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

April 24, 2018

Ms. Cheryl A. Gayheart
Regulatory Affairs Director
Southern Nuclear Operating Company, Inc.
P.O. Box 1295 / Bin 038
Birmingham, AL 35201-1295

SUBJECT: VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2 – INSERVICE INSPECTION ALTERNATIVE REGARDING THE USE OF CODE CASE N-729-4 (VEGP-ISI-ALT-04-01) (EPID L-2017-LLR-0153)

Dear Ms. Gayheart:

By letter dated December 18, 2017, Southern Nuclear Operating Company, Inc. (SNC, the licensee) submitted a proposed alternative, VEGP-ISI-ALT-04-01, for the Vogtle Electric Generating Plant, Units 1 and 2 (Vogtle). SNC proposed an alternative to the inspection requirements of American Society of Mechanical Engineers [ASME] Boiler and Pressure Vessel [BPV] Code, Section XI, Code Case N-729-4, "Alternative Examination Requirements for PWR [Pressurized Water Reactor] Reactor Vessel Upper Heads with Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1," as incorporated by reference in Title 10 of *Code of Federal Regulations* (10 CFR) 50.55a.

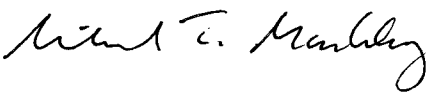
Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(2), the licensee proposed to use an alternative on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the proposed alternative and concludes, as set forth in the enclosed safety evaluation, 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 the use of alternative request VEGP-ISI-ALT-04-01, for Vogtle for the fourth 10-year inservice inspection interval, which ends on May 30, 2027.

All other ASME BPV 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.

If you have any questions, please contact the Project Manager, Michael Orenak, at 301-415-3229 or by e-mail at Michael.Orenak@nrc.gov.

Sincerely,



Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-424, 50-425

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PROPOSED ALTERNATIVE VEGP-ISI-ALT-04-01

REGARDING THE USE OF CODE CASE N-729-4

SOUTHERN NUCLEAR OPERATING COMPANY, INC.

VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2

DOCKET NOS. 50-424 AND 50-425

1.0 INTRODUCTION

By letter dated December 18, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17353A724), Southern Nuclear Operating Company, Inc., (SNC, the licensee) submitted a proposed alternative, VEGP-ISI-ALT-04-01, for the Vogtle Electric Generating Plant, Units 1 and 2 (Vogtle). SNC proposed an alternative to the inspection requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code, Section XI, Code Case N-729-4, "Alternative Examination Requirements for PWR [Pressurized Water Reactor] Reactor Vessel Upper Heads with Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1," as incorporated by reference in Title 10 of *Code of Federal Regulations* (10 CFR) 50.55a.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(2), the licensee proposed to use the alternative 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

Pursuant to 10 CFR 50.55a(z)(2), the licensee proposed to use the attainable ultrasonic examination distances for certain control rod drive mechanism (CRDM) penetration nozzles as an alternative to the examination coverage requirements of ASME Code Case N-729-4 as required and conditioned in 10 CFR 50.55a(g)(6)(ii)(D).

Paragraph (z)(2) of 10 CFR 50.55a states, in part, that alternatives to the requirements of 10 CFR 50.55a(g) may be used when authorized by the U.S. Nuclear Regulatory Commission (NRC) if the licensee demonstrates 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 the above and subjected to the following technical evaluation, the NRC staff finds that the licensee may propose an alternative and the NRC has the regulatory authority to authorize the proposed alternative.

3.0 TECHNICAL EVALUATION

3.1 ASME Code Components Affected

The proposed alternative applies to ASME Code Class 1 reactor vessel head CRDM penetration nozzles and J-groove welds. Examinations of these components are subject to Item Number B4.20 of ASME Code Case N-729-4 (UNS N06600 nozzles and UNS N06082 or UNS W86182 partial penetration welds). Specifically, the proposed alternative applies to the following CRDM nozzle penetrations and associated welds. As provided in Table 3 on page E-7 of the enclosure to the submittal, the following are subject to volumetric and surface examination:

Designation Numbers of CRDM Nozzles Addressed in the Proposed Alternative

VEGP Unit	Incidence Angle ≤ 30 degrees (Required Coverage "a" = 1.5 inches)	Incidence Angle > 30 degrees (Required Coverage "a" = 1.0 inches)
1	2, 5, 9, 14, 15, 18, 19, and 21	63, 64, 65, 66, 67, 68, 69, 72, 73, 74, 77, and 78
2	None	75 and 77

3.2 Applicable ASME Code Edition and Addenda

The current Code of Record for the Vogtle fourth 10-year inservice inspection (ISI) interval is the 2007 Edition through the 2008 Addenda of the ASME BPV Code.

