

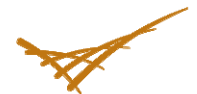
# Update of Nondestructive Examination (NDE) Projects Funded by NRC at PNNL

Steven Doctor  
Pacific Northwest National Laboratory

Presented at  
NRC/EPRI/PDI Meeting  
Juno Beach, FL  
November 30-December 1, 2010

# 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

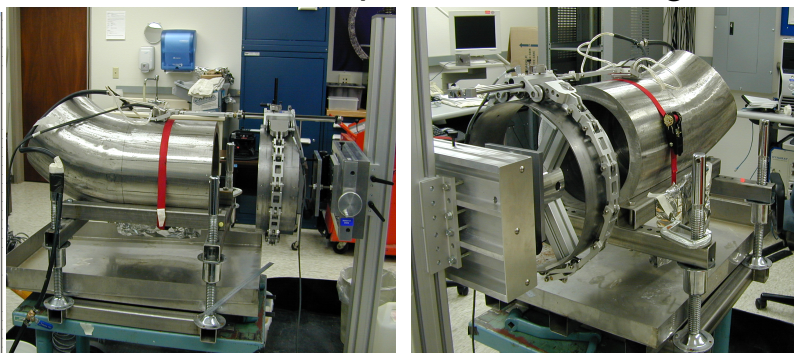
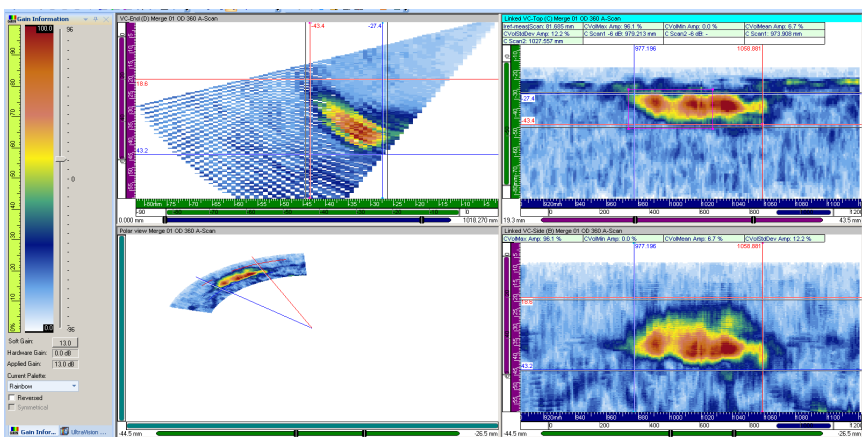


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# Examination of CASS PZR Surge Line Welds JCN-N6398

- ▶ **Revising draft NUREG/CR for phased array work on several CASS PZR line specimens**
  - Including new work by ISI supplier (S-10 procedure) and TrueFlaw in-situ grown cracks in CASS
    - ISI supplier and PNNL results almost identical
    - **All flaws** are easily detected; some tips available for depth sizing
    - Good S/N ratios for implanted and in-situ grown flaws
  - Axial and circumferential UT beam redirection measured
  - End-of-block corner trap scans to ascertain material effects
  - Specimens previously sent to EPRI for corroborating UT – preliminary results not as encouraging
    - EPRI is invited to PNNL to collaboratively re-acquire data on specimens with both PNNL and EPRI probes to ascertain discrepancies in findings

