ArevaEPRDCPEm Resource

From:	Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent:	Tuesday, October 20, 2009 6:46 PM
To:	Tesfaye, Getachew
Cc:	BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject:	Response to U.S. EPR Design Certification Application RAI No. 215, FSAR Ch 3, Supplement 4
Attachments:	RAI 215 Supplement 4 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 2 of the 24 questions of RAI No. 215 on June 18, 2009. AREVA NP submitted Supplement 1 to the response on August 19, 2009, to address 6 of the remaining 22 questions. AREVA NP submitted Supplement 2 to the response on September 17, 2009, to address 2 of the remaining 16 questions. AREVA NP submitted Supplement 3 to the response on September 29, 2009 to address 4 of the remaining 14 questions. The attached file, “RAI 215 Supplement 4 Response US EPR DC.pdf” provides technically correct and complete responses to 9 of the remaining 10 questions, as committed. Since the remaining response contains proprietary information it is being submitted separately.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 215 Questions 03.07.01-23, 03.07.02-38, 03.07.03-22, 03.07.03-23, 03.07.03-24, 03.07.03-25, 03.07.03-32, and 03.07.03-34.

The following table indicates the respective page(s) in the response document, “RAI 215 Supplement 4 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject questions.

Question #	Start Page	End Page
RAI 215 — 03.07.01-23	2	8
RAI 215 — 03.07.01-24	9	10
RAI 215 — 03.07.02-38	11	11
RAI 215 — 03.07.03-22	12	12
RAI 215 — 03.07.03-23	13	13
RAI 215 — 03.07.03-24	14	14
RAI 215 — 03.07.03-25	15	17
RAI 215 — 03.07.03-32	18	18
RAI 215 — 03.07.03-34	19	19

The schedule for a technically correct and complete response to the remaining 1 question is provided below:

Question #	Response Date
RAI 215 — 03.07.01-22	October 20, 2009

Sincerely,

Ronda Pederson
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road

Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

From: Pederson Ronda M (AREVA NP INC)
Sent: Tuesday, September 29, 2009 6:54 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 215, FSAR Ch 3, Supplement 3

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 2 of the 24 questions of RAI No. 215 on June 18, 2009. AREVA NP submitted Supplement 1 to the response on August 19, 2009, to address 6 of the remaining 22 questions. AREVA NP submitted Supplement 2 to the response on September 17, 2009, to address 2 of the remaining 16 questions. The attached file, “RAI 215 Supplement 3 Response US EPR DC.pdf” provides technically correct and complete responses to 4 of the remaining 14 questions, as committed.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 215 Questions 03.07.02-40, 03.07.03-27, and 03.07.03-33.

The following table indicates the respective pages in the response document, "RAI 215 Supplement 3 Response US EPR DC.pdf” that contain AREVA NP’s response to the subject questions.

Question #	Start Page	End Page
RAI 215 — 03.07.02-39	2	2
RAI 215 — 03.07.02-40	3	3
RAI 215 — 03.07.03-27	4	4
RAI 215 — 03.07.03-33	5	5

The schedule for technically correct and complete responses to the remaining 10 questions has been changed due to their interdependence with other responses that remain in process and is provided below:

Question #	Response Date
RAI 215 — 03.07.01-22	October 20, 2009
RAI 215 — 03.07.01-23	October 20, 2009
RAI 215 — 03.07.01-24	October 20, 2009
RAI 215 — 03.07.02-38	October 20, 2009
RAI 215 — 03.07.03-22	October 20, 2009
RAI 215 — 03.07.03-23	October 20, 2009
RAI 215 — 03.07.03-24	October 20, 2009
RAI 215 — 03.07.03-25	October 20, 2009
RAI 215 — 03.07.03-32	October 20, 2009
RAI 215 — 03.07.03-34	October 20, 2009

Sincerely,

Ronda Pederson
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

From: Pederson Ronda M (AREVA NP INC)
Sent: Thursday, September 17, 2009 4:58 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT); RYAN Tom (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 215, FSAR Ch 3, Supplement 2

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 2 of the 24 questions of RAI No. 215 on June 18, 2009. AREVA NP submitted Supplement 1 to the response on August 19, 2009, to address 6 of the remaining 22 questions. The attached file, "RAI 215 Supplement 2 Response US EPR DC.pdf" provides technically correct and complete responses to 2 of the remaining 16 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 215 Question 03.07.01-21

The following table indicates the respective pages in the response document, "RAI 215 Supplement 2 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 215 — 03.07.01-21	2	2
RAI 215 — 03.07.03-26	3	5

The schedule for technically correct and complete responses to the remaining 14 questions has been changed due to design change processing delays for several of the responses and is provided below:

Question #	Response Date
RAI 215 — 03.07.01-22	September 29, 2009
RAI 215 — 03.07.01-23	September 29, 2009
RAI 215 — 03.07.01-24	September 29, 2009
RAI 215 — 03.07.02-38	September 29, 2009
RAI 215 — 03.07.02-39	September 29, 2009
RAI 215 — 03.07.02-40	September 29, 2009
RAI 215 — 03.07.03-22	September 29, 2009
RAI 215 — 03.07.03-23	September 29, 2009
RAI 215 — 03.07.03-24	September 29, 2009
RAI 215 — 03.07.03-25	September 29, 2009
RAI 215 — 03.07.03-27	September 29, 2009
RAI 215 — 03.07.03-32	September 29, 2009

RAI 215 — 03.07.03-33	September 29, 2009
RAI 215 — 03.07.03-34	September 29, 2009

Sincerely,

Ronda Pederson

ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

From: Pederson Ronda M (AREVA NP INC)
Sent: Wednesday, August 19, 2009 4:51 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 215, FSAR Ch 3, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 2 of the 24 questions of RAI No. 215 on June 18, 2009. The attached file, “RAI 215 Supplement 1 Response US EPR DC.pdf” provides technically correct and complete responses to 6 of the remaining 22 questions, as committed.

The responses to three questions cannot be provided as originally commited at this time. Responses to RAI 215, Questions 03.07.01-24, 03.07.02-38, and 03.07.03-23 are being deferred due to their interdependence with other responses that are not scheduled to be submitted until September 29, 2009.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 215 Questions 03.07.01-20, 03.07.02-42, 03.07.03-29, and 03.07.03-30.

The following table indicates the respective pages in the response document, “RAI 215 Supplement 1 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject questions.

Question #	Start Page	End Page
RAI 215 — 03.07.01-20	2	2
RAI 215 — 03.07.02-41	3	4
RAI 215 — 03.07.02-42	5	5
RAI 215 — 03.07.03-28	6	6
RAI 215 — 03.07.03-29	7	7
RAI 215 — 03.07.03-30	8	8

The schedule for technically correct and complete responses to the remaining 16 questions has been revised as provided below:

Question #	Response Date
RAI 215 — 03.07.01-21	September 18, 2009
RAI 215 — 03.07.01-22	September 18, 2009
RAI 215 — 03.07.01-23	September 29, 2009
RAI 215 — 03.07.01-24	September 29, 2009
RAI 215 — 03.07.02-38	September 29, 2009
RAI 215 — 03.07.02-39	September 29, 2009
RAI 215 — 03.07.02-40	September 29, 2009
RAI 215 — 03.07.03-22	September 18, 2009
RAI 215 — 03.07.03-23	September 29, 2009
RAI 215 — 03.07.03-24	September 18, 2009
RAI 215 — 03.07.03-25	September 18, 2009
RAI 215 — 03.07.03-26	September 18, 2009
RAI 215 — 03.07.03-27	September 18, 2009
RAI 215 — 03.07.03-32	September 29, 2009
RAI 215 — 03.07.03-33	September 29, 2009
RAI 215 — 03.07.03-34	September 29, 2009

Sincerely,

Ronda Pederson

ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

From: WELLS Russell D (AREVA NP INC)
Sent: Thursday, June 18, 2009 4:14 PM
To: 'Getachew Tesfaye'
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. 215, FSAR Ch 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 215 Response US EPR DC.pdf" provides technically correct and complete responses to 2 of the 24 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 215 Question 03.07.03-31.

The following table indicates the respective pages in the response document, "RAI 215 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 215 — 03.07.01-20	2	2
RAI 215 — 03.07.01-21	3	3
RAI 215 — 03.07.01-22	4	4
RAI 215 — 03.07.01-23	5	6
RAI 215 — 03.07.01-24	7	7
RAI 215 — 03.07.02-38	8	8
RAI 215 — 03.07.02-39	9	9
RAI 215 — 03.07.02-40	10	10
RAI 215 — 03.07.02-41	11	11
RAI 215 — 03.07.02-42	12	12
RAI 215 — 03.07.03-22	13	13
RAI 215 — 03.07.03-23	14	14
RAI 215 — 03.07.03-24	15	15
RAI 215 — 03.07.03-25	16	16
RAI 215 — 03.07.03-26	17	17
RAI 215 — 03.07.03-27	18	18
RAI 215 — 03.07.03-28	19	19
RAI 215 — 03.07.03-29	20	20
RAI 215 — 03.07.03-30	21	21
RAI 215 — 03.07.03-31	22	22
RAI 215 — 03.07.03-32	23	23
RAI 215 — 03.07.03-33	24	24
RAI 215 — 03.07.03-34	25	25
RAI 215 — 03.12-17	26	27

A complete answer is not provided for 22 of the 24 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 215 — 03.07.01-20	August 19, 2009
RAI 215 — 03.07.01-21	September 18, 2009
RAI 215 — 03.07.01-22	September 18, 2009
RAI 215 — 03.07.01-23	September 29, 2009
RAI 215 — 03.07.01-24	August 19, 2009
RAI 215 — 03.07.02-38	August 19, 2009
RAI 215 — 03.07.02-39	September 29, 2009
RAI 215 — 03.07.02-40	September 29, 2009
RAI 215 — 03.07.02-41	August 19, 2009
RAI 215 — 03.07.02-42	August 19, 2009
RAI 215 — 03.07.03-22	September 18, 2009
RAI 215 — 03.07.03-23	August 19, 2009
RAI 215 — 03.07.03-24	September 18, 2009
RAI 215 — 03.07.03-25	September 18, 2009
RAI 215 — 03.07.03-26	September 18, 2009
RAI 215 — 03.07.03-27	September 18, 2009
RAI 215 — 03.07.03-28	August 19, 2009
RAI 215 — 03.07.03-29	August 19, 2009
RAI 215 — 03.07.03-30	August 19, 2009
RAI 215 — 03.07.03-32	September 29, 2009

