UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 4, 2014

Vice President, Operations
Entergy Nuclear Operations, Inc.
Palisades Nuclear Plant
27780 Blue Star Memorial Highway
Covert, MI 49043-9530

SUBJECT: PALISADES NUCLEAR PLANT – PROPOSED ALTERNATIVE, USE OF ALTERNATE ASME CODE CASE N-770-1 BASELINE EXAMINATION (TAC NO. MF3508)

Dear Sir or Madam:

By letter dated February 25, 2014 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML14056A533), as supplemented by letters dated March 1, 4, 6, 9, and 11, 2014 (ADAMS Accession Nos. ML14072A361, ML14063A089, ML14070A182, ML14066A409, ML14069A004, and ML14070A477, respectively), Entergy Nuclear Operations, Inc. (ENO, the licensee) requested relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Code Case N-770-1, as conditioned by Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(g)(6)(ii)(F) at Palisades Nuclear Plant (PNP). The licensee proposed an alternate inspection for nine branch connection dissimilar metal welds in the primary coolant loop piping as documented in relief request (RR) 4-18.

Specifically, pursuant to 10 CFR 50.55a(a)(3)(ii), the licensee requested relief from the requirements of 10 CFR 50.55a(g)(6)(ii)(F) to perform baseline volumetric inspections of the nine subject welds on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The NRC staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that ENO has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(a)(3)(ii). Therefore, during a conference call on March 12, 2014 (ADAMS Accession No. ML14073A274), the NRC staff verbally authorized the use of RR 4-18 at PNP until the next scheduled refueling outage in the fall of 2015.

All other ASME Code, Section XI requirements for which relief was not specifically requested and authorized in the subject proposed alternative remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the Project Manager Jennie Rankin at (301) 415-1530 or at Jennivine.Rankin@nrc.gov.

Sincerely,

David L. Pelton, Chief
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-255

Enclosure:
Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST RR 4-18

ALTERNATE INSPECTION OF PRIMARY COOLANT LOOP BRANCH CONNECTION

DISSIMILAR METAL WELDS

PALISADES NUCLEAR PLANT

ENTERGY NUCLEAR OPERATIONS, INC.

DOCKET NO. 50-255

1.0 INTRODUCTION

By letter dated February 25, 2014 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML14056A533), as supplemented by letters dated March 1, 4, 6, 9 and 11, 2014 (ADAMS Accession Nos. ML14072A361, ML14063A089, ML14070A182, ML14066A409, ML14069A004, and ML14070A477, respectively), Entergy Nuclear Operations, Inc. (ENO, the licensee) requested relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Code Case N-770-1, as conditioned by Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(g)(6)(ii)(F) at Palisades Nuclear Plant (PNP). The licensee proposed an alternate inspection for nine branch connection dissimilar metal welds in the primary coolant loop piping as documented in relief request (RR) 4-18.

Specifically, pursuant to 10 CFR 50.55a(a)(3)(ii), the licensee requested relief from the requirements of 10 CFR 50.55a(g)(6)(ii)(F) to perform baseline volumetric inspections of the nine subject welds on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The request was to support the restart of PNP in March 2014. Therefore, during a conference call on March 12, 2014 (ADAMS Accession No. ML14073A274), the U.S. Nuclear Regulatory Commission (NRC) staff verbally authorized the use of Relief Request RR 4-18 at PNP until the next scheduled refueling outage in the fall of 2015 (1R24). This safety evaluation documents the NRC staff's detailed technical basis for the verbal authorization.

2.0 REGULATORY EVALUATION

The inservice inspection (ISI) of ASME Code Class 1, 2 and 3 components is to be performed in accordance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Code and applicable editions and addenda as required by 10 CFR

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50.55a(g), except where specific written relief has been granted by the Commission.

10 CFR 50.55a(g)(6)(ii) states that the Commission may require the licensee to follow an augmented ISI program for systems and components for which the Commission deems that added assurance of structural reliability is necessary. 10 CFR 50.55a(g)(6)(ii)(F) requires, in part, augmented inservice volumetric inspection of ASME Code Class 1 piping and nozzle dissimilar metal butt welds of pressurized water reactors in accordance with ASME Code Case N-770-1, subject to the conditions specified in paragraphs (2) through (10) of 10 CFR 50.55a(g)(6)(ii)(F).

