ArevaEPRDCPEm Resource

From:	BRYAN Martin (EXTERNAL AREVA) [Martin.Bryan.ext@areva.com]
Sent:	Thursday, July 08, 2010 7:23 PM
To:	Tesfaye, Getachew
Cc:	DELANO Karen (AREVA); ROMINE Judy (AREVA); BENNETT Kathy (AREVA); CORNELL Veronica (EXTERNAL AREVA); VAN NOY Mark (EXTERNAL AREVA); GARDNER George Darrell (AREVA); COLEMAN Sue (AREVA); PATTON Jeff (AREVA); SANDERS Harris (AREVA); SLAY Lysa (AREVA); RYAN Tom (AREVA); WILLIFORD Dennis (AREVA)
Subject:	DRAFT Response to U.S. EPR Design Certification Application RAI No. 370, FSAR Ch. 3, Questions 3.7.2-64 and 3.7.3-38
Attachments:	RAI 370 Supplement 3 Response US EPR DC - DRAFT.pdf

Getachew,

On June 24, 2010, AREVA provided a final response schedule of August 10, 2010 for questions 03.07.02-64 and 03.07.02-38. To support NRC review a draft response of these questions is provided. Please let me know if the NRC staff has any questions or if the response can be sent as final.

Thanks,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
702 561-3528 cell
Martin.Bryan.ext@areva.com

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 1671

Mail Envelope Properties (BC417D9255991046A37DD56CF597DB7106CDCF62)

Subject: DRAFT Response to U.S. EPR Design Certification Application RAI No. 370, FSAR Ch. 3, Questions 3.7.2-64 and 3.7.3-38
Sent Date: 7/8/2010 7:22:40 PM
Received Date: 7/8/2010 7:24:57 PM
From: BRYAN Martin (EXTERNAL AREVA)

Created By: Martin.Bryan.ext@areva.com

Recipients:
"DELANO Karen (AREVA)" <Karen.Delano@areva.com>
Tracking Status: None
"ROMINE Judy (AREVA)" <Judy.Romine@areva.com>
Tracking Status: None
"BENNETT Kathy (AREVA)" <Kathy.Bennett@areva.com>
Tracking Status: None
"CORNELL Veronica (EXTERNAL AREVA)" <Veronica.Cornell.ext@areva.com>
Tracking Status: None
"VAN NOY Mark (EXTERNAL AREVA)" <Mark.Vannoy.ext@areva.com>
Tracking Status: None
"GARDNER George Darrell (AREVA)" <Darrell.Gardner@areva.com>
Tracking Status: None
"COLEMAN Sue (AREVA)" <Sue.Coleman@areva.com>
Tracking Status: None
"PATTON Jeff (AREVA)" <Jeff.Patton@areva.com>
Tracking Status: None
"SANDERS Harris (AREVA)" <Harris.Sanders@areva.com>
Tracking Status: None
"SLAY Lysa (AREVA)" <Lysa.Slay@areva.com>
Tracking Status: None
"RYAN Tom (AREVA)" <Tom.Ryan@areva.com>
Tracking Status: None
"WILLIFORD Dennis (AREVA)" <Dennis.Williford@areva.com>
Tracking Status: None
"Tesfaye, Getachew" <Getachew.Tesfaye@nrc.gov>
Tracking Status: None

Post Office: AUSLYNCMX02.adom.ad.corp

Files	**Size**	**Date & Time**
MESSAGE	522	7/8/2010 7:24:57 PM
RAI 370 Supplement 3 Response US EPR DC - DRAFT.pdf	558381	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Response to

Request for Additional Information No. 370, Supplement 3

3/25/2010

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.07.01 - Seismic Design Parameters
SRP Section: 03.07.02 - Seismic System Analysis
SRP Section: 03.07.03 - Seismic Subsystem Analysis

Application Section: 03.07

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

Question 03.07.02-64:

Follow Up to RAI 248, Question 03.07.02-53:

The applicant has proposed utilizing a lateral-force resisting system (LFRS) with a controlled collapse zone as the design basis for the NAB under an SSE event. In order for the staff to evaluate the acceptability of this design feature and whether it meets Acceptance Criteria 8 of SRP 3.7.2, the staff is requesting the following additional information:

1. The design codes applicable to the LFRS and the controlled collapse zone.
2. A detailed description of the LRFS and the controlled collapse zone.
3. Figures that depict the physical dimensions of the LFRS and the collapse zone of the NAB.
4. A description of the loads and the loading combinations applicable to each portion of the building.
5. A description of the methods used to control the collapse of the non-seismic portion of the NAB in such a way that the collapse zone does not impact a Category I structure or reduce the structural integrity of the LFRS.
6. A description of the seismic analysis method including assumptions, description of the model, description and point of application of the seismic input, and a description of how the seismic loads are determined and applied to the NAB structure.
7. A description of the method used to calculate the seismic displacement of the NAB from which it is concluded that the gap between the NAB and Safeguard building (SB4) and the gap between the NAB and Fuel Building is sufficient to prevent an interaction with these adjacent Category I structures.
8. The results of an analysis that demonstrates that the NAB does not slide or overturn into adjacent Category I structures.
9. The interaction between the LFRS and the controlled collapse zone including the collapse or impact loads that are expected to be applied to the LFRS by the collapse zone.
10. The interaction between the NAB and the RWB including a detailed description of how the NAB prevents an indirect transfer of load from the RWB to Seismic Category I structures. Include in your response a description of the loads that will be transmitted to the NAB by a failure of the RWB and describe how these loads will be accounted for in the design of the LFRS.
11. Examples of a LFRS and collapse zone design concept used in the seismic design of structures that have been built especially structures at nuclear power plants.

Response to Question 03.07.02-64:

AREVA NP will not use a lateral-force resisting system (LFRS) with a controlled collapse zone for the Nuclear Auxiliary Building (NAB). Instead, the NAB is analyzed to safe shutdown earthquake (SSE) load conditions and designed to Seismic Category I codes and standards so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the NAB does not have a safety function, it may slide or uplift provided that the gap between the NAB and any Category I structure is adequate to prevent interaction. Consequently, no answer is provided for items 1, 2, 3, 5, 9, and 11 of the question.

In addition, AREVA will address Items 7 and 8, interaction between the NAB and Seismic Category I structures, in the response to RAI 335 Question 03.08.04-09.

For the remaining items:

4. The NAB is analyzed and designed using the independent loads and load combinations found in the design codes applicable to Category I structures.

6. NAB seismic analysis is performed in accordance with U.S. EPR FSAR Tier 2, Section 3.7.2. U.S. EPR FSAR Tier 2, Section 3.7.1 includes seismic inputs for Category I structural design. The NAB is analyzed and designed for the same seismic inputs as Category I structures.

10. Postulation of the Radioactive Waste Processing Building (RWPB) (a Non-Seismic, Category I structure) collapse and load transfer through the NAB (a Category II structure) to a Category I structure is not required by NRC regulation or guidance. Nevertheless, a qualitative discussion on this postulated interaction is presented:

    The RWPB is a reinforced concrete shear wall structure designed in accordance with RW-IIa criteria as set forth by RG 1.143 and is not adjacent to a Seismic Category I structure. It is designed using the codes associated with Category I structures and analyzed for ½ SSE. This provides significant lateral force resistance capacity, thus catastrophic collapse of the RWPB during an SSE event is improbable. The NAB is a reinforced concrete structure located adjacent to the RWPB. The NAB is designed using Seismic Category I structural design codes and analyzed to full SSE, which yields an inherently robust design. In the event that the RWPB collapsed and impacted the NAB, damage to the NAB would be limited. Thus, there is no potential for the RWPB to interact with NI structures.

FSAR Impact:

U.S. EPR FSAR Tier 2, Table 3.2.2-1 and Sections 3.7.2.8 and 3.7.2.3.3 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-38:

Follow Up to RAI 215, Question 03.07.03-32:

In its markup of the FSAR the applicant has identified two approaches for non seismic SSC that could impact a Seismic Category I SSC. In the first approach, if the non seismic SSC can impact a Seismic Category I SSC, an evaluation is performed to determine if the target has significant structural integrity to withstand impact without loss of ability to perform its safety-related function. Since there is a risk that the Seismic Category I SSC may not be able to perform its safety-related function due to the impact of a non seismic SSC, the applicant is requested to provide an example of how such an interaction evaluation will be performed and include this information in the FSAR. In addition, the ability of an SSC to perform its safety related function goes beyond maintaining its structural integrity. If the SSC performs a control function, that function could be impaired by the impact of the non-seismic SSC which could cause an unacceptable acceleration or vibration of the safety-related SSC. The applicant needs to address this condition of interaction and describe how it will be evaluated.

