Update of Nondestructive Examination (NDE) Projects Funded by NRC at PNNL

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Primary NDE Research Project: JCN-N6398

- JCN-N6398, "Reliability of Nondestructive Examination (NDE) for Nuclear Power Plant (NPP) Inservice Inspection"
  - Project Objectives:
    - Evaluate accuracy and reliability of NDE methods used for ISI
    - Provide information to NRC staff to assess adequacy of proposed industry changes to ISI programs
    - Provide recommendations to NRC staff to improve NDE methods
    - Evaluate effectiveness of ISI techniques for detecting service degradation. Examples:
      - PWSCC in Alloy 600, 82, 182 dissimilar metal welds and J-groove penetrations
      - IGSCC in austenitic welds
      - Potential degradation in cast stainless steel and weldments
    - Provide technical assistance on NDE and related issues to NRC program offices on as-needed basis
- Wallace Norris, RES Project Manager
- Mike Anderson, PNNL Project Manager

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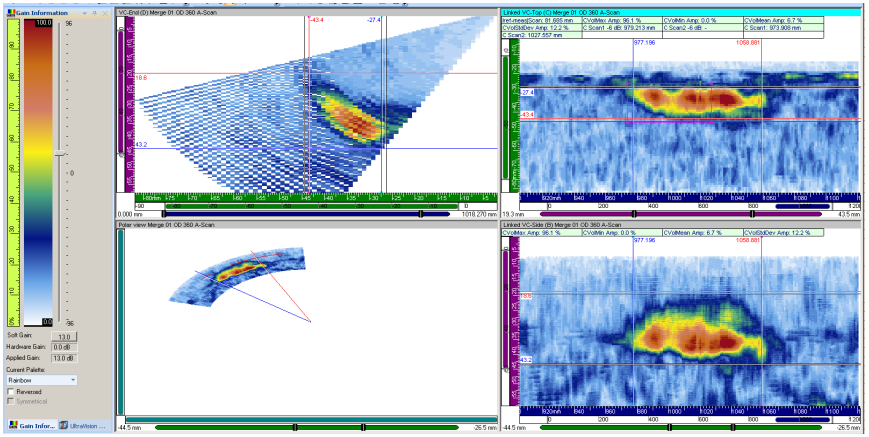
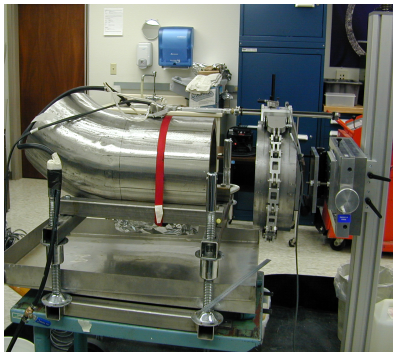
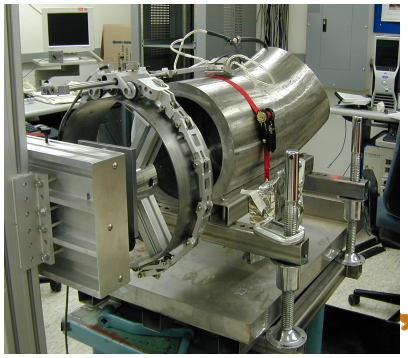
Examination of CASS PZR Surge Line Welds JCN-N6398

- **Completed NUREG/CR for phased array work on several CASS PZR line specimens**
  - NUREG/CR being reviewed by NRC (May 2010)
    - Noted that **all flaws** were easily detected; some tips available for depth sizing
    - Measured axial and circumferential UT beam redirection
    - Reported end-of-block scans to ascertain material effects
    - Reports high S/N ratios for implanted flaws
  - Specimens sent to EPRI for corroborating UT – EPRI preliminary results not as encouraging
    - We have invited EPRI to PNNL to re-acquire data on specimens with both PNNL and EPRI probes to ascertain discrepancies in findings







