



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

September 23, 2019

Mr. Joseph W. Shea  
Vice President, Nuclear Regulatory  
Affairs and Support Services  
Tennessee Valley Authority  
1101 Market Street, LP 3R-C  
Chattanooga, TN 37402-2801

SUBJECT: SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2 – ALTERNATIVE  
REQUEST 18-ISI-1 REGARDING EXAMINATION OF DISSIMILAR METAL  
WELDS IN REACTOR VESSEL HEAD (EPID L-2019-LLR-0006)

Dear Mr. Shea:

By letter dated January 30, 2019, as supplemented by letter dated June 19, 2019, Tennessee Valley Authority (TVA, the licensee) requested relief from the examination requirements of Table IWB-2500-1 (Item Nos. B14.20 and B14.21) of the American Society of Mechanical Engineers Boiler & Pressure Vessel Code, Section XI (ASME Code), 2007 Edition with Addenda through 2008, for the welds in the control rod drive and in-core instrumentation housings. TVA also requested relief from the examination requirements of Table 1 (Inspection Item B) of ASME Code Case N-770-2, "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," for welds in the upper head injection housings at Sequoyah Nuclear Plant (Sequoyah), Units 1 and 2.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(2), TVA requested to use the proposed alternative in Relief Request 18-ISI-1 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. This proposed alternative is applicable to the fourth (present to April 30, 2025, for both units), fifth (estimated as May 1, 2025, to April 30, 2035, for both units), and sixth 10-year inservice inspection intervals. The sixth inservice inspection intervals are estimated as May 1, 2035, to September 17, 2040, for Unit 1 and May 1, 2035, to September 15, 2041, for Unit 2.

The U.S. Nuclear Regulatory Commission (NRC) staff determines that the licensee has demonstrated that Relief Request 18-ISI-1, as supplemented, provides reasonable assurance of structural integrity of the subject components. The NRC staff finds that complying with the specified ASME 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 applicable regulatory requirements set forth in 10 CFR 50.55a(z)(2). Therefore, the NRC staff authorizes the use of Relief Request 18-ISI-1 at Sequoyah, Units 1 and 2, for the remainder of the licenses of the plants, which is currently scheduled to end on September 17, 2040, for Unit 1 and September 15, 2041, for Unit 2.

All other ASME Code Section XI and 10 CFR 50.55a(g) requirements for which relief was not specifically requested and approved in the subject request for relief remains applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the Sequoyah Project Manager, Andrew Hon, at 301-415-8480 or by e-mail to [Andrew.Hon@nrc.gov](mailto:Andrew.Hon@nrc.gov).

Sincerely,

***/RA Dennis J. Galvin for/***

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

Docket Nos. 50-327 and 50-328

Enclosure:  
Safety Evaluation

cc: Listserv



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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PROPOSED ALTERNATIVE 18-ISI-1 REGARDING

EXAMINATION OF DISSIMILAR METAL WELDS IN

UPPER HEAD INJECTION, CONTROL ROD DRIVE MECHANISM,

AND INCORE INSTRUMENTATION HOUSINGS

SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2

TENNESSEE VALLEY AUTHORITY

DOCKET NOS. 50-327 AND 50-328

1.0 INTRODUCTION

By letter dated January 30, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19031C848) with supplement dated June 19, 2019 (ADAMS Accession No. ML19171A025), Tennessee Valley Authority (TVA, the licensee) requested relief from the examination requirements of Table IWB-2500-1 (Item Nos. B14.20 and B14.21) of the American Society of Mechanical Engineers Boiler & Pressure Vessel Code, Section XI (ASME Code), 2007 Edition with Addenda through 2008, for the welds in the control rod drive (CRD) and in-core instrumentation (ICI) housings. TVA also requested relief from the examination requirements of Table 1 (Inspection Item B) of ASME Code Case N-770-2, "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," for welds in the upper head injection (UHI) housings at Sequoyah Nuclear Plant (Sequoyah), Units 1 and 2.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(2), the licensee requested to use the proposed alternative in Relief Request 18-ISI-1 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. This proposed alternative is applicable to the fourth (present to April 30, 2025, for both units), fifth (estimated as May 1, 2025, to April 30, 2035, for both units), and sixth 10-year inservice inspection (ISI) intervals. The sixth ISI intervals are estimated as May 1, 2035, to September 17, 2040, for Unit 1 and May 1, 2035, to September 15, 2041, for Unit 2.

