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

October 14, 2015

Mr. Mano Nazar
President and Chief Nuclear Officer
Nuclear Division
NextEra Energy
P.O. Box 14000
Juno Beach, FL 33408-0420

SUBJECT: TURKEY POINT NUCLEAR GENERATING UNIT NO. 3 – SAFETY EVALUATION FOR RELIEF REQUEST NO. 1, REVISION 1 FOR FIFTH 10-YEAR INSERVICE INSPECTION INTERVAL – REPAIR OF PRESSURIZER STAINLESS STEEL HEATER SLEEVE WITHOUT FLAW REMOVAL (CAC NO. MF5798)

Dear Mr. Nazar:

By letter dated March 2, 2015, as supplemented by letter dated September 15, 2015, Florida Power & Light Company (the licensee) submitted Relief Request No. 1, Revision 1 for the fifth 10-year inservice inspection (ISI) interval of Turkey Point Nuclear Generating Unit No. 3 (Turkey Point 3). Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 55a(a)(z)(2) (formerly 10 CFR 50.55a(a)(3)(ii)), the licensee requested the U.S. Nuclear Regulatory Commission (NRC) to authorize an alternative to the requirements of the American Society of Mechanical Engineers (ASME) Code, Section XI, 2007 Edition with Addenda through 2008, subparagraph IWB-3142.3, "Acceptance by Corrective Measures or Repair/Replacement Activity," because compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The NRC staff reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that the licensee adequately addressed all regulatory requirements in 10 CFR 50.55a(a)(z)(2). Accordingly, the NRC staff authorizes Relief Request No. 1, Revision 1 at Turkey Point 3 for the remainder of the fifth 10-year ISI interval, which is currently scheduled to end on February 21, 2024.

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

If you have any questions regarding this issue, please contact the project manager, Ms. Audrey Klett, at (301) 415-0489 or by e-mail at Audrey.Klett@nrc.gov.

Sincerely,

Shana R. Helton

Shana R. Helton, Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-250

Enclosure:
Safety Evaluation

cc w/encl.: Distribution via Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST NO. 1, REVISION 1

FOR THE FIFTH 10-YEAR INSERVICE INSPECTION INTERVAL

FLORIDA POWER & LIGHT COMPANY

TURKEY POINT NUCLEAR GENERATING UNIT NO. 3

DOCKET NO. 50-250

1.0 INTRODUCTION

By letter dated March 2, 2015,[1] as supplemented by letter September 15, 2015,[2] Florida Power & Light Company (the licensee) submitted Relief Request No. 1, Revision 1 for the fifth 10-year inservice inspection (ISI) interval of Turkey Point Nuclear Generating Unit No. 3 (Turkey Point 3). Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 55a(z)(2) (formerly 10 CFR 50.55a(a)(3)(ii)), the licensee requested the U.S. Nuclear Regulatory Commission (NRC) to authorize an alternative to the requirements of the American Society of Mechanical Engineers (ASME) Code, Section XI, 2007 Edition with Addenda through 2008, subparagraph IWB-3142.3, "Acceptance by Corrective Measures or Repair/Replacement Activity," [3] because compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

During the Turkey Point 3 refueling outage that began in March 2014, the licensee observed evidence of leakage in the annulus between the outer surface of one heater sleeve and the pressurizer bottom head bore at Heater Penetration No. 11. By letters dated April 4, April 9, and April 14, 2014,[4] the licensee submitted Relief Request No. 1 and responses to NRC's requests for additional information (RAIs) to support the repair of the Turkey Point 3 stainless steel pressurizer nozzle and leaving the flaw in the abandoned pressure boundary weld. Because of the emergent nature of the discovery and repair, the duration of the relief request

[1] Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML15077A213.
[2] ADAMS Accession No. ML15264A004.
[3] As defined in the Preface to the ASME Code, Section XI, under "Organization of Section XI," all references beginning with IWA- or IWB- are to parts of the ASME Code, Section XI. Numbers ending in units of 1000 refer to "Articles," units of 100 are "Subarticles," units of 10 are "Subsubarticles," units of 1 are "Paragraphs," and units of .1 are "Subparagraphs."
[4] ADAMS Accession Nos. ML14098A036, ML14101A366, and ML14106A603, respectively.

Enclosure

was for one refueling cycle until a life-of-plant ASME Code, Section XI flaw evaluation was prepared to support the duration of the fifth 10-year ISI interval. Specifically, the pressurizer heater sleeve repair was performed to the requirements of the ASME Code, Section XI using an ASME Code, Section III design by replacing the pressurizer heater sleeve and relocating the pressure boundary to the outside diameter of the pressurizer shell and abandoning the existing heater sleeve and inside diameter weld in place.

During a conference call with the licensee on April 15, 2014, the NRC verbally authorized the licensee's use of Relief Request No. 1 for Turkey Point 3 for that unit's 18-month operating cycle that began after the spring 2014 refueling outage.[5] The NRC's subsequent safety evaluation for that relief request was issued in a letter dated October 9, 2014.[6] Relief Request No. 1, Revision 1 provides the results of the life-of-plant ASME Code, Section XI flaw evaluation and corrosion analysis.

In Relief Request No. 1, Revision 1, the licensee requested NRC authorization of a proposed alternative to the ASME Code, Section XI, 2007 Edition with Addenda through 2008, subparagraph IWB-3142.3, which states that a component containing relevant conditions is acceptable for continued service if the relevant conditions are corrected by a repair/replacement activity or by corrective measures to the extent necessary to meet the acceptance standards of Table IWB-3410-1. The licensee performed a "half-nozzle" repair that relocated the pressure boundary weld to the outside of the pressurizer bottom head shell and, thus, left the flaw that caused the leakage in place. The licensee's proposed alternative is to relocate the pressure boundary weld to the outside surface of the pressurizer and not correct the item(s) containing the flaw(s). The licensee requested the NRC to authorize the proposed alternative for the fifth 10-year ISI interval of Turkey Point 3, which ends February 21, 2024.

