ArevaEPRDCPEm Resource

From: WELLS Russell (AREVA) [Russell.Wells@areva.com]
Sent: Wednesday, April 27, 2011 5:04 PM
To: Tesfaye, Getachew
Cc: CORNELL Veronica (EXTERNAL AREVA); BENNETT Kathy (AREVA); DELANO Karen (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA)
Subject: Response to U.S. EPR Design Certification Application RAI No. 448, FSAR Ch. 3, Supplement 3
Attachments: RAI 448 Supplement 3 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 448 on November 22, 2010. To allow additional time to finalize the responses and interact with NRC staff, the schedule has been revised. On February 11, 2011, AREVA NP submitted Supplement 1 to provide a revised schedule for the final responses. On March 17, 2011, AREVA NP submitted Supplement 2 to provide a final response to Question 03.08.01-55 and a revised schedule for the final responses to Questions 03.08.01-49, 03.08.01-50, 03.08.01-51, 03.08.01-52, 03.08.01-53 and 03.08.01-54.

The attached file, "RAI 448 Supplement 3 Response US EPR DC.pdf" provides technically correct and complete FINAL responses to Questions 03.08.01-53 and 03.08.01-54, as committed.

The following table indicates the page in the response document, "RAI 448 Supplement 3 Response US EPR DC.pdf" that contains AREVA NP's response to the subject questions.

Question #	**Start Page**	**End Page**
RAI 448 — 03.08.01-53	2	3
RAI 448 — 03.08.01-54	4	8

The schedule for Question 03.08.01-50 is being revised to allow additional time for AREVA NP to interact with the NRC. The schedule for Questions 03.08.01-51and 03.08.01-52 is being revised to allow AREVA NP additional time to address NRC Comments. The schedule for the remaining question is unchanged.

The schedule for technically correct and complete responses to the remaining questions is provided below.

Question #	Response Date
RAI 448 — 03.08.01-49	May 16, 2011
RAI 448 — 03.08.01-50	**May 24, 2011**
RAI 448 — 03.08.01-51	**July 8, 2011**
RAI 448 — 03.08.01-52	**July 8, 2011**

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)

434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: WELLS Russell (RS/NB)
Sent: Thursday, March 17, 2011 10:55 AM
To: 'Tesfaye, Getachew'
Cc: CORNELL Veronica (External RS/NB); BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 448, FSAR Ch. 3, Supplement 2

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 448 on November 22, 2010. To allow additional time to finalize the responses and interact with NRC staff, the schedule has been revised. On February 11, 2011, AREVA NP submitted Supplement 1 to provide a revised schedule for the final responses.

The attached file, “RAI 448 Supplement 2 Response US EPR DC.pdf” provides a technically correct and complete FINAL response to question 03.08.01-55, 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 448 Question 03.08.01-55.

The following table indicates the page in the response document, “RAI 448 Supplement 2 Response US EPR DC.pdf” that contains AREVA NP’s response to the subject question.

Question #	Start Page	End Page
RAI 448 — 03.08.01-55	2	2

The schedule for Questions 03.08.01-49, 03.08.01-50, 03.08.01-51, 03.08.01-52, 03.08.01-53 and 03.08.01-54 is revised to allow additional time for AREVA NP to interact with the NRC.

The schedule for technically correct and complete responses to the remaining questions is provided below.

Question #	Response Date
RAI 448 — 03.08.01-49	May 16, 2011
RAI 448 — 03.08.01-50	April 27, 2011
RAI 448 — 03.08.01-51	April 27, 2011
RAI 448 — 03.08.01-52	April 27, 2011
RAI 448 — 03.08.01-53	April 27, 2011
RAI 448 — 03.08.01-54	April 27, 2011

Sincerely,

Russ Wells
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From: BRYAN Martin (External RS/NB)
Sent: Friday, February 11, 2011 3:18 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); CORNELL Veronica (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 448, FSAR Ch. 3, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 448 on November 22, 2010. To allow additional time to finalize the responses and interact with NRC staff, the schedule has been revised.

