CarestreamNDT

WHITE PAPER

# Throwing light over Computed Radiography myths through sound and practical Imaging Plates information.

# 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.

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# Digital transformation of computed radiography processes

Computed radiography (CR) is publicized in general NDE advertising literature as a substitutive process to film radiography that employs the same technical support elements such as cassettes, screens or radiation sources, and where imaging plates (IP) substitute radiographic film and a scanner/computer system substitutes the chemicals involved in radiographic film development processes. In our experience, this simplistic and substitutive approach is often at the core of many failed CR deployment initiatives.

Understanding the fundamentals of CR, including the differences in performance, handling and care of IP, compared with radiographic film, will facilitate the evaluation and integration of CR technology to routine NDE imaging workflows by making informed decisions related to: a) which steps in the imaging process will remain unaltered after digital transformation as with film radiography; and b) which other steps need to be integrated, modified or eliminated due to the specific requirements, distinctiveness and limitations of CR technologies.

Schallmo, Williams and Boardman in [1] highlight not only the importance of an industry-wide perspective of digital transformation processes, but also the ineludible necessity of an intimate knowledge of the processes and technologies involved as follows: *"The digital transformation framework includes the networking of actors such as businesses and customers across all value-added chain segments, and the application of new technologies. As such, digital transformation requires skills that involve the extraction and exchange of data as well as the analysis and conversion of that data into actionable information. This information should be used to calculate and evaluate options to enable decisions and/or initiate activities. In order to increase the performance and reach of a company, digital transformation involves companies, business models, processes, relationships, products, etc."*

They propose a five-stage roadmap for digital transformation, as shown in Figure 1, that guides the transition from digital reality and digital ambition to digital implementation. This transformation process starts with the analysis of the digital reality that includes the sketching of current processes, a value-added analysis of those processes and the surveying of customers' requirements. Those three activities — which form the core of digital reality analysis — are ineludible before adopting CR for your imaging process to avoid that digital ambition outnumbers the digital potential and digital fit resulting in digital implementation failure.

# A Digital Transformation Roadmap


**Figure 1**: A five stages roadmap proposed for the digital transformation of imaging processes, Adapted from Schallmo, Williams and Boardman [1]

## Computed radiography sustainability 101

As we explained in a previous article in this series, digital imaging, including computed radiography, is inexorably linked to technologies that allow the digitization of analog signals and also to the advances and evolution of digital information systems and telecommunication technologies related to the capture, storage, processing, retrieving, transmission, analysis and displaying of information. Today it is completely feasible through affordable computing devices transporting, storing and displaying computed radiography images that were technologically and economically challenging merely three decades ago.

ASTM E1316 "Standard Terminology for Nondestructive Examinations"[3] defines computed radiography as *"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."*

Proper handling and care of imaging plates should be exerted along every stage of the process in order to obtain satisfactory results in computed radiography. Also, appropriate knowledge of the structure of both radiographic film and imaging plates is indispensable to support their adequate handling and care. Table 1 includes data of layer thicknesses for some industrial imaging plate types compared with the layers that constitute an industrial film.

| Plate | Total Thickness (µm) | Overcoat (µm) | Phosphor (µm) | Support (µm) | Backing (µm) |
|---|---|---|---|---|---|
| GP | 584 | 11 | 290 | 254 | 29 |
| HR | 436 | 4 | 160 | 254 | 18 |
| Blue | 436 | 4 | 160 | 254 | 18 |

| Film | Total Thickness (µm) | Overcoat (µm) | Emulsion (µm) | Support (µm) | Emulsion (µm) | Overcoat (µm) |
|---|---|---|---|---|---|---|
| AA400 | 196 | 1 | 8 | 178 | 8 | 1 |

**Table 1**: Layer thicknesses for some industrial imaging plate types vs. an industrial film, from White, B. [4]

Figure 2 provides a general description of the structure and constituent layers for both imaging plates and radiographic film through cross-sectional diagrams.