## 2.0 REGULATORY EVALUATION

TVA requested authorization of an alternative to the requirements of Table IWB-2500-1 and Subarticle IWB-2411(a) of the ASME Code Section XI and ASME Code Case N-770-2, pursuant to 10 CFR 50.55a(z)(2).

Per the regulation in 10 CFR 50.55a(g)(4), the 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.

The regulation in 10 CFR 50.55a(g)(6)(ii)(F) states that licenses shall implement the requirements of ASME Code Case N-770-2. The regulation in 10 CFR 50.55a(z)(2) states that alternatives to the requirements of 10 CFR 50.55a(g) may be authorized by the Director of the Office of Nuclear Reactor Regulation, provided that the licensee demonstrates that compliance with existing requirements would result in hardship or unusual difficulty, without a compensating increase in the level of quality and safety.

The regulation in 10 CFR 50.55a(g)(4)(ii) states that inservice inspection examinations must comply with the requirements of the latest edition and addenda of the ASME Code, incorporated by reference, 12 months before the start of the ISI interval. Pursuant to this regulation, licensees must update their ISI programs to reflect more current editions of the ASME Code prior to entering a new 10-year ISI interval. Therefore, licensee ISI requirements evolve over time as the ASME Code is revised and licensee ISI programs are updated.

The regulation in 10 CFR 50.55a(g)(6)(ii)(D) states that licensees of pressurized water reactors are required to augment their ISI of the reactor vessel closure head with ASME 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," with conditions.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that it has the regulatory authority to authorize the alternative proposed by the licensee. However, since the proposed alternative addresses multiple ISI intervals, the staff must view the licensee proposal in light of evolving ISI requirements over time.

## 3.0 TECHNICAL EVALUATION

### 3.1 ASME Code Components Affected

The affected components are the full penetration butt welds in the CRD, ICI, and UHI housings at Sequoyah, Units 1 and 2. The CRD and ICI welds are classified as ASME Code Class 1, Examination Category B-O, Item Nos. B14.20 and B14.21, in accordance with the ASME Code, Section XI, Table IWB-2500-1. The UHI housing welds are classified as Inspection Item B, in accordance with ASME Code Case N-770-2.

### 3.2 Applicable Code Edition and Addenda

The code of record for the fourth 10-year ISI interval at Sequoyah, Units 1 and 2, is the ASME Code, Section XI, 2007 Edition through 2008 Addenda.

The NRC staff notes that the licensee requested the proposed alternative for the fourth, fifth, and sixth ISI intervals. The code of record for the fifth and sixth ISI intervals are unknown at present. However, Section 50.55a(g)(4)(ii) of 10 CFR requires that ISI examinations of components and system pressure tests conducted during successive 120-month inspection intervals must comply with the requirements in the latest edition and addenda of Section XI of the ASME Code, incorporated by reference in 10 CFR 50.55a(b), 12 months prior to the start of the 120-month interval, subject to the conditions listed therein.

### 3.3 Applicable Code Requirement

The proposed alternative is related to ASME Class 1 full penetration dissimilar metal welds adjoining Alloy 600 head penetration sleeve adapters to stainless steel pipe. The components affected include fifteen peripheral CRD housing welds, five peripheral in-core thermocouple housing welds, and four peripheral UHI head penetration sleeve adapters. ASME Code Section XI rules require that the CRD housing welds and in-core thermocouple housing welds be categorized differently based on their function: B14.20 for CRD housings and B14.21 for ICI nozzles. The ISI rules for the UHI head penetration sleeve adapters are specified in 10 CFR 50.55a(g)(6)(ii)(F), which requires implementation of ASME Code Case N-770-2, subject to conditions specified in paragraphs (g)(6)(ii)(F)(2) through (13). The UHI penetration sleeve adapters are classified as Inspection Item B.

