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TOKYO, JAPAN

November 18, 2009

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

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-09530

Subject: MHI's Responses to US-APWR DCD RAI No. 465-3382 Revision 1

Reference: 1) "Request for Additional Information No. 465-3382 Revision 1, SRP Section: 03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components And Their Associated Supports," dated 10/6/2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 465-3382 Revision 1."

Enclosed are the responses to 6 RAIs contained within Reference 1. Of the RAIs in Reference 1, 2 will not be answered within this package. They are;

Question 03.12-18, which has a 60-day response time, as agreed to between the NRC and MHI, and will be issued at a later date by a separate transmittal.

Question 03.12-23, which was to be included with this transmittal, will be issued with Question 03.12-18 at a later date by a separate transmittal. The reason for this deferment is to coordinate information related to the public meeting with NRC staff on November 16, 2009.

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

Sincerely,

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

D081
NRO

Enclosure:

1. Responses to Request for Additional Information No. 465-3382, Revision 1

CC: J. A. Ciocco
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Docket No. 52-021
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Enclosure 1

UAP-HF-09530
Docket No. 52-021

Responses to Request for Additional Information No. 465-3382, Revision 1

November, 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

11/18/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 465-3382 REVISION 1**
SRP SECTION:	**03.12 – ASME CODE CLASS 1, 2, AND 3 PIPING SYSTEMS AND PIPING COMPONENTS AND THEIR ASSOCIATED SUPPORTS**
APPLICATION SECTION:	**3.12**
DATE OF RAI ISSUE:	**10/6/2009**

QUESTION NO. 03.12-18:

MHI response for RAI 260-2023 question 03.12-15, provided design loading combinations for building differential settlement as shown in Table 3.12-4. The staff requests MHI to clarify why the building differential settlement loading is added by SRSS in Level D service.

ANSWER:

The building differential settlement loading (*SET*) is not intended to be added by SRSS in Level D service. The markup of Table 3.12-4 for RAI 260-2023, Question 03.12-15 was incorrect; however the error was correctly incorporated into DCD Revision 2. The third design loading combination for Level D Service is the following in Table 3.12-4 of DCD Revision 2:

$$DL + L_{DMS} + L_{DFF} + TH_{MTL} + SET + SRSS(DBPB + (SSEI + SSEA + SE))^{(1),(2),(3)}$$

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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DATE OF RAI ISSUE:	**10/6/2009**

QUESTION NO. 03.12-19:

In DCD Section 3.12.3.2.4, MHI states that RG 1.92 Rev.1 is used in modal combination for the low frequency (non-rigid) modes and 10% grouping method is used for combining the responses of closely spaced modes. In Section 3.7.2.7.1, MHI states that in the response spectra analysis, the low frequency modes are combined by one of the modal combination methods in accordance with RG 1.92, Rev.2. The staff noted that RG 1.92, Rev. 2 does not credit 10% grouping method. Is the statement in the last sentence of the third paragraph of section 3.7.2.7 applicable to section 3.12? The staff requests MHI to clarify the use of revisions 1 and 2 of RG 1.92 in Chapter 3 including which revision is normally applied and when the exceptions for using revision 1 are invoked.

ANSWER:

Yes, the last sentence of the third paragraph of Subsection 3.7.2.7 is applicable to Section 3.12. To clarify that the more conservative modal combination methods contained in Revision 1 of RG 1.92 are used for piping, the next to last paragraph in Subsection 3.7.2.7 will be revised to identify the use of RG 1.92, Revision 1.

RG 1.92, Revision 2 is not used for piping design described in Section 3.12.

Impact on DCD

See Attachment 1 for a mark-up of DCD Tier 2, Section 3.7 changes to be incorporated.

- Add the following as the last sentence of the next-to-last paragraph in Subsection 3.7.2.7: "The 10% grouping method is used for piping as described in Subsection 3.12.3.2.4."

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO. 03.12-20:

In DCD Section 3.12.3.2.4, MHI states that the response from high frequency modes (i.e., modes with frequencies greater than the ZPA cutoff frequency) must be included in the response of the piping system, if it results in an increase in the dynamic response of more than 10%. RG 1.92, Rev. 2, Regulatory Position C1.4.1 states that 10% criterion is non-conservative and should not be used. The staff requests MHI to demonstrate that this criterion is adequate or modify this criterion.

