

March 23, 2012

MEMORANDUM TO: Hossein G. Hamzehee, Chief  
US-APWR Projects Branch  
Division of New Reactor Licensing  
Office of New Reactors

FROM: Dennis J. Galvin, Project Manager */RA/*  
US-APWR Projects Branch  
Division of New Reactor Licensing  
Office of New Reactors

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION AUDIT REPORT  
FOR THE AUDIT PERFORMED DURING MARCH 17, 2011,  
REGARDING SECTION 3.9.4, "CONTROL ROD DRIVE  
MECHANISM," OF THE UNITED STATES - ADVANCED  
PRESSURIZED WATER REACTOR DESIGN CONTROL  
DOCUMENT

As part of its review of the United States - Advanced Pressurized Water Reactor (US-APWR) Design Certification application during March 17, 2011, members of the U.S. Nuclear Regulatory Commission staff performed an audit at the Mitsubishi Nuclear Energy Systems, Inc. facility in Arlington, Virginia. The purpose of the audit was to verify that the component design and qualification of the Control Rod Drive Mechanism are being performed in accordance with the methodology and criteria described in the US-APWR Design Control Document.

The audit plan is documented and can be found in the Agencywide Document Access and Management System (ADAMS) under accession number ML110600374, dated March 14, 2011. The results of the audit entitled, "Standard Review Plan Section 3.9.4, "Control Rod Drive Mechanism," are provided as Enclosure 1. A List of Attendees is provided as Enclosure 2. A List of Documents Made Available to the NRC staff is provided as Enclosure 3.

Pursuant to Title 10 of the *Code of Federal Regulations* Part 2.390, we have determined that the audit report contains proprietary information and therefore is not available to the public. We have prepared a redacted, non-proprietary version of the audit report which is provided as Enclosure 1. The proprietary version of the audit report is documented as Enclosure 4, however it is not available to the public.

Docket No. 52-021

Enclosures:  
As stated

cc w/encls 1, 2, 3: See next page

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ADAMS Accession No.: ML112140207      Package: ML112140203      NRC-002

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**STANDARD REVIEW PLAN SECTION 3.9.4, "CONTROL ROD  
DRIVE MECHANISM," AUDIT REPORT**

NRC Audit Staff: Dennis Galvin, Project Manager, NRO/DNRL/NMIP  
Pei-Ying Chen, Sr. Mechanical Engineer, NRO/DE/EMB1  
Jason Huang, General Engineer, NRO/DE/EMB1  
Terri Spicher, Mechanical Engineer, NRO/DE/EMB1

1.0 SUMMARY

Mitsubishi Heavy Industries Ltd. (MHI) submitted to the U.S. Nuclear Regulatory Commission (NRC), Design Control Document (DCD) Revision 0, Revision 1, and Revision 2 for its United States - Advanced Pressurized Water Reactor (US-APWR) application in December 2007, August 2008, and October 2009, respectively. After conducting a review of the information and responses to Requests for Additional Information (RAIs) associated with DCD Tier 2, Section 3.9.4, "Control Rod Drive Mechanism," the NRC staff concluded that a review of the design details and testing results was needed to make the determination that MHI meets the regulatory requirements for control rod drive mechanisms (CRDMs).

An audit was conducted by the NRC staff at the Mitsubishi Nuclear Energy Systems (MNES) office in Arlington, Virginia on March 17, 2011. The NRC staff conducted the audit in accordance with the NRC Office of New Reactors (NRO) Office Instruction NRO-REG-108, "Regulatory Audits". The plan for this audit was documented and can be found in the Agencywide Document Access and Management System (ADAMS) under accession number ML110600374, dated March 14, 2011.

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

- A. Review the raw data for "Summary of the Control Rod Drop Function Test Results in Japan," (UAP-HF-09273, Attachment-1) described in the response to Request for Additional Information (RAI) 604-4775, Question 03.09.04-9, dated July 28, 2010. (see Enclosure 3)
- B. Review the paper published in the Nuclear Engineering International April 1990 Issue, mentioned in the response to RAI 604-4775, Question 03.09.04-9, dated July 28, 2010. (see Enclosure 3)
- C. To understand the design and qualification of latches for the function of CRDM under seismic excitation.
- D. Identify any additional information that is necessary for the applicant to submit for the NRC staff to reach a safety determination for the seismic adequacy of the CRDM for the US-APWR design certification application. This audit may result in RAIs.

## 2.0 REGULATORY BASIS

- NUREG-0800, "Standard Review Plan," Section 3.9.4, "Control Rod Drive Systems"
- NUREG-0800, "Standard Review Plan," Section 3.10, "Seismic and Dynamic Qualification of Mechanical and Electrical Equipment"

## 3.0 OBSERVATIONS AND RESULTS

The NRC staff reviewed the testing of CRDMs described in the documents provided by MHI. The testing evaluated the insertability of pressurized water reactor control rods in the event of an earthquake, using full-scale mode, 17x17 control rod test components. The NRC staff made the following observations:

1. During the staff's review of

[[ ]], the staff noted on Page 40, S2 seismic wave (earthquake) target maximum acceleration is [[ ]] Gal (1 Gal = 1cm/s<sup>2</sup>) and [[ ]] Gal for CRDM middle support (A3) and CRDM upper support (A2), respectfully, versus the measured value of [[ ]] Gal and [[ ]] Gal. The test response spectra (TRS) must envelop the required response spectra (RRS) for the equipment to be seismically qualified. At the CRDM middle support and CRDM upper support locations, the TRS envelop the RRS.