RAI 215 — 03.07.03-33	September 29, 2009
RAI 215 — 03.07.03-34	September 29, 2009

Sincerely,

(Russ Wells on behalf of)
Ronda Pederson

ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
New Plants Deployment
AREVA NP, Inc.
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

From: Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Tuesday, May 19, 2009 9:33 PM
To: ZZ-DL-A-USEPR-DL
Cc: Manas Chakravorty; Jim Xu; Sujit Samaddar; Kaihwa Hsu; Anthony Hsia; Michael Miernicki; Jay Patel; Joseph Colaccino; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 215 (2560, 2561,2565, 2588), FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on April 14, 2009, and on May 19, 2009, you informed us that the RAI is clear but you needed clarification for Questions 3.7.3-26 and 3.7.3-31. To support the review schedule, we have decided to issue the RAI as is and conduct the clarification telecon at a later time. 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: 888

Mail Envelope Properties (5CEC4184E98FFE49A383961FAD402D3101543729)

Subject: Response to U.S. EPR Design Certification Application RAI No. 215, FSAR Ch 3, Supplement 4
Sent Date: 10/20/2009 6:45:41 PM
Received Date: 10/20/2009 6:45:46 PM
From: Pederson Ronda M (AREVA NP INC)

Created By: Ronda.Pederson@areva.com

Recipients:
"BENNETT Kathy A (OFR) (AREVA NP INC)" <Kathy.Bennett@areva.com>
Tracking Status: None
"DELANO Karen V (AREVA NP INC)" <Karen.Delano@areva.com>
Tracking Status: None
"VAN NOY Mark (EXT)" <Mark.Vannoy.ext@areva.com>
Tracking Status: None
"Tesfaye, Getachew" <Getachew.Tesfaye@nrc.gov>
Tracking Status: None

Post Office: AUSLYNCMX02.adom.ad.corp

Files	**Size**	**Date & Time**
MESSAGE	14488	10/20/2009 6:45:46 PM
RAI 215 Supplement 4 Response US EPR DC.pdf		251853

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

Response to

Request for Additional Information No. 215, Supplement 4

5/19/2009

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.07.01 - Seismic Design Parameters
SRP Section: 03.07.02 - Seismic System Analysis
SRP Section: 03.07.03 - Seismic Subsystem Analysis
SRP Section: 03.12 - ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports
Application FSAR Ch. 3

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)
QUESTIONS for AP1000 Projects Branch 1 (NWE1)

Question 03.07.01-23:

Follow-Up RAI to Question 03.07.01-15:

The response provided to **Question 03.07.01-15** refers to a proprietary report which provided the results of a test program that demonstrated that certain cable tray systems achieved damping values as high as 20 to 25 percent under dynamic loads. This report is the basis for allowing up to 20 percent damping for flexible supported cable tray systems. In reviewing a summary of the report, it appeared that for those systems achieving higher damping the response was nonlinear and could include yielding of the cable tray support system. The report also states that the resonant frequency of the cable tray system was dependent on the input level of the support excitation. Higher input levels resulted in lower resonant frequencies. Response spectrum analysis methods are often used for suspended systems and are based on an assumption of a linear response in the system being analyzed. The load applied to the system is a function of the system modal frequencies used in combination with a design response spectrum curve. It is not clear how the nonlinear behavior of the cable tray systems and dependence of natural frequencies on excitation level that were documented in the test report are applied in analysis methods that calculate the response of a system by linear elastic methods.

Although not accepted by the NRC, the recommendations of ASCE 43-05 stipulate a maximum damping value of 15 percent for cable tray systems wherein the total elastic demand exceeds the code capacity. For cable tray systems where the elastic demand is equal to or less than the code capacity, a maximum of 10 percent damping is specified for cable trays that are 50 percent or more full and 7 percent for trays that are empty. This is consistent with the R.G. 1.61 damping values which for full cable trays is 10 percent and for empty trays is 7 percent. The ANCO report is not a reference to the Regulatory Guide. NUREG/CR-6919, which does reference the ANCO report, recommends in Section 5.2.1 damping values for cable trays which are identical to those in the current version of the Regulatory Guide.

The markup to 3A.3.5 of the U.S. EPR FSAR appears to provide additional criteria for selecting damping values beyond what is specified in FSAR table 3.7.1-1 and states “The damping values [of] cable tray systems with less than 50 percent loading may be determined from Figure 3.7.1-16, which is dependent on the flexibility of the cable tray system, including both the cable tray and its supports for an input ground motion ZPA up to and exceeding 0.35g.” However, if Figure 3.7.1-16 is dependent on the flexibility of the cable tray system, it does not provide any additional guidance or limitation on its use in this regard.

In its markup of the FSAR the applicant has added a note to Table 3.7.1-1 that limits the use of higher damping values to flexibly supported rod and strut-hung trapeze systems, and strut-type cantilever and braced-cantilever cable tray systems loaded to greater than 50 percent of the maximum rated loading. The staff believes the information provided is insufficient to support the use of higher damping values in seismic Category I cable tray systems with flexible supports. To justify the higher damping, the applicant needs to submit on a case-by-case basis the following information:

a. The applicable design code and design allowables for the cable tray system including the anchor system;

b. The method of analysis, how natural frequencies are determined, how the loads are determined, and the ratio of actual demand in the cable tray system and loads in the anchors to the code allowables;

c. The design methods and design procedures that are used to implement the test results from the ANCO report;

d. A correlation and applicability of the cable tray configuration (support system, percent filled, use of ties, anchor system, etc.) to the test configurations and results from the ANCO test report; and

e. The technical basis for Figure 3.7.1-16 and how the flexibility of the cable tray system is accounted for in the use of this figure and what configurations are covered under the definition of a flexible support system.

For the damping values of the empty trays provided in Table 3.7-1, there is a note D, which does not appear to apply to an empty tray. This should be corrected in the markup to the FSAR.

Response to Question 03.07.01-23:

Nonlinear cable tray system dynamic behavior observed in the Bechtel-ANCO Report 1053-21.1-4 (see U.S. EPR FSAR Tier 2, Section 3.7.1.4, Reference 3) is predominantly attributed to amplitude dependent energy dissipation caused by friction between cables, and movement and bouncing of cables within the tray. The cable tray and its support system components behaved elastically and only cable behavior contributed to the observed nonlinear response. Localized yielding of support connection fittings was observed in a few test cases where the connections experienced large amplitude loading. This is accounted for in analysis and design by modeling connections as flexible joints with appropriately degraded rotational stiffnesses obtained from experimental tests of representative strut and joint configurations. The Bechtel-ANCO experimental tests for rotational stiffness will be supplemented with additional stiffness tests during the design phase, as necessary. If modeling with flexible connections is determined to not be conservative, other boundary conditions (e.g., pinned or rigid connections) that produce more conservative results will be used.

Results of the Bechtel-ANCO report showed that system fundamental frequency of cable tray systems for all percentages of fill is dependent on the input level of support excitation and that higher input levels tend to result in slightly lower system fundamental frequencies. This degradation in system fundamental frequency, which is linear with respect to input acceleration (in-structure response spectrum (ISRS) zero-period acceleration (ZPA)), is attributable to higher intensities of friction between cables and movement and bouncing of cables within the tray as input acceleration increases, and was only observed after a significant number of loading cycles. Figure 03.07.01-23-1 includes a list of manufacturers and shows transverse system fundamental frequency trends for typical cable trays with strut trapeze-type supports and transverse bracing. System fundamental frequency is observed to decrease monotonically as a function of ISRS ZPA, with the rate of decrease dependent on cable loading. The offset between the trend curves illustrated in Figure 03.07.01-23-1 is caused by change in cable mass. These results, shown with the frequency axis non-dimensionalized in Figure 03.07.01-23-2, indicate that acceleration dependent system fundamental frequencies can be determined from the calculated static (i.e., ZPA) system fundamental frequency by applying an adjustment in accordance with the trend curves.

Figure 03.07.01-23-1 shows analytical and computer models that were developed and calibrated to evaluate the cable tray systems that were experimentally tested. These models are used to predict the system fundamental frequency of the experimentally tested systems for the case of low acceleration within reasonable accuracy. For design purposes, the system fundamental frequencies at ZPA can be used to determine the system fundamental frequencies at higher acceleration input by using the trend lines shown in Figure 03.07.01-23-2, which are based on experimental test data. The acceleration used to make the correction is the ISRS ZPA corresponding to the location where the cable tray is to be mounted. When the trend line correction is applied, the system fundamental frequency is bracketed by ±20 percent to account for modeling uncertainties. Response spectrum methods can then be used to obtain the response of the cable tray system based on the highest acceleration within the bracketed system fundamental frequency bandwidth.

The higher damping values for cable tray systems are based on identified damping ratios for specific configurations measured during the Bechtel-ANCO study, not the recommendations provided in ASCE 43-05. While ASCE 43-05 stipulates a damping value of 15 percent based on Bechtel-ANCO test results, the rationale and bases for such a value are established independently.

Damping ratios for various cable tray configurations and by various manufacturers that were measured during the Bechtel-ANCO test program have been disseminated in the paper titled, "Seismic Testing of Electric Cable Tray Systems" (see U.S. EPR FSAR Tier 2, Section 3.7.1.4, Reference 4) and are shown in Figure 03.07.01-23-3. As illustrated in Figure 03.07.01-23-3, damping ratios can be as high as 50 percent. Despite these high damping ratios, the systems that were tested in the Bechtel-ANCO study behaved elastically. In a few test cases there was some localized inelastic behavior at the joints. Thus, the higher damping ratios observed in the Bechtel-ANCO report are not due to inelastic behavior of the cable tray system, but rather due to energy dissipation associated with friction between cables, and movement and bouncing of cables within the tray. However, because of scatter in the experimental data, a damping ratio curve was developed (see curve 1 in Figure 03.07.01-23-3) that provides a lower bound on the damping ratios. This lower bound curve is the basis for U.S. EPR FSAR Tier 2, Figure 3.7.1-16.

