ArevaEPRDCPEm Resource

From:	Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
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
Attachments:	RAI 215 Supplement 1 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. 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: 742

Mail Envelope Properties (5CEC4184E98FFE49A383961FAD402D3101291914)

Subject: Response to U.S. EPR Design Certification Application RAI No. 215, FSAR Ch 3, Supplement 1
Sent Date: 8/19/2009 4:51:16 PM
Received Date: 8/19/2009 4:51:18 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	7210	8/19/2009 4:51:18 PM
RAI 215 Supplement 1 Response US EPR DC.pdf		134713

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

Response to

Request for Additional Information No. 215, Supplement 1

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 03.07.01-20:

Follow-Up RAI to Question 02.05.02-2 and 03.07.01-3

The site soil profiles presented in the U.S. EPR FSAR are assumed to be strain compatible profiles. Guideline 5 in U.S. EPR FSAR Section 2.5.2.6 states that applicant will demonstrate that the idealized site soil profile is similar to or bounded by the 10 generic soil profiles used for the U.S.EPR but does not contain the requirement that the site soil profile used in the comparison needs to be a strain compatible profile. The applicant is requested to add to Guideline 5 of U.S.EPR FSAR Section 2.5.2.6, the requirement that the site soil profile that is compared to the U.S. EPR soil profile needs to be a strain compatible soil profile.

Response to Question 03.07.01-20:

U.S. EPR FSAR Tier 2, Section 2.5.2.6 will be revised to identify the requirement that the site soil profile is to be strain-compatible.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 2.5.2.6 will be revised as described in the response and indicated on the enclosed markup

Question 03.07.02-41:

Follow-Up RAI to Question 03.07.02-32:

Specific to the Nuclear Island Common Basemat Structures, the dynamic model is a lumped mass model while the static model is a FEM. Describe how the results from the lumped mass model are distributed to the finite element model and include in your response the following information:

a. How accelerations are distributed between elevations of the lumped mass model.

b. How accelerations are distributed within the same elevation when more than one lumped mass has been provided at that elevation.

c. How the loads on the circular walls are determined, (both in-plane and out-of-plane) from the results of a lumped mass model that are given in three orthogonal directions.

This information should also be included in the FSAR.

Response to Question 03.07.02-41:

Lumped mass dynamic model zero period acceleration (ZPA) values are applied to finite element model (FEM) elements in the three orthogonal directions using the 1.0, 0.4, 0.4 method. Seismic acceleration modification factors are used to normalize equivalent forces and moments with soil-structure interaction (SSI) model results (see U.S. EPR FSAR Tier 2, Section 3.8.3.4.4). Forces and pressures are scaled by the ZPA values and applied in the appropriate direction (see U.S. EPR FSAR Tier 2, Section 3.8.4.4.1). The appropriate ZPA value is mapped onto the FEM from the lumped mass model in the vertical and horizontal planes as follows:

a. Vertically, lumped masses are determined based on the weight of slabs, walls, and loads within half the height to the next key elevation below and above (see U.S. EPR FSAR Tier 2, Section 3.7.2.3.1). ZPA determined at the elevation of a lumped mass (see the Response to part b.) is conservatively applied to FEM elements and loads that fall within the range bounded by that elevation and the key elevation below (see the Response to RAI 222, Question 03.08.03-18).

b. Horizontally, at each given elevation along the individual stick models, the worst ZPA at the lumped mass location and building corners is used as the ZPA for that elevation (see U.S. EPR FSAR Tier 2, Section 3.7.2.4.6). Thus, there is only one ZPA per elevation per building. The Reactor Shield Building (RSB), Reactor Containment Building (RCB), Reactor Building Internal Structures (RBIS), Safeguard Building (SB)1, SB23, SB4, Fuel Building (FB), SB23 shield wall, and FB shield wall elements are given ZPA values from their corresponding stick models. The exception to this is the RBIS above elevation +63 ft, 11-3/4 inches. There is an east and a west SG compartment that receives separate lumped masses at each elevation to allow separate motions (see U.S. EPR FSAR Tier 2, Section 3.7.2.3.1.2). ZPA values are applied to each compartment from its corresponding lumped mass.

