TVA

November 26, 2015

10 CFR 50.4
10 CFR 50.46

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

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

Subject: **10 CFR 50.46 Combined Annual and 30-Day Report for Sequoyah Nuclear Plant, Units 1 and 2.**

Reference: TVA letter to NRC, "10 CFR 50.46 Annual Report of Non-Significant Changes," dated November 21, 2014 [ML14330A326]

The purpose of this letter is to provide the current status of the calculated peak cladding temperature (PCT) for the Sequoyah Nuclear Plant emergency core cooling system (ECCS) evaluation model. The enclosure contains a summary of the changes to the calculated PCT made since the submittal of the referenced letter to NRC.

This submittal satisfies the annual reporting requirement of 10 CFR 50.46(a)(3)(ii).

This submittal also satisfies the requirement in 10 CFR 50.46(a)(3)(ii) that the NRC be notified within 30 days of a change in PCT that exceeds 50°F. A change was made to the small break loss of coolant accident (SBLOCA) analysis within the past 30 days and the change results in a greater than 50°F increase in PCT.

In addition, 10 CFR 50.46(a)(3)(ii) requires that for a change in PCT that exceeds 50°F, a proposed schedule for providing a reanalysis to show compliance with 10 CFR 50.46 requirements be provided to the NRC. The enclosure demonstrates that the updated net licensing basis PCT for the SBLOCA is below the 10 CFR 50.46(b)(1) PCT limit of 2200°F. This provides the requisite demonstration of compliance with the 10 CFR 50.46 requirements. Therefore, TVA has concluded that no reanalysis is required.
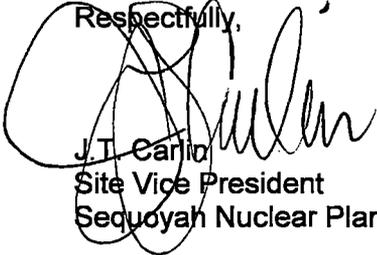
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There are no regulatory commitments associated with this submittal. Should you have any questions, please contact Jon Johnson at (423) 843-8129.

Respectfully,

J. T. Carlin
Site Vice President
Sequoyah Nuclear Plant

Enclosure
    10 CFR 50.46 2015 Annual and 30-Day Report of Changes in PCT

cc (Enclosure):
    NRC Regional Administrator – Region II
    NRC Senior Resident Inspector – Sequoyah Nuclear Plant
    Division of Radiological Health - State of Tennessee

ENCLOSURE

TENNESSEE VALLEY AUTHORITY (TVA)
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2

10 CFR 50.46 2015 ANNUAL AND 30-DAY REPORT OF CHANGES IN PCT

Both reactor cores at SQN utilize two fuel assembly designs: (1) the AREVA Advanced W17 High Thermal Performance (HTP) fuel type and (2) the AREVA Mark BW fuel type. The loss of coolant accident (LOCA) analyses of record (AORs) for both fuel types are detailed in Topical Reports ANP-2970(P) and ANP-2970Q1(P), "Sequoyah Units 1 and 2 HTP Fuel Realistic Large Break LOCA Analysis," and ANP-2971(P), "Sequoyah Units 1 and 2 HTP Fuel S-RELAP5 Small Break LOCA Analysis." These reports were submitted to the Nuclear Regulatory Commission (NRC) as part of SQN Technical Specifications (TS) Change TS-SQN-2011-07 to modify the TS to authorize the use of HTP fuel assemblies. The TS change associated with the HTP fuel design and supporting documentation were reviewed and approved by NRC as documented in the associated Safety Evaluation dated September 26, 2012 (Reference 1).

Table 1 details the changes in the calculated peak cladding temperature (PCT) currently applied to the AOR PCTs. The changes in PCTs since the previous 10 CFR 50.46 report (Reference 2) can be summarized for SQN Unit 1 and Unit 2 as follows:

- The PCT in the Large Break LOCA (LBLOCA) remains unchanged, with a current licensing basis PCT of 1940°F.

- The PCT in the Small Break LOCA (SBLOCA) increased 151°F to a new licensing basis PCT of 1543°F.

