Overview 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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JCN-N6398 Primary Task Focus Areas:

- Task 1 – ISI Reliability and ASME Code Requirements:
  - Evaluate reliability and accuracy of current NDE being used for ISI, including performance-based methods, to provide recommendations for improvements to ASME Code, Section XI
    - Participate in international programs to assess and quantify NDE technology and procedures
    - Cooperate with international and domestic entities to elevate NDE capabilities in "ISI problem areas"
      - MOU between NRC and IRSN on cast stainless steel inspections
    - Evaluate industry approaches for performance demonstration of NDE methods and techniques
    - Assist RES and participate in NRC's Technical Advisory Group (TAG) on NDE

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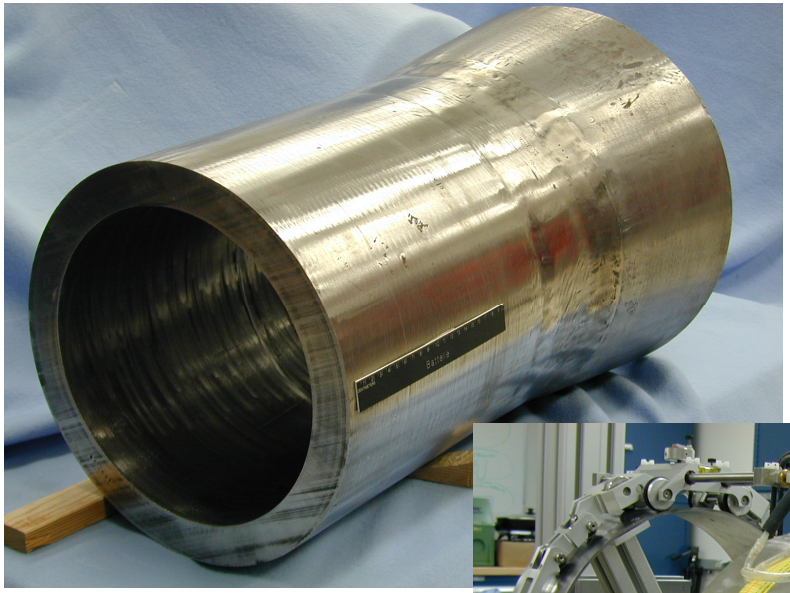
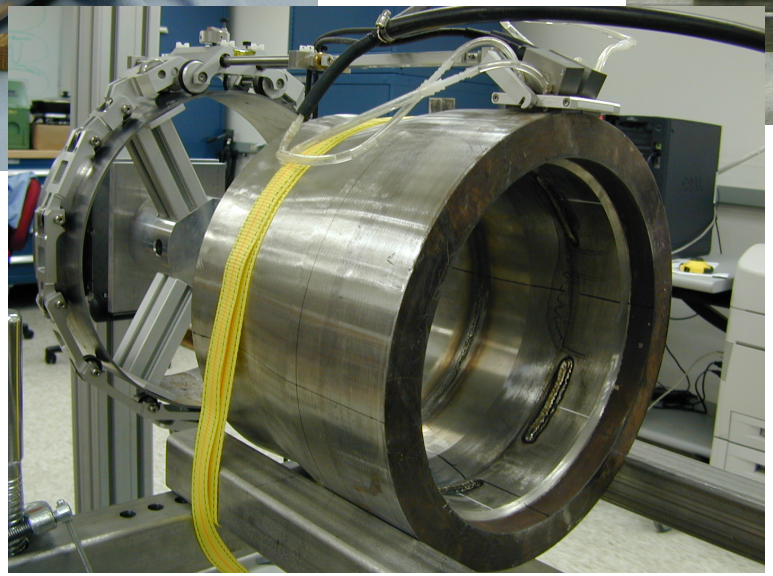
JCN-N6398 Primary Task Focus Areas:

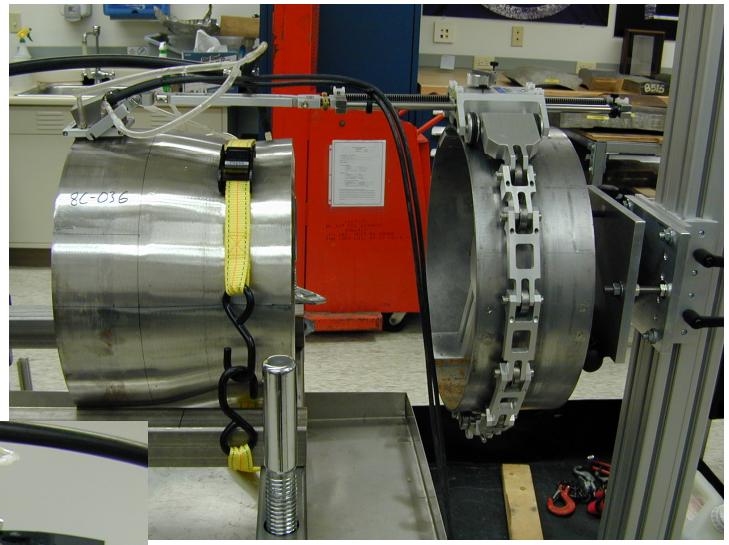
- Task 2 – Encompasses wide range of difficult inspection issues and assessment of advanced NDE methods for:
  - Cast austenitic stainless steel piping (CASS)
  - Dissimilar metal welds (DMWs); e.g., Alloys 600, 82, 182
  - Inspection through wrought stainless steel welds
  - High density polyethylene piping (HDPE)
  - Welded overlays/cladding/in-lays
  - Reactor internal examinations
  - Vessel Penetrations (CRDM and BMI nozzles)
- Research priorities periodically updated by RES based on emergent needs:
  - PTS rule comments
  - St. Lucie PZR nozzle
  - xLPR issues
  - OWOL

DMW Examinations JCN-N6398

- Examined flawed DMW specimens – PZR surge line configuration







WNP-3 surge line-to-primary system weld

PNNL fabricated surge line DMW

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On-going Task 2 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 can not 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

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

- Remote Visual Examinations
  - Assess capabilities and limitations of remote visual (ASME VT-1) examinations 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 judge adequacy of current industry equipment, procedures and personnel
    - Quantify effectiveness of current practice
    - Determine if improvement is needed and this could include options such as performance demonstration

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JCN-N6398 Primary Task Focus Areas:

- Task 3 – ISI Program Requirements – Failure Probability, Fracture mechanics, and NDE Reliability
  - Ensure structural integrity is adequately maintained
  - Support NRC to evaluate overall effectiveness of proposed industry initiatives
    - Risk-informed ISI
    - Appendix L fatigue assessments
    - Benchmarking of new structural mechanics codes (Pro-LOCA)
    - Vessel repair flaw evaluations
    - New construction issues
- Task 4 – Flaw Density and Distribution
  - Started in 1989 on RPV to develop empirical database with validated results includes all major RPV manufacturers
  - Used in NRC PTS re-evaluation

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JCN-N6398 Primary Task Focus Areas:

- Task 5 – National Codes and Standards
  - Participate in development of ASME Code, Section V and XI to achieve acceptance of RES-sponsored research results to improve NDE and ISI requirements
    - Task Group on Appendix VIII – Performance Demonstration, CASS, Alloy 600, Special Working Group HDPE and Working Group on Volumetric Examination and Procedure Qualification
- Task 6 – Consultation on Emergent Issues
  - Respond to NRR requests (through RES) for immediate expert assistance in NDE and ISI; examples
    - VC Summer
    - DMW cracks at Duane Arnold, Millstone, etc.
    - St. Lucie PZR nozzle

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NDE-Related Research Projects

- JCN-N6319 – "PWSCC in Leak-Before-Break (LBB) Systems"
  - Assess strategies for managing PWSCC to ensure piping rupture remains extremely low (GDC-4) via inspection, stress improvement, and material replacement
  - Assessing POD in DMWs through collaboration with EPRI PDI
  - Determining ability to detect existing cracks in post-MSIP welds
  - NRC Project Manager – Wallace Norris
  - PNNL Project Manager – Mike Anderson
- JCN-N6547 – "Residual Stress Analyses and Validation"
  - Measure stress distribution in DMWs to validate finite element analysis (FEA) codes
  - Developing weld residual stress specimens for making empirical measurements to validate models
  - NRC Project Manager – Howard Rathbun
  - PNNL Project Manager – Mike Anderson

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) - A planned 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.

