ArevaEPRDCPEm Resource

From:	BRYAN Martin (EXTERNAL AREVA) [Martin.Bryan.ext@areva.com]
Sent:	Monday, August 23, 2010 4:36 PM
To:	Tesfaye, Getachew
Cc:	DELANO Karen (AREVA); ROMINE Judy (AREVA); BENNETT Kathy (AREVA); CORNELL Veronica (EXTERNAL AREVA)
Subject:	Response to U.S. EPR Design Certification Application RAI No. 320, FSAR Ch 3, Supplement 2, Part 1 of 2
Attachments:	RAI 320 Supplement 2 Response US EPR DC (Part 1 of 2) - INTERIM.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 320 on November 24, 2009. AREVA NP submitted Supplement 1 on June 21, 2010, to provide a revised schedule for responding to RAI 320.

The attached file, “RAI 320 Supplement 2 US EPR DC (Part 1 of 2) – INTERIM.pdf” andthe file “RAI 320 Supplement 2 US EPR DC (Part 2 of 2) – INTERIM.pdf” in subsequent email, provide technically correct and complete INTERIM responses to Question 03.07.02-63 and Question 03.07.03-37, as committed.

The following table indicates the respective pages in the response document, “RAI 320 Supplement 2 US EPR DC (Part 1 of 2) – INTERIM.pdf,” that contains AREVA NP’s INTERIM response to Question 03.07.02-63 and Question 03.07.03-37.

Question #	Start Page	End Page
RAI 320 — 03.07.02-63	2	3
RAI 320 — 03.07.03-37	4	4

The schedule for technically correct and complete FINAL responses is unchanged and provided below:

Question #	Interim Response Date	Final Response Date
RAI 320 — 03.07.02-63	August 23, 2010 (Actual)	January 13, 2011
RAI 320 — 03.07.03-37	August 23, 2010 (Actual)	January 13, 2011

Sincerely,

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

From: BRYAN Martin (EXT)
Sent: Monday, June 21, 2010 7:09 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); VAN NOY Mark (EXT); CORNELL Veronica (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 320, FSAR Ch 3, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI No. 320 on November 24, 2009.

Based upon the civil/structural re-planning activities and revised RAI response schedule presented to the NRC during the June 9, 2010, Public Meeting, the schedule for Questions 03.07.02-63 and 03.07.03-37 has been changed.

Prior to submittal of the final RAI response, AREVA NP will provide an interim RAI response that includes:

(1) a description of the technical work (e.g., methodology)
(2) U.S. EPR FSAR revised pages, as applicable

The revised schedule for an interim response and the technically correct and complete response to these questions is provided below.

Question #	Interim Response Date	Final Response Date
RAI 320 — 03.07.02-63	August 23, 2010	January 13, 2011
RAI 320 — 03.07.03-37	August 23, 2010	January 13, 2011

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
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From: WELLS Russell D (AREVA NP INC)
Sent: Monday, November 30, 2009 10:15 AM
To: 'Getachew Tesfaye'; 'Michael Miernicki'
Cc: Pederson Ronda M (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 320, FSAR Ch 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 320 Response US EPR DC.PDF" provides a schedule for a technically correct and complete response to the 2 questions.

The following table indicates the respective pages in the response document, "RAI 320 Response US EPR DC.PDF," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 320 — 03.07.02-63	2	2
RAI 320 — 03.07.03-37	3	3

A complete answer is not provided for 2 of the 2 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 320 — 03.07.02-63	June 21, 2010
RAI 320 — 03.07.03-37	June 21, 2010

Sincerely,

(Russ Wells on behalf of)

Ronda Pederson

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Licensing Manager, U.S. EPR Design Certification
New Plants Deployment
AREVA NP, Inc.
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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Friday, October 30, 2009 2:10 PM
To: ZZ-DL-A-USEPR-DL
Cc: Chakravorty, Manas; Hawkins, Kimberly; Miernicki, Michael; Patel, Jay; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 320 (3881, 3880),FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on October 22, 2009, and on October 30, 2009, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 1878

Mail Envelope Properties (BC417D9255991046A37DD56CF597DB71074C8F9B)

Subject: Response to U.S. EPR Design Certification Application RAI No. 320, FSAR Ch 3, Supplement 2, Part 1 of 2
Sent Date: 8/23/2010 4:36:09 PM
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From: BRYAN Martin (EXTERNAL AREVA)

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

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MESSAGE	5732	8/23/2010 4:41:53 PM
RAI 320 Supplement 2 Response US EPR DC (Part 1 of 2) - INTERIM.pdf	6559223	

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

Response to

Request for Additional Information No. 320 (3881, 3880), Supplement 2

10/30/2009

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

Application Section: Ch 3

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

Question 03.07.02-63:

Follow Up Question to Question 03.07.02-39

As part of the response to Question 03.07.02-39, it is stated that the U.S. EPR FSAR will not be changed. However, FSAR, Section 3.7.2.1.1 (Rev. 1) currently states that when the stiffness matrix, [K], or damping matrix, [C] is non-linear the direct integration technique is used to solve the equations of motion. Section 3.7.2.1.1 further states that this method is used to determine the stability of the NI Common Basemat structures against seismic sliding or overturning and their potential for seismic structural interaction. As structural stability is now determined using a linear analysis as described in the response to Question 03.07.02-39, the applicant is requested to change FSAR Section 3.7.2.1.1 to reflect this revised analysis approach.

Response to Question 03.07.02-63:

The stability of the Nuclear Island (NI) Common Basemat structures against seismic sliding or overturning and their potential for seismic structural interaction is determined by time history analysis using an embedded finite element model (FEM). The direct integration method is not used. The soil-structure interaction (SSI) analysis of the embedded NI Common Basemat structures uses a linear-elastic time history analysis. In conjunction with this change, the following U.S. EPR FSAR Tier 1 and Tier 2 sections will be revised:

<u>U.S. EPR FSAR Tier 1</u>

- U.S. EPR FSAR Tier 1, Table 5.0-1 will be revised to specify the peak ground accelerations for the high frequency input motion.
- U.S. EPR FSAR Tier 1, Figure 5.0-1 will be revised to include the spectra for the high frequency input motion.

<u>U.S. EPR FSAR Tier 2</u>

- U.S. EPR FSAR Tier 2, Section 2.5.2 and Table 2.1-1 will be revised to introduce the high frequency seismic input motion and clarify the values for the angle of internal friction and coefficient of friction.
- U.S. EPR FSAR Tier 2, Section 3.7.1 and Section 3.8.5 will be revised to describe the high frequency seismic input motion and update the number of generic soil profiles used for the SSI analysis of the embedded FEM model of the NI Common Basemat Structures.
- U.S. EPR FSAR Tier 2, Section 3.7.2 will be revised to describe the SSI analysis of the embedded FEM model of the NI Common Basemat Structures, and the SSI analysis of the FEM model of the Emergency Power Generating Building (EPGB) and the Essential Service Water Building (ESWB) using high frequency seismic input motion. The maximum accelerations (zero period accelerations (ZPAs)) and in-structure response spectra (ISRS) will be revised.
- U.S. EPR FSAR Tier 2, Section 3.7.2.1.1 will be revised to delete the use of non-linear analysis for the NI Common Basemat stability check.

The final results from the revised analyses are not available and are denoted by “will be provided later” within the enclosed markup. The results will be provided with the final response to this question.

FSAR Impact:

U.S. EPR FSAR Tier 1, Table 5.0-1 and Figure 5.0-1 and U.S. EPR FSAR Tier 2, Table 2.1-1, Section 2.5.2, Section 3.7.1, Section 3.7.2, and Section 3.8.5 will be revised as described in the response and indicated in the enclosed markup.

Question 03.07.03-37:

Follow up RAI to Question 03.07.03-33

In its response the applicant states that the displacements at supports are combined in the most unfavorable combination as stated in the U.S. EPR FSAR Tier 2, Section 3.7.3.9 and In accordance with SRP 3.7.3-II-SAC-9. However, in the next to last sentence the applicant states that examination of support displacements and engineering judgment are used in establishing whether displacements are to be imposed in-phase or out-of-phase. The two statements are contradictory and as a result the criteria for applying displacements at supports are not clear. The applicant is requested to revise its response such that the method or methods used are not in conflict with the SRP acceptance criteria. If, however, engineering judgment is used in certain cases and displacements are not combined in the most unfavorable combination, the applicant is requested to provide the conditions under which this method is applied, how it is implemented, its' technical justification, and include this description in the FSAR. In addition, the applicant states that when more realistic results are warranted a dynamic analysis will be performed. As such, the applicant is requested to describe this dynamic analysis including the analysis assumptions and time history inputs. In addition, the applicant should state how the displacement results from this analysis are applied to subsystems and update Section 3.7.3.9 of the FSAR to include the time history methodology.

Response to Question 03.07.03-37:

U.S. EPR FSAR Tier 2, Section 3.7.3.9 will be revised to state that the method used for applying displacements at supports is in conformance with the SRP 3.7.3-II-SAC-9 acceptance criteria and Topical Report ANP-10264, including Section 3.2.4 on time history methodology.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.3.9 will be revised as described in the response and indicated in the enclosed mark up.

U.S. EPR Final Safety Analysis Report Markups

RAI 320, Question 03.07.02-63

Table 5.0-1—Site Parameters for the U.S. EPR Design (3 Sheets)

Precipitation	
Parameter	**Value(s)**
Rainfall rate	≤19.4 in/hr
Normal winter precipitation event ground load	≤100 psf
Normal winter precipitation event roof load	≤70 psf
Extreme liquid winter precipitation event roof load	0 psf (1)
Extreme frozen winter precipitation event ground load	≤43 psf (based on 55 inches)
Extreme frozen winter precipitation event roof load	≤30 psf
Extreme roof winter precipitation load	≤100 psf (100-year Mean Recurrence Interval)
Seismology	
Parameter	**Value(s)**
Horizontal SSE Acceleration	0.3g Peak for EUR and 0.21g Peak for HF (CSDRS shapes – See Figure 5.0-1)
Vertical SSE Acceleration	0.3g Peak for EUR and 0.18g Peak for HF (CSDRS shapes – See Figure 5.0-1)
Fault Displacement Potential	No fault displacement is considered for safety-related SSC in U.S. EPR design certification.
Flood Level	
Parameter	**Value(s)**
Maximum flood or tsunami	Maximum flood or tsunami level is no more than 1 ft below grade.
Temperature	
Parameter	**Value(s)**
Design ambient temperature	The 0% exceedance maximum ambient temperature is 115°F Dry Bulb and 80°F Wet Bulb (mean coincident).(2) The 0% exceedance minimum ambient temperature is -40°F.(2) The 1% exceedance (seasonal basis)(3) maximum ambient temperature is 100°F Dry Bulb and 77°F Wet Bulb (mean coincident). The 1% exceedance (seasonal basis) (3) minimum ambient temperature is -10°F.

(Hard, Medium and Soft Sites) and HF

Figure 5.0-1—Design Response Spectra for EUR Control Motions ~~(Hard, Medium and Soft Sites)~~

RAI 320, Question 03.07.02-63

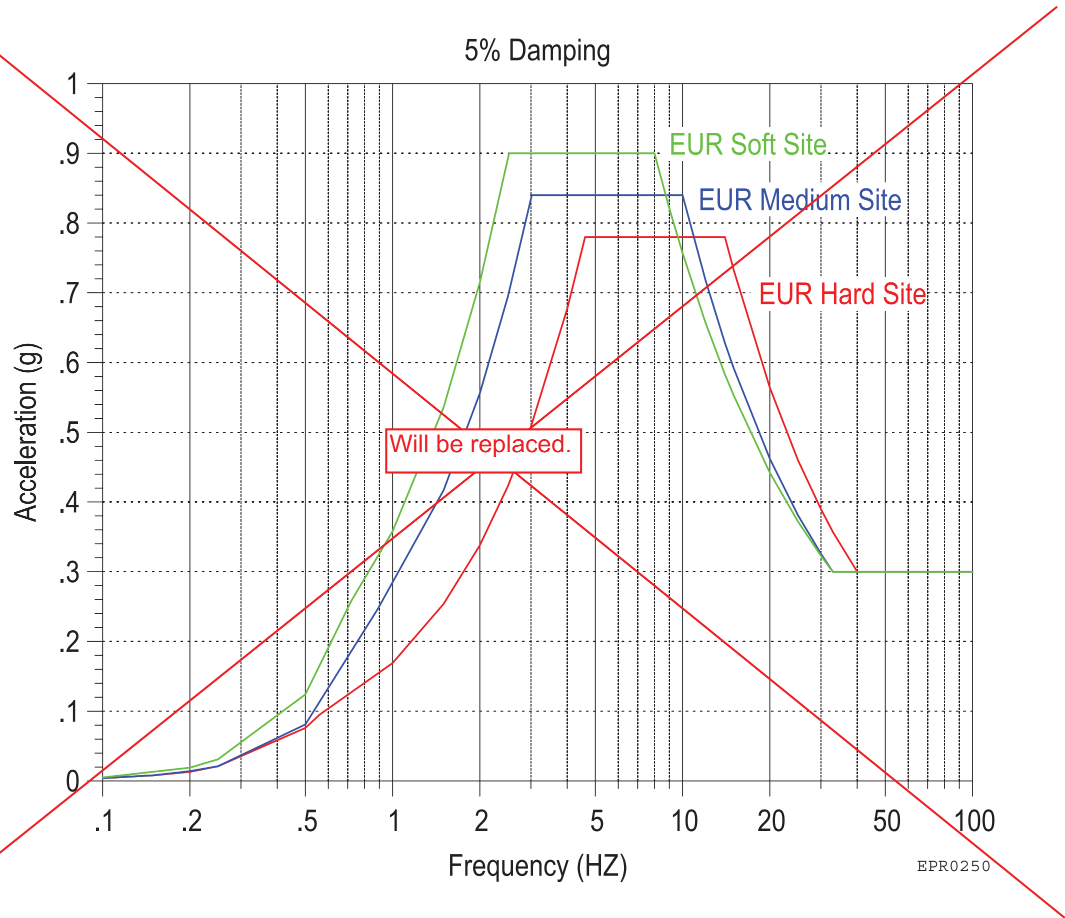

**Table 2.1-1—U.S. EPR Site Design Envelope
Sheet 1 of 7**

U.S. EPR Site Design Envelope	
Precipitation (Refer to Section 2.4)	
Rainfall rate	≤19.4 in/hr
Normal winter precipitation event ground load	≤100 psf
Normal winter precipitation event roof load	≤70 psf
Extreme liquid winter precipitation event roof load	0 psf[1]
Extreme frozen winter precipitation event ground load	≤43 psf (based on 55 inches)
Extreme frozen winter precipitation roof ground load	≤30 psf
Extreme winter precipitation roof load	≤100 psf (100-year MRI)
Seismology (Refer to Sections 2.5 & 3.7)	
Horizontal SSE Acceleration	0.3g Peak (CSDRS shapes – See Section 3.7)
Vertical SSE Acceleration	0.3g Peak (CSDRS shapes – See Section 3.7)
Fault Displacement Potential	No fault displacement is considered for safety-related SSC in U.S. EPR design certification.

for EUR and 0.21g Peak for HF

for EUR and 0.18g Peak for HF

2.5 Geology, Seismology, and Geotechnical Engineering

Geology, seismology, and geotechnical engineering information are specific to the site and region and will be addressed by applicants on a site-specific basis. A range of ~~generic~~ site conditions which encompasses a number of potential reactor sites throughout the United States has been selected for evaluating the U.S. EPR.

2.5.1 Basic Geologic and Seismic Information

A combined license (COL) applicant that references the U.S. EPR design certification will use site-specific information to investigate and provide data concerning geological, seismic, geophysical, and geotechnical information.

2.5.1.1 Regional Geology

Regional geology is site specific and will be addressed by the COL applicant.

2.5.1.2 Site Geology

Site-specific geology information will be addressed by the COL applicant.

2.5.2 Vibratory Ground Motion

A COL applicant that references the U.S. EPR design certification will review and investigate site-specific details of seismic, geophysical, geological, and geotechnical information to determine the safe shutdown earthquake (SSE) ground motion for the site and compare site-specific ground motion to the Certified Seismic Design Response Spectra (CSDRS) for the U.S. EPR.

The seismic design basis for the U.S. EPR is presented in Section 3.7.1.1.1. As noted therein, the U.S. EPR is designed for three sets of control motions anchored at a peak ground acceleration (PGA) of 0.3g ~~peak ground acceleration (PGA) design~~ and an additional set of ground motions with high frequency content. These ground motions ~~which is~~ are defined as ~~a~~ hypothetical free-field outcrop motions at approximately 41.33 ft below grade at the bottom elevation of the foundation basemat for the Nuclear Island (NI) Common Basemat Structures (GDC 2). The ~~certified seismic design response spectra (~~CSDRS~~)~~ for the U.S. EPR are shown in Figure 3.7.1-1. ~~The CSDRS are the same in both horizontal directions and in the vertical direction.~~

Section 3.7.1.3 describes a range of ~~10 generic~~ soil profiles and associated dynamic soil properties selected for the design of the U.S. EPR. Table 3.7.1-6 shows the soil layering, the assumed strain-dependent properties, and the CSDRS design control motion associated with the profile. The variation in shear wave velocity in each of the assumed profiles is illustrated in Figure 3.7.1-31 and Figure 3.7.1-32. The soil properties associated with the various shear wave velocities assumed in the ~~10 generic~~ soil profiles are discussed further in Section 3.7.2.4.1 and summarized in Table 3.7.2-9. Section 3.7.1.3 and Section 3.7.2.4.1 discuss that, for soil-structure interaction (SSI) analysis for the U.S. EPR design certification, the assumed ~~generic~~ shear wave velocities in each profile are taken to be strain-compatible values during seismic events.

Refer to Section 3.7.1 and Section 3.7.2 for additional description of soil-structure interaction analyses performed for the U.S. EPR. Liquefaction of soils and stability of slopes is addressed in Section 2.5.4.8 and Section 2.5.5, respectively.

2.5.2.1 Seismicity

Seismicity is site specific and will be addressed by the COL applicant.

2.5.2.2 Geologic and Tectonic Characteristics of the Site and Region

Geologic and tectonic characteristics are site specific and will be addressed by the COL applicant.

The guidance of RG 1.208 and RG 1.165 will be met, as appropriate, in performing the required studies to determine the SSE using probabilistic seismic hazard analyses.

2.5.2.3 Correlation of Earthquake Activity with Seismic Sources

Correlation of earthquake activity with seismic sources is site specific and will be addressed by the COL applicant, consistent with the guidance of RG 1.208 and RG 1.165, as appropriate.

2.5.2.4 Probabilistic Seismic Hazard Analysis and Controlling Earthquake

The probabilistic seismic hazard analysis is site specific and will be addressed by the COL applicant, consistent with the guidance of NUREG/CR-6372 (Reference 1), RG 1.165, and RG 1.208, as appropriate.

2.5.2.5 Seismic Wave Transmission Characteristics of the Site

Seismic wave transmission characteristics are site specific and will be addressed by the COL applicant.

2.5.2.6 Ground Motion Response Spectrum

A COL applicant that references the U.S. EPR design certification will compare the final site-specific soil characteristics with the U.S. EPR design ~~generic~~ soil parameters and verify that the site-specific seismic characteristics are enveloped by the CSDRS ~~(anchored at 0.3g PGA)~~ and the ~~10 generic~~ soil profiles discussed in Section 2.5.2 and Section 3.7.1 and summarized in Table 3.7.1-6. The applicant will develop~~s~~ site-specific ground motion response spectra (GMRS) and foundation input response spectra (FIRS). The FIRS shall be defined using the NEI approach (SHAKE outcrop) of ISG-17. The applicant will also describe site-specific soil conditions and evaluate the acceptability of the U.S. EPR standard design described in Section 3.7.1 for the particular site. In making this comparison, the applicant will refer to Sections 3.7.1

and 3.7.2 for a description of the soil-structure interaction analyses performed for the U.S. EPR in addressing the following evaluation guidelines.

1. The applicant will confirm that the peak ground acceleration for the GMRS is less than the PGA for the CSDRS (0.3g~~.~~ or if high frequency content is present, 0.21g and 0.18g for the horizontal and vertical, respectively).

2. The applicant will confirm that the low-strain, best-estimate, value of shear wave velocity at the bottom of the foundation basemat of the NI Common Basemat Structures and other Seismic Category I structures is 1000 fps, or greater. This comparison will confirm that the NI Common Basemat Structures and other Seismic Category I structures are founded on competent material.

3. The applicant will demonstrate that the FIRS for the NI Common Basemat Structures is enveloped by the CSDRS. In addition, the applicant will demonstrate that the input motion, which considers the difference in elevation between each structure and the NI Common Basemat Structures, the embedment of the ESWB, and SSSI effect of the NI Common Basemat Structures is less than the modified CSDRS used for the design of the EPGB and the ESWB (see Section 3.7.1.1.1).

4. The applicant will demonstrate that the site-specific profile is laterally uniform by confirming that individual layers with in the profile have an angle of dip no greater than 20 degrees.

5. The applicant will compare the final site-specific soil characteristics including backfill with the U.S. EPR design ~~generic~~ soil parameters and demonstrate that the idealized strain-compatible site soil profile is similar to or bounded by the ~~10 generic~~ soil profiles used for the U.S. EPR. The ~~10 generic~~ profiles include a range of uniform and layered site conditions. The applicant also considers the assumptions used in the SSI analyses including backfill, as described in Section 3.7.1 and Section 3.7.2. Site soil properties of soil columns beneath Category I structures must be bounded by design soil properties listed in Tables 3.7.1-6 and 3.7.2-9. The soil column beneath the embedded NI Common Basemat and the soil column, starting at grade, for the EPGB and ESWB must meet this requirement.

6. If the conditions of steps one through five are met, the characteristics of the site fall within the site parameters for the U.S. EPR and the site is acceptable.

7. If the conditions of steps one through five are not met, the applicant will demonstrate by other appropriate means that the U.S. EPR is acceptable at the proposed site. The applicant may perform intermediate-level additional studies to demonstrate that the particular site is bounded by the design of the U.S. EPR. An example of such studies is to show that the site-specific motion at top-of-basemat level, with consideration of the range of structural frequencies involved, is bounded by the U.S. EPR design.

8. If the evaluations of step 7 are not sufficient, the applicant will perform detailed site-specific SSI analyses for the particular site. This site-specific evaluation will include dynamic seismic analyses and development of in-structure response spectra (ISRS) for comparison with ISRS for the U.S. EPR. These analyses will be

performed in accordance with the methodologies described in Section 3.7.1 and Section 3.7.2. Results from this comparison will be acceptable if the amplitude of the site-specific ISRS do not exceed the ISRS for the U.S. EPR ~~by greater than 10 percent on a location by location basis~~. Comparisons will be made at the following key locations, defined in Section 3.7.2:

A. Reactor Building Internal Structures (RBIS)—Reactor Vessel Support at elevation +16 ft, 10-3/4 in (Figures 3.7.2-74, 3.7.2-75, and 3.7.2-76) and steam generator supports at elevation +63 ft, 11-3/4 in (Figures 3.7.2-77, 3.7.2-78, and 3.7.2-79).

B. Safeguards Building (SB) 1—elevation +26 ft, 7 in (Figures 3.7.2-80, 3.7.2-81, and 3.7.2-82) and +68 ft, 10-3/4 in (Figures 3.7.2-83, 3.7.2-84, and 3.7.2-85).

C. SBs 2/3—elevation +26 ft, 7 in (Figures 3.7.2-86, 3.7.2-87, and 3.7.2-88) and +50 ft, 6-1/4 in (Figures 3.7.2-89, 3.7.2-90, and 3.7.2-91).

D. SB 4—elevation +68 ft, 10-3/4 in (Figures 3.7.2-92, 3.7.2-93, and 3.7.2-94).

E. Reactor Containment Building (RCB)—Polar crane support at elevation +123 ft, 4-1/4 in (Figures 3.7.2-95, 3.7.2-96, and 3.7.2-97) and top-of-dome at elevation +190 ft, 3-1/2 in (Figures 3.7.2-98, 3.7.2-99, and 3.7.2-100).

(Figures 3.7.2.-110, 3.7.2-111, and 3.7.2-112).

F. Fuel Building (FB)—elevation + 12 ft, 1-2/3 in.

G. Emergency Power Generator Building (EPGB)—basemat elevation. +0 ft, 0 in at Node ~~1172~~ (Figures 3.7.2-101, 3.7.2-102, and 3.7.2-103) ~~and +51 ft, 6 in~~.

yyyyy

XXXXX

xyxyxy

H. Essential Service Water Building (ESWB)—Node ~~10385~~ on elevation ~~+14 ft, 0 in~~ (Figures 3.7.2-107, 3.7.2-108, and 3.7.2-109) and Node ~~12733~~ on elevation +63 ft, 0 in (Figures 3.7.2-104, 3.7.2-105, and 3.7.2-106).

9. Exceedances in excess of the limits discussed in step 8 will require additional evaluation to determine if safety-related structures, systems, and components of the U.S. EPR at the location(s) in question will be affected.

As a result of the reconciliation process described above, the applicant may redesign selected features of the U.S. EPR, as required. Redesigned features will be identified as exceptions to the FSAR and addressed by the COL applicant.

2.5.3 Surface Faulting

No surface faulting is considered to be present under foundations for Seismic Category I structures in the U.S. EPR (GDC 2).

A COL applicant that references the U.S. EPR design certification will investigate site-specific surface and subsurface geologic, seismic, geophysical, and geotechnical aspects within 25 miles around the site and evaluate any impact to the design. The COL applicant will demonstrate that no capable faults exist at the site in accordance with the requirements of 10 CFR 100.23 and of 10 CFR 50, Appendix S. If non-capable surface faulting is present under foundations for safety-related structures, the COL applicant will demonstrate that the faults have no significant impact on the structural integrity of safety-related structures, systems, or components.

2.5.4 Stability of Subsurface Materials and Foundations

The stability of subsurface materials under the ~~and~~ foundations for Seismic Category I structures is demonstrated in Section 3.8.5 for the U.S. EPR ~~10 generic~~ soil profiles described in Section 3.7.1 and Section 3.7.2. As described in Section 3.8.5, lateral soil pressure loads under saturated conditions are considered for the design of below-grade walls. Soil loads are based on the parameters described in Section 2.5.4.2.

A COL applicant that references the U.S. EPR design certification will present site-specific information about the properties and stability of soils and rocks that may affect the nuclear power plant facilities under both static and dynamic conditions, including the vibratory ground motions associated with the CSDRS and the site-specific SSE.

2.5.4.1 Geologic Features

Geologic features are site specific and will be addressed by the COL applicant.

2.5.4.2 Properties of Subsurface Materials

The following soil properties are used for design of U.S. EPR Seismic Category I structures.

- Soil density:
  - Saturated soil = 134 lb/ft^3.
  - Moist soil = 128 lb/ft^3.
  - Dry soil = 110 lb/ft^3.
- Angle of internal friction = ~~35~~26.6 degrees. minimum
- Coefficient of friction acting on foundation basemats and near surface foundations for Seismic Category I structures = 0.~~7~~5. minimum

minimum

For a cohesionless soil site, the soil below and adjacent to the safety-related foundation basemat will have ~~a~~ friction angle ~~in excess~~ of ~~35~~26.6 degrees. For a cohesive soil site, the soil will have an undrained strength equivalent to or exceeding a drained strength of ~~35~~26.6 degrees (yielding a friction coefficient greater than 0.~~7~~5~~)~~.

or equal to

Section 2.5.4.5 discusses the use of mud mats under the foundation basemats to facilitate construction. When used, the governing friction value at the interface zone

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or lean concrete

is determined by a thin soil layer (soil-on-soil) under the mud mat. As indicated above, the underlying soil (expected to be compacted backfill) will have a friction angle greater than ~~35~~26.6 degrees. Typical values of friction coefficient between concrete and dry soil and rock are in the range of approximately 0.~~7~~5. Due to the interlock of concrete with soil as the concrete is placed, the friction between the mud mat and underlying soil media is generally higher than the friction resistance of soil-on-soil so that continuity of load transfer across the interface is maintained.

Waterproofing systems are addressed in Section 3.4.2.

Earthquake induced soil pressures for the design of the U.S. EPR are developed in accordance with Section 3.5.3 of ASCE 4-98 (Reference 2). Maximum ground water and maximum flood elevations used for determining lateral soil loads for the U.S. EPR are as specified in Table 2.1-1.

A COL applicant that references the U.S. EPR design certification will reconcile the site-specific soil properties with those used for design of U.S. EPR Seismic Category I structures and foundations described in Section 3.8.

2.5.4.3 Foundation Interfaces

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minimum

Foundation interfaces with underlying materials are site specific and will be addressed by the COL applicant. The COL applicant will confirm that the site soils have (1) sliding coefficient of ~~fiction equal to at least~~ 0.~~7~~5, (2) adequate shear strength to provide adequate static and dynamic bearing capacity, (3) adequate elastic and consolidation properties to satisfy the limits on settlement described in Section 2.5.4.10.2, and (4) adequate dynamic properties (i.e., shear wave velocity and strain-dependent modulus-reduction and hysteretic damping properties) to support the Seismic Category I structures of the U.S. EPR under earthquake loading.

2.5.4.4 Geophysical Surveys

Geophysical surveys are site specific and will be addressed by the COL applicant.

2.5.4.5 Excavations and Backfill

Excavations and backfill are site-specific and will be addressed by the COL applicant. Mud mats may be provided under foundations for ease of construction. Mud mats may be designed as structural plain concrete elements on a site-specific basis in accordance with ACI 318 (Reference 3).

2.5.4.6 Ground Water Conditions

Ground water conditions are described in Section 2.4 and provided in Table 2.1-1 for the U.S. EPR. Ground water conditions are considered in the structural design of the U.S. EPR, as described in Section 3.8. However, groundwater conditions are not explicitly considered in the SSI analyses described in Section 3.7.1 and Section 3.7.2.

The COL applicant will address site-specific ground water conditions.

2.5.4.7 Response of Soil and Rock to Dynamic Loading

Section 2.5.2 notes that the design of the U.S. EPR is based on the assumption that the shear wave velocities assumed for the ~~10 generic~~ soil profiles described in Section 3.7.1.3 are strain-compatible properties. For SSI analysis for the U.S. EPR, assumed relationships to depict the strain-dependent modulus-reduction and hysteretic damping properties are not explicitly considered. The COL applicant will address site-specific response of soil and rock to dynamic loading, including the determination of strain-dependent modulus-reduction and hysteretic damping properties.

2.5.4.8 Liquefaction Potential

The design of the U.S. EPR assumes that the plant is not founded on liquefiable materials (GDC 2).

The COL applicant will address site-specific liquefaction potential. As stated in Section 3.7.1, the evaluation of liquefaction is performed for the seismic level of the site-specific SSE.

2.5.4.9 Earthquake Site Characteristics

Section 3.7.1 describes the seismic design basis for the U.S. EPR. Section 2.5.2 presents a brief summary of the seismic design basis.

Site-specific earthquake site characteristics will be described by the COL applicant.

2.5.4.10 Static Stability

Static stability pertaining to bearing capacity and settlement for the U.S. EPR is described in the following section. Additional information is provided in Section 3.8.5 for the foundations of Seismic Category I structures.

2.5.4.10.1 Bearing Capacity

The maximum bearing pressure under static loading conditions for the foundation basemat beneath the NI Common Basemat Structures is 22,000 lb/ft^2, which includes the dead weight of the structure and components and 25 percent of the live load. The maximum bearing pressure under safe shutdown earthquake loads combined with other loads, as described in Section 3.8.5, is 26,000 lb/ft^2. Refer to Appendix 3E for details of these bearing pressures under the basemat (GDC 2).

A COL applicant that references the U.S. EPR design certification will verify that site-specific foundation soils beneath the foundation basemats of Seismic Category I

3.7 Seismic Design

The Code of Federal Regulations, 10 CFR 50, Appendix A, requires that structures, systems, and components (SSC) related to plant safety features be designed to maintain the capability to perform their safety function when subjected to potential earthquakes. To fulfill this requirement, the SSC for the U.S. EPR are placed according to safety function into the applicable seismic design category (GDC 2).

Appendix S of 10 CFR 50 defines the safe shutdown earthquake (SSE) as "the vibratory ground motion for which certain structures, systems, and components must be designed to remain functional." The SSE terminology of Appendix S is defined for a specific site through an evaluation of the maximum earthquake potential considering the regional and local geology, seismology, and specific characteristics of local subsurface material. As explained in the following sections, the design of the U.S. EPR standard plant is not based on conditions for a specific site, but is based on a group of ~~three~~ standardized seismic control motions and a group of ~~generic~~ soil profiles. However, the term SSE is ubiquitous, so for consistency in usage a 'standard plant design SSE' is defined in Section 3.7.1. In addition, its relationship to the site-specific SSE of 10 CFR 100, Appendix A, and 10 CFR 50, Appendix S, is explained in that section.

Appendix S of 10 CFR 50 also refers to the operating basis earthquake (OBE) which, like the SSE, is defined for a specific site. The term OBE used throughout this document is defined in terms of the standard plant design SSE. The OBE for the U.S. EPR standard plant design is defined as one-third of the standard plant SSE. Appendix S further notes that the applicant is not required to perform explicit design response or design analysis for the OBE level event when the OBE is one-third of the SSE. Therefore, OBE analysis and design cases are not a requirement for the U.S. EPR. The design of certain equipment that is potentially sensitive to low-level seismic fatigue resulting from an accumulation of OBE-induced stress cycles (seismic-induced fatigue) is based on either full or fractional SSE events, as explained in Section 3.7.3.

The U.S. EPR is an evolutionary design based on the standard EPR designed for the European market. This evolutionary design is derived from the combined knowledge and experience of operators and vendors in France and Germany. The U.S. EPR is designed with several special features to provide thorough protection against a comprehensive spectrum of external events, including seismic events at and beyond the level of the SSE. The design philosophy for the U.S. EPR is based on four independent safety trains of safety-related electrical and mechanical systems. The material presented in Section 3.7 describes the seismic analysis and design methodology that provides reasonable assurance that Seismic Category I SSC remain within the conservative limits established by U.S. EPR design criteria for the standard plant design SSE seismic event.

The seismic analysis and design of the reactor coolant system (RCS) is presented in Appendix 3C. The seismic margin of the U.S. EPR SSC, assessed on a plant basis, is discussed in Section 19.1.

Seismic protection for SSC for the U.S. EPR is based on a deterministic design approach that verifies the capability of the SSC to perform their safety functions in case of an SSE. In this approach each SSC is assigned to one of the following seismic categories based on its function:

- Seismic Category I.
- Seismic Category II.
- Conventional Seismic.
- Radwaste Seismic.
- Non-Seismic.

The definition of these seismic categories and a list of those SSC included in each category are provided in Section 3.2.1.

The potential for structure-to-structure interaction between the Nuclear Island (NI) Common Basemat Structures and adjacent Conventional Seismic structures under SSE loading is evaluated using the structural interaction criteria described in Section 3.7.2.8. In addition, an explicit seismic analysis and design case for a ½ SSE level seismic event is performed for structures that are classified as Radwaste Seismic in accordance with RG 1.143, Rev. 2. For radwaste structures, the term ½ SSE used throughout this document corresponds to the standard plant design SSE. Design measures provide reasonable assurance that unacceptable radiological releases from these buildings are avoided, and that the consequences of potential failures of components in the Radwaste Seismic structures during seismic events greater than ½ SSE have no adverse effects on safety-related SSC.

Appendix S of 10 CFR 50 further requires that suitable instrumentation be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly after an earthquake, and that the plant be shutdown if vibratory ground motion exceeding that of the OBE occurs or if significant plant damage occurs. RG 1.12, Rev. 2 describes acceptable seismic monitoring instrumentation. Criteria for evaluating the need to shut down the plant following an earthquake are established using the cumulative absolute velocity approach and OBE exceedance criteria developed by EPRI and incorporated into RG 1.166 and RG 1.167. The installation of instruments for the seismic monitoring system and the controlled shutdown logic to be followed are described in Section 3.7.4.

Section 3.7.2 describes the methodologies for performing dynamic seismic analysis of Seismic Category I structures. The analyses are accomplished by developing mathematical models using finite elements and multi-lumped mass systems. Dynamic soil properties and damping coefficients are determined, and models representing the structures are used to obtain natural frequencies, mode shapes, internal forces, and floor equipment response spectra. Time history response analysis is used and applied to the models to obtain the seismic structural loads and in-structure response spectra (ISRS). The ISRS provide the earthquake environment for the design of internal equipment, systems, and components for the effects of the SSE. Section 3.7.3 describes methodologies for performing dynamic seismic analyses of Seismic Category I subsystems.

3.7.1 Seismic Design Parameters

This section presents the vibratory ground motion for which the safety-related Seismic Category I structures of the U.S. EPR certified standard plant are designed. The manner in which the vibratory ground motion is defined, and in turn is used to develop implementing time histories, as well as the ~~generic~~ site conditions assumed for purposes of design certification, are outlined below. The evaluation of liquefaction of soils and the stability of soil or rock slopes is outside the scope of the certified design. These features are evaluated on a site-specific basis for the Ground Motion Response Spectra (GMRS) discussed below and in Section 2.5.2.

3.7.1.1 Design Ground Motion

For design certification, the guiding principle for the standardized seismic design basis of the U.S. EPR is to define the design ground motion (i.e., the certified seismic design response spectra (CSDRS)) as smoothed response spectra ~~anchored at 0.3g~~ and to consider sufficient bounding site conditions so that the certified design is suitable for most of the potential sites in the Central and Eastern United States (CEUS). Section 3.7.1.3 describes the ~~generic~~ site conditions considered for the U.S. EPR.

The ground motion selection process considers the following:

- Potential CEUS sites.
- Past precedent and competitive designs.
- Research and recent studies over the past several decades.
- The original design basis for the European EPR design.

The design basis ground motion described below compensates for some of the concerns raised by seismological studies over the past several decades, which suggest that the high frequency content of RG 1.60, Rev. 1, ground motion should be enhanced. The full extent of the concerns captured in RG 1.165 and RG 1.208 will be addressed by the combined license (COL) applicant, as described in Section 3.7.1.1.1.

3.7.1.1.1 Design Ground Motion Response Spectra

The European community has collectively developed the European Utility Requirements (EUR) document (Reference 1), which defines a common set of safety requirements. With respect to seismic requirements, the EUR defines three sets of control motions as design ground response spectra, corresponding to hard, medium and soft soil conditions. Table 3.7.1-2—U.S. EPR Design Response Spectra – Amplification Factors for Control Points (as taken from the European Utility Requirements Document) ~~is taken from the EUR document and~~ shows the amplification factors, spectral bounds, and corner frequencies (based on peak ground acceleration normalized to 1.0g), which together define the EUR control motions. For design certification in the U.S. market, the seismic design of the U.S. EPR standard plant is based on ~~design response spectra~~ the three EUR control motions anchored to 0.30g peak ground acceleration. To capture high frequency content, a fourth control motion is added. This additional control motion is identified hereon as HF motion where HFH represents the high frequency control motion in the horizontal direction and HFV represents the high frequency control motion in the vertical direction. HFH is anchored to 0.21g PGA and HFV is anchored to 0.18g PGA. The EUR vertical motion is considered to be the same as the EUR horizontal motion, which is considered to be reasonable for a standard design and is generally conservative except for a high magnitude near fault seismic events. The design response spectra ~~of the EUR control motions~~ for five percent damping are shown in Figure 3.7.1-1—Design Response Spectra for EUR Control Motions ~~(hard, medium and soft sites)~~ (hard, medium and soft sites), HFH and HFV. These EUR and HF Control Motions are used for the seismic analysis and design of the Seismic Category I Nuclear Island (NI) Common Basemat Structures.

The seismic design of the U.S. EPR standard plant also establishes a minimum horizontal design basis that meets the requirements of 10 CFR 50, Appendix S, iv.(a)(1)(i), which states that the design basis for a horizontal component that is in the free-field at the foundation level of the structures must use an appropriate response spectrum with a peak ground acceleration of at least 0.1g. For the U.S. EPR standard plant, the appropriate response spectrum is provided by the envelope of the ~~three~~ EUR design response spectra. ~~Therefore, the~~ The minimum horizontal design response spectra is the envelope of the three EUR design response spectra anchored at 0.1g and assumed to occur as a free-field outcrop motion at the bottom of the NI Common Basemat.