In the second approach, if an unacceptable interaction can occur between a Seismic Category I SSC and non seismic SSC, the non seismic SSC is classified as Seismic Category II. These are then “analyzed and supported so that an SSE event does not cause an unacceptable interaction with the Seismic Category I item, in accordance with the provisions of SRP 3.7.2-SAC II-8.” In this approach the applicant in its response states that the full SSE load is applied to the Seismic Category II SSC. However this is not stated in the FSAR. As it appears that it is acceptable for some type of interaction to occur under this approach, the applicant needs to describe under what types of situations this might be used and give examples of its application. The applicant should include in the FSAR and in its response the following information:

1. How the SSE load acting on the non-seismic SSC is determined.
2. How the impact load is calculated on the Seismic Category I SSC.
3. How it is determined that the Seismic Category I SSC maintains its safety function and that the seismic qualification of the component or piece of equipment is not invalidated.
4. How it is assured that after impact that the non-seismic SSC doesn’t collapse or fall on the Seismic Category I SSC.
5. The code and code allowables that apply to Seismic Category II SSCs subjected to the SSE loads.

Response to Question 03.07.03-38:

If any part of a Seismic Category I subsystem lies within the impact zone of a non-Seismic Category I subsystem component, one of the following methods is used to prevent the Seismic Category I subsystem from losing functionality as a result of impact from the non-Seismic Category I component during the SSE event:

1. The two components are isolated from one another so that interaction will not occur.
2. The Seismic Category I subsystem is analyzed to confirm that its safety function is not lost as a result of impact from a non-Seismic Category I component during the SSE event. An impact analysis assumes the non-Seismic Category I component falls from a static state and impacts the Seismic Category I component concurrent with SSE loading. Impact loads are

determined in accordance with SRP 3.5.3.II.2 and locally added to the analyzed stress of the Seismic Category I subsystem for all load combinations that include seismic. Code allowables for the Seismic Category I subsystem with the additional impact load shall not be exceeded. This method shall not be used for vibratory sensitive Seismic Category I subsystems. Isolation or application of a restraint system shall be used for vibratory sensitive Seismic Category I subsystems.

3. A restraint system is used to confirm that no interaction occurs between the Seismic Category I subsystem and the non-Seismic Category I subsystem. The restraint system is designed to Seismic Category I standards and qualifications and is classified as Seismic Category II. Examples of restraint systems are barriers, lanyards, or shields.

During the April 26-30, 2010, NRC audit, it was determined that the response to Question 03.07.03-39, including the subsystem interface criteria added to U.S. EPR FSAR Tier 2, Section 3.7.3.8, applied to piping subsystems. U.S. EPR FSAR Tier 2, Section 3.7.3.8 will be modified to include piping in the interface criteria.

For clarification, U.S. EPR FSAR Tier 2, Sections 3.7.3, 3.7.3.8, 3.7.3.8.1, and 3.7.3.8.2 references to “seismic” and “non-seismic” subsystems will be changed to “Seismic Category I” and “non-Seismic Category I”, respectively.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.7.3, 3.7.3.8, 3.7.3.8.1, and 3.7.3.8.2 will be revised as described in the response and as indicated on the enclosed mark-ups.

U.S. EPR Final Safety Analysis Report Markups

Table 3.2.2-1—Classification Summary
Sheet 158 of 190

KKS System or Component Code	SSC Description	Safety Classification (Note 15)	Quality Group Classification	Seismic Category (Note 16)	10 CFR 50 Appendix B Program (Note 5)	Location (Note 17)	Comments/ Commercial Code
PA	**Circulating Water Supply System**	NS	E	NSC	No	UMA, UZT	
STRUCTURES							
UFA, UJA, UJB, UJH, UJK, UJE, JM	**Nuclear Island Structural System (Fuel, Reactor, Safeguard Buildings)**	S	N/A	I	Yes	UFA, UJA, UJB, UJH, UJK, UJE, JM	
JMK	Piping Containment Penetrations	S	B	I	Yes	UJA, UJB	ASME Class 2[2]
JML	Cable Containment Penetrations	S	B	I	Yes	UJA, UJB	ASME Class 2[2]
UBP	**Emergency Power Generating Buildings**	S	N/A	I	Yes	UBP	
URB	**Essential Service Water Cooling Tower Structures**	S	N/A	I	Yes	URB	
UQB	**Essential Service Water Pump Buildings**	S	N/A	I	Yes	UQB	
UKA	**Nuclear Auxiliary Building**	NS-AQ	N/A	RS, ~~CS~~II	~~No~~Yes	UKA	

03.07.02-64

DRAFT

the EPGB, modifications are made to the slab stiffness at elevation +51 ft, 6 inches to accurately represent the stiffness of composite beams. For the ESWB, two additional modeling features are used:

- Space frame elements are used to simulate the fill support beams and the distribution header supports.
- Rigid water mass, calculated in accordance with the procedure in ASCE 4-98, Reference 1 and ACI 350.3 (Reference 3), is lumped on the appropriate basin walls. Both low water and high water level are separately considered.

