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

April 13, 2018

Mr. J. Ed Burchfield, Jr.
Site Vice President
Oconee Nuclear Station
Duke Energy Carolinas, LLC
7800 Rochester Highway
Seneca, SC 29672-0752

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1 AND 2 – SAFETY EVALUATION FOR RELIEF REQUEST NO. 17-ON-001 (EPID L-2017-LLR-0099)

Dear Mr. Burchfield:

By letter ONS-2017-72 dated October 3, 2017, as supplemented by letters ONS-2017-079 and ONS-2018-023 dated November 13, 2017, and March 20, 2018, respectively, Duke Energy Carolinas, LLC (the licensee) submitted Relief Request No. 17-ON-001 to the U.S. Nuclear Regulatory Commission (NRC or the Commission) for fifth 10-year inservice inspection (ISI) intervals of the Oconee Nuclear Station, Units 1 and 2 (Oconee 1 and 2). Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Paragraph 55a(z)(2), the licensee requested the NRC to authorize the use of an alternative to the examination frequency requirements of Section XI of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Case N-770, "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated with UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities Section XI, Division 1," as required by 10 CFR 50.55a(g)(6)(ii)(F), for reactor vessel core flood nozzle dissimilar metal butt welds.

The NRC staff reviewed the subject request and, as set forth in the enclosed safety evaluation, concludes that the licensee adequately addressed the regulatory requirements in 10 CFR 50.55a(z)(2). The NRC staff concluded that compliance with the ASME Code Case-770 examination frequency requirements for reactor vessel core flood nozzle dissimilar metal butt welds would result in hardship or unusual difficulty without a compensating increase in the level of quality or safety. The staff also concluded that the proposed alternative provides reasonable assurance of the structural integrity and leak tightness of the reactor vessel core flood nozzles. Therefore, the NRC authorizes use of the alternative presented in Relief Request No. 17-ON-001 for the remainder of the fifth 10-year ISI intervals for Oconee 1 and 2, which are scheduled to end on July 15, 2024.

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

Any inquiries can be directed to Ms. Audrey Klett at 301-415-0489 or via e-mail at Audrey.Klett@nrc.gov.

Sincerely,

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

Docket Nos. 50-269 and 50-270

Enclosure:
Safety Evaluation

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UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PROPOSED ALTERNATIVE TO REACTOR VESSEL NOZZLE WELD

EXAMINATION FREQUENCY REQUIREMENTS

DUKE ENERGY CAROLINAS, LLC

OCONEE NUCLEAR STATION, UNITS 1 AND 2

DOCKET NOS. 50-269 AND 50-270

1.0 INTRODUCTION

By letter ONS-2017-72, dated October 3, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17279A108), as supplemented by letters ONS 2017-079 and ONS-2018-023 dated November 13, 2017 (ADAMS Accession No. ML17321A076), and March 20, 2018 (ADAMS Accession No. ML18088A167), respectively, Duke Energy Carolinas, LLC (the licensee) submitted Relief Request No. 17-ON-001 to the U.S. Nuclear Regulatory Commission (NRC or the Commission) for fifth 10-year inservice inspection (ISI) intervals of the Oconee Nuclear Station, Units 1 and 2 (Oconee 1 and 2). Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Paragraph 55a(z)(2), the licensee requested the NRC to authorize the use of an alternative to the examination frequency requirements of Section XI of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code Case N-770, "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated with UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities Section XI, Division 1," as required by 10 CFR 50.55a(g)(6)(ii)(F), with conditions, for reactor vessel core flood nozzle dissimilar metal butt welds (DMBWs) at Oconee 1 and 2. Specifically, pursuant to 10 CFR 50.55a(z)(2), the licensee requested to use the proposed alternative on the basis that compliance with the specified ASME BPV Code requirements 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(g)(4), "Inservice inspection standards requirement for operating plants," 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, "Rules for Inservice Inspection of Nuclear

Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components.

Pursuant to 10 CFR 50.55a(g)(6)(ii), "Augmented ISI program," the NRC may require licensees to follow an augmented ISI program for systems and components for which the Commission deems that added assurance of structural reliability is necessary.

