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

December 28, 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-10353

Subject: MHI's Responses to US-APWR DCD RAI No. 659-5133 Revision 2 (SRP 03.07.01)

Reference: 1) "Request for Additional Information No. 659-5133 Revision 2, SRP Section: 03.07.01 - Seismic Design Parameters," dated 11/15/2010.

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. 659-5133, Revision 2."

Enclosed are the responses to 2 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,

Atsushi Kumaki for.

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

Enclosure:

1. Response to Request for Additional Information No. 659-5133, Revision 2

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

DD81
NRO

Enclosure 1

UAP-HF-10353
Docket No. 52-021

Response to Request for Additional Information No. 659-5133, Revision 2

December, 2010

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/28/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 659-5133 REVISION 2**
SRP SECTION:	**03.07.01 – Seismic Design Parameters**
APPLICATION SECTION:	**3.7.1**
DATE OF RAI ISSUE:	**11/15/10**

QUESTION NO. RAI 03.07.01-17:

This request for additional information (RAI) is necessary for the staff to determine if the application meets the requirements of 10 CFR Part 50, Appendix A, General Design Criteria 2; 10 CFR Part 50 Appendix S; and 10 CFR Part 100; as well as the guidance in NUREG-0800, 'Standard Review Plan for the Review of Safety Analysis for Nuclear Power Plants,' Chapter 3.7.1, "Seismic Design Parameters."

Section 3.2 of MHI's Topical Report, MUAP-10006 (R0), addresses site conditions and states that Tables 3-3A through 3-3H present the input material properties of the subgrade. However, the basis for the values in these tables is not discussed. In order to conduct a technical evaluation of the supporting media used for the seismic analysis, the staff requests that the applicant provide the following information:

1. The origin of the information in the tables
2. A description of how and to what extent the information does or does not relate to the data shown in Tables 5.2-3 through 5.2-11 of MUAP-10001 (R1)
3. A statement as to whether the properties shown are low-strain or strain-iterated properties
4. If the properties are strain-iterated properties, a description of which time histories (i.e. horizontal H1, horizontal H2, vertical, or some combination) were used to generate the properties
5. A description of how the compressional wave speeds and damping used in the vertical seismic analysis were developed.

ANSWER:

1. MHI Technical Report MUAP-10001 Section 5.2 is the origin of the information contained in Technical Report MUAP-10006 Tables 3-3A through 3-3H. Please note that the strain compatible properties for generic profiles 270 and 560 listed in Tables 5.2-3 through 5.2-8 of MUAP-10001(R1) have been revised in Revision 2 of the report to show the updated results of the site response analyses.
2. The median strain-compatible soil properties listed in Tables 5.2-3 through 5.2-11 and shown in Figures 5.2-6 through 5.2-14 of the updated revision of MUAP-10001(R2) Section 5.2 are used as input for the site-independent soil-structure interaction (SSI)

analyses of US-APWR standard plant Category I buildings documented in MUAP-10006(R0). The site independent SSI analyses consider the foundations of the Category I buildings to be supported on the surface of the subgrade that is located at depth approximately 40 ft below the surface of the finished grade of the plant. Since the top 40 ft of the soil are excavated, the eight generic subgrade profiles used for the site independent SSI analyses of surface mounted foundations are obtained by removing the top 40 ft of soil from the generic profiles with median strain-compatible properties developed in Technical Report MUAP-10001. The layering of the profiles are adjusted in order to ensure that the ACS SASSI models are capable of transmitting seismic waves with frequencies equal to or lower than the cut off frequency of SSI analyses. The figures below show comparison of the profiles of the median shear wave velocities obtained from the site response analyses in MUAP-10001 and the profiles of the shear velocities used as input for the SSI analyses presented in MUAP-10006. Please note that in response to RAI 625-4924, it has been explained that one soil profile, the "270-100" profile and its associated Table 5.2-3 and Figure 5.2-8, is to be deleted from suite of profiles considered in the standard design.

