

From: Wall, Scott
Sent: Monday, May 16, 2022 2:27 PM
To: Lashley, Phil H (EH)
Cc: Morgan, Jeffrey D.; Nevins, Kathleen J
Subject: Final RAI - Perry - Proposed Inservice Inspection Alternative IR-063 (EPID: L-2022-LLR-0005)

Dear Mr. Lashley,

By letter dated January 5, 2022, (Agencywide Documents and Access Management System (ADAMS) Accession No. ML22006A167), Energy Harbor Nuclear Corporation (EHNC or the licensee) submitted Relief Request (RR) IR-063 for Perry Nuclear Power Plant (PNPP). In IR-063, the licensee proposes alternative inservice inspection (ISI) requirements for the volumetric inspection of the plant's reactor feedwater (RFW) nozzles from those required for the nozzles in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, Table IWB-2500-1, Examination Category B-D, "Full Penetration Welded Nozzles in Vessels," Inspection Items B3.90, "Nozzle-to-Vessel Welds," and B3.100, "Nozzle Inside Radius Section."

The NRC staff has reviewed the submittals and determined that additional information is needed to complete its review. The specific questions are found in the enclosed request for additional information (RAI). By email on May 16, 2022, the EHNC staff indicated that a response to the RAIs would be provided by July 18, 2022.

If you have questions, please contact me at 301-415-2855 or via e mail at Scott.Wall@nrc.gov.

Scott P. Wall, LSS BB, BSP
Senior Project Manager
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation
301.415.2855
Scott.Wall@nrc.gov

Docket No. 50-440

Enclosure:
Request for Additional Information

cc: Listserv

RAI-NVIB (IR-063)

REQUEST FOR ADDITIONAL INFORMATION

EMERGENCY RESPONSE FACILITY AUGMENTATION TIMES

ENERGY HARBOR NUCLEAR CORP

PERRY NUCLEAR POWER PLANT, UNIT NO. 1

NRC DOCKET No. 50-440

INTRODUCTION

By letter dated January 5, 2022, (Agencywide Documents and Access Management System (ADAMS) Accession No. ML22006A167), Energy Harbor Nuclear Corporation (EHNC or the licensee) submitted Relief Request (RR) IR-063 for Perry Nuclear Power Plant (PNPP). In IR-063, the licensee proposes alternative inservice inspection (ISI) requirements for the volumetric inspection of the plant's reactor feedwater (RFW) nozzles from those required for the nozzles in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, Table IWB-2500-1, Examination Category B-D, "Full Penetration Welded Nozzles in Vessels," Inspection Items B3.90, "Nozzle-to-Vessel Welds," and B3.100, "Nozzle Inside Radius Section."

Specifically, EHNC proposes to reduce the population of RFW nozzle-to-vessel welds and RFW nozzle inside radius sections subject to volumetric inspections (i.e., subject to either ultrasonic test (UT) or radiographic test (RT) inspection methods) from 100% of each RFW nozzle component type down to 25% of the population for each RFW nozzle component type. The licensee identifies that the proposal in IR-063 is for the remainder of the 4th 10-Year ISI Interval for PNPP. IR-063 included two supporting attachments which provide the deterministic and probabilistic parts of the supporting analyses for the PNPP RFW nozzle component types.

1. Structural Integrity Associates (SIA) Calculation Package No. 2001178.301, Revision 0, "Feedwater Nozzle Loads, Finite Element Model, and Stress Analysis" (SIA Calculation Package No. 2001178.301).
2. SIA Calculation Package No. 2001178.302, Revision 0, "Probabilistic Fracture Mechanics Evaluation for Perry Feedwater Nozzle" (SIA Calculation Package No. 2001178.302).

In order for the U.S. Nuclear Regulatory Commission (NRC) staff to determine if the proposed alternative may be authorized pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(2), the staff requests the licensee provide the following additional information.

APPLICABLE REGULATION AND GUIDANCE

The regulations in 10 CFR 50.55a(g)(4), "Inservice inspection standards requirement for operating plants," states, in part, that ASME Code Class 1, 2, and 3 components must meet the requirements, except the design and access provisions and the pre-service examination requirements, set forth in the ASME Code, Section XI.