The EUR control motions are similar to the RG 1.60 spectra. Figure 3.7.1-2—Comparison of CSDRS to RG 1.60 and the Minimum Required Spectrum, Horizontal Motion, ~~Horizontal Motion,~~ and Figure 3.7.1-3—Comparison of CSDRS to RG 1.60, Vertical Motion, compare the EUR and HF control motions to the design ground motion from RG 1.60 and to the 0.1g minimum horizontal design ground motion. The EUR control motions provide an enhanced high frequency range when compared to RG 1.60 spectra. For horizontal motion, the RG 1.60 horizontal spectrum exceeds the EUR spectra below about 3 Hz and the HFH spectrum below about 10.5 Hz. For vertical motion, the ~~EUR spectra exceed RG 1.60 vertical spectrum~~ RG 1.60 vertical spectrum exceeds the EUR spectra except in the frequency range below approximately

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and the HFV spectrum below about 11.0 Hz

0.65 Hz. The EUR control motions anchored at 0.3g also exceed the 0.1g minimum horizontal design ground motion.

and HFH control motion anchored at 0.21g

and high frequency content motion, HFH for the horizontal and HFV for the vertical directions,

The three EUR control motions comprise the seismic design basis for the U.S. EPR standard plant (i.e., the ~~certified seismic design response spectra (~~CSDRS~~)~~). The standard plant SSE is the CSDRS since the minimum horizontal design response spectra requirement is also met by the design for the CSDRS. ~~The same CSDRS are used as the standard plant SSE design ground motions for both the horizontal and vertical directions.~~

the

For the U.S. EPR standard plant, the bottom of the NI Common Basemat is located 41.33 ft below plant grade. For ~~purposes of~~ seismic analysis of the U.S. EPR standard plant, ~~a simplifying assumption is made to define~~ the ~~point of~~ seismic input at the foundation level (at elevation -41.33 ft). Consistent with the guidance of SRP 3.7.1 (Reference 6) and RG 1.208, the control point is modeled in site response and soil-structure interaction (SSI) analyses as an outcrop or hypothetical outcrop at the same -41.33 ft foundation level. ~~This control point concept is illustrated in Figure 3.7.1-29—Idealized Control Motion for Seismic Input to NI Common Basemat. With this specification of control point, the effect of the overlying 41.33 ft of material is not included in the models for site response and SSI analyses.~~ For Seismic Category I structures that are not on the NI Common Basemat, namely, the Emergency Power Generating Buildings (EPGB) and the Essential Service Water Buildings (ESWB), the seismic input at the basemat for those structures is the design basis motion (the CSDRS) modified to account for the effects of structure-soil-structure interaction (SSSI) between those structures and the Nuclear Island Common Basemat Structures. The SSI analyses in Section 3.7.2provide insight into the effects of seismic-induced structure-soil-structure interaction between the NI Common Basemat Structures and nearby Seismic Category I and non-Seismic Category I structures. The SSI analysis of the NI Common Basemat Structures establishes an SSSI amplification factor (greater than 1.0) applied to the CSDRS, which defines the amplified seismic input to the respective structural model. Figure 3.7.1-33—Input Motion for Structures not on the Nuclear Island Common Basemat, Horizontal Motion 5% Damping ~~and~~ Figure 3.7.1-34—Input Motion for Structures not on the Nuclear Island Common Basemat, Vertical Motion 5% Damping~~,~~ show the ~~modified~~ input motion for the Seismic Category I Structures that are not on the NI Common Basemat, and Section 3.7.2.4 describes the basis for the development of these spectra in more detail. This input motion does not constitute ~~a second~~ seismic design basis (i.e., a second set of CSDRS); rather it is the logical extension of the seismic design basis CSDRS to provide input motion to structures not on the common basemat.

is defined

(EUR)

(EUR)

an additional

Figure 3.7.1-49-Horizontal FIRS for ESWB Structures (HFH), Figure 3.7.1-50-Vertical FIRS for ESWB Structures (HFV), Figure 3.7.1-51-Horizontal FIRS for EPGB Structures (HFH), and Figure 3.7.1-52-Vertical FIRS for EPGB Structures (HFV) show the high frequency input motion for the ESWB and EPGB, respectively.

Figure 3.7.1-4—EUR Design Ground Spectra for Hard Conditions Normalized to 0.3g, Figure 3.7.1-5—EUR Design Ground Spectra for Medium Conditions Normalized to 0.3g, and Figure 3.7.1-6—EUR Design Ground Spectra for Soft Conditions Normalized to 0.3g, illustrate the seismic demand associated with the CSDRS spectra on SSC as a function of the damping values used in the seismic analysis. Critical damping values used for the seismic analysis of U.S. EPR SSC are provided in Section 3.7.1.2.

3.7.1.1.2 Design Ground Motion Time History

Statistically ~~Three statistically~~ independent sets of synthetic time histories are generated for the ~~three~~ EUR and HF (HFH and HFV) control motions comprising the CSDRS. The three components of each set are designated according to their respective control motion, for example as EURH1, EURH2, and EURH3 for the EUR control motion for a hard site, with the third designator, EURH3, representing vertical motion. An additional ~~A fourth~~ set of statistically independent synthetic time histories is developed for seismic input for the Seismic Category I structures not located on the common basemat. As noted above in Section 3.7.1.1.1, the input motion represented by this additional ~~fourth~~ set of time histories does not constitute a second set of CSDRS; rather it is the logical extension of the design basis CSDRS to provide input motion to structures not on the common basemat considering the effect of SSSI. The components of the additional ~~fourth~~ time history set are designated as SSSI1 and SSSI2 for the horizontal components and SSSI3 for the vertical component. In both seismic structural analyses and in SSI analyses the three components of each set correspond to the three orthogonal axes of the SSI analysis model. The three EUR-based time history sets for the CSDRS are developed using the CARES computer program. The additional ~~fourth~~ time history set developed for the input motion for the analysis of Seismic Category I structures not on the common basemat is developed using the Bechtel computer program BSIMQKE (Reference 8). The ~~four~~ time history sets are developed in accordance with the requirements of Option 1, Approach 2 of SRP Section 3.7.1 (Reference 6) for synthetic time histories. For each of the ~~four~~ synthetic time history sets, properties such as the cross-correlation coefficients among time history components, the response spectra of the time histories, Arias intensity functions, and maximum values of integrated ground velocities and displacements are computed.

The acceptance criteria for time histories developed under Option 1, Approach 2 are:

- Small time increment and sufficient time duration.
- Minimum Nyquist frequency of 50 Hz.
- Spectra at five percent damping for 100 points per frequency decade.
- Target spectrum from 0.1 Hz to 50 Hz or Nyquist frequency.
- No more than nine consecutive frequency points (±10 percent frequency window) fall below the target spectrum.
- Minimum no lower than 90 percent and maximum no greater than 130 percent of target spectrum (in lieu of a power spectral density requirement).

- Total duration exceeding 20 seconds and strong motion duration based on cumulative energy ratio from five percent to 75 percent on the Arias intensity function.

- V/A and AD/V^2 are generally consistent with characteristic values for appropriate controlling events defined for the uniform hazard response spectra (UHRS).

- Statistical independence among three components of synthetic time histories as defined by a maximum absolute value of correlation coefficient of 0.16.

These criteria equal or exceed the corresponding guidelines in NUREG/CR-6728 (Reference 9).

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Each acceleration time history includes 4096 points at an interval of 0.005 seconds. The earthquake duration is 20.48 seconds, which is greater than the 20 second minimum total duration. The time interval of 0.005 seconds corresponds to a Nyquist frequency of 1/(2Δt) = 100 Hz. Plots of the synthetic time histories for acceleration, velocity, and displacement are provided in Figure 3.7.1-7—Synthetic Acceleration Time Histories for EUR Hard CSDRS, Figure 3.7.1-8—Synthetic Velocity Time Histories for EUR Hard CSDRS, Figure 3.7.1-9—Synthetic Displacement Time Histories for EUR Hard CSDRS, Figure 3.7.1-10—Synthetic Acceleration Time Histories for EUR Medium CSDRS, Figure 3.7.1-11—Synthetic Velocity Time Histories for EUR Medium CSDRS, Figure 3.7.1-12—Synthetic Displacement Time Histories for EUR Medium CSDRS, Figure 3.7.1-13—Synthetic Acceleration Time Histories for EUR Soft CSDRS, Figure 3.7.1-14—Synthetic Velocity Time Histories for EUR Soft CSDRS, and Figure 3.7.1-15—Synthetic Displacement Time Histories for EUR Soft CSDRS, for the EUR hard, medium and soft ~~CSDRS, respectively.~~

The HF motions have longer than 20 seconds, and also have a time interval of 0.005 seconds. This motion is padded with zeroes at the end of time history for a total of 8192 points to provide adequate quiet zone for Fast Fourier Transforms (FFT) analysis.

motions, and in Figure 3.7.1-42-Synthetic Acceleration Time Histories for HF CSDRS (FIRS) and of Free-Field Surface Motion, Figure 3.7.1-43-Synthetic Velocity Time Histories for HF CSDRS (FIRS) and of Free-Field Surface Motion, and Figure 3.7.1-44-Synthetic Displacement Time Histories for HF CSDRS (FIRS) and of Free-Field Surface Motion, for the HF motion.

Figure 3.7.1-35—Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI1) Motion, Figure 3.7.1-36—Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI2) Motion, ~~and~~ Figure 3.7.1-37—Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Vertical (SSSI3) Motion, show plots of the acceleration, velocity, and displacement time histories for the set of time histories used for the Seismic Category I structures not located on the common basemat.

Figure 3.7.1-53-Synthetic Acceleration Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI1HF) Motion, Figure 3.7.1-54-Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI2HF) Motion and Figure 3.7.1-55-Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island common Basemat, Vertical (SSSI3HF) Motion

EUR

For each component, the CARES code generates the synthetic time history in which response spectra achieve approximately a mean-based fit to the target design spectra. Compliance with the preceding acceptance criteria is demonstrated in Figure 3.7.1-17—Response Spectrum of Time History H1 vs. Target Spectrum for EUR Hard Motion (TH1 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-18—Response Spectrum of Time History H2 vs. Target Spectrum for EUR Hard Motion (TH2 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-19—Response Spectrum of Time History H3 (Vertical) vs. Target

Spectrum for EUR Hard Motion (TH3 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-20—Response Spectrum of Time History H1 vs. Target Spectrum for EUR Medium Motion (TH1 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-21—Response Spectrum of Time History H2 vs. Target Spectrum for EUR Medium Motion (TH2 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-22—Response Spectrum of Time History H3 (Vertical) vs. Target Spectrum for EUR Medium Motion (TH3 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-23—Response Spectrum of Time History H1 vs. Target Spectrum for EUR Soft Motion (TH1 Target, 0.90* Target and 1.30*Target at 5% Damping), Figure 3.7.1-24—Response Spectrum of Time History H2 vs. Target Spectrum for EUR Soft Motion (TH2 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-25—Response Spectrum of Time History H3 (Vertical) vs. Target Spectrum for EUR Soft Motion (TH3 Target, 1.30*Target and 0.90*Target at 5% Damping), Figure 3.7.1-26—Cumulative Energy Ratio Plot for Time History H1, H2, and H3 for EUR Hard Motion, Figure 3.7.1-27—Cumulative Energy Ratio Plot for Time History H1, H2, and H3 for EUR Medium Motion, Figure 3.7.1-28—Cumulative Energy Ratio Plot for Time History H1, H2, and H3 for EUR Soft Motion, Figure 3.7.1-38—Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI1) Component, Figure 3.7.1-39—Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI2) Component, Figure 3.7.1-40—Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Vertical (SSSI3) Component, ~~and~~ Figure 3.7.1-41—Cumulative Energy Plot for Time Histories for Structures not on the Nuclear Island Common Basemat. The five percent damped response spectra in Figures 3.7.1-17 through 3.7.1-25 compare the respective response spectra for the three time history sets for the EUR control motions to the corresponding smooth CSDRS target spectrum. ~~An internal AREVA code, RESPEC,~~ Version ~~1.1A~~, is used to compute these response spectra. Figure 3.7.1-38 thru 3.7.1-40 provide a similar comparison for the time history set used for the Seismic Category I structures not on the NI Common Basemat. The computer program BSIMQKE (Reference 8) is used to compute response spectra for this time history set. For all of these comparisons the response spectra are computed at a minimum of 100 points per frequency decade, uniformly spaced over the log frequency scale from 0.1 Hz to 50 Hz, or the Nyquist frequency. These figures show that the spectra satisfy the recommended guidelines for response spectrum enveloping. Bounding envelopes shown on these plots also demonstrate that the five percent damping response spectrum of each synthetic time history does not exceed the corresponding target spectrum by more than 30 percent nor does it fall below by more than 10 percent of the target.

Figures 3.7.1-26 to 3.7.1-28 and Figure 3.7.1-41 show the Arias intensity function (or Cumulative Energy function) and the strong motion duration of each synthetic time history in the five percent to 75 percent Arias intensity. The strong motion durations

Figure 3.7.1-45-Response Spectrum of Time History H1 vs. Target Spectrum for HFH Motion (TH1 Target, 0.90* Target and 1.30*Target at 5% Damping), Figure 3.7.1-46-Response Spectrum of Time History H2 vs. Target Spectrum for HFH Motion (TH2 Target, 1.30*Target and 0.90*Target at 5% Damping), 3.7.1-47-Response Spectrum of Time History H3 (Vertical) vs. Target Spectrum for HFV Motion (TH3 Target, 1.30*Target and 0.90*Target at 5% Damping),

Figure 3.7.1-48-Cumulative Energy Ratio Plot for Time History H1, H2, and H3 for HF Motion,

(EUR), and Figure 3.7.1-59-Cumulative Energy Plot for Time Histories for Structures not on the Nuclear Island Common Basemat (HF).

Figure 3.7.1-56-Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI1HF) Component, Figure 3.7.1-57-Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI2HF) Component, Figure 3.7.1-58-Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI3HF) Component,

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The HF control motion is developed in the same manner and is shown in Figure 3.7.1-56 through Figure 3.7.1-58.

and Figure 3.7.1-59

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and HF

calculated for the EUR time histories are shown in Table 3.7.1-3—Strong Motion Duration of Synthetic Time Histories. The minimum strong motion duration is six seconds, which meets the guideline in SRP Section 3.7.1 (Reference 6).

The maximum ground velocity (V) and the maximum ground displacement (D) are obtained from the ground velocity and displacement time histories. The V/A and AD/V^2 values that are calculated using these two parameters are summarized in Table 3.7.1-4—Values of V/A and AD/V^2 for Synthetic Time Histories. As noted in SRP 3.7.1 (Reference 6), time histories that are computed in accordance with Option 1, Approach 2 have characteristics generally consistent with the characteristic values for the magnitude and distance of the appropriate controlling events defined for the UHRS.

The three components of synthetic time history are statistically independent of each other because the cross-correlation coefficients between them, as listed in Table 3.7.1-5—Cross-Correlation Coefficients Among Synthetic Time Histories, are well within the limit value of 0.16.

3.7.1.2 Percentage of Critical Damping Values

Structural systems or materials that experience seismic excitation exhibit energy dissipation through viscous damping. Viscous damping is a form of damping in which the damping force is proportional to the velocity. The mathematical modeling techniques described in Section 3.7.2 and Section 3.7.3 for elastic seismic analysis account for the damping of SSC by including terms to represent equivalent viscous modal damping as a percentage of critical damping.

The equivalent modal damping values for SSE used in the seismic dynamic analysis of U.S. EPR Seismic Category I structures are presented in Table 3.7.1-1—Damping Values for Safe Shutdown Earthquake. The damping values are based primarily on the guidance in RG1.61, Rev. 1 and ASCE Std 43-05 (Reference 2). Piping analyzed for the U.S. EPR uses damping in accordance with RG 1.61, Revision 1. A damping ratio of four percent of critical is used when the USM response spectrum method is used to analyze piping systems that are susceptible to stress corrosion cracking or that contain supports that are designed to dissipate energy by yielding.

Values of critical damping in Table 3.7.1-1 for the seismic analysis of the RCS are consistent with RG 1.61. Seismic analysis of the reactor pressure vessel (RPV) Isolated Model is by direct step-by-step integration time history analysis techniques, owing to the non-linear nature of the pressure vessel internals. As such, Rayleigh damping is applied. The Rayleigh mass and stiffness weighted damping coefficients are selected to provide generally conservative damping across the frequency range of interest relative to the values in Table 3.7.1-1. The elements representing the fuel assemblies are damped at a maximum value of 30 percent, as described in Framatome Technologies

Topical Report BAW-10133NP-A (Reference 7). ~~The same values of damping are used in the analysis for high-energy line break~~For high energy line break analyses more conservative values of Rayleigh mass and stiffness weighted damping coefficients are used. This is addressed further in Section 3C.4.2.1.1.

In-structure response spectra (ISRS) for the NI Common Basemat Structures are generated using SSE damping values rather than the OBE damping values suggested in Table 2 of RG 1.61. It is appropriate to use SSE structural damping for the NI Common Basemat Structures to generate ISRS. This approach is used because the standard plant seismic design basis (see Section 3.7.1.1) coupled with a representative set of soil cases (see Section 3.7.1.3) results in structural loads on both walls and floor diaphragms of NI Common Basemat Structures that are expected to produce cross section demands greater than 50 percent of ultimate capacity.

The ISRS for the Emergency Power Generating Building and the Essential Service Water Buildings are based on OBE structural damping.

The damping values for conduits and cable tray systems are presented in Table 3.7.1-1. Several test programs and studies have demonstrated that higher damping values may be utilized for certain cable tray systems (References 3 through 5). For cable tray systems that are similar to those tested by Bechtel-ANCO Engineers, Inc. (Reference 3) and satisfy tray loading criteria of RG 1.61, the damping values in Figure 3.7.1-16—Damping Values for Cable Tray Systems, may be used on a case-by-case basis and are limited to maximum 15 percent damping. For cable tray systems that are significantly different than those tested by Reference 3, the damping values of RG 1.61 shall be used. See Appendix 3A for additional discussion on cable tray and conduit system damping.

Heating, ventilation, and air conditioning duct systems use damping values of 10 percent for pocket-lock construction, seven percent for companion-angle construction, and four percent for welded construction. The damping values provided in Table 3.7.1-1 are applicable to time history, response spectra and equivalent static analysis procedures for structural qualification as discussed in regulatory position C.4 of RG 1.61.

The seismic qualification of passive electrical and mechanical equipment by analysis is performed using the damping values listed in Table 3.7.1-1, which are in conformance with regulatory position C.5 of RG 1.61. The seismic qualification of active electrical and mechanical equipment is performed by testing as described in Section 3.10.

Modes of vibration of a structure, component, or subsystem composed of the same material are assigned the appropriate damping value. Damping values for structures, components, and systems composed of materials of different properties are determined using the procedures in Table 3.7.1-1 (Note 1) and Section 3.7.2.15 and Section 3.7.3.5.

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Material damping values for soils are presented below in Section 3.7.1.3.

3.7.1.3 Supporting Media for Seismic Category I Structures

Chapter 3.8 provides a detailed description of the NI Common Basemat Structures and other Seismic Category I structures. Figure 3B-1—Dimensional Arrangement Reference Plant Building Location, illustrates the general arrangement of the standard plant and provide key dimensions and separation distances between the NI Common Basemat Structures and other Seismic Category I and non-Seismic Category I structures. The NI Common Basemat provides common support for the shield structure, Safeguard Buildings 1 through 4, the Fuel Building, the Reactor Building, the Containment Building, and the Internal Structure. The NI Common Basemat for the standard plant is supported either on rock, native soil, engineered fill, or a combination of these media. The embedment depth, structural foundation dimensions and general details, as well as structural description and details, are found in Section 3.8.5. ~~Figure 3.7.2-64 is a dimensional plan view showing the footprint for the NI Common Basemat.~~

including high frequency soil profiles

Profiles include

or HF control motion

are

The supporting media for seismic analysis and foundation design for the standard plant is performed for ~~10 generic~~ soil profiles as shown in Table 3.7.1-6—~~Generic~~ Soil Profiles for the U.S. EPR Standard Plant. ~~Six profiles represent~~ uniform half-space profiles and ~~four represent~~ various layered profiles. Each soil profile is associated with one ~~or two~~ of the three EUR ~~generic~~ control motions (i.e., hard, medium, and soft). ~~The soil profiles labeled 2u and 4u in the table are associated with two EUR control motions.~~ For the NI Common Basemat Structures, the ~~result is 12~~ analysis cases for SSI analysis which combine the soil profile and the corresponding control motion~~, as~~ shown in Table 3.7.1-6. The ~~same 10 generic~~ profiles ~~are~~ used for the SSI analysis of the EPGB and ESWB~~, but the input motion is the CSDRS modified to account for the affects of SSSI, as described above in Section 3.7.1.1.1. Seismic SSI analyses are described in Section 3.7.2.4.~~

are slightly different; the profiles from the bottom of the NI basemat are used as the soil profile starting at grade for the EPGB and ESWB, except for HF profile

Table 3.7.1-6 shows the soil layering, the assumed strain-dependent properties, and the EUR design control motion associated with the ~~12~~ analysis cases. The variation in shear wave velocity in each of the assumed profiles is illustrated in Figure 3.7.1-31—U.S. EPR Standard Plant ~~Generic~~ Soil Profiles - Shear Wave Velocity for SSI Analysis Cases, and Figure 3.7.1-32—U.S. EPR Standard Plant ~~Generic~~ Soil Profiles - Shear Wave Velocity for SSI Analysis Cases. Section 3.7.2.4.1 notes that, for SSI analysis for U.S. EPR design certification, the assumed ~~generic~~ shear wave velocities are taken to be strain-compatible values during seismic events, i.e., assumed relationships to depict the strain-dependent modulus-reduction and hysteretic damping properties are not used.

Uniform

Layered

Soil density is varied to correspond with the assumed ~~generic~~ site conditions associated with the ~~three~~ EUR control motions; for example, the SSI model for an analysis case

and HF

that involves a control motion for a soft site includes lower soil density in the ~~generic~~ profiles than a model for a control motion for a hard soil site. Soil density variations also account for the assumed material variation within a profile. Soil densities in the SSI analysis vary from 110 to 156 pcf for soil. Material damping values for soil vary from 1 to 7 percent, with 1 percent damping used for stiffer soils and 7 percent for softer soils. The soil material damping ratio for compression wave propagation (β_p) is conservatively taken to be one-third of the shear wave propagation damping ratio. The maximum material damping value for soil does not exceed 15 percent. The soil properties associated with the various shear wave velocities assumed in the ~~10 generic~~ soil profiles are discussed further in Section 3.7.2.4.1 and summarized in Table 3.7.2-9.

Details of the site response and SSI analyses are provided in Section 3.7.2.4. Section 2.5 addresses the geologic, seismologic, and geotechnical requirements necessary to confirm that conditions for a specific site are enveloped by the ~~generic~~ soil profiles used to design the standard plant.

3.7.1.4 References

1. European Utility Requirements for LWR Nuclear Power, Volume 2, Revision C, April 2001.

2. ASCE/SEI 43-05, “Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities,” American Society of Civil Engineers, 2005.

3. Report 1053-21.1-4, “Cable Tray and Conduit Raceway Seismic Test Program, Release 4,” Bechtel-ANCO Engineers, Inc., December 15, 1978.

4. P. Koss, “Seismic Testing of Electrical Cable Support Systems, Structural Engineers of California Conference,” Bechtel Power Corporation, Los Angeles Power Division. Paper presented at the 48th Annual Convention of the Structural Engineers Association of California, Coronado, CA, October, 4-6, 1979.

5. Slaughterback, C. B., and Ware, A. G., “A Survey of Cable Tray and Conduit Damping Research,” EGG-EA-7346, Revision 1, August 1986. Prepared for the U. S. Nuclear Regulatory Commission.

6. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants”, Nuclear Regulatory Commission, March 2007.

7. BAW-10133NP-A, Revision 1, Addendum 1 and Addendum 2, “Mark-C FA LOCA-Seismic Analyses,” Framatome Technologies, December 2000.

8. "CE980 (BSIMQKE) Bechtel Simulated Earthquake Motions,” Bechtel Standard Computer Program, Bechtel Geotechnical and Hydraulic Engineering Services, Bechtel National, Inc., Version B1-4PCL, 1999.

9. NUREG/CR-6728, “Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk- Consistent Ground Motion Spectra Guidelines,” Nuclear Regulatory Commission, October 2001.

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Table 3.7.1-3—Strong Motion Duration of Synthetic Time Histories

	Time (seconds)		
Motion	**EURH1**	**EURH2**	**EURH3**
Strong Motion Duration (seconds)	5.97 (=6.0)	6.57	6.89
Motion	**EURM1**	**EURM2**	**EURM3**
Strong Motion Duration (seconds)	6.49	6.33	6.55
Motion	**EURS1**	**EURS2**	**EURS3**
Strong Motion Duration (seconds)	7.16	7.41	8.71
Motion	**SSSI1**	**SSSI2**	**SSSI3**
Strong Motion Duration (seconds)	7.2	7.5	8.7

Will be updated later.

Table 3.7.1-4—Values of V/A and AD/V² for Synthetic Time Histories

Motion	EURH1	EURH2	EURH3
Peak ground Displacement, D (inch)	2.0	2.4	1.7
Peak Ground Velocity, V (in/s)	4.6	5.7	6.1
Peak Ground Acceleration, A (g)	0.3	0.3	0.303
V/A - (cm/s)/g	39.2	48.2	51.0
AD/V^2	10.9	8.45	5.32
Motion	**EURM1**	**EURM2**	**EURM3**
Peak ground Displacement, D (inch)	2.2	2.2	2.5
Peak Ground Velocity, V (in/s)	7.5	6.1	7.9
Peak Ground Acceleration, A (g)	0.312	0.314	0.310
V/A - (cm/s)/g	60.7	49.3	64.3
AD/V^2	4.83	7.06	4.87
Motion	**EURS1**	**EURS2**	**EURS3**
Peak ground Displacement, D (inch)	2.6	2.5	2.3
Peak Ground Velocity, V (in/s)	11.9	9.3	10.9
Peak Ground Acceleration, A (g)	0.303	0.311	0.313
V/A - (cm/s)/g	99.6	76.1	88.3
AD/V^2	2.12	3.41	2.28
Motion	**SSSI1**	**SSSI 2**	**SSSI 3**
Peak ground Displacement, D (inch)	2.78	2.56	2.32
Peak Ground Velocity, V (in/s)	12.84	10.13	12.40
Peak Ground Acceleration, A (g)	0.38	0.38	0.38
V/A - (cm/s)/g	85.2	67.6	82.7
AD/V^2	2.51	3.66	2.23

Will be updated later.

Table 3.7.1-5—Cross-Correlation Coefficients Among Synthetic Time Histories

EURH1 with EURH2	**EURH1 with EURH3**	**EURH2 with EURH3**
0.010	0.027	0.030
EURM1 with EURM2	**EURM1 with EURM3**	**EURM2 with EURM3**
0.015	0.034	0.078
EURS1 with EURS2	**EURS1 with EURS3**	**EURS2 with EURS3**
0.038	0.051	0.045
SSSI1 with SSSI2	**SSSI1 with SSSI3**	**SSSI2 with SSSI3**
0.04	0.07	0.06

Will be updated later.

Table 3.7.1-6—~~Generic~~ Soil Profiles for the U.S. EPR Standard Plant

Soil Case No.	Seismic Control Motion Applied[2]	Soil Profile (Half-space or Layered)	Shear-wave Velocity of Soil[1]
1u	EUR Soft	Half-space	700 ft/s
2u	EUR Soft and Medium	Half-space	1640 ft/s
3u	EUR Medium	Half-space	2625 ft/s
4u	EUR Medium and Hard	Half-space	3937 ft/s
5u	EUR Hard	Half-space	5249 ft/s
5a	EUR Hard	Half-space	13,123 ft/s
1n2u	EUR Soft	Linear gradient within a 100 ft layer over a half-space	820 to 1640 ft/s
2sn4u	EUR Medium	49 ft uniform layer over a half-space	1640/3937 ft/s
2n3u	EUR Medium	Linear gradient within a 200 ft layer over a half-space	1640 to 2625 ft/s
3r3u	EUR Medium	20 ft uniform layer over 33 ft stiffer layer followed by soil half-space	2625/5249/2625 ft/s

Will be updated later.

Notes:

1. Shear wave velocities of ~~generic~~ soil profiles are strain-compatible.
2. For the EPGB and ESWB, the modified ~~CSDRS~~ input motion is used for all soil profiles, except hfub, hflb, and hfbe, where the high frequency (HF) input motion is used.
3. See Table 3.7.2-9 for damping ~~valves~~ values used.

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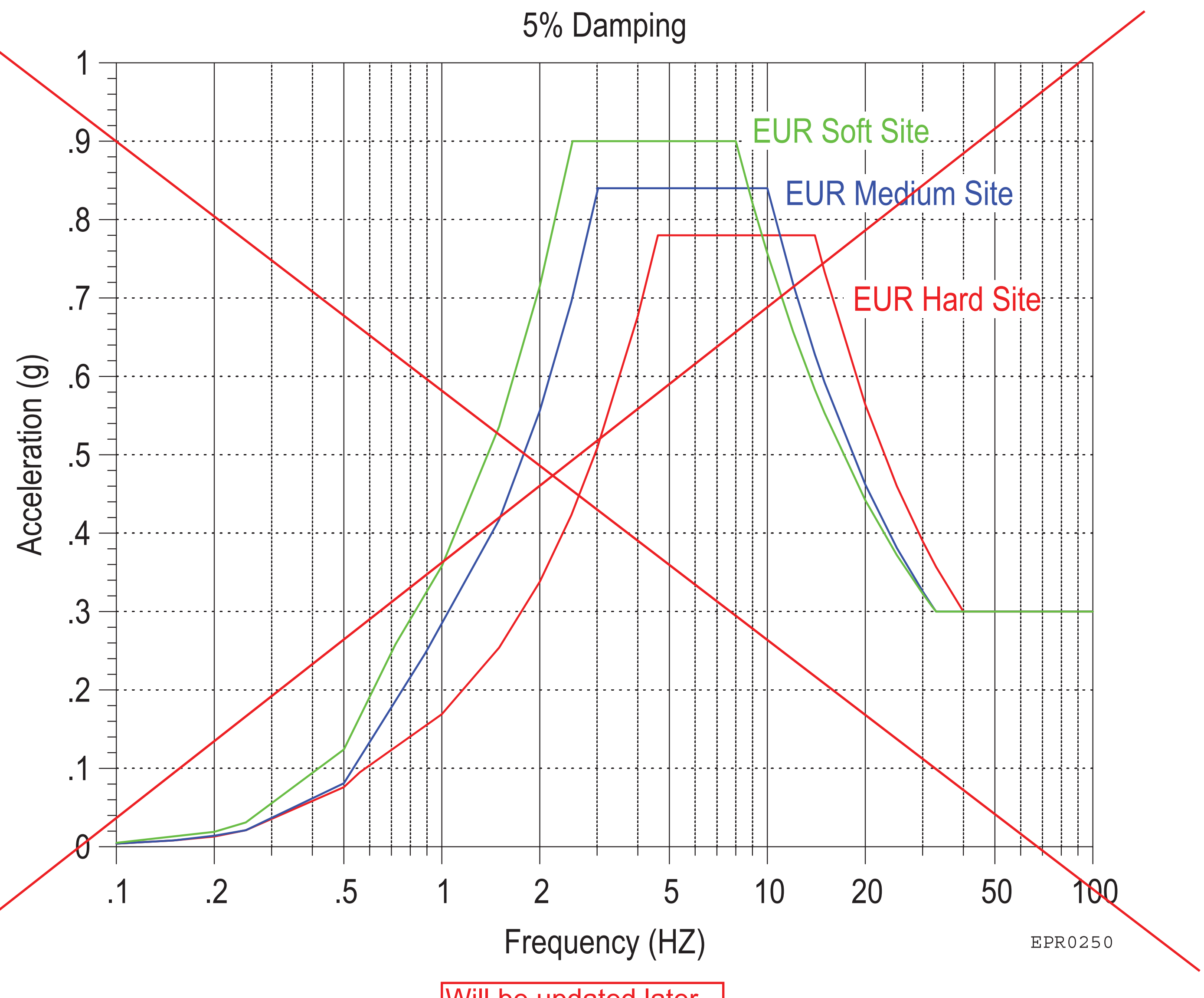
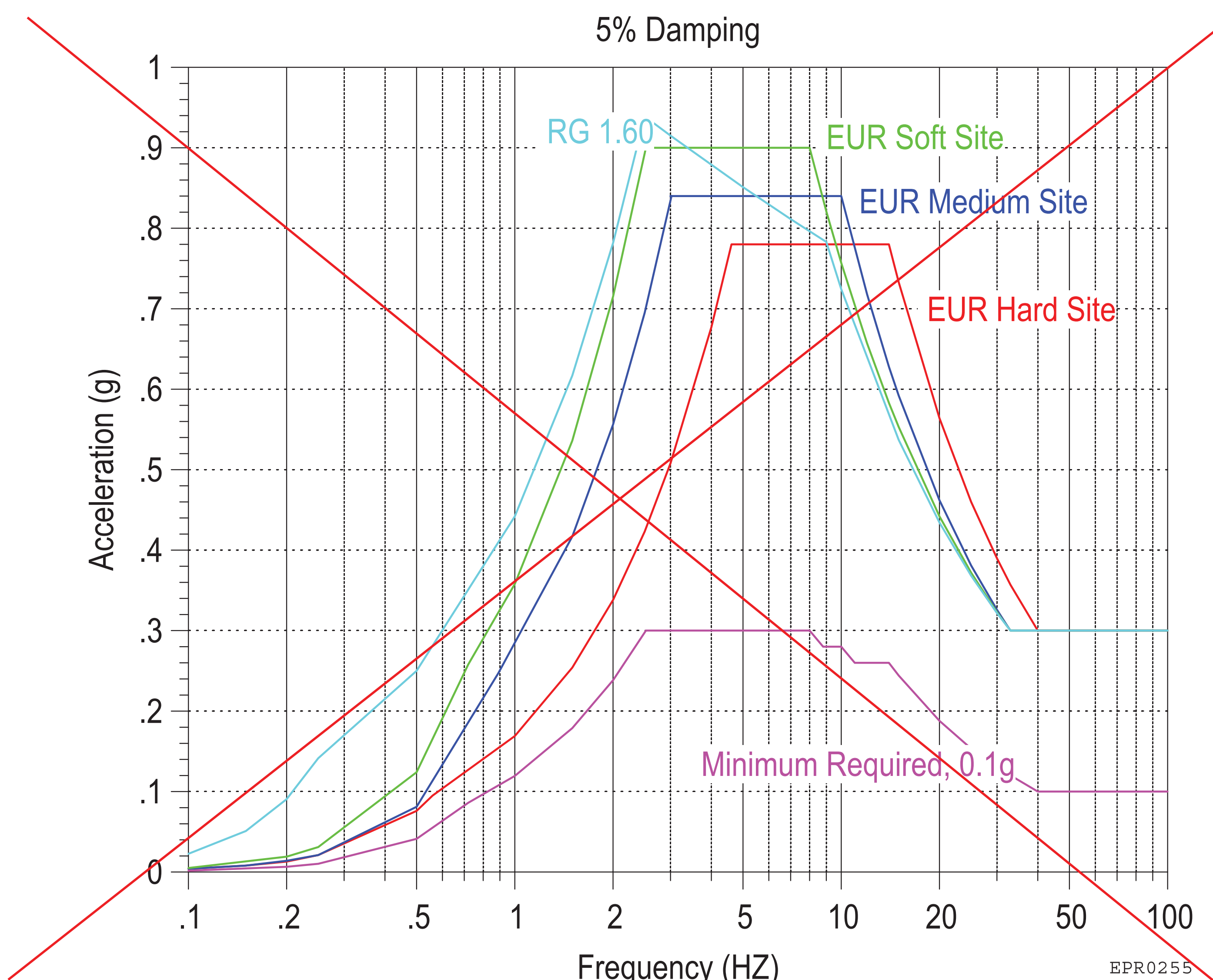
(hard, medium and soft sites) and HF

Figure 3.7.1-1—Design Response Spectra for EUR Control Motions ~~(hard, medium and soft sites)~~



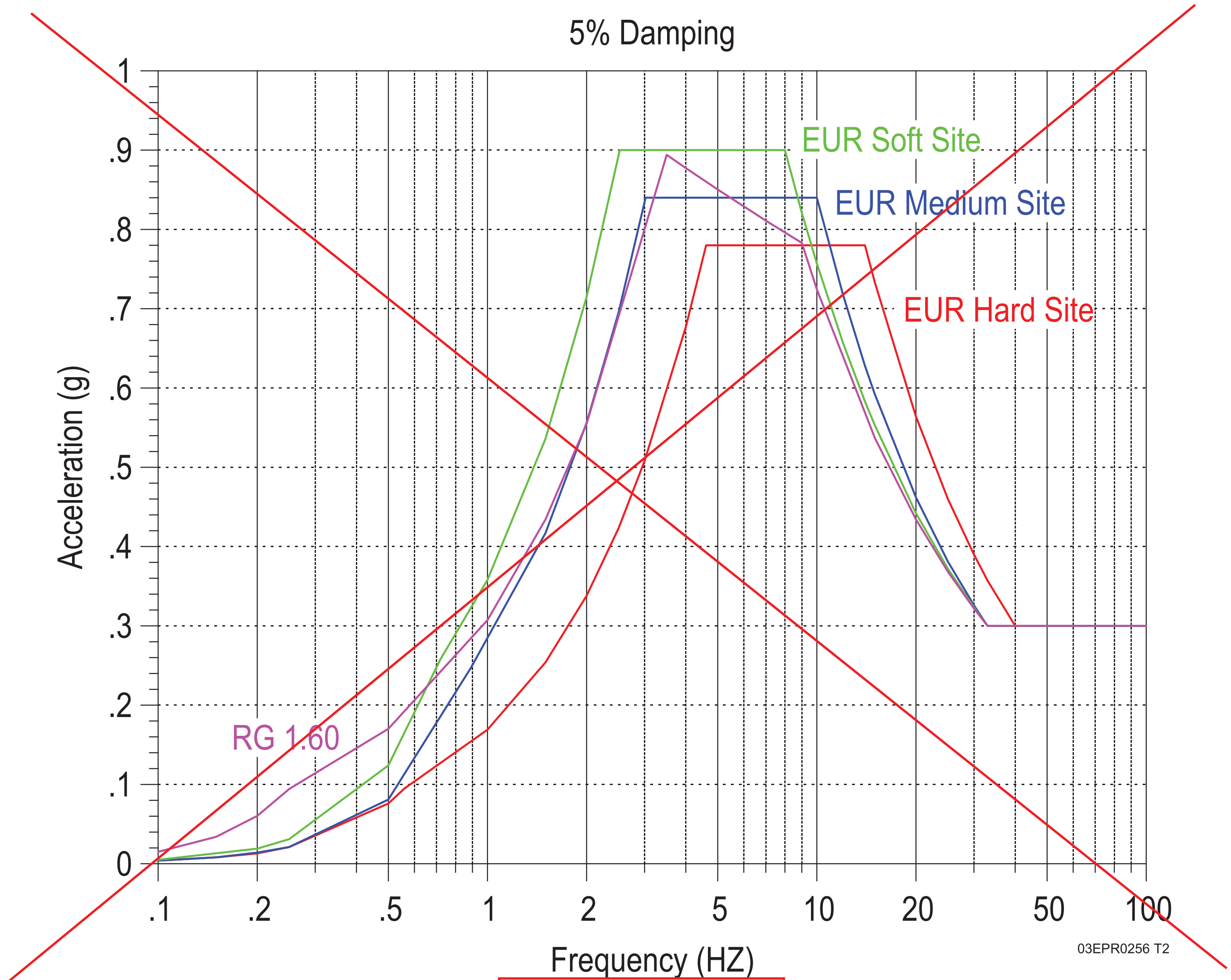
Will be updated later.

Figure 3.7.1-2—Comparison of CSDRS to RG 1.60 and the Minimum Required Spectrum, Horizontal Motion



Will be updated later.

Figure 3.7.1-3—Comparison of CSDRS to RG 1.60, Vertical Motion



Will be updated later.

