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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATING TO END-OF-CYCLE MODERATOR TEMPERATURE COEFFICIENT
TECHNICAL SPECIFICATION BASES CHANGE
GEORGIA POWER COMPANY
VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2
DOCKET NOS. 50-424 AND 50-425

1.0 INTRODUCTION

By letter dated March 29, 1991 (Ref. 1), Georgia Power Company (GPC) requested concurrence with a Technical Specification (TS) (Ref. 2) Bases change for the Vogtle Electric Generating Plant (VEGP), Units 1 and 2. The proposed TS Bases change would revise the method of determining the end of cycle life (EOL) most negative moderator temperature coefficient (MTC) and the associated 300-ppm surveillance requirement (SR) limits specified in the Core Operating Limits Report (COLR) (Ref. 3). The purpose of the 300-ppm SR is to ensure that the most negative MTC at EOL remains within the bounds of the Vogtle 1 and 2 safety analyses (Ref. 4), in particular for those transients and accidents that assume a constant value of the moderator density coefficient (MDC) of 0.43 delta-K per gm/cc.

The current Vogtle TS 3.1.1.3 states that:

> "The moderator temperature coefficient (MTC) shall be within the beginning of cycle life (BOL) and the end of cycle life (EOL) limit specified in the Core Operating Limits Report (COLR)."

The corresponding action for exceeding this limiting condition for operation (LCO) is to be in hot shutdown within 12 hours. The Vogtle SR involves an MTC measurement at any thermal power within 7 effective full power days (EFPD) after reaching an equilibrium primary coolant boron concentration of 300-ppm.

After appropriate corrections are made, the measured value is compared to the 300-ppm SR limit value specified in COLR Section 2.3 at the all rods withdrawn (ARO), rated thermal power (RTP) condition. In the event that the measured MTC is more negative than the 300-ppm SR limit, the MTC must be remeasured and compared with the EOL MTC LCO value at least once per 14 EFPD during the remainder of the operating cycle. The Vogtle 1 and 2 300-ppm SR and EOC LCO values for the most negative MTC are conservative (less negative) when compared to the value of the MTC (actually the MDC) which is used in the safety analyses.

The use of 18-month cycles at Vogtle has led to higher core average burnups resulting in more negative EOL MTC values. Recent reload designs have approached the 300-ppm SR limit and anticipated high energy 18-month cycle designs for future power uprated conditions are approaching the EOL MTC limit specified in COLR Section 2.3. Failure to satisfy the 300-ppm SR MTC does not necessarily mean that the most negative MTC that occurs at EOL would be exceeded or that the safety analysis MTC (or MDC) would be exceeded. The additional MTC measurements once every 14 EFPDs, if needed to comply with the SR, could become an undue burden for plant operations because they can require that load swings be performed, causing temperatures to deviate from the programmed reference temperature which perturbs nominal steady-state reactor operation. Additionally repeated MTC measurements require the resources of multiple operations personnel and require greater water processing for measurements via the boration/dilution method.

GPC proposes to revise the current method for determining the 300-ppm surveillance and the EOL MTC limits specified in the COLR. The revised method for determining the COLR MTC limits will result in a change to the Technical Specifications Bases Section B 3/4.1.1.3. This revised method and the COLR MTC limit changes do not affect the maximum moderator feedback safety analysis assumption of a constant moderator density coefficient (MDC) value of 0.43 delta-k/gm/cc, which corresponds to an MTC value of -56 pcm/°F. These changes apply to the current and future reload cycles for Vogtle Units 1 and 2 and are supported by an evaluation provided by Westinghouse (Ref. 5) as referenced in the GPC request. The staff review of these proposed changes to the most negative MTC TS Bases follows.

2.0 EVALUATION

2.1 Methodology

The current method used to determine the most negative MTC is described in Bases Section 3/4.1.1.3 of the VEGP Unit 1 and Unit 2 Technical Specifications (TS) (Ref. 2). This method is based on incrementally correcting the conservative MDC used in the safety analyses to obtain the most negative MTC value or, equivalently, the most positive MDC at nominal hot full power (HFP) core conditions. The corrections involve subtracting the incremental change in the MDC, which is associated with a core condition of all control rods inserted (ARI), to an all rods out (ARO) core condition. The MTC is then equal to the product of the MDC times the rate of change of moderator density with temperature at rated thermal power (RTP) conditions.

This TS Bases method of determining the most negative MTC LCO value results in an ARO MTC value which is significantly less negative than the MTC used in the safety analysis and may even be less negative than the best estimate EOL ARO MTC for extended burnup reload cores. This has the potential for requiring the plant to be placed in a hot shutdown condition by TS 3.1.1.3 even though substantial margin to the safety analysis MDC still exists. The problem with the current method is caused by adjusting the MDC from HFP ARI to a HFP ARO condition in defining the most negative MTC. The HFP ARI condition is not allowed by the TS on control rod positions for allowable power operation in which the shutdown banks are completely withdrawn from the core and the control banks must meet rod insertion limits (RIL).