With respect to circular walls:

c. Using the 1.0, 0.4, 0.4 rule, accelerations from the lumped mass model are applied in the three orthogonal directions to FEM elements and loads of circular walls (see RAI

155, Question 03.08.01-8 response for a more detailed description of the RCB seismic loading).

FSAR Impact:

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

Question 03.07.02-42:

Follow-Up RAI to Question 03.07.02-33:

The applicant is requested to provide the information contained in its response to **Question 03.07.02-33** in the FSAR.

Response to Question 03.07.02-42:

U.S. EPR FSAR Tier 2, Section 3.7.2.3.1 will be revised to state:

> "The sloshing frequency ranges from approximately 0.1 Hz to 0.5 Hz. The fundamental frequency for the associated structures ranges from approximately 2.5 Hz to 13 Hz."

U.S. EPR FSAR Tier 2, Section 3.7.3.14 will be revised to include this paragraph:

> "Convective forces resulting from the sloshing 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 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."

U.S. EPR FSAR Tier 2, Section 3.7.3.15 will be revised to include the following reference:

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

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.7.2.3.1, 3.7.3.14, and 3.7.3.15 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-28:

Follow-Up RAI to Question 03.07.03-10:

The staff has asked in the Follow-Up RAI to **Question 3.07.03-3** how the floor time history results from each soil condition are used in the design of supported subsystems. However, the applicant in its response to Question 03.07.03-10 provided two references for the time history generation from ISRS; FSAR Section 3.9 and Section 3.2.4. There is no FSAR Section 3.2.4 and no description of the method for time history generation could be found in FSAR Section 3.9. The applicant is requested to correct or revise the references provided for this response.

Response to Question 03.07.03-28:

The correct reference for time history generation method description is ANP-10264NP-A Rev. 0, “U.S. EPR Piping Analysis and Support Design Topical Report,” Section 3.2.4, which is listed in U.S. EPR FSAR Tier 2, Section 3.7.3.15 as Reference 1.

FSAR Impact:

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

Question 03.07.03-29:

Follow-Up RAI to Question 03.07.03-12:

In its response to **Question 03.07.03-12**, the applicant is requested to correct the revision to R.G. 1.92 provided on page 3.7-305 to Revision 2 from Revision 3.

Response to Question 03.07.03-29:

The R.G. 1.92 reference typographical error will be changed from Revision 3 to Revision 2.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.3.7.1 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.03-30:

Follow-Up RAI to Question 03.07.03-13:

The applicant is requested to change the definition in the FSAR of the {r} vector appearing on page 3.7-304 to make it consistent with the other terms in the equation that appears at the bottom of the page.

Response to Question 03.07.03-30:

The definition of the total inertia forces (F_t and F_s) and the missing forces considering unit ground acceleration (F_M) will be changed to be consistent with ASCE Standard 4-98, “Seismic Analysis of Safety-Related Nuclear Structures and Commentary,” which is listed in U.S. EPR FSAR Tier 2, Section 3.7.3.15 as Reference 4.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.3.7.2 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

soil-structure interaction analyses performed for the U.S. EPR in addressing the following evaluation guidelines.

1. The applicant will confirm that the peak ground acceleration for the GMRS is less than 0.3g.

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

3. The applicant will demonstrate that the FIRS are enveloped by the CSDRS for the U.S. EPR using the guidance provided in Section 3.7.1.1.1.

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

03.07.01-20

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

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

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

8. If the evaluations of step 7 are not sufficient, the applicant will perform detailed site-specific SSI analyses for the particular site. This site-specific evaluation will include dynamic seismic analyses and development of in-structure response spectra (ISRS) for comparison with ISRS for the U.S. EPR. These analyses will be performed in accordance with the methodologies described in Section 3.7.1 and Section 3.7.2. Results from this comparison will be acceptable if the amplitude of the site-specific ISRS do not exceed the ISRS for the U.S. EPR by greater than 10 percent on a location-by-location basis. Comparisons will be made at the following key locations, defined in Section 3.7.2:

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

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

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

03.07.02-42

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

The combination method used considers the effects of closely spaced modes. Modes are defined as being closely spaced if their frequencies differ from each other by 10 percent or less of the lower frequency.

