The Innovation and Modernization of Radiography in the Nuclear Industry

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Abstract

Computed Radiography (CR) has become a major digital imaging modality in the Nuclear Industry. CR systems change workflow from the conventional way of using film/screen by employing photostimulable phosphor plate technology. This results in the changing perspectives of technical and quality control issues in the radiography department. CR is continuously taking place of dry film in the nuclear industry. CR has been adopted by URS Energy and Construction along with the Steam Generating Team for various Nuclear Projects. This article will cover the workflow of CR used on various nuclear projects from procedure establishment through archiving. The following are benefits associated with CR use and how URS and SGT have become more competitive and successful by converting to non-film imaging.

Keywords: Computed Radiography (CR), CR in the Nuclear Industry, CR Workflow, Radiography, URS, SGT, MOX, SWPF

What is the Nuclear Industry’s Experience with CR?

What is the Nuclear Industry’s Experience with CR? Here are a few facilities that have experience with CR. Not all of them consist of Nuclear Power Plants but the others are still constructed with same governing regulatory compliance & quality.

- Duke Power
- Dominion Power
- Entergy Operations, Inc.
- Exelon
- Florida Power & Light
- New York Power Authority
- Ontario Power (Canada)
- Tennessee Valley Authority
- Public Service Electric & Gas
- Pacific Gas & Electric
- Savannah River Site - MOX Project
- Savannah River Site - SWPF

Introduction

Computed Radiography (CR) has become a major digital imaging modality in the Nuclear Industry. CR systems change the conventional way of using film by employing photostimulable phosphor plate technology. This results in the changing perspectives of technical and quality control issues in the radiography department. Concerns revolve around the original radiographic techniques, so the questions are asked.
Do we need to use SE-75 isotopes?
Yes, lower energy photons provide a better response on the phosphor imaging plates and is best when used for Carbon Steel ≤1.5” in thickness.

Can we still use IR-192 & CO-60 isotopes?
Yes, on thicker test specimens where SE-75 doesn’t provide enough penetration…the traditional isotopes are still utilized.

Are the same size plates available as for conventional film?
Yes, most all sizes are available for imaging plates.

Is CR more susceptible to artifacts?
In my opinion, no…with the proper cleaning of imaging plates & CR equipment artifacts can be eliminated. The plastic can also be kept on the leads to eliminate any lead oxide transfer onto the plate. Hepa filters can be used to reduce any airborne particles in the air. There are also scanners with passive cooling on the market that are more reliable in harsh environments like construction sites, so no more fans polluting the inside of the scanners.

Can we cut our exposure times down?
In some cases yes, but for Nuclear Quality applications I feel there still needs to be an adequate amount of exposure to the plate & good radiography still needs to be performed! The higher the SNR, the less filters or enhancements that needs to be applied all resulting in sharper images that will detect minuet indications in various thickness ranges!!

**Factors Considered**

With that being said, what factors were considered for establishing our computed radiography programs? Strategic planning was taken for converting to digital means of radiography for the MOX Project, Salt Waste Processing Facility and the Steam Generating Team. Thought was given while considering the technology, capabilities, cost, code issues and ideas for potential applications. Numerous process evaluations and tests were carried out prior to adopting phosphor imaging plates for the new medium for radiography. In all, new techniques were developed, source capability validations executed, procedures amended, personnel trained and on-site customer demonstrations performed.

**CR vs. Film**

With the ongoing innovation and modernization with radiography, conventional film along with all means associated with it has been superseded. Digitizing equipment has replaced automatic film processors. High resolution monitors replaced film viewers. Network servers, Electronic Document Management Software (EDMS) and optical media has all replaced filing of conventional film.

Although CR has made itself valuable in the nuclear industry, some are skeptical of its ability to replace conventional film and archiving data for the life of a plant. The fear is that the data can be manipulated, corrupted, or even lost. Well DICONDE ensures the reliability of the data and its format and personnel can also get assistance from IT to propose a safe & secure form of archiving.
There are even uncertainties about the quality of CR images, some people feel images may have a grainy look; some just don’t like to adjust (window/level) the images. Well the longer the exposure time…the higher the Signal to Noise Ratio which will result in a less grainy image. Need to rely on the exposure more than the digitizing equipment. Also with continuous advancements in CR, filters are being offered with many different types of algorithms. One click of the mouse and the entire image is automatically optimized for interpretation, no window/leveling required! Produces a Film-like Image (sharp & crisp) with extremely wide latitude.

**Mixed Oxide Fuel Fabrication Facility (MOX Project)**

The MOX Fuel Fabrication Facility has become the first major nuclear construction project in the United States to use computed radiography exclusively to inspect the ongoing installation of over 80 miles of piping. The MOX Project has been utilizing CR since the start of the project in 2007.

