MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

August 11, 2011

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-11258

**Subject:** Amended MHI's Response to US-APWR DCD RAI No. 604-4775 Revision 0 (SRP 03.09.04)

**Reference**: 1) "Request for Additional Information No. 604-4775 Revision 0, SRP Section: 03.09.04 – Control Rod Drive Systems, Application Section: 3.9.4," dated 6/25/2010
2) "MHI's Response to US-APWR DCD RAI No. 604, UAP-HF-10221," dated 6/28/2010

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") documents entitled "Amended Response to Request for Additional Information No. 604-4775, Revision 0"

Enclosed is the response to the Question No. 03.09.04-9 of the RAI (Reference 1).

This response amends the previously transmitted answers submitted under MHI Reference UAP-HF-10221 on July 28, 2010 (Reference 2) in order to clarify the seismic qualification for the Control Rod Drive System and to attach summary of the CRDM performance during earthquake.

As indicated in the enclosed materials, this submittal contains information that MHI considers proprietary, and therefore should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential. A non-proprietary version of the document is also being submitted with the information identified as proprietary redacted and replaced by the designation "[ ]".

This letter includes a copy of the proprietary version (Enclosure 2), a copy of the non-proprietary version (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all materials designated as "Proprietary" in Enclosure 2 be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittals. His contact information is provided below.

D081
NRO

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosures:

1. Affidavit of Yoshiki Ogata

2. Amended Response to Request for Additional Information No. 604-4775, Revision 0 (Proprietary)

3. Amended Response to Request for Additional Information No. 604-4775, Revision 0 (Non-Proprietary)

CC: J. A. Ciocco
C. K. Paulson

Contact Information
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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-11258

**MITSUBISHI HEAVY INDUSTRIES, LTD.**

**AFFIDAVIT**

I, Yoshiki Ogata, state as follows:

1. I am General Manager, APWR Promoting Department, of Mitsubishi Heavy Industries, LTD ("MHI"), and have been delegated the function of reviewing MHI's US-APWR documentation to determine whether it contains information that should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled "Amended Response to Request for Additional Information No. 604-4775, Revision 0", dated August 2011, and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. All pages contain proprietary information as identified with the label "Proprietary" on the top of the page, and the proprietary information has been bracketed with an open and closed bracket as shown here "[ ]". The first page of the document indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The information identified as proprietary in the enclosed documents has in the past been, and will continue to be, held in confidence by MHI and its disclosure outside the company is limited to regulatory bodies, customers and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and is always subject to suitable measures to protect it from unauthorized use or disclosure.

4. The basis for holding the referenced information confidential is that it describes the unique design parameters developed by MHI for the Control Rod Drive Mechanism and the JNES test information which is permitted to be reprinted under condition that those are handled as proprietary information.

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of information to the NRC staff.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. Other than through the provisions in paragraph 3 above, MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI.

7. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without incurring the costs or risks

associated with the design of the subject systems. Therefore, disclosure of the information contained in the referenced document would have the following negative impacts on the competitive position of MHI in the U.S. nuclear plant market:

A. Loss of competitive advantage due to the costs associated with the development of the unique design parameters.

B. Loss of competitive advantage of the US-APWR created by the benefits of the Control Rod Drive Mechanism operation.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information and belief.

Executed on this 11th day of August, 2011.

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure 3

UAP-HF-11258
Docket No. 52-021

Amended Response to Request for Additional Information
No. 604-4775, Revision 0

August 2011

(Non-Proprietary)

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**08/11/2011**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No. 52-021**

| | |
|---|---|
| **RAI NO.:** | **NO. 604-4775 REVISION 0** |
| **SRP SECTION:** | **03.09.04 - CONTROL ROD DRIVE SYSTEMS** |
| **APPLICATION SECTION:** | **3.9.4** |
| **DATE OF RAI ISSUE:** | **06/25/2010** |

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**QUESTION NO.: 03.09.04-9**

This question is a follow-up to question 03.09.04-2, RAI 569-4433.

The staff does not find the applicant's response to be adequate.

In the applicant's response on page 2, "Since the Latch Assembly is supported by the CRDM pressure housing which is classified as seismic category I, the motion of the Latch Assembly is not jammed." The applicant is requested to clarify how the latch assembly cannot be jammed.

The applicant is also requested to provide a justification to explain why the latch mechanism does not need to be seismically qualified to comply with GDC 2, or to revise the seismic qualification for the safety functions of the Control Rod Drive System.

The applicant is also requested to clarify the deletions to be incorporated into DCD Revision 3 of the 2nd paragraph of Subsection 3.9.4.2.3.

> ~~Sticking and galling of the latch mechanism are safety related.~~ The design, fabrication, inspection, and testing of the ~~safety-related~~ latch mechanism comes under the quality assurance requirement regarding safety components in 10 CFR 50.55a (Reference 3.9-29).