TABLE 1

Summary of Changes in LOCA PCTs for Sequoyah Units 1 and 2

Report Year	Description	LBLOCA PCT (°F)	Change in LBLOCA PCT (°F)	SBLOCA PCT (°F)	Change in SBLOCA PCT (°F)	Notes
2013	**New AORs** for AREVA HTP fuel: ANP-2970(P) Rev. 0, ANP-2970Q1(P), Rev. 0, and ANP-2971(P), Rev. 1	**1950**	-------	**1470**	-------	1
2012	Sleicher–Rouse heat transfer correlation equation error	-------	-------	-------	-89	2
2013	Cathcart-Pawel uncertainty correlation error in RLBLOCA applications	-------	0	-------	0	3
2013	RODEX3a error in treatment of "trapped stack" condition	-------	-10	-------	0	4
2014	S-RELAP5 vapor absorptivity correlation	-------	0	-------	+11	5
2014	Axial power shape mapping by modal decomposition	-------	0	-------	0	6
2015	Operator action time allowance for restarting the high head ECCS pumps when transferring the pump suctions from the RWST to the containment sump.	-------	0	-------	+151	7
2015	**Updated Licensing Net PCT** $AOR\ PCT + \sum \Delta\ PCT$	**1940**	**-10**	**1543**	**73**	-------
	Cumulative sum of PCT changes $\sum |\Delta\ PCT|$	-------	**10**	-------	**251**	-------

<u>Notes:</u>

1) New AOR emergency core cooling system (ECCS) PCT associated with the use of AREVA W17 HTP Fuel at SQN

   The current SQN, Units 1 and 2, AORs for the AREVA W17 Advanced HTP fuel design are detailed in Topical Reports ANP-2970(P) and ANP-2970Q1(P), "Sequoyah Units 1 and 2 HTP Fuel Realistic Large Break LOCA Analysis," and ANP-2971(P), "Sequoyah Units 1 and 2 HTP Fuel S-RELAP5 Small Break LOCA Analysis." These AORs constitute a reanalysis of the ECCS evaluation models. As such, the cumulative sums of the absolute magnitudes of the PCT changes for both units have been restored to zero for 10 CFR 50.46(a)(3)(ii) reporting purposes. Subsequent changes and errors that affect PCT are detailed in Table 1 of this enclosure.

2) S-RELAP5 Sleicher-Rouse heat transfer correlation equation error

   Sleicher-Rouse is a mathematical correlation used in the S-RELAP computer code for predicting convective heat transfer between the fuel and coolant single-phase vapor. This correlation is applicable to both the LBLOCA and SBLOCA analyses performed with S-RELAP5. During a review of the behavior of the Sleicher-Rouse correlation relative to other single-phase vapor heat transfer correlations, an error was discovered in the form of the correlation used in the S-RELAP5 implementation. The difference is related to the form of the equation for calculating the exponent of the temperature ratio correction term. The S-RELAP form of the Sleicher-Rouse heat transfer correlation has been updated to:

   $$n = -[\log 10(T_w/T_g)]^{1/4} + 0.3$$

   This correction resulted in a 35°F reduction in LBLOCA PCT for SQN Units 1 and 2. However, this 35°F reduction in PCT was described in ANP-2970Q1(P) and acknowledged as being included in the analysis by NRC in the Safety Evaluation Report approving SQN Technical Specifications (TS) Change TS-SQN-2011-07. The 35°F reduction for Sleicher-Rouse is therefore applied and reflected in the stated 1950 °F AOR PCT for the LBLOCA.

   Correction of the Sleicher-Rouse error in the SBLOCA was not similarly discussed and incorporated during the license amendment process for HTP fuel and therefore is not reflected in the stated AOR value (1470 °F). Instead, the Sleicher-Rouse adjustment for the SBLOCA (-89 °F) is explicitly applied to the AOR PCT, as seen in Table 1.

3) Cathcart-Pawel uncertainty correlation error in RLBLOCA applications

   For Realistic LBLOCA (RLBLOCA) analyses, the rate-dependent correlation developed by Cathcart-Pawel is used to model the metal-water reaction during a LOCA. The rate constants for the Cathcart-Pawel equation are determined experimentally and the data are subjected to a statistical analysis to determine the relevant uncertainty parameters for the derived correlation. The RLBLOCA analysis uses a log-normal function for the uncertainty multiplier applied to the rate constant. The formula and standard deviation were found to be incorrect.

   Analysis of the error confirmed that the effect on previous RLBLOCA analyses was negligible. There is no change to the LBLOCA PCT value for SQN, Units 1 and 2, from this error. This error did not apply to the SBLOCA analysis.

4) RODEX3a error in treatment of "trapped stack" condition

A "trapped stack" condition exists when any fuel rod contains a gap dimension that is calculated to be less than 0.5 mil with open gaps lying at lower axial levels. If this condition exists, then a trapped stack model is applied. However, a coding error was identified that essentially deactivated the trapped stack model. Although the effect of this error is small, it was determined that it could be conservative or non-conservative depending on the steady-state initial stored energy.

A development version of S-RELAP5 was prepared with the correct evaluation of the trapped stack model and several code validation and plant sample problems were repeated. Analysis of the identified coding error using this updated version of S-RELAP5 determined that it was conservative for SQN and resulted in a 10°F reduction in PCT for the LBLOCA. This error is not applicable to the SBLOCA analysis because it uses RODEX2 rather than RODEX3a.