3.3 Applicable Code Requirements

The regulation in 10 CFR 50.55a(g)(6)(ii)(D)(1) requires that examinations of the reactor vessel head be performed in accordance with Code Case N-729-4, subject to the conditions that are specified in 10 CFR 50.55a(g)(6)(ii)(D)(2) through (4).

Paragraph 2500 of Code Case N-729-4 states, in part, that:

> If obstructions or limitations prevent examination of the volume or surface required by Fig. 2 for one or more nozzles, the analysis procedure of Mandatory Appendix I shall be used to demonstrate the adequacy of the examination volume or surface for each such nozzle. If Mandatory Appendix I is used, the evaluation shall be submitted to the regulatory authority having jurisdiction at the plant site.

The regulation in 10 CFR 50.55a(g)(6)(ii)(D)(2) states that Appendix I of Code Case N-729-4 shall not be implemented without prior NRC approval.

Figure 2 in Code Case N-729-4, as referenced by paragraph 2500, requires that the volumetric or surface examination coverage distance below the toe of the J-groove weld (dimension "a") be

1.5 inches for incidence angle, θ, less than or equal to 30 degrees; 1 inch for incidence angle, θ, greater than 30 degrees; or to the end of the tube, whichever is less. These coverage requirements are applicable to the Vogtle reactor vessel head penetrations.

3.4 Reason for Request

The licensee stated that due to the physical configuration and limitations of the examination equipment associated with certain reactor head penetration nozzles, the full examination volume required by Table 1 of Code Case N-729-4, item No. B4.20, cannot be achieved. The bottom end of the reactor vessel head CRDM penetrations at Vogtle are externally (i.e., outside diameter) threaded, internally (i.e., inside diameter) tapered, and have an ultrasonic testing corner shadow zone produced by the thread relief. The shadow zone precludes ultrasonic or eddy current data acquisition in the lower nozzle area. For several of the penetrations, this geometric limitation reduces the lower coverage inspection distance from the bottom of the J-groove weld fillet to the top of the thread relief to a value less than the required coverage dimension "a" shown in Figure 2 of Code Case N-729-4.

3.5 Proposed Alternative and Its Basis

As an alternative to the volumetric and surface examination coverage requirements shown as dimension "a" in Figure 2 of Code Case N-729-4, the licensee proposed the use of attainable ultrasonic examination distances (as shown in Tables 1 and 2 of the licensee's request). The alternative applies to the nozzle regions below the J-groove welds of the penetration nozzles specified in Table 3 of the proposed alternative (i.e., those in the table in Section 3.1 of this safety evaluation). The examination coverage for the other head penetrations is expected to meet or exceed dimension "a" in Figure 2 of Code Case N-729-4. In addition, the licensee will examine the wetted surfaces on the vent line and vent line J-groove weld using the eddy current method that was used in the previous examinations.

The licensee stated that Appendix I of Code Case N-729-4 provides the analysis procedure for the evaluation of an alternative examination area or volume to that specified in Figure 2 of the Code Case if impediments prevent the examination of the complete zone. In support of this proposed alternative, the licensee used the techniques of both Sections I-2000 and Section I-3200 (Method 1) of Code Case N-729-4.

3.5.1 Stress Analysis

Section I-2000 of Code Case N-729-4 requires that plant-specific analysis demonstrate that the hoop and axial stresses remain below 20 thousand pounds per square inch (ksi) (tensile) over the entire region outside the alternative examination zone but within the examination zone as defined in Figure 2 of Code Case N-729-4. The licensee performed stress analyses in accordance with Appendix I, Section I-2000, of Code Case N-729-4 as documented in Westinghouse Report WCAP-16493-P, Revision 0, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Vogtle Units 1 and 2," dated November 2005. By letter dated June 2, 2006 (ADAMS Accession No. ML061580121), the licensee submitted the WCAP-16493 report to the NRC to support the examinations under NRC Order EA-03-009 (ADAMS Accession No. ML030380470).

Westinghouse performed stress analyses for five different CRDM geometries, including the rows at the penetration nozzle incidence angle (θ) of 0, 26.2, 44.3, 45.4 and 48.7 degrees.

Table 4 of the proposed alternative further describes the Vogtle reactor head penetration nozzles that are bounded by the analyzed penetration nozzle incidence angles.