On August 11, 2015, the NRC staff performed a regulatory audit at the Westinghouse Electric Company (WEC) office in Rockville MD. By letter dated September 28, 2015,[7] the NRC issued a summary of the audit. By electronic mail (email) dated August 17, 2015,[8] the NRC staff issued an RAI to the licensee. By letter dated September 15, 2015, the licensee responded to the NRC staff's request.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(z)(2), the licensee proposed an alternative to 10 CFR 50.55a(g)(4) - specifically to the ASME Code, Section XI, subparagraph IWB-3142.3.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI to the extent practical within the limitations of design, geometry, and materials of construction of the components.

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[5] The memorandum documenting the verbal relief request is dated April 16, 2014, and is available in ADAMS under Accession No. ML14106A050.
[6] ADAMS Accession No. ML14122A268.
[7] ADAMS Accession No. ML15266A324.
[8] ADAMS Accession No. ML15231A391.

Pursuant to 10 CFR 50.55a(g)(4)(i) and 10 CFR 50.55a(g)(4)(ii), inservice examination of components and system pressure tests conducted during the first and subsequent 10-year inspection intervals must comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(a) 12 months before the start of the 120-month inspection interval.

Pursuant to 10 CFR 50.55a(g)(6)(i), the Commission may grant such relief and may impose such alternative requirements as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest giving due consideration to the burden upon the licensee.

Pursuant to 10 CFR 50.55a(z)(2), alternatives to the requirements of 10 CFR 50.55a(g) may be used when authorized by the Director of the NRC Office of Nuclear Reactor Regulation if compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Based on its regulatory and technical evaluations in this safety evaluation, the NRC staff concludes that the 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 NRC staff reviewed and evaluated the licensee's request pursuant to 10 CFR 50.55a(z)(2).

The code of record for the fifth 10-year ISI interval is the 2007 Edition with Addenda through 2008 of the ASME Code, Section XI.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Proposed Alternative

3.1.1 ASME Code Components Affected and Applicable Code Edition and Addenda

The components for which the licensee sought proposed alternatives are the pressurizer and pressurizer heater sleeve nozzle No. 11. The pressurizer heater sleeve is internally welded to the pressurizer lower head cladding. The components are examination category B-P, "All Pressure Retaining Components," Code Item No. B15.10. The stainless steel SA-213 TP316 sleeve has a 1.125-inch nominal outside diameter and a 0.095-inch wall thickness. The pressurizer lower head base material (carbon steel) is SA-216 Grade WCC. The cladding is austenitic stainless steel. The original construction code for the pressurizer is the ASME Code, Section III, 1965 Edition, including Addenda through summer 1965, Class A. The code of record for the fifth 10-year ISI interval is the 2007 Edition with Addenda through 2008 of the ASME Code, Section XI, subject to the limitations and modifications in 10 CFR 50.55a(b).

3.1.2 ASME Code Requirement for Which Licensee Proposed an Alternative

The licensee requested relief from the requirements of the ASME Code, Section XI, IWB-3142.3, which states that a component containing relevant conditions is acceptable for continued service if the relevant conditions are corrected by a repair/replacement activity or by corrective measures to the extent necessary to meet the acceptance standards of Table IWB-3410-1.

3.1.3 Licensee's Proposed Alternative

In its letter dated April 4, 2014, the licensee stated that visual examination of the Turkey Point 3 pressurizer heater sleeve penetrations during the spring 2014 refueling outage revealed evidence of leakage in the annulus between the outer surface of the heater sleeve and the pressurizer lower head bore at Heater Penetration No. 11. The licensee stated that it performed manual nondestructive examination (NDE) from the sleeve bore using eddy current testing (ECT) after the heater was removed from the heater sleeve. The licensee stated that the ECT examination did not reveal a flaw in the sleeve. Therefore, the licensee concluded the most likely location of the flaw is in the partial penetration stainless steel weld between the heater sleeve and the stainless steel cladding on the inside of the pressurizer bottom head.

In its letter dated April 4, 2014, the licensee stated that removal of the flaw would constitute a hardship because removal of a flaw in the partial penetration weld would require the licensee to perform work from inside the pressurizer, which would result in high personnel radiation dose, personnel safety hazards, and potential foreign material generation. The licensee repaired Heater Sleeve No. 11 using the "half-nozzle" method, which relocated the pressure boundary weld to the outside of the pressurizer bottom head. The licensee requested a proposed alternative to the requirements of the ASME Code, Section XI, IWB-3142.3 to leave the presumed flaw in place in the original weld.

In its application dated March 2, 2015, the licensee stated that its proposed alternative is to not correct the original weld. The licensee stated that the heater sleeve base material was removed to approximately the mid-wall of the pressurizer lower head. The heater sleeve was repaired by relocating the pressure boundary weld from the inside surface of the pressurizer to the outside surface. The licensee stated that the repair is in accordance with the Class 1 requirements of the ASME Boiler and Pressure Vessel Code, Section III. The licensee removed the heater and severed the heater sleeve below the pressurizer lower head. The licensee removed the remaining lower portion of the heater sleeve by boring to approximately mid-wall of the lower head. The licensee replaced the removed portion of the stainless steel sleeve with a section (half-nozzle) of low carbon stainless steel, which it then welded to the outside surface of the pressurizer lower head using low carbon stainless steel weld filler. The licensee welded a new heater to the bottom of the replacement lower sleeve using low carbon stainless steel weld filler. The upper portion of the sleeve, including the partial penetration weld, will remain in place. The licensee stated that heater sleeve welds on pressurizers with Alloy 600 material have been repaired by the industry using a similar "half-nozzle" technique. The licensee stated that the half-nozzle method was used at St. Lucie Unit 2 and many other Combustion Engineering designed nuclear steam supply system plants.