For subsystems analyzed using the USM method and with no closely spaced modes, the SRSS method is applied to obtain the representative maximum response of each element, as shown in the following equation:

$$R = \left[\sum_{k=1}^{N} R_k^2 \right]^{\frac{1}{2}}$$

Where:

R = the representative maximum response due to earthquake motion in one direction. (This calculation is performed in each of the earthquake directions.)

R_k = the peak response due to the k^{th} mode

N = the number of low frequency modes.

If modes with closely spaced frequencies exist, the SRSS method is not applicable, and one of the two methods presented in C.1.1.2 and C.1.1.3 of RG1.92, Revision ~~3~~2 should be used instead.

03.07.03-29

The more conservative methods of the combining modal responses as described in RG 1.92, Revision 1 remain acceptable; however, when using the Revision 1 methods, the residual response provisions of Revision 2 for treatment of the missing mass modes (as discussed in C.1.4.1 and C.1.5.1 of RG 1.92, Revision 2) shall be implemented.

3.7.3.7.2 High Frequency (Rigid) Modes

Modes with frequencies greater than the ZPA cutoff frequency are considered as high frequency, or rigid range, modes. For flexible subsystems, the high frequency response may not be significant since a significant portion of the system mass is excited at frequencies below the ZPA. For subsystems, portions of subsystems that are more rigidly restrained or have lumped masses near rigid restraints, a significant portion of the system mass may not be accounted for in the low frequency modal analysis. This mass which is not excited at the lower frequencies is termed the missing-mass of the system. While high frequency modes usually involve small displacement amplitudes and small stresses, they can have a significant impact on support loads.

The response from high frequency modes must be included in the response of the subsystem. Guidance for including the missing mass effects is provided in SRP Section 3.7.3 of Reference 6, RG 1.92 for subsystems supported at a single point and for multiply supported subsystems analyzed by USM. Guidance for subsystems analyzed by ISM is provided in Reference 8, Volume 4.

The peak modal responses of the system at frequencies above the ZPA are considered to be in phase. For subsystems supported at a single point and for multiply support subsystems analyzed by either USM or ISM methods of analysis, the responses of high frequency modes are combined by algebraic summation.

The U.S. EPR design calculates the response of the high frequency modes by including a missing mass correction.

The total inertia forces in a subsystem under simple excitation in a steady-state condition with unit acceleration applied in a specified direction is mathematically represented by the following expression.

$$\{F_1\} = [M]\{r\}\ddot{u}g$$

Where:

$\{F_t\}$ = total inertia forces in the specified direction

$[M]$ = mass matrix

$\{r\}$ = mass point displacement vector produced by a statically applied unit ground displacement.

03.07.03-30

$\ddot{u}g$ = ground acceleration

The sum of the inertia forces for each mode included in the modal analysis is calculated as:

$$\{F_s\} = \sum_{n=1}^{N}\{F_n\} = \sum_{n=1}^{N}[M]\left[\{\phi_n\}\{\phi_n\}^T[M]\{r\}\right]\ddot{u}g$$

Where:

$\{F_s\}$ = total inertia force seen by the system in the low frequency modal analysis

$\{F_n\}$= inertia force of mode n

$\{\phi_n\}$= mode shape

N = number of modes calculated in the modal analysis.

Therefore, the missing forces considering unit ground acceleration in a specified direction are calculated as:

03.07.03-30

$$\{F_m\} = \{F_t\} - \{F_s\} = [M]\{r\}\ddot{u}g - \sum_{n=1}^{N} [M]\{\phi_n\}\{\phi_n\}^T [M]\{r\}\ddot{u}g$$

or:

$$\{F_m\} = [M]\{r\}\ddot{u}g\left[1 - \sum_{n=1}^{N} [M]\{\phi_n\}\{\phi_n\}^T\right]$$

The missing inertia forces are calculated independently for all input components of earthquake motion (i.e., in each direction for each support group). The mode displacements, member end action, and support force corresponding to each missing force vector are determined.

For subsystems supported at a single point or for multiple supported systems analyzed by the USM method, these results are treated as an additional modal result in the response spectra analysis. This missing mass mode is considered to have a modal frequency and acceleration defined at the cut-off frequency used in the modal analysis. 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

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

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.

03.07.02-42

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.

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.

Next File

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.

03.07.02-42

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