

REQUEST FOR ADDITIONAL INFORMATION 660-5134 REVISION 2

11/15/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.07.02 - Seismic System Analysis

Application Section: 3.7.2

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

03.07.02-25

RAI 3.7.2-52

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 System Analysis."

According to the reference sections of MHI's Topical Reports, MUAP-10001 (R1) and MUAP-10006 (R0), the SSI analyses reported were performed using ACS SASSI Version 2.2. Version 2.2.1 of ACS SASSI is subject to a 10 CFR Part 21.21 report regarding numerical instabilities that may occur with high numbers of soil layers even though the properties and number of layers are within the parameters stated in the User's Manual. In order for the staff to complete the evaluation of the SSI analysis, the staff requests the applicant to provide additional information demonstrating that the SSI results are valid and meet the guidelines of SRP 3.7.2.II.4

03.07.02-26

RAI 3.7.2-53

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 System Analysis."

Several subgrade conditions are used for the SSI analyses described in MHI's Topical Reports, MUAP-10001 (R1) and MUAP-10006 (R0). However, the potential effect of structural fill (backfill) on SSI evaluation and the seismic response of the structures is not discussed.

The staff requests the applicant to provide a basis and technical justification for how the evaluation meets the guidelines of SRP 3.7.2.II.4 and how the potential effects of structural fill in the SSI analysis are considered.

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03.07.02-27

RAI 3.7.2-54

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 System Analysis."

Tables 3-3A through 3-3H of MHI's Topical Report, MUAP-10006 (R0), show depths to the top of the half-space layer that range from 72.3 feet (Table 3-3E) to 660 feet (Tables 3-3G and 3-3H). The staff requests that the applicant describe the criteria used for selecting the lower boundaries of the SSI models as shown in Tables 3-3A through 3-3H.

03.07.02-28

RAI 3.7.2-55

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 System Analysis."

Sections 3.6.1 and 3.6.2 of MHI's Topical Report, MUAP-10006 (R0), describe the procedures for calculating the equivalent seismic loads on the R/B complex and PS/B. The staff finds the descriptions to be unclear. In order for the staff to evaluate the SSE design loads used the design of the Seismic Category I R/B complex and the PS/B, the staff requests that the applicant provide the following information:

1. It appears that the procedures given in Section 3.6.1 and 3.6.2 for calculating equivalent static loads are different. Provide justification for using two different procedures for calculating design forces for Category I structures and explain how the two different procedures will lead to the same final seismic design forces. Provide a common and complete description for both procedures.
2. Provide a detailed description of how the loads F_{Hi} , F_{Vi} , and the moments M_{Ri} , and M_{Ti} from steps 2 through 5 in Section 3.6.1 are developed.
3. Provide a detailed description of exactly what demands are being combined by the "SRSS" method in steps 6 and 7 of Section 3.6.1.
4. Provide detailed descriptions and definitions of the forces and moments F_V , M_{NS} , M_{EW} , and M_T that appear in steps 8 and 9 of Section 3.6.1. In particular, provide clear definitions of the directions of the moment vectors.
5. Provide detailed examples showing the development of the equivalent seismic loads using the procedure(s) in Sections 3.6.1 and 3.6.2.

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03.07.02-29

RAI 3.7.2-56

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 System Analysis."

Tables 4-5, 4-6, and 4-7 of MHI's Topical Report, MUAP-10006 (R0), provide the SSE design loads that are used for the design of the PCCV, CIS, and R/B structural members, respectively. The origin of the acceleration values in these tables is unclear. In some cases (e.g. node CV07 in Table 4-5) the acceleration values appear to be the zero-period accelerations (ZPAs) from the appropriate ISRS in Appendices C, D, and E. In other cases (e.g. node CV11 of Table 4-5 or node IC15 of Table 4-6), this does not appear to be the case. To better understand the design loads that are being used for the design of the safety-related structures, the staff requests that the applicant provide a detailed description of how the quasi-static accelerations A_{NS} , A_{EW} , and A_V that appear in Tables 4-5, 4-6, and 4-7 are determined.

03.07.02-30

RAI 3.7.2-57

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 System Analysis."

Table 3-4 of MHI's Topical Report, MUAP-10006 (R0), provides maximum frequencies and cut-off frequencies used for the SSI analyses of the R/B and PS/B. The method for computing the maximum frequencies is unclear to the staff. To better understand the methodology, the staff requests the applicant to explain how the maximum frequencies for the R/B and PS/B were calculated and what they represent.