The regulations in 10 CFR 50.55a(g), "Preservice and inservice inspection requirements," require that the ISI of ASME Code Class 1, 2, and 3 components be performed in accordance with Section XI of the ASME Code and applicable addenda. Specifically, the provisions in ASME Code, Section XI, Table IWB-2500-1, Examination Category B-D require that all ASME Code Class 1 nozzles (that are welded to ASME Code Class 1 vessels using full penetration pressure-retaining welds) be volumetrically inspected during each 10-year ISI interval. The rules in ASME Code Section XI Inspection Items B3.90 and B3.100 specify that the volumetric

inspections of each nozzle should achieve essentially 100% of the nozzle-to-vessel shell weld volume and 100% of the nozzle inner radius section volume, as depicted in the applicable figure for the applicable weld type or inside radius location in Figures IWB-2500-7(a) through (d) "Nozzle in Shell or Head," of the ASME Code, Section XI.

(IR-063) RAI-NVIB-01

Topic of RAI: Modeling of Inaccessible Weld Areas in Flaw Growth Analyses

Summary of Informational Gap: EHNC references the NRC staff's approval (ML21096A048) of the corresponding Energy Northwest Relief Request No. 4ISI-09 for Columbia Generating Station (CGS) (ML20114E235) as the basis for the proposed ISI population alternative proposed in PNPP IR-063. However, there are some differences between the analytical bases for the two relief requests. For example, in the past probabilistic fracture mechanics (PFM)-based ISI relief request for CGS, Energy Northwest referenced an achieved inspection coverage of approximately 99% coverage by volume for the past UT inspections that were performed on the RFW nozzle-to-vessel welds and nozzle inside radius locations during the 3rd 10-Year ISI Interval for the CGS unit.

In contrast, EHNC references that the past UT inspections performed on the PNPP RFW nozzle components during the 3rd 10-Year ISI Interval for PNPP achieved a UT inspection coverage of 100% for the RFW nozzle inside radius sections but only an inspection coverage of 82.7% for the corresponding RFW nozzle-to-vessel weld locations. IR-063 does not appear to address how the inaccessible volumes in the PNPP RFW nozzle-to-vessel welds were accounted for in the VIPERNOZ PFM crack growth modeling for stress intensity paths (i.e., stress paths P3 and P4) that apply to the RFW nozzle-to-vessel weld locations at PNPP.

Request: For assessed RFW nozzle-to-vessel welds, clarify how the VIPERNOZ PFM crack growth methods model the impacts of postulated cracks in the inaccessible regions (i.e., un-inspected regions) of the referenced weld locations (i.e., for RFW Nozzle Weld ID Nos. 1B13-N4A-KA thru 1B13-N4F-KA).

(IR-063) RAI-NVIB-02

Topic of RAI: Stresses and Number of Analyzed Stress Paths Performed

Summary of Informational Gap: EHNC references the NRC staff's approval (ML21096A048) of the corresponding Energy Northwest Relief Request No. 4ISI-09 for Columbia Generating Station (CGS) (ML20114E235) as the basis for the proposed ISI population alternative proposed in PNPP IR-063. However, there are some differences between the analytical bases for the two relief requests. For example, the VIPERNOZ PFM crack growth methods for PNPP IR-063 models four specific stress paths: two stress paths (P1 and P2) for the PNPP RFW nozzle inside radius locations; and two stress paths (P3 and P4) for the PNPP RFW nozzle-to-vessel weld locations. However, the past VIPERNOZ PFM crack growth modeling for the corresponding CGS relief request modeled more analyzed stress paths than have been modeled for PNPP. There is also some uncertainty regarding the specific types of loads applicable to each of the four loading paths (P1 – P4) assessed as part of the PNPP VIPERNOZ runs for specific types of nozzle component flaw orientations. Thus, the NRC staff seeks further clarifications on the criteria for stress paths that are being evaluated as part of SIA random-generated VIPERNOZ Monte Carlo runs for assessed PNPP RFW nozzle-to-vessel weld and nozzle inside radius section component locations and the orientation of flaws for the specific load path(s) that apply to each RFW nozzle component location type.