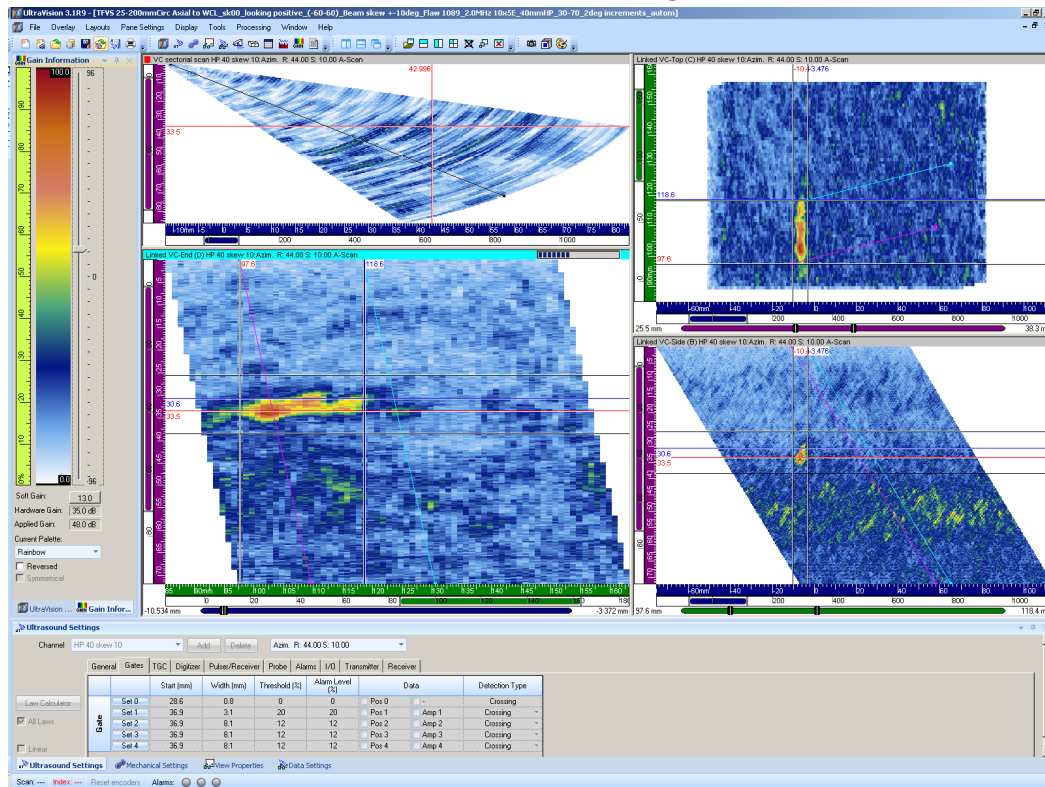


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# Examination of CASS PZR Surge Line Welds JCN-N6398

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



Trueflow 070BAB1089 1 mm

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



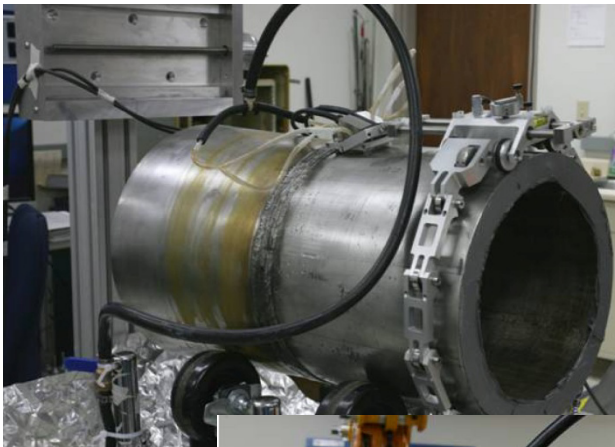
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# DMW Examinations JCN-N6398

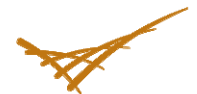
- ▶ Examined small-bore DMWs (specimens representing PZR surge, shut-down cooling and safety injection) - TLR to NRC (PNNL 19018)
- ▶ Acquired UT data on RCP DMW – FPL specimen at EPRI
  - **Awaiting EPRI OK to analyze data**
- ▶ Working with EPRI to access “practice” large-bore DMW specimens



# 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**
  - Final TLR submitted to NRC (PNNL 19002)
  - Comparing CASS chemistry to ferrite content and grain structures
- ▶ **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)



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# 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 completed in **August 2010**
  - Three companies (including NDE vendors and camera manufacturers) participated in Phase I tests.
  - Analysis of results completed, and planning for phase II continuing in collaboration with EPRI

