Diablo Canyon Power Plant, Unit 2
Relief Request Pre-submittal Meeting

Request for Approval of an Alternative to the ASME Code Section XI, for Preemptive Structural Weld Overlays

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Topics

- Issue Background
- Root Cause Evaluation Findings
- Phased Array Ultrasonic Examination Technology Applied in 2013 and Planned for 2014 Re-examinations
- Key Elements of Updated Flaw Analysis
- General Content and Schedule for Submittal of Revision 3 of Relief Request
- Questions and Feedback

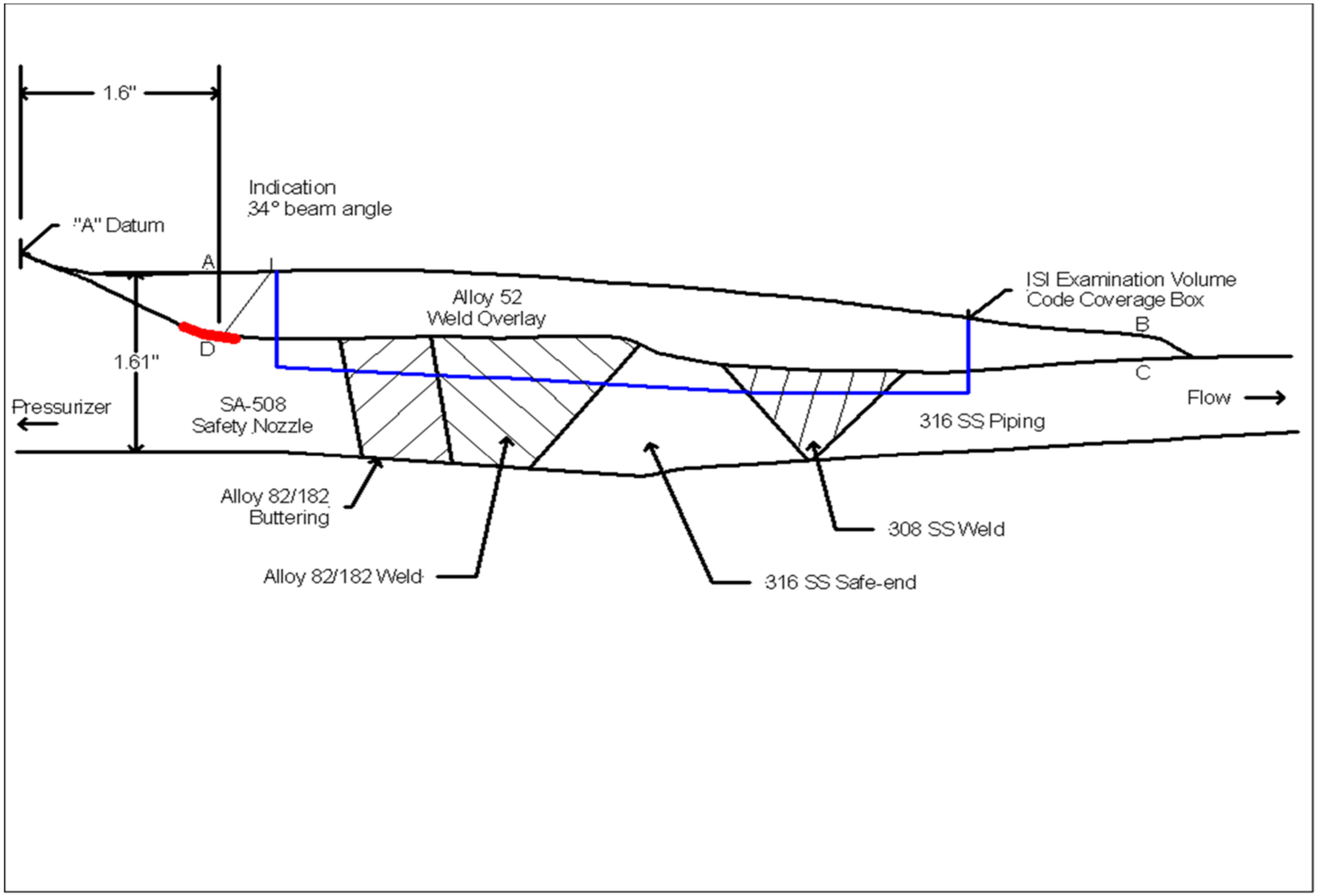
Issue Description

- The 2013 In-service Inspection (ISI) of Unit 2 pressurizer Safety Nozzle B full structural weld overlay (SWOL) identified fabrication flaws that were not reported during acceptance examinations in 2008 or ISI of 2009
  - Flaws classified as lack of bond/inter-bead non-fusion
  - Flaws exceeded 3” length criteria of SWOL installation relief request REP-1 U2 Revision 1 for laminar type flaws
- 2013 ISI scope expanded to include all six pressurizer nozzle SWOLs
  - Similar fabrication flaws exceeding the 3” length criteria identified in Safety Nozzle A and Spray Nozzle
  - Acceptable lack of bond indications identified in Safety Nozzle C
  - PORV and Surge nozzles – No recordable indications

