TVA

R. M. Krich
Vice President
Nuclear Licensing

Tennessee Valley Authority
1101 Market Street, LP 3R
Chattanooga, Tennessee 37402-2801

April 2, 2010

10 CFR 50.4

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Units 1 and 2
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Subject: **Responses to Requests for Additional Information Regarding Core Operating Limits Report (TAC Nos. ME1193 and ME1165)**

By letter dated March 9, 2010, the NRC requested additional information regarding the Core Operating Limits Reports (COLRs) submitted by the Tennessee Valley Authority on April 27, 2009 and April 30, 2009, for Sequoyah Nuclear Plant (SQN), Unit 2 Cycle 16, and SQN, Unit 1 Cycle 17, respectively. Specifically, the SQN, Unit 2 COLR submittal indicated that the previous revision of the COLR (submitted June 3, 2008) contained errors in the calculation of the departure from nucleate boiling maximum allowable peaking limits. During NRC review of these COLRs, it was determined that additional information was required by the NRC staff in order for it to complete its evaluation. The enclosure provides the responses to those requests for additional information.

There are no regulatory commitments in this letter. Should there be any questions regarding this letter, please contact Rod Cook at (423) 751-2834.

Respectfully,

D. E. Cribbe
for
R. M. Krich

Enclosure:
Responses to Requests for Additional Information Regarding the Core Operating Limits Report

cc: (Enclosure)

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Sequoyah Nuclear Plant

D030
NRR

ENCLOSURE

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2
RESPONSES TO REQUESTS FOR ADDITIONAL INFORMATION
REGARDING THE CORE OPERATING LIMITS REPORT

Item 1:

With respect to the SQN Unit 2 Cycle 16 COLR, the licensee stated that an error was identified with the departure from nuclear boiling maximum allowable peaking limits. Please clarify the following: (a) identify the error that impacted the parameters listed in Section 1.0 of the April 27, 2009, submittal; (b) discuss the methodology used to analyze the impact of the input error; and (c) describe the analysis used to determine the impact of the error and to justify that there is sufficient margin to account for the error.

Response:

1(a) The Mark-BW fuel assembly design used at Sequoyah Nuclear Plant (SQN) includes eight grids. Beginning at the bottom of the fuel assembly, the first grid is an Inconel end grid, followed by one Zircaloy-4 intermediate spacer grid with no mixing vanes, five Zircaloy-4 intermediate spacer grids with mixing vanes, and finally a top Inconel end grid. For departure from nucleate boiling (DNB) analyses, the bottom end grid and the first intermediate spacer grid with no mixing vanes are modeled with the NRC-approved BWU-N critical heat flux (CHF) correlation. The axial region beginning with the second intermediate spacer grid is modeled with the NRC-approved BWCMV-A CHF correlation due to the presence of mixing vanes. The top end grid is above the fueled axial region.. Calculations of the limiting DNB ratio (DNBR) depend upon the axial height of the limiting location and must be based on the BWU-N or the BWCMV-A CHF correlation, whichever is applicable to that axial region.

The Initial Condition DNB (IC-DNB) Maximum Allowable Peaking (MAP) limits specified in Section 2.6 and Table 2 of the SQN, Unit 2 Cycle 16 COLR are associated with the $F_{\Delta H}$ limit specified in the Technical Specification 3/4.2.3. These limits were produced by a generic analysis applicable to SQN, Units 1 and 2. The analysis used version 27.1 of the NRC-approved LYNXT thermal-hydraulic computer code (Reference 1). This version of the LYNXT code calculated the limiting axial location with respect to DNB but required a manual process to ensure that the CHF correlation applicable to the limiting axial location was used. Later versions of LYNXT include an automated feature to perform the selection of the limiting CHF correlation.

During SQN, Unit 2 Cycle 16 operation, while doing a related calculation, a later version of the LYNXT code with the automated feature was used to recalculate some of the generic IC-DNB MAP limits. While comparing the new results to the generic results, a discrepancy was noticed. It was determined that the discrepancy resulted from an error in some of the generic analysis cases. Specifically, the error was identified as incorrect selection of the appropriate combination of limiting axial height and CHF correlation when using the manual process to select the CHF correlation, which resulted in a nonconservative error at some of the MAP limit values specified in Table 2 of the Core Operating Limits Report (COLR).

