# 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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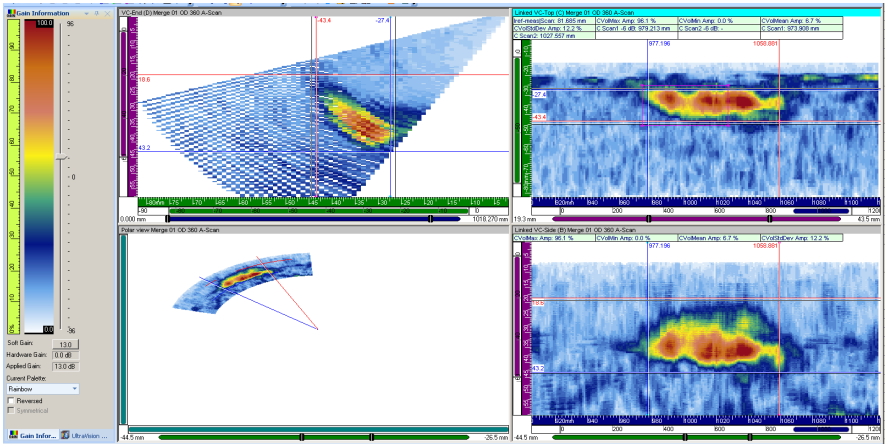
# Examination of CASS Piping JCN-N6398

- **NUREG/CR for phased array work on several CASS PZR line specimens being finalized by NRC**
  - Includes work by ISI supplier (Supplement10 procedure) and TrueFlaw in-situ grown thermal fatigue cracks in CASS surge line
    - 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 and reported
  - Specimens re-sent to EPRI for corroborating UT – detection results are similar
    - Meeting to compare results occurred at NDE Center in April
    - ASME moving forward with Code Case for new Appendix III, Supplement 2



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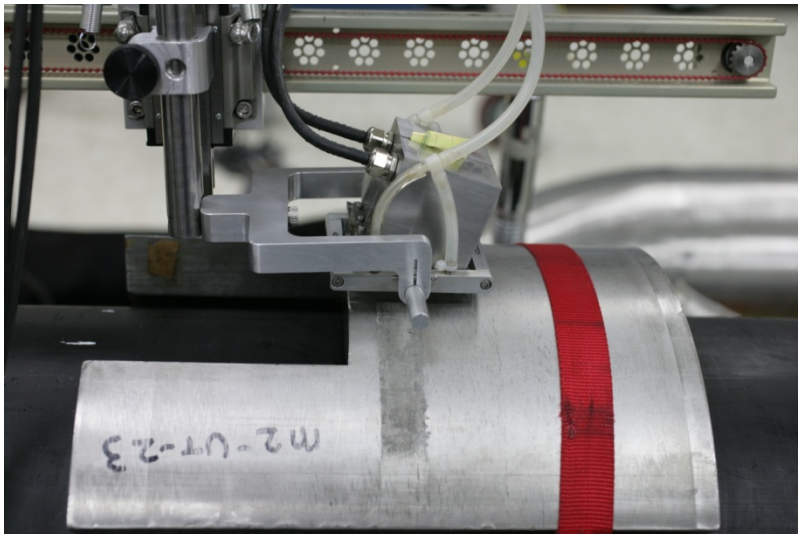
# Examination of CASS Piping
# JCN-N6398

- Continue to evaluate CASS materials
  - New materials acquired from Calvert Cliffs – WNP-4 salvage
  - Thick-walled materials from French foundry
  - Examining CASS calibration blocks, on-loan from EPRI
  - Polishing and etching samples to display microstructure



