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

January 24, 2020

Mr. Daniel G. Stoddard
Senior Vice President and
Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Blvd., Floor: IN-2SW
Glen Allen, VA 29060

SUBJECT: VIRGIL C. SUMMER NUCLEAR STATION, UNIT NO. 1 – RELIEF REQUEST REGARDING USE OF ENCODED PHASED ARRAY ULTRASONIC EXAMINATION TECHNIQUES IN LIEU OF RADIOGRAPHY (RR-4-20) (EPID NO. L-2019-LLR-0069)

Dear Mr. Stoddard:

By letter dated July 17, 2019, Dominion Energy South Carolina, Inc. (DESC, the licensee), submitted an alternative request (RR-4-20) for the Virgil C. Summer Nuclear Station, Unit No. 1 (Summer). The proposed alternative requests approval to use encoded phased array ultrasonic testing (PAUT) as an alternative to radiographic examination as required in the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," Paragraph IWA-4221 and Subsubarticle IWA-4520. The licensee requested to use the alternative for the remainder of the fourth 10-year inservice inspection (ISI) program interval, which began on January 1, 2014, and is scheduled to end on December 31, 2023.

The licensee requested to use the proposed alternative pursuant to Title 10 of the *Code of Federal Regulations* 10 CFR 50.55a(z)(1) on the basis that the alternative provides 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 proposed alternative described in Relief Request No. RR-4-20 provides an acceptable 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)(1). Therefore, the NRC staff authorizes the proposed alternative for the remainder of the fourth 10-year ISI interval at Summer.

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

If you have any questions, please contact the senior project manager, Shawn Williams, at 301-415-1009 or by e-mail at Shawn.Williams@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-395

Enclosure:
Safety Evaluation

cc: Listserv

SUBJECT: VIRGIL C. SUMMER NUCLEAR STATION, UNIT NO. 1 – RELIEF REQUEST REGARDING USE OF ENCODED PHASED ARRAY ULTRASONIC EXAMINATION TECHNIQUES IN LIEU OF RADIOGRAPHY (RR-4-20) (EPID NO. L-2019-LLR-0069) DATED JANUARY 24, 2020

DISTRIBUTION:

PUBLIC
RidsNrrPMSummer Resource
RidsACRS_MailCTR Resource
RidsNrrDorlLpl2-1 Resource
RidsNrrKGoldstein Resource
RidsRgn2MailCenter Resource
RidsNrrdnrlNphp Resource
BFu, NRR

ADAMS Accession No.: ML19361A070

OFFICE	NRR/DORL/LPL2-1/PM	NRR/DORL/LPL2-1/LA	NRR/DNRL/NPHP/BC
NAME	SWilliams	KGoldstein	MMitchell
DATE	1/17/2020	01/15/2020	12/23/2019
OFFICE	NRR/DORL/LPL2-1/BC	NRR/DORL/LPL2-1/PM	
NAME	MMarkley	SWilliams	
DATE	1/24/2020	1/24/2020	

OFFICIAL RECORD COPY

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST RR-4-20

REGARDING USE OF ENCODED PHASED ARRAY ULTRASONIC EXAMINATION

IN LIEU OF RADIOGRAPHY

DOMINION ENERGY SOUTH CAROLINA, INC.

VIRGIL C. SUMMER NUCLEAR STATION, UNIT NO. 1

DOCKET NO. 50-395

1.0 INTRODUCTION

By letter dated July 17, 2019 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML19204A117), Dominion Energy South Carolina, Inc. (DESC, the licensee), submitted alternative request RR-4-20 for the Virgil C. Summer Nuclear Station, Unit No. 1 (Summer). The proposed alternative requests approval to use encoded phased array ultrasonic testing (PAUT) as an alternative to radiographic examination as required in the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," Paragraph IWA-4221 and Subsubarticle IWA-4520.

The licensee requested to use the proposed alternative pursuant to Title 10 of the *Code of Federal Regulations* 10 CFR 50.55a(z)(1) on the basis that the alternative provides an acceptable level of quality and safety.

2.0 REGULATORY REQUIREMENTS

Paragraph 10 CFR 50.55a(g)(4), Inservice inspection standards, requirement for operating plants, states, in part:

> Throughout the service life of a boiling or pressurized water-cooled nuclear power facility, components… (including supports) that are classified as ASME Code Class 1, Class 2, and Class 3 must meet the requirements, except design and access provisions and preservice examination requirements, set forth in Section XI of editions and addenda of the ASME BPV Code (or ASME OM Code for snubber examination and testing) that become effective subsequent to editions specified in paragraphs (g)(2) and (3) of this section and that are incorporated by reference in paragraph (a)(1)(ii) or (iv) for snubber examination and testing of this section, to the extent practical within the limitations of design, geometry, and materials of construction of the components.

