AUDIT REPORT
SOUTH TEXAS PROJECT, UNITS 3 AND 4
CONTAINTMENT HYDRODYNAMIC LOADS REPORT

NRC Audit Team:

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1.0 PURPOSE

The purpose of the audit is to gain an understanding of the evaluation of the containment hydrodynamic loads and pool swell analysis in the South Texas Project (STP), Units 3 and 4, Advanced Boiling Water Reactor (ABWR) design is supported by the analysis and other supporting document developed by Toshiba America Nuclear Corporation (Toshiba) and Nuclear Innovation North America, LLC. (NINA).

This audit follows the guidelines in Office of New Reactors (NRO) Office Instruction NRO-REG-108, "Regulatory Audits."

2.0 BACKGROUND AND AUDIT BASES

On March 31, 2014, General Electric-Hitachi Nuclear Energy (GEH) issued an interim Title 10 of the *Code of Federal Regulations* (10 CFR) Part 21 notification, "10 CFR 21.21a)(2) 60-Day Interim Report Notification: Containment Loads Potentially Exceed Limits with High Suppression Pool Water Level in the ABWR Design," regarding a potential error associated with the ABWR containment hydrodynamic loads. During the August 5, 2014, public teleconference meeting, (ML14220A336), NINA provided a preliminary assessment performed by Toshiba (ML14223B141) of the containment hydrodynamic loads for STP, Units 3 and 4.

On August 29, 2014, GEH issued the final 10 CFR Part 21 interim report, "Containment Loads Potentially Exceed Limits with High Suppression Pool Water Level in the ABWR Design," (ML14246A225). The GEH final evaluation concluded that the predicted increase in the suppression pool (SP) water level above the value used for defining the ABWR loads and applied in structural analysis will not result in a substantial safety hazard or lead to exceeding Technical Specification (TS) safety limit for the ABWR Certified Design.

On September 15, 2014, NINA issued a letter entitled, "Nuclear Innovation North America Response to General Electric-Hitachi Final 10 CFR Part 21 Report," (ML14261A148), regarding its separate evaluation of this issue for STP, Units 3 and 4. The NINA/Toshiba evaluation concluded that a change to the assumption of TS high SP level to a higher level following a large-break loss of coolant accident (LOCA) has an insignificant (less than one percent) impact on the containment structure. In addition, the report stated that NINA/Toshiba did not evaluate the impact on other structures in the suppression pool, most notably the access tunnel, because they are not yet designed. The NRC staff identified a need to audit the analyses developed by NINA/Toshiba in support of the containment hydrodynamic loads for STP, Units 3 and 4.

3.0 OBJECTIVES

The objective of the staff's audit was to:

- Review the assumptions, calculations, and a conclusion that increased SP water level following a large break LOCA (LBL) has an insignificant (less than one percent) impact on the containment structure.

4.0 OBSERVATIONS AND RESULTS

The staff reviewed the document listed in Reference 1 below, and confirmed that the report provided figures and tables to capture the results of calculation of increased loads on the containment wall and the access tunnel due to the increase in water level by one meter during a LOCA over the TS high water level. To assess the impact of a high water level, induced pressure loads were applied over a larger area of the SP walls and access tunnels due to the increased SP level. Detailed calculations for determination of the increased loads on the containment wall and the access tunnel were not available during the audit. However, the reported results appeared to be reasonable based on review of the pressure loading diagrams in the report. The percentage increase in loads due to change in SP water level are as shown below:

Loading	Containment Wall	Access Tunnel
Condensation Oscillation (CO)	10%	60%
Chugging (CH)	12%	63%
Safety Relief Valve (SRV) Actuation	15%	80%

Because the STP ABWR design has not progressed to the detailed stress analysis and structural evaluation, the applicant performed conservative bounding estimate of the impact of the increased load using the structural analysis results reported in the ABWR Design Control Document (DCD) instead of a plant specific detailed analysis.

For evaluation of the containment wall, load combination 15 from DCD Table 3H.1-5a, "Load Combinations, Load Factors and Acceptance Criteria for the Reinforced Concrete Containment," was identified as the most limiting loading combination for the time period during LBL involving increase in SP water level. Load combination 15 includes dead load (D), live load (L), containment pressure (P_a), temperature (T_a), and pipe support reaction (R_a) loads associated with the LOCA, local effects including restraint reaction (Y_r) jet impingement (Y_j) missile impact (Y_m) on the containment due to design basis accident, CO, and the safe shutdown earthquake (SSE) loads. The staff reviewed the applicant's evaluation in which the applicant made some conservative assumptions and determined that the contribution of CO load on the calculated maximum stress in the reinforcing steel in the containment wall at mid-height was 20 mega Pascal (MPa) (2,901 pounds per square inch [psi]). The applicant also used load combination 8 from ABWR DCD Table 3H.1-5a and the corresponding rebar stress from ABWR DCD Table 3H.1-16, "Rebar and Concrete Stresses Due to Load Combination 8," for this evaluation. Load combination 8 includes dead load (D), live load (L), temperature load (T_a) and pressure (P_a) associated with the LOCA, and CO. Loads due to P_a and CO includes a factor of 1.5 in the load combination. The applicant conservatively assumed that the stress in

the rebar due load combination 8 is caused entirely by the accident pressure P_a, and CO pressure on the containment wall. The ratio between P_a and CO pressure was determined using these values from ABWR DCD Tables 3H.1-2, "SIT and LOCA Pressure Loads," and 3H.1-3, "Hydrodynamic Loads," respectively, and calculating the load on the containment wall.

Maximum stress in the reinforcing steel at mid-height of the containment wall was obtained from ABWR DCD Table 3H.1-17, "Rebar and Concrete Stresses Due to Load Combination 15," for load combination 15 in ABWR DCD Table 3H.1-5a, and was equal to 282.28 MPa (40,941 psi). This load combination included CO as one of the loading elements. Based on this the applicant concluded that the contribution due to CO for the maximum stress in the containment wall was about 7 percent (20x100/282.28=7.08). The allowable load for load combination 15, shown ABWR DCD Table 3H.1-17, is greater than 30 percent of the calculated load of 282.28 MPa (40,941 psi). From the above evaluation the applicant concluded that the impact of 10 percent increase in the CO pressure load due increase in water level would be less than one percent, and is not significant.

The staff found the above evaluation by the applicant to be a reasonable bounding evaluation, and did not have any further questions on this evaluation.

The applicant did not perform any structural evaluation of the access tunnels in the COLA, and stated in the summary report listed in Reference 2 below that such evaluation will be performed later as part of detailed design. The applicant also stated that based on the access tunnel stress analysis for the Japanese ABWR plants, the increased CO, CH, and SRV loads also will result in a relatively small increase in the total load, since the governing load for the access tunnels is the much larger thermal load. The staff discussed with the applicant how it would be ensured that the increased hydrodynamic load would be considered during detailed design and reflected in the as-built structures.

5.0 CONCLUSION

Based on the review of the information and calculations provided by the applicant, the NRC staff gained an understanding of the applicant's conclusion of increased pool level has an insignificant (less than one percent) impact on the containment structure. The access tunnels were not evaluated for the increased hydrodynamic loading and it should be ensured that such evaluation is performed during detail design.

The audit is considered to be complete, and there are no other outstanding issues. No other documents were considered necessary for audit.

6.0 REFERENCES

1. COD-2014-100271, Revision 3, "Suppression Pool Water Level Increment and Initial Evaluation of Containment," TANE-STP2014-0022, dated August 2014, Toshiba Corporation.

2. "NINA/Toshiba Evaluation of GEH Part 21 on ABWR Hydrodynamic Loads," a summary report.

3. NRO Office Instruction NRO-REG-108 (Revision 0), “Regulatory Audits.”