Entergy - NRC Meeting

Palisades Primary Coolant System Branch Connection Weld Volumetric Examination Status

April 14, 2015

One White Flint

Rockville, MD

Entergy

Agenda

- Introductions
- Purpose of Meeting
- Background
- Palisades Preparations for Inspections in 2015 Refueling Outage
- Industry Activities
- Planned Relief Request
  - Need for Relief Request
  - Technical Basis for Relief Request
- Planned Schedule
- Questions/Discussion

Introduction of Entergy Team

- Otto Gustafson - Director, Regulatory and Performance Improvement
- Jeff Hardy - Regulatory Assurance Manager
- Jeff Erickson - Regulatory Assurance Engineer
- William Sims - Director, Chief Engineer
- Dave Mannai - Senior Manager, Regulatory Assurance
- Jake Milliken - Engineering Supervisor
- Will Harper – Superintendent, Site Projects
- Steve Davis - Project Manager
- Michael Bratton - Project Coordinator and Technical Adviser
- Carl Latiolais - Electric Power Research Institute
- Dick Mattson - Structural Integrity Associates
- Chris Lohse - Structural Integrity Associates

Purpose of Meeting

The purpose of the meeting is to discuss:

- Entergy's progress in preparing for the primary coolant system (PCS) branch connection dissimilar metal weld inspections at Palisades during the 2015 refueling outage (1R24).
- Industry activities related to the weld inspections.
- Entergy's plans to submit a relief request for inspection of these welds.

Background

During Palisades' 2014 refueling outage (1R23), an NRC Region III inspector raised a question concerning the applicability of Code Case N-770-1 to nine PCS dissimilar metal branch connection welds (eight welds on PCS cold legs and one weld on PCS hot leg).

The question was passed on to NRR, and NRR responded that the nine subject welds are considered to be butt welds per ASME Code Section III and therefore are subject to N-770-1 volumetric inspection requirements under 10 CFR 50.55a(g)(6)(ii)(F).

Background

10 CFR 50.55a(g)(6)(ii)(F)(1) states, for dissimilar-metal butt welds, that Licensees of existing, operating PWRs as of July 21, 2011, shall implement the requirements of ASME Code Case N-770-1, subject to the conditions specified in paragraphs (g)(6)(ii)(F)(2) through (g)(6)(ii)(F)(10) of this section, by the first refueling after August 22, 2011.

(F)(3) states that baseline examinations must be completed by the end of the next refueling outage after January 20, 2012.

Background

During refueling outage 1R22 (Spring 2012), Palisades performed N-770 volumetric inspections of PCS Alloy 600 butt welds per 10 CFR 50.55a(g)(6)(ii)(F).

The population of welds inspected did not include the subject nine PCS branch connection welds.

Background

During refueling outage 1R23, Palisades submitted a relief request (RR 4-18) to defer the nine PCS branch connection weld inspections until the following refueling outage (1R24) because of:

- The lack of a qualified inspection technique at that time.
- The lack of an approved repair/replacement design at that time.
- The excessive dose that would be incurred with unplanned inspections.
- A bounding primary water stress corrosion cracking (PWSCC) growth analysis showed 112* years for an axial flaw to grow through-wall when initiating at day one.

*Second Supplemental Response to RAI #1 for RR 4-18, dated March 9, 2014 (ADAMS Accession No. ML14069A004)

Background

The NRC subsequently approved the relief request with the following conditions:

1) Perform periodic system leakage tests in accordance with ASME Section XI Examination Category B-P, Table IWB-2500-1.
2) Perform visual examinations (per Code Case N-722-1) and dye penetrant surface examinations (per ASME Section XI Examination Category B-J, Table IWB-2500-I) of the welds in accordance with ASME requirements.
3) Perform a volumetric examination, using ASME Code, Section XI, Appendix VIII, Supplement 10 qualified procedures, equipment and personnel, on each of the nine subject welds of this alternative during the next scheduled refueling outage (1R24).
4) Until the next scheduled refueling outage, if unidentified PCS leakage increases by 0.15 gpm above the WCAP-16465NP baseline mean, and is sustained for 72 hours, take action to be in Mode 3 within 6 hours and Mode 5 within 36 hours, and perform bare metal visual examinations of the nine subject welds of this alternative, unless it can be confirmed that the leakage is not from these welds.

Background

The NRC subsequently issued a non-cited violation of 10 CFR 50.55a(g)(6)(ii)(F)(3) for failure to complete required baseline volumetric examinations for the nine dissimilar metal branch connection butt welds in the PCS that were fabricated from Alloy 82/182 weld metal and were susceptible to PWSCC.

Background

In December 2014, Entergy contracted with Structural Integrity Associates to support a flaw readiness evaluation for the 1R24 examinations of the nine PCS branch connection nozzle welds.

While preparing a new weld residual stress evaluation for the hot leg drain nozzle, a discrepancy in the weld residual stresses was identified when the new analysis results were compared to previous analysis results.

The previous analysis results were used as a basis for Relief Request 4-18.

Palisades notified the NRC of the error and the calculations are being corrected.

Palisades Preparations for Inspections in 2015 Refueling Outage

- The 2015 refueling outage is scheduled in the Fall of 2015.
- A Performance Demonstration Initiative (PDI) qualified ultrasonic testing technique is in development by a vendor with Electric Power Research Institute (EPRI) support. Planned completion is just prior to the 2015 refueling outage.
- Repair/replacement contingencies are in development. A repair/replacement design is planned to be completed just before the 2015 refueling outage.

Palisades Preparations for Inspections in 2015 Refueling Outage

Branch Connection Project PDI Qualification Work:

- EPRI Contracted 6/6/14
- Mockup Vendor Contracted 9/3/14
- Mockup Fabrication Start 9/3/14
- Nondestructive Examination (NDE) Vendor Contracted 9/17/14
- Scanner and Delivery System Start 9/27/14

Palisades Preparations for Inspections in 2015 Refueling Outage

Mockup Fabrication Status:

- Nozzles machined
- Piping clad and machined
- Welding is in process
  - Welding concerns were identified during the welding of the first mockup. The fabrication vendor stopped the process and contacted EPRI.
  - EPRI worked on a solution.
  - EPRI contacted Entergy to discuss the issue.