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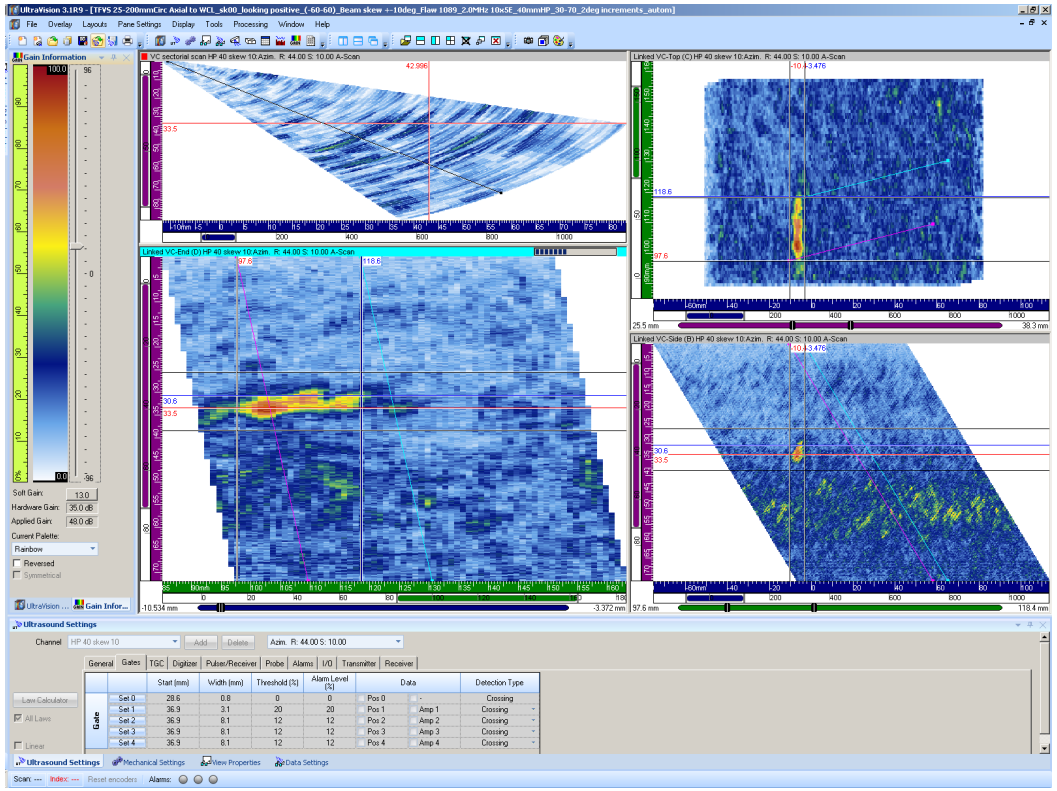
Examination of CASS PZR Surge Line Welds JCN-N6398

- Continue to evaluate CASS PZR materials
  - New materials acquired from Calvert Cliffs – WNP-4 salvage
    - Polishing and etching samples to display microstructure
  - Placing thermal fatigue cracks in CASS via Trueflaw process



- Approx. 21.8 mm flaw length, less than 10% flaw depth
- 30-70° raster, +10° skew

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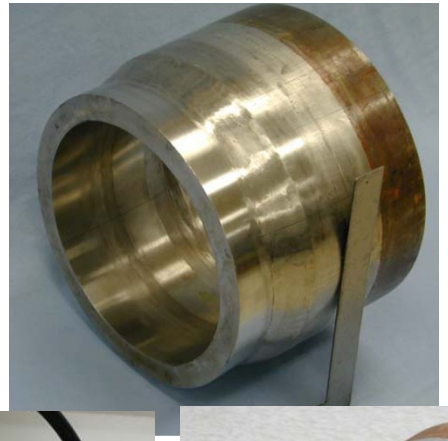
DMW Examinations
JCN-N6398

- Examined small-bore DMWs with phased array (specimens representing PZR surge, shut-down cooling and safety injection)
  - Final TLR to NRC on December 12, 2009 (PNNL 19018)
- Acquired UT data on RCP DMW – FPL specimen at EPRI
  - Awaiting EPRI OK to analyze data



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Assessing Casting Process, Microstructural Effects, and Potential In-situ Measurements JCN-N6398