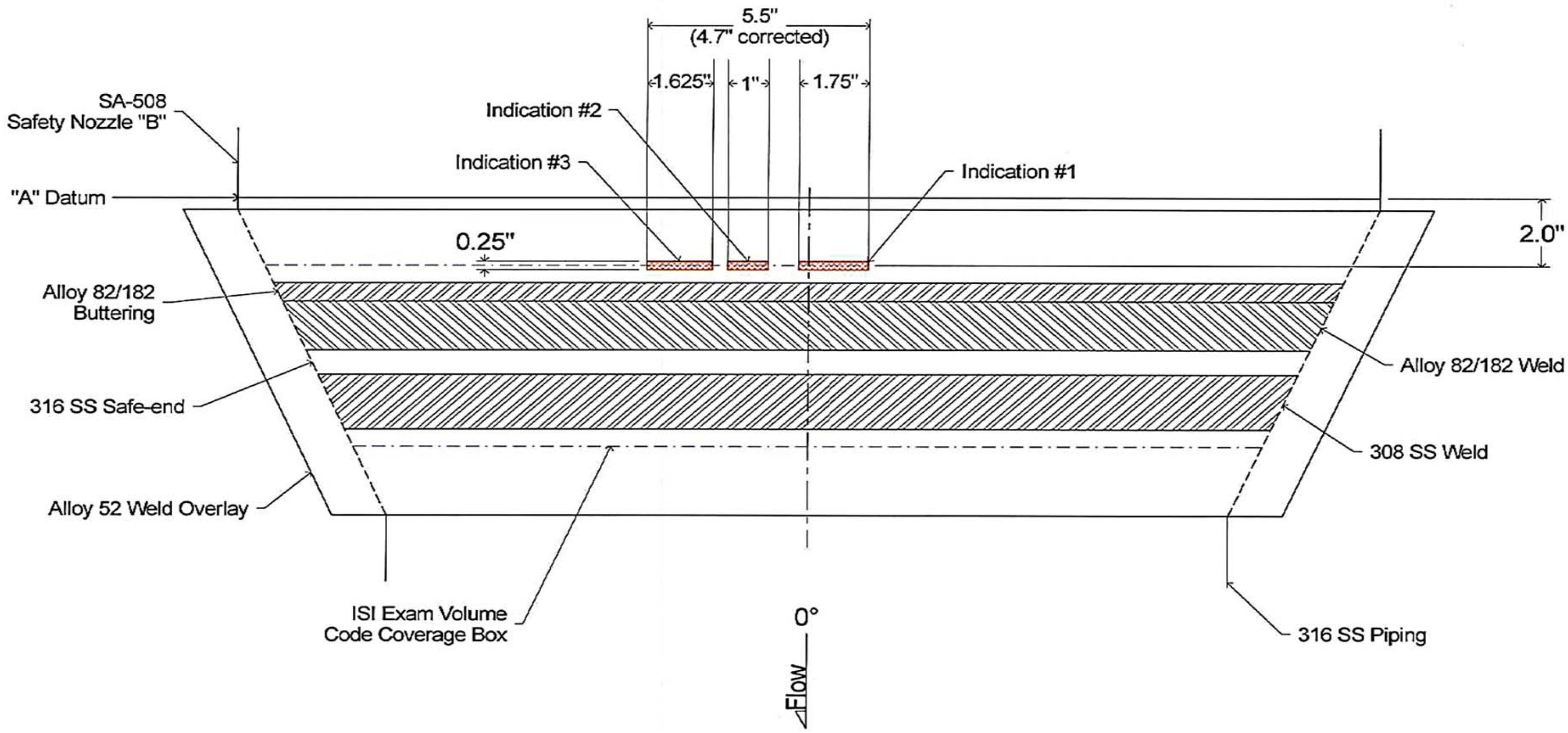
Issue Resolution 2013

- Issue documented in Corrective Action Program
- Examination findings communicated to NRR and NRC Resident Inspector
- Fracture mechanics evaluation of flaws performed
  - Evaluations demonstrated that overlays were not structurally challenged by flaws
- Relief Request REP-1 U2 Revision 2 (and supplement) describing flaws detected in 2013 submitted
  - NRC granted approval for single cycle of operation

Safety Nozzle Cross Section



Safety Nozzle B Indication Rollout



Precipitating Events Timeline

- Six U2 pressurizer SWOLs installed in 2008 per relief request REP-1 U2 Revision 1
  - Fabrication flaws introduced at this time
- Ultrasonic acceptance examinations performed by installation vendor (OEM) using conventional ultrasonic examination procedure PDI-UT-8 Revision F
  - Two small lack of bond indications approximately 1” in length recorded on Safety Nozzle A
- First ISI examination of all six SWOLs performed in 2009 by OEM using conventional UT procedure PDI-UT-8 Revision F
  - 45 degree exam only per procedure
  - OEM reported results identical to acceptance examination

Root Cause Evaluation Process

Diverse team assembled to investigate missed detections

- Team sponsor – Jeff Summy, DCPP Sr. Director of Engineering
- Team Lead – Patrick Nugent, Manager Tech Support Engineering
- EPRI – Carl Latiolais, PDI Program Manager
- OEM – Brad Thigpen, Manager NDE Research and Development
- Industry Peer – Doug Hansen, Palo Verde NDE Level III
- DCPP ISI – Dave Gonzalez, ISI supervisor
- DCPP ISI – Mike Leger, Lead ISI specialist
- DCPP Cause Analyst – Corrado Sansone
- DCPP Training – Larry Cossette

