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

# SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

## CANOPY SEAL WELDS RELIEF REQUEST

## TENNESSEE VALLEY AUTHORITY

## SEQUOYAH NUCLEAR POWER PLANT UNIT NO. 1

## DOCKET NO. 50-327

The purpose of this evaluation is to determine the acceptability of the use of an alternative to the American Society of Mechanical Engineers (ASME) Code Section XI repair requirements proposed by the Tennessee Valley Authority (TVA, or licensee) for three canopy seal welds on the Sequoyah Nuclear Plant (SQN) Unit 1 reactor pressure vessel. Two of the three seal welds are associated control rod drive mechanism (CRDM) penetrations and the third is associated with a thermocouple penetration.

### 1.0 BACKGROUND

By letter dated October 11, 1995, and supplemented by letters dated December 19, 1995 and April 3, 1996, TVA requested relief from the ASME Code, Section XI repair requirements under 10 CFR 50.55a(a)(3). It proposed to repair three lower canopy seal welds by applying weld buildup rather than removing the defect and performing a Code weld repair.

The licensee stated that it considers weld buildup to be an acceptable repair technique because the canopy seal weld does not provide structural integrity or act as a pressure retaining boundary for the threaded joint. Despite this fact, the weld buildup over the canopy seal is considered a repair under ASME Section XI, IWA-4000 because welding is performed on pressure retaining components.

Furthermore, the licensee requested approval of its inspection technique as an alternative to ASME requirements. The ASME Code requires that seal welds receive either a magnetic particle or liquid penetrant examination. TVA proposed to visually examine the final weld by a remote video camera at a magnification of about 8X to 10X. The licensee stated its fracture mechanics analyses show that the critical flaw size would be large enough to detect.

### 2.0 DISCUSSION

#### ASME Section XI Code Requirement

The 1980 edition of ASME Section XI, with Winter 1981 addenda, which is used at SQN, requires in IWA-4120 that "repairs shall be performed in accordance with the Owner's Design Specification and Construction Code of the component or system. Later editions of the Construction Code or of Section III, either

ENCLOSURE

in the entirety or portions thereof, may be used. If repair welding cannot be performed in accordance with these requirements, the following may be used: (a) IWB-4000 for Class 1 components..."

Basis for Relief

The licensee requested relief, stating the following:

> Repair options have been evaluated and it was determined that the most appropriate repair was the use of weld buildup rather than removing the defect and performing a weld repair. Weld buildup is considered by TVA to be an acceptable repair technique because the canopy seal weld does not provide structural integrity or act as a pressure retaining boundary for the threaded joint.

The seal welds are required to receive either a magnetic particle or liquid penetrant examination. TVA states:

> TVA has evaluated performance of these examinations and has determined that either examination would be impractical. The affected canopy seal welds are located in a high radiation area (2 rem/hour on contact and 1000-1500 millirem/hour at 1 foot) and access to the welds is difficult due to the limited clearance between the adjacent CRDMs.

Proposed Alternative

The licensee proposed the following as an alternative, stating:

> TVA's Code of Record for Repairs and Replacements is ASME Section XI, 1980 Edition through the Winter 1981 Addenda. TVA proposed to use Code Case N-389, which allows the use of later code editions and addenda of Section XI. Code Case N-389 is approved for use in the latest revision of Regulatory Guide 1.147. IWB-3640 and Appendix C of the 1989 Edition of ASME Section XI is used to perform the required fracture mechanics and to design a weld overlay repair of the flawed canopy seal weld. Code Case N-504-1 is also used for guidance. Code Case N-504-1 allows repair by addition of weld material without removal of the underlying defect to be considered as a code repair. 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 is based on the net section collapse (limit load) criteria, which are defined in detail in Appendix C of Section XI. Also, NUREG-0313, Revision 2 is used for guidance. The repair design is based on conservative treatment of applied stresses, and includes allowance for continued flaw growth, as required by Section XI.

The material used for the repair is Alloy 625 weld material, which is stronger than the underlying base material, more resistant to degradation mechanisms such as stress corrosion cracking, and is highly ductile. The load carrying capability of the repaired location is greater than the original component.

Dye penetrant examinations that are required by NB-5271 will not be performed due to the space limitations, which prevent examiners the needed access to successfully perform the examination. As an alternative examination, TVA will use a remote video camera with a magnification of about 8 to 10X and perform a visual examination of the final weld at enhanced magnification. The entire process of the repair will be recorded on video tape. The basis for this approach is that post weld dye penetrant examinations are surface examinations and provides minimal assurance of repair integrity when compared to an enhanced visual examination. Additionally, fracture mechanics analyses demonstrate that the critical flaw size is significantly larger than a flaw that would be reliably detected by the enhanced visual examination.