Figure 03.07.01-23-4 presents damping ratios experimentally identified and documented in the Bechtel-ANCO report for rigidly mounted cable tray systems (support fundamental frequency greater than approximately 50Hz) fabricated by different manufacturers that were loaded from near zero to 100 percent of full cable loading. From this figure it can be inferred that above an input acceleration of 0.25g, damping ratios of at least 15 percent are developed in the cable tray system regardless of the tray manufacturer. Since the tray was rigidly mounted during these tests, it is further concluded that all of the damping is attributed to the damping of the tray and the damping due to friction between cables and movement and bouncing of cables within the tray. Actual cable tray systems will be mounted with flexible supports, but by rigidly mounting the cable tray the support flexibility is unable to contribute to damping. Hence, 15 percent damping is justified for input accelerations above 0.25g regardless of the cable tray support conditions.

For design purposes, damping ratios that are consistent with RG 1.61 (up to 10 percent for greater than 50 percent loaded cable trays and 7 percent for empty cable trays) will be used for general cable tray configurations that are different from the configurations that were experimentally tested and reported in the Bechtel-ANCO report. For cable tray systems similar to the configurations tested in the Bechtel-ANCO report, and which are greater than 50 percent loaded, damping ratios of up to 15 percent will be used in accordance with curve 2 in Figure 03.07.01-23-3. Note that this is even more conservative than the original curve proposed from findings in the Bechtel-ANCO report, which was shown to be a lower bound of the experimental data. The additional conservative measures as described above will be implemented by modifying U.S. EPR FSAR Figure 3.7.1-16 to reflect curve 2 in Figure 03.07.01-23-3.

Use of maximum damping of 15 percent for cable tray systems similar to those tested in the Bechtel-ANCO study is not unprecedented. Damping ratios of 15 percent for cable trays with 50 percent to full cable loading and ISRS ZPA greater than 0.25 g have long been recognized as acceptable within the industry. As documented in the commentary of ASCE 4-98, the design basis damping values accepted by the NRC for the Vogtle nuclear plant and the Palo Verde nuclear plant are 15 and 20 percent, respectively. Shake table studies of cable tray systems conducted by URS/Blume, which are referred to in ASCE 4-98, have demonstrated experimentally measured damping ratios greater than 15 percent. However, as stated in ASCE 4-98, to reflect incomplete knowledge of the damping phenomena, a limit of 15 percent damping should be used in the analysis. Hence, using the proposed damping curve with a maximum damping ratio of 15 percent will prompt the consideration of the Bechtel-ANCO experimental data while acknowledging that the damping phenomena in cable trays is not incontrovertibly understood given the current state of research.

Based on findings from the Bechtel-ANCO report, the statement in U.S. EPR FSAR Tier 2, Section 3A.3.5 that U.S. EPR FSAR Tier 2, Figure 3.7.1-16 is “dependent on the flexibility of the cable tray system” will be revised. For an ISRS ZPA greater than 0.25 g, a damping ratio of at least 15 percent is provided for flexibly supported cable tray and for rigidly mounted cable tray, and thus the 15 percent has no dependence on support flexibility. U.S. EPR FSAR Tier 2, Section 3A.3.5 will be revised by removing this statement.

As previously stated, support flexibility has been shown to have little effect on damping. Experimentally identified damping ratios in the Bechtel-ANCO test study were observed to be at least 15 percent for ISRS ZPAs above 0.25 g regardless of whether cable trays are flexibly supported or rigidly mounted. Therefore, the damping is associated with the cable tray and the friction between cables and movement and bouncing of cables within the tray, not the supports.

a) Cable tray systems are designed to design allowables in accordance with the codes and standards listed in U.S. EPR FSAR Tier 2, Section 3A.3.1. The anchor system will be designed in accordance with Appendix B of the American Concrete Institute (ACI) 349-01 – Code Requirements for Nuclear Safety Related Concrete Structures, 2001.

b) Methods of analysis in accordance with the acceptance criteria of SRP 3.7.3 will be used to qualify the cable tray systems. For cable tray systems representative of the configurations tested in the Bechtel-ANCO report, the system fundamental frequencies will be determined using the procedure described earlier in this response. As stated therein, system fundamental frequencies at zero-acceleration will first be calculated. The system fundamental frequencies are then reduced by the curves in Figure 03.07.01-23-1 using the ISRS ZPA for the location where the cable tray system is to be mounted. When the system fundamental frequency is reduced by applying the trend line correction, the system fundamental frequency is bracketed by ±20 percent and the cable tray system is evaluated based on the highest acceleration within the bracketed frequency bandwidth.

The cable tray system and anchor system, including their components, are designed to remain within the code allowables in accordance with the applicable codes described in Item a of this response.

c) Application of test results from the Bechtel-ANCO report in design methods and procedures used to qualify cable tray systems dynamic response are described in Items a and b of this response. Additional information on the manner in which test results are applied is provided at the beginning of this response.

d) The 15 percent damping will be used only for systems that are determined to be the same or substantially similar systems as those that were experimentally tested in the Bechtel-ANCO study and only when cable trays are greater than 50 percent filled. System similarity will be determined on a case-by-case basis between investigated cable tray systems and cable tray system configurations tested in the Bechtel-ANCO test report. Similarity of the two systems will be justified by determining the correlation of all significant cable tray components (e.g., material, dimensions, connections, boundary conditions). The Bechtel-ANCO report identified several parameters that do not significantly influence cable tray system dynamics. These include splice plate location, type of tray (manufacturer), mix of cable sizes in the tray, and the presence of cable ties. Anchor system flexibility will be incorporated when significant and will be evaluated on a case-by-case basis during design implementation

e) The technical basis for U.S. EPR FSAR Tier 2, Figure 3.7.1-16 was addressed in a previous section of this response, wherein Figure 03.07.01-23-3 of this response was discussed. U.S. EPR FSAR Tier 2, Figure 3.7.1-16 is not dependent on the flexibility of the cable tray system. A damping ratio of at least 15 percent has been demonstrated for both flexibly supported cable trays and for rigidly mounted cable trays, and thus the damping ratio is not dependent on support conditions. The statement in U.S. EPR FSAR Section 3A.3.5 regarding the dependence of U.S. EPR FSAR Figure 3.7.1-16 on the flexibility of the cable tray system will be corrected.

Configurations representative of those tested in the Bechtel-ANCO study are covered because U.S. EPR FSAR Tier 2, Figure 3.7.1-16 is a lower bound on the experimental data (as shown in Figure 03.07.01-23-3, for the various configurations). System similarity considerations justifying application of the Bechtel-ANCO test report will be provided and documented in the design calculations on a case-by-case basis.

U.S. EPR FSAR Tier 2, Table 3.7.1-1 will be revised to remove reference to Note D for the “Empty” bullet under “Cable Trays and Supports” because Note D is not applicable to empty cable tray configurations.

Figure 03.07.01-23-1—General Trends in Transverse System Fundamental Frequency Based on Bechtel-ANCO Report Test Data for Various Manufacturers

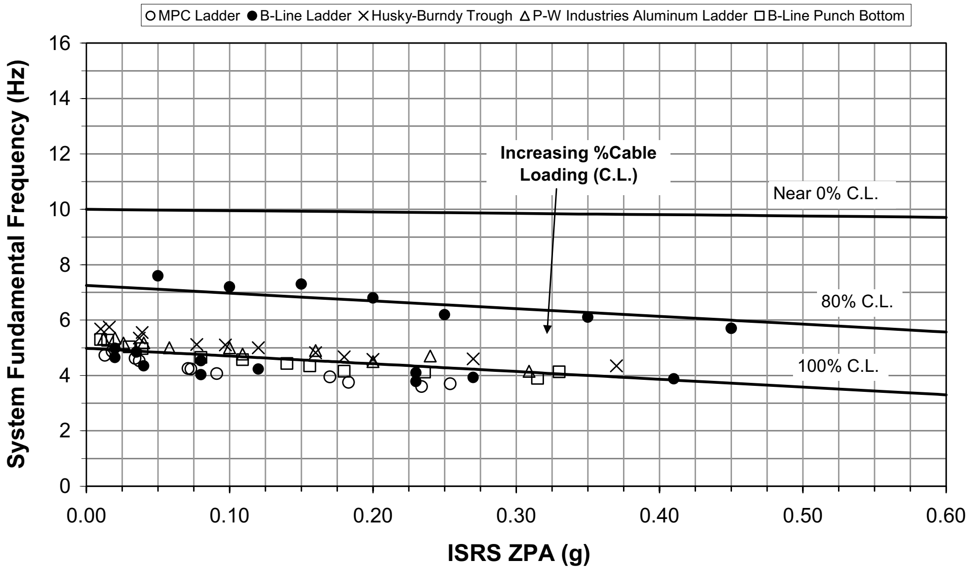


Figure 03.07.01-23-2—General Trends in Transverse Non-Dimensionalized System Fundamental Frequency

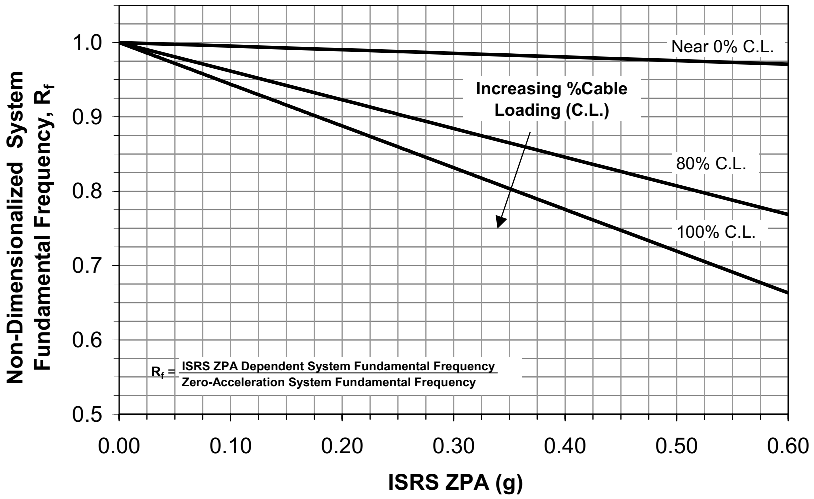


Figure 03.07.01-23-3—Damping Ratio Experimental Data from Bechtel-ANCO Report, Damping Curve with Maximum Damping Ratio of 20%, Proposed Damping Ratio Curve with Maximum Damping Ratio of 15%, and Damping Ratios Based on RG 1.61

