COMPUTED RADIOGRAPHY IN NDT APPLICATIONS

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Abstract: Computed Radiography, or digital radiography by use of reusable Storage Phosphor screens, offers a convenient and reliable way to replace film. In addition to the reduced cost on consumables, the return on investment of CR systems is strongly determined by savings in exposure time, processing times and archival times. But also intangible costs like plant shutdown, environment safety and longer usability of isotopes are increasingly important when considering replacing film by Storage Phosphor systems. But more than in traditional radiography, the use of digital images is a trade-off between the speed and the required quality. Better image quality is obtained by longer exposure times, slower phosphor screens and higher scan resolutions. Therefore, different kinds of storage phosphor screens are needed in order to cover every application.
Most operations have the data, associated with the tests to be performed, centrally stored in a database. Using a digital radiography system gives not only the advantages of the manipulation of digital images, but also the digital data that is associated with it. Smart methods to associate cassettes and Storage screens with exposed images enhance the workflow of the NDT processes, and avoid human error. Automated measurements tools increase the throughput in different kinds of operations.
This paper gives an overview of the way certain operations have decided to replace film by Computed Radiography, and what the major benefits for them have been.

Introduction: As experienced NDT professionals know, multiple NDT methods can be required to fully meet the demands of a particular inspection application. The same has been true for radiography, where a wide assortment of films has been developed for the specific quality and throughput requirements. Today, the options for radiography include not only film, but with recent technological advantages, it is now possible to meet a wide range of NDT inspection applications with digital solutions that are reliable and cost effective. More and more applications can be covered by the improving image quality of digital radiography systems, and together with the digitisation of radiographic applications, come the enhancements in workflow, that are made possible by availability of digital images.

Results: The Digital Radiography System

Before describing the details of digital detectors, the most important component of a digital radiography system should be covered. The performance of the workstation and the accompanying software will determine the efficiency of a digital system. Where new developments in digital technology always follow the developments of the medical industry, it should not be forgotten that NDT applications have completely different needs than hospitals, and that radiographic workflows should be adapted to the necessities of the industry.
The main functions of the workstation are described as :

- Control digital image acquisition
- Display and analyse digital images
- Manage information and data

- Control the output

Digital image acquisition
One and the same workstation software should be able to control any kind of acquisition modality. Albeit film scanning, Computed Radiography or Direct Radiography, a lot of different applications will offer a home for one of these modalities, depending on throughput requirements, working conditions or required image quality.
Image display and analysis :
Besides the user friendliness of the common imaging tools like contrast enhancement, sharpening, pan, scroll and zooming, which make evaluation of digital images so much easier than viewing films on a light box, is now the development of the software more moving into the direction of accurate measurements and workflow. The workstation will soon be communicating with external application databases, such as quality surveillance databases of refineries or production control packages in serial manufacturing plants. Also, more advanced measuring tools will be available in the software. GE Inspection Technologies will soon start offering a sophisticated wall thickness measurement software tool, specially designed for on-stream applications. The software takes the source – to – object distance and the nominal pipe diameter as a reference, and will calculate the rest wall thickness at a certain predefined area.
Smoother line density profile measurement by averaging different lines, angle measurement and area measurement also make part of the broader range of possibilities of today's digital radiography systems.

Manage information and data
The strength of digital radiography systems lies not only in the imaging possibilities, but also in the management of data associated with a certain image. All data can be entered, manually or automatically, in the same record in the database of the workstation. In the more sophisticated CR systems, data can be coupled to an image at the time of exposure, using a predefined worklist. (see below in the section CR Systems).
Most important, the database is designed this way that original image data is always preserved, prohibiting image manipulation as long as the original data is not securely saved. This is needed in order to use the images in a later stage as evidence material, which would of course be impossible if the original content of an image has been modified.

Control the output
As the workstation is a Windows 2000 compatible computer, all common peripherals can be used to communicate with the outside world, including printers, networks, etc. The software itself foresees in easy-to-use options to create reports or write images on a CD or DVD.

Computed Radiography
Computed radiography uses a reusable imaging plate in place of the film. This plate employs a coating of photostimulable storage phosphors to capture images.

When exposed to X-rays, electrons inside the phosphor crystals are excited and trapped in a semi-stable higher-energy state. The CR reader scans the plate by means of a laser beam.
The laser energy releases the trapped electrons, causing visible light to be emitted. This light is captured and converted into a digital bit stream which encodes the digital image.

- No more retakes

The storage phosphors on the Imaging plate have an extremely wide dynamic range. This gives a high tolerance for varying exposure conditions and more degrees of freedom in selecting the exposure dose. As a consequence, the need for retakes is drastically reduced.

