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TOKYO, JAPAN

November 16, 2011

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-11392

Subject: MHI's Amended Responses to US-APWR DCD RAI No.766-5819 (03.07.02) and 767-5821(SRP 03.08.04)

Reference: 1) "Request for Additional Information No. 766-5819 Revision 3 SRP Section: 03.07.02 – SEISMIC SYSTEM ANALYSIS,
2) "Request for Additional Information No. 767-5821 Revision 3 SRP Section: 03.08.04 – OTHER SEISMIC CATEGORY I STRUCTURES" dated June 9, 2011.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Amended Responses to Request for Additional Information No. 766-5819 Revision 3" and "Amended Responses to Request for Additional Information No. 767-5821 Revision 3".

Enclosed is the response to 9 RAIs contained within Reference 1 and 2.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittals. His contact information is below.

Sincerely,

Atsushi Kumaki for

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

Enclosure:

1. Amended Responses to Request for Additional Information No. 766-5819 Revision 3
2. Amended Responses to Request for Additional Information No. 767-5821 Revision 3

D081
NRO

CC: J. A. Ciocco
C. K. Paulson

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Docket No. 52-021
MHI Ref: UAP-HF-11392

Enclosure 1

UAP-HF-11392
Docket Number 52-021

Amended Responses to Request for Additional Information
No. 766-5819 Revision 3

November 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 766-5819 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-40:

In MUAP-11002 (R0), Section 1.0 "Introduction" (page 7) the second paragraph states that "Also presented in this report are stress ratios for select T/B and Electrical Room steel members estimated using GT STRUDL and ACS SASSI based on the fixed-base condition, and results of a sliding and overturning analysis of the T/B and Electrical Room." Further, in Section 2 of MUAP-11002 (R0), the second paragraph (page 9), the Applicant states that "This report provides allowable stress ratios for select T/B and Electrical Room steel members calculated using GT STRUDL and ACS SASSI based on the fixed base condition."
The design of the steel structure is based on a fixed base condition for the T/B building. The report does not contain any specific numerical data to demonstrate that ignoring SSI effects results in conservative stress ratios. The Applicant is requested to state whether the SSI seismic analysis is based on the preliminary or the final design of the Turbine building structures and provide technical justification and supporting analysis to show that the fixed base analysis is conservative for determining stresses in the steel structures. Also, the Applicant is requested to provide the criteria used in selecting critical steel members in checking the stress ratios.
In addition, the Applicant is requested to clarify what is meant by the term "allowable" in stating "allowable yield stress" for the structural steel material, ASTM A992/ASTM 572, Grade 50, cited in the first paragraph of Subsection 7.2 of MUAP-11002 (R0) (page 25).

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

The SSI seismic analysis discussed in the Turbine Building Model Properties, SSI Analyses, and Structural Integrity Evaluation document MUAP-11002 (R0) is based on a final Turbine Building (T/B) roof height of 193 feet 1 inch. This higher roof elevation differs from the DCD. The rationale for using the 193 feet 1 inch elevation was presented in MUAP-11002 (R0), Reference 13 (Page 93 of 94). The T/B model referenced in MUAP-11002 (R1) reflects the revised roof height in the DCD, Revision 3 of 169 feet 10 inches.

In MUAP-11002 (R0), steel member stress ratio values for members in the T/B and Electrical Room (E/R) are provided in Table 03.07.02-40a, shown below. These stress ratio values were calculated using a 1% representative sampling of all 5,682 analysis members included in the T/B and E/R GTSTRUDL models. 57 of the 5,232 T/B members and 6 of the 450 E/R members were selected for a combined total of sixty three (63) structural members. These selected members included columns, operating floor beams, roof beams, horizontal bracing and vertical bracing and were selected based on their location in the building under the presumption they would be critical members and experience stresses close to their allowable capacities. The select members are located at the ends and middle column rows as well as all top and bottom corners of the T/B to capture and compare the dynamic performance of the T/B as a whole. Equivalent member identification numbers from the GTSTRUDL and ACS SASSI models are listed in the attached Table 03.07.03-40a.

Steel member stress ratio values shown in Table 03.07.02-40a were determined by:

1. GTSTRUDL models for the T/B and E/R structures were used to determine the controlling design load combination for each select member based on all load combinations inclusive of seismic forces. These seismic forces were previously determined using the GTSTRUDL models by performing a direct integration time history analysis for a Safe-Shutdown Earthquake (SSE) ground motion resulting in pseudo-static loads. Additional analyses determined these direct integration time history analysis results to be conservative against results obtained from a mode superposition time history seismic analysis. The pseudo-static seismic loads are the maximum values of the forces generated from the dynamic time history analysis. Design load combinations inclusive of seismic forces incorporated "+1" and "-1" load factors to ensure maximum effects from seismic forces were evaluated and included in the design and in determining the governing load combination used in comparing results from GTSTRUDL and ACS SASSI.
2. Member stress ratios listed in the GTSTRUDL column of the attached Table 03.07.02-40a were determined from GTSTRUDL output and based on the controlling design load combination for each select member.
3. Member end forces and moments for the 63 members for all eight of the SSI soil profiles were then extracted from ACS SASSI output. These forces and moments for all eight soil profiles are only due to seismic loading.
4. Member end forces and moments for the 63 members were then extracted from GTSTRUDL output for each controlling design load combination. These forces and moments were used to determine actual and allowable member stresses in a separate calculation to verify the GTSTRUDL stress ratios.
5. Seismic forces and moments from ACS SASSI (step 3) were used in lieu of the GTSTRUDL seismic forces and substituted back into the controlling load combination for each of the members. The separate calculation was used to determine member stress ratios for the 63 select members and for all eight of the SSI soil profiles. The stress ratios for all eight SSI soil profiles and the maximum stress ratio for each select member are listed under the ACS SASSI columns in the attached Table 03.07.02-40a.
6. The seismic member end forces and moments determined using GTSTRUDL and ACS SASSI for the steel member stress ratio comparison included positive and negative values for each member end. Positive values determined using GTSTRUDL for a specific member end were compared with positive values determined from ACS SASSI for the same end. This process was consistently followed for negative values from GTSTRUDL and ACS SASSI results.

