February 3, 2006

Mr. Karl W. Singer
Chief Nuclear Officer and
Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, Tennessee 37402-2801

SUBJECT: SEQUOYAH NUCLEAR PLANT, UNIT 1 — RELIEF REQUEST 1-ISI-27 REGARDING AUTHORIZATION TO EXTEND THE SECOND INSERVICE INSPECTION INTERVAL FOR REACTOR VESSEL WELD EXAMINATION (TAC NO. MC7561)

Dear Mr. Singer:

By letter dated July 8, 2005, the Tennessee Valley Authority (TVA), the licensee for Sequoyah Nuclear Plant, Unit 1 (SQN 1), submitted a request for authorization to extend the second 10-year inservice inspection (ISI) interval for reactor vessel weld examinations. Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 55(a)(3)(i), TVA requested approval to use an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Paragraph IWB-2412, "Inspection Program B," for SQN 1. Additional clarifying information was provided in a TVA letter dated November 1, 2005.

The U.S. Nuclear Regulatory Commission staff has completed its review of TVA's request, and concludes that the proposed alternative is justified on the basis that it would provide an acceptable level of quality and safety. Therefore, the staff authorizes the proposed alternative pursuant to 10 CFR 50.55a(a)(3)(i) for the second 10-year ISI interval at SQN 1. The proposed alternative is authorized until the end of the unit's Fall 2007 refueling outage. 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.

Sincerely,

/RA/
Michael L. Marshall, Jr., Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-327

Enclosure: Safety Evaluation

cc w/enclosure: See next page

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Tennessee Valley Authority

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR AUTHORIZATION TO EXTEND THE SECOND AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE, SECTION XI 10-YEAR INTERVAL FOR REACTOR VESSEL WELD EXAMINATION

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR PLANT, UNIT 1

DOCKET NUMBER 50-327

1.0 INTRODUCTION

The Tennessee Valley Authority (TVA), by letter dated July 8, 2005 (ADAMS Accession No. ML051950261), as supplemented by letter dated November 1, 2005 (ADAMS Accession No. ML053140131), submitted a request for authorization to extend the inservice inspection (ISI) interval for performing reactor vessel (RV) weld examinations beyond the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) allowable time frame at Sequoyah Nuclear Plant, Unit 1 (SQN 1). The RV weld ISI consists of ultrasonic examinations intended to discover flaws or other discontinuities. Periodic examination is performed to determine whether flaws have initiated, pre-existing flaws have extended, or if pre-existing flaws that may have been missed using older non-destructive examination technologies are discernable using more advanced technology. The examinations must be performed at least once during every ISI program interval, as defined in Section XI of the ASME Code.

2.0 REGULATORY EVALUATION

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 55a, requires licensees to perform periodic inspections of components. As stated in 10 CFR 50.55a(g) licensees are required to perform surveillance testing in accordance with the ASME Code, Section XI requirements. The code of record for SQN 1 for the second 10-year ISI interval, which began on December 16, 1995, is the 1989 Edition. Subsection IWA-2430(a) of this edition of the ASME Code states:

> The inservice examinations and system pressure tests required by IWB, IWC, IWD, and IWE shall be completed during each of the inspection intervals for the service lifetime of the power unit. The inspections shall be performed in accordance with the schedules of Inspection Program A of IWA-2431, or optionally Inspection Program B of IWA-2432.

SQN 1 is using Inspection Program B.

IWA-2430(d) states, "For components inspected under Program B, each of the inspection intervals may be extended or decreased by as much as 1 year. Adjustments shall not cause successive intervals to be altered by more than 1 year from the original pattern of the intervals." TVA has taken advantage of this paragraph to extend the end of the second interval to May 31, 2006. As a result of the ASME Code-allowed extension, the subject exams are currently scheduled for the Spring 2006 refueling outage.

Title 10 CFR 50.55a(a)(3)(i) states, in part, that the Director of the Office of Nuclear Reactor Regulation (NRR) may authorize alternatives to the requirements of 10 CFR 50.55a(g). In order for the Director of NRR to authorize an alternative in accordance with 10 CFR 50.55 (a)(3)(i), TVA must demonstrate that the proposed alternative provides an acceptable level of quality and safety.

TVA proposes to extend the second ISI interval for the SQN 1 RV weld examinations through the end of the Fall 2007 refueling outage.

This request does not affect the inspection requirements of the SQN 1 third 10-year ISI interval which currently begins on June 1, 2006.

