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

October 30, 2018

Mr. Mano Nazar
President, Nuclear Division
and Chief Nuclear Officer
Florida Power & Light Company
Mail Stop EX/JB
700 Universe Blvd.
Juno Beach, FL 33408

SUBJECT: ST. LUCIE PLANT, UNIT NO. 1 – SAFETY EVALUATION FOR RELIEF REQUEST NO. 5 FOR THE FIFTH 10-YEAR INSERVICE INSPECTION INTERVAL (EPID L-2018-LLR-0002)

Dear Mr. Nazar:

By letter dated February 8, 2018, Florida Power & Light Company (the licensee) submitted Relief Request No. 5 for the fifth 10-year inservice inspection interval of St. Lucie Plant, Unit No 1. Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(2), the licensee requested the U.S. Nuclear Regulatory Commission (NRC) to authorize a proposed alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, specifically related to repair/replacement activities for Alloy 600 small bore nozzles.

The NRC staff reviewed the submittal and, as set forth in the enclosed safety evaluation, concludes that the licensee's proposed alternative to the ASME Code, Section XI provides reasonable assurance of structural integrity and leak tightness of the Alloy 600 small bore nozzles, and that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(z)(2), the NRC staff authorizes the licensee's proposed alternative in Relief Request No. 5 for the remainder of the fifth 10-year inservice inspection interval at St. Lucie Plant, Unit No. 1, which expires on February 10, 2028.

If you have any questions regarding this issue, please contact the project manager, Mr. Michael Wentzel, at (301) 415-6459 or by e-mail at Michael.Wentzel@nrc.gov.

Sincerely,

Undine Shoop, Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-335

Enclosure:
Safety Evaluation

cc: Listserv

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST NO. 5

FIFTH 10-YEAR INSERVICE INSPECTION INTERVAL

FLORIDA POWER & LIGHT COMPANY

ST. LUCIE PLANT, UNIT NO. 1

DOCKET NO. 50-335

1.0 INTRODUCTION

By letter dated February 8, 2018 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML18039A437), Florida Power & Light Company (the licensee) requested relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, specifically related to repair/replacement activities. The licensee requested that the Alloy 600 small bore nozzles on the hot leg pipes previously repaired by the "half-nozzle" technique remain in service in the fifth 10-year inservice inspection (ISI) interval of the St. Lucie Plant, Unit No. 1 (St. Lucie, Unit 1).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(2), the licensee submitted Relief Request No. 5 (RR-5) in which it proposed an alternative "half-nozzle" repair/replacement technique for Alloy 600 small bore nozzles, 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.

2.0 REGULATORY EVALUATION

Components (including supports) that are classified as ASME Code Class 1, Class 2, and Class 3 must meet the requirements in 10 CFR 50.55a(g)(4), *Inservice Inspection Standards Requirement for Operating Plants,* throughout the service life of a boiling- or pressurized-water reactor (BWR or PWR). The exception is the design and access provisions and preservice examination requirements set forth in Section XI of editions and addenda of the ASME Code that become effective subsequent to editions specified in paragraphs (g)(2) and (3) of 50.55a, which are incorporated by reference in paragraph (a)(1)(ii) of 50.55a to the extent practical within the limitations of design, geometry, and materials of construction of the components.

Pursuant to 10 CFR 50.55a(g)(4)(ii), *Applicable ISI Code: Successive 120-month Intervals,* inservice examination of components and system pressure tests conducted during successive 120-month inspection intervals must comply with the requirements of the latest edition and addenda of the ASME Code incorporated by reference in paragraph (a) of 50.55a 12 months before the start of the 120-month inspection interval (or the optional ASME Code Cases listed in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.147, *Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1,* when using ASME Code, Section XI, as incorporated by reference in paragraph (a)(3)(ii) of 50.55a), subject to the conditions listed in paragraph (b) of 50.55a. However, a licensee whose inservice inspection interval commences during the 12-month through 18-month period after August 17, 2017, may delay the update of their Appendix VIII program by up to 18 months. Alternatively, licensees may, at any time in their 120-month ISI interval, elect to use the Appendix VIII in the latest edition and addenda of the ASME Code incorporated by reference in paragraph (a) of 50.55a, subject to any applicable conditions listed in paragraph (b) of 50.55a. Licensees using this option must also use the same Edition and Addenda of Appendix I as Appendix VIII, including any applicable conditions listed in paragraph (b) of 50.55a.

Pursuant to 10 CFR 50.55a(z), *Alternatives to Codes and Standards Requirements,* alternatives to the requirements of paragraphs (b) through (h) of 50.55a, or portions thereof, may be used when authorized by the Director, Office of Nuclear Reactor Regulation, or Director, Office of New Reactors, as appropriate. A proposed alternative must be submitted and authorized prior to implementation. The applicant or licensee must demonstrate that: (1) *Acceptable Level of Quality and Safety*, the proposed alternative would provide an acceptable level of quality and safety; or (2) *Hardship without a Compensating Increase in Quality and Safety,* compliance with the specified requirements of 50.55a would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request, and the NRC to authorize, the alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 Background

RR-5 is related to several previous relief requests, which include letters dated January 8, 2003, November 21, 2003, April 29, 2005, and January 15, 2010 (ADAMS Accession Nos. ML030100006, ML033290288, ML051310170, and ML100260384, respectively). The previous relief requests related to alternative repair/replacement by "half-nozzle" technique in accordance with the NRC-approved, Westinghouse non-proprietary topical report (TR) WCAP-15973-NP-A, *Low-Alloy Steel Component Corrosion Analysis Supporting Small-Diameter Alloy 600/690 Nozzle Repair/Replacement Programs* (ADAMS Accession No. ML050700431), and its proprietary version, WCAP-15973-P-A, in conjunction with the NRC-imposed conditions on the use of the TR. The NRC-imposed conditions are delineated in Sections 4.1, 4.2, and 4.3 of the NRC safety evaluation for the TR. The NRC authorized the licensee's proposed alternatives for the third and fourth 10-year ISI intervals.

The TR provides a technical basis for the "half-nozzle" technique in the reactor coolant pressure boundary (RCPB) of the Combustion Engineering (CE)-designed PWR. This type of repair/replacement leaves the through-wall cracks and remnant Alloy 600/82/182 nozzles susceptible to primary water stress corrosion cracking (PWSCC) intact. In addition, it potentially allows the ferritic portions of the piping to be exposed to the borated reactor coolant. To utilize the TR, the NRC requires that the licensee perform plant-specific engineering evaluations and discuss its findings to each of the conditions delineated in Sections 4.1, 4.2, and 4.3 of the NRC safety evaluation for the TR. With this type of alternative repair/replacement, the remnant

Alloy 600/82/182 materials left intact will not receive additional examinations during ISI. However, the new RCPB welds located on the exterior surface of the reactor coolant system (RCS) components will be examined in accordance with the applicable requirements of Sections III and XI of the ASME Code.

3.2 Component Affected

ASME Code Class 1 partial penetration J-groove welds that join Alloy 600 small bore nozzles to the RCS hot leg pipes are affected. Table 1 of RR-5 lists the affected components with information detailing the date of repair, method of repair, materials of construction, and reason for repair. The licensee stated that the hot leg pipe base material is carbon steel SA-516, Gr. 70, inside radius is 21 inches, and wall thickness is 3.75 inches. The nozzle bore diameter is 0.997 inch.

The licensee stated that one nozzle with Tag ID No. PDT-1121D (Table 1) that had evidence of leakage was repaired by the "half-nozzle" technique in April 2001 refueling outage, leaving the through-wall flaws and the PWSCC susceptible materials in service. All other nozzles in Table 1 were preemptively replaced by the "half-nozzle" technique in the fall 2005 refueling outage, leaving the PWSCC susceptible materials in service.

3.3 Applicable Code Edition and Addenda

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

3.4 Duration of Relief Request

The licensee submitted RR-5 for the fifth 10-year ISI interval, which commenced on February 11, 2018, and is scheduled to end on February 10, 2028.

3.5 ASME Code Requirement

The ASME Code requirements applicable for this request originate in Article IWB-3000 of Section XI. According to IWB-3131(a), the volumetric and surface examinations required by IWB-2500 and performed in accordance with IWA-2200 shall be evaluated by comparing the examination results with the acceptance standards specified in Table IWB-3410-1.

According to IWB-3132.2, "Acceptance by Repair/Replacement Activity," a component whose volumetric or surface examination detects flaws that exceed the acceptance standards of Table IWB-3410-1 is unacceptable for continued service until the additional examination requirements of IWB-2430 are satisfied and the component is corrected by Article IWA-4000, "Repair/Replacement Activities" to the extent necessary to meet the acceptance standards of IWB-3000.

According to IWB-3132.3, "Acceptance by Analytical Evaluation," a component whose volumetric or surface examination detects flaws that exceed the acceptance standards of Table IWB-3410-1 is acceptable for continued service without a repair/replacement activity if an analytical evaluation, as described in IWB-3600, meets the acceptance criteria of IWB-3600. The area containing the flaw shall be subsequently reexamined in accordance with IWB-2420(b) and (c).

3.6 Proposed Alternative

The licensee proposed that the previously repaired or preemptively replaced Alloy 600 small bore nozzles on the RCS hot leg pipes by the "half-nozzle" technique that left the through-wall cracks, remnant Alloy 600 nozzles, and associated original attachment Alloy 82/182 welds susceptible to PWSCC in service, continue to remain in service. Details of this proposed alternative are as follows.

- In 2001, the licensee repaired a leaking Alloy 600 small bore nozzle (Table 1 of RR-5) with a PWSCC resistant Alloy 690 nozzle using the "half-nozzle" technique.
- In 2005, the licensee preemptively replaced several non-leaking Alloy 600 small bore nozzles (Table 1 of RR-5) with PWSCC resistant Alloy 690 nozzles using the "half-nozzle" technique.

In lieu of IWB-3132.2 and IWB-3132.3, the licensee performed the above alternative "half-nozzle" repair/replacement in accordance with NRC-approved non-proprietary TR, WCAP-15973-NP-A, and proprietary TR, WCAP-15973-P-A, with the NRC's conditions delineated in Sections 4.1, 4.2, and 4.3 of the NRC safety evaluation for the TR. The procedure for the alternative "half-nozzle" repair/replacement is as follows:

- Alloy 600 nozzle was cut outboard of the original fabrication partial penetration weld approximately mid-wall of the hot leg pipe wall thickness and removed;
- The borehole was slightly enlarged to maintain the proper diametral clearance for a partial penetration welded nozzle;
- The external cut section of Alloy 600 nozzle was replaced with a short section of Alloy 690;
- Alloy 690 nozzle section was welded to the exterior surface of the hot leg pipe;
- The remainder of Alloy 600 nozzle including the original attachment weld remained in place.

With the "half-nozzle" technique, the new attachment weld on the exterior surface of the hot-leg pipe becomes the new RCPB. The remainder of Alloy 600 nozzle, including the original attachment weld, remain in place without correction and subsequent inspections. The new RCPB weld located on the exterior surface of the hot-leg pipe will be examined in accordance with the applicable requirements of Sections III and XI of the ASME Code.

3.7 Basis for Use

The licensee stated that the NRC-approved TR, in conjunction with the conditions the NRC imposed for use of the TR, serve as the technical basis for this request. The NRC's imposed condition is that if the methodology in the TR is utilized for the repair/replacement of a small bore nozzle, plant-specific analyses shall be performed. The required plant-specific analyses include: general corrosion assessment, thermal fatigue crack growth assessment, and stress corrosion crack growth assessment. A brief description of the NRC-imposed conditions for use of the TR and the required plant-specific analyses follows.

For the general corrosion assessment, Section 4.1 of the NRC safety evaluation for the TR states that licensees seeking to use the methods of the TR will need to perform the following plant-specific calculation in order to confirm that the ferritic portions of the vessels or piping with the scope of the TR will be acceptable for service through the licensed-life of their plant:

1. Calculate the minimum acceptable wall thinning thickness for the ferritic vessel or piping that will adjoin to the "half-nozzle" repair;

2. Calculate the overall general corrosion rate for the ferritic materials based on the calculation methods in TR, using the general corrosion rates listed in TR for normal operations, startup conditions (including hot standby conditions), cold shutdown conditions, and the respective plant-specific times (in percentage of total-plant-life) at each of the operating modes;

3. Track the time at cold shutdown conditions to determine whether this time does not exceed the assumptions made in the analysis. If these assumptions are exceeded, the licensees shall provide a revised analysis to the NRC, and provide a discussion on whether a volumetric inspection of the area is required;

4. Calculate the amount of general corrosion based thinning for the vessels or piping over the life of the plant, as based on the overall general corrosion rate calculated in Step 2 and the thickness of the ferritic vessel or piping that will adjoin to the "half-nozzle" repair;

5. Determine whether the vessel or piping is acceptable over the remaining life of the plant by comparing the worst case remaining wall thickness to the minimum acceptable wall thickness for the vessel or pipe.

For the thermal fatigue crack growth assessment, Section 4.2 of the NRC safety evaluation for the TR states that licensees seeking to reference this TR for future licensing applications need to demonstrate the following:

1. The geometry of the leaking penetration is bounded by the corresponding penetration reported in proprietary Calculation Report CN-CI-02-71, Revision 1, "Summary of Fatigue Crack Growth Evaluation Associated with Small Diameter Nozzles in CEOG [Combustion Engineering Owners Group] Plants";

2. The plant-specific pressure and temperature profiles in the pressurizer water space for the limiting curves (cooldown curves) do not exceed the analyzed profiles shown in Figure 6-2(a) of proprietary Calculation Report CN-CI-02-71, Revision 1, as stated in Section 3.2.3 of the NRC safety evaluation for the TR;

3. The plant-specific Charpy upper shelf energy (USE) data shows a USE value of at least 70 foot pounds (ft-lb) to bound the USE value used in the analysis. If the plant-specific Charpy USE data does not exist and the licensee plans to use Charpy USE data from other plants' pressurizers and hot leg piping, then justification (e.g., based on statistical or lower bound analysis) has to be provided.

For the stress corrosion crack growth assessment, Section 4.3 of the NRC safety evaluation for the TR states that licensees seeking to implement mechanical nozzle seal assembly repairs or "half-nozzle" replacements may use the Westinghouse Owners Group stress corrosion assessment as the bases for concluding that existing flaws in the weld metal will not grow by stress corrosion, if they meet the following conditions:

1. Conduct appropriate plant chemistry reviews and demonstrate that a sufficient level of hydrogen overpressure has been implemented for the RCS, and that the contaminant

concentrations in the reactor coolant have been typically maintained at levels below 10 parts per billion (ppb) for dissolved oxygen, 150 ppb for halide ions, and 150 ppb for sulfate ions.

2. Review their plant-specific reactor coolant chemistry histories over the last two operating cycles for their plants, and confirm that these conditions have been met over the last two operating cycles.

Additional details concerning the evaluations may be found in the NRC technical evaluation portion of this document

3.8 Basis for Hardship

The licensee stated that as a result of PWSCC susceptibility of the original nozzle base metals and the partial penetration attachment weld metals, cracks may develop in these materials resulting in leakage of the RCS. The leak path from the flaw through the weld and base materials cannot be determined. To remove PWSCC crack(s) and susceptible materials entirely, the licensee would have to enter into a confined area to access the internal surface of the hot leg piping to grind out the entire original attachment weld metals and Alloy 600 nozzle base metals. These activities would expose involved personnel to a high radiation dose, as well as safety hazards. In addition, grinding on the internal surface of the RCS piping increases the possibility of introducing foreign material into the RCS that could damage the fuel cladding. In the April 23, 2003, letter (ADAMS Accession No. ML031140498), the licensee discussed details of exposure to radiological and occupational safety hazards associated with such repairs, replacements, or mitigations associated with the complete removal of unacceptable flaws and PWSCC susceptible materials.

3.9 NRC Staff Evaluation

The NRC staff evaluated RR-5 pursuant to 10 CFR 50.55a(z)(2). The NRC staff focused on whether compliance with the specified requirements of 10 CFR 50.55a(g), or portions thereof, would result in hardship or unusual difficulty, without a compensating increase in the level of quality and safety. The NRC staff notes that during third 10-year ISI interval in 2001 and 2005, the NRC authorized repair or replacement of the subject nozzles by an alternative "half-nozzle" technique. The licensee performed the "half-nozzle" repair/replacement in accordance with the non-proprietary TR, WCAP-15973-NP-A, or proprietary TR, WCAP-15973-P-A, and the conditions the NRC imposed for use of the TR, which required a plant-specific general corrosion assessment, thermal fatigue crack growth assessment, and stress corrosion crack growth assessment. For the fourth 10-year ISI interval, the NRC approved the plant-specific engineering analyses provided by the licensee for that interval.

In evaluating RR-5, the NRC staff focused on reviewing the plant-specific engineering evaluations provided by the licensee for the fifth interval. This review did not include the details of alternative "half-nozzle" repair/replacement designs, analyses, and hardship associated with compliance with the Code required repair because the details reviewed and approved by the NRC in 2001 and 2005.

In evaluating RR-5, the NRC staff assessed the safety significance of leaving flaws and remnant of PWSCC-susceptible materials in service, as well as potentially exposing the ferritic portions of the affected piping to borated water as a result of alternative "half-nozzle" repair/replacement technique. For the subject small bore nozzles on the hot-leg piping at St. Lucie, Unit 1, the licensee used the methods and analyses delineated in TR. In its January 12, 2015, letter transmitting its safety evaluation of the TR, the NRC staff stated that methods and analyses are acceptable for use by licensees, provided that the conditions imposed by the NRC staff for use of the TR are met. These conditions, delineated in Sections 4.1, 4.2, and 4.3 of the NRC safety evaluation for the TR, are as follows.

- *Conditions in Section 4.1* *"General Corrosion Assessment"*
- *Conditions in Section 4.2* *"Thermal Fatigue Crack Growth Assessment"*
- *Conditions in Section 4.3* *"Stress Corrosion Crack Growth Assessment"*

<u>*Conditions in Section 4.1 "General Corrosion Assessment"*</u>

<u>*Condition 4.1.1*</u> *requires the licensee to calculate the minimum acceptable wall thinning thickness for the piping that will adjoin to the "half-nozzle" repair.*

The NRC staff notes that Section 2.4 of the TR discusses methods for calculating acceptable wall-thinning thickness and limiting allowable diameter or borehole size for the ferritic piping after consideration of material loss during service due to corrosion. From the review of Tables 2 and 3 of RR-5, the NRC staff verified the following:

- To facilitate the alternative "half-nozzle" repair/replacement, the licensee enlarged the borehole diameter to 1.063 inches from its original diameter of 0.997 inch.
- From the TR, the licensee obtained the limiting allowable borehole diameter applicable to the small bore nozzles on the hot-leg pipe at St. Lucie, Unit 1, and that is 1.27 inches.
- The resulting allowable increase in diameter due to diametral corrosion allowance is calculated to be 0.207 inch.

The NRC staff finds that the licensee's results documented in Table 2 of RR-5 are acceptable because (a) the limiting allowable diameter for the "half-nozzle" repairs is based on bounding CE-designed PWR configuration that does not exceed the ASME Code limits, as documented in the TR, and (b) the licensee's calculated plant-specific maximum borehole diameter after repair with consideration of material loss during service due to corrosion does not exceed the limiting allowable diameter.

Therefore, the NRC staff determines that the licensee has satisfied Condition 4.1.1, because the licensee-calculated minimum wall-thinning thickness and determined that the ASME Code limits were not exceeded.

<u>*Condition 4.1.2*</u> *requires the licensee to calculate the overall general corrosion rate for the ferritic materials based on the calculation methods in the TR, the general corrosion rates listed in the TR for normal operations, startup conditions (including hot standby conditions), and cold shutdown conditions, and the respective plant-specific times (in percentage of total plant life) at each of the operating modes.*

The NRC staff notes that Section 2.3 of the TR discusses a method for calculating overall corrosion rate for ferritic materials. This method is based on exposure of carbon or low-alloy steels to bulk solutions of boric acid. The NRC staff verified that the licensee's calculated plant-specific overall corrosion rate for ferritic materials is 1.20 mils per year (mpy). For this calculation, the licensee used the plant-specific data from the date the first repair was performed by the "half nozzle" technique, April 15, 2001, through December 31, 2017, and the

TR-specified corrosion rate for ferritic materials at each of the operating modes and temperature conditions. The plant-specific data is the percentage of total plant time spent at each of the temperature conditions, which is 91.9 percent at high temperature, 1.7 percent at intermediate temperature, and 6.4 percent at low temperature, from April 15, 2001, through December 31, 2017. The TR-specified corrosion rate for CE-designed PWR (obtained from laboratory testing data) for ferritic materials for each temperature condition is 0.4 mpy for high-temperature conditions, 19.0 mpy for intermediate-temperature conditions, and 8.0 mpy for low-temperature conditions.

The NRC staff finds that the licensee's plant-specific overall corrosion rate of 1.20 mpy for ferritic materials is acceptable and bounded by the overall allowable corrosion rate of 1.53 mpy for CE-designed PWR. Therefore, the NRC staff finds that the licensee has satisfied Condition 4.1.2, and that the licensee's overall corrosion calculations for the "half nozzle" repairs is acceptable, because the licensee followed the TR methods and the overall corrosion rate or increase in hole diameter does not exceed the allowable limit.

<u>Condition 4.1.3</u> requires that the licensee track the time at cold shutdown conditions to determine whether this time exceeds the assumptions made in the analysis. If these assumptions are exceeded, the licensees shall provide a revised analysis to the NRC, and provide a discussion on whether volumetric inspection of the area is required.

The NRC staff verified that the licensee's provided percentage of total time the plant spent at low-temperature conditions or cold shutdowns (i.e., 6.4 percent from April 15, 2001, to December 31, 2017) is bounded by the analysis assumption of 10 percent of time for cold shutdowns as documented in Section 2.3 of the TR.

Furthermore, the NRC staff verified that even if the plant hypothetically has remained in shutdown for remainder of the fifth 10-year inspection interval and experienced cold shutdown corrosion rate of 8 mpy, as documented in Section 2.3 of the TR, the total calculated diametral loss or increase in hole diameter due to exposure of ferritic steels to bulk solutions of boric acid would be 0.198 inch, which is bounded by the diametral corrosion allowance of 0.207 inch as documented in Table 2 of RR-5.

Therefore, the NRC staff finds that the licensee has satisfied Condition 4.1.3, because the licensee has been tracking the time the plant has spent at cold shutdown conditions, and that the assumptions made in the analysis are not exceeded.

<u>Condition 4.1.4</u> requires the licensee to calculate the amount of general corrosion-based thinning for the piping over the life of the plant, as based on the overall general corrosion rate calculated in Step 2, and the thickness of the ferritic piping that will adjoin to the "half-nozzle" repair.

The NRC staff verified that for the first "half-nozzle" repair, the amount of diametral loss is calculated to be 84 mils (0.084 inch) for the period from April 15, 2001, to the renewed license expiration date of March 1, 2036. The NRC staff also verified that the diametral loss of all other repairs performed by the "half-nozzle" technique, as shown in Table 1 of RR-5, are bounded by 84 mils, because they will have fewer years-of-service than the first-repaired nozzle; therefore, the material loss will be less. The NRC staff finds that the licensee's calculation is acceptable because the licensee used the overall general corrosion rate in Condition 4.1.2 to determine the lifetime diametral loss of "half-nozzle" repairs.

Therefore, the NRC staff finds that the licensee has satisfied Condition 4.1.4 for the "half-nozzle" repairs because the licensee calculated the amount of general corrosion-based thinning for the piping over the life of the plant, and the limiting allowable diameter for "half-nozzle" repairs in Table 2 of RR-5 are not exceeded.

Condition 4.1.5 requires the licensee to determine whether the piping is acceptable over the remaining life of the plant by comparing the worst case remaining wall thickness to the minimum acceptable wall thickness for the pipe.

From review of Table 2 of RR-5, the NRC staff finds that the repairs/replacements performed by the "half-nozzle" technique are acceptable for the remaining life of the plant because the computed worst case repair bore diameter after 35 years is less than the limiting allowable bore diameter. Therefore, the NRC staff finds that the licensee has satisfied Condition 4.1.5 for the "half-nozzle" repairs.

Therefore, the NRC staff finds that as a result of meeting all conditions of Section 4.1, reasonable assurance exists that the potential of general corrosion of ferritic materials in the crevice region inherent to "half-nozzle" repair is very low.

Conditions in Section 4.2 "Thermal Fatigue Crack Growth Assessment

Condition 4.2.1 requires the licensee to demonstrate that the geometry of the leaking penetration is bounded by the corresponding penetration reported in proprietary Calculation Report CN-CI-02-71, Revision 1 "Summary of Fatigue Crack Growth Evaluation Associated with Small Diameter Nozzles in CEOG Plants."

From reviewing the submittal, the NRC staff verified that the geometry of St Lucie, Unit 1, small diameter penetrations listed in Table 1 of RR 5 are bounded by the geometry of corresponding small diameter penetrations in proprietary Calculation Report CN-CI-02-71, Revision 1.

Therefore, The NRC staff determines that the licensee has satisfied Condition 4.2.1 because the geometry of the penetration listed in Table 1 of RR-5 is bounded by the corresponding geometry of penetration reported in proprietary Calculation Report CN-CI-02-71.

Condition 4.2.2 requires the licensee demonstrate that the plant-specific pressure and temperature profiles in the pressurizer water space for the limiting curves (cooldown curves) do not exceed the analyzed profiles shown in Figure 6-2(a) of proprietary Calculation Report CN-CI-02-71, Revision 1, as stated in Section 3.2.3 of the NRC safety evaluation of the TR.

The NRC staff notes that this condition applies only to the small-diameter penetrations on the pressurizer due to potential for pressurizer insurges that occur during plant heat-ups and cool-downs. However, the subject small bore nozzles are located on the hot-leg piping, not on the pressurizer. Therefore, the NRC staff finds that Condition 4.2.2 is not applicable to this relief request, because the small-diameter penetrations listed in Table 1 of RR-5 are all located on the hot-leg piping.

Condition 4.2.3 requires the licensee to demonstrate that the plant-specific Charpy USE data shows a USE value of at least 70 ft-lb to bound the USE value used in the analysis. If the plant-specific Charpy USE data does not exist and the licensee plans to use Charpy USE data from other plants' pressurizers and hot leg piping, then justification (e.g., based on statistical or lower bound analysis) has to be provided.

From the review of the the licensee's August 25, 2005, October 13, 2005, and January 15, 2010, letters (ADAMS Accession Nos. ML052420490, ML052900402, and ML100260384, respectively), the NRC staff verified that the hot-leg piping associated with the small bore nozzles listed in Table 1 of RR-5 was fabricated from carbon steel (SA-516, Gr. 70) plate material with two heat numbers (Melt No. C7293 Slab No. 65 and Melt No. C7293 Slab No. 67) supplied by Lukens Steel Company. The licensee used samples from these two heat numbers to demonstrate a plant-specific Charpy USE value of at least 70 ft-lb for hot-leg piping. The NRC staff notes that the Charpy USE value is the absorbed energy at 100 percent shear. The 100 percent shear state is obtained by performing Charpy test at progressively higher temperatures. As the testing temperature increases, the absorbed energy and the percent shear increase also. The NRC staff finds that with increasing test temperature, the above plates are expected to exhibit a USE value of at least 70 ft-lb at 100 percent shear.