3. Refer to MUAP-10001 Section 4.2.2. The properties are equivalent to strain-iterated properties. The approach for the US-APWR CSDRS strain compatible properties is that the properties are developed in a fully probabilistic manner, in which each base-case profile is randomized in velocity as well as nonlinear dynamic material properties. Thirty realizations were generated for each profile category and depth to hard or soft rock. Random vibration theory (RVT) equivalent-linear site response analyses were then performed on each random profile for horizontal motions while for vertical motions, linear analyses were used by assuming that the soil compressional velocities are not strain dependent. Section 5.2.1 of MUAP-10001 provides more information regarding the approach used for site response analyses for vertical motions and how the results of these analyses relate to the vertical CSDRS design spectrum which is based on the RG 1.60 V/H ratio. For the horizontal component site response analyses, modulus reduction and hysteretic damping curves from EPRI TR-102293 are used. The curves are appropriate for generic soils comprised of gravels, sands, and low PI clays. For the soft and firm rock profiles (560m/sec and 900m/sec), an unpublished suite of curves appropriate for soft and firm rock conditions were used. The rock curves were developed during the EPRI project (refer to TR-102293) assuming soft and firm rock exhibits a nonlinear dynamic material behavior similar to gravels. The rock curves were not included in TR-102293 as the final suite of amplification factors was based on soil profiles intended to capture the behavior of soils ranging from gravels to low plasticity sandy clays at CENA nuclear power plants.

4. Random vibration theory (RVT) was used with equivalent-linear site response (EPRI, 1993; Silva et al., 1996) to develop the strain compatible properties (MUAP-10001 (R1), Section 5.2.1). In this approach time histories are not required as random process theory is used to estimate peak cyclic shear strains as well as oscillator response (5% damped response spectra; MUAP-10001 (R1), Figure 5.2-3). Please refer to Section 5.2.1 of MUAP-10001 for more information on the point-source model used to generate the ground motions used as input for the RVT based site-response analyses.

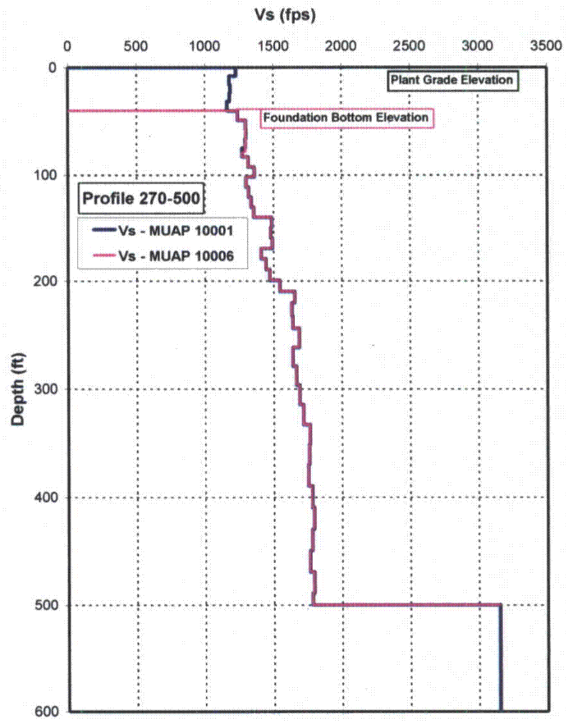
5. Because far fewer measured compressional-wave velocity profiles are available compared to shear-wave velocity profiles, due principally to surface geophysical techniques, significantly more judgment had to be used in developing the generic compressional-wave profiles. The general approach involved averaging available measured shear- and compressional-wave profiles binned into similar surficial geology or site category such as Geomatrix (Silva, 1997). For example, profile 270m/sec is close to shear-wave velocity averages for Geomatrix categories C and D or alternatively Quaternary Alluvium. Similarly profile 560m/sec is close to Geomatrix A and B or Tertiary Bedrock (Silva et al., 1999). For each profile bin reflecting a category (e.g. firm soil, close to 270m/sec), median velocity and Poisson ratio profiles were computed which were then

smoothed to produce smooth generic profiles. At this point, as the number of available measured profiles falls off rapidly beyond about 100 ft, the smoothed profiles were extrapolated to the required depths using the shallower more well constrained portions as guides along with the remaining deep measured profiles. To achieve the desired $\overline{V_S}$ (30m), the closest measurement driven smooth generic shear-wave velocity profile was adjusted typically by the addition or subtraction of a constant factor. To generate a corresponding or companion smooth generic compressional-wave profile, the corresponding Poisson ratio was applied to the adjusted shear-wave profile. This process would typically not result in a smooth compressional-wave profile increasing with depth in a manner consistent with the companion shear-wave velocity profile. At this point the derived (from Poisson ratio) compressional-wave profile was adjusted followed by a computation of the corresponding Poisson ratio. This process was iterated upon to achieve both a smooth and realistic compressional-wave profile (e.g. generally mirroring the gradient in the shear-wave velocity profile) as well as a smooth and realistic Poisson ratio profile. Consistency in Poisson ratios between profile categories also provided a constraint such that the Poisson ratio profiles either decreased or remained the same with increasing category stiffness.