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

Question #	Response Date
RAI 448 — 03.08.01-49	March 25, 2011
RAI 448 — 03.08.01-50	March 18, 2011
RAI 448 — 03.08.01-51	March 18, 2011
RAI 448 — 03.08.01-52	March 18, 2011
RAI 448 — 03.08.01-53	March 18, 2011
RAI 448 — 03.08.01-54	March 18, 2011
RAI 448 — 03.08.01-55	March 18, 2011

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
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From: BRYAN Martin (External RS/NB)
Sent: Monday, November 22, 2010 10:13 AM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); CORNELL Veronica (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 448, FSAR Ch. 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 448 Response US EPR DC.pdf" provides a schedule since a technically correct and complete response to the 7 questions can not be provided at this time.

The following table indicates the respective pages in the response document, "RAI 448 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 448 — 03.08.01-49	2	3
RAI 448 — 03.08.01-50	4	5
RAI 448 — 03.08.01-51	6	7
RAI 448 — 03.08.01-52	8	8
RAI 448 — 03.08.01-53	9	9
RAI 448 — 03.08.01-54	10	11
RAI 448 — 03.08.01-55	12	12

A complete answer is not provided for the 7 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 448 — 03.08.01-49	February 28, 2011
RAI 448 — 03.08.01-50	February 28, 2011
RAI 448 — 03.08.01-51	February 28, 2011
RAI 448 — 03.08.01-52	February 28, 2011
RAI 448 — 03.08.01-53	February 28, 2011
RAI 448 — 03.08.01-54	February 28, 2011
RAI 448 — 03.08.01-55	February 28, 2011

Sincerely,

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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Monday, October 25, 2010 4:41 PM
To: ZZ-DL-A-USEPR-DL
Cc: Xu, Jim; Hawkins, Kimberly; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 448 (4898, 5084),FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on September 17, 2010, and discussed with your staff on October 25, 2010. No changes were made to the draft RAI as a result of that discussion. 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: 2900

Mail Envelope Properties (1F1CC1BBDC66B842A46CAC03D6B1CD41044AA60A)

Subject: Response to U.S. EPR Design Certification Application RAI No. 448, FSAR Ch. 3, Supplement 3
Sent Date: 4/27/2011 5:03:50 PM
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From: WELLS Russell (AREVA)

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RAI 448 Supplement 3 Response US EPR DC.pdf		73216

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Response to

Request for Additional Information No. 448(4898, 5084), Revision 0
Supplement 3

10/25/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.08.01 - Concrete Containment
Application Section: 3.8.1

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

Question 03.08.01-53:

Follow-up to RAI 211, Question 3.8.1-31

The RAI response has provided the additional information regarding the U.S. EPR ISI program. The staff has evaluated the response and determined that the information provided is inadequate with respect to meeting 10 CFR 50.55a and 10 CFR 50, Appendix A, GDC 1, as it relates to concrete containment being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed, and as described in SRP 3.8.1.II.7.D and RG 1.90. The staff requests that the applicant provide further clarification as discussed below:

a. Regarding the issue of maximum tensile stresses in the RCB reinforcement under the ISI test pressure, the RAI response appears to contradict subsequent discussions with AREVA. During the meeting on December 14 and 15, 2009, AREVA indicated that the RCB design is consistent with the criterion in RG 1.90, Alternative B, which prescribes a maximum tensile stress of 0.5fy in the reinforcement under the ISI test pressure. The staff notes that one of the considerations for using Alternative B (deformation monitoring under pressure tests) given in RG 1.90 is that the design of the containment should be conservative so that cracking under repeated ISI pressure tests is minimized. It follows that, whether 1.15Pd or Pa is used as the ISI test pressure, the containment should be designed to minimize cracking under repeated ISI pressure tests in either case. Therefore, confirm that the RCB is designed so that, under ISI test pressure, membrane compression stresses are maintained and maximum tensile stresses in the reinforcement are limited to 0.5fy, regardless of whether 1.15Pd or Pa is used as the ISI test pressure. It is emphasized that the issue of ISI pressurization levels is pending resolution under RAI 3.8.1-12.