Therefore, the NRC staff finds that the licensee has satisfied Condition 4.2.3, because the licensee demonstrated that a USE value of at least 70 ft-lb is reached and bounded by the analysis USE value.

Therefore, the NRC staff finds that as a result of meeting all conditions of Section 4.2, reasonable assurance exists that the potential for crack growth by thermal fatigue is very low.

Conditions in Section 4.3 "Stress Corrosion Crack Growth Assessment"

Condition 4.3.1 requires that the licensee conduct appropriate plant chemistry reviews and demonstrate that a sufficient level of hydrogen overpressure has been implemented for the RCS, and that the contaminant concentrations in the reactor coolant have been typically maintained at levels below 10 ppb for dissolved oxygen, 150 ppb for halide ions, and 150 ppb for sulfate ions.

The NRC staff notes that the licensee has reviewed the St. Lucie, Unit 1, reactor coolant chemistry data, and determined the following:

- The level of hydrogen concentration has been maintained at 40 cubic centimeter per kilogram (cc/kg) to 45 cc/kg. The licensee accomplished this by keeping the hydrogen overpressure in the RCS between 27 pound per square inch (psig) and 31 psig.
- The contaminant concentrations for dissolved oxygen, halide ions, and sulfate have been maintained at less than 5 ppb.

Therefore, the NRC staff finds that the licensee has satisfied Condition 4.2.3, because the licensee has conducted appropriate plant chemistry reviews, and the results showed that the contaminant concentrations in the reactor coolant were maintained at dissolved oxygen below 10 ppb, halide ions below 150 ppb, sulfate ions below 150 ppb, and hydrogen between 25 cc/kg and 50 cc/kg.

Condition 4.3.2 requires that during the outage in which the "half-nozzle" repair is scheduled to be implemented, licensees adopting the TR's stress corrosion crack growth basis will need to review their plant-specific reactor coolant chemistry histories over the last two operating cycles for their plants, and confirm that these conditions have been met over the last two operating cycles.

The NRC staff finds that the licensee has satisfied Condition 4.3.2, because the licensee reviewed the reactor coolant chemistry history from the last two operating cycles and determined that the contaminant concentrations met the required limits, and there were no water chemistry transients during the last two operating cycles. Therefore, the NRC staff finds that as a result of meeting all conditions of Section 4.3, reasonable assurance exists that the potential for crack growth by the PWSCC is very low.

In summary, the NRC staff finds that the licensee's proposed alternative in RR-5 is acceptable, because the plant-specific engineering evaluations provided by the licensee satisfactorily met the conditions imposed by the NRC staff for use of the TR. The NRC staff also determines that there is reasonable assurance that the remnant of original nozzles including the flaws and PWSCC materials left in service will not impact the structural integrity of the primary pressure boundary.

4.0 CONCLUSION

As set forth above, the NRC staff determines that the proposed alternative provides reasonable assurance of structural integrity and leak tightness of the subject small bore nozzles, and that complying with the specified requirement 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(z)(2). Therefore, the NRC staff authorizes use of the proposed alternative at St. Lucie, Unit 1, for the fifth 10-year ISI interval, which is scheduled to end on February 10, 2028.

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

Principal Contributor: Ali Rezai

Date: October 30, 2018

SUBJECT: ST. LUCIE PLANT, UNIT NO. 1 – SAFETY EVALUATION FOR RELIEF REQUEST NO.5 FOR THE FIFTH 10-YEAR INSERVICE INSPECTION INTERVAL (EPID L-2018-LLR-0002) DATED OCTOBER 30, 2018

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