THIS IS ASSOCIATED WITH "MISSING MASS DUE TO RESIDUAL RIGID RESPONSE" PER RG 1.92, POSITION C.1.4. THESE MODES ARE BEYOND CUTOFF FREQUENCY. THIS IS REQUIRED FOR PIPING ANALYSIS ONLY. SEE ALSO SRP 3.7.2, Item II.7.

ANSWER:

The third paragraph in DCD Subsection 3.12.3.2.4 paragraph, identified as **High Frequency (rigid) modes**, will be revised to delete the qualifying statement "if it results in an increase in the dynamic response of more than 10%".

Impact on DCD

See Attachment 2 for a mark-up of DCD Tier 2, Section 3.12 changes to be incorporated.

- Revise the next-to-last sentence of the next-to-last paragraph in Subsection 3.12.3.2.4 to the following: "The response from high frequency modes must be included in the response of the piping system."

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO. 03.12-21:

In DCD Appendix 3C, Section 3C.1, MHI states that the RCL dynamic anlysis is performed using the time-history direct integration. Explain how the time history analysis will account uncertainties (similar to peak shifting in the response spectrum analysis) in the piping analysis using the time history method.

ANSWER:

To account for uncertainties, the building stiffness, that is the Young's modulus of the containment internal structure (CIS) coupled with the reactor coolant loop (RCL), is varied by -30 or +35 percent, corresponding to the peak frequency shift of the building. Three cases of seismic response analysis with building Young's modulus 70%, 100%, 135% are performed for each soil condition, then the maximum responses are applied as the design values for piping analysis.

The above method produces the same effect as the peak shifting method described in Subsection N-1222.3 of ASME Section III, Division 1 Appendices, which "has similar effect to widening the spectral peak".

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION:	**3.12**
DATE OF RAI ISSUE:	**10/6/2009**

QUESTION NO. 03.12-22:

In DCD Section 3.12.6.12, MHI states that the applicable loading combinations for instrumentation lines will follow those used for normal and faulted levels in DCD Table 3.12-4. Explain why the load combinations for upset and emergency levels are not applicable to instrumentation line supports.

ANSWER:

Instrumentation line supports are conservatively evaluated in the NF code equations for the faulted (most critical) load combinations using stress allowables for the less-critical upset load combinations. Since the instrumentation lines are very small, they will produce very small loads on the supports. This practice will therefore not yield unnecessarily heavy pipe supports, while conservatively satisfying the code acceptance criteria. Supports are also evaluated for the normal load combinations using normal stress allowables.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO. 03.12-24

SRP Section 3.9.2, Acceptance Criteria Item II.2.A(i)(3) requires an investigation for a sufficient number of modes to be included in the piping modeling to ensure that all significant modes have participated in the analysis. Provide the criterion that would ensure this requirement.

THIS IS ASSOCIATED WITH MODES CONSIDERED BELOW THE CUTOFF FREQUENCY AND HAVE PARTICIPATED IN THE DYNAMIC ANALYSIS OF THE SYSTEM. THIS IS TO ENSURE THAT ALL SIGNIFICANT DYNAMIC MODES ARECONSIDERED IN THE ANALYSIS AND REQUIRED FOR ANY STRUCTURAL ANALYSIS (INCLUDING COMPONENTS AND PIPING).

ANSWER:

The intent to consider participation of all significant modes is implied in Subsection 3.12.3.2.4 paragraphs identified as "**Low frequency (non-rigid) modes**" and "**High frequency (rigid) modes**". However, a statement will be added to DCD Subsection 3.12.3.2.4 to clarify this intention.

Impact on DCD

See Attachment 2 for a mark-up of DCD Tier 2, Section 3.12 changes to be incorporated.

- Insert the following as the last sentence of the second paragraph in Subsection 3.12.3.2.4:

  "The response of low frequency (non-rigid) modes is obtained from all the low frequency modes with frequencies at least up to the ZPA cutoff frequency."