Pursuant to 10 CFR 50.55a(g)(6)(ii)(F), "Augmented ISI requirements: Examination requirements for Class 1 piping and nozzle dissimilar-metal butt welds—(1) Implementation," licensees shall implement the requirements of ASME BPV Code Case N-770-2 instead of ASME BPV Code Case N–770–1, subject to the conditions specified in paragraphs (g)(6)(ii)(F)(2) through (13) of this section, by the first refueling outage starting after August 17, 2017.

Pursuant to 10 CFR 50.55a(z)(2), alternatives to the requirements of paragraphs (b) through (h) of Section 50.55a, or portions thereof, may be used when authorized by the NRC if the licensee demonstrates that compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality or safety.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the NRC to authorize the licensee's proposed alternative for the remainder of the fifth 10-year ISI intervals for Oconee 1 and 2. Accordingly, the NRC staff reviewed and evaluated the licensee's request pursuant to 10 CFR 50.55a(z)(2).

3.0 TECHNICAL EVALUATION

3.1 ASME Code Components Affected by the Proposed Alternative

The licensee's request is applicable to the following nozzle-to-safe end DMBWs for the Core Flood Nozzles:

- Oconee 1: 1-RPV-WR53 - Reactor Vessel Core Flood Nozzle-to-Safe End, 14" DMBW
- Oconee 1: 1-RPV-WR53A - Reactor Vessel Core Flood Nozzle-to-Safe End, 14" DMBW
- Oconee 2: 2-RPV-WR53 - Reactor Vessel Core Flood Nozzle-to-Safe End, 14" DMBW
- Oconee 2: 2-RPV-WR53A - Reactor Vessel Core Flood Nozzle-to-Safe End, 14" DMBW

3.2 Applicable Code Edition, Addenda, and Requirement

The code of record for the fifth 10-year ISI intervals at Oconee 1 and 2 is the ASME BPV Code, Section XI, 2007 Edition and 2008 Addenda. Paragraph 50.55a(g)(6)(ii)(F)(1) of 10 CFR requires the use of ASME Code Case N-770-2. The licensee's request pertains to the examination frequency requirements of ASME Code Case N-770-2, Table 1, Item B, which requires volumetric examination of unmitigated butt welds at cold leg operating temperature greater than or equal to 525 degrees Fahrenheit (°F) and less than 580 °F every second inspection period not to exceed 7 years.

3.3 Licensee's Proposed Alternative

The licensee's proposed alternative is to extend the weld examination frequency required by Code Case N-770-2, Table 1, Item B for the Oconee 1 and 2 Core Flood Nozzle DMBWs listed

in Section 3.1 of this safety evaluation from "every second inspection period not to exceed 7 years" to "a maximum of 10 years from the previous examination."

3.4 Licensee's Bases for Use

The licensee explained that this alternative would allow the ASME Code Case N-770-2 inspections of these welds to coincide with the 10-year ISI refueling outages for the respective units, currently scheduled as follows:

	Oconee 1	Oconee 2
Outage ID:	1EOC32	2EOC31
Date:	Fall 2022	Fall 2023

The licensee is seeking NRC authorization of the proposed alternative in accordance with 10 CFR 50.55a(z)(2) on the basis that compliance with the required examination frequency would result in hardship or unusual difficulty without a compensating increase in the level of quality or safety. The licensee's basis for hardship or unusual difficulty is discussed in Section 3.5 of this safety evaluation. In its application, the licensee indicated that its proposed alternative does not adversely impact the level of safety or quality and provides reasonable assurance that the structural integrity and the leak tightness of the weld will be maintained for several reasons, including but not limited to:

- Baseline inspections were performed in accordance with ASME Section XI, Appendix VIII, Supplement 10 requirements and found no reportable circumferential or axial indications. The licensee's inspections of these welds, which were done in accordance with IWB-2500, Item B5.10 and conducted over the past 40 years (i.e., the past 4 ISI intervals), have not found reportable circumferential or axial indications.
- Results of the most recent volumetric examinations, which were done in 2012 and 2013 and performed to Section XI, Appendix VIII, Supplement 10 requirements, achieved essentially 100 percent coverage for both circumferential and axial flaws and resulted in no reportable primary water stress corrosion cracking (PWSCC) indications.
- The licensee did not identify any recorded repairs on the welds.
- Results from residual stress analyses and crack growth analyses for circumferential and axial cracking, including the maximum calculated and allowable flaw sizes for the Core Flood DMBWs, showed that the time to reach a 75 percent through wall flaw size would take more than 10 years. The licensee selected the initial assumed flaw size of 10 percent through wall because the requirements of the ASME Section XI, Appendix VIII, Supplement 10 inspection qualification procedure sets the minimum detectable flaw depth as being 10 percent of the wall thickness.

The licensee provided additional information in its supplement dated November 13, 2017, about the welds' characteristics, the licensee's methodology to calculate weld residual stress values, and the welds' operating environment and loading to support their flaw evaluation calculations.

3.5 Licensee's Reason for the Proposed Alternative

The licensee proposed the alternative of extending the 7-year examination frequency to a maximum of every 10 years so that the examination would coincide with the core barrel removal for the reactor vessel weld inspections, which are done per Table IWB-2500-1, Category B-A exam requirements. The licensee explained that the plant design limits access to the outer

surface of the subject DMBWs. With the core barrel removed, the licensee noted that examination coverage of these welds can be achieved without significant hardship when approached from the inner diameter of the weld. The outer surfaces of these welds are located underneath the annulus shield blocks in the approximately 3-foot wide reactor vessel annulus. The licensee noted that these physical interferences and high dose rates associated with the weld location are significant hardships. In addition, the licensee explained that each core barrel removal is a hardship that produces increased plant risk and elevates the outage dose to workers.

The licensee concluded that based on the acceptable results from conservative fracture mechanics analyses for these welds and the hardship associated with examination from the outside diameter of the weld and additional removal of the core barrel within a 10-year period, there is no compensating increase in quality or safety by performing the required inspection every 7 years as opposed to every 10 years.

3.6 Duration of Proposed Alternative

The licensee requested that the NRC authorize the alternative for the remainder of the fifth 10-year ISI intervals for Oconee 1 and 2, which end on July 15, 2024.

3.7 NRC Staff's Technical Evaluation

The NRC staff has reviewed and evaluated the licensee's request 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. The applicable ASME BPV Code requirement is the qualified volumetric inspection of the subject welds within 7 years of the previous qualified volumetric inspection. This requirement, which is in ASME BPV Code Case N-770-2, is based on a general assessment of the necessary qualified volumetric inspection frequency for all cold leg operating temperature DMBWs of any size in the reactor coolant system to maintain structural integrity. Under this inspection requirement, the welds are expected to have no previous indications of PWSCC nor to have been mitigated against PWSCC. The NRC staff confirms that the licensee-identified DMBWs that are the subject of the proposed alternative are applicable to this inspection category and technical basis for qualified volumetric inspection frequency.

The licensee identified two hardships associated with the performance of the qualified volumetric inspection frequency within the required 7 years. The licensee explained that performance of the qualified volumetric examination from the inside diameter would require access via removal of the reactor pressure vessel core barrel. The NRC staff finds that an additional evolution to remove the core barrel increases risk of damage to the vessel or the core barrel. The NRC staff notes that while this activity can be done remotely, the activity would still impose additional radiological dose for personnel. Therefore, the NRC staff finds that the additional removal of the core barrel for inside diameter access for the required volumetric inspection of these welds is a hardship. The licensee would also have the option of performing the qualified volumetric examination from the outside diameter of the subject DMBWs. However, the licensee has identified that the outer surfaces of the subject DMBWs are confined within an approximately 3-foot wide reactor vessel annulus and underneath the annulus shield blocks. The licensee also noted that the inspection of the subject DMBWs from the outside diameter would result in significant dose for the inspectors. Historically, the NRC staff has found that physical limitations and high radiological dose rates constitute hardships in performing these types of outside diameter volumetric inspections. Therefore, the NRC staff

finds that the performance of the required volumetric inspection of these welds from the outside diameter is a hardship. Given these licensee-identified hardships, the NRC staff finds that the licensee has demonstrated an overall hardship in performing the volumetric examinations within the required inspection frequency of 7 years.

