



U.S. NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Nondestructive Examination Research Program Highlights

Carol Nove

NRC/RES/DE/CIB

March 11, 2014

Regulatory Requirements

- Appendix A to Part 50: GDC-1 for NPP – Overall Requirements
 - *Criterion 1—Quality standards and records.*
- Appendix B to Part 50--Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants
 - *IX. Control of Special Processes*
- 10 CFR 50.55(a)(b) incorporates by reference the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section III, *Rules for Construction of Nuclear Facility Components*, and Section XI, *Rules for Inservice Inspection of Nuclear Power Plant Components*.

Resources:

- Primary contractor is Pacific Northwest National Laboratory
- Stakeholders include:
 - NRC Office of Nuclear Reactor Regulation
 - NRC Office of New Reactors
 - Electric Power Research Institute
 - Nuclear Industry
 - ASME Code
 - International Partners
 - Public

Primary research objective is to enhance the reliability of Nondestructive Examination (NDE) performed for Inservice Inspection (ISI) at U.S. Commercial Reactors

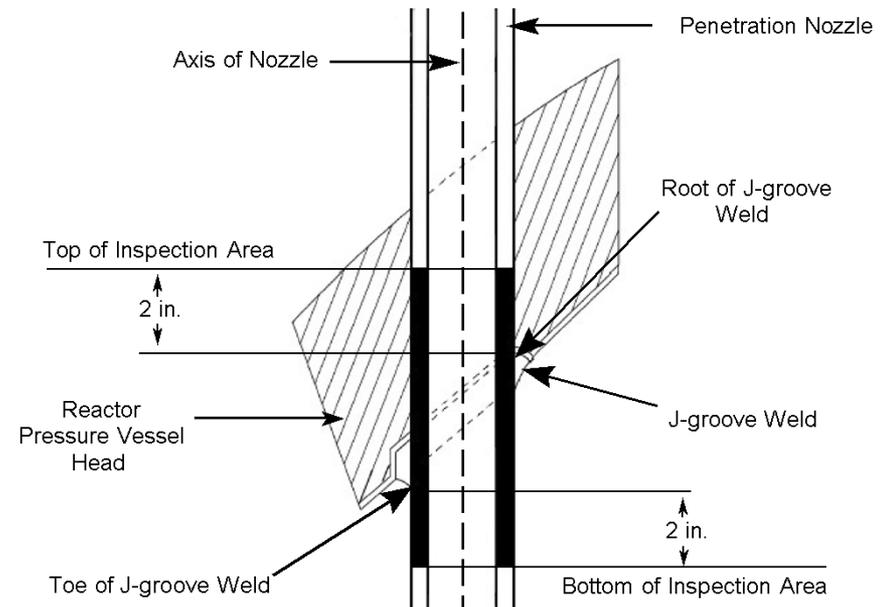
- NDE needed for timely detection of service-induced flaws
- Plant aging increases likelihood of service-induced flaws
- NDE increasingly important due to industry trends to reduce:
 - Inspection time during outages
 - Radiation exposure
 - Number of examinations

Focus areas for RES' s Nondestructive Examination (NDE) Program

- Evaluate accuracy and reliability of NDE methods used for ISI
- Assess adequacy of proposed industry changes to ISI programs
- Assess advanced/emergent 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 to other NRC Offices



