REQUEST FOR ADDITIONAL INFORMATION 205-1584 REVISION 0

2/25/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components
Application Section: 3.9.2.2

QUESTIONS for Engineering Mechanics Branch 1 (AP1000/EPR Projects) (EMB1)

03.09.02-10

RAI 3.9.2-10

The applicant stated in Subsection 3.9.2.2.2 of the DCD that the stiffness of the seismic subsystem anchorage must be determined and the assumptions made in the analysis must be verified as accurately reflecting the mounting condition.

The DCD does not provide sufficient information to allow the review of the seismic subsystem analysis. The stiffness of the anchorage can affect natural frequencies of the subsystem significantly. The applicant is requested to provide a list of anchorage type, the method for determining their stiffness, the related assumptions, and the procedure for verification of the assumptions. The staff needs this information to ensure conformance with GDC-2. Revise the DCD to include the requested information.

03.09.02-11

RAI 3.9.2-11

In the Mitshubishi Heavy Industries, Ltd. (MHI) technical report MUAP-08005 the applicant described the development of the coupled model, modeling method and assumptions, the analysis approach, and analysis results such as frequencies and mode shapes of dominant modes, acceleration and displacement responses of the structure, and in-structure response spectra (ISRS). The applicant stated in Sections 3.3 and 6.3 of the technical report that the lumped mass model considers a rigid base mat resting on the surface of a uniform elastic-half-space. Six sets of two parameters, one for stiffness and the other for damping, are developed in accordance with Subsection 3.3.4.2 of American Society of Civil Engineers (ASCE) 4-98 to represent the properties of the SSI in each of the six degrees of freedom (DOF). The values of the SSI soil damping in the two horizontal directions are conservatively set at 60% of the theoretical dash pot values based on ASCE 4-98. The MHI technical report does not address any reduction of the theoretical dashpot value in the vertical direction. Furthermore, Section 3.7.1 of the SRP states that the maximum soil damping value acceptable to staff is 15%.

The staff's review of the technical report MUAP-08005 indicated that the report did not address whether the soil damping in all three directions used in the coupled SSI seismic analysis is consistent with the maximum soil damping value of 15% in Section 3.7.1 of the SRP. The soil damping greatly affects the ISRS for subsystem seismic analysis. The applicant is requested to confirm that the soil damping values in all three directions used in the coupled soil-structure interaction (SSI) seismic analysis are consistent with the 15% damping value limit of SRP Section 3.7.1. The staff needs this information to ensure conformance with GDC-2.

03.09.02-12

RAI 3.9.2-12

The applicant stated in Section 4.1 of the MHI technical report MUAP-08005 that both the reactor building (R/B) Complex and reactor coolant loop (RCL) are represented by an adequate number of DOF to represent significant modes in the range of frequencies up to 50 Hz.

The staff reviewed the MHI technical report MUAP-08005 and found that the report does not include sufficient information to allow the review of the coupled lumped mass models. Future sites in eastern US could experience high-frequency seismic loading. The applicant is requested to provide additional information to justify that the coupled lumped mass models are detailed enough, i.e., have sufficient dynamic degree of freedom, to amplify high frequency inputs to as high as 50 Hz. The staff needs this information to ensure conformance with GDC-2.

03.09.02-13

RAI 3.9.2-13

The applicant stated in Section 6.2 of the MHI technical report MUAP-08005 that for RCL analysis, the four loops of the RCL are modeled as combination of reactor vessel, steam generator (SG), RCP, and main coolant piping (MCP). These combined system models include both the translational and rotational stiffness, mass characteristics of the RCL piping and components, and the stiffness of supports. The stiffness and mass effects of auxiliary line piping are considered when they affect the system.

The staff’s review indicates that the MHI technical report does not address the location of snubber support and modeling of the snubber stiffness. The applicant is requested to provide additional information whether the location of snubber support and the snubber stiffness are addressed in the RCL analysis model. The staff needs this information to ensure conformance with GDC-2.

03.09.02-14

RAI 3.9.2-14

The applicant described in the MHI technical report MUAP-08005 the coupled lumped mass stick model, modeling method and assumptions, and the analysis approach and results. Section 3.7.2 of the SRP states that in developing a lumped mass model it is necessary to consider the local regions of the structures, such as individual slabs or walls. They may have fundamental vibration modes that can be excited by the seismic loading.

The DCD Tier 2, Section 3.7.2, or the technical report MUAP-08005 do not give a detailed description of the method for addressing wall and floor flexibility. The applicant is requested to provide additional information regarding the method for addressing wall and floor flexibility to ensure that the additional amplification due to local vibration is included in the generation of floor response spectra for the subsystem seismic analysis. The staff needs this information to ensure conformance with GDC-2.

03.09.02-15

RAI 3.9.2-15

In DCD Tier 2, Subsection 3.7.2.9, the applicant stated that to account for variations in the structural frequencies due to the uncertainty in parameters, such as material and mass properties of the structures, damping values, and soil properties, SSI analysis techniques, and the seismic modeling methods, the computed ISRS are smoothed by filling valleys between peaks. In addition, the applicant stated in Subsection 3.7.3.1.5 of the DCD that the ISRS were developed by filling-in the valleys between “all” peaks. Because the design ISRS is developed by enveloping the ISRS of the four types of soil sites with shear wave velocity of 304.8, 1066.8, 1981.2, and 2438.4 m/s (1000, 3500, 6500 and 8000 ft/s), filling the valleys between the peaks could take into consideration these soil sites with shear wave velocity between the four sites.

The staff reviewed Sections 3.7.2 and 3.7.3 of the DCD and the MHI technical report MUAP-08005, and found that in Fig. 3.7.2-12 of the DCD the smoothed ISRS still shows valleys between peaks. Also, the ISRS in the MHI technical report MUAP-08005 show many valleys between peaks; examples include: Fig. 8.1, sheets 1- 4, 15-20, and 27-30, Fig. 8.2, sheets 1-4, 12-20, 24-26, and 29-31, and Fig. 8.3, sheets 21-23, and 31-32. It is not clear under what circumstances the ISRS are smoothed. The applicant is requested to provide (a) the criteria by which the computed ISRS are smoothed by filling the valleys between peaks, (b) a clarification whether all valleys are filled or just some of the valleys, and (c) explain why in the examples of ISRS given below, the valleys have not been filled. The staff needs this information to ensure conformance with GDC-2. Revise the DCD to include the requested information

03.09.02-16

RAI 3.9.2-16

In DCD Tier 2, Subsection 3.7.2.4, the applicant stated that four types of soil site are considered in the lumped mass soil-structure interaction analysis. The four type soil sites are soft soil site, medium rock site 1 and 2, and hard rock site. The shear wave velocity, Vs, of these four sites is 304.8, 1066.8, 1981.2, and 2438.4 m/s (1000, 3500, 6500 and 8000 ft/s), respectively. The applicant further stated that the hard rock site is treated as fixed base in the SSI analysis model.

The staff reviewed relevant sections of the DCD and found that the applicant did not provide sufficient information regarding SSI effects in the seismic analysis of seismic Category I equipment and components. The applicant is requested to provide the ISRS generated by using shear wave velocity Vs=2438.4 m/s (8000 ft/s) in some important locations to demonstrate that the difference between the ISRS obtained using Vs=2438.4 m/s and the fixed base case has negligible impact on the supported subsystems. The staff needs this information to ensure conformance with GDC-2.

03.09.02-17

RAI 3.9.2-17

The applicant stated that for piping analysis, the three sets of mutually orthogonal components of earthquake motion are combined in accordance with RG 1.92, Rev.1, by the SRSS method; details are discussed in DCD Subsection 3.12.3.2. In Subsection 3.12.3.2.6 of the DCD the applicant stated that where supports are located within different structures, the seismic motions at these locations are assumed to move 180 degree out-of-phase (i.e., the most unfavorable condition) in the analysis. Where supports are located within a single structure, the seismic motions are considered to be in-phase and the relative displacement between the support locations is considered in the analysis. Section 3.7.3 of the SRP states that support displacements are imposed on the supported item in the most unfavorable combination for item supported by either a single structure or two separate structures.

The staff reviewed relevant sections of the DCD and found that the applicant's assumption of in-phase motion for item supported in a single structure might not be conservative. Out-of-phase vertical motion could exist due to their frequency difference and local vibration. Also, out-of-phase horizontal motion could occur also to walls due to their local flexibility. The applicant is requested to provide additional information to justify the assumption of in-phase motion for items supported in a single structure. The staff needs this information to ensure conformance with GDC-2.

03.09.02-18

RAI 3.9.2-18

In DCD Tier 2, Subsection 3.12.3.2.3, the applicant stated that piping systems supported by structures located at multiple elevations within one or more buildings maybe analyzed using uniform support motion (USM). This analysis method applies a single set of spectra at all support locations, which envelops all of the individual response spectra for these locations. The enveloped response spectrum is developed and applied in the two mutually perpendicular horizontal directions and the vertical direction. Floor response spectrum curves used for USM may be generated using damping values identified in Table 3 or the frequency-dependent damping values of Fig. 1 from RG 1.61, Rev. 1. The applicant stated in DCD Section 3.12.5.1 that if any piping is laid out in the yard, the COL Applicant is to generate site-specific seismic response spectra, which can be used for the design of these piping systems or portions of piping system.

However, the applicant does not provide sufficient details in the DCD regarding the seismic analysis methods. Also, the exact definition of “portions of the piping” is not clear. The applicant is requested to provide the seismic analysis methods (including support displacements) for a piping that is partly laid out in the yard and partly supported by a building, equipment, or components. The staff needs this information to ensure conformance with GDC-2.