September 12, 2000

Mr. J. A Scalice
Chief Nuclear Officer
and Executive Vice President
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SUBJECT: SEQUOYAH NUCLEAR PLANT, UNIT 1 - RELIEF FROM ASME CODE REPAIR REQUIREMENTS FOR CANOPY SEAL WELDS (TAC NO. MA9095)

Dear Mr. Scalice:

By letter dated March 6, 2000, the Tennessee Valley Authority (TVA) submitted a request for relief from the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI repair requirements under Title 10, *Code of Federal Regulations* (10 CFR), Section 50.55a(a)(3)(i) for the Sequoyah Nuclear Plant, Unit 1. The request addressed repair of one control rod drive mechanism lower canopy seal weld, identified during the Cycle 10 refueling outage, by weld buildup rather than the removal of the defects and performing a Code weld repair.

The U.S. Nuclear Regulatory Commission staff has completed its review of the information provided in TVA's March 6, 2000, letter. Our evaluation and conclusions are contained in the Enclosure. The staff finds that the alternate repair and inspection of the lower canopy seal weld provides an acceptable level of and quality safety. Accordingly the staff authorizes the use of such alternative pursuant to 10 CFR 50.55a(a)(3)(i).

Sincerely,

/RA/

Richard P. Correia, Chief, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-327

Enclosure: Safety Evaluation

cc w/enclosure: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

OF THE ALTERNATIVE TO ASME CODE REPAIR REQUIREMENTS

FOR CANOPY SEAL WELDS FOR

FOR

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR PLANT, UNIT 1

DOCKET NUMBER 50-327

1.0 INTRODUCTION

Title 10, *Code of Federal Regulations* (10 CFR), Section 50.55a, requires that inservice inspection (ISI) of certain American Society of Mechanical Engineers (ASME) Code Class 1, 2, and 3 components be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel (B&PV) Code applicable Edition and Addenda, except where specific written relief has been granted by the U.S. Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 50.55a(g)(6)(i). It is stated in 10 CFR 50.55a(a)(3) that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

As authorized by 10 CFR 50.55a, the Commission may grant relief from ASME Code requirements or approve proposed alternatives upon making the necessary findings. The NRC's findings with respect to granting the requested relief or authorizing the proposed alternative as part of the licensee's ISI program are contained in this Safety Evaluation (SE).

The purpose of this evaluation is to determine the acceptability of the use of an alternative to ASME Code Section XI repair and examination requirements proposed by the Tennessee Valley Authority (TVA or licensee) for one control rod drive mechanism (CRDM) lower canopy seal weld. While disassembling the reactor vessel during the March 2000 refueling outage, the licensee noticed boric acid residue on CRDM J-1. Further inspection showed that the CRDM had started leaking at the lower canopy seal weld.

By a letter dated March 6, 2000, TVA requested approval of an alternative to the ASME Code, Section XI repair and examination requirements under 10 CFR 50.55a(a)(3)(i). TVA proposed to repair the lower canopy seal welds by applying weld buildup rather than removing the defect and performing a Code weld repair. This relief request is consistent with the relief request submitted during Sequoyah Nuclear Plant (SQN), Unit 1, Cycle 7, refueling outage on

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October 11, 1995, as approved by NRC on April 24, 1996. Similarly, Watts Bar Nuclear Plant submitted relief request for repair of canopy seals on September 20, 1997, and March 19, 1999, as approved by NRC on February 12, 1998, and August 25, 1999.

SQN's CRDMs and thermocouple penetrations are Class A vessels as defined by ASME Section III, 1968 Edition. N-518.4 of the 1968 Edition of the ASME Section III code and NB-5271 of later editions of the Section III code require seal welds to receive either a magnetic particle or liquid penetrant examination. The CRDMs are fabricated in sections with threaded joints providing the pressure-retaining capabilities. Since the threaded joint provides pressure retention, the canopy seal weld is not pressure retaining and is for leakage control. The 1971 Edition, Addenda through Winter 1972 of ASME Section III, does not allow threaded joints as the only seal as described in Paragraph NB-3671.3. Paragraphs NB-3227.7 and NB-4360 address the design of canopy seal welds and qualification requirements for welding specially designed welded seals, respectively.