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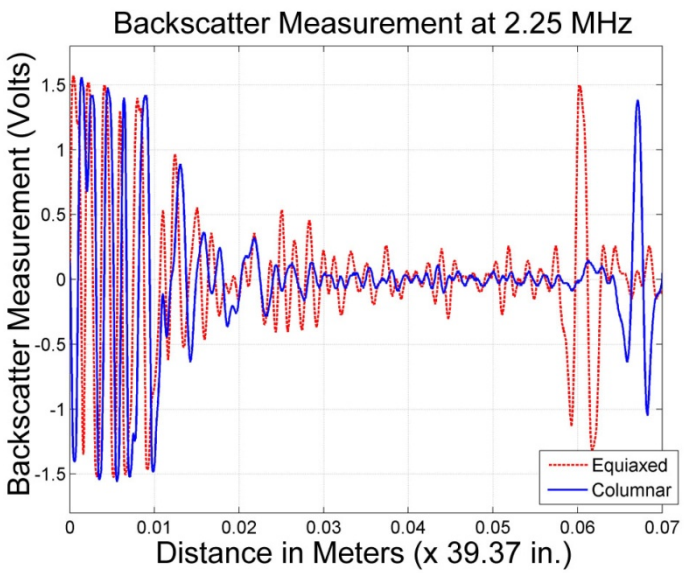
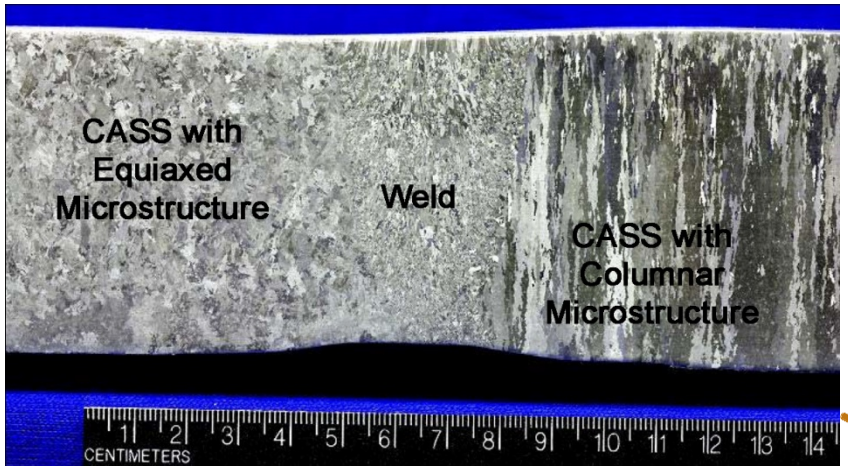
# Microstructural Effects and Potential In-situ Measurements for CASS JCN-N6398

## 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 recently completed
  - Mapping cross-sectional delta ferrite via ET recently completed
  - Final report to NRC for in-situ grain determination scheduled for June 2011

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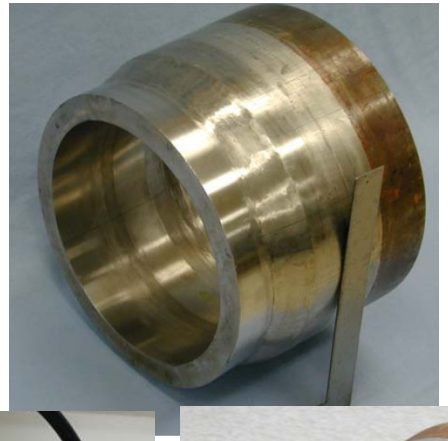
# DMW Examinations
# JCN-N6398

- UT of specimens representing PZR surge, shut-down cooling and safety injection DMWs, Technical Report to NRC (PNNL-19018)
- Acquired UT data on RCP DMW – FPL specimen at EPRI
  - EPRI recently gave OK to analyze data
- Working with EPRI to access “practice” large-bore DMW specimens



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# Remote VT Activities
# JCN-N6398

- Remote Visual Examinations
  - Assess capabilities and limitations of remote visual examination to detect cracking in RPV internal components
    - Parameters affecting reliable examinations
      - Crack opening dimension (COD)
      - System calibration (resolution) standards
      - Magnification and lighting effects
      - VT scanning speed
      - Crack length
      - Others?
  - **Conduct round-robin exercises** to evaluate current industry application and assess new technologies
  - Phase I testing at the EPRI NDE Center completed in **August 2010**
  - Planning for phase II continuing in collaboration with EPRI
    - Parametric study planned for Fall 2011 to refine specific parameters impacting remote visual examinations
    - Specimen preparation in progress
    - Recruitment of NDE vendors for Phase II in progress



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# HDPE Activities
# JCN-N6398

- High Density Polyethylene Piping
  - Industry thrust to use HDPE for non-safety system applications
  - NRC concerns about **lack of fusion flaws** being created in butt fusion joints
  - Conducting program to **assess several NDE technologies** for performing volumetric inspections of butt fusion joints using laboratory techniques and commercially available technology
    - Ultrasonic testing with phased arrays and time-of-flight diffraction
    - Microwaves
    - Visual examination
    - NDE inspections and destructive evaluations completed
    - Data correlated and analyzed
  - Draft NUREG/CR report documenting all work has been submitted for NRC review and approval (May 2011)