Reference: MHI's Response to US-APWR DCD RAI No.570-4428; MHI Ref: UAP-HF-10132; dated May 13, 2010; ML101380128.

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**ANSWER:**

The integrity of the Latch Assembly was confirmed by the endurance test described in the Reference-1 of UAP-HF-08278. The Latch Assembly was continually operated in ten million steps during the test, and the motion of the Latch Assembly was not jammed.
As far as we know through the gathering of trouble information, a jamming event of the type L-106A latch assembly does not occur around the world. However, a transitory behavior such as misstepping or slipping occurs at a fairly low rate of occurrence.
Since the Latch Assembly is supported by the CRDM pressure housing which is classified as seismic category I, the seismic loads on the latch assembly are not significant. And, the release motion of the Latch Assembly is not jammed.

Additionally, several research programs for the control rod behavior during earthquakes had been carried out in Japan.
One of the research programs was carried out by the Japanese Nuclear Energy Safety Organization (JNES), which is a PWR control rod inserting capability test conducted as part of equipment fragility test. As shown in Attachment-1, in the JNES test, it was confirmed that the CRDM operates normally when releasing the control rod under the condition of 3.3 times the design basis extreme earthquake S2 which is similar to Safety Shutdown Earthquake (SSE).
On the other hand, in the end of December 2010, response acceleration at the CRDM housing location (near the center of latch assembly) was calculated in the response analysis which is reported in MUAP-09002-P/NP(2) "Summary of Seismic and Accident Load Conditions for Primary Components and Piping."
The results of a comparison between the response spectrum generated from the measured acceleration data at CRDM middle seismic support location measured in the test (see Figure 4 in Attachment-1) and the response spectrum generated from the response acceleration at the latch housing location calculated based on the US-APWR seismic conditions are shown in Figure 1.
Although there is no measured data that corresponds to the latch housing location in the test, a comparison between the response spectrum generated for the latch housing location that corresponds to the antinodes in the analysis and the response spectrum generated for middle seismic support location that corresponds to a node in the test will be a conservative evaluation.
In Figure 1, the Test Response Spectrum (TRS) generated from the test results nearly exceeds the Required Response Spectrum (RRS) generated from the analysis results of the US-APWR. Under severe conditions where the CRDM responds largely to the large input (i.e., range around approx.[ ]Hz to [ ]Hz), it was confirmed that the TRS exceeds the RRS. Thus, it is judged that the CRDM functions can be maintained at the assumed seismic conditions of the US-APWR. However, when the frequency is around [ ] Hz, the RRS for the US-APWR exceeds the TRS. The middle seismic support is structured by establishing the clearance to avoid interference of thermal expansion, etc. When the amplitude range of CRDM response is smaller than the clearance, the natural frequency is approximately [ ] Hz to [ ] Hz. In contrast, when the amplitude range of CRDM response is larger than the clearance, the middle part of CRDM will be supported by the middle seismic support. In such condition, the natural frequency of CRDM becomes more than [ ] Hz.

The Latch Assembly is classified as non-safety component. The release function of the latch assembly by gravity is maintained during earthquake.
Therefore, the latch assembly does not need to be seismically qualified to comply with GDC 2.

Since the latch assembly is not categorized as "safety-related", the descriptions of "safety-related" were deleted.

Figure 1 Comparison between TRS and RRS for US-APWR CRDM

**Impact on DCD**

There is no impact on DCD Rev.3 since RAI 604-4775 was already incorporated into Revision 3 of the DCD.

**Impact on R-COLA**

There is no impact on the R-COLA.

**Impact on S-COLA**

There is no impact on the S-COLA.

**Impact on PRA**

There is no impact on the PRA.

# Summary of the CRDM Performance during earthquake in the JNES Test

## 1. Introduction

A PWR control rod inserting capability test was conducted by the Japanese Nuclear Energy Safety Organization (JNES) as part of the equipment fragility test. This document summarizes the overview and the scope of demonstration of CRDM motion during earthquake in the test.
The JNES test is evaluated in "Evaluation of JNES Equipment Fragility Tests for Use in Seismic Probabilistic Risk Assessments for U.S. Nuclear Power Plants" (NUREG/CR-7040) .

## 2. Purpose

The purpose of this attached document is to summarize the scope of demonstration of CRDM motion (control rod releasing) during earthquake in the tests.

## 3. Test Conditions

### 3.1 Test Models and Test Equipments

Drive-line components and control rod cluster should be those that meet a 17×17 type fuel assembly which is currently the standard type for 3 and 4 loop PWR plants in Japan. As for CRDM, L-106A type which is a common type in Japan was applied.
A comparison between the actual plant and the test model for actual plant test is shown in Figure 1. The test models and peripheral equipments are composed of parts described below:

Test Models

- 3 Fuel Assemblies
- Rod Cluster Control Assembly
- RCCA Guide Tube
- Control Rod Drive Mechanism (including drive rod assembly)

Peripheral Equipments

- Mock-up Reactor Internals
- Vessel
- Vessel Support Rib

### 3.2 Test Procedure

The entire equipment that forms control rod insertion channel in the actual plant was simulated. As shown in Figure 1, the CRDM, the RCCA guide tube, and the entire fuel assembly were installed in the test vessel and were vibrated on the large size shaking table in water to measure displacement of each equipment, acceleration, and stress. At the same time, the power supply to the CRDM was interrupted during excitation and the control rod insertion time was measured.
At the beginning of each test condition, the control rod was pulled out to the maximum withdrawal position by actuating the CRDM.

