MITSUBISHI HEAVY INDUSTRIES, LTD.
16-5, KONAN 2-CHOME, MINATO-KU
TOKYO, JAPAN

September 16, 2010

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-10254

Subject: MHI's Responses to US-APWR DCD RAI No. 614-4853

Reference: 1) "Request for Additional Information No. 614-4853 Revision 0, SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components," dated 08/13/2010.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 614-4853, Revision 0."

Enclosed are the responses to 3 RAIs contained within Reference 1. Of the RAIs in Reference 1, four (4) will not be answered within this package. They are RAIs 3.9.2-88, 89, and 90 which have a 45 day response time, and RAI 3.9.2-91 which has a 60-day response time, as agreed to between the NRC and MHI, and will be issued at a later date by separate transmittals.

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

Sincerely,

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

Enclosure:

1. Response to Request for Additional Information No. 614-4853, Revision 0

D081
MRO

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

Contact Information
C. Keith Paulson, Senior Technical Manager
Mitsubishi Nuclear Energy Systems, Inc.
300 Oxford Drive, Suite 301
Monroeville, PA 15146
E-mail: ck_paulson@mnes-us.com
Telephone: (412) 373-6466

Enclosure 1

UAP-HF-10254
Docket No. 52-021

Response to Request for Additional Information No. 614-4853, Revision 0

September, 2010

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/16/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 614-4853 REVISION 0**

SRP SECTION: **03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components**

APPLICATION SECTION: **3.9.2**

DATE OF RAI ISSUE: **8/13/2010**

QUESTION NO. RAI 03.09.02-85:

In MHI's response to US-APWR DCD RAI 205-1584, question number 3.9.2-14, the applicant stated that the in-structure response spectra (ISRS), considering local vibration modes, (i.e., wall and floor flexibility) and the description of the analysis method will be provided in Revision 2 of the DCD. The applicant further stated that it would provide a description of the ISRS local vibration modes and the analysis method in DCD Tier 2, Section 3.7, Revision 2. The staff reviewed DCD Section 3.7, Revision 2, but did not find where the applicant had included a detailed description of the analysis method used to account for the wall and floor flexibility in deriving the ISRS. In DCD Revision 2, Section 3.7.2.5, second paragraph, the applicant stated, "The local analyses of floor slab systems with respect to out-of-plane flexibility and effects on the ISRS are addressed as part of a later technical report." The applicant also provided a brief description on the methodology in generation of the ISRS by modeling the local flexibility as a single degree of freedom system. However, the staff noted that the adequacy of the generated ISRS with local flexibility has to be evaluated to ensure the accuracy of the seismic analysis of subsystems supported at these locations.

The applicant is requested to provide the ISRS generated for various locations with local flexibility. Alternatively, provide a reference document where this information is available.

Reference: MHI's Response to US-APWR DCD RAI No. 205-1584; MHI Ref: UAP-HF-09184; dated April 30, 2009; ML091240113.

ANSWER:

To account for the wall and floor flexibility, the existing coupled lumped mass stick model of the reactor building (R/B) complex is enhanced by adding single degree of freedom (SDOF) models to capture the out-of-plane flexibility of the slabs. SDOF oscillators are also used to capture the out-of-plane horizontal flexibility of slabs and walls. The Technical Report (TR) "Seismic Design Bases of the US-APWR Standard Plant," MUAP-10001, Rev. 1, Section 4.3 provides a detailed

description of the analytical methodology used to account for the wall and floor flexibility for the R/B. Section 4.4 of MUAP-10001, Rev. 1, describes the finite element model used for the site independent SSI analyses of the PS/B. The refinement of the FE mesh of PS/B dynamic model allows an accurate representation of the response characterized by local vibration modes.