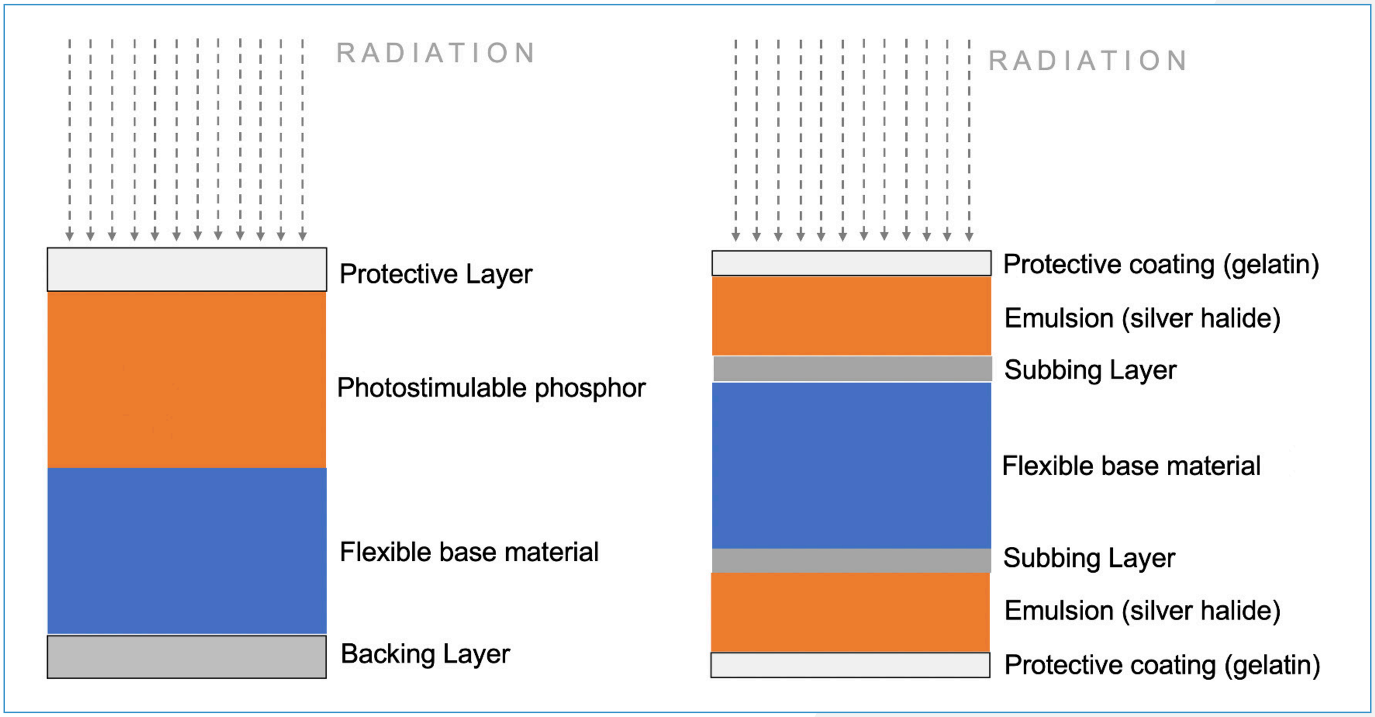


**Figure 2**: Cross-sectional diagrams for imaging plates (left) and radiographic film (right), adapted from ASNT [2] and White, B. [4] and [5]

# Debunking myths in CR through comparative tests results

A prevalent myth related to CR processes and IP is the still-enduring perception that radiographic film durability per dollar paid is superior to imaging plates.  Another prevalent myth is the frailty and artifacts susceptibility of imaging plates under regular radiographic imaging procedures.

In 2013, Brian White, Research Scientist and Level III Radiographer at Carestream NDT, led a set of comparison tests of specific parameters that affect durability for imaging plates and radiographic film [4] [5]. The objectives of those comparison tests were: a) to compare the durability of computed radiography imaging plates to analog film; b) to describe the key differences between digital and analog radiography, and how those differences influence perceptibility; and c) to provide usage criteria and guidelines for maximizing imaging plate lifecycle. Both his white paper and associated presentations are available at ASNT's Digital Library here; the content is worthy of a detailed analysis if you are interested in this topic. We would like to share his most relevant findings, which are included in Table 2.

