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UniStar
NUCLEAR ENERGY

10 CFR 50.4
10 CFR 52.79

May 1, 2009

UN#09-228

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

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3,
RAI No. 58, Seismic Design Parameters
RAI No. 63, Seismic Subsystem Analysis
RAI No. 65, Seismic System Analysis

References:

1) John Rycyna (NRC) to Robert Poche (UniStar), "RAI No. 58 SEB2 1966.doc (PUBLIC)" email dated February 17, 2009

2) John Rycyna (NRC) to Robert Poche (UniStar), "RAI No. 63 SEB2 1973.doc (PUBLIC)" email dated February 18, 2009

3) John Rycyna (NRC) to Robert Poche (UniStar), "RAI No. 65 SEB2 1971.doc (PUBLIC)" email dated February 18, 2009

4) Greg Gibson (UniStar) Letter to Document Control Desk (NRC), Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 58, Seismic Design Parameters, RAI No. 63, Seismic Subsystem Analysis, RAI No. 65, Seismic System Analysis, dated March 19, 2009

5) Greg Gibson (UniStar) Letter to Document Control Desk (NRC), Transmittal of Schedule for Seismic Analysis and Geotechnical Schedules, dated April 22, 2009.

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The purpose of this letter is to respond to the requests for additional information (RAIs) identified in the NRC e-mail correspondence to UniStar Nuclear, dated February 17, 2009 (Reference 1) and February 18, 2009 (References 2 and 3).

These RAIs address Seismic Design, as discussed in Section 3.7 of the Final Safety Analysis Report (FSAR), as submitted in Part 2 of the CCNPP Unit 3 Combined License Application (COLA), Revision 4.

Enclosure 1 provides a summary of the scheduled dates and deliverables for responses to RAI questions associated with RAIs 58, 63 and 65 that have not been answered previously or in this submittal. The information presented in Enclosure 1 reflects the updated response schedule that was previously provided for RAI questions associated with RAIs 58, 63, and 65 (References 4 and 5). The response to RAI 58 Question 03.07.01-9 has been extended to June 12, 2009 to ensure all preliminary issues and issues to be resolved in the final detailed design have been addressed. Enclosure 2 provides our response to RAI 58 Question 03.07.01-8; and RAI 65 Questions 03.07.02-1, 03.07.02-10, 03.07.02-14, 03.07.02-21, and 03.07.02-25.

COLA impacts associated with these RAI responses are noted with the question response. A Licensing Basis Document Change Request has been initiated to incorporate these changes into a future revision of the COLA. Our responses do not include any new regulatory commitments.

If there are any questions regarding this transmittal, please contact me at (410) 470-4205, or Mr. Michael J. Yox at (410) 495-2436.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on May 1, 2009

Christian Clement for Greg Gibson

Greg Gibson

Enclosures: 1) Response Summary for Requests for Additional Information,
RAI No. 58, Seismic Design Parameters,
RAI No. 63, Seismic Subsystem Analysis, and
RAI No. 65, Seismic System Analysis
Calvert Cliffs Nuclear Power Plant Unit 3

2) Response to NRC Request for Additional Information
RAI No. 58, Seismic Design Parameters, and
RAI No. 65, Seismic System Analysis
Calvert Cliffs Nuclear Power Plant Unit 3

cc: John Rycyna, NRC Project Manager, U.S. EPR COL Application
Laura Quinn, NRC Environmental Project Manager, U.S. EPR COL Application
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Loren Plisco, Deputy Regional Administrator, NRC Region II (w/o enclosure)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2
U.S. NRC Region I Office

Enclosure 1

Response Summary for Requests for Additional Information, RAI No. 58, Seismic Design Parameters, RAI No. 63, Seismic Subsystem Analysis, and RAI No. 65, Seismic System Analysis Calvert Cliffs Nuclear Power Plant Unit 3

RAI Set 58 **Question**	**Description of RAI Item**	**Response Date**
03.07.01-1	Justify assumptions of rigid basemat in SSI analysis of Nuclear Island including lower bound soil properties (where shear wave velocity is less than 1000 fps)	September 15, 2009
	Identify impact on the SSI analysis results and on the design of the foundation mat and supported superstructure.	September 15, 2009
03.07.01-2	Provide a figure in the FSAR to depict SSI model of Nuclear Island including the model of subgrade.	July 15, 2009
	State whether or not embedment effects were considered in this analysis and, if not, what is the justification for not including them and what impact could this have on the analysis results.	September 15, 2009
	Describe the properties of the structural backfill and how the fill was modeled in the SSI analysis.	July 15, 2009
	As the groundwater table is close to the bottom of the base mat, how are groundwater effects treated in the SSI confirmatory analysis.	July 15, 2009
	Identify computer codes to perform SSI analysis of NI; provide description of codes, extent of application and basis for validation.	July 15, 2009
	Provide similar information on computer codes used in the generation of FIRS for each Category I structure.	July 15, 2009
	Provide similar information on computer codes used in seismic analysis in Section 3.7.1,3.7.2, and 3.7.3.	July 15, 2009
03.07.01-3	For EPGB and ESWB, provide methodology to calculate FIRS at grade elevation computed from the GMRS which were determined at an and applicable elevation 41 ft below grade.	August 15, 2009
	Describe computer codes, soil column model, and the basis for the shear, wave velocity of the structural backfill that supports both the EPGB and ESWB and the impact of this backfill on the development of the FIRS.	December 31, 2009
	Provide in the FSAR the spectra at the foundation level of each structure meeting Appendix S requirements.	February 15, 2010 (1)
	Provide in the FSAR a comparison of the FIRS at the foundation level of each structure meeting the requirements of Appendix S to the CSDRS provided in the U.S. EPR FSAR.	February 15, 2010 (1)
	Provide the basis for not performing confirmatory analysis for the EPGB and ESWB similar to that for NI.	July 15, 2009