The licensee stated that it used a borescope to examine the portion of the original heater weld to the pressurizer. An area of discoloration approximately one-half inch along the reinforcing fillet weld face was noted. However, no indication of cracking was identified in the discolored region or any other part of the weld that was viewed. The licensee proposed that the original heater sleeve remnant and weld to not receive any additional NDE. The licensee stated that it examined the new lower heater sleeve-to-lower head and heater/plug-to-lower heater sleeve pressure boundary welds on the exterior surface of the pressurizer in accordance with the applicable requirements of the ASME Code, Sections III and XI.

3.1.4 Licensee's Basis for the Proposed Alternative

The licensee's basis for the proposed alternative is summarized as follows:

- The heater sleeve material (Type 316 stainless steel) and the sleeve-to-clad weld (austenitic stainless steel weld metal) are generally not susceptible to a stress corrosion cracking (SCC) mechanism; therefore the licensee believes the most likely mechanism for the leak was an original fabrication flaw that propagated in service from a combination of thermal fatigue and SCC.

- There has been no leakage at other pressurizer heater locations at Turkey Point 3 and 4 or throughout the industry in pressurizers with similar materials and configurations comprising over 100,000 sleeve-years of experience (3800 sleeves with 23 to 42 years of operating time).

- Further characterization of the pressurizer shell material adjacent to the J-groove weld and of the weld by NDE to locate and size the flaw is not practical because of the lack of qualified volumetric NDE techniques for this type of configuration.

- The licensee performed a flaw evaluation per ASME Code, Section XI, IWB-3600. Allowable end-of-evaluation period flaw sizes were determined using linear elastic fracture mechanics, considering the applicable loadings from design-basis events. A fatigue evaluation considering the cycles resulting from normal and upset conditions was performed starting with an initial postulated flaw with a depth equal to the partial penetration weld plus the cladding thickness. The fatigue evaluation considered the number of cycles for 60 years. The flaw evaluation showed the maximum end-of-evaluation period flaw size would not be exceeded for the remaining service life.

- The licensee performed a corrosion assessment of exposed carbon steel material and concluded that the increase in diameter of the heater sleeve bore and partial penetration weld preparation will not cause structural margins to be exceeded.

3.1.5 Duration of Proposed Alternative

The licensee requested the staff to authorize the alternative for the fifth 10-year inservice inspection interval for Turkey Point 3, which expires on February 21, 2024.

3.2 NRC Staff's Evaluation

3.2.1 Evaluation of Compliance with ASME Code Requirements

The heater sleeves fall under examination category B-P; therefore, per IWB-2500, Table IWB-2500-1, they are subject to a VT-2 visual examination each refueling outage during the system leakage test conducted prior to plant startup. The table refers to IWB-3522 for acceptance standards, which states:

A component whose visual examination (IWA-5240) detects any of the following relevant conditions shall meet IWB-3142 and IWA-5250 prior to continued service:

a) any through-wall or through-weld, pressure retaining material leakage from insulated and non-insulated components;

b) leakage in excess of limits established by the Owner from mechanical connections (such as pipe caps, bolted connections, or compression fittings) or from components provided with leakage limiting devices (such as valve packing glands or pump seals);

c) areas of general corrosion of a component resulting from leakage;

d) discoloration or accumulated residues on surfaces of components, insulation, or floor areas that may be evidence of borated water leakage; or

e) leakages or flow test results from buried components in excess of limits established by the Owner.

IWB-3142.1(b) states:

> A component whose visual examination detects the relevant conditions described in the standards of Table IWB-3410-1 shall be unacceptable for continued service, unless such components meet the requirements of IWB-3142.2, IWB-3142.3, or IWB-3142.4.

The licensee chose the option of IWB-3142.3 for acceptance with corrective measures or repair/replacement activities, which states that a component containing relevant conditions is acceptable for continued service if the relevant conditions are corrected by a repair/replacement activity or by corrective measures to the extent necessary to meet the acceptance standards of Table IWB-3410-1. The licensee implemented the repair in the form of a half-nozzle repair. However, the licensee proposed an alternative to the Code requirements because the repair, while it will stop leakage and restore the pressure boundary integrity, will not remove the defect that caused the leak, which is presumed to be in the J-groove weld because it was not found in the tube.

3.2.2 Evaluation of Hardship

Because the flaw causing the leak is assumed to be in the original J-groove weld, removing the defect that caused the leak would require removing the original J-groove weld, which would have to be performed from inside the pressurizer. In its application dated March 2, 2015, the licensee stated that removing the heater sleeve-to-pressurizer weld requires accessing the internal surface of the pressurizer and removing the weld and remaining sleeve base material. Such an activity would result in high radiation exposure to the personnel involved, which is considered a hardship. The licensee also stated that grinding or machining within the components would also expose personnel to safety hazards and could introduce foreign material in the pressurizer that could later affect fuel performance.

The NRC staff concludes that removing the original weld would result in a hardship to the licensee because of the radiation exposure to personnel, personnel safety hazards, and foreign material risk. The benefit to be gained with respect to safety from removing the original J-groove weld does not compensate for the hardship because, based on experience with similar half-nozzle repairs on similar nozzle configurations, there has never been a case of unacceptable flaw growth into the vessel. Therefore, in this case, the NRC staff concludes that to comply with the ASME Code requirement would constitute a hardship without a compensating increase in safety.