The team used a variety of evaluation tools

- Comparative Timeline © to capture and contrast contributing factors
- Events and Causal Factor Chart with Fault Tree Analysis to identify causes; Results independently verified by Stream Analysis
- Human Error Investigation Tool

Root Cause Investigations and Findings

EPRI, PG&E and OEM investigations indicated that subject flaws are detectable with conventional UT overlay exam procedure, PDI-UT-8 Revision F:

- PG&E Level III examiners found that scan speeds slower than the maximum allowed by procedure are required to produce easily recognizable indications with zero degree search unit
  - OEM acceptance exam zero degree scan times indicate speeds were at or near procedure maximum
- Conventional 45 degree angle beam indications have good signal to noise as seen on Safety Nozzle B
  - Conventional 45 degree indications maintain good signal to noise at procedure maximum scan speed
  - Under-sizing of indications during acceptance exams on Safety Nozzle A attributed to examiner human performance issues

Root Cause Conclusions

- The conventional UT procedure PDI-UT-8 has proven in qualification testing the ability to detect flaws as specified by ASME XI, Appendix VIII, Supplement 11 rules. Additionally, the procedure has identified rejectable laminar type flaws in the field
- Based on EPRI review of manual conventional UT and manual PA SWOL qualification test results from 2010 through 2013, regardless of the advantages of PA for field application, no statistical advantage for either method exists regarding missed detections of fusion type (LOB) flaws in qualification testing
- *This evidence supports the conclusion that, if the rigor applied in the qualification setting is transferred to the field, acceptable performance of the conventional UT process should be expected*

Corrective Actions

- Prohibit use of PDI-UT-8 Revision F at DCPP
- Employ Phased Array for subsequent examinations of pressurizer SWOLs
- Communicate Root Cause findings to industry

2013 SWOL Phased Array Examinations

Phased Array Examination Technique Attributes

- **Full range of angles from 0° through 85° for optimum response from slightly off-axis flaws and flaws with "character"**
- **High sensitivity settings for low angles results in easily recognizable indications**
- **Improved user interface**
  - simultaneously displays all angles
  - provides spatial relationship of indications
  - color amplitude encoding of signals
  - simultaneous A-scan display
  - enhanced persistence of indications due to multiple angle interrogation

Phased Array Exam Planning

2013 Exam preparation – a carefully preplanned project with deliberate actions to address recent industry OE for missed indications; aspects of the plan included:

- Review of overlay application history including exam and fabrication records, surface contours and thickness profiles;
- Detailed scan plan including calibration and exam parameters developed and tested pre-outage;
- Formal oversight plan developed;
- Extensive pre-job brief that included elements specific to recent OE on missed indications;
- Recent phased array exam training and practice at EPRI;
- Monitored hands-on practice on representative EPRI "Rhino Horn" overlay sample prior to exam in 2R17.

2013 Phased Array Examination Implementation

Diablo Canyon Field Implementation Elements

- Exams performed by PG&E level III personnel
- Formal oversight of examinations by PG&E level III experienced in PA applications
- Full access to SWOLs, Essentially 100% coverage of exam volumes
- Previously unrecorded flaw detected early in first 2013 exam, sensitizing examiners to the possibility of additional indications in all nozzles
- Recorded exam durations indicate careful approach to scanning
- Verification of flaw indications were performed to validate sizes and positions
- Sample time-encoded data forwarded to EPRI and OEM experts for independent review of indication characterization

2014 Overlay Re-examinations

The same Phased Array technique that detected the fabrication flaws will be used to re-examine Safety A, Safety B, Safety C and Spray Nozzles per IWB-2420 in 2014

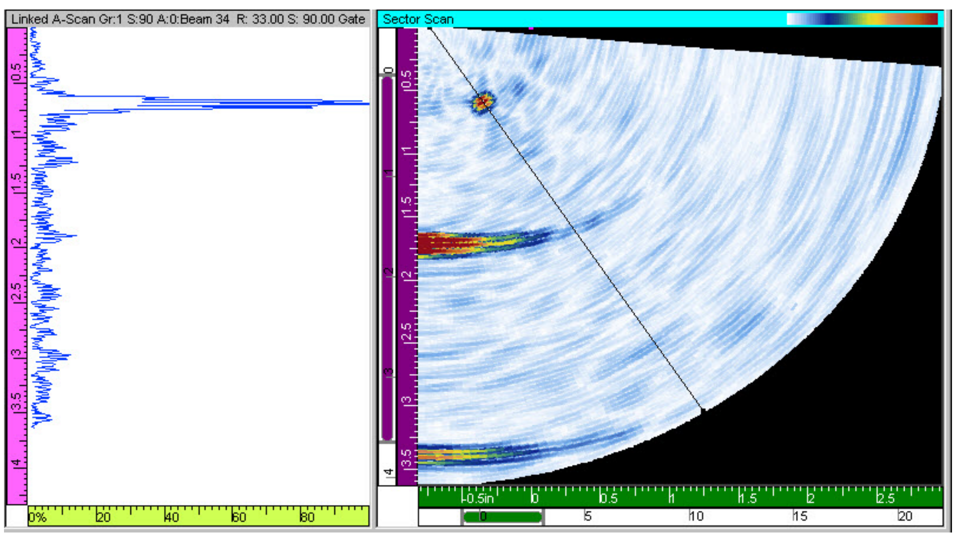
- The level of planning and implementation rigor applied in 2013 will be repeated
  - DCPP new and revised NDE planning and oversight procedures formally address exam implementation rigor
- PG&E will engage EPRI experts to be present for the 2014 re-examinations