It can be seen from the maximum member stress ratios using GTSTRUDL and ACS SASSI output and those based only from GTSTRUDL output in Table 03.07.02-40a that all stress ratios are less than 1.0 which satisfies the requirements of AISC N690-1994 (R2004).

A similar comparison will be performed for a report for audit committed by the letter UAP-HF-11319 dated September 22, 2011, using the six steps shown above and the revised T/B roof height in the DCD, Revision 3 of 169 feet 10 inches. However, for this report the member stress ratios will be calculated for all members using the SSI results from the six soil profiles shown in MUAP-11002 (R1). The site-specific design of the T/B and E/R will consider any effects from the site-specific SASSI analysis.

The "allowable yield stress" could also be read as "specified minimum yield stress." ASTM A992 is the preferred material specification for wide-flange shapes in the superstructure which allows a minimum yield stress of 50 kips per square inch and a specified minimum tensile strength of 65 kips per square inch. ASTM A572 is the material specification used in the design of built-up plate members which allows a specified minimum yield stress of 50 kips per square inch for plates up to 4 inches thick and 42 kips per square inch for plates up to 6 inches thick. The use of these specifications conforms to the requirements of AISC N690-1994 (R2004).

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

Table 03.07.02-40a, Select Steel Member Stress Ratios											
ACS SASSI Group - Member Number	GT STRUDL Member Number	Member Stress Ratio[1]									Controlling Profile[2]
		ACS SASSI								GT STRUDL	
		Profile 270 - 200	Profile 270 - 500	Profile 560 - 100	Profile 560 - 200	Profile 560 - 500	Profile 900 - 100	Profile 900 - 200	Profile 2032 - 100	Maximum		
1 - 39	C3015Aa	0.60	0.56	0.62	0.60	0.61	0.65	0.64	0.66	0.66	0.67	2032 - 100
1 - 41	C3015Ac	0.33	0.32	0.34	0.33	0.33	0.34	0.34	0.35	0.35	0.38	2032 - 100
2 - 54	V9805051	0.23	0.22	0.23	0.22	0.22	0.23	0.23	0.23	0.23	0.29	2032 - 100
2 - 55	V9805052	0.29	0.28	0.28	0.29	0.28	0.28	0.28	0.29	0.29	0.35	270 - 200
1 - 120	C6015Aa	0.76	0.76	0.78	0.78	0.77	0.75	0.76	0.73	0.78	0.76	560 - 100
1 - 130	C6015Da	0.54	0.53	0.55	0.54	0.53	0.52	0.52	0.51	0.55	0.54	560 - 100
1 - 142	C7015Da	0.71	0.68	0.73	0.71	0.71	0.72	0.72	0.70	0.73	0.70	560 - 100
1 - 144	C8015Aa	0.62	0.59	0.63	0.62	0.64	0.68	0.68	0.67	0.68	0.75	900 - 200
1 - 154	C8015Da	0.81	0.78	0.80	0.81	0.80	0.80	0.80	0.80	0.81	0.92	270 - 200
1 - 162	D501501a	0.59	0.59	0.63	0.62	0.61	0.60	0.61	0.59	0.63	0.56	560 - 100
1 - 163	D501501b	0.59	0.59	0.64	0.62	0.61	0.61	0.61	0.60	0.64	0.54	560 - 100
1 - 170	C3020Aa	0.77	0.76	0.78	0.77	0.77	0.77	0.78	0.77	0.78	0.87	900 - 200
1 - 205	C8020Aa	0.53	0.52	0.54	0.53	0.54	0.54	0.54	0.53	0.54	0.67	560 - 100
1 - 234	V9301503	0.54	0.50	0.54	0.53	0.54	0.55	0.55	0.54	0.55	0.70	900 - 200
1 - 254	F501501d	0.32	0.32	0.32	0.32	0.32	0.33	0.32	0.30	0.33	0.30	900 - 100
1 - 261	F601501d	0.34	0.33	0.33	0.33	0.33	0.34	0.34	0.33	0.34	0.33	900 - 100
1 - 320	D302501	0.56	0.52	0.61	0.57	0.59	0.61	0.62	0.61	0.62	0.71	900 - 200
1 - 372	V9701513	0.44	0.41	0.44	0.43	0.44	0.44	0.44	0.44	0.44	0.50	900 - 100
1 - 373	V9701514	0.40	0.37	0.41	0.40	0.41	0.42	0.42	0.41	0.42	0.43	900 - 100
1 - 480	C4035Da	0.51	0.48	0.51	0.51	0.50	0.50	0.50	0.49	0.51	0.63	270 - 200
1 - 481	C4035Db	0.45	0.43	0.45	0.45	0.44	0.45	0.44	0.43	0.45	0.55	270 - 200