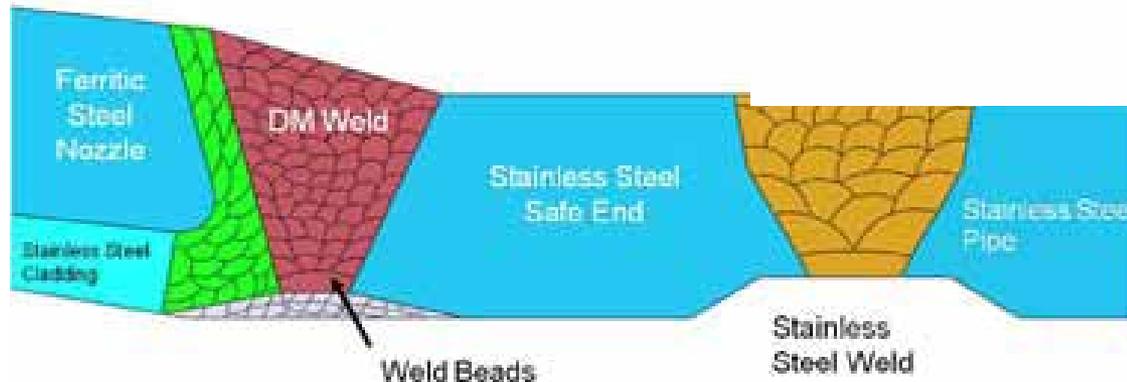
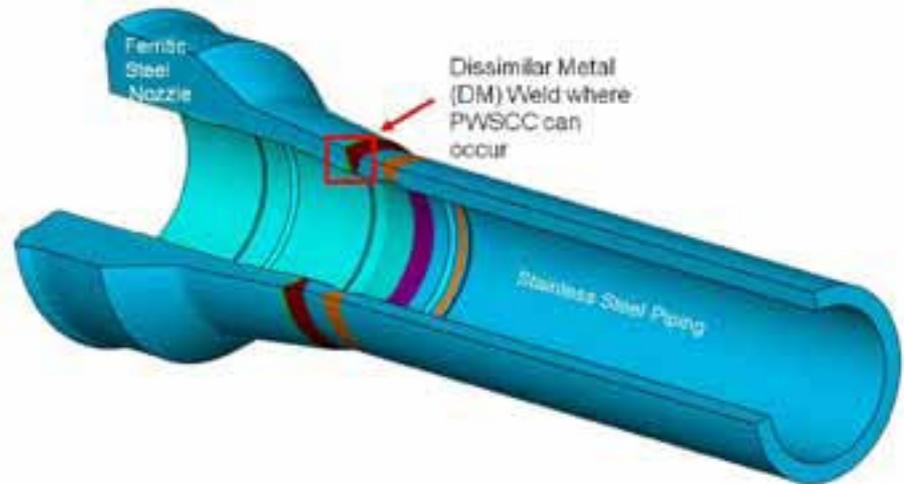
Breadth of NRC's NDE Program

- Dissimilar Metal (DM) Weld Examinations
- NDE Modeling
- Examination of Cast Austenitic Stainless Steel (CASS) Piping and Associated Welds
- Remote Visual Testing Activities
- High Density Polyethylene Piping (HDPE)
- Ultrasonic Testing (UT) in lieu of Radiographic Testing (RT)
- Program to Assess Reliability of Emerging Nondestructive Techniques (PARENT)
- ASME NDE (ANDE) Personnel Certification Program

Dissimilar Metal (DM) Weld Examinations

- Welds susceptible to primary water stress corrosion cracking (PWSCC)
- Examinations impacted by surface features, component geometries, welds in close proximity, etc.
- Research aimed at assuring that reliable and effective exams are performed

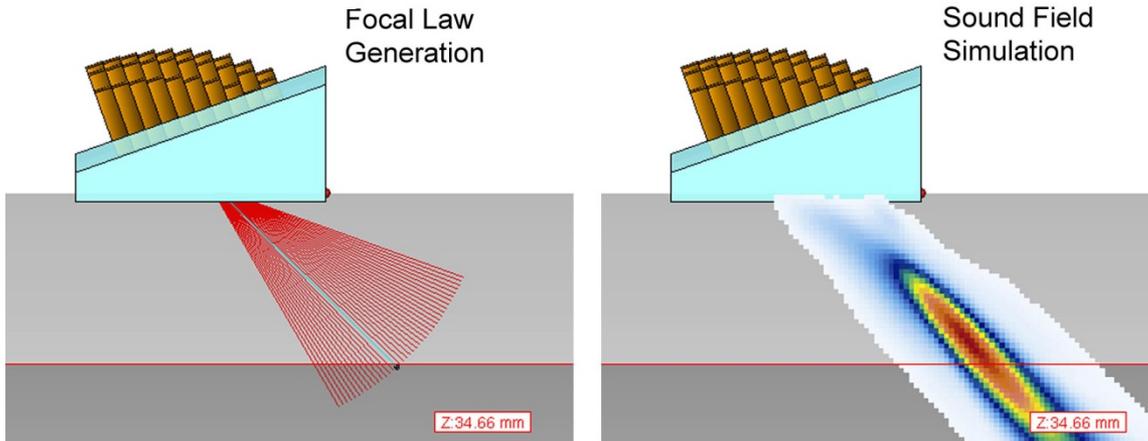
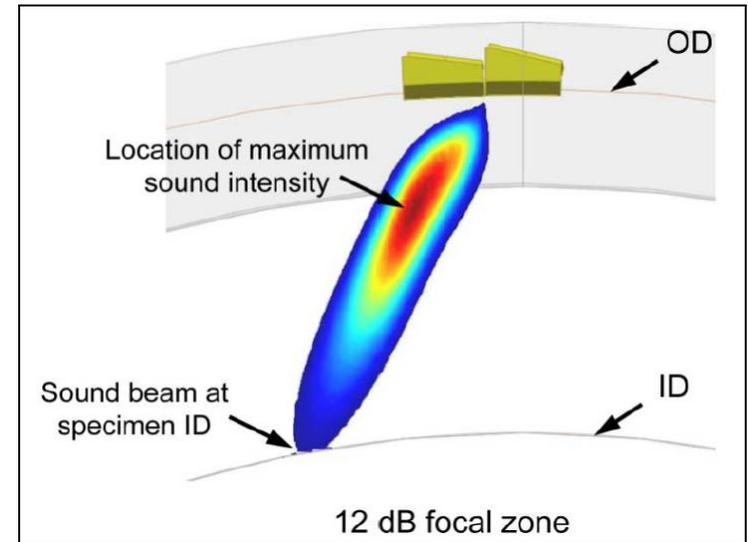
Cutaway view of a carbon steel nozzle DM weld and stainless steel piping typical in a light-water cooled NPP