Figure 3.7.2-57—Isometric View of GTSTRUDL FEM for Emergency Power Generating Building and Figure 3.7.2-58—Section View of GTSTRUDL FEM for Emergency Power Generating Building illustrate an isometric view and a section view of the 3D FEM of the EPGB. Figure 3.7.2-59—Isometric View of GTSTRUDL FEM for Essential Service Water Building and Figure 3.7.2-60—Section View of GTSTRUDL FEM for Essential Service Water Building, depict the 3D FEM of the ESWB.

For walls and slabs, adjustment is made to account for cracked section properties. Specifically, a value of $0.5E_c$ is typically used to determine out-of-plane stiffness of these concrete walls and floors. There remains the possibility that the wall stiffness may be between the fully cracked and uncracked conditions. To bound the dynamic response in the SSI analysis, SDOF out-of-plane oscillators based on uncracked section properties are included in the SASSI model at the center of selected slabs and walls.

3.7.2.3.3 Seismic Category II Structures

03.07.02-64

The seismic analysis and design of Seismic Category II structures and members meets the requirements for Seismic Category I structures and membersNon-Seismic Category I structures with potential to impair the design basis safety function of a Seismic Category I SSC will be classified as Seismic Category II in accordance with the criteria identified in Section 3.2.1.2. [[Seismic Category II structures are analyzed to SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria.]] Because Category II structures do not have a safety function, they may slide or uplift provided that the gap between the Category II structure and any Category I structure is adequate to prevent interaction. Procurement, quality control, and QA requirements for Category II structures will be performed according to the guidance provided in Section 3.2.1.2.

3.7.2.3.4 Conventional Seismic (CS) Structures

The analysis and design of Conventional Seismic building structures shall will be in accordance with the applicable requirements of the International Building Code (IBC) (Reference 4) and other codes, as appropriate (see Section 3.2.1.4 for description of CS design basis tornado loading. Therefore, the vent stack has no potential for adverse interaction with the NI Common Basemat Structures.

Nuclear Auxiliary Building

Figure 3B-1 shows that the separation gap between the Nuclear Auxiliary Building and the NI Common Basemat Structures is 18 in. An evaluation of the potential for seismic interaction between the NAB and the NI Common Basemat Structures indicates that the maximum relative seismic displacement between the two structures is less than the gap dimension. The evaluation is performed using results from a series of nonlinear analyses using dynamic finite element models of each structure. The model used for the NI Common Basemat Structures is the nonlinear lumped parameter model described in the second of half of Section 3.8.5.4.2. A similar nonlinear model was created for the NAB building based upon the linear lumped parameter stick model described in Section 3.7.2.3.1.2. Analyses were conducted for a coefficient of friction at the soil-structure interface of 0.5 and 0.7.

To provide sufficient design margin to prevent collapse or unacceptable performance under SSE loading, the design forces and moments for critical structural elements of the NAB are modified in accordance with the guidance of Reference 5. A reduction in the forces and moments due to seismic effects is taken using an inelastic energy absorption factor (F_μ) from Table 5-1 of ASCE 43-05 (Section 5.) for reinforced concrete shear walls. The inelastic energy absorption factor is based on the Limit State A criterion of ASCE 43-05 where permanent distortion, short of collapse, is permitted. The factor is for seismic design criteria and, hence, no reduction in force and moments is taken for other load cases including tornado effects. The F_μ factor is applied to tension, in-plane shear, and out-of-plane bending moment. A value of $F_\mu = 2$ is adopted for in-plane bending moments and shear in conjunction with axial tension. Per Section C5.1.2.3 of ASCE 43-05, a value of $F_\mu = 1$ is used for out-of-plane shear in conjunction with axial tension. For elements subjected to combined axial force and bending, a value of $F_\mu = 2$ is only applied to moment. Applicable provisions and design criteria for RS structures are also applied in finalizing the design.The NAB is classified as an RS structure designed and analyzed to meet the commitments defined for RW-IIa structures in RG 1.143. The NAB is also classified as Seismic Category II due to its potential to interact with a Seismic Category I structure during an SSE. The NAB is analyzed to SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the NAB does not have a safety function, it may slide or uplift provided that the gap between the NAB and any Category I structure is adequate to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (e.g., building deflections, settlement) must be considered when demonstrating the gap adequacy between NAB and adjacent Seismic Category I structures.

03.07.02-64

03.07.02-64

Evaluation to SSE loads confirms that the NAB to NI common basemat structure separation gap is sufficient to preclude interaction.