Additionally, in Section 5.1 of SIA Calculation Package No. 2001178.301, EHNC states that the deterministic stress analysis in Calculation 200117.301 modeled the cladding in the RFW nozzle-to-weld region (0.1825 inches in thickness) in the finite element modeling (FEM) that used for the analyses. For the corresponding VIPERNOZ PFM flaw analyses of the reactor pressure vessel (RPV) nozzle-to-vessel welds that were performed in SIA Calculation Package No. 2001178.302 (for load paths P3 and P4 in the welds), Figure 1 in the package shows the cladding of the RFW weld regions was included in the FEM. However, SIA Calculation Package No. 2001178.302 does not discuss whether the residual stress due to the welding process for depositing the cladding (i.e., cladding residual stress or sometimes simply “clad stress”) has been included in the assumed loads for load paths P3 and P4.

Request: Justify the basis for the difference in the number of analyzed stress paths that were previously analyzed for the VIPERNOZ Monte Carlo runs of the CGS RFW nozzle components versus the number of stress paths (i.e., the four stress paths P1 – P4) that have been analyzed for the PNPP RFW nozzle components in RR# IR-063. As part of this justification, please explain:

- (a) similarities and differences between the assumed stress types (i.e., hoop or axial) for stress paths P1 and P2 being applied to the PNPP RFW nozzle inside radius sections, as analyzed using the reiterative VIPERNOZ Monte Carlo runs for random generated inside radius semi-elliptical flaws in the radius sections;
- (b) which orientation of semi-elliptical flaw is being applied to stress paths P3 and P4 for the VIPERNOZ RFW nozzle-to-vessel weld assessments at PNPP;
- (c) the similarities and differences between the assumed stress type (i.e., hoop or axial stress) being applied to the VIPERNOZ Monte Carlo runs for PNPP RFW nozzle-to-vessel weld semi-elliptical axial flaws and semi-elliptical circumferential flaws (under the applicable stress path, P3 or P4, for the specified flaw type, including all applicable stress inputs).
- (d) why the past VIPERNOZ Monte Carlo analyses for RFW nozzle-to-vessel welds at CGC, as explained in Energy Northwest RAI response (ML20296A684), ran more stress path assessments for random-generated semi-elliptical axial flaws in the welds. Whereas, presumably the stress path modeling for the corresponding VIPERNOZ Monte Carlo analyses for RFW nozzle-to-vessel welds at PNPP is only modeling one stress path for random generated semi-elliptical axial flaws in welds (i.e., under either stress path (P3 or P4), as applicable to the axial flaw orientation, where the other path (P4 or P3) would be used for the semi-elliptical circumferential flaw analysis runs in the welds).

(IR-063) RAI-NVIB-03

Topic of RAI: Further Support on Use of a Material Fracture Toughness (K_{IC}) Value of 200 $\text{ksi}\sqrt{\text{in}}$

Summary of Informational Gap: On pages 5, 8 and A-2 of SIA Calculation Package No. 2001178.302, EHNC states that the performed VIPERNOZ PFM Monte Carlo flaw analysis runs utilize a fracture mechanics acceptance criterion (i.e., K_{IC} linear elastic fracture mechanics [LEFM] acceptance criterion on applied stress intensities) of 200 $\text{ksi}\sqrt{\text{in}}$. The licensee states that this K_{IC} value correlates to the upper shelf fracture toughness value approved in BWRVIP-

108-A for nozzle materials in the un-irradiated condition. The licensee justifies use of the 200 ksi√in value for RFW nozzle materials in the un-irradiated condition by making the following statements on page 8 of SIA Calculation Package 2001178.302: (1) the “nozzles are not in the RPV beltline region and operate at high temperatures for the upper shelf fracture toughness to be applicable,” and (2) the “Perry feedwater nozzle (N4) experiences fluence less than 1.00×10^{17} n/cm² for 54 EPFY for 60 years of plant operation.” The licensee cites Reference 22 in SIA Calculation Package No. 2001178.302 as the basis for the *italicized* statements quoted in the previous sentence.

