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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-11297

Subject: MHI's Responses to US-APWR DCD RAI No. 799-5877 Revision 3 (SRP 03.07.03)

Reference: 1) "Request for Additional Information No. 799-5877 Revision 3, SRP Section: 03.07.03 – Seismic Subsystem Analysis," dated 8/5/2011.

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. 799-5877, Revision 3."

Enclosed are the responses to 3 RAIs contained within Reference 1. Of the RAIs in Reference 1, three will not be answered within this package. They are RAI 3.7.3-7, 10 and 11 which have 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.

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,

Y. Ogata

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

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NRO

Enclosure:

1. Responses to Request for Additional Information No. 799-5877, Revision 3

CC: J. A. Ciocco
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Enclosure 1

UAP-HF-11297
Docket No. 52-021

Responses to Request for Additional Information No. 799-5877, Revision 3

September, 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/7/2011

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

RAI NO.:	**NO. 799-5877 REVISION 3**
SRP SECTION:	**03.07.03 – Seismic Subsystem Analysis**
APPLICATION SECTION:	**3.7.3**
DATE OF RAI ISSUE:	**8/5/2011**

QUESTION NO. RAI 03.07.03-6:

In Subsection 3.7.3.1.2 of DCD (R3), "Single DOF, Single Mode Dominant or Rigid Structures and Components", the second bullet of the first paragraph (page 3.7-47) states, "The equivalent static seismic load for the direction of excitation is defined as the product of the component mass and the seismic acceleration value corresponding to the natural frequency of the support from the applicable ISRS."

The SRP Acceptance Criteria 2.A.ii(3) (page 3.9.2-11 to -12) of SRP 3.9.2 states, "In addition, for equipment which can be modeled adequately as a one-degree-of-freedom system, the use of a static load equivalent to the peak of the floor response spectra is acceptable." Therefore, per SRP 3.9.2, the peak acceleration of the ISRS should be used not the acceleration value corresponding to the natural frequency of the support from the applicable ISRS. The Applicant is requested to provide justification for calculating the equivalent static load using the spectral acceleration corresponding to the natural frequency of the support rather than the peak spectral acceleration from the ISRS at the base of the support. The uncertainties in the natural frequency estimation of the supports need to be addressed in the discussion.

ANSWER:

Both SRP 3.9.2 and SRP 3.7.2 permit an equivalent static load factor of less than 1.5 to be used with a justification but with no set limit on minimum value. The responses to RAI 213-1951 Questions 3.7.3-02 (ML090910119) and RAI 3.7.3-04 (ML091180437) provided justifications (similar to that requested in this question) for utilizing the acceleration corresponding to the SSC natural frequency for certain situations.

For calculating the equivalent static load using the spectral acceleration corresponding to the natural frequency of the support (for rigid components supported by a flexible spring which can be analyzed as a single degree of freedom (DOF) model, and the natural frequency is to the right of applicable in-structure response spectra (ISRS) peak), the justification is that any potential multi-modal effects will not increase the response amplitude. In other words, for a structure and component which can be analyzed adequately using a single DOF model, and the supported component is determined to have a frequency to the right of the ISRS peak, any potentially higher modes that may be present will produce accelerations less than those corresponding to the calculated fundamental natural frequency of the supported component. Hence for this case, there is no possibility of the structure being accelerated by a value greater than the acceleration corresponding to the natural frequency of the supported component in a more refined response spectra analysis, and the approach is therefore conservative.

It is noted that the natural frequency of the "support" (as it is referred to in Subsection 3.7.3.1.2 of DCD) is determined considering the rigid component mass, support mass, and stiffness of the rigid component's support.

Uncertainties in determining the natural frequency estimation of the support are accounted for by use of ISRS that are broadened in accordance with Regulatory Guide (RG) 1.122. In addition, uncertainties are offset by conservatism which requires use of the peak acceleration for supports of rigid components where the natural frequencies are not known, or are less than the frequency corresponding to the peak floor acceleration.

Based on the above justification and the guidance in SRP 3.9.2 Acceptance Criteria 2.A.ii(3) and SRP 3.7.2 Acceptance Criteria 1.B.iii, the second bullet in DCD Subsection 3.7.3.1.2 will be revised as indicated below in "Impact on DCD" to:

(1) clarify that the frequency of the "support" is the frequency of the "supported component". Hence, the supported component includes the rigid component mass, support mass, and stiffness of the rigid component's support.

and

(2) apply the peak acceleration of the applicable ISRS when the frequency of the supported component is not determined, and when the natural frequency has been determined to be to the left of the ISRS peak, for supported rigid equipment that can be modeled adequately as a one-degree-of-freedom system. Using the peak acceleration for these situations is justified by the guidance given in SRP 3.9.2 and 3.7.2.

Impact on DCD

See the Attachment 1 mark-up of DCD Tier 2, Subsection 3.7, changes to be incorporated. The second bullet in DCD Subsection 3.7.3.1.2 is revised to read as follows:

- "A rigid component (fundamental frequency greater than 50 Hz), whose support can be adequately represented by a flexible spring, can be modeled as a single DOF model in the direction of excitation (horizontal or vertical directions). The equivalent static seismic load for the direction of excitation is defined as the product of the component mass and the seismic acceleration value corresponding to the natural frequency of the supported component from the applicable ISRS. If the frequency of the supported component is not determined, the peak acceleration from the applicable ISRS is used. Supported components which have been determined to have natural frequencies less than the frequency corresponding to the peak floor acceleration (i.e., whose natural frequencies are to the left of spectra peak on an acceleration versus the frequency spectra plot) also utilize the peak acceleration."

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 no impact on a Technical/Topical Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/7/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 799-5877 REVISION 3**
SRP SECTION:	**03.07.03 – Seismic Subsystem Analysis**
APPLICATION SECTION:	**3.7.3**
DATE OF RAI ISSUE:	**8/5/2011**

QUESTION NO. RAI 03.07.03-8:

In Subsection 3.7.3.3 of DCD (R3), Analysis Procedure for Damping", the third paragraph (page 3.7-52), states "Piping systems are analyzed for SSE using 4% damping. Alternatively, frequency dependent damping values may be utilized as noted and described in Tables 3.7.3-1(a) and 3.7.3-1(b). The seismic analysis of piping and other mechanical subsystems is addressed in further detail in Sections 3.9 and 3.12."

The Applicant is requested to clarify if frequency-dependent damping values are used for the reactor coolant loop piping (RCL) in the SSI analysis for the US-APWR standard plant design. If so, the Applicant is requested to describe how these values were used in the ACS- SASSI analyses.

ANSWER:

As permitted in RG 1.61 Section 2, and as stated in DCD Subsection 3.7.3.3, frequency dependent damping values may be utilized for subsystem design, subject to the limitations noted in DCD Tables 3.7.3-1(a) and 3.7.3-1(b). However, frequency-dependent damping values are not used in the ACS-SASSI soil-structure interaction (SSI) analyses, which couple a dynamic model comprised of the reactor coolant loop (RCL) piping and nuclear steam supply system (NSSS) components with the overall Reactor Building complex dynamic model. As stated in DCD Appendix 3C, Section 3C.5, 3% operating-basis earthquake (OBE) damping is applied to the RCL components including the piping, which conforms to guidance in Table 3 of RG 1.61.

The seismic input for the design of the RCL subsystem is obtained from the results of the ACS-SASSI coupled model soil-structure interaction analyses. The RCL subsystem design uses a decoupled RCL analysis model with 3% damping, and also does not utilize frequency-dependent damping. For RCL component and piping design, the independent support motion method (ISM), which is presented in MUAP-09002-P(R2), "Summary of Seismic and Accident Load Conditions for Primary Components and Piping", Dec. 2010, is applied. For RCL support design, the time history analysis method is adopted, considering the non-linear effect of one-directional supports, such as the steam generator lower lateral support.

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 no impact on a Technical/Topical Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/7/2011

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QUESTION NO. RAI 03.07.03-9

In Subsection 3.7.3.9 of DCD (R3), "Methods for Seismic Analysis of Aboveground Tanks", the third paragraph (page 3.7-54) states, "The horizontal response analysis considers both the impulsive mode (in which a portion of the water moves in unison with the tank wall) and the horizontal convective mode (water motion associated with wave oscillation)."

SRP Acceptance Criteria 14 (page 3.7.3-6) of SRP 3.7.3 states in the last sentence of the first paragraph, "The SSI effects may also be very important for tank responses, and they may need to be considered for both horizontal and vertical motions." The Applicant is requested to confirm that the SSI effects were considered in the seismic analyses of above tanks. If not, the Applicant is requested to provide justification for not considering the SSI effects. If yes, the Applicant is requested to provide specific technical details as to how the SSI effects were considered in the analyses.

ANSWER:

Soil-structure interaction (SSI) effects are considered in the seismic analyses of aboveground tanks. The following description describes the manner in which SSI effects are considered, which is based on the use of a dynamic finite element (FE) model for the reactor building (R/B) complex now being used for seismic design; as described in the supplemental response to RAI 542-4262 (ML11188A250). This description supplements information provided previously in the response to RAI 342-2000 Question 3.8.4-4 (ML091900558) and RAI 497-3734 Question RAI 03.08.04-34 (ML100550204).

Seismic category I liquid-retaining vessels listed in Subsection 3.7.3.9 of the DCD are reinforced concrete vessels. The hydrodynamic effect of the liquid contained in these liquid-retaining vessels is considered in the SSI seismic analysis. The mass of the liquid and liquid-retaining vessel are included in the SSI model of the supporting structure, including the basemat and subgrade. The liquid is separated into regions in which fluid motions can develop under horizontal seismic excitation. Within each region the behavior of the liquid is characterized by the motion of the rigid (impulsive) mass and the sloshing (convective) mass using the Modified Housner Method that conforms to the provisions of SRP 3.7.3 Acceptance Criteria 14, and guidance of ASCE 4-98, Subsection 3.5.4. To account for this behavior, the total liquid mass is divided into the sloshing (convective) and the rigid (impulsive) mass. The upper portion of the liquid is excited principally in the sloshing modes by the horizontal ground motion. The lower parts of the liquid act like rigid masses and are excited by both horizontal and vertical ground motion. For each region the magnitude of these masses is a function of the liquid depth and the depth-to-length ratio in the direction of seismic excitation. The impulsive response of the liquid is part of the seismic response from the SSI ACS-SASSI analysis, which includes impulsive masses directly in the model and which captures SSI effects due to building and foundation mat flexibility. Then the SSI seismic ACS-SASSI loads are applied and combined with the convective loads and other design loads in a detailed ANSYS model used for equivalent static design. It is acceptable to separate the convective effects from the SSI response of these structures that considers the impulsive fluid mass because the fundamental sloshing frequencies are very low with respect to the structural response frequencies.

For other aboveground tanks considered as seismic subsystems that are not analyzed in conjunction with the supporting structure, basemat, or subgrade, the tank fluid hydrodynamic analysis approach is similarly applied to the local configuration of the aboveground tank subsystem. However, the seismic input is taken from the SSI analysis of the supporting structure at the support location of the subsystem in the form of an amplified time history or in-structure response spectra (ISRS) as described in Section 3.7.3.1 of the DCD.

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 no impact on a Technical/Topical Report.

3.7.3.1.2 Single DOF, Single Mode Dominant or Rigid Structures and Components

For rigid structures and components, single DOF structures and components, or for cases where the response is such that the response of the system is single mode dominant, the following procedures may be used:

- For rigid SSCs (fundamental frequency greater than 50 Hz), an equivalent seismic load is defined for the direction of excitation as the product of the component mass and the ZPA value obtained from the applicable ISRS.

- A rigid component (fundamental frequency greater than 50 Hz), whose support can be adequatelyrepresented by a flexible spring, can be modeled as a single DOF model in the direction of excitation (horizontal or vertical directions). The equivalent static seismic load for the direction of excitation is defined as the product of the component mass and the seismic acceleration value corresponding to the natural frequency of the supported component from the applicable ISRS. If the frequency of the supported component is not determined, the peak acceleration from the applicable ISRS ~~times a factor of 1.5~~ of the supported component is used. Supported componentss which have been determined to have natural frequencies less than the frequency corresponding to the peak floor acceleration (i.e., whose natural frequencies are to the left of spectra peak on an acceleration versus the frequency spectra plot) also utilize the peak acceleration ~~times a factor of 1.5~~.

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- If the structure, equipment, or component has a distributed mass whose dynamic response is single mode dominant, the equivalent static seismic load for the direction of excitation is defined as the product of the component mass and the seismic acceleration value at the component natural frequency from the applicable ISRS times a factor of 1.5, with exceptions noted as follows. A factor of less than 1.5 may be used if justified, such as using a factor of 1.0 when the component natural frequency is in the rigid range (greater than 50 Hz), such that no dynamic amplification will occur. A factor of 1.0 is used for structures or equipment that can be represented as simply supported, fixed-simply supported, or fixed-fixed beams as discussed in References 3.7-36 and 3.7-37. In accordance with ASCE 4-98, Subsection 3.2.5.2 (Reference 3.7-9), for cantilever beams with uniform mass distribution, the equivalent-static-load base shear is determined using the peak acceleration, and the base moment is determined using the peak acceleration times a factor of 1.1. If the frequency of a structure, equipment, or component is not determined, the peak acceleration from the applicable ISRS times a factor of 1.5 is used, unless a lower factor is applicable as discussed herein or otherwise justified. Any structures, equipment, or components which have been determined to have natural frequencies less than the frequency corresponding to the peak floor acceleration (i.e., whose natural frequencies are to the left of spectra peak on an acceleration versus the frequency spectra plot) also utilize the peak acceleration times a factor of 1.5 unless a lower factor is applicable as discussed herein or as otherwise justified.