b. No mention is made in either FSAR Section 3.8.1.7.2 or the RAI response of the visual examination component of the ISI program. The staff notes that according to RG 1.90 the ISI program should consist of three distinct activities: (a) force monitoring of ungrouted test tendons; (b) periodic reading of instrumentation for determining prestress level (Alternative A) or monitoring of deformations under pressure (Alternative B) at preestablished sections; and (c) visual examination. The force monitoring of ungrouted test tendons is pending resolution under RAI 3.8.1-12. However, additional information should be provided on the visual examination component of the ISI program. This information should also be included in the appropriate sections of the FSAR.

In addition, revise and update the relevant sections of the FSAR as needed to address the staff's concerns listed above.

Response to Question 03.08.01-53:

For completeness, also see the Response to Question 03.08-01-50.

Item a:

The U.S. EPR design is based on the use of Alternative B in RG 1.90, Revision 1 for monitoring deformations under pressure. Membrane compression will be maintained and the maximum stress in the tensile reinforcing will be limited to one-half the yield strength of the reinforcing steel (0.5fy) under the peak expected pressure for inservice inspection (ISI) tests.

U.S EPR FSAR Tier 2, Section 3.8.1.1.2 will be revised to include this information.

Item b:

The ISI program and visual inspection of tendons is addressed in the response to RAI 448, Question 03.08.01-50.

FSAR Impact:

The U.S. EPR FSAR Tier 2, Section 3.8.1.1.2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.08.01-54:

Follow-up to RAI 155, Question 03.08.01-8

1. The response to Item 1 of the RAI confirms that a single FE model of the NI, including RCB, RSB, RBIS, SB, FB, and common basemat, has been used for analysis of all loads identified in FSAR Section 3.8.1.3. The response also provides a description of how each of the following loads is applied to the FE model: dead loads (D), live loads (L), soil loads (H), hydrostatic loads (F), thermal loads (To), normal pipe reactions (Ro), tendon loads (J), relief valve loads (G), pressure variant loads (Pv), construction loads, test loads (Pt and Tt), temperature loads (Ta), pressure loads (Pa), accident pipe reactions (Ra), pipe break loads (Rr), and seismic loads (E').

   The staff has evaluated the response and determined that the information provided is inadequate with respect to meeting 10 CFR 50, Appendix A, GDC 2, as it relates to the design of safety-related structures being able to withstand the most severe natural phenomena such as earthquakes, and GDC 50, as it relates to the concrete containment being designed with sufficient margin of safety to accommodate appropriate design loads, and as described in SRP 3.8.1.II.3 and 4. The staff requests that the applicant clarify the response to Item 1 of the RAI as discussed below.

   In addition, the staff finds several inconsistencies between loads described in this RAI response and those described in other RAI responses. Some of these inconsistencies are related to RAIs pending resolution, while others are due to ongoing changes in the analysis methods (e.g., new FEM SSI analysis of the NI, revised set of soil cases). Therefore, to resolve Item 1 of this RAI, reconcile and resubmit the response to reflect the current status of the DC application.

   a. The RAI response indicates that there are no (L), (H) and (F) loads applied to the FE model of the RCB. However, the response to RAI 3.8.1-5 Item 2 states that (L) loads are applied "in the Reactor Building near the equipment hatch (due to staging of equipment during a refueling outage)." Also, the response to RAI 3.8.1-7 Item 2 indicates that (L), (H), and (F) loads are applied to the RCB indirectly through the basemat. Clarify these inconsistencies.