Alternatives to requirements under 10 CFR 50.55a(g) may be authorized by the NRC pursuant to 10 CFR 50.55a(a)(3)(i) or 10 CFR 50.55a(a)(3)(ii). In proposing alternatives or requests for relief, the licensee must demonstrate that: (1) the proposed alternatives would provide an acceptable level of quality and safety; or (2) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

In RR 4-18, the licensee requests authorization of an alternative to the requirements of 10 CFR 50.55a(g)(6)(ii)(F) pursuant to 10 CFR 50.55a(a)(3)(ii). Based on analysis of the regulatory requirements, the NRC staff finds that regulatory authority exists to authorize the licensee's proposed alternative on the basis that compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Accordingly, the staff has reviewed and evaluated the licensee's request pursuant to 10 CFR 50.55a(a)(3)(ii).

3.0 TECHNICAL EVALUATION

3.1 Relief Request RR 4-18

The licensee requested relief from volumetric examinations on nine pressure retaining dissimilar metal nozzle-to-piping butt welds containing Alloy 600 nozzles and Alloy 82/182 weld material. Each of the nozzles formed a branch connection with the low alloy steel primary coolant loop piping. Specifically, the affected components are:

1) Three cold leg drain nozzles, 2 inch diameter (Weld IDs: PCS-30-RCL-1A-5/2, PCS-30-RCL-1B-5/2, PCS-30-RCL-2A-5/2)
2) One cold leg drain and letdown nozzle, 2 inch diameter (Weld ID: PCS-30-RCL-2B-5/2)
3) Two cold leg charging nozzles, 2 inch diameter (Weld IDs: PCS-30-RCL-1A-11/2, PCS-30-RCL-2A-11/2)
4) Two cold leg pressurizer spray nozzles, 3 inch diameter (Weld IDs: PCS-30-RCL-1B-10/3, PCS-30-RCL-2A-11/3)
5) One hot leg drain nozzle, 2 inch diameter (Weld ID: PCS-42-RCL-1H-3/2)

The code of record is the ASME Code, Section XI, 2001 Edition through the 2003 Addenda as amended by 10 CFR 50.55a. 10 CFR 50.55a(g)(6)(ii)(F)(1) requires that licensees implement Code Case N-770-1 subject to the conditions specified in items (2) through (10) of paragraph

(g)(6)(ii)(F), by the first refueling outage after August 22, 2011. Regulation 10 CFR 50.55a(g)(6)(ii)(F)(3) states that baseline examinations for welds in Code Case N-770-1, Table 1, Inspection items A-1, A-2, and B, shall be completed by the end of the next refueling outage after January 20, 2012. The subject welds are classified as Inspection Items A-2 and B for which visual and essentially 100 percent (%) volumetric examination, as amended by 10 CFR 50.55a(g)(6)(ii)(F)(4), are required. The licensee is requesting relief from 10 CFR 50.55a(g)(6)(ii)(F), items (1) and (3), for performance of the required baseline volumetric examinations of the nine subject welds.

There are currently no Performance Demonstration Initiative demonstrated volumetric techniques for the subject weld joint configurations. The licensee previously concluded that Code Case N-770-1 applied only to circumferential butt welds and that these branch connection butt welds were exempt; therefore, they did not follow the ASME Code Section XI Appendix VIII guidance for developing and qualifying volumetric inspection procedures, equipment, and personnel for these welds. The licensee estimates that a minimum of approximately 18 months is required to qualify procedures and personnel to reliably perform qualified examinations of the subject welds. The licensee was in refueling outage 1R23 when this request for relief was submitted.

The licensee stated by letter dated February 25, 2014, that attempting "best-effort" phased array ultrasonic examinations would not produce reliable results without a demonstrated and qualified procedure. Although qualified procedures exist for the weld thickness and diameter, the licensee believes the component geometry would negatively impact sound path calibration, search unit focusing, inside diameter impingement angles, and would cause misorientation angles. The licensee believes the component geometry would challenge their capability to correctly characterize and size indications identified during the examinations and could lead to false positive indications as well as increased radiation exposure to examination personnel. Furthermore, the licensee does not have a design mitigation strategy approved for this weld configuration, and creating one would require time for development of tooling, qualification of procedures and personnel, and mockup verification.

As an alternative to completing the required volumetric examinations of the subject welds during the current 1R23 refueling outage, the licensee proposed the following in letter dated March 11, 2014:

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-2500-1) 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 [Primary Coolant System] leakage increases by 0.15 gpm above the WCAP-16465NP baseline mean, and is sustained for 72 hours, ENO will 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.

The licensee performed a structural evaluation of the weld which connects the hot leg to the drain nozzle. The evaluation included finite element analysis of the welding process to estimate residual stresses in the component, as well as a flaw growth analysis of postulated circumferential and axial flaws.

