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

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-11324

Subject: MHI's Responses to US-APWR DCD RAI No. 810-5874 Revision 3 (SRP 03.07.02)

Reference: 1) "Request for Additional Information No. 810-5874 Revision 3, SRP Section: 03.07.02 – Seismic Systems Analysis," dated 8/22/2011.

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. 810-5784, Revision 3."

Enclosed are the responses to five (5) RAIs contained within Reference 1. They are RAIs 3.7.2-97, 99, 102, 106 and 107. Of the RAIs in Reference 1, thirteen (13) will not be answered within this package. Those RAI responses have a 60-day response time, as agreed to between the NRC and MHI, and will be issued at a later date by a separate transmittal.

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

Sincerely,

Y. Ogata

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

*DOB
NRC*

Enclosure:

1. Responses to Request for Additional Information No. 810-5784, Revision 3

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

Contact Information

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Docket No. 52-021
MHI Ref: UAP-HF-11324

Enclosure 1

UAP-HF-11324
Docket No. 52-021

Responses to Request for Additional Information No. 810-5874,
Revision 3

September, 2011

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/22/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 810-5874 REVISION 3
SRP SECTION: 03.07.02 – Seismic System Analysis
APPLICATION SECTION: 3.7.2
DATE OF RAI ISSUE: 8/22/2011

QUESTION NO. RAI 03.07.02-97:

In Subsection 3.7.2.8 of DCD (R3), "Interaction of Non-Seismic Category I Structures with Seismic Category I Structures", the fourth paragraph (page 3.7-38) states, "NS structures that are not located beyond the range of impact are isolated by heavy concrete walls from seismic category I SSCs."

The Applicant should identify the locations of these heavy concrete walls and demonstrate how the presence of the heavy walls conforms to the guidelines of SRP Acceptance Criteria 8 of SRP 3.7.2.

ANSWER:

The statement quoted in the RAI question above is more applicable to subsystem design described in DCD Subsection 3.7.3 of the DCD, and hence the statement will be deleted from Subsection 3.7.2.8 of the DCD. A similar question was asked in RAI 213-1951 Question RAI 3.7.3-11 pertaining to the review of subsystems and equipment with respect to SRP Acceptance Criteria 8 of SRP 3.7.3, which also applies Acceptance Criteria 8 of SRP 3.7.2. To explain how the Acceptance Criteria are met, DCD Subsection 3.7.3 was modified in response to RAI 213-1951 (ML090910119) to state (in part):

"Each non-category I system and component is designed to be isolated from any seismic category I systems and components by either a constraint or barrier, or is remotely located with regard to the seismic category I systems and components. If it is not feasible or practical to isolate the seismic category I systems and components, adjacent non-category I systems and components are analyzed for the same seismic input motion that is applicable to the seismic category I systems and components."

As stated in DCD Subsection 3.7.3, constraints or barriers such as heavy concrete walls may be used in some locations to meet SRP 3.7.3 Acceptance Criteria 8. DCD Subsection 3.7.2.8 conforms to SRP 3.7.2 Acceptance Criteria 8 in that it states:

"NS structures have been located such that, in case of their collapse or failure, they do not have the potential to impact seismic category I SSCs, either directly or indirectly."

Impact on DCD

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

The fourth paragraph in DCD Subsection 3.7.2.8 is deleted as follows:

~~"NS structures that are not located beyond the range of impact are isolated by heavy concrete walls from seismic category I SSCs."~~

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

9/22/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 810-5874 REVISION 3
SRP SECTION: 03.07.02 – Seismic System Analysis
APPLICATION SECTION: 3.7.2
DATE OF RAI ISSUE: 8/22/2011

QUESTION NO. RAI 03.07.02-99:

In Subsection 3.7.2.14 of DCD (R3), "Determination of Dynamic Stability of Seismic Category I Structures", the last sentence of the second paragraph (page 3.7-44) states, "The site-specific factor of safety against liquefaction is determined to confirm the dynamic stability of seismic category I structures for the US-APWR standard design with respect to liquefaction."

The staff expects this to be a COL item, but this information is not included in Subsection 3.7.5, "Combined License Information". The applicant should include this as a COL item or provide a justification for not doing so.

ANSWER:

The requested justification currently exists in the DCD. The preceding sentence to the one quoted in this question refers to Section 2.5.4.8 of Tier 2 of the DCD that states, "The US-APWR standard plant design is based on the premise that there is no potential of liquefaction occurring at the site. Site-specific foundation materials adjacent to and under safety-related structures that are saturated soils, or soils that have a potential to become saturated and the water table is above bedrock, are analyzed for the potential of liquefaction occurring at the site." Liquefaction is identified as a key site parameter in Table 2.0-1 of the DCD (R3). Table 2.1-1 of Tier 1 of the DCD contains the same key site parameters as those listed in Tier 2 Table 2.0-1, including the parameter that there be no potential for liquefaction. Section 2.1.1 of Tier 1 of the DCD states, "A site for construction of a US-APWR plant will be acceptable if the site-specific characteristics fall within the key site parameter values specified in Table 2.1-1." Section 2.5.2.1 of Tier 2 of the DCD also states, "In addition, any earthquake-induced geologic failure is to be described, such as liquefaction (including paleoseismic evidence of large prehistoric earthquakes), landsliding, land spreading, and lurching, including the estimated level of strong motion that induced failure and the physical properties of the materials." DCD Tier 2 Section 2.5.4.7, through item 1, states, "The response of soil and rock to dynamic loading is to be provided, including the following information as appropriate: Any investigations to determine the effects of prior earthquakes on the soils and rocks in the vicinity of the site, including evidence of liquefaction and sand cone formation."

The above cited site specific investigation and review from Chapter 2 of DCD (Tier 1 and Tier 2) related to liquefaction is thus already covered as part of the Chapter 2 COL item 2.5(1) of Tier 2 of the DCD which states, "The COL Applicant is to provide sufficient information regarding the seismic and geologic characteristics of the site and the region surrounding the site."

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/22/2011

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

RAI NO.: NO. 810-5874 REVISION 3
SRP SECTION: 03.07.02 – Seismic System Analysis
APPLICATION SECTION: 3.7.2
DATE OF RAI ISSUE: 8/22/2011

QUESTION NO. RAI 03.07.02-102:

In Subsection 3.7.2.3.4 of DCD (R3), "Subsystem Coupling Requirements", the last paragraph (page 3.7-20) states in part, "In addition, the requirements of NOG-1 (Reference 3.7-22) for the design of cranes may require that the crane design analysis be performed by coupling the crane model with the overall building model. If found that is required, the site-specific seismic analysis of the US-APWR standard plant must be performed on models that incorporate the PCCV polar crane and the fuel handling crane, as appropriate."

This is a required COL action item. However this information is not included in Subsection 3.7.5, "Combined License Information". The Applicant is requested to discuss why this item is not included in Subsection 3.7.5. The same topic was addressed in RAI 542-4262, Question 3.7.2-7 (identified as question 3.7.2-34 in the Applicant's response) against DCD (R2), and the staff disagrees with the response that COL Action Items 3.7(4), 3.7(23), and 3.7(25) address the crane question. The staff's position is that COL Action Item (11) should be reinstated in the DCD.

ANSWER:

COL Action Item 3.7(11) will be reinstated into DCD Tier 2, Subsections 3.7.2.3.4 and 3.7.5 and Subsection 1.8, Table 1.8-2 (Sheet 5).

Impact on DCD

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

Subsection 3.7.2.3.4, last paragraph is revised to add the following sentence as the third sentence of the paragraph:

"Therefore, it is the responsibility of the COL Applicant to confirm the masses and frequencies of the PCCV polar crane and fuel handling crane and to determine if coupled site-specific analyses are required."

Subsection 3.7.5 is revised to reinstate the following COL Action Item 3.7(11):

"It is the responsibility of the COL Applicant to confirm the masses and frequencies of the PCCV polar crane and fuel handling crane and to determine if coupled site-specific analyses are required."

See the Attachment 2 mark-up of DCD Tier 2 Table 1.8-2 (Sheet 5), changes to be incorporated.

COL Item 3.7(11) in Table 1.8-2 is revised to reinstate the following COL Action Item 3.7(11):

"It is the responsibility of the COL Applicant to confirm the masses and frequencies of the PCCV polar crane and fuel handling crane and to determine if coupled site-specific analyses are required."

Impact on R-COLA

The reinstated COL Action Item 3.7(11) above will be addressed in the R-COLA with mark-ups in a future revision to the R-COLA.

Impact on S-COLA

The reinstated COL Action Item 3.7(11) above will be addressed in the S-COLA with mark-ups in a future revision to 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.

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9/22/2011

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RAI NO.: NO. 810-5874 REVISION 3
SRP SECTION: 03.07.02 – Seismic System Analysis
APPLICATION SECTION: 3.7.2
DATE OF RAI ISSUE: 8/22/2011

QUESTION NO. RAI 03.07.02-106:

In Subsection 3.7.2.4.1 of DCD (R3), "Requirements for Site-Specific SSI Analysis of US-APWR Standard Plant", the fifth paragraph (page 3.7-31) states in part, "The input control motion that is derived from the site-specific GMRS, is applied in the SASSI analysis as within motion at the bottom of the basemat."

The staff noticed that in DC/COL-ISG-017, the foundation input response spectrum (FIRS) is the starting point for conducting the soil-structure interaction analysis. Also, in the Nuclear Energy Institute (NEI) white paper entitled, "CONSISTENT SITE-RESPONSE/ SOIL-STRUCTURE INTERACTION ANALYSIS AND EVALUATION" (Reference 3 of DC/COL-ISG-017), the FIRS is used rather than the GMRS. Therefore, the Applicant is requested to either delete the above quoted sentence or modify it to be consistent with DC/COL-ISG-017. Also, the applicant is requested to define the term "within motion" mentioned in the above quoted sentence.

ANSWER:

The input control motion for the site-specific soil-structure interaction (SSI) analyses described in DCD Subsection 3.7.2.4.1 is derived from the foundation input response spectra (FIRS), rather than the ground motion response spectra (GMRS), which is consistent with ISG-017.

It is required that the object motion be defined as "within-layer" motion for use in ACS SASSI. "Within-layer motion", or "within motion" as stated in the above quoted sentence, refers to the requirement that the SSI analyses must consider a soil column which includes the embedment depth of the soil above the bottom of the foundation, and where the soil column properties are strain-compatible with the input motion as discussed in DCD Subsection 3.7.2.4.1, which is consistent with ISG-017 and the NEI white paper.

The clarification made with respect to "within motion" pertains to embedded analyses; however, please note that the COL Applicant is not restricted from performing separate SSI analyses in which the standard plant structures are also analyzed as surface-mounted structures.

Based on the above explanation, the sentence from Subsection 3.7.2.4.1 of the DCD that is quoted in the RAI question will be corrected and clarified as stated in "Impact on DCD" below.

Impact on DCD

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

The second sentence in the fifth paragraph of DCD Subsection 3.7.2.4.1 is revised to read as follows:

"The input control motion derived from the site-specific FIRS is applied in the SASSI analyses at the bottom-of-foundation control point location as motion within a soil column that includes the embedment materials and their strain-compatible 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

9/22/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 810-5874 REVISION 3
SRP SECTION: 03.07.02 – Seismic System Analysis
APPLICATION SECTION: 3.7.2
DATE OF RAI ISSUE: 8/22/2011

QUESTION NO. RAI 03.07.02-107:

In Subsection 3.7.2.4.1 of DCD (R3), the first paragraph states, "The COL Applicant referencing the US-APWR standard design is required to perform a site-specific SSI analysis for the R/B-PCCV-containment internal structure, and PS/B model, utilizing the program ACS SASSI SSI (Reference 3.7-17) which contains time history input incoherence function capability. The SSI analysis using SASSI is required in order to confirm that site-specific effects are enveloped by the standard design. After the SASSI analysis is first performed for a specific unit, subsequent COLAs for other units may be able to forego SASSI analyses if the FIRS and GMRS derived for those subsequent units are much smaller than the US-APWR standard plant CSDRS, and if the subsequent unit can also provide justification through comparison of site-specific geological and seismological characteristics."

The Applicant is requested to clarify the meaning and intent of this paragraph and provide the definition of "unit" as used in the above paragraph. Is the word "unit" intended to mean a site or a specific structure? Also, the Applicant is requested to define the situations in which SASSI analyses are or are not required for site-specific seismic qualification of Standard Plant SSC's and should state the regulatory basis for this position.

The staff notes that the first paragraph of Subsection 3.7.2.4.1 is repeated as COL Item 3.7(25). Therefore, any clarifications to Subsection 3.7.2.4.1 should be incorporated into COL Item 3.7(25) as applicable.

ANSWER:

The first portion of the paragraph in Subsection 3.7.2.4.1 of the DCD requires the COL Applicant to demonstrate site suitability using SASSI analyses. The second portion of this paragraph was intended to offer a COL Applicant relief from further SASSI analyses for other nuclear unit COLAs provided the Applicant can demonstrate that the new site response spectra, geological and seismological characteristics are sufficiently bounded by the standard plant analysis. The regulatory basis for COL Item 3.7(25), and other COL Items in Sections 3.7 and 3.8, is that these COL Items serve as a mechanism by which the COL Applicant demonstrates, for the site-specific

conditions at a particular plant location, compliance with the criteria given in Title 10, Code of Federal Regulations (CFR), Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants". In particular, General Design Criteria (GDC) 2 as discussed in Subsection 3.1.1.2 of the DCD forms the regulatory basis for these COL Items. These COL Items also serve as a mechanism by which the COL Applicant demonstrates, for the site-specific conditions at a particular plant location, compliance with the requirements of Title 10, CFR Part 50 Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants".

The SASSI relief option for additional COL Applicant nuclear sites is being removed from the DCD. Hence the statements in the first paragraph of DCD Subsection 3.7.2.4.1, and in COL 3.7(25), are revised as indicated below in "Impact on DCD".

Impact on DCD

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

The first paragraph in DCD Subsection 3.7.2.4.1 and COL Item 3.7(25) are revised to read as follows:

"The COL Applicant referencing the US-APWR standard design is required to perform a site-specific SSI analysis for the R/B-PCCV-containment internal structure, and PS/B model, utilizing the program ACS SASSI SSI (Reference 3.7-17) which contains time history input incoherence function capability. The SSI analysis using SASSI is required in order to confirm that site-specific effects are enveloped by the standard design."

See the Attachment 2 mark-up of DCD Tier 2, Subsection 1.8, changes to be incorporated.

COL Item 3.7(25) in Table 1.8-2 is revised to read as follows:

"The COL Applicant referencing the US-APWR standard design is required to perform a site-specific SSI analysis for the R/B-PCCV-containment internal structure, and PS/B model, utilizing the program ACS SASSI (Reference 3.7-17) which contains time history input incoherence function capability. The SSI analysis using SASSI is required in order to confirm that site-specific effects are enveloped by the standard design."

Impact on R-COLA

The revised COL Action Item 3.7(25) above will be addressed in the R-COLA with mark-ups in a future revision to the R-COLA.

Impact on S-COLA

The revised COL Action Item 3.7(25) above will be addressed in the S-COLA with mark-ups in a future revision to 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.

1. INTRODUCTION AND GENERAL DESCRIPTION OF THE PLANT

US-APWR Design Control Document

Table 1.8-2 Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 6 of 35)

COL ITEM NO.	COL ITEM
COL 3.7(10)	<i>It is the responsibility of the COL Applicant to further address structure-to-structure interaction if the specific site conditions can be important for the seismic response of particular US-APWR seismic category I structures, or may result in exceedance of assumed pressure distributions used for the US-APWR standard plant design.</i>
COL 3.7(11)	It is the responsibility of the COL Applicant to confirm the masses and frequencies of the PCCV polar crane and fuel handling crane and to determine if coupled site-specific analyses are required.
COL 3.7(12)	<i>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.</i>
COL 3.7(13)	<i>The COL Applicant is to set the value of the OBE that serves as the basis for defining the criteria for shutdown of the plant, according to the site specific conditions.</i>
COL 3.7(14)	<i>The COL Applicant is to determine from the site-specific geological and seismological conditions if multiple US-APWR units at a site will have essentially the same seismic response, and based on that determination, choose if more than one unit is provided with seismic instrumentation at a multiple-unit site.</i>
COL 3.7(15)	<i>Deleted</i>
COL 3.7(16)	<i>The COL Applicant shall provide free-field seismic instrumentation in the vicinity of the power block area at surface grade which shall be used for shutdown determination, unless otherwise justified. Any such justification shall be based on conditions and requirements specific to the site, and shall include justification for evaluation of OBE exceedance using only measurements from instrumentation installed on the buildings and the structures of the US-APWR standard plant.</i>
COL 3.7(17)	<i>Deleted</i>
COL 3.7(18)	<i>Deleted</i>
COL 3.7(19)	<i>The COL Applicant is to identify the implementation milestone for the seismic instrumentation implementation program based on the discussion in Subsections 3.7.4.1 through 3.7.4.5.</i>
COL 3.7(20)	<i>The COL Applicant is to validate the site-independent seismic design of the standard plant for site-specific conditions, including geological, seismological, and geophysical characteristics, and to develop the site-specific GMRS.</i>
COL 3.7(21)	<i>The COL Applicant is responsible for the seismic design of those seismic category I and seismic category II SSCs that are not part of the US-APWR standard plant.</i>

DCD_03.07.
02-102

1. INTRODUCTION AND GENERAL DESCRIPTION OF THE PLANT

US-APWR Design Control Document

Table 1.8-2 Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 7 of 35)

COL ITEM NO.	COL ITEM
COL 3.7(22)	The COL Applicant is required to perform site-specific seismic analyses, including SSI analysis which may consider seismic wave transmission incoherence and analysis of the CAV of the seismic input motion, in order to determine if high-frequency exceedances of the CSDRS could be transmitted to SSCs in the plant superstructure with potentially damaging effects.
COL 3.7(23)	The COL Applicant is to verify that the results of the site-specific SSI analysis for the broadened ISRS and basement walls lateral soil pressures are enveloped by the US-APWR standard design.
COL 3.7(24)	The COL Applicant is to verify that the site-specific ratios V/A and AD/V^2 (A , V , D , are PGA, ground velocity, and ground displacement, respectively) are consistent with characteristic values for the magnitude and distance of the appropriate controlling events defining the site-specific uniform hazard response spectra.
COL 3.7(25)	The COL Applicant referencing the US-APWR standard design is required to perform a site-specific SSI analysis for the R/B-PCCV-containment internal structure, and PS/B model, utilizing the program ACSSASSI (Reference 3.7-17) which contains time history input incoherence function capability. The SSI analysis using SASSI is required in order to confirm that site-specific effects are enveloped by the standard design. After the SASSI analysis is first performed for a specific unit, subsequent COLAs for other units may be able to forego SASSI analyses if the FIRS and GMRS derived for those subsequent units are much smaller than the US-APWR standard plant CSDRS, and if the subsequent unit can also provide justification through comparison of site-specific geological and seismological characteristics.
COL 3.7(26)	SSI effects are also considered by the COL Applicant in site-specific seismic design of any seismic category I and II structures that are not included in the US-APWR standard plant. Consideration of structure-to-structure interaction is discussed in Subsection 3.7.2.8. The site-specific SSI analysis is performed for buildings and structures including, but not limited to, to the following: <ul style="list-style-type: none"> • Seismic category I ESWPT • Seismic category I PSFSV • Seismic category I UHSRS
COL 3.7(27)	It is the responsibility of the COL Applicant to perform any site-specific seismic analysis for dams that may be required.
COL 3.7(28)	The overall basemat dimensions, basemat embedment depths, and maximum height of the US-APWR R/B, PCCV, and containment internal structure on their common basemat are given in Table 3.7.1-3 and as updated by the COL Applicant to include site-specific seismic category I structures.

DCD_03.07.
02-107

3. DESIGN OF STRUCTURES, SYSTEMS, US-APWR Design Control Document COMPONENTS, AND EQUIPMENT

$$R_f = (\text{fundamental frequency of supported system})/(\text{dominant frequency of support motion})$$

If these criteria require the subsystem to be coupled with the primary seismic model, both the stiffness and the mass of the subsystem are included in the overall model to assure the accuracy of the calculated frequencies. This is the approach used for ~~including~~integrating the RCL seismic subsystem with the R/B complex dynamic FE model in the coupled RCL R/B PCCV containment internal structure lumped mass stick model discussed in Technical Report MUAP-10001 (Reference 3.7-47). To account for the effects of dynamic coupling of the containment internal structure with the equipment and the piping, the dynamic FE model of the R/B complex also includes a lumped mass stick model of the RCL representing the stiffness and mass inertia properties of the major equipment and piping located in the PCCV. Spring elements are used to model the stiffness of the supports of the components and piping. The lumped mass stick model of the RCL and major piping components used for seismic analyses of nuclear steam supply system are translated into an acceptable ACS SASSI format and then coupled with the dynamic containment internal structure model.

DCD_03.07.
02-35

When it has been determined through investigation of the above criteria that a subsystem is not required to be coupled with the primary seismic model, then the subsystem is assumed absolutely rigid and only its mass is included at appropriate node points of the global seismic model. The PCCV polar crane and fuel handling crane are incorporated into the overall ~~lumped mass stick~~ model in this manner. In addition, the requirements of NOG-1 (Reference 3.7-22) for the design of cranes may require that the crane design analysis be performed by coupling the crane model with the overall building model. Therefore, it is the responsibility of the COL Applicant to confirm the masses and frequencies of the PCCV polar crane and fuel handling crane and to determine if coupled site-specific analyses are required. If found that is required, the site-specific seismic analysis of the US-APWR standard plant must be performed on models that incorporate the PCCV polar crane and the fuel handling crane, as appropriate.

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02-35DCD_03.07.
02-102

3.7.2.3.5 Section and Material Properties ~~for Lumped Mass Stick Models~~

DCD_03.07.
02-35

The values of the modulus of elasticity and Poisson's ratio (ν) for concrete and steel used in ~~the lumped mass stick~~the dynamic models are discussed below. The values are for materials at or near ambient temperatures.

DCD_03.07.
02-35

a. Concrete

The concrete modulus of elasticity E_c , and shear modulus G_c corresponding to the compressive strengths of normal weight concrete used in the R/B, PCCV, and containment internal structure and their common basemat are summarized in Table 3.7.2-2 and are computed as follows:

$$E_c \text{ (ksi)} = 57,000 \sqrt{f'_c}$$

$$G \text{ (ksi)} = E_c / 2 (1 + \nu_c)$$

where

3. DESIGN OF STRUCTURES, SYSTEMS, US-APWR Design Control Document COMPONENTS, AND EQUIPMENT

damping. The three-dimensional (3-D) linear elastic FE model of the RB complex includes the containment internal structures and soil foundations. The FE model stiffness and damping values are based on its stiffness before or after concrete cracking, as applicable. As an example, for seismic plus operating-thermal loading conditions, the concrete is expected to be mostly uncracked. For seismic plus accident-thermal loading conditions, the concrete is expected to be cracked in SC walls as well as the reinforced concrete slabs.

DCD_03.07.
02-35

Perform two SSI analyses to bound the range of stress levels and associated cracking anticipated for the containment internal structures; one using the higher stiffness associated with seismic plus operating-thermal loading conditions, and one using the lower stiffness associated with seismic plus accident-thermal loading conditions.

The results of the SSI analysis are used to develop the following:

- i. ISRS for equipment and attachments
- ii. acceleration plots
- iii. translational ARS in the three orthogonal directions at the base of the containment internal structures. These results represent the envelope of responses obtained by conducting dynamic analyses of the linear elastic FE models with the two stiffness and damping levels described above.
- iv. Compute response spectra acceleration as described in Subsection 3.7.2.

3.7.2.4.1 Requirements for Site-Specific SSI Analysis of US-APWR Standard Plant

The COL Applicant referencing the US-APWR standard design is required to perform a site-specific SSI analysis for the R/B-PCCV-containment internal structure, and PS/B model, utilizing the program ACS SASSI SSI (Reference 3.7-17) which contains time history input incoherence function capability. The SSI analysis using SASSI is required in order to confirm that site-specific effects are enveloped by the standard design. ~~After the SASSI analysis is first performed for a specific unit, subsequent COLAs for other units may be able to forego SASSI analyses if the FIRS and GMRS derived for those subsequent units are much smaller than the US-APWR standard plant CSDRS, and if the subsequent unit can also provide justification through comparison of site-specific geological and seismological characteristics.~~

DCD_03.07.
02-107

SSI effects are also considered by the COL Applicant in site-specific seismic design of any seismic category I and II structures that are not included in the US-APWR standard plant. Consideration of structure-to-structure interaction is discussed in Subsection 3.7.2.8. The site-specific SSI analysis is performed for buildings and structures including, but not limited to, to the following:

- Seismic category I ESWPT
- Seismic category I PSFSV

3. DESIGN OF STRUCTURES, SYSTEMS, COMPONENTS, AND EQUIPMENT

- Seismic category I UHSRS

The site-specific seismic response analysis of R/B-PCCV building structure addresses factors that affect the response of the combined soil-structure dynamic system that include, but are not limited to, the following:

- Properties and layering of the soil, including fill concrete and backfill modeled depending on its horizontal extent
- Depth of the water table
- Basemat embedment
- Flexibility of the basemat
- Presence of nearby structures

Up-to-date modeling techniques capable of capturing the various site-specific SSI effects are used for the analysis. The computer program SASSI is used for the site-specific SSI analysis, because it is based on the use of the FE technique and sub-structuring method with frequency-dependent impedance functions to model the interaction of the embedded flexible basemat with the surrounding soil.

The input used for the site-specific analysis must be derived from geotechnical and seismological investigations of the site. ~~The input control motion that is derived from the site-specific GMRS, is applied in the SASSI analysis as within motion at the bottom of the basemat.~~ The input control motion derived from the site-specific FIRS is applied in the SASSI analyses at the bottom-of-foundation control point location as motion within a soil column that includes the embedment materials and their strain-compatible properties. Site-specific SSI analyses account for the uncertainties and variations of the subgrade properties by using at least three sets of site profiles that represent the best estimate, lower bound, and upper bound (BE, LB, and UB for equations, respectively) soil and rock properties. If sufficient and adequate soil investigation data are available, the LB and UB values of the initial (small strain) soil properties are established to cover the mean plus or minus one standard deviation for every layer. In accordance with the specific guidelines for SSI analysis contained in Section II.4 of SRP 3.7.2 (Reference 3.7-16), the LB and UB values for initial soil shear moduli (G_s) are established as follows:

$$G_s^{(LB)} = \frac{G_s^{(BE)}}{(1 + C_v)} \quad \text{and} \quad G_s^{(UB)} = G_s^{(BE)} (1 + C_v)$$

For well investigated sites, the C_v should be no less than 0.5. For sites that are not well investigated, the C_v for shear modulus shall be at least 1.0.

The SSI analysis must use stiffness and damping properties of the subgrade materials that are compatible with the strains generated by the site-specific design earthquake (SSE or/and OBE). However, soil material damping shall not exceed 15% as stipulated in SRP 3.7.1 (Reference 3.7-10). The COL Applicant is to evaluate the strain-dependent

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3.2. By definition, seismic category II structures are designed to retain their position to the extent necessary to assure that they will not impact the function or integrity of seismic category I SSCs.

NS structures have been located such that, in case of their collapse or failure, they do not have the potential to impact seismic category I SSCs, either directly or indirectly.

~~NS structures that are not located beyond the range of impact are isolated by heavy concrete walls from seismic category I SSCs.~~

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~~With respect to the coupling of the dynamic responses of adjacent structures through the soil, the phenomenon of structure to structure interaction is neglected in the SSI analyses for the standard plant discussed in Subsection 3.7.2.4. Instead, the variations of site properties considered by the four general subgrade conditions are deemed sufficient to address the uncertainties related to possible structure to structure interaction effects on the overall seismic response results.~~ The same methodology used to evaluate structure-to-structure interaction between seismic Category I structures and non-seismic Category I structures is used to evaluate structure-to-structure interactions between seismic Category I structures. This methodology is described in Subsection 3.7.2.4. It is the responsibility of the COL Applicant to further address structure-to-structure interaction if the specific site conditions can be important for the seismic response of particular US-APWR seismic category I structures, or may result in exceedance of assumed pressure distributions used for the US-APWR standard plant design.

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Maximum lateral earth pressure due to the backfill, surcharge due to live load or adjacent basemat bearing pressures, groundwater, and other such static-load effects on below-grade exterior walls are discussed in Section 3.8. The design of below grade exterior walls for US-APWR seismic category I structures takes into account any dynamic increases of these loads due to a seismic event. This is accomplished through the use of conservative maximum static and dynamic lateral pressure distribution profiles developed using analysis methods provided in Section 3.5.3 of ASCE 4-98 (Reference 3.7-9).

The COL Applicant is to assure that the design or location of any site-specific seismic category I SSCs, for example pipe tunnels or duct banks, will not expose those SSCs to possible impact due to the failure or collapse of non-seismic category I structures, or with any other SSCs that could potentially impact, such as heavy haul route loads, transmission towers, non safety-related storage tanks, etc. Alternately, site-specific seismic category I SSCs are designed for impact loads due to postulated failure of the non-seismic category I SSCs.

Following is a discussion of major structures in the power block area with respect to potential interaction with seismic category I structures.

3.7.2.8.1 AC/B

The AC/B is structurally designed as a NS structure on reinforced concrete foundation located at the west side of the A/B (seismic category II). The AC/B is not located adjacent to any seismic category I SSCs. If the AC/B were to fail or collapse, it could impact the A/B which is a seismic category II structure. AC/B is smaller, shorter, and much less massive than the reinforced concrete A/B. In the unlikely event of impact, there would not

3. DESIGN OF STRUCTURES, SYSTEMS, COMPONENTS, AND EQUIPMENT

- COL3.7(6) *The COL Applicant is to develop site-specific GMRS and FIRS by an analysis methodology, which accounts for the upward propagation of the GMRS. The FIRS are compared to the CSDRS to assure that the US-APWR standard plant seismic design is valid for a particular site. If the FIRS are not enveloped by the CSDRS, the US-APWR standard plant seismic design is modified as part of the COLA in order to validate the US-APWR for installation at that site.*
- COL3.7(7) *The COL Applicant is to determine the allowable static and dynamic bearing capacities based on site conditions, including the properties of fill concrete placed to provide a level surface for the bottom of foundation elevations, and to evaluate the bearing loads to these capacities.*
- COL3.7(8) *The COL Applicant is to evaluate the strain-dependent variation of the material dynamic properties for site materials.*
- COL3.7(9) *The COL Applicant is to assure that the design or location of any site-specific ~~seismic category I~~ safety-related SSCs, for example pipe tunnels or duct banks, will not expose those SSCs to possible impact due to the failure or collapse of non-seismic category I structures, or with any other SSCs that could potentially impact, such as heavy haul route loads, transmission towers, non safety-related storage tanks, etc.* DCD_03.07.02-88
- COL3.7(10) *It is the responsibility of the COL Applicant to further address structure-to-structure interaction if the specific site conditions can be important for the seismic response of particular US-APWR seismic category I structures, or may result in exceedance of assumed pressure distributions used for the US-APWR standard plant design.*
- COL3.7(11) ~~Deleted~~ It is the responsibility of the COL Applicant to confirm the masses and frequencies of the PCCV polar crane and fuel handling crane and to determine if coupled site-specific analyses are required. DCD_03.07.02-102
- COL3.7(12) *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.*
- COL3.7(13) *The COL Applicant is to set the value of the OBE that serves as the basis for defining the criteria for shutdown of the plant, according to the site specific conditions.*
- COL3.7(14) *The COL Applicant is to determine from the site-specific geological and seismological conditions if multiple US-APWR units at a site will have essentially the same seismic response, and based on that determination, choose if more than one unit is provided with seismic instrumentation at a multiple-unit site.*
- COL3.7(15) Deleted

3. DESIGN OF STRUCTURES, SYSTEMS, US-APWR Design Control Document COMPONENTS, AND EQUIPMENT

COL3.7(25) *The COL Applicant referencing the US-APWR standard design is required to perform a site-specific SSI analysis for the R/B-PCCV-containment internal structure, and PS/B model, utilizing the program ACS SASSI (Reference 3.7-17) which contains time history input incoherence function capability. The SSI analysis using SASSI is required in order to confirm that site-specific effects are enveloped by the standard design. ~~After the SASSI analysis is first performed for a specific unit, subsequent COLAs for other units may be able to forego SASSI analyses if the FIRS and GMRS derived for those subsequent units are much smaller than the US-APWR standard plant GSDRS, and if the subsequent unit can also provide justification through comparison of site-specific geological and seismological characteristics.~~*

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COL3.7(26) *SSI effects are also considered by the COL Applicant in site-specific seismic design of any seismic category I and II structures that are not included in the US-APWR standard plant. Consideration of structure-to-structure interaction is discussed in Subsection 3.7.2.8. The site-specific SSI analysis is performed for buildings and structures including, but not limited to, to the following:*

- *Seismic category I ESWPT*
- *Seismic category I PSFSV*
- *Seismic category I UHSRS*

COL3.7(27) *It is the responsibility of the COL Applicant to perform any site-specific seismic analysis for dams that may be required.*

COL3.7(28) *The overall basemat dimensions, basemat embedment depths, and maximum height of the US-APWR R/B, PCCV, and containment internal structure on their common basemat are given in Table 3.7.1-3 and as updated by the COL Applicant to include site-specific seismic category I structures.*

COL3.7(29) *Table 3.7.2-1, as updated by the COL Applicant to include site-specific seismic category I structures, presents a summary of dynamic analysis and combination techniques including types of models and computer programs used, seismic analysis methods, and method of combination for the three directional components for the seismic analysis of the US-APWR standard plant seismic category I buildings and structures.*

COL 3.7(30) *The COL Applicant is to provide site-specific design ground motion time histories and durations of motion.*

3.7.6 References

3.7-1 General Design Criteria for Nuclear Power Plants, Domestic Licensing of Production and Utilization Facilities, Energy. Title 10 Code of Federal