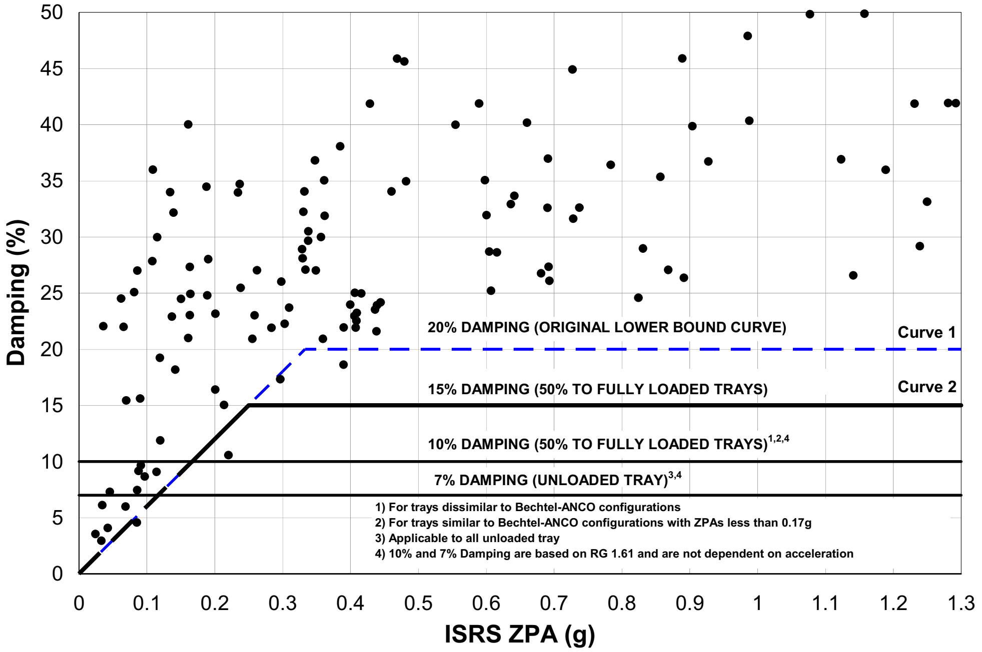
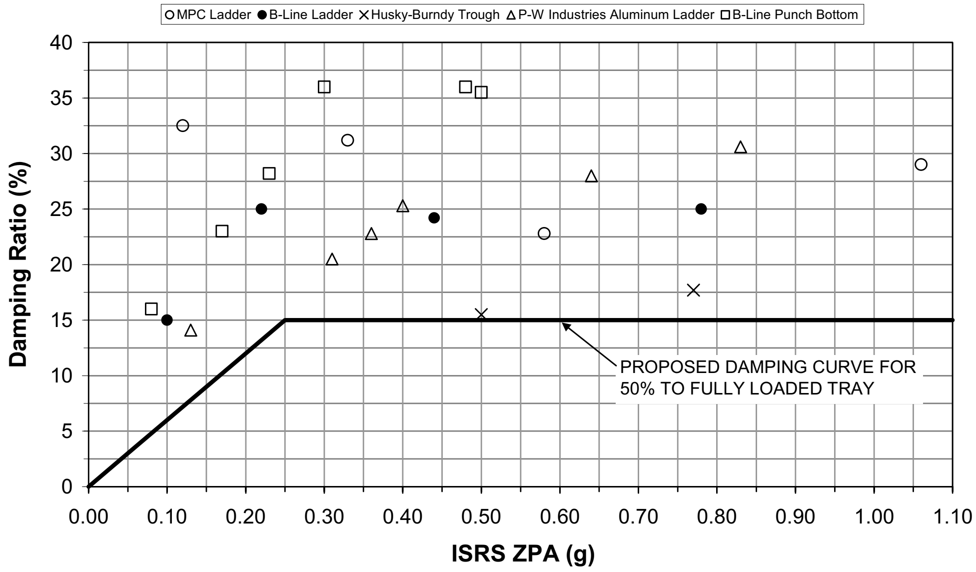


Figure 03.07.01-23-4—Comparison of Proposed Damping Ratio Curve with Transverse Lowest Mode Trends in Damping Ratios Using Data from Bechtel-ANCO Report for Rigidly Mounted Cable Tray from Various Cable Tray Manufacturers



FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.7.1.2, 3A.3.5, Table 3.7.1-1, and Figure 3.7.1-16 will be revised as described in the response and as indicated on the enclosed markup.

Question 03.07.01-24:

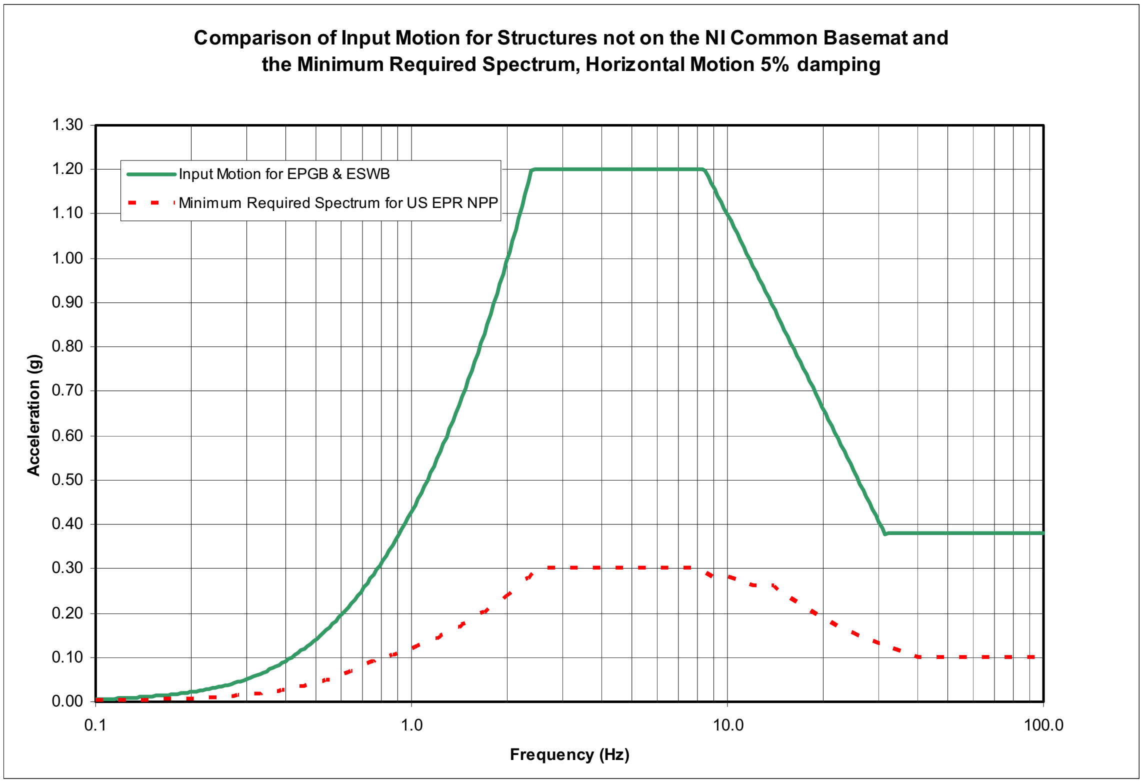
Follow-Up RAI to Question 03.07.01-18:

To meet the regulation requirements of Appendix S of 10 CFR Part 50, the applicant is requested to provide in the U.S. EPR FSAR the response spectra used to meet the minimum horizontal response spectra required in the free field at the foundation levels of the EPGB and ESWB structures.

Response to Question 03.07.01-24:

Input motion for Emergency Power Generating Building (EPGB) and Essential Service Water Building (ESWB) in terms of 5 percent damped acceleration response spectrum is provided in Figure 03.07.01-24-1. As discussed in U.S. EPR FSAR Tier 2, Section 3.7.1.1.1, this motion is the certified seismic design response spectra (CSDRS), envelope of European utility requirement (EUR) spectra anchored to 0.3 g, plus structure-to-structure amplification from NI common basemat. Comparison in Figure 03.07.01-24-1 shows that input motion for EPGB and ESWB at the foundation levels envelop the appropriate design spectrum for U.S. EPR, which is discussed in U.S. EPR FSAR Tier 2, Section 3.7.1.1.1 and shown in U.S. EPR FSAR Tier 2, Figure 3.7.1-2. Thus, it also meets 10 CFR 50, Appendix S minimum horizontal response spectrum requirement.

Figure 03.07.01-24-1—Comparison of Input Motion for Structures Not on the NI Common Basemat and the Minimum Required Spectrum, Horizontal Motion 5% Damping



FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 03.07.02-38:

Follow-Up RAI to Question 03.07.02-2:

In response to **Question 03.07.02-2** it is stated that a presentation by R. Kennedy and F. Ostadan, at a workshop entitled "Consistent Site-Response/Soil-Structure Interaction Calculations", that took place at EPRI Palo Alto, California, in September 25-26, 2008 will be used as a reference (Reference 10) for some of the methods used to calculate soil motions in SSI analysis. The applicant should identify the technical information contained in Reference 10 and how this information supports the SSI analysis methods described in the FSAR. In addition, although the reference is to be added to the list of references, the text of the FSAR does not indicate where this reference is used. This needs to be identified.

Response to Question 03.07.02-38:

Response to Question 03.07.02-2 provided an explanation of the design method used to convert "outcrop" ground motion to "in column" ground motion through application of Shake2000 analysis code. The soil column includes soil layers above the foundation level, which is consistent with the soil layers used in subsequent soil-structure interaction (SSI) analyses.

The Shake2000 seismic analyses for these structures were performed before the R. Kennedy – F. Ostadan workshop conducted by EPRI in Palo Alto, California, September 25-26, 2008, titled "Consistent Site-Response/Soil-Structure Interaction Calculations." The methodology provided in this workshop was not referenced by the design certification calculations. Kennedy – Ostadan was cited in the RAI Question 03.07.02-2 response, with addition of corresponding U.S. EPR FSAR Tier 2, Section 3.7.2, Reference 10, to support the discussion and convey that the design certification seismic analysis methodology is consistent with Kennedy - Ostadan.