In addition, the applicant should provide justification for not incorporating models that support transmitting frequencies of up to 50 Hz value recommended by ISG-01.

RAIs 3.7.2-37 and 3.7.2-49

03.07.02-31

RAI 3.7.2-58

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

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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 System Analysis."

It is stated in Section 3.2 of MHI's Topical Report, MUAP-10006 (R0), that eight generic soil profiles were selected for SSI analysis. In contrast, the first sentence of Section 5.2.2 of MUAP-10001, (R1) refers to the nine combinations of soil profile categories and depths to hard or soft rock material. A comparison of the eight soil profiles listed in Section 3.5 of MUAP-10006 (R0) with the nine soil profiles listed in Table 5.2-2 of MUAP-10001 (R1) showed that the profile "270-100" in Table 5.2-2 is not included in the SSI evaluations presented in MUAP-10006 (R0). It is not clear to the staff why this soil profile was not used in the evaluations presented in MHI's Topical Report, MUAP-10006 (R0).

The staff requests that the applicant provide an explanation and justification for why the $V_{s30}=270$ m/sec, and depth to rock=100 feet (i.e. the "270-100") soil profile was not included in the SSI evaluations. The question is posed to determine if the soil profiles used in the SSI analysis are consistent with the profiles developed for the analysis, and thus 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.

RAI related to Question 3.7.2-50

03.07.02-32

RAI 3.7.2-59

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 System Analysis."

The second paragraph of Section 3.1 of MHI's Topical report, MUAP-10006 (R0), states that the maximum frequency of analysis is determined from the thickness of the soil layers in the model. The staff expects the applicant to define the maximum soil layer thickness so that maximum frequency of interest in the model could be properly transmitted. Also, the last sentence in Section 3.1 states that the analysis results were checked to ensure that the maximum frequency of analysis captures the critical seismic response.

The staff requests that the applicant clarify the criteria used for selecting the maximum frequencies of analysis, explain how these criteria meet the intent of ISG-01, and explain how the results were checked to ensure that the selected maximum frequencies capture the critical structural seismic responses.

RAIs relate to questions 3.7.2-37, 3.7.2-49, and 3.7.2-57.

03.07.02-33

RAI 3.7.2-60

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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 System Analysis."

In MHI's Topical Report, MUAP-10006 (R0), It appears from the relatively high values of Poisson's ratios in Tables 3-3A through 3-3G of MUAP-10006 (R0) that the soil profiles selected for the analyses represent saturated soils. To better understand the analysis presented in the tables, the staff request that the applicant describe the assumptions regarding ground water level that were used in developing the soil profiles used in the SSI analysis. Discuss the sensitivity studies performed to address the effect of variability of the ground water table (i.e., dry versus saturated soil) on the SSI analysis results. Also, the applicant should describe how the variability in pore water and the variability of ground water level with time affect the seismic response of the structures per SRP Section 3.7.2.1.4.

03.07.02-34

RAI 3.7.2-61

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 System Analysis."

In MHI's Topical Report, MUAP-10006 (R0), the last paragraph of Section 3.5 and also Table 3-13 indicate that the vertical in-structure response spectra (ISRS) for the three gas turbine generators (GTGs) and the GTG panels are developed by averaging the vertical response at two representative nodes within the GTG footprint area. This is in contrast to the other ISRS presented in Table 3-13 where the ISRS are developed as an envelope of representative nodal responses. The staff requests that the applicant provide the technical justification for using an averaging process instead of an enveloping process when developing the vertical ISRS for the GTGs and panels.

03.07.02-35

RAI 3.7.2-62

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 System Analysis."

Section 3.6.3 of MHI's Topical Report, MUAP-10006 (R0), presents the procedure for calculating the seismic dynamic earth pressures on the embedded walls of the R/B

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complex and the PS/Bs. The acceleration of 0.3g is specified for both the horizontal and vertical components of an earthquake in determining the seismic lateral pressure for the exterior walls of the basements. However, the quasi-static acceleration values of 0.55g (Table 4-7) and as high as 0.84g (Table 4-10) are shown at the base and below the ground surface for Category I structures. Provide a justification for not specifying these values in determining the seismic lateral pressure.

Also, the procedure includes a factor of 20% that represents an additional design margin to account for uncertainties in the embedment soil properties and the applied methodology.

