Advancements in CR Radiography:

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Abstract:

Digital Radiography using storage phosphor plates is known as “Computed Radiography” or CR for short. This “filmless” technique is for many applications an excellent alternative for traditional X-ray films. In addition to the reduced cost of consumables, CR-technology is more sensitive to radiation, thus requiring a lower exposure dose and shorter exposure times. The high dynamic range of CR makes it a ‘more forgiving’ technology than Film Radiography resulting in fewer retakes.

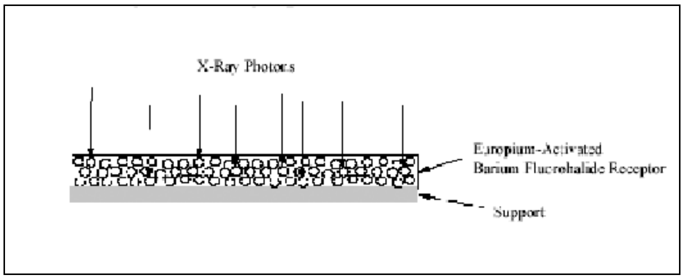
In 2005 the European Standard EN 14784 and the ASTM 2445/2446 and have been published. These standards describe a qualification method and a classification for CR systems - additionally CR was also adopted in ASME V. CR Technology is introduced in more and more applications for instance in the Oil & Gas and Chemical Industry (Corrosion monitoring, weld inspection) , in the Aerospace Industry (Castings Inspection) and in Security Applications.

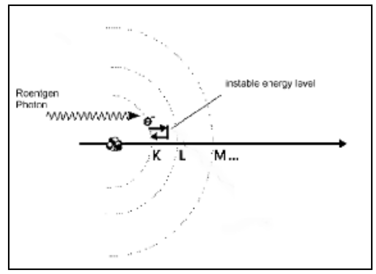
One of the main advantages of CR is the digital data format. Digital data give the user a better data access, allow for data sharing and networking, and they enable archiving easy data retrieval. This makes it possible for the user to rethink his data management and his workflow. With the current technology inspections and evaluations can for instance be done remotely. The adoption of the DICONDE data format in the NDT Industry will further promote the digital format.

GEIT has developed an NDT multimodal software platform for reviewing, analyzing, archiving and sharing digital inspection information. It can be configured for the specific user needs and contains application specific tools to improve efficiency and reproducibility of results. One example is the Wall Thickness Measurement Tool that was validated by the BAM Institute.

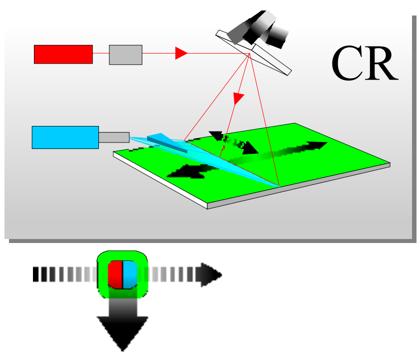
This presentation gives an overview of the current status of the CR Technology, the CR standards and some successful applications. It also shows some of the advantages and benefits that the software brings to the inspection process.

1. Introduction to Computed Radiography: CR is a two step process. The image is not formed directly, but through an intermediate phase as is the case with conventional X-ray film. Instead of storing the latent image in silver halide crystals and developing it chemically, the latent image with CR is stored (the intermediate phase) in a radiation sensitive phosphor layer.
The Image information is, elsewhere and later, converted into light in the CR-scanner by means of laser stimulation and only then transformed into a digital image. The phosphor layer consisting of fine grains has been applied to a flexible, transparent carrier and been provided with a protective coating.