Figure 3.7.1-29—~~Idealized Control Motion for Seismic Input to NI Common Basemat~~ Deleted

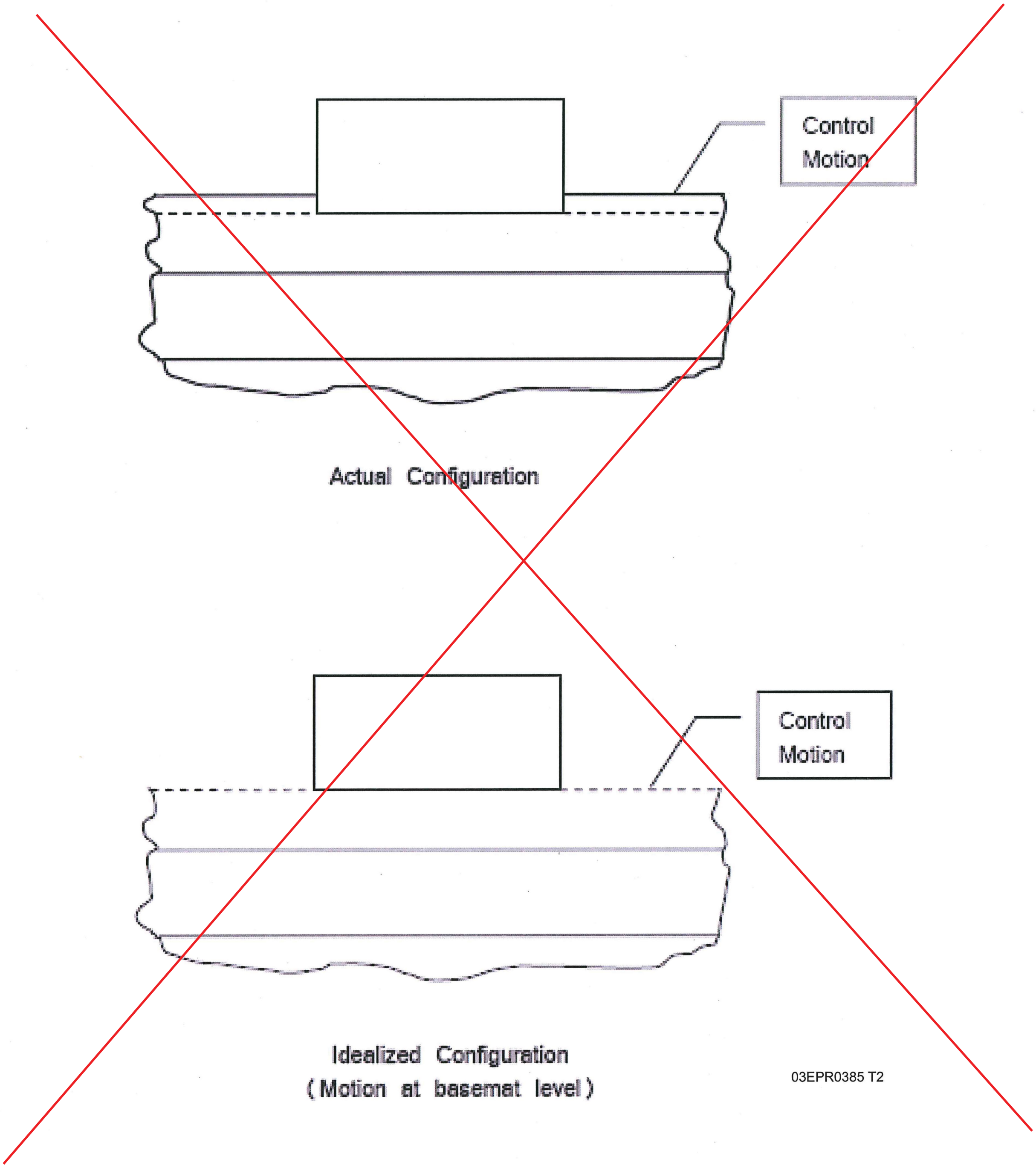
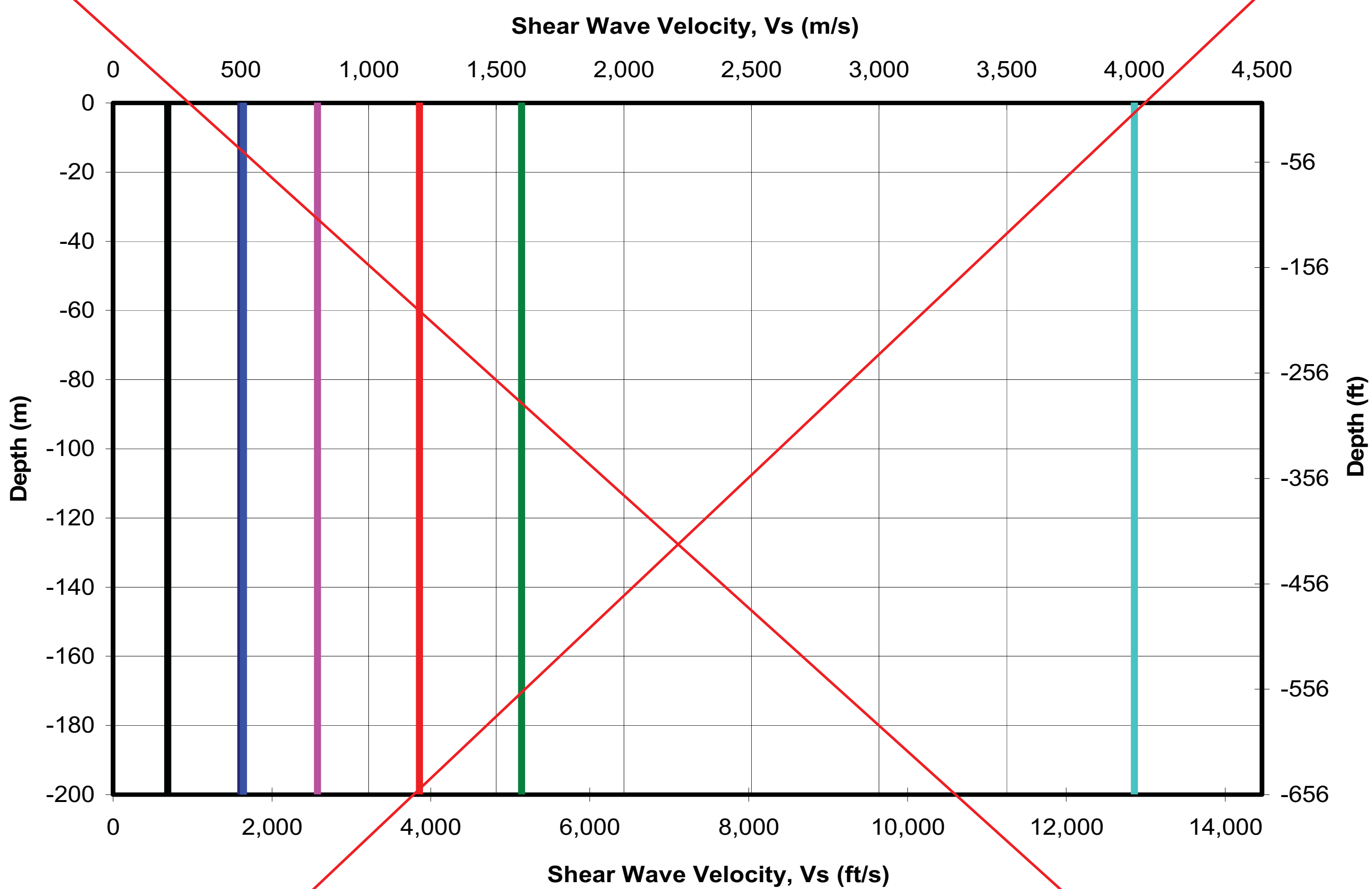


Figure 3.7.1-30—Figure Deleted

Figure 3.7.1-31—U.S. EPR Standard Plant ~~Generic~~ Soil Profiles - Shear

Uniform



Wave Velocity for SSI Analysis Cases

Will be provided later.

Layered

Figure 3.7.1-32—U.S. EPR Standard Plant ~~Generic~~ Soil Profiles - Shear Wave Velocity for SSI Analysis Cases

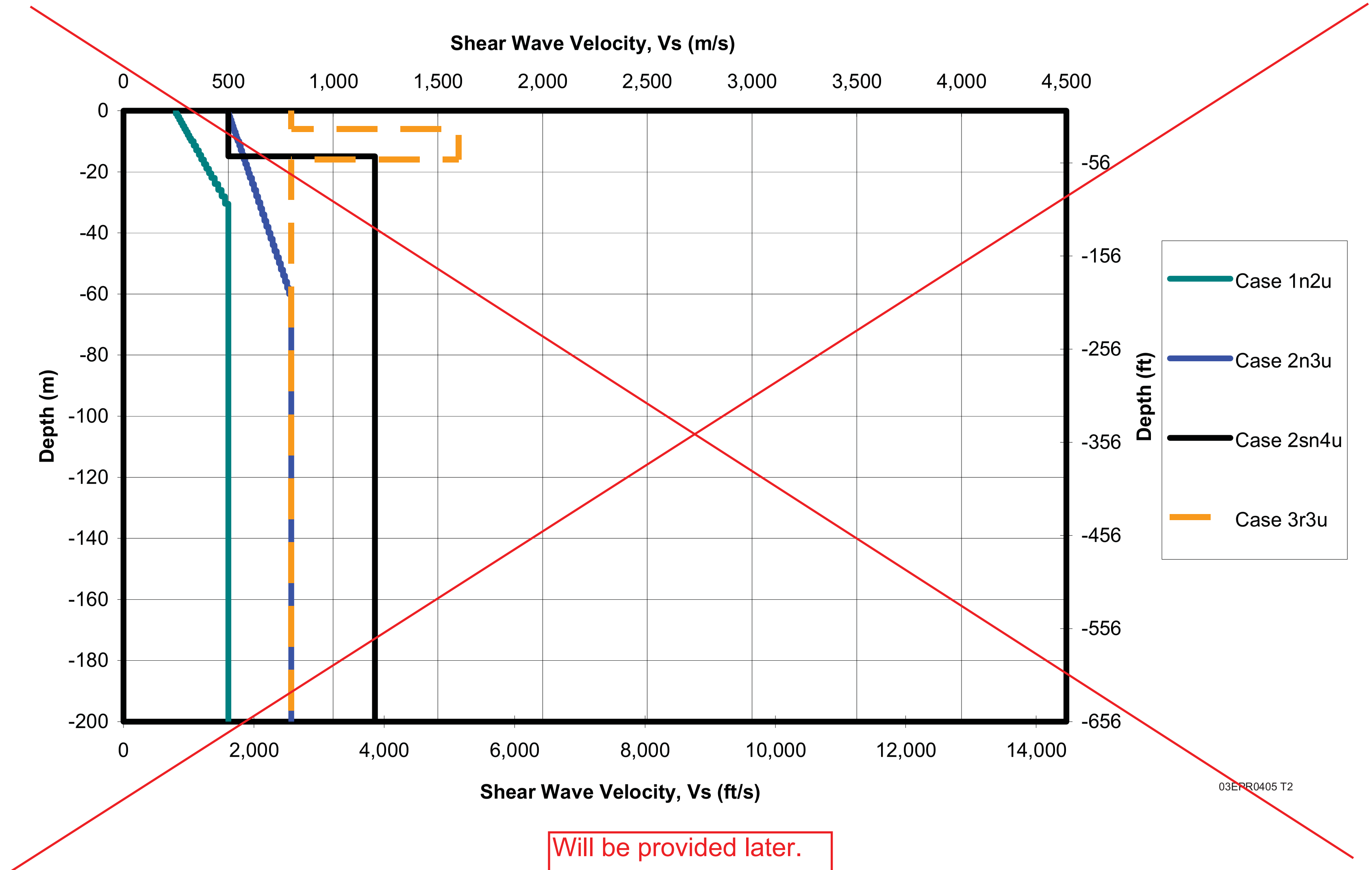


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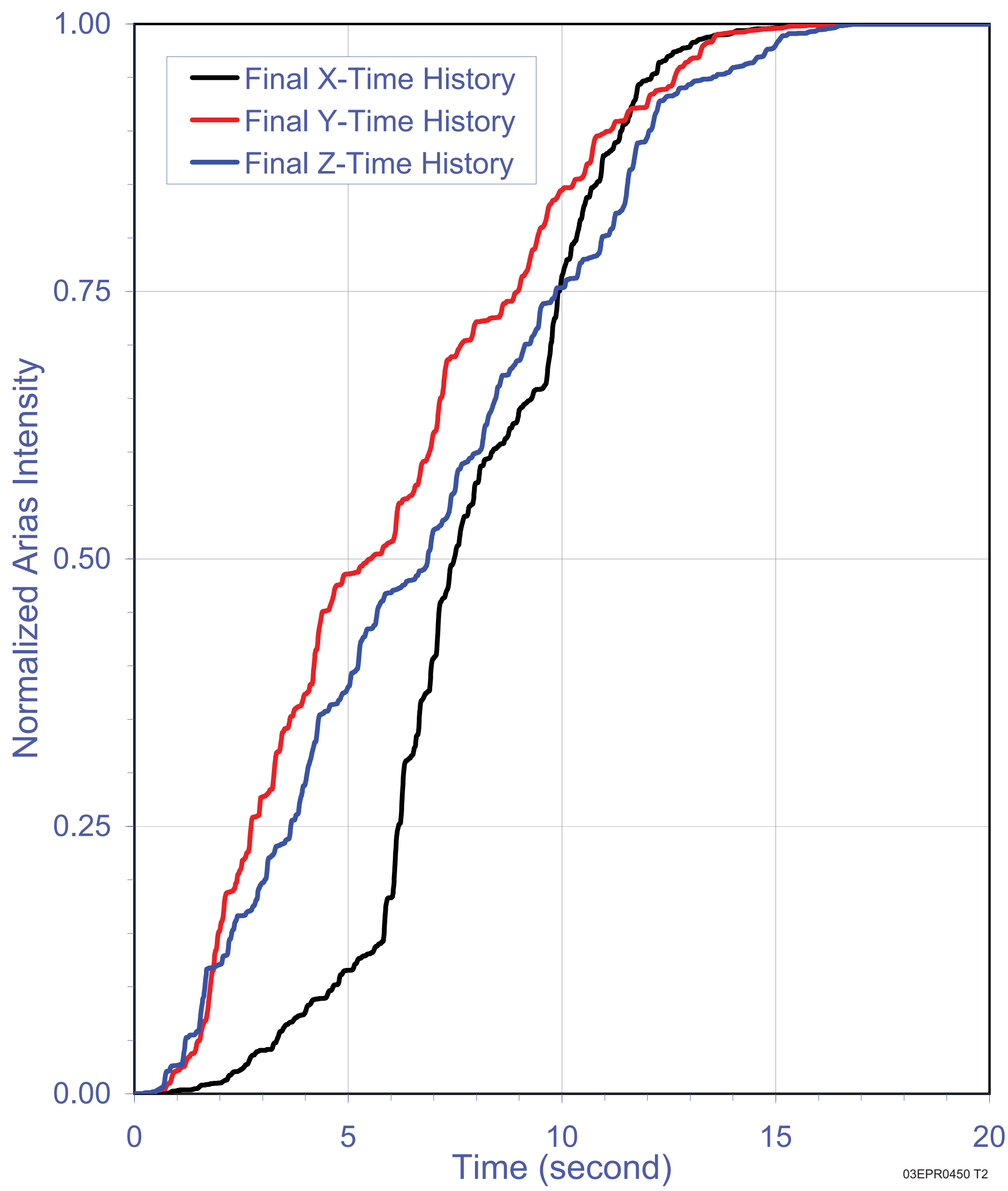
Figure 3.7.1-41—Cumulative Energy Plot for Time Histories for Structures not on the Nuclear Island Common Basemat

(EUR)



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TO BE PROVIDED LATER

Figure 3.7.1-42 Synthetic Acceleration Time Histories for HF CSDRS (FIRS) and Free-Field Surface Motion

<u>RAI 320, Question 03.07.02-63</u>

TO BE PROVIDED LATER

Figure 3.7.1-43 Synthetic Velocity Time Histories for HF CSDRS (FIRS) and Free-Field Surface Motion

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TO BE PROVIDED LATER

Figure 3.7.1-44 Synthetic Displacement Time Histories for HF CSDRS (FIRS) and Free-Field Surface Motion

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TO BE PROVIDED LATER

Figure 3.7.1-45 Response Spectrum of Time History vs Target Spectrum for HF1 Motion (HF1 Target, 1.30 Target*and 0.90-Target at 5% Damping)

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TO BE PROVIDED LATER

Figure 3.7.1-46 Response Spectrum of Time History vs Target Spectrum for HF2 Motion (HF2 Target, 1.30 Target*and 0.90-Target at 5% Damping)

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TO BE PROVIDED LATER

Figure 3.7.1-47 Response Spectrum of Time History vs Target Spectrum for HV Motion (HV Target, 1.30 Target*and 0.90-Target at 5% Damping)

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TO BE PROVIDED LATER

Figure 3.7.1-48 Cumulative Energy Ratio Plot for Time History H1, H2, and H3 for HF GMRS

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TO BE PROVIDED LATER

Figure 3.7.1-49 Horizontal FIRS for ESWB Structures (HFH)

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TO BE PROVIDED LATER

Figure 3.7.1-50 Vertical FIRS for ESWB Structures (HFV)

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TO BE PROVIDED LATER

Figure 3.7.1-51 Horizontal FIRS for EPGB Structures (HFH)

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TO BE PROVIDED LATER

Figure 3.7.1-52 Vertical FIRS for EPGB Structures (HFV)

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TO BE PROVIDED LATER

Figure 3.7.1-53 Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI1HF) Motion

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TO BE PROVIDED LATER

Figure 3.7.1-54 Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI2HF) Motion

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TO BE PROVIDED LATER

Figure 3.7.1-55 Synthetic Acceleration, Velocity, and Displacement Time Histories for Structures not on the Nuclear Island Common Basemat, Vertical (SSSI3HF) Motion

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TO BE PROVIDED LATER

Figure 3.7.1-56 Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI1HF) Motion

RAI 320, Question 03.07.02-63
TO BE PROVIDED LATER

Figure 3.7.1-57 Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Horizontal (SSSI2HF) Motion

RAI 320, Question 03.07.02-63

TO BE PROVIDED LATER

Figure 3.7.1-58 Time History Response Spectrum vs. Input Spectrum for Structures not on the Nuclear Island Common Basemat, Vertical (SSSI3HF) Motion

RAI 320, Question 03.07.02-63
TO BE PROVIDED LATER

Figure 3.7.1-59 Cumulative Energy Plot for Time Histories for Structures not on the Nuclear Island Common Basemat (HF)

3.7.2 Seismic System Analysis

This section provides seismic analysis details for Seismic Category I, II, Conventional Seismic (CS), and Radwaste Seismic (RS) structures that are considered in conjunction with the foundation and its supporting media as seismic systems. Other seismic structures, systems, equipment, and components that are not designated as seismic systems (i.e., heating, ventilation and air-conditioning systems; electrical cable trays; piping systems) are designated as seismic subsystems. The analysis of seismic subsystems other than piping is presented in Section 3.7.3. The analysis of piping subsystems is described in Section 3.9.2 and Section 3.12.

A three-dimensional rendering of the U.S. EPR is shown in Figure 1.2-1. Typical building locations are shown in the dimensional arrangement drawing of Figure 3B-1. The Nuclear Island (NI) Common Basemat Structures consist of ten buildings that share one common basemat. The NI common basemat is a heavily reinforced concrete slab which supports the Reactor Building (RB), Reactor Building Internal Structures, Safeguard Buildings (SB) 1 thru 4, Fuel Building (FB), SBs 2 and 3 shield structure, FB shield structure, RB shield structure, as well as the main steam valve stations (MSVS), the Vent Stack (VSTK), and the staircase towers (SCT) (see Figure 3B-1). Safeguard~~s~~ Building 2 and 3 are separate structures that share a common wall. An interior cutaway view of the U.S. EPR NI Common Basemat Structures is shown in Figure 3.7.2-1—Decoupling of the Nuclear Island Common Basemat Interior Structures from the Outer Shield Walls, which illustrates the hardened protection afforded by the aircraft protection shield structures and the decoupling between them and the remaining structures on the NI common basemat. The shield structures are discussed in more detail below.

The RB occupies the central portion of the NI common basemat and houses the reactor coolant system (RCS). The RB consists of three concrete structures:

- The inner Reactor Containment Building (RCB).
- The outer Reactor Shield Building (RSB).
- The RB Internal Structures (RBIS).

The RBIS are housed within the RCB. The main steam system (MSS) and main feedwater system valve stations are located within SBs 1 and 4. The SCTs are reinforced concrete structures located at the perimeter of the RSB. The SCTs are located in the areas where the footprints of the SBs and the FB overlap.

The primary function of the RSB is to protect the RCB from missiles and loads resulting from external design basis events such as hurricanes and tornados, as well as beyond design basis events such as extreme aircraft hazards and explosion pressure waves. The hardened cylindrical shell and dome are part of the monolithic protective shield that extends from the north wall of SBs 2 and 3, over the RCB, and to the south wall of the FB. The exterior walls and roof slab of the SCTs are part of this monolithic protective shield. The space between the interior surface of the RSB and the exterior surface of the RCB forms the RB Annulus. The approximately six-foot wide annulus serves as an access area for personnel and as a shelter for cables, piping, and heating, ventilation, air conditioning ducts, and it provides clearance to prevent structural interactions during design basis and beyond design basis events.

The common basemat provides assurance that overturning of the supported structures as a result of a seismic event or other hazards, such as aircraft impact, will not occur. To provide additional protection from external hazards and beyond design basis events, the containment interior structures are decoupled from the outer walls (see Figure 3.7.2-1). Because of the decoupling, containment interior structures are only connected by the common basemat foundation to the surrounding structure. In addition, except for electrical and mechanical system tie-ins, the NI Common Basemat Structures are structurally isolated from adjacent structures.

Two Emergency Power Generating Buildings (EPGB) and four Essential Service Water Buildings (ESWB) are situated in the vicinity of the NI Common Basemat Structures. The EPGB provides emergency power for the plant to allow safe shutdown and maintain safe shutdown, while the ESWB provides component cooling water for the safe operation and emergency shutdown of the plant. Key attributes of the two structures are:

- Each EPGB contains two diesel powered generators as well as two 120,000 gallon fuel storage tanks.
- Each ESWB includes a pumphouse and mechanical cooling towers with cells 60 feet square.

and high frequency content

An embedded 3D finite element model (FEM) of the NI Common Basemat Structures and an embedded stick model of the NAB are

The U.S. EPR EUR-based certified seismic design response spectra (CSDRS), as described in Section 3.7.1, are associated with a variety of potential soil and rock conditions intended to encompass the majority of potential sites in the central and eastern United States. A soil-structure interaction (SSI) analysis is performed on the U.S. EPR NI Common Basemat structures, Nuclear Auxiliary Building (NAB), EPGB, and ESWB to compute the global seismic responses of the structures for the variety of soil conditions considered in Section 3.7.1.3. ~~Stick models are~~ used in the seismic SSI analysis ~~of the NI Common Basemat Structures and NAB, and the stick models are dynamically compatible with the respective 3D finite element models (FEM) of the structures~~. For the EPGB and ESWB, 3D FEM of the structures are ~~directly~~ used in the seismic SSI analysis. As described in Section 3.7.1, the input ground motion for the SSI analysis of the EPGB and ESWB is different from that for the NI and NAB.

The following sections describe the seismic analyses performed for the Seismic Category I, II, CS, and RS structures of the U.S. EPR. The seismic classification of U.S.

EPR structures is defined in Section 3.2. These seismic analyses meet the requirements of 10 CFR 50, GDC 2 and 10 CFR 50, Appendix S, with respect to the capability of the structures to withstand the effects of earthquakes. Application of the criteria in Section 3.7 to the seismic analysis and design of the U.S. EPR results in a robust design with significant seismic margin, as demonstrated in the seismic margin assessment of Section 19.1. A COL applicant that references the U.S. EPR design certification will confirm that the site-specific seismic response is within the parameters of Section 3.7 of the U.S. EPR standard design. The impact of changes to the standard design at the detailed design stage is evaluated using the following criteria.

- The effects of deviations are evaluated using methods that are consistent with those of Section 3.7 as used for the certified design.
- The evaluation considers the combined effect of such deviations.
- The combined deviations in amplitude of the in-structure response spectra will be evaluated on a case-by-case basis.

3.7.2.1 Seismic Analysis Methods

The response of a multi degree-of-freedom system subjected to seismic excitation may be represented by the differential equations of motion in the following general form:

Equation 1

$$[M]\{\ddot{X}\}+[C]\{\dot{X}\}+[K]\{X\}=-[M]\{\ddot{u}_g\}$$

Where:

$[M]$ = mass matrix (n x n)

$[C]$ = viscous damping matrix (n x n)

$[K]$ = stiffness matrix (n x n)

$\{X\}$ = column vector of relative displacements (n x 1)

$\{\dot{X}\}$ = column vector of relative velocities (n x 1)

$\{\ddot{X}\}$ = column vector of relative accelerations (n x 1)

n = number of degrees of freedom

$\{\ddot{u}_g\}$ = column vector of input acceleration

Depending on the type of analysis and application, the following seismic analysis methods are used to solve the above equations of motion to determine the seismic responses of~~,~~ the U. S. EPR structures.

- Time history analysis method.
- Response spectrum method.
- Complex frequency response analysis method.
- Equivalent-static load method of analysis.

Seismic analysis is performed for the three orthogonal (two horizontal and one vertical) components of earthquake motion defined in Section 3.7.1. The orthogonal axes are aligned with the global axes of the seismic analysis models.

3.7.2.1.1 Time History Analysis Method

Equation 1 is solved using the time history analysis method in the time domain for the seismic response of the system using either the direct integration technique or the modal superposition technique. The choice of the technique depends on whether or not the system is a linear one.

When nonlinearity occurs in the stiffness matrix, [K], or damping matrix, [C], the direct integration technique is used to solve Equation 1. ~~This technique is used for the time history analysis of the NI Common Basemat safety-related structures to determine their stability against seismic sliding or overturning and their potential for seismic structural interaction. In this analysis, the approximate soil springs and dampers representing the soil under the foundation basemat are nonlinear in nature to allow for sliding or uplift of the basemat to occur. The ANSYS computer code is used in this nonlinear time history analysis of the U. S. EPR structures.~~

When the system is linear elastic and the damping of the system in lieu of the damping matrix [C] may be explicitly specified as modal damping ratios associated with the normal modes of the system, the modal superposition technique is used to solve Equation 1 for the seismic response of the system. The modal time history analysis technique is used in ~~two applications. The first application is~~ the ~~modal time history~~ analysis of the fixed-base NI Common Basemat Structures ~~and NAB structures~~ to demonstrate dynamic compatibility between the ~~stick models~~ used in the SSI analysis and the 3D FEM~~'s~~ used in the static analysis. The modal time history analysis generates in-structure response spectra (ISRS) at representative locations of the structures for both the stick model~~s~~ and FEMs. The ~~stick model is~~ considered compatible with the FEM when the ISRS of the ~~stick~~ model are similar to those at corresponding locations of the FEM. For the NI Common Basemat Structures, ~~computer codes~~ used in such modal time history analyses ~~are the GTSTRUDL code,~~

The modal time history analysis technique is also used in the analysis of the fixed-base NAB structures to demonstrate dynamic compatibility between the stick model used in the SSI analysis and the static 3D FEM used in the static analysis.

dynamic 3D FEM

dynamic FEM and the NAB stick model used in the SSI analysis are

corresponding static

ANSYS code, Version 11.0 is

static

SSI analysis

~~Version 28, for the stick models and ANSYS code, Version 10.0, for the FEMs~~. For the NAB, the GTSTRUDL code, Version 29, is used in the modal time history analysis of both the stick model and FEM. ~~The second application of the modal time history analysis is the local seismic analysis of the flexible slabs and walls in the NI Common Basemat Structures subsequent to the SSI analysis. In this case, the modal time history analysis of single-degree-of-freedom (SDOF) oscillators representing the flexible slabs and walls is performed to determine the amplified out-of-plane acceleration response and ISRS at such slabs and walls. The GTSTRUDL code, Version 28, is used in this application.~~

To solve Equation 1 numerically in the time domain using either the direct integration or modal superposition technique, the time step for numerical integration must be sufficiently small for stability and convergence of the solution. ~~As a general rule, the value for the maximum~~ The time step is set to be no larger than one-~~fifth~~ tenth of the lowest natural period of interest. Normally, the lowest period of interest need not be less than the reciprocal of the zero period acceleration (ZPA) frequency. The general rule for solution convergence is that a time step must be small enough that use of one-half its duration does not change the response by more than ten percent, as defined by ASCE 4-98 (Reference 1), Section 3.2.2.1(c).

3.7.2.1.2 Response Spectrum Method

Response spectrum analyses are performed on flexible long span floors and roof of the NAB Non-Seismic Category I structure to obtain the amplified vertical accelerations of the floors. Input motion to the analysis is the vertical ISRS at the slab locations generated from the seismic SSI analysis of the NI Common Basemat Structures and NAB. This analysis technique is used for the Vent Stack, which is a Seismic Category I steel structure approximately 100 ft high located on top of the stair towercase structure between the FB and SB 4 (see Figure 3B-1).

Similar to the modal time history analysis method, when the response spectrum method is used it is assumed that the damping matrix [C] in Equation 1 may be explicitly represented by modal damping ratios so that the equation of motion given in Section 3.7.2.1 may be transformed to the equations of motion of the normal modes. The maximum seismic response of interest for each given mode is a function of the modal participation factor, mode shape and the input response spectrum acceleration at the corresponding modal frequency and damping ratio. The maximum modal responses are combined to determine the maximum response of interest in accordance with the combination method described in Section 3.7.2.7.

3.7.2.1.3 Complex Frequency Response Analysis Method

With this analysis method, the damping of the system is not represented by the viscous damping matrix, [C], but as the imaginary part of a complex stiffness matrix. Thus Equation 1 becomes complex and must be solved in the frequency domain. To facilitate the analysis, the time history of input ground motion is transferred to the frequency domain by Fast Fourier Transform (FFT). The seismic responses calculated in the frequency domain are then transferred back to the time domain as outputs by inverse FFT.

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The complex frequency response analysis method is used in the seismic SSI analysis of all Seismic Category I structures. ~~AREVA~~ computer code SASSI, Version ~~4.1B~~, is used in the SSI analysis of the NI Common Basemat Structures and NAB. Bechtel computer code SASSI 2000, Version 3.1, is used in the SSI analysis of the EPGBs and ESWBs. For the SSI analysis results to be sufficient, the following requirements are met:

- A sufficiently high cut-off frequency is selected to ensure all significant SSI frequencies are included.
- A sufficient number of frequency points is used to accurately define the transfer functions within the cut-off frequency.
- The time step size for the input ground motion time histories is sufficiently small to be compatible with the selected cutoff frequency.

The SSI analysis generates the maximum ZPA at various floor locations, the floor acceleration time histories at representative locations for ISRS generation, the maximum member or element forces and moments, and the maximum relative displacements at the structural basemats with respect to the free-field input motions.

the NI Common Basemat Structures and

SHAKE91 and

respectively,

The complex frequency response analysis method is also used in the soil column analysis using Bechtel computer code SHAKE2000, Version 1.1, to compute the free-field "in-column" motion at the foundation level of ESWB, for use as the input motion to the SSI analysis. This is because the SSI analysis of the ESWB considers structural embedment, and the input ground motion specified in Section 3.7.1 corresponds to a hypothetical free-field "outcrop" motion at the foundation level ~~of ESWB~~. Bechtel code SASSI 2000 requires that the input motion, when specified at the foundation level, be an "in-column" motion converted from the "outcrop" motion through a soil column analysis~~.~~

MTR/SASSI, Version 8.3 and

NI Common Basemat Structures and

3.7.2.1.4 Equivalent Static Load Method of Analysis

Alternatively, a surface motion converted from the "outcrop" motion can also be used.

This analysis method is used to determine the seismic induced element forces and moments in the 3D FEMs of the NI Common Basemat Structures, EPGB, ESWB and NAB. In the analysis, equivalent static loads corresponding to the ZPAs generated from the seismic SSI analyses are applied to the 3D FEMs of the structure and basemat for the applicable SSI analysis cases. Computer codes used in the analyses include ANSYS code Version ~~10.0~~ for the NI Common Basemat Structures, GTSTRUDL code Version ~~27~~ for the EPGB ~~and~~ ESWB, and ~~GTSTRUDL code Version 29 for the~~ NAB.

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and

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Consideration of torsional loading induced by accidental eccentricities is presented in Section 3.7.2.11.

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3.7.2.2 Natural Frequencies and Response Loads

each

are represented by an embedded 3D FEM, and the

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In the SSI analysis, the NI Common Basemat Structures~~,~~ RCS~~,~~ and NAB are represented by stick models ~~and the~~ EPGB and ESWB are represented by 3D FEMs. ~~The stick models are developed to ensure a reasonable dynamic compatibility with the corresponding 3D FEMs that are used in the equivalent static analysis.~~ Section 3.7.2.3 discusses the development of the structural models.

, one for the SSI analysis based on the EUR motions and the other based on the HF motion.

Table 3.7.2-1 -- Frequencies and Modal Mass Ratios for NI Common Basemat Structures with All Masses Included, shows the frequencies and modal mass ratios of the dynamic 3D FEM of the NI Common Basemat Structures, and

Table 3.7.2-4—Modal Frequencies of the Simplified Stick Model of Reactor Coolant Loop, shows the frequencies of the first 50 modes of the simplified stick model of the RCS. ~~Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS, shows the frequencies and modal mass ratios computed by GTSTRUDL code for the first 256 modes of the stick model of the NI Common Basemat Structures including the vent stack and RCS. This overall stick model of the NI Common Basemat Structures~~ includes applicable masses in addition to the masses of the concrete. ~~It consists of three major stick models: STICK-1T for the RBIS, STICK-3T for the RCB, and STICK-2T for the composite sticks representing the remaining structures on the NI Common Basemat.~~ Frequencies and modal mass ratios of ~~these three individual major sticks~~ are shown in~~:~~

STICK-1T is the stick model for the RBIS and

STICK-1T

- ~~Table 3.7.2-1—Frequencies and Modal Mass Ratios for Balance of NI Common Basemat Structures STICK-2T with All Masses Included.~~
- ~~Table 3.7.2-2—Frequencies and Modal Mass Ratios for Reactor Containment Building STICK-3T with Polar Crane Included.~~
- Table 3.7.2-3—Frequencies and Modal Mass Ratios for Reactor Building Internal Structures STICK-1T with All Masses Included.

(EUR Motions), and Table 3.7.2-30 -- Modal Frequencies of 3D FEM of Emergency Power Generating Building (HF Motion), show the frequencies of the 3D FEMs of the EPGB used in SSI analysis based on the EUR motions and HF motion, respectively.

used in SSI analysis based on the EUR motions and HF motion,

s

Table 3.7.2-6—Modal Frequencies of the Stick Model of NAB shows the frequencies and modal mass ratios computed by GTSTRUDL code for the first 25 modes of the NAB stick model. Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building~~, and~~ Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building~~,~~ show the frequencies of the 3D FEM of the ~~EPGB and~~ ESWB, respectively.

(EUR Motions), and Table 3.7.2-31 --Modal Frequencies of 3D FEM of Emergency Service Water Building (HF Motion)

Since the SSI analysis is performed using the complex frequency response method where the equation of motion is solved in the frequency domain, the modal frequencies and mass ratios presented in the tables above are for reference information only.

3.7.2.3 Procedures Used for Analytical Modeling

Seismic SSI analysis of the Seismic Category I structures is performed following the guidance in ASCE 4-98 (Reference 1) and SRP 3.7.2 (Reference 2). Methodology for development of the structural models is discussed below. Methodology for development of the SSI analysis model is discussed in Section 3.7.2.4.

3.7.2.3.1 Seismic Category I Structures – Nuclear Island Common Basemat

The NI Common Basemat is approximately 10 feet thick and transitions to a thickened section where the cylindrical walls of the RSB and the RCB intersect with the basemat. The basemat then steps down at the outer edge of the tendon gallery wall and continues out under the SBs, FB, and the SCTs (see Figure 3.7.2-3 ~~and Figure 3.7.2-4~~).

The SBs basemat is approximately 10 feet thick from the intersection with the outer surface of the RSB wall to the internal wall dividing the radiological control area and nonradiological control area, where it thickens to approximately 13 feet and continues to the intersection with the exterior wall.

The FB basemat is approximately 10 feet thick throughout, with the exception of an area of the basemat that steps down to form a sump at the common wall with the RSB wall, and then steps up and continues out to the intersection with the exterior wall.

A total of ~~twelve~~ eight SSI analyses are performed for the NI and NAB for the various soil and rock conditions encompassed by the EUR design spectra for the hard, medium, and soft soil conditions , and HF GMRS for upper bound, lower bound, and best estimate soil conditions as described in Section 3.7.1. The purpose of the SSI analyses is to generate sets of global seismic response loads which can be used in the design of the Seismic Category I SSC. The seismic response loads generated include forces on the members and accelerations at ~~modal~~ nodal locations, ISRS at representative locations, and amplified ISRS at representative flexible slabs.

In the SSI analysis, the NI Common Basemat Structures, are represented by an embedded 3D FEM, and the RCS and NAB are represented by stick models. ~~The basemats of both the NI Common Basemat Structures and NAB are assumed rigid for the purpose of SSI analysis because they are sufficiently thick and, in addition, are stiffened in out-of-plane deformation by the structural walls above the basemat. For the NI Common Basemat Structures, the stick model is an~~ The 3D FEM is ~~assemblage of nine individual stick models, as conceptually~~ illustrated ~~in~~ Figure 3.7.2-113 - Dynamic 3D Finite Element Model of Nuclear Island, Isometric View. ~~Figure 3.7.2-2—Plan View of Schematic Stick Model for Nuclear Island Common Basemat Structures, and Figure 3.7.2-4—Schematic Elevation View of Stick Model for Nuclear Island Common Basemat Structures in Global X-Z Plane, which are rigidly tied together at their bases on the common basemat. SBs 2 and 3, which share a common wall, are represented by one stick model.~~ "INSERT 1" The NAB~~, which is included in the SSI analysis for the NI Common Basemat Structures,~~ is represented by a single embedded stick model supported on a separate basemat. "INSERT 2" The SSI analysis is discussed in more detail in Section 3.7.2.4.

~~The stick models are developed by first locating key elevations (typically the major floor slab elevations) in the structure. Between two successive key elevations, two vertical massless sticks are developed. One stick is located at the center of shear area~~

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Development of the 3D FEMs for the NI Common Basemat Structures is described in Section 3.7.2.3.1.1 (static 3D FEM) and 3.7.2.3.1.2 (dynamic 3D FEM). The static FEM is used in the equivalent static analysis and provides the basis for the development of the dynamic FEM, which is used in SSI analysis of the NI Common Basemat Structures. The RCS is represented by a simplified stick model that is separately developed and coupled with the FEM of the RBIS for the SSI analysis of the NI Common Basemat Structures. The simplified RCS stick model is shown in Figure 3.7.2‑56—Simplified Stick Model of Reactor Coolant Loop, and is compatible with a more detailed RCS model. The stick model for the RBIS is developed for RCS structural analysis and is dynamically compatible with the 3D FEM of the RBIS.

INSERT 2

The stick model for the NAB is developed in a manner similar to that used for the RBIS stick and is dynamically compatible with the 3D FEM of the NAB. Development of the stick models is described in Section 3.7.2.3.1.3.