RAI Set 58 **Question**	**Description of RAI Item**	**Response Date**
03.07.01-4	In FSAR Section 3.7.1.1.1, on page 3.0-32, it discusses the design response spectrum used to analyze the Ultimate Heat Sink (UHS) Makeup Water Intake Structure. The spectral comparison between the European Utility Requirements (EUR) soft soil spectrum scaled to 0.15 g, the RG 1.60 spectrum scaled to 0.1 g, and the ground motion response spectra (GMRS) shown in Fig. 3.7-38 indicates that the RG 1.60 spectrum and GMRS exceed the EUR spectrum at frequencies below 0.7 and 0.4, respectively. What is the corresponding comparison of displacements and velocities for these spectrum motions, and if the EUR displacements are exceeded, how will this be addressed in the design of piping and other appurtenances connected to these buildings including the design of buried utilities?	July 15, 2009
03.07.01-5	For Ultimate Heat Sink Electrical Building, provide and include in the RAI response FSAR the horizontal and vertical spectra depicting design spectra and applicable envelope.	August 15, 2009
	Provide in the FSAR a reconciliation of the design response spectrum with the horizontal foundation input response spectra (FIRS) for this structure which meets the minimum requirements of 10 CFR Part 50, Appendix S.	May 31, 2010 (1)
	Include a description of how the FIRS are developed including the soil model, soil properties, backfill properties, computer programs and analysis assumptions.	January 31, 2010 (1)
03.07.01-6	Provide in the FSAR how the design response spectrum and assumed soil properties used in the analysis of the UHS MWIS will be reconciled with the FIRS that meets the requirements of Appendix S and the final soil properties determined from the site final geotechnical studies.	August 31,2009
	Include in the FSAR a comparison of the FIRS with the design response spectra used in the analysis.	January 15, 2010 (1)
	Include a description of how the FIRS are developed including the soil model, soil properties, computer programs, and analysis assumptions.	December 31, 2009
03.07.01-7	Provide in the FSAR a discussion of the site-specific spectra that were considered for buried utilities.	December 31, 2009
	Provide justification for the use of the EUR soft soil spectrum including possible displacement and velocity differences that may exist with the use of this spectrum as opposed to using a site specific spectrum.	December 31, 2009
	Provide a comparison of the EUR soft soil spectrum with appropriate site specific spectra that are applicable to buried utilities.	December 31, 2009
03.07.01-8	This Letter – see Enclosure 2	

RAI Set 58 **Question**	**Description of RAI Item**	**Response Date**
03.07.01-9	FSAR Section 3.7.1.1.1, page 3.0-32 characterizes the geotechnical data as preliminary. In general, noted throughout FSAR Section 3.7 there are issues that are to be resolved in the final detailed design. It is not clear how the site-specific structures will meet the requirements of GDC 2. Provide a table that lists the items to be resolved in the final detailed design, how the items will be closed, and how these are to be incorporated into the final version of the FSAR.	June 12, 2009
03.07.01-10	State explicitly or by reference design ground motion time histories for RAI partial Nuclear Island, EPGB and ESWB structures.	September 15, 2009
	What are the site specific design ground motions and their bases that apply to these structures? Provide this information in Section 3.7.1.1.2 of the FSAR.	February 15, 2010 (1)

RAI Set 63 **Question**		**Response Date**
03.07.03-1	For the analysis of buried utilities, provide the following information: • Describe any computer codes used for the analysis and their application to the analysis and design of buried utilities. • Provide the soil properties used in the analysis and explain how differences in soil properties were accommodated in the analysis. • Provide the design codes and acceptance criteria for each category of buried utilities. • Describe the missile protection provided for safety-related buried utilities. • Describe how ground water effects were considered in the analysis. • For utility runs that are both above and below ground, describe how above ground inertial effects were combined with below ground seismic wave effects. • Describe how the wave velocities were determined for calculating the maximum axial strain. • Provide the basis for determining the maximum friction force per unit length of pipe.	July 15, 2009
	For the analysis of buried utilities, provide the following information: Describe how the building anchor point displacements were determined and how these were combined with seismic wave effects and soil loads	December 15, 2009

RAI Set 65 **Question**	**Description of RAI Item**	**Response Date**
03.07.02-1	This Letter – see Enclosure 2	
03.07.02-2	In FSAR Section 3.7.2.1.4 (Equivalent Static Load Method of Analysis) on page 3.0-35, it states that the equivalent static load method is used for the UHS EB by applying 0.5 g acceleration in all directions. Assuming the zero period acceleration (ZPA) of the design input ground motion is .35 g, provide the justification for the amplification of ground acceleration used for this structure, i.e. .5/.35, or 1.43. In addition, an assumption is made that the walls and slabs are stiff. This is used as the basis for assuming there is no additional amplification of the seismic response of the structure due to local flexibility of the structural elements. While it may be true the in-plane stiffness of the walls and slabs exceed 33 Hz, it may not be true that this is the case for their out-of-plane response. Provide the results of an analysis that demonstrates that the out-of-plane response for walls and slabs exceeds 33 Hz. Include in this analysis technical consideration of whether the walls and slabs are cracked or uncracked under the applied design loads.	June 12, 2009
03.07.02-3	Describe how the Ultimate Heat Sink Electrical Building displacements are calculated which are needed as inputs for the analysis of buried conduit, duct banks, and piping that interface with this structure.	June 12, 2009
03.07.02-4	Provide results of SSI analysis for Ultimate Heat Sink Electrical Building that meet the acceptance criteria 4.A.vii of SRP 3.7.1 and acceptance criteria 4 of SRP 3.7.2 using subgrade model of final soil and backfill properties or justify alternative.	May 31, 2010 (3)
	Include SSSI effects from UHS MWIS.	May 31, 2010 (3)
	Reconcile with the results of assumed seismic response and ISRS.	May 31, 2010 (3)