   b. The RAI response states that (Ro) and (Ra) loads are not applied to the FE model of the RCB since they are considered part of the local design. However, the response to RAI 3.8.1-26 indicates that these are independent loads applied to the FE model of the NI. Clarify this inconsistency. In addition, provide additional details of how these loads are applied to the FE model of the NI; especially, a description of how multi-directional effects are considered.

   c. The RAI response provides details on how (J) loads are developed and applied to the FE model of the RCB to account for three-dimensional tendon profiles, geometric and material properties of the tendons and containment, wobble and curvature effects, creep and shrinkage properties of concrete, relaxation of tendon materials, and number of jacking ends, for both a 0-year and a 60-year period. Since the response to RAI 3.8.1-35 states "Bonding between the tendon and surrounding grout is not assumed in RCB design," explain whether the methodology used for determining (J) loads is consistent with the unbounded tendon assumption.

d. The RAI response provides details of how seismic ZPA values in the three principal directions are computed for different elevations of the RCB. The response indicates that these ZPA computations are based on stick models used in the SSI analysis for the various soil types and ground motions considered in the FSAR. However, as indicated in the response to RAI 3.8.5-8, a new FEM SSI analysis of the NI has been performed using fully embedded conditions for a reduced number of soil cases. The stick models have been superseded by this new analysis methodology and are no longer applicable. Clarify this inconsistency.

2. The response to Item 6 of the RAI indicates that the RCB liner is modeled with 4-node SHELL181 elements applied on the inner surface as a pressure load transfer element, smeared over the inner face of the SOLID45 concrete elements. The liner and its anchorages are not considered as structural elements in the structural design of the RCB, so the liner anchorage is not explicitly modeled in the FE model. The stiffness of the liner material is reduced to 1% of its actual value to make the liner structurally inactive in the FE model. Finally, liner anchorage design loads are not determined from FE analysis but are determined using an energy approach described in Bechtel Topical Report BC-TOP-01 Rev. 1 (1971) “Containment Building Liner Plate Design Report.”

   To ensure compliance with 10 CFR 50, Appendix A, GDC 16, as it relates to the capability of the concrete containment to act as a leak-tight membrane, and as described in SRP 3.8.1.II.4.J, explain how the liner plate is designed for “local” loads that are not applied to the FE model of the RCB (e.g., jet impingement loads). Also, provide a description of the energy approach used to determine anchorage design loads (which is stated to follow Bechtel Topical Report BC-TOP-01 Rev. 1), as well as a discussion on how the anchorage design satisfies ASME BVP Code, Section III, Division 2, Article 3810, items (a) through (h). Finally, include a summary of this information in the relevant sections of the FSAR.

Response to Question 03.08.01-54:

Item 1a:

The live (L) loads identified in the Response to RAI 155 Supplement 1, Question 3.8.1-5, Item 2 are applied to the Reactor Building Internal Structure (RBIS) floor area, but not in Reactor Containment Building (RCB) walls. There are no live loads for the RCB wall and dome. The floor access to the equipment hatch in RBIS is subjected to temporary live loads for staging of equipment during the refueling outage (refer to the Response to RAI 155 Question 3.8.1-5, Item 2). The live load is considered in the critical section design for the RBIS.

Soil (H) and hydrostatic (F) loads are not directly applied to the RCB, since the RCB wall is surrounded by other buildings that shield it from these loads. The effects on the RCB from these loads are considered through the Nuclear Island (NI) common basemat structure when analysis is performed for load combinations.

Item 1b:

Accident pipe reaction (R_a) and normal pipe reaction (R_o) loads are not directly applied to the RCB wall of the finite element model (FEM). However, accident pipe reaction and normal pipe reaction loads from nuclear steam supply system (NSSS) components are applied to RBIS of the FEM of NI common basemat structure.

