Deeper into the Digital Realm – How Does Digital Radiography Work?

Amorphous silicon (a-Si) indirect flat panel detectors were invented over decades of research and were made commercially available in the mid 1990's. Standards for the use of a-Si detectors in nondestructive testing applications were developed in the early 2000's. The initial industrial technology was tethered, had folded-out electronics with heavy shielding, was not portable, and had a large pixel pitch.

Digital detector arrays (DDA) now dominate medical radiology, dentistry, and security applications. The technology is mostly a-Si detectors; however, there are complementary metal oxide semiconductor (CMOS) with less than 100 µm pixel pitch. Figure 11 presents examples of commercially available DDA's for industrial radiography in both rigid and conformable types.

Figure 11: Examples of DDA Radiography Detectors, adapted from White [1]

Current industrial DDA's either have folded-out electronics or electronics behind the thin-film transistor (TFT) photodiode array. The pixel array can either be on glass or on polyimide substrates. Flexible detectors have entered the market to replace film and CR for single viewing applications. Industrial DDA's have additional shielding to protect the electronics from the high energy and dose levels often required compared to those used in health-related applications. They may be either tethered or wireless and may be battery-operated and portable. The scintillator is usually Gadolinium Oxysulfide Terbium activated (GOS) for industrial applications.

For high energy and dose, DDA lifetime has sometimes been an issue; however, additional shielding design has improved this concern. Detectors may produce static or real-time images. The advantages of DDA systems are improved image quality and productivity.

Figure 12 presents the principle of operation for indirect amorphous silicon detectors. X-rays or gamma rays cause the scintillator to glow with light; the photodiodes respond to the light and create electrons, and the TFT's store the charge. The voltage from each pixel is read out as an analog signal and is then digitized. The signal for each pixel is proportional to the dose that it receives.

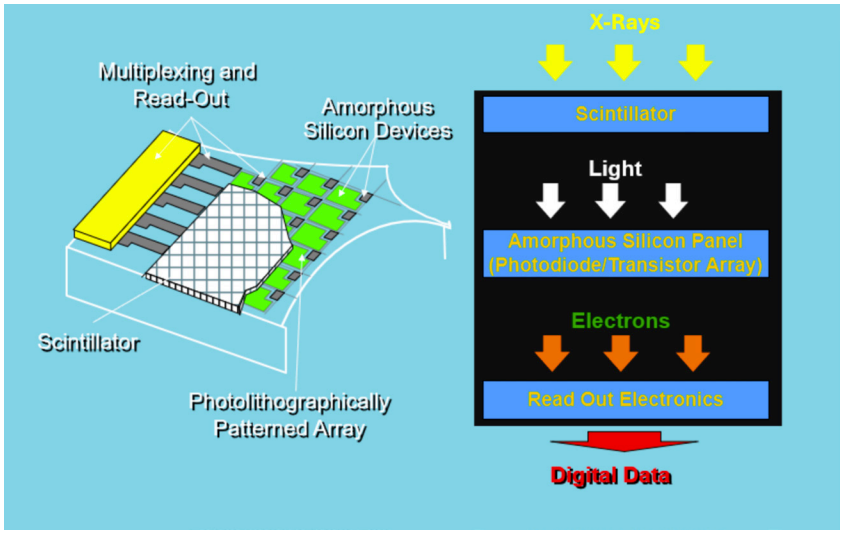


Figure 12: Amorphous Silicon (a-Si) Principle, adapted from White [1]

Figure 13 provides a cross-section for a typical GOS scintillator. The phosphor layer is coated on top of a thick reflective support for added dimensional stability. As radiation penetrates and attenuates through an object, it excites electrons in the photodiode array. This charge is stored in the TFT, the voltage is readout, then the analog signal is digitized. Each pixel's grey value is proportional to the radiation dose.