- Evaluating the effects of casting processes on grain structures in centrifugally and statically cast SS piping
  - Collect data via published literature and foundry visits
    - Acquired vintage CASS piping from French foundry
  - Assess whether microstructures can be defined (and controlled) via control of process parameters
  - Final TLR submitted to NRC on January 4, 2010 (PNNL 19002)
- **Assessing in-situ acoustic and electromagnetic methods for defining grain structures**
  - Preliminary data suggests that columnar can be differentiated from equiaxed
    - Ratio of shear-to-longitudinal velocities
    - Attenuation and backscatter measurements continuing
    - Mapping cross-sectional delta ferrite via ET continuing
    - Interim report to NRC on April 20, 2010 (PNNL 19325)

On-going Task 2 Remote VT Activities JCN-N6398

- Remote Visual Examinations
  - Assess capabilities and limitations of remote visual (ASME VT-1) to detect cracking in RPV internal components
    - Define parameters affecting reliable examinations
      - Crack opening dimension (COD)
      - System calibration (resolution) standards
      - Magnification and lighting effects
      - VT scanning speed
  - **Conduct round-robin exercise** to evaluate current industry application and assess new technologies
    - Quantify effectiveness of current practice
    - Determine if improved capabilities are needed
  - Phase I Round Robin testing at the EPRI NDE Center is scheduled for **August 2010**
    - Most cracked samples have been developed; remaining samples to be completed by July
    - Four companies (including NDE vendors and camera manufacturers) have expressed interest in participating in Phase I tests

Other Related Work JCN-N6398

- **Assessing UT of full structural overlays on small-bore dissimilar metal welds**
  - Two WOL specimens (PZR surge) being procured
  - Finger-printing of implanted flaws just completed on first specimen
- **Evaluated EPRI POD DMW report** (MRP-262)
  - Compares POD with recent round robin exercises
  - Draft report to NRC in April 2010
    - Findings shared with EPRI – comments forthcoming
- **Evaluating UT responses from cracks, pre- and post-MSIP**
  - "Squeezed" NDE specimen at NuVision Engineering in December
  - Westinghouse and PNNL each performed UT, before and after MSIP
  - Strain-gauging during process to assess delta strain at ID
  - Draft report in progress

On-going Task 2 HDPE Activities JCN-N6398 (cont'd.)

- High Density Polyethylene Piping
  - Industry thrust to use HDPE for non-safety system applications – service water Calloway piping is 36" diameter and 4" wall
  - ASME Code Case being developed to support HDPE use
  - NRC concerns about **lack of fusion flaws** being created in butt fusion joints – industry claim that these cannot be detected by volumetric examinations
  - Conducting program **assessing several NDE technologies** for performing volumetric inspections of butt fusion joints using laboratory techniques and commercially available technology
    - Ultrasonics with phased arrays and time-of-flight diffraction
    - Microwaves
    - NDE inspections completed, developing destructive evaluation plan using high speed tensile tests, guided bend tests and mechanical slicing
  - **Summarized all NDE measurements for validation plan**
    - High speed tensile test
    - **Guided side bend test**
    - Fusion normal immersion testing with high frequency UT
    - Slicing and polishing cross sections