~~and the other at the center of axial area respectively, of the vertical structural elements between the two given key elevations. Section properties of the two sticks are determined by hand calculations based on the structural drawings. The total axial area of the vertical structural elements is assigned to the stick located at the center of axial area. The remaining five section properties, including the total shear areas along the two global axes and the total moments of inertia about the three global axes, are assigned to the stick located at the center of shear area. The two sticks are connected to each other at both their upper and lower ends with a horizontal rigid beam. For the NI stick models, no structural credit is taken for the stiffness of the steel liner plate in both the reactor containment and the spent fuel pool.~~

~~At the key elevations of the structure, a lumped mass is placed at the center of mass. The lumped mass is connected with horizontal rigid beams to the center of shear area and center of axial area located at the same elevation. It includes mass contributions from the following elements:~~

- ~~Floor or roof slab(s), when applicable, at the particular elevation.~~
- ~~Walls and miscellaneous floor slabs and platforms (including platform live load) within half height to the next key elevation below.~~
- ~~Walls and miscellaneous floor slabs and platforms (including platform live load) within half height to the next key elevation above.~~
- ~~Permanent equipment and distribution systems supported by slabs and platforms.~~
- ~~Water in pools under normal operating conditions.~~
- ~~Twenty-five percent of the live loads (variable loads) on floor slabs and platforms.~~
- ~~Seventy-five percent of the maximum snow load on roof slabs.~~
- ~~Miscellaneous dead loads of at least 50 psf.~~

~~The total mass of water in a pool during normal operating conditions is lumped at the bottom slab of the pool in the vertical direction. In the horizontal direction, the mass of the water is distributed to the nodes along the height of the pool using tributary areas. For the purpose of the stick model, water mass is considered as a permanent load if present during normal operating conditions. The frequency of water sloshing is typically low compared to the first horizontal mode frequency of the structure housing the pool. The sloshing frequency ranges from approximately 0.1 Hz to 0.5 Hz. The fundamental frequency for the associated structures ranges from approximately 2.5 Hz to 13 Hz. As such, water sloshing has a negligible effect on the global seismic response of the structure and hence may be ignored in the development of the stick model. The effect of water sloshing however, is considered in the local analysis and detailed design of the pool. For the NI Common Basemat Structures, the spent fuel racks are~~

~~considered by lumping 100 percent of the spent fuel load at the bottom slab in the vertical direction and by distributing it along the height of the pool in the horizontal direction. Rack-structure interaction is not considered in development of the structural stick model for the FB as far as global seismic response is concerned.~~

~~Floor/roof slabs and walls are assumed rigid when developing the stick models for the NI Common Basemat Structures, except that out-of-plane flexibilities of the following slabs and walls are explicitly accounted for by SDOF oscillators in the stick models:~~

- ~~The removable walls at the steam generator (SG) towers above elevation +63 ft, 11-1/2 inches of the RBIS.~~
- ~~The walls and roof slab of the SBs 2 and 3 shield structure and FB shield structure.~~
- ~~The two flexible slabs at elevation +26 ft, 7 inches of SBs 2 and 3.~~

~~At these locations, SDOF oscillators representing the out-of-plane vibration of the slabs and walls are connected to the lumped masses at the proper elevations of the respective stick models. The effect of flexible floors and walls not included in the stick models is accounted for, after the SSI analysis is completed, in subsequent modal time history analyses of the flexible slabs and walls that are represented by SDOF oscillators. The out-of-plane vibration frequency of a flexible slab or wall is determined by hand calculations if the configuration is simple, or by modal analysis of a local FEM of the slab/wall. The input motions to these subsequent time history analyses are the applicable floor acceleration time histories output from the SSI analysis (see Section 3.7.2.4.7).~~

~~The RBIS and RCB are free-standing structures supported by the common basemat. The seven balance-of-NI Common Basemat Structures (RSB, SBs 1, 2/3 and 4, FB, SBs 2 and 3 shield structure and FB shield structure) are structurally coupled to each other laterally both at and above the basemat. The lateral structural couplings above the basemat are simulated by laterally connecting the stick models of the seven structures at the necessary elevations with flexible, massless horizontal beams. The section properties of these flexible horizontal beams are estimated at the same time the properties of the individual stick models developed by hand calculations are adjusted. The adjustment provides a reasonable dynamic compatibility between the stick models and the corresponding 3D FEM of the structures when only the masses of concrete and other applicable permanent dead weights are considered. The procedure of adjustment is briefly summarized as follows.~~

~~The hand-calculated section properties of the stick models and, in the case of the balance-of-NI Common Basemat Structures, the estimated properties of the flexible horizontal beams simulating the lateral structural coupling between structures are adjusted on a trial and error basis so that the two models are reasonably similar to each other in not only the modal frequencies and mass ratios but also the ISRS at selected~~

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~~locations of the structure. More detailed descriptions of the development of the stick models for the NI Common Basemat Structures are given in Section 3.7.2.3.1.2.~~

~~Development of the 3D FEMs for the NI Common Basemat Structures is described in Section 3.7.2.3.1.1. The 3D FEMs not only are used in the equivalent static analysis but also provide the basis for the development of the stick models.~~

~~The RCS is represented by a simplified stick model that is separately developed and coupled with the stick model of the RBIS for the SSI analysis of the NI Common Basemat Structures. The simplified RCS stick model is shown in Figure 3.7.2-56—Simplified Stick Model of Reactor Coolant Loop, and is compatible with a more detailed RCS model.~~

~~The stick model for the NAB is developed in a manner similar to that used for the NI Common Basemat Structures and is dynamically compatible with 3D FEM of the NAB.~~

3.7.2.3.1.1 3D Finite Element Models for Static Analysis

static is

The 3D FEM~~s~~ developed for the static and/or equivalent static analysis of the NI Common Basemat Structures ~~and NAB are~~ used as the basis for adjusting or fine tuning the section properties of the stick model~~s~~ to provide a reasonable dynamic compatibility between the two types of model. The static 3D FEM for the NI Common Basemat Structures consists of the following:

NAB

The static FEM is used to ensure dynamic compatibility between the static and dynamic FEM as described in Section 3.7.2.3.1.2. Similarly, the 3D FEM developed for the static and/or equivalent static analysis of the NAB is

- A shell element 3D FEM of the seven balance-of-NI Common Basemat Structures consisting of the RSB, SB 2 and 3 shield structure, FB shield structure, SBs 1, 2/3 and 4, and FB. The Static FEM is developed for the ANSYS computer code. There is lateral structural coupling among the seven structures at some elevations above the top of the common basemat. Representations of the FEM are shown in Figure 3.7.2-5—3D Finite Element Model of Balance of NI Common Basemat Structures Perspective View, Figure 3.7.2-6—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on Y-Z Plane, and Figure 3.7.2-7—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on X-Z Plane.

- A solid element Static 3D FEM of the RCB is developed for the ANSYS computer code. This model is shown in Figure 3.7.2-8—3D Finite Element Model of Reactor Containment Building.

- A shell element Static 3D FEM of the RBIS developed for the ANSYS code, as shown on Figure 3.7.2-9—3D Finite Element Model of Reactor Building Internal Structures. The only exception is that solid elements are used to represent the lower portion of the Reactor Pressure Vessel (RPV) pedestal.

static s

The static 3D FEMs of the NI Common Basemat Structures are connected to the top of the common basemat which is represented by solid elements of the ANSYS code. The particular elements of the ANSYS code used are listed below.

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- SOLID45 – An eight-node solid element used to model the common basemat.
- SHELL43 – A four-node shell element used to model walls, slabs and the shell of the RB. This element is suitable for moderately thick shell structures and can also provide out of plane shear forces.
- BEAM44 – Used to model beams and columns.

~~As an option, the 3D FEM, or a simplified version of the 3D FEM, of the NI Common Basemat Structures may be used in the SSI analysis as a replacement for the 3D stick models. Dynamic compatibility between the simplified and detailed 3D FEM models is demonstrated when this option is adopted in the SSI analysis.~~

The 3D FEM of the NAB consists of shell elements and is developed using the GTSTRUDL code, Version 29. It is used in the equivalent static analysis and serves as the basis for tuning the stick model of the NAB to ensure reasonable dynamic compatibility with the FEM.

"INSERT 3"

~~3.7.2.3.1.2~~ 3.7.2.3.1.3 Development of Stick Models for NI Common Basemat Structures and NAB

"INSERT 4"

~~Nine sticks, divided into three groups, represent the NI Common Basemat Structures supported on the common basemat. The three stick groups are Stick 1T (or Stick 1) for the RBIS, Stick 3T (or Stick 3) for the RCB, and Stick 2T for the seven balance of NI Common Basemat Structures including Stick 2 for the RSB, Stick 4 for SB 1, Stick 5 for SBs 2 and 3, Stick 6 for SBs 2 and 3 shield structure, Stick 7 for SB 4, Stick 8 for FB and Stick 9 for FB shield structure. Figure 3.7.2-2—Plan View of Schematic Stick Model for Nuclear Island Common Basemat Structures, illustrates schematically the plan locations of the nine sticks. Figure 3.7.2-3 and Figure 3.7.2-4 illustrate elevation views of the schematic locations of the stick models in the global Y-Z and X-Z planes, respectively.~~

~~(1) Stick Model STICK-2T for Fixed Base Balance-of-NI Common Basemat Structures~~

~~One stick model is first developed for each of the seven individual balance-of-NI Common Basemat Structures. They are:~~

- ~~Stick 2 (RSB)—base at elevation -14 ft, 1-1/4 inches.~~
- ~~Stick 4 (SB 1)—base at elevation -28 ft, 2-1/2 inches.~~
- ~~Stick 5 (SBs 2 and 3)—base at elevation -28 ft, 2-1/2 inches.~~
- ~~Stick 6 (SBs 2 and 3 shield structure)—base at elevation -28 ft, 2-1/2 inches.~~
- ~~Stick 7 (SB 4)—base at elevation -28 ft, 2-1/2 inches.~~
- ~~Stick 8 (FB)—base at elevation -31 ft, 6 inches.~~

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3.7.2.3.1.2 3D Finite Element Models for Dynamic Analysis

The dynamic 3D FEM is developed for the SSI analysis of the EPR NI Common Basemat Structures. When the FE model and the degree of discretization are selected, it is ensured that the model can reliably be used to determine the structural response within the relevant frequency range. The stiffness of individual parts of the structure is realistically represented by shell or beam finite elements, and only structural elements relevant to assure a correct dynamic behavior of the NI buildings are considered. For each building except the RBIS, a base grid consisting of axes in all three directions is defined. The distance between adjacent axes as well as the size of typical shell finite elements is about 1.5 m. The following simplifications are made in the development of the model:

- Foundation level for all buildings is -38 ft, 10-1/2 inches (-11.85 m).
- Elements representing walls in the solid part of the basemat are considered to be rigid.
- Walls, ceilings and openings are moved to the nearest axes of the base grid.
- Openings smaller than about 1.5m^2 are not considered.
- Walls and ceilings having a thickness less than 0.30m such as staircases, landings or channels are not considered.

For the dynamic FEM, shell elements are used to model walls and slabs, and the solid elements used to model the basemat in the static FEM are replaced with shell elements. Two removable walls, which enclose the inside faces of the SG towers above Elev. +63 feet, 11-3/4 inches, are also modeled by shell elements. The two side edges and bottom edge of each removable wall is attached to the SG using pinned boundary conditions at the wall supports. Most material properties of the dynamic FEM, with the exception of the walls inside the basemat that are assumed to be rigid, remain the same as the static FEM. The elements to model the tendons and steel liner plate in the static FEM are not included in the dynamic FEM. Beam elements are used to model internal columns, shield building buttresses, Polar Crane (PC) beams, and RCS beams. Lumped masses are included to model the PC and NSSS equipment.

To model structural loads, the dead and live loads are applied to the model and solved statically without self weight (no gravity applied). The reactions at each node are found and then applied to the dynamic FEM as lumped masses, which include mass contributions from the following elements:

- Permanent equipment and distribution systems supported by slabs and platforms.
- Water in pools under normal operating conditions.
- Twenty-five percent of the live loads (variable loads) on floor slabs and platforms.
- Seventy-five percent of the maximum snow load on roof slabs.
- Miscellaneous dead loads of at least 50 psf.

In the dynamic FEM, the hydrodynamic loads are considered by adding the tributary water mass to the pool walls and slabs. For the static FEM, the hydrodynamic loads are developed using the method provided in TID-7024 and applied to the pool walls and slabs in the form of pressure distribution. The spent fuel racks are considered by lumping 100 percent of the spent fuel load at the bottom slab in the vertical direction and by distributing it along the height of the pool in the horizontal direction. Rack-structure interaction is not considered in development of the FEM for the FB as far as global seismic response is concerned.

The sufficiency of the dynamic FEM is established by a comparison of the five percent damping ISRS envelopes between the static FEM and dynamic FEM at various locations of the FEMs. The input ground motions are the three components of synthetic time histories for the EUR Hard motion and HF motion. The ANSYS code, Version 11.0 is used in the modal time history analysis of the static and dynamic FEMs. The figures listed show the spectrum comparison at the following locations:

- RSB
  - Apex of dome at elevation +200 ft, 5 inches. See Figure 3.7.2-14—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, X-Direction, Figure 3.7.2-15—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, Y-Direction, and Figure 3.7.2-16—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, Z-Direction.
- SB 1
  - Roof at elevation +95 ft, 1-3/4 inches. See Figure 3.7.2-17—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, X-Direction, Figure 3.7.2-18—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Y-Direction, and Figure 3.7.2-19—Static

FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Z-Direction.

- Floor at elevation +26 ft, 3 inches. See Figure 3.7.2-20—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, X-Direction, Figure 3.7.2-21—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Y-Direction, and Figure 3.7.2-22—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Z-Direction.

- SB 4
  - Roof at elevation +95 ft, 1-3/4 inches. See Figure 3.7.2-23—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, X-Direction, Figure 3.7.2-24—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Y-Direction, and Figure 3.7.2-25—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Z-Direction.
  - Floor at elevation +26 ft, 3 inches. See Figure 3.7.2-26—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, X-Direction, Figure 3.7.2-27—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Y-Direction, and Figure 3.7.2-28—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Z-Direction.
- SB 2 and 3
  - Floors at elevation +68 ft, 10-3/4 inches. See Figure 3.7.2-29—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, X-Direction, Figure 3.7.2-30—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction, and Figure 3.7.2-31—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction.
  - Floors at elevation +26 ft, 3 inches. See Figure 3.7.2-32—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, X-Direction, Figure 3.7.2-33—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction, and Figure 3.7.2-34—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction.
- FB

- Floors at elevation +62 ft, 4-1/4 inches. See Figure 3.7.2-35—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, X-Direction, Figure 3.7.2-36—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, Y-Direction, and Figure 3.7.2-37—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, Z-Direction.
- Floors at elevation +23 ft, 7-1/2 inches. See Figure 3.7.2-38—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, X-Direction, Figure 3.7.2-39—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Y-Direction, and Figure 3.7.2-40—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Z-Direction.

- RCB
  - Apex of dome at elevation +190 ft, 3-1/2 inches. See Figure 3.7.2-41—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex, 5% Damping, X-Direction, Figure 3.7.2-42—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) -Containment Dome Apex, 5% Damping, Y-Direction, and Figure 3.7.2-43—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) -Containment Dome Apex, 5% Damping, Z-Direction.
  - Circular crane rail support at elevation +123 ft, 4-1/4 inches. See Figure 3.7.2-44—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building, 5% Damping, X-Direction, Figure 3.7.2-45—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) -Containment Building, 5% Damping, Y-Direction, and Figure 3.7.2-46—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) -Containment Building, 5% Damping, Z-Direction.
- RBIS
  - Upper lateral supports for the SGs at elevation +63 ft, 11-3/4 inches. See Figure 3.7.2-50—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) -Reactor Building Internal Structure, 5% Damping, X-Direction, Figure 3.7.2-51—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) -Reactor Building Internal Structure, 5% Damping, Y-Direction, and Figure 3.7.2-52—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) -Reactor Building Internal Structure, 5% Damping, Z-Direction.

- Support for the RPV at elevation +16 ft, 10-3/4 inches. See Figure 3.7.2-53—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) -Reactor Building Internal Structure, 5% Damping, X-Direction, Figure 3.7.2-54—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) -Reactor Building Internal Structure, 5% Damping, Y-Direction, and Figure 3.7.2-55—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) -Reactor Building Internal Structure, 5% Damping, Z-Direction.

To bound the dynamic response in the SSI analysis considering the fully cracked and uncracked conditions for walls and slabs, an additional dynamic 3D FEM for the NI Common Basemat Structures is developed. The wall and slab thicknesses for this model are reduced to a value corresponding to 0.5I (where I = moment of inertia of uncracked section) to simulate cracked section properties in the out-of-plane direction.

INSERT 4

The stick model for the RBIS is developed for RCS structural analysis. The NAB stick model and the simplified stick model for the RCS are developed for SSI analysis of the NI Common Basemat Structures. The stick models are developed by first locating key elevations (typically the major floor slab elevations) in the structure. Between two successive key elevations, two vertical massless sticks are developed. One stick is located at the center of shear area and the other at the center of axial area respectively, of the vertical structural elements between the two given key elevations. Section properties of the two sticks are determined by hand calculations based on the structural drawings. The total axial area of the vertical structural elements is assigned to the stick located at the center of axial area. The remaining five section properties, including the total shear areas along the two global axes and the total moments of inertia about the three global axes, are assigned to the stick located at the center of shear area. The two sticks are connected to each other at both their upper and lower ends with a horizontal rigid beam.

At the key elevations of the structure, a lumped mass is placed at the center of mass. The lumped mass is connected with horizontal rigid beams to the center of shear area and center of axial area located at the same elevation. It includes mass contributions from the following elements:

- Floor or roof slab(s), when applicable, at the particular elevation.
- Walls and miscellaneous floor slabs and platforms (including platform live load) within half height to the next key elevation below.

- Walls and miscellaneous floor slabs and platforms (including platform live load) within half height to the next key elevation above.
- Permanent equipment and distribution systems supported by slabs and platforms.
- Water in pools under normal operating conditions.
- Twenty-five percent of the live loads (variable loads) on floor slabs and platforms.
- Seventy-five percent of the maximum snow load on roof slabs, when applicable.
- Miscellaneous dead loads of at least 50 psf.

Floor/roof slabs and walls are assumed rigid when developing the stick model, except that out-of-plane flexibilities of the following RBIS walls are explicitly accounted for by SDOF oscillators in the stick model:

- The removable walls at the steam generator (SG) towers above elevation +63 ft, 11-1/2 inches of the RBIS.

At these locations, SDOF oscillators representing the out-of-plane vibration of the walls are connected to the lumped masses at the proper elevations of the stick model.

For the RBIS, the properties of the stick model developed by hand calculations are adjusted to provide a reasonable dynamic compatibility between the stick model and the corresponding dynamic 3D FEM of the structures when only the masses of concrete and other applicable permanent dead weights are considered. For the NAB, the adjustment is made considering the models that also account for 25% of live load and 75% of roof snow load. The adjustment is made on a trial and error basis so that the two models are reasonably similar to each other in not only the modal frequencies and mass ratios but also the ISRS at selected locations of the structure.

- ~~Stick 9 (FB shield structure, including the vent stack on the roof) - base at elevation -31 ft, 6 inches.~~

~~The seven sticks are then laterally interconnected to each other to form the composite stick model, STICK-2T. The properties of the individual sticks are initially developed by hand calculations based on the structural drawings except for the RSB. For the RSB, the lower portion of the stick model representing the cylindrical walls is also developed by hand calculations while the upper portion representing the dome, which is a 2-mass stick, is developed based on the modal properties of an ANSYS shell element FEM of the dome. The individual sticks are further supplemented by the addition of the following features to form STICK-2T: (a) the SDOF oscillators representing out-of-plane flexibilities of the walls and slabs previously identified in 3.7.2.3.1 for SBs 2 and 3 (stick 5), SBs 2 and 3 shield structure (Stick 6) and FB shield structure (Stick 9), (b) one SDOF oscillator simulating the in-plane vibration of the slab at elevation +63 ft, 11-3/4 inches of the FB (Stick 8), and (c) a combination of rigid and flexible horizontal beams to link the individual sticks at applicable elevations to simulate the lateral structural coupling among the structures.~~

~~Figure 3.7.2-10—Stick Model STICK-2T for Balance of NI Common Basemat Structures - Plan View, and Figure 3.7.2-11—Stick Model STICK-2T for Balance of NI Common Basemat Structures - Perspective View, show a plan view and a perspective view of the composite stick model, STICK-2T, for the balance of NI Common Basemat Structures. Tuning of the composite stick model is done by first adjusting the total concrete mass of each individual stick where necessary, for a close correlation with the total concrete mass of the FEM shown in Figure 3.7.2-5. The total adjusted concrete mass of the composite stick model closely matches the total concrete mass of the FEM.~~

~~Section properties of the individual sticks are then adjusted in conjunction with an estimate of the section properties of the flexible radial beams and flexible horizontal beams inter-connecting the individual sticks. The sufficiency of the adjusted composite stick model (STICK-2T), with only concrete mass considered, is demonstrated by comparing the 5 percent damping response spectrum envelopes between the stick model and FEM at representative locations of the buildings. The GTSTRUDL and ANSYS codes are used in the modal time history analysis of the stick model and FEM, respectively. Seismic input ground motions used in generating the response spectrum are the synthetic time histories associated with the EUR Hard motion previously described in Section 3.7.1. The figures listed show the spectrum comparison at the following locations:~~

- ~~RSB (Stick 2)~~
  - ~~Apex of dome at elevation +200 ft, 5 inches. See Figure 3.7.2-14—Stick vs. FEM Spectrum Comparison at Elev. +200, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, X-Direction, Figure 3.7.2-15—Stick vs. FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of~~

~~Reactor Shield Building, 5% Damping, Y-Direction, and Figure 3.7.2-16—Stick vs. FEM Spectrum Comparison at Elev. +200ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, Z-Direction.~~

- ~~SB 1 (Stick 4)~~
  - ~~Roof at elevation +95 ft, 1-3/4 inches. See Figure 3.7.2-17—Stick vs. FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, X-Direction, Figure 3.7.2-18—Stick vs. FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Y-Direction, and Figure 3.7.2-19—Stick vs. FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Z-Direction.~~
  - ~~Floor at elevation +26 ft, 3 inches. See Figure 3.7.2-20—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, X-Direction, Figure 3.7.2-21—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Y-Direction, and Figure 3.7.2-22—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Z-Direction.~~
- ~~SB 4 (Stick 7)~~
  - ~~Roof at elevation +95 ft, 1-3/4 inches. See Figure 3.7.2-23—Stick vs. FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, X-Direction, Figure 3.7.2-24—Stick vs. FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Y-Direction, and Figure 3.7.2-25—Stick vs. FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Z-Direction.~~
  - ~~Floor at elevation +26 ft, 3 inches. See Figure 3.7.2-26—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, X-Direction, Figure 3.7.2-27—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Y-Direction, and Figure 3.7.2-28—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Z-Direction.~~
- ~~SB 2 and 3 (Stick 5)~~
  - ~~Floors at elevation +68 ft, 10-3/4 inches. See Figure 3.7.2-29—Stick vs. FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, X-Direction, Figure 3.7.2-30—Stick vs. FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction, and Figure 3.7.2-31—Stick vs. FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction.~~

- ~~Floors at +26 ft, 3 inches. See Figure 3.7.2-32—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, X-Direction, Figure 3.7.2-33—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction, and Figure 3.7.2-34—Stick vs. FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction.~~

- ~~FB (Stick 8)~~

  - ~~Floors at elevation +62 ft, 4-1/4 inches. See Figure 3.7.2-35—Stick vs. FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, X-Direction, Figure 3.7.2-36—Stick vs. FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping Y-Direction, and Figure 3.7.2-37—Stick vs. FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, Z-Direction.~~

  - ~~Floors at +23 ft, 7-1/2 inches. See Figure 3.7.2-38—Stick vs. FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, X-Direction, Figure 3.7.2-39—Stick vs. FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Y-Direction, and Figure 3.7.2-40—Stick vs. FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Z-Direction.~~

~~Table 3.7.2-1 lists the frequencies and modal mass ratios for the first 110 modes of STICK-2T, applicable masses included.~~

~~(2) Stick Model STICK-3T for Fixed Base Reactor Containment Building~~

~~The stick model for the RCB is designated STICK-3T. Properties of the stick model for the cylindrical wall up to the spring line at elevation +144 ft, 1-1/4 inches are developed by conventional hand calculations. The dome above elevation +144 ft, 1-1/4 inches is represented by a 2-mass stick which is developed based on the modal properties of a GTSTRUDL shell element FEM of the dome.~~

~~A single-mass rigid stick, of which the base is connected to the main stick at elevation +123 ft, 4-1/4 inches where the crane rail is located, is used to represent the polar crane. During normal operation, the polar crane is parked on the circular crane rail with the crane bridge oriented in the 0-180° direction (global Y-direction) and the main trolley and secondary trolley are parked on the zero and 180° end, respectively, of the crane bridge. The lumped mass of the SDOF oscillator is located at the center of mass of the crane assembly. The estimated location of the center of mass of the crane assembly is at elevation +141 ft, 1 inches and eccentric from the vertical axis of the containment by 13 ft, 1-1/2 inches in the positive global Y (Plant 0°) direction. The mass of the crane rail is combined with the lumped mass at elevation +123 ft, 4-1/4 inches of the containment stick.~~

~~Figure 3.7.2-12—Stick Model STICK-3T for Reactor Containment - Perspective View, shows the stick model, STICK-3T, of the containment with the polar crane assembly represented by a rigid single-mass stick. The stick model, in the absence of the polar crane assembly, is tuned by adjusting only the section properties of the portion of the stick representing the cylindrical wall. Dynamic compatibility of the adjusted stick model with the solid element FEM of the containment shown in Figure 3.7.2-8, in the absence of the polar crane assembly, is demonstrated in Figure 3.7.2-41—Stick vs. FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex (Without Polar Crane), 5% Damping, X-Direction, Figure 3.7.2-42—Stick vs. FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex (Without Polar Crane), 5% Damping, Y-Direction, Figure 3.7.2-43—Stick vs. FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex (Without Polar Crane), 5% Damping, Z-Direction, Figure 3.7.2-44—Stick vs. FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building (Without Polar Crane), 5% Damping, X-Direction, Figure 3.7.2-45—Stick vs. FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building (Without Polar Crane), 5% Damping, Y-Direction, and Figure 3.7.2-46—Stick vs. FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building (Without Polar Crane), 5% Damping, Z-Direction, which compare the five percent damping response spectrum between the two models without the polar crane, at the apex of the dome (elevation +190 ft, 3-1/2 inches) and at the circular crane rail support (elevation +123 ft, 4-1/4 inches). The GTSTRUDL and ANSYS codes are used in the modal time history analysis of the stick model and FEM, respectively. The input seismic ground motions are the same as those used previously in the tuning of the stick model, STICK-2T, for the balance of NI Common Basemat Structures.~~

~~Table 3.7.2-2 shows the frequencies and modal mass ratios of the first 16 modes of the fixed-base tuned stick model, STICK-3T, which includes the mass of the circular crane rail and the rigid single-mass stick representation of the polar crane assembly. Because the mass of the crane assembly is relatively small compared to that of the Containment Building, the seismic response of the containment is not expected to be sensitive to the modeling of the polar crane assembly. A parametric study is performed to verify the sufficiency of representing the crane assembly with a rigid single-mass stick model. This is done by comparing the five percent damping response spectrum envelope generated from the stick model, STICK-3T, with the corresponding spectrum envelope generated from a modified stick model in which the rigid single-mass stick for the crane assembly is replaced by a flexible one. In the absence of well documented frequencies for the polar crane assembly, the flexible crane assembly is conservatively assumed to have a frequency coincident with the fundamental mode frequency of the containment in each of the three directions. According to Table 3.7.2-2, the fundamental mode frequency of the stick model STICK-3T is about 4.7, 4.9, and 12.0 Hz for vibration in the global X, Y, and Z direction, respectively. Figure 3.7.2-47—~~

~~Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building (Rigid vs. Flexible Polar Crane), 5% Damping, X-Direction, Figure 3.7.2-48—Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building (Rigid vs. Flexible Polar Crane), 5% Damping, Y-Direction, and Figure 3.7.2-49—Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building (Rigid vs. Flexible Polar Crane), 5% Damping, Z-Direction compare the five percent damping response spectrum envelopes for the two stick models at elevation +123 ft, 4-1/4 inches. The comparison establishes the sufficiency of the rigid polar crane representation in STICK-3T because it gives a more conservative response spectrum envelope at elevation +123 ft, 4-1/4 inches for use as the seismic input to the design of the polar crane assembly.~~

(1)

~~(3)~~ Stick Model STICK-1T for Fixed Base Reactor Building Internal Structures

This stick model is developed using the GTSTRUDL code and is fixed at its base at elevation -21 ft., 4 inches. It is split into two sticks at and above elevation +63 ft, 11-3/4 inches because the two SG compartments are separated from each other except for a few miscellaneous walls and slabs that form a minor structural coupling between the two. The two split sticks are taken to be symmetrically located with respect to the Y-Z plane although they may have slightly different section properties and masses. As usual, rigid horizontal beams are used to link the lumped masses to the sticks where they are not coincidentally located. The only exception is taken at elevation +63 ft, 11-3/4 inches where the lumped mass is connected to the lower ends of the two split sticks of the SG compartments with horizontal flexible beams. In addition, a horizontal flexible beam is used to connect the lumped masses on the split sticks at each of the two higher elevations, +79 ft, 0-3/4 inches and +93 ft, 6 inches. Figure 3.7.2-13—Stick Model STICK-1T for Reactor Building Internal Structure - Perspective View and Figure 3.7.2-~~9~~ 120-Dynamic 3D Finite Element Model of Reactor Building Internal Structure (RBIS), show the GTSTRUDL code stick model, STICK-1T, and the ~~ANSYS code~~ dynamic 3D FEM, respectively, of the fixed base RBIS.

The section properties of the vertical stick elements are adjusted and the flexible horizontal beams at and above elevation +63 ft, 11-3/4 inches are estimated, on a trial-and-error basis, to ensure a reasonable compatibility between the stick model and dynamic FEM. The sufficiency of the stick model is established by a comparison of the ~~four~~ five percent damping ISRS envelopes between the concrete-only stick model and dynamic FEM at ~~two~~ three representative elevations, +63 ft., 11-3/4 inches (at upper lateral supports for the SGs), +30 ft., 9-1/4 inches (at lower lateral supports for the SGs) and +16 ft, 10-3/4 inches (at support for the RPV). The input ground motions are the three components of synthetic time histories for the EUR Hard motion and HF motion. ~~Note that the response spectrum envelope at elevation +63 ft, 11-3/4 inches represents the envelope of the spectra at eight locations (i.e., four each for each SG compartment). The spectrum envelope in each given direction at elevation +16 ft, 10-3/4 inches represents the envelope of the spectra at four locations that are 90° apart from each other around the RPV support. The GTSTRUDL and ANSYS codes are used in the~~

~~modal time history analysis of the stick model and FEM, respectively. Figure 3.7.2-50—Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 4% Damping, X-Direction, Figure 3.7.2-51—Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 4% Damping, Y-Direction, Figure 3.7.2-52—Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 4% Damping, Z-Direction, Figure 3.7.2-53—Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 4% Damping, X-Direction, Figure 3.7.2-54—Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 4% Damping, Y-Direction, and Figure 3.7.2-55—Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 4% Damping, Z-Direction, show the spectrum comparison.~~

Table 3.7.2-3 shows the frequencies and modal mass ratios of the first 30 modes of STICK-1T with all applicable masses included.

(2)

~~(4)~~ Simplified Stick Model for Reactor Coolant System

Figure 3.6.3-1 shows a plan view of the configuration of the RCS. A simplified stick model of the RCS is developed for the purpose of the SSI analysis of the NI Common Basemat Structures. The simplified stick model is shown in Figure 3.7.2-56. The simplified stick model is coupled to appropriate nodal locations of the ~~stick model, STICK-1T,~~ of the RBIS. The modal frequencies of the simplified RCS stick model are shown in Table 3.7.2-4.

dynamic 3D FEM

(3)

~~(5)~~ Stick Model for NAB

The stick model for the NAB is developed in a manner similar to that for the ~~NI Common Basemat Structures~~. Dynamic compatibility between the stick model and 3D FEM is ensured by comparing the ISRS generated at selected locations for both models. Figure 3.7.2-66—Elevation View of NAB Stick Model in X-Z Plane and Figure 3.7.2-67—Elevation View of NAB Stick Model in Y-Z Plane, show elevation views of the stick model in the global X-Z and Y-Z plane, respectively.

RBIS stick model

3.7.2.3.2 Seismic Category I Structures – Not on Nuclear Island Common Basemat

29

Two 3D FEMs are developed for each structure, one for the SSI analysis based on the EUR motions and the other based on the HF motion.

~~Unlike the stick model approach utilized for the NI Common Basemat Structures and NAB, 3D~~ FEM's for the EPGB and ESWB are developed with GTSTRUDL code, Version ~~27~~, for use in both the equivalent static analysis and SSI analysis. For SSI analysis, the GTSTRUDL FEM's are translated to a format suitable for the Bechtel code SASSI 2000, Version ~~3.1~~.

The reinforced concrete base mat, floor slabs, and walls of both structures are modeled in GTSTRUDL using shell elements, SBHQ6 and SBHT6, to accurately represent the structure and calculate both in-plane and out-of-plane effects from applied loads. For 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.

(EUR Motions)

used in SSI analysis based on the EUR motions

(EUR Motions)

(EUR Motions)

(EUR Motions)

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.

"INSERT 5"

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

Non-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 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 structures).

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used in SSI analysis based on the EUR motions. Figure 3.7.2-135—Isometric View of GTSTRUDL FEM for Emergency Power Generating Building (HF Motion) and Figure 3.7.2-136—Isometric View of GTSTRUDL FEM for Essential Service Water Building (HF Motion) illustrate an isometric view of the 3D FEM of the EPGB and ESWB used in SSI analysis based on the HF motion.

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3.7.2.4 Soil-Structure Interaction

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The SSI analysis of the NI Common Basemat Structures and NAB ~~are~~ performed using ~~the AREVA computer code~~ SASSI, Version ~~4.1B~~, for the ~~generic~~ soil cases specified in Table 3.7.1-6. The free-field input motion to the SSI analysis is the certified seismic design response spectra (CSDRS) previously described in Section 3.7.1.1.1 for the seismic design of NI Common Basemat Structures.

For EPGB and ESWB, Bechtel computer code SASSI 2000, Version 3.1, is used in the seismic SSI analysis. The free-field input motion to the SSI analysis is the modified CSDRS described in Section 3.7.1.1.1. The modified CSDRS accounts for the approximate structure-soil-structure interaction (SSSI) effect of the NI Common Basemat Structures on the free-field motions at the locations of these structures, and is developed based on the results of the SSI analysis of the NI Common Basemat Structures and NAB.

Methodology for the SSI analysis of the NI Common Basemat Structures and NAB, EPGB and ESWB is discussed in the following.

3.7.2.4.1 Step 1 - Selection of ~~Generic~~ Soil Profiles

soil profiles considered for SSI analysis of the NI Common Basemat Structures and NAB

1n2ue, 2sn4ue, 4ue, 5ae, and 1n5ae,

, and hfub, hflb, and hfbe, representing soil conditions associated with high-frequency ground motion

e

whereas Case 1n5ae simulates a soft backfill underlain by the same hard rock. Cases hfub, hflb and hfbe also contain a range of backfill soil layers.

The ~~ten generic~~ soil profiles previously specified in Table 3.7.1-6 are considered representative of potential sites in the central and eastern United States (CEUS). The~~y~~ are Soil Cases ~~1u to 5u, 5a, 1n2u, 2sn4u, 2n3u, and 3r3u~~ ranging from soft soil to medium soil to hard rock conditions. Case 5a ~~is~~ intended to simulate the hypothetical condition of a hard rock approaching a rigid foundation medium. Table 3.7.2-9—Soil Properties Associated With Different ~~Generic~~ Shear Wave Velocities, lists the soil properties associated with the various shear wave velocities considered in the ~~generic~~ soil profiles. For US EPR design certification, the ~~generic~~ soil properties are taken to be strain-compatible values during seismic events. Column 2 of Table 3.7.1-6 shows the free-field input motion associated with each of the ~~ten generic~~ soil cases considered in the SSI analysis of the NI Common Basemat Structures and NAB. Each ~~generic~~ soil case is associated with one of the ~~three~~ free-field input motions ~~except that Soil Cases 2u and 4u are associated with two different input motions~~, giving rise to a total of ~~twelve~~ SSI analysis cases for the NI Common Basemat Structures and NAB. Figure 3.7.1-31 and Figure 3.7.1-32 illustrate the shear wave velocity profiles of the ~~ten generic~~ soil cases.

eight

The ~~same ten generic~~ soil cases ~~are~~ considered in the SSI analysis of the EPGB and ESWB~~, and the modified CSDRS is the common free-field input motion in all soil cases~~.

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are also specified in Table 3.7.1-6. The seismic input for the EPGB and ESWB is the modified CSDRS that accounts for the effects of structure-soil-structure interaction between those structures and the Nuclear Island Common Basemat Structures, as described in Section 3.7.1.1.1. Two modified CSDRS are developed, one based on the EUR motions and the other based on the HF motion. As in the analysis of the NI Structures and NAB, some of the soil cases considered in the analysis of the EPGB and ESWB are associated with the EUR-based modified CSDRS and the others are associated with the HF-based modified CSDRS.

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3.7.2.4.2 Step 2 - Development of Models for Structures and Basemat

(1) NI Common Basemat Structures and NAB

dynamic 3D FEM

Development of the ~~lumped-mass stick models~~ for the NI Common Basemat Structures has previously been described in Section 3.7.2.3.1.2. ~~There are three major sticks: STICK-1T for the reinforced concrete RBIS, STICK-3T for the pre-stressed concrete RCB, and STICK-2T for the seven remaining reinforced concrete structures on the common basemat. These three major stick models are structurally uncoupled from each other except through the reinforced concrete basemat. The bases of structural sticks are at the respective tops of the concrete basemat.~~ "INSERT 7"

~~According to the guidelines of ASCE 4-98, Reference 1, Section 3.3.1.6, the basemat may be taken to be rigid as far as the SSI analysis is concerned. This is especially true in view of the thickness of the basemat. Thus the basemat is represented by a stick model consisting of horizontal rigid beams at the top elevations of the basemat to connect the bases of the various NI sticks to a centrally located vertical rigid beam. The lower end of the vertical rigid beam is connected to the rigid beam grids over the footprint of the basemat at the bottom elevation, -38 ft, 10-1/2 inches, of the basemat at Node 417.~~

~~Figure 3.7.2-61—Plan View of NI Common Basemat Structures and Stick Model, shows the plan view of the stick model representing the NI Common Basemat Structures and basemat. The bottom node, Node 417, of the stick model, is at elevation -38 ft, 10-1/2 inches and is centrally located on a grid of rigid horizontal beams spanning the footprint of the NI Common Basemat Structures. Nodes on the rigid beam grid serve the function of soil-structure interaction nodes in the SSI analysis model. Figure 3.7.2-62—Plan View of SSI Model for NI Common Basemat Structures and NAB shows the NI Common Basemat Structures stick model and the rigid-beam basemat grid as a part of the SSI analysis model for the NI Common Basemat Structures and NAB. Figure 3.7.2-63—Elevation View of SSI Model for NI Common Basemat Structures and NAB in X-Z Plane shows the elevation view of the NI Common Basemat Structures stick model and basemat grid on the surface of the schematic soil model.~~

RBIS finite element

The RCS components are represented by the simplified stick model previously shown in Figure 3.7.2-56 ~~and discussed above~~. The simplified stick model is coupled to the ~~stick~~ model~~, STICK-1T, of the RBIS~~ at the appropriate locations. ~~The coupled stick models of the RBIS and RCS are shown in Figure 3.7.2-65—RCS Stick Coupled to Model STICK-1T for Reactor Building Internal Structure.~~

The stick model of the RCS along with other beam elements of the NI Structures are shown in Figure 3.7.2-122-SSI Analysis Model-Nuclear Island Beam Elements.

~~The vent stack is a welded steel thin-wall cylindrical structure. It is 99 ft, 5 inches tall, has an outer diameter of 12 ft, 5-1/2 inches, and is mounted on the roof of the FB shield structure at elevation +111 ft, 6-1/2 inches of the composite stick model,~~

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The dynamic 3D FEM incorporates all the NI Common Basemat Structures including the RBIS, RCB, RSB, FB, SBs 1, 2/3 and 4, SB 2/3 shield structure, FB shield structure, Polar Crane, and RCS. The ground surface is at elevation -9-3/4 inches (-0.25 m) and the bottom of the NI basemat is at elevation -38 ft, 10-1/2 inches (-11.85 m). A reinforced concrete tendon gallery extends down from the bottom of the RCB base to elevation -52 ft, 2 inches (-15.90 m). An isometric and elevation view of the dynamic 3D FEM is shown in Figure 3.7.2-113—Dynamic 3D Finite Element Model of Nuclear Island, Isometric View and Figure 3.7.2-114— Dynamic 3D Finite Element Model of Nuclear Island, Elevation View, respectively. The finite element models of FB, SB1, SB2/3, SB4, RCB and RBIS are shown in Figure 3.7.2-115 through Figure 3.7.2-120. The dynamic 3D FEM is a relatively detailed finite element model that consists mainly of shell elements that represent the concrete floors, walls and basemat, as depicted in Figure 3.7.2-123— SSI Analysis Model – Nuclear Island Shell Elements. The excavated soil representing the region occupied by the subgrade portion of the NI foundation is modeled by solid elements as shown in Figure 3.7.2-121—SSI Analysis Model – Excavated Soil Solids Elements, Nuclear Island Foundation.

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128-SSI Analysis Model - Nuclear Auxiliary Building Stick Model shows

The NAB foundation rigid beams, NAB side wall rigid beams and NAB foundation excavated soil are shown in Figure 3.7.2-126-SSI Analysis Model-Nuclear Auxiliary Building Foundation Rigid Beams, Figure 3.7.2-127-SSI Analysis Model-Nuclear Auxiliary Building Side Wall Rigid Beams and Figure 3.7.2-129-SSI Analysis Model-Nuclear Auxiliary Building Foundation Excavated Soil, respectively.