The licensee states in Section 5 of IR-063 that the RFW nozzles are outside of the scope of the BWRVIP-108A (ML19297F806) and BWRVIP-241-A reports (ML19297G738) and outside the scope of ASME Code Case N-702, “Alternative Requirements for Boiling Water Reactor (BWR) Nozzle Inner Radius and Nozzle-to-Shell Welds,” Section XI, Division 1, February 20, 2004. Additionally, Reference 22 in SIA Calculation Package No. 2001178.302 is a PNPP-specific record that has not been submitted or included for PNPP Docket No. 50-440 in ADAMS. The NRC staff will use the criteria ASME Section XI, Appendix G to check the validity of the selected 200 ksi√in K_{IC} value. However, per the ASME Section XI criteria, K_{IC} varies as a natural logarithmic function of the metal temperature and the fluence-dependent (fluence attenuated) adjusted reference temperature value (i.e., RT_{NDT} value) at the crack tip of the assessed ferritic Class 1 component of interest. Thus, the NRC staff will need additional technical information to confirm that use of a 200 ksi√in K_{IC} value is adequate and reasonable for the reiterative VIPERNOZ Monte Carlo-type flaw growth and fracture analysis runs.

Request:

- (a) Identify the 54 effective full power year (EPFY) neutron fluence value and 54 EPFY RT_{NDT} value (or ranges of these values at 54 EPFY) for the assessed RFW nozzle inside radius sections and RFW nozzle-to-vessel welds in the VIPERNOZ runs.
- (b) Identify the RFW metal temperature value (or range of RFW metal temperatures) used for the VIPERNOZ runs of the assessed RFW nozzle inside radius locations and the assessed RFW nozzle-to-vessel weld locations and clarify whether the metal temperature is based on that for the inside surface of the component (e.g., metal temperature of the inside surface of the component cladding for RFW nozzle welds assessed under path P3 and P4 or the metal temperature of the inside ferritic steel surface for assessed RFW inside radius sections under Paths P1 and P2) or the metal temperature at the assessed crack tip of the evaluated component flaw in the VIPERNOZ PFM Monte Carlo run for the assessed RFW nozzle component location. [NOTE: Per the FEM diagrams in IR-063, the RFW nozzle-to-vessel welds have inside cladding layers, but the RFW inside radius sections do not have any clad surface layers. The crack tips of the evaluated flaw types are depicted in the following figures in SIA Calculation No. 2001178.302: (a) Figure A-1 for the semi-elliptical inside surface flaw in the assessed RFW nozzle inside radius section, (b) Figure A-2 for a semi-elliptical, axially-oriented inside surface flaw in the assessed RFW nozzle-to-vessel weld component, and (c) Figure A-3 for a semi-elliptical, circumferentially-oriented inside surface flaw in the assessed RFW nozzle-to-vessel weld component.]

(IR-063) RAI-NVIB-04

Topic of RAI: Modeling of Operational Basis Earthquake (OBE) Loads

Summary of Informational Gap: In Section 4.1 and Table 2 of SIA Calculation Package No. 2001178.301 and in Section 3.2.2, "Transients and Projected 60-Year Cycles," of SIA Calculation No. 2001178.302, EHNC states:

"It is assumed that there are 40 internal cycles for each OBE event. Therefore, 2 OBE events x 40 internal cycles = 80 OBE cycles are evaluated for 60 years of plant operation."

In Section 3.2.3, "Piping Loads," of SIA Calculation No. 2001178.302, EHNC states:

"The PFM evaluation also conservatively included stresses due to deadweight and seismic OBE, which were excluded as negligible in the Columbia feedwater nozzle PFM evaluation . . . The stresses from the seismic piping load are conservatively evaluated at the minimum and maximum temperatures for the bounding transient 3B (Startup) and the OBE cycles in Table 1."

From the above statements the NRC staff's understanding is that EHNC is conservatively modeling the OBE loads within the scope of analyzed nozzle-pipe end loads.

Request:

- (a) Confirm that the SIA VIPERNOZ Monte Carlo flaw growth methods account for OBE load contributions as part of the "Bounding Group Event" Startup transient contributions to the reiterative VIPERNOZ Monte Carlo fatigue flaw growth runs (that is, as part of the "Startup" transient fatigue contributions to the runs for RFW nozzle inside radius sections and nozzle-to-vessel welds as a result of moments caused by loads applied at the nozzle-to-nozzle safe-ends regions).
- (b) If the NRC staff's understanding is correct, clarify how any ΔK (i.e., $K_{\max} - K_{\min}$) contributions from OBE event seismic load cycles are factored into the maximum ΔK assumed for the "Bounding Group Event" Startup transient and how the 80 cycles have been accounted for as a factor of the 260 cycle assumption for the "Bounding Group Event" Startup transient.
- (c) If the NRC staff's understanding is incorrect, explain how the OBE event stresses and cycles are accounted for in the VIPERNOZ Monte Carlo fatigue flaw growth runs for the assessed RFW inside radius sections under load Paths 1 and 2 and for the assessed RFW nozzle-to-vessel welds under Load Paths 3 and 4.