- Dose Reduction

The wide exposure latitude of the Imaging plates allows, in many cases, the visualisation of all diagnostic information with only one exposure. In this way, the use of Imaging plates results in a substantial reduction of the dose load. Also the fact that the sensitivity is about 10 times higher than the sensitivity of conventional film results in shorter exposure times and thus significant dose reduction.

- Long Lifetime

NDT Imaging plates are protected by an EBC (electron-beam-cured) top coat. EBC top coating is an Agfa-proprietary technology for hardening a prepolymer lacquer coat into a high-density polymer on top of the phosphor layer. This results in plates with superb protection from mechanical wear and extensive immunity to chemical cleaning solutions. Superior durability of the Imaging plate is thus secured.

- Image Quality

The recent efforts done for medical CR systems to be used in mammography applications, have also found their way into the NDT applications. Where until recently the image quality could be compared with D7 or D8, are we now comparing to D5 and even D4 image quality.

- Flexibility and robustness

The light weight cassettes and imaging plates allow for access in difficult to reach areas, where you do not want to use expensive flatpanels. The low sensitivity for extreme temperatures makes CR the ideal solution for refineries and chemical plants. The newest identification tools also allow automated workflow in factories.

Stationary CR Scanner (CR Tower)
This scanner has been designed for utmost convenience in digitising 8" x 10" (20 x 25cm) and 14"x 17" (35 x 43cm) imaging plates. 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 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. The specially designed NDT cassettes with built-in lead sheets avoid any unnecessary plate handling, increasing their lifetime by 3 times. The scanner provides a reliable, cost effective solution for low volume and mobile applications where a small footprint is required. The system offers ease-of-use and low maintenance, ensuring reliable and repeatable system operation.
The CR cassettes have a programmable chip that can be programmed with a handheld identification station (or ID station). This creates a greatly improved workflow: The ID Station is programmed by the main workstation, and contains a worklist. This worklist

can be created at the workstation, or can come from an outside application. A team goes out with an amount of cassettes and the ID station, and every time before an exposure is made, the data associated with the exposure is copied from the ID station into the cassette on which the exposure is made. At the end of the day, the cassettes are brought to the scanner, which has the ability to read the image and the chip at the same time, making sure the data in the chip is copied in the right fields in the database, together with the image. The cassettes are identified at the time of exposure, not at the time of scanning, avoiding human mistakes in data input.

Mobile CR Scanner (CR 100)
Applications that require special sizes of plates or require a mobile scanner cannot use a stationary scanner like CR Tower. Especially for these operations, GE Inspection Technologies offers a compact and all-round CR scanning solution.
After exposure, the plates are manually removed from the cassette and inserted into the scanner for readout.
The CR 100 scans custom sizes and shapes up to 14" (35cm) wide.

Portable scanner (CR Voyager)
This is a response to the market request for having a light weight and thus transportable scanner. In our field, there are lots of applications that require on the spot testing and inspection. To give a few examples : off shore inspection (unit has to be flown from one platform to another by helicopter), security inspections e.g. at airports, where suspicious packages have to be inspected without being moved.
Another advantage of the light weight of this scanner is that inspectors can work in better working conditions, not having to carry heavy weight scanners. The CR Voyager can easily be carried by one person. Its ultra light weight (15.5 kg) permits the operator to access areas which were unthinkable of in the past. Wherever you need the scanner, on oil platforms, refineries, airports, etc.
Storage Phosphor plates
Speed of exposure and obtained image quality are strongly related with each other. That is why different application will have the need for different imaging plates. In these 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 D7 film –like defect recognition is required, the standard storage phosphor screens can be used. This will result in exposure times of 10% of the exposure time of D7 film. If the defect recognition becomes more important, the premium storage phosphor plates can be used for sharper and higher quality, giving in speed by a factor 3.

Example Applications

On Stream Pipe Inspection
In the industrial environment of refineries and chemical plants, inspections often have to be performed in difficult to reach locations, on pipes that might be isolated or might have higher temperatures. CR cassettes, loaded with storage phosphor plates, bring here a serious advantage over flatpanel detectors : cassettes are cheap, light, strong, robust and

have no need for cabling. Moreover, storage phosphor plates are available in any size (but this limited by the scanner)
Compared with film, the availability of advanced measuring tools shows evidently the advances of digital images where corrosion and wall thickness have to be measured. There is no need to remove insulation of tubular pipes before inspection. The maintenance of a chemical plant requires that critical points have to measured on timely intervals. The CR system interacts with the user's maintenance management system. This system gives the required data in a daily worklist and loads it in the portable identification system. This portable computer loads the data in the cassette before exposure, making usre that data in the worklist is read by the CR scanner, putting the right data in the right records of the database after scanning. Transferred measurement data makes sure that measurements are always done at the same spot. A team of inspectors can be sent out with a load of cassettes and a handheld Identification station, programmed before by the CR system's workstation. The worklist tells them where to go and what to do, and with one click, the cassette is loaded with the data before each exposure. After retuning at the end of the job, the CR scanner sequentially scans the cassettes, and the data is read from the cassette into the scanner. The CR workstation puts this data in the required fields in the database, and is available for transferring it back to the customer's environment.

