NRC Interest in Human Factors in Nondestructive Examinations

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Human Performance Issues in Recent Operating Experience

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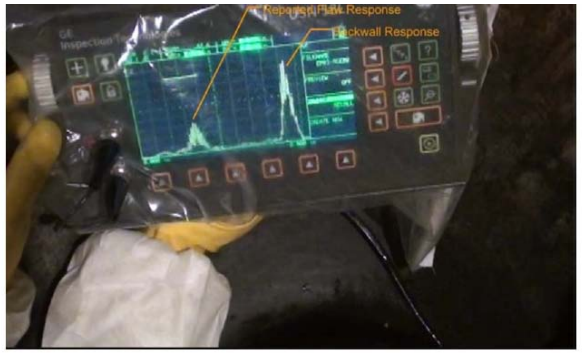
There have been recent examples of flaws missed in the field despite the fact that the procedures were capable of detecting the flaws

- Diablo Canyon pressurizer overlay welds
- Shearon Harris Control rod drive nozzle



Human factors may have played a part in the missed flaws at North Anna Unit 1 in 2012

The NRC staff has believes that addressing human factors issues may provide the opportunity to improve inspections of safety-significant welds

Some Important Factors Today

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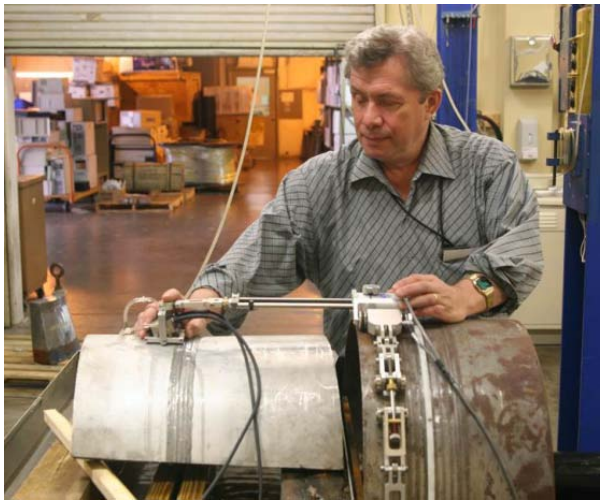
Personnel and Procedures need to pass ASME Code, Section XI, Appendix VIII blind testing for most piping components

Appendix VIII-qualified personnel need to perform 8 hours of hands-on practice per year

NUREG-0700 and OSHA requirements describe stay times for high heat and ear protection for noise greater than 85 dB

Experience requirements in ASME Code, Section XI, Appendix VII helps to assure that inspection personnel are familiar with the work environment



Limits in Appendix VIII Qualification Testing

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Appendix VIII blind testing provides confidence that:

- The equipment and procedures being used in the field are capable of detecting flaws in test blocks designed with realistic flaws
- The personnel performing the examinations have shown that they can use the procedure effectively

Appendix VIII testing shows that the procedures and personnel can succeed under laboratory conditions that do not represent field-like conditions

Differences Between Qualification Tests and Field Examinations

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Number of Flaws

Time Pressure

Practice

Working Conditions

Numbers of Flaws

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During a qualification test the number of flaws is usually larger than the number of test blocks

During inspections, there are far fewer flaws than welds

Many components have never had a service-induced flaw

Inspectors thus have a very different mindset and a very different set of expectations going into the examinations

Testing for and correcting this issue is challenging

Time Pressure

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Scanning speed is very different between a qualification test and in the field

In the field, inspectors are under pressure to perform the examinations in a timely manner

Radiation dose rates may limit the amount of time available to an inspector

Equipment with poor ergonomics or other design issues may be easy to use given sufficient time, but present challenges to the personnel when they are hurried

Practice

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Personnel have access to practice specimens prior to an Appendix VIII test at the Performance Demonstration Initiative

Pre-job practice on flawed specimens prior to actual inspections is not commonly performed (with some notable exceptions)

Personnel are qualified at peak performance but often conduct the actual inspections without the benefit of practice, often years after qualifying

Working Conditions

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Qualification tests are performed in a laboratory environment while the inside of containment can present challenges to an inspector

Heat, noise, contamination, protective clothing, close quarters, and other issues may interfere with an inspection

Team scanning may be used when the inspectors have little or no experience with team scanning

Long hours with few breaks may degrade performance

Human Factors Studies

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Some interesting work is contained in NUREG/CR-6605, PISC III, and recent work at BAM and other institutions

Some highlights of these studies include:

- NDE equipment design is often not optimized for use in difficult conditions
- PISC III found that there were no significant differences in performance between “studio” conditions and in a “transportable environment laboratory”
- PISC III Showed that performance degrades after two weeks of 12 hour days
- Signals with a weak amplitude or a brief duration can be challenging to detect
- Recent work at BAM has shown that time pressures degrade performance

Search Unit Ergonomics

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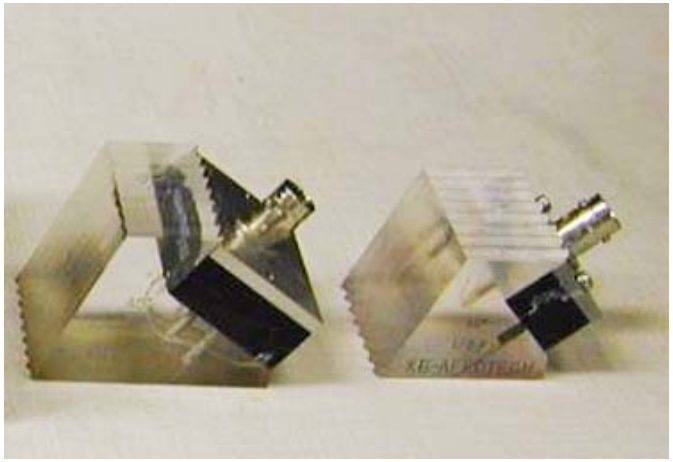
Typical NDE Search Units are not optimized for hand holding



Medical Search Units are waterproof and optimized for hand holding

Photograph from BK Medical
http://www.bkmed.com/8837_cardiac_en.htm

Lessons From Steam Generator Tube Inspections

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One area that has undergone an extensive process of optimization is the inspection of steam generator tubing

- All Encoded Automated Data Collection
- Computer-Assisted Data Analysis
- Independent Analysts
- Site-specific training and testing prior to inspections

Implementing many of these would be impractical, but some ideas could be used to improve NDE outside of the steam generator arena

NRC Interests in the Future

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The NRC staff are looking at the effects of human factors in NDE performance

The NRC staff is concerned that pitfalls may be present in the current qualification and inspection system

Targeted improvements in inspection processes, based on knowledge of human factors, may be possible