

October 8, 2013

**SECTION 3.8.3 CONTAINMENT INTERNAL STRUCTURES DESIGN REPORTS AND
CALCULATIONS AUDIT PLAN**

October 21 - 25, 2013

**US-APWR DESIGN CERTIFICATION
Mitsubishi Heavy Industries, Ltd.
Docket No. 52-021**

Location: Mitsubishi Nuclear Energy Systems, Inc.
1001 19th Street North, Suite 710
Arlington, VA 22209

Purpose:

The purpose of this audit is to review design reports and calculations for the design of the containment internal structures (CIS) of the United States - Advanced Pressurized Water Reactor (US-APWR), in order to:

- (1) Address outstanding technical issues associated with the analysis and design of the CIS.
- (2) Verify the analysis and design approaches used in the calculations are consistent with the information described in the US-APWR Design Certification Document (DCD) Tier 2, Section 3.8.3, "Concrete and Steel Internal Structures of Steel or Concrete Containments," as well as the related technical reports. These reports include: MUAP-11013-P, Revision 2, "Containment Internal Structure Design and Validation Methodology," MUAP-11018-P, Revision 1, "Containment Internal Structure: Stiffness and Damping for Analysis," MUAP-11019-P, Revision 1, "Containment Internal Structure: Design Criteria for SC Walls," and MUAP-11020-P, Revision 1, "Containment Internal Structure: Anchorage and Connection Design and Detailing."

This audit follows the guidelines in the U.S. Nuclear Regulatory Commission (NRC) Office of New Reactors (NRO) Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits."

Background:

Mitsubishi Heavy Industries, Ltd. (MHI) has developed a design methodology and design criteria for the US-APWR CIS and their associated connections, and these have been described in the DCD and presented in greater detail in the related Technical Reports. The design methodology and design criteria were developed based on the ACI 349-06 design code for reinforced concrete (RC) walls and the results of experimental and analytical research conducted on CIS Steel-Concrete (SC) walls and connections. The audit will address technical issues, verify that the

analysis and design approaches used in the calculations are consistent with the proposed approaches, increase the understanding of the design details, and assist the NRC staff to complete its review and make a safety finding.

Regulatory Audit Bases:

DCD Tier 2, Section 3.8.3, is being reviewed by the NRC staff in accordance with the relevant requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Part 52, and Part 100. In addition, the acceptance criteria associated with the relevant requirements of the NRC regulations General Design Criteria 2 of Appendix A to 10 CFR Part 50; Appendix S to 10 CFR Part 50, and Appendix A to 10 CFR Part 100. Implementing guidance such as the Standard Review Plan (NUREG-0800), Regulatory Guides, and Interim Staff Guidance, along with cited codes and standards, informs the staff review and represents an acceptable technical approach for demonstrating compliance with the regulations.

Regulatory Audit Scope:

A. Audit of Technical Issues

This part of the audit is intended to confirm resolution of, and to resolve, key technical issues that have been raised in the prior review and for which details are expected to be provided in the calculations which can be used to resolve the outstanding issues.

The NRC staff will focus on the review of calculations documenting:

1. (a) The benchmarking process of the a nonlinear inelastic finite element (NIFE) analysis model of the actual US-APWR CIS using test results (MHI Task 3), (b) the nonlinear pushover analysis using the benchmarked NIFE model (MHI Task 4-A), and (c) the limit states for beyond safe shutdown earthquake loads and the comparison of the limit states with those in reinforced concrete structures (MHI Task 4-B). MHI Tasks 3, 4-A, and 4-B are described in MUAP-11013, Revision 2. (Request for additional information (RAI) 858-6126, Questions 03.08.03-43, 46, 54, and 55).
2. The 1/6th scale testing, including the test results, description of the various configuration details and material properties, a comparison to the US-APWR CIS, the basis for considering only a portion of the primary shield structure, the evaluation of the US-APWR primary shield wall analysis, and the use of the study results in the CIS design. (RAI 858-6126, Questions 03.08.03-44 and 47).
3. The linear elastic finite element response spectra analysis used for the US-APWR CIS design, including a description of the models (computer code, element types used in computer model, damping, and assumptions on boundary conditions), input loading, analysis procedures, assumptions, results, analysis for other loads, combination of loadings, etc. (RAI 858-6126, Question 03.08.03-50 and RAI 958-6608, Question 03.08.03-96).