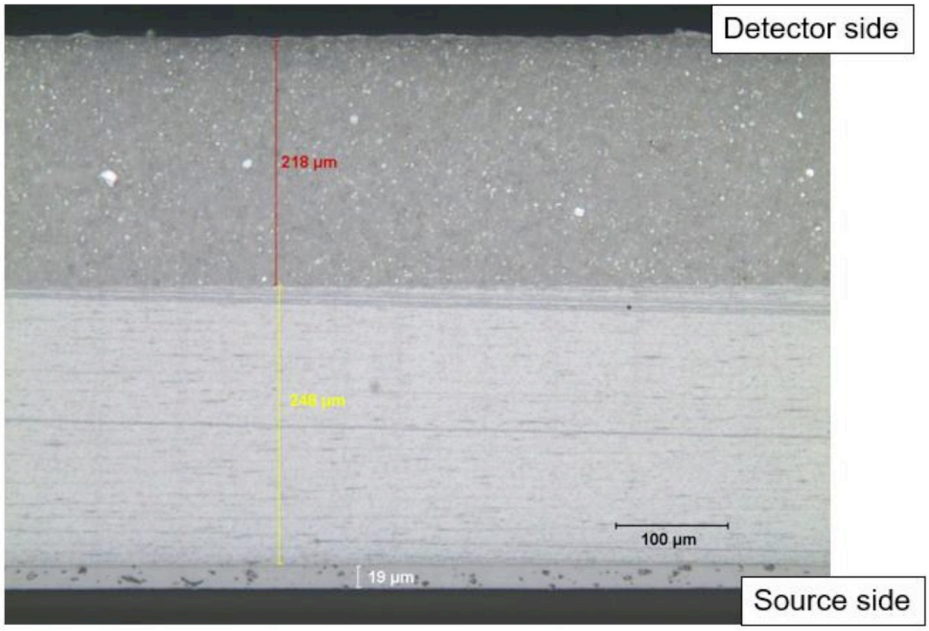


Figure 13: Cross-section Image of GOS Scintillator, adapted from White [1]

Table 5 provides information on commercially available GOS scintillators. The scintillator is chosen based on the resolution capability and pixel pitch of the detector. The thinner the phosphor imaging layer, the better the resolution, and the lower the brightness.

Scintillator Type	Supporting Layer (µm)	Phosphor Layer (µm)	Protective Layer (µm)	Total Tickness (µm)
DRZ High Resolution	250	70	6	326
DRZ Fine	250	110	6	366
DRZ Standard	250	140	6	396
DRZ Plus	250	210	6	466
DRZ High	170	310	9	489
DRZ PI200	170	420	9	596

Table 5: Geometric characteristics of DRZ Gadolinium Oxysulfide Terbium (GOS) Scintillators employed in the manufacturing of DDAs for Digital Radiography Imaging processes, adapted from White [1].

Table 6 provides a comparison of four available Carestream DDA types. The active area, size, weight, scintillator type, pixel pitch, image resolution, and array size are important aspects to consider when choosing a detector for a specific application. Detectors are typically segmented by resolution capability and size.

Specifications	DIGITAL RADIOGRAPHY PRODUCTS			
	INDUSTREX HPX-ARC 1043 PH Digital Solution	INDUSTREX HPX-ARC 1025 PH Digital Solution	INDUSTREX HPX-DR 3543 PE Non-Glass Detector	INDUSTREX HPX-DR 2530 PH Non-Glass Detector
Active Area (cm)	10 x 43	10 x 25	35 x 43	25 x 30
Size (cm)	13.0 x 49.0 x 2.7	13.0 x 31 x 2.7	38.3 x 45.9 x 1.5	28.2 x 33.2 x 1.5
Weight (lbs)	5.7	4.2	11.9	6.8
Scintillator	CSH Fine	CSH Fine	DRZ Standard	DRZ Fine
Pixel Pitch (µm)	98	98	139	98
Image Resolution (µm)	107	107	142	103
Array Size (pixels)	1008 x 4336	1008 x 2544	2544 x 3056	3056 x 2544
Image Size (MegaPixels)	4.37	2.56	7.77	7.77
Type	Flexible	Flexible	Rigid	Rigid

Table 6: Portfolio of Carestream NDT Digital Radiography Products, from White [1].

Figure 14 compares the pixel intensity response as a function of dose for the four DDAs included in the previous table. As the pixel pitch decreases, the resolution improves; however, the fill factor decreases, which results in the need for additional dose. In addition, as the scintillator thickness is decreased, an additional dose is required to get to the same pixel intensity for a given dose level. Both the fill factor and scintillator type result in the resolution dose trade-off.

