

SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS
ALTERNATIVE REQUEST REGARDING PRESERVICE INSPECTION REQUIREMENTS FOR
STEAM GENERATOR NOZZLE TO REACTOR COOLANT PUMP CASING WELDS
SOUTH CAROLINA ELECTRIC AND GAS COMPANY
SOUTH CAROLINA PUBLIC SERVICE AUTHORITY
VIRGIL C. SUMMER NUCLEAR STATION UNITS 2 AND 3
DOCKET NOS. 52-027 AND 52-028

1.0 INTRODUCTION

By letter dated July 7, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16189A312), South Carolina Electric & Gas Company (SCE&G, the licensee), acting on behalf of itself and the South Carolina Public Service Authority, submitted Virgil C. Summer Nuclear Station (VCSNS), Units 2 and 3 – Request for Alternative: Preservice Inspection Requirements for Steam Generator Nozzle to Reactor Coolant Pump Casing Welds to the U.S. Nuclear Regulatory Commission (NRC) for review and approval. In the letter, the licensee requested authorization to use an alternative, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z), to the requirements of the 2007 Edition, including the 2008 Addenda, of American Society of Mechanical Engineers (ASME) Section XI, IWB-2500 for VCSNS Units 2 and 3. Specifically, the licensee’s request would allow the preservice examination of the AP1000 steam generator (SG) nozzle to reactor coolant (RCP) pump casing butt welds (hereafter referred to as SG-to-RCP welds) to be performed in accordance with the 2013 Edition of ASME Section XI.

2.0 REGULATORY EVALUATION

The regulations in 10 CFR 50.55a require that ASME Code Class 1 components (including their supports) meet the preservice examination requirements set forth in either the edition and addenda of ASME Section XI applied to the construction of the component, or in subsequent editions and addenda that have been incorporated by reference into 10 CFR 50.55a. Per 10 CFR 50.55a(z), alternatives to the requirements of 10 CFR 50.55a may be used when authorized by the Commission. In proposing alternatives, the licensee must demonstrate that: (1) the proposed alternative would provide an acceptable level of quality and safety; or (2) compliance would result in hardship or unusual difficulty without a compensating increase in quality and safety.

In its letter dated July 7, 2016, the licensee determined that the 2007 Edition, including the 2008 Addenda, of ASME Section XI does not provide examination requirements for the SG-to-RCP welds. To address this issue, pursuant to 10 CFR 50.55a(z)(1), the licensee proposes to use the examination requirements stipulated in the 2013 Edition of ASME Section XI, IWB-2500 to examine the SG-to-RCP welds prior to initial plant startup.

3.0 EVALUATION OF THE ALTERNATIVE

3.1 Items for Which an Alternative is Requested

The components affected by this request are the AP1000 SGs and RCPs. The AP1000 design uses four RCPs. Two pumps are coupled with each SG. The AP1000 design is unique in that a RCP is directly connected to each of the two outlet nozzles on the SG channel head. The dissimilar metal circumferential butt weld joining the two components is part of the reactor coolant pressure boundary and is therefore classified as ASME Code Class 1.

3.2 Applicable Code Requirements

The regulations in 10 CFR 50.55a require that ASME Code Class 1 components (including their supports) meet the preservice examination requirements set forth in either the edition and addenda of ASME Section XI applied to the construction of the component, or in subsequent editions and addenda that have been incorporated by reference in 10 CFR 50.55a. The ASME Code of Record for the preservice inspection of VCSNS Units 2 and 3 is the 2007 Edition, including the 2008 Addenda, of ASME Section XI. The inspection requirements for Class 1 components in the 2007 Edition, including the 2008 Addenda, of ASME Section XI are provided in Subsection IWB. ASME Section XI, Table IWB-2500-1, "Examination Category B-F" provides the required methods of examination for pressure-retaining dissimilar metal welds in vessel nozzles. To provide a baseline for subsequent inservice examinations, ASME Section XI, IWB-2200 requires that all examinations required by ASME Section XI, Table IWB-2500-1 (with the exception of Examination Category B-P and the VT-3 examination of the internal surfaces of Categories B-L-2 and B-M-2) be performed prior to initial plant startup.

3.3 Proposed Alternative

The licensee proposes to use the examination requirements stipulated in the 2013 Edition of ASME Section XI, IWB-2500 for the preservice examination of the SG-to-RCP welds. In addition to the examinations required by the 2013 Edition of ASME Section XI, the licensee proposes to perform an eddy current examination of the welds from the inner diameter (ID) surface and to partially adopt the six NRC proposed conditions on ASME Code Case N-799, "Dissimilar Metal Welds Joining Vessel Nozzles to Components," documented in the *Federal Register*, Volume 81, No. 41, March 2, 2016, Proposed Rules, "Approval of American Society of Mechanical Engineers' Code Cases."