Cross-section of nozzle to pipe weld highlighting weld bead pattern

NDE Modeling

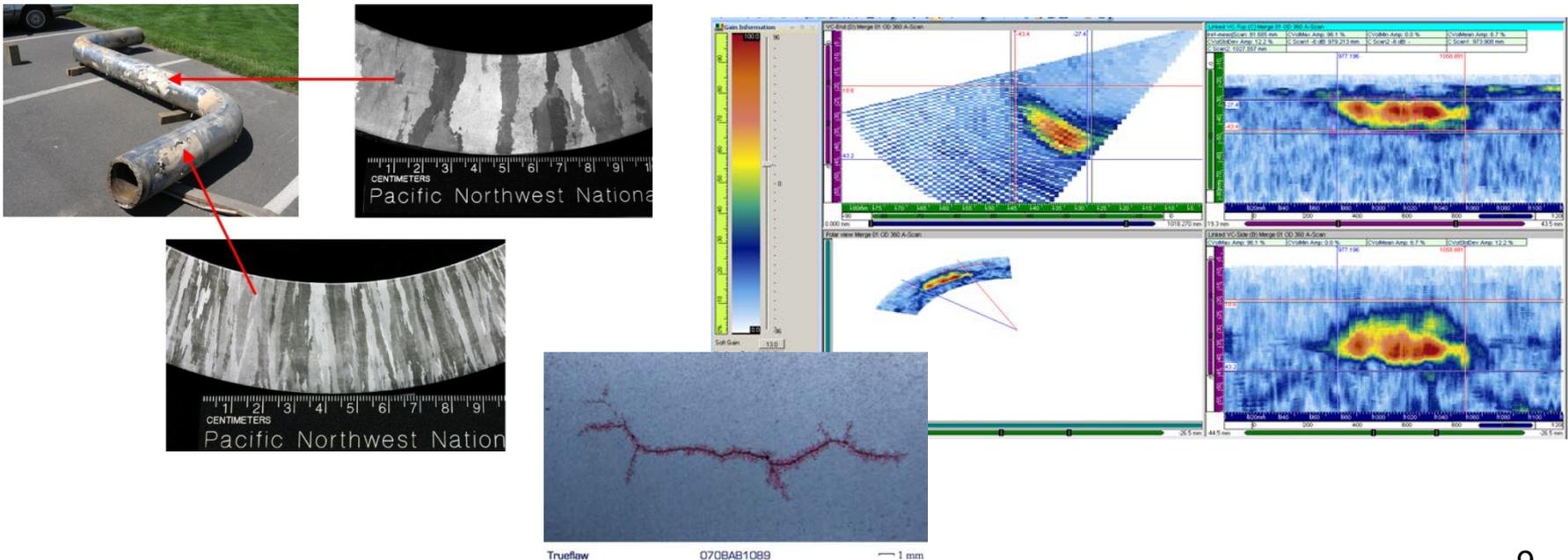
- Improvement of inspection technique
- Refinement of sensor/probe design
- Assess licensee claims in relief requests:
 - Coverage of required volume
 - Impingement angle and sound density at inner surface, etc.
 - Predict measurement system's response to specific flaws in the test object
- Improve models for flaw response, attenuation, and material noise in coarse grained structures such as welds and CASS