The fracture mechanics analyses assume that an initial flaw is completely through the repair membrane. Thus, there is a large margin in the analyses. TVA considers the fracture mechanics analyses, coupled with the enhanced visual examination, suitable to provide an acceptable alternative to the code required dye penetrant examination.

Description of the Deviated Condition

The licensee found boric acid residue on a CRDM during the Unit 1 refueling outage. Further inspection showed that two CRDMs and one thermocouple penetration had started leaking at the lower canopy seal weld. These penetrations 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 these types of joints. Later editions of ASME Section III address threaded joints and do not allow them as the only seal as described in NB-3671.3. NB-3227.7 addresses the design of canopy seal welds. NB-5271 requires that seal welds receive either a magnetic particle or liquid penetrant examination.

Due to physical space limitations and for ALARA considerations, the licensee states it cannot remove the flaws. Moreover, it states that if the flaws were removed, it would be impossible to reproduce the canopy seal back to its original design condition as required by IWA-4000 and IWB-4000.

Licensee's Evaluation

The licensee's failure evaluation, performed by Structural Integrity Associates (SIA) determined that transgranular stress corrosion cracking was the likely mode of failure, based on similar experiences at Zion. The licensee stated that the geometry and dimensions of the CRDM lower canopy seal and design of the overlay at Sequoyah are essentially identical to those at Zion.

SIA evaluated the stress corrosion cracking (SCC) resistance of the repair to predict the remaining life using methods outlined in NUREG-0313, Rev. 2. It also used these methods in designing and evaluating the remaining life of the repair to appropriately consider resistance to SCC. It postulated a maximum possible defect of 360° through-wall in the original canopy seal weld to design a standard weld overlay. It performed a crack growth analysis. The weld residual stress distribution from the repair, which is much more significant than the sustained loads in providing the driving force for SCC, was determined by the WELD3 computer program. The weld repair model was confirmed on a weld mockup.

The licensee performed a fracture mechanics analysis to determine the maximum size flaw the repair weld could tolerate in the heat affected zone at the pressure boundary. It stated:

> Structural Integrity Associates calculated the critical flaw lengths for four cases. The lengths of flaws ranged from 4.4 to 7.3 inches. Their conclusions were that these results demonstrate under a variety of conservative assumptions that the critical flaw size predicted for the repair geometry of the canopy seal weld is in all cases of significant length.
>
> Welding Services Inc. [WSI] performed a test of the video system for Prairie Island where the same type of repairs were made. The test demonstrated that two wires of 0.005 and 0.001 inches in diameter and 0.4 inches long could be adequately viewed. The test was performed on a mockup of a canopy seal housing similar to the configuration to the Prairie Island design which is also similar to Sequoyah's design. WSI's QC [Quality Control] personnel were able to adequately resolve the two wires on the mockup using the remote video equipment. WSI used identical equipment at Sequoyah as they did in their test and at Prairie Island. TVA performed a demonstration examination for the Authorized Nuclear Inspector using the remote video equipment at SQN prior to using it for examination purposes. The demonstration was performed using a machinist scale to determine if a 1/32 of an inch graduation could be distinguished. This is the normal requirement for a visual examination. The demonstration examination was found acceptable. Therefore, based upon the above, SQN finds that the remote video equipment can adequately detect the postulated cracks which provides an adequate assurance of safety and is an acceptable substitution for the dye penetrant examination.

Staff Evaluation

Weld overlay repairs have been used frequently and successfully to repair inter-granular stress corrosion 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 other plants. Weld overlay repairs used at those plants are similar to the one proposed for SQN. The design is in accordance with ASME Section XI IWB-3642 and the NRC guidance outlined in NUREG-0313, Revision 2 for the repair of SCC flaws.

The licensee's fracture mechanics analyses and video qualification testing showed that a through-wall flaw of a size much smaller than the critical flaw size could be detected by visual examination, thus assuring a wide safety margin.

The licensee used standard procedures in its fracture mechanics analyses — those according to Appendix C of the ASME Code, Section XI as well as linear elastic fracture mechanics methods — for evaluating both axial and circumferential flaws. It used a computer program pc-CRACK for the analyses, a program the NRC has accepted frequently in licensees' analyses.

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 since it ensures that the required structural integrity will be maintained.

## 3.0 CONCLUSION

The staff concludes that the licensee's proposed alternative will provide an acceptable level of quality and safety and is authorized under 10 CFR 50.55a(a)(3)(i).

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Dated: April 24, 1996

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SEQUOYAH NUCLEAR PLANT

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