REQUEST FOR ADDITIONAL INFORMATION 625-4924 REVISION 0

8/30/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.07.02 - Seismic System Analysis
Application Section: 3.7.2 (Technical Report MUAP 10001 rev 1)

QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)

03.07.02-11

RAI 3.7.2-38

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 3.7.2, 'Seismic Design Parameters

SRP Subsections 3.7.2.II.1 and 3.7.2.II.3 contain guidelines for determining if lumped mass models have sufficient degrees of freedom to properly capture the dynamic response of the structure of interest and if acceptable modeling procedures are employed. On the basis of the staff's review of the spectra comparisons shown in section 5.3.3.3, the staff disagrees with the conclusion in the first paragraph of Section 5.3.3.3 of MUAP-10001, Rev. 1 that the ARS for the PCCV models indicate that the stick model properly captures the structural response in all directions. Provide the acceptance criteria and technical bases are used to justify that the stick model properly captures the structural response in all directions.

Also, the staff understands that the ANSYS lumped mass model and the SASSI lumped mass model are effectively identical models being run in two different codes. If this is the case, provide the reason for the approximately 30% difference in response between the SASSI stick model and the ANSYS stick model at 11 Hz in Figure 5.3.3.3-9. If the models are different, describe the differences in the models.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-12

RAI 3.7.2-39

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 3.7.2, 'Seismic Design Parameters.
Based on the staff's review of stiffness comparison plots in section 5.3.4.1, the staff disagrees with the conclusion in the first paragraph of Section 5.3.4.1 of MUAP-10001, Rev. 1 that the comparisons of stiffness between the R/B stick model and the distributed mass are acceptable. Please explain the acceptance criteria and technical bases are used to justify this conclusion and how do the acceptance criteria meet the guidance provided in SRP 3.7.2.II.A.iv.

As an example, in Figure 5.3.4.1-5, the difference in stiffness is approximately 100% at an elevation of 25 ft. Explain the basis for which this difference is determined to be acceptable.

Also, explain why the upper elevation limits in Figures 5.3.4.1-1 through 5.3.4.1-8 vary from approximately 100 feet to approximately 155 feet.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-13

RAI 3.7.2-40

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 3.7.2, 'Seismic Design Parameters
SRP Subsections 3.7.2.II.1 and 3.7.2.II.3 contain guidelines for determining if lumped mass models have sufficient degrees of freedom to properly capture the dynamic response of the structure of interest and if acceptable modeling procedures are employed. Based on the staff's review of Figures 5.3.4.3-1 through 5.3.4.3—25, of MUAP-10001, Rev. 1, the staff disagrees with the conclusion in Section 5.3.4.3.that the lumped mass models of the R/B properly capture the structural response to dynamic loads in all directions because in numerous cases the ISRS from the stick models show significantly different responses in both frequency and magnitude compared to the distributed mass model. As an example, in Figure 5.3.4.3-1 the peak spectral acceleration at 6 Hz from the distributed mass model is 3.4*g*, while for the lumped mass stick model the peak acceleration is 1.9*g*, which is approximately 45% lower than the target. Similar discrepancies hold for other figures in this section. It is also evident from Figures 5.3.4.3-22 and 5.3.4.3-23 that the stick models respond to frequencies that that are not predicted by the distributed mass model.

Provide the acceptance criteria used to support the conclusion that the stick models are adequate to capture the structural response to dynamic loads in all directions and how do the acceptance criteria meet the guidelines of the SRP. The applicant should resolve

the differences in responses of the lumped mass and distributed mass models of the R/B and develop a lumped mass stick model that adequately captures and predicts distributed mass model seismic responses in both frequency and in magnitude.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-14

RAI 3.7.2-41

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 3.7.2, 'Seismic Design Parameters.
Based on the staff's review of comparisons of the stiffness between the CIS stick model and the distributed mass model, the staff disagrees with the conclusion in the first paragraph of Section 5.3.5.1 of MUAP-10001, Rev. 1 that the comparisons of stiffness between the CIS stick model and the distributed mass are acceptable. As an example, differences of stiffness of approximately 30% between the lumped mass model and the distributed mass model are shown in Figures 5.3.5.1-2 and 5.3.5.1-4.