A modal analysis using ANSYS is performed on the 3-D finite element (FE) models of R/B complex and PS/B and compared with the transfer function results obtained from soil-structure interaction (SSI) analysis performed on the R/B complex and PS/B SASSI models resting on the surface of a half-space with hard-rock properties. This is to simulate the response of the structures under a fixed base condition. Transfer Functions at selected nodes are obtained from the SSI analysis and are compared with the dominant natural frequencies developed from the ANSYS modal analysis. The results indicate amplification spikes at or close to the dominant frequency points. TR MUAP-10001, Rev. 1, Sections 5.3.4.2 and 5.4.2 provide a detailed description of this comparison. The acceleration response spectra (ARS) for representative SDOF elements, which represent locations with local flexibility, can be found in TR MUAP-10001, Rev. 1, Figures 5.3.4.3-21 thru -25.

TR MUAP-10006, Rev. 0, "Soil-Structure Interaction Analyses Results for the US-APWR Standard Plant", documents the site independent SSI analyses of the R/B complex and PS/B. Sections 3.5 and 4.1 describe the methodology used to develop ISRS that includes the effects of local vibrations of flexible walls and slabs. A 3-D FE SASSI model of the R/B complex structures is under construction and will be used for site independent SSI analyses. The results from the SSI analyses of SASSI FE model of the R/B complex will be used to validate that the ISRS generated from the lumped-mass-stick model envelope all of the local vibration responses.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/16/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 614-4853 REVISION 0**

SRP SECTION: **03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components**

APPLICATION SECTION: **3.9.2**

DATE OF RAI ISSUE: **8/13/2010**

QUESTION NO. RAI 03.09.02-86:

In MHI's response to US-APWR DCD RAI 498-3782, question 03.09.02-62, the applicant stated that Topical Report MUAP-10001 (Rev. 0) "Seismic Design Bases of the USAPWR Standard Plant," "... issued in February 2010 will provide the detailed descriptions regarding these modeling and analysis enhancements, which will be used as a basis for the re-runs of the R/B complex and PS/B dynamic analyses,..." based on SASSI analyses. In its review the staff noted that the report describes in detail the modeling of SDOF models to enhance R/B stick model for capturing the out-of-plane response of flexible slabs and walls. The location, spring-constant, and effective mass of each SDOF model are tabulated. The staff, however, noted that only those slabs and walls that have a fundamental frequency less than 40 Hz are modeled by SDOF, whereas, the ground design response spectra of US-APWR are anchored at 50 Hz. The staff also noted that the SDOF of each slab or wall is located at center of mass (CM) of the slab or wall, however, the support of equipment or system could be located at a distance away from the mass center.

The applicant is requested to (a) provide justification that only floors and slabs with fundamental frequency less that 40 Hz are modeled with SDOF, and do not include floors and slabs with fundamental frequency up to 50 Hz, and (b) clarify whether the calculated floor response spectra at the location of SDOF (i.e. center of mass) is applicable to the equipment or system located at a distance away from the CM. If they are not applicable, explain how to determine the floor spectra for equipment or system located at a distance away from the CM.

Reference: MHI's Response to US-APWR DCD RAI No. 498-3782; MHI Ref: UAP-HF-10031; dated February 3, 2010; ML100470583.

ANSWER:

Item a)

Refer to Response to RAI No.: 603-4666, Rev. 0, Question RAI 03.07.02-10, Item No. 1 for a detailed discussion of this issue (MHI Ref: UAP-HF-10238 dated August 30, 2010). The following is a partial quotation from that response.

> "The flexible slabs and walls for which the out-of-plane response, considering reduced cracked stiffness, is characterized by natural frequencies between 40 Hz and 50 Hz, are to be grouped with the appropriate group of ISRS defined in Technical Report, MUAP-10006. These ISRS are deemed adequately conservative to envelope the response of the flexible slabs and walls with fundamental frequencies between 40 and 50 Hz. This will be validated at a later date by performing a set of site-independent SSI analyses using a 3-D finite element (FE) structural model of the R/B complex structures that will be capable of capturing local responses up to 50 Hz".

Item b)

For a flexible slab the greatest deflection will be located at mid-span of the slab. This coincides with the center of mass (CM) of the slab. Therefore the slab's greatest deflections will be at the slab's CM, and the most conservative in-structure response spectra (ISRS) are generated at that point.