3.0 TECHNICAL EVALUATION

3.1 Systems / Components for Which Relief Is Requested

The affected component is the SQN 1 reactor vessel. The extension is being proposed for the ASME Code, Section XI examination categories and item numbers shown in the table below, which pertain to the RV.

Examination Category	Item Number	Description
B-A	B1.11	Circumferential Shell Weld (W02-03, W03-04, W04-05 and W06-06)
B-A	B1.21	Circumferential Head Weld (W01-02, and W09-10)
B-A	B1.22	Meridional Head Weld (W2A, W2B, W2C, W2D, W2E, and W2F)
B-A	B1.30	Shell-to-Flange Weld (W06-07)
B-D	B3.90	Nozzle-to-Vessel Welds (N11, N12, N13, N14, N15, N16, N17, and N18)
B-D	B3.100	Nozzle Inner Radius Areas (N11-IR, N12-IR, N13-IR, N14-IR, N15-IR, N16-IR, N17-IR, and N18-IR)

These examination categories and item numbers are from IWB-2500 and Table IWB-2500-1 of the ASME Code, Section XI and were provided by TVA as part of its submittal.

3.2 Basis for Relief

An alternative is requested from the requirement of IWB-2412, Inspection Program B, that volumetric examination of essentially 100% of RV pressure retaining welds, Examination Categories B-A, and B-D welds, be performed once each ten-year interval. Extension of the ISI interval for Examination Category B-A and B-D by one refueling cycle beyond the currently scheduled inspection is requested.

The intent of the requested one refueling cycle extension is to allow for deferment of the subject examinations to allow time for Nuclear Regulatory Commission (NRC) review of industry efforts to extend the ISI interval for the subject examinations from 10 to 20 years. These efforts use ASME Section XI Code Case N-691, "Application of Risk-Informed Insights to Increase the Inspection Interval for Pressurized Water Reactor Vessels," Section XI, Division 1, November 2003, as a basis for using risk-informed insights to show that extending the inspection interval from 10 to 20 years results in a small change in the RV failure frequency that satisfies the requirements of Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," November 2002. Following NRC approval of these efforts, TVA intends to submit a separate request to extend the current 10-year interval for SQN to 20 years. The 20-year inspection interval will result in a reduction in man-rem exposure and examination costs.

To establish a technical basis for the requested alternative, TVA provided a qualitative assessment of the risk of RV failure. The assessment included the following:

- Description of previous plant-specific RV ISI history.
- Description of fleet-wide RV ISI history.
- Discussion of degradation mechanisms that are known or expected to apply to the locations that are the subject of the proposed alternative.
- Discussion regarding the material condition of the welds (including a discussion about neutron embrittlement).
- Review of events that could challenge hypothetical flaws or discontinuities in the welds.
- A description of the procedures used by the operators to identify, monitor, and mitigate potential PTS [Pressurized Thermal Shock] events.

TVA said it examined the Category B-A and B-D welds twice previously: once during the preservice inspection (PSI) of the RV, and once during the ISI exam in the first interval. Those examinations achieved acceptable coverage, and no indications were found during the PSI, except for the circumferential head weld W09-10. This PSI indication on weld W09-10 was originally detected and sized in accordance with the ASME Code, Section XI, 1974 Edition, with the Addenda through the summer of 1975, and found to exceed the allowable limits of Table IWB-3510. The flaw met the acceptability criteria of IWB-3600 and was subjected to successive examinations as required in IWB-2420(b) and (c). The flaw was re-examined during the 1984, 1990, and 1993 ISIs and was determined to be allowable in accordance with IWB-3510 of the ASME Code, Section XI, 1977 Edition with Addenda through the summer of 1978. During the 1993 exam the flaw was recorded and sized using the guidelines of Regulatory Guide 1.150, Revision 1, "Ultrasonic Testing of Reactor Vessel Welds During

Preservice and Inservice Examinations," Appendix A; and, applying the requirements of the 1986 Edition of the ASME Code, Section XI, the flaw was found to be within the allowable limits of Table IWB-3510-1. The flaw remained essentially unchanged for three successive inspection periods. TVA concluded that the flaw is not a significant flaw that would challenge structural integrity. TVA also concluded that the ISI examinations that have been performed were of sufficient quality to detect any significant flaws that would challenge RV integrity.

TVA described results of ISI examinations at 14 Westinghouse and Combustion Engineering plants representing 301 total years of service, including plants fabricated by various vendors. No reportable indications were discovered at that group of plants. TVA noted that studies by Pacific Northwest National Laboratory (PNNL) indicate that surface-breaking flaws are unlikely to extend through multiple layers of cladding. The SQN 1 RV is constructed with multipass cladding and, therefore, has a low probability of containing through-cladding, surface-breaking flaws. Finally, TVA noted that all pressurized water reactor (PWR) plants have performed at least one ISI including the subject examinations and that no surface-breaking, or near-surface flaws, of any significance have been found.

