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February 19, 2010

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-10047

Subject: MHI's Responses to US-APWR DCD RAI No. 497-3734

Reference: 1) "Request for Additional Information No. 497-3734 Revision 0, SRP Section: 03.08.04 - Other Seismic Category I Structures," dated 12/1/2009.

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. 497-3734, Revision 0."

Enclosed are the responses to 16 RAIs contained within Reference 1. This transmittal completes the response to this RAI.

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.

Enclosure:

1. Response to Request for Additional Information No. 497-3734, Revision 0

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

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Enclosure 1

UAP-HF-10047
Docket No. 52-021

Response to Request for Additional Information No. 497-3734,
Revision 0

February, 2010

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-32:

This Request for Additional Information was written based on Revision 1 of the DCD.

In their response to Part (a) of Question 3.8.4-1 (of RAI 342-2000 hereinafter unless indicated otherwise), MHI describes the engineered concrete fill placed between building basemats and the supporting media. Normally, the thickness of the fill is small, but in cases where more excavation is necessary to reach suitable supporting material, the thickness is increased accordingly. MHI points out that the COL Applicant must address site-specific aspects of the concrete fill, such as dimensions, thickness, and strength. In response to Part (b) of the question, MHI explained that for the seismic analysis of the standard plant, the engineered concrete mat fill is considered as part of the basemat subgrade, which means that the fill concrete is horizontally infinite. As a result, the 4 in. gap between adjoining foundation basemats does not exist for the engineered concrete fill. MHI further noted that the COL Applicant must perform site-specific soil-structure interaction (SSI) analyses. It is also noted that whether the engineered concrete fill is considered as part of the supporting subgrade or as part of the building basemat depends on the thickness and extent of the concrete fill.

MHI's response to Question 3.8.4-1 is generally acceptable. However, in the response to Part (a) of the question, MHI stated that "The strength of the fill concrete is selected based on the site-specific properties of the subgrade ... the COL Applicant is to address these site-specific aspects of the fill concrete design." The staff is unable to find a COL item that contains this requirement. The applicant is requested to specify which current COL item includes this requirement, and if there is none, to add a COL item to the DCD.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

Refer to the response to RAI 496-3735, Question RAI 03.08.05-35, which indicates COL 3.7(7) will be revised to clarify that properties of fill concrete used as a supporting medium is discussed in DCD Subsection 3.7.1.3.

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.

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-33:

In its response to Question 3.8.4-2, MHI explains that the amplification factor, C_d , in ASCE/SEI 7-05 was not used because analyses carried out for the US-APWR are based on the requirements of SRP 3.7.1 and 3.7.2 which are different from and much more stringent than those in ASCE/SEI 7-05. In addition, MHI notes that the US-APWR seismic analyses are based on generic ground motion response spectra that must be confirmed for a particular specific plant site. Also, these analyses are based on a mean annual probability of exceedance lower than or equal to 10^{-4}, while development of ground motion spectra using ASCE 7-05 is based on a mean annual probability of exceedance of 10-2. MHI states that using ASCE/SEI 7-05 requires use of an amplification factor in an attempt to account for the uncertainties in several factors, such as site-specific soil amplification, lower intensity of ground motion obtained by using ASCE 7-05, and others. MHI also notes that ASCE/SEI 7-05 does not contain any special requirements for SSI analysis, while these were carried out for US-APWR. MHI concludes that ASCE/SEI 7-05 is more suitable for application to commercial or residential buildings and is not appropriate for the US-APWR NPP.

The staff notices that In the response, MHI states that "ASCE/SEI 7-05 code seismic design is based on design ground motion with mean annual probability of exceedance of approximately 10^2." If "mean annual probability of exceedance" means "mean annual frequency of exceedance"; then, this statement is not correct. The annual probability of exceedance for the ground motion considered in ASCE/SEI 7-05 is 4×10^{-4}. MHI also stated that "The design ground motion is defined by mapped spectral values without explicit consideration of site-specific geological, seismological, geophysical or geotechnical conditions." This statement is not correct. ASCE/SEI 7-05 does consider all these factors. For example, the site classification procedure in Chapter 20 of ASCE/SEI 7-05 and the Site Coefficients, F_a and F_v, in Table 11.4-1 and Table 11.4-2 of ASCE/SEI 7-05 are used to consider the site-specific conditions.

In the response, MHI gave several reasons why ASCE/SEI 7-05 requires the gap displacement calculated based on the elastic analysis be amplified by a deflection amplification factor. However, MHI failed to mention that one of the main reasons for applying an amplification factor to the displacement calculated based on the elastic analysis is to account for the effect of concrete cracking and the p-delta effect. One can avoid using this amplification factor by performing a nonlinear analysis that takes the concrete cracking into consideration. For the US-APWR standard plant MHI calculated the displacement based on the lump-mass stick model which is an elastic analysis, and the effect of concrete cracking is not considered. However, the staff notices that the major lateral stiffness of the US-APWR plant comes from the shear walls, and in its response to Question 3.8.4-20 of this RAI, MHI indicated that shear walls of the USAPWR standard plant will crack. As a result of this, the lateral stiffness of the plant structure is reduced and the lateral displacement will be increased. Therefore, the effect of concrete cracking should be accounted for in the displacement calculation. MHI stated that the requirements of SRP 3.7.1 and 3.7.2 are more stringent than those of ASCE/SEI 7-05, and the staff agrees with MHI on this point, and that is why MHI is requested to consider the concrete cracking. The staff realizes that ASCE/SEI 7-05 may not be applicable for the standard seismic design of US APWR seismic Category I and II buildings. Finally, MHI did not address the question in the last sentence in which MHI is requested to consider the effect of the differential settlement at the basemat in the lateral displacement calculation.

The applicant is requested to provide the following information:

1. If the applicant does not want to follow the methodologies used in ASCE/SEI 7-05 to account for the concrete cracking; i.e., applying an amplification factor to the elastic solution, the applicant is requested to perform an analysis considering the effect of concrete cracking.

The applicant is requested to address the last sentence in the question, which is to consider the effect of the differential settlement at the basemat in the lateral displacement calculation.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

The design of US-APWR standard plant structures is based on seismic responses analyses of the dynamic models of US APWR structures considering the effects of soil-structure interaction (SSI). The review of the seismic response analyses presented in Revision 1 of the US APWR DCD brought the following questions regarding:

- the development of adequate acceleration time histories compatible to the US APWR CSDRS used in the analyses as input design ground motion;
- the consideration of generic soil profiles that can provide an adequate representation of the site conditions at the candidate sites within continental US
- an adequate consideration of the frequency dependence of the SSI
- ability of the models to adequately represent the dynamic properties of the structures and address effects of concrete cracking on the seismic response.

As a result a set of SASSI analyses will be performed on the R/B complex and the model of the bounding PS/B configuration. The SASSI analyses will employ improved time histories, generic soil profiles with layering effects, and modeling enhancements which consider frequency dependence of the SSI as described in the recently issued technical report MUAP-10001, Revision 0, "Seismic Design Bases of the US-APWR Standard Plant". The modeling and analysis methodology are described in the report but are summarized as follows. The results of the SASSI analyses will be presented in a subsequent technical report.

The enhancements to the R/B complex include use of a FE model for the basement (below-grade) portion of the R/B. The modeling enhancements also include addition of single degree of freedom (SDOF) models, representing the out-of-plane response of flexible slabs and walls, into the lumped mass stick models of the R/B complex superstructure. The enhancements to the R/B complex model assure that adequate degrees of freedom are met to capture seismic response in the high frequency range and to address cracking effects (in-plane and out-of-plane) for reinforced concrete.

To evaluate cracking and address the effects in the R/B complex model, an evaluation of member stress levels under the service load state (unfactored loads) is first made. For members with uncracked sections/elements, the stiffness is directly obtained from the concrete linear elastic properties and the section or element geometric dimensions.

Where flexural and flexure-dominated members (such as slabs or girders) are identified as cracked, the provisions of ACI 349-01, Subsections 9.5.2.3 and 9.5.2.4, are used to calculate an effective cracked moment of inertia. The calculations provide the reduction factor for the gross moment of inertia.

The provisions of ACI 349-01 are also used to evaluate the cracking of the shear walls due to out-of-plane bending. If the bending stress level in the shear wall is higher than the concrete cracking stress, the reduction factor for flexural rigidity in Table 3-1 of ASCE 43-05 (Reference 14) is used after being validated using the ACI provisions. For shear walls with in-plane shear stress levels higher than the nominal concrete shear capacity, the stiffness reduction factor in Table 3-1 of ASCE 43-05 is used to calculate the cracked in-plane stiffness properties. For shear walls with in-plane shear stress levels lower than the nominal concrete shear capacity, the uncracked in-plane stiffness properties are considered in the dynamic analysis.