The finite element model, developed using ANSYS software, was three dimensional and encompassed 90° of the nozzle circumference. Generally, the weld and nozzle radial stress on the inside diameter (ID) was in the range of 0 to 17 ksi (tensile), with a region of slightly compressive stress through about half the thickness, transitioning back to tensile stress at the outer surface of the pipe/weld, with peak radial tensile stress around 40 ksi. The circumferential stress on the ID was between approximately 13 and 20 ksi (tensile), and remained tensile through the thickness of the weld, peaking to about 45 ksi near the outer diameter.

The licensee then performed a flaw growth evaluation to assess the consequences of hypothetical primary water stress corrosion cracking (PWSCC). The licensee estimated from their analysis that it would take 60 effective full power years for a circumferential flaw to grow 75% through-wall. From the original axial flaw analysis, the licensee estimated that it would take more than 34 effective full power years for an axial flaw to grow 75% through-wall. The modified axial flaw analysis, assuming a 50% weld repair, predicted over 33 years for the proposed axial flaw to reach 93.125% through-wall. The relatively small reduction in time for the flaw to reach a greater depth in the material can be attributed to the reduced crack growth rate at the lower temperature of 583°F, and the smaller initial crack depth used in the analysis.

Finally, the licensee noted the expected lower probability of PWSCC initiation as a result of the nickel alloy material being exposed to the post weld heat treatment that was applied to the adjacent carbon steel piping during initial fabrication. Additionally, the post weld heat treatment relieved some of the residual stresses in the weld and surrounding material, and that was reflected in the finite element analysis.

3.2 NRC Staff Evaluation

The NRC staff notes that the generic rules for the frequency of volumetric examination of dissimilar metal butt welds were established to provide reasonable assurance of the structural integrity of the reactor coolant pressure boundary. As such, the NRC staff finds that plant specific analysis could be used to provide a basis for inspection relief if the inspection requirement presents a significant hardship. As such, the staff reviewed the licensee's proposed alternative under the requirements of 10 CFR 50.55a(a)(3)(ii), including the licensee's basis for hardship.

The staff found that without a readily available qualified volumetric inspection technique for these nine subject welds, no currently available inspection would provide reasonable assurance of flaw detection and characterization. Further, the radiological dose for performing any unplanned best-effort volumetric examinations of the nine subject welds would be a hardship in relation to the questionable value of these examinations. A delay in the inspection requirement for one operating cycle would allow for the development of tooling, qualification of procedures and personnel, and mockup verification to minimize radiation dose to personnel. Therefore, the NRC staff concludes the licensee has provided sufficient information to identify the hardship.

In order to review the licensee's technical basis for relief, the NRC staff performed a flaw analysis of the limiting weld configuration. There are two significant components of a flaw analysis: weld residuals stress calculation and flaw growth calculations, both of which include some uncertainties. The effect of these uncertainties is limited in some cases by choosing conservative inputs into the calculations. Typically, these inputs cause variability in analysis results without necessarily invalidating any particular result.

The NRC staff performed independent finite element analysis of weld residual stress and crack growth calculations in order to assess the structural integrity and leak tightness of the subject nozzles. The staff used a two dimensional, axisymmetric finite element model of the same hot leg nozzle and weld geometry modeled by the licensee. Two dimensional, axisymmetric models are often used to evaluate residual stresses in piping and nozzle welds, and they have been used in NRC/Industry validation programs. NUREG-2162, "Weld Residual Stress Finite Element analysis Validation: Part 1 – Data Development Effort" (ADAMS Accession No. ML14087A118) describes weld residual stress measurement methods and finite element modeling techniques for predicting weld residual stress. An isotropic material hardening law was applied. Because the model was not three dimensional, it used a flat plate to simulate the carbon steel hot leg pipe to which the nozzle was welded. Given the large 42-inch inside diameter of the hot leg and the relatively small portion of the carbon steel pipe that was modeled, this approximation is acceptable for estimating residual stresses in the nozzle weld. Both the NRC analysis and the licensee's analysis use a static heat source, which involves heating an entire weld pass at once. The NRC analysis does not model the welding of the stainless steel cladding to the hot leg, while the licensee's model only approximates application of the clad layer as a single layer fully deposited in one pass. Because the clad application would primarily affect the hot leg and not the Alloy 600 or weld materials of interest, both the NRC's and the licensee's methods are acceptable. The NRC staff's model and that of the licensee are comparable in technique, differing only slightly in three dimensional geometric effects.

