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

Steven Doctor, Michael Anderson, Leonard Bond and Stephen Cumblidge
Pacific Northwest National Laboratory

Presented at
NRC-EPRI-PDI Meeting
December 1-2, 2009

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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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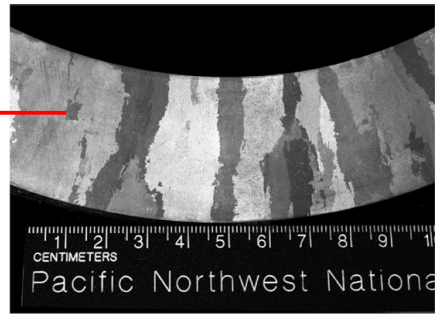
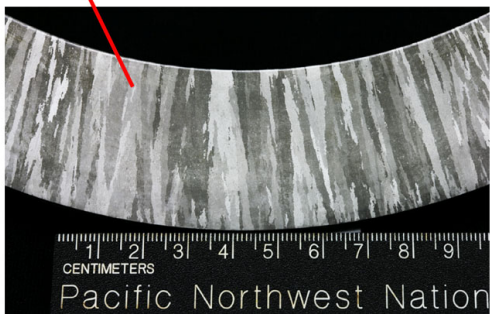
Examination of CASS PZR Surge Line Welds JCN-N6398

- **Completed phased array work on several CASS PZR line specimens**
  - **Draft TLR** to RES in August 2009; this TLR being re-formatted as NUREG/CR
  - Noted that **all flaws were easily detected**; some tips available for depth sizing – somewhat surprising considering the microstructure
  - Specimens sent to EPRI for corroborating UT - no EPRI summary as yet





➢Results to be used as basis for new ASME Code action on performance demonstration for less than 2.0-inch thick CASS piping welds

➢Draft Code Case introduced at TG-CSS similar to Supplement 12 – "add-on" to Supplement 10 qualifications

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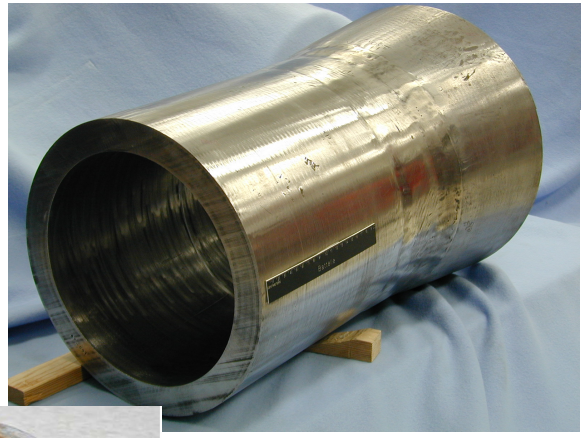
DMW Examinations JCN-N6398

- Continued to **examine small-bore DMWs with phased array** (5 specimens representing PZR surge, shut-down cooling and safety injection)
  - **Draft TLR** to RES on November 30, 2009
    - All flaws detected
    - Weld crown removal necessary (if they exist)
    - Sizing of deep (near OD surface) flaws difficult with existing PA probes



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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**
    - Identified **vintage CASS piping at French foundry** – PNNL and EPRI acquiring segments for further research
  - If possible, determine whether microstructures can be defined (and controlled) **via control of process parameters**
  - **Draft TLR** submitted to NRC on November 30, 2009
- **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 is also showing promise

Other Relevant Work JCN-N6398

- **Assessing UT of full structural overlays on small-bore dissimilar metal welds**
  - Two WOL specimens (PZR surge) being procured
- **Collaborated with EPRI to produce POD report for DMWs**
  - Frank Ammirato and Pat Heasler
  - Report published in October (MRP-262, Rev. 1)
- **Evaluating UT responses from cracks, pre- and post-MSIP**
  - “Squeezing” NDE specimen at NuVision Engineering on December 9
  - Westinghouse and PNNL will each perform UT, before and after MSIP
  - Strain-gauging during process to assess delta strain at ID
  - Expect report early in 2010

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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 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
  - **Summarizing all NDE measurements for developing validation plan**
    - High speed tensile test
    - Guided bend test
    - Fusion normal immersion testing with high frequency UT
    - Slicing and polishing cross sections