Summary

- DCPP's attention to detail in the implementation of the 2013 examinations combined with the robustness of the phased array technique provide high confidence that any fabrication flaws that may have an impact over the remaining service life of the pressurizer SWOLs were detected and correctly sized
- An equivalent level of detail will be applied to the 2014 re-examinations to assure the same high confidence in the results

Conventional vs. Phased Array Demonstration

0° Conventional UT, Safety Nozzle A



PA UT, Safety Nozzle A

Key Elements of the Flaw Analysis Modeling and Analytical Approach

Key Elements of the Flaw Analysis: Scope of the Problem

March 2013 Flaw Evaluations

- Considered laminar and assumed planar flaws
- 8/28/13 - NRC SER accepted general approach for one fuel cycle, but requested additional analysis to include growth of laminar indications
- 9/12/13 – Telecon with NRC clarified that conservative flaw combination was acceptable and that all detectable indications shall be considered

Key Elements of the Flaw Analysis Modeling and Analytical Approach

– To address the NRC's concerns from Section 3.2.4 of the SER, as clarified in the 9/12/13 NRC telecon, the following analysis approach is proposed:

- Combine multiple flaws into one or more larger, bounding flaws in accordance with ASME Code proximity rules
- Extract stresses from uncracked 2D axisymmetric finite element models
- Use classical crack models for stress intensity factors (K's)
- Calculate fatigue crack growth for remaining life
- Evaluate final flaw sizes in accordance with Code rules

Key Elements of the Flaw Analysis Modeling and Analytical Approach

Bounding Laminar Flaw Concept

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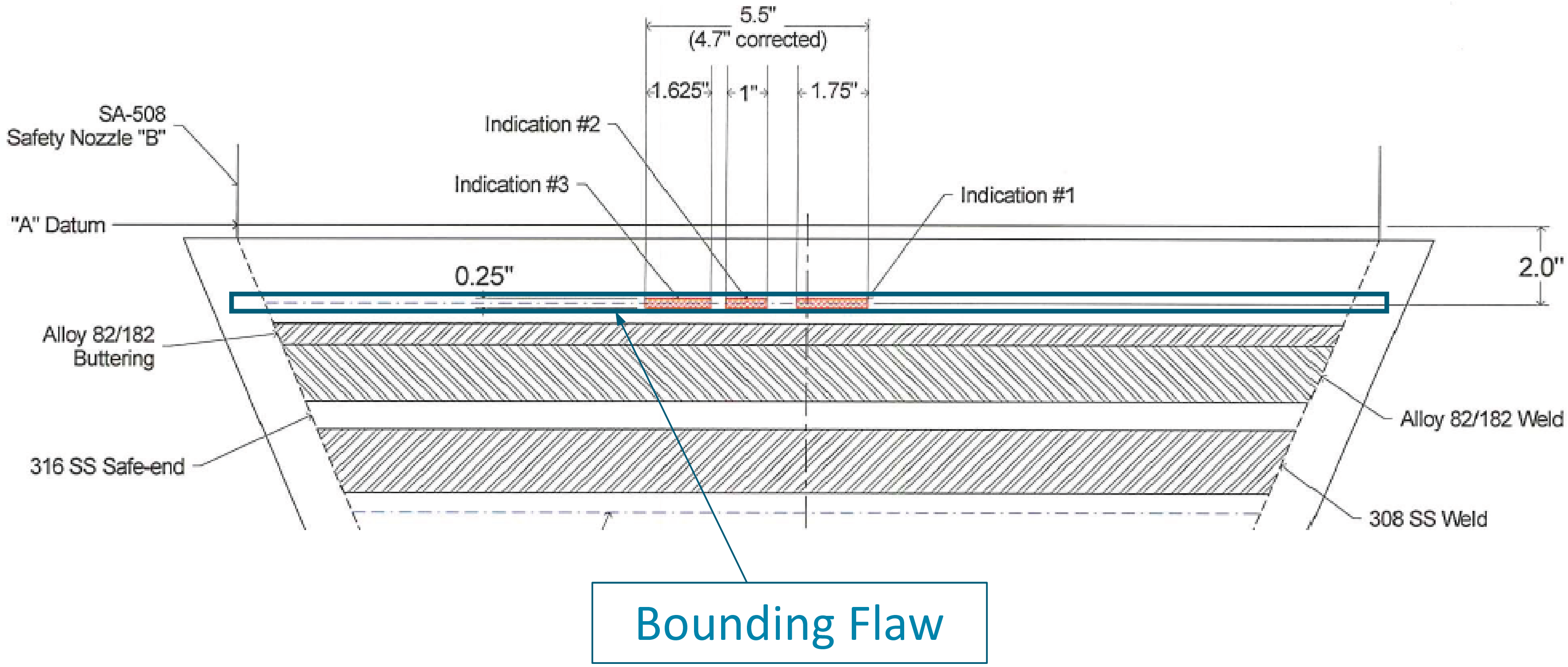
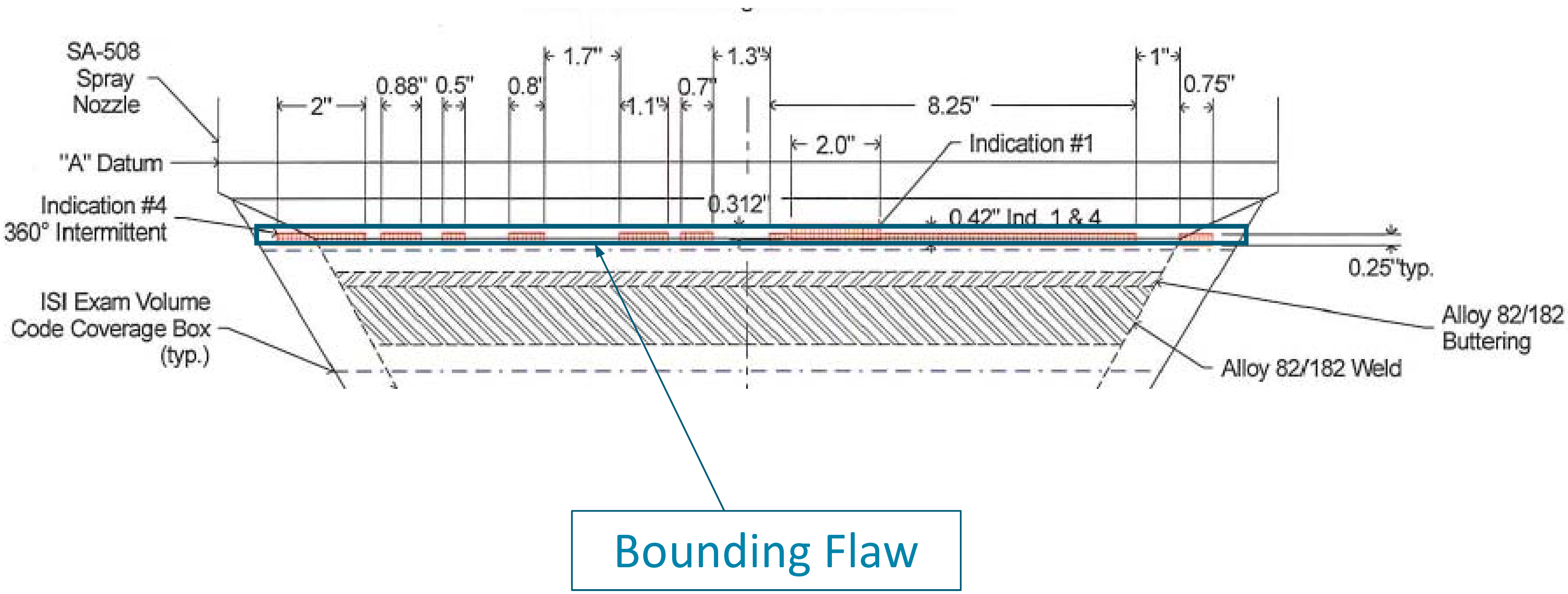