Table 03.07.02-40a, Select Steel Member Stress Ratios											
ACS SASSI Group - Member Number	GT STRUDL Member Number	Member Stress Ratio[1]									Controlling Profile[2]
		ACS SASSI								GT STRUDL	
		Profile 270 - 200	Profile 270 - 500	Profile 560 - 100	Profile 560 - 200	Profile 560 - 500	Profile 900 - 100	Profile 900 - 200	Profile 2032 - 100	Maximum		
1 - 502	C8035Da	0.64	0.61	0.61	0.62	0.57	0.57	0.57	0.56	0.64	0.64	270 - 200
1 - 506	D303501a	0.71	0.68	0.72	0.70	0.70	0.72	0.72	0.72	0.72	0.73	900 - 200
1 - 594	D704001a	0.53	0.51	0.52	0.52	0.51	0.48	0.48	0.47	0.53	0.57	270 - 200
2 - 690	D8401501	0.74	0.69	0.79	0.74	0.78	0.86	0.86	0.85	0.86	0.46	900 - 200
2 - 694	D8302501	0.81	0.81	0.81	0.80	0.81	0.83	0.83	0.82	0.83	0.49	900 - 200
2 - 698	D8303501	0.75	0.71	0.73	0.74	0.73	0.74	0.74	0.72	0.75	0.76	270 - 200
1 - 743	C8050Da	0.43	0.41	0.43	0.42	0.41	0.41	0.41	0.41	0.43	0.59	270 - 200
1 - 744	C8050Db	0.40	0.38	0.40	0.39	0.39	0.38	0.38	0.38	0.40	0.54	270 - 200
1 - 746	D305001	0.38	0.37	0.39	0.38	0.38	0.36	0.36	0.35	0.39	0.21	560 - 100
1 - 809	C3055C	0.53	0.50	0.54	0.53	0.52	0.51	0.51	0.51	0.54	0.60	560 - 100
1 - 910	C3060C	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.22	270 - 200
1 - 931	C5060Da	0.57	0.56	0.60	0.61	0.59	0.59	0.59	0.57	0.61	0.62	560 - 200
1 - 932	C5060Db	0.54	0.53	0.56	0.56	0.55	0.55	0.55	0.53	0.56	0.58	560 - 100
1 - 933	C6060Aa	0.47	0.47	0.48	0.47	0.46	0.45	0.45	0.45	0.48	0.48	560 - 100
1 - 956	C8060Aa	0.38	0.37	0.38	0.38	0.37	0.38	0.38	0.39	0.39	0.55	2032 - 100
1 - 1020	V9406011	0.24	0.24	0.24	0.23	0.23	0.22	0.22	0.22	0.24	0.29	270 - 500
1 - 1021	V9406012	0.25	0.25	0.25	0.25	0.25	0.23	0.23	0.23	0.25	0.35	270 - 200
1 - 1038	D556001a	0.69	0.71	0.74	0.71	0.77	0.69	0.69	0.67	0.77	0.83	560 - 500
1 - 1039	D556001b	0.69	0.71	0.74	0.71	0.71	0.69	0.69	0.67	0.74	0.81	560 - 100
1 - 1045	F556001d	0.32	0.31	0.32	0.31	0.32	0.37	0.37	0.32	0.37	0.30	900 - 100
1 - 1102	D303551c	0.69	0.68	0.71	0.69	0.69	0.70	0.71	0.69	0.71	0.54	560 - 100

Table 03.07.02-40a, Select Steel Member Stress Ratios												
ACS SASSI Group - Member Number	GT STRUDL Member Number	Member Stress Ratio[1]										Controlling Profile[2]
		ACS SASSI									GT STRUDL	
		Profile 270 - 200	Profile 270 - 500	Profile 560 - 100	Profile 560 - 200	Profile 560 - 500	Profile 900 - 100	Profile 900 - 200	Profile 2032 - 100	Maximum		
1 - 1234	V9305554	0.35	0.33	0.35	0.35	0.34	0.35	0.35	0.34	0.35	0.85	560 - 100
1 - 1235	V9306054	0.36	0.35	0.36	0.35	0.35	0.35	0.35	0.33	0.36	0.78	270 - 200
1 - 1354	D404051c	0.88	0.88	0.94	0.89	0.90	0.93	0.94	0.91	0.94	0.84	560 - 100
2 - 1704	V9302059	0.69	0.67	0.68	0.68	0.68	0.67	0.68	0.68	0.69	0.77	270 - 200
2 - 1705	V9302060	0.70	0.67	0.68	0.68	0.68	0.67	0.68	0.66	0.70	0.75	270 - 200
2 - 1718	V9802063	0.63	0.61	0.63	0.63	0.63	0.64	0.63	0.64	0.64	0.72	2032 - 100
2 - 1719	V9802064	0.49	0.47	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.57	2032 - 100
2 - 1733	V9556007	0.51	0.49	0.52	0.51	0.51	0.51	0.51	0.49	0.52	0.56	560 - 100
2 - 1734	V9556008	0.59	0.58	0.59	0.58	0.59	0.61	0.61	0.59	0.61	0.66	900 - 200
2 - 1736	V9301507	0.33	0.32	0.33	0.33	0.33	0.34	0.34	0.35	0.35	0.43	2032 - 100
2 - 1737	V9301508	0.27	0.25	0.28	0.27	0.28	0.29	0.29	0.30	0.30	0.38	2032 - 100
2 - 1738	V9401514	0.46	0.42	0.48	0.46	0.47	0.50	0.50	0.50	0.50	0.51	900 - 200
1 - 1818	D704051c	0.90	0.89	0.88	0.87	0.86	0.86	0.86	0.84	0.90	0.83	270 - 200
1 - 1915	F803551a	0.37	0.35	0.36	0.35	0.36	0.32	0.32	0.32	0.37	0.35	270 - 200
1 - 1955	D803551c	0.79	0.77	0.89	0.87	0.86	0.84	0.84	0.82	0.89	0.81	560 - 100
2 - 3318	C2015Aa	0.77	0.77	0.80	0.80	0.80	0.77	0.78	0.66	0.80	0.74	560 - 500
2 - 3446	C1035b	0.28	0.28	0.28	0.27	0.27	0.26	0.26	0.24	0.28	0.25	270 - 200
2 - 3518	R102001e	0.63	0.64	0.72	0.67	0.66	0.57	0.58	0.53	0.72	0.52	560 - 100
2 - 3538	R101501e	0.76	0.77	0.84	0.79	0.77	0.68	0.69	0.61	0.84	0.63	560 - 100
2 - 3614	R8102502	0.20	0.19	0.20	0.19	0.19	0.20	0.18	0.15	0.20	0.19	560 - 100
2 - 3647	V9103506	0.84	0.84	0.82	0.84	0.80	0.71	0.71	0.68	0.84	0.81	270 - 500