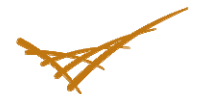


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# Other Related Work JCN-N6398

- ▶ **Assessing UT of full structural overlays on small-bore dissimilar metal welds**
  - First WOL specimen (PZR surge) being examined
  - Second specimen being delivered in December
- ▶ **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



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# On-going Task 2 HDPE Activities JCN-N6398

## ▶ High Density Polyethylene Piping

- Industry thrust to use HDPE for non-safety system applications – service water Calloway piping is 36” diameter and 4” wall
- 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 with DE**
  - **Examples follow of selected results**
- **NUREG/CR report being developed to document all work conducted**



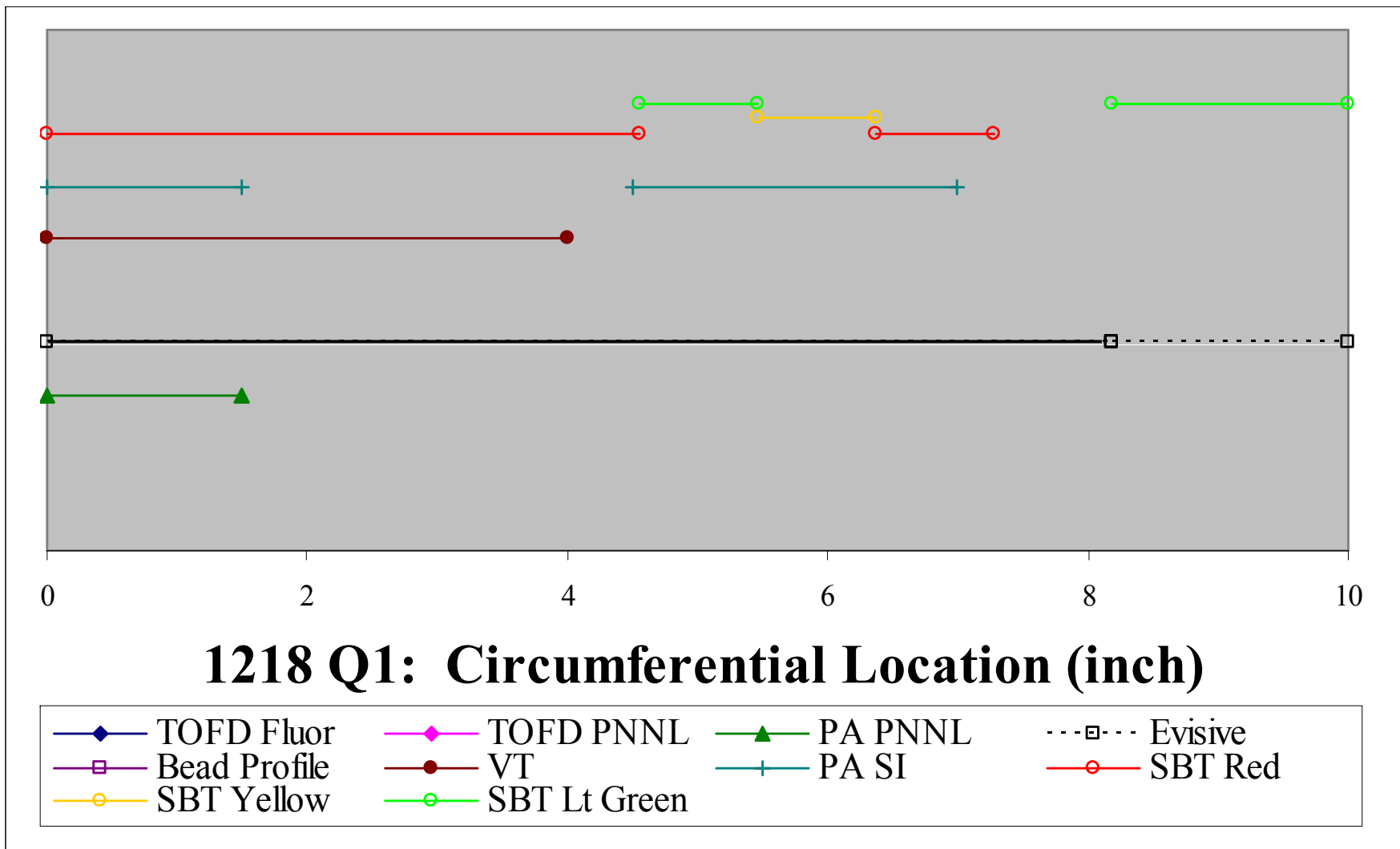
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# On-going Task 2 HDPE Activities JCN-N6398

