Cast Austenitic Stainless Steel Performance Demonstration Program Development

Examination Technique Enhancements and PFM Evaluation of CASS PWR Piping

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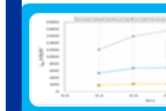
Cast Austenitic Stainless Steel

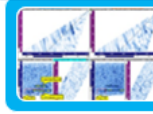
Project Objective & Scope

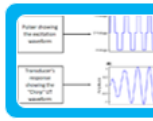
- Address the inspectability issues related to CASS
  - Ultrasonic Testing of CASS components has been historically unreliable due to material microstructure
- Work with Material Reliability Program engineering to develop a multi-faceted approach to manage the issue

Ongoing Projects

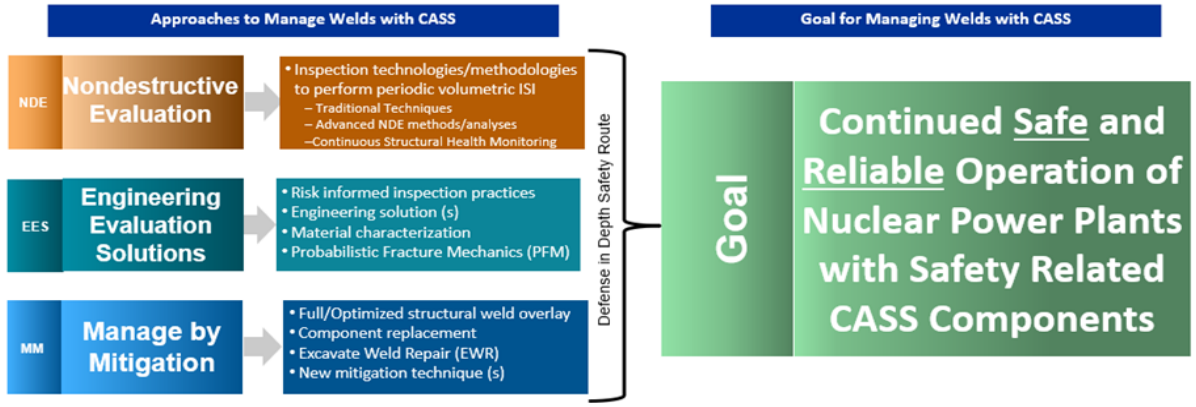

Technique Enhancements for CASS Examination Techniques


Probabilistic Fracture Mechanics Evaluation of CASS PWR Piping Components


Multi-Frequency PA-UT for CASS


Advanced Ultrasonic Techniques for Cast Austenitic Stainless Steel Materials

Multi-faceted Approach for CASS Materials



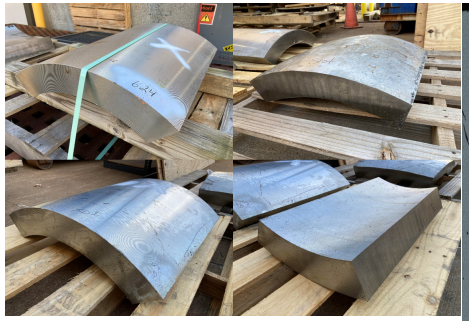
RFA Status and Deliverables

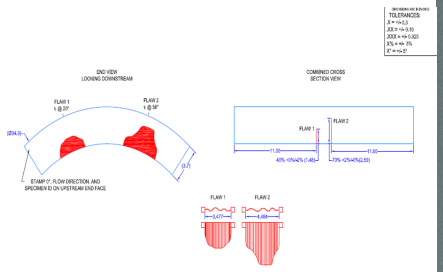
- **2021** - Probabilistic Fracture Mechanics Evaluation of PWR Cast Austenitic Stainless Steel Piping Components (3002020449)
- **2022** Probabilistic Fracture Mechanics Evaluation of PWR Cast Austenitic Stainless Steel Piping Components – Axial Cracking Methods and Results (3002025221)
- **2023**
  - Publish PFM results obtained for axial and circumferential cracking
  - Continue advancing flaw making technologies
  - Continue advancing NDE techniques
- **2023-2026**
  - Develop ASME Code qualification requirements and changes to flaw acceptance criteria

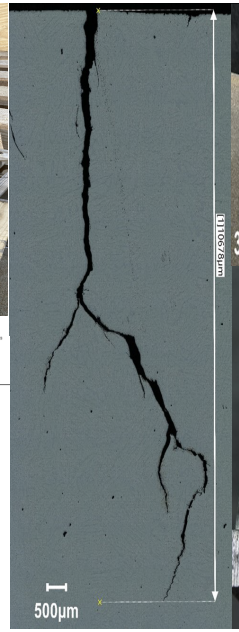
Technique Enhancements for CASS Examinations