3.4 Basis for the Alternative

The licensee stated that the 2007 Edition, including the 2008 Addenda, of ASME Section XI does not describe requirements for the examination of the SG-to-RCP welds. As such, the licensee proposed to use the examination requirements provided in the 2013 Edition of ASME Section XI. The 2013 Edition of ASME Section XI lists these welds in Table IWB-2500 as Examination Category B-F, Item Number B5.71, "NPS 4 or Larger Nozzle-to-Component Butt Welds." Item Number B5.71 requires the performance of both volumetric and surface examination in accordance with Figure IWB-2500-8.

In its letter, the licensee proposed to perform the examinations required by the 2013 Edition of ASME Section XI, which include a volumetric examination from the ID and a surface examination on the outer diameter (OD). The licensee also stated that the required volumetric examination will be performed using ultrasonic testing (UT) techniques that are qualified in accordance with the Electric Power Research Institute (EPRI) Performance Demonstration Initiative (PDI) Program. Specifically, EPRI designed and fabricated an AP1000 SG-to-RCP weld specimen in accordance with the EPRI/PDI program. The specimen serves as a blind test specimen to qualify the UT procedure as well as the personnel. The UT and personnel qualification are conducted by the PDI program in accordance with ASME Section XI, Appendix VIII.

In addition to meeting the requirements of the 2013 Edition of ASME Section XI, the licensee proposed to perform an eddy current examination of the SG-to-RCP welds from the ID surface. The licensee's proposal states that the eddy current examination will be qualified in accordance with ASME Section V, Article 14 (2007 Edition through the 2008 Addenda). Also, the licensee is proposing to partially adopt the six NRC proposed conditions documented in *Federal Register*, Volume 81, No. 41, March 2, 2016, Proposed Rules, which conditionally accepts Code Case N-799. The staff notes that the examination requirements for the SG-to-RCP welds provided in the 2013 Edition of Section XI were first introduced via Code Case N-799. The six NRC proposed conditions, documented in the *Federal Register*, and the licensee's implementation of those conditions are summarized in Table 1.

Table 1: Licensee's Proposed Application of Proposed NRC Conditions provided in *Federal Register*, Volume 81, No. 41, March 2, 2016, Proposed Rules, "Approval of American Society of Mechanical Engineers' Code Cases"

	Condition Requirement	Licensee's Proposed Action
1	Scanning surfaces have a gap less than 0.032-inch	Meet the condition
2	The examination requirements of ASME Section XI, Mandatory Appendix I, Paragraph I-3200(c) must be applied	Meet the condition
3	Examination of the dissimilar metal welds between reactor vessel nozzles and components, and between steam generator nozzles and pumps must be full volume	Take exception
4	Ultrasonic depth and sizing qualifications for Cast austenitic stainless steel (CASS) components must use the ASME Code requirements in ASME Section XI, Appendix VIII, Supplement 10	Meet the condition
5	The examination's acceptability be based on an ultrasonic examination of the qualified volume and a flaw evaluation of the largest hypothetical crack that could exist in the volume not qualified for ultrasonic examination	Take exception
6	Cracks that are detected but cannot be depth-sized with performance-based procedures, equipment, and personnel qualifications consistent with Section XI, Appendix VIII, shall be repaired or removed	Meet the condition

As described in the table above, the licensee proposes to take exception to two of the six NRC proposed conditions documented in the *Federal Register*. First, the licensee proposes to take exception to the condition requiring the examination of the weld to be full volume. Specifically, the licensee would like approval to perform volumetric examinations of the inner 1/3 of the weld volume, as required by the 2013 Edition of ASME Section XI, and not the entire volume. The licensee states that UT and eddy current testing will be performed from the ID surface and, therefore, the impact of sound beam redirecting will be minimized. The licensee also stated that the full volume of the SG-to-RCP welds have been volumetrically examined using radiographic testing (RT) and UT during fabrication. The RT was performed as required by the Construction Code (ASME Section III) while the UT was imposed by the design organization and performed in accordance with ASME Section V. The UT included in-progress inspections of the buttering material on both the SGs and RCP as well as post-weld inspections of the weld volume using multiple angle beam techniques from both the ID and OD surfaces. The licensee also stated that the post-weld UT results were evaluated against ASME Section III and ASME Section XI standards for acceptance.

In addition, the licensee proposes to take exception to the condition requiring the examination's acceptability be based on an ultrasonic examination of the qualified volume and a flaw evaluation of the largest hypothetical crack that could exist in the volume not qualified for ultrasonic examination. Specifically, the licensee states that this condition is not applicable to the examination that will be performed because the examination procedure to be utilized was qualified on a mock-up representing the full thickness of the weld. As such, detection and length sizing qualification was extended to the full thickness.

The licensee also provided Figures 1 and 2 (in the application) to describe the location of the weld in question and the proposed examination volume.

3.5 NRC Staff Evaluation

10 CFR 50.55a(g)(3) requires that ASME Code Class 1 components (including supports) must meet the preservice examinations set forth in the editions and addenda of ASME Sections III or XI. ASME Section XI, Subsection IWB provides requirements for the preservice and inservice inspection of ASME Code components. As indicated by the licensee, the SG-to-RCP welds are classified as ASME Code Class 1. Therefore, the requirements of ASME Section XI, Subsection IWB must be applied.