Key Elements of the Flaw Analysis Modeling and Analytical Approach

Bounding Laminar Flaw Concept



Key Elements of the Flaw Analysis
Modeling and Analytical Approach

Classical Crack Models

- Used to calculate crack-tip K's
- Center-cracked panel (CCP) model for laminar flaws
- Full 360 degree circumferential flaw model for the assumed planar flaw

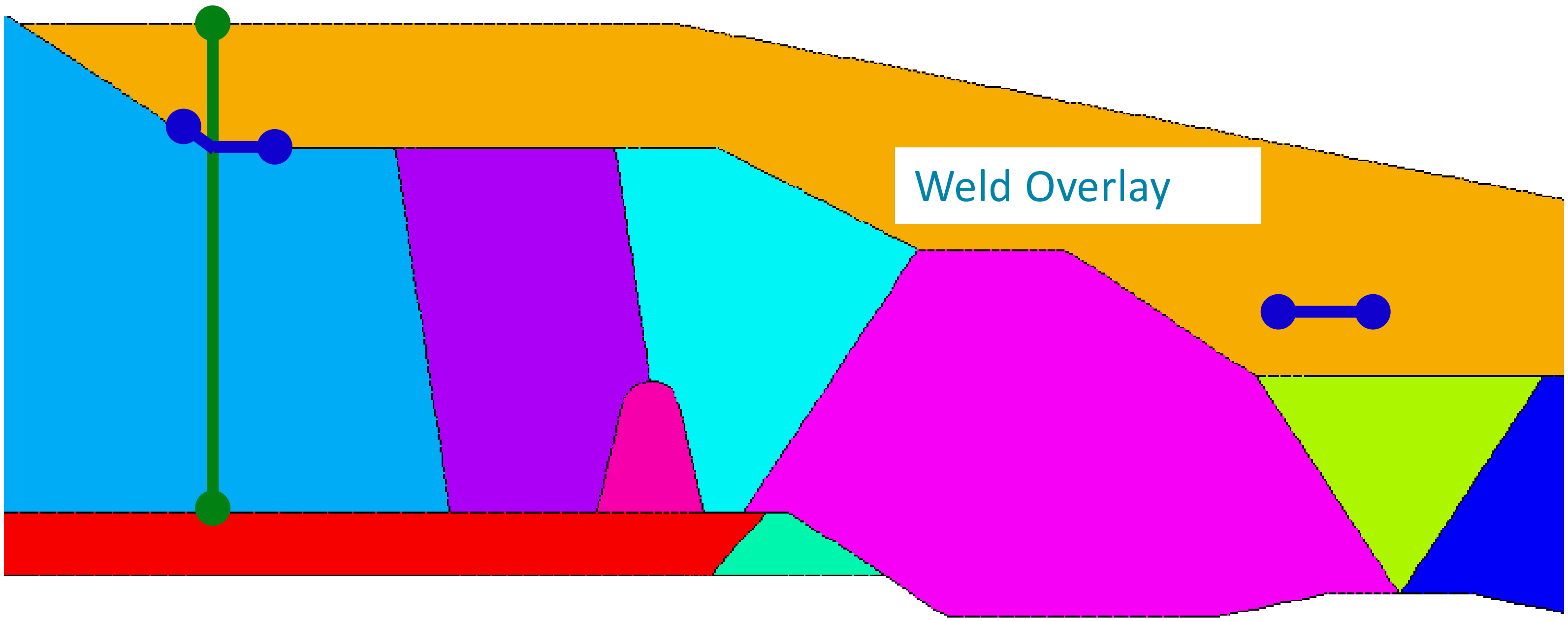
Key Elements of the Flaw Analysis Modeling and Analytical Approach

