UNITED STATES
NUCLEAR REGULATORY COMMISSION
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ENCLOSURE

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATE ANALYSIS DEFLECTION CRITERIA

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR POWER PLANT UNITS 1 AND 2

DOCKET NOS. 50-327 AND 50-328

## 1.0 INTRODUCTION

The Tennessee Valley Authority, the licensee, used alternate analysis criteria to qualify nuclear safety class piping and piping supports at Sequoyah Units 1 and 2. This alternate analysis criteria provided general criteria and guidelines to locate pipe supports in lieu of performing a rigorous piping analysis. The criteria were generally used for nuclear safety class piping systems that are 4 inches in diameter and smaller. Because deficiencies were identified with the implementation of the alternate analysis criteria, TVA initiated a corrective action program. This program was implemented in two phases at Sequoyah Units 1 and 2. The first phase, which addressed the significant safety concerns, was completed prior to the restart of Units 1 and 2. The second phase of the program was completed after the restart of Units 1 and 2. The staff's evaluation of this program is contained in NUREG-1232, Volume 2, "Safety Evaluation Report on Tennessee Valley Authority: Sequoyah Nuclear Performance Plan."

The staff's evaluation identified an open issue regarding the technical basis for the licensee's deflection criteria used in pipe support design. The licensee committed to perform an evaluation, during the post-restart phase of the program, to justify the adequacy of the deflection criteria. This evaluation was submitted to the NRC in a TVA letter dated October 22, 1990. As a result of the staff's review of this submittal, the licensee provided additional information to support its use of the deflection criteria in TVA letters dated August 26, 1991, and March 16, 1992.

## 2.0 EVALUATION

The licensee's deflection criteria requires that the pipe support deflection in each loading direction be limited to 1/8-inch under each loading condition. In addition, the licensee's criteria requires the deflection limit be reduced to 1/16-inch for supports adjacent to critical equipment. The licensee presented a technical justification for its deflection criteria in the October 22, 1990 submittal. As discussed in the licensee's October 22, 1990 submittal, the purpose of the deflection criteria is to assure that the support stiffness does not have an adverse impact on the results of the piping

analysis. The licensee's submittal provided a discussion of the conservatism in the piping design and an evaluation of a sample piping problem.

The submittal contained general discussions of conservatism in dynamic analysis, results of the dynamic testing of piping systems and piping performance during earthquakes. Although the issues of piping analysis conservatism, dynamic testing and piping performance during past earthquakes provide useful insights for evaluating piping analysis criteria, the licensee did not demonstrate any direct applicability between these discussions and the issue of the deflection criteria used at Sequoyah. Consequently, these discussions were not considered in this evaluation.

The licensee's submittal also contained a discussion of the conservatism in the application of the alternate analysis methodology at Sequoyah. In its submittal, the licensee stated that the alternate analysis criteria uses a modified response spectra input. The modified response spectra input involves using the spectra peak acceleration for frequencies that fall on the low frequency side of the spectra peak. This procedure results in a conservative estimate of the seismic loads when it is applied to low frequency piping systems.

To demonstrate the conservatism of its criteria, the licensee provided a comparison of results between a sample piping problem analyzed using the Sequoyah alternate analysis criteria and the same problem analyzed using the rigorous analysis criteria. The sample piping problem was 2 inches in diameter and had 8 two-way supports and two anchors. In this study, the licensee varied the support stiffness values in the rigorous analyses and compared the results to those obtained using the alternate analysis criteria. The comparison showed that the alternate analysis criteria provided more conservative pipe stresses and support loads than the rigorous analyses.

The licensee's study of the 2-inch diameter piping system using rigorous analysis techniques showed that support stiffness variation did not affect the results significantly for stiffness values of 5000 lbs/in and greater. Although the case where the stiffness values were reduced to 1000 lbs/in showed significant increases in support loads when compared to the results using higher stiffness values, the licensee argued that these stiffness values were lower than the deflection criteria would permit based on the minimum design load used for 2-inch diameter piping in the alternate analysis criteria. Even though the criteria would not permit these stiffness values, the loads calculated based on the alternate analysis criteria were still greater than the loads predicted by rigorous analysis for the majority of the support locations. The staff considers the results of this study adequate to justify the deflection criteria for 2-inch diameter and smaller piping systems. However, the staff requested that the licensee provide additional information to demonstrate the adequacy of the criteria for larger pipe sizes used in the alternate analysis program.

The licensee provided an additional study in its August 26, 1991 submittal. In the additional study, the licensee evaluated a 4-inch diameter piping problem using the same basic arrangement as the previous study with longer

pipe spans between the supports. This study showed that the support stiffness variations, using rigorous analysis techniques, impacted the results when the stiffness was reduced to 10000 lb/in and that the impact was significant when the stiffness was reduced below that value. For most cases where significant increases in loads occurred, the licensee argued that the stiffness values were lower than the deflection criteria would allow based on the calculated load. In addition the licensee argued that, for those cases that meet the deflection criteria, the loads calculated using the alternate analysis criteria exceed the loads that were generated from rigorous analysis for all but one support point. For the one case, the licensee argued that the exceedance is only 5 percent. The staff concurs with the licensee's argument that an exceedance of 5 percent at one support point is not significant for this study and that the results of this study demonstrate the adequacy of the alternate analysis criteria.

Although alternate analysis criteria were generally used for piping systems 4 inches in diameter and smaller, the licensee identified that the criteria had also been used on some 6-inch diameter piping. The licensee stated that they did not perform a stiffness study on this size piping because it was a small percent of the population of alternately analyzed piping and the support designs were uniquely developed. The staff did not agree with the licensee's basis for excluding this pipe size from the study. After further discussion with the staff, the licensee agreed to evaluate the 6-inch diameter piping. The results of this evaluation were summarized in the licensee's March 16, 1992 submittal. In that submittal, the licensee stated that 276 supports were evaluated and that one support required modification. The licensee further stated that the alternate analysis criteria have been revised to provide a minimum design load for the 6-inch diameter piping support designs. The use of a minimum design load in combination with the deflection criteria should result in an adequate support stiffness for future designs. The staff considers the licensee's corrective action described above to have adequately addressed the concern with regard to the use of deflection criteria for the design of 6-inch diameter alternately analyzed piping at Sequoyah.

## 3.0 CONCLUSION

The licensee performed sample studies to confirm the adequacy of the deflection criteria used for the evaluation of pipe supports in the alternate analysis program at Sequoyah. The staff concludes that these sample studies adequately address the open issue regarding the use of deflection criteria for alternately analyzed piping that is 4 inches and smaller in diameter. The licensee also identified that 6-inch diameter piping had been designed using alternate analysis criteria. The licensee's evaluation of the 6-inch diameter piping found one support that required modification due to inadequate stiffness. As a corrective action for future evaluations, the licensee stated that the alternate analysis criteria have been revised to provide a minimum design load for the evaluation of 6-inch diameter pipe supports. On the basis

of the licensee's evaluations and corrective actions described above, the staff concludes that the licensee has adequately addressed the open issue with regard to the use of deflection criteria for the design of alternately analyzed pipe supports at Sequoyah identified in NUREG-1232, Volume 2.

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