Procedures were established and approved by the client for the use of phosphor imaging plates in lieu of film for ASME and AWS code work. MOX NDE department, IT and Document Control personnel worked together to establish a repeatable and consistent workflow for implementing the CR program.

As shown in the diagram above, the process begins by scanning the imaging plates, we then review the images and the test specimen for code and procedure acceptability, complete a inspection report and create a week ending folder for the raw data.
Next, the inspection report(s) and radiograph(s) are transmitted to the client, the client then imports the radiographs from their CR workstation for final review and acceptance. The inspection report and images are sent to document control for conversion into .pdf format. The raw data is then archived to a designated drive on the network (can be done with or without a copy of the DICONDE viewer).

The raw data that is archived is done so by “week ending” for easy retrieval of the images. Using a .pdf format of the radiographs creates easy access for auditors (such as NNSA, DOE, NRC) to review the final records from any computer onsite. If an auditor wants full capabilities and adjustment of the images, the archived data can be retrieved from the CR workstation. A copy of the archived image (which is RAW DATA) is pulled into the system for viewing while the archived study remains in storage. By archiving to the network, it provides fast, efficient, reliable storage and retrieval for the radiographic images.

### MOX Vendor Computed Radiography Workflow

MOX has recently started using a similar workflow for vendors. After the radiographic images have been accepted by a MOX surveillance inspector, the optical media is shipped & report scanned to the MOX NDE department. The images are then imported off the disc for final acceptance & review. Next, the inspection report is placed into our online project records center while noting the location of the optical media. This process creates less work for us by eliminating the need of re-archiving the images onto the server.
Salt Waste Processing Facility (SWPF)

The Salt Waste Processing Facility Project has been utilizing CR since the start of the project in 2009. Production has been a key success for URS with totals averaging to 30-40 welds a day. With more personnel being added in the future, daily weld totals will average from 60-80 a day and in some cases reaching 100 welds!

The SWPF project consists of roughly 60,000 welds ranging in sizes up to 36” NPS with the majority being ≥ 3”NPS. Today the project has completed 5,000 acceptable welds, all utilizing one of the major digital modalities, computed radiography.

**SWPF Computed Radiography Workflow**

Unlike the MOX Project...URS is using 2 CR workstations due to production. On the 1st station employees scan the IP’s, perform the initial review for acceptance, document results on the inspection report, then the client reviews. Personnel on Station 2 import the images to create the permanent records for the project, they also archive the images to a remote drive.
The Steam Generating Team (SGT)

The Steam Generating Team has also adopted computed radiography to inspect ASME Section III fabrication NDE, component repair and replacement NDE, ASME Section XI PSI and ISI, and noninvasive component internal inspections during steam generating replacement projects.

Strategic planning started in February of 2004, involving tests being performed on authorized mock-ups. SGT also coordinated with ASME Code Committee on upcoming approval of Section V, Article 2, Appendix VIII. In 2005, tests were performed to verify image quality acceptability and also to compare results between different CR systems.

This chart describes how CR is being employed during SGT’s projects. It consists of the same steps as our typical CR workflows but has options of archiving unlike the MOX and SWPF; as it is not site specific. Images can be electronically archived in various ways. For instance, they can be converted into .pdf format for placement into electronic document management software (EDMS). They can also be burned to optical media with a copy of a DICONDE viewer. If using a clients CR workstation that is on a network, the raw data may be archived to a limited access designation on the server or even on a separate remote drive.

SGT has used CR on various projects such as Three Mile Island, Salem, Diablo Canyon, St. Lucie and ANO. SGT’s success with CR has been recognized in Nuclear News as one projects main success. Over 400 radiographs were taken using CR at TMI’s Unit 1 steam generator replacement. Concurrent radiography was performed in numerous evolutions with no issues, Rick Libra, director of work management for Exelon, said, “The radiography performed was significant and that I have never heard of such success before in our industry.” Personally, I don’t think such recognition would have been achieved with conventional film!
Uncertainties with Electronic Archiving

When there was uncertainties regarding electronically archived radiographic images, the provisions in ASME’s code case 2602-1 were used to convert digital radiographic images to a analog hard copy format. As written in the code case...the word OPTICAL is used for contrast sensitivity & for dynamic range, so no need to measure the density on the printed images. The Mylar film used in printing will last 25-30 years or longer under the required storage conditions from the manufacturer.

URS Competitive Edge

How has URS become more competitive and successful by converting to non-film imaging?

The reduction in their carbon footprint, decreasing the amount of paper and film being used and the limited amount of radiation risk are just some of the ways that this revolutionary process has changed the nuclear industry. The ease and options of archiving, speed of processing and the return on investment of the CR system are the most cost efficient to our company and our customers. Also the amount of reshots are minimized and the potential for human error is decreased just in utilizing the computed radiography system.

In Summary

The benefits to utilizing Computed Radiography are endless and with the popularity of this major digital imaging modality, it is impossible to ignore the possibilities.
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