Please explain the acceptance criteria and technical bases used to justify the conclusion that the comparisons of the CIS stick model stiffness and the distributed mass model are acceptable. Also explain how the acceptance criteria for the statement above meet the guidance provided in SRP 3.7.2.II.A.iv.

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Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-15

RAI 3.7.2-42

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 3.7.2, 'Seismic Design Parameters.

SRP Subsections 3.7.2.II.1 and 3.7.2.II.3 contain guidelines for determining if lumped mass models have sufficient degrees of freedom to properly capture the dynamic

response of the structure of interest and if acceptable modeling procedures are employed.

Table 5.3.5.2-1 of MUAP-10001, Rev. 1 shows the modal properties of the detailed distributed mass CIS finite element model in the N-S direction. The first three natural frequencies of the CIS in the N-S direction are shown as 6.2 Hz, 8 Hz, and 11.3 Hz. In Figure 5.3.5.2-1, the first two peaks in the transfer functions occur at approximately 5 Hz and 7.5 Hz. Specifically, the amplifications in the transfer functions at the frequencies in Table 5.3.5.2-1 are significantly lower than the peak amplifications.

Explain how MHI propose to resolve such discrepancies and account for the fact that the natural frequencies in the N-S direction as calculated from the detailed distributed mass model fall in “valleys” and not on the ‘peaks’ of the transfer functions from the lumped mass stick model. The applicant should resolve the differences in responses of the lumped mass and distributed mass models of the CIS and develop a lumped mass stick model that adequately captures and predicts distributed mass model seismic responses in both frequency and in magnitude.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-16

RAI 3.7.2-43

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 3.7.2, 'Seismic Design Parameters.
SRP Subsections 3.7.2.II.1 and 3.7.2.II.3 contain guidelines for determining if lumped mass models have sufficient degrees of freedom to properly capture the dynamic response of the structure of interest and if acceptable modeling procedures are employed.

Table 5.3.5.2-2 of MUAP-10001, Rev. 1 shows the modal properties of the detailed distributed mass CIS finite element model in the E-W direction. The first three natural frequencies of the CIS in the E-W direction are shown as 6.4 Hz, 7.6 Hz, and 11.7 Hz. In Figure 5.3.5.2-2, the first two peaks in the transfer functions occur at approximately 5.25 Hz and 7.5 Hz. Specifically, the amplification at 6.4 Hz in the transfer functions is significantly lower than the peak amplification at 5.25 Hz. Also, it appears that the third natural frequency at 11.7 Hz does not appear at all in the transfer functions shown in Figure 5.3.5.3-2.

Explain how MHI propose to resolve such discrepancies and account for the discrepancies in the dynamic response of the lumped mass stick model and the distributed mass model of the CIS in the E-W direction. The applicant should resolve the differences in responses of the lumped mass and distributed mass models of the CIS

and develop a lumped mass stick model that adequately captures and predicts distributed mass model seismic responses in both frequency and in magnitude.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-17

RAI 3.7.2-44

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 3.7.2, 'Seismic Design Parameters.

SRP Subsections 3.7.2.II.1 and 3.7.2.II.3 contain guidelines for determining if lumped mass models have sufficient degrees of freedom to properly capture the dynamic response of the structure of interest and if acceptable modeling procedures are employed.

Table 5.3.5.2-3 of MUAP-10001, Rev. 1 shows the modal properties of the detailed distributed mass CIS finite element model in the vertical direction. The first three natural frequencies of the CIS in the vertical direction are shown as 13.3 Hz, 17.2 Hz, and 19.7 Hz. In Figure 5.3.5.2-3, there is no indication that the first vertical frequency at 13.3 Hz is captured in the transfer functions.

