UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 13, 2016

Mr. Dennis L. Koehl
President and CEO/CNO
STP Nuclear Operating Company
South Texas Project
P.O. Box 289
Wadsworth, TX 77483

SUBJECT: SOUTH TEXAS PROJECT, UNITS 1 AND 2 - RE: FEBRUARY 4 AND 16, 2016, REGULATORY AUDIT SUMMARY ASSOCIATED WITH A RISK-INFORMED SOLUTION TO GENERIC SAFETY ISSUE 191 (CAC NOS. MF2400, MF2401, MF2402, MF2403, MF2404, MF2405, MF2406, MF2407, MF2408, AND MF2409)

Dear Mr. Koehl:

By letter dated June 19, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML131750250), as supplemented by letters dated October 3, October 31, November 13, November 21 and December 23, 2013 (two letters); and January 9, February 13, February 27, March 17, March 18, May 15 (two letters), May 22, June 25, July 15, 2014; and March 10, March 25, and August 20, 2015 (ADAMS Accession Nos. ML13295A222, ML13323A673, ML13323A128, ML13338A165, ML14015A312, ML14015A311, ML14029A533, ML14052A110, ML14072A075, ML14086A383, ML14087A126, ML14149A353, ML14149A354, ML14149A439, ML14178A467, ML14202A045, ML15072A092, ML15091A440, and ML15246A125, respectively), STP Nuclear Operating Company (STPNOC) submitted exemption requests accompanied by license amendment requests for a risk-informed approach to resolve Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR [Pressurized-Water Reactor] Sump Performance," at South Texas Project, Units 1 and 2 (STP).

The U.S. Nuclear Regulatory Commission (NRC) staff conducted a thermal-hydraulic regulatory audit at the Westinghouse Electric Company office in Rockville, Maryland, on February 4 and 16, 2016, in order resolve remaining open NRC staff concerns associated with your current analysis for in-vessel boric acid precipitation during design-basis accidents. Specifically, the NRC staff reviewed your modeling, assumptions, and calculations for the hot-leg switchover time to ensure long-term core cooling in accordance with Title 10 of *Code of Federal Regulations* 50.46(b)(5). This review is important as it forms a basis for portions of STPNOC's resolution of GSI-191.

Conducting the audit improved the NRC staff's knowledge and understanding of STPNOC's assumptions, modeling, and calculations which form the bases for the hot-leg switchover time. The enclosure to this letter describes the observations, questions, and results of the NRC staff's audit.

If you have any questions, please contact me at 301-415-1906 or via e-mail at Lisa.Regner@nrc.gov.

Sincerely,

Lisa M. Regner, Senior Project Manager
Plant Licensing Branch IV-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-498 and 50-499

Enclosure:
Audit Report

cc w/encl: Distribution via Listserv

AUDIT REPORT – FEBRUARY 4 AND 16, 2016

REVIEW OF DESIGN BASIS BORIC ACID PRECIPITATION CALCULATIONS

ASSOCIATED WITH THE RISK-INFORMED SOLUTION TO GSI-191

STP NUCLEAR OPERATING COMPANY

SOUTH TEXAS PROJECT, UNITS 1 AND 2

1.0 BACKGROUND

By letter dated June 19, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML131750250), as supplemented by letters dated October 3, October 31, November 13, November 21 and December 23, 2013 (two letters); and January 9, February 13, February 27, March 17, March 18, May 15 (two letters), May 22, June 25, July 15, 2014; and March 10, March 25, and August 20, 2015 (ADAMS Accession Nos. ML13295A222, ML13323A673, ML13323A128, ML13338A165, ML14015A312, ML14015A311, ML14029A533, ML14052A110, ML14072A075, ML14086A383, ML14087A126, ML14149A353, ML14149A354, ML14149A439, ML14178A467, ML14202A045, ML15072A092, ML15091A440, and ML15246A125, respectively), STP Nuclear Operating Company (STPNOC, the licensee) submitted exemption requests accompanied by license amendment requests for a risk-informed approach to resolve Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR [Pressurized-Water Reactor] Sump Performance," at South Texas Project, Units 1 and 2 (STP).

In order for the NRC staff to complete its review, a better understanding of the effects of boric acid precipitation (BAP) in STPNOC's application were needed; therefore, the NRC staff asked requests for additional information (RAI) questions SNPB 4 through 10 dated April 15, 2014, and SSIB 66 dated March 3, 2015 (ADAMS Accession Nos. ML14087A075 and ML14357A171, respectively). The licensee responded in letters dated June 25, 2014, July 15, 2014, and August 20, 2015. The NRC staff determined that a regulatory audit would allow a more efficient review of the assumptions, modeling, and calculations associated with the licensee's consideration of BAP as it impacts STPNOC's resolution of GSI-191.

2.0 SCOPE AND PURPOSE

On February 4 and 16, 2016, the NRC staff audited STPNOC's analyses related to STP's hot-leg switchover (HLSO) timing and BAP control procedures at the Westinghouse Electric Company LLC (Westinghouse) office in Rockville, Maryland. The purpose of the audit was for NRC staff to gain a better understanding of the modeling, assumptions, and calculations associated with considerations of BAP in the reactor pressure vessel during design-basis accidents. Boric acid precipitation is believed to impede core cooling during loss-of-coolant accidents (LOCAs) and necessitates the determination of an HLSO time used during emergency operating procedures to mitigate for the effects of BAP. The current licensing basis HLSO time is used as an input into STPNOC's resolution of GSI-191; therefore, the adequacy of the HLSO calculation as it accounts for debris is important to the NRC staff's review of GSI-191.

Enclosure

The NRC's scope of the audit was to review documents providing assurance of the adequacy of the current licensing basis HLSO time as it relates to the NRC staff's review of the HLSO time for resolution of GSI-191. Further, the audit was intended to determine what, if any, additional information would need to be docketed to resolve the NRC staff concerns.

The following NRC staff members participated in the audit:

- Reed Anzalone – Technical reviewer, General Engineer
- Joshua Kaizer – Technical reviewer, Reactor Systems Engineer

The following STPNOC staff members participated in the audit:

- Charles Albury – STPNOC
- Steven Smiley – STPNOC
- James Spring – Westinghouse, contractor for STPNOC

The NRC staff provided the enclosed draft questions to the licensee by e-mail dated March 18, 2016 (ADAMS Accession No. ML16081A004).

3.0 AUDIT REPORT

The STPNOC staff provided an overview of the Westinghouse BAP analyses and discussion of the impacts to the analysis following the withdrawal of NRC approval of the calculation guidance, CENPD-254-P, "Post-LOCA Long Term Cooling Model," due to non-conservative modeling assumptions. Withdrawal of NRC approval was documented in a November 23, 2005, letter from the NRC staff to the Westinghouse Owners Group (ADAMS Accession No. ML053220569). This letter provided four items to be addressed by licensees on a plant-specific basis for any NRC submittals concerning post-LOCA long-term core cooling. These items included:

(1) The mixing volume must be justified and the void fraction must be taken into account when computing the boric acid concentration.

(2) The time variation of the mixing volume, including the effects of loop pressure drop, must be accounted for in determining the boric acid concentration.

(3) The solubility limit must be justified, especially if containment pressures greater than 14.7 pounds per square inch absolute (psia) are assumed or additives are contained in the sump water.

(4) When using a Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix K evaluation model, the decay heat must be multiplied by 1.2. If using a non-Appendix K model, a realistic decay heat model may be used with sufficient justification.

The licensee stated that the STP BAP control analysis addressed these items through the use of certain modeling assumptions, and discussed how each item was addressed by the assumptions. These modeling assumptions included:

- A boric acid solubility limit of 29.97 weight percent at 14.7 psia and 103.3 degrees Celcius
- The use of the modified Yeh[1] correlation to determine core void fractions
- Credit for both the lower plenum and the barrel-baffle region as mixing volumes
- Vapor holdup in containment sufficient to saturate the containment atmosphere at the initiation of the event
- A 1.2 multiplier on decay heat
- The loop pressure drop calculations include 10 percent voiding in the downcomer and fully voided loop seals

The NRC staff has not previously formally approved the use of mixing in the barrel-baffle region in a BAP analysis; therefore, the NRC staff asked for additional justification. The licensee discussed the results from the previous industry and NRC testing supporting STPNOC's claim that the barrel-baffle region is an appropriate mixing volume.

The testing discussed by the licensee included the BACCHUS test conducted by Mitsubishi Heavy Industries in 2004. The BACCHUS test was conducted to support the purported flow path through the barrel-baffle region by showing that flow entered the barrel-baffle at the top of the core and exited at the bottom. The other test discussed was the PKL H5 test, which attempted to demonstrate that there is thorough mixing between the core and the barrel-baffle region with similar concentrations being measured throughout the transient in both regions. However, detailed analysis of the experimental data was not presented and the results were used only as qualitative support of STPNOC's assumptions of barrel-baffle region mixing.

The NRC staff subsequently viewed the licensee's BAP analysis, which was performed in part using the SKBOR software. The SKBOR software performs a two-volume transient calculation of the boron concentration. One volume is the core, where boric acid concentrates as water boils off, since the steam carries no boric acid as it exits the core. Vapor generated in the core is assumed to condense in containment and is returned to the second volume, which is the containment sump. In the sump, the boron concentration dilutes over time, since the condensate returned to the containment sump contains no boric acid. SKBOR also computes the transient void fraction in the core based on the total core power level and a uniform power distribution.

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[1] H. C. Yeh, "Modification of Void Fraction Calculation," Proceedings of the Fourth International Topical Meeting on Nuclear Thermal-Hydraulics, Operations and Safety, Volume 1, Taipei, Taiwan, June 6, 1988. The document is publicly available through the International Atomic Energy Agency: http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/35/095/35095494.pdf.

The volumes credited as the total mixing volume in the core node of the SKBOR analysis included the core, the upper plenum up to the bottom of the cold leg, the barrel-baffle region, and one half of the lower plenum. The available volume for mixing in the core, upper plenum, and barrel-baffle regions was reduced by the void fraction. The core and barrel-baffle region used the core void fraction. This had the effect of reducing the available barrel-baffle mixing volume to approximately half that of the total volume of the region. However, the barrel-baffle region contributes approximately 10-15 percent of the total mixing volume in the analysis. The upper plenum mixing volume was reduced by the upper plenum void fraction. This upper plenum void fraction was computed by taking the core exit void fraction and correcting it to account for the change in superficial velocity due to the flow area change at the core exit.

The NRC staff also viewed the portions of the analysis not performed using SKBOR, which included calculations of the loop pressure drop, the minimum timing for hot leg switchover, and the hot-leg refill rates once HLSO has been established. The primary observation the NRC staff made regarding these analyses is that the pressure drop calculation assumes that loop seals are fully voided, which STPNOC asserts to be conservative. Since loop seal behavior is more important for small-break LOCAs and large-break LOCAs are limiting for STP for BAP, the NRC staff determined that loop seal behavior was not a concern.

4.0 CONCLUSION

The NRC staff found that the audit provided a better understanding of the licensee's assumptions, modeling, and calculations used to support the hot-leg switchover time considering the effects of BAP during a large-break LOCA. These audit activities helped the audit team members understand better the impacts of debris on long-term core cooling at STP and will inform decisions regarding the risk-informed submittal for GSI-191. The audit also answered several of the NRC staff's concerns and questions. There was open communication throughout the audit and the draft RAI question resulting from the audit is provided in the Attachment.

Attachment:
Audit Report Draft Question

AUDIT REPORT DRAFT QUESTION

STP NUCLEAR OPERATING COMPANY

SOUTH TEXAS PROJECT, UNITS 1 AND 2

DOCKET NOS. 50-498 AND 50-499

Thermal-Hydraulic Analysis:
Note: these questions were provided by e-mail from the NRC to STPNOC on March 18, 2016 (Agencywide Documents Access and Management System Accession No. ML16081A004).

In response to SNPB RAI 10 and SSIB RAI 66 (issued in ML14357A171), STPNOC stated (ML15246A128) that the current risk-over-deterministic (RoverD) analysis relies on the hot leg switchover (HLSO) timing of 5.5 hours as stated in STP UFSAR Section 15.6.5.2. As such, the NRC staff believes that changes to the HLSO timing would impact the RoverD analysis and thus the risk-informed resolution to GSI-191. In order to better understand the basis for the current HLSO timing, NRC staff have audited STPNOC's current boric acid precipitation (BAP) control analysis on two occasions, in March 2015 and February 2016.

During the February 2016 audit, NRC staff were presented with testing data supporting STPNOC's contention that the barrel-baffle region mixes with the core under certain conditions. This region has not been previously credited in a BAP analysis. Given this, the NRC staff is not satisfied that a sufficient level of quantitative support has been provided for inclusion of any portion of the barrel-baffle region in the mixing volume. The NRC staff requests that STPNOC either:

a. Provide additional quantitative justification for the use of the barrel-baffle region in the mixing volume, including discussion of the applicability of test data to the STP plants (e.g., scaling of the tests used and the design of the test facilities relative to the design of STP), or

b. Perform a sensitivity analysis of the impact of omitting the barrel-baffle region from the mixing volume, to demonstrate that the current STP HLSO timing of 5.5 hours would be supported.

Attachment

If you have any questions, please contact me at 301-415-1906 or via e-mail at Lisa.Regner@nrc.gov.

Sincerely,

/RA/

Lisa M. Regner, Senior Project Manager
Plant Licensing Branch IV-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-498 and 50-499

Enclosure:
Audit Report

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ADAMS Accession No. ML16096A065

OFFICE	NRR/DORL/LPL4-1/PM	NRR/DORL/LPL4-1/LA	NRR/DSS/SNPB/BC
NAME	LRegner	JBurkhardt	JDean
DATE	4/6/16	4/6/16	4/11/16

OFFICE	NRR/DORL/LPL4-1/BC	NRR/DORL/LPL4-1/PM
NAME	RPascarelli	LRegner
DATE	4/12/16	4/13/16

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