The staff requests that the applicant provide the basis for selecting a 20% increase for the additional design margin to account for uncertainties in the embedment soil properties and the applied methodology. Provide relevant data or studies performed to support the technical position.

03.07.02-36

RAI 3.7.2-63

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 System Analysis."

MHI's Topical Report, MUAP-10006 (R0), contains numerous in-structure response spectra (ISRS), all of which are produced at 5% spectral damping. The ISRS at damping values of other than 5% are generally needed for the design of SSCs of the Standard Plant. Discuss the procedure and the basis for generating ISRS at damping values other than 5%.

03.07.02-37

RAI 3.7.2-64

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 System Analysis."

Appendix H of MHI's Topical Report, MUAP-10006 (R0) provides bubble plots of the maximum accelerations in the PS/Bs. However, the report does not describe how the bubble plots were created, what assumptions were made, or how the plots will be used. Because the bubble plots appear to represent the loads to which the PS/Bs will be designed, the staff is requesting that the applicant provide the following information to better evaluate the appropriateness of the design loads:

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1. A detailed description of how the bubble plots were created and what contributions are included in the resulting accelerations. Include a step-by-step example of how the bubble plots were created and will be used in the design.
2. Discuss whether the number of points in the bubble plots matches the number and location of nodes in the PS/B structural models. If the numbers and locations do not match, provide an explanation as to how bubble plot accelerations were determined at points where nodes do not exist in the structural model and also how nodal accelerations from the structural model may have been combined to create accelerations in the bubble plots.
3. Discuss if and how the accelerations in the bubble plots account for multi-modal behavior in the PS/Bs.
4. Provide the basis for not constructing and providing bubble plots for R/B and what effect it has on the design of the R/B complex.

03.07.02-38

RAI 3.7.2-65

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 System Analysis."

MHI's Topical Report, MUAP-08005 (R0), documents the SSI results of a coupled RCL-R/B-PCCV-CIS lumped mass stick model. That evaluation was based on four uniform soil conditions using a frequency-independent impedance function approach. In contrast, reports MUAP-10001 (R1) and MUAP-10006 (R0) document SASSI analyses of the R/B complex based on a different set of subgrade conditions. In order for the staff to understand and evaluate the basis of the seismic design of the R/B complex, the staff is requesting that the applicant state the role and relevance of MUAP-08005 (R0) in the context of MUAP-10001(R1) and MUAP-10006 (R0).

Is MUAP-08005 (R0) obsolete in light of MUAP-10001 and MUAP-10006? If the report is still relevant, identify specific portions and their relevance. Does MHI intend to revise MUAP-08005?

Similarly, the applicant should describe the role of MUAP-08002 in the context of MUAP-10001(R1) and MUAP-10006 (R0).

03.07.02-39

RAI 3.7.2-68

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 System Analysis."

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In support of the DCD, the applicant has provided various supporting Topical Reports and Appendices to the DCD. Appendix 3C to DCD Rev. 0 describes reactor coolant loop analysis methods, Appendix 3H to DCD Rev. 0 describes an uncoupled model of the R/B-PCCV-CIS, Appendix 3I contains ISRS from the uncoupled model described in Appendix 3H, MUAP-08002 (R0) provides results from lumped mass stick models of the PS/Bs, MUAP-08005 (R0) describes the seismic analysis of the coupled RCL-R/B-PCCV-CIS model, MUAP-10001 (R1) also describes models of the PS/Bs and a coupled model of the R/B complex, MUAP-10006 (R0) provides additional documentation of SSI results for the PS/Bs and R/B complex.

The staff also understands that new revisions of MUAP-10001 and MUAP-10006 are forthcoming along with reports documenting the seismic analysis of the T/B, A/B, and AC/B.

Because of the number of reports submitted and the evolutionary process of the documentation for the seismic analysis of the Standard Plant, the staff requests that the applicant clearly indicate the documentation strategy for the DCD and supporting topical reports. The applicant should state the role of the various appendices and reports that have been and are expected to be issued in support of the DCD. The applicant should indicate which appendices or reports, if any, are obsolete, which appendices or reports have superseded any obsolete appendices or reports, and which documents contain or will contain the final design values of record that will be used for the US-APWR Standard Plant. It will be helpful if the applicant provides a table showing the relationships between and the roles of the various appendices and reports.