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# Other Related Work

- **Assessing UT of full structural overlays on small-bore dissimilar metal welds**
  - Full WOL specimens examined
  - Analyses to begin in June
  - Appears that original flaws are easily detected through overlay
- **Evaluated EPRI POD DMW report** (MRP-262)
  - Compares POD with recent round robin exercises
  - Draft report to NRC in April 2010
    - Assessment shared with EPRI – comments forthcoming?
- **Evaluated UT responses from cracks, pre- and post-MSIP**
  - IGSCC flaws at Ignalina Plant (Lithuania)
  - NDE specimen "squeezed" at NuVision Engineering
    - Strain-gauging during process to assess delta strain at ID
  - Reports on strain results and NDE submitted to NRC for comments

# Other Related Work

- NRC-EPRI Memo of Understanding for NDE Collaborative Program signed
- Currently includes several cooperative areas:
  - Examining CASS piping and welds
  - Remote visual testing
  - Using UT in lieu of RT; digital RT
  - Documenting technical basis for UT performance demonstration through Appendix VIII
  - Flaw-depth-sizing of DMWs examined from ID
- Future potential collaborative areas:
  - Assessing technical issues for use of HDPE piping
  - ANDE, or addressing training/qualification issues in some manner



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# Assess Emerging NDE for Dissimilar Metal Welds JCN - N6593

- The NRC Project Manager - Iouri Prokofiev
- PNNL Project Manager – Brett Braatz
- Project consists of three tasks:
  - **Program for the Inspection of Nickel Alloy Components (PINC)** - A cooperative international program to provide experimental data and correlations for assessing integrity of DMWs and BMIs – **Complete**
    - **NUREG/CR-7019** "Results of the Program for the Inspection of Nickel Alloy Components**"**
  - **Program to Assess the Reliability of Emerging Nondestructive Techniques (PARENT)** – An international program to evaluate current and emerging NDE methods
  - Review, update and document technical bases used in developing the performance demonstration criteria specified in Appendix VIII

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# PARENT Program

- PARENT is currently underway, and is being supported by multilateral international agreements
  - The scope of work was developed cooperatively with international committee members at the PARENT-1 project kick-off meeting in June 2010
  - Bottom mounted instrumentation (BMI) nozzles and dissimilar metal weld (DMW) large and small bore piping will be included in open and blind testing phases
    - Open testing to assess emerging NDE methods
    - Blind testing for field deployable technology as applied by qualified inspectors
  - Test blocks identified for use in round robin tests and proposals for test plans and flaw implantation methods were reviewed at PARENT-3 meeting in May 2011
  - Closure on international agreements is expected in late 2011

# Technical Bases 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 current version of Section XI, Appendix VIII documented for posterity
- Steven Doctor and Tom Taylor initially went through Appendix VIII requirements and produced an annotated version containing technical basis, or rationale, as best remembered
  - Mike Gothard provided some comments on an early draft
  - More recently, EPRI NDE Center provided input and comments on draft technical basis report (part of NRC-EPRI MOU)
    - Included Larry Becker in this review
    - PNNL has begun to incorporate these comments – there are many good comments, but several others not related to goal of the report
- This draft to be re-formatted and published as a NUREG/CR
- Note – based on NRC-EPRI collaborative work on NDE training and qualification, changes to Appendix VIII may be forthcoming…



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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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# NDE-Related Research Projects – Wallace Norris/Carol Nove NRC Project Managers Al Pardini PNNL Project Manager

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

  The evaluation will assess UT and RT capabilities, effectiveness, and reliability
  - Follow-on to JCN-N6585 Gap Analysis
  - Evaluating the interchangeability of UT and RT
  - Status: Work is on-going to assess the capability of both UT and RT to detect and size welding fabrication flaws in piping (first task)

- PNNL supporting this project with internal laboratory capital equipment funds
  - 450 KV X-ray machine and vault
  - Computed Radiography Capability – Phosphor Plate Reader
  - Perkin Elmer Flat Panel Detector and XYZ Translator for 450 KV X-ray