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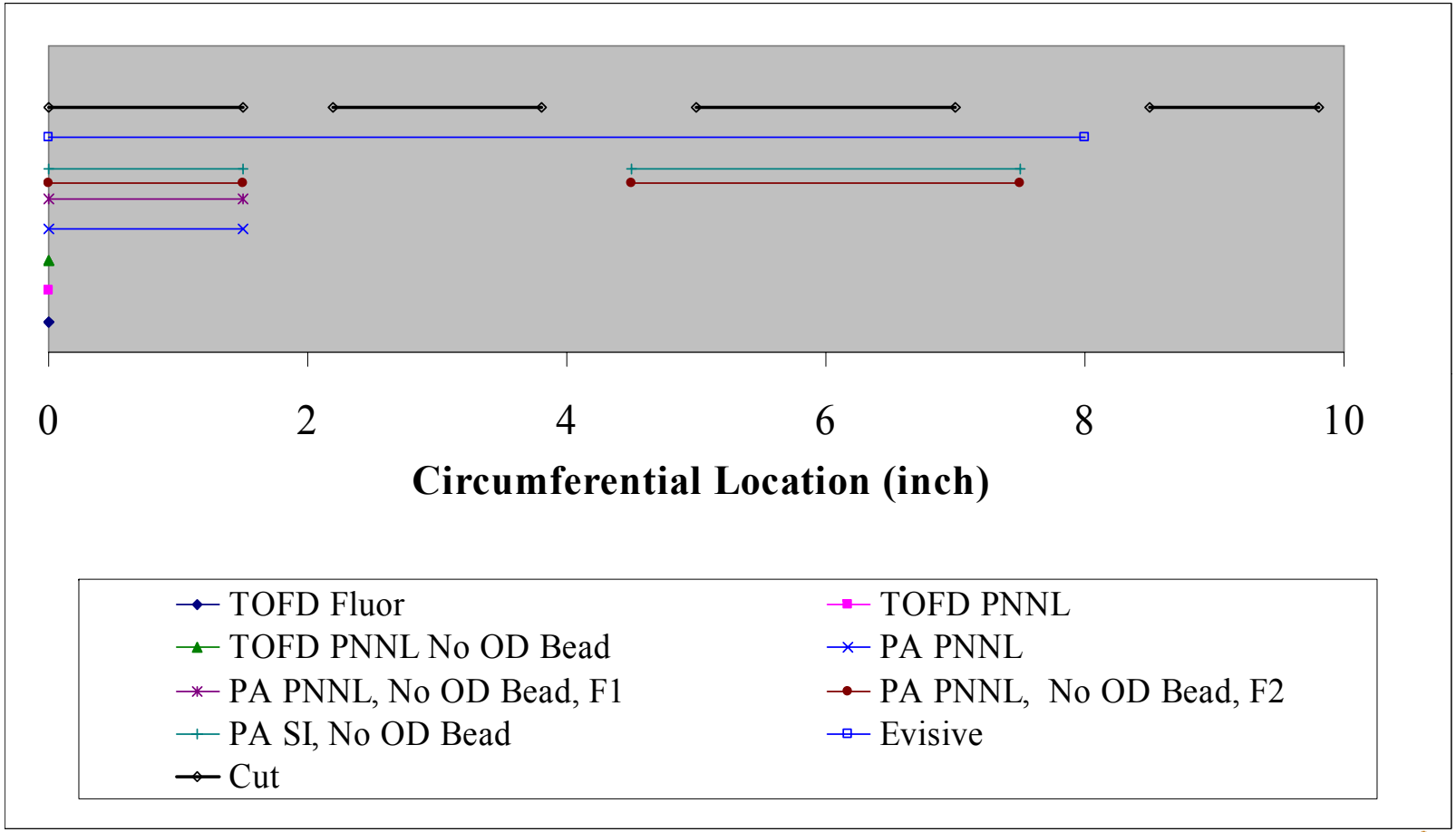
On-going Task 2 HDPE Activities JCN-N6398 Pipe 1218 Quadrant 1: NDE Summary Results



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On-going Task 2 Remote VT 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
  - **All round robin specimens have been created with range of crack opening dimensions.**
    - Evaluating methods to introduce patina to simulate field conditiosn

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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)** - 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

