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

September 17, 2019

Mr. Steve Snider
Vice President
Nuclear Engineering
Duke Energy
526 South Church Street, EC-07H
Charlotte, NC 28202

SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2; CATAWBA NUCLEAR STATION, UNITS 1 AND 2; H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT 2; MCGUIRE NUCLEAR STATION, UNITS 1 AND 2; OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3; AND SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1 — ALTERNATIVE TO USE ENCODED PHASED ARRAY ULTRASONIC EXAMINATION IN LIEU OF RADIOGRAPHY (EPID L-2019-LLR-0046)

Dear Mr. Snider:

By letter dated May 23, 2019, Duke Energy Carolinas, LLC and Duke Energy Progress, LLC (the licensee) submitted Relief Request 19-GO-001 for the use of an alternative to the requirements of the American Society of Mechanical Engineers Boiler & Pressure Vessel Code (ASME Code) at Brunswick Steam Electric Plant, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2; H. B. Robinson Steam Electric Plant, Unit 2; McGuire Nuclear Station, Units 1 and 2; Oconee Nuclear Station, Units 1, 2, and 3; and Shearon Harris Nuclear Power Plant, Unit 1. The proposed alternative to ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," paragraph IWA-4221 and subsubarticle IWA-4520, uses phased array ultrasonic testing in lieu of the required radiographic testing in the examination of welds in ferritic and austenitic piping as part of repair and replacement activities.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee requested to use the alternative on the basis that it will provide an acceptable level of quality and safety.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the subject request 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)(1). Therefore, the NRC staff authorizes the use of the proposed alternative for the facilities requested in the licensee's request for the duration of the applicable 10-year inservice inspection intervals.

If you have any questions, please contact the Duke Fleet Project Manager, Dennis Galvin, at 301-415-6256 or by e-mail to Dennis Galvin@nrc.gov.

Sincerely,

/RA Andrew Hon for/

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

Docket Nos. 50-413, 50-414, 50-369, 50-370, 50-269, 50-270, 50-287, 50-324, 50-325, 50-400, and 50-261

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELIEF REQUEST 19-GO-001
PROPOSED ALTERNATIVE TO USE ENCODED PHASED ARRAY ULTRASONIC TESTING IN LIEU OF RADIOGRAPHIC TESTING FOR FERRITIC OR AUSTENITIC PIPING WELDS
CATAWBA NUCLEAR STATION, UNITS 1 AND 2
MCGUIRE NUCLEAR STATION, UNITS 1 AND 2
OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3
BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2
SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1
H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT 2
DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC
DOCKET NOS. 50-413, 50-414, 50-369, 50-370, 50-269, 50-270, 50-287, 50-325, 50-324, 50-400, AND 50-261

1.0 INTRODUCTION

By letter dated May 23, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19143A072), Duke Energy Carolinas, LLC and Duke Energy Progress, LLC (the licensee) submitted Relief Request 19-GO-001 to request the use of an alternative to the requirements of the American Society of Mechanical Engineers Boiler & Pressure Vessel Code (ASME Code) at Brunswick Steam Electric Plant, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2; H. B. Robinson Steam Electric Plant, Unit 2; McGuire Nuclear Station, Units 1 and 2; Oconee Nuclear Station, Units 1, 2, and 3; and Shearon Harris Nuclear Power Plant, Unit 1. The proposed alternative to ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," paragraph IWA-4221 and subsubarticle IWA-4520, uses phased array ultrasonic testing (PAUT) in lieu of the required radiographic testing (RT) in the examination of welds in ferritic and austenitic piping as part of repair and replacement activities.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(1), the licensee requested to use the alternative on the basis that it will provide an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(z)(1), the licensee is proposing an alternative to paragraph IWA-4221 and subsubarticle IWA-4520 of the 2007 Edition with the 2008 Addendum of the ASME Code, Section XI.

The regulations in 10 CFR 50.55a(g)(4) state, in part, that 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 applicable editions and addenda of the ASME Code, Section XI, to the extent practical, within the limitations of design, geometry, and materials of construction of the components. ASME Code, Section XI, covers preservice inspection and inservice inspection (ISI) requirements for nuclear power plant components.

The regulations in 10 CFR 50.55a(z) state, in part, that alternatives to the requirements in paragraphs (b) through (h) of 10 CFR 50.55a may be used, when authorized by the U.S. Nuclear Regulatory Commission (NRC or Commission) if: (1) the proposed alternative would provide an acceptable level of quality and safety; or (2) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

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 for the Commission to authorize, the alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Relief Request 19-GO-001

3.1.1 ASME Code Component(s) Affected

All ASME Code, Section XI, ferritic and austenitic piping welds requiring radiography during repair/replacement activities at plants identified in Table 1.