Palisades Preparations for Inspections in 2015 Refueling Outage

NDE Mockup Fabrication:

- Fabrication NDE mockup defects continue to challenge mockup production schedule.
- Initial fabrication issues identified resulted in increased man hours and oversight to resolve.
- Project team has dedicated oversight with a focus to address concerns and issues as they are identified.

Palisades Preparations for Inspections in 2015 Refueling Outage

Scanner Development:

- X-axis and Y-axis tooling machining - 70% complete
- Rotational-axis machining - 50% complete
- Aluminum scanner mock-up design drawings complete
- Aluminum scanner mock-ups in process at fabrication facility. Mockups 1 and 2 complete and delivered. Mockup 3 in fabrication.
- Carbon steel scanner mock-up will follow (This is for functional testing/training on the delivery system for the PDI procedure demonstration.) Two mockups are in fabrication.
- Motor controller, scan models, programs, etc. are in process
  - In parallel, a separate back-up motor controller is being fabricated to assure us of the June 22nd date for PDI demo only. 50% complete.
- Final personnel qualifications to follow immediately after completion of procedure demo
- Using an automated encoded examination.

Palisades Preparations for Inspections in 2015 Refueling Outage

Optional Eddy Current

- An NDE vendor was contacted to provide an estimate for ECT to look for surface breaking flaws if indications were found.
- No system entry point. The system would have to be cut to deploy.
- Requires fuel offload.
- Requires temporary reactor cover.
- For these reasons it is impractical to prepare for this option.

Palisades Preparations for Inspections in 2015 Refueling Outage

Contingency Planning for Repair/Replacement:

- PWROG Task - Westinghouse developing weld pad/half nozzle repair/replacement
- Work started in January 2015
- Repair/replacement design due May 2015
- Repair/replacement analysis due August 2015
- PWROG Task – Areva developing procedures/mockups
  - Revisions being voted on for additional mockups needed for vertical welding
  - Generic relief request being drafted – draft to be issued for comment in October 2015.

Palisades Preparations for Inspections in 2015 Refueling Outage

Contingency Repair/Replacement Option:

- Tooling being designed to bound all nine locations
- Plans for mockup will be completed just prior to outage
- Mockup welders/field supervisors will mobilize to site if an NDE call made that cannot be evaluated
- Additional welders/site support will be required
- Expected significant outage extension for one repair/replacement

Palisades Preparations for Inspections in 2015 Refueling Outage

Preparation for Contingency:

- Schedule fragnet is being developed
- Work orders written but waiting on design to be complete
- ALARA plan is being developed
- Drain down plan is being developed
- Core offload plan is being developed
- Temporary reactor cover has been located at another site.

Industry Activities

- March 10, 2014 - ASME approved inquiry 14-382 (branch welds not included in Code Case N-770)
- June 23, 2014 - NRC letter to ASME recommending revision to N-770
- August 2014 - Section XI Task Group High Strength Nickel Alloy Issues (TGHSNAI) focus group initiated
  - Branch welds inadvertently removed from N-722 and need to be added back to N-722, moved to N-770, or a combination of both
  - Focus group to provide recommendations based on PWROG tasks
  - NRC represented in focus group

Industry Activities

- PWROG Task – Areva to perform crack growth analysis for the < 2 inch branch welds to be completed by July 31, 2015
  - Input to be provided to the TGHSNAI focus group for Code Case change(s)
  - Recommendations expected late 2015 or early 2016
- B&W utilities contracted EPRI to develop mockups to qualify procedures/personnel/equipment for ultrasonic testing (UT) vendor qualification not expected until 2016
  - Only two vendors in United States available to build mockups

Industry Activities

- October 2014 - NRC requested public comments on Draft Regulatory Issue Summary
- The industry comments included the following comments from ASME:
  - Only ASME has the authority to interpret its Codes and Standards (including Code Cases).
  - ASME does not believe that Alloy 82/182 dissimilar metal full penetration branch connection welds are required to be classified as butt welds for application of Code Case N-770 inspection requirements.
- ASME opinion is that N-770 and 10CFR50.55(a) do not require UT for branch connection welds and that 10CFR50.55(a) should be revised if the NRC requires such inspections.

Industry Activities

- PWROG Task –3rd party review of the 2014 evaluation
  - "…since PWHT is performed after any weld repairs, it is reasonable not to assume a repair. Therefore, the axial flaw at the hot leg location has been shown to take 112 years to grow through-wall."
  - "For a similar configuration at the cold leg location, the factor of improvement is 2.75. Hence, the cold leg location can be shown to be acceptable for 308 years."
  - "Therefore, bare metal visual examinations are sufficient to ensure that cracking in hot and cold leg nozzles does not pose an immediate safety concern."

These figures for the number of years to grow through-wall will be reduced due to the calculation error discussed on slide #11.

Planned Relief Request

Need for Relief Request

- Hardship in accordance with 10 CFR 50.55(a)(3)(ii)
  - Current estimate – 14.5 Rem (reduced from 37 Rem due to planning)
  - PDI qualification still in process and may not be available
  - First-of-kind examination
    - False calls possible
      - Unnecessary repairs
      - Require core offload and PCS drain down dose increases
      - Extended outage – potentially greater than 30 days
        - » Temporary cover from another site
    - Should examine the spare Areva branch connection welds prior to first examination on an operating plant
      - UT may not be feasible (pending fabrication process and weld quality)

Planned Relief Request

Need for Relief Request

Areva Branch Connection Welds

- Full penetration branch welds exist that have not been placed in service.
- It is recommended that these be inspected prior to a first-of-a - kind examination on an operating plant in order to determine the industry risk for false calls.
- NDE will not be available in time to support UT prior to 2015 refueling outage.
  - Inspections should be performed to minimize enterprise risk.

Planned Relief Request

Need for Relief Request

- There currently is no Code inspection guidance for the branch connection welds.
- The industry is currently performing a flaw analysis to determine recommended inspection requirements to adopt in either Code Case N-770 (volumetric), Code Case N-722 (visual), or both.
  - New inspection Code rules (N-770, N-722, or both revisions) expected to minimize or eliminate the hardship of UT
- Code Case revisions are expected by end of 2015 or early 2016.
- Entergy would commit to the new Code rules.