1(b) AREVA NP Topical report BAW-10163P-A (Reference 2) and the report (BAW-10220P, Reference 3) submitted to support the license amendment request for the SQN fuel transition to AREVA NP fuel, which received a Safety Evaluation by the Nuclear Regulatory Commission Office of Nuclear Reactor Regulation for Amendment Number 223 to Facility Operating License DPR-77 and Amendment Number 214 to Facility Operating License DPR-79, dated April 21, 1997, fully describe the methodology used to calculate DNB MAP limits and their use in reload core safety evaluations.

These NRC-approved methods were used to analyze the impact of the input error. Version 29.0 of the LYNXT computer code (Reference 1) was used to regenerate the IC-DNB MAP limits using the NRC-approved methodology described in BAW-10163P-A (Reference 2). This later version of LYNXT includes an automatic feature to select the appropriate CHF correlation.

Both BAW-10163P-A (Section 2) and BAW-10220P (Section 7) discuss generation and use of DNB MAP limits. From a thermal-hydraulic analysis of the reactor core, elevation-dependent initial condition relative power peaking limits that preserve the minimum DNBR during the limiting loss of forced reactor coolant flow transient are determined. These relative peaking limits, referred to as MAP limits, represent allowable combinations of radial peaking, axial peaking, and elevation that yield the design minimum DNBR at the specified statepoint conditions. The MAP limits are generated based upon a statistical DNB design limit that includes allowances for uncertainties and measurement error. NRC-approved topical report BAW-10170P-A (Reference 4) describes the statistical core design methods used in the thermal-hydraulic analysis. The IC-DNB MAP limits are incorporated into the reload core maneuvering analysis that validates the core axial flux difference (AFD) operating limits specified in the COLR and thus they represent the effective $F_{\Delta H}$ limits for the core. DNB peaking margins relative to the IC-DNB MAP limits, calculated from limiting power distributions for the reload core, are also used in the core power distribution monitoring software to validate the core power peaking surveillance requirements when monthly incore flux map results are generated.

1(c) A detailed evaluation was performed for this issue, including revision and correction of the generic DNB MAP limit analysis and cycle-specific maneuvering analysis. The evaluation determined that sufficient margin existed and that SQN, Unit 2 Cycle 16 could operate at rated power during its entire fuel cycle length. SQN, Unit 1 Cycle 16 was shut down for refueling at the time of the evaluation; however, the results of the SQN, Unit 2 evaluation can be also extended to include SQN, Unit 1 Cycle 16.

The evaluation consisted of the following steps:

- Correction of the generic DNB MAP limit analysis and generation of corrected IC-DNB MAP limits using LYNXT version 29.0
- Generation of a comparison of the corrected IC-DNB MAP limits to the limits that contained errors; the comparison indicated that most of the MAP limit errors were constrained to power distributions with high normalized axial peaking factors (F_z)

of 1.50 and greater. For most power distributions with normalized axial peaking factors less than 1.50, the corrected IC-DNB MAP limits were actually greater than the original generic MAP limit set that contained the errors. The maximum error in the IC-DNB MAP limits was 6.1 percent, which would have occurred for a severely inlet-peaked power distribution with a normalized axial peak (F_z) of 1.50. The MAP limit errors were actually conservative for operation of the Units at normal design conditions where they operate at rated thermal power with a small regulating bank reactivity bite, a small AFD, and a relatively small normalized axial peaking factor.