Finite Element Models

- 2D axisymmetric models (no voids)
- Path lines located at flaw indications from ISI report and oriented to capture required stresses
- Radial and shear stresses required for laminar flaws
- Axial stresses required for the assumed planar flaw in Safety Nozzle A

Key Elements of the Flaw Analysis Modeling and Analytical Approach

Pathlines for Stress

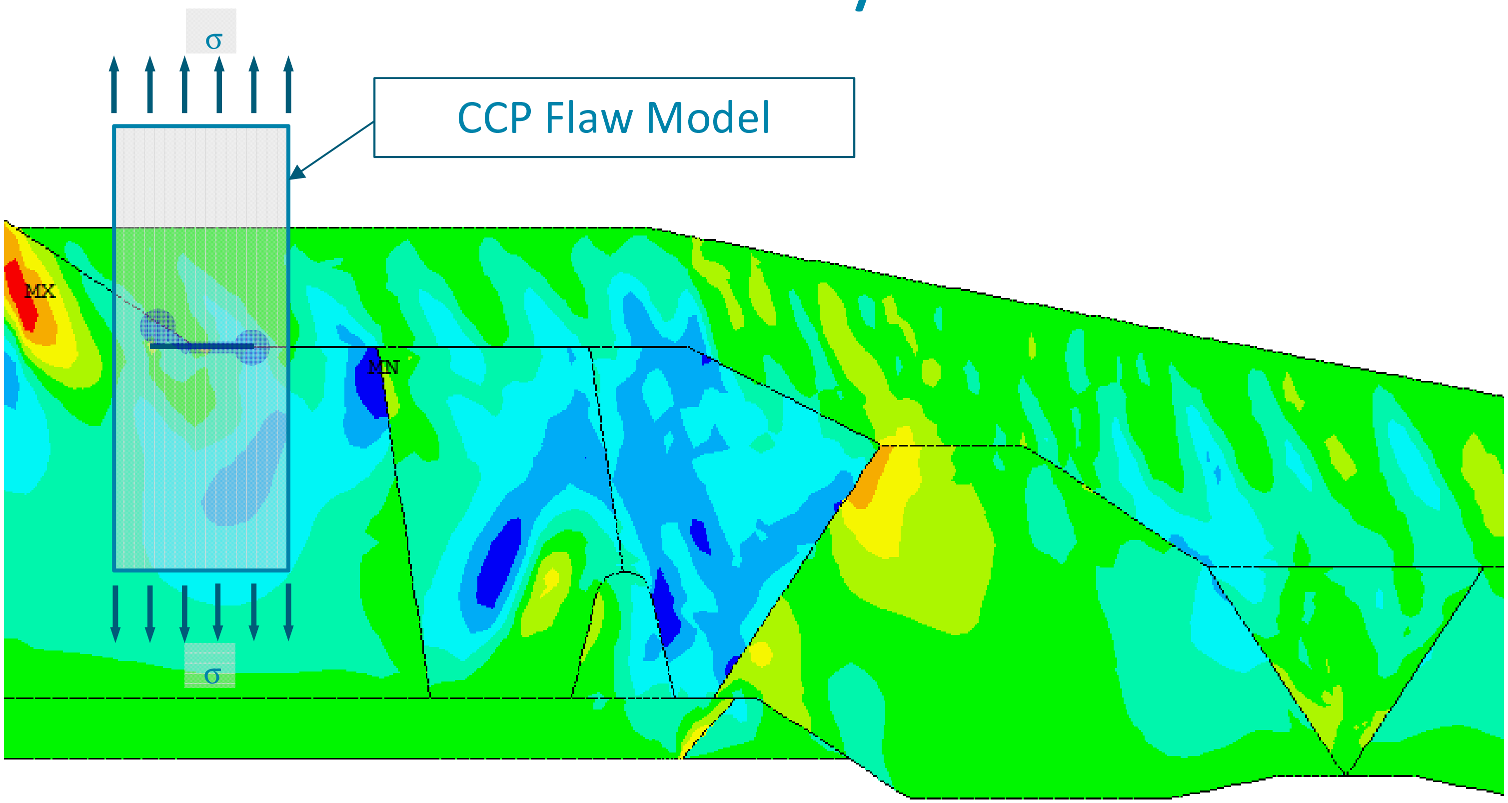



Radial and Shear Stress
Map on Laminar Flaw


Axial Stress
Map on Planar Radial Flaw

Key Elements of the Flaw Analysis Modeling and Analytical Approach

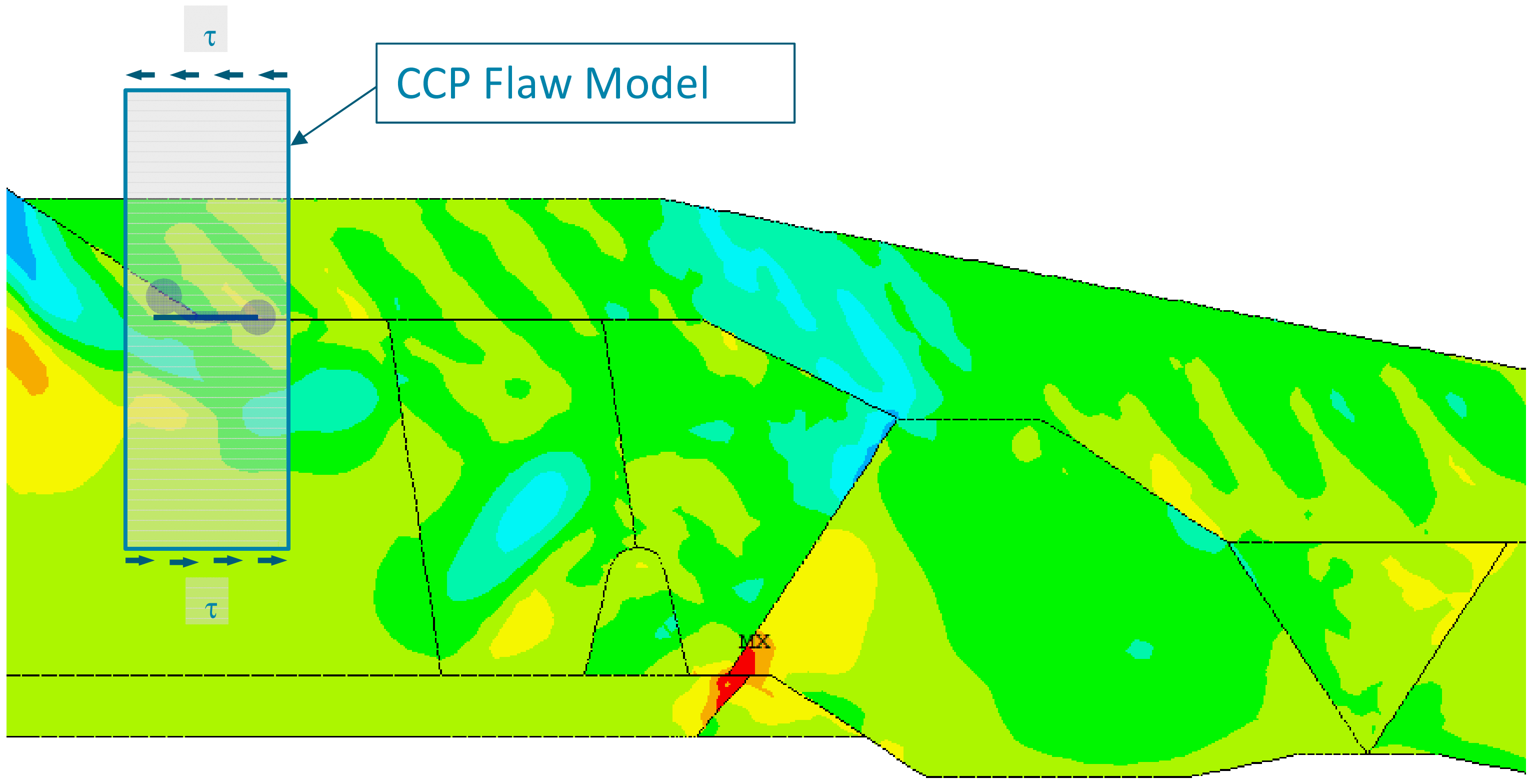
Laminar Flaw Model w/ Radial Stresses



Representative Stresses

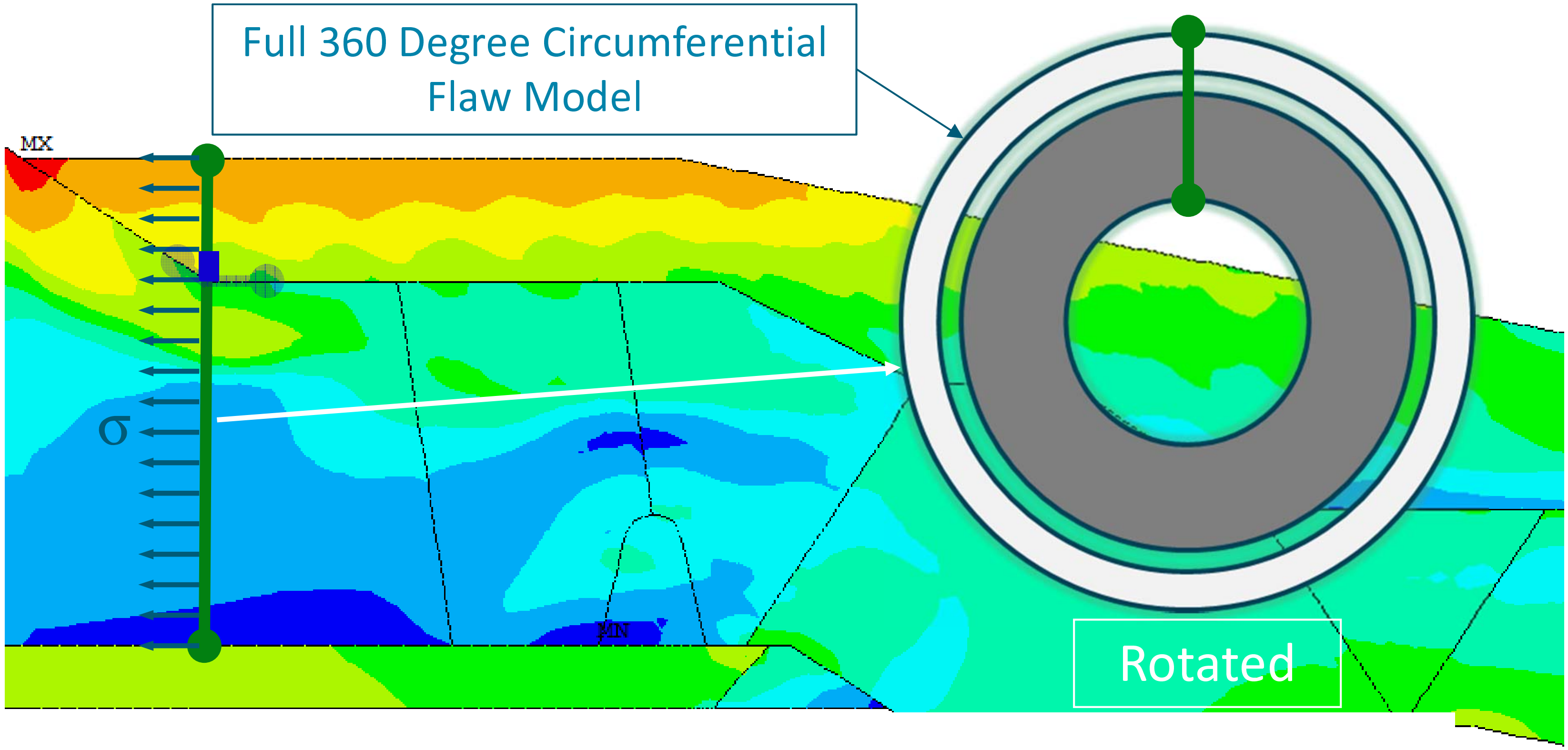
Key Elements of the Flaw Analysis Modeling and Analytical Approach

Laminar Flaw Model w/ Shear Stresses



Key Elements of the Flaw Analysis Modeling and Analytical Approach

Planar Flaw Model w/ Axial Stresses



Key Elements of the Flaw Analysis: Conclusions

Summary