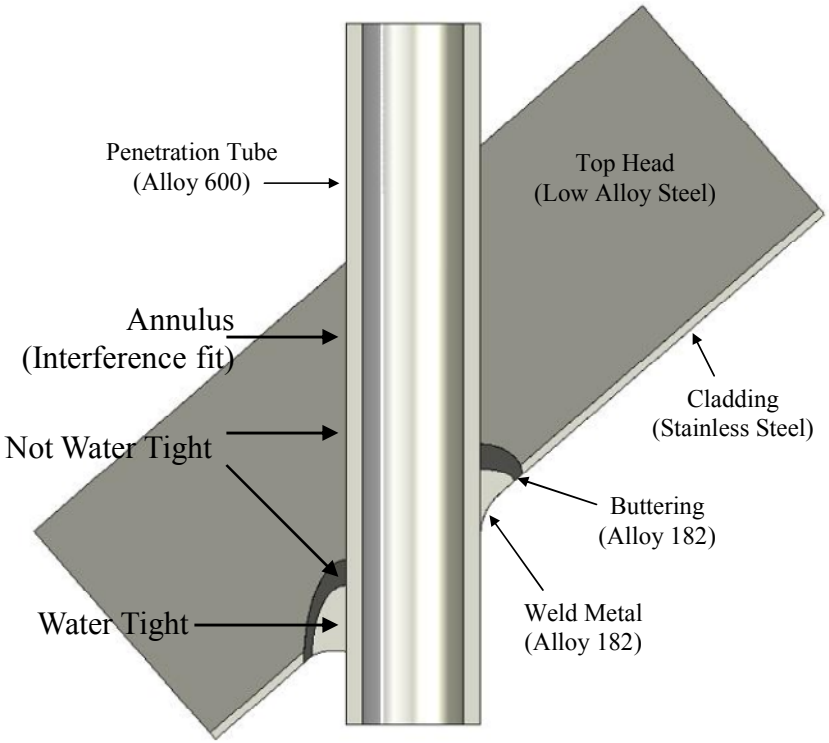
- The PINC program worked with regulators, universities and industrial groups in **Europe, Japan, Korea and with EPRI** to use round-robin tests to evaluate the effectiveness of qualified and experimental NDE techniques. The participants have bilateral agreements with the NRC
- The NDE techniques were scored to determine their effectiveness in detecting and sizing flaws in dissimilar metal welds
- The first PINC program concluded in 2009. The results will be published as a **NUREG/CR "Results of the Program for the Inspection of Nickel Alloy Components"**
- 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 scope of work is being developed in cooperation with the current and future members of the international committee.

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 Thomas Taylor went through the Appendix VIII requirements and produced an annotated version containing the 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** reviewing of the TLR has been positive and next action is to **convert this TLR into a NUREG/CR**
  - Reviews

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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Destructive validation of NDE Reponses

- 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"**
- **Program completed November 30, 2009**

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Proactive Management of Materials Degradation (PMMD) – JCN-N6029 Ending Fall 2009

- 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-N6957 – Started October 1, 09

- NRC Program Managers – Gene Carpenter, Amy Hull, Shah Malik
- PNNL Program Manger – Leonard Bond
  - 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

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International Forum for LWR aging Management (part of N 6029 and N 6957 scope)

- **Asia Engagement workshop** held Seoul – South Korea

  (Japan, Korea, China, Taiwan and India had participants present)

  - establish a **flat, flexible organizational structure** to facilitate issue-oriented cooperation.
  - **building cooperation** among existing, and developing, programs
  - **identify high priority issues**
  - **facilitate joint projects** among parties with mutual interests on specific issues.
  - **will not fund** and/or initiating new directly funded research projects.
  - parties involved in the forum will provide resources for the work.

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International Forum for LWR aging Management (part of N 6029 and N 6957 scope) - cont

- **Draft Forum Charter** under development (to be circulated **Jan 2010**)
- **European Engagement workshop** – planning for **June 2010**
- **Launch of Forum Fall 2010**

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New PMMD Program and Information Tool Website

PMMD Proactive Management of Materials Degradation

Search PMMD

PMMD Program

- Rationale
- Thrusts
- PMMD Project
- International Forum
- Technical Issues
- Technical Reports
- Technical Meetings
- Contact Us
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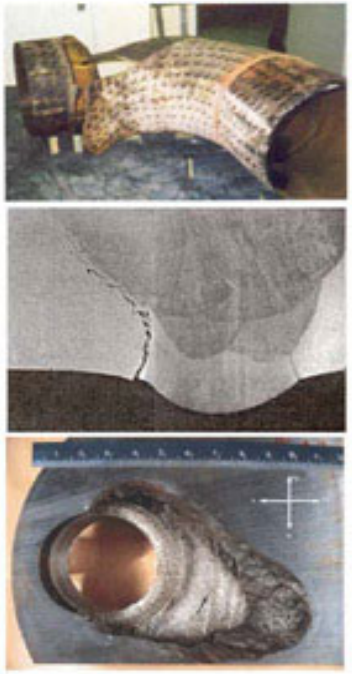
- Home