TVA identified fatigue as the only operable degradation mechanism for these welds, indicated the fatigue usage factor is very low, and identified the cooldown transient as the most challenging loading sequence. Since approximately only one additional cooldown transient is anticipated during the extension period, TVA concluded that any hypothetical fatigue crack growth would be inherently small.

TVA noted that the SQN 1 RV weld material is below, and will remain below, the PTS screening criteria (according to 10 CFR 50.61) during the extension period.

TVA indicated that, from a loading perspective, the most severe operational challenge to RV integrity is due to PTS events. TVA identified the steps in the emergency operating procedures that would direct the operator to use critical safety function status trees. The status trees for PTS (F-0.4) are used to identify the approach to PTS conditions based on monitoring primary system temperatures and pressures. The PTS safety function status tree directs operator action to Function Restoration Procedure FR-P.1, "Pressurized Thermal Shock," based on plant conditions. This procedure contains the detailed instructions for the PTS mitigation strategies of: 1) terminating the primary system cooldown, 2) terminating emergency core cooling system flow (if proper criteria are met), 3) depressurization of the primary system, 4) establishment of stable primary system conditions in the normal operating range, and 5) implementation of a thermal "soaking" period prior to any cooldown outside of the normal operating region. Combining the low probability of an uncontrolled PTS event with the low probability of a flaw existing in the RV, TVA concluded that the probability of RV failure due to PTS is very small.

TVA notes that no Alloy 600, 82 or 182 materials are present in any of these welds, or adjacent base materials, addressed by the subject request for an alternative.

3.3 NRC Staff Evaluation

ISI of RV welds helps to ensure structural integrity by identifying flaw growth before flaws become large enough to represent challenges to pressure boundary integrity. TVA summarized prior examinations performed on the RV welds. All of the subject welds have been examined and one indication was identified. This PSI indication on weld W09-10 was monitored for three

successive periods without growing. Eventually, SQN 1 determined the indication was acceptable when compared to the acceptance criteria of the ASME Code, Section XI, Table IWB-3510-1, so that it was neither reportable, nor required monitoring. Although ultrasonic examination technology has improved over the past decades, the geometry and materials involved in RV weld examinations are such that these exams have not been particularly challenging from an inspection technology perspective. Therefore, the staff agrees with TVA's qualitative assessment that the prior examinations were of sufficient quality to identify any significant flaws that would challenge RV integrity and that no significant flaws had been identified.

TVA discussed the population of all PWRs and indicated that no surface-breaking flaws have been discovered and, for a population of 14 plants that were reviewed in detail, no reportable indications were identified in any of the RV welds. TVA also noted that NUREG/CR-6471, "Characterization of Flaws in U. S. Reactor Pressure Vessels," provides an estimate of the most likely flaw distribution for RV welds, and large flaws are not generally expected. The staff concludes that the fleet ISI experience and the ISI experience specific to SQN 1 are consistent with the PNNL evaluations: no significant flaws are expected. Furthermore, the staff agrees the two-layer cladding process used during fabrication of the SQN 1 RV results in a low probability that a surface-breaking flaw could extend through the cladding to either the manganese-molybdenum RV plate or weld material.

TVA indicated that fatigue is the only operative mechanism that could have caused flaws to either initiate or grow in the welds during the period since the previous inspection. The staff concludes that corrosion, stress corrosion cracking, and other forms of degradation due to the material's interaction with its chemical environment are not active degradation mechanisms for the RV welds. This is because the RV plates and welds are separated from the reactor coolant by a layer of corrosion-resistant cladding. Even if the cladding were breached (for example, due to an original fabrication flaw in the cladding), the coolant water chemistry would be controlled such that oxygen and other aggressive contaminants are maintained at very low levels so that the coolant is not aggressive to the ferritic material. Furthermore, the welds have not been subjected to a history of abnormal operational loading events, so mechanical overload has not been an active flaw initiation or propagation mechanism. Therefore, the staff agrees with the conclusion that fatigue is the only likely operative mechanism that could have created or propagated flaws since the date the previous ISI examinations were performed.

TVA said that the usage factor for these welds will be much lower than 1.0 after 40 projected years of operation, and that the most severe fatigue transient would be the cooldown. The staff agrees that any flaw growth due to normal operational transients during the period since the last ISI examination is likely to be very minimal.