Accident pipe reactions are categorized as:

1. Equipment reactions during accident conditions, and
2. Pipe support reactions during accident conditions.

The only accident pipe reaction loads included in the global FEM are the NSSS system loads, which includes reactions due to the reactor pressure vessel, pressurizer, steam generators, and reactor coolant pumps. Additional accident pipe reaction is considered in critical section design. The accident pipe reaction due to NSSS components are conservatively applied to the NI FEM in the upward (U), downward (D), eastward (E), westward (W), northward (N), and southward (S) in each of the six load input files.

Normal pipe reactions are categorized as:

1. Equipment reactions during normal operating conditions, and
2. Pipe support reactions during normal operating conditions.

The normal pipe reaction loads included in the global FEM are the NSSS system loads, which includes reactions due to the reactor pressure vessel, pressurizer, steam generators, and reactor coolant pumps. Additional normal pipe reaction is considered in critical section design. The normal pipe reactions due to NSSS components are conservatively applied to the NI FEM in the upward (U), downward (D), eastward (E), westward (W), northward (N), and southward (S) directions in each of the six load input files.

In the expansion of load combinations for accident pipe reactions or normal pipe reactions, the horizontal loads (N, S, E, W) and the vertical loads (U, D) result in 4x2=8 variations. These variations are used for final load combinations.

A series of load combination permutations were developed in such a way that the maximum magnitude of the variable loads is used, and the direction of the loads is aligned to maximize the global effect on the overall structure. Local effects, such as one or more of the variable independents acting in one direction while the remainder act in a different direction, were not captured by the global load combinations. Instead, local effects are investigated during the development of critical sections on a case-by-case basis.

Item 1c:

The tendon loads were calculated based on the ungrouted tendon ducts, such as the hollow ducts, consistent with unbonded tendons, for zero-year and 60-year periods. The duct is grouted after the installation of tendons that forms bonding among tendons, grout, ducts, and concrete. This additional bonding is neglected since it would reduce the creep and relaxation losses. The grout is mainly served as corrosion inhibitor.

Item 1d:

For U.S. EPR design, current zero period acceleration (ZPA)s are calculated based on the embedded soil-structure interaction (SSI) FEM as described in U.S. EPR FSAR Tier 2, Section 3.7. The ZPAs calculated from NI stick model are replaced with the ZPAs calculated from the embedded SSI FEM in analysis of NI common basemat structure. The stick model is used only for obtaining the NSSS loads.

Item 2:

A pipe break hazard analysis performed for the U.S. EPR design indicates that local dynamic impact loads, such as pipe whip, missile impact, and jet impingement are not applicable to the liner plate. COL Information Items 3.6-1 and 3.6-2 require the COL applicant to perform a pipe break hazard analysis that will demonstrate that the liner plate is protected from dynamic loads. In addition, U.S. EPR FSAR Tier 1, Section 3.8 includes an ITAAC that addresses the dynamic and environmental effects of piping systems.

The method used to determine anchorage loads is outlined as follows:

1. The two-dimensional state of strain is obtained from load combinations in accordance with ASME Section III Division 2. The largest strain is used to determine the uni-axial yield stress that must exist if the strains are to be converted to stress by Hook’s law.
2. Load vs. Displacement curves for the anchor and bent plate are determined.
3. The spring constant for the plate relaxation is calculated.
4. The force N’ is calculated. This force N’ simulates the effects of multiple anchor movements as presented in Section 5.1 (Equation 9) of Bechtel Power Corporation Topical Report, BC-TOP-01, *Containment Building Liner Plate Design Report, Revision 1, December 1972.*
5. The effect of additional internal or external pressure loading can be converted to an equivalent axial load N’’ according to Section 5.1 of BC-TOP-01 (Equation 15). N’’ is combined with N’ to get the final axial load.
6. The anchorage deformation is calculated based on either an elastic solution or plastic solution, whichever is appropriate based on the stress level in the anchor.
7. The energy required in obtaining equilibrium in the anchor is calculated as the area under the Load-Displacement curve of the anchor. This energy is compared against the total energy obtained from test results presented in Appendix B of BC-TOP-01. The required energy is less than the total energy obtained from test.

