ArevaEPRDCPEm Resource

From: WELLS Russell D (AREVA NP INC) [Russell.Wells@areva.com]
Sent: Friday, June 12, 2009 6:07 PM
To: Tesfaye, Getachew
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. 190, FSAR Ch 3, Supplement 1
Attachments: RAI 190 Supplement 1 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for the responses to the 3 questions of RAI No. 190 on March 20, 2009. The attached file, "RAI 190 Supplement 1 Response U.S. EPR DC" provides technically correct and complete responses to 2 of the 3 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 190 Question 03.08.01-28.

The following table indicates the respective pages in the response document, "RAI 190 Supplement 1 Response U.S. EPR DC," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 03.08.01-28	2	3
RAI 03.08.01-30	4	4

A revised schedule for a technically correct and complete response to the remaining question is provided below.

Question #	Response Date
RAI 03.08.01-29	October 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
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From: Pederson Ronda M (AREVA NP INC)
Sent: Friday, March 20, 2009 3:33 PM
To: 'Getachew Tesfaye'
Cc: PORTER Thomas (EXT); DELANO Karen V (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 190, FSARCh. 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 190 Response US EPR DC.pdf" provides a schedule since a technically correct and complete response to the 3 questions is not provided.

The following table indicates the respective page in the response document, "RAI 190 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 190 — 03.08.01-28	2	2
RAI 190 — 03.08.01-29	3	3
RAI 190 — 03.08.01-30	4	4

The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 190 —03.08.01-28	June 12, 2009
RAI 190 —03.08.01-29	June 12, 2009
RAI 190 —03.08.01-30	June 12, 2009

Sincerely,

Ronda Pederson
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From: Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Friday, February 20, 2009 11:11 AM
To: ZZ-DL-A-USEPR-DL
Cc: Jim Xu; Sujit Samaddar; Michael Miernicki; Joseph Colaccino; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 190 (2205), FSARCh. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on February 18, 2009, and on February 20, 2009, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI except to correct a typographical error in the RAI numbering. The RAI no is changed from 190(2083) to 190(2205) in the email subject line and from 2205 to 190 (2205) in the attachment. 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: 576

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Subject: Response to U.S. EPR Design Certification Application RAI No. 190, FSAR Ch 3, Supplement 1
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From: WELLS Russell D (AREVA NP INC)

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RAI 190 Supplement 1 Response US EPR DC.pdf		122176

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Recipients Received:

Response to

Request for Additional Information No. 190, Supplement 1

2/18/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.08.01 - Concrete Containment
Application Section: FSAR Ch 3

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

Question 03.08.01-28:

As a result of the structural audit conducted by the NRC staff at AREVA offices, during the week of January 26, 2009, a question arose regarding the use of seismic modification factors when performing the seismic equivalent static analysis of the Nuclear Island (NI) structures. Provide an explanation why these seismic modification factors are used and how they are developed. Also, demonstrate that when using these factors, the resulting member forces (shears and moments) at selected key locations are equal to or more conservative than the corresponding member forces from the SASSI soil-structure interaction analyses. The technical basis for the use of these seismic modification factors should be described in Section 3.8 of the FSAR.

Response to Question 03.08.01-28:

Maximum accelerations are determined from the soil-structure interaction (SSI) analysis for use in developing design forces and moments in a detailed equivalent static model. Using maximum accelerations at all floor elevations, rather than modeling accelerations in the time domain considering signs or specific accelerations for each floor elevation, produces conservative design forces and moments. The degree of conservatism present is determined by comparing SSI analysis base forces and moments with those from application of maximum accelerations on a detailed finite element static model (see Table 03.08.01-28-1). Acceleration modification factors are then developed to normalize excess conservatism inherent in this approach.