(IR-063) RAI-NVIB-05

Topic of RAI: Does Design Basis Include Any Repairs of the RFW Nozzle Welds

Issue: Page 5 of IR-063 includes the following information regarding activities to mitigate any RFW nozzle weld repair stresses:

"As documented in Perry's Updated Safety Analysis Report Section 5.3.3.3, 'The shell and vessel head were made from formed low alloy steel plates, and the flanges and nozzles from low alloy steel forgings.' The section goes on to state, 'Post weld heat treatment of 1,100°F minimum was applied to all low alloy steel welds.' This heat treatment should reduce residual stresses from any repairs such that they would not be a dominant force requiring consideration in the analysis. Weld residual stress (after post

weld heat treatment) was included in the probabilistic fracture mechanics design input as described in Attachment 2.”

The Updated Safety Analysis Report (USAR) credit for post-weld heat treatment as a stress mitigation technique for weld residual stresses would only apply during the fabrication of the RPV in the vendor shop that fabricated the PNPP RPV. Post weld heat treatment would not apply if weld repairs of the RFW nozzle-to-vessel welds (or even the RFW nozzle-to-safe end welds) were made after placing the RPV into initial service from the initial plant startup or subsequent startups of the unit coming out of scheduled refueling, maintenance, or unanticipated plant outages.

Request:

- (a) Confirm that EHNC has not made any weld repairs of the six RFW nozzle-to-vessel welds (or even the RFW nozzle-to-safe end welds) since initial startup of the PNPP reactor unit.
- (b) If EHNC has implemented weld repairs in any of the RFW nozzle-to-vessel welds (or nozzle-to-safe end welds) since initial operation of the unit, clarify how stresses introduced by the repair welds were accounted for in the FEM stress analyses for the assessed RFW nozzle-to-vessel weld components (including treatment of any weld residual stresses that may have been introduced into the nozzles as a result of repair welding melt and solidification processes).

(IR-063) RAI-NVIB-06

Topic of RAI: Needed Clarification on Basis for Reduction of Population to 25% of the RFW nozzle-to-vessel welds and 25% of the RFW nozzle inside radius sections

Issue: The information in IR-063 indicates design of the ASME Code Class 1 reactor coolant pressure boundary at PNPP includes six RFW nozzle-to-vessel welds and six RFW nozzle inside radius sections associated with the following RFW nozzles (with ID#s as stated):

- 1B13-N4A
- 1B13-N4B
- 1B13-N4C
- 1B13-N4D
- 1B13-N4E
- 1B13-N4F

Section 5, “Proposed Alternative and Basis for Use” (on Page 2) of IR-063 includes the following statement:

“In lieu of performing examinations on 100 percent of the population of RFW nozzle assemblies, Energy Harbor Nuclear Corp. proposes to examine a minimum of 25 percent of the population of the nozzle-to-vessel welds and a minimum of 25 percent of the population of the inner radii using volumetric inspection methods performed in accordance with ASME Section XI, Appendix VIII, ‘Performance Demonstration for Ultrasonic Examination Systems,’ as modified by 10 CFR 50.55a.”

The information in IR-063 does not specify exactly how many RFW nozzle-to-vessel welds and RFW nozzle inside radius sections will be inspected during the remainder of the 4th 10-Year ISI

interval for the reactor unit (i.e., mathematically, 25% of 6 would yield 1.5 nozzle welds and 1.5 inside radius sections being inspected under the proposed alternative). Nor does the information in IR-063 indicate which of the specified RFW nozzle(s) will be selected for the reduced population of inspected RFW nozzle-to-vessel weld and nozzle inside radius section locations.