Access Building

~~[[The separation gaps between the AB and SBs 3 and 4 is 0.98 ft and 1.31 ft, respectively (see Figure 3B-1).]] The walls of the AB are not physically connected to the SBs except through crossovers (passageways) providing access to the SBs. SB 3 is protected by the aircraft hazard (ACH) shield wall which not only protects the structure but also isolates control room personnel from adverse impact effects. SB 4 is not protected by the ACH shield wall. The seismic interaction assessment of the AB confirms that the separation gaps between SBs 3 and 4 are sufficient to preclude interaction. The crossover passageways are designed to accommodate the differential displacements without imparting unacceptable loads to the supporting structures.~~The AB is a non-Seismic Category I structure for which continued operation during an SSE event is not required. The AB is classified as Seismic Category II based on its proximity to the NI, a Seismic Category I structure. [[The AB is analyzed to site-specific SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the AB does not have a safety function, it may slide or uplift provided that the gap between the AB and any Category I structure is adequate to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (i.e. building deflections, settlement) must be considered when demonstrating the gap adequacy between the AB and adjacent Category I structures. The separation gaps between the AB and SBs 3 and 4 are 0.98 ft and 1.31 ft, respectively (see Figure 3B-1).]] The walls of the AB are not physically connected to the SBs except through crossovers (passageways) providing access to the SBs. SB 3 is protected by the aircraft hazard (ACH) shield wall which not only protects the structure but also isolates control room personnel from adverse impact effects. SB 4 is not protected by the ACH shield wall. The crossover passageways are designed to accommodate the differential displacements without imparting unacceptable loads to the supporting structures.

A COL applicant that references the U.S. EPR design certification will demonstrate that the response of the AB to an SSE event will not impair the ability of Seismic Category I systems, structures, or components to perform their design basis safety functions.

For COL applicants that have incorporated the conceptual design for the AB presented in the U.S. EPR FSAR (i.e., [[the AB is analyzed to site-specific SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria]]), this COL item is addressed by demonstrating that the gap between the AB and adjacent Category I structures is

Crossovers from the TB to the NI Common Basemat Structures are supported primarily by the walls or roof of the ACH shield structure. Seismic interaction through the crossover is between the TB and the ACH shield structure rather than with SBs 2 and 3. Design measures limit the interaction forces between the NI Common Basemat Structures and TB transmitted through the crossover structures. The ACH shield structure and design measures isolate control room personnel from adverse effects of the interaction forces generated through the crossover structures.

A COL applicant that references the U.S. EPR design certification will demonstrate that the response of the TB (including SB on the common basemat) to an SSE event will not impair the ability of Seismic Category I systems, structures, or components to perform their design basis safety functions.

For COL applicants that have incorporated the conceptual design for the TB presented in the U.S. EPR FSAR (i.e., [[the TB is analyzed to site-specific SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria]]), this COL item is addressed by demonstrating that the gap between the TB and adjacent Category I structures is sufficient to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (i.e., building deflections, settlement) must be considered when demonstrating the gap adequacy between the TB and adjacent Category I structures.

Radioactive Waste Processing Building

The RWPB has no significant potential to seismically interact with either the NI Common Basemat Structures or with the nearest Seismic Category I structure not on the common basemat (i.e., the EPGB) therefore, the RWPB is not evaluated for SSE.

03.07.02-64

~~The NAB is located between the RWPB and the NI Common Basemat Structures and shields the NI Common Basemat Structures from potential interaction. Both the NAB and RWPB are classified as RS structures and are designed for the standard plant 1/2 SSE using criteria in RG 1.143 for RW-IIa structures. The resulting designs are ductile designs with inherent margin against catastrophic collapse under SSE. In addition, this same robust design provides inherent margin against progressive collapse of the NAB caused by seismic interaction with the RWPB. In addition, the evaluation of the NAB itself for seismic interaction with the NI Common Basemat Structures under SSE loading is described above. Therefore, the NAB shields the NI Common Basemat Structures from any adverse effect of collapse of the RWPB~~ The RWPB is a reinforced concrete shear wall structure designed according to RW-IIa criteria in RG 1.143; thus it is designed using the codes and standards associated with Category I structures and analyzed for 1/2 SSE. This provides significant lateral force resistance capacity, thus catastrophic collapse of the RWPB during an SSE event is unlikely. The NAB is a reinforced concrete structure located between the RWPB and the NI. The NAB is

03.07.02-64

designed using the codes associated with Category I structures and analyzed to full SSE, resulting in an inherently robust design. If the RWPB were to collapse and impact the NAB, the damage to the NAB would be limited. Therefore, there is no potential for indirect interaction between the RWPB and the NI structures.