PINC and Parent Programs

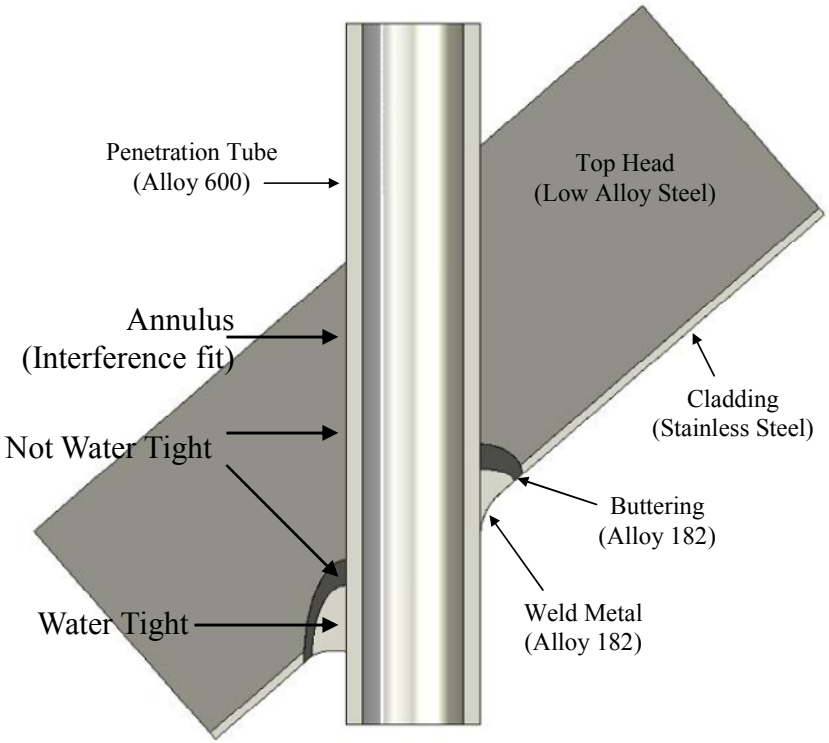
- The PINC program worked with regulators, universities and industrial groups in Europe, Japan, Korea and with EPRI to use round-robin tests to evaluate the effectiveness of qualified and experimental NDE techniques. The participants have bilateral agreements with the NRC
- The NDE techniques were scored to determine their effectiveness in detecting and sizing flaws in dissimilar metal welds – draft report sent to participants for review.
- The first PINC program will conclude in 2009.
- A PINC II/PARENT program is currently being developed by the NRC with PNNL support. New program will be supported by a multilateral international agreement and will be developed to be open to the Public.
- The future participants requested new round-robin tests.

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 and the current supplements documented.
- Steven Doctor and Thomas Taylor went through the Appendix VIII requirements and supplements and produced an annotated version containing the technical basis or rationale behind each .
- This work will be published as a technical letter report titled “The Technical Basis Supporting ASME Code Section XI, Appendix VIII”

Non-destructive & Destructive Examination of Salvaged CRDMs and J-welds from North Anna 2 JCN - Y6867

- NRC Project Manager - Wallace Norris
- PNNL Project Manager - Stephen Cumblidge
- The overall goal was to examine the control rod drive (CRDM) nozzles and J-groove welds from the North Anna 2 head to confirm degradation, for better characterization of the cracking, for evidence of boric acid corrosion and leak path development, including evidence of annulus plugging.



