January 21, 2016

MEMORANDUM TO: Ronaldo V. Jenkins, Chief
Licensing Branch 3
Division of New Reactor Licensing
Office of New Reactors

FROM: Adrian Muñiz, Project Manager **/RA/**
Licensing Branch 3
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: GENERAL ELECTRIC HITACHI NUCLEAR ENERGY U.S. ADVANCED BOILING WATER REACTOR CONTAINMENT HYDRODYNAMIC LOADS REGULATORY AUDIT SUMMARY REPORT

The U.S. Nuclear Regulatory Commission staff performed an audit at the GE Hitachi Nuclear Energy (GEH) office in Washington, D.C., on October 28, 2015. The NRC staff audited GEH's analysis and other supporting documents performed to support the suppression pool water swell analysis and resulting hydrodynamic load increase, which could affect the U.S. Advanced Boiling Water Reactor structural design. The regulatory audit summary report is enclosed.

Docket No. 52-045

Enclosure:
As stated

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REGULATORY AUDIT SUMMARY REPORT
GE HITACHI U.S. ADVANCED BOILING WATER REACTOR CONTAINTMENT HYDRODYNAMIC LOADS REPORT

U.S. Nuclear Regulatory Commission (NRC) Audit Team:

- Ata Istar, Structural Engineer, NRC
- Hanry Wagage, Senior Reactor Engineer, NRC
- Adrian Muniz, Project Manager, NRC

Audit Date: October 28, 2015

1.0 PURPOSE

To audit GE Hitachi (GEH) analysis and other supporting documents performed to support the suppression pool water swell analysis and resulting hydrodynamic load increase which could affects U.S. Advanced Boiling Water Reactor (U.S. ABWR) structural design. This audit follows the guidelines in Office of New Reactors (NRO) Office Instruction NRO-REG-108, "Regulatory Audits."

2.0 BACKGROUND AND AUDIT BASIS

The GEH issued a Title 10 of the *Code of Federal Regulations* (10 CFR) Part 21 interim notification on March 31, 2014, "10 CFR 21.21(a)(2) 60-Day Interim Report Notification: Containment Loads Potentially Exceed Limits with High Suppression Pool Water Level in the ABWR Design," (reference 1) regarding a potential change associated with the U.S. ABWR reinforced concrete containment vessel (RCCV) hydrodynamic loads. GEH issued a 10 CFR 21.21 closure notification on August 29, 2014, "10 CFR 21.21(a)(2) Closure Report Notification: Containment Loads Potentially Exceed Limits with High Suppression Pool Water Level in the U.S. ABWR Design," (reference 2) describing the evaluation for the increase in hydrodynamic loads generated during a postulated design basis accident (DBA) loss of coolant accident (LOCA) event on the suppression pool (SP) wall boundaries, access tunnels, and submerged structures. The GEH final evaluation concluded that the predicted increase in the SP water level, due to a postulated LOCA event, above the value used for defining the U.S. ABWR loads and applied in structural analysis will neither result in a safety issue nor lead to exceeding Technical Specification (TS) safety limit for the U.S. ABWR Certified Design.

In request for additional information 06.02.01-1, in a letter, dated April 20, 2015, the staff requested GEH describe the impact of this error on the GEH ABWR Design Certification renewal application (ML15110A122). In response, in a letter, dated May 29, 2015, GEH concluded that potential increases or changes to hydrodynamic loads that were defined for the ABWR containment, which are associated with elevated suppression pool water level, will not result in exceeding ABWR structural design limits (ML15149A233, ML15149A234, and ML15149A235).

The NRC staff identified a need to audit the analyses supporting this conclusion.

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

During the audit on October 28, 2015, the applicant provided a detailed presentation of the reports "PRC 14-02/CR9349, Rev. 0," (referenced 4) and "ECO: ECO-0006828, PLM No.: 001N6204, Rev 0," (reference 5). The applicant also showed a testing video simulating the chugging event. The applicant stated that the SP level swell hydrodynamic loads occur due to the main streamline break (MSLB) and feedwater line break (FWLB) in the U.S. ABWR design. The subcategories of hydrodynamic loads include condensation oscillation (CO) and chugging, as well as safety relief valve (SRV) actuation loads impacting on the Suppression Pool Wall Boundaries, the Access Tunnel, and the Submerged Structures. During the audit, the applicant stated that CO loads typically occur during the first 30 seconds followed by a chugging event that may have duration of six hours due to a DBA-LOCA event.

The applicant developed load scale factors using a set of conservative and realistic assumptions that may be applied to the specific hydrodynamic loads to determine the effect of elevated SP water level in the report "PRC 14-02/CR9349, Rev. 0." The applicant demonstrated that the elevated SP water level does not exceed design margin in report, "PLM No.: 001N6204, Rev. 0." The staff reviewed the referenced reports, and confirmed that the reports provided figures and tables to capture the results of calculation of increased loads on the containment wall, the access tunnel and due to the increase in SP water during a postulated LOCA event.