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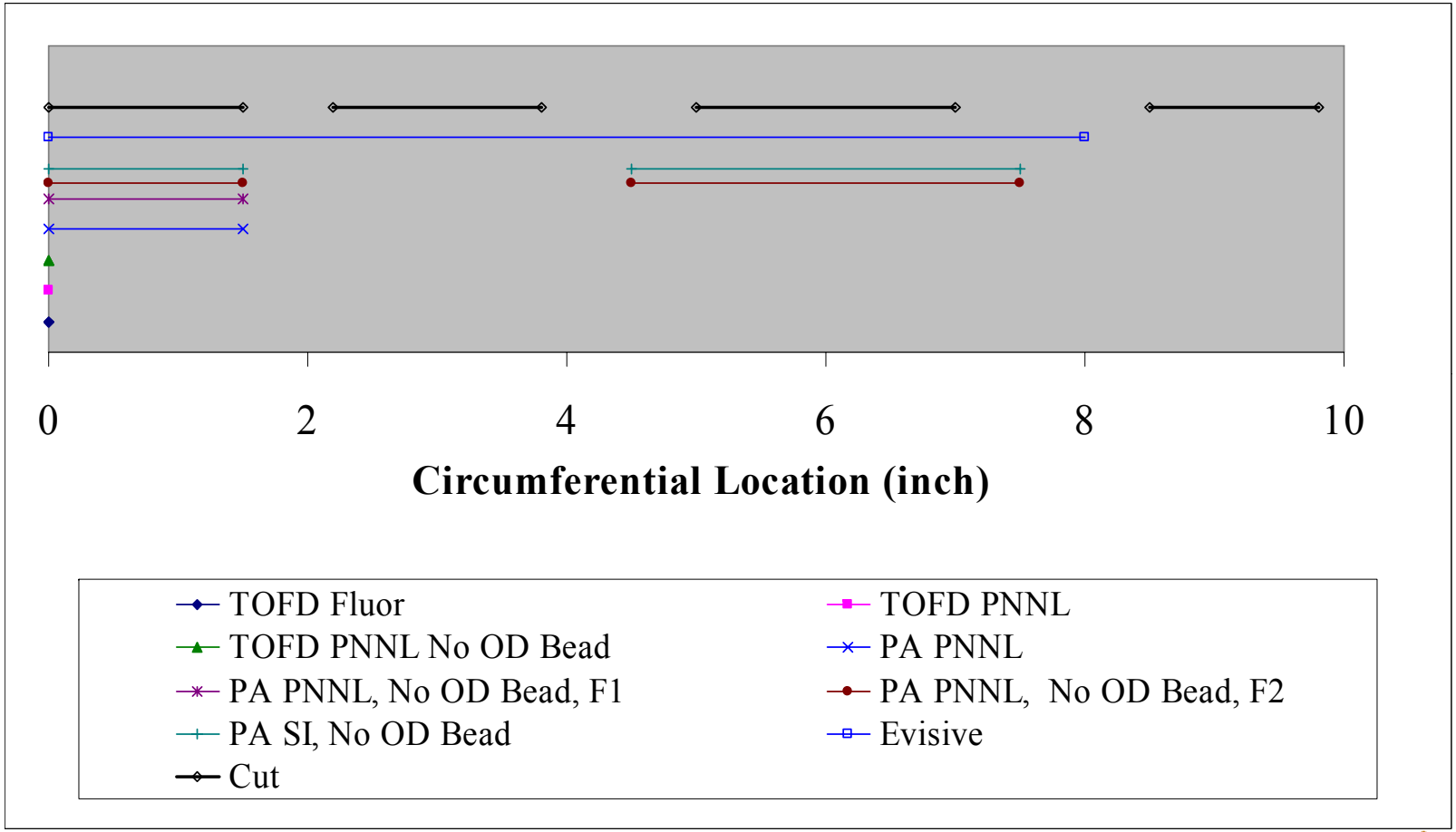
On-going Task 2 HDPE Activities JCN-N6398 Pipe 1218 Quadrant 1: NDE Summary Results