- The core maneuvering analysis was revised to generate corrected IC-DNB peaking margin versus axial power offset correlations using the corrected IC-DNB MAP limit set. The peaking margin versus axial power offset correlations were then examined to determine if any adjustments were needed to the AFD limits specified in the COLR. The evaluation indicated that even at the limits of normal operation, the AFD limits specified in the COLR were adequate to prevent exceeding power peaking limits based upon DNB criteria, and thus no modifications to the AFD limits were required. The most limiting core power distributions based upon DNB criteria occur for outlet-peaked axial power shapes. Even for these conditions, the peaking margin calculation results demonstrated that greater than 9.5 percent IC-DNB peaking margin at the positive AFD limit existed.
- A comparison of the corrected IC-DNB peaking margins to the LOCA peaking margins was performed. The comparison showed that the LOCA peaking margins remained more limiting than the corrected IC-DNB peaking margins for almost every case; however, even for those cases where the core-wide minimum peaking margin was set by IC-DNB, the margin was always sufficient (greater than 9.5 percent) to accommodate the IC-DNB MAP limit error without requiring modification to COLR AFD limits. Consequently, the core remained LOCA-limited even when the allowance for the MAP limit error was considered. DNB margin factors are generated and used in the on-line core power distribution monitoring software to calculate the limiting margins based on measured peaking factors extracted from processing monthly incore flux maps. The software also contains the IC-DNB MAP limits in its cycle-specific database update. The DNB margin factors were re-calculated using the corrected IC-DNB margins from the maneuvering analysis evaluation. Both the corrected DNB margin factors and the corrected IC-DNB MAP limits were then incorporated into a revised software database update for use at the plant.
- Finally, plant operational data from SQN, Unit 1 Cycle 16 and SQN, Unit 2 Cycle 16 were examined to ensure that neither SQN Unit had operated in a condition that deviated significantly from design conditions. The review consisted of evaluation of the daily power histories for the two fuel cycles and the results from the monthly power peaking surveillance IC-DNB margin calculations from the on-line plant power distribution software for both fuel cycles. The results of the review clearly demonstrated that neither Unit had operated in a condition that would have caused peaking factors to increase to levels that would challenge the DNB-based peaking limits, even when accounting for the error in the IC-DNB MAP limits. The minimum measured IC-DNB peaking margin for limiting conditions was always greater than 8 percent for both SQN, Unit 1 Cycle 16 and

SQN, Unit 2 Cycle 16, which is greater than the maximum reduction seen in the IC-DNB MAP limits due to the error.

The evaluation described by these steps provided the justification that there was always sufficient margin to accommodate the error in the IC-DNB MAP limits in Table 2 of the COLR for SQN, Unit 2 Cycle 16. Consequently, operation at rated thermal power was validated for SQN, Unit 2 Cycle 16 without modification to the AFD limits in the COLR.

Item 2:

Please clarify that the SQN Unit 1 Cycle 17 COLR does not have an error similar to the one identified for the Unit 2 Cycle 16 COLR.

Response:

The SQN, Unit 1 Cycle 17 COLR did not have an IC-DNB MAP limit error similar to the one identified for the SQN, Unit 2 Cycle 16 COLR. The error in the IC-DNB MAP limit analysis affected the generic calculation of MAP limits for SQN. As a result of the Issue Evaluation required by the AREVA NP Corrective Action Program, the generic analysis was corrected. The reload safety evaluations for SQN, Unit 1 Cycle 17, SQN, Unit 2 Cycle 17, and succeeding evaluations have all used the corrected IC-DNB MAP limits. The corrected IC-DNB MAP limits were incorporated into the reload documentation, into the cycle-specific plant power distribution software database updates, and into the COLRs for these fuel cycles.

References:

1. LYNXT – Core Transient Thermal-Hydraulic Program, BAW-10156P-A, Revision 1, dated August 1993
2. Core Operating Limit Methodology for Westinghouse-Designed PWRs, BAW-10163P-A, dated June 1989
3. Mark-BW Fuel Assembly Application for Sequoyah Nuclear Units 1 and 2, BAW-10220P, dated March 1996 (see NRC SER Related to Amendment No. 223 to Facility Operating License No. DPR-77 and Amendment No. 214 to Facility Operating License No. DPR-79, dated April 21, 1997)
4. Statistical Core Design for Mixing Vane Cores, BAW-10170P-A, dated December 1988