3.2.3 Evaluation of Leak Tightness and Structural Integrity

3.2.3.1 Flaw Evaluation

In Enclosure 1[9] to its application dated March 2, 2015, the licensee provided a flaw evaluation in the proprietary Westinghouse Commercial Atomic Power (WCAP) report, WCAP-17973-P, Revision 1, "Turkey Point Units 3 and 4 Pressurizer Heater Sleeve Flaw Evaluation to Support Half-Nozzle Repairs." A maximum end-of-evaluation period flaw size was determined based on the largest flaw that could withstand the most limiting loading from normal, upset, emergency, or faulted conditions and meet the ASME Code, Section XI criteria. During the staff's August 11, 2015 audit, the NRC staff reviewed the actual stress results, stress intensity factors, and values of several other parameters used in the analyses to enhance its understanding of how the stress analysis and fracture mechanics analysis were performed. This information also enabled the staff to verify it used appropriate inputs for its confirmatory calculations related to the fracture mechanics evaluation.

3.2.3.1.1 Stress Analysis

The licensee calculated the stresses in the pressurizer bottom head resulting from the applicable transients using a three-dimensional finite element analysis (FEA). The FEA model consists of a wedge of the pressurizer bottom head spanning one-half the angle between two adjacent outer row penetrations. The licensee's FEA model included both a heater sleeve on the innermost row and a heater sleeve on the outermost row. The licensee stated that the failed heater sleeve was in the inner row, but outer row penetrations typically have the highest stresses. However, the licensee indicated that the FEA contained calculated stresses for both the inner and the outer row heater sleeves. The most limiting stresses were selected as input to the fracture mechanics analysis. The NRC staff reviewed the information in the FEA model that included stress distributions, boundary conditions, and modeling simplifications, and the NRC staff found the information to be acceptable.

3.2.3.1.2 Fracture Mechanics Analysis

The licensee determined the maximum acceptable flaw size using linear elastic fracture mechanics (LEFM) and acceptance criteria from the ASME Code, Section XI. There are two alternative sets of flaw acceptance criteria for continued service without repair in paragraph IWB-3600 of the ASME Code, Section XI. Either of the following criteria may be

[9] ADAMS Accession No. ML15077A215.

used per paragraph IWB-3610 to determine the maximum allowable end-of-evaluation period flaw size: acceptance criteria based on flaw size (IWB-3611); or acceptance criteria based on stress intensity factor (IWB-3612). In addition to these two acceptance criteria, paragraph IWB-3610 of the ASME Code, Section XI also requires that the primary stress limit of the ASME Code, Section III, NB-3000 be met assuming a local area reduction of the pressure retaining membrane that is equal to the area of the flaw. Therefore, the maximum allowable flaw size determined using the primary stress limit is also used in the maximum allowable end-of-evaluation period flaw size determination.

During the audit performed on August 11, 2015, WEC clarified that it did not use the criteria of IWB-3611 because the less limiting of either IWB-3611 or IWB-3612 criteria may be used, and application of the IWB-3612 criteria yielded acceptable results. From IWB-3612, the acceptance criterion for normal and upset conditions is $K_I < K_{IC}/\sqrt{10}$. For emergency and faulted conditions, the acceptance criterion is $K_I < K_{IC}/\sqrt{2}$. K_I is the applied stress intensity factor in units of kilopounds per square inch times the square root inches (ksi$\sqrt{\text{in}}$), and K_{IC} is the static crack initiation fracture toughness in units of ksi$\sqrt{\text{in}}$.

The K_I values are determined using the applied stress values from the FEA in conjunction with formulas from American Petroleum Institute (API) 579-1/ASME FFS-1 (API 579, Second Edition), "Fitness-for-Service," dated June 2007. The licensee used the equations for two corner flaws emanating from a hole in a plate. In its RAI, the staff requested the licensee to confirm the exact equation from API 579 that it used for the K_I solution (RAI-2). The licensee responded to RAI-2 that it used the equations for the "Plate with Hole, Corner Crack, Semi-Elliptical Shape, through Wall Membrane and Bending Stress (KPHSC2)" case from Section C.4.4 of API 579-1/ASME FFS-1. The licensee also provided a figure of the schematic of the flaw geometry, which it stated is from Figure 4-1 of WCAP-17973, and that the figure is also consistent with Figure C.10 of API 579. The staff confirmed the licensee's figure of the schematic is consistent with Figure C.10 in API 579.

The staff reviewed the geometry corresponding to the case used by the licensee and finds that it is appropriate for the heater sleeve J-groove weld geometry, except that for the case used by the licensee, the crack and geometry dimensional limits in Section C.4.4.2 of API 579 provide limits of $0.5 \leq R_h/t \leq 2.0$ for this applied stress intensity factor solution. From Figure C.10 of API 579, R_h is the hole radius and t is the plate thickness. WCAP-17973-P and WCAP-17973-NP did not provide the values of R_h or t that were used in the Turkey Point 3 heater sleeve flaw evaluation. However, based on the staff's knowledge of typical pressurizer heater sleeve and bottom head dimensions, the staff was concerned that R_h/t might be outside the applicability limit for the equation. Therefore, in its RAI, the staff requested that the licensee provide R_h and t applicable to the determination of K_I for the Turkey Point 3 heater sleeve (RAI-3). The staff also requested that if the limit of $0.5 \leq R_h/t \leq 2.0$ is not met by the Turkey Point 3 heater sleeve geometry, that the licensee justify this by using the equation from Section C.4.4 of API 579 outside the specified bounds of applicability.