Planned Relief Request

Need for Relief Request

Repair/replacement contingencies are in development but need associated Code rules to be completed.

- The first draft of repair Code Case N-853 is planned to be discussed in the ASME High Strength Nickel Alloy Issues Task Group in April 2015.
- A revision to N-770 may be required as well.
- ASME approval of these Code Cases is not expected to occur until 2016.

Planned Relief Request

Need for Relief Request

If Entergy inspected the branch connection welds this outage, a Section XI repair relief request would likely be needed prior to the outage.

This will be difficult to develop since even draft Code repair rules are not yet available.

Planned Relief Request

Technical Basis for Relief Request

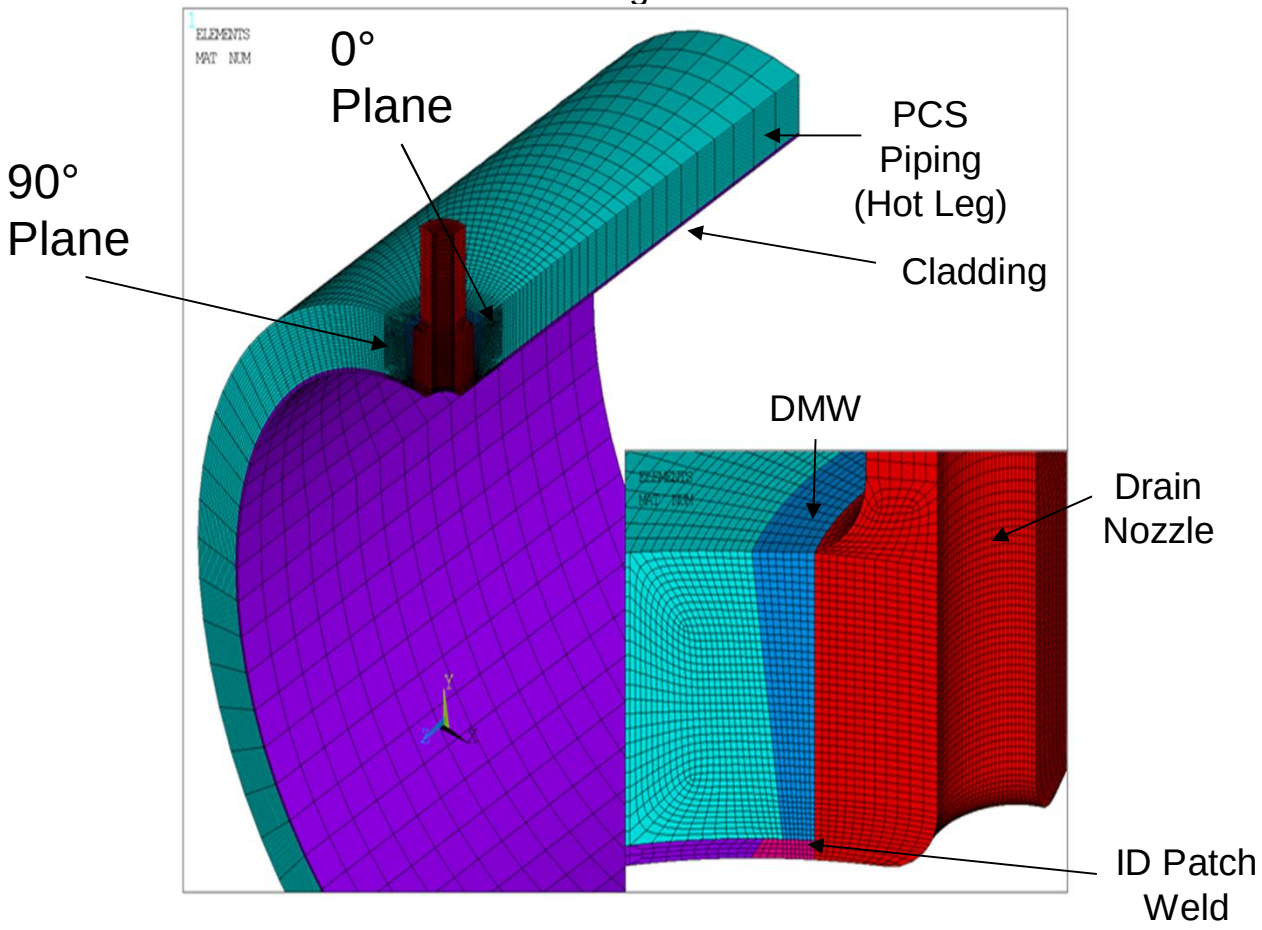
Finite Element Model (FEM) Development

- Of the nine weld locations, eight are cold leg (CL) nozzles and one is a hot leg (HL) nozzle.
- FEMs were developed for the HL nozzle and a bounding CL nozzle.
- FEMs were used to perform weld residual stress evaluations and calculation of stress intensity factors (K) in the welds.
- Crack growth due to PWSCC was evaluated utilizing “K” distributions for postulated circumferential and axial flaws.