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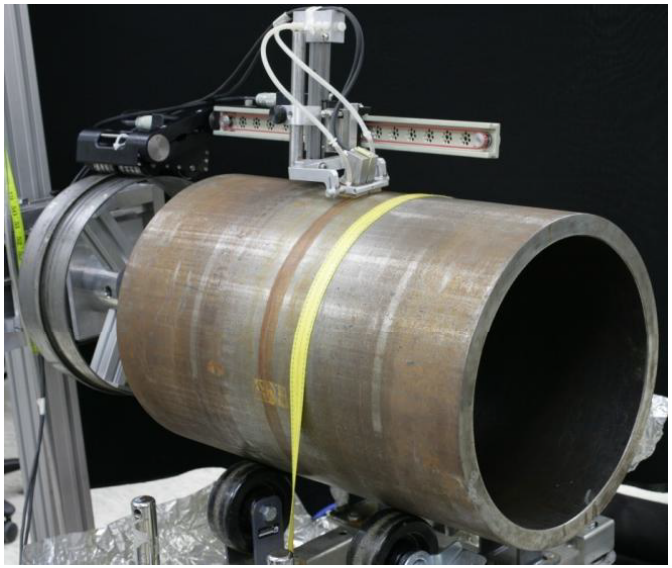
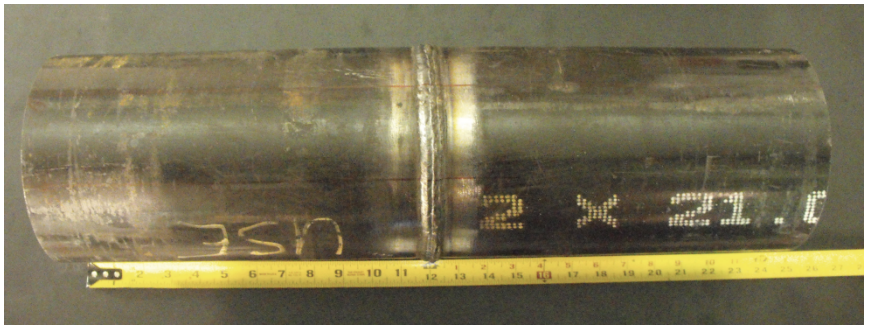
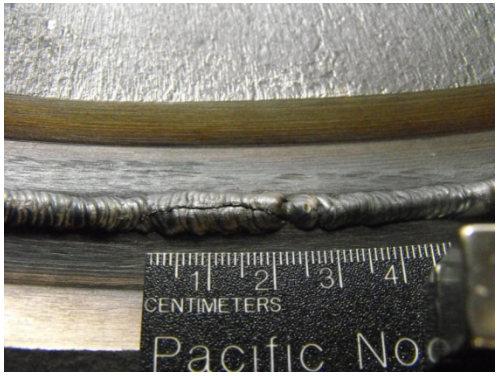
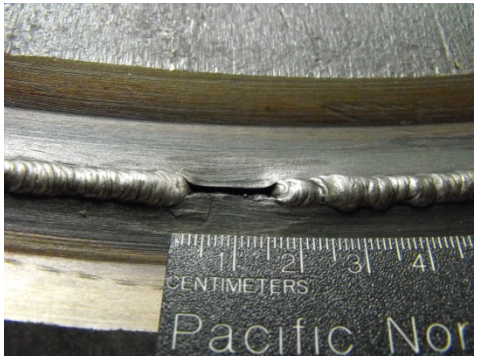
# NDE-Related Research Projects – JCN-V6097 (cont'd.)

- PNNL is evaluating multiple sample specimens some with implanted flaws, some with real flaws