Pursuant to 10 CFR 50.55a(z), alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be used when authorized by the Director, Office of Nuclear Reactor Regulation. A proposed alternative must be submitted and authorized prior to implementation. The licensee must demonstrate (1) the proposed alternative would provide an acceptable level of quality and safety; or (2) compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

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 2008 Addenda of the ASME Code, Section XI.

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 Commission to authorize the alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 Proposed Alternative

3.1.1 ASME Code Components Affected

All ASME Code, Section XI, ferritic and austenitic piping welds requiring radiography during repair/replacement activities.

3.1.2 Applicable Code Edition and Addenda

The Code of record for the Fourth 10-year ISI [inservice inspection] interval is the ASME Code, Section XI, 2007 Edition with 2008 Addenda.

3.1.3 Applicable Code Requirements

Paragraph IWA-4221 of the 2007 Edition with 2008 Addenda 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 ASME Code 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:

> Replacement of piping is periodically performed in support of the Flow Accelerated Corrosion (FAC) program as well as other repair and replacement activities. The use of encoded Phased Array Ultrasonic Examination Techniques (PAUT) in lieu of radiography (RT) to perform the required examinations of the replaced welds would eliminate the safety risk associated with performing RT, which includes both planned and unplanned radiation exposure to plant workers. PAUT also minimizes the impact on other outage activities normally involved with

performing RT such as limited access to work locations. In addition, 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 Licensee's Proposed Alternative

The licensee proposed to perform encoded PAUT in lieu of the code-required RT examination for ASME ferritic and austentitic piping repair/replacement welds. Aspects of the proposed alternative, as stated, in part, by the licensee, include:

- A written ultrasonic examination procedure qualified by performance demonstration shall be used.
- Ultrasonic examination personnel shall be qualified in accordance with IWA-2300. In addition, examination personnel shall demonstrate their capability to detect and size flaws by performance demonstration, using the qualified procedure…"
- The personnel performance demonstration shall be conducted in a blind fashion (flaw information is not provided).
- The examination volume shall include 100% of the weld volume and the weld-to-base metal interface.
- All detected flaws from (d)(1) [Angle beam examination of the complete examination volume for fabrication flaws oriented parallel to the weld joint] and (d)(2) [Angle beam examination for fabrication flaws oriented transverse to the weld joint] above shall be considered planar flaws and shall be compared to the preservice acceptance standards for volumetric examination in accordance with Article IWB-3000, IWC-3000, or IWD-3000, as applicable.
- The ultrasonic examination shall be performed using encoded UT [ultrasonic testing] technology that produces an electronic record of the ultrasonic responses indexed to the probe position, permitting off-line analysis of images built from the combined data. Where component configuration does not allow for effective examination for transverse flaws (e.g., pipe-to-valve, tapered weld transition, weld shrinkage), use of non-encoded UT technology may be used for transverse flaws. The basis for the non-encoded examination shall be documented.

3.1.6 Basis for Use

The licensee stated:

> 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, associated industry experience, articles, and the results of RT and encoded PAUT examinations. The examination procedure and personnel performing examinations will be 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. The demonstration of the examination procedure and personnel's ability to

appropriately detect and size flaws will provide an acceptable level of quality and safety alternative as allowed by 10 CFR 50.55a(z)(1).

3.1.7 Duration of Proposed Alternative

The licensee is requesting approval of the proposed alternative for the remainder of the Fourth 10-year ISI interval, which commenced on January 1, 2014, and is scheduled to end on December 31, 2023.

3.2 NRC Staff Evaluation

The NRC staff evaluated the propose alternative pursuant to 10 CFR 50.55a(z)(1) to determine if the proposed alternative provides an acceptable level of quality and safety. The proposed alternative is based on and very similar to the provisions of ASME Code Case N-831-1, "Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic or Austenitic Pipe Section XI, Division 1."

Ultrasonic testing, like RT, is a volumetric inspection technique that is commonly used to inspect welds in nuclear power plants and in other industries. Ultrasonic examinations are not the same as radiographic examinations as they use different physical mechanisms to detect and characterize discontinuities. These differences in physical mechanisms result in several key differences in sensitivity and discrimination capability. The NRC staff reviewed the capabilities and limitations of the application of PAUT in lieu of RT for both ferritic steel welds and austenitic steel welds.

Ferritic Steel Welds

The NRC staff has been assessing the effectiveness of the use of ultrasound in lieu of radiography for ferritic steel welds since 2009, including literature reviews, detailed evaluations of previous relief requests and proposed alternatives, and confirmatory experimental work to validate the findings. An assessment of the use of UT in lieu of RT by the NRC is described in the 2015 document NUREG/CR-7204, "Applying Ultrasonic Testing In Lieu of Radiography for Volumetric Examination of Carbon Steel Piping" (ADAMS Accession No. ML15253A674). This report included evaluation of the use of UT in lieu of RT for ferritic steel welded pipes and plates with thicknesses ranging from 0.844 inches to 2.2 inches.