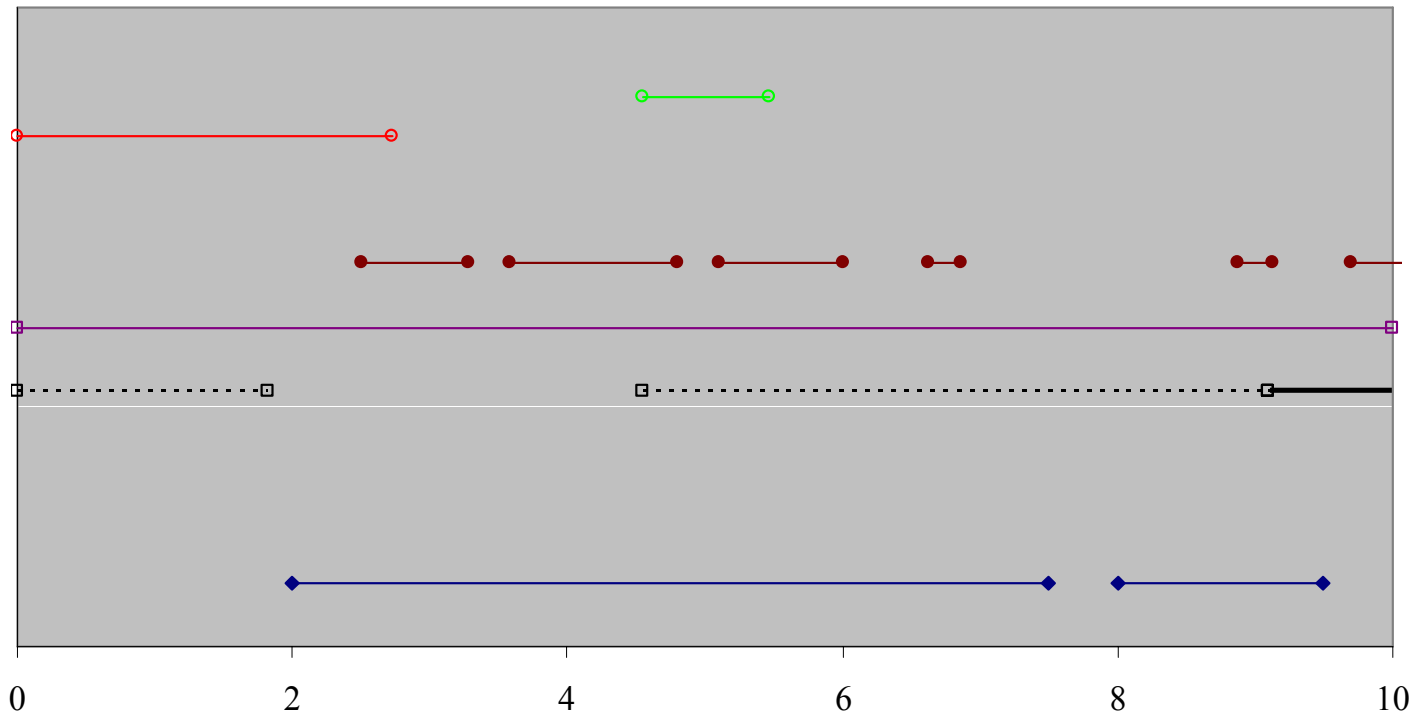
## Pipe 1218 Quadrant 1: DE and NDE

### Summary Results



# On-going Task 2 HDPE Activities JCN-N6398

