



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

ENCLOSURE

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SHUTDOWN MARGIN

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR POWER PLANT UNITS 1 AND 2

DOCKET NOS. 50-327 AND 50-328

1.0 INTRODUCTION

During scrams at Sequoyah Unit 2 in May and June, 1988, excessive decreases in reactor coolant average temperature (Tavg) were noted. Most American PWRs including Sequoyah exhibit a markedly negative moderator temperature coefficient at the end of core life. A temperature drop of the magnitude that occurred at Sequoyah adds significant reactivity to the core and may compromise the minimum shutdown margin requirements of the Sequoyah Technical Specifications (TS). Therefore, the NRC conducted a detailed inspection of shutdown margin during July 11-14, 1988. This review is documented in Inspection Report (IR) 88-35 dated September 12, 1988 with an attached notice of violation. The Tennessee Valley Authority (TVA) discussed the shutdown margin issue in Licensee Event Reports, LER 88-030 dated July 14, 1988 and LER 88-030-01 dated September 9, 1988, and in a letter dated August 31, 1988. In this latter submittal, TVA proposed interim corrective action to assure that shutdown margin was maintained after a reactor trip. The post-trip procedure at Sequoyah was modified to direct the operator to inject specified amounts of borated water into the reactor coolant if coolant temperature drops below designated values.

In a Safety Evaluation Report (SER) dated September 30, 1988, the staff concluded that, as an interim measure, the procedural changes proposed by TVA were adequate to provide reasonable assurance that shutdown margin would be maintained. This conclusion was limited to short-term operation since the corrective action relied on immediate operator action to compensate for identified deficiencies at Sequoyah in either design or system maintenance or both. TVA committed to provide a long-term corrective action plan by October 14, 1988. The staff's approval of long-term operation of Sequoyah 1 Cycle 4 and of Unit 2 startup following refueling for Cycle 4 was conditioned on review of this long-term corrective action plan. That review is the subject of this SER.

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2.0 EVALUATION

In letters dated October 5 and 14, 1988, TVA provided details of their long-term corrective action program to assure that excessive temperature drop following a scram did not result in violation of requirements to maintain the minimum shutdown margin required by the TS for the Sequoyah plant. The October 5, 1988 letter provided a list of commitments TVA made in the September 13, 1988 meeting with the staff on post-trip cooldown experienced at Sequoyah. The major elements of this program included the following:

- A. To prevent overcooling of the steam generators, the reactor trip response procedure (ES-0.1) was to be revised to require manual control of auxiliary feedwater (AFW) after a trip and manual boration if reactor coolant temperature cannot be maintained within acceptable limits.
- B. Formal training of operators given on the revised procedure.
- C. To limit mass loss from the steam generators, the Tavq steam dump controllers will be optimized to prevent excessive cooldown to the steam generators following a reactor trip. Modifications are to be completed by February 28, 1989 for Unit 1 and prior to startup following the Unit 2 Cycle 3 refueling in early 1989.
- D. Various changes were made to Sequoyah administrative procedures to assure that the safety impact of future similar issues is identified.

Validation of the revised post-trip procedure on the simulator and classroom and simulator training of operators in its use were monitored by a resident inspector. This was documented in IR 88-49 dated December 13, 1988 as were the results of an audit of the administrative corrective actions discussed above.

On November 18, 1988, a scram occurred on Sequoyah Unit 1. During this scram, even though the revised procedure to limit overcooling was in place, reactor coolant Tavq dropped to 522°F. The details of the staff's review of this event are given in IR 88-55 dated December 28, 1988. Because of ineffectiveness of the revised procedures in limiting the temperature drop, TVA undertook an exhaustive study of both operator and system performance during and following the trip. The results of this study and a discussion of the additional and modified corrective actions TVA undertook to prevent future similar events is given in Sequoyah Unit 1 LER 88-045-01 dated January 25, 1989.

TVA identified three principal and related causes of the excessive cooldown following the November 18, 1988 scram. First, the post-trip procedure revision was unclear as to exactly when the operator should take manual control of auxiliary feedwater (AFW) and to what value it should be throttled. Second, the simulator did not model accurately the precipitous drop in temperature that occurred after AFW started. Third, the training the operators received was not sufficient in intensity or duration to overcome the previous TVA operating philosophy that automatic systems should be relied on to bring the plant to a stable condition prior to assuming manual control.

Also TVA identified deficiencies in their procedure in that the mode of boron addition was not specified and the operator chose a relatively inappropriate method of affecting the boron addition required by the procedure when manual AFW control was unable to maintain temperature at an acceptable level. TVA also identified several minor equipment malfunctions which tended to obscure the actual situation during the scram.

TVA identified a number of corrective actions to address the deficiencies found during their review. They have already completed the following short term actions:

- A. Modified the post-trip procedures to provide exact guidance as to when to take manual control of AFW and what flow rate to maintain.
- B. Clarified the procedure to specify when and how much to borate the coolant and which flowpath to use.
- C. Reprogrammed the Sequoyah simulator to model more accurately the actual plant cooldown.
- D. Repaired defects in the AFW turbine pump flow indicator and a steam dump flow control valve position indicator.
- E. Modified the low Tavg main feedwater isolation steam dump controller setpoints to minimize heat loss after a trip. This modification has been completed on Unit 1 and will be completed on Unit 2 prior to startup from the current Cycle 3 refueling.
- F. Trained operators on the procedural and hardware changes discussed above.

In the longer term, TVA will incorporate more extensive training in post-trip procedures in the annual retraining cycle for operators; will institute a program by which training instructors will monitor control room operations on a monthly basis to assess effectiveness of operator training; and will verify accuracy of simulator modeling prior to training operators on novel transients.

The staff has reviewed TVA's corrective actions in light of its own examination of the circumstances surrounding the November 18, 1988 scram and concludes that the program discussed above should address the problems identified during that transient. The staff notes that, after the majority of the corrective actions were put in place, a scram occurred at Unit 1 on December 26, 1988. In these scrams, minimum coolant temperature went no lower than 540°F. This magnitude of temperature swing is not untypical of that experienced at many Westinghouse reactors and, given the levels of operator action provided in the procedure and the modifications which were yet to be completed, is considered acceptable by the staff.

The Sequoyah resident inspectors have monitored the additional training described in Item F above; this review is documented in IR 88-56 dated January 31, 1989. Also the residents reviewed post-trip performance for the

two latest scrams identified above. Based on these reviews, the staff finds that the immediate corrective actions identified in LER 88-045 have been adequately implemented.

3.0 CONCLUSION

Based on the reviews, inspections and submittals discussed above, the NRC staff concludes that the procedural, hardware and training enhancements implemented and committed to by TVA will provide reasonable assurance that adequate shutdown margin will be maintained at Sequoyah. This conclusion is predicated on the successful and prompt completion of the additional longer-term corrective actions discussed above and on continuing successful performance in maintaining coolant temperature after future trips.

The staff notes that certain other commitments in the broader areas of post-trip review, LER review, control and review of vendor documents and review of emergency operating procedures were made in TVA's various submittals and presentations on shutdown margin. Although these commitments are not directly relevant to the technical resolution of the immediate issue and are not discussed above, their implementation is considered part of the corrective action necessary to resolve the Notice of Violation on this subject issued by the NRC on September 12, 1988.

This closes out the staff review of this shutdown margin issue. TVA will be requested to inform the staff, within 30 days of completion, when it has implemented the additional longer-term corrective actions discussed above and has implemented the commitments in the areas of post-trip review, LER review, control and review of vendor documents, and review of emergency operating procedures.

Principal Contributor: E. Goodwin

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