~~STICK-2T, for the balance-of-NI Common Basemat Structures. The stack is modeled as a stick having four equal beam elements in the SSI analysis of the NI Common Basemat Structures. The total mass of the vent stack is negligibly small when compared to the lumped mass located at the roof elevation of the stick model for the FB shield structure. Table 3.7.2-5 lists the frequencies and modal mass ratios calculated using the GTSTRUDL code for the first 256 modes of the fixed-base stick model of the NI Common Basemat Structures. These 256 modes include the first 90 modes of the coupled stick models for the RBIS and RCS as well as the first 16 modes of the stick model for the reactor containment. The remaining modes belong to the stick models of the vent stack and balance-of- NI Common Basemat Structures. The modal properties of the containment stick correspond to those of STICK-3T previously shown in Table 3.7.2-2.~~

Figure 3.7.2~~-66 and Figure 3.7.2-67 show elevation views of~~ the stick model of the NAB structure~~, which is connected to Node 930 centrally located on the grid of horizontal rigid beams representing the bottom of the NAB basemat. Figure 3.7.2-62 shows the plan view of the grid which, for the purpose of the SSI analysis, is taken to be at the same elevation, -38 ft, 10-1/2 inches, as that for the bottom of the NI Common Basemat~~. Table 3.7.2-6 lists the frequencies and modal mass ratios calculated using the GTSTRUDL code for the first 25 modes of the fixed-base stick model of the NAB structure.

Structural damping values used in the SSI analysis are based on Table 3.7.1-1:

- Reinforced concrete (RBIS, balance-of-NI Common Basemat Structures and NAB) – 7 percent.
- Prestressed concrete (containment) – 5 percent.
- RCS components – 4 percent.
- ~~Vent stack – 4 percent.~~

~~As an option noted previously in Section 3.7.2.3.1.1, the 3D FEM of the NI Common Basemat Structures or a dynamically compatible simplified 3D FEM may be used in lieu of the stick models in the SSI analysis.~~

, Table 3.7.2-30, Table 3.7.2-8 and Table 3.7.2-31

(2) EPGB and ESWB

Section 3.7.2.3.2 describes the development of the GTSTRUDL code 3D FEM of the structure, the translation of the FEM to that suitable for the Bechtel SASSI 2000 code, and the addition of SDOF oscillators to the FEM to simulate out-of-plane flexibility of selected slabs and walls. Table 3.7.2-7 ~~and Table 3.7.2-8~~ show the frequencies computed by GTSTRUDL for the 3D FEM of the EPGB and ESWB, respectively.

(EUR motions), EPGB (HF motion), ESWB (EUR motions)

(HF motion)

Both EPGB and ESWB are reinforced concrete structures. A structural damping equal to 4 percent is conservatively used in the SSI analysis.

3.7.2.4.3 Step 3 - Development of Soil Model

To develop the soil model for use in the SSI analysis with the SASSI code, each of the ~~ten generic~~ soil profiles is discretized into a sufficient number of sub-layers, followed by a uniform half space beneath the lowest sub-layer. The soil properties of the sub-layers corresponding to different generic shear wave velocities are shown in Table 3.7.2-9. ~~Generic soil cases 1n2u and 2n3u consist of a top soil layer within which the shear wave velocity increases linearly with depth. In such cases, the soil properties are linearly interpolated accordingly.~~

-9-3/4 inches (-0.25m)

embedded

As discussed in Section 3.7.2.4.4, the NI Common Basemat Structures and NAB are analyzed as ~~surface-founded~~ structures ~~and structural embedment is ignored~~ in the SSI analysis. The surface of the soil model is placed at elevation ~~-38 ft, 10-1/2 inches which corresponds to the bottom of the NI Common Basemat~~. For the SSI analysis of the EPGB and ESWB, the surface of the soil model is at the grade (elevation 0 ft, 0 inches).

3.7.2.4.4 Step 4 - Development of SSI Analysis Model

(1) NI Common Basemat Structures and NAB

~~The footprint of the NI Common Basemat is similar to a cross, being about 357.61 ft wide in the global X-direction and about 341.2 ft long in the global Y-direction. The area of the footprint is approximately 77,339 ft² (see Figure 3.7.2-64—Schematic Footprint Area of NI Common Basemat). The radius of an equivalent circle having the same area is:~~

$$\cancel{R_e = (77{,}339/\pi)^{1/2} = 156.82 \text{ ft}}$$

~~The maximum depth of embedment of the NI Common Basemat is 41.34 ft. The embedment ratio is 41.34 ft/156.82 ft = 0.26. According to the guidelines of ASCE 4-98, Reference 1, Section 3.3.4.2.4, the effect of the structural embedment on the seismic SSI response of the NI Common Basemat Structures may be ignored because the embedment ratio is less than 0.30. In addition, the portions of the NI Common Basemat adjacent to the NAB and Access Building are only slightly embedded. Thus, in the SSI analysis model, the NI Common Basemat Structures and basemat are taken to be a surface founded structure and the surface of the soil profile is taken to be at elevation -38 ft, 10-1/2 inches. For the NAB, the two sides adjacent to the NI Common Basemat are unembedded, the side adjacent to the Radioactive Waste Building, depending on its final design, may not be fully embedded, and only the south side is fully embedded. Thus, for the SSI analysis it is sufficient to take the NAB to be also~~

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The NI Common Basemat Structures and NAB are embedded with the ground surface modeled at elevation -9-3/4 inches (-0.25m) and the bottom of the basemat at elevation -38 ft, 10-1/2 inches (-11.85 m).

~~surface founded and to take the bottom of the NAB basemat to be at the same elevation as that of the NI Common Basemat Structures.~~

the stick model for the

dynamic 3D FEM

The SSI analysis model is established by coupling the ~~stick models~~ for ~~both~~ the NI Common Basemat Structures and NAB with ~~the surface of~~ each of the ~~ten generic~~ soil models described in Step 3, at all nodes ~~on the rigid beam grids at elevation -38 ft, 10-1/2 inches~~ that represent the bottom faces of the NI Common Basemat Structures and NAB basemats. With consideration of the soil profile and control motion combinations of Table 3.7.1-6, this gives rise to a total of ~~twelve~~ SSI analysis models. ~~Figure 3.7.2-62 shows a plan view of the SSI analysis model.~~ The surrounding Seismic Category I structures, EPGB and ESWB, are much lighter than the NI Common Basemat Structures. It is expected that, through the soil, the SSI of the NI Common Basemat Structures will have some effects on the free-field seismic ground motions at these structures. To capture such effects, simple grids of massless rigid beams representing the footprints of these surrounding structures are placed at the respective plan locations on the soil surface of the SSI analysis model. The soil surface response motions at the footprints of the surrounding structure are extracted from the SSI analysis of the NI Common Basemat Structures and NAB to serve as the basis for developing the free-field input motion for the SSI analysis of the surrounding structures.

interface

eight

"INSERT 8"

"INSERT 9"

"INSERT 10"

"INSERT 11"

Figure 3.7.2-130

isometric

~~Figure 3.7.2-63~~ shows an ~~elevation~~ view of the SSI model ~~(NAB stick is not shown for clarity) in the X-Z plane, which includes a schematic soil model,~~ to illustrate ~~(a) the discretized sub-layering of the soil and the underlying half space in the soil model, (b)~~ the interaction coupling between the soil model and NI Common Basemat Structures/ NAB basemats, and ~~(c)~~ the interaction coupling between the soil and the other rigid grids representing the massless footprints of the surrounding structures.

(a)

(b)

(2) EPGB and ESWB

Similarly, the SSI analysis models for EPGB and ESWB are established by coupling the 3D FEM of the structure with each of the soil models for the ~~ten generic~~ soil profiles. The surface of the soil models is at grade (elevation 0 ft, 0 inches). The EPGB is surface founded, and the bottom face nodes of the FEM basemat are coupled to the soil model at the surface. For the ESWB, the exterior walls and basemat bottom of the 3D FEM are embedded in the soil model.

3.7.2.4.5 Step 5 - Performing SSI Analysis

, Version 8.3

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The SSI analysis of the NI Common Basemat Structures and NAB is performed using ~~the AREVA code,~~ SASSI. SASSI code performs the analysis in the frequency domain using the complex frequency response analysis method and then outputs the seismic responses in the time domain. One analysis is performed for each of the ~~twelve~~ SSI

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and the lateral faces of the sidewalls. The interface nodes are shown in Figure 3.7.2-130—Nuclear Island and Nuclear Auxiliary building Interface Nodes.

INSERT 9

Figure 3.7.2-131—Foundation and Embedment Layout of Adjacent Structures Relative to Nuclear Island, shows the layout of the adjacent structures and their proximity to the Nuclear Island.

INSERT 10

Figure 3.7.2-124— SSI Analysis Model – Adjacent Structures Foundation Rigid Beam Elements, shows the layout of the rigid beam elements.

INSERT 11

All exterior NI sidewalls below grade bear against soil except for those that are located next to the NAB and AB walls, as shown in Figure 3.7.2-132—Nuclear Island Foundation Layout showing Basemat, Sidewalls and Shear Key. The NAB and AB are also embedded to approximately the same depth as the NI Common Basemat Structure. The NI sidewalls that are not bearing against soil are not connected to any soil interaction nodes except at the base of the wall and along the vertical edges common with other soil-bearing walls at which load transfer from soils onto those walls can occur.

In order to output the ground responses near the NI sidewalls, vertical columns of soil nodes at varying distance from the centerline of sidewalls 2, 6, 10 and 11 are included in the SSI model. Location of the sidewalls 2, 6, 10 and 11, and layout of the nodes are shown in Figure 3.7.2-132 and 3.7.2-133—Near Field Soil Nodes, respectively. The calculated motions at these soil nodes are used to calculate the displacement of the sidewalls relative to the soils.

In addition to the above nodes, a series of ground nodes are also incorporated next to and along the vertical centerline of sidewalls 2, 6, 10 and 11. These nodes are connected to the sidewalls using very soft springs in order to track relative displacements of the soil next to the walls. Figure 3.7.2-125—SSI Analysis Model – Near-Field Springs for Displacement Tracking, shows the location of these springs in the SSI model.

Furthermore, a set of soil nodes on the Fire Protection Building foundation footprints as well as along several horizontal lines at the ground surface projecting radially away from the center of the NI are also included in the SSI model, as shown in Figure 3.7.2-134—Fire Protection Building Foundation and Surface Nodes for Tracking Response Attenuations. These nodes are used for tracking the response attenuation at various locations away from the NI.

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four

analysis cases resulting from the combination of the ~~ten generic~~ soil profiles and the ~~three~~ CSDRS design ground motions.

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Similarly, the SSI analysis of the EPGB and ESWB is performed using the Bechtel code SASSI 2000. One SSI analysis is performed for each of the ~~ten generic~~ soil profiles, and the modified CSDRS is the input motion at the surface of the soil model for the EPGB and at the basemat elevation of the soil model for the ESWB.

The analysis cases are also specified in Table 3.7.1-6.

3.7.2.4.6 Step 6 - Extracting Global Seismic SSI Responses

The analysis cases combining each of the soil profiles with the corresponding ground motion are specified in Table 3.7.1-6.

(1) NI Common Basemat Structures and NAB

eight

The SSI analyses of the NI Common Basemat Structures generate the global seismic responses of the NI Common Basemat Structures of all of the ~~twelve~~ SSI analysis cases. In each analysis case, the analysis is performed for one component of the input motion at a time, and it outputs the time histories of the requested seismic responses (floor accelerations, member forces and moments, etc.) to the particular component of input motion. To account for the contributions from the three components of input motion to the floor acceleration response, the three output time histories for the floor acceleration in a given global direction and at a given location are algebraically summed to produce the total floor acceleration response time history in the corresponding global direction. The ZPA is the maximum amplitude of the total floor acceleration time history in the corresponding global direction. ~~For global member forces and moments, only the maximum values are usually needed. In this case, the STRESS module of SASSI code is used to output the maximum global member force/moment due to each input motion component. The maximum collinear member forces/moments due to the three input motion components are then combined by the square root of sum of squares (SRSS) rule to obtain the global maximum total member forces/moments.~~ In addition, as discussed in Section 3.7.2.5 below, the in-structure response spectra (ISRS) for the floor acceleration time histories at specified locations are computed using AREVA code ~~RESPEC~~, Version ~~1.1A~~.

1.1

FEM for the

structure

SASSIEXT

envelope of ZPAs

Table

Table

At each given elevation along the individual ~~stick model~~, the ~~worst ZPA~~ at the ~~lumped mass location and~~ building corners is taken to be the ZPA representative of the particular SSI analysis case. They are shown in ~~Figure~~ 3.7.2-10—Reactor Containment Building ZPAs ~~to~~ ~~Figure~~ 3.7.2-17—Fuel Building Shield Structure ZPAs for the ~~sticks~~ for the NI Common Basemat Structures. Each table presents the individual worst ZPAs from the ~~twelve~~ SSI analysis cases as well as the envelope of the worst ZPAs.

FEM

Table

eight

~~Figure~~ 3.7.2-18—Maximum Base Forces and Moments at Bottom of NI Common Basemat shows the maximum base forces and moments at the bottom face (elevation -38 ft, 10~~.53~~ inches) of the common basemat for the individual SSI analysis cases. ~~Among the twelve SSI analysis cases, five cases are the most critical as far as ZPAs and base forces and moments for the NI Common Basemat Structures are concerned. These five cases are: 2n3um, 2sn4um, 3r3um, 4um, and 5ah. Figure 3.7.2-19—Worst~~

-1/2

~~Case Inter-Story Forces and Moments in Reactor Building Internal Structures to Table 3.7.2-25—Worst Case Inter-Story Forces and Moments in Safeguard Building 2/3 Shield Structure show the worst case inter-story forces and moments in the members of the individual sticks for the NI Common Basemat Structures.~~

The time history of the displacement at the NI Common Basemat relative to the input ground motion is determined by double integrating the acceleration response time history at the basemat ~~Node 417~~, applying a linear baseline correction, and subtracting from it the displacement time history of the free field ground motion for each SSI analysis case. Table 3.7.2-26—Maximum NI Common Basemat Displacement Relative to Free Field Input Motion lists the peak relative displacement at the basemat ~~Node 417~~ for all eight ~~twelve~~ SSI analysis cases. The maximum relative displacement at a given structural location in the NI Common Basemat Structures with respect to the basemat is conservatively taken from the equivalent static analysis of the FEM of the NI Common Basemat Structures described in Section 3.8.4.

(2) EPGB and ESWB

From the nodal acceleration response time histories generated from the SSI analysis, maximum nodal accelerations in each given global direction and due to each of the three components of the input ground motion are extracted. For each of the ~~ten generic~~ soil cases, the extracted maximum nodal accelerations are used to compute the weighted averaged maximum nodal accelerations in each direction and due to each ground motion component at each given elevation for the entire floor or for different regions on the floor. The weighting factors used in the averaging process are the applicable nodal masses. In each direction, the averaged maximum nodal accelerations due to the three ground motion components are then combined using the (1.0, 0.4, 0.4) factor rule to determine the combined average maximum nodal acceleration in the given direction. These maximum nodal accelerations form the basis of the seismic loads used in the equivalent static analysis of the structural design. Table 3.7.2-27—Worst Case Maximum Accelerations in EPGB and Table ~~Figure~~ 3.7.2-28—Worst Case Maximum Accelerations in ESWB show the worst case maximum ZPAs at different elevations of the EPGB and ESWB, respectively.

As discussed in Section 3.8.4.4.3, subsequent analyses will incorporate certain design details for the EPGBs and ESWBs that are not reflected in the existing respective SASSI models used for the SSI analyses described in Section 3.7.2. The subsequent analyses will determine the impact of these design details on the seismic responses and ISRS presented in Section 3.7.2.

3.7.2.4.7 Step 7 – Determining Amplified Seismic Responses for Flexible Slabs and Walls

(1) NI Common Basemat Structures

"INSERT 12"

~~A concrete slab or wall in the NI Common Basemat Structures is considered flexible when the frequency of its first out-of-plane vibration mode is less than 40 Hz assuming uncracked concrete condition. Subsequent to the SSI analysis of the NI Common Basemat Structures, modal time history analyses using the GTSTRUDL code are performed for those SDOF oscillators simulating the first out-of-plane vibration mode of the flexible slabs or walls in the NI Common Basemat Structures. Input motions to the modal time history analyses are the floor acceleration time histories output from the SSI analyses at the applicable slab or wall locations. Since the flexible slabs and walls are reinforced concrete elements, the damping ratio of the SDOF oscillators is taken to be seven percent of critical.~~

~~Each flexible slab or wall in the NI Common Basemat Structures is assumed to respond in both un-cracked and cracked condition for out-of-plane vibration. The effective moment of inertia,~~ $\cancel{I_c}$, ~~of the slab or wall in cracked condition is taken to be 0.5 times the un-cracked, or gross, moment of inertia,~~ $\cancel{I_g}$. ~~Thus the out-of-plane vibration frequency of the cracked slab or wall is equal to 0.707 times that of the uncracked slab or wall. Generation of response spectra for the flexible slabs and walls in the NI Common Basemat Structures are discussed in Section 3.7.2.5.~~

(2) EPGB and ESWB

The out-of-plane seismic responses of flexible slabs and walls are directly available from the SSI analysis because the meshing of the 3D FEM of the structure is sufficient to represent the flexible slabs and walls in cracked condition while the SDOF oscillators added to the 3D FEM simulate the un-cracked condition. Generation of response spectra for the flexible slabs and walls are discussed in Section 3.7.2.5.

3.7.2.5 Development of Floor Response Spectra

The ISRS for the U.S. EPR Seismic Category I structures are developed following the guidance in RG 1.122, Revision 1. They are calculated for 2 percent, 3 percent, 4 percent, 5 percent, 7 percent and 10 percent damping.

(1) NI Common Basemat Structures and NAB

For NI Common Basemat Structures and NAB, the floor acceleration response time histories in a given direction due to the three components of input motion are combined algebraically to produce the combined floor acceleration time history in the same direction, from which the ISRS in the corresponding direction is then

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The out-of-plane seismic responses of flexible slabs and walls are directly available from the SSI analysis because the meshing of the dynamic 3D FEM of the NI Common Basemat Structure is sufficient to represent the flexible slabs and walls. The seismic responses accounting for the fully cracked and uncracked conditions for walls and slabs are simulated, respectively, by the dynamic FEMs with cracked and uncracked section properties for the concrete walls and floors. Generation of response spectra for the flexible slabs and walls are discussed in Section 3.7.2.5.

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computed. The ISRS are calculated using AREVA code ~~RESPEC~~ SASSIEXT, Version ~~1.1A~~ 1.1, at the following ~~79~~ 98 frequencies:

Frequency Range (Hz)	Frequency Increment (Hz)
~~0.2~~ 0.1 to 3.0	0.10
3.0 to 3.6	0.15
3.6 to 5.0	0.20
5.0 to 8.0	0.25
8.0 to 15.0	0.50
15.0 to 18.0	1.00
18.0 to 22.0	2.00
22.0 to ~~50.0~~ 100.	3.00
~~50 to 100~~	~~50.0~~

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The above frequencies for ISRS generation comply with the guidelines set forth in Table 3.7.1-1 of SRP Section 3.7.1 in Reference 2. At each given structural elevation along the ~~stick models~~ FEM for the individual building, ISRS at the ~~lumped mass point and building corner nodes (typically four corner nodes)~~ key locations (nodes at wall-floor junctions) are calculated for each SSI analysis case. The envelope of the ISRS at these locations represents the ISRS at the particular structural elevation for the ~~SSI~~ particular SSI analysis case. The ISRS from the ~~twelve~~ eight SSI analysis cases, with each case considering both FEMs simulating cracked and uncracked section properties, are enveloped, and the spectrum envelope is broadened by ±15 percent and smoothed to account for uncertainty anticipated in the structural modeling and SSI analysis techniques.

(2) EPGB and ESWB

Response spectra are calculated using Bechtel computer code SASSI 2000, Version 3.1, at a total of 241 frequencies from 0.2 to 50 Hz, with 100 frequencies per decade that are uniformly spaced in the log scale. This is equivalent to a frequency increment of approximately 2.33 percent between all adjacent frequency points. At each given direction and location in the structural model, response spectra are first computed separately for the floor acceleration response time histories due to the three components of input ground motion. The three resulting response spectra are then combined using the SRSS method to produce the ISRS in the corresponding direction and at the given structural location. The ISRS from ~~all ten generic~~ the analyzed soil cases are then enveloped, and the ISRS envelope is broadened by ±15 percent and smoothed to account for uncertainty anticipated in the structural modeling and SSI analysis techniques.

Results of the Response Spectrum Development

The results of the response spectrum development are presented below for the NI Common Basemat Structures, EPGB and ESWB separately:

(1) NI Common Basemat Structures

Figure 3.7.2-68—Response Spectra at NI Common Basemat Bottom Node ~~417~~ 274 - 5% Damping, X-Direction, Figure 3.7.2-69—Response Spectra at NI Common

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The key output nodes are shown in Figure 3.7.2-137—Location of Response Output Nodes, NI Common Basemat, Figure 3.7.2-138—Location of Response Output Nodes, Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m), Figure 3.7.2-139—Location of Response Output Nodes, Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m), Figure 3.7.2-140—Location of Response Output Nodes, Safeguard Building 1 - Elev. +26 ft, 3 in (+8.10m), Figure 3.7.2-141—Location of Response Output Nodes, Safeguard Building 1 - Elev. +68 ft, 10-3/4 in (+21.00m), Figure 3.7.2-142—Location of Response Output Nodes, Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m), Figure 3.7.2-143—Location of Response Output Nodes, Safeguard Building 2&3 - Elev. +50 ft, 6-1/4 in (+15.40m), Figure 3.7.2-144—Location of Response Output Nodes, Safeguard Building 4 - Elev. +68 ft, 10-3/4 in (+21.00m), Figure 3.7.2-145—Location of Response Output Nodes, Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m), Figure 3.7.2-146—Location of Response Output Nodes, Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m), and Figure 3.7.2-147—Location of Response Output Nodes, Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m).

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Basemat Bottom Node ~~417~~ - 5% Damping, Y-Direction, and Figure 3.7.2-70—Response Spectra at NI Common Basemat Bottom Node ~~417~~ - 5% Damping, Z-Direction show the ISRS at Node ~~417~~, the center bottom node of NI Common Basemat at elevation -38 ft, 10-1/2 inches, for five percent damping for the individual SSI analysis cases. No spectrum peak broadening and smoothing is applied.

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Figure 3.7.2-71—Soil Model Surface Response Spectra at Centers of Footprints of EPGB and ESWB - 5% Damping, X-Direction, Figure 3.7.2-72—Soil Model Surface Response Spectra at Centers of Footprints of EPGB and ESWB - 5% Damping, Y-Direction, and Figure 3.7.2-73—Soil Model Surface Response Spectra at Centers of Footprints of EPGB and ESWB - 5% Damping, Z-Direction show the 5 percent damping response spectra of the response motions from all ~~twelve~~ SSI analysis cases at the soil model surface (i.e., elevation -38 ft, 10-1/2 inches) at the center nodes of the footprints of EPGB 1 and 2 and ESWB 1 to 4. These response spectra are used as the basis for developing the modified CSDRS discussed in Section 3.7.2.1.1 for use as seismic input to the SSI analysis of the EPGB and ESWB.

The listed figures show the peak-broadened and smoothed ISRS envelopes at representative locations of the NI Common Basemat Structures.

– RBIS

  - Elevation +16 ft., 10-3/4 inches. See Figure 3.7.2-74—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-75—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-76—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

  - Elevation +63 ft, 11-3/4 inches. See Figure 3.7.2-77—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-78—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-79—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

3

– SB 1

  - Elevation +26 ft, ~~7~~ inches. See Figure 3.7.2-80—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 3 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-81—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 3 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-82—Spectrum Envelope of

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Safeguard Building 1 - Elev. +26 ft, 3 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

- Elevation +68 ft, 10-3/4 inches. See Figure 3.7.2-83—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 10-3/4 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-84—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 10-3/4 in (+21.00m) 2%, 3%, 4%, 5%, 7,% and 10% Damping, Y-Direction, and Figure 3.7.2-85—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 10-3/4 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

– SBs 2 and 3

- Elevation +26 ft, 7 inches. See Figure 3.7.2-86—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-87—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-88—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

- Elevation +50 ft, 6-1/4 inches. See Figure 3.7.2-89—Spectrum Envelope of Safeguard Building 2&3 - Elev. +50 ft, 6-1/4 in (+15.40m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-90—Spectrum Envelope of Safeguard Building 2&3 - Elev. +50 ft, 6-1/4 in (+15.40m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-91—Spectrum Envelope of Safeguard Building 2&3 - Elev. +50 ft, 6-1/4 in (+15.40m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

– SB 4

- Elevation +68 ft, 10-3/4 inches. See Figure 3.7.2-92—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 10-3/4 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-93—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 10-3/4 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-94—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 10-3/4 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

– RCB

- Elevation +123 ft, 4-1/4 inches. See Figure 3.7.2-95—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-96—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction. and Figure 3.7.2-97—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

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  - Elevation +190 ft, 3-1/2 inches. See Figure 3.7.2-98—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-99—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction~~.~~, and Figure 3.7.2-100—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

– FB

  - Elevation +12 ft, 1-2/3 inches. See Figure 3.7.2-110—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-111—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-112—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

(2) EPGB and ESWB

Figure 3.7.2-101—Spectrum Envelope of EPGB at Elev. +0 ft, 0 in at Node 1172 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-102—Spectrum Envelope of EPGB at Elev. +0 ft, 0 in at Node 1172 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-103—Spectrum Envelope of EPGB at Elev. +0 ft, 0 in at Node 1172 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction show the peak-broadened and smoothed ISRS envelopes at Node 1172 on elevation +0 ft, 0 inches of the EPGB.

Figure 3.7.2-104—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-105—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, Figure 3.7.2-106—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction, Figure 3.7.2-107—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-108—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-109—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction show the peak-broadened and smoothed ISRS envelopes at Node 12733 on elevation +63 ft, 0 inches and Node 10385 on elevation +14 ft, 0 inches of the ESWB.

As discussed in Section 3.8.4.4.3 and Section 3.8.4.4.4, subsequent analyses will incorporate certain design details for the EPGBs and ESWBs that are not reflected in the existing respective SASSI models used for the SSI analyses described in Section 3.7.2. The subsequent analyses will determine the impact of these design details on the seismic responses and ISRS presented in Section 3.7.2.

3.7.2.6 Three Components of Earthquake Motion

(1) NI Common Basemat Structures and NAB

As previously stated in Section 3.7.2.4.6, the floor acceleration time history in a given direction is obtained by algebraically combining the three corresponding time histories due to the three earthquake components. Therefore, both the floor ZPA and the ISRS for the floor acceleration time history properly account for the contributions from the three components of earthquake motion. ~~For member forces and moments in the stick models, the STRESS module of SASSI code outputs the maximum member force/moment in the stick model due to each earthquake motion component. The maximum member forces/moments due to the three earthquake motion components are then combined by the SRSS rule to obtain the maximum total member force/moment. The use of the SRSS rule is consistent with the guidelines specified in RG 1.92, Revision 2.~~

(2) EPGB and ESWB

As previously stated in Section 3.7.2.4.6, the ZPA of the floor acceleration time histories in a given direction due to the three earthquake motion components are combined using the (1.0, 0.4, 0.4) rule. The response spectra for the floor acceleration time histories in a given direction due to the three earthquake motion components are combined using the SRSS rule to determine the combined ISRS. The (1.0, 0.4, 0.4) rule is also consistent with the guidelines specified in RG 1.92, Revision 2.

3.7.2.7 Combination of Modal Responses

When the response spectrum method of analysis is used, the maximum modal responses are combined using one of the methods specified in RG 1.92, Section C, Revision 2. Such combination methods include the grouping method, ten percent method and double sum methods, and they consider the effects of closely spaced modes having frequencies differing from each other by 10 percent or less of the lower frequency.

The effect of missing mass for modes not included in the analysis is accounted for by calculating the residual seismic load in accordance with AREVA NP Topical Report ANP-10264NP-A (Reference 11) and RG 1.92, Appendix A, Revision 2.

3.7.2.8 Interaction of Non-Seismic Category I Structures with Seismic Category I Structures

Figure 1.2-1 and Figure 3B-1 show the layout of structures for a typical U.S. EPR standard plant. The Access Building and Turbine Building are site-specific structures. A COL applicant that references the U.S. EPR design certification will provide the site-specific separation distances for the Access Building and Turbine Building. The potential for seismic-induced interaction between Seismic Category I structures and non-seismic Category I structures is assessed to verify the ability of Seismic Category I

SSC to perform their safety functions. The basis for the seismic interaction assessment guidelines given below is to prevent impairment of Category I structure design basis safety functions.

- The collapse of the non-Category I structure does not cause the non-Category I structure to strike a Category I SSC.
- The collapse of the non-Category I structure does not impair the integrity of seismic Category I SSC, nor result in incapacitating injury to control room occupants.
- The non-Category I structure will be analyzed and designed to prevent its failure under SSE conditions such that the margin of safety is equivalent to that of a Category I structure.

The seismic interaction criteria and assessment guidelines are summarized in Table 3.7.2-29—Seismic Structural Interaction Criteria for Building Structures. The NAB, Access Building (AB), and the Turbine Building (TB) have the potential to interact with the NI Common Basemat Structures and are categorized as Seismic Category II. Results of the seismic interaction assessment for those structures are presented below, with associated discussions of the Radioactive Waste Building (RWB) and Fire Protection Storage Tanks and Building.

The TB and AB are conceptual design structures, as stated in Section 1.8, and a seismic interaction analysis has not been performed.

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.

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.

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

Access Building

The Access Building is a non-Seismic Category I structure for which continued operation during an SSE event is not required. The Access Building is classified as Seismic Category II based on its proximity to the NI, a Seismic Category I structure. [[The Access Building 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 Access Building does not have a safety function, it may slide or uplift provided that the gap between the Access Building 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 the Access Building and adjacent Category I structures. The separation gaps between the Access Building and SBs 3 and 4 are 0.98 ft and 1.31 ft, respectively (see Figure 3B-1).]] The walls of the Access Building 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 Access Building 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 incorporate the conceptual design for the Access Building presented in the U.S. EPR FSAR (i.e., [[the Access Building 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 Access Building and adjacent Category I structures is sufficient 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 the Access Building and adjacent Category I structures.

Turbine Building

The TB (including Switchgear Building on the common basemat) is a non-Seismic Category I structure for which continued operation during an SSE event is not required. The TB is classified as Seismic Category II based on its proximity to the NI, a

Seismic Category I structure. [[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. Because the TB does not have a safety function, it may slide or uplift provided that the gap between the TB 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 the TB and adjacent Category I structures. The separation between the TB and NI Common Basemat Structures is approximately 30 ft (see Figure 3B-1).]] 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 Switchgear Building 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 incorporate 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 (e.g., building deflections, settlement) must be considered when demonstrating the gap adequacy between the TB and adjacent Category I structures.

Radioactive Waste Building

The RWB 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 RWB is not evaluated for SSE. The RWB 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 RWB during an SSE event is unlikely. The NAB is a reinforced concrete structure located between the RWB and the NI. The NAB is designed using the codes associated with Category I structures and analyzed to full SSE, resulting in an inherently robust design. If the RWB 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 RWB and the NI structures.

Potential interaction between the RWB and EPGB is precluded by separation and by design and site selection and foundation design criteria for the RWB. The RWB is embedded a significant distance below grade and has a clear height above grade of +52.5 ft, while the clearance between the RWB 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 RWB. Failure of the RWB 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 RWB 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. [[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.

3.7.2.10 Use of Constant Vertical Static Factors

Vertical seismic loads are generated from the SSI analysis for use in the seismic design of U.S. EPR Seismic Category I structures and Seismic Category II structures. Therefore, there is no need for the use of constant vertical static factors in the design of those structures.

3.7.2.11 Method Used to Account for Torsional Effects

Torsional effects due to the eccentricity built into the stick models or 3D FEM of the structures are accounted for during the seismic SSI analysis. Additional seismic loads due to accidental torsion are accounted for as required by Standard Review Plan, Section 3.7.2, Seismic System Analysis, paragraph II.11 (Reference 2) and in ASCE 4-98, Reference 1. This is to account for uncertainties in material densities, member sizes, architectural variations, equipment loads, etc., from design assumptions. Due to these potential uncertainties, an additional torsional moment is introduced into the design and evaluation of structural members.

For the NI Common Basemat Structures, the additional torsional moment at a particular elevation is calculated as the story inertia force in each horizontal direction of interest times a moment arm equal to five percent of the building plan dimension in the perpendicular direction. Results due to the story inertia forces in both horizontal directions are summed to produce the total additional torsional moment at the particular elevation. For design purposes, this torsional moment is taken to be resisted by only selected major shear walls, and a simplified 3D FEM is developed for each of the NI Common Basemat Structures which includes only the selected shear walls. The additional torsional moment at each given elevation is applied to all wall nodes at the same elevation, constrained like a rigid diaphragm, of the simplified FEM to determine the additional design shear forces in the selected shear walls.

For the EPGB and ESWB, the additional torsional moment at a particular elevation is calculated as the story inertia force in each horizontal direction of interest times a moment arm equal to five percent of the building plan dimension in the perpendicular direction. This additional torsional moment due to the story inertia force in the given direction is converted into equivalent nodal inertial forces acting on the particular elevation where each equivalent nodal inertial force is proportional to the product of the nodal mass and the distances from the node to the shear center of the walls immediately below the elevation of interest. Equivalent nodal forces corresponding to the additional torsional moment due to the story inertia force in the other horizontal direction are calculated in the similar manner. The equivalent nodal forces at all applicable elevations are applied to the 3D FEM of the structure in the equivalent static analysis to determine the additional element forces and moments due to the accidental torsion.

3.7.2.12 Comparison of Responses

The response spectrum method is used ~~in~~ only in the local seismic analysis of selected slabs in the NAB and the Vent Stack ~~not in the seismic analysis and design of the Seismic Category I structures~~. Comparison of responses between the response spectrum method and a time history analysis method is not applicable.

3.7.2.13 Methods for Seismic Analysis of Category I Dams

See Section 3.7.3.13.

3.7.2.14 Determination of Dynamic Stability of Seismic Category I Structures

Overturning of the common basemat of the NI Common Basemat Structures due to a seismic event, or other hazards such as aircraft, does not occur due to the inherent stability offered by its foundation dimensions and thickness. Section 3.8.5 describes specific details related to overturning analysis cases and factors of safety for the U.S. EPR structures.

3.7.2.15 Analysis Procedure for Damping

Section 3.7.1.3 describes the damping ratios used for seismic analysis of the SSC for the U.S. EPR. These damping values are summarized in Table 3.7.1-1 as a percentage of critical damping. ~~For the modal time history analysis applied both to the concrete-only stick models and FEM for the purpose of tuning the stick models and to the SDOF oscillators representing out-of-plane vibration of the flexible slabs and walls, only one single modal damping is required and calculation of composite modal damping is not required.~~ For the SSI analysis of structures, the complex frequency response method does not require the computation of composite modal damping although the SSI analysis model consists of ~~stick models~~ the 3D FEM and soil models having different damping values.

3.7.2.16 References

1. ASCE Standard 4-98, "Seismic Analysis of Safety-Related Nuclear Structures and Commentary," American Society of Civil Engineers, ~~September 1986~~ 1999.

2. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Nuclear Regulatory Commission, March 2007.

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

4. IBC-2009 International Code Council, International Building Code, 2009 Edition.

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

6. ACI 318-05, "Building Code Requirements for Structural Concrete and Commentary," American Concrete Institute, 2005.

7. ANSI/AISC 341, "Seismic Provisions for Structural Steel Buildings," American National Standards Institute/American Institute of Steel Construction, 2005.

8. ANSI/AISC 360, "Specifications for Structural Steel Buildings," American National Standards Institute/American Institute of Steel Construction, 2005.

9. ASCE Standard 7-05, "Minimum Design Loads for Buildings and Other Structures," Appendix 11A, "Quality Assurance Provisions," American Society of Civil Engineers, January 1, 2006.

10. Deleted.

11. ANP-10264NP-A, Revision 0, "U.S. EPR Piping Analysis and Support Design Topical Report," AREVA NP Inc., November 2008.

Table 3.7.2-1—Frequencies and Modal Mass Ratios for ~~Balance of~~ NI Common Basemat Structures ~~STICK-2T~~ with All Masses Included ~~Sheet 1 of 2~~

Will be provided later.

Mode	Frequency	Modal Participating Mass Ratios			Mode	Frequency	Modal Participating Mass Ratios		
No.	(Hz)	X	Y	Z	No.	(Hz)	X	Y	Z
1	4.05	0.000	0.520	0.000	31	6.80	0.000	0.000	0.000
2	4.22	0.422	0.000	0.000	32	6.80	0.000	0.000	0.000
3	4.49	0.000	0.003	0.000	33	6.80	0.000	0.000	0.000
4	4.54	0.000	0.002	0.000	34	6.92	0.000	0.000	0.022
5	4.55	0.000	0.000	0.000	35	7.01	0.003	0.000	0.000
6	4.55	0.000	0.000	0.000	36	7.10	0.000	0.000	0.000
7	4.55	0.000	0.000	0.000	37	7.30	0.000	0.000	0.061
8	4.55	0.000	0.000	0.000	38	7.50	0.017	0.000	0.000
9	4.58	0.000	0.000	0.000	39	8.01	0.004	0.000	0.000
10	4.59	0.000	0.000	0.000	40	8.46	0.001	0.007	0.000
11	4.60	0.000	0.000	0.000	41	8.84	0.002	0.000	0.000
12	4.60	0.000	0.000	0.000	42	8.97	0.034	0.000	0.006
13	4.60	0.000	0.000	0.000	43	8.97	0.000	0.000	0.000
14	4.69	0.000	0.123	[illegible]	[illegible]	8.98	0.000	0.000	0.000
15	4.74	0.001	0.000	0.000	45	8.99	0.000	0.000	0.000
16	4.76	0.103	0.000	0.000	46	8.99	0.000	0.000	0.000
17	5.18	0.000	0.005	0.000	47	9.01	0.000	0.000	0.027
18	5.19	0.000	0.071	0.000	48	9.23	0.000	0.000	0.039
19	5.60	0.129	0.004	0.000	49	9.24	0.002	0.000	0.025
20	5.62	0.013	0.003	0.000	50	9.28	0.001	0.000	0.071
21	5.97	0.064	0.006	0.000	51	9.40	0.009	0.000	0.147
22	6.08	0.002	0.020	0.000	52	9.49	0.000	0.000	0.004
23	6.50	0.000	0.000	0.030	53	9.76	0.003	0.000	0.100
24	6.76	0.001	0.000	0.000	54	10.06	0.000	0.000	0.001
25	6.78	0.000	0.000	0.000	55	10.20	0.000	0.012	0.000
26	6.79	0.000	0.000	0.000	56	10.77	0.000	0.000	0.022
27	6.79	0.000	0.000	0.000	57	11.39	0.000	0.022	0.000
28	6.79	0.000	0.000	0.000	58	11.42	0.018	0.000	0.000
29	6.79	0.000	0.000	0.000	59	12.04	0.000	0.003	0.000
30	6.79	0.000	0.000	0.000	60	12.54	0.000	0.051	0.000

~~Table 3.7.2-1—Frequencies and Modal Mass Ratios for Balance-of-NI Common Basemat Structures STICK-2T with All Masses Included~~

~~Sheet 2 of 2~~

Will be provided later.