Potential interaction between the RWPB and EPGB is precluded by separation and by design and site selection and foundation design criteria for the RWPB. The RWPB is embedded a significant distance below grade and has a clear height above grade of +52.5 ft, while the clearance between the RWPB and EPGB is at least 49.5 ft (see Figure 3B-1). Therefore, the separation between the two is only a small distance less than the height above grade of the RWPB. Failure of the RWPB in such a manner as to strike the EPGB is not considered credible due to the separation distance and because of the seismic design for 1/2 SSE loading described above. In addition, site selection and foundation design criteria for the U.S. EPR standard plant ensure that the RWPB is founded on competent soils, while the embedded section below grade provides additional stabilization against rotation.

[[Fire Protection Storage Tanks and Buildings]]

[[The Fire Protection Storage Tanks and Buildings are classified as Conventional Seismic Structures.]] RG 1.189 requires that a water supply be provided for manual firefighting in areas containing equipment for safe plant shutdown in the event of a SSE. [[~~Therefore, t~~The fire protection storage tanks and building are designed to provide system pressure integrity under SSE loading conditions. Seismic load combinations are developed in accordance with the requirements of ASCE 43-05 using a limiting acceptance condition for the structure characterized as essentially elastic behavior with no damage (i.e., Limit State D) as specified in the Standard.]]

The Fire Protection Storage Tanks and Buildings are site-specific structures. A COL applicant that references the U.S. EPR design certification will provide the seismic design basis for the sources of fire protection water supply for safe plant shutdown in the event of a SSE.

3.7.2.9 Effects of Parameter Variations on Floor Response Spectra

Uncertainties in seismic modeling, due to such items as uncertainties in material properties, mass properties, concrete cracking under normal loading, and structural and soil modeling techniques can affect the accuracy of floor response spectra calculated using any of the approaches for seismic analysis presented in Section 3.7.2.1. To compensate for the effect of these uncertainties, the ISRS for U.S. EPR Seismic Category I structures are broadened by ±15 percent. These broadened ISRS are used in the subsequent design of structural elements of those structures, including flexible floors and walls.

3.7.3 Seismic Subsystem Analysis

Seismic analysis methodology for U.S. EPR standard plant structural subsystems is described in this section. The plant structural subsystems include heating, ventilation, and air conditioning (HVAC) duct, cable tray, conduit, and tubing distribution systems; equipment and component supports; platforms and support frame structures; buried piping, tunnels, and conduits; yard structures; and atmospheric tanks. Structural subsystems include structural items that are not directly impacted by seismic forces imparted through the soil, but are directly impacted by seismic forces as they are transmitted through the building structure.

03.07.03-38

Seismic analysis for piping subsystems is outside the scope of this section and is addressed in Sections 3.9.2 and 3.12With the exception of Seismic Category I to non-Seismic Category I interface criteria in Section 3.7.3.8, seismic analysis for piping subsystems is addressed in Sections 3.9.2 and 3.12. Seismic and dynamic qualification methods for mechanical equipment are addressed in Section 3.10. Section 3.11 addresses seismic qualification of electrical equipment. Design criteria for distributed subsystem supports for piping, HVAC ducts, cable trays, and conduits are contained in Appendix 3A. Appendix 3C addresses seismic and dynamic analysis of supports for the reactor coolant system.

As addressed in Section 3.7, the design of the U.S. EPR does not consider explicit design analysis for the operating basis earthquake (OBE). The requirement for seismic fatigue through a cyclic load basis of one safe shutdown earthquake (SSE) and five OBEs is met for the U.S. EPR by consideration of full and fractional SSE events.

Seismic Category I subsystems are designed to withstand the effects of an SSE and maintain the capability to perform their safety functions. This design is accomplished by performing seismic analyses for Seismic Category I subsystems using methods in accordance with 10 CFR 50, GDC 2 and 10 CFR 50, Appendix S, per SRP 3.7.3 (Reference 6). These methods, as described in the following sections, include the response spectrum method, time history method or, where applicable, the equivalent static load method.

3.7.3.1 Seismic Analysis Methods

3.7.3.1.1 Response Spectrum Method

The effects of the ground motion during an SSE event are transmitted through structures to the subsystem at support and equipment anchorage locations. In the response spectrum method of analysis, values are determined for each mode of the subsystem from the in-structure response spectra (ISRS). The ISRS represent the maximum acceleration response of an idealized single-degree-of-freedom damped oscillator as a function of natural frequency to the vibratory input motion of the structure.

These modal results are combined with the low frequency modal results using the methods described in Section 3.7.3.7.1.