ASME Code, Section XI, Table IWB-2500-1, Examination Category B-O, Item No. B 14.20, requires volumetric or inside diameter surface examinations of 10 percent of peripheral CRD housings each inspection interval. A total of two CRD housings per ISI interval (10 percent of 15) are required to be examined for each reactor. ASME Code, Section XI, Table IWB-2500-1, Examination Category B-O, Item No. B 14.21, requires volumetric or inside diameter surface examinations of 10 percent of ICI housings each inspection interval. A total of one ICI housing per ISI interval (10 percent of five) are required to be examined for each reactor. ASME Code Case N-770-2, Table 1, Inspection Item B, requires visual examination of all four UHI housing welds once per interval, and volumetric examination of all four UHI housing welds every second inspection period, not to exceed 7 years between examinations. However, note (3) of Table 1 of Code Case N-770-2 states that an ultrasonic examination is acceptable in lieu of the visual examination requirement of Inspection Item B.

### 3.4 Licensee's Proposed Alternative

Under the current examination requirements, TVA examines four UHI housing welds every second ISI period, not to exceed 7 years, per ASME Code Case N-770-2, Table 1, Item B, and two CRD and one ICI housing welds every 10-year interval per the ASME Code, Section XI, Table IWB-2500-1, Category B-O.

In lieu of the above, TVA proposed to modify the inspection schedule for the CRD, ICI, and UHI housing welds found in ASME Section XI, Examination Category B-O, and ASME Code Case N-770-2 to match the inspection schedule for the RPV head nozzle penetrations as required by Code Case N-729-4. Code Case N-729-4, Table 1, Item No. B4.20, requires that all RPV head nozzles and partial penetration welds be inspected by either volumetric or surface examinations every 8 calendar years, or before the susceptibility parameter reinspection years (RIY) = 2.25, whichever is less. The licensee stated that according to its calculation of RIY, the volumetric examination frequency for the RPV head nozzle penetrations is once every 8 years.

TVA proposed to perform remote volumetric examinations of the four UHI piping dissimilar metal welds and the two CRD and one ICI housing dissimilar metal welds on a schedule that corresponds with the RPV head penetration volumetric examination required by ASME Code Case N-729-4 (i.e., once every 8 years).

In addition, TVA proposed to select 2 empty penetration housing welds from a total set of 12 spare CRD housings instead of selecting from 2 of the ASME Code-required peripheral CRD housing welds. The proposed alternative results in an increase in the number of CRD and ICI weld examinations from six to nine, but a reduction in the number of UHI examinations from 16 to 12. Overall, the proposed alternative results in a net reduction of one dissimilar metal housing weld examination per unit over the licensed period of extended operation (from 22 welds to 21 welds).

### 3.5 Licensee's Basis for Use

The proposed alternative allows the licensee to perform volumetric examination of the CRD, ICI, and UHI dissimilar metal butt welds at the same time as the Code Case N-729-4, Item No. B4.20 examinations of the RPV head nozzle penetrations. Thus, TVA reduces radiological exposure by reducing the number of vendor tooling deployments over the period of extended operation. TVA estimates that 14.8 rem of radiological exposure per reactor is avoided as a result of the proposed alternative, while still performing volumetric examinations on the affected dissimilar metal welds.

### Design

The two reactor vessel closure upper heads at Sequoyah, Units 1 and 2, contain 78 CRD and ICI penetration sleeves, 4 UI penetration sleeves, and 1 vent line penetration sleeve. These 83 penetrations were fabricated from nickel-chromium Alloy 600 material. The final step of the fabrication process involves welding the penetration sleeves to the underside of the RPV head using partial penetration J-groove welds. The penetration sleeves were then welded to 304 stainless steel process pipes using a full penetration butt weld with Alloy 82/182 weld metal. In the proposed alternative, 18-ISI-1, the licensee referenced Westinghouse report LTR-PCAM-04-26, which states that the temperature of these locations should be assumed to be equal to the cold leg temperature of 547 degrees Fahrenheit (°F).