U.S. EPR FSAR Tier 2, Section 3.7.2.16 will be revised by deleting Reference 10.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.2.16 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-22:

Follow-Up RAI to Question 03.07.03-1

The piping topical report referenced in AREVA's response to **Question 03.07.03-1** has been accepted by the staff. However, at this time the approval to use the peak shifting method is applicable only to piping systems. The applicant should describe the applicability of the methodology to other subsystems in the U.S.EPR standard design and define the context in which application to other subsystems would be used. Backup support for this information should be provided in the FSAR from the WRC Bulletin 300 or from the ASME Boiler and Pressure Vessel Code. In addition it should be noted that the markup provided on Section 3.7.3.14 does not appear to be applicable to the response to Question 03.07.03-1.

Response to Question 03.07.03-22:

The peak shifting method presented in ASCE 4-98, ASME BPV Code, Section III, Division 1, Appendix N, Paragraph N-1226.3(d), WRC Bulletin 300 and U.S. EPR FSAR Tier 2, Section 3.7.3.1.1 is only applicable to piping systems. The Peak Shifting Method paragraph in U.S. EPR FSAR Tier 2, Section 3.7.3.1.1 will be revised to state that it is only applicable to piping systems. A related reference will be added in U.S. EPR FSAR Tier 2, Section 3.7.3.15.

The U.S. EPR FSAR Tier 2, Section 3.7.3.14 markup provided in the Response to Question 03.07.03-1, corrected an editorial error and should not have been included with the Response to Question 03.07.03-1. Disregard this markup as it is inapplicable to Question 03.07.03-1.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.7.3.1.1 and 3.7.3.15 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-23:

Follow-Up RAI to Question 03.07.03-3:

Although the first method described in the response to Question 03.07.03-3 to account for uncertainties in the seismic analysis of structures is an acceptable approach, the applicant is requested to describe in the FSAR how the multiple sets of time histories are considered in the code qualification of a subsystem , i.e. how the 12 sets of time histories for the NI common basemat structures and 10 sets of time histories applicable to the EPGB and ESWB are accounted for in the subsystem design and how the seismic support loads for these subsystems are determined.

The use of the second method is not covered by the topical report and its use has not been accepted by the staff. The applicant is requested to describe how the development of such a synthetic time history will meet SRP 3.7.1, SAC-1.B for design time histories and provide a comparison of the time history response spectra with the ISRS at sample locations within the NI common basemat structures, the EPGB, and the ESWB. In addition, for systems supported at points having different ISRS, and therefore different synthetic time histories, the phase relationship between the time histories would be lost and should not be used for these types of applications.

Response to Question 03.07.03-23:

In the first method, analyses for each of the twelve NI common basemat structure sets of co-directional time histories and ten sets of Emergency Power Generating Building (EPGB) and Essential Service Water Building (ESWB) time histories are performed individually. The results are then enveloped.

The second method, which is not covered in the piping topical report, is not used for piping or other distribution systems. When the second method is used, time histories are developed to match the enveloped response spectra in accordance with SRP 3.7.1, SAC-1B. Currently, this second method is used only in spent fuel rack design. This second method of using time histories to represent enveloped ISRS is not employed for subsystems supported at multiple points with different ISRS (i.e., where independent support motion or uniform support motion methods are applied.)

U.S. EPR FSAR Tier 2, Section 3.7.3.1.2 will be revised to clarify application of these methods.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.3.1.2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-24:

Follow-Up RAI to Question 03.07.03-4:

The staff finds the response to Question 03.07.03-4 to be acceptable, but the applicant is requested to revise the FSAR markup to be consistent with the response provided and include in the FSAR the method of ASCE 4-98 Section 3.2.2.1 (c).

Response to Question 03.07.03-24:

U.S. EPR FSAR Tier 2, Section 3.7.3.1.2 will be revised to add a sentence regarding solution convergence and a reference to ASCE 4-98, Section 3.2.2.1(c) as described in the Response to Question 03.07.03-4:

> “In solution convergence, the general rule 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 4), Section 3.2.2.1(c).”

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.3.1.2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-25:

Follow-Up RAI to Question 03.07.03-5:

To assist the staff in completing its review of the response to Question 03.07.03-5, the applicant should provide the following:

a. Describe how a MMF < 1.5 will be determined and provide examples of specific applications.

b. Describe the limits placed on the model configuration. Describe how differential anchor motion between support points is treated.

c. The process described requires that there not be any cross coupling of dynamic response. What criteria are used to assure that a subsystem selected for the equivalent static method does not respond to out-of-plane motion due to in-plane excitation?

d. Provide the design procedures that implement the methods described.

e. Provide the portions of the references that support the methods used in the response.

f. Provide examples of the type of configurations for which these methods will be used and describe how the methods will be implemented for each. Include in your response the studies on simple frame-type piping models contained in References 1 and 2.

Response to Question 03.07.03-25:

a. Multi-degree-of-freedom (MDOF) subsystems that apply the equivalent static method approach use a multi-mode factor (MMF) of 1.5. Single-degree-of-freedom (SDOF) systems with a known fundamental frequency or rigid systems, with fundamental frequency beyond the cutoff frequency, may use a factor of 1.0 with the highest spectral acceleration at that frequency or any subsequent higher frequency (as may be the case for multiple peak input spectra). U.S. EPR FSAR Tier 2, Section 3.7.3.1.4 will be revised to describe the use of multi-mode factors.

b. The equivalent static load method is limited to subsystems that can be represented as simple structural models, such as those described on Page 2 of Reference 1. U.S. EPR FSAR Tier 2, Section 3.7.3.9 describes the methods used to account for differential displacements between supports. In addition, the AREVA Topical Report ANP-10264NP-A (Reference 6), Section 4.2.2.5 describes the methods used to account for differential displacements in piping systems.

c. The equivalent static load method is limited to simple structural models. Subsystems that may have a cross-coupling of dynamic responses will be evaluated as required in SRP 3.7.2 – SAC II-1.B.i and as stated in U.S. EPR FSAR Tier 2, Section 3.7.3.1.4 to justify that the simplified model is realistic and provides conservative results.

d. The term “design procedure” in this context refers to design guidelines as opposed to stepwise procedures. Design guidelines follow the descriptions provided in U.S. EPR FSAR Tier 2, Section 3.7.3.1.4. Use of equivalent static load methods for rigid systems is consistent with guidance as expressed in Reference 4, and other applications of equivalent static load method are consistent with guidance expressed in Reference 7.

e. References 4 and 5 of the Response to Question 03.07.03-5 support the use of the equivalent static method by comparing the results using the response spectrum method to the results of an equivalent static analysis. References 4 and 5 from the Response to Question 03.07.03-05 are available from various published and public sources, including the Internet, as distribution of these papers is not limited.

    4. NTIS DE92003449 Report# ANL/CP-74619, “A Structural Design and Analysis of a Piping System Including Seismic Load,” B.J. Hsieh and C.A. Kot, 1991.

       Section 7 of this document discusses comparison of equivalent static method results for a piping system (the system is described in Section 2) with results obtained using the response spectrum method.

    5. NTIS DE91011834 Report# ANL/CP-72564, “Observations on the Structural Design and Analysis of a Piping System,” B.J. Hsieh and C.A. Kot, 1991.

       Section 7 of this document discusses comparison of equivalent static method results for a piping system (the system is described in Section 2) with results obtained using the response spectrum method.

f. Part (b) of this response addresses the type of configurations for which the equivalent static method is used. References from the Response to RAI 03.07.03-05 that include studies on simple frame-type piping models are described below.

   Reference 1 from the Response to Question 03.07.03-05 is copyrighted but can be obtained from the ASME Linda Hall Library as ASME Paper No. 74-NE-9. Pages 2 through 7 of Reference 1 compare the equivalent static method with the dynamic analysis for simple structural models, and page 8 offers a conclusion regarding results.

   References 2 and 3 from the Response to Question 03.07.03-05 are available from various published and public sources, including the Internet, as distribution of these papers is not limited.

    2. NTIS 5206840 Report# CONF-800403-(Vol.2), “A Justification of the Static Coefficient of 1.5 for Equipment Seismic Qualification,” C. W. Lin, 1980.

       This reference is contained on pages 773-780 of “American Nuclear Society/European Nuclear Society Topical Meeting on Thermal Reactor Safety,” CONF-800403(Vol. 2).

       Section 2.0 of this Reference is applicable to determine the MMF factor for use in the equivalent static method.

    3. “Equivalent Static Coefficients for Simplified Analysis of Piping Systems,” C.W. Lin and T.C. Esselman, Transactions of 7th SMIRT Conference Vol. K(b), pp.335-341, Chicago, IL, 1983.

This entire reference is applicable to justify the MMF factor for use in the equivalent static method.

References for Question 03.07.03-25

1. ASME Paper 74-NE-6, "Amplification Factors to be Used in Simplified Seismic Dynamic Analysis of Piping Systems," J.D. Stevenson and W.S. LaPay, 1974.

2. NTIS 5206840 Report# CONF-800403-(Vol.2), "A Justification of the Static Coefficient of 1.5 for Equipment Seismic Qualification," C.W. Lin, 1980.

3. Transactions of 7th SMIRT Conference Vol. K(b), "Equivalent Static Coefficients for Simplified Analysis of Piping Systems," C.W. Lin and T.C. Esselman, pp.335-341, Chicago, IL, 1983.

4. NTIS DE92003449 Report# ANL/CP-74619, "A Structural Design and Analysis of a Piping System Including Seismic Load," B.J.Hsieh and C.A. Kot, 1991.

5. NTIS DE91011834 Report# ANL/CP-72564, "Observations on the Structural Design and Analysis of a Piping System," B.J.Hsieh and C.A. Kot, 1991.

6. ANP-10264NP-A, “U.S. EPR Piping Analysis and Pipe Support Design Topical Report,” AREVA NP, November 2008.

7. ASCE Standard 4-98, “Seismic Analysis of Safety-Related Nuclear Structures and Commentary,” 1998.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.3.1.4 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-32:

Follow-Up RAI to Question 03.07.03-15:

The applicant is requested to include in the FSAR the acceptance criteria of SRP 3.7.2, SAC-8.B which states that for those situations where the collapse of a non Category I structure could impair the integrity of a Category I structure the technical basis for the determination that the collapse of the non Category I structure is acceptable should be provided. It should also include a description of the additional loads imposed due to the collapse of the non Category I structure and the methods used to conclude that these loads are not damaging.