RAI Set 65 **Question**	**Description of RAI Item**	**Response Date**
03.07.02-5	In FSAR Section 3.7.2.3.2 (Seismic Category I Structures - Not on Nuclear Island Common Base Mat) on page 3.0-36, it describes the finite element model used in the analysis of the Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS). • SRP 3.7.2, SRP Acceptance Criteria 3.C.ii. states the element mesh size should be selected on the basis that further refinement has only a negligible effect on the solution results. Describe any sensitivity studies that were implemented in determining the mesh size for the UHS MWIS, and if no sensitivity study was performed provide justification for not doing so. • SRP 3.7.2, SRP Acceptance Criteria 3.D. states that in addition to the structural mass, a floor load of 244.64 kg/m2 (50 pounds/ft^2) should be included to represent miscellaneous dead weights and a mass equivalent to 25 percent of the floor design live load and 75 percent of the roof design snow load should be included in the model. Describe how this acceptance criterion has been addressed in the model of the UHS MWIS, and if no additional mass was added provide the justification for not doing so.	June 12, 2009
03.07.02-6	Describe how the SSI analysis for Ultimate Heat Sink Makeup Water Intake Structure (UHS MWIS) performed meets the acceptance criteria and 4.A.vii of SRP 3.7.1 or justify alternative.	February 15, 2010 (2)
	Provide a figure depicting the soil-structure model used for the seismic analysis.	December 31, 2009
	Provide the basis for the assumed soil properties and profile used to calculate the frequency independent impedance functions.	August 15, 2009
	Provide the method and formulas used to calculate the values of the soil springs under the foundation as well as the lateral soil springs that represent the embedment effects.	August 15, 2009
	State whether the soil properties used in the analysis are strain dependent or simply the low strain values. If these are low strain values, justify their use and quantify the impact of not using strain dependent properties on the results of the analysis. If the soil properties are strain dependent, describe how the final soil properties are determined in the analysis.	August 15, 2009
	For large values of Poisson's ratio, the dynamic stiffness and damping are frequency dependent. Provide justification for assuming that the impedance functions of the supporting foundation are frequency independent.	August 31, 2009
	Confirm that the control motion is applied at the base of the soil structure analysis model.	August 31, 2009

RAI Set 65 **Question**	**Description of RAI Item**	**Response Date**
	Provide a reconciliation of the final soil properties and the foundation input response spectra (FIRS) that are based on these properties with the seismic analysis results described in the FSAR.	January 31, 2010 (1)
03.07.02-7	In FSAR Section 3.7.1.1 (pg 3.0-29), it indicates that the Category I makeup water intake structure (MWIS) is founded below sea level. The description of the soil-structure-interaction (SSI) analysis for this structure does not describe how the ground water effects were included in the analysis. Describe how the SSI calculations included these effects, and if they did not, provide justification for not doing so and address the impact.	June 12, 2009
03.07.02-8	FSAR Section 3.7.2.3.2 states that the Ultimate Heat Sink Makeup Water Intake Structure is analyzed in GTSTRUDL. It further states that the walls "are not anticipated" to crack. Provide the basis for this statement including numerical results for typical concrete sections using the applicable wall design loads.	June 12, 2009
03.07.02-9	See UniStar Nuclear Energy letter dated March 19, 2009	
03.07.02-10	This Letter – see Enclosure 2	
03.07.02-11	In FSAR Section 3.7.2.4 on page 3.0-37, it states that the convective frequencies associated with sloshing effects occur in the range where the scaled down European Utility Requirements (EUR) spectra do not exceed either the CCNPP Unit 3 spectra (zero period acceleration (ZPA) of 0.067 g) or Regulatory Guide 1.60 spectra scaled to a ZPA of 0.10 g. It goes on to say that due to the lower acceleration levels at the convective frequencies and the lower convective water mass, the convective forces are anticipated to be minimal with respect to the impulsive forces. If the foundation input response spectra (FIRS) for this structure are the scaled down EUR spectra, explain why this is an appropriate response spectra for this site when the low frequency input is less than that of the ground motion response spectra (GMRS) which has a ZPA of .067 g. What is the basis for the calculation of the convective water mass? Why was this mass not included in the analysis of the UHS MWIS? How will the difference in input response spectra be resolved in determining the proper convective design loads for the structure?	June 12, 2009
03.07.02-12	Provide results of a structure-to-structure interaction analysis between UHS MWIS and EB.	May 31, 2010 (3)
03.07.02-13	In FSAR Section 3.7.2.6 (Three Components of Earthquake Motion) on page 3.0-40, it states for the Ultimate Heat Sink (UHS) Electrical Building that due to building symmetry cross-coupling is determined to be negligible. As no dynamic analysis was performed for this structure, what is the justification for this statement?	June 12, 2009
03.07.02-14	This Letter – see Enclosure 2	

RAI Set 65 **Question**	**Description of RAI Item**	**Response Date**
03.07.02-15	In FSAR Section 3.7.2.6 on page 3.0-40, it states that for the Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS), three statistically independent time histories are applied for each of the six soil cases to determine accelerations at select locations. Describe how the accelerations obtained from this dynamic analysis are applied to the static model to obtain forces and moments for structural design and provide examples of how the three components of earthquake motion are combined and compare the results to those of the 100-40-40 rule presented in RG 1.92, Revision 2. The use of an equivalent static approach to determine forces and moments in the structure may not be conservative as dynamically computed forces and moments will retain the appropriate sign from the analysis and the static approach will not. How will this be addressed in the development of loads used in the design of the structure?	July 15, 2009
03.07.02-16	UniStar Nuclear Energy letter dated March 19, 2009	

RAI Set 65 **Question**	**Description of RAI Item**	**Response Date**
03.07.02-17	The interaction of non-seismic Category I structures with Seismic Category I systems is described in FSAR Section 3.7.2.8. In this section on page 3.0-41, it states that fire protection SSCs are categorized as either Seismic Category II-SSE, meaning the SSC must remain functional during and after a Safe Shutdown Earthquake (SSE), or Seismic Category II, meaning the SSC must remain intact after an SSE without deleterious interaction with a Seismic Category I or Seismic Category II-SSE SSC. In the U.S. EPR FSAR on page 3.7-95, it states that Seismic Category II is designed to the same criteria as Seismic Category I structures. In SRP 3.7.2, SRP Acceptance Criteria 8, which addresses the interaction of non-Category I structures with Category I SSCs, it states that when non-Category I structures are designed to prevent failure under SSE conditions; the margin of safety shall be equivalent to that of the Seismic Category I structure. • Describe how this margin of safety is achieved for the Seismic Category II-SSE and Seismic Category II portions of the fire protection system. Include in your response the seismic inputs, loading combinations, codes and acceptance criteria. What are the differences in the method of design for these two seismic categories? • Describe the basis and provide figures in the FSAR of the design response spectra used to analyze above ground seismic Category II and seismic Category II-SSE fire protection SSCs including the fire protection tanks. • What are the methods of analysis and acceptance criteria for both the buried and above ground portions of the fire protection system that are Seismic Category II-SSE that will ensure that these portions of the system will remain functional following an SSE event? • What are the modeling and analysis methods used for the fire protection tanks and to what extent do the fire protection tanks meet the acceptance criteria of SRP 3.7.3, SRP Acceptance Criteria 14.A. thru J? When the tank analysis does not meet the acceptance criteria, provide the technical justification for not doing so.	June 12, 2009
03.07.02-18	Clarify the seismic classification of fire protection tank and building.	July 15, 2009
	Reconcile the U.S. EPR seismic analysis for NAB with the site-specific soil properties and foundation input response spectra (FIRS)	September 15, 2009
	Demonstrate in the FSAR that the displacement of this structure relative to the nuclear island common basemat structure is enveloped by the results of the U.S. EPR analysis.	September 15, 2009