Mode	Frequency	Modal Participating Mass Ratios		
No.	(Hz)	X	Y	Z
61	12.83	0.000	0.014	0.001
62	13.19	0.000	0.016	0.001
63	13.39	0.000	0.003	0.000
64	13.68	0.018	0.000	0.037
65	14.10	0.000	0.004	0.014
66	14.20	0.001	0.001	0.036
67	14.36	0.005	0.000	0.096
68	14.88	0.041	0.000	0.001
69	15.10	0.001	0.000	0.006
70	15.14	0.003	0.000	0.000
71	15.71	0.000	0.010	0.005
72	15.78	0.000	[illegible]	[illegible]
73	16.27	0.000	0.001	0.001
74	16.65	0.000	0.005	0.000
75	16.78	0.000	0.000	0.014
76	17.49	0.000	0.001	0.070
77	18.06	0.001	0.001	0.000
78	18.09	0.000	0.000	0.000
79	18.18	0.007	0.001	0.001
80	18.21	0.001	0.001	0.001
81	18.32	0.000	0.007	0.000
82	18.43	0.000	0.000	0.001
83	18.49	0.001	0.000	0.005
84	18.58	0.001	0.000	0.000
85	19.31	0.010	0.000	0.000

Mode	Frequency	Modal Participating Mass Ratios		
No.	(Hz)	X	Y	Z
86	19.33	0.001	0.000	0.000
87	20.21	0.000	0.005	0.000
88	20.33	0.000	0.001	0.005
89	20.62	0.000	0.005	0.000
90	21.08	0.002	0.000	0.000
91	21.64	0.000	0.002	0.007
92	21.98	0.000	0.008	0.000
93	22.09	0.004	0.000	0.000
94	22.21	0.002	0.001	0.000
95	22.40	0.001	0.000	0.000
96	22.83	0.001	0.002	0.000
[illegible]	23.73	0.001	0.000	0.017
98	23.76	0.013	0.000	0.001
99	24.07	0.000	0.000	0.000
100	24.25	0.001	0.000	0.000
101	24.44	0.000	0.003	0.000
102	24.80	0.003	0.000	0.000
103	25.42	0.000	0.000	0.000
104	26.04	0.000	0.010	0.000
105	26.53	0.000	0.002	0.000
106	26.72	0.003	0.001	0.000
107	26.84	0.003	0.002	0.000
108	26.98	0.001	0.000	0.000
109	27.98	0.000	0.002	0.000
110	28.65	0.001	0.000	0.000

Table 3.7.2-2—~~Frequencies and Modal Mass Ratios for Reactor Containment Building~~
~~STICK-3T with Polar Crane Included~~

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Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
1	4.78	0.749	0.000	0.000
2	5.00	0.000	0.749	0.000
3	9.70	0.000	0.000	0.000
4	12.16	0.000	0.000	0.753
5	13.73	0.162	0.000	0.000
6	14.31	0.000	0.160	0.000
7	17.45	0.000	0.000	0.078
8	18.80	[illegible]	[illegible]00	0.000
9	18.85	0.000	0.005	0.000
10	21.52	0.000	0.000	0.030
11	22.30	0.002	0.000	0.000
12	22.96	0.000	0.000	0.000
13	24.85	0.003	0.000	0.000
14	25.60	0.000	0.036	0.000
15	29.33	0.000	0.000	0.000
16	34.98	0.023	0.000	0.000

Table 3.7.2-3—Frequencies and Modal Mass Ratios for Reactor Building Internal Structures STICK-1T with All Masses Included

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
1	6.38	0.304	0.000	0.000
2	6.77	0.132	0.001	0.000
3	6.85	0.003	0.015	0.000
4	7.65	0.000	0.519	0.001
5	9.66	0.000	0.000	0.002
6	9.96	0.028	0.000	0.000
7	10.09	0.000	0.000	0.000
8	10.09	0.000	0.000	0.000
9	10.11	0.000	0.000	0.000
10	10.32	0.059	0.000	0.000
11	11.08	0.008	0.000	0.000
12	12.53	0.157	0.000	0.002
13	13.01	0.004	0.001	0.053
14	16.05	[illegible]	[illegible]	0.345
15	17.54	[illegible]	[illegible]	0.037
16	17.76	0.000	0.100	0.064
17	17.99	0.000	0.006	0.032
18	18.46	0.000	0.000	0.009
19	20.31	0.000	0.000	0.001
20	22.94	0.109	0.000	0.000
21	24.35	0.000	0.000	0.002
22	25.07	0.000	0.000	0.002
23	25.50	0.000	0.011	0.030
24	27.95	0.000	0.000	0.070
25	29.82	0.001	0.000	0.000
26	30.26	0.000	0.069	0.006
27	31.68	0.000	0.000	0.084
28	33.05	0.013	0.000	0.000
29	35.31	0.000	0.000	0.000
30	35.44	0.000	0.000	0.001

Will be provided later.

Table 3.7.2-4—Modal Frequencies of the Simplified Stick Model of Reactor Coolant Loop
Sheet 1 of 2

Mode Number	Frequency (Hz)	Mode Characterization
1	5.5562	SG
2	5.6042	SG
3	5.6103	SG
4	5.6106	SG
5	6.5902	SG
6	6.5907	SG
7	6.5913	SG
8	6.5914	SG
9	11.804	RC Pump
10	11.807	RC Pump
11	11.818	RC Pump
12	11.819	RC Pump
13	12.300	Piping (Crossover Leg)
14	13.383	RC Pump
15	13.428	RC Pump
16	13.428	RC Pump
17	13.481	RC Pump
18	13.534	RC Pump
19	13.541	RC Pump
20	13.542	RC Pump
21	13.752	RC Pump
22	14.006	RC Pump
23	14.028	RC Pump
24	14.030	RC Pump
25	14.231	RC Pump
26	14.496	Pressurizer
27	14.496	Pressurizer
28	15.280	RV
29	15.468	Piping (Crossover Leg)
30	15.469	Piping (Crossover Leg)
31	15.499	Piping (Crossover Leg)

Table 3.7.2-4—Modal Frequencies of the Simplified Stick Model of Reactor Coolant Loop
Sheet 2 of 2

Mode Number	Frequency (Hz)	Mode Characterization
32	15.531	SG
33	16.554	SG
34	16.601	SG
35	16.739	RV
36	17.063	RV
37	19.965	Piping (Crossover Leg)
38	20.798	Piping (Crossover Leg)
39	20.803	Piping (Crossover Leg)
40	20.807	Piping (Crossover Leg)
41	22.076	RV
42	22.611	Piping (Crossover Leg)
43	24.993	Piping (Crossover Leg)
44	24.997	Piping (Crossover Leg)
45	25.042	Piping (Crossover Leg)
46	25.164	Pressurizer
47	25.164	Pressurizer
48	25.454	Piping (Crossover Leg)
49	28.756	RC Pump
50	28.757	RC Pump

Table 3.7.2-5—~~Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS~~
~~Sheet 1 of 9~~

Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
1	3.77	0.002	0.002	0.000			Vent Stack
2	3.79	0.001	0.003	0.000			Vent Stack
3	4.04	0.000	**0.386**	0.000			SB/SG1/SG4
4	4.22	**0.317**	0.000	0.000			SB/SG1/SG4
5	4.49	0.000	0.002	0.000			
6	4.54	0.000	0.001	0.000			
7	4.55	0.000	0.000	0.000			
8	4.55	0.000	0.000	0.000			
9	4.55	0.000	0.000	0.000			
10	4.55	0.000	0.000	0.000			
11	4.58	0.000	0.000	0.000			
12	4.59	0.000	0.000	0.000			
13	4.60	0.000	0.000	0.000			
14	4.60	0.000	0.000	0.000			
15	4.60	0.000	0.000	0.000			
16	4.68	0.000	**0.092**	0.000			BONI
17	4.70	**0.064**	0.000	0.000		1	
18	4.73	0.003	0.000	0.000			
19	4.76	**0.072**	0.001	0.000			SG23
20	4.91	**0.056**	0.000	0.000	1		
21	4.92	0.000	**0.061**	0.000		2	
22	5.17	0.000	0.001	0.000			
23	5.19	0.000	**0.055**	0.000			FB
24	5.40	0.000	0.000	0.000	2		
25	5.45	0.000	**0.021**	0.000	3		
26	5.56	0.000	**0.009**	0.000	4		
27	5.60	**0.093**	0.003	0.000			SB/FBsh
28	5.62	**0.012**	0.002	0.000			FB
29	5.65	0.001	0.000	0.000	5		
30	5.71	0.000	**0.031**	0.000	6		
31	5.97	**0.049**	0.005	0.000			SG23sh/FBsh

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Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 2 of 9

Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
32	6.08	0.002	**0.015**	0.000			SB
33	6.17	**0.023**	0.000	0.000	7		
34	6.20	0.000	0.002	0.000	8		
35	6.50	0.000	0.000	**0.023**			SG23
36	6.52	0.000	0.000	0.000	9		
37	6.54	0.000	0.000	0.000	10		
38	6.63	0.004	0.000	0.000	11		
39	6.76	0.000	0.000	0.000			
40	6.78	0.000	0.000	0.000			
41	6.79	0.000	0.000	0.000			
42	6.79	0.000	0.000	0.000			
43	6.79	0.000	0.000	0.000			
44	6.79	0.000	0.000	0.000			
45	6.79	0.000	0.				
46	6.80	0.000	0.000	0.000			
47	6.80	0.000	0.000	0.000			
48	6.80	0.000	0.000	0.000			
49	6.92	0.000	0.000	**0.017**			SG23sh
50	7.01	0.002	0.000	0.000			
51	7.10	0.000	0.000	0.000			
52	7.20	0.000	**0.035**	0.000	12		
53	7.30	0.000	0.000	**0.045**			SG23
54	7.50	**0.012**	0.000	0.000			SG23sh
55	8.00	0.003	0.000	0.000			
56	8.45	0.001	0.005	0.000			
57	8.84	0.001	0.000	0.000			
58	8.96	**0.025**	0.000	0.004			SB/SG1/SG4
59	8.97	0.000	0.000	0.000			
60	8.98	0.000	0.000	0.000			
61	8.99	0.000	0.000	0.000			
62	8.99	0.000	0.000	0.000			

Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 3 of 9

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Mode No.	Freq (Hz)	Modal Mass Ratios X	Y	Z	RBI-RCS Modes	CTMT Modes	Balance of NI Modes
63	9.00	0.000	0.000	0.020			SG23
64	9.16	0.014	0.000	0.000	13		
65	9.22	0.000	0.000	0.031			SG1/SG4/FBsh
66	9.24	0.002	0.000	0.018			FBsh
67	9.27	0.000	0.000	0.002	14		
68	9.28	0.001	0.000	0.052			BONI
69	9.40	0.006	0.000	0.108			BONI
70	9.49	0.000	0.000	0.003			
71	9.64	0.013	0.000	0.000	15		
72	9.68	0.000	0.000	0.000		3	
73	9.75	0.002	0.000	0.078			SB/SG1/SG4
74	10.06	0.000	0.000	0.000			
75	10.08	0.000	0.000	0.000	16		
76	10.09	0.000	0.000	0.000	17		
77	10.10	0.000	0.000	0.000	18		
78	10.20	0.000	0.009	0.000			
79	10.21	0.006	0.000	0.000	19		
80	10.77	0.000	0.000	0.017			FBsh
81	10.90	0.004	0.000	0.000	20		
82	11.38	0.000	0.016	0.000			SG1/SG4
83	11.41	0.013	0.001	0.000			SG23
84	11.52	0.000	0.002	0.018	21		
85	12.00	0.000	0.000	0.064		4	
86	12.04	0.000	0.003	0.000			
87	12.13	0.000	0.004	0.000	22		
88	12.31	0.000	0.000	0.000	23		
89	12.53	0.000	0.038	0.000			SG1/SB/SG23sh/FBsh
90	12.57	0.000	0.000	0.000	24		
91	12.69	0.000	0.003	0.003	25		
92	12.71	0.000	0.000	0.000	26		

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Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 4 of 9

Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
93	12.74	0.000	0.000	0.002	27		
94	12.78	0.000	0.001	0.001	28		
95	12.82	0.000	0.000	0.000	29		
96	12.83	0.000	0.011	0.000			BONI
97	12.90	0.000	0.000	0.002	30		
98	12.90	0.000	0.000	0.000	31		
99	13.04	0.000	0.000	0.002	32		
100	13.11	0.000	0.002	0.033	33		
101	13.18	0.000	0.012	0.000			SG23
102	13.38	0.000	0.002	0.000	34		
103	13.39	0.000	0.002	0.002			
104	13.47	0.000	0.000	0.000	35		
105	13.51	0.000	0.000	0.000	36		
106	13.61	0.000	0.00	DELETED			
107	13.66	0.013	0.000	0.029			FB
108	13.72	0.013	0.000	0.000		5	
109	13.96	0.000	0.000	0.001	38		
110	14.03	0.000	0.000	0.001	39		
111	14.09	0.000	0.003	0.014			BONI
112	14.19	0.001	0.001	0.031			FBsh
113	14.28	0.000	0.013	0.000		6	
114	14.34	0.004	0.000	0.060			FB
115	14.52	0.000	0.006	0.028	40		
116	14.82	0.000	0.000	0.000	41		
117	14.87	0.031	0.000	0.001			SG1/SG4/SB/ FBsh
118	15.09	0.000	0.000	0.004			
119	15.13	0.002	0.000	0.000			
120	15.54	0.000	0.000	0.001	42		
121	15.62	0.000	0.000	0.000	43		
122	15.68	0.000	0.000	0.000	44		

Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 5 of 9

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Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
123	15.69	0.000	0.001	0.000	45		
124	15.71	0.000	0.008	0.004			
125	15.78	0.000	0.000	0.000			
126	16.27	0.000	0.001	0.001			
127	16.37	0.000	0.000	0.000	46		
128	16.55	0.000	0.000	0.000	47		
129	16.65	0.000	0.003	0.000			
130	16.78	0.000	0.000	0.011			SB
131	16.90	0.000	0.000	0.000	48		
132	16.99	0.000	0.002	0.000	49		
133	17.00	0.000	0.003	0.001	50		
134	17.38	0.001	0.000	0.006		7	
135	17.45	0.000	0.000	0.055			SB/SG23sh
136	17.49	0.000	0.000	0.001	51		
137	17.78	0.000	0.000				
138	17.85	0.000	0.000	0.000	53		
139	17.93	0.000	0.000	0.000	54		
140	17.96	0.006	0.000	0.000	55		
141	18.06	0.001	0.000	0.000			
142	18.09	0.000	0.000	0.000			
143	18.15	0.000	0.001	0.001			
144	18.20	0.000	0.000	0.000			
145	18.31	0.001	0.005	0.000			
146	18.43	0.000	0.000	0.001			
147	18.48	0.000	0.000	0.003			
148	18.57	0.001	0.000	0.000			
149	18.79	0.000	0.000	0.000		8	
150	18.84	0.000	0.000	0.000		9	
151	19.27	0.015	0.000	0.000	56		
152	19.29	0.006	0.000	0.000			
153	19.32	0.002	0.000	0.000			

Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 6 of 9

Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
154	19.65	0.000	0.000	0.000	57		
155	19.81	0.000	0.000	0.000			
156	19.90	0.000	0.000	0.000			
157	20.21	0.000	0.003	0.000			
158	20.33	0.000	0.001	0.004			
159	20.63	0.000	0.003	0.000			
160	21.07	0.002	0.000	0.000			
161	21.47	0.000	0.000	0.002		10	
162	21.63	0.000	0.002	0.005			
163	21.77	0.000	0.002	0.007	58		
164	21.97	0.000	0.006	0.000			
165	22.09	0.003	0.000	0.000			
166	22.20	0.002	0.001	0.000			
167	22.26	0.000	0.000	0.000		11	
168	22.40	0.001	0.000	[illegible]	[illegible]		
169	22.46	0.000	0.000	0.002	59		
170	22.69	0.000	0.000	0.001	60		
171	22.83	0.001	0.001	0.000			
172	22.87	0.000	0.000	0.000		12	
173	22.92	0.001	0.000	0.000	61		
174	23.06	0.000	0.000	0.000	62		
175	23.36	0.000	0.000	0.005	63		
176	23.71	0.000	0.000	0.014			SG23
177	23.74	0.000	0.000	0.007	64		
178	23.75	0.010	0.000	0.001			
179	24.05	0.000	0.000	0.000			
180	24.25	0.000	0.000	0.000			
181	24.44	0.000	0.002	0.000			
182	24.57	0.003	0.000	0.000		13	
183	24.79	0.002	0.000	0.000			
184	25.36	0.000	0.003	0.000		14	

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Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 7 of 9

Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
185	25.41	0.000	0.006	0.001	65		
186	25.42	0.000	0.000	0.000			
187	25.50	0.000	0.000	0.000	66		
188	26.04	0.000	0.008	0.000			
189	26.46	0.000	0.003	0.002	67		
190	26.53	0.000	0.001	0.000			
191	26.72	0.002	0.001	0.000			
192	26.82	0.002	0.001	0.000			
193	26.98	0.000	0.000	0.000			
194	27.63	0.000	0.000	0.002	68		
195	27.70	0.000	0.000	0.000	69		
196	27.86	0.000	0.000	0.000	70		
197	27.96	0.000	0.002	0.000			
198	28.02	0.000	0.000	0.000	71		
199	28.43	0.001	0.000	[illegible]	[illegible]		
200	28.64	0.000	0.000	0.002	73		
201	28.65	0.001	0.000	0.000			
202	29.15	0.000	0.001	0.000			
203	29.26	0.000	0.000	0.000		15	
204	29.47	0.000	0.000	0.000			
205	29.50	0.000	0.000	0.000	74		
206	29.51	0.000	0.000	0.000	75		
207	29.56	0.000	0.000	0.000	76		
208	29.57	0.000	0.001	0.000	77		
209	29.60	0.001	0.002	0.001			
210	29.65	0.005	0.001	0.000			
211	29.74	0.000	0.000	0.009			SG1
212	30.02	0.000	0.000	0.000			
213	30.45	0.000	0.000	0.000	78		
214	30.49	0.001	0.000	0.000			
215	30.54	0.000	0.000	0.000	79		

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Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 8 of 9

Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
216	30.58	0.000	0.000	0.000	80		
217	30.72	0.000	0.000	0.000			
218	30.74	0.000	0.000	0.000	81		
219	30.81	0.000	0.000	0.003			
220	30.88	0.000	0.000	0.000	82		
221	30.91	0.000	0.000	0.008			
222	31.28	0.000	0.000	0.001	83		
223	31.84	0.000	0.000	0.000			
224	32.04	0.000	0.000	0.000			
225	32.19	0.000	0.002	0.000			
226	32.24	0.000	0.000	0.000	84		
227	32.91	0.000	0.000	0.000			
228	33.34	0.001	0.000	0.000			
229	33.62	0.000	0.000	[illegible]	[illegible]		
230	33.72	0.003	0.000	[illegible]			
231	34.16	0.000	0.002	0.000	86		
232	34.35	0.000	0.001	0.000			
233	34.61	0.000	0.002	0.000			
234	34.71	0.000	0.000	0.005			
235	34.98	0.002	0.000	0.000		16	
236	35.30	0.000	0.000	0.001			
237	35.92	0.003	0.000	0.000			
238	36.44	0.000	0.002	0.000			
239	36.52	0.000	0.000	0.003			
240	36.55	0.001	0.000	0.000			
241	36.84	0.001	0.000	0.000			
242	36.98	0.000	0.000	0.000			
243	37.64	0.000	0.000	0.000			
244	37.73	0.000	0.004	0.000			
245	37.99	0.001	0.001	0.000			
246	38.30	0.001	0.001	0.000			

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Table 3.7.2-5—Modal Frequencies of the Stick Models of NI Common Basemat Structures and RCS
Sheet 9 of 9

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Mode No.	Freq (Hz)	Modal Mass Ratios			RBI-RCS Modes	CTMT Modes	Balance of NI Modes
		X	Y	Z			
247	38.43	0.004	0.000	0.000	87		
248	38.45	0.000	0.000	0.001	88		
249	38.55	0.000	0.000	0.000			
250	38.64	0.000	[illegible]	[illegible]			
251	38.93	0.000	[illegible]	[illegible]	89		
252	39.87	0.000	0.000	0.000			
253	40.03	0.000	0.000	0.000			
254	40.42	0.000	0.000	0.000			
255	40.85	0.000	0.000	0.000	90		
256	40.87	0.000	0.000	0.007			
	Sum	0.965	0.961	0.901			

Table 3.7.2-6—Modal Frequencies of the Stick Model of NAB

Mode No.	Frequency (Hz)	Modal Mass Ratios		
		X	Y	Z
1	4.24	0.000	0.636	0.002
2	4.96	0.601	0.000	0.000
3	7.54	0.044	0.002	0.000
4	10.65	0.001	0.201	0.051
5	12.90	0.207	0.002	0.018
6	14.33	0.009	0.009	0.582
7	19.06	0.001	0.034	0.042
8	19.33	0.003	0.003	0.036
9	19.50	0.000	0.026	0.057
10	20.58	0.019	0.000	0.001
11	23.89	0.046	0.003	0.000
12	24.47	0.003	0.024	0.001
13	29.48	0.006	0.003	0.000
14	30.49	0.002	0.018	0.000
15	31.58	0.009	0.001	0.000
16	34.25	0.000	0.000	0.041
17	35.92	0.013	0.002	0.001
18	36.29	0.009	0.006	0.001
19	37.19	0.003	0.001	0.000
20	40.41	0.001	0.000	0.010
21	42.11	0.000	0.000	0.053
22	43.05	0.004	0.000	0.001
23	43.58	0.001	0.000	0.001
24	44.95	0.000	0.015	0.000
25	49.54	0.000	0.004	0.000

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building (EUR Motions)
Sheet 1 of 6

Mode No.	Freq (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass	Comments
1	10.72	0.00	0.00	74.99	Z Direction Global Mode
2	11.20	69.52	0.02	0.00	X Direction Global Mode
3	11.58	0.00	0.00	0.02	
4	12.24	0.00	0.00	0.01	
5	12.75	2.81	0.30	0.00	X Direction Global Drift
6	13.50	0.75	0.01	0.00	X Direction Global Drift
7	13.51	0.00	0.00	0.01	
8	13.84	2.64	0.21	0.00	X Direction Global Drift
9	14.47	0.00	0.00	0.17	
10	14.53	0.00	4.18	0.00	Local Response from Slabs
11	14.60	0.00	0.00	0.33	
12	15.14	0.00	0.18	0.00	
13	15.39	0.00	0.00	0.03	
14	15.57	0.38	0.01	0.00	
15	16.56	0.00	0.00	2.88	Local Response from Electrical Room & Walls
16	17.33	0.00	0.00	0.15	
17	17.58	0.05	35.91	0.00	Local Response from Slabs
18	18.20	0.00	0.00	0.09	
19	18.61	0.00	0.00	0.08	
20	19.17	0.00	0.34	0.00	
21	19.18	0.00	0.00	0.01	
22	19.64	1.82	2.20	0.00	Local Response from Wall & Slabs
23	21.12	0.00	0.00	0.07	

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building (EUR Motions) Sheet 2 of 6

Mode No.	Freq (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass	Comments
24	22.42	0.00	0.00	0.06	
25	23.06	0.44	0.24	0.00	
26	23.11	0.00	0.00	2.60	Local Response from Electrical Room & Walls
27	23.52	0.00	0.00	2.77	Local Response from Electrical Room & Walls
28	23.54	0.01	0.40	0.00	
29	24.09	0.00	0.00	0.02	
30	24.36	0.40	0.06	0.00	
31	24.57	0.00	0.00	0.09	
32	24.90	0.10	0.01	0.00	
33	25.36	0.00	0.00	0.02	
34	25.86	0.00	0.00	0.08	
35	25.97	0.14	0.28	0.00	
36	26.06	0.00	0.00	0.02	
37	26.26	0.10	0.00	0.00	
38	26.31	0.00	0.00	0.09	
39	26.74	0.00	0.00	0.35	
40	26.75	0.06	0.08	0.00	
41	26.93	0.02	0.06	0.00	
42	27.30	0.00	0.00	0.01	
43	27.52	0.00	0.00	0.27	
44	27.57	0.00	0.19	0.00	
45	28.17	0.11	0.00	0.00	
46	28.30	0.01	0.09	0.00	
47	28.31	0.00	0.00	0.28	
48	28.54	0.00	0.00	0.01	
49	28.59	0.87	0.01	0.00	Local Response from Walls

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building (EUR Motions)
Sheet 3 of 6

Mode No.	Freq (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass	Comments
50	29.10	0.00	0.00	1.70	Local Response from Walls
51	29.69	0.00	0.00	0.05	
52	29.92	0.03	0.01	0.00	
53	30.66	0.51	0.52	0.00	Local Response from Walls & Slabs
54	30.83	0.35	0.35	0.00	
55	31.58	0.00	0.00	0.01	
56	31.65	0.00	0.09	0.00	
57	32.14	0.00	0.00	0.06	
58	32.28	0.46	0.91	0.00	Local Response from Slabs
59	32.73	0.00	0.00	0.02	
60	32.91	0.27	1.66	0.00	Local Response from Slabs
61	32.96	0.00	0.00	0.05	
62	33.19	0.00	0.00	0.08	
63	33.33	0.13	0.28	0.00	
64	33.51	0.24	0.13	0.00	
65	33.57	0.00	0.00	0.04	
66	33.97	0.00	0.00	0.01	
67	34.02	0.00	1.85	0.00	Local Response from Slabs
68	34.28	0.00	0.00	0.01	
69	34.57	0.05	1.56	0.00	Local Response from Slabs
70	34.60	0.00	0.00	0.08	
71	35.14	0.30	0.17	0.00	
72	35.72	0.43	0.91	0.00	Local Response from Slabs
73	35.75	0.00	0.00	0.05	

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building (EUR Motions)
Sheet 4 of 6

Mode No.	Freq (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass	Comments
74	36.32	0.46	1.79	0.00	Local Response from Slabs
75	36.90	0.00	0.00	0.03	
76	37.04	0.00	0.00	0.15	
77	37.51	0.06	0.13	0.00	
78	37.57	0.00	0.00	0.00	
79	37.71	0.00	0.00	0.02	
80	37.82	0.00	0.00	0.03	
81	38.02	0.01	0.01	0.00	
82	38.60	0.00	0.00	0.05	
83	38.61	0.04	0.04	0.00	
84	38.72	0.00	0.03	0.00	
85	38.86	0.00	0.00	0.01	
86	39.01	0.01	0.03	0.00	
87	39.56	0.29	0.00	0.00	
88	39.69	0.00	0.00	0.14	
89	39.79	0.00	0.00	0.21	
90	40.02	0.07	0.05	0.00	
91	40.05	0.00	0.00	0.36	
92	40.25	0.00	0.00	0.07	
93	40.35	0.09	0.43	0.00	
94	40.58	0.03	0.01	0.00	
95	41.02	0.00	0.00	0.14	
96	41.06	016	0.85	0.00	Local Response from Slabs
97	41.54	0.00	0.00	0.00	
98	41.79	0.00	0.00	0.01	
99	42.24	0.02	7.67	0.00	Local Response from Slabs
100	42.32	0.00	0.00	0.13	
101	42.52	0.00	0.00	0.00	
102	42.71	0.01	0.26	0.00	

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building (EUR Motions)
Sheet 5 of 6

Mode No.	Freq (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass	Comments
103	43.50	0.00	0.00	0.09	
104	43.51	0.05	0.11	0.00	
105	43.84	0.00	0.00	0.33	
106	44.96	0.00	0.00	0.13	
107	45.66	0.03	5.10	0.00	Local Response from Slabs
108	46.04	0.00	0.00	0.01	
109	46.50	0.84	1.08	0.00	Local Response from Wall & Slabs
110	46.75	1.27	0.02	0.00	Local Response from Walls
111	46.85	0.00	0.00	0.06	
112	47.02	0.00	0.00	0.01	
113	47.31	0.13	0.01	0.00	
114	47.37	0.00	0.00	0.01	
115	47.47	0.49	1.35	0.00	Local Response from Wall & Slabs
116	47.99	0.00	0.00	0.34	
117	48.04	0.04	0.00	0.00	
118	48.13	0.00	0.00	0.00	
119	48.53	0.13	0.18	0.00	
120	48.58	0.00	0.00	0.02	
121	48.85	0.10	1.13	0.00	Local Response from Wall & Slabs
122	48.88	0.00	0.00	0.00	
123	48.96	0.00	0.00	0.17	
124	49.01	0.09	0.54	0.00	Local Response from Wall & Slabs
125	49.24	0.00	0.45	0.00	

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Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building (EUR Motions)
Sheet 6 of 6

Mode No.	Freq (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass	Comments
126	49.27	0.00	0.00	0.01	
127	49.98	0.33	0.99	0.00	Local Response from Wall & Slabs
128	50.20	0.04	0.13	0.00	
129	50.37	0.00	0.00	0.32	
130	50.46	0.09	0.14	0.00	
131	50.72	0.37	0.17	0.00	
132	50.73	0.00	0.00	0.00	
133	50.99	0.47	0.06	0.00	
134	51.17	0.00	0.00	0.06	
135	51.28	0.00	0.00	0.00	
136	51.49	0.00	0.00	0.00	
137	51.53	0.02	0.01	0.00	
138	51.56	0.06	0.09	0.00	
139	51.70	0.00	0.00	0.00	
140	51.82	0.01	0.01	0.00	

Note:

1. Y is in vertical direction for GTSTRUL FEM of EPGB.

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 1 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
1	6.670	0.00	0.00	25.22
2	6.855	0.00	0.00	0.84
3	7.209	39.61	0.06	0.00
4	7.597	0.00	0.00	0.00
5	7.605	0.00	0.00	0.00
6	7.646	0.00	0.00	0.00
7	7.653	0.00	0.00	0.00
8	7.717	0.00	0.00	0.00
9	7.723	0.00	0.00	0.02
10	7.796	0.00	0.00	10.92
11	7.797	0.00	0.00	0.00
12	7.803	0.00	0.00	0.00
13	7.876	0.00	0.00	0.00
14	7.882	0.00	0.00	0.02
15	7.945	0.01	0.00	0.00
16	7.951	0.00	0.00	0.00
17	8.002	0.00	0.00	0.00
18	8.008	0.00	0.00	0.00
19	8.039	0.25	0.00	0.00
20	8.043	0.00	0.00	0.00
21	8.078	0.00	0.00	0.00
22	8.083	0.00	0.00	0.03
23	9.151	0.09	0.00	0.00
24	9.190	0.00	0.00	0.02
25	9.228	0.00	0.00	0.09
26	9.288	0.00	0.00	0.14
27	9.294	0.00	0.00	0.00
28	9.296	0.01	0.00	0.00
29	9.335	0.00	0.00	0.00
30	9.337	0.00	0.00	0.00
31	9.341	0.00	0.00	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 2 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
32	9.344	0.00	0.00	0.00
33	9.346	0.00	0.00	0.00
34	9.347	0.00	0.00	0.00
35	9.355	0.00	0.00	0.00
36	9.357	0.00	0.00	0.00
37	9.362	0.00	0.00	0.00
38	9.364	0.00	0.00	0.00
39	9.368	0.00	0.00	0.00
40	9.368	0.00	0.00	0.00
41	9.373	0.00	0.00	0.01
42	9.391	0.00	0.00	0.05
43	9.473	0.06	0.00	0.00
44	9.649	0.03	0.85	0.00
45	9.723	4.83	0.00	0.00
46	9.763	0.02	1.07	0.00
47	9.824	0.00	0.00	0.00
48	9.963	0.00	0.00	0.01
49	10.454	0.00	0.38	0.00
50	10.519	0.08	0.00	0.00
51	10.578	1.89	0.10	0.00
52	11.068	2.49	0.01	0.00
53	11.430	0.00	0.00	0.01
54	11.674	0.00	0.00	0.00
55	11.733	0.15	0.03	0.00
56	11.981	0.04	0.37	0.00
57	12.141	0.00	0.01	6.17
58	12.171	0.05	9.37	0.00
59	12.318	0.00	0.00	6.03
60	12.952	0.00	1.75	0.00
61	13.066	0.01	8.25	0.00
62	13.127	0.00	0.00	0.01

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 3 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
63	13.184	0.06	0.13	0.00
64	13.210	0.00	0.00	0.11
65	13.288	0.00	0.00	0.00
66	13.456	0.00	0.00	0.15
67	13.553	0.06	0.03	0.00
68	13.607	0.00	0.00	0.72
69	13.656	0.25	0.01	0.00
70	13.704	0.00	0.00	6.84
71	13.849	0.09	0.00	0.00
72	14.002	1.29	0.01	0.00
73	14.126	0.00	0.00	0.16
74	14.180	0.16	0.00	0.00
75	14.347	0.00	0.00	0.01
76	14.501	0.00	0.00	0.26
77	14.629	0.00	0.00	0.02
78	14.781	2.38	0.03	0.00
79	14.946	0.00	0.00	0.00
80	15.135	0.02	0.02	0.00
81	15.161	0.00	0.00	0.15
82	15.220	0.00	0.00	0.00
83	15.261	0.02	0.00	0.00
84	15.349	0.00	0.01	0.00
85	15.426	0.00	0.02	0.00
86	15.933	0.00	0.00	0.16
87	16.098	0.01	0.04	0.00
88	16.137	0.00	1.92	0.00
89	16.204	0.00	0.07	0.00
90	16.417	0.01	1.29	0.00
91	16.521	0.00	0.00	0.25
92	16.645	0.00	0.00	0.01
93	16.902	0.00	0.00	0.00

**Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 4 of 10**

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
94	16.905	0.00	0.00	0.00
95	16.963	0.00	0.00	0.00
96	16.966	0.00	0.00	0.00
97	17.048	0.00	0.00	0.00
98	17.050	0.00	0.00	0.00
99	17.050	0.00	0.12	0.00
100	17.052	0.00	0.00	0.00
101	17.137	0.01	0.02	0.00
102	17.148	0.00	0.00	0.00
103	17.170	0.02	0.02	0.00
104	17.187	0.03	0.11	0.00
105	17.212	0.00	0.00	0.03
106	17.219	0.00	0.00	0.02
107	17.250	0.00	0.00	0.01
108	17.253	0.00	0.00	0.00
109	17.274	0.00	0.00	0.03
110	17.274	0.00	0.01	0.00
111	17.328	0.00	0.00	0.02
112	17.374	0.00	0.07	0.00
113	17.393	0.05	0.03	0.01
114	17.405	0.01	0.00	0.12
115	17.757	0.00	0.00	0.00
116	18.027	0.00	0.00	0.06
117	18.456	0.01	0.50	0.00
118	18.524	0.00	0.00	0.11
119	18.599	0.00	0.00	0.00
120	18.657	0.00	0.00	0.00
121	18.727	0.01	0.01	0.00
122	18.737	0.00	0.00	0.00
123	18.791	0.00	0.00	0.00
124	18.804	0.00	0.00	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 5 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
125	18.826	0.00	0.00	0.00
126	18.837	0.00	0.00	0.06
127	18.845	0.00	0.00	0.01
128	18.852	0.02	0.01	0.00
129	18.854	0.00	0.00	0.00
130	18.891	0.00	0.05	0.00
131	18.908	0.00	0.00	0.00
132	18.930	0.00	0.00	0.00
133	18.938	0.00	0.00	0.00
134	19.022	0.00	0.00	0.00
135	19.044	0.00	0.01	0.00
136	19.095	0.01	5.23	0.00
137	19.152	0.00	0.00	0.00
138	19.190	0.00	0.01	0.00
139	19.337	0.00	0.00	0.61
140	19.473	0.00	0.00	0.02
141	19.739	0.03	12.19	0.00
142	19.844	0.00	0.01	0.00
143	19.876	0.00	0.00	0.31
144	19.974	0.00	0.00	0.08
145	20.013	0.00	0.32	0.00
146	20.016	0.00	0.09	0.01
147	20.169	0.00	0.00	0.00
148	20.204	0.00	0.00	0.00
149	20.447	0.00	0.00	1.12
150	20.580	0.00	0.00	0.01
151	20.673	0.00	0.00	0.71
152	20.904	0.14	0.00	0.00
153	20.926	0.59	0.01	0.00
154	21.109	0.00	0.00	0.12
155	21.275	1.28	0.01	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 6 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
156	21.383	0.00	0.00	0.01
157	21.388	0.93	0.02	0.00
158	21.407	0.05	0.00	0.00
159	21.418	0.00	0.00	0.04
160	21.504	0.05	0.01	0.00
161	21.599	0.00	0.00	0.00
162	21.686	0.00	0.00	0.00
163	21.909	0.63	0.00	0.00
164	22.081	0.08	0.32	0.00
165	22.094	0.00	0.00	0.00
166	22.231	0.05	0.00	0.00
167	22.274	0.00	0.00	0.00
168	22.408	0.00	0.00	0.64
169	22.435	0.00	0.00	0.00
170	22.480	0.00	0.00	0.11
171	22.552	0.00	0.00	0.28
172	22.588	0.03	0.44	0.00
173	22.797	0.65	0.09	0.00
174	22.830	0.34	0.04	0.00
175	23.010	0.00	0.00	0.39
176	23.034	0.00	0.02	0.00
177	23.148	0.00	0.00	0.85
178	23.325	0.06	1.59	0.00
179	23.376	0.50	0.02	0.00
180	23.425	0.06	1.32	0.00
181	23.540	0.04	0.00	0.24
182	23.549	0.69	0.03	0.01
183	23.692	0.00	0.00	0.00
184	24.149	0.00	0.00	0.06
185	24.297	0.14	0.00	0.00
186	24.470	0.60	0.01	0.00

**Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 7 of 10**

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
187	24.579	0.55	0.00	0.00
188	24.816	0.00	0.01	0.00
189	24.845	0.01	0.19	0.00
190	24.874	0.10	0.03	0.00
191	25.195	1.31	0.14	0.00
192	25.209	0.43	0.08	0.00
193	25.358	0.00	0.00	0.00
194	25.496	0.01	0.00	0.00
195	25.501	0.00	0.00	0.00
196	25.577	0.00	0.00	0.00
197	25.595	0.46	0.98	0.00
198	25.626	0.00	0.01	0.00
199	25.660	0.00	0.00	0.00
200	25.681	0.00	0.00	0.00
201	25.711	0.01	0.01	0.01
202	25.755	0.01	0.01	0.00
203	25.851	0.32	5.11	0.00
204	25.907	0.10	0.84	0.00
205	25.982	0.00	0.00	0.00
206	26.058	0.00	0.00	0.00
207	26.107	0.00	0.05	0.00
208	26.126	0.26	4.15	0.00
209	26.151	0.01	0.07	0.00
210	26.173	0.01	0.12	0.00
211	26.228	0.00	0.00	0.00
212	26.262	9.74	0.03	0.00
213	26.274	0.02	0.02	0.00
214	26.282	0.03	0.01	0.02
215	26.516	0.00	0.00	0.01
216	26.680	0.00	0.00	0.00
217	26.691	0.00	0.00	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 8 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
218	26.740	0.22	0.41	0.00
219	26.744	0.16	0.21	0.01
220	26.794	0.00	0.00	0.03
221	26.805	0.09	0.01	0.00
222	26.816	0.00	0.03	0.00
223	27.010	0.00	0.00	0.00
224	27.025	0.00	0.00	0.00
225	27.036	0.97	0.01	0.00
226	27.084	0.02	0.01	0.00
227	27.117	0.03	0.17	0.00
228	27.156	0.17	0.01	0.00
229	27.191	0.00	0.00	0.02
230	27.227	0.01	0.00	0.00
231	27.323	0.00	0.00	0.00
232	27.329	0.01	0.00	0.02
233	27.359	0.54	0.00	0.00
234	27.366	0.00	0.00	0.00
235	27.381	0.00	0.00	0.00
236	27.519	0.00	0.00	0.25
237	27.551	0.00	0.06	0.00
238	27.673	0.00	0.00	0.01
239	27.798	0.68	0.05	0.00
240	27.980	1.89	0.31	0.00
241	28.347	0.01	0.01	0.00
242	28.489	0.00	0.00	0.16
243	28.668	0.00	0.00	0.85
244	28.908	0.00	0.00	0.05
245	29.103	0.00	0.00	0.00
246	29.163	0.08	0.02	0.00
247	29.348	0.00	0.00	0.62
248	29.544	0.15	0.09	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 9 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
249	29.945	0.03	0.18	0.00
250	29.965	0.00	0.01	0.02
251	30.023	0.00	0.00	0.18
252	30.097	0.03	0.47	0.00
253	30.399	0.00	0.00	0.09
254	30.678	0.04	0.22	0.00
255	30.752	0.00	0.00	0.01
256	30.876	0.26	0.31	0.00
257	30.982	0.00	0.00	0.05
258	31.095	0.20	0.63	0.00
259	31.128	0.00	0.00	0.04
260	31.375	0.00	0.00	0.04
261	31.425	0.00	0.23	0.00
262	31.625	0.05	0.08	0.04
263	31.640	0.05	0.08	0.04
264	31.822	0.02	0.46	0.00
265	31.914	0.00	0.12	0.00
266	32.062	0.29	0.09	0.00
267	32.146	0.00	0.00	1.95
268	32.293	0.02	0.54	0.00
269	32.406	0.30	0.00	0.00
270	32.585	0.00	0.01	0.00
271	32.713	0.00	0.01	0.00
272	32.850	0.04	0.62	0.00
273	32.999	0.00	0.00	0.11
274	33.179	0.00	0.07	0.00
275	33.235	0.00	0.00	0.01
276	33.402	0.00	0.00	0.16
277	33.589	0.00	0.00	0.01
278	33.614	0.01	0.03	0.00
279	33.670	0.06	0.05	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Emergency Service Water Building (EUR Motions)
Sheet 10 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
280	33.770	0.01	0.02	0.00
281	33.853	0.01	0.01	0.00
282	33.954	0.00	0.00	0.00
283	33.960	0.00	0.00	0.00
284	33.982	0.06	0.03	0.00
285	33.997	0.00	0.00	0.00
286	34.008	0.04	0.03	0.00
287	34.017	0.00	0.00	0.00
288	34.019	0.02	0.01	0.00
289	34.024	0.00	0.00	0.00
290	34.064	0.01	0.01	0.00

Note:

1. Y is in vertical direction for GTSTRUDL FEM of ESWB.

Table 3.7.2-9—Soil Properties Associated With Different ~~Generic~~ Shear Wave Velocities

Shear Wave Velocity (ft/s)	Shear Wave Velocity (m/s)	Poisson's Ratio μ	Weight Density (pcf)	Weight Density (kN/m3)	S-Wave Damping (%)	Dynamic Shear Modulus (ksf)	Static Shear Modulus (ksf)
700	213	0.40	110	17.28	7	1668	834.2
820	250	0.40	110	17.28	7	2298	1149
1640	500	0.40	110	17.28	4	9193	4597
2625	800	0.40	115	18.07	2	24,610	12,310
3937	1200	0.40	120	18.85	1	57,760	28,880
5249	1600	0.40	125	19.64	1	107,000	53,500
13,123	4000	0.35	156	24.51	1	834,500	417,300

Will be provided later.