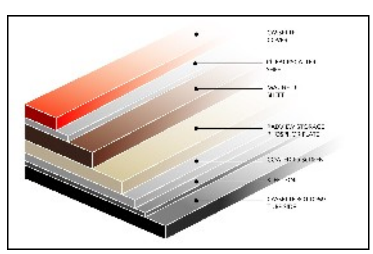


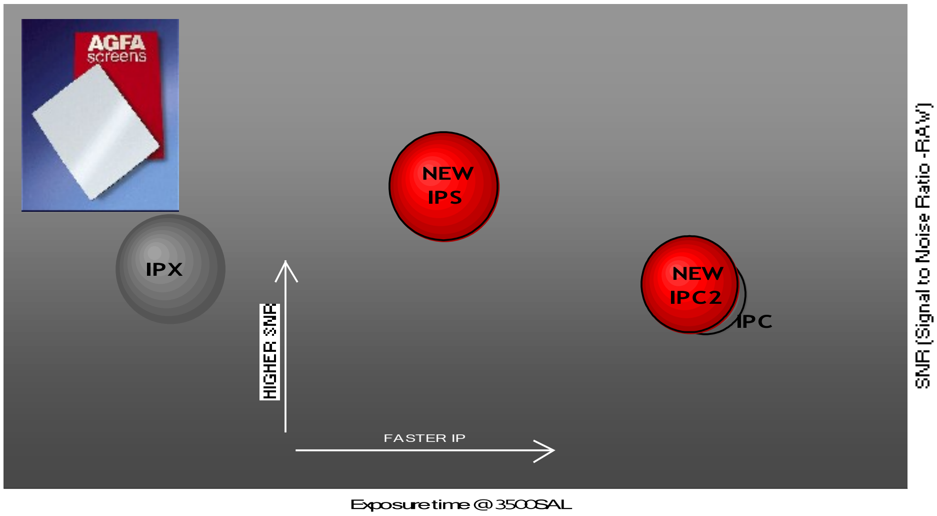
As a result of incident X-Ray or gamma-ray radiation on the storage phosphor, parts of its electrons are excited and trapped in a semi-stable, higher energy state. This creates the latent (invisible) image in the screen.



These trapped electrons can be released again by laser beam energy stimulation, causing visible (blue) light to be emitted, which then can be captured by a PMT (Photo-Multiplier Tube) and converted into a digital signal. This process takes place in the phosphor plate scanner.

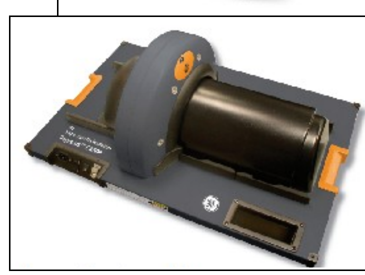
Speed of exposure and obtained image quality are strongly related with each other. That is why different application will have the need for different type of imaging plates. In applications where the main factor is the reduction of exposure time (typically the on-stream applications, where wall thickness of tubular pipes is measured, and Agfa D7 film – like defect recognition is required), the standard storage phosphor screens can be used. This will result in exposure dose reduction of a factor 10 compared to traditional film. If the defect recognition becomes more important, the premium image quality storage phosphor plates can be used for sharper and higher quality. The specially designed NDT cassettes with or without built-in lead sheets avoid any unnecessary plate handling, increasing the lifetime by 3 times.





2. CR-Scanner assortment:

The CRxTower digitizer has been designed for utmost convenience in digitizing 15x30cm, 20x25cm, 20x30cm and 35x42cm imaging plates at an optical resolution of 50 microns. The practical cassette system limits the handling of the plates to a minimum. The cassette is placed in the scanner's input tray. The internal mechanism brings the cassette in place, takes the plate out of the cassette, transports it to the scanner unit, erases the plate after scanning and places the plate back in the cassette. The cassette is then unloaded from the scanner, ready for the next exposure.



CR50P and CR50XP are both portable computed radiography scanners (22kg (14kg)) that are light and compact enough to be used for on-site inspections at remote locations. They are the first field portable scanners in the GE Inspection Technologies portfolio with 50µm scanning capability, and are ideal for applications requiring both high throughput and high resolution. For applications where speed and efficiency are of the essence, CR 50P and CR50XP really perform. The ability to manage custom sized imaging plates (up to 35cm (30cm) width), makes it ideal for applications such as weld examination and inspection of castings in foundries. There's no waiting between plates, you can feed the next one in while the previous plate is still being scanned.