In its response to RAI-3, the licensee indicated that R_h/t has an approximate value of 0.1 for the fracture mechanics evaluation for Turkey Point 3 based on the pressurizer heater sleeve and bottom head dimensions. The licensee provided the results of a sensitivity study in which it plotted the value of K_I versus R_h/t for various R_h/t values both within the applicability limit (between R_h/t of 0.5 to 0.7) and below the applicability limit (from R_h/t from 0.5 down to close to zero). The licensee also plotted the case for R_h/t equals zero, which was determined based on the API 579 solution for a semi-elliptical flaw in a plate with no hole. The plots show that the plate with hole, corner crack, semi-elliptical shape solution follows a consistent curve that appears to be continuous with the solution for a semi-elliptical flaw in a plate with no hole. Based on the sensitivity study, the licensee concluded that use of the "Plate with Hole, Corner Crack, Semi-elliptical Shape, Through Wall Membrane and Bending Stress" (KPHSC2) equation in API 579 is acceptable for R_h/t values below 0.5 for the Turkey Point 3 pressurizer heater sleeve flaw evaluation because the extrapolated stress intensity factor values show that as R_h/t decreases, the K_I values also decrease on a consistent trend right up to the case for stress intensity factors for a plate with no hole. The staff finds the licensee's response to RAI-3 to be acceptable because the sensitivity study demonstrates that the K_I values for R_h/t ratios less than 0.5 follow a consistent trend and would converge with the plate with no hole solution, which suggests the K_I values are reasonable at the smaller R_h/t ratio of the heater sleeve geometry. The staff also notes that the licensee's use of the API 579, Second Edition equations is appropriate because the ASME Code, Section XI, Appendix A does not contain any K_I equations for this type of geometry.

In the case used by the licensee, Figure C.10 of API 579 shows that W is the distance from the hole centerline to the edge of the plate, or one-half the plate width. In its RAI, the staff asked the licensee to provide the basis for the value of W used in the flaw evaluation because the pressurizer bottom head has numerous heater sleeves with a hole for each (RAI-4). In its response to RAI-4, the licensee stated the value of W used in the flaw evaluation is based on the minimum distance between the centerline of the penetration hole of interest to the next closest (adjacent) penetration hole. The staff finds the licensee's response to RAI-4 to be acceptable because it clarified how W was determined.

In its RAI, the staff asked the licensee to identify the weld residual stress profiles that were considered in the determination of the applied K values for fatigue crack growth and the allowable end-of-evaluation period flaw size, or to explain and justify if weld residual stresses were not considered (RAI-5). In its response to RAI-5, the licensee provided two reasons that the weld residual stresses were not considered. First, the hypothetical flaw is postulated so that the flaw captures not only the weld depth but also the additional layer of cladding between the weld and the base metal. Therefore, the effect of welding residual stresses are negated as the flaw depth encompasses the partial penetration weld and the adjacent layer of cladding. The licensee stated the second reason for not considering the welding residual stresses is because the weld depth represents less than 5 percent of the total wall thickness including cladding; therefore, the effect of weld residual stresses for this small weld depth will have an insignificant impact on the fracture mechanics evaluation of the remaining pressurizer lower head base metal as the welding residual stresses dissipate away from the location of the partial penetration weld.

The NRC staff reviewed the licensee's response to RAI-5 against the NRC approved topical report, WCAP-15973-NP-A, "Low-Alloy Steel Component Corrosion Analysis Supporting Small-Diameter Alloy 600/690 Nozzle Repair/Replacement Programs,"[10] which provides a justification for discounting residual stresses in flaw evaluations of the pressurizer bottom head considering cracked J-groove welds in pressurizer instrumentation nozzles and heater sleeves. The discussion in Section 3.1 of WCAP-15973-NP-A states that solidification and shrinkage of the

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[10] ADAMS Accession No. ML050700431.

cladding (overlay) and buttering will develop residual stresses, the magnitude of which will be related to the yield strength of the respective weld metals, and that yield strengths of the nickel base weld metals, such as Alloys 82 and 182, are typically similar to those in stainless steel weld metals, such as Types 308 or 309, which are used for cladding applications. The staff notes the Turkey Point 3 pressurizer bottom head is clad with stainless steel rather than nickel-based weld metal. WCAP-15973-NP-A further states that the residual stresses in weld metals tend to be highest near the surface of the last layer deposited, and that several layers of weld metal were deposited to develop the required cladding (or overlay) or butter thickness. WCAP-15973-NP-A further states that each layer, after the initial layer of weld metal, has the effect of reducing the residual stresses in the previous layers, thereby significantly reducing the residual stresses at the cladding/butter-base metal interface, and that the highest stressed locations in the buttering for the instrument nozzles were removed by the grinding used to prepare the surface for liquid penetrant testing and for finishing the weld preparation, resulting in even lower stresses in the buttering.

One factor that is different between the Turkey Point 3 pressurizer heater sleeves and the pressurizer nozzles evaluated in WCAP-15973-NP-A is that the Turkey Point 3 heater sleeve weld and bottom head cladding is stainless steel rather than a nickel-based alloy. This would potentially result in higher stresses due to differential thermal expansion at the clad-base metal interface than for nickel-based cladding, which has a more similar coefficient of thermal expansion to carbon steel than does stainless steel. However, as noted in the licensee's application dated March 2, 2015, the pressurizer bottom head was post-weld heat treated (i.e., stress-relieved) after the cladding layers were deposited, which would relieve much of the residual stress in the cladding and the underlying carbon steel base metal. WCAP-15973-NP-A indicates that post-weld heat treatment of the pressurizer bottom head after cladding will relieve 30 to 40 percent of the residual stress in the cladding and up to 90 percent of the residual stress in the carbon or low-alloy steel base metal. In addition, the staff notes that the FEA for the Turkey Point 3 heater sleeve accounts for the cladding-induced stresses during the various transients.

The staff finds the licensee's response to RAI-5 reasonable because the small size of the weld compared to the thickness of the bottom head plus cladding is small, which would tend to result in smaller residual stresses. Further, since the weld does not penetrate the second layer of cladding, most of the residual stresses should dissipate in the second layer of cladding. In addition, growth of the flaw through the J-groove weld and cladding layers would relieve the residual stresses in the vicinity of the crack tip. In addition, the licensee's justification for discounting residual stress is consistent with the justification in the NRC-approved topical report WCAP-15973-NP-A.

