

**The NRC Staff Perspective on Recent Operating Experience**

Stephen Cumblidge  
2014 RIC  
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United States Nuclear Regulatory Commission  
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**Outline**



Glossary

Operating Experience

- Five Missed Cracks Resulting in Leakage at North Anna
- Missed Laminar Flaws in a Weld Overlay at Diablo Canyon
- Missed Crack in a Control Rod Drive Mechanism Nozzle in Sharron Harris

Common Issues

Paths to Improve Nondestructive Examinations

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**A Quick Glossary of Ultrasonic Inspection Terms**

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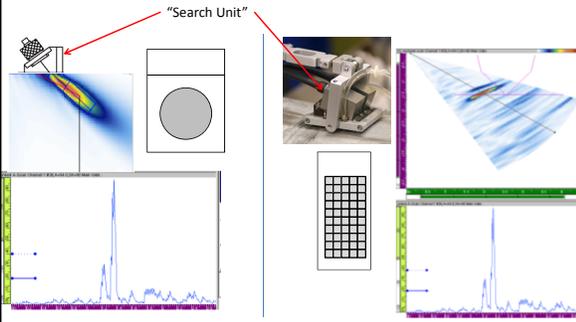
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**Manual Phased Array and Manual Conventional Ultrasonic Testing**



"Search Unit"



The image shows a "Search Unit" with a probe and a control panel. It includes a B-scan image showing a curved defect, a C-scan image showing a rectangular defect, and two A-scan waveforms showing amplitude versus time. The probe is shown in a manual testing setup on a metal surface.

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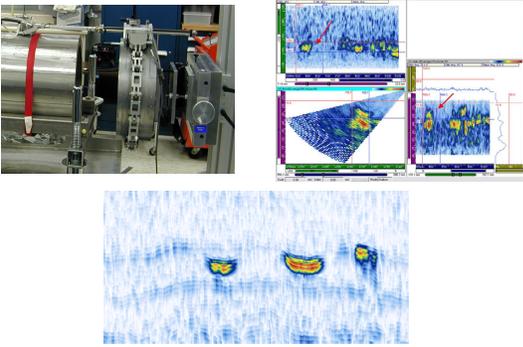
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**Encoded Scanning**



The image shows an encoded scanning machine with a red safety strap. The software output includes a B-scan image with a curved defect, a C-scan image with a rectangular defect, and a large A-scan waveform showing multiple peaks.

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**Inspection Terms**



Indication	Someone sees something with an NDE technique
Flaw	The indication is confirmed by the licensee to be reproducible and caused by something undesirable
Crack	A flaw is identified by some means to be a crack

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### Appendix VIII and PDI



The American Society of Mechanical Engineers (ASME) Code Section XI Appendix VIII describes blind testing for procedures and personnel prior to use in nuclear power plants



These tests are challenging and even skilled inspectors have a chance of failing

The tests are conducted at the Performance Demonstration Initiative (PDI) in Charlotte, North Carolina

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### Root Cause Analysis



For some issues a licensee performs a detailed analysis to determine the root causes and contributing factors

A Root Cause Analysis (RCA) is typically an internal document that may or may not be made public

- The information in the root cause analysis may be proprietary in nature and not publically available
- The NRC staff has access to the documents

This presentation focuses on issues identified in the RCAs most interesting to NRC staff

- Publically available information only
- Our analysis is not limited to the RCA

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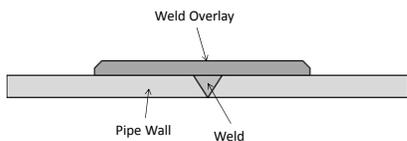
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### Weld Overlay



A weld overlay is a repair and mitigation procedure where a cracked or susceptible weld is covered in weld metal

The weld overlay is made of a non-susceptible material and effectively replaces the weld



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**Operating Experience**

**North Anna  
2012**

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**North Anna 1**

In March of 2012, five large axial cracks were missed by a manual conventional ultrasonic inspection

The cracks were located in a dissimilar metal weld joining the steam generator to the hot-leg piping safe end

The cracks were discovered when the weld was machined in preparation for a weld overlay

The cracks were covered by the application of a full structural overlay




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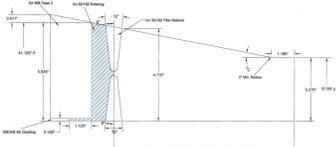
  
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**North Anna Site Specific Issues**

The steam generator weld had an 11 degree taper  
 - PDI has no matching test blocks

The licensee used this site specific mockup to justify the use of a different ultrasonic search unit to account for the 11 degree taper

This new search unit had NOT been qualified via Appendix VIII Blind testing



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### Factors in North Anna 1

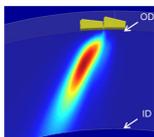


The North Anna Root Cause Analysis described inadequate oversight

A report by the Pacific Northwest National Laboratory showed that the unqualified search unit was not well-suited for the inspection

The site-specific mockup examination showed:

- implanted cracks were only detectable when the search unit was in an optimal position
- maximum allowed scanning speed was two inches per second
- actual cracks may only have been visible on the screen for a fraction of a second



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### Industry Response



A group called the NDE Improvement Focus Group (NIFG) was created.