Table 03.08.01-28-1 – Soil Case 5ah at Base without ZPA Modification Factors

	Vx (kN)	Vy (kN)	Pz (kN)	Myy (kN-m)	Mxx (kN-m)
Static Equivalent Results	2.247E06	2.196E06	2.799E06	6.717E07	6.597E07
SSI Results	1.371E06	1.405E06	1.595E06	4.134E07	5.254E07
Ratio (SSI/Static)	0.61	0.64	0.57	0.62	0.79

The process used in calculating modified shears and moments is as follows:

Maximum accelerations are extracted from the SSI analysis at each floor elevation. Static forces based on mass times acceleration are then used to calculate forces at each node. From these forces, base shear and moments are statically calculated and compared with the corresponding SSI-derived shear and moments. This process is used for each soil case. Accelerations are then adjusted by a modification factor until the SSI-derived results are in effective agreement with the statically calculated results.

Modified accelerations are then applied to the equivalent static model. Interstory shears and moments from the equivalent static model are compared to SSI-derived shears and moments at the base and confirmed to be at least as high as the SSI-derived loads at the base (Table 03.08.01-28-2).

Table 03.08.01-28-2 – Soil Case 5ah at Base with ZPA Modification Factors

	Vx (kN)	Vy (kN)	Pz (kN)	Myy (kN-m)	Mxx (kN-m)
Static Equivalent Results with Factored ZPA	1.461E06	1.867E06	1.679E06	4.635E07	5.585E07
SSI Results	1.371E06	1.405E06	1.595E06	4.134E07	5.254E07
ZPA Modification Factor	X Factor = 0.65				
	Y Factor = 0.85				
	Z Factor = 0.60				

AREVA NP has confirmed that interstory shears and moments from the SSI analysis and those from the equivalent static analyses are conservative and comparable. Nevertheless, multiple acceleration correction factors that model variation in conservatism in the interstory forces and moments according to elevation provide a better match to SASSI produced interstory shears and moments. U.S. EPR FSAR Tier 2, Section 3.8 will be revised as follows to include such a procedure:

3.8.3.4.4 1st paragraph, append:

> "Seismic acceleration modification factors are used to adjust the equivalent static forces and moments to be consistent with the SSI model results."

3.8.4.4.1, 1st paragraph under *Seismic and Other Dynamic Analyses and Design,* append:

> "Seismic acceleration modification factors are used to adjust the equivalent static forces and moments to be consistent with the SSI model results."

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.8 will be revised as described in the response and indicated on the enclosed markup.

Question 03.08.01-30:

As a result of the structural audit conducted by the NRC staff at AREVA offices, during the week of January 26, 2009, a question arose regarding the finite element analysis of the Emergency Power Generating Building (EPGB). The AREVA calculation containing the development of the FEM for the EPGB contains a mesh sensitivity analysis for one of the walls which had openings. This sensitivity analysis concluded that a load factor was required to account for the need of a finer mesh representation of the wall. Explain why this mesh sensitivity analysis was only performed for one wall and not for the other walls as well.

Response to Question 03.08.01-30:

Emergency Power Generating Building (EPGB) Wall 11 and Wall C were identified as critical structural elements. Refinement of Wall 11 finite element (FE)-mesh was further evaluated because this wall has large openings and some of its elements are among the largest used for the EPGB FE model (up to 3.4 times the wall thickness). Evaluation showed that the Wall C mesh is appropriate since it is a solid wall (i.e., no openings or re-entrant corners on each story) and its elements are generally smaller than Wall 11 elements (not greater than 2.75-times the wall thickness). Wall C is subject only to small concentrated loads (e.g., steel platform support reactions). Based on standard industry practice, plate element size of up to three times the wall thickness is satisfactory for obtaining design forces when these conditions are present.

In response to this RAI, refinement of Wall C FE-mesh was investigated. Wall C is typical of other walls perpendicular to Wall 11.