Analysis will be performed to address the previously identified NRC concerns by including crack growth for the remaining life of all detected laminar indications and demonstrating compliance with the following ASME Code requirements:

- Laminar area (Table IWB-3514-3)
- Remaining shear area (NB-3227.2)

In addition, the planar flaw evaluation performed per IWB-3640 for the assumed planar flaw will be updated.

General Content and Schedule for Submittal of Relief Request

General Content of Relief Request

Background

1. ASME Code Component Affected
2. Applicable Code Edition and Addenda
3. Applicable Code Requirements
4. Reason for Request

General Content of Relief Request

5. Proposed Alternative and Basis for Use
   - Relief will be requested pursuant to the following two clauses:
     - 10 CFR 50.55a(a)(3)(i) proposed alternative
     - 10 CFR 50.55a(a)(3)(ii) hardship
   - Acceptance and Preservice Examination results
   - Continuing Inservice inspections
   - Root cause executive summary and findings related to missed detections
   - 2013 Phased array examination and characterization of flaws

General Content of Relief Request

5. Proposed Alternative and Basis for Use (continued)
   - Executive Summary of Analysis Report
     - Scope of the problem (Description and list of bounding flaws that are analyzed for each nozzle)
     - Key elements of modeling and analytical approach
     - Analysis Results and Conclusions
   - Potential hardship
   - Subsequent Inspections (in each of the next three ISI periods)
   - Conclusions

General Content of Relief Request

6. Precedents
7. Duration of Proposed Alternative
   - Relief will be requested for the remainder of the third inspection interval (i.e. until March 2016)
   - However, analysis covers a period of 38 years
8. References
   - Attachments
     - Analysis Reports from AREVA (proprietary)
     - Analysis Reports from AREVA (non-proprietary)

Tentative Schedule for Submittal of Relief Request

- Submittal of RR : March 2014
- Review period :
  - (including RAIs): March to July 2014
- Approval requested: July 2014
- Unit 2 Outage (2R18): October 2014

NRC feedback is requested prior to outage work schedule planning/ preparation phase

Concluding Remarks

by

PG&E

Questions and Feedback

NRC Staff Questions and Feedback