However, in the area concerning the latch housing, and subsequently the latches, there were no response spectra in the report. In the report, this area was designated as "A4." The MHI staff could not locate the test response spectra for S2 excitation at the "A4" location. In addition, the required response spectra were based on Japanese seismic requirements. The NRC staff requested MHI to provide the RRS for the US-APWR CRDM housing location and determine if it can be bounded by the TRS for S2 excitation at the "A4" housing location.

2. An additional seismic test was noted in the [[ ]].

*"Japan Nuclear Energy Organization (JNES) conducted tests from 2004 to 2005 to confirm 12 ft drive line CRDM and rod drop function under extremely large seismic events. FA displacement was 1.77" (45mm) and buckling of fuel grids."*

The NRC staff requested for MHI and MNES to provide more details concerning the displacement at the latch location and the magnitudes simulated during this test. MHI stated that they would contact JNES for this test report.

3. In February 2011, Revision 1 of MUAP-09009-P(R1), "Summary of Stress Analysis Results for the US-APWR Control Rod Drive Mechanism," was

submitted. Revision 0 of this document was originally submitted in March 2009. The transmittal letter for Revision 1 of MUAP-09009-P(R1) stated that the stress analysis report was updated due to sophistication of methodology for building seismic analysis.

The estimated [[ ]] inch deflection at Level D condition of the CRDM pressure housing was originally submitted in response to RAI 107-1293, Question 1293-01, with Revision 0 of MUAP-09009-P(R0), regarding the effect of a loss-of-coolant accident and safe-shutdown earthquake loads. The NRC staff requested clarification regarding how the estimated deflection at Level D condition is calculated and if it has changed in Revision 1 of the "Summary of Stress Analysis Report."

As a result of the audit, the NRC staff has the following requests for MHI:

1. Provide the Required Response Spectrum (RRS) for US-APWR CRDM housing location and compare response with test response spectrum (TRS) for S2 excitation at "A4" location.
2. Japan Nuclear Energy Organization (JNES) conducted tests from 2004 to 2005 to confirm a 12 ft drive line CRDM and rod drop function under extremely large seismic events. Fuel assembly displacement was 1.77" (45mm) and buckling of fuel grids occurred. Provide more detailed information and describe these test results with respect to its applicability for the US-APWR CRDM.
3. How is the estimated Level D deflection of CRDM housing calculated and has this estimated value changed in Revision 1 of MUAP-09009-P(R1), "Summary of Stress Analysis Results for the US-APWR Control Rod Drive Mechanism?"

The NRC staff discussed these observations and requests with the MHI and MNES staff. The MNES staff indicated that they would evaluate the extent that the responses to RAI 107-1293, Question 1293-01 and RAI 604-4775, question 03.09.04-9 could be modified to address the NRC staff's concerns. MNES also indicated that since the audited documents were not developed specifically for the licensing of the US-APWR, relevant information would be abstracted into appropriate new documentation.

#### 4.0 CONCLUSION

The NRC staff determined that the audited materials supported the goals of the audit. Based on the audit discussions, MHI will submit revised documentation supporting the seismic qualification of the CRDMs and address the requests made by the NRC staff at the close of the audit by either submitting supplemental responses or revising their original responses to RAI 107-1293, Question 1293-01 and RAI 604-4775, Question 03.09.04-9.



**LIST OF ATTENDEES**

STANDARD REVIEW PLAN SECTION 3.9.4, "CONTROL ROD DRIVE  
MECHANISM" AUDIT HELD ON MARCH 17, 2011

<b><u>NAME</u></b>	<b><u>REPRESENTING</u></b>
Chikara Karimura	Mitsubishi Heavy Industries, LLC.
Masanori Suzuki	Mitsubishi Heavy Industries, LLC.
Masaya Hoshi	Mitsubishi Nuclear Energy Systems
Ryan Sprengel	Mitsubishi Nuclear Energy Systems
Dennis Galvin	U.S. Nuclear Regulatory Commission
Jason Huang	U.S. Nuclear Regulatory Commission
Pei-Ying Chen	U.S. Nuclear Regulatory Commission
Terri Spicher	U.S. Nuclear Regulatory Commission

**LIST OF DOCUMENTS MADE AVAILABLE TO THE NRC STAFF**

1. S. Kawakami, H. Akiyama, H. Shibata, T. Ichikawa, and K. Fujita, "Nuclear Engineering International (Control rod behavior in earthquakes)", dated April 1990.
2. Kansai Electric Power Company, Hokkaido Electric Power Company, Shikoku Electric Power Company, Kyushu Electric Power Company, Japan Atomic Power Company, Mitsubishi Heavy Industries, Ltd, Mitsubishi Electric Corporation, and Mitsubishi Nuclear Engineering, "Joint Research on the Evaluation of the Functionality of Active Components in an Earthquake, Final Report (Supplementary Volume), Control Rod Drop Function Test" (English Translation Version), dated March 1983.
3. Mitsubishi Heavy Industries, Ltd, Appendix C of "Study on Function of PWR-CRDM Subjected to Earthquake", 25J00506, dated April 1983, Mitsubishi Heavy Industries, Ltd.