4. Out-of-plane shear strength (V_c) design of SC walls and the reliability analysis determining the adequacy of using the 1.5 factor for V_c calculation. (RAI 905-6311, Question 03.08.03-77).
5. Revision of the basic CIS design analysis using the revised design accident thermal loads.

B. Verification of analysis and design methodology

This part of the audit is intended to verify that the analysis and design approaches (beyond those reviewed above) used in the calculations for the design of the CIS are consistent with the methodology described in the US-APWR DCD Section 3.8.3 and related technical reports.

The NRC staff will focus on the review of calculations documenting:

1. The design of CIS structures:
 - a. Structural Category 1.
 - b. Structural Category 2.
 - c. Structural Category 3.
 - d. Structural Category 4.
 - e. Structural Category 5.
 - f. Structural Category 6.
2. The design of SC connections (RAI 931-6467, Question 03.08.03-82):
 - a. Full-strength connection design for selected cases of SC wall to RC wall, SC wall to SC wall, SC wall to RC slab, SC wall to RC basemat, SC to RC mass concrete (Structural Category-5), SC to steel structure (Structural Category-6).
 - b. Over-strength connection design (if any).
 - c. Construction sequence at the SC-basemat connection area and the use of self-consolidating concrete for SC wall connections. (RAI 931-6467, Question 03.08.03-85 and 86).
3. The design of SC wall penetration detailing. (RAI 905-6311, Question 03.08.03-74).

Audit Team:

- Mohamed Shams, NRC, Branch Chief SEB1.
- Pravin Patel, NRC, Structural Engineer, SEB1.
- Milton Valentín, NRC, Structural Engineer, SEB1.
- Dennis Galvin, NRC, Project Manager, DNRL.
- Joseph Braverman, Brookhaven National Laboratory, Technical Reviewer.

- Xing Wei, Brookhaven National Laboratory, Technical Reviewer.

Information and Other Materials Needed for the Audit:

The NRC staff requests MHI to provide the design reports and calculations discussed in the audit scope. MHI is also requested to identify other documents, which the licensee deems as necessary to support the NRC staff's audit and any other documents or calculations referenced by them. MHI is also requested to prepare a list of the documents made available, including the document titles, identifying numbers, and dates.

All material subject to the site visit (hard copy or electronic) will be left at the site. If any documentation is required to support the staff's regulatory findings, the staff will identify it in a RAI.

MHI is requested to make available applicant personnel who are knowledgeable in the US-APWR CIS analysis and design discussed in the DCD and MHI technical reports. MHI should also have the ability to make available modeling/analysis information, which may not be included in the relevant documents.

Logistics:

The audit will be conducted at the location identified above. The audit is scheduled to start on October 21, 2013, and run through October 25, 2013, as necessary (i.e., until finished). The audit is scheduled to begin at 9:00 a.m. each day. Participating individuals will meet at the audit location. An exit briefing will be conducted with MHI on the last day.

The NRC staff request that space be allocated for the team members to meet privately and discuss the progress of the audit.

Schedule and Deliverables:

A summary report of the audit will be prepared and issued in accordance with NRO-REG-108.

References:

1. NRO Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits."
2. US-APWR DCD, Revision 4.
3. MUAP-11013-P, Revision 2, "Containment Internal Structure Design and Validation Methodology."
4. MUAP-11018-P, Revision 1, "Containment Internal Structure: Stiffness and Damping for Analysis."
5. MUAP-11019-P, Revision 1, "Containment Internal Structure: Design Criteria for SC Walls."

6. MUAP-11020-P, Revision 1, "Containment Internal Structure: Anchorage and Connection Design and Detailing."

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6. MUAP-11020-P, Revision 1, "Containment Internal Structure: Anchorage and Connection Design and Detailing."

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