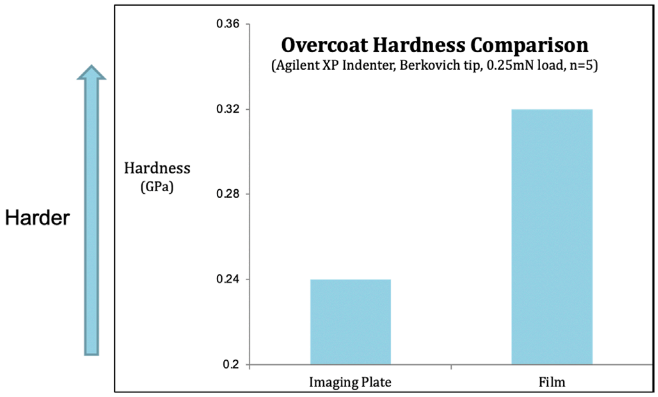


**Figure 3a**:
Presents the hardness results for an industrial imaging plate versus an industrial film. Film overcoats are thinner and harder than imaging plate overcoats. Therefore, film is less susceptible to marring and indentation relative to imaging plates. Imaging plate marring can result in overcoat damage, which influences both the red laser stimulation and blue light collection optics in the reader. Imaging artifacts from marring can be seen in the digital image. Because film is harder than imaging plates, it is also more brittle.

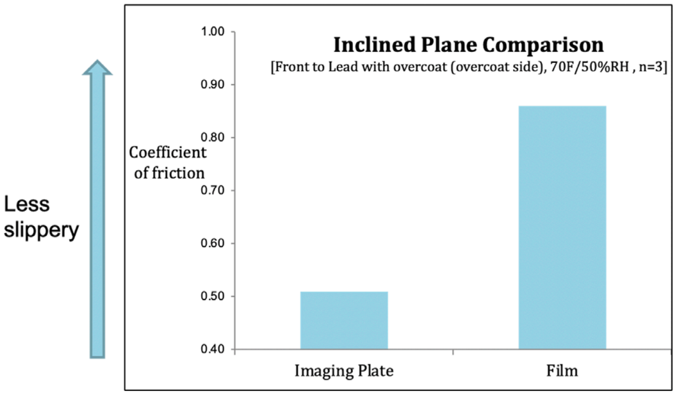


**Figure 3b**:
Imaging plate overcoats have lower coefficient of friction relative to film overcoats. Figure 3(b) demonstrates this result for a representative industrial imaging plate versus an industrial film. The surface of the imaging plate was more slippery than the film surface.

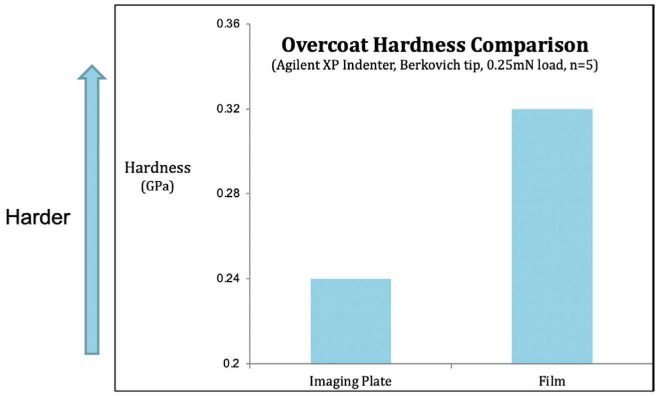


**Figure 3c**:
Provides an assessment of nanoscratch performance for an imaging plate versus a film. The film failed sooner, with lighter loads, than the imaging plate. This may seem counterintuitive relative to industry perception; however, because film is more brittle and the overcoat layers are thinner, fracture and delamination occur more quickly for films relative to imaging plates.

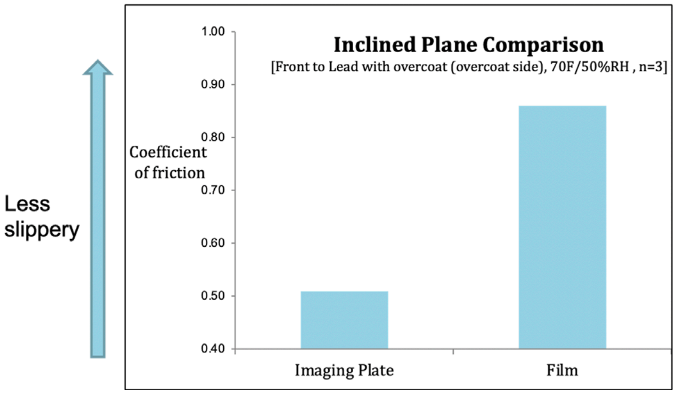


**Figure 3d**:
Provides an assessment of microscratch performance for an imaging plate versus film. The film failed faster at lower stylus weight than the imaging plate. Once again, the thinner film overcoat and brittleness resulted in failure more quickly than imaging plates.