### Primary Water Stress Corrosion Cracking

Primary water stress corrosion cracking (PWSCC) is an intergranular degradation mechanism that has occurred in nuclear component dissimilar metal welds. PWSCC occurs where high tensile stress, susceptible material microstructure, and adverse chemical environment (e.g., reactor primary coolant) all exist simultaneously. U.S. nuclear plant owners have been performing volumetric and surface examinations of CRD housing dissimilar metal welds and similar locations in accordance with ASME Code Category B-O and Code Case N-770-2, Inspection Item B. The licensee stated that no PWSCC has been identified in these locations for Sequoyah, Units 1 and 2.

### Examination Results

The licensee reviewed previous examination results for the CRD and UHI housing welds for Sequoyah, Units 1 and 2. The examination techniques included manual examinations;

nonencoded ultrasonic examinations; and remote, automated ultrasonic examinations. All ultrasonic examinations obtained 100 percent coverage and identified no recordable indications.

### 3.6 DURATION OF PROPOSED ALTERNATIVE

The licensee proposed an alternative for the remainder of the current renewed operating licenses for Sequoyah, Units 1 and 2, as shown in Tables 1 and 2 in the submittal dated January 30, 2019, respectively.

### 3.7 NRC STAFF EVALUATION

The NRC staff reviewed the licensee's proposed alternative 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 examination requirements are ASME Code, Examination Category B-O, for the CRD and ICI housings, and ASME Code Case N-770-2, Inspection Item B, for the UHI housings. The NRC staff confirms that the licensee correctly categorized these welds and identified the appropriate examination requirements.

The licensee identified a hardship associated with personnel radiological exposure during manual volumetric exams of these welds. The licensee proposed to perform the examinations remotely to reduce radiological exposure of personnel. The licensee explained that deployment of tooling required to perform remote examinations also results in radiological exposure to personnel. The proposed alternative allows the licensee to deploy the requisite remote examination tooling once each 10-year ISI interval (as opposed to two or three times) for examination of four types of components: full penetration welds in CRD housings, ICI housings, and UHI housings, and partial penetration J-groove welds. The licensee estimated a reduction of 14.8 rem of radiological exposure (per unit) by performing the examinations remotely, with additional reduction of 2-3 rem of exposure by aligning the examination schedules. Thus, the NRC staff finds that complying with the examination requirements results in a hardship related to radiological dose accumulation during manual exams and remote tooling deployment.

ASME Code, Section XI, Examination Category B-O, requires that two CRD housings on the periphery of the RPV head be examined each 10-year inspection interval. However, the licensee explained that the remote examination equipment will only fit in open housings. Therefore, the licensee proposed that 2 empty penetration housings be selected from a total population of 12 spare CRD housings each inspection interval for examination. These empty penetration housings are of similar design and are under similar operating conditions as the peripheral CRD housings. The staff finds that examination of the empty housings provides relevant data to determine if inservice degradation (e.g., PWSCC) is occurring in RPV upper head penetrations.

The licensee's proposed alternative rearranges the examination schedule for the CRD housing welds, ICI housing welds, and UHI housing welds. Code Case N-770-2 requires that the UHI housing welds be examined four times total during the period of extended operation. Rearranging the examination schedule results in the UHI housing welds being examined three times during the period of extended operation. In terms of total welds, the proposed alternative results in a reduction of UHI welds examined from 16 to 12. At the same time, however, the total number of CRD and ICI welds examined increases from 6 to 9. Thus, the licensee proposed to examine one weld less than the number of welds to be examined under the current requirement per unit. While the proposed alternative shifts the emphasis of the examinations

from UHI locations to the CRD/ICI locations, each of these components experiences similar operation conditions. Therefore, the NRC staff, using risk insights, finds that the small decrease in total number of welds examined will not affect the overall examination requirement of monitoring structural integrity of these welds given the identified hardship.

Finally, the licensee proposed the alternative for three successive ISI intervals spanning a timeframe of 21 years from the present to the end of the period of extended operation (i.e., 60-year license). In TVA's supplement dated June 19, 2019, the licensee discusses how evolving operating experience and ISI requirements over 21 years of operation will be accounted for. Both units will undergo two ISI program updates before the end of the current operating licenses. In addition, the licensee pointed out that it is also subject to mid-interval ISI program revisions due to operating experience or updated regulations. If operating experience or regulatory changes dictate, TVA will either submit an updated alternative or revert to the established examination requirements.