PMMD Information Tool

- Users Guide (1.4Mb)
- Users Guide (Power Point 4Mb)
- NUREG/CR-6923
- Flag View
- Rainbow View
- Parts List View
- Expert View

Welcome to the U.S. Nuclear Regulatory Commission Program on Proactive Management of Materials Degradation (PMMD) for LWRs. The NRC has initiated a new program to promote the understanding and use of PMMD methods and technology in extending the life of LWRs. The program will build national and international collaboration on regulatory research issues. The goal of PMMD activities over the next five years is to place NRC in a position where it has the technical basis to answer some key aging-related degradation questions, including:

- Can licensees safely extend the operating life of existing NPPs to 60-80 years and potentially longer?
- What are the key technical and regulatory issues that require attention to enable license extension?
- What information is needed to position NRC to adequately process and respond to applications for a second (and subsequent) license extension?
- What are the remaining open technical and regulatory issues?



Site at: http://pmmd.pnl.gov

Last Updated: March, 2009
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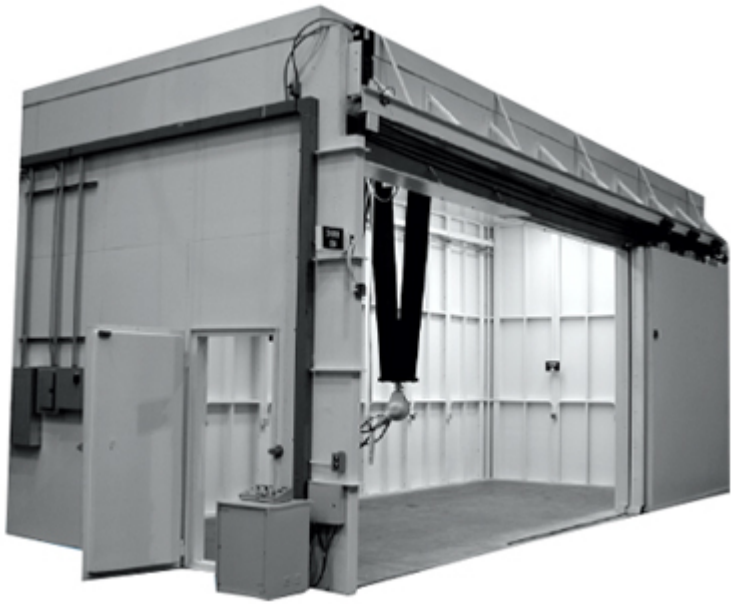
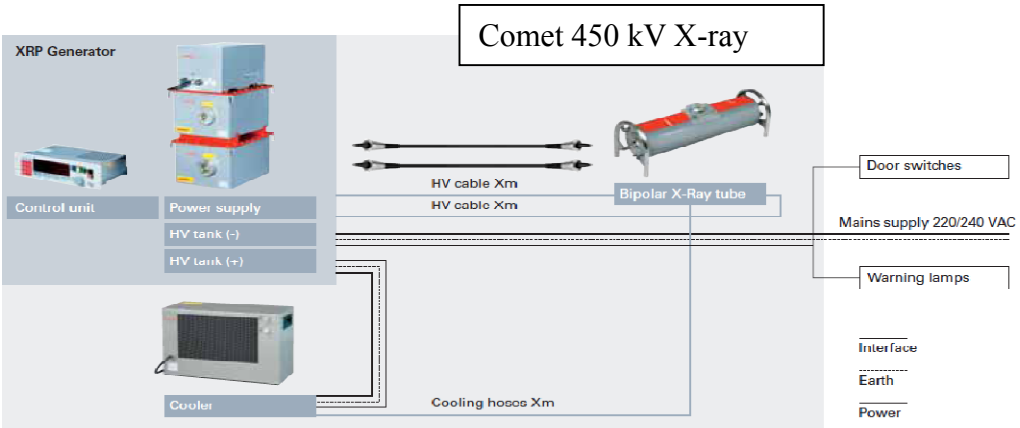
NDE-Related Research Projects – Wallace Norris NRC Project Manager Al Pardini PNNL Project Manager

- JCN-N6585, Effectiveness and Reliability of UT and RT for Construction, Preservice, and Inservice Volumetric Examination Activities
  - Addresses use of **UT in lieu of RT for fabrication and repair**
  - **TLR** on literature survey submitted to NRC Nov. 30, 2009
- PNNL supporting this project with internal laboratory capital equipment funds





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