Westinghouse (Ref. 5) has provided an alternative method for adjusting the safety analysis MDC to obtain a most negative MTC. This method is termed the most negative feasible (MNF) MTC. The MNF MTC method seeks to determine the conditions for which a core will exhibit the most negative MTC value that is consistent with operation allowed by the TS. For example, the MNF MTC method would not require the conversion assumption of the ARI HFP condition but would require the conversion assumption that all control rod banks are inserted to the maximum amount that is permitted by the TS. Westinghouse uses the MNF MTC method to determine EOL MTC sensitivities to those design and operational parameters that directly impact the MTC in such a way that the sensitivity to one parameter is independent of the assumed values for the other parameters.

The parameters considered with this MNF MTC method include:

(1) soluble boron concentration in the primary coolant
(2) moderator temperature and pressure
(3) control rod insertion
(4) axial power shape
(5) transient xenon concentration

The MNF MTC approach uses this sensitivity information to derive an EOL ARO HFP MTC LCO value based on the safety analysis value of the MDC.

This MNF MTC approach has, according to Westinghouse, a number of advantages over the previous method for determining the most negative MTC LCO value. The MNF MTC will be sufficiently negative so that repeated MTC measurements from a 300-ppm core condition to EOL would not be required. The MNF MTC method does not change the safety analysis moderator feedback assumption. The safety analysis value of MDC is unchanged. The MNF MTC method is a conservative and reasonable basis to assume for an MTC value of a reload core and is consistent with plant operation defined by other TS. Finally, the MNF MTC method retains the SR on MTC at the 300-ppm core condition to verify that the core is operating within the bounds of the safety analysis.

Westinghouse has determined the sensitivity of the above parameters on the EOL MTC for three different reload designs representative of future Vogtle Units 1 and 2 reloads (Ref. 5). These reload designs included fuel designs, discharge burnups, and cycle lengths which are typical of those expected for Vogtle. The soluble boron concentration was not used in the sensitivity analysis because the EOL HFP ARO MTC TS value is assumed to be at 0-ppm of boron, the definition of EOL, and because the most negative MTC occurs at 0-ppm of boron in the coolant.

The sensitivity study did not include the radial power distribution which can vary under normal operation and can affect the MTC. The operational activities that affect the radial power distribution do so through the movement of control rods and other activities that affect the xenon concentration. The allowed changes in the radial power distribution are implicitly included in the MTC sensitivity to control rod insertion and xenon concentration.

Westinghouse states (Ref. 5) that the SR MTC value would be obtained in the same manner as currently described in the Westinghouse Standard Technical Specifications (STS) Bases (Ref. 6). The SR MTC value is obtained from the EOC ARO MTC value by making corrections for burnup and boron at a core condition of 300-ppm of boron.

The staff has reviewed the assumptions and basis for the MNF MTC method described above and concludes that they are acceptable because they will result in conservative most negative MTC SR and EOL values that could result from allowed operation of Vogtle Units 1 and 2 from nominal conditions and because the MTC measurement at 300-ppm of boron core condition will assure, using the SR value of MTC, that the safety analysis MDC will not be exceeded.

2.2 Vogtle Units 1 and 2 Accident Analysis MDC Assumption

Westinghouse uses an MDC for performing accident analyses. For events sensitive to maximum negative moderator feedback, a constant value of the MDC of 0.43 delta-K/gm/cc is assumed throughout the analysis. For HFP and full flow nominal operating conditions, the temperature and pressure are 591.8°F and 2250 psia, respectively. At these conditions the MTC, equivalent to the MDC of 0.43 delta-k/gm/cc, is -56 pcm/°F. We will refer to this MTC as the safety analysis MTC. Based on its review, the staff concludes that the evaluation of the MTC from the MDC is acceptable because it conforms to the physical relationship of MTC to MDC; that is, the MTC is equal to the MDC times the rate of change of density with temperature at the nominal pressure and temperature of the coolant at rated thermal power conditions.

2.3 Sensitivity Results

Vogtle Units 1 and 2 TS 3.2.5 provides the LCO values of the departure from nucleate boiling (DNB) parameters, reactor coolant system average temperature (T_{avg}) and pressurizer pressure. The minimum allowable indicated pressurizer pressure is 2224 psig and the maximum allowable T_{avg} is 591.0°F. To account for expected future fuel designs and possible power uprate conditions, conservative bounding values for RCS pressure of 2200 psia and for RCS temperature of 595.7°F were used for the Westinghouse analyses. The current nominal design T_{avg} for Vogtle Units 1 and 2 is 588.5°F so that the safety analysis represents a 7.2°F maximum allowable increase over T_{avg} nominal conditions. The current nominal design pressure is 2250 psia so that the safety analysis represents a 50 psi maximum allowable decrease from nominal pressurizer pressure. Based on these maximum allowed system variations, a maximum allowable limit is placed on the moderator density variation. Using the sensitivity of the MTC to temperature and pressure, derived from the analysis of three reload designs, Westinghouse obtained for Vogtle Units 1 and 2 a bounding delta MTC (a proprietary value) associated with these maximum allowable coolant temperature and pressure deviations from nominal conditions.