Wall C FE-mesh was refined by doubling the number of elements in both horizontal and vertical directions. By this, each element was effectively divided into four equal-size elements. For the sensitivity analysis, an individual wall panel was modeled using the original mesh as well as the refined mesh and each was subjected to a uniform pressure of 10 ksf. Fixed and simple supports were considered. To compare the FE analysis results, horizontal and vertical section cuts were made on both the current and the refined FE-meshes.

Finite element analyses were executed and section forces determined using the “LIST SUM FORCE” command in GT STRUDL. Moments and shear forces from the two FE-meshes were compared for both fixed and simple boundary conditions. Comparison of results shows that shears computed using the refined mesh are equal to or less than, shears produced using the original mesh. Computed moments from the refined mesh are 6 percent higher at some locations.

Thus, AREVA NP concludes that FE analysis results using the original mesh are conservative compared to those produced by the refined mesh and confirms that the original FE-mesh for Wall C is typical of the other walls and adequate for design purposes.

FSAR Impact:

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

U.S. EPR Final Safety Analysis Report Markups

The design of bolted connections in combination with welded connections is in accordance with Section Q.15.10 of ANSI/AISC N690.

Openings in walls and slabs of RB internal structures are shown on construction drawings. Openings in slabs are acceptable without analysis if they meet the criteria identified in ACI 349, Section 13.4.2. Round pipe sleeves are used in lieu of rectangular penetrations, where possible. Corners of rectangular openings in walls or slabs are provided with diagonal reinforcing to reduce cracking due to stress concentrations at these locations in accordance with ACI 349, Section 14.3.7.

Appendix 3E provides a description of analysis and design results for critical areas of the RB internal structures.

Section 5.4.14 describes the design of interfacing steel assemblies which support the NSSS components and attach to, or interact with, embedments in the concrete. Steel supports for the RCS components and piping, including the base plates at the face of concrete structures, are designed in accordance with ASME Section III Division 1, Subsection NF. Embedded portions of RCS component and pipe supports, which are beyond the jurisdictional boundary of the ASME Code, are designed in accordance with ~~ACI 349-2001, including Appendix B~~ ACI 349-06 (Appendix D with exceptions stated in Section 3.8.1.2.1, "Codes"), and also in accordance with ANSI/AISC N690-1994 (R2004), including Supplement 2.

3.8.3.4.3 Static Analysis and Design

Dead loads (D), live loads (L), hydrostatic loads (F), pipe reactions (R_o), and normal thermal loads (T_o) are considered in the analysis and design of RB internal structures for the static normal load concrete and service load steel loading combinations. Normal thermal loads are considered as self-relieving for the overall RB internal structures. Concrete and steel members are designed to accommodate these static loads within the elastic range of their section strength.

Static fluid pressure loads are considered for design of the walls and floors of the IRWST and refueling canal. Moving loads are considered for mobile plant equipment (e.g., the polar crane, refueling machine, and other cranes and hoists).

3.8.3.4.4 Seismic and Other Dynamic Analyses and Design

Seismic analyses and designs of the RB internal structures conform to the procedures described in Section 3.7.2. The procedures in ASCE Standard 4-98 are used in the analysis and design of structural elements and members subjected to load combinations that include seismic loadings. Seismic accelerations are determined from the structural stick model described in Section 3.7.2. These accelerations are applied to the ANSYS model of the RB internal structures as static-equivalent loads at the elevations used in the stick model. Seismic acceleration modification factors are

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used to adjust the equivalent static forces and moments to be consistent with the SSI model results.

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Seismic SSE (E') loads are obtained by multiplying the dead load and 25 percent of the design live load by the structural acceleration obtained from the seismic analysis of the structure. To remain consistent with this methodology, the live load in load combinations that include seismic loads is reduced to achieve the same effective live load as in the seismic loads (25 percent). The resulting forces and moments from the remaining 75 percent of the live load are manually determined and added to the ANSYS results. Seismic loads are also considered due to the mass of fluids in tanks and canals as described herein (Section 3.8.3.4.4). The design live load is used for the local analysis of structural elements and members. Consideration is given to the amplification of these accelerations due to local flexibility of structural elements and members. Construction loads are not included when determining seismic loads. Other temporary loads are evaluated for contributing to the seismic loads on a case-by-case basis.