NIFG developed a set of documents for the Electric Power Research Institute (EPRI) issued guidance on how to prevent a similar issue in the future

The new guidance covers:

- Improved rules for the use of site specific mockups
- Hands-on training
- Pre-job briefings
- Oversight of NDE Personnel
- Protocols for the use of team scanning
- Increased use of encoded examinations

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### NRC Perspective on North Anna 1



A slower scanning speed would have increased the amount of time the indications were visible on the screen

A qualified search unit that produced a stronger response from the cracks would have increased the chances of the cracks being found

A phased-array search unit would have provided more time for the inspector to notice the indications

An encoded examination would have had a much better chance of finding the cracks

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**Operating Experience**  
  
**Diablo Canyon**  
**2013**

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**Diablo Canyon 2013**

Diablo Canyon Unit 2 had alloy 52 weld overlays installed on six pressurizer welds in 2008

In 2008 an Appendix VIII-qualified conventional manual ultrasound procedure was used for an acceptance examination

In 2013 a manual phased array ultrasonic examination found several embedded laminar flaws missed by the 2008 acceptance examination

One of the flaws was 16 inches long and a second was essentially 360 degrees around the overlay

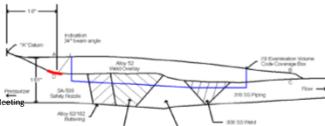


Diagram provided by Pacific Gas and Electric for a Public Meeting  
 ADAMS Accession No. ML13274A514

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**Diablo Canyon 2013**

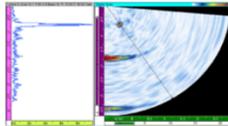
- Both the 2008 and 2013 techniques were Appendix VIII qualified
- The procedure used in 2013 used a manual phased array search unit that included many more angles than were used in the acceptance examination

2008



0° Conventional UT, Safety Nozzle A

2013



PA UT, Safety Nozzle A

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### Diablo Canyon



The licensee's root cause analysis cited insufficient oversight of the inspection vendor and scan speed as issues

During an October 2, 2013 public meeting, the licensee demonstrated the capabilities of the two search units

At a scan speed of 2 inches per second the flaws "flickered" in and out of view on the screen with the manual conventional technique

The manual conventional probe needed to be held carefully during the inspection or the signal could be lost

When scanning slowly the manual conventional search units were easy to use and flaws were readily detectable

The manual phased array search unit used in the 2013 inspection provides more time to observe the flaw than the manual conventional search unit

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### Industry Response



The licensee has implemented several changes to the weld overlay inspections

- Disallow the use of the 2008 inspection procedure in future inspections
- Employ Phased Array for subsequent examinations of pressurizer SWOLs

The procedure used in the 2008 examination was revised by PDI to give additional guidance on scan speed

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### NRC Perspective on Diablo Canyon



The search unit used in 2008 was capable of finding the flaws

The scan speed and difficulty keeping the manual conventional search unit perpendicular to the pipe appear to be significant factors in the missed detections

The phased array search units provide a more persistent image of the flaws allowing the inspector more time to see the flaws

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**Operating Experience**

**Shearon Harris  
2013**

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**Shearon Harris Control Rod Drive Mechanism 49**

  
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In 2012 Sharon Harris performed an encoded examination of all CRDM penetration tubes in Unit 1

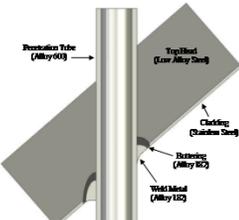
The examinations were encoded and the recorded data was examined by two inspectors

Eight cracks were detected in four penetration tubes

In preparation for an upcoming outage, the licensee asked an independent outside reviewer to evaluate the data

The independent review discovered an indication in Nozzle 49 that exceeded the acceptance criteria

The power plant was shut down to repair the crack



The diagram shows a vertical penetration tube with a crack labeled 'Cracking (Nozzle 49)' and a weld bead labeled 'Weld Bead (Nozzle 49)'. Other labels include 'Penetration Tube (Nozzle 49)' and 'Top Weld (Lower Alloy Steel)'.

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**Licensee Root Causes**

  
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Inadequate oversight of inspections by licensee

Time Pressures

Distractions

- Noisy and cramped environment

Fatigue

- Both inspectors had worked for weeks without a day off

Root cause information in July 10, 2013 NRC Inspection Report ML13192A154

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**Industry Response**



Still under development

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**NRC Perspective on Shearon Harris**



The crack was recorded in the encoded data  
The inspection procedure was effective

During the review it was determined that the crack was only visible in a small region of the recorded data  
Time pressures and the distracting environment are likely contributors

The use of encoded data did not prevent the crack from being missed  
The inspectors got eight out of nine cracks, not zero out of five as with North Anna 1 in 2012

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**Common Issues**



**Insufficient Oversight of Inspectors**  
– Cited in all three root cause analysis

**Time Pressure**  
– A large number of welds are scanned every outage  
– A limited time is available

**Persistence of information**  
– Manual conventional scans may only produce a visible indication for a fraction of a second  
– Rapid evaluations of encoded data can result in missed flaws

**Qualification Issues**  
– The qualification programs show that the procedures can work, but does not guarantee that they will work in the field

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**Paths to Improved NDE Inspections**



**Organizational**

Increased oversight and site-specific training of inspection vendors by licensees

**Procedural**

Reduced scan speeds for manual procedures  
Analyze procedures to find and remove "error traps" that come in to play when a procedure is moved from the laboratory to the field

**Technological**

Increased use of phased array ultrasound  
Increased use of encoding  
Improved ergonomics for search units  
Increased use of alarms or amplitude set points to catch transient signals

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**How do we Implement these Improvements?**



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