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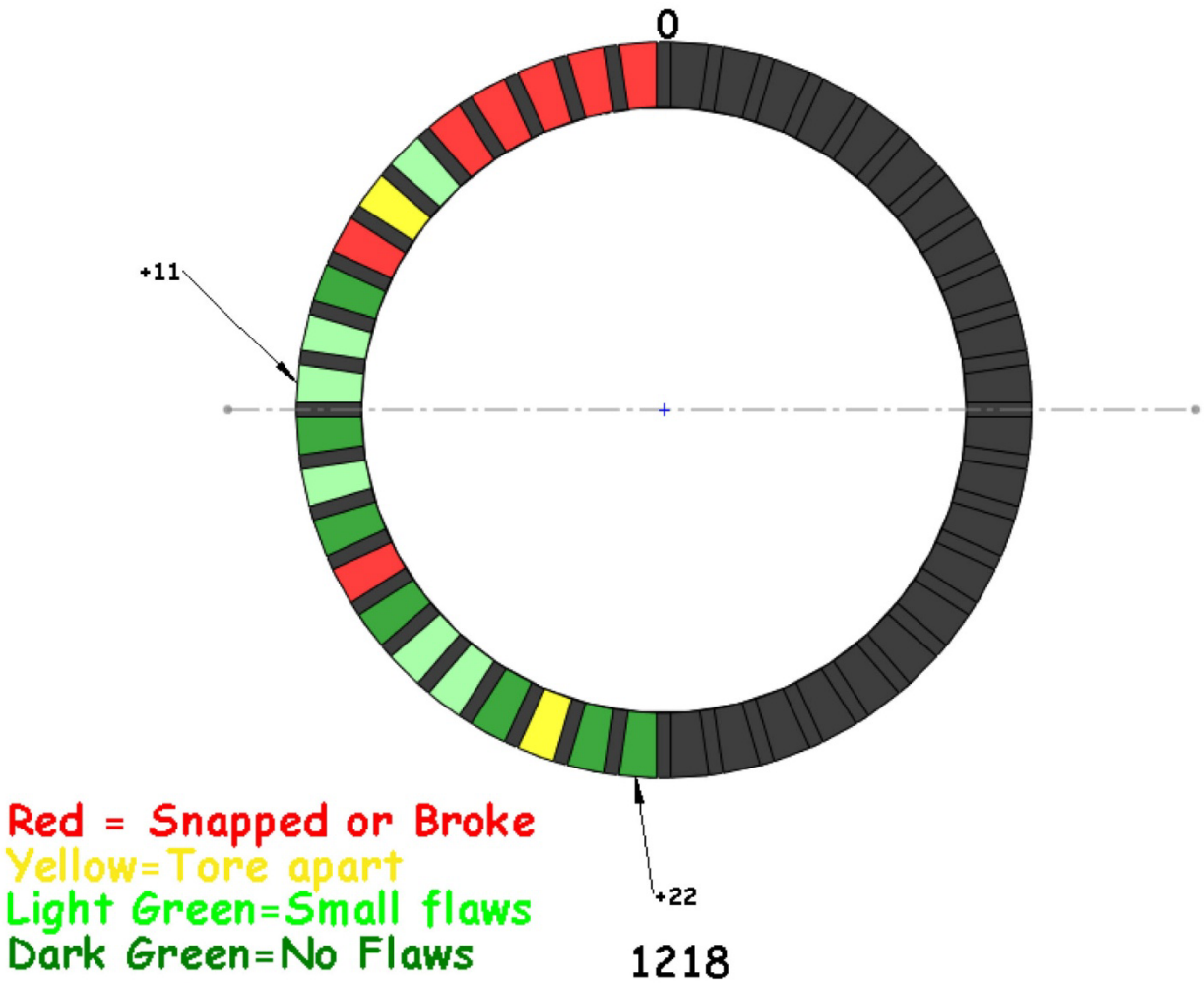
Specimen 1218 – Grease in Joint Area – Print Line Area After Heating



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Assess Emerging NDE for Dissimilar Metal Welds JCN - N6593

- The NRC Project Manager - Iouri Prokofiev
- PNNL Project Manager - Stephen Cumblidge
- This project has three major objectives:
  - **Program for the Inspection of Nickel Alloy Components (PINC)** - A cooperative international program to provide the experimental data and correlations necessary for assessing the integrity of dissimilar metal piping welds and BMIs
  - **Program to Assess the Reliability of Emerging Nondestructive Techniques (PARENT)** – An international program to evaluate current and emerging NDE methods
  - Review and update the technical basis used in developing the acceptance criteria specified in Appendix VIII

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PINC and Parent Programs

- The PINC program included regulators, universities and industrial groups in Europe, Japan, Korea and EPRI; used round-robin tests to evaluate effectiveness of qualified and experimental NDE techniques
  - The NDE techniques were scored to determine their effectiveness in detecting and sizing flaws in dissimilar metal welds
  - The first PINC program concluded in 2009. Results to be published as a NUREG/CR "Results of the Program for the Inspection of Nickel Alloy Components"
- The Program to Assess the Reliability of Emerging Nondestructive Techniques (PARENT) is underway. PARENT will be supported by a multilateral international agreement and developed for results to be "Open to the Public"
  - The scope of work for PARENT is being developed in cooperation with the members of the international committee
  - The current plan is to include open and closed testing of Bottom mounted instrumentation nozzles, dissimilar metal welds in large bore piping and DMW in small bore piping
  - The PARENT Kick-Off meeting was held at PNNL on June1-3, 2010