The inward curvature of the liner plate is evaluated as no more than 1/8 inch during fabrication and erection of the liner plate as given in Section 3.1 of BC-TOP-1.

Plate thickness variation is defined by the standard rolling tolerance. For a ¼ inch plate, a thickness variation within the limits of +16 percent and -4 percent is allowed. In keeping with development of BC-TOP-1, for a plate with -4 percent variations in thickness, a lower stiffness would result in an increase in anchor loading. This condition is highly improbably and therefore it is not necessary to consider the case of a plate which is -4 percent under the nominal thickness. A plate with +16 percent thickness variations is conservative as long as the excess thickness is constant throughout a large area; a thickness panel with inward curvature would be stiffer and therefore, the anchor load would decrease. In the analysis, a panel with outward curvature that is +16 percent over the nominal thickness is considered adjacent to a plate with inward curvature of nominal thickness.

The liner plate differs from a typical structural component such that, a lower value of yield will limit the stress and the forces on the liner plate and the anchors. For a liner plate with higher yield stress due to rolling processes and biaxial loading, the anchor will be subjected to a higher load. Consistent with ASME (CC3810(c),1), this is adequately satisfied by converting liner strain to stress and membrane forces assuming the plate remains elastic.

Weld offset is mitigated through quality control in accordance with ASME Section III Division 2 CC-4523.2. The structural discontinuities areas, such as pipe penetration and openings, are designed as special regions. The construction sequence used is such that effects of concrete voids behind the liner are mitigated as the liner is used as a form, in case of the cylinder and dome. The base plate is grouted to fill voids after installation.

Anchorage spacing will affect the stiffness of the system. If anchors are further apart than specified, panels with inward curvature will have less stiffness than a panel with the specified spacing which would result in higher anchor loads. Since it is relatively simple to fabricate anchors to the specified spacing, any small variation in spacing is not considered to have any appreciable effect on the anchorage system.

Variation of the concrete modulus affects the energy required for the anchorage system to reach equilibrium. A higher concrete modulus is advantageous as the energy required to reach equilibrium is lower. On the contrary, a lower concrete modulus requires higher energy absorption to reach equilibrium. In practice, a lower modulus is mitigated due to the code required overstrength and the extensive performance testing required of the concrete mix.

When an anchorage system has sufficient safety factors, the local yielding of concrete will be minor and it is not an area of concern since it is simply a mean of stress redistribution to obtain a maximum load capacity.

There is no stud in the anchorage system. Stud anchors are not applicable to the U.S.EPR design.

U.S. EPR FSAR Tier 2, Section 3.8.1.1.3 will be revised to include a summary of the U.S. EPR liner anchorage system. U.S. EPR FSAR Tier 2, Section 3.8.6 will be updated to add BC-TOP-01 Rev. 1 as a reference.

FSAR Impact:

The US EPR FSAR, Tier 2 Sections 3.8.1.1.3 and 3.8.6 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

3.8.1.1.2 Post-Tensioning System

Tendons are provided both horizontally and vertically in the cylindrical portion of the RCB. Tendons are provided in two orthogonal directions in the plan view of the containment dome. Layouts of the tendons vary to accommodate penetrations through the RCB wall.

The Freyssinet C-range post-tensioning system is the tendon system used for post-tensioning the concrete RCB. The Freyssinet 55C15 tendon system is made up of 55 seven-wire strands in each tendon. Section 3.8.1.6.3 describes the material properties of the tendon system. With the exception of the three greased test tendons of each type (vertical, gamma, and horizontal hoop) provided for force monitoring, the other tendons are grouted in place after tensioning.The tendons are grouted in place after tensioning.

A total of 119 horizontal hoop tendons are provided around the cylindrical shell of the RCB. The tendons terminate at the three vertical buttresses provided around the outside of the containment wall. Terminations alternate so that each buttress has a horizontal tendon terminating every third hoop (i.e., each hoop tendon extends the full circumference of the building).