Planned Relief Request

Technical Basis for Relief Request

Isometric View of the Hot Leg Nozzle Finite Element Model



Planned Relief Request

Technical Basis for Relief Request

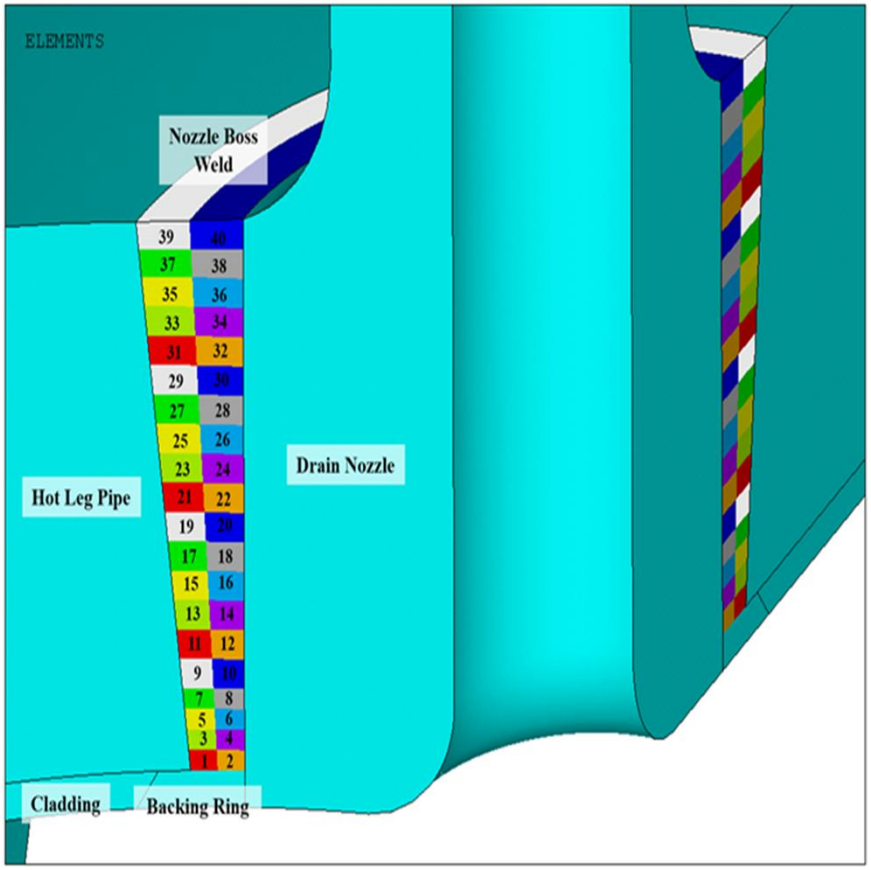
Weld Residual Stress Analyses:

- Deposit cladding on the pipe inside surface
- Install nozzle, backing ring, and deposit nozzle boss weld
- Remove backing ring and deposit ID patch weld
- Perform post weld heat treatment
- Subject the configuration to a hydrostatic test
- Impose 5 cycles of “shakedown” at normal operating temperature and pressure to stabilize the residual stress fluctuations.

Planned Relief Request

Technical Basis for Relief Request

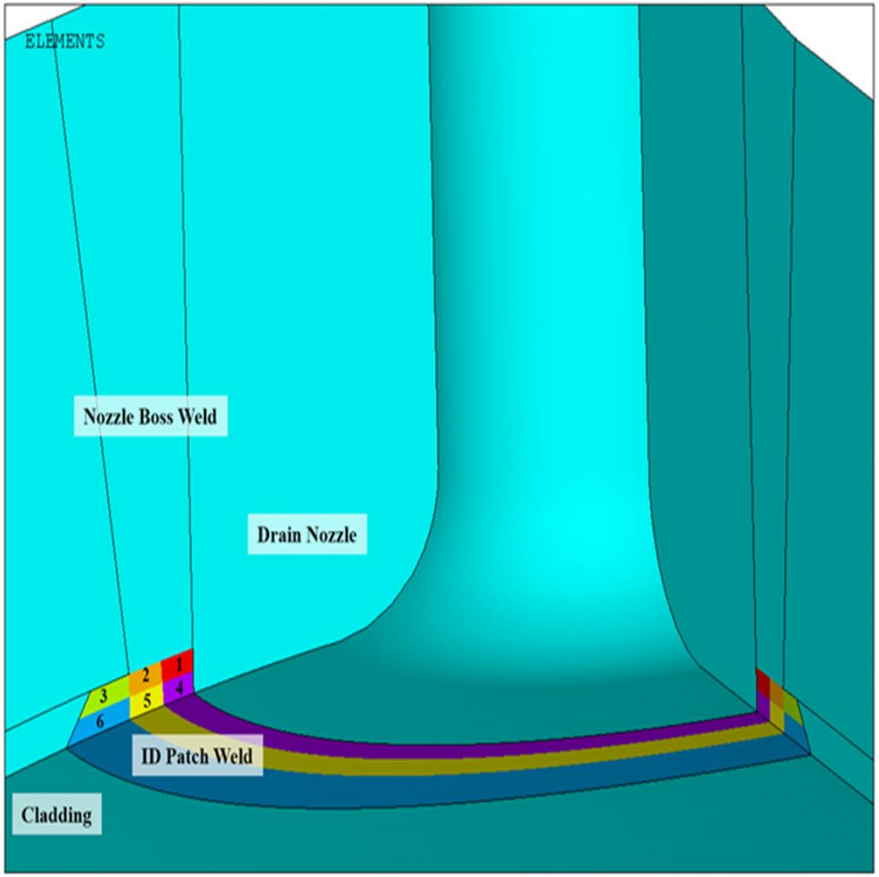
Weld Nugget Definitions for the Hot Leg Drain Nozzle Boss Weld