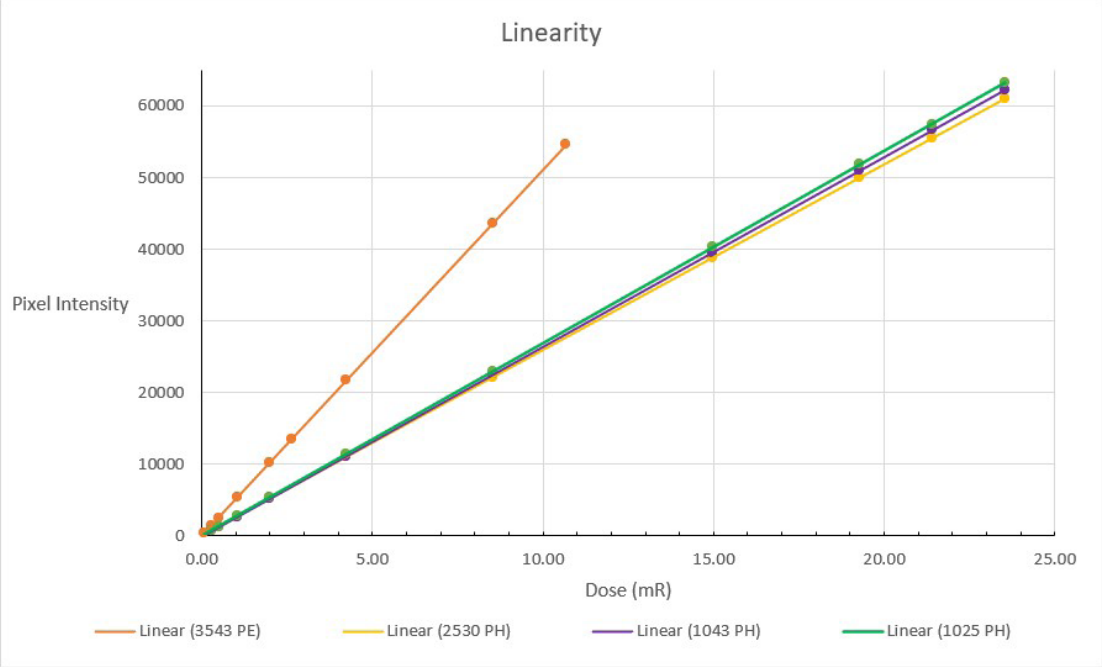


Figure 14: Linear proportionality between applied dose and pixel intensity obtained in Carestream NDT Series of Products for Digital Radiography, adapted from White [1]

Acceptable image quality requires that the DDA corrections be executed properly. Offset correction is done without radiation and subtracts the signal response from a baseline level. Gain correction is a flat field image with radiation that normalizes the pixel response across the entire active area. A bad pixel map correction is the process of replacing values for nonconforming pixels at specific locations with values from neighboring pixels. Pixel maps can have correctable bad pixels, non-correctable pixels, correctable non-relevant clusters, non-correctable relevant clusters, and correctable single lines or non-correctable multiple lines. Bad pixels may be non-responding, under-responding, over-responding, noisy, non-uniform, persistent, laggy, have a bad neighborhood, or may fall outside a specified range.

The major components of a DR system are the housing, scintillator, TFT photodiode array, shielding, electronics, the computer, monitor, and the software. **DR advantages include digital images, digital metadata, contrast sensitivity, image quality, productivity, portability, and artifact correction.**

DR disadvantages are replacement cost, offset temperature dependence, moisture sensitivity, weight, thickness, and the technology requires prominent levels of training and commitment.

Enriching Imaging Ecosystems and Leveraging Digital Platforms

Radiographic Film, Imaging Plates (IPs) for Computed Radiography (CR), and Digital Detectors Arrays (DDAs) for Digital Radiography (DR) offer a rich palette of imaging capabilities that range from the carefully controlled environment of an R&D laboratory to the harsh and often hostile environmental conditions of field applications in an offshore platform.

Competitive and sustainable imaging operations must have not only a clear perspective of the constituents of their imaging ecosystem, as is shown in Figure 15, but also of the role that any supporting imaging software platform should have to streamline the capture, analysis, transmission, storage, and preservation of trustworthy images. A vendor-independent DICONDE-compliant imaging platform ensures that technological advancements in imaging media, hardware, and software create a positive synergetic effect on the rest of the constituents of the imaging ecosystem; here, the importance of establishing a proper alignment between the adoption of advancements in recording media technology, imaging platforms, computing hardware, and the technical requirements integrated into codes and regulations.