Notes:

1. P-wave damping is taken to be 1/3*S-wave damping.
2. When shear wave velocity varies linearly in a layer, other properties vary accordingly.
3. P-wave velocity = S-wave velocity*$[2(1-\mu)/(1-2\mu)]^{1/2}$.
4. Shear-wave velocities and S-wave damping values are strain compatible. Damping values do not exceed 15 percent.
5. Dynamic (best-estimate) shear modulus = mass density*S-wave velocity^2.
6. Static shear modulus is taken as half of the dynamic shear modulus.

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Table 3.7.2-10—Reactor Containment Building ZPAs
Sheet 1 of 3

Containment Building														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-2.3	X	0.18	0.23	0.34	0.34	0.27	0.25	0.32	0.29	0.33	0.27	0.28	0.29	0.34
	Y	0.18	0.24	0.35	0.34	0.31	0.23	0.32	0.30	0.35	0.26	0.28	0.29	0.35
	Z	0.27	0.37	0.45	0.42	0.34	0.33	0.36	0.36	0.38	0.29	0.30	0.29	0.45
2.6	X	0.18	0.23	0.36	0.3[illegible]	[illegible]	[illegible]	[illegible]	0.33	0.38	0.29	0.31	0.31	0.38
	Y	0.17	0.24	0.36	0.35	0.31	0.23	0.31	0.30	0.35	0.26	0.31	0.33	0.36
	Z	0.27	0.36	0.47	0.43	0.36	0.35	0.39	0.38	0.43	0.31	0.33	0.32	0.47
8.1	X	0.18	0.24	0.41	0.37	0.26	0.25	0.42	0.38	0.44	0.34	0.42	0.43	0.44
	Y	0.16	0.25	0.37	0.36	0.32	0.23	0.33	0.31	0.38	0.28	0.37	0.43	0.43
	Z	0.27	0.36	0.49	0.45	0.37	0.36	0.43	0.41	0.48	0.33	0.36	0.44	0.49
12	X	0.18	0.25	0.45	0.38	0.28	0.26	0.44	0.41	0.48	0.39	0.48	0.51	0.51
	Y	0.16	0.26	0.39	0.36	0.32	0.23	0.35	0.32	0.43	0.30	0.41	0.48	0.48
	Z	0.27	0.35	0.50	0.46	0.37	0.37	0.47	0.44	0.51	0.35	0.39	0.54	0.54
17.8	X	0.18	0.26	0.51	0.43	0.31	0.26	0.50	0.45	0.55	0.43	0.56	0.61	0.61
	Y	0.16	0.27	0.44	0.39	0.32	0.23	0.39	0.35	0.49	0.33	0.44	0.53	0.53
	Z	0.28	0.35	0.52	0.48	0.39	0.39	0.51	0.49	0.56	0.39	0.49	0.68	0.68

Will be provided later.

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Table 3.7.2-10—Reactor Containment Building ZPAs
Sheet 2 of 3

Will be provided later.

Containment Building														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
22.5	X	0.18	0.27	0.56	0.46	0.34	0.27	0.53	0.49	0.57	0.45	0.60	0.67	0.67
	Y	0.17	0.29	0.48	0.42	0.31	0.24	0.42	0.38	0.56	0.34	0.44	0.54	0.56
	Z	0.28	0.35	0.53	0.49	0.41	0.41	0.54	0.52	0.59	0.44	0.56	0.79	0.79
28.8	X	0.17	0.30	0.64	[illegible]	[illegible]	[illegible]	[illegible]	0.53	0.63	0.47	0.62	0.73	0.73
	Y	0.17	0.33	0.54	0.42	0.34	0.26	0.49	0.41	0.62	0.41	0.55	0.61	0.62
	Z	0.28	0.35	0.54	0.54	0.43	0.44	0.58	0.56	0.64	0.50	0.65	0.91	0.91
34	X	0.17	0.32	0.70	0.56	0.38	0.32	0.61	0.57	0.67	0.51	0.61	0.75	0.75
	Y	0.17	0.36	0.58	0.44	0.37	0.27	0.54	0.46	0.67	0.47	0.62	0.70	0.70
	Z	0.28	0.36	0.55	0.56	0.44	0.46	0.60	0.58	0.67	0.54	0.71	1.01	1.01
37.6	X	0.18	0.33	0.74	0.55	0.39	0.35	0.65	0.59	0.71	0.55	0.60	0.78	0.78
	Y	0.18	0.38	0.61	0.45	0.40	0.28	0.58	0.49	0.69	0.50	0.67	0.78	0.78
	Z	0.28	0.36	0.57	0.58	0.45	0.47	0.62	0.59	0.69	0.57	0.74	1.06	1.06
43.92	X	0.19	0.37	0.81	0.57	0.40	0.40	0.68	0.63	0.76	0.61	0.66	0.86	0.86
	Y	0.19	0.41	0.66	0.48	0.44	0.29	0.64	0.54	0.75	0.53	0.72	0.89	0.89
	Z	0.29	0.37	0.58	0.60	0.45	0.49	0.64	0.61	0.72	0.61	0.79	1.13	1.13

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Table 3.7.2-10—Reactor Containment Building ZPAs
Sheet 3 of 3

Will be provided later.

Containment Building														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3[illegible]	Case [illegible]	Case [illegible]	Case [illegible]	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
53.3	X	0.21	0.42	0.91	0.64	0.46	0.47	0.74	0.66	0.87	0.68	0.87	0.92	0.92
	Y	0.23	0.46	0.76	0.56	0.51	0.37	0.74	0.68	0.84	0.67	0.83	1.03	1.03
	Z	0.34	0.40	0.69	0.68	0.54	0.59	0.78	0.75	0.85	0.89	1.02	1.62	1.62
58	X	0.23	0.49	1.01	0.72	0.53	0.51	0.90	0.75	0.97	0.92	1.33	1.39	1.39
	Y	0.27	0.50	0.97	0.68	0.55	0.53	0.99	0.96	1.07	0.83	1.14	1.40	1.40
	Z	0.47	0.54	0.86	1.20	0.79	0.99	1.60	1.37	1.64	1.44	1.58	2.52	2.52

Table 3.7.2-11—Reactor Building Internal Structures ZPAs
Sheet 1 of 3

Will be provided later.

Reactor Building Internals														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-6.15	X	0.18	0.23	0.33	0.34	0.28	0.25	0.31	0.28	0.32	0.27	0.28	0.29	0.34
	Y	0.19	0.24	0.35	0.34	0.32	0.22	0.32	0.30	0.35	0.26	0.28	0.29	0.35
	Z	0.25	0.34	0.44	0.40	0.32	0.32	0.34	0.35	0.36	0.28	0.30	0.29	0.44
-2.3	X	0.18	0.23	0.34	0.34	0.28	0.25	0.33	0.30	0.34	0.28	0.29	0.29	0.34
	Y	0.18	0.24	0.36	0.34	[illegible]	[illegible]	[illegible]	[illegible]	0.36	0.28	0.29	0.30	0.36
	Z	0.26	0.34	0.44	0.40	0.32	0.32	0.34	0.35	0.37	0.29	0.31	0.30	0.44
1.5	X	0.18	0.23	0.38	0.38	0.30	0.27	0.38	0.34	0.39	0.31	0.33	0.38	0.39
	Y	0.18	0.23	0.39	0.34	0.31	0.24	0.33	0.33	0.38	0.31	0.31	0.35	0.39
	Z	0.26	0.34	0.47	0.43	0.33	0.33	0.37	0.37	0.40	0.34	0.36	0.41	0.47
5.15	X	0.19	0.24	0.41	0.41	0.31	0.29	0.42	0.37	0.46	0.37	0.37	0.42	0.46
	Y	0.17	0.24	0.41	0.37	0.30	0.25	0.38	0.36	0.44	0.33	0.34	0.41	0.44
	Z	0.27	0.34	0.48	0.45	0.34	0.36	0.40	0.40	0.43	0.37	0.43	0.51	0.51
6.92	X	0.19	0.24	0.42	0.42	0.31	0.29	0.43	0.38	0.44	0.37	0.37	0.43	0.44
	Y	0.16	0.24	0.43	0.38	0.30	0.26	0.41	0.38	0.47	0.34	0.38	0.43	0.47
	Z	0.27	0.34	0.49	0.45	0.35	0.37	0.41	0.41	0.44	0.39	0.47	0.56	0.56

Table 3.7.2-11—Reactor Building Internal Structures ZPAs
Sheet 2 of 3

Reactor Building Internals														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
9.38	X	0.20	0.25	0.43	0.44	0.31	0.30	0.44	0.39	0.46	0.36	0.39	0.43	0.46
	Y	0.17	0.26	0.43	0.40	0.30	0.27	0.45	0.40	0.51	0.35	0.44	0.44	0.51
	Z	0.27	0.34	0.50	0.46	0.35	0.37	0.43	0.43	0.45	0.42	0.50	0.60	0.60
13.8	X	0.20	0.26	0.46	[illegible]	[illegible]	[illegible]	[illegible]	0.40	0.51	0.42	0.45	0.50	0.51
	Y	0.18	0.28	0.45	0.43	0.30	0.29	0.51	0.44	0.58	0.40	0.42	0.50	0.58
	Z	0.28	0.34	0.51	0.47	0.36	0.39	0.45	0.45	0.49	0.47	0.55	0.68	0.68
19.5	X	0.22	0.27	0.53	0.50	0.32	0.34	0.52	0.44	0.57	0.50	0.54	0.63	0.63
	Y	0.19	0.31	0.53	0.48	0.35	0.32	0.61	0.54	0.71	0.47	0.50	0.59	0.71
	Z	0.28	0.34	0.57	0.57	0.40	0.46	0.68	0.65	0.73	0.62	0.67	0.91	0.91
24.1	X	0.23	0.30	0.59	0.59	0.39	0.36	0.67	0.60	0.78	0.67	0.71	0.94	0.94
	Y	0.22	0.35	0.59	0.54	0.41	0.42	0.74	0.62	0.81	0.61	0.68	0.84	0.84
	Z	0.27	0.35	0.57	0.61	0.48	0.49	0.67	0.63	0.72	0.77	0.90	1.38	1.38
24.1	X	0.24	0.29	0.62	0.51	0.40	0.40	0.65	0.57	0.78	0.63	0.66	0.78	0.78
	Y	0.24	0.38	0.57	0.52	0.43	0.37	0.65	0.58	0.70	0.70	0.76	0.85	0.85
	Z	0.27	0.34	0.59	0.60	0.48	0.48	0.73	0.68	0.78	0.85	0.94	1.27	1.27

Will be provided later.

Table 3.7.2-11—Reactor Building Internal Structures ZPAs
Sheet 3 of 3

Reactor Building Internals														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
28.5	X	0.27	0.33	0.67	0.63	0.46	0.49	0.77	0.67	0.94	0.88	0.97	1.30	1.30
	Y	0.25	0.37	0.66	0.58	0.46	0.50	0.89	0.72	0.94	0.77	0.89	1.13	1.13
	Z	0.28	0.36	0.60	0.64	[illegible]	[illegible]	[illegible]	0.68	0.78	0.88	1.03	1.56	1.56
28.5	X	0.29	0.38	0.71	0.59	0.47	0.46	0.82	0.67	0.91	0.73	0.84	1.22	1.22
	Y	0.32	0.42	0.58	0.58	0.51	0.41	0.92	0.60	0.87	0.97	0.95	1.21	1.21
	Z	0.27	0.36	0.60	0.61	0.51	0.49	0.79	0.70	0.80	0.95	1.03	1.44	1.44
34.45	X	0.33	0.40	0.77	0.75	0.59	0.68	1.02	0.95	1.14	1.30	1.51	2.00	2.00
	Y	0.28	0.41	0.71	0.63	0.48	0.53	0.97	0.75	1.01	0.91	1.01	1.23	1.23
	Z	0.28	0.36	0.59	0.60	0.44	0.46	0.68	0.59	0.69	0.71	0.87	1.25	1.25
34.45	X	0.35	0.48	0.84	0.82	0.66	0.71	1.16	0.92	1.18	1.19	1.39	1.96	1.96
	Y	0.31	0.44	0.62	0.67	0.54	0.45	0.89	0.69	0.91	1.01	1.06	1.18	1.18
	Z	0.27	0.36	0.62	0.63	0.41	0.51	0.78	0.72	0.82	0.78	0.87	1.31	1.31

Will be provided later.

RAI 320, Question 03.07.02-63

Table 3.7.2-12—Safeguard Building 1 ZPAs
Sheet 1 of 2

Safeguards Building 1														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-8.6	X	0.18	0.23	0.32	0.34	0.28	0.25	0.30	0.28	0.32	0.28	0.28	0.29	0.34
	Y	0.21	0.24	0.34	0.33	0.32	0.21	0.31	0.29	0.33	0.25	0.28	0.29	0.34
	Z	0.32	0.40	0.55	0.52	0.40	0.42	0.44	0.46	0.37	0.33	0.30	0.29	0.55
-4.5	X	0.18	0.23	0.36	0.34	[illegible]	[illegible]	[illegible]	0.31	0.34	0.31	0.32	0.33	0.36
	Y	0.20	0.25	0.35	0.35	0.33	0.22	0.33	0.31	0.35	0.28	0.32	0.32	0.35
	Z	0.32	0.41	0.58	0.54	0.45	0.42	0.47	0.47	0.43	0.36	0.36	0.36	0.58
0	X	0.17	0.23	0.39	0.36	0.28	0.27	0.38	0.34	0.38	0.35	0.35	0.34	0.39
	Y	0.19	0.25	0.40	0.36	0.34	0.24	0.38	0.35	0.39	0.31	0.40	0.40	0.40
	Z	0.32	0.41	0.61	0.57	0.48	0.43	0.53	0.50	0.49	0.39	0.43	0.45	0.61
4.7	X	0.17	0.24	0.45	0.37	0.28	0.28	0.44	0.40	0.43	0.36	0.37	0.39	0.45
	Y	0.18	0.26	0.43	0.37	0.32	0.26	0.40	0.39	0.44	0.36	0.47	0.46	0.47
	Z	0.33	0.42	0.64	0.60	0.51	0.44	0.60	0.52	0.58	0.45	0.51	0.58	0.64
8.1	X	0.17	0.25	0.50	0.39	0.29	0.28	0.48	0.44	0.48	0.36	0.43	0.44	0.50
	Y	0.18	0.28	0.45	0.36	0.32	0.27	0.42	0.43	0.47	0.40	0.51	0.50	0.51
	Z	0.33	0.42	0.66	0.62	0.53	0.46	0.65	0.55	0.66	0.50	0.56	0.67	0.67

Will be provided later.

RAI 320, Question 03.07.02-63

Table 3.7.2-12—Safeguard Building 1 ZPAs
Sheet 2 of 2

Will be provided later.

Safeguards Building 1														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
12	X	0.18	0.26	0.55	0.40	0.30	0.30	0.53	0.49	0.53	0.38	0.52	0.49	0.55
	Y	0.18	0.31	0.50	0.38	0.32	0.27	0.47	0.45	0.50	0.46	0.54	0.55	0.55
	Z	0.33	0.44	0.69	0.63	0.56	0.47	0.70	0.62	0.75	0.55	0.62	0.83	0.83
16.8	X	0.19	0.28	0.61	0.43	[illegible]	[illegible]	[illegible]	0.53	0.57	0.43	0.56	0.50	0.61
	Y	0.19	0.33	0.57	0.40	0.31	0.28	0.55	0.49	0.61	0.46	0.55	0.64	0.64
	Z	0.33	0.45	0.73	0.65	0.58	0.49	0.76	0.67	0.81	0.60	0.68	0.93	0.93
21	X	0.19	0.29	0.66	0.46	0.33	0.33	0.63	0.57	0.62	0.47	0.59	0.55	0.66
	Y	0.19	0.34	0.64	0.41	0.34	0.31	0.63	0.52	0.69	0.47	0.62	0.75	0.75
	Z	0.33	0.45	0.75	0.66	0.60	0.51	0.80	0.70	0.85	0.64	0.74	1.02	1.02
24.7	X	0.20	0.31	0.71	0.48	0.34	0.34	0.67	0.59	0.68	0.52	0.65	0.60	0.71
	Y	0.20	0.35	0.69	0.44	0.37	0.35	0.68	0.57	0.75	0.53	0.72	0.84	0.84
	Z	0.33	0.45	0.76	0.66	0.61	0.52	0.81	0.72	0.87	0.66	0.77	1.07	1.07
29.3	X	0.20	0.32	0.76	0.53	0.36	0.36	0.70	0.62	0.76	0.60	0.71	0.66	0.76
	Y	0.20	0.37	0.74	0.48	0.41	0.40	0.74	0.62	0.82	0.59	0.81	0.95	0.95
	Z	0.33	0.46	0.76	0.66	0.61	0.52	0.83	0.73	0.88	0.68	0.79	1.10	1.10

Table 3.7.2-13—Safeguard Building 2 & 3 ZPAs
Sheet 1 of 2

Will be provided later.

Safeguards Building 2/3													
Zero Period Accelerations at Each Floor Level (g)													
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)													
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-8.6	X	0.18	0.23	0.31	0.35	0.30	0.25	0.31	0.28	0.33	0.28	0.29	0.29	0.35
	Y	0.20	0.24	0.34	0.34	0.32	0.23	0.32	0.30	0.35	0.26	0.28	0.29	0.35
	Z	0.32	0.46	0.47	0.44	0.38	0.38	0.38	0.40	0.39	0.34	0.34	0.29	0.47
-4.5	X	0.18	0.24	0.33	0.36	[illegible]	[illegible]	[illegible]	0.32	0.37	0.29	0.31	0.34	0.37
	Y	0.19	0.25	0.37	0.36	0.34	0.25	0.34	0.31	0.36	0.34	0.32	0.33	0.37
	Z	0.33	0.47	0.52	0.47	0.40	0.37	0.41	0.43	0.43	0.45	0.45	0.39	0.52
0	X	0.18	0.25	0.38	0.39	0.34	0.29	0.41	0.36	0.42	0.33	0.33	0.38	0.42
	Y	0.19	0.27	0.40	0.39	0.37	0.27	0.36	0.33	0.42	0.40	0.36	0.38	0.42
	Z	0.33	0.48	0.55	0.49	0.43	0.37	0.49	0.47	0.53	0.56	0.55	0.49	0.56
4.7	X	0.20	0.27	0.45	0.46	0.36	0.35	0.48	0.43	0.51	0.47	0.50	0.51	0.51
	Y	0.19	0.28	0.44	0.43	0.42	0.31	0.46	0.37	0.52	0.40	0.43	0.45	0.52
	Z	0.33	0.48	0.66	0.65	0.47	0.48	0.66	0.58	0.64	0.64	0.63	0.63	0.66
8.1	X	0.22	0.27	0.51	0.50	0.37	0.37	0.52	0.47	0.58	0.54	0.60	0.67	0.67
	Y	0.20	0.30	0.52	0.47	0.45	0.34	0.51	0.43	0.62	0.39	0.46	0.51	0.62
	Z	0.33	0.49	0.70	0.70	0.52	0.52	0.74	0.62	0.73	0.70	0.68	0.78	0.78

Table 3.7.2-13—Safeguard Building 2 & 3 ZPAs
Sheet 2 of 2

Will be provided later.

Safeguards Building 2/3														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
12	X	0.23	0.28	0.58	0.55	0.38	0.39	0.59	0.54	0.69	0.65	0.70	0.83	0.83
	Y	0.21	0.32	0.61	0.53	0.48	0.38	0.59	0.53	0.72	0.45	0.54	0.65	0.72
	Z	0.33	0.50	0.75	0.[illegible]	[illegible]	[illegible]	[illegible]	0.66	0.81	0.78	0.80	0.89	0.89
15.4	X	0.25	0.29	0.63	0.57	0.39	0.40	0.66	0.59	0.78	0.73	0.77	0.92	0.92
	Y	0.21	0.34	0.69	0.58	0.51	0.40	0.68	0.62	0.79	0.51	0.66	0.73	0.79
	Z	0.34	0.50	0.79	0.77	0.57	0.57	0.85	0.71	0.87	0.89	0.94	1.02	1.02
21	X	0.29	0.33	0.71	0.68	0.47	0.50	0.83	0.71	0.99	0.85	0.94	1.20	1.20
	Y	0.21	0.37	0.79	0.62	0.55	0.44	0.79	0.75	0.87	0.68	0.81	0.88	0.88
	Z	0.34	0.51	0.82	0.79	0.61	0.59	0.88	0.75	0.92	0.98	1.04	1.17	1.17
26.8	X	0.26	0.30	0.70	0.63	0.42	0.43	0.76	0.66	0.90	0.83	0.86	1.01	1.01
	Y	0.22	0.40	0.90	0.68	0.58	0.50	0.89	0.85	0.92	0.77	0.90	0.96	0.96
	Z	0.34	0.51	0.83	0.79	0.62	0.59	0.90	0.77	0.94	1.01	1.07	1.22	1.22

Table 3.7.2-14—Safeguard Building 4 ZPAs
Sheet 1 of 2

Safeguards Building 4														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-8.6	X	0.18	0.23	0.32	0.34	0.28	0.25	0.30	0.28	0.32	0.28	0.28	0.29	0.34
	Y	0.19	0.25	0.35	0.36	0.32	0.24	0.33	0.31	0.36	0.26	0.28	0.29	0.36
	Z	0.31	0.46	0.48	0.39	0.35	0.38	0.42	0.39	0.46	0.32	0.34	0.29	0.48
-4.5	X	0.18	0.23	0.35	0.34	[illegible]	[illegible]	[illegible]	0.32	0.36	0.32	0.31	0.32	0.36
	Y	0.19	0.26	0.37	0.36	0.35	0.25	0.36	0.31	0.38	0.32	0.32	0.31	0.38
	Z	0.31	0.47	0.53	0.41	0.37	0.38	0.49	0.45	0.53	0.38	0.40	0.37	0.53
0	X	0.17	0.23	0.38	0.35	0.27	0.26	0.38	0.35	0.39	0.35	0.34	0.33	0.39
	Y	0.19	0.27	0.41	0.38	0.39	0.26	0.37	0.32	0.40	0.36	0.34	0.37	0.41
	Z	0.31	0.48	0.58	0.42	0.39	0.39	0.55	0.50	0.60	0.44	0.47	0.45	0.60
4.7	X	0.17	0.24	0.45	0.36	0.28	0.27	0.44	0.40	0.45	0.36	0.35	0.37	0.45
	Y	0.19	0.28	0.46	0.38	0.41	0.27	0.42	0.36	0.47	0.37	0.37	0.45	0.47
	Z	0.31	0.49	0.64	0.44	0.41	0.42	0.61	0.55	0.66	0.50	0.54	0.58	0.66
8.1	X	0.17	0.25	0.49	0.40	0.29	0.28	0.48	0.43	0.51	0.35	0.41	0.42	0.51
	Y	0.19	0.29	0.50	0.41	0.43	0.28	0.45	0.41	0.54	0.41	0.41	0.51	0.54
	Z	0.31	0.50	0.67	0.46	0.43	0.45	0.67	0.58	0.71	0.55	0.62	0.70	0.71

Will be provided later.

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Table 3.7.2-14—Safeguard Building 4 ZPAs
Sheet 2 of 2

Will be provided later.

Safeguards Building 4														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
12	X	0.18	0.26	0.54	0.41	0.30	0.29	0.52	0.47	0.56	0.37	0.46	0.47	0.56
	Y	0.19	0.30	0.55	0.45	0.44	0.29	0.54	0.50	0.62	0.46	0.48	0.57	0.62
	Z	0.31	0.51	0.70	0.48	0.46	0.48	0.71	0.61	0.75	0.60	0.73	0.84	0.84
16.8	X	0.19	0.28	0.61	0.[illegible]	[illegible]	[illegible]	[illegible]	0.52	0.62	0.42	0.49	0.48	0.62
	Y	0.20	0.32	0.60	0.49	0.45	0.32	0.64	0.60	0.69	0.50	0.52	0.64	0.69
	Z	0.31	0.51	0.72	0.49	0.48	0.49	0.74	0.63	0.78	0.65	0.81	0.95	0.95
21	X	0.20	0.30	0.65	0.48	0.32	0.35	0.63	0.57	0.67	0.48	0.57	0.51	0.67
	Y	0.21	0.33	0.64	0.53	0.47	0.34	0.72	0.68	0.76	0.52	0.59	0.69	0.76
24.7	X	0.20	0.31	0.69	0.51	0.33	0.37	0.67	0.60	0.71	0.53	0.63	0.55	0.71
	Y	0.22	0.34	0.67	0.55	0.48	0.35	0.77	0.72	0.81	0.56	0.67	0.77	0.81
	Z	0.33	0.52	0.76	0.51	0.51	0.51	0.77	0.65	0.82	0.71	0.93	1.12	1.12
29.3	X	0.21	0.33	0.75	0.56	0.36	0.39	0.73	0.64	0.77	0.60	0.69	0.64	0.77
	Y	0.23	0.36	0.73	0.59	0.50	0.38	0.82	0.77	0.87	0.65	0.76	0.85	0.87
	Z	0.33	0.52	0.76	0.52	0.51	0.51	0.77	0.65	0.83	0.74	0.96	1.15	1.15

Table 3.7.2-15—Reactor Shield Building ZPAs
Sheet 1 of 3

Will be provided later.

Reactor Building Shield Structure														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-4.3	X	0.18	0.23	0.34	0.34	0.28	0.25	0.34	0.30	0.35	0.30	0.30	0.31	0.35
	Y	0.19	0.25	0.37	0.3[illegible]	[illegible]	[illegible]	[illegible]	0.31	0.37	0.29	0.30	0.31	0.37
	Z	0.28	0.35	0.47	0.42	0.36	0.34	0.36	0.37	0.39	0.30	0.32	0.30	0.47
2.6	X	0.17	0.23	0.40	0.35	0.27	0.26	0.39	0.35	0.39	0.31	0.30	0.28	0.40
	Y	0.18	0.25	0.37	0.35	0.33	0.24	0.31	0.30	0.38	0.29	0.30	0.31	0.38
	Z	0.28	0.36	0.49	0.44	0.37	0.35	0.40	0.40	0.44	0.34	0.36	0.35	0.49
8.1	X	0.17	0.25	0.49	0.38	0.28	0.28	0.48	0.43	0.49	0.34	0.40	0.40	0.49
	Y	0.17	0.26	0.40	0.36	0.37	0.25	0.36	0.34	0.42	0.33	0.36	0.37	0.42
	Z	0.28	0.37	0.50	0.47	0.41	0.36	0.45	0.42	0.48	0.38	0.40	0.42	0.50
12	X	0.18	0.26	0.55	0.40	0.30	0.29	0.52	0.48	0.55	0.35	0.47	0.44	0.55
	Y	0.17	0.27	0.43	0.36	0.37	0.26	0.38	0.37	0.48	0.37	0.40	0.39	0.48
	Z	0.28	0.37	0.52	0.48	0.42	0.37	0.48	0.45	0.52	0.40	0.43	0.46	0.52

Table 3.7.2-15—Reactor Shield Building ZPAs
Sheet 2 of 3

Reactor Building Shield Structure														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
16.8	X	0.19	0.28	0.61	0.43	0.31	0.31	0.57	0.53	0.61	0.40	0.52	0.47	0.61
	Y	0.17	0.28	0.50	0.40	0.38	0.27	0.42	0.41	0.56	0.40	0.43	0.43	0.56
	Z	0.28	0.38	0.54	0.49	0.43	0.38	0.50	0.47	0.57	0.46	0.49	0.56	0.57
22.5	X	0.19	0.29	0.66	[illegible]	[illegible]	[illegible]	[illegible]	0.56	0.63	0.44	0.56	0.52	0.66
	Y	0.18	0.30	0.54	0.41	0.38	0.28	0.46	0.45	0.59	0.41	0.47	0.48	0.59
	Z	0.27	0.38	0.58	0.52	0.43	0.39	0.53	0.50	0.64	0.48	0.53	0.57	0.64
28.8	X	0.20	0.32	0.76	0.54	0.36	0.39	0.72	0.64	0.76	0.57	0.69	0.64	0.76
	Y	0.18	0.34	0.66	0.45	0.42	0.30	0.55	0.50	0.73	0.53	0.61	0.60	0.73
	Z	0.28	0.39	0.59	0.51	0.45	0.43	0.56	0.52	0.66	0.52	0.55	0.66	0.66
34	X	0.19	0.34	0.79	0.52	0.38	0.39	0.70	0.64	0.80	0.58	0.71	0.70	0.80
	Y	0.20	0.36	0.72	0.51	0.48	0.34	0.63	0.59	0.78	0.60	0.66	0.66	0.78
	Z	0.27	0.39	0.60	0.54	0.46	0.41	0.59	0.56	0.68	0.58	0.63	0.68	0.68
37.6	X	0.19	0.34	0.85	0.56	0.40	0.41	0.75	0.68	0.85	0.65	0.76	0.76	0.85
	Y	0.20	0.38	0.76	0.56	0.44	0.32	0.64	0.58	0.82	0.66	0.72	0.72	0.82
	Z	0.29	0.43	0.59	0.54	0.49	0.44	0.64	0.59	0.71	0.57	0.64	0.74	0.74

Will be provided later.

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Table 3.7.2-15—Reactor Shield Building ZPAs
Sheet 3 of 3

Will be provided later.

Reactor Building Shield Structure													
Zero Period Accelerations at Each Floor Level (g)													
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)													
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case [illegible]	Case [illegible]	Case [illegible]	Case [illegible]	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
45.2	X	0.22	0.37	0.93	[illegible]	[illegible]	[illegible]	[illegible]	0.73	1.01	0.74	0.92	0.91	1.01
	Y	0.21	0.42	0.87	0.66	0.49	0.35	0.74	0.66	0.93	0.77	0.86	0.84	0.93
	Z	0.29	0.44	0.61	0.55	0.50	0.46	0.67	0.61	0.75	0.60	0.69	0.79	0.79
55.2	X	0.27	0.45	1.04	0.77	0.59	0.57	1.14	0.96	1.28	0.85	1.16	1.13	1.28
	Y	0.21	0.47	1.02	0.78	0.56	0.41	0.92	0.80	1.10	0.91	1.06	1.03	1.10
	Z	0.28	0.42	0.65	0.55	0.50	0.51	0.68	0.61	0.78	0.68	0.81	1.21	1.21
61	X	0.29	0.49	1.14	0.86	0.65	0.63	1.31	1.11	1.44	0.92	1.32	1.33	1.44
	Y	0.23	0.49	1.14	0.86	0.61	0.48	1.03	0.88	1.20	1.05	1.18	1.06	1.20
	Z	0.31	0.37	0.66	0.61	0.56	0.53	0.81	0.70	0.90	0.98	1.16	1.78	1.78

Table 3.7.2-16—Safeguard Building 2/3 Shield Structure ZPAs
Sheet 1 of 2

Safeguards Building 2/3 Shield Structure														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-8.6	X	0.18	0.24	0.31	0.35	0.30	0.25	0.31	0.28	0.33	0.28	0.29	0.29	0.35
	Y	0.20	0.24	0.34	0.34	0.32	0.23	0.32	0.30	0.35	0.26	0.28	0.29	0.35
	Z	0.33	0.47	0.48	0.45	0.39	0.38	0.38	0.41	0.39	0.34	0.35	0.29	0.48
-4.5	X	0.18	0.24	0.33	0.34	0.30	0.24	0.32	0.30	0.34	0.29	0.30	0.31	0.34
	Y	0.19	0.25	0.37	0.[illegible]	[illegible]	[illegible]	[illegible]	0.31	0.36	0.29	0.32	0.33	0.37
	Z	0.33	0.47	0.49	0.46	0.39	0.38	0.39	0.42	0.42	0.37	0.37	0.33	0.49
0	X	0.18	0.25	0.36	0.35	0.30	0.25	0.36	0.33	0.37	0.33	0.32	0.31	0.37
	Y	0.19	0.26	0.38	0.38	0.35	0.25	0.33	0.31	0.38	0.33	0.34	0.35	0.38
	Z	0.33	0.47	0.51	0.48	0.39	0.38	0.41	0.44	0.44	0.39	0.40	0.36	0.51
4.7	X	0.18	0.25	0.41	0.37	0.30	0.26	0.41	0.38	0.41	0.34	0.33	0.32	0.41
	Y	0.18	0.25	0.38	0.36	0.35	0.24	0.33	0.32	0.40	0.30	0.35	0.35	0.40
	Z	0.33	0.48	0.52	0.50	0.40	0.38	0.42	0.46	0.46	0.41	0.42	0.40	0.52
8.1	X	0.17	0.25	0.45	0.38	0.30	0.27	0.46	0.41	0.46	0.35	0.39	0.37	0.46
	Y	0.17	0.26	0.39	0.36	0.36	0.25	0.35	0.34	0.42	0.30	0.34	0.35	0.42
	Z	0.33	0.48	0.53	0.51	0.40	0.40	0.44	0.47	0.48	0.42	0.44	0.42	0.53

Will be provided later.

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Table 3.7.2-16—Safeguard Building 2/3 Shield Structure ZPAs
Sheet 2 of 2

Safeguards Building 2/3 Shield Structure													
Zero Period Accelerations at Each Floor Level (g)													
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
12	X	0.17	0.26	0.50	0.40	0.30	0.28	0.51	0.46	0.54	0.35	0.47	0.42	0.54
	Y	0.17	0.26	0.42	0.37	0.36	0.26	0.37	0.35	0.45	0.32	0.37	0.36	0.45
	Z	0.33	0.48	0.54	0.[illegible]	[illegible]	[illegible]	[illegible]	0.48	0.50	0.44	0.45	0.46	0.54
15.4	X	0.18	0.27	0.54	0.42	0.31	0.29	0.55	0.49	0.56	0.37	0.47	0.43	0.56
	Y	0.17	0.27	0.46	0.37	0.36	0.26	0.39	0.36	0.47	0.33	0.40	0.38	0.47
	Z	0.33	0.48	0.55	0.53	0.41	0.42	0.47	0.49	0.51	0.46	0.47	0.49	0.55
21	X	0.19	0.29	0.63	0.46	0.32	0.33	0.61	0.55	0.63	0.43	0.57	0.52	0.63
	Y	0.17	0.29	0.53	0.39	0.38	0.28	0.43	0.41	0.55	0.37	0.45	0.45	0.55
	Z	0.33	0.49	0.56	0.54	0.41	0.43	0.48	0.51	0.54	0.49	0.50	0.56	0.56
28.8	X	0.19	0.32	0.73	0.50	0.36	0.38	0.68	0.62	0.70	0.53	0.69	0.62	0.73
	Y	0.18	0.32	0.60	0.43	0.40	0.29	0.51	0.46	0.63	0.46	0.51	0.54	0.63
	Z	0.33	0.49	0.57	0.55	0.42	0.44	0.51	0.52	0.57	0.55	0.58	0.66	0.66

Will be provided later.

Table 3.7.2-17—Fuel Building Shield Structure ZPAs
Sheet 1 of 3

Fuel Building Shield Structure														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
-9.6	X	0.18	0.23	0.34	0.36	0.28	0.26	0.30	0.28	0.32	0.28	0.28	0.29	0.36
	Y	0.20	0.24	0.34	0.34	0.32	0.23	0.32	0.30	0.35	0.26	0.28	0.29	0.35
	Z	0.34	0.49	0.51	0.44	0.48	0.37	0.37	0.37	0.40	0.31	0.29	0.29	0.51
-6.2	X	0.18	0.23	0.37	0.36	[illegible]	[illegible]	[illegible]	0.30	0.34	0.29	0.29	0.29	0.37
	Y	0.19	0.25	0.36	0.36	0.33	0.24	0.33	0.31	0.36	0.29	0.29	0.29	0.36
	Z	0.34	0.50	0.54	0.45	0.48	0.38	0.39	0.39	0.43	0.31	0.33	0.34	0.54
-3.4	X	0.18	0.23	0.40	0.35	0.27	0.26	0.34	0.31	0.35	0.31	0.30	0.30	0.40
	Y	0.19	0.25	0.37	0.37	0.34	0.24	0.32	0.31	0.38	0.30	0.31	0.32	0.38
	Z	0.34	0.50	0.56	0.46	0.50	0.39	0.41	0.40	0.44	0.32	0.34	0.38	0.56
0	X	0.18	0.23	0.42	0.35	0.27	0.26	0.37	0.34	0.38	0.32	0.31	0.33	0.42
	Y	0.18	0.25	0.38	0.36	0.35	0.25	0.33	0.32	0.39	0.31	0.34	0.35	0.39
	Z	0.34	0.50	0.59	0.47	0.51	0.39	0.43	0.42	0.46	0.34	0.37	0.42	0.59
3.7	X	0.18	0.24	0.44	0.36	0.27	0.26	0.40	0.37	0.42	0.33	0.33	0.36	0.44
	Y	0.18	0.26	0.39	0.36	0.35	0.25	0.35	0.32	0.41	0.33	0.41	0.39	0.41
	Z	0.35	0.51	0.62	0.49	0.53	0.40	0.44	0.43	0.48	0.36	0.39	0.48	0.62

Will be provided later.

Table 3.7.2-17—Fuel Building Shield Structure ZPAs
Sheet 2 of 3

Fuel Building Shield Structure														
Zero Period Accelerations at Each Floor Level (g)														
	Motion =>	EURS	EURS	EURM	EURM	EURS	EURM	EURM	EURM	EURM	EURH	EURH	EURH	
	Soil Case =>	1u	1n2u	2sn4u	2n3u	2u	2u	3r3u	3u	4u	4u	5u	5a	
Acceleration (g)														
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
7.4	X	0.18	0.25	0.47	0.38	0.29	0.27	0.45	0.41	0.47	0.34	0.36	0.39	0.47
	Y	0.18	0.27	0.40	0.36	0.36	0.26	0.36	0.35	0.42	0.38	0.46	0.44	0.46
	Z	0.35	0.51	0.64	0.51	0.54	0.41	0.46	0.46	0.51	0.38	0.43	0.53	0.64
11.1	X	0.18	0.25	0.50	0.39	[illegible]	[illegible]	[illegible]	.44	0.52	0.34	0.38	0.41	0.52
	Y	0.17	0.28	0.42	0.38	0.37	0.26	0.39	0.38	0.45	0.42	0.50	0.47	0.50
	Z	0.35	0.52	0.65	0.52	0.55	0.42	0.47	0.47	0.54	0.39	0.46	0.57	0.65
14.8	X	0.18	0.26	0.55	0.41	0.32	0.29	0.52	0.48	0.56	0.35	0.42	0.44	0.56
	Y	0.18	0.29	0.46	0.40	0.39	0.27	0.43	0.42	0.50	0.45	0.53	0.49	0.53
	Z	0.35	0.52	0.67	0.53	0.56	0.43	0.49	0.48	0.57	0.41	0.49	0.61	0.67
19.5	X	0.19	0.28	0.61	0.44	0.33	0.32	0.57	0.52	0.61	0.39	0.48	0.48	0.61
	Y	0.18	0.31	0.52	0.43	0.41	0.28	0.46	0.47	0.57	0.48	0.54	0.49	0.57
	Z	0.35	0.53	0.68	0.55	0.57	0.44	0.51	0.50	0.60	0.42	0.52	0.64	0.68
24.2	X	0.20	0.31	0.70	0.49	0.34	0.36	0.64	0.58	0.69	0.48	0.60	0.56	0.70
	Y	0.18	0.32	0.60	0.45	0.44	0.29	0.49	0.48	0.65	0.49	0.53	0.52	0.65
	Z	0.35	0.53	0.69	0.56	0.58	0.44	0.53	0.51	0.62	0.45	0.55	0.68	0.69

Will be provided later.

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Table 3.7.2-17—Fuel Building Shield Structure ZPAs
Sheet 3 of 3

Will be provided later.