In NUREG/CR-7204, the NRC staff stated that:

> Considering overall detections/non-detections for the piping specimens, as well as the Navy plates, it appears that PA-UT [phased array ultrasonic inspection], based on the techniques applied in this study, provides an equally effective examination for identifying the presence of fabrication flaws in carbon steel welds. The PA-UT parameters applied were shown to be more effective for planar flaws, but slightly less effective for small volumetric flaws, than RT.

Based on this research, the NRC staff finds that there is sufficient technical basis to support the use of UT in lieu of RT for ferritic steel welds. While the spatial resolving power of UT is lower than that of RT, the UT methods can provide more contrast (signal-to-noise ratio in UT) than RT. UT has a higher sensitivity to planar flaws and similar sensitivity to volumetric flaws and can detect cracks and lack of fusion defects more effectively than simple RT. The higher spatial

resolving power of RT allows RT to effectively discriminate between different types of planar and volumetric flaws. RT provides a clear image of many flaws, allowing the examiner to distinguish between slag, porosity, undercut, and cracks by looking at the image. UT generally presents all indications as similar-looking regions, and multiple inspection angles are required to distinguish planar flaws from volumetric flaws, and different types of volumetric flaws provide nearly identical indications to UT techniques. In ferritic materials, advanced PAUT methods can detect, size and differentiate between planar flaws such as cracks and lack of fusion defects and volumetric flaws such as slag and porosity.

Austenitic Steel Welds

The Electric Power Research Institute (EPRI) Technical Report (TP) 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," (June 2017) summarizes EPRI's performance-based approach based on the 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.

When compared to ferritic steel materials, the primary difference is that the ability to discriminate between planar and volumetric flaws has not been demonstrated for the more challenging austenitic materials. Austenitic welds have larger grain sizes than ferritic welds, and the austenitic weld grains are anisotropic, meaning that sound goes faster in some crystalline directions than others. These large anisotropic grains can redirect the ultrasonic beam and provide reflections, creating increased noise. While detection and sizing of flaws is possible in an austenitic weld, it is significantly more challenging to discriminate between a volumetric flaw and a planar flaw. For this reason, the licensee proposed alternative does not discriminate between a volumetric flaw and a planar flaw. All flaws detected using angle-beam UT will be treated as planar flaws and will be evaluated against the preservice acceptance standards of ASME Section XI, IWB-3400, IWC-3400, or IWD-3400 for ASME Code Class 1, 2, or 3 welds, respectively. Since it is not necessary to differentiate between planar and volumetric flaws, the primary weakness of UT, in lieu of RT in austenitic welds, is mitigated.

Given the above, the NRC staff evaluated if the proposed alternative applies UT such that it provides reasonable assurance of finding structurally-significant flaws. The NRC staff notes the following important aspects of its evaluation:

- Ultrasonic examination procedures shall be qualified by using either a blind or a non-blind performance demonstration using a minimum of 30 flaws covering a range of sizes, positions, orientations, and types of fabrication flaws. The demonstration set shall include specimens to represent the minimum and maximum diameter and thickness covered by the procedure.

- The flaw through-wall heights for the performance demonstration testing shall be based on the applicable acceptance standards for volumetric examination in accordance with IWB-3400, IWC-3400 or IWD-3400. At least 30 percent of the flaws shall be classified as acceptable planar flaws, with the smallest flaws being at least 50 percent of the maximum allowable size based on the applicable a/l aspect ratio for the flaw.

- The examination volume shall include 100 percent of the weld volume and the weld-to-base metal interface.

- The electronic data files for the PAUT examinations will be stored as archival-quality records. In addition, hard copy prints of the data will be included as part of the PAUT examination records to allow viewing without the use of hardware or software.

- Ultrasonic examination personnel shall demonstrate their capability to detect and size flaws by performance demonstration using the qualified procedure. The demonstration specimen set shall contain at least 10 flaws covering a range of sizes, positions, orientations, and types of fabrication flaws.

3.3 NRC Staff Conclusion

Based on the inspection and qualification requirements described in the licensee's request for alternative and the evaluation results reported in NUREG/CR-7204 and EPRI Technical Report No. 3002010297, the NRC staff concludes that there is reasonable assurance that the encoded PAUT, applied and qualified as proposed by the licensee, will provide an adequate level of quality and safety because (1) in ferritic steel welds, encoded PAUT provides capability for detection and sizing fabrication flaws, and (2) in austenitic steel welds, all flaws similarly detected by encoded PAUT will be treated as planer flaws and will subsequently be evaluated against appropriate preservice acceptance standards. Therefore, the staff finds the licensee's proposed alternative acceptable.

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 leak tightness of ferritic and austenitic piping welds requiring radiography during repair/replacement activities. Thus, ultrasonic examination using the procedure described in Proposed Alternative RR-4-20 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 Proposed Alternative RR-4-20 for the remainder of the Fourth 10-year ISI interval for Summer.

The NRC staff notes that the approval of Proposed Alternative RR-4-20 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: B. Fu, NRR

Date: January 24, 2020