Planned Relief Request

Technical Basis for Relief Request

Weld Nugget Definitions for the Hot Leg Drain Nozzle ID Patch Weld

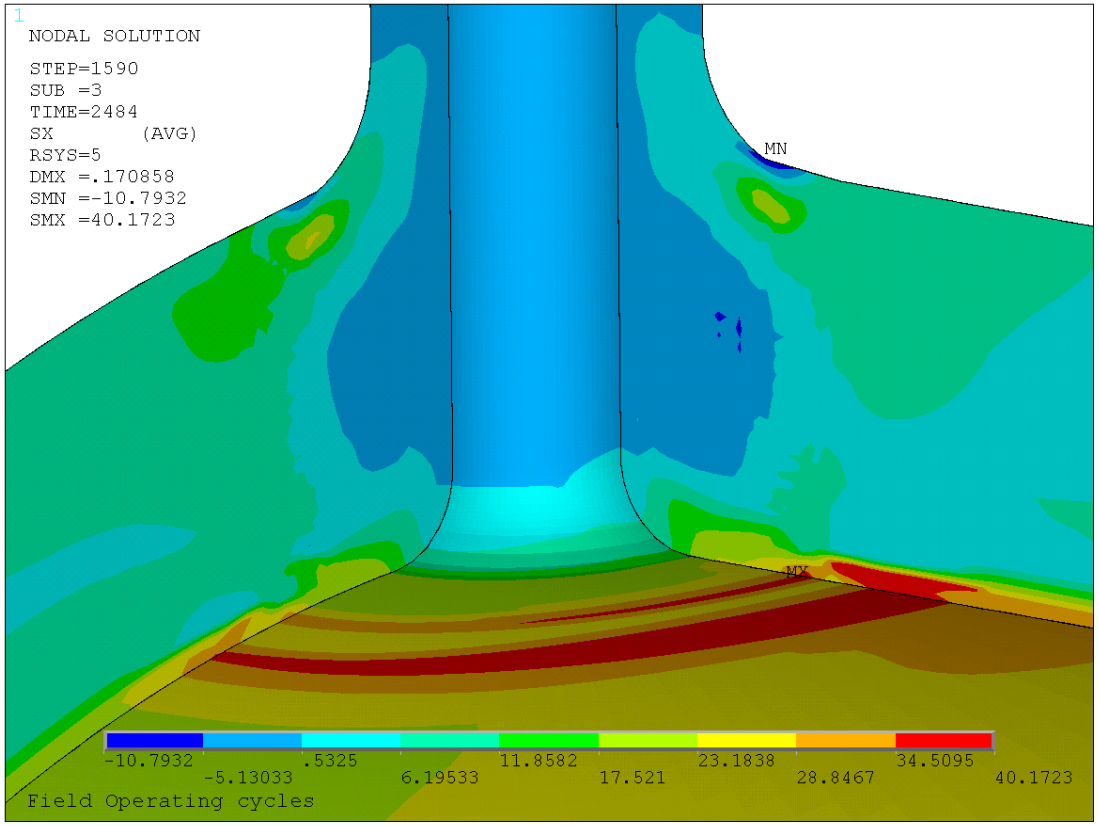


Planned Relief Request

Technical Basis for Relief Request

Radial Stresses at Operating Conditions for the Hot Leg Drain Nozzle

Radial stresses are shown in the nozzle axis radial direction and units are in ksi.

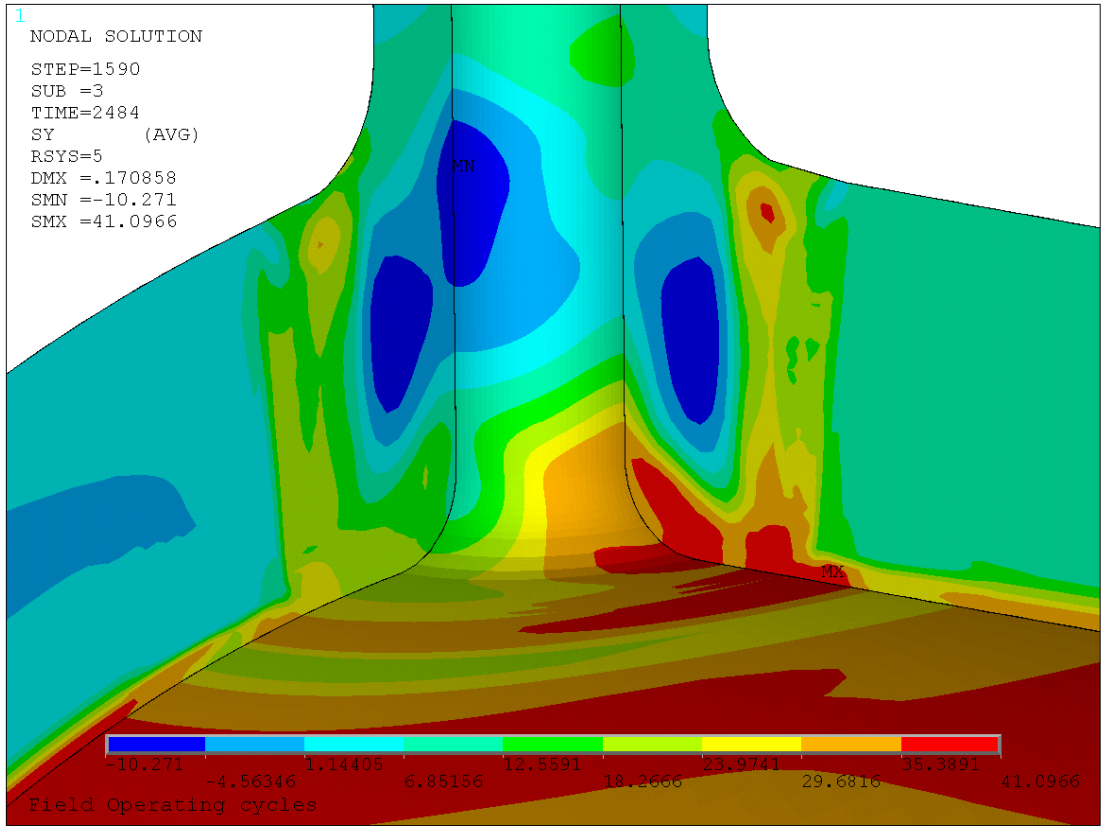


Planned Relief Request

Technical Basis for Relief Request

Circumferential Stresses at Operating Conditions for the Hot Leg Drain Nozzle

Circumferential stresses are shown in the nozzle axis circumferential direction and units are in ksi.