## Pipe 123 Quadrant 1: DE and NDE Summary Results



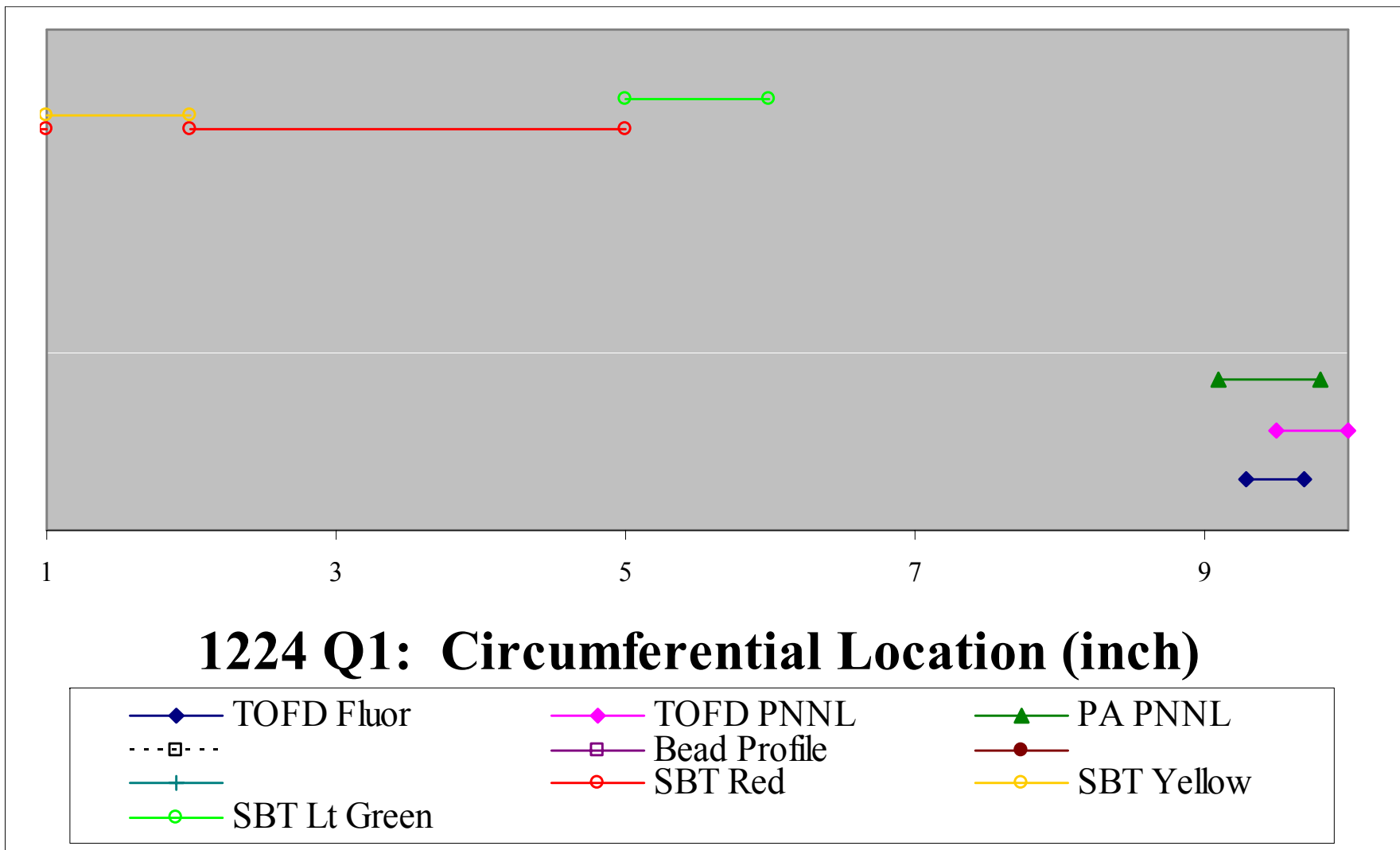
123 Q1: Circumferential Location (inch)