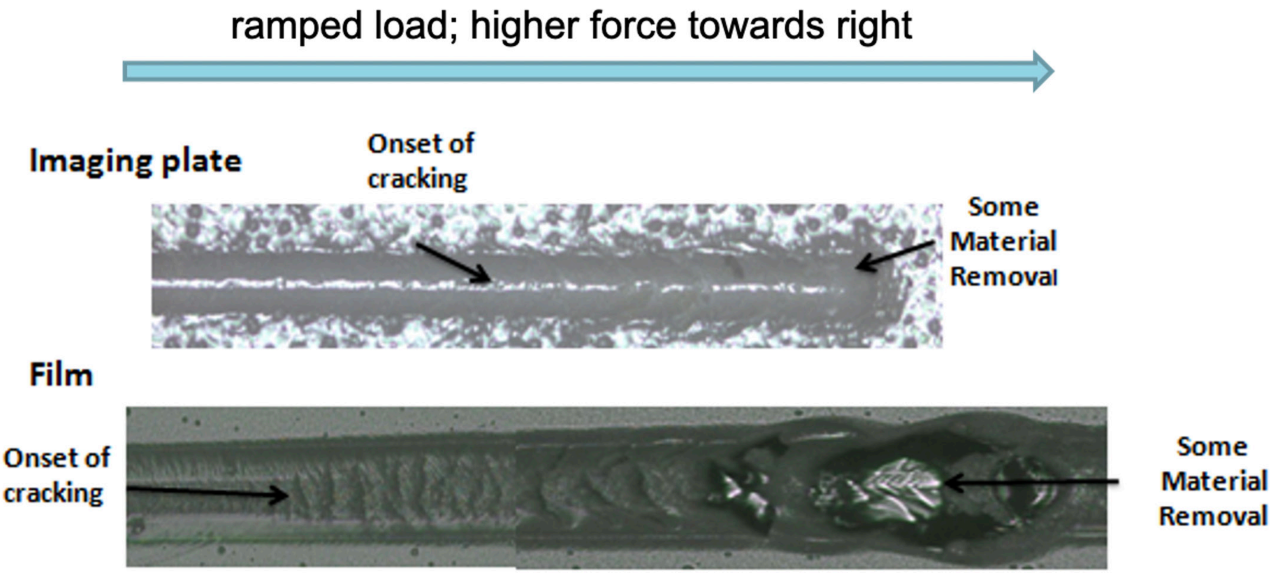


**Figure 3e**:
Provides an assessment of microscratch performance for an imaging plate versus film. The film failed faster at lower stylus weight than the imaging plate. Once again, the thinner film overcoat and brittleness resulted in failure more quickly than imaging plates. In everyday radiographic inspection processes, imaging plate abrasions are a result of contact with lead scatter control screens as the major contributor towards artifact formation.

**Figure 3 –** Layer thicknesses for some industrial imaging plate types vs. an industrial film, from White, B. [4]

## Conclusions derived from the test results obtained

The conclusions obtained from White's comparative reliability study are resumed in Table 3. They provide supplementary information that imaging plates can be more durable per use than radiographic film, if IP usage criteria restrictions are respected and guidelines for maximizing imaging plate life are followed.

| Table 2 - Conclusions derived from reliability comparative tests. |
| --- |
| 1. Industry perception is that film durability per dollar paid is superior to imaging plates. The reality is that **imaging plates can be more durable per use than film depending upon the usage conditions.** |
| 2. Film overcoats are thinner and harder than imaging plates, which makes them more resistant to marring, however film is more brittle, which causes delamination. **Film scratches more quickly than imaging plates.** |
| 3. **Imaging plates have a lower coefficient of friction than film, which makes them more slippery.** |
| 4. **Physical imperfections are more easily seen in digital images due to the ability to adjust contrast, brightness, apply image processing and utilize zoom magnification.** Imaging plate durability defects are more easily seen as a result of the digital image enhancement. Industry perception is also affected because imaging plates can be utilized for thousands of testing cycles. Since film is utilized only once, it has only one chance to be damaged. |
| 5. **Imaging plate image quality is rarely impacted by peroxides, moisture, ultraviolet radiation and ozone gas;** only extreme circumstances will cause chemical damage to occur. **Proper usage criteria and guidelines must be exercised for maximized plate life.** Under normal use conditions, an imaging plate can be utilized for a long period of time. |