3. The digital radiography workstation:

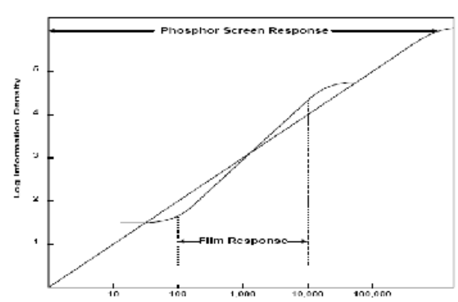
Rhythm Review is a powerful PC-based DICOM/DICONDE workstation platform which provides scalable image and data management solutions for non-destructive testing applications. The Rhythm Review workstation has an easy to learn and intuitive user interface and runs on the popular Windows 2000 or Windows XP operating systems, making it easy for anyone with basic PC skills to get started.

Designed for high throughput image examination and disposition, the software has been tailored specifically for industrial applications and complies with DICOM/DICONDE standards. The software layout and available controls can be configured for various classes of users, such as inspectors and supervisors. The configurable features include a configurable View port with variable magnifier for reviewing related images and making comparisons to a master image or historical data, a Pictorial Index (and Data Selector for rapid image identification) and workflow planning, observation documentation capability for reporting, a set of Tool tabs providing access to key functions, and Toolbars that provide single-click shortcuts to commonly used functions.

Rhythm Review allows for part specific image review techniques (including predefined sets of fixed grayscale, magnification, and filtering options) to be developed and optimized by supervisors, ensuring images are reviewed consistently and to minimize the reviewer's time.

4. CR Imaging provides many benefits compared to Traditional Film Radiography:

Computed Radiography examination requires lower exposure doses resulting in smaller safety perimeters, shorter plant shutdowns and longer isotope source life. If the same source activity is applied as with traditional film radiography, the exposure time can be dramatically reduced. Required technique for CR is more forgiven than for film as there is less risk for under- or overexposure. Because of the high latitude, different material thicknesses can be displayed in one single shot.



Once the digital image is available to the user, common imaging tools like contrast/brightness enhancement, panning, scroll and zooming are available for easier and faster analyzing of defect indications. Networking access and electronic distribution of digital images and data comes in

place. Digital data archive solutions provide efficient space utilization and facilitates intelligent data management.
When going CR, darkroom facilities are not required anymore. No more expensive film and chemicals consumption is required. No environmental issues with film and chemical disposal anymore. All of this can be taken into account for justification of the digital equipment purchase cost and in order to determine how fast the system will pay for itself considering future operating costs.

5. Available standards for Computed Radiography:

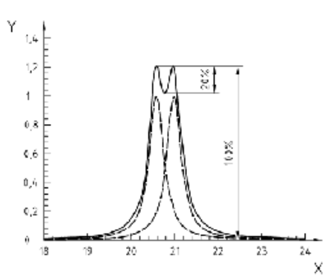
CEN Standards:
EN 14784 : Industrial CR with storage phosphor imaging plates
Part 1 : Classification of systems
Part 2 : General principles for examination of metals using X-rays and gamma rays

ASTM standards:
ASTM 2007-00 : Standard Guide for Computed Radiography
ASTM 2033-99 : Standard Practice for Computed Radiography
ASTM 2445-05 : Standard Practice for Qualification and Long-Term Stability of CR systems
ASTM 2446-05 : Standard Practice for Classification of CR systems
ASTM 2339-04 : Digital Imaging and Communication in NDE (DICONDE)

ASME standards:
ASME SEC.V Art.2 Appedix VIII: Radiography using phosphor imaging plates
ASME Code Case 2476: Radiography using storage phosphor imaging plates

Both EN 14784 and ASTM 2446 have defined a system classification characterized by the parameters "Normalized Signal to Noise Ratio" and "Basic Spatial resolution". Signal to noise ratio should be measured in accordance to the step wedge procedure where referred to and normalized with the spatial resolution of the system.

IP System classes			
System class CEN	System class ISO	System class ASTM	Minimum Signal-noise ratio
IP 1		IP-AS Special	130
IP 2	IP-T 1		117
IP 3			78
IP 4	IP-T2	IP-AS 1	65
IP 5	IP-T3	IP-AS 2	52
IP 6	IP-T4	IP-AS 3	43



For testing of basic spatial resolution, the duplex wire IQI (EN462-5) can be applied. The duplex wire shall be positioned directly on the cassette filled with digital imaging plate without object in between. Measurement shall be performed both perpendicular and parallel to the scanning direction of the laser beam. The first unresolved wire pair shall be taken for determination of the un-sharpness value corresponding to

EN462-5. This is the first wire pair that is projected with a dip between the wires of less than 20%.