A total of 47 vertical tendons are provided around the cylindrical shell of the RCB. The vertical tendons terminate at the top of the ring girder that is provided at the transition of the wall to the spherical dome roof. A total of 104 gamma tendons are also provided vertically up through the containment wall where they then wrap over the dome and terminate at the ring girder on the opposite side of the wall. The gamma tendons are separated into two groups that are placed 90° apart in the RBC dome. The bottom of both the vertical tendons and the gamma tendons terminate at the tendon gallery.

03.08.01-53

The U.S. EPR design is based on the use of Alternative B of RG 1.90, Revision 1 for monitoring deformations under pressure. Membrane compression will be maintained and the maximum stress in the tensile reinforcing will be limited to one-half the yield strength of the reinforcing steel (0.5fy), under the peak expected pressure for inservice inspection (ISI) tests.

Additional information on layout and design of the tendons is provided in Appendix 3E for the RCB cylindrical wall, and buttress areas. The minimum required post tensioning force to offset the structural integrity test (SIT) pressure loading is 801k/ft hoop force, 401k/ft vertical force, and 548k/ft in both directions for the dome.

Figure 3.8-18—Finite Element Model of Reactor Containment Building Tendon Layout in Cylindrical Wall and Figure 3.8-19—Finite Element Model of Reactor Containment Building Tendon Layout in Dome show the finite element model of the tendon layout.

3.8.1.1.3 Liner Plate System

A carbon steel liner plate covers the entire inside surface of the RCB, excluding penetrations. The steel liner is 0.25 inch thick and is thickened locally around penetrations, large brackets, and at major attachments. Except for the bottom horizontal surface, angle and channel steel sections anchor the liner plate to the concrete containment structure. The in-containment refueling water storage tank (IRWST), including the containment sumps, are lined with 0.25 inch thick stainless steel liner plates that serve as additional corrosion protection for the underlying carbon steel liner. See Section 3.8.3 for a description of the IRWST.

Steel shapes reinforce the plate both longitudinally and laterally to provide rigidity during prefabrication, erection, and concrete placement. The steel shapes are welded to the liner plate and are fully embedded in the concrete to provide a rigid connection to the inside surface of the RCB concrete. The concrete foundation of the RB internal structures is poured on top of the liner plate at the basemat surface, embedding the lower region of the liner plate in the foundation. The liner plate is not used as a strength element to carry design basis loads; however, the liner supports the weight of wet concrete during the construction of the RCB.

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Section CC3810 of ASME Section III, Division 2 prescribes the criteria for design of liner anchorage system. The U.S. EPR liner anchorage system is designed using an energy approach described in BC-TOP-01, Revision 1 (Reference 69), which addresses ASME criteria. The methodology considers the variation in liner yield strength analytically by converting liner strain to stress and membrane forces assuming the plate remains elastic. In addition, the variation of liner plate thickness is accounted for by considering a thicker panel (+16 percent) with outward curvature being adjacent to a nominal plate with inward curvature (refer to Figure 2 through 4 of Reference 69). The inward curvature is evaluated as no more than 1/8 inch during fabrication and erection of the liner plate as given in Reference 69. The weld offset is mitigated through quality control in accordance with ASME Section III Division 2 CC-4523.2. The effects of concrete voids behind the liner are mitigated by the construction method employed. Lower concrete modulus is mitigated due to the code required over strength and the extensive performance testing required of the concrete mix. The variation of anchorage spacing is mitigated by quality control during the fabrication process. The anchorage system is designed with a safety factor so that the local crushing of the concrete is limited and a means of stress redistribution to obtain a maximum load capacity. The structural discontinuities areas, such as pipe penetration and openings, are designed as special regions.

Section 3.8.2 contains a description of the penetrations through the containment liner, including the equipment hatch, airlocks, piping penetration sleeves, electrical penetration sleeves, and the fuel transfer tube penetration sleeve.

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