All equipment or systems located on the slab are analyzed with the ISRS generated for the CM. Therefore any equipment or system located at a distance away from the CM of a particular flexible slab will be conservatively designed.

Further, the design of equipment and subsystems mounted to slabs and walls account for the flexibility of the supports and intervening structural elements. Refer to the response to RAI 493-3983 Question RAI 03.07.03-5 (MHI Ref: UAP-HF-10019; dated January 28, 2010; ML100330615) for related discussion.

The results from the SSI analyses performed on the SASSI FE model of the R/B complex will be used to validate that the ISRS generated from lumped-mass-stick model envelope all of the local vibration responses.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/16/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 614-4853 REVISION 0**

SRP SECTION: **03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components**

APPLICATION SECTION: **3.9.2**

DATE OF RAI ISSUE: **8/13/2010**

QUESTION NO. RAI 03.09.02-87:

The staff noted that in US-APWR DCD Tier 2, Rev. 2, Tables 3.7.3-1(a) and 3.7.3-1(b) have been revised, and the SSE damping and OBE damping values listed in the tables are consistent with the acceptable values specified in RG 1.61, Revision 1, for SSE and OBE analyses. The staff further noted that although the damping values specified for CRDM have been deleted in Tables 3.7.3-1(a) and -1(b) of DCD Rev. 2. In its response to RAI 498-3782, question 03.09.02-83, the applicant stated that the damping values specified for welded and friction-bolted steel structures and equipment are also used for CRDM. However, the staff also noted that DCD Rev. 2, Tables 3.7.3-1(a) and -1(b) also list the damping values for steel-concrete modules. It is not clear to the staff which SSCs are included in this category or how were the damping values selected.

The applicant is requested to (a) clarify which SSCs are considered "steel-concrete modules, and (b) describe the basis for selecting the SSE damping and OBE damping values of 5 percent and 4 percent, respectively, for these modules.

Reference: MHI's Response to US-APWR DCD RAI No. 498-3782; MHI Ref: UAP-HF-10008; dated January 15, 2010; ML100200161.

ANSWER:

Item (a)

Steel-concrete (SC) modules are described in DCD Subsections: 3.8.3.1.5: Primary Shield Wall; 3.8.3.1.6: Secondary Shield Wall; 3.8.3.1.7: Refueling Cavity; 3.8.3.1.8: Refueling Water Storage Pit (RWSP); 3.8.3.1.9: Interior Compartments; and 3.8.3.1.10: SC Modules. Additional description is provided in Subsection 3.8.3.4: Design and Analysis Procedures. The extents of SC modules are shown in: Figure 3.8.3-5: SC Module Isometrics, and Figure 3.8.3-6: Interior Compartments Wall Layout and Configuration. SC module details are presented in Figure 3.8.3-7.

Item (b)

Justification for the safe-shutdown earthquake (SSE) and operating-basis earthquake (OBE) damping values of 5 percent and 4 percent respectively for SC modules is provided in the response to RAI 211-1946, Question 3.7.1-5 (MHI Ref: UAP-HF-09187; dated April 23, 2009; ML091170058). The response to RAI 211-1946 provides clarifications for the basis for the stiffness and damping values used for the SC modules, validation of the lumped mass stick model for the containment internal structures (CIS) and the methodology for calculation of stiffness, damping, etc.

The following is repeated from the response to RAI 211-1946:

> The "stiffnesses based on elastic properties and composite behavior of steel and concrete are acceptable and have been verified by many test results. See DCD Reference 3.8-27, which shows the $1/10^{th}$ scale mode test results of a CIS in a PWR which used SC modular walls to provide validation of the above evaluation method. This reference provides test results that show the equivalent viscous damping of the SC modules at design load level (SSE) of 5 percent. This generally remained constant up to the load level at which the SC module steel plates started yielding. Therefore, it is reasonable to use 4 percent damping for the OBE based on these test results."

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

This completes MHI's responses to the NRC's questions.