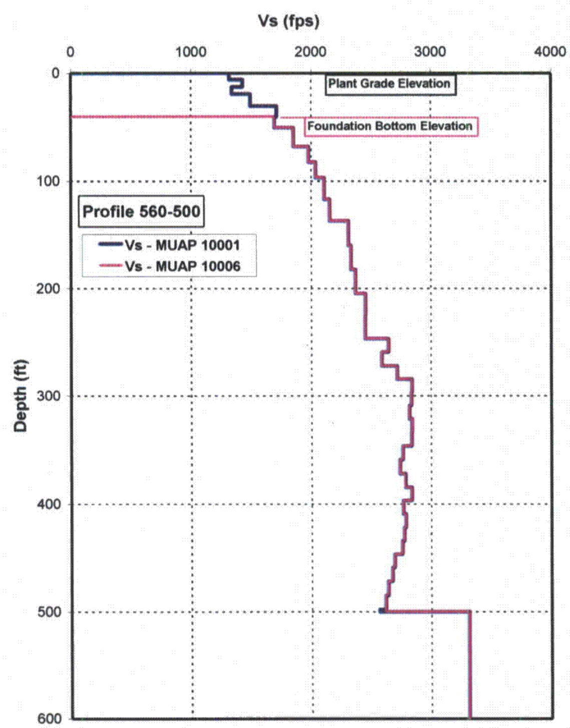
References:

Silva, W.J. (1997). "Characteristics of vertical strong ground motions for applications to engineering design." *Proc. Of theFHWA/NCEER Workshop on the Nat=l Representation of Seismic Ground Motion for New and Existing Highway Facilities,* I.M. Friedland, M.S Power and R. L. Mayes eds., Technical Report NCEER-97-0010.

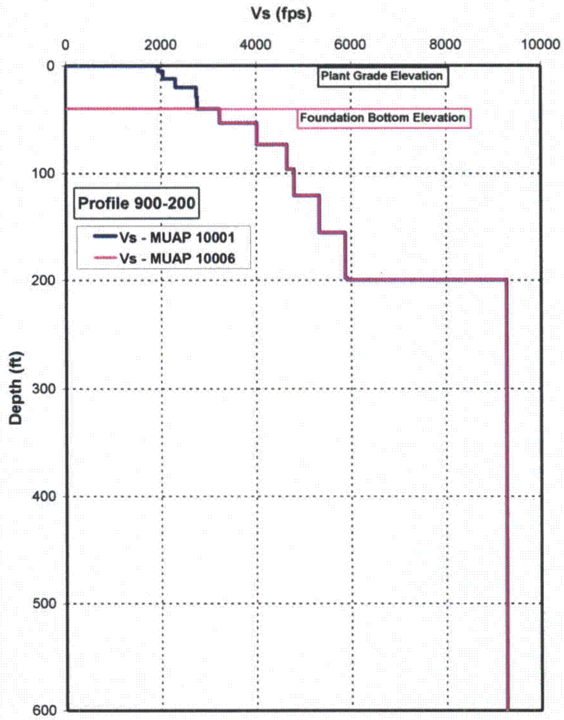
Silva, W. J.,S. Li, B. Darragh, and N. Gregor (1999). "Surface geology based strong motion amplification factors for the San Francisco Bay and Los Angeles Areas."A PEARL report to PG&E/CEC/Caltrans, Award No. SA2120-59652.