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Technical basis for Appendix VIII

- As many who wrote Appendix VIII will soon be retiring or have already retired, the NRC decided to have the rationale behind Section XI, Appendix VIII documented
- Steven Doctor and Tom Taylor went through Appendix VIII requirements and produced an annotated version containing this technical basis or rationale
  - Mike Gothard provided some comments on early draft
- This work will be published as a technical letter report (TLR) titled "The Technical Basis Supporting ASME Code Section XI, Appendix VIII" – submitted Nov. 25, 2009
- NRC reviewed the TLR and converted into a NUREG/CR
  - EPRI NDE Center may provide input on technical basis

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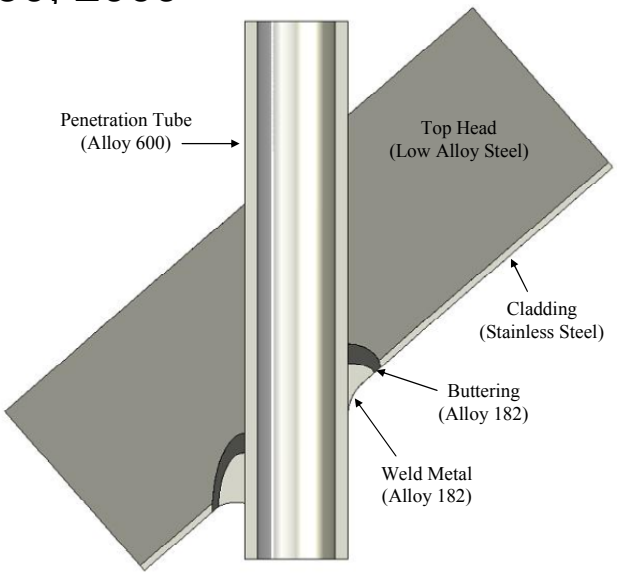
Destructive validation of NDE Reponses in Control Rod Drive J-Groove Welds, JCN-Y6867

- The goals were to examine CRDM nozzles and J-groove welds from North Anna 2 head to confirm degradation, characterize cracking, assess evidence of boric acid corrosion and leak path development, including evidence of annulus plugging
- ET performed best of all of the NDE techniques applied
- The detailed results were published as NUREG/CR 6996 “Nondestructive and Destructive Examination Studies on Removed-from-Service Control Rod Drive Mechanism Penetrations”
- Program completed November 30, 2009



CRDM J-groove Weld Diagram

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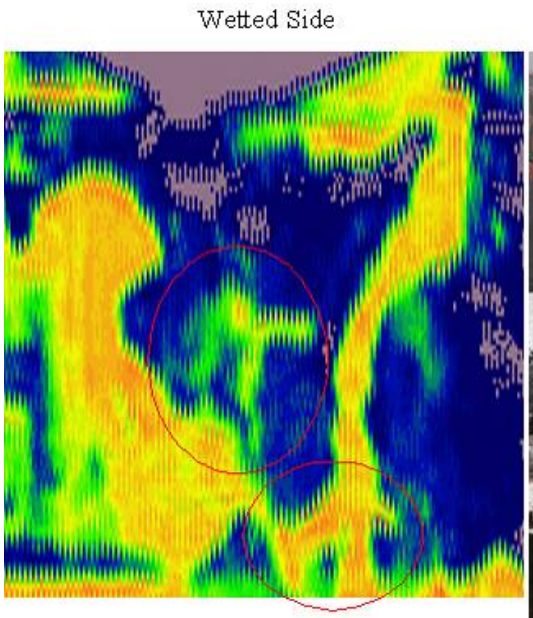
Evaluating the Effectiveness of Ultrasonic Leakage path Measurements – JCN-N6783