CRDM J-groove Weld Diagram

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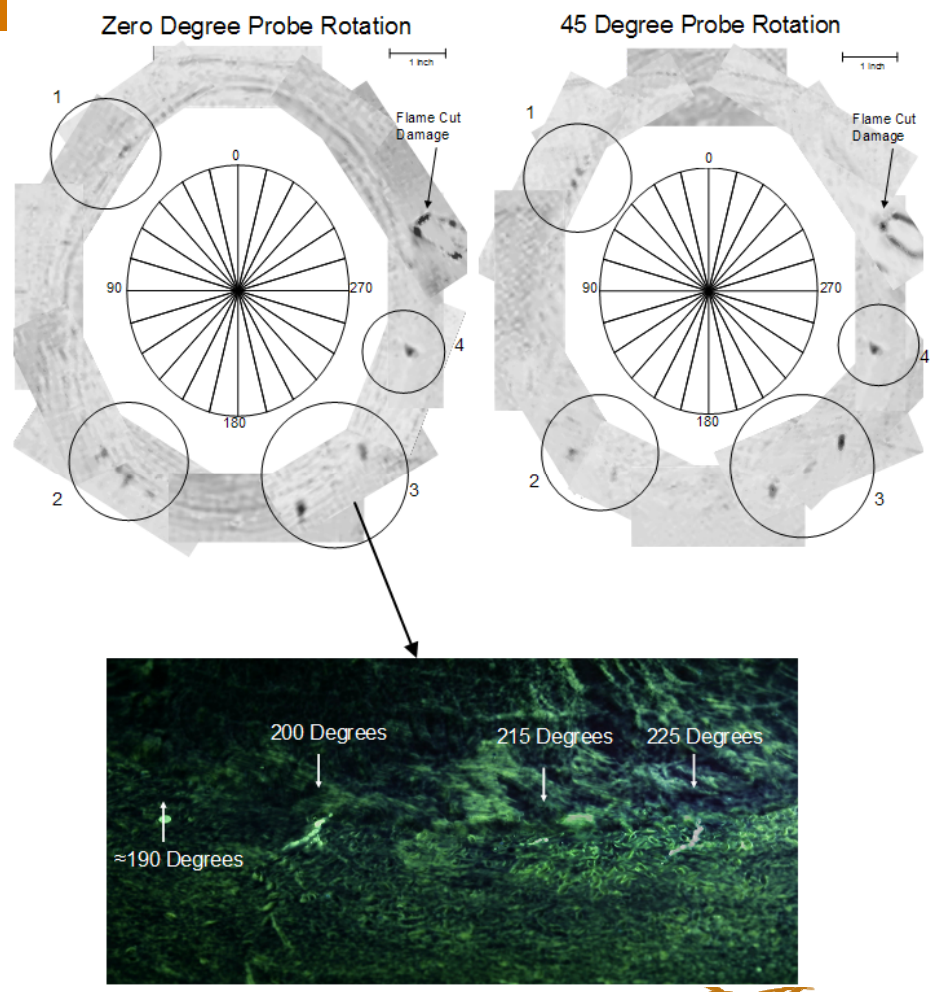
Nondestructive Testing Results

- Two CRDM nozzles, 31 and 59, were extensively examined with nondestructive testing techniques.
- The interior of the penetration tubes were examined using TOFD, ET, and visual testing via replicant material.
- The J-groove weld of Nozzle 31 was examined using eddy current testing, penetrant testing, and visual testing.
- Sixteen crack-like eddy current indications were found, three of which were confirmed using penetrant testing



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Destructive validation of NDE Reponses

- The crack-like indication found by eddy current at 155 degrees was determined via destructive evaluation to propagate through the weld and into the annulus at 135 degrees.
- A second deep crack at 255 degrees was found to have penetrated through the weld but was not yet leaking.
- Of all of the NDE techniques applied, only eddy-current was able to find the deep cracks.
- The detailed results will be published soon in a NUREG/CR “Nondestructive and Destructive Examination Studies on Removed-from-Service Control Rod Drive Mechanism Penetrations”

Proactive Management of Materials Degradation (PMMD) – JCN-N6029

- NRC Program Managers – Gene Carpenter, Amy Hull, Shah Malik
- PNNL Program Manger – Leonard Bond
- **Goal is to <u>proactively address potential future degradation</u> in operating plants to avoid failures and to maintain integrity, operability and safety**
  - Supporting the NRC in developing a **<u>Road Map</u>** for PMMD
    - Identification of technical and regulatory gaps and research needs
  - Developing an **<u>Information Tool – PMMD.PNL.GOV</u>**
    - NUREG/CR-6923 PMDA
    - Other reports such as GALL
    - LWR component failure databases
    - Operating history

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Proactive Management of Materials Degradation (PMMD) JCN-N6029 cont'd

- Conducting **fundamental science** to better understand **degradation processes** regarding initiation and growth
  - Will provide guidance on what needs to be detected and how to interpret
- **Assessing mitigation and repair** methodologies
- **Assessing NDE** for adequacy to manage degradation
  - Periodic NDE to reliably detect and accurately size all expected forms of degradation
  - Continuous on-line monitoring technologies