Westinghouse calculated the distance below the J-groove weld that needs to be examined based on the point at which the CRDM penetration hoop stress distribution for the operating stress levels is less than 20 ksi (tensile). The licensee stated that the hoop stress distribution plots, as shown in Figures 1 through 4 of the proposed alternative, indicated that the achievable inspection coverage below the bottom of the J-groove weld ensures the stresses remain below 20 ksi (tensile) over the entire region outside the alternative examination zone but within the examination zone defined in Figure 2 of Code Case N-729-4, as required by I-2000 of Code Case N-729-4.

3.5.2 Fracture Mechanics Analysis

In addition to the stress analysis, the licensee performed a fracture mechanics analysis in accordance with Code Case N-729-4, Appendix I, Section I-3200 (Method 1). Flaw tolerance charts resulting from this analysis are provided in Figures 5 through 8 of the proposed alternative. As a result of this analysis, the licensee proposed that a postulated crack in the unexamined zone will not grow to reach the toe of the J-groove weld in less than 8 calendar years or 2.25 reinspection years, as required by Table 1 of Code Case N-729-4. As a result, the licensee proposed that the achievable inspection coverage and proposed inspection interval are acceptable

3.5.3 Potential Use of Surface Examination as a Substitute

The licensee is not proposing to perform surface examinations for those CRDM nozzles having only limited examination coverage below the J-groove weld due to personnel radiation exposure concerns and the practical difficulties of dye penetrant and eddy current examinations.

3.6 Duration of the Proposed Alternative

The duration of the proposed alternative is for the fourth 10-year ISI interval at Vogtle. These examinations are scheduled to be performed on Unit 1 and Unit 2 during the fall 2018 and spring 2019 refueling outages, respectively, and every fourth refueling outage thereafter. The end date of the fourth 10-year interval is May 30, 2027.

3.7 NRC Staff Evaluation

Areas of the high tensile stress in susceptible materials, such as alloy 600, can experience primary water stress corrosion cracking (PWSCC). PWSCC propagates in response to time, adverse environment, and stress intensity. The Vogtle reactor vessel heads are cooled by injection water and have slower PWSCC crack growth rates; however, the J-groove welds are still susceptible to PWSCC.

The NRC staff's review was based on 10 CFR 50.55a(z)(2) that allows the use of alternatives to the requirements of 10 CFR 50.55a if compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

3.7.1 Alternative Examination Coverage

Tables 1 and 2 of the proposed alternative provide the previous inspection coverage length obtained for CRDM nozzles at Units 1 and 2, respectively. In comparison with the examination coverage requirements of Code Case N-729-4, the licensee identified that 20 CRDM nozzles of Unit 1 and two CRDM nozzles of Unit 2 are applicable for this proposed alternative (as described in the table in Section 3.1 of this safety evaluation).

In addition, the licensee indicated that during ultrasonic testing (UT) the examination location is changed in increments of 0.04 inches. The licensee also clarified that, given these increments, the proposed alternative identifies in its scope the penetration nozzles that have attainable inspection coverage length within the 0.04 inches of the Code Case-specified coverage (i.e., 1.5 or 1.0 inches, depending on the incidence angle). The NRC staff finds that the licensee's method for identifying nozzles within the proposed alternative's scope is acceptable because it adequately considers the discrete increments in the UT examination coverage.

3.7.2 Stress Analysis

The licensee requested to use Mandatory Appendix I of Code Case N-729-4 in accordance with 10 CFR 50.55a(g)(6)(ii)(D)(2). Appendix I provides the analysis procedure for evaluation of an alternative examination area or volume if impediments prevent examination of the complete zone. The licensee performed, as required by Section I-1000, a stress analysis for the subject penetration nozzles and a deterministic fracture mechanics analysis to demonstrate that a potential axial crack in the unexamined zone will not grow to the toe of the J-groove weld prior to the next examination that is scheduled in accordance with Code Case N-729-4.

Figures 1 through 4 of the proposed alternative provide the hoop stress distribution plots. The licensee stated that, as the stress distributions indicate, the minimum attainable examination coverage below the bottom of the J-groove weld ensures that the stresses remain below 20 ksi (tensile) over the entire region outside the alternative examination zone but within the examination zone defined in Figure 2 of Code Case N-729-4.

The NRC staff finds that, based on the stress analysis, the licensee demonstrated that the areas of missed inspection coverage have stresses that are less than 20 ksi in the area of interest, thus minimizing the initiation and propagation of PWSCC. The NRC staff also finds that the stress distributions meet the 20-ksi stress criteria in Appendix I, Section I-2000, of Code Case N-729-4.

