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January 27, 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-11016

Subject: MHI's Supplemental Responses to US-APWR DCD RAI No. 497-3734 (SRP 03.08.04)

References:
1) "Request for Additional Information No. 497-3734 Revision 0, SRP Section: 03.08.04 – Other Seismic Category I Structures," dated 12/01/2009.
2) "Response to Request for Additional Information No. 497-3734 Revision 0, SRP Section: 03.08.04 – Other Seismic Category I Structures," (MUAP-HF-10047), dated 2/19/2010.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Supplemental Responses to Request for Additional Information No. 497-3734, Revision 0."

Enclosed are the supplemental responses to clarify the previous responses submitted in Reference 2 to 16 RAIs contained within Reference 1. This transmittal completes the response to this RAI.

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,

Y. Ogata

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

Enclosure:

1. Supplemental Responses to Request for Additional Information No. 497-3734, Revision 0

D081
NRO

CC: J. A. Ciocco
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Enclosure 1

UAP-HF-11016
Docket No. 52-021

Supplemental Responses to Request for Additional Information No. 497-3734, Revision 0

January, 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/27/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 – Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-37:

In its response to Part (a) of Question 3.8.4-11, MHI provides an explanation as to how the time histories are converted to equivalent static forces. MHI states that the maximum story shears which result from time history analysis are used to develop the SSE loads, and describes these analyses. For Part (b) MHI describes when the equivalent static forces are applied to the FE model. Several tables are provided that show the SSE floor rocking moments that are calculated from the results of the time history analyses. For Part (c) MHI presents the rationale for using the FE model fixed at elevation 3'-7". It is stated that for most of the load combinations considered the approach produces conservative results.

The staff notes that in their response to Question 3.8.4-26 MHI states that they will perform a confirmatory analysis to show that sufficient design margin exists to cover the effects of interaction between the subgrade, basemat, and the R/B superstructure. The applicant is requested to provide the staff with the results of that confirmatory analyses.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

The confirmatory analysis will be completed as part of the validation of the R/B complex stick models. The analysis results will be presented in a subsequent technical report.

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.

Supplemental Response:

SSI analysis is performed in which the R/B Complex is seismically analyzed as surface-mounted structure in conjunction with a suite of generic layered soil profiles as documented in MHI Technical Reports MUAP-10001 and MUAP-10006. The effects of embedment are neglected in the standard design as discussed in DCD Tier 2 Section 3.7.2.4. Further justification for neglecting the embedment effects in the seismic analysis is provided in the response to RAI 212-1950 Question 3.7.2-20 and RAI 660-5134 Question 3.7.2-53.

For purposes of static design, the R/B Complex is analyzed with a detailed finite element (FE) model with a surface-mounted condition, with appropriate soil stiffnesses for equivalent static analysis assigned to the subgrade. The design of the R/B superstructure is also performed considering a fixed-base condition at the bottom of the foundation. Dynamic lateral earth pressures on below-grade walls are accounted for in the structural design as described in the responses to RAI 212-1950 Questions 3.7.2-13 and 3.7.2-14, RAI 496-3735 Question 3.8.5-30, RAI 340-2004 Question 3.8.5-9, and most recently RAI 657-5135 Question 3.8.5-39. The design also accounts for static and other loads on below-grade walls as described in DCD Section 3.8.4. Therefore, as also stated in the supplementary response to RAI 497-3734 Question 3.8.4-44, MHI's modeling approach is to perform the static analysis of the R/B Complex using a detailed FE model which extends to the base of the foundation.

Utilizing the approach described above, interaction between the subgrade, basemat, and the superstructure is accounted for in the design of the R/B Complex. There is no need to perform a confirmatory analysis to confirm the validity of a fixed-base at elevation 3'-7" as stated in the original response to this question, since this approach is no longer used.

Impact on DCD

See the supplemental response to question RAI 03.08.04-44 for impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/27/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 – Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-44:

In their response to Part (a) of Question 3.8.4-26, MHI provides their rationale for not using the whole R/B model in the first row case in Table 3.8.4-5 of the DCD. MHI refers to their response to Question 3.8.4-11 of this RAI in which the question is similar to this current question. MHI contends that by adding a design margin of 20-30 % to member seismic forces, this allows the use of the fixed-base model, which is more cost effective than using the whole model. MHI states that they will perform a confirmatory analysis using the R/B whole model to validate the fixed-base analysis. For Part (b) MHI describes the three-dimensional NASTRAN finite element model of the R/B whole model. The R/B whole model employs soil springs as described in this response.

In the response, MHI claims that the fixed-based model is more cost-effective, and a confirmatory analysis will be performed to assess its accuracy. The applicant is requested to provide the staff with the results of that confirmatory analysis to allow the staff to complete its determination of the acceptability of the applicant's original response to this question.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

The confirmatory analysis will be completed as part of the validation of the R/B complex stick models which will be presented in a subsequent technical report. The DCD will be appropriately revised if the results of the confirmatory analysis do not validate the modeling approach.

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.