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Planned Relief Request

Technical Basis for Relief Request

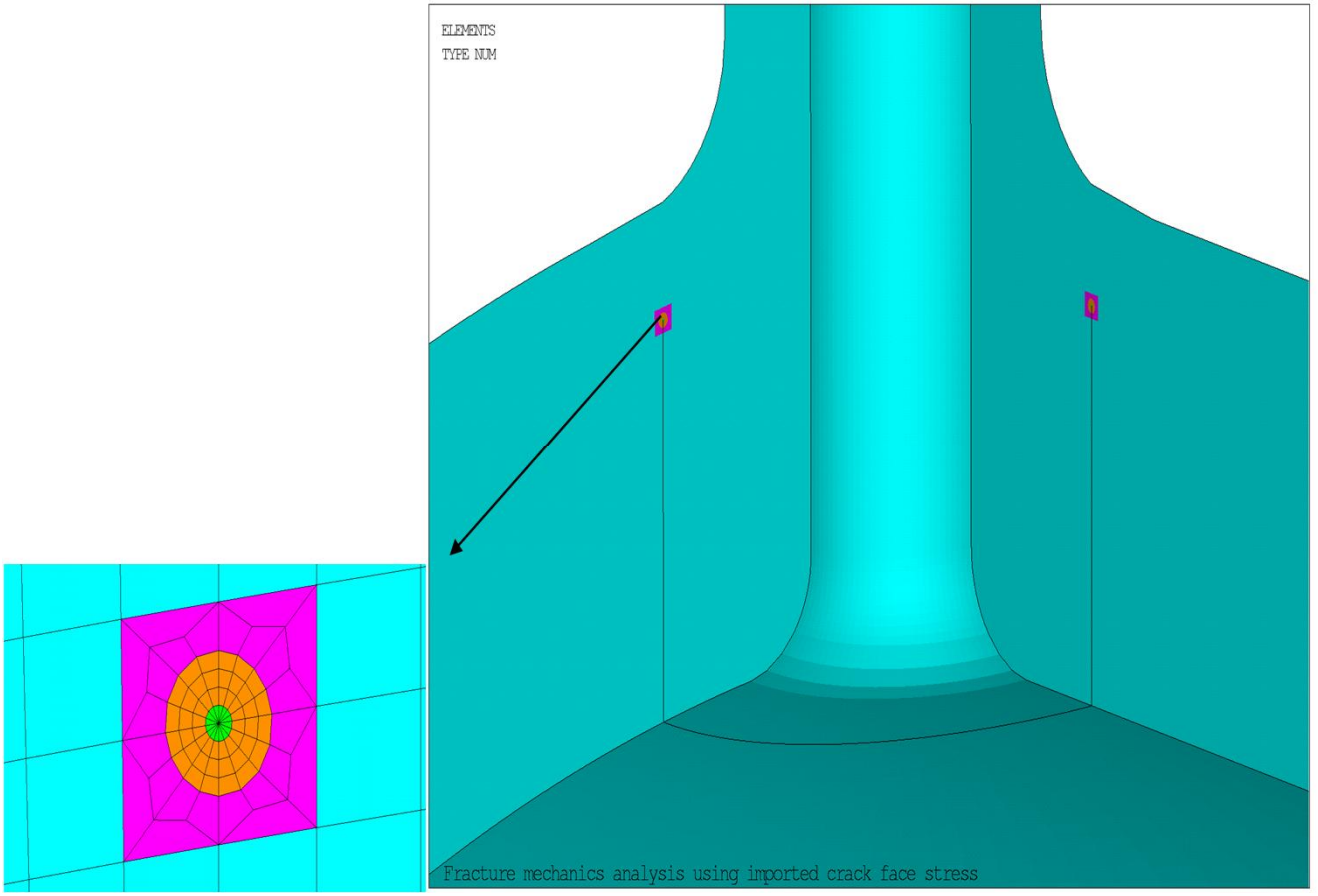
Crack Growth Evaluations:

- Postulated axial and circumferential flaws
- Only PWSCC growth considered - Based on MRP-115
- Initial flaw depth = 0.025” for both the HL and CL
- Temperature = 583°F (hot leg) and 537°F (cold leg)
- Wall thickness = 4” (hot leg) and 3” (cold leg)
- “Ks” were calculated for 5 flaw depths for both circumferential and axial flaws
  - 360°F circumferential flaw
  - Two axial flaws – at the 0° and 90° azimuths
- Includes pressure and bounding piping loads

Planned Relief Request

Technical Basis for Relief Request

79% Deep Circumferential Flaw with Crack Tip Elements Inserted



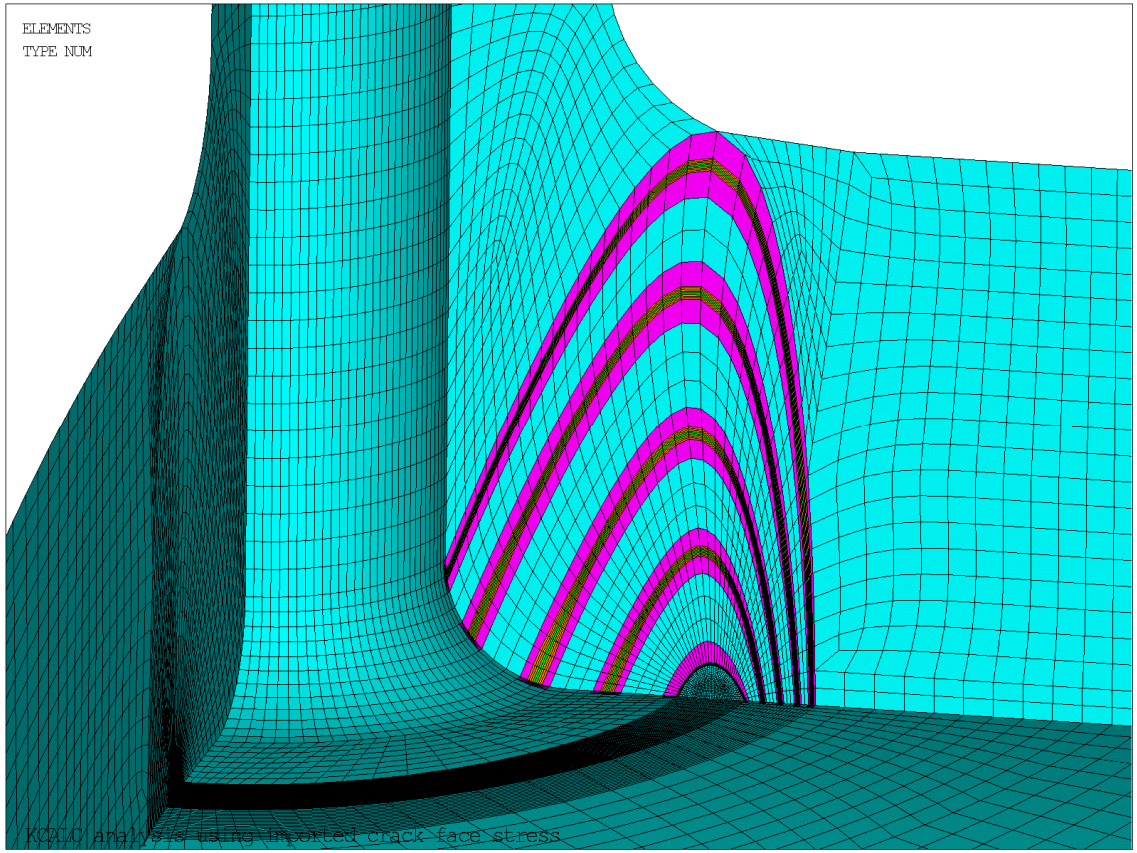
Entergy

Planned Relief Request

Technical Basis for Relief Request

Axial Flaws on the 0° Face with Crack Tip Elements Inserted

0° axial flaws are shown. The 90° flaws are similar.