Explain how MHI propose to resolve such discrepancies and account for the discrepancies in the dynamic response of the lumped mass stick model and the distributed mass model of the CIS in the vertical direction. The applicant should resolve the differences in responses of the vertical lumped mass and distributed mass models of the CIS and develop a lumped mass stick model that adequately captures and predicts distributed mass model seismic responses in both frequency and in magnitude.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-18

RAI 3.7.2-45

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 3.7.2, 'Seismic Design Parameters.
SRP Subsections 3.7.2.II.1 and 3.7.2.II.3 contain guidelines for determining if lumped mass models have sufficient degrees of freedom to properly capture the dynamic response of the structure of interest and if acceptable modeling procedures are employed. Based on Figures 5.3.5.3-1 through 5.3.5.3-12, of MUAP-10001, Rev. 1, the staff disagrees with the conclusion that the lumped mass models of the CIS properly capture the structural response to dynamic loads in all directions because in numerous cases the ISRS from the stick models show significantly different responses in both frequency and magnitude compared to the distributed mass model.

As an example, in Figure 5.3.5.3-3 the peak spectral acceleration at 16 Hz from the distributed mass model is 1.6*g*, while for the lumped mass stick model the peak acceleration is 0.82*g*, which is approximately 50% lower than the target. Similar discrepancies hold for other figures in this section. It is also evident from Figure 5.3.5.3-2 that the distributed mass model responds to frequencies that that are not predicted by the lumped mass model.

Provide the acceptance criteria used to support the conclusion that the stick models are adequate and how do the acceptance criteria meet the guidelines of the SRP. The applicant should resolve the differences in response from the lumped mass and distributed mass models of the CIS and propose a lumped mass stick model that adequately captures and predicts distributed mass model seismic responses in both frequency and in magnitude.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-19

RAI 3.7.2-46

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 3.7.2, 'Seismic Design Parameters.
SRP Subsections 3.7.2.II.1 and 3.7.2.II.3 contain guidelines for determining if lumped mass models have sufficient degrees of freedom to properly capture the dynamic response of the structure of interest and if acceptable modeling procedures are employed.

Figure 5.4.2-3 of MUAP-10001, Rev. 1 shows that the vertical displacement at the northwest corner of the PS/B stick model decreases between the 30 foot and 40 foot elevations. Explain the physical interpretation of this result with regards to the safety function of this structure.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-20

RAI 3.7.2-47

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 3.7.2, 'Seismic Design Parameters.
The staff, based on its review of MUAP-10001, Rev. 1 finds that the applicant has used inconsistent approaches, qualitatively and quantitatively to account for concrete cracking in the seismic models, as noted below.

1. On p. 3-3, is the third sentence in the second paragraph intended to mean that concrete cracking is accounted for by broadened ISRS.
2. On p. 3-3, it is stated that the stiffness of the CIS lumped mass stick model is reduced by 25% to account for concrete cracking resulting from thermal loads.
3. On p. 4-14, it is stated that the elastic modulus of selected slabs in the R/B reduced by 50% to simulate a cracked condition.
4. On p. 4-15, it is stated that the FH/A shear wall areas reduced by 50% for concrete cracking.
5. On p. 4-22, a factor of 0.5 is used for the reduction of flexural stiffness of shell elements in the PS/B lumped mass model.
6. On p. 4-23, it is stated that the stiffness of the lumped mass stick model of the CIS is reduced by 25% to address potential effects due to cracking of the SC modules.

Explain the overall methodology for addressing concrete cracking and explain how the qualitatively and quantitatively different methods of accounting for cracking that are given above result in a consistent approach for accounting for cracking.