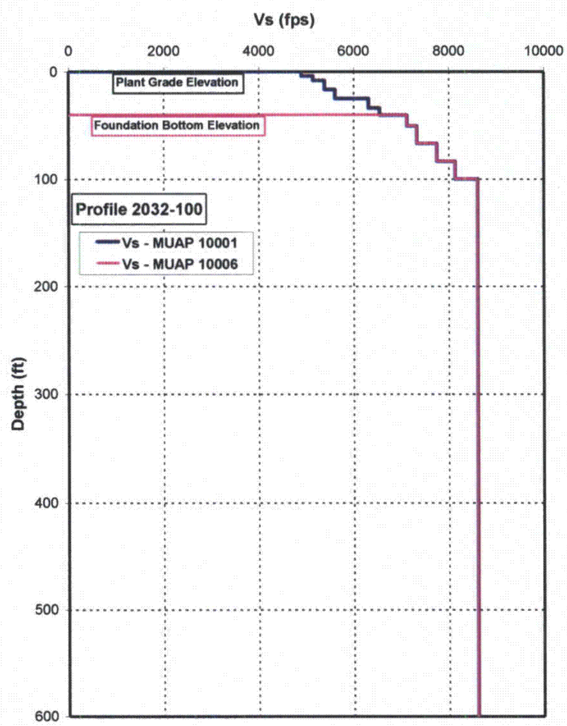


Vs (fps)
0
500
1000
1500
2000
2500
3000
3500
Plant Grade Elevation
Foundation Bottom Elevation
Profile 270-500
Vs - MUAP 10001
Vs - MUAP 10006
Depth (ft)
0
100
200
300
400
500
600



Vs (fps)
0
1000
2000
3000
4000
Plant Grade Elevation
Foundation Bottom Elevation
Profile 560-500
Vs - MUAP 10001
Vs - MUAP 10006
Depth (ft)
0
100
200
300
400
500
600


Vs (fps)
0
2000
4000
6000
8000
10000
0
100
200
300
400
500
600
Depth (ft)
Plant Grade Elevation
Foundation Bottom Elevation
Profile 900-200
Vs - MUAP 10001
Vs - MUAP 10006


Vs (fps)
0
2000
4000
6000
8000
10000
0
100
200
300
400
500
600
Depth (ft)
Plant Grade Elevation
Foundation Bottom Elevation
Profile 2032-100
Vs - MUAP 10001
Vs - MUAP 10006

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

12/28/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 659-5133 REVISION 2**
SRP SECTION:	**03.07.01 – Seismic Design Parameters**
APPLICATION SECTION:	**3.7.1**
DATE OF RAI ISSUE:	**11/15/10**

QUESTION NO. RAI 03.07.01-18:

This request for additional information (RAI) is necessary for the staff to determine if the application meets the requirements of 10 CFR Part 50, Appendix A, General Design Criteria 2; 10 CFR Part 50 Appendix S; and 10 CFR Part 100; as well as the guidance in NUREG-0800, 'Standard Review Plan for the Review of Safety Analysis for Nuclear Power Plants,' Chapter 3.7.1, "Seismic Design Parameters."

RG 1.61 provides acceptable damping values for computing in-structure response spectra (ISRS). However, Table 3-7 in MHI's Topical Report, MUAP-10006 (R0), indicates that SSE damping values are used in the ISRS computation.

In order to ensure that the seismic responses of plant-specific systems or subsystems are not under-predicted, the applicant should either add a COL Action Item that states that this issue must be satisfactorily addressed for the seismic analysis of plant-specific structures, or else provide a technical justification for not including this as a COL Action Item.

ANSWER:

RG 1.61 Section 1.2 states that:

> "In general, for certified standard plant designs where the design-basis in-structure response spectra represent the envelope of the in-structure responses obtained from multiple analyses conducted to consider a range of expected site soil conditions, it is not necessary for combined license applicants to address this issue. However, if plant-specific seismic analyses are conducted for Category I structures and/or structures not included as part of the standard plant design, then the applicant is expected to address this issue accordingly."

The soil-structure interaction analyses and results presented in MHI Technical Report MUAP-10006, including the ISRS generated using SSE damping values, are obtained using as input a set of generic layered profiles. The generic layered profiles, for which strain-compatible properties, shear- and compressional-wave velocities and corresponding hysteretic damping values are developed, provide a wide variation of properties that addresses ranges in dynamic soil properties expected at typical sites across central and eastern United States. The site soil conditions are described in detail in MHI Technical Report MUAP-10001. Use of SSE damping for the standard plant analyses documented in MUAP-10006 is considered to be acceptable based on the guidance given in RG 1.61 Section 1.2 and the above description of the generic layered profiles.

To prevent under-prediction of seismic responses, the DCD does contain a COL Action Item that requires this issue to be addressed on a plant-specific (i.e. site-specific) basis.

COL Item 3.7(4) states:

> To prevent non-conservative results, the COL Applicant is to review the resulting level of seismic response and determine appropriate damping values for the site-specific calculations of ISRS that serve as input for the seismic analysis of seismic category I and seismic category II subsystems.

Based on COL Item 3.7(4) in Tier 2 of the US-APWR DCD, MHI believes that provisions are already in place in the DCD to require that this issue be addressed by COL applicants.

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.