RAI Set 65 **Question**	**Description of RAI Item**	**Response Date**
03.07.02-19	In FSAR Section 3.7.2.8 on page 3.0-42 it states that the conventional seismic switchgear building, conventional seismic grids systems control building, the conventional seismic circulating water intake structure and the Seismic Category II retaining wall surrounding the CCNPP Unit 3 intake channel could potentially interact with Seismic Category I SSCs. For each of the above structures, describe in the FSAR how the seismic interaction acceptance criteria of SRP 3.7.2, SRP Acceptance Criteria 8 are met, or justify an alternative. If they are intended to meet criterion B, provide the technical basis for the determination that the collapse of the non-Category I structure is acceptable. For criterion C, confirm that the structure will be analyzed and designed to have a margin of safety equivalent to that of a Category I structure and state how this will be accomplished.	June 12, 2009
03.07.02-20	In FSAR Section 3.7.2.8 on page 3.0-42, it states that the existing non-seismic bulkhead could potentially interact with the Ultimate Heat Sink (UHS) Makeup Water Intake Structure and UHS Electrical Building. Identify and describe the methods used to determine that this structure will not have any unacceptable interaction with either of the Seismic Category I structures?	June 12, 2009
03.07.02-21	This Letter – see Enclosure 2	
03.07.02-22	UniStar Nuclear Energy letter dated March 19, 2009	
03.07.02-23	At the end of FSAR Section 3.7.2.15, on page 3.0-44, there is a description of a comparison of an analysis result using ANSYS to solve the complex eigen-value solution of the non-classical damping formulation with an analysis result using GT STRUDL to solve the real eigen-value solution of the classical damping formulation in which the off-diagonal terms of the damping matrix are neglected. It is not clear from the discussion which of the damping methods was used in the seismic analysis of the Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS). In addition, no comparison of the results using the two methods cited has been provided. Provide the method used to account for damping in the seismic analysis of the UHS MWIS and provide in the FSAR the results of the study comparing the non-classical damping formulation with the classical damping formulation.	June 12, 2009
03.07.02-24	Per COLA item 3.7-1, address that the seismic response of the nuclear island common base mat structures, seismic Category II structures, the Nuclear Auxiliary Building and the Radioactive Waste Processing Building is within the parameters of Section 3.7 of U.S. EPR FSAR.	September 15, 2009
	Provide a summary for each structure, either directly or by reference, September 15, which describes how the COI item is met.	September 15, 2009
03.07.02-25	This Letter – see Enclosure 2	

RAI Set 65 **Question**	**Description of RAI Item**	**Response Date**
03.07.02-26	SRP 3.7.2, SRP Acceptance Criteria 14 states that the determination of seismic overturning moments and sliding forces should include three components of input motion and conservative consideration of the simultaneous action of the vertical and horizontal seismic forces. How overturning moments and sliding forces are determined has not been provided in either FSAR Section 3.7.2, 3.8.5 or in Section 3E.4. The applicant is requested to provide this information in Section 3.7.2 and describe how this information is used in determining the overturning and sliding stability of the Ultimate Heat Sink (UHS) Makeup Water Intake Structure and UHS Electrical Building.	June 12, 2009

(1) Potential SER Open Item 1 – confirm FIRS with CSDRS and design SSE (RAI 58 Question 03.07.01-3, 5, 6, 10, and RAI 65 Question 03.07.02-6)

(2) Potential SER Open Item 2 – perform SSI analysis using System for Analysis of Soils Structure Interaction (SASSI) code (RAI 65 Question 03.07.02-6)

(3) Potential SER Open Item 3 – reconcile analysis results with existing analysis (RAI 65 Question 03.07.02-4 and -12)

Enclosure 2

Response to NRC Request for Additional Information
RAI No. 58 - Seismic Design Parameters, and
RAI No. 65, Seismic System Analysis
Calvert Cliffs Nuclear Power Plant Unit 3

RAI No. 58

Question 03.07.01-8

In FSAR Section 3.7.1.2 (Percentage of Critical Damping Values) provide in the FSAR the structural damping values to be used in the analysis of site-specific Seismic Category I, Seismic Category II-SSE, and Seismic Category II structures and provide the justification for the values selected.

Response

The structural damping values used in analysis of site-specific Seismic Category I structures that are not included within the U.S. EPR standard design are based on U.S. EPR Table 3.7.1-1 – Damping Values for Safe Shutdown Earthquake of U.S. EPR FSAR. The values listed in Table 3.7.1-1 are based on Regulatory Guide 1.61, Rev 1.

The damping values for site-specific Seismic Category II-SSE structures are also in accordance with RG 1.61, Rev. 1. The damping values for site-specific Seismic Category II structures correspond to Response Level 3 values provided in Table 3-2 of ASCE 43-05. As described in Section 3.4.3 of ASCE 43-05, Response Level 3 may be used for structures designed to Limit State A, defined in Table 1-4 of ASCE 43-05.