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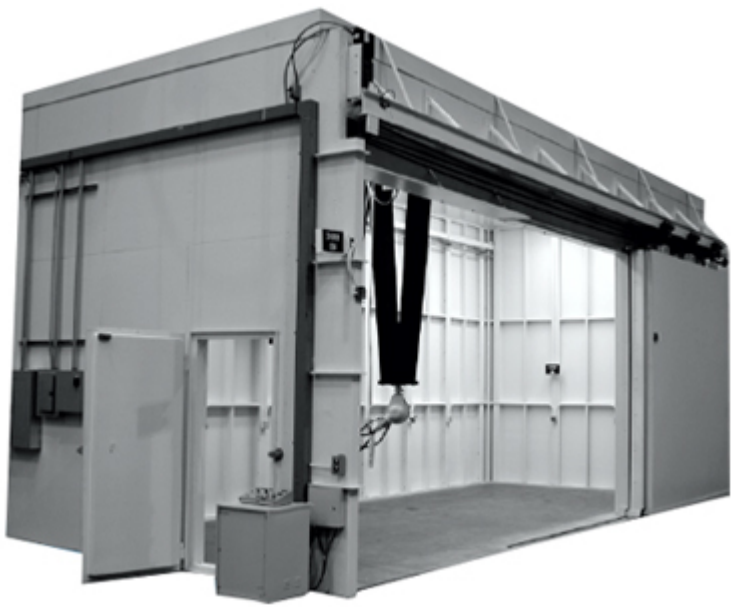
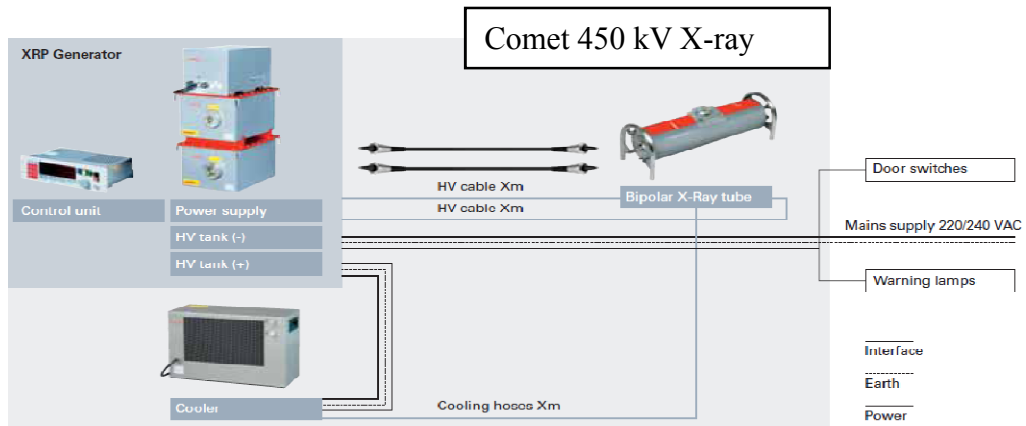
NDE-Related Research Projects – Wallace Norris NRC Project Manager Al Pardini PNNL Project Manager

- JCN-N6585, Effectiveness and Reliability of UT and RT for Construction, Preservice, and Inservice Volumetric Examination Activities
  - New project just starting
  - Addresses use of UT in lieu of RT for fabrication and repair
- PNNL supporting this project with internal laboratory capital equipment funds





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Engineering Support for NRR

- "On-call" assistance projects, on a task-order basis:
  - JCN-J3217 - "Review of Inservice Inspection-Relief Request Licensing Actions and Risk-Informed Inservice Inspection Programs"
    - Evaluate licensee NDE/ISI requests, make recommendations for NRR SERs
  - JCN-J3218 - "Regulatory Improvement Activities"
    - Industry initiatives (EPRI, PDI, MRP, BWRVIP)
    - Generic NDE reliability concerns
    - MOV program assessment
- Engineering database updates and maintenance:
  - JCN-J3219 - "Update of the Inservice Inspection Relief Request Database"
  - JCN-J3139 - "Update of the Reactor Vessel Integrity Database (RVID)"
- Rachel Glaros – NRR Project Officer
- Mike Anderson – PNNL Project Manager

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