# On-going Task 2 HDPE Activities JCN-N6398

## Pipe 1224 Quadrant 1: DE and NDE

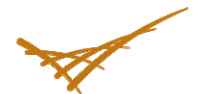
### Summary Results





# Assess Emerging NDE for Dissimilar Metal Welds JCN - N6593

- ▶ The NRC Project Manager - Iouri Prokofiev
- ▶ PNNL Project Manager – Brett Braatz
- ▶ 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

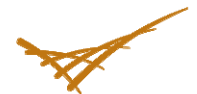


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# PINC and PARENT Programs

- ▶ 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 first PINC program concluded in 2009. Results have been published as **NUREG/CR-7019** “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 was developed cooperatively with the international committee members at the PARENT-1 project kick-off meeting in June 2010. Bottom mounted instrumentation (BMI) nozzels and dissimilar metal weld (DMW) large and small bore piping will be included in the open and closed testing.
  - Test blocks identified for use in the round robin testing and proposals for test plans and flaw implantation were reviewed at the PARENT-2 meeting in October, 2010.
  - Closure on international agreements is expected in early 2011.



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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 requested conversion into a NUREG/CR
  - EPRI NDE Center may provide input on technical basis
  - Part of the MOU being established between NRC and NDE Center

# 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 November 2010 – (New JCN planned for FY11 with start date 12/1/2010)
- ▶ International Forum on Reactor Aging Management (IFRAM) – Charter Drafted and first meeting will be two days prior to the 15<sup>th</sup> Environmental Degradation Conference scheduled for August 7-11, 2011 in Colorado Springs, CO
- ▶ IAEA PLIM meeting ~ June 2012 being co-sponsored by NRC and DOE-NE

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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 development continues as GALL is integrated with NUREG/CR-6923
  - 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



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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: **Completed**
  - 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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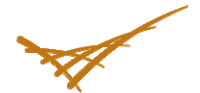
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# NDE-Related Research Projects – Wallace Norris NRC Project Manager Al Pardini PNNL Project Manager

- ▶ 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

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

- ▶ PNNL supporting this project with internal laboratory capital equipment funds to acquire in FY 2011:
  - Computed Radiography Capability – Phosphor Plate Reader
  - Flat Panel Detector for 450 keV X-ray
  - XYZ Translator for Detector
  
- ▶ Project Highlights
  - International Workshop on UT and RT in Orlando, FL March 15-16, 2011
  - PNNL is Compiling a Component Database
  - 16” Schedule 100 Pipe to Pipe Weld on Loan from LMT
  - PNNL is Analyzing the PVRUF Welds – RT vs UT
  - PNNL Established Contract for Welding with Local College
  - PNNL Contracted with AREVA to Provide Radiography Support



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# Effectiveness and Reliability of Acoustic Emission for NDE in Advanced Reactors – JCN N6907

- ▶ NRC Project Manager – Iouri Prokofiev
- ▶ PNNL Project Manager – Brett Braatz
- ▶ 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.
- ▶ Status
  - Literature review complete
  - Literature acquisition and evaluation in progress



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# NDE-Related Research Projects – Properties of CRDM Welds - JCN N6783

- ▶ Greg Oberson and Darrell Dunn – NRC Project Managers
- ▶ Brady Hanson – PNNL Project Manager
- ▶ Objectives – Assess the Leak Path on North Anna Unit-2 Nozzle 63
  - Ultrasonically Evaluate the Interference Fit – region between the penetration tube and carbon steel for wastage and boric acid deposits
  - Destructively Evaluate the Leak Path – keeping the nozzle and J-groove weld intact for possible later testing
  
- ▶ Status
  - Ultrasonic Scanner and Phased Array Probe Purchased
  - Mock-up Calibration Specimen Fabricated
  - Probe Evaluation and System Calibration in Progress



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