Paragraph NB-5271, “Welds of Specially Designed Seals,” of ASME Section III, requires seal welds to receive either a magnetic particle or liquid penetrant examination. TVA has determined that either examination would be impractical. Therefore, TVA plans to use an alternative examination technique--a remote video camera.

TVA’s proposed alternative canopy seal weld repair and inspection methods have been implemented at TVA’s SQN, as approved by NRC in a letter dated April 24, 1996 and at TVA’s Watts Bar Nuclear Plant as approved by NRC in letters dated February 12, 1998, and August 25, 1999. Similar weld overlay repairs have also been used at other nuclear power plants.

2.0 DISCUSSION

ASME Section XI Code Requirement

ASME Section XI, 1989 Edition, IWA-4110 (a) states, “This Article provides rules and requirements for repair of pressure retaining components and their supports, including appurtenances, subassemblies, parts of a component, and core support structures, by welding, brazing, or metal removal.”

For repair of the defect, TVA requested relief from the following ASME Section XI, 1989 Edition, IWA-4000, Repair Procedure requirements:

- Paragraph IWA-4120(a): “Repairs shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later Editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used. If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements of IWA-4500 and the following may be used: (1) IWB-4000 for Class 1 components.”

- Paragraph IWA-4130(a)(2): “Repair operations shall be performed in accordance with a program delineating essential requirements of the complete repair cycle including . . . (2) . . . below: (2) the flaw removal method, method of measurement of the cavity

created by removing the flaw, and dimensional requirements for reference points during and after the repair";

- Subarticle IWA-4300, "Defect Removal," in its entirety.

For examination, TVA requests relief from the following ASME Section III, 1971 Edition, through Winter 1971 Addenda, Paragraph NB-5200, "Examination of Weld" requirements.

- Paragraph NB-5271: "Welds of this type (welds of specially designed seals, i.e., canopy seal welds) shall be examined by either the magnetic particle or liquid penetrant method."

Basis for Relief

During the SQN Unit1 Cycle 10 Refueling Outage inspection of the reactor vessel head, boric acid residue was noticed on a CRDM at the J-1 location at the lower canopy seal weld. The CRDMs are part of the nuclear steam supply system procured from Westinghouse Electric Company under Contract 91934. Westinghouse Engineering Specification 678890 is certified to Paragraph N-141 of the ASME B&PV Code, Section III. Paragraph 2.3.3(b) of this document references ASME B&PV Code, Section III, "Nuclear Vessels," and Addenda. This is the 1968 Edition of ASME Section III and its Addenda. These documents establish the Design Specification and the Construction Code for the SQN CRDM's. The CRDMs are Class A vessels as defined by ASME Section III, 1968 Edition.

The CRDMs are fabricated in sections with threaded joints providing the pressure-retaining capabilities. Since the threaded joint provides pressure retention, the canopy seal weld is not pressure retaining and is for leakage control. The 1968 Edition of ASME Section III does not specifically address (either allowing or disallowing) these types of joints. Later editions of ASME Section III do address threaded joints and do not allow them as the only seal as described in Paragraph NB-3671.3. Paragraphs NB-3227.7 and NB-4360 address the design of canopy seal welds and qualification requirements for welding specially designed welded seals, respectively. Paragraph NB-5271 requires that seal welds receive either a magnetic particle or liquid penetrant examination.

Due to physical space limitations and in consideration of the need to keep worker dose as low as reasonably achievable, removal and repair of the defects is not the most favorable method of repair. The affected canopy seal weld is located in a high radiation area (2 rem/hour on contact and approximately 700 millirem/hour general area) and access to the welds is difficult due to the limited clearance between the adjacent CRDMs. In addition, if the defect was removed, it would be impossible to restore the configuration of the canopy seal to its original design condition as required by IWA-4000.