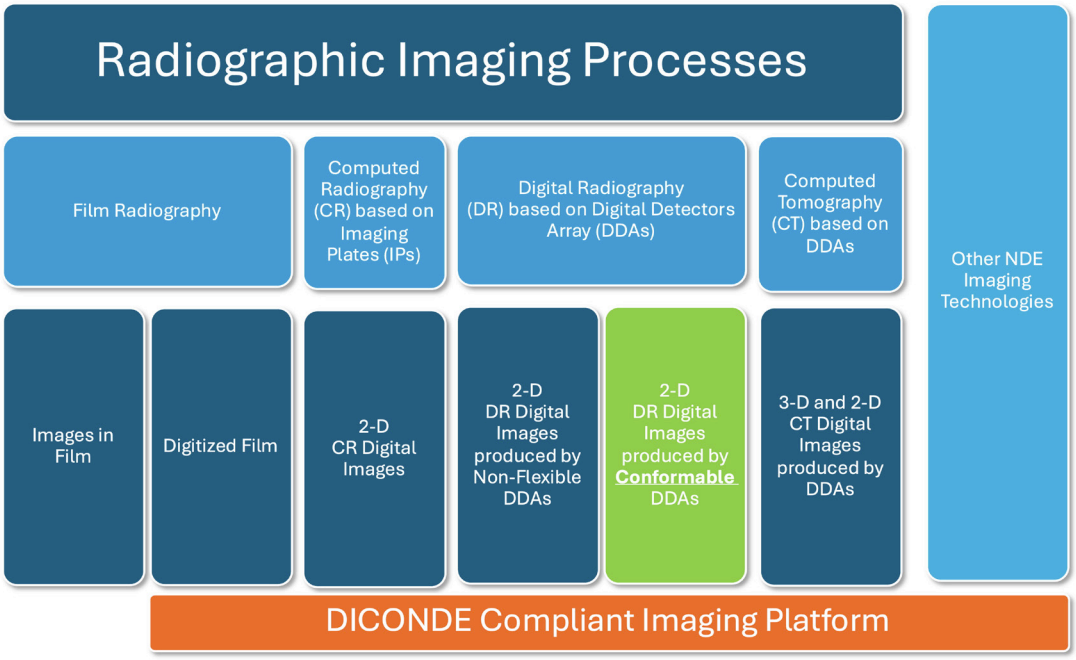


Figure 15: Radiographic NDE Imaging Ecosystem Diagram, adapted from White [2]

The incorporation of digital technology necessitates a comprehensive evaluation of the upfront investment costs associated with specific imaging technologies. This evaluation should also consider the image quality requirements imposed by applicable regulations, the workflow productivity enhancement resulting from the investment, and the cost per image associated with the technological investment.

By considering these factors, a well-informed and trustworthy decision can be made.

The historic overview in this white paper aims to enhance and enrich your perspective on how radiographic imaging technologies have evolved and contribute to making a more informed decision that will ultimately enrich and evolve your imaging capabilities.

- For readers interested in exploring how to enrich and diversify their own NDE imaging ecosystems:

  https://www.carestream.com/en/us/nondestructive-testing-ndt-solutions

Here are some supplementary information resources from Carestream NDT's products and services portfolio:

Showcased Products:

- INDUSTREX Film for Non-Destructive Testing
- INDUSTREX Photochemicals
- HPX-PRO Portable Digital System
- INDUSTREX HPX-1 Plus Digital System
- INDUSTREX Flex HR AP and XL Blue G2 Digital Imaging Plates
- INDUSTREX HPX-ARC 1025 PH Digital Solution
- INDUSTREX HPX-ARC 1043 PH Digital Solution
- INDUSTREX HPX-DR 3543 PE Non-Glass Detector
- INDUSTREX HPX-DR 2530 PH Non-Glass Detector
- INDUSTREX Fieldview Tablet
- INDUSTREX Digital Viewing Software

Services - Training and Supplementary Resources:

- Advanced Industrial Radiographic Training Academy
- Resource Center
- Virtual NDT Showcase

References:

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10. Takahashi, K., "Mechanism of Photostimulated Luminescence Process in BaFBr:Eu2+ Phosphors", Journal of Applied Physics, Volume 33, pp. 178-185, 1994

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