NRC staff analyzed axial and hoop stresses for the base configuration, along with an additional model which includes an assumed 50% weld repair. An inner diameter weld repair is often assumed in residual stress analyses of piping butt welds since it can produce an undesirable tensile stress on the inner surface of the weld. The licensee had no record of repairs of the subject welds, but noted by letter dated March 6, 2014, that during fabrication, if dye penetrant testing or radiographic examinations revealed indications, any detected defects would have been removed and weld repaired. The 50% weld repair assumed in the NRC model was made prior to the post-weld heat treatment, according to the sequence that would have been practiced during fabrication. The licensee did not model a weld repair because they stated that the inner diameter patch weld, performed after the main butt weld and removal of the backing ring, would

induce stresses similar to an inner diameter repair. Following further discussion, the licensee revised their axial crack model to reflect the increased tensile hoop stresses observed in the NRC staff's model as a result of the weld repair.

The NRC staff's model without weld repair produced similar hoop stresses as those obtained by the licensee. A notable difference in the analysis is the NRC staff evaluated the through-wall stresses along a path through the weld where there were maximum stresses. The licensee evaluated hoop stress along the nozzle-to-weld interface, which was not always the area of maximum stress. The staff's analysis showed inner diameter hoop stress was actually slightly lower than the licensee's predictions, but hoop stresses were approximately 10 ksi higher than the licensee's predictions through the remaining thickness of the weld. The NRC staff found that the post weld heat treatment reduced stresses in the weld, but because it was conducted at temperatures designed for the carbon steel loop piping, it was not fully effective in reducing stresses to a level at or below the nickel alloy's yield strength. Therefore, the post weld heat treatment would not be sufficient alone to prevent initiation of cracking in the alloy 600 base material and alloy 182/82 weld materials.

Radial stresses were found to be very low or compressive through about the first half of the thickness of the weld, producing similar trends as shown by the licensee. It was determined that the licensee's circumferential flaw growth and stability calculations provided reasonable assurance of structural integrity and leak tightness of the welds in regard to a hypothetical circumferential flaw during the period of requested relief.

The NRC staff performed confirmatory crack growth calculations for a hypothetical axial flaw. The two-dimensional model and its associated stresses were revolved to a three-dimensional model, and the Finite Element Alternating Method was applied to calculate stress intensity factors for assumed semi-elliptical flaws placed in the component. The NRC's analysis predicted the postulated time to leakage in the range of 9 to 35 effective full power years, depending on where K (crack driving force) was extracted along the crack front.

Since no volumetric inspection had been performed of these welds since initial plant startup, the potential existed for a flaw to have initiated and grown undetected during that time period. While NRC staff determined there was reasonable assurance of structural integrity of the welded joints, the staff could not rule out the potential for leakage over the next fuel cycle from an axial flaw. Therefore, more stringent leakage monitoring, as outlined in the licensee's alternative, remains necessary until volumetric examinations can be completed during the next refueling outage in the fall of 2015. The licensee's final proposed alternative, described in letter dated March 11, 2014, is as follows:

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-2500-1) 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 [Primary Coolant System] leakage increases by 0.15 gpm above the WCAP-16465NP baseline mean, and is sustained for 72 hours, the licensee will 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.

Given the licensee's identified hardship, flaw and structural evaluation, and conditions of relief identified in the proposed alternative, the NRC staff concludes the licensee has provided sufficient information to demonstrate reasonable assurance of the structural integrity of the nine subject welds for one cycle of operation without performing a volumetric examination. Further, if leakage should occur from the weld locations, the licensee's actions will ensure that the leakage will be promptly identified, and as such, the NRC staff concludes the effects of any such leakage would be minimal on other plant components.

4.0 CONCLUSION

Based on information submitted, the NRC staff determines that the licensee provided sufficient technical basis to demonstrate that compliance with the requirements of 10 CFR 50.55a(g)(6)(ii)(F) would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(a)(3)(ii). Additionally, the licensee has provided sufficient information to demonstrate reasonable assurance of the structural integrity of the nine subject welds for one cycle of operation without performing a volumetric examination. Further, while leakage may occur, the licensee's actions as outlined in the proposed alternative of this relief request will ensure that the leakage will be promptly identified, and as such, the staff concludes the effects of any such leakage would be minimal on other plant components. Therefore, the NRC staff authorizes the licensee's proposed alternative, Relief Request RR 4-18, as supplemented by letters dated March 1, 4, 6, 9, and 11, 2014, at PNP, until the next scheduled refueling outage in the fall of 2015 (1R24).

All other requirements of ASME Code, Section XI, for which relief was not specifically requested and authorized by the NRC staff remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: Jay Collins

Date: September 4, 2014

If you have any questions, please contact the Project Manager Jennie Rankin at (301) 415-1530 or at Jennivine.Rankin@nrc.gov.

Sincerely,

/RA/

David L. Pelton, Chief
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-255

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