For multiply supported systems analyzed using ISM, the rigid range (missing mass) results will be combined with the low frequency modal results by SRSS, per Reference 8, Volume 4. All of the provisions of Reference 8 for the ISM method of analysis will be followed. For ISM, the responses in the rigid range are considered in phase and combined by algebraic summation and the total rigid response will then be combined with the modal results by SRSS.

3.7.3.8 Interaction of ~~Other Systems~~ Non-Seismic Category I ~~with Seismic Category I Systems~~Subsystems

03.07.03-38

The U.S. EPR uses state-of-the-art computer modeling tools for design and location of structures, subsystems, equipment, and piping. These same tools are used to minimize interactions of ~~seismic and non-seismic~~ Seismic Category I and non-Seismic Category I components, making it possible to protect Seismic Category I subsystems from adverse interactions with ~~non-seismic~~ non-Seismic Category I subsystem components. ~~In the design of the U.S. EPR, the primary method of protection for seismic SSC is isolation from each non-seismically analyzed SSC. In cases where it is not possible, or practical to isolate the seismic SSC, adjacent non-seismic SSC are classified as Seismic Category II and analyzed and supported so that an SSE event does not cause an unacceptable interaction with the Seismic Category I items, in accordance with the provisions of SRP 3.7.2 SAC II-8. However, for non-seismic subsystems classified as Seismic Category II, inelastic analytical methods may be used, if necessary. An interaction evaluation may be performed to demonstrate that the interaction does not prevent the Seismic Category I distribution subsystem from performing its safety-related function.~~If any part of Seismic Category I subsystem lies within the impact zone of a non-Seismic Category I subsystem component, one of the following methods is used to prevent the Seismic Category I subsystem from losing functionality as a result of impact from the non-Seismic Category I component during the SSE event.

1. The two components are isolated from one another so that interaction does not occur.

2. The Seismic Category I subsystem is analyzed to confirm that its safety function is not lost as a result of impact from a non-Seismic Category I component during the SSE event. An impact analysis assumes the non-Seismic Category I component falls from a static state and impacts the Seismic Category I component concurrent with SSE loading. Impact loads are determined in accordance with SRP 3.5.3.II.2 and locally added to the analyzed stress of the Seismic Category I subsystem for load combinations that include seismic. Code allowables for the Seismic Category I subsystem with the additional impact load shall not be exceeded. This method shall not be used for vibratory sensitive Seismic Category I subsystems. Isolation or application of a restraint system shall be used for vibratory sensitive Seismic Category I subsystems.

03.07.03-38

3. A restraint system is used to verify that no interaction occurs between the Seismic Category I subsystem and the non-Seismic Category I subsystem. The restraint system is designed to Seismic Category I standards and qualifications and is classified as Seismic Category II. Examples of restraint systems are barriers, lanyards, or shields.

For non-seismic subsystems attached to seismic subsystems, the dynamic effects of the non-seismic subsystem are accounted for in the modeling of the seismic subsystem. The attached non-seismic subsystem, classified as Seismic Category II, is designed to preclude the effect of causing failure of the seismic subsystem during a seismic event. Section 3.7.3.3 describes decoupling criteria used to determine if the flexibility of the non-seismic subsystem is included in the subsystem modelFor non-Seismic Category I subsystems attached to Seismic Category I subsystems, the dynamic effects of the non-Seismic Category I subsystem are accounted for in the modeling of the Seismic Category I subsystem. The attached non-Seismic Category I subsystem is classified as Seismic Category II and is designed to not cause failure of the Seismic Category I subsystem during a seismic event. Section 3.7.3.3 describes decoupling criteria used to determine if the flexibility of the non-Seismic Category I subsystem is included in the subsystem model.

03.07.03-38

Seismic Category I subsystem design requirements extend to the first seismic restraint beyond the system boundary with non-Seismic Category I subsystems. In addition, the following requirements must be met:

- If the first seismic restraint beyond the Seismic Category I subsystem boundary is an anchor restraining the Category I subsystem in the six degrees of freedom, the analysis model includes the Category I system and any extended portion of the system which is Category II up to the anchor defining the analysis boundary. The subsystem components within the analysis boundary will be designed to Seismic Category I requirements. Loads from the non-Seismic Category I subsystem will be developed as described in Section 5.5 of Reference 1.

- If the first seismic restraint cannot be an anchor, the non-Seismic Category I subsystem and supports beyond this location that affect the Seismic Category I subsystem dynamic analysis are classified Seismic Category II, included in the model, and designed to the same requirements as Seismic Category I components. Loads from the non-Seismic Category I subsystem will be developed as described in Section 5.5 of Reference 1.

03.07.03-38

Boundary conditions of the model at the Seismic Category I to non-Seismic Category I interface are described in Section 5.5 of Reference 1.