With respect to fracture toughness used in the LEFM evaluation, because plant-specific data were not available, the licensee used generic data for SA-216 Grade WCC (the pressurizer lower head material). A reference nil-ductility temperature (RT_{NDT}) was determined based on data compilation of data from many different heats of material. The licensee's response to RAI-3b in its letter dated April 9, 2014, which was for the one operating cycle relief request, stated the NUREG-0800 method was used to determine the RT_{NDT}. Some of the methods for determining initial RT_{NDT} of Branch Technical Position (BTP) 5-3 (formerly MTEB 5-2) of

NUREG-0800[11] have been shown to be potentially nonconservative, specifically the methods described in Sections B1.1(3)(a) and (b) and B1.1(4). Details of NRC staff and industry evaluations of the potential nonconservatism were presented at the public meeting held on February 19, 2015.[12] Therefore, in its RAI dated August 17, 2015, the NRC requested the following information from the licensee (RAI-6):

1. Describe how the initial RT_{NDT} for the SA-216, Grade WCC material was determined. The description should address whether BTP 5-3 (MTEB 5-2) was used, which regulatory position from BTP-5-3 was used, and any additional margin that was added to the generic value.

2. Discuss the need to add additional margin to the initial RT_{NDT} value for the SA-216, Grade WCC material to adjust for the nonconservatism in the determination of initial RT_{NDT}.

3. If the initial RT_{NDT} is modified, revise the flaw evaluation as necessary.

In its September 15, 2015, response to RAI-6, the licensee indicated it did not use BTP 5-3 to determine the initial RT_{NDT} of the pressurizer bottom head material because the RT_{NDT} was determined directly from fracture toughness data, as discussed in WCAP-17973, Section 4.2.1.1, pages 4 and 5. The staff reviewed the information in WCAP-17973-P,[13] and observes that the ASME Code, Section XI K_{IC} curve with an assumed RT_{NDT} value, bounds virtually all the measured fracture toughness data for the SA-216, Grade WCC material. This assumed RT_{NDT} value was used as the RT_{NDT} for the pressurizer bottom head material. Therefore, since the licensee directly used fracture toughness data to determine RT_{NDT}, and did not use BTP 5-3, the staff's finds the licensee's response to RAI-6 is acceptable.

To show that the allowable end-of-evaluation period flaw size would not be exceeded during plant life, the licensee postulated an initial flaw and performed a fatigue crack growth calculation considering all applicable fatigue cycles. The licensee applied the design number of fatigue cycles for 60 years to the postulated flaw, even though less than 20 years remain in the period of extended operation (PEO) for Turkey Point 3, which is conservative. The postulated initial flaw was assumed to be oriented radially through the entire cross section of the original J-groove weld and the two layers of cladding so that the tip of the flaw would be in contact with the low-alloy steel pressurizer bottom head material. The licensee used the fatigue crack growth rates from the ASME Code, Section XI, Appendix A, Article A-4000 for a water environment. The maximum and minimum K_I values for the fatigue crack growth calculation are determined using the maximum and minimum stresses for each transient from the FEA and the equation from API 579 previously discussed. The staff finds the crack growth rates used by the licensee to be acceptable because the rates are from the ASME Code. The staff also finds that the use of the crack growth rate for water is appropriate because the postulated flaw is open to the inside surface of the pressurizer, thus the crack tip would be exposed to reactor coolant.

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[11] ADAMS Accession No. ML070850035.
[12] ADAMS Accession Nos. ML15096A128, ML15061A065, ML15061A075, ML15061A085, ML15061A091, and ML15061A095.
[13] This report contains proprietary information and is not publicly available.

The licensee also considered additional crack growth caused by corrosion based on the composite corrosion rate determined in the general corrosion evaluation. The corrosion crack growth rate per year was based on a weighted average considering the rates during normal operation, startup, and shutdown conditions. The licensee based the corrosion rates for these various conditions on WCAP-15973-P-A, "Low-Alloy Steel Component Corrosion Analysis Supporting Small-Diameter Alloy 600/690 Nozzle Repair/Replacement Programs."[14] The staff finds the corrosion crack growth rates acceptable because they are based on an NRC-approved topical report and are appropriate for these conditions and configuration. However, the staff does not consider it necessary to add crack growth due to general corrosion to a fatigue crack when the effects of the reactor coolant water environment are already considered in the fatigue crack growth rate. However, the additional crack extension due to corrosion added by licensee represents an additional conservatism.

The licensee did not consider crack growth caused by SCC. In its safety evaluation dated October 9, 2014, the NRC staff evaluated the likelihood of SCC growth in the pressurizer low-alloy steel material, and found it extremely unlikely. Therefore, the staff finds it is acceptable to not consider flaw growth caused by SCC in determining the end-of-evaluation period flaw size.

The fatigue cycles used by the licensee are based on the reevaluation of the fatigue cycles for the extended power uprate (EPU) license amendments for Turkey Point 3 and 4. The staff verified that the fatigue cycles used are the same as those approved in the EPU license amendment for Turkey Point 3, which were provided in Attachment 4, "Licensing Report,"[15] of the licensee's EPU license amendment request dated December 14, 2010. The NRC issued the EPU license amendments on June 15, 2012.[16] In addition, WCAP-17973-NP states that the insurge and outsurge transients for the pressurizer are based on a modified operating procedure (MOP) that is described in Westinghouse Report, WCAP-14950, "Mitigation and Evaluation of Pressurizer Insurge/Outsurge Transients," Revision 0, dated February 25, 1998.[17] However, the MOP does not appear to be incorporated into the Turkey Point 3 Technical Specifications or Updated Final Safety Analysis Report (UFSAR). Therefore, in its RAI, the staff requested that the licensee explain how WCAP-14950 is incorporated into the Turkey Point 3 design basis, how it can be assured that Turkey Point 3 will follow the MOP, and how the pressurizer insurge/outsurge transients are conservative for use at Turkey Point 3 (RAI-1).

In its response to RAI 1, the licensee indicated that its operating procedures are based on WCAP-13588, "Operating Strategies for Mitigating Pressurizer Insurge/Outsurge Transients," Revision 0,[18] but that the MOPs of WCAP-14950 are the same. The licensee also indicated that WCAP-14950 incorporated the results of additional work that was recommended in WCAP-13588, including monitoring the effects of the MOPs with thermocouples that were installed to monitor and collect data to determine the effectiveness of the MOPs and to develop insurge and outsurge transients on the pressurizer nozzle and lower shell during heat up and cool down. The licensee also indicated that WCAP-14950 is indirectly referenced in the license

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[14] This document contains proprietary information and is not publicly available. The non-proprietary version is available at ADAMS Accession No. ML050700431.
[15] ADAMS Accession No. ML103560177.
[16] ADAMS Accession No. ML11293A365.
[17] This document contains proprietary information and is not publicly available.
[18] This document contains proprietary information and is not publicly available.

renewal application (LRA)[19] because the shop order to update WCAP-13588 is referenced in WCAP-14574-A, "License Renewal Evaluation: Aging Management Evaluation for Pressurizers," dated July 1996,[20] which is referenced in the LRA, although WCAP-14950 was not published until 1998. WCAP-14574-A is also referenced in NUREG-1759, "Safety Evaluation Report Related to the License Renewal of Turkey Point Nuclear Plant, Units 3 and 4," dated April 2002.[21] The licensee also stated in its RAI response that in 2014, the Turkey Point pressurizer surge nozzle and lower head fatigue evaluation were updated in WCAP-17152-P, "Turkey Point Units 3 and 4 Extended Power Uprate (EPU) Engineering Report," Revision 1, using the appropriate pressurizer transients identified in WCAP-14950.

The licensee stated in its RAI response that the Turkey Point heat up and cool down operating procedures currently reference and incorporate the strategy in WCAP-13588 for mitigating pressurizer insurge and outsurge transients, and that an action has been initiated in the Turkey Point corrective action program to further enhance the procedures to identify and annotate the steps associated with the modified steam bubble MOP with WCAP-13588, WCAP-14950, the licensing letter associated with the flaw evaluation, and the relief request. Changes to the operating procedures are performed in accordance with 10 CFR 50.59, so the NRC staff has reasonable assurance that any changes to these essential steps in the Turkey Point operating procedures will not be made without prior NRC approval if required.

The licensee stated in its RAI response that because Turkey Point is following the MOPs identified in WCAP-13588 and WCAP-14950, the flaw evaluation performed in WCAP-17973-P using the transients identified in WCAP-14950 is applicable and bounding for Turkey Point 3. The licensee also stated that the fatigue evaluation in WCAP-17973-P assumes the entire 200 heat up and cool down transient cycles are applied to the pressurizer heater sleeve nozzle flaw from the point of discovery in 2014. The licensee further stated that this is conservative because Turkey Point 3 has only had 107 plant heat up and cool down cycles prior to the repair of the pressurizer heater sleeve in 2014. The licensee noted that the pressurizer insurge and outsurge transients identified in WCAP-14950 only occur during the 200 design heat up and cool down transient cycles and, therefore, the fatigue evaluation assumes more fatigue cycles than the number of remaining design heat up and cool down cycles available for the plant. The licensee stated that a review of the most recent Turkey Point 3 heat up and cool down cycles in 2014 showed that the current operating procedures for maintaining continuous outsurge have effectively reduced the magnitude of the pressurizer insurge events below the transient delta T values identified in WCAP-17973-P, Table 2-2 that are applied to the fatigue evaluation. Therefore, the pressurizer insurge and outsurge transients identified in WCAP-14950 are appropriate and conservative for Turkey Point 3. The NRC staff notes that the MOP, as defined in WCAP-14950, describes additional transient loadings caused by rapid pressurizer insurges and outsurges during normal heat up and cool down that were not included in the original set of fatigue cycles applicable to the reactor coolant system in the Turkey Point 3 design basis.

The NRC staff finds that the licensee's response to RAI 1 provides adequate assurance that it will continue to follow the MOP for the remainder of the fifth 10-year ISI interval. This assurance is based on the licensee's initiation of corrective actions to reference the WCAP reports defining

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[19] ADAMS Accession No. ML003749538.
[20] ADAMS Accession No. ML010660292.
[21] ADAMS Accession Nos. ML021280496, ML021280532, and ML021560094.

the MOP and the relief request in its operating procedures, which will prevent the procedures from being modified to remove the MOP without applying 10 CFR 50.59. In addition, the MOP is a key part of the fatigue evaluations for license renewal and the EPU for Turkey Point 3, so the licensee would also have to follow 10 CFR 50.59 if it wanted to deviate from the MOP.

The licensee stated in its application that in addition to the critical flaw sizes for normal/upset/test and emergency/faulted transients, paragraph IWB-3610 of the ASME Code, Section XI also requires that the primary stress limit of the ASME Code, Section III, NB-3000 be met assuming a local area reduction of the pressure retaining membrane that is equal to the area of the indication. Therefore, the licensee indicated that the maximum allowable end-of-evaluation period flaw size is also determined using the primary stress limit and is compared to the maximum allowable end-of-evaluation period flaw sizes determined for all normal/upset/test and emergency/faulted condition transients. The licensee stated that the primary stress limit calculation was found to be more governing than the ASME Code, Section XI, Paragraphs IWB-3611 or IWB-3612 acceptance criteria, and limited the flaw depth to a ratio of flaw depth to pressurizer bottom head thickness to 0.225, or 22.5 percent of the pressurizer lower head thickness. The licensee also stated that this limiting maximum allowable end-of-evaluation period flaw size is used in the creation of the crack growth chart. During the August 11, 2015, audit, WEC stated the primary stress limit was conservatively determined by reducing the wall thickness of the entire pressurizer bottom head by the assumed flaw depth, then calculating the stress using the membrane stress equation for a sphere because the bottom head is hemispherical. The staff performed a confirmatory calculation using the equation for the pressure thickness of a sphere from the ASME Code, Section III, Paragraph NB-3324, and determined an allowable flaw depth that is similar to that calculated by the licensee. Therefore, the staff finds the licensee's evaluation of the primary stress limit is acceptable.

The results of the licensee's flaw evaluation showed that the maximum allowable ratio of the flaw depth to the pressurizer bottom head thickness (a/t) was 0.225. The maximum flaw size calculated flaw depth, considering the number of fatigue cycles for 40 years of operation, in terms of a/t is 0.183, and is 0.141 for 20 years' worth of fatigue cycles. The staff also verified during the audit that the allowable end-of-evaluation period flaw sizes based on the LEFM evaluation were larger than an a/t ratio of 0.225 that was determined from the primary stress limit evaluation.

Using the licensee's methodology, the NRC staff performed a sample calculation of final flaw stability, using information on stresses from the audit, for the most limiting normal and faulted transients. The staff's calculation showed that the margins of IWB-3612 for the ratio of K_I to K_{Ic} are met for the two transients for a certain flaw size (a/t) greater than the limiting flaw size (a/t equal to 0.225) identified by the licensee based on the primary stress limit. The staff found the licensee's methodology for the flaw evaluation is acceptable because it used the methods of the ASME Code, Section XI, which is incorporated by reference in 10 CFR 50.55a. The methodology used NRC-accepted topical reports and an appropriate K_I solution for the flaw geometry for which the ASME Code did not provide any guidance. The methodology also applied the following conservative inputs and assumptions:

- Stresses for outer-row heater sleeves were used, which tend to be higher than inner row heater sleeves such as the one that leaked.

- The number of cycles assumed for fatigue crack growth calculations are conservative because the design number of cycles for 60 years of operation was applied, while less than 20 years remain in the period of extended operation for Turkey Point 3.

- Additional crack growth due to corrosion was added to the crack growth by fatigue, which is not required by the ASME Code.

- The flaw size based on primary stress limit was calculated based on an assumption of uniform wall thinning of the pressurizer bottom head, rather than just the loss of the area of the postulated flaw.

The results of the licensee's crack growth evaluation showed the postulated crack would reach a depth of 14.1 percent of the wall thickness considering 20 years' worth of fatigue cycles plus general corrosion, and 18.3 percent of the wall thickness considering 40 years' worth of fatigue cycles plus general corrosion. These final crack sizes are both less than the allowable flaw depth of 22.5 percent of the wall thickness. Because the results of the flaw evaluation showed the flaw size would not exceed the allowable flaw size by the end of the PEO of Turkey Point 3, the staff finds the flaw evaluation supports authorizing the proposed alternative through the end of the fifth 10-year ISI interval for Turkey Point 3, which ends on February 21, 2024.

3.2.3.2 General Corrosion Evaluation

The licensee performed a general corrosion evaluation of the exposed carbon steel in the penetration to determine the service life of the repair weld on the pressurizer bottom head outer diameter. The licensee stated that corrosion of the pressurizer lower head material would increase the diameter of the heater sleeve bore (hole) and decrease the area of the effective weld and the reinforcement area around the hole. The licensee stated that maximum allowable hole diameter is calculated considering the reduction in the effective weld shear area and the required area of reinforcement based on Section III of the ASME Code. The licensee's evaluation determined that a hole diameter increase of 0.435 inches is justifiable for the heater sleeve penetrations. The licensee stated that based on the calculated corrosion rate per year, it would take much longer than 40 years for the hole diameter to increase by 0.435 inches. The licensee stated that because the remaining service life of Turkey Point 3 is less than 40 years, the heater sleeve hole diameter remains acceptable, even with corrosion, for the remaining life of the plant. The licensee used the methodology from WCAP-15973-P-A for this evaluation. The staff finds the licensee's general corrosion evaluation acceptable because it uses a methodology from an NRC-approved topical report and is appropriate for the configuration and environment of the Turkey Point 3 pressurizer heater sleeve.

3.2.3.3 NRC Staff Conclusion on Leak Tightness and Structural Integrity

Based on its review of the licensee's flaw evaluation and the licensee's corrosion assessment, the staff concludes that there is reasonable assurance that the structural integrity of the pressurizer will not be jeopardized by not removing a postulated flaw in the original J-groove weld. The staff also concludes that general corrosion of the carbon steel exposed to reactor coolant by the repair design will be acceptable for the remainder of plant life (i.e., until the end of the period of extended operation).

4.0 CONCLUSION

Based on its review of the licensee's submittals, the NRC staff concludes that the licensee's proposed alternative – Relief Request No. 1, Revision 1 – provides reasonable assurance that the leak tightness and structural integrity of the Turkey Point 3 pressurizer will be maintained for the fifth 10-year ISI interval at Turkey Point 3. The NRC staff also concludes that complying with the requirements of IWB-3142.3 would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The NRC staff, therefore, authorizes the licensee's requested alternative for the remainder of the fifth 10-year ISI interval at Turkey Point 3, which expires on February 21, 2024.

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

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Date: October 14, 2015

If you have any questions regarding this issue, please contact the project manager, Ms. Audrey Klett, at (301) 415-0489 or by e-mail at Audrey.Klett@nrc.gov.

Sincerely,

/RA/

Shana R. Helton, Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-250

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