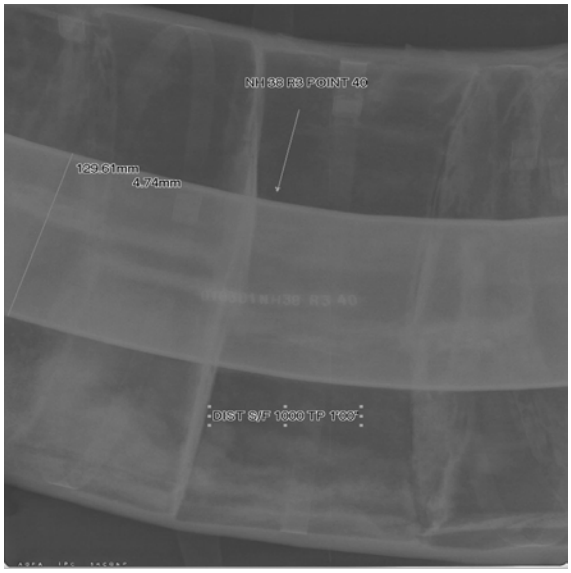

Figure : Testing of Corrosion without removing the insulation

Waxes and Casting inspection
In foundries, an essential cost saving can be done by detecting defects in the wax part before the foundry process takes place. The reliability and the robustness of CR systems, makes this the ideal solution in this application. The very short exposure time, and the fast scanning process, ensures high throughput and continuation of the production process, while digital images are immediately after the exposure, and anywhere in the factory for making the most accurate decisions or corrective actions.
The choice between flatpanel detector and CR system however becomes a bit more difficult. Flatpanels are more expensive, and their reliability has to be proven. The programmable cassettes and the identification station (which is also capable of

programming the X-ray source) compete with the ease-of-use of a flatpanel, but it will often be easier to integrate a flatpanel in an existing workflow.
In casting inspection the advantages of the high dynamic range come into the game. Various thickness in difficult to penetrate materials required bipack or tripack film systems, layering different sensitivities of film on top of each other, to cover the different thicknesses of the part. Not with CR systems : the high dynamic range, and the smart digital imaging tools, allowing to use preprogrammed presets for different parts, and the less sensitive but sharper Premium Phosphor plates give the whole result in one image. Again, flatpanels might be the better choice considering the workflow, but dropping a heavy part on a flatpanel might fatally damage the expensive detector. A CR cassette is robust, and cheap.

Composite material inspection
Dynamic range and speed of inspection are the driving factors here. A wing of an airplane is not limited to 14x17 inch areas. So the application has a need for larger detectors. Up to 50 inch long storage phosphor plates are produced to cover the need of the airplane aileron inspection application. Example is a sandwich of aluminium, with a honeycomb structure in between. At the edge, the aluminium plates are connected with each other with an aluminium U-profile. Everything is glued together. The inspection need is to inspect the honeycomb, the glue between the honeycombs and the aluminium, and the glue of the U-profile. With a CR image, the whole 50 inch image can be viewed in one image, where it replaced a tripack of D4, D5 and D7 film. As the D4 film is not used for the sharpness, but for the sensitivity, the application can be covered with Standard Imaging Plates. If sharper images are need, giving in exposure time, the premium plates will offer sufficient quality.

Security Inspection
The flexibility and the speed of CR systems save lives in the security field. Unidentified “lost” packages in crowded areas are a sensitive issue since terrorism is growing. A found unidentified pack should not be touched and should be identified as soon as possible. Considering that the personnel that is executing this task, is wearing protective clothing, which is already very heavy, portability of equipment is of highest importance. The person has to go to the spot, has to be able to view the image at the same spot, and must be able to take a decision based on the image.
Film is not an option here. Carrying development equipment to remote locations is impossible. Flatpanels, connected to the computer by wires, are too thick and and heavy to carry around and to place behind an object (consider that the object should not be touched, thus the detector has to be placed between the object and e.g. a wall). And if an explosion takes place, a cassette is cheap to replace. A small CR system is the solution : 15 kg weight of scanner, a few cassettes and a portable computer and X-ray source. Security inspection also finds its way in the inspection of found ammunition originated in previous wars. The beaches of the Netherlands and Belgium are places where unexploded granates are found on daily basis. Although today flatpanels are used for this purpose, the use of CR systems in certainly a competitive alternative

Conclusions: CR systems are not an in-between step in the process of film replacement. Computed Radiography is one of the modalities 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. Important is however that one digital solution does not compete the other, and both have to be considered in any choice.