Response to Question 03.07.03-32:

Collapse of non-seismic SSC is acceptable when an evaluation verifies that the collapse will not impair the design basis safety function of Seismic Category I SSC. U.S. EPR FSAR Tier 2, Sections 3.7.3.8 and 3.7.3.8.2 address interaction evaluation, and will be revised to provide criteria for assessing the potential for non-seismic structure collapse to interact with Category I SSC.

Additional loads that could be imposed on Category I SSC due to potential non-Category I structure collapse and consequent interaction will be calculated based on full SSE forces and determining the effect of collapse on design basis safety functions of the Category I SSC. When a determination is made that indicates potential design basis safety function impairment consequent to such interaction, appropriate measures will be taken to prevent this impairment.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.7.3.8 and 3.7.3.8.2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-34:

Follow-Up RAI to Question 03.07.03-19:

In its response to **Question 03.07.03-19**, the applicant did not provide a specific comparison of the differences between the 1987 version of IEEE Standard 344 and the 2004 version as it relates to equipment fatigue nor is this comparison found in U.S. EPR FSAR, Tier 2, Section 3.11.2.3.4. As a result, the staff is asking the applicant to provide reconciliation between the two versions of the Standard as it applies to fatigue evaluation.

Response to Question 03.07.03-34:

Comparison of IEEE 344-1987 (Section 6.6, Section 7.6.5 and Appendix D) with IEEE 344-2004 (Section 7.6, Section 8.6.5 and Annex D) fatigue requirements indicates that there is no difference between the 1987 version and the 2004 version except for the qualification methods for complex electrical equipment stated in the last sentence of Section 6.6 (1987 version) and Section 7.6 (2004 version), respectively. The 1987 version requires only consideration of Testing (Section 7), whereas the 2004 version requires consideration of Testing (Section 8), Combined Analysis and Testing (Section 9), and Experience (Section 10). In the 2004 version the additional qualification method for Combined Testing and Analysis may also be used to address fatigue evaluation.

U.S. EPR FSAR Tier 2, Section 3.11.2.3.4 will be revised by adding this information.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.11.2.3.4 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

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.

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. Because the standard plant seismic design basis (see Section 3.7.1.1) coupled with the broad range of soil cases (see Section 3.7.1.3) results in high enveloping structural loads on both the walls and floor diaphragms of the NI Common Basemat Structures it is reasonable to conclude, on an overall stress level basis, that it is appropriate to use SSE structural damping for the NI Common Basemat Structures to generate ISRS. The ISRS for the Emergency Power Generating Building and the Essential Service Water Buildings are based on OBE structural damping.

03.07.01-23

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 ~~kinds of~~ cable tray~~s with flexible support~~ systems (References ~~2~~3 through 5). ~~Flexible support systems include the rod-hung and strut-hung trapeze systems, and the strut-type cantilever and braced cantilever support systems discussed in regulatory position C.3 of RG 1.61.~~ For cable tray~~s with flexible support~~ 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~~s with Flexible Support~~ Systems, may be used on a case-by-case basis and are limited to maximum ~~20~~15 percent damping. For cable tray systems that are significantly different than those tested by Reference 3, ~~but satisfy loading criteria, a maximum~~ the damping values of ~~15 percent may be used in accordance with ASCE 43-05 (Reference 2)~~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.

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

Table 3.7.1-1—Damping Values for Safe Shutdown Earthquake
Sheet 1 of 2

Item	Percent Critical Damping, SSE [4]
Reinforced concrete structures	7
Prestressed Concrete Structures	5
Welded Steel or Bolted Steel with Friction Connections [1]	4
Bolted Steel with Bearing Connections [1]	7
Motor, Fan, and Compressor Housings	3
Pressure Vessels, Heat Exchangers, and Pump and Valve Bodies	3
Welded Instrument Racks	3
Electrical Cabinets, Panels, and Motor Control Centers (MCC)	3
Piping Systems	See Note 2
● Time history and ISM response spectrum analysis	
● USM response spectrum analysis	
● Systems susceptible to Stress Corrosion Cracking (SSC)	
● Systems with supports designed to dissipate energy by yielding	
Reactor Coolant System [6]	
● Component Shells	3
● Component Internals	4
● RPV Closure Head Equipment Tie Rods	7
● RCS Component Supports	4
● RCS Piping (including Surge Line)	4
● Fuel Assemblies [5]	30 max
Cable trays and supports [3] 03.07.01-23	
● Maximum Cable Loading [A, D]	10
● Empty [B~~, D~~]	7
● Sprayed-on Fire Retardant or other cable-restraining mechanism [C]	7
● ~~Flexible Support Systems~~~~[E]~~Cable Tray Systems Represented by Reference 3 [E]	~~20~~15 max
Conduits [3]	
● Maximum Cable fill [A]	7
● Empty [B]	5

Table 3.7.1-1—Damping Values for Safe Shutdown Earthquake
Sheet 2 of 2

HVAC Duct Systems	
● Pocket lock	10
● Companion angle	7
● Welded	4
Metal Atmospheric Storage Tanks	
● Impulsive Mode	3
● Sloshing mode	0.5

NOTES:

1. For steel structures with a combination of different connection types, use the lowest specified damping value, or as an alternative, use a “weighted average” damping value based on the number of each type present in the structure.

2. As specified in RG 1.61, Revision 1 and ANP-10264NP-A.

3. The following clarifications~~, taken from RG 1.61,~~ are applicable.

03.07.01-23

   A. Maximum cable loadings, in accordance with the plant design specification, are to be utilized in conjunction with these damping values.

   B. Spare and initially empty cable trays, may be analyzed with zero cable load and these damping values. (Note: Reanalysis is performed when put into service.)

   C. Restraint of the free relative movement of the cables inside a tray reduces the system damping.

   D. Selected damping value is to be justified and documented on an individual basis when cable loadings less than 50 percent of the maximum rated loading are specified for design calculations.

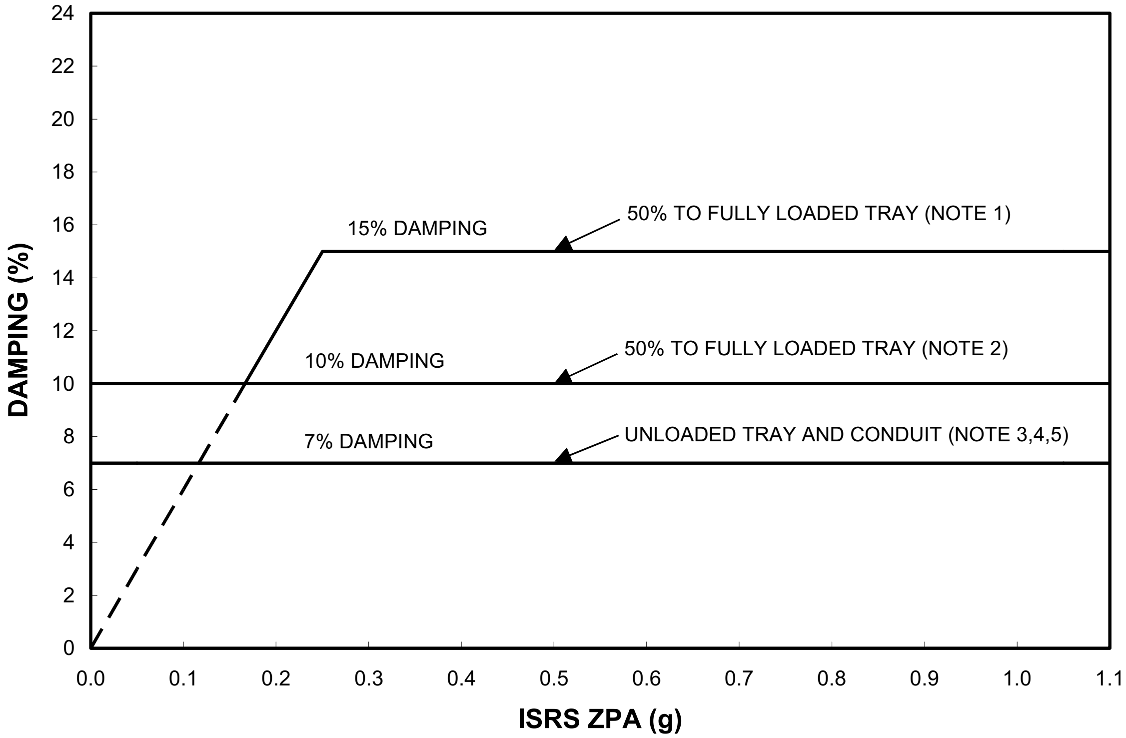
   E. Higher damping values limited to ~~flexibly supported rod and strut-hung trapeze systems, and strut-type cantilever and braced-cantilever~~ cable tray systems representative of systems tested in Reference 3 and loaded to greater than 50 percent of the maximum rated loading.

4. SSE damping values are used for generation of ISRS for the NI Common Basemat Structures. A damping value of four percent is used for generation of the ISRS for the EPGB and ESWB.

5. The model elements representing the fuel assemblies are damped at a maximum of 30% per Framatome Topical Report BAW 10133PA-01 (including Addendum 1 and Addendum 2) (Reference 7).

03.07.01-23

Figure 3.7.1-16—Damping Values for Cable Tray Systems



NOTES:

1. For cable tray systems similar to those tested in Bechtel-ANCO Report 1053-21.1-4 (Reference 3 of 3.7.1.4) with greater than 50 percent loading:

    a. ZPA greater than 0.25g use a damping value of 15 percent.
    b. ZPA between 0.17g and 0.25g use a damping value consistent with the linearly varying line between 15 percent and 10 percent.
    c. ZPA less than 0.17g use a damping value of 10 percent.

2. For cable tray systems that are significantly different than those tested use a damping value of 10 percent for tray with greater than 50 percent loading.

3. Use a damping value of 7 percent for cable tray systems that are unloaded or loaded less than 50 percent.

4. For cable tray systems with rigid fireproofing, use 7 percent damping.

5. For conduit systems, use 7 percent damping.

REV 002
03EPR0320 T2

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.