However, the examination requirements of the 2007 Edition, including the 2008 Addenda, of ASME Section XI, Table IWB-2500-1 do not include component-to-component welds, such as the AP1000 SG-to-RCP welds. In addition, ASME Section XI, Subsection IWB does not provide any requirements for items not identified in Table IWB-2500-1. Therefore, the staff believes that it is appropriate for the licensee to pursue alternative examination requirements in order to ensure that the pressure-retaining integrity of the aforementioned welds is maintained throughout the operating life of the plant.

In the proposed alternative, the licensee proposed to perform following examinations for the AP1000 SG-to-RCP welds:

- Volumetric and surface examinations required by the 2013 Edition of ASME Section XI, Table IWB-2500-1, Examination Category B-F, Item Number B5.71, "NPS 4 or Larger Nozzle-to-Component Butt Welds," and
- An eddy current examination from the ID surface using methods qualified in accordance with the 2007 Edition, including the 2008 Addenda, of ASME Section V, Article 14.

In addition, the licensee proposed to adopt four of the six NRC proposed conditions provided in the *Federal Register*, Volume 81, No. 41, March 2, 2016, Proposed Rules, which conditionally accepts Code Case N-799. Upon review of the alternative request and all associated documents, the staff identified two issues. First, the licensee did not provide a technical justification to support the proposal to examine only 1/3 of the weld volume in lieu of examining the full weld volume. To resolve this issue, the staff requested that the licensee, at a minimum, provide an analysis which considers the size and nature of the largest potential defect which could be expected to be present in the weld volume that will not be examined as well as the operating loads to which the weld will be subject for the licensed lifetime of the facility. The analysis would be expected to demonstrate that the initiation of active degradation of the weld would not be expected to occur from the largest potential defect in the outer 2/3 of the weld over the licensed lifetime of the facility.

In letters dated February 1, 2017 (ADAMS Accession No. ML17032A212), and February 9, 2017 (ADAMS Accession No. ML17040A488), the applicant provided additional information to support the proposal to examine only 1/3 of the weld volume. Specifically, the licensee described the type and size of fabrication flaws found during RT and UT of the current set of SG-to-RCP welds. The licensee also provided an analysis to show that postulated flaws in the outer 2/3 of the weld would not grow to exceed the size of service flaws allowed by ASME Section XI over the licensed lifetime of the plant. The staff reviewed the type and size of fabrication flaws found in the welds and determined those found by RT were acceptable per ASME Section III and that those found by UT met the acceptance standards of ASME Section XI. The staff also reviewed the licensee's flaw tolerance analysis and determined that it was sufficient to support the alternative because (1) it was performed in accordance with ASME Section XI, and (2) the type and size of postulated flaws analyzed were sufficient to conservatively bound the fabrication flaws found in the welds. On this basis, the staff determined that the information provided was sufficient to support the alternative request.

The second issue identified during the staff's review was that the weld configuration in the licensee's alternative request was different than the weld configuration used to illustrate the examination requirements in the 2013 Edition of ASME Section XI. Specifically, the AP1000 SG-to-RCP weld joints are of a double-sided configuration while the figure in ASME Section XI used to illustrate the examination requirements is for a single-sided weld joint. To resolve this issue, the staff requested that the licensee describe why the examination requirements proposed for a single-sided weld joint are applicable and acceptable for use on the aforementioned welds, which are double-sided. In response dated February 1, 2017 (ADAMS Accession No. ML17032A212), the licensee clarified that Figure 2 in the alternative request shows the proposed exam volume. The licensee also stated that Figure 2 is to scale and that the proposed examination volume captures all of the innermost weld, including the weld and weld end buttering width.

The staff found that the licensee's response was acceptable because (1) the width of the proposed examination volume, which includes the weld, weld end buttering, and base material, was in accordance with the 2013 Edition of ASME Section XI, and(2) the depth of the proposed examination volume includes the root of the weld.

Based on the review described above, the staff finds that the licensee has demonstrated that the proposed alternative provides an acceptable level of quality and safety. This finding is based on the fact that the licensee has described, in detail, the surface and volumetric examinations to be performed. For the weld volume that cannot be volumetrically examined, the licensee has provided an analysis to demonstrate that defects in the region of interest will not exceed the flaw size allowed by ASME Section XI over the licensed lifetime of the plant. This information provides a reasonable assurance that the structural and leaktight integrity of the SG-to-RCP welds will be maintained.

4.0 CONCLUSION

The staff concludes that the proposed alternative to the requirements of the 2007 Edition, including the 2008 Addenda, of ASME Section XI, IWB-2500 is authorized for VCSNS Units 2 and 3, on the basis that the proposed alternative provided an acceptable level of quality and safety. All other requirements of ASME Section XI and 10 CFR 50.55a, for which an alternative has not been specifically requested and authorized, remain applicable.