Seismic loads from the three components of the earthquake are combined using the SRSS method or the 100-40-40 percent rule described in ASCE 4-98. The 100-40-40 combination is expressed mathematically as follows:

~~Where:~~

Let R_1, R_2, R_3 be the maximum responses of an SSC caused by each of the three earthquake components calculated separately. The maximum seismic response attributable to earthquake loading in three orthogonal directions shall be evaluated as:~~R = the reaction force or moment that is applied in the three orthogonal directions x, y, and z.~~

$R = (\pm 1.0R_{X1} \pm 0.4R_{Y2} \pm 0.4R_{Z3})$,

$R = (\pm 0.4R_{X1} \pm 1.0R_{Y2} \pm 0.4R_{Z3}$, or$)$

$R = (\pm 0.4R_{X1} \pm 0.4R_{Y2} \pm 1.0R_{Z3})$.

Whichever is greatest.

The effects of local flexibilities in floor slabs and wall panels are considered to determine if additional seismic accelerations should be applied to their design beyond those determined from the seismic stick model. Local flexibility evaluations are performed by determining the natural frequency of the floor or wall panel and comparing this to the frequency of the zero period acceleration on the applicable response spectra. Additional acceleration is applied when the natural frequency of the panel results in higher accelerations than the zero period acceleration. In cases where local flexibilities are determined to be a factor, additional out-of-plane accelerations criteria identified in ACI 349, Section 13.4.2. Round pipe sleeves are used in lieu of rectangular penetrations where possible. Corners of rectangular openings in walls and slabs are provided with diagonal reinforcing to reduce cracking due to stress concentration at these locations in accordance with ACI 349, Section 14.3.7.

Appendix 3E describes analysis and design results for critical sections of other Seismic Category I structures.

Section 3.7.2 addresses design procedures applicable to non-safety-related structures to preclude adverse interaction effects on Seismic Category I structures.

Static Analysis and Design

Dead loads (D), live loads (L), hydrostatic loads (F), soil loads and lateral earth pressure loads (H), wind loads (W), pipe reactions (R_o), and normal thermal loads (T_o) are considered in the analysis and design of other Seismic Category I structures for the static normal load concrete and service load steel loading combinations. Concrete and steel members are designed to accommodate these static loads within the elastic range of their section strength. For concrete structures, uncracked section properties are used to proportion loadings to members. However ultimate strength design is used to reinforce concrete elements and members subjected to the normal factored loading combinations defined in Section 3.8.4.3.2.

Static fluid pressure loads are considered for design of the walls and floors of tanks and storage pools. Moving loads are considered for mobile plant equipment (e.g., cranes, hoists, truck bays in buildings, maintenance aisles).

Seismic and Other Dynamic Analyses and Design

Seismic analyses and designs of other Seismic Category I structures conform to the procedures described in Section 3.7.2. The requirements of ASCE 4-98 are used in the analysis and design of structural elements and members subjected to load combinations that include seismic loadings. Seismic accelerations are determined from structural stick models as described in Section 3.7.2. These accelerations are applied to the finite element computer models of other Seismic Category I structures as static-equivalent loads at the elevations used in the stick model. Seismic acceleration modification factors are used to adjust the equivalent static forces and moments to be consistent with the SSI model results.

03.08.01-28

Seismic SSE (E') loads are obtained by multiplying the dead load and 25 percent of the design live load by the structural accelerations obtained from the seismic analyses of each structure. A minimum of 75 percent of the roof snow load is included in the structural mass for seismic analysis of Seismic Category I structures. Seismic loads are also considered due to the mass of fluids in tanks and canals as described below for hydrodynamic loads. The full potential live load, including precipitation, is used for