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Planned Relief Request

Technical Basis for Relief Request

Initial Flaw Size (in)	Final Depth	Hot Leg		Cold Leg	
		Axial Flaw (0° plane) (years)*	Circumferential Flaw (years)	Axial Flaw (0° plane) (years)*	Circumferential Flaw (years)
0.025	95%	36.7	42.1	77.0	66.2

***Only bounding axial flaw case is shown.

Planned Relief Request

Technical Basis for Relief Request

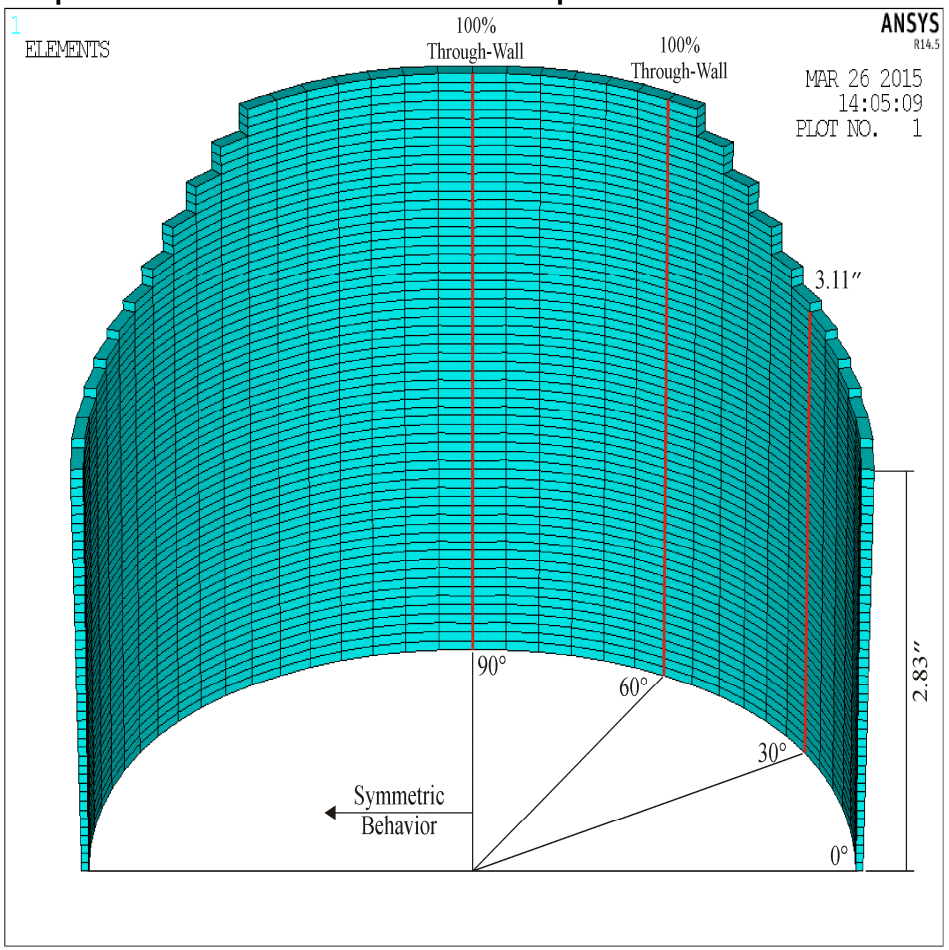
Limit Load Evaluations were performed to show stability of postulated through-wall axial and circumferential flaws

- Guidance taken from the ASME Code, Section III, NB-3228.1 for limit analysis
- Z-factor from ASME Code, Section XI, Appendix C, C-6330 for SMAW weld material used to reduce the yield strength in the analysis
- Through-wall axial flaw was stable
- Through-wall circumferential flaw (35 degree of 90 degree arc) was stable and results in leakage

Planned Relief Request

Technical Basis for Relief Request

Example Circumferential Flaw Shape for Limit Load Evaluation



Planned Relief Request

Technical Basis for Relief Request

Post weld heat treatment (PWHT) crack growth rate – studies have shown a factor of 2 improvement:

- Dominion Engineering letter submitted with RR 4-18 documentation (ML14072A361)
- S. Le Hong, et. al., "Measurements of Stress Corrosion Cracking Growth Rates in Weld Alloy 182 in Primary Water of PWR"

Initial Flaw Size (in)	Final Depth	Hot Leg		Cold Leg	
		Axial Flaw (0° plane) (years)*	Circumferential Flaw (years)	Axial Flaw (0° plane) (years)*	Circumferential Flaw (years)
0.025	95%	73.4	84.2	154	132.4

*Only bounding axial flaw case is shown.

Palisades is estimated to be at 28.8 effective full power years by 1R25.