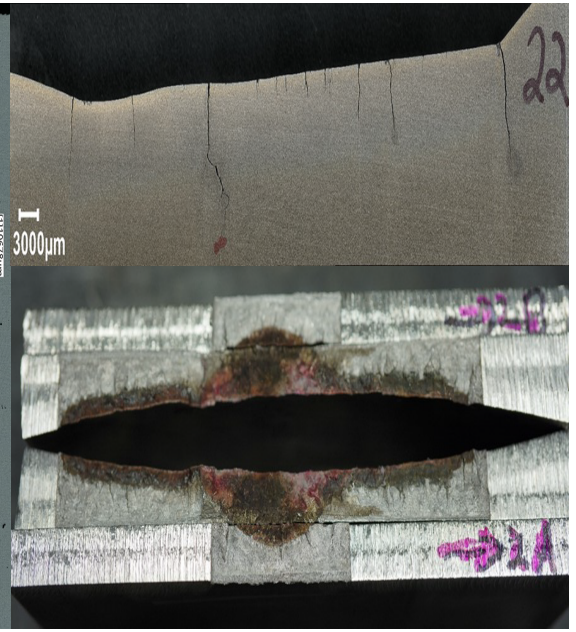
Project Objective & Scope

- EPRI conducted a round robin study of modern CASS UT techniques
  - Global Inspection Vendors
  - Equipment Manufacturers
  - Regulatory Bodies and Research Organizations
- Results fell short of current performance demonstration requirement levels
- Techniques were reviewed to determine if enhancements could be made
  - Reviewed raw data results
  - Best performing techniques were identified
  - New data was collected with best available equipment and techniques









Results

- 12” (300 mm) & 28” (700 mm) OD specimens
  - **100% detection of circumferential flaws with as-welded weld crowns**
  - **Flaw sizing unreliable**
- 36” (900 mm) OD specimens
  - **Not all flaws detected**
  - **Flaw sizing unreliable**
- Investigated removal of weld crowns
  - Characterization and sizing were improved, but insufficient to meet current performance demonstration sizing rules

Additional Activities

- Due to missed indications in 36” (900 mm) specimens, **destructive testing was performed**
  - First of a kind flaw development had been used
    - **Flaws did not meet the depth requested** and profiles were quite shallow along the length
    - **High numbers of unintended flaws** associated with implantation process
      - Some nearly as deep as the intended flaws
- New flaw development activities are currently underway
  - Targeting depth >25% thickness, with expected aspect ratio of >3:1 length-to-height
- **Engineering work will continue to drive future technique enhancements and focus**

PFM Evaluation of CASS PWR Piping Components

Project Objective & Scope

- Use of probabilistic fracture mechanics (PFM) to evaluate the effect of these limitations
  - To support development of ASME Section XI, Appendix VIII, Supplement 9; alternatives to Section XI, IWB-2500 inspection requirements; and changes to IWB-3514 and IWB-3640 flaw acceptance and evaluation

Objective 1 (axial cracking)

Investigate axial fatigue cracking assuming no benefit of periodic NDE nor online leak detection

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Desired outcome is to demonstrate that detection of axial cracks is not necessary to maintain structural and leak tight integrity

Objective 2 (circumferential cracking)

Investigate circumferential fatigue cracking assuming periodic NDE without a qualified flaw depth-sizing process

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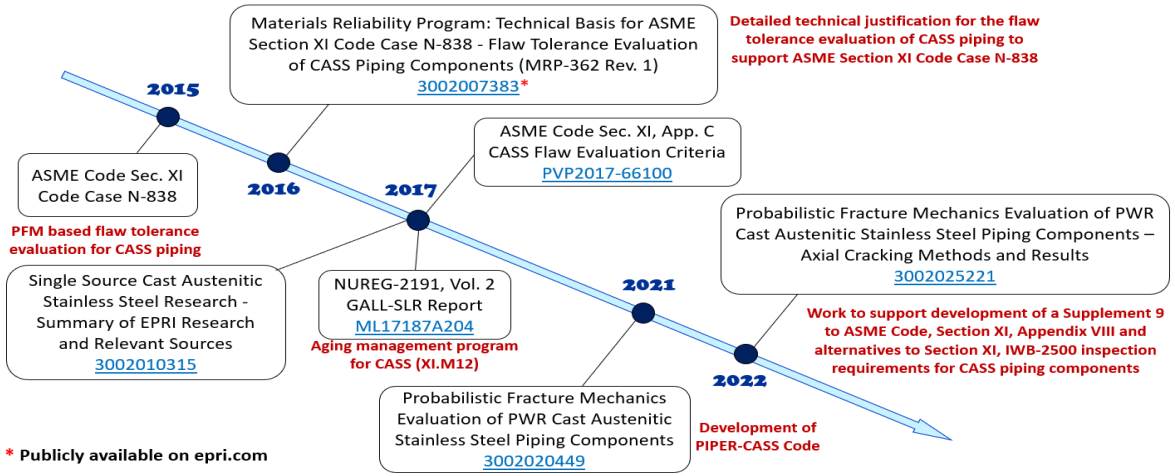
Desired outcome is to demonstrate that an alternative flaw evaluation procedure ensures structural and leak tight integrity

- **Technical Report to be published in Q4, 2023**
  - Results and conclusions obtained for axial and circumferential cracking
  - Will be **publicly available**



Current Status

- **PFM modeling shows periodic examination to detect axial flaws is unnecessary to ensure structural and leak tight integrity for the following cases:**
  - WEC main loop piping in both base load and flexible power operation PWRs
  - CE surge lines in base load PWRs
- **Fatigue crack growth for 80 years is modeled to bound the concerns for both fatigue crack initiation and manufacturing flaws**
- Action initiated for a proposed ASME Code Case for axial flaws (TG Inspectability)
- PFM evaluation for **circumferential flaw** cases
  - **Proposed flaw evaluation approach is in development**
  - Currently running PFM cases to investigate the range of conditions for which the candidate methodology results in acceptably low rupture probabilities

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