TVA provided the unirradiated nil-ductility transition reference temperature ($RT_{NDT(u)}$) values for each of the RV beltline materials and provided the PTS reference temperature (RT_{PTS}) values to permit assessment of the effects of neutron irradiation. TVA noted that the RT_{PTS} value for each RV material will remain below the screening criteria of 10 CFR 50.61 for the remaining period of its original license. The NRC staff had previously reviewed and approved these calculations as part of its review of the SQN 1 response to Generic Letter 92-01, "Reactor Vessel Structural Integrity." Since the materials will remain below the screening criteria, the probability of brittle fracture is acceptably low. The analyses that supported the development of 10 CFR 50.61 included assumptions about the size, number, and distribution of hypothetical

flaws that bound the size, number, and distribution identified by SQN 1 during their previous ISI examinations of the RV welds (no reportable flaws). Therefore, the staff concludes that complying with 10 CFR 50.61 is sufficient to demonstrate that the probability of RV failure due to PTS is adequately low.

The PTS risk associated with operation during any time interval is the product of the likelihood that a significant flaw exists and the likelihood that a PTS event occurs during the interval which would challenge the flaw. An increased risk associated with the requested extension period arises from the potential existence of a significant flaw that would have been detected and repaired during the inspection at the end of the original interval. With an extended interval, this flaw would continue to be vulnerable to a severe PTS event during the period the inspection interval is extended. Instead of attempting to estimate this increased risk, TVA argued that the likelihood of a severe PTS event during the next operating cycle, which could challenge the integrity of the RV if a significant flaw exists, is very low.

TVA characterized SQN 1's response to three scenarios (developed by the NRC staff during its PTS risk re-evaluation work) that are believed to be the most likely scenarios that could cause a PTS event that would challenge significant flaws in the RV welds. The three scenarios are initiated by the following infrequent events:

- excessive loss of main steam caused by an unisolable failure of the main steam boundary
- simultaneous failure of two, or more, pressurizer safety-relief valves to properly operate
- a relatively large failure of the reactor coolant pressure boundary (RCPB) in some specific locations

TVA discussed the procedures at SQN 1 that the operators would use to identify and mitigate the severity of a PTS event following these initiating events. The third initiating event, RCPB rupture, normally provides little time for operator intervention following the initiating event but, as discussed above, the RT_{PTS} value for each RV material will remain below the screening criteria thereby reducing the sensitivity of the materials to relatively cooler water injection into the vessel. The staff concurs that the likelihood of any of these initiating events occurring during the extension period is low. Furthermore, existing plant procedures and material properties can mitigate the severity of, or the effects of, the PTS event that would be caused by these initiating events.

In summary, the staff has reviewed TVA's evaluation and makes the following conclusions:

- Previous RV ISI results were of sufficient quality to provide useful results.
- Previous ISI examinations did not identify any indications that are currently considered to be reportable or that currently require monitoring.
- The RV welds are not subjected to stresses or corrosive conditions that would create new flaws or cause old flaws to grow.
- Industry experience with ISI examinations of similar welds has yielded similar results: there are no known significant RV flaws.
- The most severe degradation mode that is expected to be operative is fatigue, and the most severe operational event with respect to fatigue is cooldown, which is an infrequent evolution. Therefore, growth of flaws due to fatigue would be minimal during the period since the previous ISI examination and would be very small during the proposed

extension period.

- The RV material has sufficient toughness to be acceptable with respect to PTS, as determined by TVA's compliance with the requirements of 10 CFR 50.61.
- The likelihood of a severe PTS event occurring during the proposed extension period is low.

Accordingly, the staff concurs with TVA's qualitative assessment that the SQN 1 RV welds have a low likelihood of having significant flaws and that there is a low likelihood of experiencing a severe PTS event during the proposed extension period. The staff finds that the risk associated with the one-cycle extension of the examination interval is sufficiently small that it need not be quantified to support the conclusion that this alternative continues to provide an acceptable level of quality and safety. Operation of the RV for an additional cycle without performing the ISI examination of the subject welds would not significantly increase the risk of flaw growth due to fatigue or to RV failure due to PTS.

4.0 CONCLUSION

Pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff concludes that TVA's proposed alternative provides an acceptable level of quality and safety. Therefore, the NRC staff authorizes the extension of the second 10-year ISI interval until the end of the Fall 2007 refueling outage to complete the SQN 1 RV examinations.

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.

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Dated: February 3, 2006