03.07.02-38

10. ~~R. Kennedy and F. Ostadan, "Consistent Site-Response," Workshop on Seismic Issues: Consistent Site-Response/Soil-Structure Interaction Calculations, at EPRI Palo Alto, California, September 25-26, 2008, (ADAMS Accession No. 082550165)~~Deleted.

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

The ISRS are developed as described and are applied to the subsystem at locations of structural attachment, such as support or equipment locations (see Section 3.7.2.5). The response spectra analysis is performed using either enveloped uniform response spectra or independent support motion (ISM) using multiple spectra input.

ISRS for each of the three directional components of earthquake motions are applied separately to the subsystem. Modal responses are determined by accelerating each mode with the spectral acceleration corresponding to the frequency of that mode. The modal and co-directional responses are then combined by the methods described in Sections 3.7.3.7 and 3.7.3.6, respectively.

Peak Broadening Method

ISRS are generated from the seismic structural analysis using the methods provided in Section 3.7.2 and following guidance from RG 1.122. ISRS are peak broadened by a minimum of ±15 percent to account for uncertainties in the structural response, as described in Section 3.7.2.5.

03.07.03-22

Peak Shifting Method

Peak shifting as described in ASCE 4-98 (Reference 4) and ASME BPV Code, Section III, Division 1, Appendix N (Reference 12) may be used in place of peak broadening to obtain a more realistic design. However, the peak shifting method described by these codes is applicable only to piping systems. Similar to broadening, peak shifting considers a minimum of ±15 percent uncertainty in the peak structural frequencies. However, spectral shifting refines the analysis by considering only one mode of the distribution subsystem to respond at the peak acceleration.

In the peak shifting method, the structural frequencies of the distribution subsystem within the maximum peak acceleration, broadened spectral frequency range are determined. If no distribution subsystem natural frequencies exist within this frequency range, successively lower acceleration peaks are broadened until the first range containing at least one natural frequency of the subsystem is found.

Considering that the peak structural frequency may lie at any one frequency within the broadened range, N+3 separate response spectra analyses are then performed, where N is the number of subsystem modes within the broadened frequency range. The first analysis uses the unbroadened response spectrum. The second and third analyses use the unbroadened spectrum modified by shifting the frequencies associated with each spectral value by $-\Delta f_j$ and $+\Delta f_j$, where Δf_j is the amount of peak shifting required to account for the uncertainties of the structural response. The remaining N analyses also use the unbroadened spectrum modified by shifting the frequencies associated with each spectral value by a factor of:

$$1 + \frac{(f_e)_n - f_j}{f_j}$$

Where:

$(f_e)_n$= Subsystem natural frequency occurring within the broadened range, for n = 1 to N,

f_j = frequency at which the peak acceleration occurs (for the peak under consideration).

For each response spectra analysis performed in the peak shifting method, the modal results are combined separately to obtain responses of interest by the methods described in Section 3.7.3.7. The peak shifting method is preformed for each orthogonal direction of earthquake input motion resulting in three sets of analysis results. Each set of analysis results includes thereby N+3 responses. The governing response for each direction of earthquake input motion is obtained by enveloping the N+3 separate analysis results in each set. The co-directional responses are then determined using the combination methods described in Section 3.7.3.6.

Multiply-Supported Systems

Section 3.7.3.9 describes the uniform support motion (USM) and ISM for subsystems supported at multiple locations within one or more buildings.

3.7.3.1.2 Time History Method

Seismic analyses may be performed using time history analysis methods in lieu of response spectrum analysis. The modal superposition method of time history analysis is used for seismic analysis of U.S. EPR subsystems. This method is based on decoupling of the differential equations of motion, considering a linear elastic system. The total response of the system is determined by integrating the decoupled equations for each mode and combining the results of the modes at each time step using algebraic addition.

Mode shapes and frequencies are determined in the response spectrum analysis method. The cutoff frequency for determining modal properties is selected to account for the principal vibration modes of the subsystem based on mass and stiffness properties, modal participation factors, and the frequency content of the input forcing function. The missing mass effects of high frequency modes are included based on the same principles described in Section 3.7.3.7.

03.07.03-24

The time step is set to be no larger than one-tenth of the shortest period of importance (e.g., the reciprocal of the cutoff frequency). In solution convergence, the general rule 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 4), Section 3.2.2.1(c). Other factors that are considered in the selection of an acceptable time step are the fundamental frequency of the subsystem being analyzed and the input time history.

03.07.03-24

To account for uncertainties in the structural analysis, one of two methods may be used following the guidance of ASCE-4-98 (Reference 4). Similar to peak shifting in the response spectrum method of analysis, three separate input time histories from the structure dynamic analysis may be analyzed with modified time steps. In this approach, the frequency content of the input data is varied by minimum ±15 percent to account for uncertainties in the analysis of the supporting structure. Variation in the frequency content is done by using the same time history ~~date~~data with at least three different time steps, the initial time step ~~D~~Δt and ~~D~~Δt(1±0.15). Additional variations of the time step shall be determined based on consideration of the subsystem frequencies and the frequency content of the excitation data.

03.07.03-23

When time history analysis is performed using this method, a separate analysis is performed for each set of time histories for each of the analysis cases addressed in Section 3.7.2.4.1. The results (e.g., support loads) from the individual analysis cases are then combined to create an enveloping design.

Alternatively, a more conservative approach using a generated synthetic time history may be used as a subsystem forcing function. Time histories are developed to match the enveloped response spectra in accordance with SRP 3.7.1, SAC-1B. This method is not used for U.S. EPR design of subsystems supported at multiple points and having different ISRS. This approach conservatively accounts for uncertainties in the structure frequencies if the response spectra computed from the synthetic time history envelop the broadened ISRS. When this method is used, the additional variation of frequency content is not required because the effects of uncertainties in the supporting structure are included in the broadened ISRS.

Damping values and procedures are addressed in Section 3.7.3.5.

The total response of the subsystems due to excitation in three directions is calculated by methods described in Section 3.7.3.6.

3.7.3.1.3 Inelastic Analysis Methods

Inelastic analysis is not used to qualify seismic subsystems for the U.S. EPR standard plant.

3.7.3.1.4 Equivalent Static Load Method

An alternate method of analyzing the effects of the SSE on a subsystem is to use an equivalent static load method. This simplified analysis considers the mass of subsystem components as lumped masses at their center of gravity locations. The seismic response forces from these masses are then statically determined by multiplying the contributing mass by an appropriate seismic acceleration coefficient. The seismic acceleration coefficient is determined from response spectrum based on the system natural frequency. When the equivalent static load method is used, justification is provided that the use of a simplified model is realistic and the results are conservative. Additionally, relative motion between all points of support, where determined to be significant, are considered in the analysis. Maximum relative support displacements may be determined using conventional static analysis methods and then imposed in the most unfavorable combination. Every support is considered active in the analysis.

In general, many subsystems, and especially distribution subsystems, are multiple degree-of-freedom systems and have a number of significant modal frequencies in the amplified region of the response spectrum curve below the zero period acceleration (ZPA). For these systems, the peak response system may be conservatively used. When the subsystem frequency is not determined analytically, or is determined to be equal to or less than the peak frequency of the appropriate ISRS, the seismic acceleration coefficient is taken as the peak acceleration of the ISRS.

Alternatively, the frequency determination method may be used when the subsystem frequency is greater than the peak frequency of the appropriate ISRS. In the frequency determination method, the subsystem frequency is greater than the peak frequency and the corresponding seismic acceleration is less than the ISRS peak acceleration. For ISRS with multiple peaks, the seismic acceleration coefficient shall not be less than the accelerations corresponding to subsequent ISRS peaks at frequencies higher than the subsystem frequency, as all subsequent modes will have higher frequencies and lower seismic acceleration coefficients.

03.07.03-25

The seismic acceleration coefficient, from both the peak response method and the frequency determination method is multiplied by a multi-mode factor of 1.5 to account for multi-modal participation. ~~A multi-mode factor less than 1.5 may be used, where applicable, with adequate technical justification~~Single-degree-of-freedom (SDOF) systems with a known fundamental frequency or rigid systems with fundamental frequency beyond the cutoff frequency may use a factor of 1.0 with the highest spectral acceleration at that frequency or any subsequent higher frequency (as may be the case for multiple peak input spectra).

This analysis is performed for the three directions of seismic input motion. The results of these three analyses are combined as described in Section 3.7.3.6.

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

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

3.7.3.8 Interaction of Other Systems with Seismic Category I Systems

03.07.03-32

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

For non-seismic subsystems attached to seismic subsystems, the dynamic effects of the non-seismic subsystem are accounted for in the modeling of the seismic subsystem. The attached non-seismic subsystem, classified as Seismic Category II, is designed to preclude the effect of causing failure of the seismic subsystem during a seismic event. Section 3.7.3.3 describes decoupling criteria used to determine if the flexibility of the non-seismic subsystem is included in the subsystem model.

Seismic Category I subsystem design requirements extend to the first seismic restraint beyond the system boundary with non-seismic subsystems.

If the first seismic restraint beyond the Seismic Category I subsystem boundary is an anchor restraining the Category I subsystem in all six degrees of freedom, the analysis model includes only the Category I subsystem up to the anchor, which is designed to accept loads from both the Category I subsystem and the non-seismic subsystem.

If the first seismic restraint cannot be an anchor, the non-seismic subsystem and supports beyond this location that affect the Seismic Category I subsystem dynamic analysis are classified Seismic Category II and included in the model. Boundary conditions of the model at the seismic to non-seismic interface are described in Section 5.5 of Reference 1.

3.7.3.8.1 Isolation of Seismic and Non-Seismic Systems

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

Several routing considerations are used to isolate seismic and non-seismic subsystems. When possible, non-seismic SSC are not routed in rooms containing safety-related SSC. Non-seismic SSC that can not be completely separated from seismic SSC must be shown to have no interaction with the seismic systems based on separation distance or an intermediate barrier, or be classified as Seismic Category II. To the extent possible, non-seismic systems are not routed close to any safety-related components.