Supplemental Response:

As a follow-up to the original response, MHI has revised its modeling approach to perform the static analysis of the R/B Complex using a detailed finite element model which extends to the base of the foundation. Table 3.8.4-5 and the text in Subsection 3.8.4.4.1 are revised accordingly as shown in the attached mark-up. Therefore, a confirmatory analysis as discussed in the original response to this RAI question is not required.

Impact on DCD

See Attachment 1 for the mark-up of the DCD Tier 2, Section 3.8, changes to be incorporated.

- Revise the fourth paragraph of Subsection 3.8.4.4.1 to read as follows:

  "The design considers normal loads (including construction, dead, live, and thermal), and the SSE. Seismic forces are obtained from the dynamic analysis described in Subsection 3.7.2. These loads are applied to the linear elastic FE model, which extends to the base of the R/B foundation, as equivalent static forces. Soil stiffnesses derived from the standard plant soil profiles are assigned to the subgrade for the design of the overall R/B, and the design of the R/B superstructure is also performed considering a fixed-base condition at the bottom of the foundation. Loads and load combinations are given in Subsection 3.8.4.3."

- Delete the second row of Table 3.8.4-5. The revised table will read as follows:

"Table 3.8.4-5 Summary of R/B and PS/Bs Models and Analysis Methods

Computer Program and Model	Analysis Method	Purpose	Concrete Stiffness
Three-dimensional ANSYS FE of R/B whole model	Static Analysis	To obtain member forces including thermal load	Monolithic(1)
Three-dimensional ANSYS FE of PS/B model	Static Analysis	To obtain member forces	Monolithic(1)

Note:

1. The stress analysis is performed based on the monolithic concrete stiffness, but the thermal stress is reduced by the reduction factor α (=0.5)."

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

ATTACHMENT 1
To Supplemental Response for RAI 497-3734

3.8.4.4.1 R/B

The R/B includes the MCR and the fuel storage area, and is a reinforced concrete structure consisting of vertical shear/bearing walls and horizontal slabs. The walls carry the vertical loads from the structure to the basemat. Lateral loads are transferred to the walls by the roof and floor slabs.

The fuel handling area is a reinforced concrete structure supported by structural steel framing. The new fuel is stored in racks in a dry, unlined pit. The spent fuel pit is lined with stainless steel and is normally flooded to an elevation 1 ft, 2 in. below the operating floor deck. Subsection 9.1.2 describes the design bases and layout of the fuel storage area.

The design and analysis procedures for the R/B, other than the PCCV and containment internal structure, including assumptions on boundary conditions and expected behavior under loads, are in accordance with ACI-349 (Reference 3.8-8) for concrete structures, with AISC N690 (Reference 3.8-9) for steel structures, and with American Iron and Steel Institute (AISI) specification for cold formed steel structures (Reference 3.8-38).

The design considers normal loads (including construction, dead, live, and thermal), and the SSE. Seismic forces are obtained from the dynamic analysis described in Subsection 3.7.2. These loads are applied to the linear elastic FE model, which extends to the base of the R/B foundation, ~~fixed at elevation 3 ft, 7 in.~~ as equivalent static forces. Soil stiffnesses derived from the standard plant soil profiles are assigned to the subgrade for the design of the overall R/B, and the design of the R/B superstructure is also performed considering a fixed-base condition at the bottom of the foundation. Loads and load combinations are given in Subsection 3.8.4.3.

The design of the R/B's flexible shear walls and floor slabs, like that of the main steam piping room with many openings, takes into account the out-of-plane bending and shear loads, such as live load, dead load, and seismic load. Also, the walls and slabs of the spent fuel pit and the emergency feedwater pit are designed to resist the out-of-plane bending and shear loads, such as live load, dead load, seismic, hydrostatic, and hydrodynamic pressure.

The R/B is analyzed using a three-dimensional FE model with the ANSYS computer codes (Reference 3.8-14). The FE model is shown in Figure 3.8.4-2.

The basemat design is described in Subsection 3.8.5.

Structural Design of Critical Sections

This subsection summarizes the structural design of representative seismic category I structural elements in the R/B. These structural elements are listed below and the corresponding location numbers are shown on Figure 3.8.4-3.

SECTION 1 West exterior wall of R/B, elevation 3 ft, 7 in. to elevation 101 ft, 0 in. This exterior wall illustrates typical loads such as temperature gradients, seismic, and tornado missile.

SECTION 2 South interior wall of R/B, elevation 3 ft, 7 in. to elevation 101 ft, 0 in. This is one of the most highly stressed shear walls.

Table 3.8.4-5 Summary of R/B and PS/Bs Models and Analysis Methods

Computer Program and Model	Analysis Method	Purpose	Concrete Stiffness
~~Three-dimensional ANSYS FE of R/B model fixed at elevation 3 ft, 7 in.~~	~~Static Analysis~~	~~To obtain member forces~~	~~Monolithic~~
Three-dimensional ANSYS FE of R/B whole model	Static Analysis	To obtain member forces ~~for~~ including thermal load	Monolithic(1)
Three-dimensional ANSYS FE of PS/B model	Static Analysis	To obtain member forces	Monolithic(1)

Note:

1. The stress analysis is performed based on the monolithic concrete stiffness, but the thermal stress is reduced by the reduction factor α (=0.5).