Fuel Building Shield Structure														
Zero Period Accelerations at Each Floor Level (g)														
	Motion => Soil Case =>	EURS 1u	EURS 1n2u	EURM 2sn4u	EURM 2n3u	EURS 2u	EURM 2u	EURM 3r3u	EURM 3u	EURM 4u	EURH 4u	EURH 5u	EURH 5a	
Elevation (m)	Direction	Case 1us	Case 1n2us	Case 2sn4um	Case 2n3um	Case 2us	Case 2um	Case 3r3um	Case 3um	Case 4um	Case 4uh	Case 5uh	Case 5ah	Envelope All Cases
34	X	0.20	0.34	0.79	0.53	0.38	0.39	0.70	0.63	0.80	0.58	0.68	0.70	0.80
	Y	0.21	0.35	0.73	0.49	0.49	0.35	0.64	0.59	0.79	0.58	0.64	0.64	0.79
	Z	0.36	0.54	0.71	0.57	0.60	0.45	0.59	0.56	0.68	0.49	0.59	0.72	0.72

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Table 3.7.2-18—Maximum Base Forces and Moments at Bottom of NI Common Basemat

Maximum Forces at the Base of the NI Common Basemat Superstructure								
Square Root of Sum of Squares (SRSS)								
Motion	Soil Case	Case	Axial P1(max) kN	(N-S) Shear-Y P2(max) kN	(E-W) Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
EURS	1u	1us	932930	698402	739860	3554709	18465001	17360132
EURS	1n2u	1n2us	1264307	1087139	1047388	5209445	35353946	38916211
EURM	2sn4u	2sn4um	1774284	1724397	1965878	9075055	66805657	68237699
EURM	2n3u	2n3um	1713170	[illegible]	[illegible]	6703663	46549337	48710946
EURS	2u	2us	1297671	[illegible]	[illegible]	5246059	38463191	40395444
EURM	2u	2um	1272451	974226	1013483	5698046	30293679	29806465
EURM	3r3u	3r3um	1479960	1633515	1787823	5655506	56535943	57445881
EURM	3u	3um	1507621	1449604	1664432	5662896	53803700	52550945
EURM	4u	4um	1603082	1935797	1953863	5566116	65575902	66218490
EURH	4u	4uh	1397345	1186127	1332752	5360311	44773097	45195620
EURH	5u	5uh	1479772	1265928	1306525	6327764	42213283	51202071
EURH	5a	5ah	1594920	1405012	1371250	9214202	41337112	52539171
		Envelope	1,774,284	1,935,797	1,965,878	9,214,202	66,805,657	68,237,699

Will be provided later.

Table 3.7.2-19—~~Worst Case Inter-Story Forces and Moments in Reactor Building Internal Structures~~
~~Sheet 1 of 2~~

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Maximum Forces Profile for the Reactor Building Internals								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
-6.15	1	1004	263191	279950	246495	812689	5420609	5733889
-2.3	1	1011	263191	279950	246495	812689	4480352	4696474
-2.3	2	1014	240445	246380	218889	716068	4446724	4660571
1.5	2	1021	240445	246380	218889	716068	3626493	3743655
1.5	3	1024	192[illegible]	[illegible]	[illegible]375	864089	3555280	3652522
5.15	3	1031	192444	215435	192375	864089	2860051	2875972
5.15	4	1034	168661	190168	172364	720669	2836849	2868622
6.92	4	1036	168661	190168	172364	720669	2540619	2534041
6.92	5	1038	155251	176133	160562	677657	2521788	2552598
9.38	5	1041	155251	176133	160562	677657	2137521	2127840
9.38	6	1044	135167	152113	142655	584057	2107647	2075413
13.8	6	1051	135167	152113	142655	584057	1505885	1416453
13.8	7	1054	112362	127060	122405	448407	1476522	1375600
16.45	7	1056	112362	127060	122405	448407	1158725	1051735
16.45	8	1056	111613	126564	121510	445338	1156610	1048094
19.5	8	1061	111613	126564	121510	445338	904284	833704
19.5	10,9	1068	68734	62897	62179	157433	579540	581721

Table 3.7.2-19—Worst Case Inter-Story Forces and Moments in Reactor Building Internal Structures
Sheet 2 of 2

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Maximum Forces Profile for the Reactor Building Internals									
Square Root of Sum of Squares (SRSS)									
Envelope of All 12 Soil/Motion Combinations									
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y kN	E-W Shear-X (max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
24.1	11,9	1078	68734	62238	61845	156740	368897	318250
24.1	13,12	1075	28302	31272	31508	75313	234220	242041
28.5	13,12	1085	28302	31272	31508	75313	116719	109645
28.5	26,27	1088	7576	3868	5363	7572	3130	45507
34.45	26,28	1098	7576	3868	5363	7572	3130	534

Table 3.7.2-20—~~Worst Case Inter-Story Forces and Moments in Reactor Containment Building~~
~~Sheet 1 of 2~~

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Maximum Forces Profile for the Containment								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
-2.3	1	3004	181603	173306	176276	297870	6919405	7256114
2.6	1	3014	181603	173306	176276	297870	6073003	6410111
2.6	2	3014	175603	168106	168459	289386	6078004	6398110
8.1	2	3024	175603	168106	168459	289386	5169004	5474128
8.1	3	3024	168303	162806	160900	276064	5151004	5461125
12	3	3034	168[illegible]	[illegible]	[illegible]900	276064	4526005	4826146
12	4	3034	159403	156305	153800	257715	4498005	4799141
17.8	4	3044	159403	156305	153800	257715	3605006	3893179
17.8	5	3044	147702	147404	144200	232529	3567006	3851168
22.5	5	3054	147702	147404	144200	232529	2891006	3158208
22.5	6	3054	134002	135903	132100	200275	2849003	3105153
28.8	6	3064	134002	135903	132100	200275	2053003	2262209
28.8	7	3064	117202	120702	115700	162927	1979002	2194184
34	7	3074	117202	120702	115700	162927	1488002	1581239
34	8	3074	103202	106602	101200	129021	1407002	1523214
37.6	8	3084	103202	106602	101200	129021	1110002	1147265
37.6	9	3084	81842	84122	78030	92530	998402	1058060

Table 3.7.2-20—Worst Case Inter-Story Forces and Moments in Reactor Containment Building
Sheet 2 of 2

Maximum Forces Profile for the Containment								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial DELETED.	N-S Shear-Y	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
43.92	9	3094	81842	84122	78030	92530	590601	600573
43.92	10	3094	24511	39342	35020	0	335401	375115
53.3	10	3100	24511	39342	35020	0	7433	7471
53.3	11	3100	2465	1589	1582	0	7433	7471
58	11	3101	2465	1589	1582	0	0	0

Table 3.7.2-21—~~Worst Case Inter-Story Forces and Moments in Reactor Shield Building~~
~~Sheet 1 of 3~~

Maximum Forces Profile for the Reactor Building Shield								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
-4.3	1	2004	244043	367995	411246	925810	13064261	14050984
-3.4	1	2008	244043	367995	411246	925810	12703331	13740631
-3.4	2	2008	243974	351900	406407	915162	12683416	13729972
0	2	2010	243974	351900	406407	915162	11508704	12588613
0	3	2010	243153	321556	370727	898739	11578747	12648249
2.6	3	2014	24315	DELETED.		898739	10808117	11827377
2.6	4	2014	236956	313806	358897	883341	10758092	11767340
3.7	4	2018	236956	313806	358897	883341	10437917	11426916
3.7	5	2018	236904	305998	357386	869438	10447957	11467129
4.7	5	2020	236904	305998	357386	869438	10157777	11166703
4.7	6	2020	235538	304547	348673	846675	10307934	11186614
7.4	6	2022	235538	304547	348673	846675	9535387	10375854
7.4	7	2022	235572	297472	347657	827897	9545437	10426131
8.1	7	2024	235572	297472	347657	827897	9364293	10215863
8.1	8	2024	227415	288792	321087	783489	9484383	10185908
11.1	8	2028	227415	288792	321087	783489	8720820	9328006
11.1	9	2028	227539	282332	320680	769347	8735879	9396255

Table 3.7.2-21—Worst Case Inter-Story Forces and Moments in Reactor Shield Building
Sheet 2 of 3

Maximum Forces Profile for the Reactor Building Shield								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
12	9	2034	227539	282332	320680	769347	8511692	9148008
12	10	2034	218486	274901	286252	718003	8662828	9135041
14.8	10	2038	218486	274901	286252	718003	8013307	8387441
14.8	11	2038	218605	269114	286348	701076	8033371	8468892
15.4	11	2040	218605	269114	286348	701076	7894271	8311776
15.4	12	2040	219	DELETED.	369	693892	7918291	8378191
16.8	12	2044	219157	274408	288869	693892	7591058	8003904
16.8	13	2044	205865	250191	257056	620174	7750283	7917599
19.5	13	2048	205865	250191	257056	620174	7151940	7254302
19.5	14	2048	206079	245229	258055	606810	7180043	7345664
21	14	2050	206079	245229	258055	606810	6863808	6984351
21	15	2050	203828	256118	248526	607333	7174266	7055674
22.5	15	2054	203828	256118	248526	607333	6857979	6676379
22.5	16	2054	189426	236791	226165	542563	6680943	6572695
24.7	16	2058	189426	236791	226165	542563	6243550	6057312
24.7	17	2058	187163	229082	224601	536330	6584952	6155520
28.8	17	2064	187163	229082	224601	536330	5713525	5226373
28.8	22,23	2061, 2065	168626	240375	247015	687239	5898046	5211884

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Table 3.7.2-21—Worst Case Inter-Story Forces and Moments in Reactor Shield Building
Sheet 3 of 3

Maximum Forces Profile for the Reactor Building Shield								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
34	22,23	2071, 2075	168626	240275	247015	687239	4652252	3969954
34	18	2074	154116	217121	234738	407159	4516715	3994626
37.6	18	2084	154116	217121	234738	407159	3701925	3220146
37.6	19	2084	133714	184065	201909	297558	3469722	3051552
45.2	19	2094	133714	184065	201909	297558	1979220	1666812
45.2	20	2094	73958	107996	122335	0	1389549	1225361
56.2	20	2102	73958	107996	122335	0	43999	37210
56.2	21	2102	7688	7751	9166	0	43999	37210
61	21	2104	7688	7751	9166	0	0	0

Table 3.7.2-22—~~Worst Case Inter-Story Forces and Moments in Safeguard Building 1~~

Maximum Forces Profile for the Safeguard Bldg 1								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
-8.6	83	4004	192460	111154	73955	476482	2929270	2623115
-4.5	83	4011	192460	111154	73955	476482	2634179	2185457
-4.5	84	4014	176070	101731	96532	242973	2539298	2192676
0	84	4021	176070	101731	96532	242973	2108990	1789146
0	85	4024	165088	87545	100733	284494	2075939	1780002
4.7	85	4031	165088	[illegible]	[illegible]	284494	1606771	1398409
4.7	86	4034	151543	[illegible]	[illegible]	257578	1566291	1392592
8.1	86	4041	151543	78215	92229	257578	1260331	1150214
8.1	87	4044	138380	73069	89289	269046	1304628	1146223
12	87	4051	138380	73069	89289	269046	999557	889340
12	88	4054	117124	65622	85084	334754	949112	865082
16.8	88	4061	117124	65622	85084	334754	656284	569884
16.8	89	4064	86231	48492	69024	267636	694171	525206
21	89	4071	86231	48492	69024	267636	417410	376458
21	90	4074	57177	34986	54557	201098	391941	277173
24.7	90	4081	57177	34986	54557	201098	197235	219933
24.7	91	4084	26290	15409	34899	203944	182448	118670
29.3	91	4091	26290	15409	34899	203944	76675	93022

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Table 3.7.2-23—~~Worst Case Inter-Story Forces and Moments in Safeguard Building 2/3~~

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Maximum Forces Profile for the Safeguard Bldg 2/3 Square Root of Sum of Squares (SRSS) Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
-8.6	171	5004	220909	163129	190186	691341	4316724	4334698
-4.5	171	5011	220909	163129	190186	691341	3543104	3666177
-4.5	172	5014	197469	168090	174885	1087440	3539099	3605226
0	172	5021	197469	168090	174885	1087440	2761090	2850654
0	173	5024	174802	179734	162903	1493759	2746675	2841268
4.7	173	5031	1748[illegible]	[illegible]	[illegible]03	1493759	1981932	2001676
4.7	174	5034	149805	155085	145503	1584856	1954084	1994233
8.1	174	5041	149805	155085	145503	1584856	1460094	1537093
8.1	175	5044	118856	134124	127402	1450554	1431081	1448704
12	175	5051	118856	134124	127402	1450554	994900	989972
12	176	5054	89516	102966	100502	1184500	931804	955419
15.4	176	5061	89516	102966	100502	1184500	639631	671623
15.4	177	5064	55121	65179	67672	496805	561045	543660
21	177	5071	55121	65179	67672	496805	226857	241559
21	178	5074	13154	16094	13591	147109	106957	128834
26.8	178	5081	13154	16094	13591	147109	56737	54186

Table 3.7.2-24—~~Worst Case Inter-Story Forces and Moments in Safeguard Building 4~~

Maximum Forces Profile for the Safeguard Bldg 4								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
-8.6	335	7004	175634	122493	81047	474637	2964472	2970026
-4.5	335	7011	175634	122493	81047	474637	2642289	2470291
-4.5	336	7014	168408	114531	99661	270079	2570319	2470812
0	336	7021	168408	114531	99661	270079	2127877	1984415
0	337	7024	158720	103442	104377	196427	2087773	1976018
4.7	337	7031	158720	103442	104377	196427	1602417	1550308
4.7	338	7034	147231	DELETED.		206569	1567181	1541333
8.1	338	7041	147231	92156	95400	206569	1249676	1249172
8.1	339	7044	135043	84306	91287	170315	1289151	1242530
12	339	7051	135043	84306	91287	170315	969720	926619
12	340	7054	115189	71913	85408	251459	943287	909889
16.8	340	7061	115189	71913	85408	251459	689006	587319
16.8	341	7064	85934	52341	67232	363583	701802	574708
21	341	7071	85934	52341	67232	363583	433344	419903
21	342	7074	56895	36396	52410	115620	356722	287005
24.7	342	7081	56895	36396	52410	115620	188403	203443
24.7	343	7084	26732	16463	34994	161288	163693	116050
29.3	343	7091	26732	16463	34994	161288	71062	72146

Table 3.7.2-25—~~Worst Case Inter-Story Forces and Moments in Safeguard Building 2/3 Shield Structure~~

Maximum Forces Profile for the Safeguard Bldg 2/3 Shield								
Square Root of Sum of Squares (SRSS)								
Envelope of All 12 Soil/Motion Combinations								
Elevation m	Element No.	Node No.	Axial P1(max) kN	N-S Shear-Y P2(max) kN	E-W Shear-X P3(max) kN	Torsion M1(max) kN-m	Mom-YY M2(max) kN-m	Mom-XX M3(max) kN-m
-8.6	236	6004	168476	279870	169078	1216396	5638079	7933471
-4.5	236	6011	168476	279870	169078	1216396	4976590	6795701
-4.5	237	6014	155762	274805	162957	1215400	4929550	6801721
0	237	6021	155762	274805	162957	1215400	4207806	5583067
0	238	6024	141136	[illegible]	[illegible]	1234539	4155140	5526144
4.7	238	6031	141136	[illegible]	[illegible]	1234539	3427764	4333926
4.7	239	6034	127969	239660	147530	1255714	3346064	4298374
8.1	239	6041	127969	239660	147530	1255714	2848255	3486467
8.1	240	6044	116253	217595	137243	1192292	2786204	3466407
12	240	6051	116253	217595	137243	1192292	2255179	2619862
12	241	6054	103718	188815	125196	1266542	2187519	2568937
15.4	241	6061	103718	188815	125196	1266542	1764802	1930536
15.4	242	6064	89179	167917	110854	1585441	1672780	1861597
21	242	6071	89179	167917	110854	1585441	1063502	1023005
21	243	6074	68008	121605	88477	1380985	946527	967041
28.8	243	6081	68008	121605	88477	1380985	325502	461170

DELETED.

Table 3.7.2-26—Maximum NI Common Basemat Displacement Relative to Free Field Input Motion

SSI Analysis Case	RD-X (inch)	RD-Y (inch)	RD-Z (inch)
1us	1.095	0.772	0.656
1n2us	0.673	0.698	0.380
2us	0.327	0.347	0.221
2um	0.250	0.252	0.183
2n3um	0.351	0.358	0.179
2sn4um	[illegible]	[illegible]	0.121
3r3um	0.145	0.108	0.084
3um	0.189	0.146	0.101
4um	0.108	0.090	0.052
4uh	0.061	0.056	0.038
5uh	0.037	0.036	0.023
5ah	0.000	0.001	0.000

Will be provided later.

Table 3.7.2-27—Worst Case Maximum Accelerations in EPGB

Slab Elevation	X-Direction	Y-Direction	Z-Direction
+68 ft, 0 in	1.150g	1.364g	1.116g
+51 ft, 6 in	[illegible]	[illegible]g	0.977g
+19 ft, 3 in	0.645g	0.756g	0.646g
0 ft, 0 in	0.499g	0.523g	0.633g

Will be provided later.

Table 3.7.2-28—Worst Case Maximum Accelerations in ESWB

Slab Elevation	X-Direction	Y-Direction	Z-Direction
+114 ft, 0 in	0.957g	1.018g	1.481g
+80 ft, 9 in	0.790g	0.754g	1.218g
+61 ft, 10 in	0[illegible]	[illegible]	0.738g
+33 ft, 0 in	0.586g	0.561g	0.617g
0 ft, 0 in	0.447g	0.372g	0.568g

Will be provided later.

Table 3.7.2-29—Seismic Structural Interaction Criteria for Building Structures

Basis: Control Interaction through Prevention of Structure-to-Structure Impact[4]				
Structure	**Seismic Category**	**Design Code**	**Seismic Interaction Criteria**	**Seismic Interaction Evaluation**
Turbine / SBO	II	[[AISC N690]] [[ACI 349]]	Site-specific SSE	[[COL applicant will demonstrate that there is not interaction potential]]
Access	II	[[AISC N690]] [[ACI 349]]	Site-specific SSE	[[COL applicant will demonstrate that there is not interaction potential]]
NAB	II RS	AISC N690 ACI 349	SSE	No Interaction Potential
RWB	RS	AISC N690[3] ACI 349[3]	None[1]	No Interaction Potential

Notes:

1. The RWB, as a radwaste structure, is designed for the ½ SSE in accordance with the guidance for RW-IIa structures in RG 1.143.
2. Deleted.
3. ACI 349 and AISC N690 required due to Radwaste Seismic classification.
4. This table is not applicable to equipment and subsystems qualification criteria.

Table 3.7.2-30 Modal Frequencies of 3D FEM of Emergency Power Generating Building (HF Motion)

Will be provided later.

Table 3.7.2-30 Modal Frequencies of 3D FEM of Essential Service Water Building (HF Motion)

Will be provided later.

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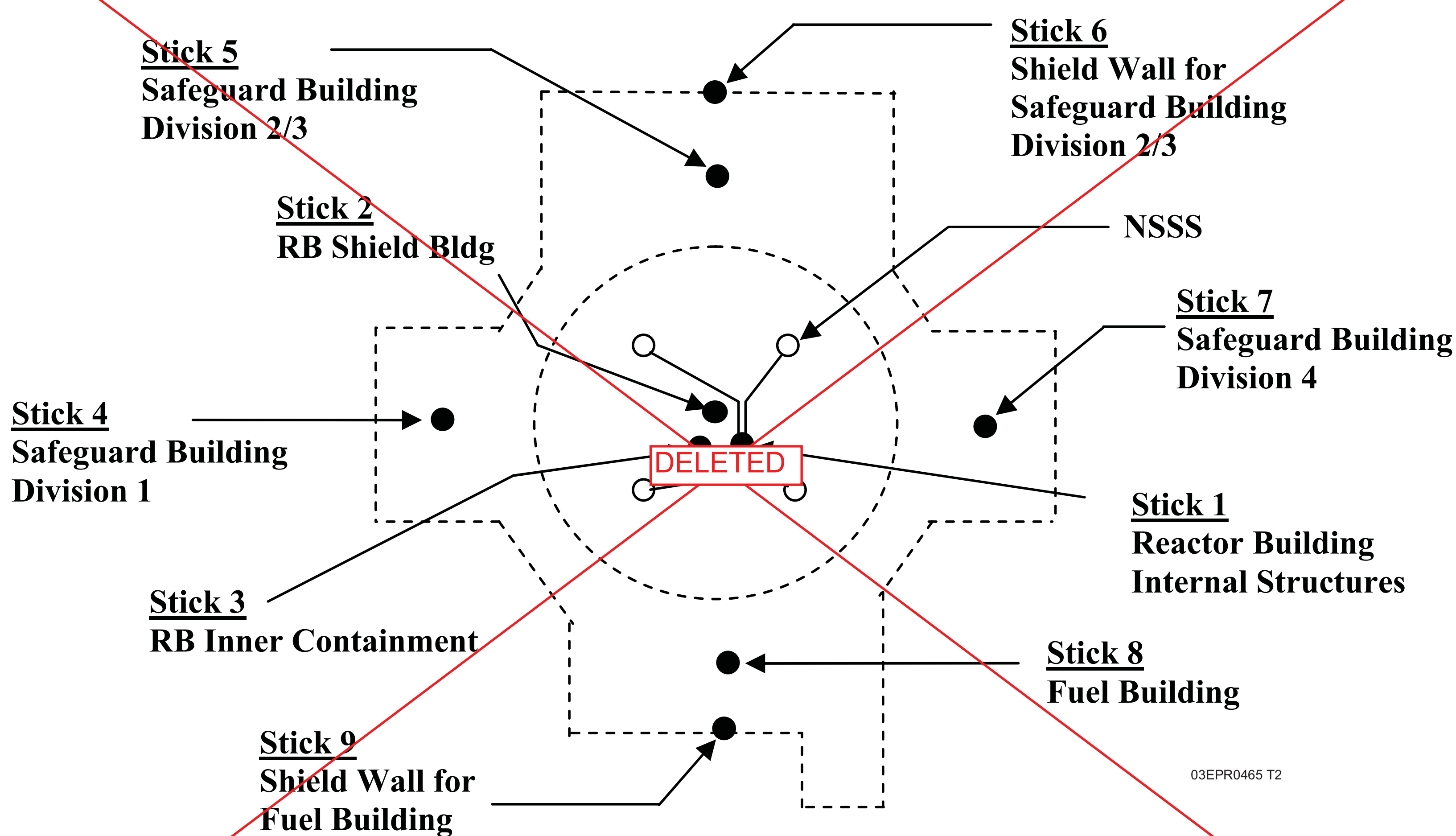
Figure 3.7.2-1—Decoupling of the Nuclear Island Common Basemat Interior Structures from the Outer Shield Walls

Will be provided later.

Figure 3.7.2-2—~~Plan View of Schematic Stick Model for Nuclear Island Common Basemat Structures~~



Reactor Building Internal

Figure 3.7.2-3—Schematic Elevation View of Stick Model for ~~Nuclear Island Common Basemat~~ Structures in Global Y-Z Plane

Will be provided later.

Figure 3.7.2-4—~~Schematic Elevation View of Stick Model for Nuclear Island Common Basemat Structures in Global X-Z Plane~~

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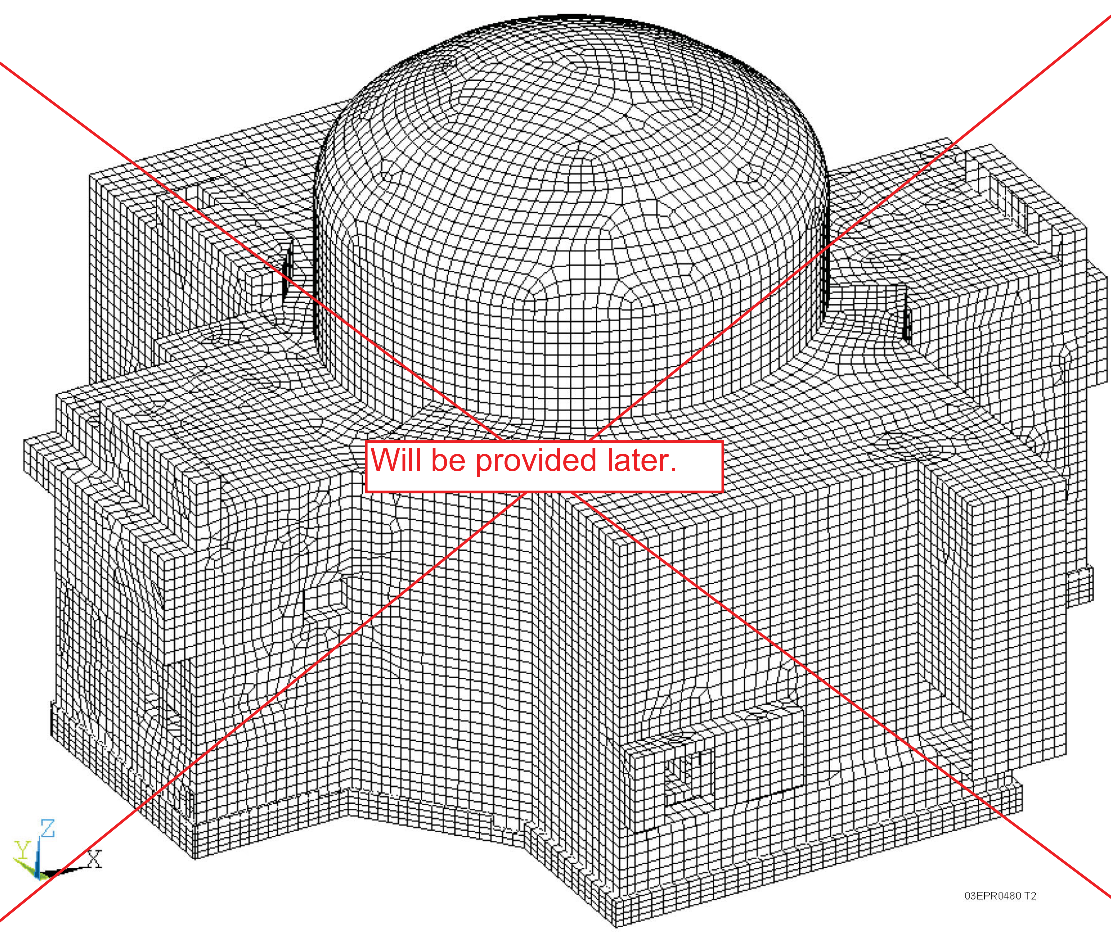
Static

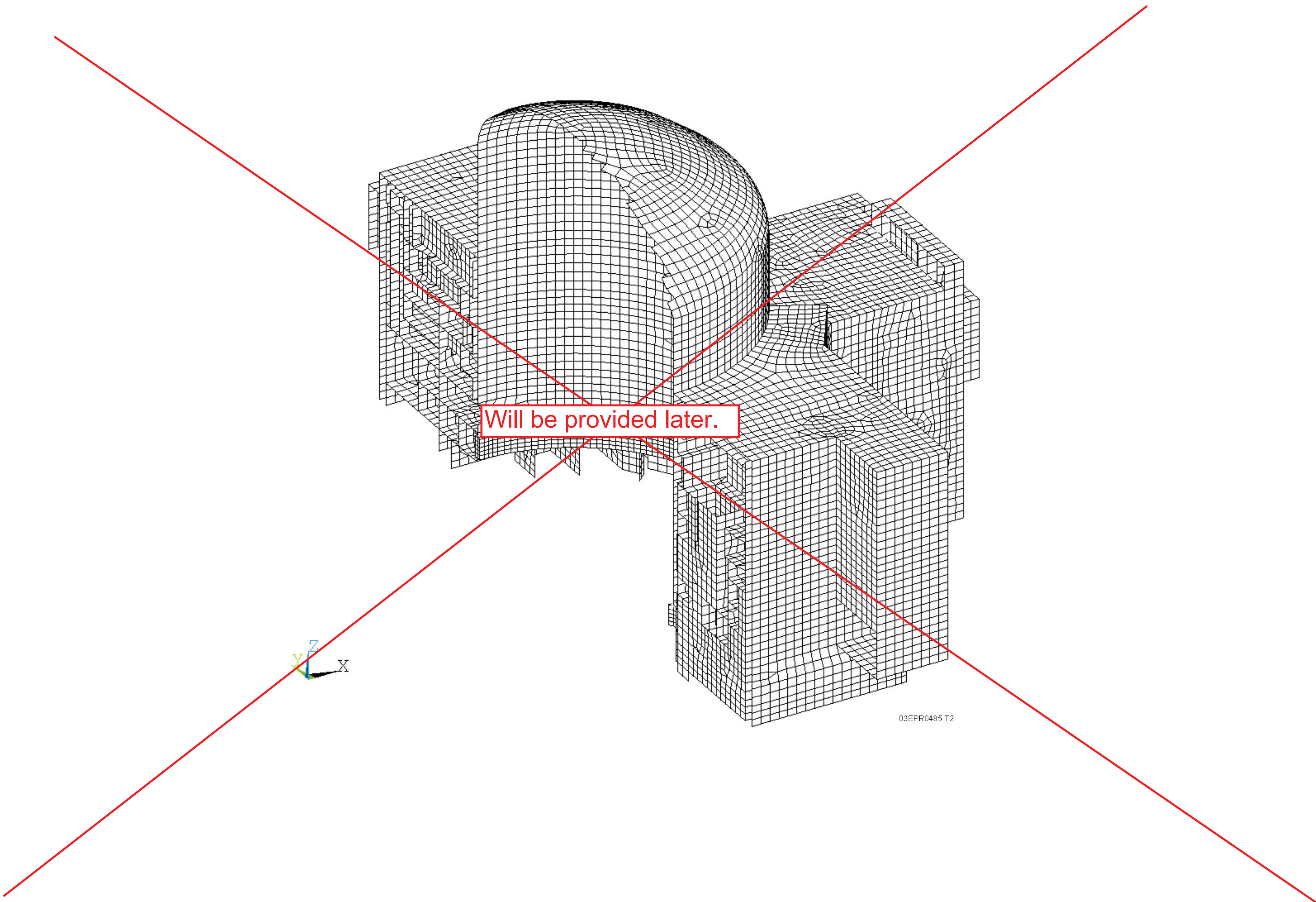
Figure 3.7.2-5—3D Finite Element Model of Balance of NI Common Basemat Structures Perspective View



Will be provided later.

Static

Figure 3.7.2-6—3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on Y-Z Plane



Static

Figure 3.7.2-7—3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on X-Z Plane

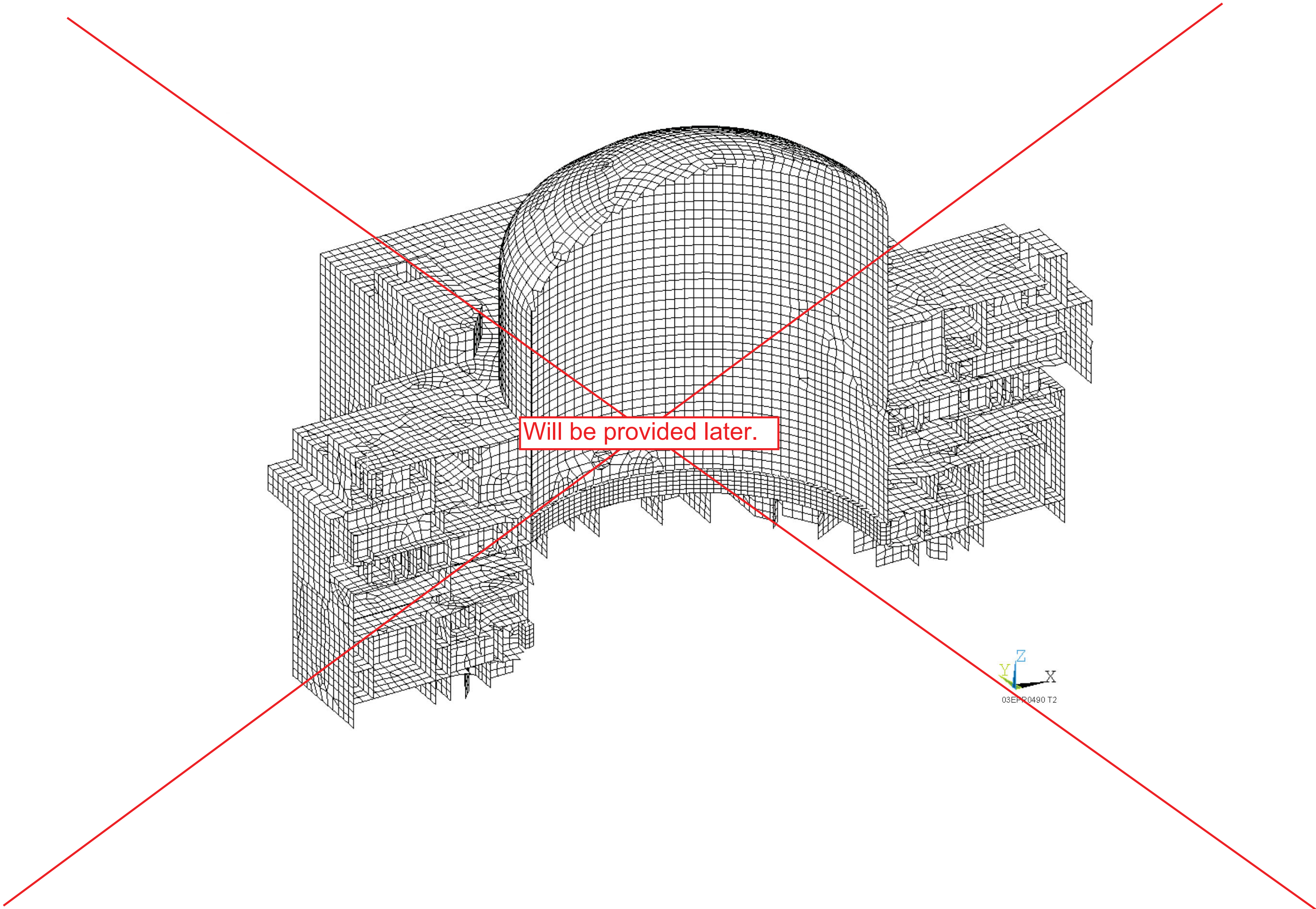


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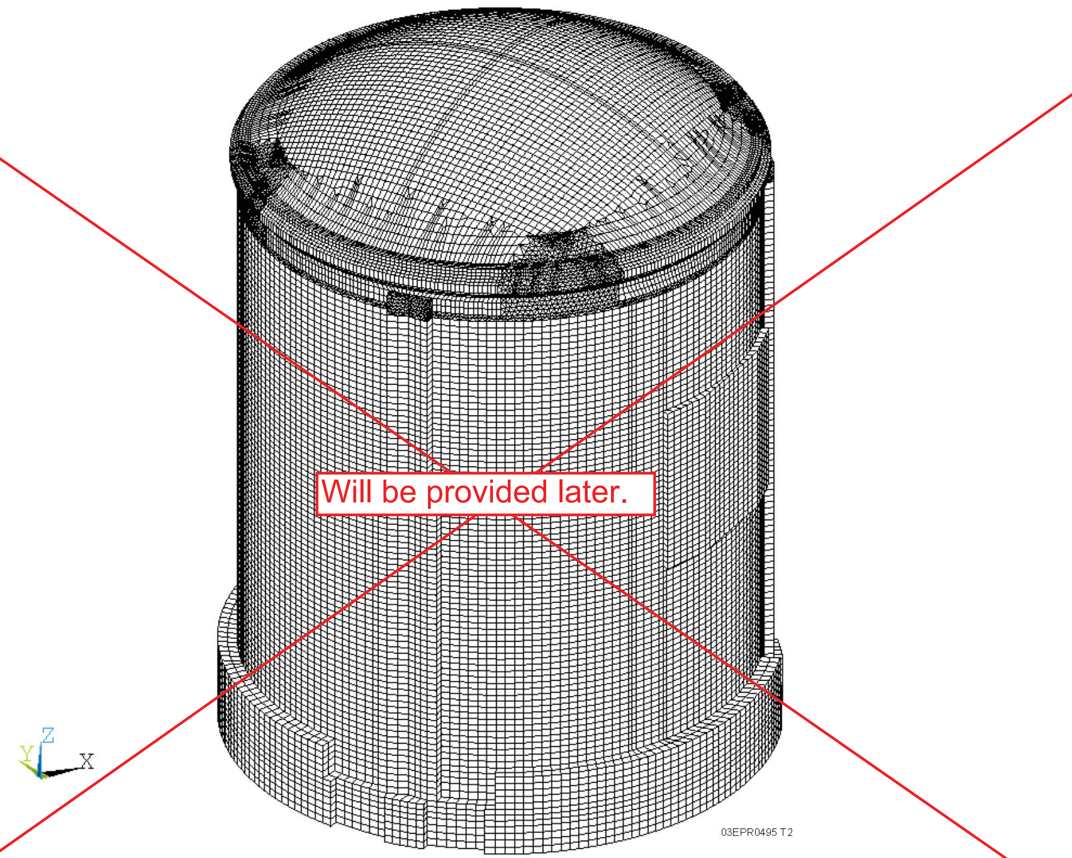
Figure 3.7.2-8—3D Finite Element Model of Reactor Containment Building



Will be provided later.

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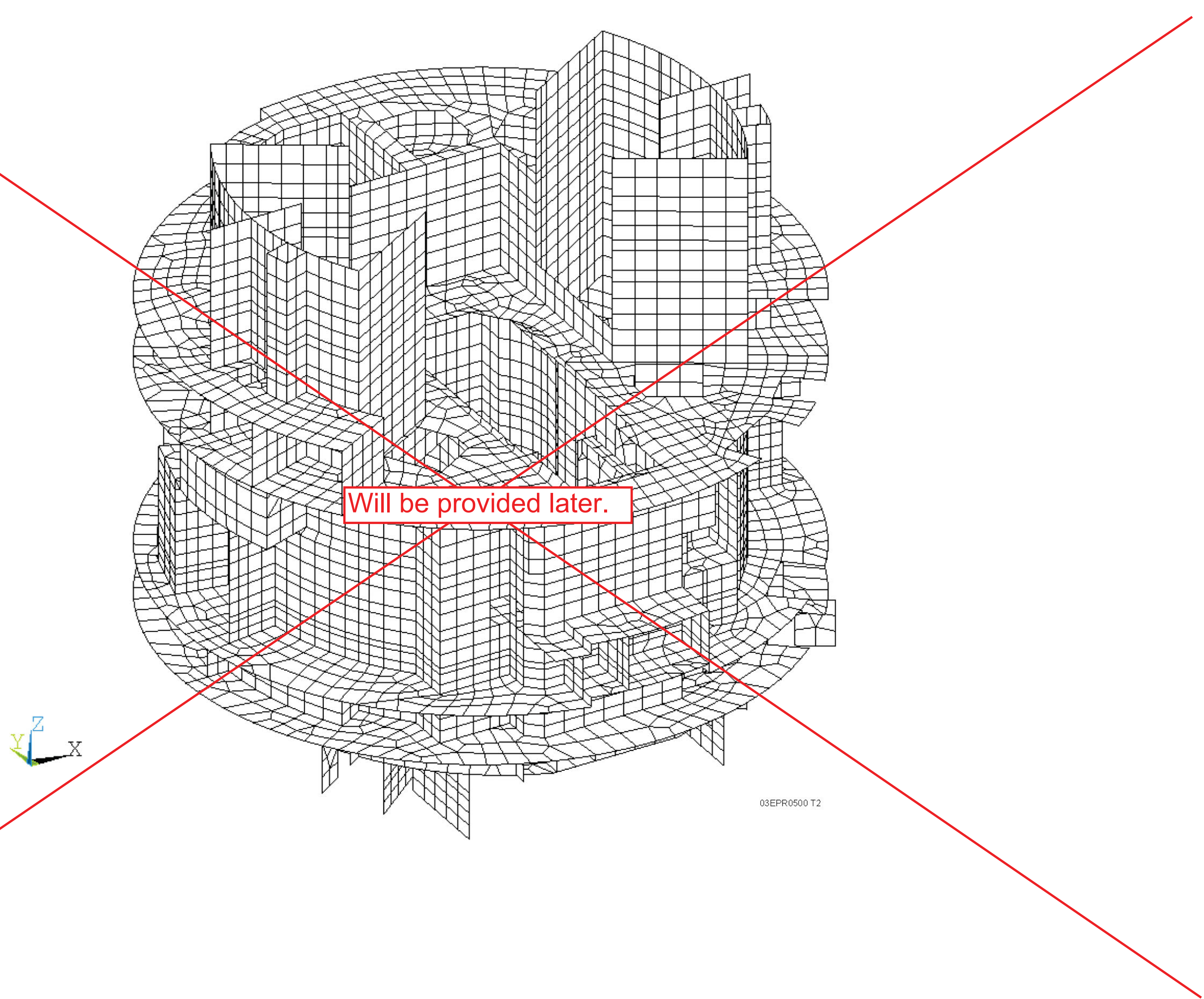
Static

Figure 3.7.2-9—3D Finite Element Model of Reactor Building Internal Structures



Will be provided later.