COLA Impact

Part 2, FSAR of the CCNPP Unit 3 COLA will be updated in a future COLA revision to incorporate the changes to FSAR Sections 3.7.1.2 and 3.7.1.4 that are identified below:

3.7.1.2 Percentage of Critical Damping Values

~~No departures or supplements.~~

This section of the U.S. EPR FSAR is incorporated by reference with the supplement described below:

The structural damping values used for dynamic analysis of site-specific Seismic Category I SSCs are based on Table 3.7.1-1 of U.S. EPR FSAR and are consistent with RG 1.61, Rev 1 (NRC, 2007c).

The damping values for site-specific Seismic Category II-SSE structures are in accordance with RG 1.61, Rev. 1 (NRC, 2007c). The damping values for site-specific Seismic Category II structures correspond to Response Level 3 values provided in Table 3-2 of ASCE 43-05 (ASCE, 2005). As described in Section 3.4.3 of ASCE 43-05 (ASCE, 2005), Response Level 3 may be used for structures designed to Limit State A, defined in Table 1-4 of ASCE 43-05 (ASCE, 2005).

3.7.1.4 References

ASCE, 2005. Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities, ASCE 43-05, American Society of Civil Engineers, January 2005.

NRC, 2007c. Damping Values for Seismic Design of Nuclear Power Plants, Regulatory Guide 1.61, Revision 1, U.S. Nuclear Regulatory Commission, March 2007.

RAI No. 65

Question 03.07.02-1

In FSAR Section 3.7.2.1.1 (Time History Analysis Method) on page 3.0-34, it states that the Ultimate Heat Sink (UHS) Electrical Building (EB) is fully embedded and relatively rigid compared to the soil stiffness, and consequently there is no significant amplification above the ground surface input motion. The UHS Makeup Water Intake Structure (MWIS) is similar to the UHS EB in that it is relatively rigid and almost entirely embedded. The zero period acceleration (ZPA) input to the UHS MWIS is 0.15 g and the structural response at grade is approximately 0.35 g in the North-South direction. This equates to an amplification of approximately 2.33 over the input motion ZPA. Why wouldn't a similar result occur for the UHS EB, and what is the technical basis for stating that there is no significant amplification above the ground surface input motion for this structure?

Response

The Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS) below the operating deck is open on one side and embedded on three sides. The seismic analysis considered two different models (half-embedded structure in accordance with ASCE 4-98 Section 3.3.1.9, and no embedment) to address the effects of embedment on structural response. Although the UHS MWIS is relatively rigid, the dynamic response of the UHS MWIS is dominated by inertial loading due to the attached Makeup Water Pump Structure, partial embedment around only three soil supported sides, and the exposed water intake side. Time history analyses were performed for both models, and results were then enveloped for the design.

The UHS Electrical Building (EB) is a rigid structure that is essentially fully embedded. The design response spectrum for UHS EB is taken as the envelope of the European Utility Requirement (EUR) Soft spectrum scaled down to a ZPA of 0.15g and the in-structure response spectrum (ISRS) of UHS Makeup Water Intake Structure (MWIS) at the operating deck level with a zero period acceleration (ZPA) of 0.35 g. In the absence of more accurate information concerning the structure-soil-structure interaction (SSSI) between the UHS MWIS and EB, the UHS MWIS operating deck ISRS, which has a ZPA of 0.35 g, is used without any reduction to conservatively account for the resulting SSSI effects. The fundamental frequencies of UHS EB with fixed base conditions exceed the zero period acceleration (ZPA) cutoff frequency of 33Hz. However, the frequencies for soil driven modes may fall in the peak region of the considered design response spectrum. Even then, the maximum design accelerations in all directions will not exceed the considered acceleration of 0.50 g, as clarified in response to RAI 65 Question 03.07.02-14. Therefore, for the purpose of design, as stated in FSAR Section 3.7.2.1.4, a conservative acceleration of 0.50 g is used in all directions.

Additionally, a System for Analysis of Soils Structure Interaction (SASSI) analysis will be performed considering confirmed geotechnical data and seismic parameters, and the preliminary design input will be reconciled (see Potential Safety Evaluation Report Open Item 2 identified in Enclosure 1).

COLA Impact

None

RAI No. 65

Question 03.07.02-10

In FSAR Section 3.7.2.4 (Soil-Structure Interaction) on page 3.0-37, it states that in the analysis of the Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS) the impulsive forces of water acting on the walls of the intake structure are calculated using an acceleration of 0.5 g. What is the basis for this acceleration value? How is the impulsive weight calculated, and is the impulsive mass of water included in the soil-structure-interaction analysis of the structure? If it is not included, describe why it was not and provide the impact this will have on the natural frequencies of the structure, provided in Tables 3.7-7 thru 3.7-12, and on the building structural loads.

Response

The acceleration value of 0.5 g, which was used to generate the equivalent static loads associated with impulsive masses of water, is conservatively based on enveloping the peak (0.45 g) of the site horizontal SSE spectrum (see FSAR Figure 3.7-38; the site SSE spectrum corresponds to the European Utility Requirement (EUR) Soft Site design spectrum scaled down from a zero period acceleration (ZPA) value of 0.3 g to 0.15 g). It is further noted that the (equivalent static) impulsive load acting perpendicular to each wall was determined by conservatively considering the entire water mass as being impulsive mass.

As indicated in the last paragraph of Section 3.7.2.3.2 of the FSAR (Revision 4 page 3.0-34), the impulsive masses of the contained water inside each chamber of the UHS Makeup Intake Structure are calculated in accordance with Equation (9-1) of Section 9.2.1 in ACI 350.3-06 (ACI, 2006). The impulsive mass associated with the forebay water on the exposed side of the intake structure was calculated using the "Westergaard Added Mass" methodology described in Section 2-19 of the U.S. Army Corps of Engineer Manual EM 1110-2-6051 (ACE, 2003).

The impulsive masses of water were applied in the direction normal to the face of the walls in the soil-structure-interaction (SSI) analysis of the UHS Makeup Water Intake Structure. Results from this analysis showed that the resulting impulsive mass acceleration were lower than the 0.5 g equivalent static value used in the subsequent static analysis performed for design purposes. It was thus verified that the impulsive load treatment in the equivalent static analysis was conservative.

Since the SSI analyses were performed with the impulsive water masses included, there is no impact on the natural frequencies of the structure, provided in FSAR Tables 3.7-7 through 3.7-12, and the building structural loads.

<u>References</u>:

ACE, 2003. Engineering and Design - Time History Dynamic Analysis of Concrete Hydraulic Structures, EM-1110-2-6051, U.S. Army Corps of Engineers Manual, December 2003.

ACI, 2006. Seismic Design of Liquid-Containing Concrete Structures, ACI 350.3-06, American Concrete Institute, 2006.

COLA Impact

None

RAI No. 65

Question 03.07.02-14

In FSAR Section 3.7.2.6 on page 3.0-40, it states that separate manual calculations, using the equivalent static analysis method are performed to determine the structural response of the site-specific Ultimate Heat Sink Electrical Building in each of the three directions. On page 3.0-35, it states that 0.5 g acceleration is used in all directions. Describe in the FSAR the manual calculations that were used, how the structural response was obtained, and provide examples of how the three components of earthquake motion are combined comparing the results to those of the 100-40-40 rule presented in RG 1.92, Revision 2, or justify an alternative. Also describe how the forces and moments are determined to design the individual elements (walls and slabs) of this structure, or justify an alternative.

Response

The manual calculations pertaining to the seismic responses of the Ultimate Heat Sink (UHS) Electrical Building (EB) are described below using a simplified structure (Figure 1), which has four exterior walls (interior walls not shown for clarity), and a roof slab. The manual calculations include calculation of the equivalent static loads, torsional effects due to both inherent and accidental torsion, and calculation of the design forces and moments.

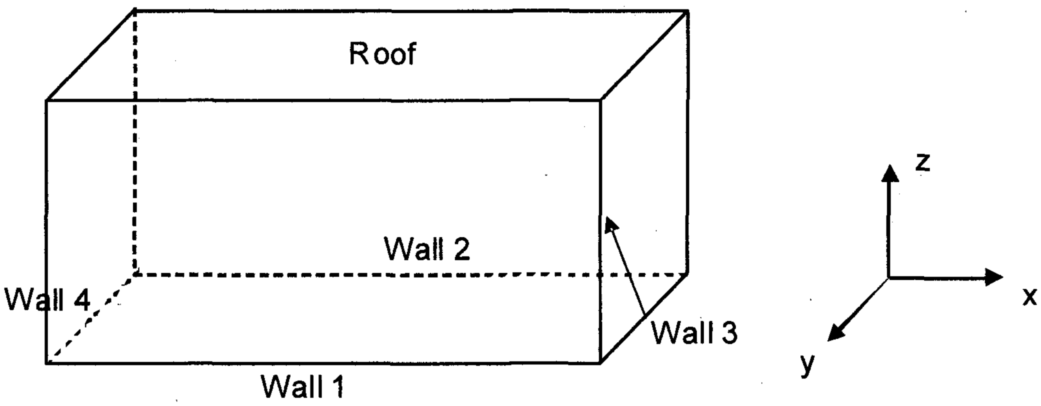

Figure 1

With respect to development of the structural response, the UHS EB is a rigid structure that is essentially fully embedded. As such, its seismic response is controlled by compatibility with the surrounding soil medium. Frequency calculations were performed by conservatively considering an at-grade structure with fixed base boundary conditions to verify that the translational frequencies in the three orthogonal directions and the torsional frequency are beyond the zero period acceleration (ZPA) cut-off frequency (33 Hz). As such, for this conservative analytical model, the soil governed mode shapes will control the response of the structure. The associated frequencies were conservatively considered to lie on the peak of the design response spectrum, which is taken as the envelope of the European Utility Requirement (EUR) Soft spectrum scaled down to a ZPA of 0.15 g and the in-structure response spectrum (ISRS) of the adjacent UHS Makeup Water Intake Structure (MWIS) at the operating deck level with a ZPA of 0.35 g.

In the absence of more accurate information concerning the structure-soil-structure interaction (SSSI) between the UHS MWIS and EB, the UHS MWIS operating deck ISRS, which has a ZPA of 0.35 g, is used without any reduction to conservatively account for the resulting SSSI effects. Conservatively considering at least 20% damping for the soil driven modes, the maximum structural response, based on the amplification factors in Reference 1 of RG 1.60 (NRC, 1973), will not exceed the considered acceleration of 0.50 g applied in all directions for the design of the UHS EB. The structural response will be confirmed during the detailed design using System for Analysis of Soils Structure Interaction (SASSI).

For calculation of the in-plane shear and moment in each wall due to the global building seismic responses, the total lateral (equivalent static) seismic load in each of the three global directions is calculated as the product of total building mass and design acceleration (0.5 g). The contributing mass includes mass of roof, walls, miscellaneous equipment (including piping, raceways, and heating, ventilating and air conditioning system), and 75% of uniform roof design snow load. To capture the effects of inherent and accidental torsion simultaneously, the center of mass coordinates are shifted from the center of rigidity coordinates by an additional ±5 percent of the maximum building dimension in each horizontal direction in accordance with SRP 3.7.2 Acceptance Criterion 11 (NRC, 2007).

Once the seismic equivalent static load is determined, it is combined with other static loads to calculate design forces and moments. The equivalent static analysis also considered the effects of the dynamic soil pressure considering the "elastic solution" described in ASCE 4-98 Section 3.5.3.2 (ASCE, 2000).

For hand calculation purposes, the lateral seismic loads are considered to be carried by parallel walls through the diaphragm action of the roof slab. Loads normal to a wall are carried by perpendicular walls in the shorter direction (one-way action).

As an example of how the three components of earthquake motion are combined, let E_X, E_Y, and E_Z represent the seismic inertia load in global x, y, and z direction, respectively. Structural response on a given wall has contributions from E_X, as well as contributions from E_Y and E_Z. In order to capture the contributions of the three earthquake components to a co-directional seismic response, E_X, E_Y, and E_Z are combined using the "100-40-40" rule per ASCE 4-98 (ASCE, 2000), which results in 24 seismic load combinations as follows.

$\pm E_X \pm 0.4E_Y \pm 0.4E_Z$
$\pm 0.4E_X \pm E_Y \pm 0.4E_Z$
$\pm 0.4E_X \pm 0.4E_Y \pm E_Z$

These combinations generate maximum seismic responses consistent with RG 1.92 (NRC, 2006).

In order to design individual elements, the seismic effects (considering the various combinations described above) are combined with static load effects per the applicable design load combinations in ACI 349-01 (ACI, 2001) and RG 1.142 (NRC, 2001). For example, one such load combination can be written as

$$D + L + H + E_X + 0.4E_Y + 0.4E_Z$$

where D, L, and H are dead load, live load, and static lateral soil pressure load, respectively.

Under this load combination, the structural responses in Wall 1 (see Figure 1), for example, are calculated in Table 1, where H_X and H_Y represent the dynamic soil pressure load associated with E_X and E_Y.

Table 1

Response	Loads	Calculation Method
In-plane (i.p.) shear	E_X, H_X	Wall 1 and 2 each carries half of the lateral load in x direction so that the in-plane shear in Wall 1 is 0.5(max(E_X,H_X)). Additional in-plane shear due to inherent and accidental torsional effects is also added.
In-plane moment	E_X, H_X	Conservatively, in-plane moment is calculated as 0.5(max(E_X,H_X)) multiplied by height of Wall 1.
Out-of-plane (o.o.p.) shear and moment	H, E_X, H_X, $0.4E_Y$, $0.4H_Y$	Considering a section of unit width, which behaves like a beam supported at the top and bottom edges, the o.o.p shear and moment are calculated using beam theory. Dynamic soil pressure or seismic inertia load, whichever governs, is added to the force from the static soil pressure load H to maximize the o.o.p. response.
Normal force (compression or tension)	D, L, $0.4E_Z$	Normal force is equal to the sum of dead load, live load, and vertical seismic inertia load associated with the wall and tributary roof slab.

The above table shows the method for calculating design forces and moments for a particular design load combination. The actual design is based on the worst case load combinations.

Note that for the UHS EB, the design is governed by loadings associated with PMH (probable maximum hurricane).

<u>References</u>:

NRC, 1973. Design Response Spectra for Seismic Design of Nuclear Power Plants, Regulatory Guide 1.60 Revision 1, U.S. Atomic Energy Commission, December 1973.

NRC, 2007. Standard Review Plan (SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800, Section 3.7.2, Seismic System Analysis, U.S. Nuclear Regulatory Commission, March 2007.

ASCE, 2000. Seismic Analysis of Safety-Related Nuclear Structures and Commentary, ASCE 4-98, American Society of Civil Engineers, 2000.

ACI, 2001. Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary, ACI 349-01, American Concrete Institute, 2001.

NRC, 2006. Combining Modal Responses and Spatial Components in Seismic Response Analysis, Regulatory Guide 1.92 Revision 2, U.S. Nuclear Regulatory Commission, July 2006.

NRC, 2001. Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments, Regulatory Guide 1.142 Revision 2, U.S. Nuclear Regulatory Commission, November 2001.

COLA Impact:

Part 2, FSAR of the CCNPP Unit 3 COLA will be updated in a future COLA revision to incorporate the changes to FSAR Section 3.7.2.1.4, 3.7.2.6, and FSAR 3.7.2.16 that are identified below:

3.7.2.1.4 Equivalent Static Load Method of Analysis

The UHS Makeup Water Intake Structure and UHS Electrical Building are analyzed using the equivalent static method. For the UHS Makeup Water Intake Structure, the equivalent static analysis uses accelerations determined directly from the time history analysis. For the UHS Electrical Building, an acceleration of 0.5 g is used in all directions. This is conservative given the input spectra (worst case ZPA of 0.35 g as per Section 3.7.2.4) and the fact that walls and the slab are shown to be rigid, i.e., with frequencies in excess of 33 Hertz (Hz). The equivalent static load is computed as the product of building mass and 0.5 g. Design force and moment on a structural member are computed manually for critical design load combinations in accordance with ACI 349 (ACI, 2001) and RG 1.142 (NRC, 2001). Lateral seismic loads are assumed to be carried by parallel walls only through the diaphragm action of the roof slab. Loads normal to a wall are assumed to be carried by perpendicular walls or slabs in the shorter direction (one-way action). Accordingly, in-plane responses of each wall are proportional to its rigidity plus the demand due to inherent and accidental torsion effects. Out-of-plane responses under static plus dynamic soil pressure are computed by conservatively considering one-way action.

3.7.2.6 Three Components of Earthquake Motion

For the site-specific UHS Makeup Water Intake Structure, three statistically independent time histories are applied component by component to the finite element model for each of the six soil cases to determine accelerations at select locations. An equivalent static analysis is then performed via the finite element model to determine forces and moments for structural component design.

Separate manual calculations, using the equivalent static analysis method described in Section 3.7.2.1.4, are performed to determine the structural response of the site-specific UHS Electrical Building in each of the three directions. Due to the building symmetry, cross-coupling is determined to be negligible.
The equivalent static analyses of both the UHS Makeup Water Intake Structure and the UHS Electrical Building use the ASCE 4-98 (ASCE, 2000~~1986~~) "100-40-40" rule to

calculate co-directional response, which is consistent with the requirement of RG 1.92 (NRC, 2006).

3.7.2.16 References

The following references are added to the COLA FSAR Section 3.7.2.16:

ACI, 2001. Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary, ACI 349-01, American Concrete Institute, 2001.

NRC, 2006. Combining Modal Responses and Spatial Components in Seismic Response Analysis, Regulatory Guide 1.92 Revision 2, U.S. Nuclear Regulatory Commission, July 2006.

NRC, 2001. Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments, Regulatory Guide 1.142 Revision 2, U.S. Nuclear Regulatory Commission, November 2001.

RAI No. 65

Question 03.07.02-21

For FSAR Section 3.7.2.11 (Method Used to Account for Torsional Effects) covered on page 3.0-43, describe how the methods used meet SRP 3.7.2, SRP Acceptance Criteria 11. How are the seismic forces due to torsional effects calculated and how are they combined with the other seismic forces of the structure?