## How you can use the information of this document in your everyday activities

The primary most prevalent and damaging imaging plate artifact that we see are abrasions caused by lead screens in contact with the front surface of the imaging plate. Here are some practical usage criteria and care guidelines derived from the results of the test discussed above [4] [5] that you can begin to use now. Both sets of elements constitute a sound foundation for the digital transformation of your CR deployment and improvement processes.

| Table 3 - Usage Criteria for Imaging Plates |
| --- |
| 1. Imaging plates are flexible detectors that are designed for thousands of use cycles under a defined set of conditions.<br>2. The film and imaging plate physical properties are similar, however because film is only used once and imaging plates are used hundreds or thousands of times, the result is that plate durability is a concern while film durability is not.<br>3. The lifetime of plates is primarily determined by the care in handling and environmental operating conditions.<br>4. Under normal conditions, imaging plates eventually will show wear.<br>5. Plate wear can result in artifacts in the digital image. This may occur from abrasion of the protective overcoat or inadvertent physical damage to the surface or edge.<br>6. Proximity to certain chemical agents also may damage the plates. |

| Table 4 - Guidelines for maximizing imaging plates life |
| --- |
| 1. When not in use, imaging plates should be kept in a dark and dry environment. Avoid getting the plates wet and do not store them in extreme humidity.<br>2. Imaging plates shall be handled by the edges; for best results, wearing cloth or rubber latex gloves is highly recommended.<br>3. Do not bend an imaging plate to the point that it creases and kinks.<br>4. Imaging plate durability for practical use is acceptable at temperatures as low as –22°F (–30°C) and as high as 120°F (49°C).<br>5. Avoid exposure to extreme surface temperatures above 100°C in the examined materials, as the overcoat and phosphor layer polymers begin to melt above that temperature.<br>6. If possible, avoid moving imaging plates against abrasive materials.<br>7. Avoid placing IQI targets or parts directly on the imaging plate surface as this can cause scratches.<br>8. Cleaning should be performed infrequently. If needed, simply wipe the imaging plate with a dry lint-free cloth.<br>9. Only manufacturer-recommended cleaners should be used for specific imaging plate types. Some industrial cleaners contain oxidizers that can yellow imaging plates. Overcoat surfaces can experience various chemical reactions, depending on what type of solvent is applied. |

For our readers interested in the explore how computed radiography (CR) can be integrated to your processes: **https://www.carestream.com/en/us/nondestructive-testing-ndt-solutions**

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

***Products Featured:***

- INDUSTREX HPX-PRO Digital System
- INDUSTREX HPX-1 Plus Digital System
- FLEX GP, FLEX HR and FLEX XL Blue Digital Imaging Plates
- INDUSTREX Digital Viewing Software
- NDT Archive Solution

***Training Services:***

- **Advanced Industrial Radiographic Training Academy**
  Computed Radiography - 40 Hour Online Course
  Digital Imaging - 40 Hour Classroom Training

***Other Carestream NDT Resources:***

- Carestream NDT Virtual NDT Showcase
- Carestream NDT Resource Center

***Resources from ASNT:***

- Radiographic Interpretation, Revised Edition 2020: https://www.asnt.org/Store/ProductDetail?productKey=826c3c22-42a3-4250-9040-913d40aa0946
- Nondestructive Testing Handbook, fourth edition: Volume 3, Radiographic Testing: https://www.asnt.org/Store/ProductDetail?productKey=83ea27b3-d68f-483d-9354-e447ef2b3915


**References:**

1. Schallmo, D., Williams, C. A., & Boardman, L. (2020). Digital transformation of business models—best practice, enablers, and roadmap. In Digital Disruptive Innovation (pp. 119-138).
2. ASNT, (2019), Nondestructive Testing Handbook, fourth edition: Volume 3, Radiographic Testing, Chapter 8, Pages 259-276 Columbus, OH, American Society of Nondestructive Testing.
3. ASTM (2021), ASTM E1316 – 21a, Standard Terminology for Nondestructive Examinations, West Conshohocken, PA, ASTM International, 2020.
4. White, B., (2013), Article " Digital Radiographic Imaging Plate Physical Properties ", 2013 ASNT Annual Conference.
5. White, B., (2013), Presentation "Digital Radiographic Imaging Plate Physical Properties" 2013 ASNT Annual Conference.





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