- Ultrasonic techniques are applied in the interference fit region of CRDMs to determine if leakage occurred during operation
- Insufficient experimental validation of the UT technique exists in the literature
- A better understanding of the capabilities and limitations of the UT technique is needed
- North Anna 2 Nozzle 63 is known to have leaked during operation,
- This CRDM will be ultrasonically examined and destructively analyzed to assess effectiveness of the ultrasonic examination



- Darrell Dunn – NRC Project Manager
- Brady Hanson- PNNL PM

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Proactive Management of Materials Degradation (PMMD) – JCN-N6957

- NRC Program Managers – Gene Carpenter, Amy Hull, Shah Malik
- PNNL Program Manager – Leonard Bond
- **Goal is to proactively address potential future degradation in operating plants to avoid failures and to maintain integrity, operability and safety**
- On-going JCN-N6957 will end Fall 2010 – (New JCN planned for FY11)

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Proactive Management of Materials Degradation (PMMD) – JCN-N6957

- Supporting the NRC in developing information regarding materials degradation mechanisms, inspection, or monitoring and behavior of materials
  - **Information tool** knowledge capture & utilization
  - Identification of **degradation scenarios NOT addressed** in current **GALL Report**.
  - **Summarize inspection and monitoring programs** and associated requirements for highly likely degradation scenarios
  - Comprehensive electronic information of inspection results recommended by GALL and plant-specific aging management programs
  - **Develop domestic and international partnerships** to share expertise related to aging management research
    - Supporting NRC in developing the proposed International Forum for Reactor Aging Management – IFRAM
    - Workshops Korea (October 09 – Europe May 10)
    - Engagement of IAEA – including CRP (PNNL June 10)

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NDE-Related Research Projects – Wallace Norris NRC Project Manager Al Pardini PNNL Project Manager

- JCN-N6585, Effectiveness and Reliability of UT and RT

  Conduct literature survey of studies performed to determine information available on effectiveness & reliability of computed & digital radiography; also comparability of results between radiographic testing (RT) & Ultrasonic Testing (UT)
  - Status: Essentially Complete (Continue Workshop Planning)
  - Final Report to NRC April 8, 2010
    - Literature surveys included 600+ journal and conference papers, and technical reports
    - Evaluation of documents focused on comparing techniques applied in accordance with 2007 ASME Code Edition/2008 Addenda, and included detection reliability for UT and RT, length and depth sizing reliability, and round-robin studies that directly compared UT and RT
    - Many technical gaps in knowledge were identified

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NDE-Related Research Projects – Wallace Norris NRC Project Manager Al Pardini PNNL Project Manager

- JCN-V6097, Effectiveness and Reliability of UT and RT for NDE

  The evaluation will assess UT and RT capabilities based on examination effectiveness, reliability, and interchangeability
  - Follow on to JCN-N6585
  - Status: Proposal Stage

- Scope of Work:
  - Assist EPRI in organizing an international workshop
  - Evaluate the use of digital radiographic testing (DRT) for repair, replacement and inservice inspection examinations
  - Evaluate the interchangeability of RT and UT

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NDE-Related Research Projects – JCN-V6097 (cont'd.)

- PNNL supporting this project with internal laboratory capital equipment funds to acquire:
  - X-ray Vault & 450 kV X-ray System
  - 160 kV X-ray System
  - PaxScan 4030 Flat Panel Detector
  - CR cassettes

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Effectiveness and Reliability of Acoustic Emission for NDE in Advanced Reactors – JCN N6907 started June 1, 2010

- NRC Project Manager – Iouri Prokofiev
- Objectives
  - Review of the acceptability of a Reliability and Integrity Management (RIM) program being developed by ASME Section XI SWG on High Temperature Gas-cooled Reactors, Division 2
  - Evaluation of current ASME requirements and existing industry codes for acoustic emission monitoring and leak detection monitoring for advanced reactors
  - Efforts will assist in development of draft regulatory guide to identify what information needs to be submitted for the technical basis and the guidelines for the assessing the acceptability of a RIM program for HTGRs and the acceptance criteria used to evaluate potential flaws identified in HTGR components.

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