Also, when the structural models are analyzed with assumed cracked section properties, the potential for load redistribution relative to the results from the models with uncracked section properties exists due to changes in modal frequencies and corresponding changes in input spectral acceleration. This redistribution has the potential for some sections that had acceptable demand-to-capacity ratios in the uncracked model to have unacceptable demand-to-capacity ratios in the cracked model. Describe how the models will be checked or modified to ensure that the final configuration of the model results in acceptable demand-to-capacity ratios at all sections.

The assumption of cracked or uncracked concrete member used in the final configuration of the cracked concrete seismic models should be validated by the final combined stresses in concrete members.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-21

RAI 3.7.2-48

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 3.7.2, 'Seismic Design Parameters.
Per SRP 3.7.1.II.3 Acceptance Criteria, the description of the Supporting Media for Seismic Category I structures must include the design groundwater elevation. On p. 4-6 of MUAP-10001, Rev. 1, it is stated that the DCD specifies a water table depth of 1 foot below the foundation. This is inconsistent with the information in Table 2.0-1 of DCD Rev. 2, Tier 2 (and also Table 2.1-1 of DCD Rev.2, Tier 1) that specifies the maximum groundwater as 1 foot below plant grade.

The common foundation of the R/B complex is located at a depth of 38'-10" from the plant grade. Clarify the upper elevation up to which saturated soil properties have been used in the seismic analysis and explain how the seismic analysis is consistent with the '1 foot below grade' statement in Tier 1 of the DCD.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-22

RAI 3.7.2-49

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 3.7.2, 'Seismic Design Parameters.

On p. 4-14 of MUAP-10001, Rev. 1, it is stated that the lumped mass stick model of the R/B complex includes SDOF oscillators for slabs and walls that contain out-of-plane frequencies below the cut-off frequency of 40 Hz. The 40 Hz cut-off frequency is in conflict with the guidance of ISG-01, which recommends that models be sufficiently refined to transmit frequencies up to 50 Hz.

Provide the technical basis for the lower cut-off frequency of 40 Hz and explain how the use of the lower cut-off frequency meets the intent of ISG-01 and how the response due

to the ground input spectrum (that is defined up to 50 Hz) are calculated beyond the cut-off frequency.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-23

RAI 3.7.2-50

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 3.7.2, 'Seismic Design Parameters.
The first sentence of Section 5.2.2 of MUAP-10001, Rev. 1 refers to the nine combinations of soil profile categories and depths to hard or soft rock material that are shown in Table 5.2-1. In that table, only eight combinations are shown. Explain why the combination of V_{s30}=100 m/sec, and depth to rock=100 feet is not shown in Table 5.2-1.

Clarify whether the soil profiles used in the SSI analysis are consistent with the nine combinations of soil profiles developed for the analysis, and also determine if the description and implementation of the Supporting Media for Seismic Category I Structures is acceptable per the guidelines of SRP 3.7.1.II.3.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073

03.07.02-24

RAI 3.7.2-51

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 3.7.2, 'Seismic Design Parameters.
According to SRP Subsection 3.7.2.II.1.a.iv, simple 1*g* static analyses of lumped mass stick models should be performed for each of the three excitation directions and compared to the results from the distributed mass model. Figures 5.3.3.1-1 and 5.3.3.1-2 of MUAP-10001, Rev. 1 show elevation vs. displacement results under 1*g* static loads for the vertical and horizontal (X) directions, but results are not shown for the Y-direction. Also, the caption for Figure 5.3.3.1-2 indicates that the horizontal displacements correspond to vertical loading rather than horizontal loading.

Clarify whether or not the horizontal displacement results in Figure 5.3.3.1-2 are actually due to vertical loading, or if they are from horizontal loading in the X-direction per the guidelines of SRP Subsection 3.7.2.II.1.a.iv. Also, provide the results from 1*g* static loading in the Y-direction per guidelines of SRP 3.7.2.

Reference: USAPWR Seismic Design Report MUAP-10001, rev 1; dated May 13,2010; ML101400073