The conservative and realistic load scale factors due to the elevated SP water level, as given in referenced 4, are as follows:

Load Scale Factors				
Loading	**Containment Wall**		**Access Tunnel**	
	Conservative	**Realistic**	**Conservative**	**Realistic**
Condensation Oscillation (CO)	1.326	0.880	1.460	0.978
Chugging (CHUG)	1.160	0.900	1.910	1.478
SRV Actuation	Insignificant increase	-	Insignificant increase	-

The applicant performed a conservative bounding estimate of the impact of the increased load using the structural analysis results reported in the U.S. ABWR Design Control Document (DCD), (reference 3). The applicant identified the load combination (LC) 15 from U.S. ABWR DCD, Tier 2, Table 3H.1-5a, "Selected Load Combinations for the Reinforced Concrete Containment Vessel," as the most limiting loading combination for the time period during LBL due to the elevated SP water level in the report PLM No.: 001N6204, Rev. 0. The LC15 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. In the report, PLM No.: 001N6204,

Rev. 0, (reference 5), the applicant provided tables listing the resultant forces in SP wall elements 5, 14, and 95 for LC15 that includes hydrodynamic loads of CO and chugging. The applicant increased the CO and chugging resultant forces in selected SP wall elements for LC15 by conservative load factors of 1.5 and 1.2, and listed them under "LC15 + 1.5CO" and "LD15 + 1.2CHUG," respectively. The applicant also calculated and tabulated the percent increases between the resultant forces in selected SP wall elements for the original LC15 and for the increased load combinations of"LC15 + 1.5CO" and "LD15 + 1.2CHUG."

During the audit, the staff confirmed by reviewing the applicant's report, PLM No.: 001N6204, Rev. 0, (reference 5), that overall resultant forces in selected elements for "LC15 with chugging loads" are larger than the resultant forces in selected elements for "LC15 with CO loads." The applicant also determined in the same report, that the resultant forces in selected elements in RCCV wall will change less than 1 percent as a result of the predicted increases in the chugging loads due to the SP water level increase. The staff performed independent calculations that confirmed the applicant's results described above. The applicant concluded that less than 1 percent increase in resultant forces in the RCCV wall would not exceed the design margin in report, PLM No.: 001N6204, Rev. 0 (reference 5). However, the applicant did not perform any comparative determination of the stress levels in any of the SP elements within the RCCV model against the allowable stress limit to ensure that this increase is still within the design margin. Therefore, the staff performed the following independent assessment to determine that less than 1 percent increase in the resultant forces in RCCV wall would be within the design margin of reinforcing steel in RCCV wall. The staff reviewed the LC8, and LC 15a and LC 15b from U.S. ABWR DCD, Tier 2, Table 3H.1-5a, "Selected Load Combinations for the RCCV." The staff used the corresponding rebar stress for LC8 from Table 3H.1-16, "Rebar and Concrete Stresses Due to Load Combination 8" and for LC 15a and LC 15b from Table 3H.1-18, "Rebar and Concrete Stresses Due to Load Combination 15a and 15b" . LC8 includes D, L, T_a and P_a associated with the LOCA, and CO. Loads due to P_a and CO includes a load factor of 1.5 in the load combination. The stress in the rebar due LC8 is caused primarily by the accident pressure P_a, and CO pressure on the containment wall. The LC15a and LC 15b include D, L, P_a, T_a, SRV actuation, CO, and SSE loads. The maximum reinforcing steel stress is 119.14 MPa (17,280 psi) for LC8 in Table 3H.1-16 at the wall of RCCV wedded mid-height elevation of Section 2 (see U.S. ABWR DCD, Tier 2, Figure 3H.1-21, "Section Considered for Analysis"). The corresponding maximum reinforcing steel stress from LC8 in Table 3H.1-16 to LC15a and LC15b in Table 3H.1-18 is 315.31 MPa 45,732 pounds per square inch (psi) at the wall of RCCV wedded mid-height elevation of Section 2. The reinforcing steel allowable stress is 372.32 MPa (54,000 psi). The percent difference in stress margin between the maximum reinforcing steel stress of 315.31 MPa (45,732 psi) for LC15a and LC15b and the reinforcing steel allowable stress of 372.32 MPa (54,000 psi) is 18 percent [= (373.32 MPa – 315.31 MPa) /315.31 MPa]. From this evaluation, the staff concluded that less than 1 percent increase in the resultant forces due to the SP water level increase has no impact on the structural capacity of the RCCV wall which still has an additional 18 percent of the design stress margin. Therefore, the staff did not have any further questions on this evaluation.

The applicant did not perform any structural evaluation of the access tunnels due to the increase in SP water during a postulated LOCA event. The staff discussed with the applicant how it would be ensured that the increased hydrodynamic load would be considered for the access tunnels. The applicant stated that in U.S. ABWR DCD, Tier 1, Inspection, Tests, Analysis and Acceptance Criteria (ITAAC) item 14 in Table 2.1.41, "Primary Containment Systems," that such evaluation will be performed later as part of 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 was satisfied with the applicant's conclusion that the increased pool level induced by the postulated LOCA event has an insignificant (less than one percent) impact on the design capacity of the containment structure. The access tunnels were not evaluated for the increased hydrodynamic loading and it would be ensured by an ITAAC process that such evaluation will be performed during as part of detailed design and will be reflected in the as-built structures.

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. GEH 10 CFR 21.21 Interim Notification, March 31, 2014, "10 CFR 21.21(a)(2) 60-Day Interim Report Notification: Containment Loads Potentially Exceed Limits with High Suppression Pool Water Level in the ABWR Design," (ML1409A068).
2. GEH 10 CFR 21.21 Closure Notification, August 29, 2014, "10 CFR 21.21(a)(2) Closure Report Notification: Containment Loads Potentially Exceed Limits with High Suppression Pool Water Level in the ABWR Design," (ML14241A306).
3. GEH U.S. ABWR Design Control Document (DCD), 25A5675AE Revision 5.
4. PRC 14-02/CR9349, Revision 0, Subject: Evaluation of High Post Blowdown Suppression Pool Water Level on ABWR Containment Hydrodynamic Loads.
5. ECO: ECO-0006828, PLM No.: 001N6204, Revision 0, Subject: PCR 14-02, Containment Loads Potentially Exceed Limits with High Suppression Pool Level.
6. NRO Office Instruction NRO-REG-108, Revision 0, "Regulatory Audits."