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PERRY NUCLEAR POWER PLANT, UNIT NO. 1 – AUTHORIZATION AND SAFETY EVALUATION FOR ALTERNATIVE REQUEST IR-063 (EPID L-2022-LLR-0005)

LICENSEE INFORMATION

Recipient's Name and Address:	Mr. Rod L. Penfield Senior Vice President Energy Harbor Nuclear Corp. Perry Nuclear Power Plant P.O. Box 97, Mail Stop A-PY-A290 Perry, OH 44081-0097
Licensee:	Energy Harbor Nuclear Corporation (EHNC, the licensee)
Plant Name and Unit:	Perry Nuclear Power Plant, Unit No. 1 (PNPP)
Docket No.:	50-440

APPLICATION INFORMATION

Submittal Date: January 5, 2022

Submittal Agencywide Documents Access and Management System (ADAMS) Accession No.: ML22006A167

Supplement Date: July 14, 2022

Supplement ADAMS Accession No.: ML22195A202

Applicable Inservice Inspection (ISI) Program Interval and Interval Start/End Dates:

The proposed alternative would be applicable for the remainder of the fourth 10-year ISI interval that started on May 18, 2019, and ends on May 17, 2029 (recognizing that the existing 40-year license expires November 7, 2026).

Alternative Provision: The licensee requested an alternative for PNPP in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), paragraph 50.55a(z)(1), on the basis that the proposed alternative provides an acceptable level of quality and safety.

ISI Requirements: The regulation in 10 CFR 50.55a(g)(4) requires the licensee to implement the ISI requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Division 1, for those systems and components that are licensed in the current licensing basis as ASME Code Class 1, 2, and 3 components. This includes the requirements in the ASME Code, Section XI, subsection IWB, that apply to the ASME Code Class 1 reactor feedwater (RFW) nozzles that are welded to the reactor pressure vessel (RPV) of the plant design.

The provisions in the specified inspection items require the licensee to perform volumetric inspections of essentially 100 percent of the RPV pressure-retaining nozzle-to-vessel welds and nozzle inside radius sections (including those included in the RFW design configurations) once every 10-year ISI interval. The “essentially 100 percent” coverage basis for the specified non-destructive volumetric inspection method type is as defined in paragraph IWA-2200(c) of the ASME Code, Section XI.

Affected Components: The following Inspection Items in Table IWB-2500-1 of the ASME Code Section XI for Examination Category B-D, “Full Penetration Welded Nozzles in Vessels”:

- Inspection Item B3.90, Nozzle-to-Vessel Welds
- Inspection Item B3.100, Nozzle Inside Radius Section

The licensee identified that the affected components within the scope of IR-063 are the RFW nozzle-to-vessel shell welds and RFW nozzle inside radius sections that are included in the PNPP RPV design. The licensee indicates that there are six (6) RFW nozzle-to-vessel welds and six (6) associated RFW nozzle inside radius sections that are included in the PNPP RPV design, as indicated in Table 1 below:

Table 1

Component ID	Component Description	ASME Inspection Item No.
1B13-N4A-KA	Feedwater Nozzle N4A to Vessel	B3.90
1B13-N4A-IR	Feedwater Nozzle N4A Inner Radius	B3.100
1B13-N4B-KA	Feedwater Nozzle N4B to Vessel	B3.90
1B13-N4B-IR	Feedwater Nozzle N4B Inner Radius	B3.100
1B13-N4C-KA	Feedwater Nozzle N4C to Vessel	B3.90
1B13-N4C-IR	Feedwater Nozzle N4C Inner Radius	B3.100
1B13-N4D-KA	Feedwater Nozzle N4D to Vessel	B3.90
1B13-N4D-IR	Feedwater Nozzle N4D Inner Radius	B3.100
1B13-N4E-KA	Feedwater Nozzle N4E to Vessel	B3.90
1B13-N4E-IR	Feedwater Nozzle N4E Inner Radius	B3.100
1B13-N4F-KA	Feedwater Nozzle N4F to Vessel	B3.90
1B13-N4F-IR	Feedwater Nozzle N4F Inner Radius	B3.100

Applicable Code Edition and Addenda: 2013 Edition of the ASME Code, Section XI.

Brief Description and Rationale for the Proposed Alternative: The licensee applies ultrasonic testing (UT) methods as the test method for complying with the volumetric inspection requirement. The licensee requests to reduce the number of RFW nozzle-to-vessel welds and RFW inside radius sections subject to the ASME Code UT inspection requirements from 100 percent of the specified RFW component types to 25 percent of the specified RFW nozzle component types. The licensee indicated that the proposed ISI population reduction for the specified RFW component types in Alternative Request IR-063 is based on a probabilistic fracture mechanics (PFM) analysis. The licensee states that the PFM analysis demonstrates that the probability of failure (PoF) values for the specified RFW nozzle component types is less than the upper bound limiting PoF value of 5×10^{-6} per reactor year that is set in NUREG-1806, “Technical Basis for Revision of the Pressurized Thermal Shock (PTS) Screening Limit in the PTS Rule (10 CFR 50.61): Summary Report,” August 2007 (ML072830076 and ML072830081) for these types of proposed ISI alternatives. The licensee further states that its proposed alternative will provide an acceptable level of quality and safety pursuant to

10 CFR 50.55a(z)(1) for the RFW nozzle-to-vessel welds and associated RFW nozzle inside radius locations in lieu of performing UT of the 100 percent of the RPV FW nozzle-to-vessel welds and inside radius sections.

For additional details on the licensee's request, please refer to the documents located at the ADAMS Accession No(s). identified above.

STAFF EVALUATION

The U.S. Nuclear Regulatory Commission (NRC) staff evaluated alternative request IR-063 pursuant to 10 CFR 50.55a(z)(1). The licensee provided a technical bases to support applicability for the remainder of the fourth 10-year ISI interval that started on May 18, 2019, and ends on May 17, 2029 (recognizing that the existing 40-year license expires November 7, 2026).

<u>NRC Guidance for Application of PFM Software Technology for Boiling-Water Reactor (BWR) RPV Nozzle Components</u>

The NRC staff's basis for assessing use of Structural Integrity Associate's (SIA's) VIPERNOZ PFM technology for alternative probabilistic ISI applications of BWR RPV nozzle components is established in two NRC records:

1. NRC Regulatory Guide (RG) 1.245, Revision 0, "Preparing Probabilistic Fracture Mechanics Submittals," January 2022 (ML21334A158).

2. NUREG-1806

RG 1.245, Revision 0, establish the staff's position on how PFM software methodologies should be qualified for software quality assurance (SQA) and verification and validation (V&V) objectives. NUREG-1806 forms the staff's basis for setting an upper bound acceptance limit of 5×10^{-6}/reactor year for VIPERNOZ PFM software-calculated through-wall cracking frequency (TWCF) values of the referenced RFW nozzle component types.

<u>Scope of Review</u>

The NRC staff's review focused on the following:

(1) Confirmation that the submittal contains sufficient information to support a past precedent conclusion that the staff has previously approved SIA VIPERNOZ PFM technology and analysis results as a basis for authorizing similar ISI alternative applications for other licensed BWRs in the U.S.A,

(2) Confirmation that SIA VIPERNOZ technology satisfies applicable SQA and V&V qualification guidelines for RG 1.245, Revision 0, Category M-4 PFM software that is subject to QV-2 SQA guidelines.

(3) Confirmation that the design, analysis, and inspection accessibility considerations of RFW nozzles for PNPP in the submittal are the same as those that are included in design of Columbia Generating Station (CGS) RFW nozzles (ML20114E235), or that the risk-informed alternative basis, finite element modeling (FEM), or PFM analysis

bases for RFW nozzles at PNPP have appropriately accounted for differences in applicable design or assessment parameters from those assessed for the corresponding CGS RFW nozzle analysis case.

(4) Confirmation that the VIPERNOZ generated TWCF values in IR-063 support a staff conclusion that:

(a) all VIPERNOZ generated TWCF values for these components are bounded by the limiting TWCF acceptance criterion value of $5x10^{-6}$/reactor year in NUREG-1806,

(b) the number of RFW nozzle-to-vessel welds and nozzle inside radius sections requiring UT inspection during the fourth 10-year ISI interval can be reduced to a 25 percent population of the RFW component types, and

(c) that the proposed risk-informed ISI alternative in IR-063 can be authorized in accordance with the provision in 10 CFR 50.55a(z)(1) and provides an acceptable level of quality and safety in lieu of complying with the applicable ISI rules in ASME Section XI, Table IWB-2500-1, Examination Category B-D, Inspections Items B3.90 and B3.100.

The following subsections address these matters, as reviewed and evaluated by the staff.

PNPP Current Licensing Basis (CLB) for RFW Nozzle ISI Inspections and Scope of Components

The licensee uses the NRC-approved methodology in General Electric Company (GE) Report No. GE-NE-523-A71-0594-A, Revision 1, “Alternate BWR Feedwater Nozzle Inspection Requirements,” May 2000 (ML003723265), as (a) its basis for complying with the requirements in 10 CFR 50.55a(g)(4)and ASME Code Section XI, Table IWB-2500-1, Examination Category B-D, Inspection Items B3.90 and B3.100, and (b) for conforming with the augmented inspection criteria in NUREG-0619, Revision 1, “BWR Feedwater Nozzle and Control Rod Return Line Nozzle Cracking: Resolution of Generic Technical Activity A-10 (Technical Report),” November 1980 (ML031600712).

The NRC staff verified that the affected components are the six (6) RFW nozzle-to-vessel shell welds and six (6) RFW nozzle inside radius sections that are included in the PNPP RPV design. The staff also verified that these components are identified and defined as the applicable ASME Code Class 1 components that are within the ASME ISI requirements of ASME Section XI, Table IWB-2500-1, “Examination Category B-D, Full Penetration Welded Nozzles in Vessels,” Inspection Items B3.90 and B3.100.

Licensee’s Basis

The licensee identified that that it cannot apply the methodologies in Electric Power Research Institute (EPRI) Report No. 3002013092, “BWRVIP-108-A: BWR Vessel and Internals Project, Technical Basis for the Reduction of Inspection Requirements for the Boiling Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii,” October 2018 (ML19297F806), and EPRI Report No. 3002013093, “BWRVIP-241-A: BWR Vessel and Internals Project, Probabilistic Fracture Mechanics Evaluation for the Boiling Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii,” October 2018 (ML19297G738), as the basis for requesting a reduction in the population of RFW nozzle-to-vessel welds and inside radius locations (i.e., from 100 percent of components to 25 percent of the components) requiring UT inspections during the fourth 10-year ISI interval because:

(1) the referenced BWRVIP methodologies exclude the BWR RFW nozzle-to-vessel welds and BWR RFW nozzle inside radius locations from the scope of the BWR nozzle population-reduction methodology in ASME Section XI Code Case N-702, "Alternative Requirements for Boiling Water Reactor (BWR) Nozzle Inner Radius and Nozzle-to-Shell Welds," February 20, 2004;

(2) the referenced BWRVIP reports refer the augmented ISI inspection bases for the referenced BWR RFW nozzle components over to the augmented volumetric inspection criteria that are established in NRC NUREG-0619, Revision 1; and

(3) the methodology in NUREG-0619, Revision 1 calls for performance of augmented volumetric inspections (in this case, UT) of essentially 100 percent of the accessible RFW nozzle-to-vessel welds and RFW inside radius locations in the BWR units, as consistent with the applicable ASME Section XI ISI requirements for ASME Section XI Inspection Items B3.90 and B3.100.

Instead, the NRC staff observed that the licensee indicates augmented inspection criteria for RFW nozzle-to-vessel welds and RFW inside radius locations in NUREG-0619 have been subsumed by the current ASME Section XI ISI requirements for the components (including volumetric examination Performance Demonstration Initiative (PDI) requirements in 10 CFR 50.55a) and that the number of RFW nozzle-to-vessel welds and RFW inside radius locations requiring UT inspection can be reduced (i.e., from a 100 percent to 25 percent population of the accessible components) if a proposed ISI alternative is submitted for NRC approval in accordance with 10 CFR 50.55a(z)(1).

The NRC staff found the licensee's statements and bases in this regard to be accurate because they are consistent with the staff's basis for sunsetting NUREG-0619 augmented inspection criteria for RFW nozzles in NRC NUREG-2221, "Technical Bases for Changes in the Subsequent License Renewal Documents NUREG-2191 and NUREG-2192," December 2017 (ML17362A126), and for eliminating Generic Aging Lessons Learned [GALL] Aging Management Program [AMP] XI.M4, "BWR Feedwater Nozzles," in Tables 2-17 and 2-29 of NUREG-2191, Volumes 1 and 2, "Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report," July 2017 (ML17187A031 and ML17187A204).

Licensee's Methodology

The licensee's proposed alternative is based on the FEM analysis and risk-informed PFM analysis methods and results in SIA Calculation Nos. 2001178.301 and 2001178.302, included as Attachments 1 and 2 to the January 5, 2022, submittal. The FEM results for the RFW nozzle-to-vessel welds and nozzle inside radius sections in SIA Calculation 2001178.301 are used as stress inputs for the stress paths in the VIPERNOZ PFM calculations, with the overall PFM results being reported in SIA Calculation 2001178.302. The licensee's PFM methodology uses the VIPERNOZ PFM methodology that calculates a yearly through-wall cracking frequency (TWCF) value for each of the stress paths that apply to the reference RFW nozzle-to-vessel weld and inside radius section locations (i.e., stress paths P1 and P2 for analyzed RFW nozzle inside radius sections and stress paths P3 and P4 for analyzed FW nozzle-to-vessel welds). The licensee compares the TWCF values to the acceptance criterion of $5x10^{-6}$/reactor year in

NUREG-1806 for licensed, operating BWRs (like PNPP) that have yet to be approved under 10 CFR 54.29, "Standards for issuance of a renewed license," for first-time plant license extensions and currently operate under the licensed requirements and any conditional provisions of a first, original operating license for the BWR unit.

The licensee states that use of VIPERNOZ PFM technology for BWR RFW nozzle ISI population reduction request was previously approved and authorized as part of the staff's past review of an analogous ISI request for the population of RFW nozzle-to-vessel welds and nozzle inside radius sections requiring ISI UT examinations during the fourth 10-year ISI interval at CGS.

Confirmation of Past Precedent – Applicability of VIPERNOZ PFM Technology

The NRC staff confirmed that the staff has previously approved an analogous proposed alternative using VIPERNOZ PFM technology that authorized implementation of a reduced population (i.e., a minimum 25 percent population) of RFW nozzle-to-vessel welds and nozzle inside radius sections requiring ASME ISI UT examinations during the fourth 10-year ISI interval of the BWR reactor unit at CGS. The NRC staff determined that this precedent serves as an acceptable basis permitting VIPERNOZ PFM technology to serve as the risk-informed ISI basis for the proposed alterative in PNPP ISI Alternative IR-063.

Confirmation of Adequate PFM Software SQA and V&V Guidelines

The NRC staff determined that, if the VIPERNOZ PFM software technology in IR-063 was compared to the guidelines in RG 1.245, the PFM modeling in the VIPERNOZ software would satisfy the staff's position and guidelines for SQA and V&V considerations in RG 1.245 based on the following observations:

- The NRC staff determined that the VIPERNOZ PFM software would qualify as a Category M-4 PFM software code given that it uses a "*well-established model not previously part of an NRC-approved code*." In this regard, while the VIPERNOZ technology has yet to be formally submitted, reviewed, and approved by the NRC, the staff confirmed that it has been endorsed through reference in EPRI BWRVIP-108-A report and in the staff's December 19, 2007, safety evaluation (SE) for BWRVIP-108-A (ML073600374).

- The NRC staff determined that, if RG 1.245 guidelines were applied to IR-063, the VIPERNOZ PFM software would be held to RG 1.245 Category QV-2 SQA guideline, in that the software falls within the bounds of "*commercial off-the shelf software designed for the specific purpose of the application*." The staff determined that the industry appropriately achieved these objectives in the staff-approved BWRVIP-108-A report and through the staff's approval of VIPERNOZ PFM software technology for BWR RPV nozzle PFM applications in the NRC staff's SE of December 19, 2007. The staff also noted that the licensee demonstrated conformance with these criteria through its detailed discussions of the ANSYS FEM modeling and VIPERNOZ PFM software technology calculational capabilities in the SIA Calculation Nos. 2001178.301 and 2001178.302 attachments of ISI Alternative IR-063.

Thus, based on the observations given above, the NRC staff determined that it is acceptable to use the VIPERNOZ PFM software for the TWCF calculations.

Informational Gap Requiring Resolution – RFW Nozzle Population

In its July 14, 2022 (ML22195A202), supplement, the licensee explained that the alternative ISI population rounds the number of RFW nozzle-to-vessel welds and nozzle insider radius sections that will are required for UT inspection up to two of the designated RFW nozzle-to-vessel welds and two of the RFW nozzle inside radius sections. The licensee also explained that there are no individual RFW design considerations that would cause it to designate and select two of specific RFW nozzle-to-vessel welds as the designated RFW nozzle-to-vessel welds for ISI examinations during the fourth 10-year ISI interval at PNPP. Similarly, the licensee explained that there are no individual RFW design considerations that would cause it to designate and select two of specific RFW nozzle inside radius sections as the designated inside radius sections for ISI examinations during the fourth 10-year ISI interval for the unit. Under this basis, the licensee explained that the selection of the RFW nozzle-to-vessel welds and insider radius sections for inspection will be coordinated with the consistent RFW nozzle-to-safe end welds that will be subject to UT examination during the fourth 10-Year ISI interval for the unit. Given that the licensee has indicated there are no special design considerations that would call for licensee to select the nozzle-to-vessel weld and inside radius section of a given PPNP RFW nozzle locations over those associated with another RFW nozzle, the NRC staff finds the alternative ISI population basis to be acceptable because the licensee will have to inspect at least two of the six RFW nozzle-to-vessel welds and associated nozzle inside radius sections during the fourth 10-year ISI interval.

Design Accessibility Differences for RFW Nozzles at PNPP Versus CGS

During its review, the NRC staff determined that the design of the RFW nozzles at PNPP was analogous to the design of the RFW nozzles at CGS, with one noted difference in the degree of accessibility to the nozzles. Specifically, the licensee identified that UT inspections of the RFW nozzle-to-vessel welds and nozzle inside radius sections would be capable of achieving a component coverage of at least 82.7 percent of the weld and nozzle inside radius section volumes. This is less than the 99 percent volume coverage for the corresponding RFW nozzles specified in the NRC-approved alternative for CGS.

In its July 14, 2022, supplement, the licensee provided the following additional explanation on how VIPERNOZ accounts for inaccessible weld regions:

> The algorithm used by VIPERNOZ in the handling of inspected percentage of weld length/volume is by a random number to identify whether an individual crack is in the inspection percentage. If the random number is less than the inspection percentage (that is, within the inspection region), the crack is inspected. For each inservice inspection, a different random number is used for each crack to simulate that a different weld region could be inspected each time. If the random number is greater than the inspection percentage, no inspection is performed, and the crack continues to grow. If the random number is less than the inspection percentage resulting in inspection, the probability of detection (POD) curve is applied. If detected, a flaw is assumed to be repaired or properly dispositioned, and thus, cannot cause failure; if not detected, the flaw continues to grow, and thus, can lead to failure.

For the first, second, and third 10-year ISI intervals, the licensee stated that the minimum total inspection volume inspected is 82.7 percent of the weld volume. For the fourth 10-year ISI interval, the licensee explained that the minimum total inspection volume inspected would be 27.6 percent of the weld volume for all evaluated RFW nozzles (i.e., 82.7% x 2/6 nozzles = 27.6% total weld volume coverage). As such, for the fourth 10-year ISI interval, the staff noted that the VIPERNOZ Monte Carlo crack runs are based on a minimum of 27.6 percent weld volume criterion for inspection credit. Based on this information, the staff finds that the VIPERNOZ Monte Carlo-type flaw methodology appropriately accounts for weld inaccessibility because the method's modeling already postulates and appropriately accounts for the possibility of cracks occurring in inaccessible portions of the RFW nozzle-to-vessel welds or RFW nozzle insider radius sections.

In its July 14, 2022, supplement, the licensee stated that RFW nozzle-to safe end weld 1B13-N4C was subject to a WOL repair and that RFW nozzle-to safe end weld 1B13-N4E was subject to MSIP. The licensee also explained the stress loads from the WOL repair processes or MISP are not modeled as the stress analysis inputs to VIPERNOZ runs because: (1) the processes impart compressive stress to the RFW nozzle safe end locations, and (2) the RFW nozzle safe ends are significantly distant from the RFW nozzle-to-vessel weld and inside radius stress paths that are evaluated. The NRC staff finds these explanations to be acceptable because (1) compressive loads, if accounted for in the Monte Carlo runs, would actually lower the applied tensile loads used for crack growth runs of the RFW nozzle-to-vessel welds or nozzle inside radius section, and (2) any stress loads or moments that could potentially be imparted by WOLs or MISP applied to RFW safe end locations would be sufficiently dissipated from the need to include them in the stress paths evaluations of the RFW nozzle-to-vessel welds or nozzle inside radius section locations.

Resolution of VIPERNOZ Technology/Methodology Differences for PFM Methods Applied to PNPP RFW Nozzle Analysis Case Versus the CGS RFW Nozzle Analysis Case

For the previous and analogous ISI alternative for the referenced RFW nozzle component types (i.e., nozzle-to-vessel welds and nozzle insider radius sections) at CGS, a full description of VIPERNOZ PFM methods and technology capabilities is discussed and evaluated in the NRC staff's SE of April 14, 2021 (ML21096A048). A more general discussion of VIPERNOZ PFM software technology (applied as a generic methodology for RPV nozzle-to-vessel welds and inside radius sections) is discussed and evaluated in the NRC staff's December 19, 2007, SE for BWRVIP-108-A. The NRC staff confirmed that the use of VIPERNOZ PFM technology for the PNPP RFW nozzle component types was identical to at the CGS application, with the exception of the design or assessment matters for the version of VIPERNOZ being applied in IR-063.

In its July 14, 2022, supplement, the licensee stated that a semi-elliptical axial flaw was used as the assessed flaw type for stress Path P3 that was applied to the RFW nozzle-to-vessel weld assessments and that a semi-elliptical circumferential flaw was used as the assessed flaw type for stress Path P4 that was applied to the RFW nozzle-to-vessel weld assessments. Additionally, the licensee addressed the similarities and differences for stress paths P1 and P2 that apply to the RFW nozzle inside radius sections and stress paths P3 and P4 that apply to the RFW nozzle-to-vessel welds by providing graphical plots of "Crack Driving Stress (ksi)" versus "Normalized Path Length (inch/inch)" across the component wall thickness for the assessed normal operation pressurization, nozzle moment load and three most severe thermal load transients.

The licensee stated that the nozzle inside radius sections are not clad, so cladding stresses were not applied to paths P1 and P2. The licensee also stated that the RFW nozzle-to-vessel weld components are clad, so cladding stresses were applied to paths P3 and P4. The licensee also explained that stresses for stress paths P1 and P3 are similar in that they both were generated in the hoop direction relative to the nozzle axis and perpendicular to the cutting planes of the FEM modeling. The figures provided in the July 14, 2022, letter show the similarities and differences for loads applying to the stress paths under the limiting normal operation pressurization, moment, and design thermal transient loadings. Based on the figures provided by the licensee, the NRC staff observed that the differences in stress loads for the analyzed stress paths (i.e., paths P1 versus P2 and paths P3 versus P4) result mainly from the differences in the normal operating pressure load for the semi-elliptical flaw type assumed in the assessment.

In its July 14, 2022, supplement, the licensee explained that the corresponding PFM analysis of the RFW nozzle-to-vessel welds at CGS included two additional stress path analyses (i.e., six stress paths in total) due to high stresses for the RFW nozzle bodies at CGS resulting from the limiting design basis thermal transient assessment. For the PNPP assessment, the licensee explained that it selected the most critical of these stress paths as the selected limiting stress paths (i.e., stress paths P3 and P4) for the VIPERNOZ PFM analyses of RFW nozzle-to-vessel weld assessments at PNPP. The licensee also explained that the nozzle body is not considered as a limiting locations as it is bounded by the stress paths for the RFW nozzle inside radius sections (i.e., stress paths P1 and P2) as a result of the high pressure stress. The NRC staff noted that the basis for the analyzed stress paths is consistent with the stress analysis basis for RPV nozzle welds and nozzle inside radius sections in the ASME Code Case N-702, “Alternative Requirements for Boiling Water Reactor Nozzle Inner Radius and Nozzle-to-Shell Welds Section XI, Division 1.” The NRC staff finds that use of two stress paths for each of the RFW nozzle component types to be acceptable because the basis is consistent with approved and referenced ASME Section XI code case criteria.

In its July 14, 2022, supplement, the licensee explained that neutron attenuation considerations did not need to be included in the VIPERNOZ flaw growth assessments for the RFW nozzle inside radius sections and nozzle-to-vessel welds because the projected neutron fluence exposures of the components are lower than 1.00×10^{17} neutrons per square centimeter (n/cm^2) at 54 effective full power years (EFPY). Specifically, the licensee explained that the N4 type RFW nozzles are located above the corresponding RPV N6 nozzles, which have a projected 54 EPFY fluence exposure of 8.1×10^{16} n/cm^2 at 54 EFPY. To support this projection, the licensee provided a limiting initial adjusted reference temperature (RT_{NDT}) value for the RFW nozzle inside radius sections and nozzle-to-vessel welds of -20 degrees Fahrenheit (°F) with standard deviation (σ_I) on initial RT_{NDT} value of 26.48 °F for the RFW nozzle inside radius sections and of 13 ºF for the RFW nozzle-to-vessel welds.

Using figure A-4200-1 in ASME Code, Section XI, Appendix A, a normal operating temperature of 552 °F, and the initial RT_{NDT} and σ_I values, the NRC staff confirmed that the use of a K_{IC} value of 200 ksi√inch for the VIPERNOZ flaw growth analyses is acceptable.

In its July 14, 2022, supplement, the licensee explained that the following two separate loading combinations were used independently to account for the 80 cycles of the OBE event and 260 cycles for the limiting reactor startup transient:

- The 80 cycles of the OBE event were conservatively assumed to occur during the “Startup” transient (as opposed to assuming the OBE cycles to occur during steady-state operations); thus, the stress intensity factor range (ΔK) load combination for the OBE event basis includes the OBE piping loads and the maximum stress from the

"Startup" transient applied to both maximum stress intensity factor value (K_{max}) and minimum stress intensity factor value (K_{min}) levels.

- In addition to the assessment of the OBE event with included "Startup" stresses, a separate load combination was applied to the maximum and minimum stresses of the assessed "Startup" transient to account for 260 startup cycles (i.e., the 80 cycles of Startup included with OBE loads are over and above those for the actual projected Startup cycles).

Additionally, the licensee provided its full list of K_{max} and K_{min} loading combinations (i.e., ΔK combinations) for the assessed "Startup" and OBE event transients. The NRC staff found the added OBE and "Startup" stress analysis explanations to be acceptable because the information provides sufficient confirmation that the licensee is conservatively including "Startup" load contributions as part of the stress loads in the OBE transient stress assessment and conservatively including OBE load contributions as part of the stress loads in the "Startup" transient stress assessment.

In its July 14, 2022, supplement regarding the PFM modeling that is applied by the VIPERNOZ software technology, the licensee confirmed that:

- crack growth is performed for the assessed load path (P1, P2, P3, or P4, as applicable) on a yearly basis, with SCC-induced growth determined first followed by the determination for fatigue-induced crack growth

- for each bounding transient event (including the OBE event) listed in table 1 of SIA Calculation Package No. 2001178.302 (as included in IR-063), the stress intensity factor range (ΔK) is calculated for each event, and, based on the ΔK value, the amount of fatigue crack growth for the event is then calculated using the number of cycles projected for the event type in Table 1 of the referenced SIA package,

- total fatigue crack growth is established based on summation of the fatigue crack growth contribution from each transient assessment.

- the probability of detection (PoD) and PoF (including PoF for portions of the RPV containing the RFW nozzle appurtenances) are checked after the combined crack growth contribution from SCC and fatigue contributions is established.

Based on these confirmatory clarifications, the NRC staff determined that the licensee described how the VIPERNOZ technology is applied as a qualified PFM model for the referenced RFW nozzle inside radius sections and nozzle-to-vessel weld assessments. Given the staff's confirmation of VIPERNOZ as a M-4 type PFM model that meets QV-2 SQA and VV quality assurance position guidance in RG 1.245, the NRC staff finds application of VIPERNOZ as the PFM modeling basis to be acceptable.

<u>Assessment of VIPERNOZ Analysis PFM Probability of Failure Results and Determination of Acceptability</u>

The NRC staff noted that the VIPERNOZ technology as a qualified PFM model for the referenced RFW nozzle inside radius sections and nozzle-to-vessel weld is limited by the PoF assessment of the RFW nozzle inside radius sections both for loadings caused by normal operations of the unit and loading conditions during a postulated low temperature overpressure (LTOP) transient for the unit under loading Path P1. The staff confirmed that the licensee assessed the PoF results against an NRC-approved acceptance criterion of $5x10^{-6}$ per reactor year, as established in NUREG-1806 for operating reactor units that have not had their license renewed.

The NRC staff noted that, for this limiting RFW nozzle inside radius section PoF basis under Path P1 loading conditions, the VIPERNOZ PFM modeling generated a PoF value of $8.33x10^{-8}$ per reactor year for the inside radius sections under the loads for normal operating conditions and a PoF value of $8.67x10^{-10}$ per reactor year under the loads for the postulated limiting LTOP transient event; the PoF value $8.67x10^{-10}$ per reactor year for the evaluated LTOP event accounts for a $1x10^{-3}$ per reactor year probability of occurrence for the postulated LTOP event.

The NRC staff noted that the licensee's PoF analyses for the RFW nozzle inside radius sections under the normal operating conditions for path P2 assessment or for the RFW nozzle-to-vessel welds under the normal operating conditions for path P3 and P4 assessments did not generate any component failures during the 1 million VIPERNOZ Monte Carlo simulations that were performed as part of the PFM analysis. Thus, the staff confirmed that the licensee used a conservative value of 1.67 $x10^{-8}$ per reactor year for the normal operating condition PoF approximations of the RFW nozzle inside radius sections under load Path P2 and the RFW nozzle-to-vessel welds under load paths P3 and P4 by assuming that at least one component failure had resulted during the 1 million Monte Carlo type PFM simulations that were performed for the components.[1] Similarly, the staff confirmed that the licensee used a conservative value of $1.67x10^{-11}$ per reactor year for the limiting LTOP event PoF approximations of the RFW nozzle inside radius sections under load Path P2 and the RFW nozzle-to-vessel welds under load paths P3 and P4 by assuming that at least one component failure had resulted during the 1 million Monte Carlo type PFM simulations that were performed for the components.[2]

The regulations of 10 CFR 50.55a(z)(1) allows the NRC to authorize a proposed ISI alternative in lieu of the applicable ASME Code, Section XI, requirements if the alternative provides an acceptable level of quality and safety. Based on this review, the NRC staff has confirmed that the licensee's PoF calculations and results for the referenced RFW nozzle component types demonstrate that the PoF values of the components will be less than 8.33 x 10^{-8} per reactor year for the evaluated loading paths and transient events. Thus, the NRC staff determined that the PoF calculations for the referenced RFW nozzle component types support approval of the proposed alternative IR-063 because the PoF results are well below the NUREG-1806 PoF acceptance criterion of $5x10^{-6}$ per reactor year for reactor units without first operating license extensions and PoF acceptance criterion of $1x10^{-6}$ per reactor year for reactor units that been approved by the Commission for license extension and have received renewed operating licenses of the facilities. As such, based on the criteria in NUREG-1806 and the guidelines of RG 1.245, the NRC staff determined that the probabilistic PoF results provide an acceptable level of quality and safety for the proposed 25 percent population of RFW nozzle inside radius sections and nozzle-to-vessel welds that will be required to be volumetrically inspected during the fourth 10-year ISI interval for the reactor unit.

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1 $1.67x10^{-8}$ = 1 component failure / 100 Monte Carlo-type PFM simulations / 60 years of postulated licensed operations.

2 $1.67x10^{-11}$ = 1 component failure * $1x10^{-3}$ per reactor year probability of occurrence for the limiting LTOP event / 100 Monte Carlo-type PFM simulations / 60 years of postulated licensed operations.

CONCLUSION

As set forth above, the NRC staff has determined that the proposed alternative in the licensee's application, as supplemented, would provide an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed the regulatory requirements in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the use of proposed alternative IR-063 at PNPP for the remainder of the current fourth 10-year ISI interval that started on May 18, 2019, and ends on May 17, 2029 (recognizing that the existing 40-year license expires November 7, 2026).

All other ASME BPV Code, Section XI, requirements for which an alternative was not specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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Date: September 30, 2022

Joel S. Wiebe

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Nancy L. Salgado, Chief
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

cc: Listserv

SUBJECT: PERRY NUCLEAR POWER PLANT, UNIT NO. 1 – AUTHORIZATION AND SAFETY EVALUATION FOR ALTERNATIVE REQUEST IR-063 (EPID L-2022-LLR-0005) DATED SEPTEMBER 30, 2022

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