3.7.3.8.2 Interaction Evaluation

Non-seismic SSC may be located in the vicinity of safety-related SSC without being qualified as Seismic Category II, provided an impact evaluation is performed to verify that no possible adverse impacts occur. In this evaluation, the non-seismic components are assumed to fall or overturn as a result of a seismic event. Any safety-related subsystem or component which may be impacted by the non-seismic component is identified as an interaction target and is evaluated to establish that there is no loss of ability to perform its safety-related function.

03.07.03-32

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

~~As a result of the seismic event:~~

- ~~Every non-seismic hanger on the non-seismic distribution subsystems is assumed to fail instantaneously.~~
- ~~Every connection on the non-seismic distribution subsystem is assumed to fail, thus allowing each section of a subsystem to fall independently.~~
- ~~Every flange on bolted connections on a non-seismic system and other distributed subsystems is assumed to fail, thus allowing each section of piping to fall independently.~~
- The non-seismic system or component (source) is assumed to fail instantaneously at every connection allowing each section to fall or overturn independently.

03.07.03-32

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

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

  For non-seismic equipment that can overturn as a result of SSE, the fall trajectory is evaluated to determine if it poses a potential impact hazard to a safety-related SSC. If it poses a hazard, and can not be relocated, it is classified as Seismic Category II.

  Non-seismic components (e.g., walls, platforms, stairs) or other structures located in the vicinity of safety-related SSC are evaluated to determine if their failure is credible.

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

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

  Non-seismic SSC located in the vicinity of safety-related SSC is acceptable without being classified as Seismic Category II, if an analysis demonstrates that the weight and configuration of the non-seismic SSC, relative to the target, and the trajectory of the falling non-seismic SSC interaction do not cause unacceptable damage to the safety-related SSC. Otherwise, the non-seismic SSC present a hazard, and are relocated or classified as Seismic Category II.

3.7.3.9 Multiply-Supported Equipment and Components with Distinct Inputs

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

$$S_d = \frac{S_a g}{\omega^2}$$

allowable strain limit, ε_a, is limited to four percent of the pipe diameter in addition to satisfying the axial strain limit.

Section 3.8.4.1.8 describes requirements placed on the COL applicants to provide a description of Seismic Category I buried conduit and duct banks.

3.7.3.13 Methods for Seismic Analysis of Category I Concrete Dams

There are no Seismic Category I concrete dams in the U.S. EPR design. A COL applicant that references the U. S. EPR design certification will provide a description of methods used for seismic analysis of site-specific Category I concrete dams, if applicable.

3.7.3.14 Methods for Seismic Analysis of Aboveground Tanks

Dynamic pressure on fluid containers in the in-containment refueling water storage tank (IRWST), spent fuel pool, and other fluid reservoirs due to the SSE are considered in accordance with ASCE 4-98 (Reference 4). Section 3.7.1.2 presents damping values for seismic analysis of aboveground tanks. Damping values for concrete aboveground tanks are seven percent of critical for impulsive modes and 0.5 percent for sloshing mode. These damping values are taken from Table 3.7.1-1.

Seismic analyses of concrete above-ground tanks consider impulsive and convective forces of the water, as well as the flexibility of the tank walls and floor, and ceiling of the tank. For the spent fuel pool, cask loading pit, cask washdown pit, and fuel transfer canal, the impulsive loads are calculated by considering a portion of the water mass responding with the concrete walls (see Section 3.7.2.3). Impulsive forces are calculated by conventional methods for tanks determined to be rigid. For non-rigid tanks, the effect of tank flexibility on spectral acceleration is included when determining the hydrodynamic pressure on the tank wall for the impulsive mode.

Convective forces resulting from the sloshing of water are calculated based on the natural frequency of the sloshing water. The natural frequency is used with the 0.5 percent damping curve to determine the spectral acceleration. Guidance from USAEC TID-7024 is used to calculate the forces which are applied as pressures and used in the design of the tank structure.

The IRWST is analyzed using finite element methods by including it in the 3D FEM model of the internal structures described in Section 3.7.2 and detailed in Section 3.8.3.

3.7.3.15 References

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

3.7.3.15 References

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

2. Deleted.

3. ASCE “Seismic Response of Buried Pipe and Structural Components,” ASCE Committee on Seismic Analysis of Nuclear Structures and Material, American Society of Civil Engineers, 1983.

4. ASCE Standard 4-98, “Seismic Analysis of Safety-Related Nuclear Structures and Commentary,” American Society of Civil Engineers, September 1986.

5. SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water (ALWR) Designs,” U.S. Nuclear Regulatory Commission, July 1993.

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

7. IEEE 344-2004, “Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations,” Institute of Electrical and Electronics Engineers, 2004.

8. NUREG-1061, “Report of the U.S. Nuclear Regulatory Commission Piping Review Committee,” U.S. Nuclear Regulatory Commission, (Vol. 1) August 1984, (Vol. 2) April 1985, (Vol. 3) November 1984, (Vol. 4) December 1984, (Vol. 5) April 1985.

9. W.S. Tseng, “Equipment Response Spectra Including Equipment–Structure Interaction Effects,” 1989 Pressure Vessel and Piping Conference, ASME PVP, Volume 155.

10. ACI 349-01/349R-01, Appendix C, “Code Requirements for Nuclear Safety Related Concrete Structures and Commentary,” American Concrete Institute, January 2001.

11. USAEC TID-7024, “Nuclear Reactors and Earthquakes,” U.S. Atomic Energy Commission, August 1963.

12. ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Facility Components,” American Society of Mechanical Engineers, 2004.

03.07.03-22

3.11.2.3.4 IEEE Std 344-2004, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

IEEE Std 344-2004 provides the recommended practices for seismic qualification of class 1E equipment. The following is a summary of a comparison of the various versions of this standard.

The IEEE Std 344-1971/1975 versions do not mention the Seismic Qualification Utility Group experience databases. The 1987 and 2004 versions discuss experience databases and how to apply operating experience to seismic qualification. Similarity for type testing is mentioned briefly in IEEE Std 1971/1975. Further discussion is given in IEEE Std 1987/2004. The IEEE Std 344-1971/1975 versions address uniaxial and biaxial excitation only. The 1987/2004 versions specify triaxial (preferred), then biaxial, then uniaxial and axial independence must be justified.

The IEEE Std 344-1971/1975 versions specify RMF or single frequency testing; 1987/2004 specifies RMF or RIM. Per application RMF can be supplemented with single frequency for peaks. The IEEE Std 1971/1975 versions specify static and dynamic analysis methods in general terms. The IEEE Std 344-1987/2004 versions specify numerous varieties of static and dynamic analyses with specific guidance. The IEEE Std 344-1971/1975 versions discuss only resonant search and modal testing. The IEEE Std 344-1987/2004 versions specify resonant search and modal testing and requirements to address resonances in testing to justify coupling. Transmissibility plots are required.

The IEEE Std 344-1971/1975 versions discuss the low impedance method and the exploratory tests used for qualification method selection. The IEEE Std 344-1987/2004 versions allow exploratory tests to be used as input for dynamic/static qualification analyses. The IEEE Std 344-1971/1975 versions defined “damping;” the 1987/2004 versions provide a method for calculating damping. The IEEE Std 344-1971/1975 versions define “seismic vibration.” The IEEE Std 1987/2004 versions define and differentiate between Seismic and Non-Seismic vibration. The IEEE Std 344-1971/1975 versions defined “ZPA;” the IEEE Std 1987/2004 versions provide a method for calculating ZPA.

03.07.03-34

Comparison of the fatigue requirements between IEEE 344-1987 (Section 6.6, Section 7.6.5, and Appendix D) and IEEE 344-2004 (Section 7.6, Section 8.6.5, and Annex D) indicates that there is no difference between the 1987 version and 2004 version except the qualification methods for complex electrical equipment, which is stated in the last sentence of Section 6.6 (1987 version) and Section 7.6 (2004 version), respectively. In the 1987 version, only Testing (Section 7) should be considered, whereas, in the 2004 version, Testing (Section 8), Combined Analysis and Testing (Section 9), and Experience (Section 10) are to be considered. The additional qualification method for Combined Testing and Analysis may also be used to address fatigue evaluation.

3A.3.4 Allowable Stress Criteria

The basic stress allowables for carbon steel cold formed sections are in accordance with the AISI cold-formed structural design specification (Reference 4). The basic stress allowables for support structural steel, welds, and bolts are in accordance with Reference 8.

3A.3.5 Damping

The damping values for the design of cable tray and conduit systems and their associated supports are addressed in Section 3.7.1.2, and are provided in Table 3.7.1-1.

03.07.01-23

Cable tray~~s with flexible support~~ systems may use higher damping values based on testing, which includes the proposed installed configuration, loading, and support system. Historic tests have demonstrated that a substantial amount of energy is dissipated by friction between cables and through movement and ~~bounding~~bouncing of cables within the tray. The increase in damping is more pronounced for loaded trays with higher input excitation but the maximum critical damping is limited to ~~20~~15 percent for ~~flexibly supported~~ cable trays with a minimum loading of 50 percent of the trays full rated loading (for input ground motion ZPA exceeding 0.25 g). ~~C~~Other cable tray systems ~~that are supported in accordance with the configurations described in ASCE 43-2005~~ are limited to a maximum critical damping of ~~15~~10 percent for ~~input ground motion ZPA limited to 0.25g. The damping values~~ cable tray systems with ~~less~~more than 50 percent loading and 7 percent with less than 50 percent loading in accordance with RG 1.61 and as shown in ~~may be determined from~~ Figure 3.7.1-16~~, which is dependent on the flexibility of the cable tray system, including both the cable tray and its supports, for an input ground motion ZPA up to and exceeding 0.35g~~. The damping value is to be reduced to the values indicated in Table 3.7.1-1 for conduit, cable trays loaded to less than 50 percent of the cable tray rated capacity, cable trays loaded primarily with conduit, or when rigid fire proofing materials are used causing the cables to become effectively bundled together.

3A.3.6 Seismic Analysis

This section describes the seismic analysis criteria for cable trays, conduits and their supports.

3A.3.6.1 Seismic Analysis Methods

Refer to Section 3.7.3.1.

3A.3.6.2 Determination of Number of Earthquake Cycles

Section 3.7.3.2 discusses the required number of earthquake cycles to be considered for seismic-induced fatigue. Rolled structural steel members for cable tray and conduit supports may be qualified for fatigue by evaluation in accordance with the provisions