3.7.3.8.1 Isolation of Seismic Category I and Non-Seismic Category I Subsystems

Isolation of seismic and non-seismic subsystems is provided by either geographical separation or by the use of physical barriers. Isolation minimizes the interaction effects that must be considered for the seismic systems and minimizes the number of non-seismic subsystems requiring more rigorous analysis.

Several routing considerations are used to isolate seismic and non-seismic subsystems. When possible, non-seismic SSC are not routed in rooms containing safety-related SSC. Non-seismic SSC that can not be completely separated from seismic SSC must be shown to have no interaction with the seismic systems based on separation distance or an intermediate barrier, or be classified as Seismic Category II. To the extent possible, non-seismic systems are not routed close to any safety-related componentsIsolation of Seismic Category I and non-Seismic Category I subsystems is provided by geographical separation. Isolation eliminates the interaction effects that must be considered for a Seismic Category I subsystem and minimizes the overall number of impact analyses performed and restraint systems needed to prevent interaction.

03.07.03-38

Several routing considerations are used to isolate Seismic Category I and non-Seismic Category I subsystems. When possible, non-Seismic Category I SSC are not routed in rooms containing safety-related SSC. If a non-Seismic Category I SSC can not be completely separated from Seismic Category I SSC, then the non-Seismic Category I SSC must be restrained or an analysis must be performed to verify that the functionality of the Seismic Category I SSC is maintained if impacted by the non-Seismic Category I component during a seismic event.

3.7.3.8.2 Interaction Evaluation

Non-seismic SSC may be located in the vicinity of safety-related SSC without being qualified as Seismic Category II, provided an impact evaluation is performed to verify that no possible adverse impacts occurUnrestrained, non-Seismic Category I SSC may be located in the vicinity of safety-related SSC provided an impact evaluation is performed and it is determined that functionality of the safety-related SSC is not lost as a result of impact. In this evaluation, the non-seismicnon-Seismic Category I components are assumed to fall or overturn as a result of a seismic event. Any safety-related subsystem or component which may be impacted by the non-seismicnon-Seismic Category I component is identified as an interaction target and is evaluated to establish that there is no loss of ability to perform its safety-related function.

The following assumptions and guidelines are used to evaluate non-seismicnon-Seismic Category I and seismicSeismic Category I interactions, resulting from an SSE seismic event:

As a result of the seismic event:

- Every non-seismic hanger on the non-seismic distribution subsystems is assumed to fail instantaneously.

DRAFT

- ~~Every connection on the non-seismic distribution subsystem is assumed to fail, thus allowing each section of a subsystem to fall independently.~~

- ~~Every flange on bolted connections on a non-seismic system and other distributed subsystems is assumed to fail, thus allowing each section of piping to fall independently.~~

03.07.03-38

- The non-Seismic Category I subsystem or component (source) is assumed to fail instantaneously at every connection allowing each section to fall or overturn independently.

- The fall trajectory of the source is evaluated for potential impacts. Impact is assumed for non-Seismic Category I subsystem or components within an impact evaluation zone around the safety-related system or component. If the falling or overturning source is outside of the impact zone, no interaction occurs. Otherwise, the falling source could potentially impact the target.

  The impact zone is defined by the volume extending in such a way that it is wholly or partially within a 15-degree angle from the vertical extending from each side of the Seismic Category I subsystem or component. The impact evaluation zone does not need to extend beyond Seismic Category I structures (e.g., walls or slabs).

- The parameters of the target are evaluated to determine if it has significant structural integrity to withstand impact without loss of ability to perform its safety-related function.

- The energy of the source impacting the target is evaluated to determine if the energy level is low enough not to cause adverse impact on the target.

Unrestrained, non-Seismic Category I SSC located in the vicinity of safety-related SSC is acceptable if an analysis demonstrates that the weight and configuration of the non-Seismic Category I SSC, relative to the target, and the trajectory of the falling non-seismic SSC interaction do not cause unacceptable damage to the safety-related SSC. Otherwise, the non-Seismic Category I SSC present a hazard, and are relocated or restrained.

3.7.3.9 Multiply-Supported Equipment and Components with Distinct Inputs

The criteria presented are primarily applicable to distribution subsystems that span between multiple locations within a structure or between locations in different structures and, as a result, experience non-uniform support motion. Two conventional methods are presented: the uniform support motion (USM) method and the independent support motion (ISM) method. For both methods: relative displacements at the support points are considered and determined by conventional static analyses, or conservatively approximated from floor response spectra. When displacements are determined from floor response spectra, the maximum displacement is predicted by the following relationship: