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September 7, 2011

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-11296

Subject: MHI's Responses to US-APWR DCD RAI No. 798-5876 Revision 3 (SRP 03.07.01)

Reference: 1) "Request for Additional Information No. 798-5876 Revision 3, SRP Section: 03.07.01 – Seismic Design Parameters," 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. 798-5876, Revision 3."

Enclosed are the responses to 3 RAIs contained within Reference 1. Of the RAIs in Reference 1, one will not be answered within this package. It is RAI 3.7.1-17, 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.

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. 798-5876, Revision 3

CC: J. A. Ciocco
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Docket No. 52-021
MHI Ref: UAP-HF-11296

Enclosure 1

UAP-HF-11296
Docket No. 52-021

Responses to Request for Additional Information No. 798-5876,
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. 798-5876 REVISION 3**
SRP SECTION:	**03.07.01 – Seismic Design Parameters**
APPLICATION SECTION:	**3.7.1**
DATE OF RAI ISSUE:	**8/5/2011**

QUESTION NO. RAI 03.07.01-14:

In Subsection 3.7.1.1 of DCD (R3), "Design Ground Motion", the first paragraph under the subtitle "FIRS" (page 3.7-4) states, "The material present above the control point elevation can be excluded from the site response analysis."

Per DC/COL-ISG-017, the effects of any soil above the control point need to be considered in calculating the properties of the soil below the control point. The applicant should confirm that the effects of any overlying soil have been properly accounted for, or provide the technical basis and justification for not conforming to DC/COL-ISG-017.

ANSWER:

The process by which the COL applicant will develop site-specific foundation input spectra from the site-specific ground motion response spectra accounts for the presence of any overlying soil. The first paragraph under the subtitle "FIRS" in DCD Subsection 3.7.1.1 will be revised, as indicated in "Impact on DCD" below, to be consistent with DC/COL-ISG-017 guidance that the effects of any soil above the control point need to be considered in calculating the properties of the soil below the control point.

Impact on DCD

See the Attachment 1 mark-up of DCD Tier 2, Subsection 3.7, changes to be incorporated.

The first paragraph under the subtitle "FIRS" in DCD Subsection 3.7.1.1 will be revised to read:

> "The site-specific GMRS serves as the basis for the development of FIRS that define the horizontal and vertical response spectra of the outcrop ground motion at the bottom elevation of the seismic category I and II basemats. Free-field outcrop spectra of site-specific horizontal ground motion are developed consistent with the horizontal GMRS using site response analyses which employ a suite of randomized soil profiles to account for uncertainties and variations in the site soil and rock properties. The profiles also include materials

present above the control point elevation in order to account for their effect on soil and rock properties."

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. 798-5876 REVISION 3**
SRP SECTION:	**03.07.01 – Seismic Design Parameters**
APPLICATION SECTION:	**3.7.1**
DATE OF RAI ISSUE:	**8/5/2011**

QUESTION NO. RAI 03.07.01-15:

In Subsection 3.7.1.1 of DCD (R3), "Design Ground Motion", the first paragraph under the subtitle "Duration of Motion" (page 3.7-8) states, "The duration of motion has been determined using random phase characteristics."

The Applicant is requested to explain how the duration of motion is determined using random phase characteristics, and describe how this approach is consistent with the acceptance criteria of SRP 3.7.1.II.1a. If the approach is not consistent with SRP guidelines, the Applicant should provide technical justification for the selected approach.

ANSWER:

This referenced sentence simply acknowledges consideration of a long enough time history such that random phase characteristics of the earthquake motion are adequately represented without altering the character of the time history. This is consistent with SRP guidelines and SRP 3.7.1 Acceptance Criteria 1.B and 1.B Option 1.ii (i.e., the enveloping requirements of Approach 2 are applied instead of those of Approach 1). See Subsections 4.1 and 5.1 of Technical Report MUAP-10001 Rev. 3 for more information on the development of the CSDRS time history for the US-APWR Standard Plant.

Impact on DCD

See the Attachment 1 mark-up of DCD Tier 2, Subsection 3.7, changes to be incorporated.

The third sentence in the first paragraph under the subtitle "Duration of Motion" in DCD Subsection 3.7.1.1 will be revised to read as follows:

> "The duration of motion has been determined to be long enough to capture the random phase characteristics of the earthquake motion."

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. 798-5876 REVISION 3**
SRP SECTION:	**03.07.01 – Seismic Design Parameters**
APPLICATION SECTION:	**3.7.1**
DATE OF RAI ISSUE:	**8/5/2011**

QUESTION NO. RAI 03.07.01-16:

In Subsection 3.7.1.1 of DCD (R3), "Design Ground Motion", the second paragraph under the subtitle "Duration of Motion" (Page 3.7-8) states, "the total duration of the ground motion time histories has been demonstrated to be long enough such that adequate representation of the Fourier components at low frequency is included in the time history."

The Applicant is requested to define "low frequency" in this context and to show how the adequate representation of the Fourier components is implemented to assure that the ground motion duration is sufficient.

ANSWER:

This referenced sentence simply acknowledges consideration of a long enough time history such that low frequency Fourier components are represented and is consistent with the similar statement of the second paragraph of NUREG-0800 SRP 3.7.1 Acceptance Criteria 1.B which states, "For linear structural analyses, the total duration of the artificial ground motion time histories should be long enough such that adequate representation of the Fourier components at low frequency is included in the time history."

For this context, "low frequency" is consistent with RG 1.208 (DCD Reference 3.7-3) guidance, which identifies "low frequency" hazards as being at 1 and 2.5 Hz. Therefore, in this context, "low frequency" is defined to be approximately 1 to 2.5 Hz.

The adequate representation of the Fourier components is implemented by complying with the requirements of SRP 3.7.1 Acceptance Criteria 1.B Option 1.ii (Approach 2). For Approach 2, the time duration used exceeds 22 seconds, which appropriately exceeds the required total duration of at least 20 seconds as stated in item a under "Design Ground Motion of Time History" in Subsection 3.7.1.1 of the DCD. The time step applied is 0.005 seconds which provides a Nyquist frequency of 100 Hz which appropriately exceeds the required minimum Nyquist frequency of 50

Hz. See Subsections 4.1 and 5.1 of Technical Report MUAP-10001 Rev. 3 for more information on the development of the CSDRS time history for the US-APWR Standard Plant.

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.

This completes MHI's responses to the NRC's questions.

Site-specific GMRS are developed at a sufficient number of frequencies (at least 25) that adequately represent the local and regional seismic hazards using the site-specific geological, seismological, and geophysical input data. A probabilistic seismic hazard analysis is performed that is based on the performance-based approach outlined in RG 1.208 (Reference 3.7-3). Horizontal GMRS are developed using a site amplification function obtained from site response analyses performed on site-specific soil profiles that include the layers of soil and rock over the generic rock defined as the rock with shear wave velocity exceeding 9,200 ft/s. The site-specific soil profiles account for the uncertainties and variations of the site soil and rock properties. The site response analysis will address probable effects of non-linearity due to strain-dependence of the subgrade materials' response. Equivalent linear methodology can be utilized with soil stiffness and damping degradation curves that represent the stiffness and damping properties of the subgrade materials as a function of strain. However, the strain-compatible soil material damping shall not exceed 15% as stipulated in SRP 3.7.1 (Reference 3.7-10).

With respect to determining the site-specific GMRS, note that Section 2.5.4 requires site-specific characterization of subsurface materials and investigation of the associated engineering properties to assure consistency with Section 3.7.2. Further, vertical GMRS are developed by combining the horizontal GMRS and the most up-to-date vertical/ horizontal response spectral ratios appropriate for the site obtained from the most up-to-date attenuation relationships.

FIRS

The site-specific GMRS serves as the basis for the development of FIRS that define the horizontal and vertical response spectra of the outcrop ground motion at the bottom elevation of the seismic category I and II basemats. ~~Free-field outcrop spectra of site-specific horizontal ground motion are derived from the horizontal GMRS using site-response analyses that consider only the wave propagation effects in materials that are below the control point elevation at the bottom of the basemat. The material present above the control point elevation can be excluded from the site response analysis.~~Free-field outcrop spectra of site-specific horizontal ground motion are developed consistent with the horizontal GMRS using site response analyses which employ a suite of randomized soil profiles to account for uncertainties and variations in the site soil and rock properties. The profiles also include materials present above the control point elevation in order to account for their effect on soil and rock properties. DCD_03.07.01-14

Appendix S (IV)(a)(1)(i) of 10 CFR 50 (Reference 3.7-7) requires that the SSE ground motion in the free-field at the basemat level must be represented by an appropriate response spectra with a PGA of at least 0.1 g. This requirement is met on a site-specific basis by considering minimum horizontal response spectra that are tied to the shapes of the US-APWR CSDRS and anchored at 0.1g. Since the CSDRS are based on modified RG 1.60-spectra, this assures that there is sufficient energy content in the low-frequency range. The COL Applicant is to assure that the horizontal FIRS defining the site-specific SSE ground motion at the bottom of seismic category I or II basemats envelope the minimum response spectra required by 10 CFR 50, Appendix S (Reference 3.7-7), and the site-specific response spectra obtained from the response analysis. The same

demonstrates that these requirements are met by showing a summary of the frequency non-exceedances.

d. In lieu of the power spectral density requirement of Option 1 Approach 1 in NUREG-0800, SRP 3.7.1 (Reference 3.7-10), Approach 2 specifies that the computed 5% damped response spectra of each artificial ground motion time history component does not exceed its target response spectra at any frequency by more than 30% (a factor of 1.3) in the frequency range of interest. For the US-APWR, the response spectra derived from the artificial time histories are checked to ensure that they do not exceed the corresponding target spectra (CSDRS) by more than 30% at any frequency range measured as described in item (b) above. The results of this check are presented in ~~Table 3.7.1-4~~Table 3.7.1-7. DCD_03.07.02-35 DCD_03.07.02-35

~~The cross-correlation coefficients between the three components of the design time histories are as follows:~~

~~ρ_{12} = 0.0892, ρ_{23} = 0.0654, and ρ_{31} = 0.0836~~

The artificial time histories also conform to NUREG-0800, SRP 3.7.1 (Reference 3.7-10), Acceptance Criteria 1B, guidance as summarized in Table 3.7.1-7 and further described below:

Cross Correlation between Components

Cross-correlation coefficients between the three artificial ground motion time histories are as follows:

ρ_{12} = 0.0892, ρ_{23} = -0.0836, and ρ_{31} = -0.0654

where 1, 2, and 3 are the three global directions corresponding to north-south, east-west, and vertical directions for the US-APWR standard plant.

Since the absolute values of the cross-correlation coefficients of the US-APWR artificial time histories are less than 0.16, as demonstrated above, in accordance with NUREG/CR-6728 (Reference 3.7-14), the time histories are considered statistically independent of each other. DCD_03.07.02-35

Duration of Motion

Each time history of the set of three statistically independent time histories which are developed for design of the US-APWR seismic category I buildings has a strong duration of motion greater than 7 seconds and a total duration of motion greater than 22 seconds. The strong duration of motion meets the acceptance criterion of 6 seconds minimum for strong motion duration as given in SRP 3.7.1 (Reference 3.7-10) for design time histories. The duration of motion has been determined ~~using~~to be long enough to capture the random phase characteristics of the earthquake motion. The total duration of motion meets the acceptance criterion of 20 seconds minimum as given in SRP 3.7.1 (Reference 3.7-10) design time histories, Option 1, Approach 2 Part (a). DCD_03.07.01-15