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

This completes MHI's response to the NRC's question.

$$R^2 = \sum_{k=1}^{N} R_k^{\,2} + 2\sum \left| R_i R_j \right| \qquad i \neq j$$

The second summation is to be done on all i and j modes whose frequencies are closely spaced to each other.

All terms for the modal combination remain the same as defined above.

The 10% grouping method is more conservative than the grouping method because the same mode can appear in more than one group. The 10% grouping method is used for piping as described in Subsection 3.12.3.2.4.

For the seismic response spectra analysis, the ZPA cut-off frequency is 50 Hz. High frequency or rigid modes must be considered using the static ZPA method, the left-out force method as described in Subsection 3.7.2.7 below, or the Kennedy Missing Mass method contained in Revision 2 of RG 1.92 (Reference 3.7-27).

3.7.2.7.1 Left-Out-Force Method (or Missing Mass Correction for High Frequency Modes)

The left-out-force method is based on the Left-Out-Force Theorem. This theorem states that for every time history load, there is a frequency, f_r, called the "rigid mode cutoff frequency" above which the response in modes with natural frequencies above f_r will very closely resemble the applied load at each instant of time. These modes are called "rigid modes." The formulation follows and is based on the method used in the computer program PIPESTRESS (Reference 3.7-29). The left-out-force method is not used for seismic analysis of the major seismic category I structures; however, it may be used for other seismic category I and II systems and subsystems.

The left-out-force vector for time history analyses, $\{ Fr \}$, is calculated based on lower modes:

$$\{ Fr \} = [1 - \sum M e_j e_j^T] f(t)$$

where

$f(t)$ = the applied load vector

M = the mass matrix

e_j = the eigenvector

Note that $\sum$ only represents the flexible modes, not including the rigid modes.

In the response spectra analysis, the total inertia force contribution of higher modes can be interpreted as:

$$\{ Fr \} = Am\,[M]\,[\{ r \} - \sum P_j e_j]$$

where

Am = the maximum spectral acceleration beyond the flexible modes

3.12.3.2.4 Modal Combination

Guidance on combining the individual modal results due to each response spectrum in a dynamic analysis is provided in RG 1.92, Rev.1 (Reference 3.12-11).

Low frequency (non-rigid) modes: For piping systems with no closely spaced modes, the SRSS method is applied to obtain the representative maximum response of each element, for each direction of excitation as delineated in Regulatory Position C1.1 of RG 1.92, Rev.1 (Reference 3.12-11). A 10% grouping method is used for combining the responses of closely spaced modes as delineated in Regulatory Position C1.1 of RG 1.92, Rev.1 (Reference 3.12-11). The response of low frequency (non-rigid) modes is obtained from all the low frequency modes with frequencies at least up to ZPA cutoff frequency.

High frequency (rigid) modes: Piping system modes with frequencies greater than the ZPA cutoff frequency are considered as high frequency or rigid range modes. The response from high frequency modes must be included in the response of the piping system~~, if it results in an increase in the dynamic response of more than 10%~~. The guidance for including the missing mass effects is provided in SRP 3.7.2 (Reference 3.12-12), as well as in RG 1.92, Rev.2 (Reference 3.12-13).

The PIPESTRESS computer program is used for analyzing most of the piping systems. This program uses the left-out-force (LOF) method in order to calculate the effect of the high frequency rigid modes. The LOF method is described in the "PIPESTRESS Theory Manual" (Reference 3.12-14) and the "Outline of Dynamic Analysis for Piping Systems" (Reference 3.12-15).

3.12.3.2.5 Directional Combination

The responses due to each of the three spatial input components of motion are combined using the SRSS method as provided in Regulatory Position C2.1 of RG 1.92, Rev.1 (Reference 3.12-11).

3.12.3.2.6 Seismic Anchor Motions

The analysis of seismic anchor motions (SAMs) is a static analysis and is performed using the same piping model used to analyze the inertial effects in a dynamic analysis.

When piping is analyzed using the USM method, effects of SAM in each of the three different spatial directions are analyzed separately considering all dynamic supports to be active. The three resulting solutions are combined by the SRSS rule to obtain cumulative effect of support displacements.

For piping supported by a single concrete building, the SAM at all elevations above the foundation basemat are considered to be in phase. Support movements relative to the foundation basemat are used in the analysis.