BAM

Federal Institute for Materials Research and Testing

CR Imaging plate system

Certificate N°: BAM/ZBA/007/06

Hereby it is certified by the BAM Certification Body that the

Industrial CR Imaging plate system

with the designation

CR^x Tower

using imaging plates of type IPS

of the manufacturer

AGFA-GEVAERT N.V., Mortsel, Belgium

meets the requirements of the highest system class IP 1/100 according to EN 14784-1 and IP Special / 100 according to ASTM E 2446 for industrial computed radiography with phosphor imaging plates for non-destructive testing, if the exposure dose is at minimum 3.2 mGy. This dose corresponds to a CEN-Speed and ISO-Speed of 320. The maximum basic spatial resolution is 100 µm at 50 µm pixel scanning. Other system classes (CEN: IP 2 / 100 to IP6 / 100; ASTM: IP I / 100 to IP [illegible] / 100) can be reached with lower exposure dose values (see test report No. BAM VIII.3/8660 of 2006-08-15).

Certificate holder according to certification contract No. BAM-ZBA-0014-2006-GE IT:

GE Inspection Technologies GmbH, Hürth, Germany

The certification is performed on the basis of certification contract N° BAM-ZBA-0014-2006-GE IT according to standard DIN EN 45011 (1998) and comprises a design type test (BAM Certification System [illegible]).

The products certified by BAM may be labeled with the BAM certification mark „BAM Baumustergeprüft" and/or "BAM Design-type tested" together with the certificate number.

The certificate has a validity of 1 year, beginning with the date of issue.

On behalf of Bundesanstalt für Materialforschung und -prüfung (BAM)
Unter den Eichen 87, 12205 Berlin, **2006-08-14**

Dr. R. Schmidt
BAM Certification Body

Dr. U. Ewert
Assessor

Distribution list: 1st Certificate holder 2nd BAM Certification Body

[illegible]

The final classification statement about the system shall be given in following form: IP_X/Y where X corresponds to minimal normalized signal–noise ratio and Y to a maximum basic spatial resolution, e.g. IP3/200.

EN 14784 part 2 specifies general rules for industrial computed X-and gamma radiography for flaw detection purposes, using storage phosphor imaging plates. It is based on the general principles for Radiographic examination of metallic materials on the basis of films (EN 444 and ISO 5579). The basic set-up of radiation source, detector and corresponding geometry shall be applied in agreement with EN 444 and ISO 5579 and the corresponding product standards as e.g. EN 1435 for welding and EN 12681 for foundry.

Mentioned Computed Radiography techniques are subdivided into two classes, Class A defined as a 'basic technique' and Class B defined as a 'improved technique' and to be used when Class A may be insufficiently sensitive.

ASME SEC.V Appendix VIII approved by RT working group committee allows the use of phosphorous plates in lieu of conventional film sheets.

ASME code 2476 allows the user to perform radiographic examination of materials including castings and weld using phosphor imaging plate in lieu of film, when the modified provisions to Article 2 as indicated in the code case and all other requirements of Article 2 are satisfied. In terms of required sensitivity, the radiography shall be performed with a technique of sufficient sensitivity to display the designated hole IQI image and the 2T hole, or the essential wire of a wire IQI.

6. Conclusions:

Over the last years the image quality offered by CR technology has been tremendously increased. Now that standards are in place, computed radiography is one of the technologies that will replace film in the future. The right solution and choice will completely depend on the requirements of the user. Throughput, environment, infrastructure and workflow are the key factors. Currently, an important challenge is there for the different NDT-federations to inform, train and support their end-users on how to use, and finally convert to digital radiography

7. References:

European Standard EN14784 part 1 and 2, ASTM Standards E2445-05 and E2446-05, ASME SEC.V Appendix VIII, ASME code 2476.