

October 31, 2012

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

**DESIGN CERTIFICATION SECTION 3.8.3  
STEEL-CONCRETE MODULE CONFIRMATORY TEST PROGRAM AUDIT PLAN**

**November 7 – November 9, 2012**

Location: Bowen Laboratory in Purdue University  
1040 South River Road  
West Lafayette, IN 47907-2101

Purpose:

The purpose of this audit is to review the confirmatory test plan, related documentation, and witness one of the tests for the steel-concrete (SC) module used in the United States- Advanced Pressurized Water Reactor (US-APWR) design. The audit will review and evaluate a selected confirmatory test, the test method and its implementation, and the test results confirmation of the SC modules performance consistent with the assumptions in the US-APWR Design Certification Documents (DCD) Section 3.8.3, "Concrete and Steel Internal Structures of Steel or Concrete Containments," as well as related technical reports: MUAP-11013-P, Revision 1, "Containment Internal Structure Design and Validation Methodology," MUAP-11018-P, Revision 0, "Containment Internal Structure: Stiffness and Damping for Analysis," MUAP-11019-P, Revision 0, "Containment Internal Structure: Design Criteria for SC Walls," and MUAP-11020-P, Revision 0, "Containment Internal Structure: Anchorage and Connection Design and Detailing."

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

The audit plan contains information that MHI considers proprietary and has been withheld from public disclosure pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 2, Section 2.390(b)(5). In the public version of the audit plan, the proprietary information has been redacted and replaced by the designation "[[ ]]". The proprietary version of the audit plan is not available to the public.

Background:

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed Mitsubishi Heavy Industries, Ltd. (MHI's) information contained in the US-APWR DCD and MHI's responses to the NRC staff's request for additional information (RAI) regarding the design of SC module walls in the US-APWR containment internal structures. To gain a better understanding of the SC wall performance and

to confirm the design approach used by MHI, the staff will audit the testing of an SC wall module. This audit will also assist the staff to complete its technical review of the SC wall design.

MHI has developed a design methodology and design criteria for SC walls and their associated connections, and these have been presented in detail in the DCD and related Technical Reports. The design methodology and design criteria were developed based on the ACI 349-06 design code for reinforced concrete (RC) structures and the results of experimental and analytical research conducted on SC walls and connections. MHI has determined that there is a need to conduct additional tests to confirm the conservatism of the established design criteria. In its white paper, "SC Wall Confirmatory Testing Summary," dated January, 2012, MHI provided an overview of the confirmatory testing, including test objectives, test approach, test setup, specimen details, instrumentation, expected results, requirements, and quality assurance plan and procedures to be used for confirmatory testing of the US-APWR SC module wall design and its anchorage connection. [[

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Objectives:

The objectives of the NRC staff's on-site audit are to:

- A. Review the test plan and related documentation.
- B. Verify that the test is conducted according to the test plan.
- C. Verify that the test results are consistent with the expected results and the results provide information to confirm the conservatism of MHI SC wall design methodology.

Scope:

- A. Confirmatory test

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]] The audit will verify that the test is conducted according to the test plan and the actual test results are consistent with the expected test results.

The NRC staff will focus perform the following:

1. Review and discuss with MHI the following items: the documented detailed test plan and associated documents. This includes the purpose of the test, test specimen design configuration and materials, planned test setup including loading and monitoring instruments, test procedure, recording of results, and expected results.
2. Review actual test setup, actual test specimen configuration, instrumentation setup and loading setup.
3. Monitor the test process to verify that the test procedure is implemented in accordance with test plan.
4. Examine test specimen after the test: review concrete cracking locations and patterns, check failure modes - shear and/or flexural failure mode, any SC specific failure mode (e.g., steel faceplate buckling, SC wall splitting, and interfacial shear failure).
5. Review the comparison of the actual test results and expected results, and to the extent that MHI can complete their assessment of the data during this audit, verify that the test results are consistent with those estimated using MHI's design methodology and any related MHI SC wall design criteria presented in the DCD and associated technical reports.
6. For Test Specimen 1 of Test Series No. 3, performed previously, MHI was requested to keep Specimen 1 in or close to the laboratory in its original condition after the test to permit the NRC staff to examine it. The NRC staff plans to review the test plan, procedures, and calculation for expected results. Then examine the test specimen for its condition as described in Item 4 above. Lastly, review the test results in accordance with Item 5 above.

#### Schedule and Deliverables:

The NRC staff will conduct the audit in the Bowen Laboratory, School of Civil Engineering, Purdue University, located in West Lafayette, Indiana, from November 7 - 9, 2012.

Following the audit, the responsible NRC staff will assemble and prepare a final audit report within 90 days after the completion of the audit. The NRC staff will use the audit outcome to identify information not currently addressed on the docket and for the submittal of additional information for making regulator findings and regulatory decisions. The audit will assist the NRC staff in the preparation and issuance of further RAIs for the safety evaluation of the US-APWR Design Certification Application.

#### Audit Team:

- Pravin Patel, NRC (Structural Engineer, SEB1)
- Vaughn Thomas, 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 detailed test plan and related documents discussed in the audit scope. MHI is also requested to identify other documents, which the applicant deems as necessary to support the NRC staff's audit (e.g., drawings, concrete mix test results, QA requirements) and any other documents or calculations referenced by them. As noted in the scope above, MHI is requested to keep Specimen 1 in or close to the laboratory in its original condition after the test.

Logistics:

The audit will be conducted at the location identified above. The audit is scheduled to start on November 7, 2012, and continue through November 9, 2012, as necessary (i.e., until finished). The audit is scheduled to begin at 9:00 a.m. each day. The audit may start earlier on November 8-9, 2012, if there is a need to discuss issues with MHI's staff in Japan. Participating individuals will meet at the audit location. The audit team leader will conduct an exit briefing with MHI on the last day.

Special Requests:

Appropriate handling and protection of proprietary information shall be acknowledged and observed throughout the audit.

The team will require the following to support the audit:

- Private conference room to support document review, and audit team meetings.
- Applicant personnel who are knowledgeable in the tests discussed in MHI's test plan, and the US-APWR CIS analysis and design discussed in the DCD and MHI technical reports.
- Appropriate personal protection equipment to assist the team in witnessing the test.

References:

1. NRO Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits."
2. MHI White Paper, "SC Wall Confirmatory Testing Summary," January, 2012.
3. MHI presentation slides, "Steel-plate Composite (SC) Design for Nuclear Facilities: Confirmatory Testing," March 12, 2012.
4. US-APWR DCD, Revision 3.
5. MUAP-11013-P, Revision 1, "Containment Internal Structure Design and Validation Methodology."

6. MUAP-11018-P, Revision 0, "Containment Internal Structure: Stiffness and Damping for Analysis."
7. MUAP-11019-P, Revision 0, "Containment Internal Structure: Design Criteria for SC Walls."
8. MUAP-11020-P, Revision 0, "Containment Internal Structure: Anchorage and Connection Design and Detailing."

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6. MUAP-11018-P, Revision 0, "Containment Internal Structure: Stiffness and Damping for Analysis."
7. MUAP-11019-P, Revision 0, "Containment Internal Structure: Design Criteria for SC Walls."
8. MUAP-11020-P, Revision 0, "Containment Internal Structure: Anchorage and Connection Design and Detailing."

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**NRC-001**

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