Proposed Alternative

TVA proposed the following alternative:

In lieu of removing the flaw and performing a Code weld repair, TVA will apply a weld overlay repair and allow the flaw to remain.

TVA's Code of Record for Repairs and Replacements is ASME Section XI, 1989 Edition. TVA will use IWB-3640 “Evaluation Procedures and Acceptance Criteria for Austenitic Piping,” and Appendix C, “Evaluation of Flaws in Austenitic Piping,” of this edition to perform the required fracture mechanics and determine the acceptability of the flaw. IWB-3640 provides criteria for acceptance of flaws without repair in ductile, austenitic materials. The basis for such acceptance is the evaluation of the structural adequacy of the flawed component after considering the predicted flaw growth over the evaluation period. The acceptance criteria are based upon the net section collapse (limit load) criteria defined in detail in Appendix C of Section XI.

TVA will also use parts of ASME Section XI Code Case N-504, “Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping,” for guidance in designing a weld overlay repair of the flawed weld. Code Case N-504 allows repair by addition of weld material without removal of the underlying defect to be considered as a code repair. Code Case N-504 is endorsed by the NRC in Regulatory Guide 1.147, “Inservice Inspection Code Case Acceptability ASME Section XI Division,” Revision 11.

TVA will also use NUREG-0313, “Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping, Final Report,” Revision 2, for guidance. The use of NUREG-0313 will result in the repair design being based upon a conservative treatment of applied stresses and allowing for continued flaw growth, as required by Section XI. Instead of applying a magnetic particle or liquid penetrant examination, TVA will perform an enhanced visual examination with a remote video camera with a magnification of approximately 8X. It will use the camera to monitor the repair and visually examine the final weld.

Licensee's Evaluation

Structural Integrity Associates (SIA), a company that performed similar overlay repairs at other plants, performed TVA’s flaw evaluation and overlay repair. SIA stated that the geometry and dimensions of the CRDM lower canopy seal and design of the overlay at Zion, SQN, and Watts Bar are essentially identical. SIA determined that transgranular stress corrosion cracking was the likely mode of failure, based on similar experiences at Zion. It, therefore, evaluated the stress-corrosion cracking (SCC) resistance of the repair to predict the remaining life. SIA evaluated the predicted weld residual stress distributions resulting from the repair and the applied stresses to determine the design life of the overlay repaired canopy seal welds, assuming the mechanism for repair degradation to be SCC.

SIA designed a weld overlay repair to meet the requirements of ASME Section XI, IWB-3640 and followed the guidance in NUREG-0313, Revision 2, for the repair of IGSCC flaws. SIA selected Inconel 625 weld material which has a tensile strength of approximately 110 kips per square inch (ksi) and is stronger than the underlying base material (304 stainless steel), more resistant to degradation mechanisms such as stress corrosion cracking, and is highly ductile. The load carrying capability of the repaired location will thus be greater than that of the original component.

SIA computed weld residual stresses with the WELD3 computer program for the repair model. The model consisted of depositing three layers of Alloy 625 weld metal. The model was confirmed on a weld mock-up performed for the Zion spare CRDM overlay.

The fracture-mechanics analysis assumes that an initial defect is an infinitely long crack completely through the original wall of the canopy seal weld. To bound the crack growth for Alloy 625, TVA used the upper bound NRC curve for IGSCC of Type 304 stainless steel specified in NUREG-0313, divided by a factor of 10. This rate is based on experience with canopy seal weld cracking of Type 308 welds, on crack growth rate data for Alloys 600 and 690, and on a comparison of the SCC resistance of Alloys 600 and 625 with that of Type 304 in various off-normal chemistry environments. This crack growth law, combined with the 3-layer overlay residual stress distribution, and a bounding 2 ksi applied membrane stress, predicted the remaining SCC life to be more than 50 years.