Response

For the Ultimate Heat Sink Makeup Water Intake Structure and UHS Electrical Building, both inherent and accidental torsional effects are accounted for in the seismic loading combinations for use in structural design. Inherent and accidental torsional responses resulting from the same direction of earthquake are combined by sum-of-the-absolute-values. Co-directional responses from earthquakes in three orthogonal directions are combined in accordance with the co-directional response combination provisions of FSAR Section 3.7.2.6.

<u>Ultimate Heat Sink Makeup Water Intake Structure</u>

A 3-Dimensional GT STRUDL Finite Element Model (FEM) is used to perform dynamic time history analysis and subsequent equivalent static analysis.

The seismic accelerations from the dynamic time history analysis are converted to equivalent static seismic loads and applied to a static 3-Dimensional GT STRUDL FEM which captures the inherent torsion.

For accidental torsion, loads due to additional eccentricity equal to ±5 percent of the maximum building dimension in each horizontal direction are calculated manually, floor-by-floor, in accordance with SRP 3.7.2, Acceptance Criterion 11 (NRC, 2007a).

<u>Ultimate Heat Sink Electrical Building</u>

As noted in FSAR Section 3.7.2.1.1, the Electrical Building is considered as a rigid structure embedded in the soil. Therefore, no dynamic analysis is performed. The 0.5 g seismic acceleration is conservatively used in the equivalent static analysis.

In order to account for torsional effects, the location of Center of Mass (CM) and Center of Rigidity (CR) are determined. Then, to capture the effect of inherent and accidental torsion simultaneously, the CM coordinates are shifted from the CR coordinates by an additional ±5 percent of the maximum building dimension, at each floor, in each horizontal direction, in accordance with SRP 3.7.2, Acceptance Criterion 11 (NRC, 2007a).

<u>References:</u>

NRC, 2007a. Standard Review Plan (SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800, Section 3.7.2, Seismic System Analysis, U.S. Nuclear Regulatory Commission, March 2007.

COLA Impact

Part 2, FSAR of the CCNPP Unit 3 COLA will be updated in a future COLA revision to incorporate the changes to FSAR Section 3.7.2.11 and FSAR 3.7.2..16 that are identified below:

3.7.2.11 Method Used to Account for Torsional Effects

~~For the UHS Makeup Water Intake Structure and UHS Electrical Building, accidental torsion is considered in accordance with ASCE 4-98 (ASCE, 1986).~~

For the UHS Makeup Water Intake Structure and UHS Electrical Building, both inherent and accidental torsional effects are accounted for in the seismic loading combinations for use in structural design. Inherent and accidental torsional responses resulting from the same direction of earthquake are combined by sum-of-the-absolute-values. Co-directional responses from earthquakes in three orthogonal directions are combined in accordance with the co-directional response combination provisions of FSAR Section 3.7.2.6.

3.7.2.11.1 Ultimate Heat Sink Makeup Water Intake Structure

A 3-Dimensional GT STRUDL Finite Element Model (FEM) is used to perform dynamic time history analysis. The seismic accelerations from the dynamic time history analysis of this model are converted to equivalent static seismic loads which are applied to a static 3-Dimensional GT STRUDL FEM to determine the building seismic responses. For accidental torsion, loads due to additional eccentricity equal to ±5 percent of the maximum building dimension, at each floor, in each horizontal direction are calculated manually and in accordance with SRP 3.7.2, Acceptance Criterion 11 (NRC 2007a).

3.7.2.11.2 Ultimate Heat Sink Electrical Building

As noted in FSAR Section 3.7.2.1.1, the Electrical Building is considered as a rigid structure embedded in the soil. Therefore, no dynamic analysis is performed. The 0.5 g seismic acceleration is conservatively used in the equivalent static analysis. In order to account for torsional effects, the location of Center of Mass (CM) and Center of Rigidity (CR) are determined. Then, to capture the effect of inherent and accidental torsion simultaneously, the CM coordinates are shifted from the CR coordinates by an additional ±5 percent of the maximum building dimension, at each floor, in each horizontal direction in accordance with SRP 3.7.2 Acceptance Criterion 11 (NRC 2007a).

The following reference will be added to the references in FSAR Section 3.7.2.16:

NRC, 2007a. Standard Review Plan (SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800, U.S. Nuclear Regulatory Commission, March 2007.

RAI No. 65

Question 03.07.02-25

FSAR Section 3.7.2.9 (Effect of Parameter Variation on Floor Response Spectra) on page 3.0-43 describes the effects of parameter variations on floor response spectra. It states that to account for uncertainties or variations in parameters, In-Structure Response Spectra (ISRS) for the Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS) are broadened +/ 5 percent in accordance with ASCE 4-98 and RG 1.122. Since ASCE 4-98 has not been accepted for use by the staff to develop ISRS and as it describes methods to account for uncertainties and parameter variations that are not included in RG 1.122, the applicant is requested to confirm that only the guidance provided in the RG is used for peak broadening or provide justification for not doing so.

Response

To account for uncertainties or variations in parameters, the In-Structure Response Spectra (ISRS) for the Ultimate Heat Sink (UHS) Make up Water Intake Structure (MWIS) are broadened ±15 percent in accordance with the Regulatory Guide 1.122 (NRC, 1978). Reference to ASCE 4-98 (ASCE, 2000) as the criterion for broadening will be deleted.

References:

ASCE, 2000. Seismic Analysis of Safety-Related Nuclear Structures and Commentary, ASCE 4-98, American Society of Civil Engineers, 2000.

NRC, 1978. Development of Floor Design Response Spectra for Seismic Design of Floor-Supported equipment or Components, Regulatory Guide 1.122, U.S. Nuclear Regulatory commission, February, 1978.

COLA Impact

Part 2, FSAR of the CCNPP Unit 3 COLA will be updated in a future COLA revision to incorporate the changes to FSAR Section 3.7.2.9 that are identified below:

3.7.2.9 Effects of Parameter Variations on Floor Response Spectra

To account for uncertainties or variation in parameters, ISRS resulting from the time history analyses for the UHS Makeup Water Intake Structure are broadened +/- 15 percent in accordance with ~~ASCE 4-98 (ASCE, 1986) and~~ Regulatory Guide 1.122 (NRC, 1978).