RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 810-5874 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**08/22/11**

QUESTION NO. RAI 03.07.02-100:

In Subsection 3.7.2.4.1 of DCD (R3), "Requirements for Site-Specific SSI Analysis of US-APWR Standard Plant," the second to last full sentence on p. 3.7-31 states that “If the strains in the subgrade media are less than 2%, the strain-compatible properties can be obtained from equivalent linear site-response analysis using soil degradation curves.”

The Applicant should clarify if the 2% soil strains refer to low-strain soil values or strain compatible values and should also state the basis for the value of 2%. Also, the statement implies that if soil strains are greater than 2%, then strain-compatible soil properties would be obtained by other means. The Applicant is requested to discuss what other means of determining strain-compatible properties are proposed if soil strains are greater than 2%, and what affect other approaches will have on the determination of the subgrade properties.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11402 (ML11332A148).

The 2% soil strain values refer to strain-compatible values selected from soil degradation curves during a time history analysis of a soil column using a software program such as SHAKE or other program with similar capabilities. Regarding the basis of the value of 2%, as described in Section 01.4.2.2 of Technical Report MUAP-10006, Rev. 3, modulus reduction and hysteretic damping curves from EPRI TR-102293 (Reference 1) are used for the horizontal component site response analyses. The curves are appropriate for generic soils comprised of gravels, sands and low plasticity index (PI) clays to establish strain compatible values when subjected to strains from ground motions, and are shown in Figure 01.4.2-2 of Technical Report MUAP-10006, Rev. 3. These curves also provide realistic strain compatible properties for generic rock materials. The text book “Geotechnical Earthquake Engineering” by Steven L. Kramer (Reference 2) provides discussion for how the non-linearity of soil behavior can be approximated by linear site response analysis. Reference 2 states that it is common to characterize the strain level of the transient record in terms of an effective shear strain that has been empirically found to vary from about 50% to 70% of the maximum shear strain. For equivalent linear approximation of the nonlinear

response, the lower value of the range up to 50% is considered. The limiting value of 2% strain corresponds to 50% of the maximum shear strain value of 4% shown in Figure 01.4.2-2 of Technical Report MUAP-10006. This is considered a conservative strain limit because it is often taken at 65% of the peak strain, above which linear approximation would not be used.

If soil or rock strains are greater than 2%, strain-compatible soil properties could be obtained by other means such as analyzing the actual nonlinear response of a soil deposit using direct numerical integration in the time domain. However, this has not been necessary because the strains have been found to be less than 2% in the standard plant analyses. Therefore, it is not necessary to consider what affect other approaches will have on the determination of the subgrade properties.

References:

1. "Guidelines for Determining Design Basis Ground Motions," Vols. 1-5, Electric Power Research Institute (EPRI) TR-102293 Palo Alto, CA, 1993.
2. Steven L Kramer, "Geotechnical Earthquake Engineering," Prentice Hall International Series in Civil Engineering and Engineering Mechanics series, Upper Saddle River, NJ, 1996.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the COLA.

Impact on S-COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

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