3.1.2 Applicable Code Edition and Addenda

The applicable code of record is the ASME Code, Section XI, 2007 Edition with the 2008 Addenda. The ISI interval for the subject plants are identified in the below table.

Table 1

Plant/Unit(s)	ISI Interval	Interval Start Date	Current Interval End Date
Brunswick Steam Electric Plant, Units 1 and 2	Fifth	05/11/2018	05/10/2028
Catawba Nuclear Station Units, 1 and 2	Fourth	08/19/2015 (Unit 1) 08/19/2015 (Unit 2)	12/06/2024 (Unit 1) 02/24/2026 (Unit 2)
H. B. Robinson Steam Electric Plant, Unit 2	Fifth	07/21/2012	02/19/2023
McGuire Nuclear Station, Units 1 and 2	Fourth	12/01/2011 (Unit 1) 07/15/2014 (Unit 2)	11/30/2021 (Unit 1) 12/14/2024 (Unit 2)

Plant/Unit(s)	ISI Interval	Interval Start Date	Current Interval End Date
Oconee Nuclear Station Units 1, 2 and 3	Fifth	07/15/2014	07/15/2024
Shearon Harris Nuclear Power Plant Unit 1	Fourth	09/09/2017	09/08/2027

3.1.3 Applicable Code Requirements

Paragraph IWA-4221 of the 2007 Edition with the 2008 Addendum of the ASME Code, Section XI, requires the owner to meet the applicable construction code requirements when performing repair and replacement activities.

Subsubarticle IWA-4520 of the 2007 Edition with the 2008 Addendum requires that welding or brazing areas and welded joints made for fabrication or installation of items be examined in accordance with the construction code identified in the repair/replacement plan with certain specified exceptions.

3.1.4 Reason for Request

The licensee stated that replacement of piping is periodically performed in support of the flow-accelerated corrosion program, as well as other repair and replacement activities. The use of encoded PAUT in lieu of RT to perform the required examinations of the repaired or replaced welds would eliminate the safety risk associated with performing RT, which includes planned exposure and the potential for accidental personnel exposure to plant workers. PAUT also minimizes the impact on other outage activities normally involved with performing RT, such as limited access to work.

In addition, the licensee stated that encoded PAUT is equivalent or superior to the Code-required RT examination for ASME ferritic and austenitic piping repair/replacement welds for detecting and sizing critical (planar) flaws, such as cracks and lack of fusion. PAUT provides sizing capabilities for both depth and length dimensions of the flaw, which are required to apply the acceptance criteria of the applicable code case. RT does not provide depth sizing capabilities.

3.1.5 Proposed Alternative

The licensee proposed to perform encoded PAUT in lieu of RT. Important aspects of the proposed alternative include:

- The examinations will be spatially encoded, and the data will be recorded.
- The licensee will store the electronic data files for the encoded PAUT as archival-quality records permitting offline analysis of images built from the data.
- The examination volume shall include 100 percent of the weld volume and the weld-to-base metal interface.
- All detected axial and circumferential flaws shall be evaluated as planar flaws and compared to the preservice acceptance standards for volumetric examination in accordance with ASME Code, Section XI, Articles IWB-3000, IWC-3000, or IWD-3000, as applicable.
- The written ultrasonic examination procedure will be qualified by performance demonstration.

- Ultrasonic examination personnel shall be qualified to detect and size flaws with the qualified procedure using blind performance demonstration testing.

The proposed alternative is based on and very similar to ASME Code Case N-831-1, "Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic or Austenitic Pipe Section XI, Division 1."

3.1.6 Basis for Use

The licensee stated that the basis for this proposed alternative is that encoded PAUT is equivalent or superior to RT for detecting and sizing critical (planar) flaws. In this regard, the basis for the proposed alternative was developed from numerous codes, code cases, relevant industry experience, articles, and the results of RT and encoded PAUT examinations.

The examination procedure and personnel performing examinations are qualified using representative piping conditions and flaws that demonstrate the ability to detect and size flaws that are both acceptable and unacceptable to the defined acceptance standards.

3.1.7 Duration of Proposed Alternative

The licensee is requesting approval of this proposed alternative for the remainder of the 10-year ISI intervals shown in Table 1 above.

3.2 NRC Staff Evaluation

The NRC staff evaluated Relief Request 19-GO-001 pursuant to 10 CFR 50.55a(z)(1), that the proposed alternative provides an acceptable level of quality and safety. In evaluating the licensee's proposed alternative, the NRC staff focused on the following aspects of the licensee's basis: (1) effectiveness of encoded PAUT on the repair/replacement weld inspection, and (2) assurance of detection of structurally-significant fabrication flaws in ferritic steel or austenitic stainless steel piping weld by encoded PAUT. The NRC staff finds that if these two criteria are met, then the proposed alternative provides an acceptable level of quality and safety.

For its review, the NRC staff utilized NUREG/CR-7204, "Applying Ultrasonic Testing In Lieu of Radiography for Volumetric Examination of Carbon Steel Piping," published September 2015 (ADAMS Accession No. ML15253A674), and ASME Code Case N-831-1, "Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic or Austenitic Pipe Section XI, Division 1," as guidance.

In the proposed rule to revise 10 CFR 50.55a, published in the *Federal Register* on August 16, 2018 (83 FR 40685), the NRC staff proposed to approve the related ASME Code Case N-831, "Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic Pipe Section XI, Division 1," by inclusion in draft NRC Regulatory Guide 1.147, Revision 19, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," with a condition that prohibits its use on new reactor construction. The NRC staff also used ASME Code Case N-831 as guidance in reviewing the submittal.

(1) Effectiveness of Encoded PAUT in Lieu of RT for Repair/Replacement Weld Inspection

Since 2009, the NRC has been assessing the effectiveness of use of the PAUT technique in lieu of the RT technique through literature reviews, detailed evaluations of previous relief requests,

and confirmatory experimental work to validate findings. While each technique is capable of detecting a spectrum of flaws resulting from fabrication welding processes, the differences in physical/material interactions can make one technique more sensitive to certain fabrication flaw types than the other technique. In NUREG/CR-7204, the NRC staff concluded that the encoded PAUT technique, as compared to RT, provides an equally effective examination for identifying the presence of fabrication flaws in the ferritic steel piping welds; however, the encoded PAUT is more effective for detection of planar flaws than small volumetric flaws (i.e., volumetric flaws with less than 0.15 inch in diameter, which are acceptable per the construction code). Based on this assessment, the NRC staff finds that there is sufficient technical basis for use of the PAUT technique in lieu of the RT technique for the repair/replacement weld inspection.

In June 2017, the Electric Power Research Institute (EPRI) published Technical Report No. 3002010297, "Technical Basis for Substituting Ultrasonic Testing for Radiographic Testing for New, Repaired, and Replacement Welds for ASME Section XI, Division 1, Stainless Steel Piping." The report summarizes the EPRI's performance-based approach based on ASME Code, Section XI, Appendix VIII, to demonstrate the effectiveness of the encoded PAUT for detection and sizing fabrication flaws in the austenitic stainless steel piping welds. Mockups containing representative welding fabrication flaws were fabricated for the performance demonstration. The flaw distribution included both rejectable and acceptable sized flaws in accordance with the acceptance standards of IWB-3514 and flaw characterization figures of IWA-3300 of the ASME Code, Section XI. The performance demonstration initiative (PDI) generic procedures PDI-UT-2 and PDI-UT-3 were utilized for examination and flaw sizing. EPRI showed that (1) the encoded PAUT is an effective technique as compared to RT for detection and sizing fabrication flaws within the ferritic steel or austenitic stainless steel welds, and (2) the ASME Code, Section XI, Appendix VIII, root mean square error criteria for flaw length and depth sizing were met.

Based on the above studies, the NRC staff finds that there is enough technical basis for the use of encoded PAUT in lieu of RT for repair/replacement inspection of the ferritic steel or austenitic stainless steel piping welds. The encoded PAUT as compared to RT, was shown to be an effective technique for both detection and characterization of fabrication flaws in the repaired/replaced ferritic steel or austenitic stainless steel piping welds.

(2) Assurance of Detection of Structurally-Significant Fabrication Flaws

In evaluating the licensee's proposed alternative requirements, the NRC staff assessed the adequacy of the licensee's technical basis, which includes: (1) the performance demonstration and qualification of the encoded PAUT, (2) achieving 100 percent coverage of the examination volume, and (3) flaw acceptance criteria. The NRC staff verified that:

- The licensee will examine 100 percent of the weld volume and the weld-to-base-metal interface.

- The licensee will perform the encoded PAUT using procedures, equipment, and personnel qualified by performance demonstration.