The NRC staff reviewed the quality and safety impact of the licensee's proposed alternative to allow a 3-year delay in the qualified volumetric examination beyond the current regulatory requirement of 7 years. As part of this analysis, the NRC staff reviewed the licensee's technical basis regarding past operating history, fabrication history, and plant specific flaw analysis. Furthermore, the NRC staff performed a flaw evaluation for the subject welds to verify the conclusions of the licensee's analysis. Finally, the NRC staff considered qualitative risk insights and engineering judgment to assist in reaching the overall NRC staff final conclusions.

In support of the proposed alternative, the licensee provided the previous inspection history of these welds, including the previous finding of no reportable PWSCC indications. The NRC staff notes that while this information is necessary to ensure the correct classification of the inspection category of the welds, the required volumetric inspection frequency is based on the past performance of qualified inspections, which found no indications of PWSCC. Therefore, the NRC staff finds that this factor alone does not provide additional basis to support the proposed alternative.

The licensee also identified that there were no weld repairs documented for these welds during initial fabrication. The NRC staff finds some assurance that no repairs were recorded during the fabrication of these welds, but the NRC staff has found that in-process weld repairs were common during the time of the fabrication of these welds, and furthermore that documentation of these types of repairs was not always required. This is noted in the industry guideline for PWSCC flaw growth analysis - Electric Power Research Institute Report, "Materials Reliability Program: Primary Water Stress Corrosion Cracking (PWSCC) Flaw Evaluation Guidance (MRP-287)," dated December 2010. MRP-287 recommends using a 50 percent inside diameter repair in the development of weld residual stress models for DMBWs. The NRC staff notes that the licensee did use a 50 percent inside diameter repair in the development of the weld residual stresses for circumferential flaw growth but did not include this factor in the analysis for axial flaw growth. Therefore, the NRC staff finds that while the licensee's inputs for the weld residual stress for the circumferential flaw analysis were in accordance with industry recommended guidelines, the axial flaw analysis was not.

The licensee performed both an axial and circumferential flaw analysis to support the extension of the required volumetric inspection frequency from 7 years to 10 years. The purpose of these analyses is to state that a hypothetical PWSCC flaw will not grow to an unacceptable size within the period of extended inspection frequency of 10 years. The NRC staff reviewed the licensee's flaw analyses' inputs and, with the previously-noted exception of weld residual stress for axial flaw growth, finds the licensee's inputs are acceptable. The licensee's analysis documented the time for a flaw to meet an ASME BPV Code limit of 75 percent through-wall depth of the weld. The licensee's most limiting analysis found that an axial flaw would take 11.0 years to reach 75 percent through-wall depth, and a circumferential flaw would take 10.4 years to reach 75 percent through-wall depth. The NRC staff notes that these times are for a flaw to grow to 75 percent through-wall and would take longer to cause a leak from the weld and longer still to cause failure of the structural integrity of the weld. The NRC staff finds that the growth of a circumferential flaw could result in a loss of structural integrity because a circumferential flaw can grow around the weld, and it could lead to a guillotine break in the pipe. Alternatively, given that PWSCC does not propagate through either the stainless steel or low alloy steel adjacent to

the weld, the NRC staff recognizes that axial flaws cannot grow sufficiently in length to cause a rupture of the weld and adjacent piping system in a DMBW. The NRC staff's review of the licensee's flaw analysis finds it is conservative for circumferential flaw growth and potentially non-conservative for axial flaw growth. Given these failure mechanisms, the NRC staff finds the licensee's flaw analysis demonstrates structural integrity of the subject DMBWs will be maintained if the volumetric inspection frequency is extended from 7 to 10 years.