5) S-RELAP5 vapor absorptivity correlation

The vapor absorptivity correlation applied to the S-RELAP5 based methodologies used in S-RELAP5 was being applied outside of its intended range of applicability. Specifically, there was no limit on the pressure at which the correlation was applied. The correlation is provided in the S-RELAP5 Models and Correlation Code Manual. The equation used for the absorption coefficient of vapor contains the pressure term that is truncated in order to obtain the correct emissivity values for an optically thick steam. No lower pressure limit on the vapor absorptivity correlation is required as the correlation is developed for optically thin gases, which already applies at low pressures. Results show that limiting the vapor absorptivity correlation to within its intended pressure range allows S-RELAP5 to predict the wall temperatures for THTF within the uncertainty bands or above the uncertainty bands (conservative). A development version of S-RELAP5 was prepared containing the pressure limit for the calculation of the vapor absorptivity in order to assess the effect on the current AOR for SBLOCA. The PCT increase was developed by comparing the AOR after the Sleicher-Rouse error correction with the new PCT results obtained with the corrected version of S-RELAP5. The limiting case and multiple break sizes around the limiting case were rerun with the developmental code version of S-RELAP5. For RLBLOCA, single phase steam only exists for a very limited time just before the beginning of reflood. During the majority of the blowdown phase and during the entire reflood phase, that are the important RLBLOCA phases, the core is in a dispersed flow regime. The S-RELAP5 methodology uses the FLECHT-SEASET reflood tests to determine the heat transfer bias and uncertainty under these conditions. In addition, the transient progression is quick and the system depressurizes in the first few seconds after the break opening. As a result of the fast depressurization, the amount of time that the correlation for vapor absorptivity used in RLBLOCA is applied outside of the range of applicability is limited and therefore the results predicted in the AOR remain valid.

The estimated effect of this change on the SQN Unit 1 and Unit 2 SBLOCA analysis calculated peak cladding temperature is +11°F resulting in a new calculated PCT of 1392°F.

6) Axial power shape mapping by modal decomposition

In 2014, AREVA identified the axial power shapes being used in the LBLOCA analysis were significantly different from the shapes predicted by the core design. These shapes are dependent on the time in cycle and cover both top and bottom peaked shapes. The shapes are generated in a 24-node format and the methodology selects an axial shape based on a sampled time in cycle, a sampled skew (i.e., top/bottom) and a sampled heat flux hot channel factor. Two bounding axial curves are determined from the sorted axial shapes and then a 24-node shape is interpolated between the two bounding curves. The 24-node axial power shape is subsequently mapped to the number of heat structure nodes and elevation points required by S-RELAP5 (40 to 52 nodes). The mapping procedure used is called modal decomposition and it uses a set of orthogonal sine functions to perform the mapping.

In the evaluation for this issue, the mapping of the axial power shapes generated by the modal decomposition method was compared to a linear interpolation method for mapping the axial power shapes. It was concluded that linear interpolation provides a significantly better fit for the axial shapes. Although modal decomposition does not represent the axial shapes as well, it remains conservative for the case set performed for the SQN AOR.

The effect of this change on the SQN Unit 1 and Unit 2 LBLOCA analysis calculated peak cladding temperature is 0°F. The SBLOCA analysis is unaffected by this error.

7) Operator action time allowance for restarting the high head ECCS pumps when transferring the pump suctions from the refueling water storage tank (RWST) to the containment sump.

The design of the ECCS provides for automatic transfer of the low head ECCS pump suctions from the RWST to the containment sump. The transfer of the high head ECCS pump suctions from the RWST to the containment sump is a manual action. During the automatic transfer of the low head ECCS pump suctions from the RWST to the containment sump, a postulated failure to close of one of the RWST supply isolation valves results in the need to shutdown the high head ECCS pumps until their suctions can be aligned to the containment sump.

The effect of this interruption of the high head ECCS pump injection on the SQN Unit 1 and 2 SBLOCA analysis calculated peak cladding temperature is 151°F. The LBLOCA analysis is unaffected by this interruption of the high head ECCS pump injection.

References:

1. Letter from NRC to TVA, "Sequoyah Nuclear Plant, Units 1 and 2 - Issuance of Amendments to Revise the Technical Specification to Allow Use of AREVA Advanced W17 High Thermal Performance Fuel (TS-SQN-2011-07) (TAC Nos. ME6538 and ME6539)," dated September 26, 2012 [ML12249A394, ML12249A415]

2. TVA Letter to NRC, "10 CFR 50.46 Annual Report of Non Significant Changes," dated November 21, 2014 [ML14330A326]