3.7.3 Fracture Mechanics Analysis

The licensee indicated that the stress distributions in Figures 1 through 4 of the proposed alternative were used to perform postulated crack growth predictions based on a deterministic fracture mechanics analysis that considered PWSCC, as shown in Figures 5 through 8 of the proposed alternative. Based on the analysis results, the licensee confirmed that the proposed examination coverages below the J-groove welds (as described in Table 5 of the proposed alternative) are sufficient to allow a minimum of six EFPY or four 18-month cycles between examinations. The licensee also stated that the fracture mechanics analysis ensures that any flaws initiated below the J-groove weld, in the region of the penetration nozzle not being inspected, would not reach the bottom of the weld before the next examination. The NRC staff identified that, in the fracture mechanics analysis, the licensee assumed that the initial upper crack tip (upper extremity) of a postulated through-wall axial flaw is located above the lowest

point of the alternative examination zone. Therefore, the NRC staff finds that the licensee's fracture mechanics analysis uses conservative assumptions regarding the initial upper crack tip locations of postulated axial through-wall flaws.

Additionally, the crack growth rate (CGR) model for PWSCC used in the fracture mechanics analysis (WCAP-16493-P) is the CGR model provided in EPRI MRP-55, Revision 1, dated November 2002 (non-public, proprietary). In comparison, Section I-3200 of Code Case N-729-4, Appendix I, specifies that the CRG model in Appendix O of ASME BPV Code, Section XI, is used in the fracture mechanics analysis per Code Case N-729-4, Appendix I. The NRC staff compared the CGR models in MRP-55, Revision 1, and Appendix O of the ASME BPV Code, Section XI, and finds that the two models are consistent. Therefore, the crack growth rate predictions in WCAP-16493-P are consistent with Code Case N-729-4, Appendix I.

Finally, the licensee's fracture mechanics analysis demonstrated that a postulated through-wall axial flaw located at the bottom edge of the uninspected region of the nozzle would not grow to the toe of the J-groove weld, in this case the edge of the reactor coolant system pressure boundary, in less than every fourth refueling outage. The NRC staff finds the inspection area for each penetration nozzle to be sufficient because, in all instances, the time required for the postulated crack to grow the necessary distance to reach the toe of the J-groove weld exceeds the time interval between inspections, allowing the licensee to identify and repair any cracking before it would affect the structural integrity of the penetration nozzle.

3.7.4 Summary

Based on the above regarding the alternative examination coverage, stress analysis, and the fracture mechanics analysis, the NRC staff finds that the proposed inspection coverage and frequency provide reasonable assurance of structural integrity of each nozzle for which an alternative to the volumetric and surface examination coverage requirements was requested.

3.7.5 Hardship

The licensee provided evidence that a physical and radiological hardship would exist in order to comply with the specified requirements. The NRC staff finds that a physical hardship exists due to the inability of ultrasonic or eddy current inspection to effectively scan the bottom end of each CRDM penetration nozzle as each nozzle is threaded on the outside diameter and internally tapered. Additionally, while dye penetrant inspection would be a possible option, the inspection would require manual application in a high radiation area, resulting in unnecessary radiation dose to the licensee staff. Therefore, the NRC staff finds that performing an ultrasonic, eddy current, or dye penetrant inspection of the nozzle bottom area would result in a significant hardship for the licensee.

The NRC staff compared the regulatory requirements to the proposed alternative and determined that, given this hardship, compliance with the regulations would not provide a compensating increase in the level of quality and safety.

4.0 CONCLUSIONS

As set forth above, the NRC staff finds that the proposed alternative provides reasonable assurance of structural integrity of the subject components and that complying with the 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 SNC has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(2). Therefore, the NRC staff authorizes the use of the proposed alternative in VEGP-ISI-ALT-04-01 at Vogtle for the fourth 10-year ISI interval, which is scheduled to end on May 30, 2027.

All other requirements in ASME BPV Code, Section XI, and 10 CFR 50.55a for which relief was not specifically requested and approved in this proposed alternative remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: S. Min, NRR

Date of Issuance: April 24, 2018

SUBJECT: VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2 – INSERVICE INSPECTION ALTERNATIVE REGARDING THE USE OF CODE CASE N-729-4 (VEGP-ISI-ALT-04-01) (EPID L-2017-LLR-0153) DATED APRIL 24, 2018

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