The NRC staff also performed a series of flaw evaluations to evaluate the licensee's analysis. The NRC staff also performed sensitivity analyses to determine the margin to leakage and rupture of the subject DMBWs. The NRC staff recognizes that there are significant uncertainties in the performance of these flaw analyses. Conservative assumptions are used to address these uncertainties. The level of conservatism applied can significantly affect the results. As a result, variations in results should not be viewed as either correct or incorrect but rather as an input to the overall assessment of the licensee's proposed alternative. The NRC staff's calculations utilize the MRP-287 guidelines, licensee inputs, and industry inputs for sensitivity analyses. The NRC staff calculation results find that leakage from an axial flaw is possible over the period of the licensee's requested volumetric inspection extension to 10 years. The NRC staff calculations for circumferential flaws confirmed the licensee's conclusion that structural integrity would be maintained during the period of the licensee's requested volumetric inspection extension to 10 years. Furthermore, the NRC staff's sensitivity analysis confirmed significant margin for time to rupture beyond the 10-year time frame even under earthquake loading conditions. In summary, the NRC staff calculations did not confirm the licensee's results for axial flaw growth in that the NRC analysis found leakage was possible during the period of extended inspection frequency. However, the NRC staff calculations did verify that structural integrity would be maintained by the subject DMBWs with significant margin for the licensee's proposed inspection interval.

Finally, the NRC staff considered the following risk insights to evaluate the results of the NRC staff calculations and review: licensee-provided inspection history of the subject welds, including previous finding of no reportable PWSCC indications; NRC staff conclusions regarding PWSCC propagation and axial flaw growth; and conservative assumptions used in the NRC staff's flaw evaluations that account for analysis uncertainties. From a safety perspective, the NRC staff notes that the degradation mechanism of concern is PWSCC. As noted previously, only circumferential PWSCC flaws can challenge the structural integrity of the DMBWs. While the NRC staff analysis found that axial PWSCC flaws could cause leakage during the period of extended inspection interval, these axial flaws would be limited in size by the width of the weld. Beyond the weld, the base material of the pipe and nozzle are not susceptible to PWSCC. Furthermore, PWSCC flaws are very tight intergranular flaws that have limited leak rates such that no concerns for a loss-of-coolant accident could occur simply because of an axial PWSCC flaw in a DMBW. Additionally, the NRC staff notes that there are several conservative assumptions in the flaw analyses performed both by the licensee and the NRC staff. The primary conservatism among both evaluations is that an axial flaw of 10 percent depth has already initiated and is growing immediately after the last volumetric inspection. While NRC staff recognizes that the hypothetical axial flaw could cause leakage during the proposed inspection interval, the NRC staff finds that this consequence is unlikely based on the conservative assumption that an axial flaw has already initiated of a precise size to be missed by a qualified volumetric exam and in a tensile stress state that would allow continued growth. Furthermore, the NRC staff notes that volumetric inspections are not the only method used by licensees to assess structural integrity of the subject welds. Plant walkdowns and plant leakage monitoring systems also provide defense-in-depth measures to assess the leak tight integrity of the subject welds. Therefore, the NRC staff finds, through an analysis using risk insights and

engineering judgment, that the licensee's proposed alternative has a minimal, if any, impact on safety.

Given the licensee's identified hardship and the NRC staff's assessment of the volumetric inspection frequency extension of 3 years, the NRC staff finds the licensee's proposed alternative is acceptable 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.

4.0 CONCLUSION

As set forth above, the NRC staff determines that the licensee has demonstrated the proposed alternative in Relief Request No. 17-ON-001 provides reasonable assurance of structural integrity of the subject components and that complying with the specified ASME BPV Code requirements 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 the use of Relief Request No. 17-ON-001 at Oconee 1 and 2 for the remainder of the fifth 10-year ISI intervals, which are scheduled to end on July 15, 2024.

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

Principal Contributors: J. Collins, NRR/MPHB
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Date: April 13, 2018

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1 AND 2 – SAFETY EVALUATION FOR RELIEF REQUEST NO. 17-ON-001 (EPID L-2017-LLR-0099) DATED APRIL 13, 2018

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