Table 03.07.02-40a, Select Steel Member Stress Ratios												
ACS SASSI Group - Member Number	GT STRUDL Member Number	Member Stress Ratio[1]										Controlling Profile[2]
		ACS SASSI									GT STRUDL	
		Profile 270 - 200	Profile 270 - 500	Profile 560 - 100	Profile 560 - 200	Profile 560 - 500	Profile 900 - 100	Profile 900 - 200	Profile 2032 - 100	Maximum		

Notes:
[1] Member Stress Ratio = Calculated Stress/Allowable Stress.
[2] Controlling profile is the subsurface profile which generates the maximum member stress ratio among the eight generic layered subsurface profiles.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 766-5819 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-44:

In MUAP-11002 (R0) Subsection 5.1, "Soil-Structure Interaction Analysis Methodology," the 4th bullet in the second paragraph states that "The superstructure and coarse mesh substructure models for the T/B and Electrical Room were combined in GT STRUDL and then was translated to ACS SASSI for the SSI analyses."
The SRP Acceptance Criteria II.3.C.ii of SRP 3.7.2 states, in part, that "The element mesh size should be selected on the basis that further refinement has only a negligible effect on the solution results." MUAP-11002 (R0) does not include any data that shows that the selection of the element mesh size meets this SRP criterion. Thus, the applicant is requested to provide information that shows that the choice of the element size has been evaluated and meets the criterion in SRP 3.7.2.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

The mesh size validation is reevaluated in MUAP-11002 (R1) Section 3 to show that compliance with the requirements of NUREG-0800 Standard Review Plan 3.7.2, Subsection 3.7.2.II is achieved. The mesh size validation consists of the following:

- A 1g static analysis to compare the structural weight, the mass properties, and the stiffness of the structures between the fine and coarse mesh models.
- Modal analysis to compare the dominant natural frequencies and mass participation factors of the structures between the fine and coarse mesh models.
- Mode superposition transient dynamic analysis to investigate the displacement response for various nodes of the structures between the fine and coarse mesh models.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 766-5819 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-46:

In MUAP-11002 (R0), Subsection 5.2.1 "Subsurface Profile/Properties," the first paragraph (page 15) states that "Subsurface profiles 270-200 and 2032-100 were selected for this SSI analysis because they are the softest and stiffest subsurface profiles of the eight, respectively. Therefore, generic layered subsurface profiles 270-200 and 2032-100 represent the extremes in properties of subsurface materials for typical sites within the continental United States..."
The staff disagrees with the applicant's use of only two soil profiles out of the eight soil profiles that were used in the SSI analyses in MHI's Technical Report MUAP-10001 (R2). In the applicant's technical report, MUAP-11001 (R0), "Auxiliary Building Model Properties, SSI Analyses, and Structural Integrity Evaluation for the US-APWR Standard Plant," the results indicate that the maximum response of the structure may be controlled by other subsurface profiles (see Subsection 4.2 of MUAP-11001, "Results of Lumped Mass Stick Model SSI Analyses.") The applicant is requested to demonstrate that the two profiles selected result in a conservative design of the T/B.

ANSWER:

This answer revises the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

The complete results for all six subsurface profiles (from TR MUAP-10001 R4) are included in Section 4.3.3 of TR MUAP-11002 (R1).__

Impact on DCD

There is no impact on the DCD

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-50:

In MUAP-11002 (R0) Subsection 4.4, "Turbine Pedestal," (page 13) it states "The turbine pedestal is a non-safety, non-seismic, reinforced concrete structure and is located in the center of the T/B. The turbine pedestal is structurally independent of the T/B superstructure and foundation. For the purpose of evaluating the space between the T/B and Electrical Room relative to the R/B and the PS/B, the weight of the turbine pedestal was included in the ACS SASSI model. The pedestal weight was uniformly distributed over the full soil contact area of the pedestal foundation. This will permit the impact of the pedestal weight to be included in the dynamic SSI analyses. Structural features of the turbine pedestal are not included. The bottom of the turbine pedestal was set at the same elevation in the SSI analysis as the bottom of the T/B basemat, elevation -24 feet 7 inches."

The staff noted that while the mass of the turbine pedestal was considered in the analysis, the potential effects of this pedestal on SSI results or on any interaction between it and the T/B foundation is not specifically addressed. No numerical data is included in the report that supports this exclusion of the pedestal. The applicant is requested to describe in detail the design of the joint between the turbine pedestal and the T/B foundation and explain why the effects (other than consideration of the mass) of the pedestal on SSI or other aspects of the analysis are not important, and that by ignoring these effects results in a conservative analysis. Additionally, the applicant should confirm that the weight of the turbine generator is included in the analysis.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

While the turbine pedestal was not modeled directly into the SASSI model in MUAP-11002 (R0), the mass of the turbine pedestal and the equipment supported by the turbine pedestal (turbine, generator, etc.) was included in the SASSI analysis in a simplified manner by modeling the turbine pedestal basemat as flat plates and applying uniform loads to the flat plates. The elevation of the bottom of the flat plates is identical to the elevation of the bottom of the Turbine Building (T/B) basemat. Although this simplification is deemed sufficient for the purpose of evaluating the gap between the R/B, PS/Bs and the TI, in response to the questions raised above, the modeling of the turbine pedestal is enhanced to include the sliding and overturning effects of the turbine pedestal in MUAP-11002 (R1). The turbine pedestal and equipment mass are modeled as a lumped mass stick model (LMSM). MUAP-11002 (R1) Subsection 1.1.4 describes the turbine pedestal LMSM.

The seismic isolation space between the turbine pedestal basemat and the T/B basemat was modeled as 1 inch. The joint between the turbine pedestal and T/B foundation is shown in the attached sketch, Figure 1.

The seismic isolation space between the turbine pedestal basemat and the T/B foundation has 2 elastomeric water stops installed at 2 different elevations to provide a barrier so that ground water does not seep into the T/B basement. Per the manufacturer's data this joint can move up to 6 inches without failure.

The movement of the turbine pedestal basemat and tabletop and the gap between the turbine pedestal basemat and tabletop and the T/B basemat and superstructure floors will be evaluated in the site specific design. In addition, a detailed turbine pedestal model will be used for the site specific design.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

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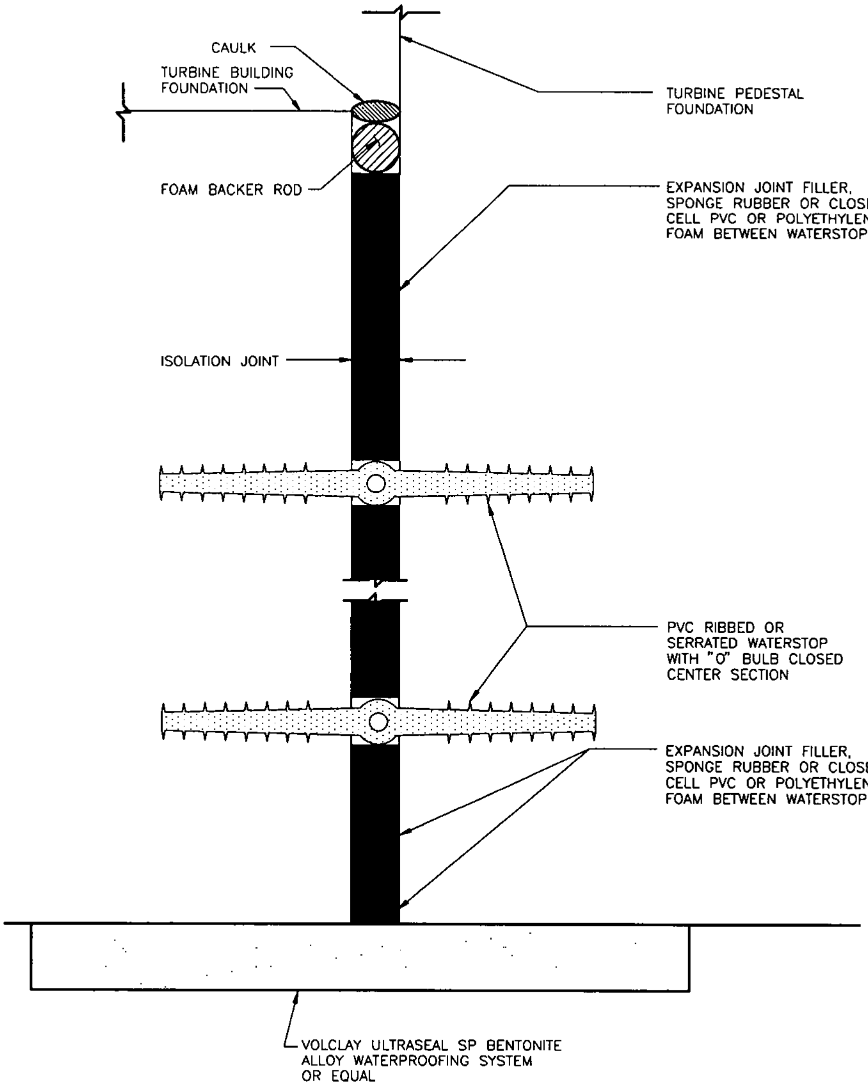

WATERSTOP DETAIL

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THIS DOCUMENT CONTAINS SEISMIC CATEGORY I ITEMS ☐ YES ☒ NO

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BLACK & VEATCH CORPORATION
TEXAS BOARD of PE FIRM NO. F-00258

MHI US-APWR TI STANDARD DESIGN	PROJECT: 164220	DRAWING NUMBER: 164220-SS-0002 / REV:
ENGINEER: JJS / DRAWN: WAH	TURBINE BUILDING & TURBINE PEDESTAL ISOLATION JOINT & WATERSTOP DETAIL	CODE: / CLIENT DRAWING NUMBER:
CHECKED: / DATE:		AREA:

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 766-5819 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-52:

In MUAP-11002 (R0) Subsection 7.1.2, "Results of Maximum Relative Displacements," the applicant identified nodes at which maximum relative displacements are determined.
Based on the information provided in the report, the staff was not able to determine whether the applicant considered all appropriate critical locations for computing building clearances for relative displacement. The applicant is requested to provide additional information such as appropriate layout drawings showing relative positions of the T/B and Electrical Room, the R/B, the PS/B, and the potential contact points between the structures.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

The attached Figure 1 shows the positions of the Reactor Building, Power Source Buildings, Turbine Building and Electrical Room. The attached Figure 2 shows the elevation view of the interface between the Turbine Building and the Electrical Room, and the attached Figure 3 shows the elevation view of the interface between the Turbine Island and the Reactor Building and Power Source Buildings. These figures are included in MUAP-11002 (R1). The minimum gap distance shown in Figures 2 and 3 is 1 foot 4 inches.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

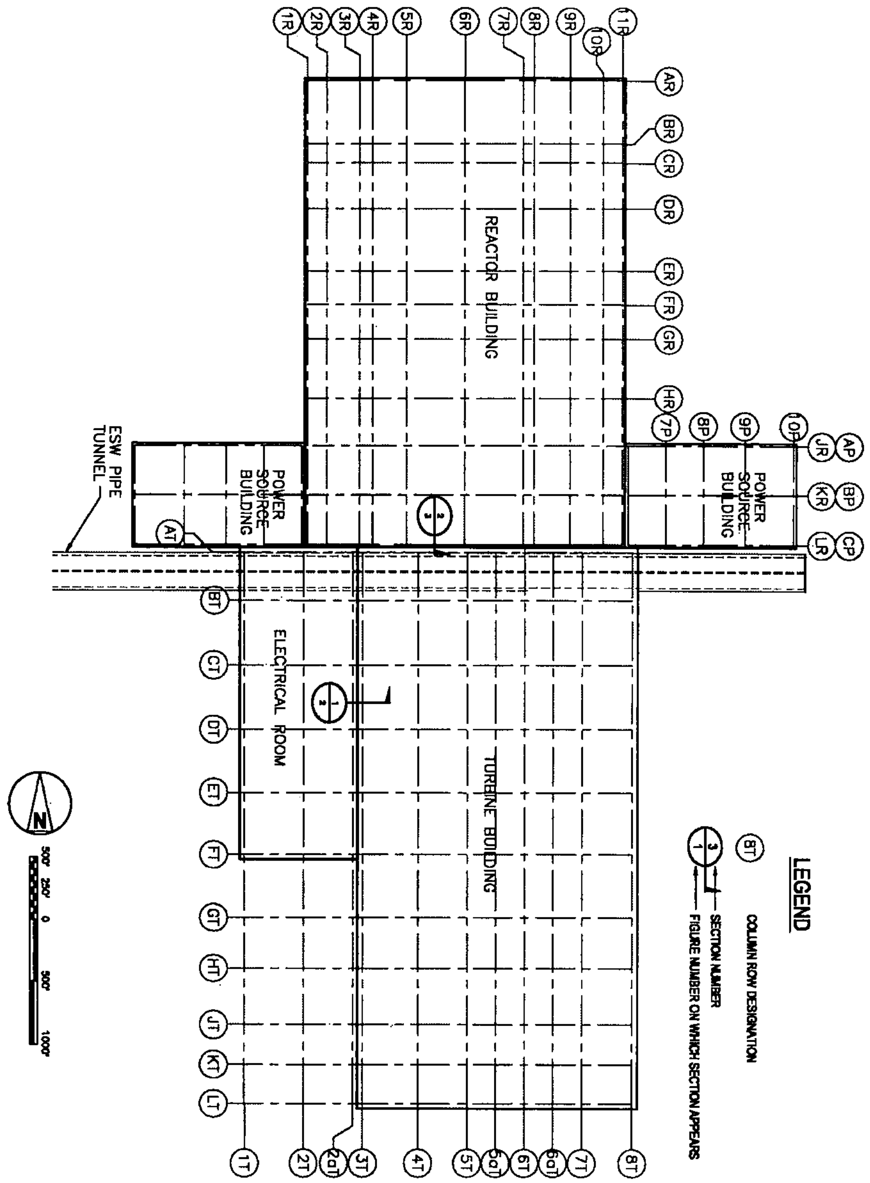
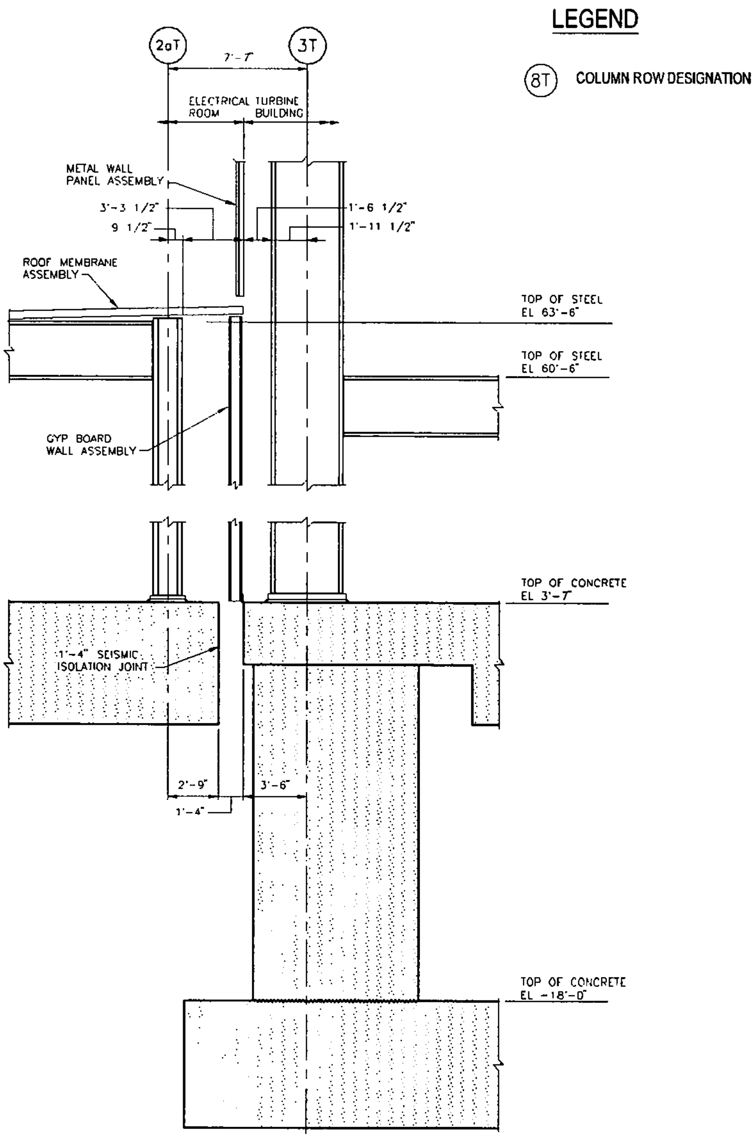
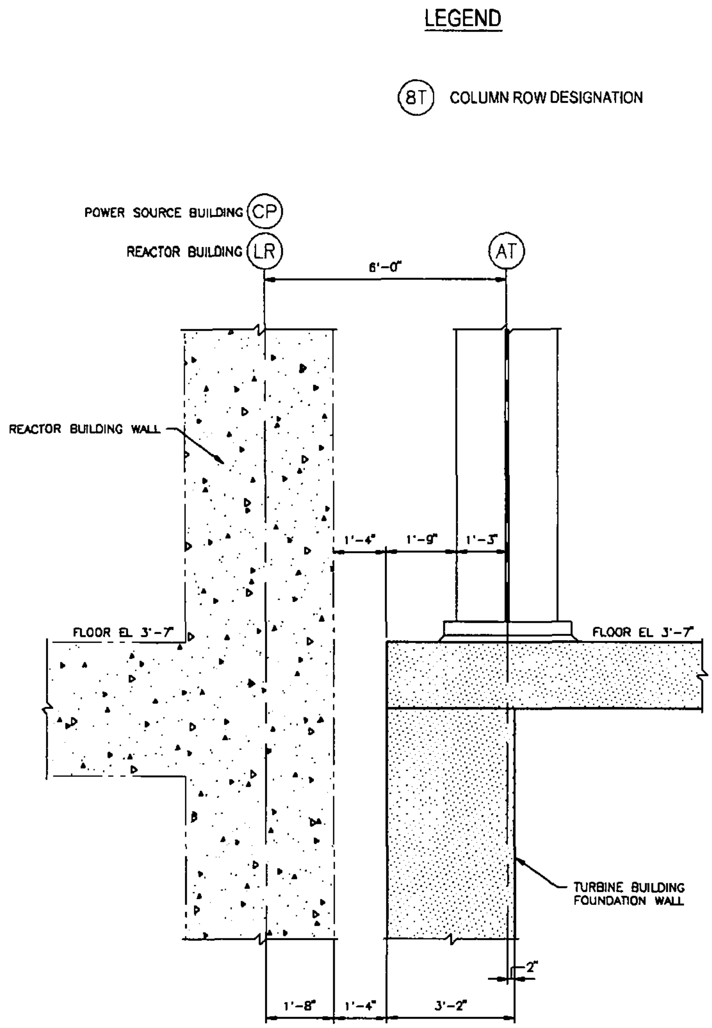


Figure 1. Plan Arrangement of Turbine Island and Adjacent Reactor Building and Power Source Buildings



Section 1

Figure 2. Cross Section Through Turbine Building and Electrical Room



Section 2

Figure 3. Cross Section Through Turbine Building, Reactor Building and Power Source Building

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 766-5819 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-60:

In MUAP-11002 (R0) Subsection 4.2, "Electrical Room," the last sentence in the first paragraph (page 12) states, "The Electrical Room is also structurally separated from the T/B."
The applicant is requested to define the meaning of "structurally separated." If there is an engineered clearance between the structures and foundations, the Applicant should demonstrate that the clearance is sufficient to prevent contact between the structures and foundations during a seismic event. If there is not an engineered clearance, the applicant should explain why a clearance is not required to prevent contact between the structures and foundations of the Electrical Room and T/B during a seismic event.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

The meaning of "structurally separated" is the Turbine Building and Electrical Room are physically separate and distinct structures with an engineered clearance between the superstructures and foundations. A clearance of 4 feet 10 inches is provided between the two steel superstructures to prevent contact during a seismic event.

At the foundation level, a clearance of 1 foot 4 inches is provided between the Turbine Building and Electrical Room foundations for seismic separation and constructability. The Turbine Building and Electrical Room superstructure and foundation clearances are reevaluated in MUAP-11002 (R1) using the SSI analysis results. The attached Figure 1 shows the elevation view of the interface between the Turbine Building and the Electrical Room looking north along column lines 2aT and 3T. This Figure is identical to Figure 2 shown in the answer to RAI 03.07.02-52.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

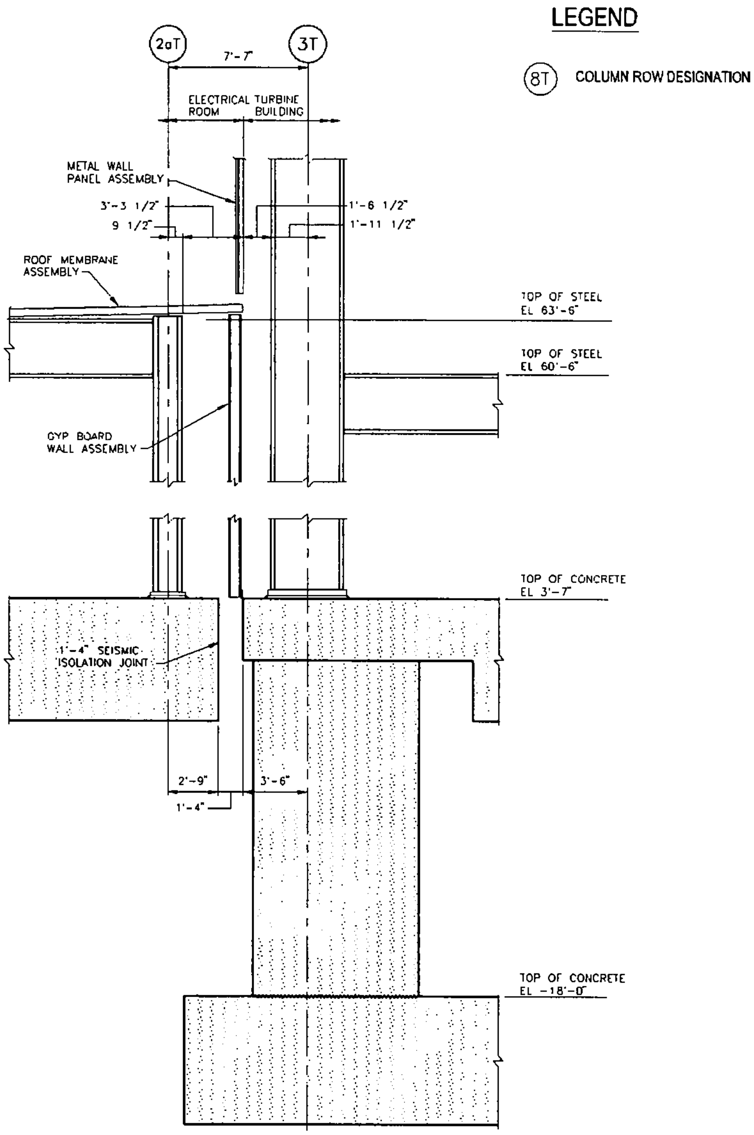


Figure 1. Cross Section Through Turbine Building and Electrical Room

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 766-5819 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-61:

In MUAP-11002 (R0) Subsection 5.2.2, "CSDRS Compatible Ground Motion Time Histories," the third paragraph (page 16) states, "The time step and duration of the acceleration time histories are 0.005 second and 22.085 seconds, respectively."

In the applicant technical report MUAP-10001(R1), the duration of the time history listed in Subsection 5.1 is 22.005 seconds. The applicant is requested to clarify this discrepancy.
In addition, the ACS SASSI analyses are performed in the frequency domain making use of the Discrete Fourier Transform (DFT). Application of the DFT to a transient excitation has the effect of assuming that the excitation is periodic, which can lead to errors. Such errors are typically prevented by introducing a "quiet zone" into the input time history of sufficient length that the damping in the structural model reduces the response of the model to insignificant levels between the applications of successive transient motions.
The applicant is requested to demonstrate that the periodic nature of the DFT is not leading to erroneous results in the SASSI evaluation.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

The total duration of the revised time history is 20.000 seconds per MUAP-10001 (R4). The total duration is revised as shown in MUAP-11002 (R1).

The time step used in the input time history is 0.005 second, and the number of total time steps is 4,001 for the 20.000 second duration. According to the ACS SASSI User Manual (Reference 1), the Fast Fourier Transform (FFT) is used to compute the Discrete Fourier Transform (DFT) and its inverse. For the FFT, the number of the Fourier points has to be a power of 2. The number of Fourier points used for the soil structure interaction (SSI) analysis in MUAP-11002 (R1) is 8,192 which is 2 to the power of 13 (or 2^{13}). The number of Fourier points is 4,191 more than the total time steps of the input time history. It indicates that 4,191 zeros were added to the end of the input time history as a quiet zone (Reference 2). The 4,191 trailing zeros represent a 20.955 second duration for the quiet zone.

Based on the predominant periods of the Turbine Building and Electrical Room from MUAP-11002 (R1), the 20.955 second quiet zone is long enough to damp out the transient response to ensure appropriate SASSI evaluation.

References:

1. ACS SASSI NQA Version 2.3.0, An Advanced Computational Software for 3D Dynamic Analysis Including Soil-Structure Interaction, User Manuals, Revision 3, December 30, 2010
2. ACSE Standard "Seismic Analysis of Safety-Related Nuclear Structure and Commentary", ASCE 4-98, 1998.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification
Mitsubishi Heavy Industries
Docket No. 52-021

RAI NO.:	**NO. 766-5819 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.07.02-66:

In MUAP-11002 (R0) Subsection 7.1.2, "Results of Maximum Relative Displacements," the second paragraph (page 24) states, "Figures 7-2 through 7-21 show the acceleration transfer function amplitudes for 10 of the 24 selected nodes for subsurface profiles 270-200 and 2032-100."
The staff reviewed the information presented in Figures 7-2 through 7-21 regarding acceleration transfer function and relative displacement with respect to free field input motion at various nodes and noted that such information for Node 1440 was not provided. Node 1440 is the node used in Subsection 7.1.3 to evaluate the 4 inch gap.
The applicant is requested to include Node 1440 in the presentation of Figures 7-2 through 7-21. Also, the applicant is requested to provide the corresponding transfer functions under the fixed base condition so that the staff can evaluate the validity of the interpolated transfer functions.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2001.

Due to revision of SSI analysis, node 1440 is no longer used to evaluate the gap between the Turbine Island and the Nuclear Island. Section 3.0 of the MUAP-11002 (R1) report has been updated to include the transfer functions of the nodes used to evaluate the gap for both SSI and fixed base conditions.

Impact on DCD

There is no impact on the DCD

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.

Enclosure 2

UAP-HF-11392
Docket Number 52-021

Amended Responses to Request for Additional Information No. 767-5821 Revision 3

November 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/16/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 767-5821 REVISION 3**
SRP SECTION:	**03.08.04 – Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**06/09/2011**

QUESTION NO. RAI 03.08.04-51:

In MUAP-11002 (R0), Subsection 7.3, "Turbine Building and Electrical Room Sliding and Overturning Analysis," the second paragraph (page 26) states, "The resistance to sliding is provided by friction at the base and sides of the substructures."
The applicant is requested to provide the numerical value used for the friction coefficient, and to provide justification for using that value.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11249 dated August 1, 2011.

The numerical value used for the coefficient of friction is provided in MUAP-11002 (R1). MUAP-11002 (R1) includes an updated sliding evaluation based on the SSI analysis results for the six subsurface profiles from MUAP-10001 (R4).

The sliding evaluation is performed assuming no relative soil to foundation sliding movement using a static or peak coefficient of friction at the interface between the concrete and the subgrade. The static coefficient of friction used for this evaluation is a minimum value of 0.7 for all material interfaces below the basemat. These interfaces include soil to mass concrete and mass concrete to mass concrete. The soil to mass concrete interface coefficient of friction is based on minimum angle of internal friction of 35 degrees and the mass concrete to mass concrete coefficient is based on a roughened surface in accordance with Section 11.7.9 of American Concrete Institute (ACI) standard ACI 349-01/349R-01, "Code Requirements for Nuclear Safety Related Concrete Structures and Commentary," January 2001.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is an impact to MUAP-11002. This impact has been incorporated in the revision 1 report. Impact to report is described in RAI answer.