For the PS/B FE model and R/B basement which is modeled with finite elements, the elastic modulus and thickness values assigned to the elements are adjusted to reflect cracked concrete properties where cracking occurs, without changing the axial stiffness or mass.

Thus concrete cracking effects are therefore accounted for as described above. The impact of concrete cracking on the magnitude of the lateral displacements is therefore incorporated into the analyses of the R/B complex and the PS/B. Lateral displacement calculations will also include effects due to differential settlement on the overall computed displacements. The current DCD limits for acceptable settlement are given in Chapter 2 Table 2.0-1.

Also, the effects of potential concrete cracking on structural stiffnesses will be considered in the development of local vibration modes for the ISRS. Updated ISRS, derived with consideration given to potential concrete cracking, will be presented in updated seismic analysis reports MUAP-08005 and MUAP-08002 for the R/B and PS/Bs, respectively.

Impact on DCD

A later revision of the DCD will reflect the results of the analyses discussed above.

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-34:

In its response to Question 3.8.4-4, MHI states that hydrodynamic loads associated with the impulsive mode were included in the analysis. They state that the Housner method as contained in Technical Information Document (TID) TID-7024 was used for computing both the impulsive and convective pressure loads. Some modifications to the equations in the Housner method were made for use in the US-APWR. The formulas used are stated in this response, as well as a figure showing the pressure distributions from convective and impulsive pressure loads.

MHI indicated that both the impulsive mode and the convective mode are included in the hydrodynamic loads. This response is considered to be acceptable. However, the staff suggests that the word "sloshing" be deleted from the sentence "Hydrodynamic loads due to seismic sloshing are calculated ..." to eliminate any confusion. Also, MHI is requested to provide technical information that shows how the maximum response acceleration of the floor, x, (defined in Table 1) is calculated.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

Sections 3.7.3.9 and 3.8.4.2 will be revised to eliminate use of the term "sloshing."

The $\ddot{X}$ shown in Table 1 in the previous response to RAI 342-2000 Question 3.8.4-4 for impulsive pressure calculation shall be the maximum horizontal spectra acceleration(s) associated with the floors at the support points of the reinforced concrete cavities and pits listed in Subsection 3.7.3.9. The $S_A(\omega_1)$ shown in Table 1 for convective pressure calculation shall be the horizontal spectra acceleration for ω_1 with 0.5% of critical damping (i.e., considering fluid damping).

Impact on DCD

See Attachment 1 for the mark-up of DCD Tier 2, Section 3.8 changes to be incorporated.

- Replace the fourth sentence in the paragraph of Subsection 3.8.4.3.2 with the following: "Impulsive and convective hydrodynamic loads due to seismic events are determined as discussed in Subsection 3.7.3.9, and included in the earthquake load as described in Subsection 3.8.4.3.6."

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

- Replace the last paragraph of Subsection 3.7.3.9 with the following:

  "Hydrodynamic loads on these liquid-retaining vessels are determined using methods that conform to the provisions of Subsection II.14 of SRP 3.7.3 (Reference 3.7-35) and guidance of ASCE 4 98, Subsection 3.5.4 (Reference 3.7-9). 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). The seismic analysis of convective hydrodynamic effects also considers the maximum wave oscillation with respect to the potential of creating flooding, which is discussed in Section 3.4."

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-35:

In its response to Question 3.8.4-5, MHI states that a description of the calculation of dynamic soil pressures is given in their response to Question 3.7.2-13. As noted in that response, the soil was considered as fully saturated.

In the response to Question 3.8.4-5, MHI refers to their response to Question 3.7.2-13, item 4, of RAI 212-1950, Revision 1 (dated 5/7/2009, MHI Ref: UAP-HF-09188, ML091320443). In that response, MHI indicated that the dynamic soil pressure was calculated based on Wood's study. The staff finds that the Wood's solution is based on elastic wave theory and the effect of water table is not considered. For the US-APWR standard plant design, the water table is 1 ft below the nominal plant grade. So, for underground walls, the soil is submerged under water from 1 ft below the surface. The applicability of using Wood's equation to calculate the dynamic soil pressure is, therefore, questionable. In addition, the vertical component of the earthquake motion is not considered in Wood's solution. The applicant is requested to provide numerical data to prove that the effect of water table is negligible and that the Wood's equation can be applied to the US-APWR. In addition, Wood's solution does not consider the earth pressure due to the rotation of the wall at its base. The applicant is requested to provide data to show that this pressure is negligible.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

The same questions and information requests were asked by the NRC Staff in RAI 496-3735 Question 03.08.05-30. See MHI response for RAI 496-3735 Question 03.08.05-30.

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

2/19/2010

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

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-36:

In its response to Question 3.8.4-8, MHI disagrees with the staff's position stated in this question and presents arguments intended to support their approach in selecting the fraction of live or snow loads to be used in the seismic analyses. MHI notes that neither Section 12.7.2 nor Chapter 2 of ASCE/SEI 7-05 requires roof live load to be evaluated concurrently with roof snow load in the design load combinations.

The staff notes that in the response to this question, MHI states "mass equivalent to 25 percent of the floor design live load and 75 percent of the roof design snow load ..." whereas in DCD it reads "mass equivalent to 25 percent of the floor design live load or 75 percent of the roof design snow load". MHI is requested to change the current wording in the DCD, "or 75 percent" to match the wording in their response, which is "and 75 percent".

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

MHI will incorporate the NRC Staff request to clarify the DCD by revising "or" to "and" on the use of live and snow loads on the seismic analyses.

Impact on DCD

See Attachment 1 for the mark-up of DCD Tier 2, Section 3.8 changes to be incorporated.

- Replace the second sentence of the second paragraph in Subsection 3.8.4.3.6.2 with the following: "In addition to the dead load, 25% of the floor live load during normal operation and 75% of the roof snow load, whichever is applicable, are also considered as accelerated masses in the seismic models."

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

- Replace the second sentence of the second paragraph in Subsection 3.7.2.3.11 with the following: "For example, 25% of the design floor live loads during normal operation (ASCE 7, Subsection 12.7.2 [Reference 3.7-24]) and 75% of the roof snow load, whichever is applicable depending on the specific location in the building or structure, have been considered in computing tributary mass at node points in the seismic models."

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-37:

In its response to Part (a) of Question 3.8.4-11, MHI provides an explanation as to how the time histories are converted to equivalent static forces. MHI states that the maximum story shears which result from time history analysis are used to develop the SSE loads, and describes these analyses. For Part (b) MHI describes when the equivalent static forces are applied to the FE model. Several tables are provided that show the SSE floor rocking moments that are calculated from the results of the time history analyses. For Part (c) MHI presents the rationale for using the FE model fixed at elevation 3'-7". It is stated that for most of the load combinations considered the approach produces conservative results.

The staff notes that in their response to Question 3.8.4-26 MHI states that they will perform a confirmatory analysis to show that sufficient design margin exists to cover the effects of interaction between the subgrade, basemat, and the R/B superstructure. The applicant is requested to provide the staff with the results of that confirmatory analysis.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

The confirmatory analysis will be completed as part of the validation of the R/B complex stick models. The analysis results will be presented in a subsequent technical report.

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.

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-38:

In its response to Part (a) of Question 3.8.4-12, MHI describes how the results of the seismic response analysis of lumped mass stick models serve as the basis for the development of the in-structure response spectra (ISRS). MHI cites the recommendation of the ASCE Standard 4 Working Group in dealing with uncertainties in frequency variation and other factors. For Part (b) MHI presents the rationale that is intended to support their approach for design and analysis, which is that the concrete is assumed to be not cracked for in-plane seismic response. A major factor claimed to support this position is that the primary lateral force resisting system for the reactor building (R/B) is comprised of shear walls, which are design to have low nominal stresses. For Part (c) the response includes a description of the types of elements used in the FE models that are used in the design of structural members of the R/B and power source buildings (PS/B) complexes.

The applicant is requested to provide the following information:

(a) In the response, MHI stated that "Frequencies in the range of 4.5 Hz to 12 Hz characterize the dynamic properties of the lumped mass stick models used for these seismic response analyses as shown in Tables 3H.3-1, 3H.3-2 and 3H.3-3 in Appendix 3H of the DCD." The staff noticed that the data presented in Tables 3H.3-1, 3H.3-2 and 3H.3-3 in Appendix 3H of the DCD are the modal frequencies of the R/B, PCCV, and Containment Internal Structures lumped Mass Stick models, respectively, not modal frequencies of the corresponding 3D FE models. The staff further notices that no studies were performed in Appendix 3H to assess the variation of the structural frequencies due to the changes in concrete stiffness. FE analyses use the 3D models, not the lumped mass stick models. The applicant is requested to perform an analysis that considers the effect of the uncertainties in the elastic modulus and shear modulus of concrete.

(b) In the response to Part (b) of the question, MHI states that "The analyses that serve as basis for the preliminary design of the R/B complex structures do not consider the effects of concrete on the in-plane seismic response of the R/B complex and the load path redistribution in the reinforced concrete members." This sentence is confusing. The applicant is requested to clarify the meaning of this sentence.

(c) MHI also states in their response to this question that "The implemented modeling approach that neglects to consider the cracking of the walls is deemed to be

> satisfactory for the determination of shear wall design forces since the concrete cracking does not significantly affect the in-plane response of the structures." The staff disagrees with this position and MHI is requested to provide data to support their argument that the concrete cracking does not significantly affect the in-plane response of the structures.

MHI further states in their response that "The consideration of a wide range of generic subgrade conditions is deemed sufficient to address the possible variations of in-plane seismic response of the structures due to concrete cracking." The staff considers this explanation to be not acceptable. Consideration of wide range of generic subgrade and the effect of concrete cracking on the structural response are two different things. Considering one effect is not necessary addressing the other effect. The applicant is requested to address this issue and provide the rationale that supports the use of analyses that do not include explicitly the effects of concrete cracking on the structural response.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

Part (a) and Part (c)

Tables 3H.3-1, 3H.3-2 and 3H.3-3 in Appendix 3H have been removed from Revision 2 of the DCD.

Seismic analysis and modeling enhancements are being made for the R/B complex and the PS/Bs as discussed in the response to Question 3.8.4-33 of this RAI. The enhancements will address variations of the structural frequencies due to changes in stiffness caused by concrete cracking.

Part (b)

The statement in the response to Question 3.8.4-12 is in error. It should have stated the following:

"The analyses that serve as basis for the preliminary design of R/B complex structures do not consider the effects of concrete **cracking** on the in-plane seismic response ..."

However, as stated tin the response to (a) and (c) above, additional analyses are being performed to evaluate the effects of concrete cracking. The previous response to Question 03.08.04-12 is therefore no longer valid.

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-39:

In its response to Part (a) of Question 3.8.4-13, MHI states that the controlling load combination case used in determining steel reinforcement in the walls will be added to the DCD in Revision 2. Several such tables are shown in this response. MHI notes that load combinations with thermal loads are controlling. For Part (b) MHI states that the highest stressed shear wall in the R/B is the south exterior wall. For Part (c) MHI states that the concrete cracking stress in some shear walls is exceeded. MHI states that the effects of cracking will be addressed in Revision 2 of the DCD.

MHI indicated that a re-analysis will be performed which will consider the effect of concrete cracking, and the re-analysis results will be included in Revision 2 to the DCD. Prior to submitting Revision 2, MHI indicated that other factors will affect what is included in the Revision. Now that Revision 2 has been submitted, the applicant is requested to review and update its response to question 3.8.4-13.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

Updated information in the tables provided in the response to Question 3.8.4-13 has been included in revision 2 of the DCD as Tables 3.8.4-6 through 3.8.4-14. Section 3.8.4.4.1.1 of the DCD provides a listing of the representative seismic category 1 structural elements of the R/B. Tables 3.8.4-6 through 3.8.4-14 are arranged by structural component and by zones and areas that correspond to those discussed in Section 3.8.4.4.1.1 of the DCD.

Analyses are currently being performed to evaluate the effects of concrete cracking as discussed in an interim technical report issued in February 2010 and as described in the response to Question 03.08.04-33 of this RAI. The results of the analyses will be documented in a subsequent technical report. The report will include tables similar to those provided in revision 2 of the DCD. It is anticipated that there will be little or no change in the required reinforcing from that shown in Tables 3.8.4-6 through 3.8.4-14. The new tables will also be included in revision 3 of the DCD.

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

2/19/2010

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

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-40:

In its response to Question 3.8.4-14, MHI states that the DCD will be revised to add horizontal cross section views of the R/B and PS/B shear walls to the vertical cross section views currently shown in the DCD.

The applicant is requested to provide the following information:

1. In its review the staff notices that in Figure 3.8.4-13 in the MHI's response to this question, the horizontal cross section for zone 1 (EL-26'-4" to EL-14'-2") shows shear reinforcement (stirrups) is provided. This suggests that the shear stresses are high in this area. Are boundary elements used in this area? If yes, the applicant is requested to provide the re-bar layout for the boundary elements. If not, provide the rationale for not using the boundary elements.

The staff also notices that the vertical cross section shown in Figure 3.8.4-13 in the response does not match the description given in Table 3.8.4-9 of the MHI's answer to Question 3.8.4-13 of this RAI. For example, zone 1 in Figure 3.8.4-13 is in the range of EL-26'-4" to EL-14'-2"; whereas in Table 3.8.4-9 it is from EL 3'-7" to EL 25'-3". The applicant is requested to clarify this discrepancy.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

Boundary elements are not utilized because the aspect ratio of the wall on column line CP is less than 2, as permitted by ACI 349-01 Section 21.6.1. A clarification which confirms the intent of ACI 349-01 Section 21.6.1 is contained in ACI 349-06 Section 21.7.6.1.

DCD Table 3.8.4-9 shows the reinforcement provided for the south external wall of the R/B, not the PS/B. DCD Table 3.8.4-12 corresponds to the vertical cross-section shown in Figure 3.8.4-13.

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

2/19/2010

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

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-41:

In its response to Question 3.8.4-19, MHI states that the thermal behavior of the basemat concrete pour is the most important characteristic in dealing with such massive concrete structures. MHI describes several provisions that will be taken to control heat generation, volume change effects, and concrete cracking control. These provisions include such things as the use of low heat cement, use of pozzolans, pre-cooling of the mix water, etc. Other techniques to be employed include, among others, limiting the size of the pour, using a checkerboard pattern of concrete placement, and others.

Considering the numerous special precautions and provisions cited in MHI's response to this question that are to be taken for the placement of concrete in the massive basemat for the R/B and PCCV complex, it seems to the staff that this constitutes "special construction techniques". Therefore, the applicant is requested to revise the DCD by adding appropriate wording to the DCD Subsection 3.8.4.6.3 that addresses these special precautions and techniques that are required for the massive concrete pour for the RB and PCCV basemat. In addition, the applicant is requested to add a COL item to the DCD that requires the COL Applicant to develop plans for the proper placement of these massive concrete pours utilizing well accepted construction practices.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

DCD Subsection 3.8.4.6.3 will be revised to address special precautions and techniques that are required for massive concrete pours.

The COL Applicant incorporates by reference (IBR) DCD Subsection 3.8.4.6.3, and therefore commits to special construction techniques as stated in DCD Subsection 3.8.4.6.3. No additional COL item is therefore necessary to require the COL Applicant to develop plans utilizing well accepted construction practices.

Impact on DCD

See Attachment 1 for the mark-up of DCD Tier 2, Section 3.8, changes to be incorporated.

- Replace the paragraph in Subsection 3.8.4.6.3 with the following:

  "Standard provisions of ACI are to be applied where necessary to address issues related to the use of massive concrete pours. As stated in Subsection 3.8.4.6.1.1, volume changes in mass concrete are controlled where necessary by applying measures and provisions outlined in ACI 207.2R (Reference 3.8-52) and ACI 207.4R (Reference 3.8-53). The following summarizes the construction techniques commonly associated, either singularly or in combination, with massive concrete pours such as basemats:

  - Limit the size of concrete pour.
  - Use a checkerboard pattern of concrete placement in a single lift. To avoid a weak horizontal shear plane, a double lift placement of concrete, in general, is avoided. However, when it is absolutely needed to have two lifts, adequate design considerations and also, in general, shear stirrups are provided.
  - Schedule concrete pours for the most advantageous day and time to control temperature rise in the concrete.
  - Post-cooling can be performed by cooling the freshly placed concrete with running chilled water lines in the concrete."

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

2/19/2010

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

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-42:

In its response to Parts (a) and (b) of Question 3.8.4-20, MHI presents the equations used to calculate the reduction factor of flexural stiffness for the cracked concrete section to the uncracked section of a 48 in. thick steel concrete (SC) module wall. MHI states that by using the same methodology, the stiffness reduction factors for the 39 in. and 56 in think walls are calculated, and all of the results are shown in a table in the response. References are cited to justify the values of the reduction factor, α, as stated. These references are in Japanese technical journals.

In examining the data presented in Table 1 of MHI's response to this question, the staff notices that the data for the reduction factors of axial stiffness and shear stiffness are far below 0.5. This trend is also observed in Table 3 for the data for flexural stiffness. Therefore, using the factor of 0.5 overestimates the shear wall stiffness. The applicant is requested to provide the rationale that supports the use of 0.5 for the reduction factors of axial stiffness and shear stiffness when many values shown are far below 0.5.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

The response to RAI 342-2000 Question 3.8.4-20 included an illustrative calculation for locating the neutral axis in a SC wall section when cracking occurs under pure flexural loading. With respect to combined flexural, axial, and shear loading, the location of the neutral axis may shift based on the magnitude and direction of the applied loading, and also cracking may not occur along the full length or width of the wall section. Therefore the reduction factor due to cracking within a section may vary along its length or width and may vary with the loading magnitude and direction. The approximate stiffness reduction for an SC module at a simulated level of SSE loading was observed from testing in DCD Reference 3.8-27 to be approximately 30%. These results, as well as the illustrative calculations included in the response to Question 3.8.4-20, indicate that the reduction in stiffness for SC modules is less than that for traditional reinforced concrete. Other experimental testing cited in the response to Question 3.8.4-20identified flexural stiffness reductions of approximately 0.5 with respect to thermal loading. Based on the stiffness reductions that were observed/measured during testing, 0.5 was previously determined to be an appropriate lower bound value for considering potential reduction in flexural stiffness due to cracking for individual SC module sections. Further, reductions in shear and axial stiffness for SC modules would be the same or less, based on comparison to guidance for reinforced concrete given in Table 3-1 of ASCE 43.

As stated in the response to RAI 491-3733 Question 3.8.3-16, MHI will perform parametric studies of the containment internal structure seismic response to confirm the effects on flexural, shear, and axial stiffness due to potential cracking and the sensitivity of the seismic response due to stiffness reductions. The studies will investigate varying stiffnesses in conjunction with the generic soil profiles being used for the standard plant. The parametric studies will be used to confirm that an appropriate stiffness reduction factor is applied for each load combination, and for each type of loading, in the pseudo-static structural design of the containment internal structure. This approach will assure that forces and moments adequately envelope forces and moments resulting from combined mechanical and thermal loads. The results of the parametric studies will be included in a technical report that is scheduled to be issued in April 2010.

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.

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-43:

In its response to Question 3.8.4-24, MHI provides a description of the restraints to be used with masonry walls, including the use of design code requirements (ACI 349 and RG 1.199). The design details are stated to be in MHI's response to Question 03.09.02-34 of RAI 214-1920. The restraints are designed using the equivalent static method described in DCD Subsection 3.7.3.1. MHI states that detailed design is dependent on the revised in-structure response spectra (ISRS) as discussed in MHI's response to Question 3.7.2-8 of RAI 212-1950.

In its review of MHI's response to Question 3.9.2-10 of RAI 205-1584, the staff noticed that MHI stated that the anchorage design for the restraint assemblies for masonry walls will be consistent with design approaches described in MHI's response to Question 03.09.02-34 (RAI 214-1920) and Question 3.9.2-10 (RAI 205-1584). In its evaluation of those responses, the staff requested MHI to provide detailed technical information that will show how the criteria cited in these responses will be satisfied.

MHI's response to Question 3.8.4-24 is not completely acceptable. The applicant is requested to address the issues identified in the staff's review of the questions cited above for Section 3.9.2 involving the use of the equivalent static load method. In addition MHI is requested to include in the DCD a list of anchorage types that were specified in its response to Question 3.9.2-10 in RAI 205-1584.

References:

MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558

MHI response to RAI 214-1920, dated 4/30/2009, MHI Ref: UAP-HF-09190, ML091240403

MHI response to RAI 212-1950, dated 3/30/2009, MHI Ref: UAP-HF-09113, ML090930727

MHI response to RAI 205-1584, dated 4/30/2009, MHI Ref: UAP-HF-09184, ML091240113

ANSWER:

A) In the design of masonry restraints, MHI agrees to take into account the flexibility of the support anchorages as committed to in the responses to RAI 205-1584 Question 3.9.2-10 and RAI 214-1920 Question 3.9.2-34.

B) The staff's questions about the use of the equivalent static load method and the inclusion of anchorage type listing into the DCD were also requested by the staff in RAI 498-3782 Question No. 03.09.02-59. See MHI's response to Question No. 03.09.02-59 for details.

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-44:

In their response to Part (a) of Question 3.8.4-26, MHI provides their rationale for not using the whole R/B model in the first row case in Table 3.8.4-5 of the DCD. MHI refers to their response to Question 3.8.4-11 of this RAI in which the question is similar to this current question. MHI contends that by adding a design margin of 20-30 % to member seismic forces, this allows the use of the fixed-base model, which is more cost effective than using the whole model. MHI states that they will perform a confirmatory analysis using the R/B whole model to validate the fixed-base analysis. For Part (b) MHI describes the three-dimensional NASTRAN finite element model of the R/B whole model. The R/B whole model employs soil springs as described in this response.

In the response, MHI claims that the fixed-based model is more cost-effective, and a confirmatory analysis will be performed to assess its accuracy. The applicant is requested to provide the staff with the results of that confirmatory analysis to allow the staff to complete its determination of the acceptability of the applicant's original response to this question.

Reference: MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558.

ANSWER:

The confirmatory analysis will be completed as part of the validation of the R/B complex stick models which will be presented in a subsequent technical report. The DCD will be appropriately revised if the results of the confirmatory analysis do not validate the modeling approach.

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-45:

In its response to Question 3.8.4-29, MHI's detailed answers are organized to follow the order of the staff's question as follows:

1. MHI agrees to reference the requirements of ASME AG-1-2003 for the HVAC ductwork.
2. MHI states that methods used to qualify local stresses reinforced and unreinforced openings of ductwork are in accordance with ASME AG-1-2003 and the AISI Specification for the Design of Cold-Formed Steel Structural Members, using either simplified or detailed design as appropriate.
3. MHI states that it was not intended to develop a subset of HVAC with special restrictions. All HVAC systems are qualifies for their associated loads and operating conditions. However, some systems have loads and/or conditions that exceed parameters used in sizing pre-qualified members. MHI will revise the DCD Appendix 3A, Section 3A.1.1 to show those HVAC systems that require qualification to specific loads and operating conditions.
4. MHI notes that this is the same question as asked by the staff in Question 3.8.4-30, Items 4 and 8. MHI explains that the AISI Specification specifies the types of loads used for design, but not the actual loads and load combinations. The reference to AISI and AISC N690 is intended to allow additional flexibility in the subsystem support system of cold-formed steel members are selected for use. MHI confirmed the original commitment in the DCD to use AISC N690 for HVAC duct supported is maintained. MHI will revise DCD Appendix 3A, Section 3A.3.1 to reflect ductwork loads that are defined in AG-1-2003 for the ductwork, as well as adding load combinations for Service Loads A, B, C, and D.
5. MHI identified DCD Tier 2 Subsections 3.7.2.1 and 3.7.3 as the appropriate references in the DCD. MHI presents the rational supporting the use of simplified design approach or a detailed design approach.
6. MHI states that the "Simplified Design Approach" uses the principles of equivalent static analysis. The design of HVAC ducts and duct support systems conforms to SRP 3.7.3 II.1 and SRP 3.7.2 II.1. MHI also refers to their responses to questions in RAI 213-1951 for further discussion.
7. MHI states that wherever possible, standard designs of HVAC ductwork and supports are utilized. MHI describes how the choice of which seismic analysis method to use is made.

MHI then describes how the various ways the response spectrum method is carried out, including the rationale for each method used.

8. MHI refers to their response to Question 3.9.2-40 in RAI 214-1920 and Question 3.8.1-14 of RAI 223-1996, Item 3 for this part.
9. MHI explains that the values of loads used are consistent with the operational parameters of a particular system. Overpressure loads due to rapid damper closure are evaluated for applicable load combinations.
10. MHI proposes to change the DCD from "as a general rule" to "unless other wise justified by analysis".
11. MHI refers to two related questions asked by the staff raising similar issues, specifically, Question 3.9.2-10 in RAI 205-1584 and Question 3.9.2-34 of RAI 214-1920. The response to this current question describes the several different types of base plate/anchor bolt assemblies. MHI will make several changes to the DCD in response to several issues raised in this and the other responses cited in this response.

With the exception of Parts 3, 6, and 11 of the question, the staff finds the applicant's responses to be acceptable. The applicant is requested to provide the following information for Parts 3, 6, and 11 of the question:

1. In their response to Part 3 of the question, MHI fails to describe specifically what HVAC subsystems are subject to the stricter criteria. The statement that when it is appropriate the subsystems are so designed is vague and non-specific. MHI is requested to provide a list or description of the HVAC ducts that need to be designed to the stricter standards/criteria. In addition, the change proposed by MHI to DCD, Appendix 3A, Subsection 3A.1 is to indicate those HVAC subsystems that do not conform to criteria allowing use of standard members and maximum span length, must be designed to satisfy these specific loads and operating conditions associated with the stricter criteria. The staff finds that this proposed revision to the DCD is still non-specific and somewhat vague. MHI is requested to clarify this by showing the parameters used for the standard design and how any given HVAC Subsystem is compared to these parameters to decide when it is necessary to use the stricter criteria.
2. In their response to Part 6 of the question, MHI refers to their answers to Questions 3.7.3-02, 3.7.3-03, 3.7.3-04 and 3.7.3-15 of RAI 213-1951. The staff reviewed these answers and was not able to find answers to the issues raised in the current question. The applicant is requested to provide justification that HVAC and HVAC support systems can be represented by a simple model and prove that the results obtained from the equivalent static load method are conservative. Also, the applicant is requested to describe how the relative motion between all points of supports is considered in the analysis.
3. In their response to Part 11 of this question, MHI cites their response to Question 3.9.2-10 in RAI 205-1584 and Question 3.9.2-34 of RAI 214-1920 as applicable to this current question. The staff finds that in response to Question 3.9.2-10, MHI notes that the equivalent static load method of analysis is the preferred method for use in seismic analysis of subsystems such as equipment and piping anchorages. MHI states further that per SRP 3.9.2, Revision 3, March 2007, "Dynamic Testing and Analysis of Systems, Structures, and Components", the SRP Acceptance Criteria 2.A.(ii) states, "An equivalent static load method is acceptable if:
   1) There is a justification that the system can be realistically represented by a simple model and the method produces conservative results in responses.
   2) The design and simplified analysis accounts for the relative motion between all points of supports.

3) To obtain an equivalent static load of equipment or components which can be represented by a simple model, a factor of 1.5 is applied to the peak acceleration of the applicable floor response spectrum. A factor of less than 1.5 may be used with adequate justification."

MHI is requested to provide detailed technical information that demonstrates how the three criteria cited above concerning the use of the equivalent static method are met.

References:

MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558

MHI response to RAI 223-1996, dated 4/14/2009, MHI Ref: UAP-HF-09161, ML091060749

MHI response to RAI 213-1951, dated 3/27/2009, MHI Ref: UAP-HF-09114, ML090910119

MHI response to RAI 213-1951, dated 4/24/2009, MHI Ref: UAP-HF-09189, ML091180437

MHI response to RAI 214-1920, dated 4/30/2009, MHI Ref: UAP-HF-09190, ML091240403

MHI response to RAI 212-1950, dated 3/30/2009, MHI Ref: UAP-HF-09113, ML090930727

MHI response to RAI 205-1584, dated 4/30/2009, MHI Ref: UAP-HF-09184, ML091240113

ANSWER:

1. It is MHI's intention and plan on the US APWR to design and construct HVAC systems including their subsystem duct supports, to use standard member sizes and maximum duct span lengths. MHI's original commitment in DCD subsection 3.A.1.1 and their initial response to part 3 with the proposed change to the DCD was made to assure that all HVAC systems, including their supports, are designed to meet their specific load and operating conditions in compliance with NRC SRP 3.9.2 and SRP 3.7.3 requirements for subsystem design. As stated in MHI's initial response to part 3, it is not our intention "to describe a subset of HVAC systems with special restrictions" in DCD Appendix 3A, Subsection 3.A.1.1. It is MHI's expectation that there will be very few, if any, HVAC system(s) which would be outside of the standard design. It is not known at this time if there are any HVAC system(s) outside of the standard design since this detail information is not available until the final design phase of HVAC systems design is essentially complete.

2. MHI response to RAI 213-1951 questions 03.07.03-2 and 03.07.03-15 provided their definition of "simple models" used in the design/analysis of HVAC duct/duct support subsystems employing the equivalent static analysis method. "Simple models" can be considered / defined to be simple linear frame-type structures consisting of members that are physically similar to beams and columns. HVAC duct/duct supports are normally constructed of standard structural shapes (such as angles, wideflanges, HSS, etc.) into simple linear frame-type structures (such as trapezes, cantilever members from ceiling, walls and floors, etc). Simple finite element models of these types of structures can be constructed using beam and axial (tension and/or compression column) elements and used in their analysis and design.

   HVAC duct/duct support subsystems are "flexible" systems. The duct is connected to their structural support through bolting or welding. Due to the layout configuration of the ductwork and the installation of flexible connections, such as bellows, within the ductwork, the differential displacements between duct supports are accommodated. Where system layout/configuration and flexible connections do not relieve relative support displacements, additional forces and moments are considered using absolute summation of relative displacements.

3. The same question was asked by the NRC Staff in RAI 498-3732 question 03.09.02-59. See MHI response in RAI 498-3732 question 03.09.02-59.

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-46:

In its response to Question 3.8.4-30, MHI's detailed answers are organized to follow the order of the staff's question as follows:

1. MHI describes the methodology used to determine conduit spans, and explains that it is an iterative procedure. Standard conduit spans are determines by hand calculations.
2. MHI's refers to their response to Question 3.9.2-40 in RAI 214-1920 and Question 3.8.1-14 of RAI 223-1996.
3. MHI discusses the loads used to design conduit supports and determine span lengths, and states that they will make changes to the DCD to clarify these loads.
4. MHI's response is the same as they gave for Question 3.8.4-29 in this RAI.
5. For Part (a) MHI describes the specific subsections in the DCD for design and analysis procedures. For Part (b) MHI refers to their response to Question 3.7.1-5 in RAI 211-1946.
6. For Part (a) MHI provides a definition of "Nominal Size Weights" and describes the meaning of "flexible conduit". For Part (b) MHI states that the design and analyses conform to SRP 3.7.3 II.1 and SRP 3.7.2 II.1.
7. Refer to MHI's response to Question 3.9.2-41 in RAI 214-1920.
8. Refer to MHI's response to Question 3.8.4-29 in this RAI.
9. MHI states that thermal loads due to an accident load case are considered if applicable.
10. Refer to MHI's response to Question 3.8.4-29, Item 11 for the response to this part of the question.

MHI states that they will make appropriate changes to the DCD to reflect all of the resolutions described above.

With the exception of Parts 5(b), 6(b), 7, and 10 of the question, the staff finds the applicant's responses to be acceptable. The applicant is requested to provide the following information for Parts 5, 6, 7. and 10 of the question:

1. In its response to Part 5(b) of Question 3.8.4-30. MHI refers to their answer to Question 3.7.1-5 in RAI 211-1946. The staff reviewed the MHI answer to Question 3.7.1-5 in RAI 211-1946 where MHI indicated that Table 3.7.3-1(a) and Table 3.7.3-1(b) of DCD will be changed to include the damping ratio for full conduits and empty conduits. However, the staff was not able to find the actual damping value used in the DCD seismic analysis. The applicant is requested to provide the actual damping value used in the DCD seismic analysis.
2. In its response to Part 6(b) of Question 3.8.4-30. MHI refers to their answers to Questions 3.7.3-02, 3.7.3-03, 3.7.3-04 and 3.7.3-15 of RAI 213-1951. The staff reviewed these responses and was not able to find answers to the question asked. MHI did not provide any justification that conduit and conduit support systems can be represented by a simple model and prove that the results obtained from the equivalent static load method are conservative. Also, MHI did not answer how to account for the relative motion between all points of supports. The applicant is requested to provide the following information:
    a. Provide justification that conduit and conduit support systems can be represented by a simple model, and shows that the results form the equivalent static load method are conservative.
    b. Provide an explanation that shows how relative motions between all points of support are accounted for in the analysis.
3. In its response to Part 7 of Question 3.8.4-30. MHI refers to MHI answer to Question 3.9.2-41 of RAI 214-1920. The staff reviewed that answer, and found that that answer also referred to Question 3.7.3-01 of RAI 212-1950. The staff reviewed that answer as well. In the answer to Question 3.7.3-01 of RAI 212-1951, MHI indicated that DCD will be changed to specify that the absolute sum method will be used in the Independent Support Motion (ISM) method to comply with the recommendation in Section 2.4 of NUREG-1061, Volume 4. However, MHI did not answer how to consider the relative displacement at the support points if the Uniform Support Motion (USM) method is used. The applicant is requested to describe how the relative displacements at the support points for the USM method are considered in the analysis.
4. In its response to Part 10 of Question 3.8.4-30, MHI refers to their responses to Questions 3.9.2-10 in RAI 205-1584 and 3.9.2-34 in RAI 214-1920. The staff reviewed the MHI answers to Question 3.9.2-10 in RAI 205-1584 and 3.9.2-34 in RAI 214-1920. In MHI answer to Question 3.9.2-10 in RAI 205-1584, MHI indicated that there will be cast-in-place anchor bolts used in the US-APWR standard plant. If this is the case, the applicant is requested to change the DCD Appendix 3F, Subsection 3F.6.6 to include the case-in-place anchor bolts. In the response to Question 3.9.2-34 in RAI 214-1920, MHI indicates that either a hand calculation method or a finite element analysis method will be used to determine the stiffness of the anchorage. This answer is acceptable. However, in order to match that MHI answer and the text in DCD, the applicant is requested to change the sentence in DCD Appendix 3F, Subsection 3F.6.6 that currently reads "The flexibility of base plate was considered in determine the anchor bolts loads" to "The flexibility of base anchorage was considered in determine the anchor bolts loads." MHI is requested to provide an explanation If they do not agree with this suggested revision.

References:

MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558

MHI response to RAI 223-1996, dated 4/14/2009, MHI Ref: UAP-HF-09161, ML091060749

MHI response to RAI 211-1946, dated 4/23/2009, MHI Ref: UAP-HF-09187, ML091170058

MHI response to RAI 213-1951, dated 3/27/2009, MHI Ref: UAP-HF-09114, ML090910119

MHI response to RAI 213-1951, dated 4/24/2009, MHI Ref: UAP-HF-09189, ML091180437

MHI response to RAI 214-1920, dated 4/30/2009, MHI Ref: UAP-HF-09190, ML091240403

MHI response to RAI 212-1950, dated 3/30/2009, MHI Ref: UAP-HF-09113, ML090930727

MHI response to RAI 205-1584, dated 4/30/2009, MHI Ref: UAP-HF-09184, ML091240113

ANSWER:

1. As stated in the response to RAI 211-1946 question 03.07.01-5, Table 3.7.3-1(a) and Table 3.7.3-1(b) of DCD was revised to include the damping ratio for full conduits and empty conduits. For the conduit subsystem support design on the US-APWR standard design, the envelope of the seismic forces from the governing SSE loading combination derived from the 7% for full conduits and the 5% for empty conduits are conservatively; used.

2. MHI response to RAI 213-1951 questions 03.07.03-2 and 03.07.03-15 provided their definition of "simple models" used in the design/analysis of conduits and conduit support subsystems employing the equivalent static analysis method. "Simple models" can be considered / defined to be simple linear frame-type structures consisting of members that are physically similar to beams and columns. Conduits and conduit supports are normally constructed of standard structural shapes (such as angles, wideflanges, HSS, etc.) into simple linear frame-type structures (such as trapezes, cantilever members from ceiling, walls and floors, etc). Simple finite element models of these types of structures can be constructed using beam and axial (tension and/or compression column) elements and used in their analysis and design.

   Conduits and conduit support subsystems are "flexible" systems. The conduit(s) is (are) connected to their structural support through bolting/clamping. Due to the layout configuration of the conduit (providing an adequate length of conduit between supports or turns in the conduit routing) and/or the installation of flexible conduit, the differential displacement between conduit supports are accommodated. Where system layout / configuration and flexible conduit connections do not relieve relative support displacements, additional forces and moments are considered using absolute summation of relative displacements

3. Section 3.7.3.1.7.1 of the DCD provides the theoretical discussion for the relative movements between support points of raceway system. As stated in MHI's response to RAI 214-1920 question 03.09.02-41, the proposed USM method of analysis, if used for conduit system, conforms to the guidance in SRP 3.9.2.II.2.G and SRP 3.7.3.II.9 and the absolute sum method is used to combine the responses due to the inertia effect and relative displacements at the support points.

4. MHI will incorporate the NRC Staff request to clarify the DCD by revising "plate" to "anchorage" on the second sentence in DCD Appendix 3F, Subsection 3F.6.6.

Impact on DCD

See Attachment 3 for the mark-up of DCD Tier 2, Appendix 3F, changes to be incorporated.

- Replace the second sentence in Subsection 3F.6.6 with the following: "The flexibility of base anchorage was considered in determining the anchor bolt loads."

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

2/19/2010

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 497-3734 REVISION 0**
SRP SECTION:	**03.08.04 - Other Seismic Category I Structures**
APPLICATION SECTION:	**3.8.4**
DATE OF RAI ISSUE:	**12/01/2009**

QUESTION NO. RAI 03.08.04-47:

In its response to Question 3.8.4-31, MHI's detailed answers are organized to follow the order of the staff's question as follows:

1. Refers to MHI's response in Part 7(a) of this question below.
2. Refers to MHI's response to Question 3.8.1-14 in RAI 223-1996.
3. MHI will add reference in the DCD to Institute of Electrical & Electronics Engineers, Inc. (IEEE) 344-1987 and IEEE 344-2004.
4. MHI describes the loads that must be considered in the design of cable trays and their supports. The DCD will be revised to define the construction live load. Thermal loads are considered in cable tray subsystem load combinations, if applicable.
5. Refers to MHI's response to Question 3.8.4-30, Item 4, for the discussion of the applicability of the AISI Specification to the load combinations specified.
6. For Part (a) MHI states that the specific applicable subsections of the DCD for seismic analysis are Subsections 3.7.2.1 and 3.7.3. For Part (b) regarding damping values, MHI assumed that all of these cases are enveloped by the values for 10% damping for full cable trays, and 7% for empty cable trays. MHI states that this assumption will be confirmed during final detailed design. For Part (c) MHI refers to their response in Part 6 (b) above. The cables are not restrained by any spray-on fire protection, and bolted steel trays are used.
7. For Part (a) MHI describes the methodology to determine standard cable tray spans, notes that it is an iterative procedure. The spans or support spacing are determined by hand calculations. This process is used to determine spacing of supports for vertical, transverse, and longitudinal direction during detailed design. For Part (b) MHI refers to their response to Questions 3.7.3-02, 3.7.3-03, 3.7.3-04, and 3.7.3-15 of RAI 213-1951.
8. Refers to MHI's response to Questions 3.9.2-41 in RAI 214-1920 and 3.7.3-01 in RAI 213-1951.
9. Refers to MHI's response to Question 3.8.4-30, Item 8 of this RAI for a discussion on the applicability of the AISI Specification for allowable stresses and stress limit coefficients.

MHI states that they will make appropriate changes to the DCD to reflect the resolutions described above.

With the exception of Parts 7 and 8 of this question, the staff finds the applicant's responses to be acceptable. The applicant is requested to provide the following information for Parts 7 and 8 of the question:

1. In their response to Question 7(a) of this Question 3.8.4-31, MHI indicates that manual hand calculations will be used to determine the standard tray spans, and that "standard" means "maximum permissible". The staff finds this answer to be acceptable. However, MHI did not answer how the support designs are carried out. The applicant is requested to provide a description of how the designs of the supports are carried out.
2. In the response to Part 7(b) of this Question 3.8.4-31, MHI refers to their answers to Questions 3.7.3-02, 3.7.3-03, 3.7.3-04 and 3.7.3-15 of RAI 213-1951. The staff reviewed these answers and was not able to find specific answers to the question asked in this question. No justification was presented that would support MHI's position that cable tray system can be represented by a simple model, and to prove that the results obtained from the equivalent static load method are conservative. Also, MHI did not answer how to account for the relative motion between all points of supports. The applicant is requested to provide the following information:
    a. Provide the rationale that supports MHI's position that the cable tray system can be represented by a simple model, and that proves that the results obtained from the equivalent static load method are conservative.
    b. Provide a description of how the relative motions between all points of support are considered in the analysis.
3. In their response to Part 8 of this Question 3.8.4-31, MHI refers to their responses to 3.7.3-01 in RAI 213-1951 and Question 3.9.2-41 in RAI 214-1920. The staff reviewed these responses. In the response to Question 3.7.3-01 of RAI 213-1951, MHI indicated that DCD will be changed to specify that the absolute sum method will be used in the Independent Support Motion (ISM) method to comply with the recommendation in Section 2.4 of NUREG-1061, Volume 4. However, MHI did not fully answer how to consider the relative displacement at the support points if the Uniform Support Motion (USM) method is used. The applicant is requested to describe how the relative displacements at the support points are considered in the analysis.

References:

MHI response to RAI 342-2000, dated 7/3/2009, MHI Ref: UAP-HF-09360, ML091900558

MHI response to RAI 223-1996, dated 4/14/2009, MHI Ref: UAP-HF-09161, ML091060749

MHI response to RAI 213-1951, dated 3/27/2009, MHI Ref: UAP-HF-09114, ML090910119

MHI response to RAI 213-1951, dated 4/24/2009, MHI Ref: UAP-HF-09189, ML091180437

MHI response to RAI 214-1920, dated 4/30/2009, MHI Ref: UAP-HF-09190, ML091240403

ANSWER:

1. <u>Supports Design Methodology</u>

Supports design methodology is outlined in Appendix 3G, Section 3G.1, "Description". Additional detail steps employing the equivalent static analysis method are outline below.

- Prepare mathematical model of the cable tray support based on support and cable tray layout and preliminary sizing of the support members.
- Determine the member stresses and support reaction forces/moments from the analysis model above for each of the applicable loads such as dead load and seismic (SSE) load.
- Determine the maximum member stresses and support reaction forces/moments from the governing load combination, which normally is the dead load plus SSE case.
- Compare the determined maximum member stresses and support reaction forces/moments to the Acceptance Criteria (allowable stresses). If OK, design is complete. If not, repeat the four bullet steps with revised preliminary member sizes and/or revised support layout until the determined maximum member stresses and support reaction forces/moments are within the Acceptance Criteria allowable stresses.

2. MHI response to RAI 213-1951 questions 03.07.03-2 and 03.07.03-15 provided their definition of "simple models" used in the design/analysis of conduits and conduit support subsystems employing the equivalent static analysis method. "Simple models" can be considered / defined to be simple linear frame-type structures consisting of members that are physically similar to beams and columns. Cable tray and cable tray supports are normally constructed of standard structural shapes (such as angles, wideflanges, HSS, etc.) into simple linear frame-type structures (such as trapezes, cantilever members from ceiling, walls and floors, etc). Simple finite element models of these types of structures can be constructed using beam and axial (tension and/or compression column) elements and used in their analysis and design.

   Cable tray and cable tray support subsystems are "flexible" systems. The cable tray(s) is (are) connected to their structural support through bolting/clamping. Due to the layout configuration of the cable tray, bolted/clamp connections to the support structure, installation of cable tray splice plates and the installation of cable tray splice expansion connections (splice plates with slotted holes) within the cable tray, the differential displacement between cable tray supports are accommodated. Where system layout/configuration and flexible connections do not relieve relative support displacements, additional forces and moments are considered using absolute summation of relative displacements.

3. Section 3.7.3.1.7.1 of the DCD provides the theoretical discussion for the relative movements between support points of raceway system. As stated in MHI's response to RAI 214-1920 question 03.09.02-41, the proposed USM method of analysis, if used for cable tray system, conform to the guidance in SRP 3.9.2.II.2.G and SRP 3.7.3.II.9 and the absolute sum method is used to combine the responses due to the inertia effect and relative displacements at the support points.

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.

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

utilized for design of individual members. Equivalent dead loads are used during global analyses as conservative uniform load allowances of minor equipment and distribution systems, including small bore piping.

3.8.4.3.1.1 Dead Loads (Uniform and/or Concentrated)

Dead loads include the weight of structures such as slabs, roofs, decking, framing (beams, columns, bracing, and walls), and the weight of permanently attached major equipment, tanks, machinery, cranes, elevators, etc. The deadweight of equipment is based on its bounding operating condition including the weight of fluids. In addition, permanently attached non-structural elements such as siding, partitions, and insulation are included. Dead loads of cranes and elevators do not include the rated capacity lift or impact.

3.8.4.3.1.2 Equivalent Dead Load (Uniform)

Equivalent dead load includes the weight of minor equipment not specifically included in the dead load defined in Subsection 3.8.4.3 and the weight of piping, cables and cable trays, ducts, and their supports. It also includes fluid contained within the piping and minor equipment under operating conditions. Floors are checked for the actual equipment loads. To account for permanently attached small equipment, piping, ductwork and cable trays, a minimum equivalent dead load of 50 lb/ft^2 is applied. Where piping, ductwork, or cable trays are supported from platforms or walkway beams, actual loads may be determined and used in lieu of a conservative loading.

For floors with a significant number of small pieces of equipment (e.g., electrical cabinet rooms), the equivalent dead load is determined by dividing the total equipment weight by the floor area that effectively supports the equipment within the room, plus an additional 50 lb/ft^2.

3.8.4.3.2 Liquid Loads (F)

The vertical and lateral pressures of liquids are treated as dead loads except for external pressures due to ground water which are treated as live loads. The effects of buoyancy and flooding on SSCs are considered, where applicable. Structures supporting fluid loads during normal operation and accident conditions are designed for the hydrostatic as well as hydrodynamic loads. Impulsive and convective ~~H~~hydrodynamic loads due to seismic events ~~sloshing~~ are determined as discussed in Subsection 3.7.3.9, and included in the earthquake load as described in Subsection 3.8.4.3.6. For the purposes of evaluating flotation in Subsection 3.8.5.3, F_b is the buoyant force of the design-basis flood or high ground water table, whichever is greater.

3.8.4.3.3 Earth Pressure (H)

A static earth pressure acting on the structures during normal operation, considered as fully saturated to account for ground and flood water levels, is included in the analysis as *H*. The dynamic soil pressure, induced during an SSE event, is considered as an earthquake load E_{ss}.

3.8.4.3.5 Wind Load

3.8.4.3.5.1 Design Wind (W)

The design wind is determined as discussed in Subsection 3.3.1 for values specified in Chapter 2. Wind loads are not combined with seismic loads.

3.8.4.3.5.2 Tornado Load (Wt)

The design for tornado loads is in accordance with Subsection 3.3.2 for values specified in Chapter 2. In addition, extreme winds such as hurricanes and tornadoes have the potential to generate missiles. Missiles generated by tornadoes and extreme winds are listed in Subsection 3.5.1.4 and barrier design for missiles is discussed in Subsection 3.5.3. These subsections describe the determination of tornado loads applicable to the protection of safety-related equipment.

3.8.4.3.6 Seismic Loads

3.8.4.3.6.1 Operating Basis (E_{ob})

For seismic category I SSCs whose design is site-specific, that is, not included in the seismic design of the US-APWR standard plant, OBE loading has to be considered only if the value of site-specific OBE is set higher than 1/3 of the site-specific SSE. Therefore, the site-specific seismic design does not have to consider OBE loads if the OBE spectra are enveloped by 1/3 of the site-specific foundation input response spectra and ground motion response spectra.

3.8.4.3.6.2 Safe Shutdown (E_{ss})

E_{ss} is defined as the loads generated by the SSE specified for the plant, including the associated hydrodynamic loads and dynamic incremental soil pressure (based on three-dimensional SSI analysis results). Earthquake loads (E_{ss}), are derived for evaluation of seismic category I structures using ground motion accelerations in accordance with Section 3.7.

Seismic dynamic analyses of the buildings consider the dead load and the equivalent dead loads as the accelerated mass. In addition to the dead load, 25% of the floor live load during normal operation ~~or~~ and 75% of the roof snow load, whichever is applicable, is also considered as accelerated mass in the seismic models.

For the local design of members loaded individually, such as the floors and beams, seismic member forces include the vertical response due to masses equal to 50% of the specified floor live loads instead of 25% of floor live load, as follows:

$$a_v(0.5L)$$

where

a_v = Vertical seismic acceleration obtained from the seismic dynamic analysis results

L = Floor live load per Subsection 3.8.4.3.4

ATTACHMENT 1
to RAI 497-3734

3.8.4.6.2 Quality Control

Chapter 17 details the quality assurance program for the US-APWR.

3.8.4.6.3 Special Construction Techniques

Standard provisions of ACI are to be applied where necessary to address issues related to the use of massive concrete pours. As stated in Subsection 3.8.4.6.1.1, volume changes in mass concrete are controlled where necessary by applying measures and provisions outlined in ACI 207.2R (Reference 3.8-52) and ACI 207.4R (Reference 3.8-53). The following summarizes the construction techniques commonly associated, either singularly or in combination, with massive concrete pours such as basemats:

- Limit the size of concrete pour.
- Use a checkerboard pattern of concrete placement in a single lift. To avoid a weak horizontal shear plane, a double lift placement of concrete, in general, is avoided. However, when it is absolutely needed to have two lifts, adequate design considerations and also, in general, shear stirrups are provided.
- Schedule concrete pours for the most advantageous day and time to control temperature rise in the concrete.
- Post-cooling can be performed by cooling the freshly placed concrete with running chilled water lines in the concrete.

~~There are no special construction techniques utilized in the construction of other seismic category I structures.~~

3.8.4.7 Testing and Inservice Inspection Requirements

Seismic category I structures, except the PCCV, are monitored in accordance with paragraph (a)(2) of 10 CFR 50.65 (Reference 3.8-29), provided there is not significant degradation of the structure. Condition monitoring, is similar to that performed as part of the inservice inspection activities required by the ASME codes, is applied to these structures. The condition of all structures is assessed periodically. The appropriate frequency of the assessments is commensurate with the safety significance of the structure and its condition.

The COL Applicant is to establish a site-specific program for monitoring and maintenance of seismic category I structures in accordance with the requirements of NUMARC 93-01 (Reference 3.8-28) and 10 CFR 50.65 (Reference 3.8-29) as detailed in RG 1.160 (Reference 3.8-30). For seismic category I structures, monitoring is to include base settlements and differential displacements.

For water control structures, ISI programs are acceptable if in accordance with RG 1.127 (Reference 3.8-47). Water control structures covered by this program include concrete structures, embankment structures, spillway structures, outlet works, reservoirs, cooling water channels, canals and intake and discharge structures, and safety and performance instrumentation.

ATTACHMENT 2
to RAI 498-3734

Comparisons of static deformations are made between the three-dimensional stick model and the FE model, as previously discussed.

iii) Comparison of ISRS

Comparisons of ISRS are made between the three-dimensional stick model and the FE model at various points in various elevations, as previously discussed.

3.7.2.3.10.3 Containment Internal Structure

i) Fixed-base FE model

Figure 3.7.2-10 shows the fixed-base FE model for the containment internal structure, which is compared with the three-dimensional stick model. To verify the three-dimensional stick model, the FE model is used to estimate its rigidity by both static and dynamic analyses.

ii) Rigidity estimation by static analysis

Comparisons of static deformations are made between the three-dimensional stick model and the FE model, as previously discussed.

iii) Comparison of ISRS

Comparisons of ISRS are made between the three-dimensional stick model and the FE model at various points in various elevations as previously discussed.

3.7.2.3.11 Equivalent Masses due to Dead and Live Loads

In the design of seismic category I and seismic category II buildings and structures, dead loads and various portions of live loads are treated as equivalent masses for consideration in the global seismic analysis models. For example, 25% of the design floor live loads during normal operation (ASCE 7, Subsection 12.7.2 [Reference 3.7-24]) ~~or~~ <u>and</u> 75% of the roof snow load, whichever is applicable depending on the specific location in the building or structure, have been considered in computing tributary mass at node points in the seismic models. This is consistent with SRP 3.7.2, Section II.3(d) (Reference 3.7-16). For the containment operating deck in the PCCV, the design floor live load for maintenance and refueling is 950 lb/ft^2 and the floor live load for normal operation is 200 lb/ft^2. Therefore, 50 lb/ft^2 (25% of 200 lb/ft^2) has been used as an equivalent live load (mass) for the seismic analysis models.

Equivalent dead loads used in the seismic analysis models also include the weight of SSCs not specifically identified or included as dead loads in the models such as the weight of minor piping systems, cables and cable trays, ducts, and all related supports. Similarly, equivalent live loads include fluid contained within the minor piping and equipment under operating conditions. The weight of permanently attached tanks (uniformly distributed over the room floor area) is included as equivalent dead load (mass) in the seismic models. For the seismic analysis models, an equivalent dead load of a minimum of 50 lb/ft^2 uniform load is applied to cover these conditions. This is consistent with SRP 3.7.2, Section II(3)(d) (Reference 3.7-16).

For floors with a significant number of small pieces of equipment (e.g., electrical cabinet

SASSI analysis with the exception that no stick model is required. Instead, plate elements are to be directly included to represent the tunnel in the SASSI model.

3.7.3.8 Methods for Seismic Analysis of Category I Concrete Dams

The US-APWR standard plant design does not include dams. It is the responsibility of the COL Applicant to perform any site-specific seismic analysis for dams that may be required.

3.7.3.9 Methods for Seismic Analysis of Aboveground Tanks

It is the responsibility of the COL Applicant to design seismic category I below- or above-ground liquid-retaining metal tanks such that they are enclosed by a tornado missile protecting concrete vault or wall, in order to confine the emergency gas turbine fuel supply.

The other seismic category I liquid-retaining vessels utilized in the design are reinforced concrete vessels whose walls and floors form part of the building structural framework, including the following:

- Spent fuel pit, located in the R/B with top of vessel at level 4F
- Refueling cavity, located in PCCV with top of vessel at level 4F
- Fuel transfer canal, which connects the spent fuel pit and refueling cavity
- Cask washdown pit located in the R/B with top of vessel at level 4F
- Cask loading pit and fuel inspection pit located in the R/B and connected to the spent fuel pit with a canal, with tops of vessels at level 4F
- New fuel storage pit located in the R/B with top of vessel at level 4F
- Refueling water storage pit, located in PCCV below level 2F

Hydrodynamic loads ~~including sloshing loads~~ on these liquid-retaining vessels are determined using methods that conform to the provisions of Subsection II.14 of SRP 3.7.3 (Reference 3.7-35) and guidance of ASCE 4-98, Subsection 3.5.4 (Reference 3.7-9). 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 ~~sloshing~~ convective mode <u>(water motion associated with wave oscillation)</u>. The seismic ~~sloshing~~ analysis of <u>convective hydrodynamic effects</u> also considers ~~potential slosh heights~~ <u>the maximum wave oscillation</u> with respect to the potential of creating flooding, which is discussed in Section 3.4.

3.7.4 Seismic Instrumentation

The proposed seismic instrumentation program for the US-APWR is in accordance with NUREG-0800, SRP 3.7.4 (Reference 3.7-39) and all aspects of 10 CFR 50, Appendix S (Reference 3.7-7), which requires that "suitable instrumentation must be provided so that the seismic response of nuclear power plant features important to safety can be

ATTACHMENT 3
to RAI 497-3734

3F.6.2 Structural Steel Shapes

The design, fabrication and installation of structural steel supports, and structural shapes and plates used in support construction, comply with AISC-N690-1994 (Reference 3F-6).

3F.6.3 Conduit

ERSC conforms to ANSI C80.1 (Reference 3F-1).

ERAC conforms to ANSI C80.5 (Reference 3F-2).

3F.6.4 Electrical Boxes

Electrical Boxes conform to NEMA Standards Publication 250 (Reference 3F-3).

3F.6.5 Welding

Welding electrodes are E70 series for structural steel shapes greater than 3/16th inch thick or E60 series for structural steel shapes less than or equal to 3/16th inch thick, in accordance with AWS A5 series specifications (Reference 3F-8).

3F.6.6 Anchor Bolts

Anchor bolts used for conduit supports, seismic category I and II, are expansion anchors qualified in accordance with ACI 355.2 (Reference 3F-9). The flexibility of base ~~plates~~ anchorage was considered in determining the anchor bolt loads.

3F.6.7 Bolts

Bolts used in conduit support, seismic category I and II; conform to American Society for Testing and Materials (ASTM) A-307 (Reference 3F-10).

3F.7 References

3F-1 American Standard for Electrical Rigid Steel Conduit (ERSC). ANSI C80.1-2005, American National Standard Institute, 2005.

3F-2 American Standard for Electrical Rigid Aluminum Conduit (EARC). ANSI C80.5-2005, American National Standard Institute, 2005.

3F-3 NEMA Standards Publication 250-2003 Enclosures for Electrical Equipment (1000 Volts Maximum). National Electrical Manufacturer Association, 2003.

3F-4 National Electric Code (NEC). NFPA 70, National Fire Protection Association, 1999.

3F-5 Specification for the Design of Cold-Formed Steel Members, Part 1 and 2. 1996 Edition and 2000 Supplement, American Iron and Steel Institute.