- The procedures will be demonstrated by using either a blind test or a nonblind test. The demonstration specimen set will include a minimum of 30 flaws covering a range of sizes, positions, orientations, and types of fabrication flaws. The demonstration set will include specimens to represent the minimum and maximum diameter and thickness covered by the procedure.

- Personnel will be qualified for detection and sizing fabrication flaws by performance demonstration using the qualified procedure. The personnel performance demonstration will be conducted using a blind test (i.e., the flaw information is not provided). The demonstration specimen set will contain at least 10 flaws covering a range of sizes, positions, orientations, and types of fabrication flaws.

- The demonstration specimens will include both planar and volumetric fabrication flaws (e.g., lack of fusion, crack, incomplete penetration, slag inclusions) representative of the welding process. The flaws will be distributed throughout the examination volume. The flaw through-wall heights for the performance demonstration will be based on the preservice acceptance standards for volumetric examination in accordance with the ASME Code, Section XI, IWB-3400, IWC-3400, or IWD-3400, as applicable. At least 30 percent of the flaws will be classified as acceptable planar flaws, with the smallest flaws being at least 50 percent of the maximum allowable size based on the applicable aspect ratio for the flaw.

- Personnel will be qualified for flaw length sizing when the root mean square error (RMSE) of the flaw lengths estimated by ultrasonic examinations, as compared with the true lengths, does not exceed 0.25 inch for nominal pipe size of 6 inches and smaller, and 0.75-inch for pipe diameter larger than nominal pipe size of 6 inches.

- Personnel will be qualified for flaw through-wall height sizing when the RMSE of the flaw through-wall heights estimated by ultrasonic examinations, as compared with the true through-wall heights, does not exceed 0.125-inch.

- The licensee will treat all flaws detected using angle-beam ultrasonic inspections as planar flaws and will evaluate the flaws against the preservice acceptance standards in the ASME Code, Section XI, IWB-3400, IWC-3400, or IWD-3400, as applicable.

- The licensee will store the electronic data files for the encoded PAUT as archival-quality records permitting offline analysis of images built from the data.

For the above reasons, the NRC staff finds that the licensee's proposed performance demonstration for the encoded PAUT, which includes procedures demonstration and personnel qualification, is adequate because it is either consistent with or exceeds the provisions in the ASME Code, Section XI, Appendix VIII, for the ferritic steel or austenitic stainless steel piping welds.

In addition, the NRC staff notes that while IWB-3400, IWC-3400, and IWD-3400 of the ASME Code, Section XI, allow larger flaws to remain in service than that of NB-5330, NC-5330, and ND-5330 of Section III, the use of Section XI acceptance standards has proven to be effective for the inspection of piping welds. The NRC staff finds that the use of the ASME Code, Section XI acceptance standards is appropriate for the proposed alternative, as the alternative is for repair/replacement activities and not for new plant construction. Therefore, the NRC staff determines that the licensee's proposed encoded PAUT for the repair/replacement weld inspection is acceptable because it provides reasonable assurance that any structurally-significant fabrication defects in repaired/replaced welds be detected.

4.0 CONCLUSION

As set forth above, the NRC staff concludes that the licensee's proposed alternative to use PAUT in lieu of RT provides reasonable assurance of structural integrity and leaktightness of ferritic and austenitic piping welds requiring radiography during repair/replacement activities. Thus, ultrasonic examination using the procedure described in Relief Request 19-GO-001 will provide an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the use of Relief Request 19-GO-001 for the remainder of the fourth 10-year ISI interval for Catawba Nuclear Station, Units 1 and 2; McGuire Nuclear Station, Units 1 and 2; and Shearon Harris Nuclear Power Plant, Unit 1; and for the remainder of the fifth 10-year ISI interval for Brunswick Steam Electric Plant, Units 1 and 2; H. B. Robinson Steam Electric Plant, Unit 2; and Oconee Nuclear Station, Units 1, 2, and 3.

The NRC staff notes that the approval of Relief Request 19-GO-001 does not imply or infer the NRC approval of ASME Code Case N-831-1 for generic use.

All other requirements of the ASME Code for which relief has not been specifically requested remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: S. Cumblidge

Date: September 17, 2019

SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2; CATAWBA NUCLEAR STATION, UNITS 1 AND 2; H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT 2; MCGUIRE NUCLEAR STATION, UNITS 1 AND 2; OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3; AND SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1 — ALTERNATIVE TO USE ENCODED PHASED ARRAY ULTRASONIC EXAMINATION IN LIEU OF RADIOGRAPHY (EPID L-2019-LLR-0046) DATED SEPTEMBER 17, 2019

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