- Costly and time-consuming experiments are minimized by performing parametric studies numerically

Examination of Cast Austenitic Stainless Steel (CASS) Piping and Associated Welds

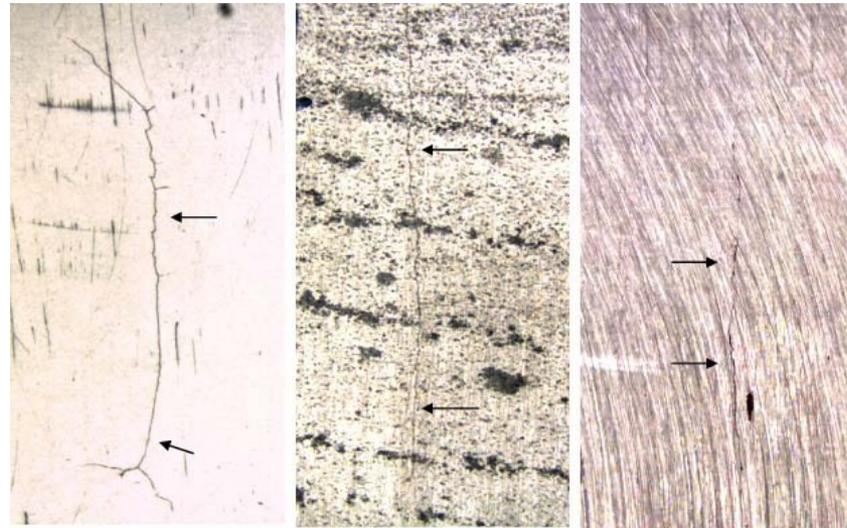
- CASS used in RCS piping susceptible to thermal aging embrittlement
- Microstructure makes examination of welds through CASS very difficult
- Low frequency phased array ultrasonic testing is capable of detecting cracking in CASS piping weld specimens
- Results of PNNL studies have been used to support ASME Code actions and inform NRR rulemaking related to the reliability of CASS examinations



Remote Visual Testing Activities

- VT significantly relied upon for vessel examinations
- Cooperative research with EPRI to assess effectiveness and reliability of remote VT to detect cracking in RPV internal components
 - Define parameters affecting reliable examinations
- Multi-phased round-robins conducted to evaluate current vendor procedures and technologies
- Phase 2 activities completed and data analysis underway at PNNL and EPRI NDE Center

Images of three 12- μ m COD cracks using diffuse axial lighting on three very different surfaces



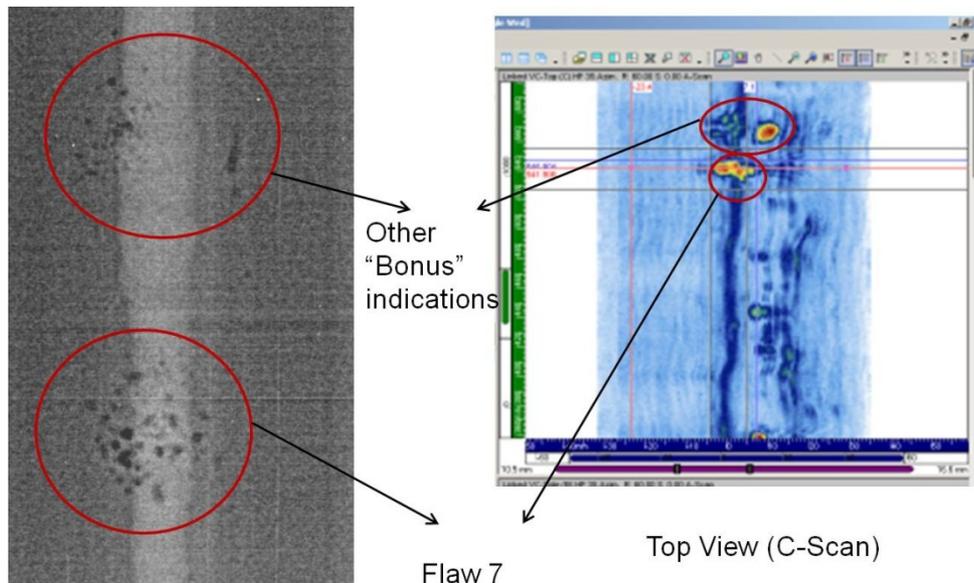
High Density Polyethylene Piping (HDPE)

- HDPE application for non-safety system applications
- NRC concerned about fundamental lack of underpinning science for the fusion process and how NDE might detect lack-of-fusion or contaminants
- RES assessing NDE technologies to perform volumetric inspections of butt fusion joints (laboratory and commercially available technologies)



Ultrasonic Testing (UT) in lieu of Radiographic Testing (RT)

- Purpose is to evaluate whether UT can reliably supplant RT to examine carbon steel welds fabricated during repair and replacement activities
- RES assessing factors such as detection reliability and sizing accuracy, when replacing RT with UT to propose additional guidance and/or changes or improvements to standards currently in use in the nuclear industry.