Liquid penetrant examinations required by NB-5271 will not be performed because of space limitations that prevent examiners from having the needed access to successfully perform the examination and the need to keep the worker dose as low as reasonably achievable. As an alternative, TVA will use a remote video camera with a magnification of about 8X to visually examine the final weld and record the entire process of the repair on video tape. Additionally, fracture-mechanics analyses that postulate a flaw in the heat-affected zone and going into the pressure boundary, show that the critical flaw size (several inches) is significantly larger than a flaw that would be reliably detected by the enhanced visual examination.

SQN has performed a demonstration examination for the Authorized Nuclear Inspector using the remote video equipment. That demonstration was performed prior to its use for examination of repair of canopy seal welds at SQN and the results were documented in a letter to the NRC dated April 3, 1996. The demonstration was performed using a machinist scale to determine if a 1/32 of an inch graduation could be distinguished and was found acceptable. The same type of video equipment will be used in conjunction with this repair as was used in the repair during the Cycle 7 Refueling Outage.

The proposed alternative weld overlay repair and visual examination requirements will be implemented in a work order using the repair and replacement program requirements in Standard Programs and Processes (SSP)-9.1, Part D, “Repairs/Replacements of ASME Section XI Components.” This repair and replacement program includes requirements for delineating the weld procedure and postweld heat treatment and nondestructive examination (NDE) to be used after the repair per Paragraph IWA-4130(a)(3); “Inspection” per Subarticle IWA-4140; “Material” per Subarticle IWA-4200; “Welding and Welder Qualifications” per Subarticle IWA-4400; and “Records” per Subarticle IWA-4800. The design of the weld overlay repair and the safety evaluation per 10 CFR 50.59, is documented in a Design Change Notice in accordance with SPP-9.3, “Plant Modifications and Design Change Control.”

SQN submitted a similar request for relief during the Unit 1, Cycle 7, refueling outage, which was approved by the NRC. SIA performed the design and analysis in support of that repair. SQN has contacted SIA about the J-1 canopy seal weld repair. SIA has documented that their original analysis and design are still valid and acceptable for this repair, as well as the balance of the periphery reactor vessel head penetrations. This validation is applicable to the additional information requested by the NRC in support of the 1996 relief request.

TVA evaluated the operability of the CRDM canopy seal welds after the weld repair using the guidance provided in Generic Letter 91-18, “Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Nonconforming Conditions and on

Operability." TVA determined that the CRDM housing will be fully operable after the repair and examination of the weld.

Staff Evaluation

The staff accepts TVA's basis for its proposed alternative repair and inspection methods of the canopy seal weld that is not pressure-retaining and is for leakage control only. The staff finds TVA's alternative to be acceptable because the access to the welds is difficult due to the limited clearance between the adjacent CRDMs and the weld is located in a high radiation area. The flaw evaluation and overlay repair are in accordance with staff-approved methods--ASME Section XI and NUREG-0313, Revision 2. Results of the analyses showed that the weld overlay will provide an adequate level of quality and safety. The alloy selected for the repair, Alloy 625, is more resistant to SCC than the originally used stainless steel. TVA showed by video qualification that a through-wall flaw of a size much smaller than the critical flaw size could be detected by visual examination, thus assuring an adequate safety margin.

The alternative is also virtually identical to that approved by the staff in its letter of April 24, 1996, for the Sequoyah Plant, to that approved in its letter of August 25, 1999, for the Watts Bar Plant, and similar to those approved for several other plants. Weld overlay repairs have been used frequently and successfully to repair IGSCC cracks in boiling water reactor stainless steel piping welds. They have also been used for CRDM canopy seal repairs at Zion, Diablo Canyon, Prairie Island and others.

On the basis of the above discussion, the staff finds the licensee's proposed actions to be a technically adequate alternative to ASME Code, Section XI repair requirements.

The staff concludes that the licensee's proposed alternative to certain of the ASME B&PV Code Section XI requirements for the repair and inspection of two lower canopy seal welds, as contained in the relief request submitted by the TVA letter dated March 6, 2000, and evaluated in this SE, provides an acceptable level of quality and safety. Therefore, the licensee's request is authorized pursuant to 10 CFR 50.55a(3)(a)(i).

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Date: September 12, 2000

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SEQUOYAH NUCLEAR PLANT

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