For example, Note 8 of Table 1 of Code Case N-729-4 and Note 5 of Table 1 of N-770-2 alter examination requirements in the event certain classes of flaws are detected during an examination. Note 8 of N-729-4 states that, "...If flaws are attributed to PWSCC, whether or not acceptable for continued service in accordance with -3130 or -3140, the reinspection interval shall be each refueling outage. Additionally, repaired areas shall be examined during the next refueling outage following the repair..."

Note 5 of N-770-2 states that, "...Subsequent Inservice Inspection of Unmitigated Welds With Inside Surface Connected Planar Flaws. (a) If planar surface flaws are detected in the butt weld/base metal inside surface, this weld shall be reexamined at the shorter frequency of every refueling outage or the frequency determined by the crack growth analysis of -3132.3. (b) This weld shall be subsequently examined at the frequency required by (a) unless mitigated..."

The trigger of Note 8 potentially places the basis for relief at risk because the proposed alternative relies on the original N-729-4 examination schedule. Accordingly, the licensee stated in its supplement dated June 19, 2019, that it will no longer apply the alternative examination frequency for the CRD and ICI welds or the UHI welds if the requirements of Note 8 are triggered. However, the licensee will continue to remotely inspect the CRD welds at locations other than the periphery of the RPV upper head. TVA stated that if Note 5 triggers an examination frequency change, then the Code Case N-770-2 examination requirements will be met for the UHI housing welds. In both cases, the licensee credits dose reduction for the basis for relief. Given this discussion in TVA's supplement dated June 19, 2019, the NRC staff finds that the licensee demonstrated appropriate awareness of potential evolving examination requirements throughout the remaining license of the plant.

Staff approval of the relief for multiple ISI intervals requires consideration of multiple factors. In this case, the licensee's risk argument relies on the fact that relief is granted over multiple intervals. For instance, the licensee stated in its supplement dated June 19, 2019, that the number of examinations and reduction in radiological exposure for each examination interval varies when viewed on an individual basis. When taken as a whole, however, the staff agrees that the licensee's proposed alternative is near risk neutral.

In addition to the licensee's arguments, the staff notes that bare metal visual inspections of the RPV upper head, as required by ASME Code Case N-729-4, Item No. B4.10, provide defense-in-depth against potentially missed cracking during volumetric examinations, since any leakage from head penetration welds will likely result in observable boric acid deposits. The



lower operating temperature of CRD, ICI, and UHI locations does not preclude the possibility of future cracking, but it does indicate that potential future cracking should be relatively slow and manageable. The staff finds that bare metal visual examinations and lower operating temperature provide additional assurance of safety for the locations referenced in alternative 18-ISI-1.

The NRC staff finds the licensee's proposed alternative is acceptable on the basis that the licensee appropriately identified a hardship and justified an acceptable alternative. The hardship is related to the fact that manual examinations of upper head components result in significant radiological exposure to personnel. The proposed alternative involves deploying remote examination equipment once each 10-year ISI interval, altering certain examination requirements. The alternative results in a net reduction of one examination throughout the remaining license of each unit, which is a near risk-neutral alternative. Therefore, the staff finds that compliance with the specified requirements of 10 CFR 50.55a(g) results in a 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 relief request 18-ISI-1, as supplemented, provides reasonable assurance of structural integrity of the subject components. The NRC staff finds that complying with the specified ASME 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 applicable regulatory requirements set forth in 10 CFR 50.55a(z)(2). Therefore, the NRC staff authorizes the use of Relief Request 18-ISI-1 at Sequoyah, Units 1 and 2, for the remainder of the licenses of the plants, which is currently scheduled to end on September 17, 2040, for Unit 1 and September 15, 2041, for Unit 2.

All other ASME Code Section XI and 10 CFR 50.55a(g) requirements for which relief was not specifically requested and approved in the subject request for relief remains applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: M. Benson

Date: September 23, 2019

SUBJECT: SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2 – ALTERNATIVE  
 REQUEST 18-ISI-1 REGARDING EXAMINATION OF DISSIMILAR METAL  
 WELDS IN REACTOR VESSEL HEAD (EPID L-2019-LLR-0006) DATED  
 SEPTEMBER 23, 2019

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\*by e-mail

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