### 3.3 Test Conditions

(1) Test Environment

- Ambient temperature
- Under water

(2) Input Wave

- Sinusoidal Wave (Vibration Characteristics Test)
- Simulated Seismic Wave

  The most severe design basis seismic earthquake was selected from PWR plants in Japan, and the simulated seismic wave was established so as to simulate the acceleration of fuel assembly and CRDM during characteristic period so that fuel

assembly and CRDM response which have great impact on control rod inserting capability will be equivalent to the actual plant.

- Simulated Fuel Assembly Wave

  In order to maximize the response of fuel assembly as mush as possible, only a frequency range (3-4Hz) related to the first mode of fuel assembly was extracted from the simulated seismic wave and was established as simulated fuel assembly wave.

(3) Flow Rate

- Static Water (Zero Flow Rate)
- Flow Water (Rated Flow Rate 1250 $m^3$/hr)

  In view of control rod insertion capability, it corresponds to assumed flow rate that could be assured in the actual plant during earthquake.

(4) Test Cases

The following tests including seismic wave excitation were conducted.

(a) Vibration Characteristics Test of Shaking Table

Installing the specimens and equipments, a random wave excitation test (up to 300gal) was conducted to obtain the vibration characteristics of the shaking table. Using these characteristics, sinusoidal wave sweep test was conducted while performing input compensation.

(b) Vibration Characteristics Test of Specimen

In order to obtain frequency of test model and vibration mode, sinusoidal wave sweep test (50gal, 2-30Hz) was conducted.

(c) Excitation Test of Seismic Wave

Excitation test of simulated seismic wave was conducted, and response of each equipment and control rod insertion time were measured. Excitation up to 3.3 times the simulated seismic wave (equivalent to S2) was conducted.

(d) Excitation Test of Simulated Fuel Assembly Wave

Excitation test of simulated fuel assembly wave was conducted, and response of each equipment and control rod insertion time were measured. It was judged that fuel assembly response will reach the limit in the seismic wave excitation. Thus, the test was conducted so as to obtain larger response.

In order to obtain the initial value of control rod insertion time and to confirm the existence of abnormality or impacts due to deformation of equipment, control rod insertion test (non-excitation) was conducted at each test.

## 3.4 Measurement Locations and Measurement Items

Measurement location of overall test equipment is shown in Figure 2. Details of measurement items and measurement location around CRDM are shown in Table 1 and Figure 3.

## 3.5 Acceptance Criteria

During excitation due to seismic wave, control rod can be released without causing abnormality (e.g., control rod stuck) by releasing the power supply to CRDM.

# 4. Test Results

In the seismic wave excitation test, the following points were organized based on the acceleration data of the CRDM location measured by 3.3×S2 seismic wave which is the maximum excitation condition:

The acceleration data measured in the middle seismic support location which is the closest location to the installation location of CRDM latch assembly were used, and the results of generation of a 1% damped response spectrum are shown in Figure 4.

In addition, it was confirmed that control rod can certainly be released during 3.3×S2

seismic wave excitation and that control rod is inserted into the bottom position.

5. Applicability to the US-APWR

In the US-APWR, the CRDM pressure housing is extended to assure control rod stroke that meets 14ft core, but the type of CRDM applied in the US-APWR is the L-106A type. It is the same CRDM type as that used for the test model in the test, and the design of the latch assembly is identical.

Therefore, regarding the motion of latch assembly during earthquake, the demonstration results of the test described herein are also applicable to the US-APWR.

6. Reference

1) JNES Report 06-KIKOHO-0001, "Report of Tests and Investigation on Technology of Seismic Resistance Evaluation for Nuclear Installations, Equipment Fragility Test Part 2 (PWR Control Rod Inserting Capability) ", FY2005.

Table 1 List of Measurement Items around CRDM

| Test Equipment | Measurement | Measurement Location | | Sensor | Sensor Direction | Number of Sensors | Figure |
|---|---|---|---|---|---|---|---|
| Control Rod Drive Mechanism (CRDM) | | | | | | | Figure 3 |
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| | | | | | | | |
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Figure 1 Comparison between Actual Plant Structure and Test Equipments

Figure 2    Measurement Locations of Test Vessel and Vessel Support Rib

Figure 3 Installation Locations of Detectors in CRDM

Figure 4 Response Spectrum generated from the Measured Acceleration Data of the CRDM Middle Seismic Support Location