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## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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1/31/2013

### US-APWR Design Certification

### Mitsubishi Heavy Industries

Docket No. 52-021

**RAI NO.:** NO. 852-6003 REVISION 3  
**SRP SECTION:** 03.07.02 – Seismic System Analysis  
**APPLICATION SECTION:** 3.7.2  
**DATE OF RAI ISSUE:** 10/24/11

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#### QUESTION NO. RAI 03.07.02-110:

Section 1 of MUAP-10001(R3), "INTRODUCTION," states "the development of the generic layered site profiles consistent with the CSDRS are documented in this technical report." That statement is not clear to the staff. For design certification, the applicant specifies the CSDRS and the generic site profiles that will be analyzed. Please explain the meaning of "generic layered site profiles consistent with the CSDRS."

On Page 1-1, the applicant identified four issues that are addressed in the seismic response analysis reported in MUAP-10001(R3). However, the applicant did not address how the effects of water table location, embedment, and structure-soil-structure interaction (due to structures in close proximity) are included in the updated SSI analyses of the USAPWR standard plant structures.

Although in Subsection 3.2 of the MUAP 10001(R3), "Generic Layered Soil Profiles and Strain Compatible Properties," (Page 3-1) the applicant states that the SSI analyses will consider the effect of the elevation of the water table." The staff is unable to find a description in MUAP-10001(R3) of the approach used by the applicant in considering the effect of water table in the SSI analyses. However, the staff noticed that the effect of high water table is addressed in an MHI technical report recently submitted to the staff, MUAP-11007(R0). The applicant is requested to provide a section in MUAP 10001 (R3) describing the approach for considering the effect of high water table in the SSI analyses. The description should address the following questions:

- How many soil profiles are used in the analyses?
- How are these soil profiles generated?
- How are the strain-compatible soil properties obtained? What degradation curves for soil modules and hysteretic damping curves are used?
- What hysteretic damping values for the shear waves and the compression waves are used in the analyses? Provide the rationale and justifications for using these damping values.

- Provide a technical basis and justification of the applicability of conclusions with regard to the effect of water table on the SSI analysis in MUAP 11007 (RO) that utilizes a different SSI model.

This information is required by the staff in order to assess the effects of these parameters on the seismic response of the SSCs and the results of the SSI analyses.

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**ANSWER:**

Technical Report MUAP-10001, Rev. 3, has been superseded and relevant information has been incorporated into Technical Report MUAP-10006, Rev. 3. Technical Report MUAP-11007, Rev. 0, has been revised to Technical Report MUAP-11007, Rev. 2, which addresses ground water effects on the US-APWR standard plant soil-structure interaction (SSI) analyses.

The phrase “generic layered site profiles consistent with the CSDRS” used in Section 01.1.0 of Technical Report MUAP-10006, Rev. 3, “INTRODUCTION,” has been clarified to read: “The development of Strain Compatible Properties (SCP) of the generic layered soil profiles consistent with the CSDRS and its applied elevation is documented in this Part of the TeR.” The generic profiles are developed in a manner such that the dynamic soil properties are compatible with the strains generated by the seismic ground motions of the certified seismic design response spectra (CSDRS), as discussed in Section 01.3.2 of Technical Report MUAP-10006. Therefore, the strain-compatible properties of the generic layered profiles are “consistent with the CSDRS.” Further explanation on the development of the standard plant profiles is presented in Sections 01.4.2 and 01.5.2 of the report.

The SSI analyses documented in Technical Report MUAP-10006, Rev. 3, are based on fully saturated soil profiles, as discussed in Sections 01.4.2.1, 01.5.2, and 03.1.0 of the report. The study of the impact of water table effects on seismic responses is addressed in Technical Report MUAP-11007, Rev. 2, which considers unsaturated soil profiles. It is concluded that water table effects have a small impact on the seismic responses obtained from the updated site-independent SSI analyses. The updated SSI results documented in Technical Report MUAP-10006, Part 3 are based on analyses of embedment conditions, which is a more accurate representation of the plant conditions than the previous surface-founded model approach. The structure-soil-structure interaction methodology is presented in Section 03.3.5 of Technical Report MUAP-10006, Rev. 3, and the results are presented in Section 03.4.2 of the same report.

Questions pertinent to the effects of groundwater table are addressed in Technical Report MUAP-10006, Rev. 3, and MUAP-11007, Rev. 2 as follows:

- How many soil profiles are used in the analyses?

The number of soil profiles used in the design-basis analyses documented in Technical Report MUAP-10006, Rev. 3, is now changed from eight (8) to six (6). The six generic profiles, which are saturated profiles, are summarized in Table 01.4.2.1-1 and Figures 01.4.2.1-1 through 01.4.2.1-3 of Technical Report MUAP-10006, Rev. 3. The study of the effects of groundwater table fluctuation is documented in Technical Report MUAP-11007, Rev. 2. The three generic profiles whose properties are significantly affected by groundwater, which are soil profiles 270-200, 270-500 and 560-500, are analyzed with low groundwater levels. This is achieved by assigning unsaturated soil properties to the layering above the water table, as explained in Technical Report MUAP-11007, Rev. 2, Sections 2.3 and 2.4.

- How are these soil profiles generated?

The generation of the design-basis generic layered profiles analyzed in Technical Report MUAP-10006, Rev. 3, is described in detail in Sections 01.4.2 and 01.5.2 of the report. Considerations of groundwater in the design-basis generic profiles, and generation of the unsaturated profiles used for the study of groundwater table effects, are described in detail in Sections 2.3 and 2.4, respectively, of Technical Report MUAP-11007, Rev. 2.

- How are the strain-compatible soil properties obtained? What degradation curves for soil modulus and hysteretic damping curves are used?

The generic subgrade properties of the soil profiles are selected from review of database information from the CEUS and WUS of initial small-strain site properties that cover the range of generic site conditions from deep soft soil to firm rock that may exist across the continental US as described in Section 01.4.2 of Technical Report MUAP-10006, Rev. 3. The strain-compatible soil properties are obtained by random vibration theory equivalent site response analyses. The modulus reduction and hysteretic damping curves from EPRI Technical Report TR-102293 are used as described in Sections 01.4.2, 01.4.2.2, and 01.5.2.2 of Technical Report MUAP-10006, Rev. 3. As described in Section 2.4 of Technical Report MUAP-11007, Rev. 2, the same shear modulus and damping value degradation curves are used to develop the strain-compatible properties for the unsaturated soil profiles.

- What hysteretic damping values for the shear waves and the compression waves are used in the analyses? Provide the rationale and justifications for using these damping values.

The hysteretic damping values for the shear waves and compression waves used in the design-basis SSI and structure-soil-structure interaction analyses are presented in Tables 03.3.1-1 through 03.3.1-6 and Figures 03.3.1-5 and 03.3.1-6. As discussed in Section 03.3.1 of Technical Report MUAP-10006, Rev. 3, the strain compatible shear wave median damping values are used for both shear and compression wave damping. Section 01.5.2 of Technical Report provides further explanation of the rationale and justifications for the damping values. The damping values for the unsaturated soil profiles analyzed in Technical Report MUAP-11007, Rev. 2, are presented in Tables 3-1 through 3-3 and Figure 3-4 of the report. As stated in Section 3.1 of Technical Report MUAP-11007, Rev. 2, the median values of shear wave damping for both shear and compression wave damping are used, consistent with the approach in Technical Report MUAP-10006, Rev. 3.

- Provide a technical basis and justification of the applicability of conclusions with regard to the effect of water table on the SSI analysis in MUAP-11007, Rev. 0 that utilizes a different SSI model.

The reactor building (R/B) complex SSI dynamic finite element (FE) model used to study the sensitivity of effects of groundwater table on the SSI analyses, as documented in Technical Report MUAP-10007, Rev. 2, no longer differs from the R/B complex SSI dynamic FE model used in Technical Report MUAP-10006, Rev. 3.

### **Impact on DCD**

There is no impact on 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.

**Impact on Technical/Topical Report**

There are no impacts on the Technical/Topical Reports.

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This completes MHI's response to the NRC's question.