Planned Relief Request

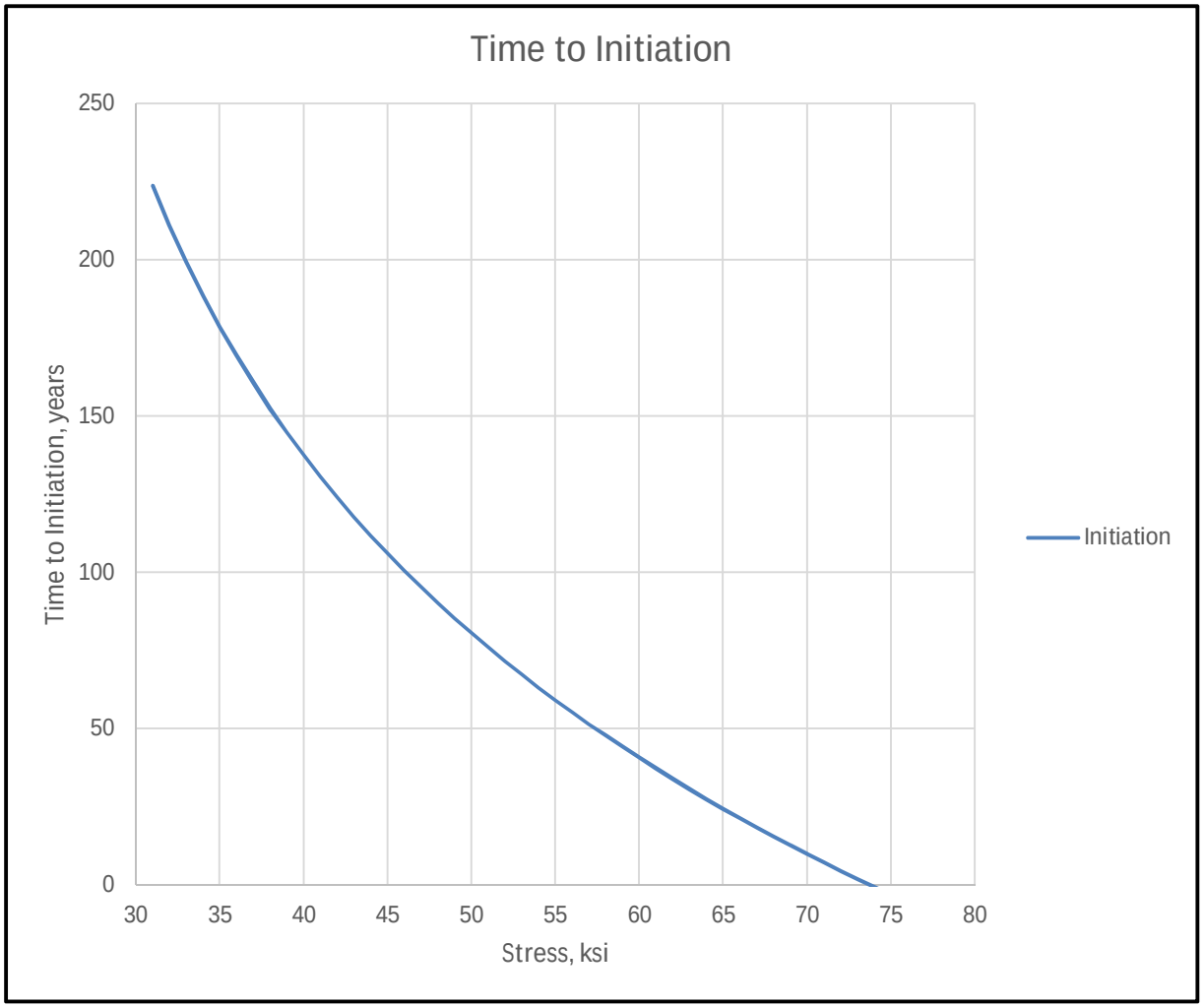
Technical Basis for Relief Request

Crack Initiation:

- Development of xLPR code has included studies of initiation models
- Model developed by EPRI. Report No. 1019032
- Model benchmarked for xLPR for use on Alloy 82/182 initiation
- Used in xLPR Version 1.0 pilot study. EPRI Report No. 1022528
- The model calculated time to initiation based on surface stress of the component – Palisades surface stresses are maximum of ~41 ksi
- Conservative lower bound (95th percentile) of input from benchmarking distribution was used
- For Palisades hot leg drain nozzle, time to initiation calculated at ~130 years

Planned Relief Request

Technical Basis for Relief Request



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Planned Relief Request

Technical Basis for Relief Request

Initial Flaw Size (in)	Final Depth	Hot Leg		Cold Leg	
		Axial Flaw (0° plane) (years)*	Circumferential Flaw (years)	Axial Flaw (0° plane) (years)*	Circumferential Flaw (years)
0.025	95%	73.4	84.2	154	132.4
Crack Initiation	N/A	130	130	130**	130**
Total	95%	203.4	214.2	284	262.4

* Only bounding axial flaw case is shown.

** Conservative value based on hot leg temperature used. Hot leg temperature = 583ºF. Cold Leg temperature = 537ºF.

Planned Relief Request

In summary:

- Hardship 9.8 Rem for inspections/significant outage extension for potential false call resulting in a repair/replacement.
- Spare vendor branch welds should be examined using revised procedure/qualification to confirm NDE capabilities and/or to revise as necessary.
- Entergy and the industry are diligently working to develop Code rules for inspection and repair/replacement requirements.
- Entergy and the industry are also working to develop inspection qualification and contingency repair/replacement capabilities.
- Additional time is needed for the industry to develop qualifications, Code inspection rules, and repair/replacement requirements.
- Entergy will commit to the new inspection requirements being developed by ASME.
- All this is planned to be completed prior to the spring 2017 outage (1R25).

Planned Relief Request

Entergy plans to submit a relief request to defer inspections of the PCS branch connection welds until the next refueling outage (1R25), scheduled in the spring of 2017.

Analysis supports no crack initiation or through-wall crack for the remaining life of plant

New commitment will be to perform inspections as required per the revised NDE Code Case(s).

Planned Relief Request

The relief request would propose the following proposed alternative:

1) Perform periodic system leakage tests in accordance with ASME Section XI Examination Category B-P, Table IWB-2500-1.
2) Perform visual examinations (per Code Case N-722-1) and dye penetrant surface examinations (per ASME Section XI Examination Category B-J, Table IWB-2500-I) of the welds in accordance with ASME requirements.
3) Perform NDE in accordance with revised Code Case N-770 and/or N-722 during the next scheduled refueling outage (1R25).
4) Until the next scheduled refueling outage, if unidentified PCS leakage increases by 0.15 gpm above the WCAP-16465NP baseline mean, and is sustained for 72 hours, take action to be in Mode 3 within 6 hours and Mode 5 within 36 hours, and perform bare metal visual examinations of the nine subject welds of this alternative, unless it can be confirmed that the leakage is not from these welds.

Planned Schedule

Palisades' 2015 refueling outage is scheduled to begin in the Fall of 2015.

Entergy plans to submit the relief request in May 2015.

Questions/Discussion