The Vogtle Unit 1 and Unit 2 TS 3.1.1.3 require an ARO configuration in the evaluation of the MTC. TS 3.1.3.5 requires that all shutdown RCCA banks be withdrawn from the core during normal power operation (Modes 1 and 2). TS 3.1.3.6 limits control bank insertion by rod insertion limits (RIL) in Modes 1 and 2. All control rods can be inserted at hot zero power (HZP) coincident with a reactor trip. In general, greater control rod insertion results in a more negative MTC assuming that all other parameters are held constant. However, greater control rod insertion will also cause a reduction in core power and T_{avg} which causes the MTC to become more positive. This effect is more pronounced at lower power with the positive change being more important than the negative change in the MTC. Based on this line of reasoning, Westinghouse determined (Ref. 5) that the most negative MTC configuration will occur at HFP with control rods inserted to the RIL. Westinghouse analyzed a typical reload core design, using a bounding value of control bank insertion at HFP with no soluble boron in the coolant. This analysis gave a bounding delta MTC (a proprietary value) associated with the control bank inserted to the RIL for Vogtle Units 1 and 2.

The axial power shape produces changes in the MTC caused primarily by the rate at which the moderator is heated as it flows up the core, with the MTC sensitivity to extremes of axial power shapes being small. This effect can be correlated with the axial flux difference (AFD), which is the difference in the power in the top half of the core minus the power in the lower half of the core. Vogtle Units 1 and 2 TSs also include limits on the AFD. Westinghouse determined that the more negative the AFD the more negative the MTC. Westinghouse examined several reload designs and determined the sensitivity of the MTC to AFD. This analysis gave for Vogtle 1 and 2 a bounding delta MTC (a proprietary value) for an assumed bounding value of AFD.

Although no TS limits exist on either the xenon distribution or concentration, the axial xenon distribution is effectively limited by TS limits on the AFD. The physics of the xenon buildup and decay process limits the xenon concentration. The effect of xenon axial distribution is quantified in the effect of the axial power shape on the MTC, as discussed previously. The effect of the overall xenon concentration on the MTC needs to be evaluated separately. Westinghouse determined that the MTC became more negative with no xenon in the core. Therefore, Westinghouse analyzed the typical reload core designs at HFP ARO with no xenon present. This analysis gave for Vogtle Units 1 and 2 a delta MTC (a proprietary value) for the xenon concentration factor.

All of the delta MTC values described above are summed to provide a total delta MTC for Vogtle Units 1 and 2 based on the allowed deviations of the various factors from nominal values.

The staff has reviewed the discussion and analysis of the primary factors of the MNF MTC method and concludes that the results obtained are acceptable because approved methods and conservative assumptions were used to generate the results.

2.4 Safety Analysis Impact of MNF MTC Approach

Changes in the parameters discussed previously could take place during a transient to make the MTC more negative than allowed during normal operation. The most adverse conditions seen in the affected transient events will not result in a reactivity insertion that would invalidate the conclusions of the FSAR accident analyses. Thus, the MDC used as a basis for the MNF MTC TS will not change. The reload safety analysis process will include verification that the MDC safety analysis value remains valid. The staff concludes that this verification process for the safety analysis MDC is acceptable.

3.0 REFERENCES

1. Letter from C. K. McCoy (GPC) to USNRC, "Vogtle Electric Generating Plant Request for NRC Concurrence with Technical Specifications Bases Change," dated March 29, 1991.

2. Vogtle Electric Generating Plant Unit 1 and Unit 2 Technical Specifications, Appendix A to License Nos. NPF-68 and NPF-81.

3. Vogtle Electric Generating Plant Unit 1 and Unit 2 Core Operating Limits Report, Revision 0 to Unit 1 Cycle 3 and Revision 0 to Unit 2 Cycle 2.

4. "Vogtle Electric Generating Plant Unit 1 and Unit 2 Final Safety Analysis Report Update," Docket Nos. 50 [illegible] and 50-425, as amended through March 28, 1990.

5. "Safety Evaluation Supporting a More Negative EOL Moderator Temperature Coefficient Technical Specification for the Alvin W. Vogtle Plant Units 1 and 2," Westinghouse Electric Corporation, January 1990.

6. "Standard Technical Specifications for Westinghouse Pressurized Water Reactors," NUREG-0452, Revision 4, issued Fall 1981.

7. "Westinghouse Reload Safety Evaluation Methodology," WCAP-9272-P-A, July 1985.