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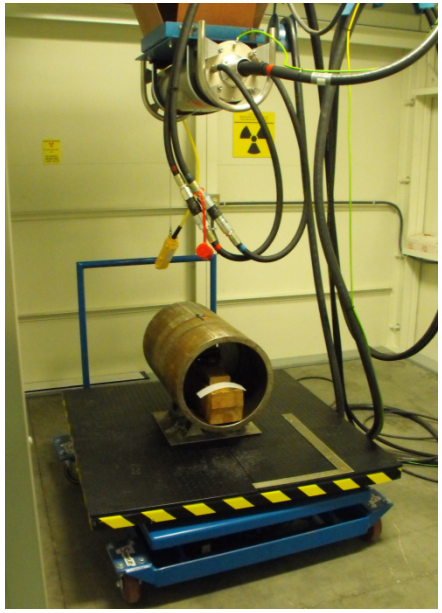
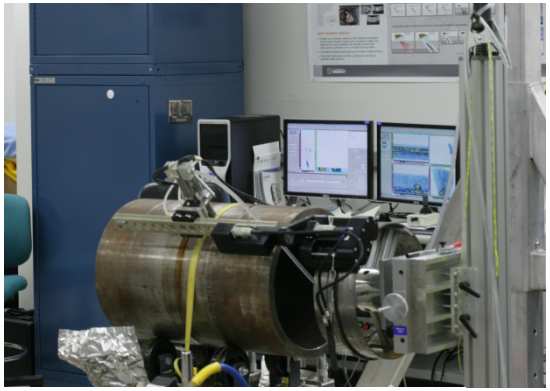
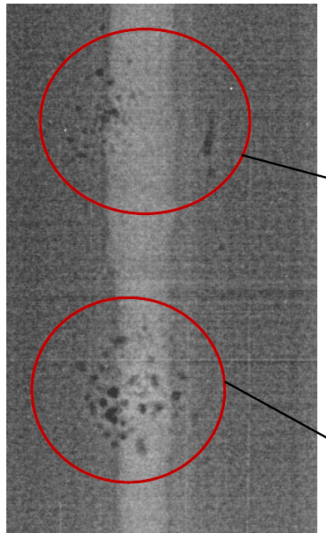
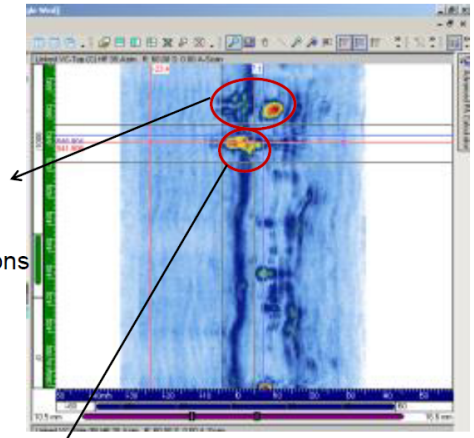
# NDE-Related Research Projects – JCN-V6097 (cont'd.)

- PNNL is performing Phased Array UT and X-ray of each specimen.









Other "Bonus" indications

Flaw 7

Top View (C-Scan)

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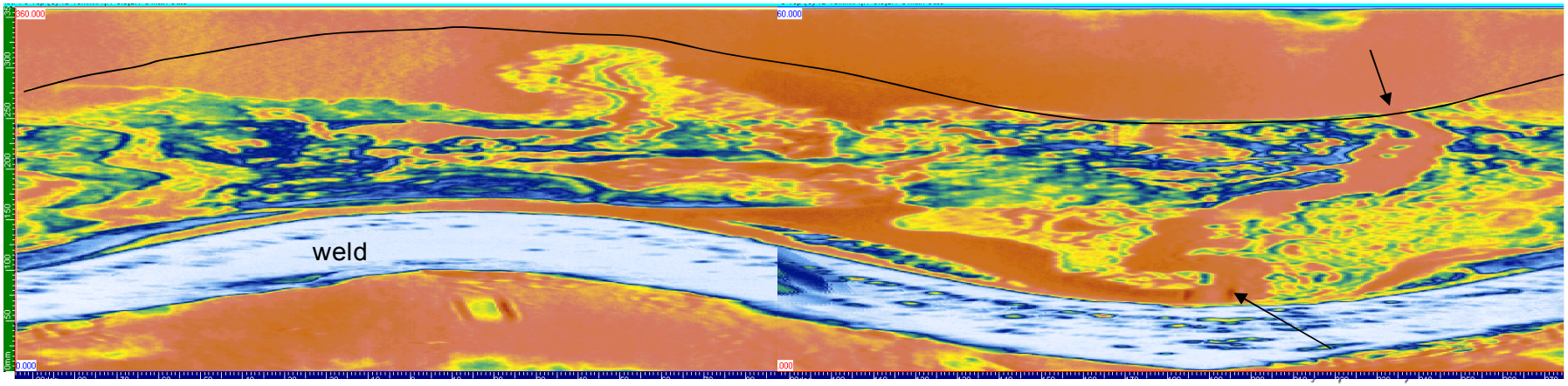
# NDE-Related Research Projects – Properties of CRDM Welds - JCN N6783

- Greg Oberson – NRC Project Manager
- Brady Hanson – PNNL Project Manager
- Objectives – Assess the leak path on North Anna Unit 2, Nozzle 63
  - Ultrasonically examine the interference fit (region between penetration tube and low alloy steel) for wastage and boric acid deposits
  - Destructively evaluate (DE) the leak path – keeping the J-groove weld intact for possible future testing
- Status
  - Suspected leak path ultrasonically examined
  - Contract for cutting to be placed in June with DE work planned for completion by end of August



# Questions?



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