- Results informing NRC's decisions on current relief requests as well as ASME Code Cases under development:

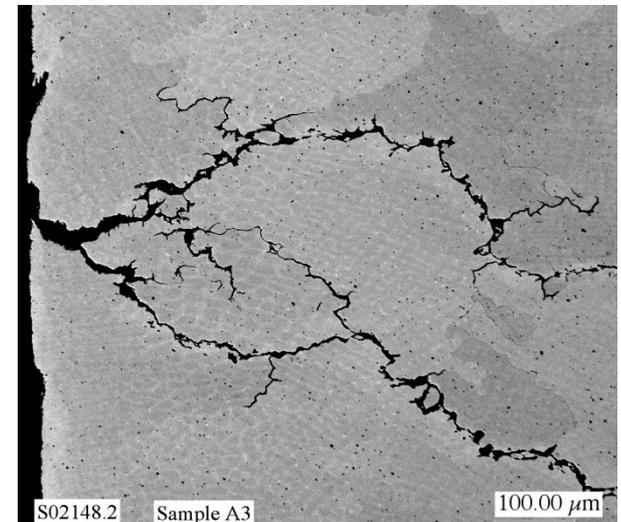
- Section III, Code Case N-818-1, Use of NDE Evaluation Approach for Acceptance of Full Penetration Butt Welds in Lieu of Weld Repair
- Sections XI, Code Case N-831, Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic Pipe

Program for the Inspection of Nickel-Alloy Components (PINC)

- International Program – bi-lateral agreements between Sweden, Japan, Finland, Korea, U.S.
- Documenting the range of locations and crack morphologies associated with primary water stress corrosion cracking (PWSCC)
- Quantitatively assessing NDE methods for accurately detecting, sizing and characterizing tight cracks such as PWSCC

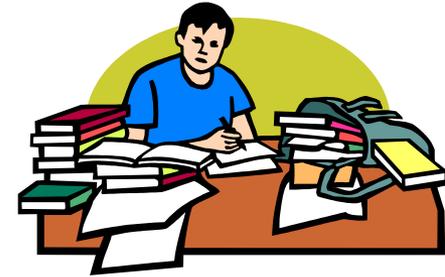
Program to Assess Reliability of Emerging Nondestructive Techniques (PARENT)

- Follow on to PINC
- Evaluate best techniques from the PINC round robin tests
- Assess cracks in dissimilar weld piping and other NPP components



ASME NDE (ANDE) Personnel Certification Program

- Goal is to establish requirements for third party, central certification programs for NDE and QC personnel
- Managed by the ASME Standards Technology, LLC
- Traditional volunteer consensus development activity
 - Draft ANDE/ANSI standard for performance-based approach has been developed and is moving through ASME review process
 - NDE methods addressed in standard are those required by ASME Code (e.g., UT, MT, PT, RT, VT, ET, etc.)
- NRC supporting project via participation in ANDE standard development, limited funding (grant) and material contributions for use practical examinations



NRC/EPRI Memorandum of Understanding (MOU)

- Utilities have sought assistance from Electric Power Research Institute (EPRI) NDE Center to address NDE issues associated with emerging mechanisms such as PWSCC
- RES conducting confirmatory research
 - Frequent interaction with NDE Center staff
- Agreement in place between RES and NDE Center
 - Benefits include exchange of technical information, leveraging of resources
- Primary areas of research: Ultrasonic Modeling and Remote Visual Testing

Looking forward...

- RES program has historically addressed known issues related to the overall effectiveness of the NDE program.
- RES recently conducted a review of NDE-related operating events
 - to evaluate whether there are commonalities, lessons learned, potential improvements, etc.
 - direct our future activities
- A group of recognized NDE experts from within and outside the nuclear industry volunteered to support the NRC to review and evaluate the operating events and generate recommendations for ways to improve NDE activities in operating plants
- RES writing a White Paper summarizing expert panel effort for NRR to use as a technical basis for potential regulatory action

Questions?