Request:

- (a) Clarify whether the alternative in IR-063 is rounding the number of nozzle weld and nozzle inside radius sections (i.e., required for ISI volumetric inspections) down to one (1) RFW nozzle-to-vessel weld and one (1) RFW nozzle inside radius section during the remainder of the 4th 10-Year ISI interval for the unit or up to two (2) RFW nozzle-to-vessel welds and two (2) RFW nozzle inside radius sections during the remainder of the 4th 10-Year ISI interval for the unit (NOTE: Justification will be needed if rounding down to 1 RFW nozzle-to-vessel weld and 1 RFW nozzle insider radius section).
- (b) Clarify whether there are any location-specific considerations that would call for EHNC to pick one or two (depending on the response to Part 1 of this request) of the specified RFW nozzles for the specified inspections over the other RFW nozzles that are included in the population of RFW nozzles in the plant design. If so, explain what the RFW nozzle location-specific considerations are and how they are used to select the specific RFW nozzle(s) that will be inspected during the remainder of the 4th 10-Year ISI Interval for the unit; and identify the specific RFW nozzles (by component ID) that will be inspected during the remainder of the 4th 10-Year ISI Interval as a result of the location-specific considerations.

(IR-063) RAI-NVIB-07

Topic of RAI: Confirmation of VIPERNOZ Monte Carlo Methods;

Basis for Requested Confirmation of Submitted Information and Additional Questions on OBE Modeling: In SIA Calculation Package No. 2001178.302, the licensee provides its bases on how the VIPERNOZ PFM runs for assumed inside surface-breaking semi elliptical flaws in the RFW nozzle-to-vessel welds and RFW nozzle inside radius sections were analyzed for potential flaw growth from both stress corrosion and fatigue crack growth mechanisms. The VIPERNOZ modeling assesses growth from stress corrosion cracking (SCC) using the SCC growth basis in NRC NUREG/CR-6923. The modeling accounts for residual stresses that may have occurred in the structural welds during weld fabrication (NOTE: the NRC staff understands residual stresses do not need to be accounted for in the inside radius section analyses).

The VIPERNOZ modeling assesses thermal fatigue growth using the fatigue flaw growth methods that were approved in BWRVIP-108A and BWRVIP-241-A. The fatigue modeling assesses fatigue-induced crack growth in terms of 28 design transients (including OBE) that apply to the PNPP RFW nozzle configuration and are assumed to be the thermal loading basis for growing the cracks by fatigue over time. The transient analysis part of the VIPERNOZ FPM methodology then groups the assessed transients into "Bounding Group Event" transients (including OBE), where the number of assessed "grouped transients" is reduced down to 10 assessed transient types for the fatigue flaw growth portions of the VIPERNOZ PFM Monte Carlo method runs.

Request:

- (a) Confirm that for each reiterative VIPERNOZ PFM Monte Carlo method run performed by the PFM methodology (as described in Appendix A of SIA Computational Pack 2001178.302), the run calculates total flaw growth caused by the applicable stress path for the assessed RFW weld or inside radius section location by: (1) first assessing SCC growth in the component location, and (2) then adding in fatigue growth to the SCC growth to derive the total flaw growth value of the assessed component location.
- (b) Confirm that for each reiterative VIPERNOZ PFM Monte Carlo method run performed by the PFM methodology, the fatigue flaw growth portion of the run includes the following assessment aspects: (1) for fatigue flaw growth determination of grouped “Bounding Group Event” transients assessed in a given Monte Carlo flaw growth run, the run applies the stress intensity range (i.e., $\Delta K [K_{\max} - K_{\min}]$) for the specific transient in the group with the highest ΔK range and uses the summed, total number of projected 60-year cycles for all transients assessed in the group, and (2) the fatigue flaw growth portion then totals (sums) the fatigue flaw growth contributions from all ten (10) of the evaluated “Bounding Group Event” transients to derive the total fatigue flaw growth contribution to total flaw growth in the Monte Carlo run (i.e. before adding it to the SCC contribution for total flaw growth in the run).
- (c) Confirm that for each reiterative VIPERNOZ PFM Monte Carlo method run, flaw probability of detection (PoD) and RPV probability of failure (PoD, including PoD for portions of the RPV containing the RFW nozzle appurtenances) are checked in the runs after accounting for total SCC and fatigue induced crack growth for the run.

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From: Wall, Scott

Created By: Scott.Wall@nrc.gov

Recipients:
"Morgan, Jeffrey D." <jdmorgan@energyharbor.com>
Tracking Status: None
"Nevins, Kathleen J" <kjnevins@energyharbor.com>
Tracking Status: None
"Lashley, Phil H (EH)" <phlashley@energyharbor.com>
Tracking Status: None

Post Office: SA0PR09MB6058.namprd09.prod.outlook.com

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