Areva EPRDCPEm Resource

From: WELLS Russell (AREVA) [Russell.Wells@areva.com]
Sent: Thursday, April 21, 2011 3:08 PM
To: Tesfaye, Getachew
Cc: CORNELL Veronica (EXTERNAL AREVA); WILLIAMSON Rick (AREVA); BREDEL Daniel (AREVA); BENNETT Kathy (AREVA); DELANO Karen (AREVA); HALLINGER Pat (EXTERNAL AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); WILLIFORD Dennis (AREVA)
Subject: Draft Revised Response to U.S. EPR Design Certification Application RAI No. 448, FSAR Ch. 3, Question 03.08.01-50
Attachments: RAI 448 Question 03.08.01-50 Response US EPR DC - DRAFT.pdf

Getachew,

Attached is a revised draft response for RAI No. 448, FSAR Ch 3, Question 03.08.01-50 in advance of the April 27, 2011 final response date.

Let me know if the staff has questions or if the draft response can be sent as a final response.

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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Russell.Wells@Areva.com

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
702 561-3528 cell
Martin.Bryan.ext@areva.com

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: 2876

Mail Envelope Properties (1F1CC1BBDC66B842A46CAC03D6B1CD410442A07F)

Subject: Draft Revised Response to U.S. EPR Design Certification Application RAI No. 448, FSAR Ch. 3, Question 03.08.01-50
Sent Date: 4/21/2011 3:08:24 PM
Received Date: 4/21/2011 3:08:42 PM
From: WELLS Russell (AREVA)

Created By: Russell.Wells@areva.com

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Files	**Size**	**Date & Time**
MESSAGE	7156	4/21/2011 3:08:42 PM
RAI 448 Question 03.08.01-50 Response US EPR DC - DRAFT.pdf	713717	

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

Response to

Request for Additional Information No. 448(4898, 5084), Revision 0
Question 03.08.01-50, Revision 1

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 03.08.01-50:

Follow-up to RAI 155, Question 3.8.1-12

The RAI response has provided 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 they relate 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 clarifications as discussed below:

a. Regarding the criterion for using Pa as ISI test pressure in years 3 and 7, instead of 1.15Pd indicated in RG 1.90, the response states that: (a) using 1.15Pd as initial structural integrity test (ISIT) pressure confirms containment integrity and quality of construction; (b) continued pressurization of the containment to 1.15Pd would induce “unnecessary cyclic loading of the structure;” and (c) using Pa instead of 1.15Pd as ISI test pressure, “will establish a continuous basis for comparison of results, will minimize gradual propagation of cracking during subsequent pressure tests, and will be in compliance with the ISI requirements of ASME BVP Code Subsection IWL, Paragraph IWL-5220.”

   The above justification for the exception taken to the ISI test pressures stipulated in RG 1.90 for years 3 and 7 is inadequate for reasons explained in the following.

   The statement of compliance with the ISI requirements of ASME BVP Code Subsection IWL, Paragraph IWL-5220 is not appropriate because Article 5000 of the Code is applicable to pressure testing of containments following repair/replacement activities and not the periodic ISI pressure tests. Also, the response implies that using 1.15Pd as ISI test pressure for years 3 and 7 is unnecessarily conservative and possibly detrimental. However, the staff notes that one of the considerations for using Alternative B (deformation monitoring under pressure tests, also see Item 2 below) given in RG 1.90 is that the design of the containment should be demonstrated with adequate conservatism (i.e., membrane compression stresses maintained and maximum tensile stress in reinforcement limited to one half of the yield strength during ISI pressure tests) 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. Consequently, the design and pressure testing of the containment should meet the regulatory positions in RG 1.90 or adequate technical justification, preferably supported by quantitative data, should be provided for the exception taken to RG 1.90.

b. Regarding the exception to RG 1.90, by which force monitoring of ungrouted test tendons is not provided, the response states that: (a) ungrouted test tendons are used to evaluate prestress losses due to concrete creep and shrinkage, and tendon steel relaxation; however, since the ungrouted test tendons will be subject to cyclic loading during every ISI, the measured results may not accurately reflect the prestress losses in the containment as a whole, and this has been acknowledged in the past by NRC (Information Notice 99-10, Attachment 3); (b) rather than using ungrouted test tendons for the force monitoring of prestress losses, the U.S. EPR ISI program will implement deformation monitoring of the containment under Pa pressure, and compare results with expected deformation and ISIT deformation; (c) deformation monitoring of the containment during ISI pressure testing has been accepted in the past by NRC (Three Mile Island and Forked River NPPs); and (d) the technical literature reports one instance (Quinshan NPP, China) where monitoring of the prestress level in the containment has been accomplished using overall deformation measurements as an alternative to tendon force measurements.

The response above gives insufficient technical justification for not providing force monitoring of ungrouted test tendons, as prescribed in RG 1.90. 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. Therefore, the deformation monitoring of the containment (item (b), Alternative B) does not eliminate the requirement to provide force monitoring of ungrouted test tendons (item (a)), but is an additional criterion of RG 1.90. Regarding Item (2)(c) in the above paragraph, explain how the acceptance by the NRC in two old NPPs for deformation monitoring of the containment during ISI tests demonstrates that monitoring of ungrouted tendons is not required. Regarding Item (2)(d) in the above paragraph, although the referenced paper reports an interesting case study where force monitoring was not used, the staff considers that it does not provide a technical basis for the exception taken to RG 1.90. Consequently, provide adequate technical justification, preferably supported by quantitative data, to demonstrate that ungrouted tendons are not needed.

c. FSAR Section 3.8.1.1 states that Pd is equal to 62 psig. The response to RAI 3.8.1-32 states that Pa (as used in the ISI) is set to 55 psig. This information should be added to FSAR Table 3.8-7 “ISI Schedule for the U.S. EPR.”

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

Response to Question 03.08.01-50:

Item a:

The U.S. EPR will use 1.15*P_d as the inservice inspection (ISI) test pressure in years three and seven as indicated in RG 1.90, Revision 1. U.S. EPR FSAR Tier 2, Table 3.8-7 will be revised to match the pressures provided in Figure 2 of RG 1.90, Revision 1.

Item b:

In accordance with RG 1.90, Revision 1, the tendons for the U.S. EPR will be included in an ISI program. The ISI program will consist of three items:

- Force monitoring of ungrouted test tendons.
- Monitoring of deformations under pressure at prescribed locations (Alternative B of RG 1.90, Revision 1).

- Visual inspection of exposed structurally critical areas of the containment and containment prestressing system.

  Visual inspection will be performed of representative areas at structural discontinuities, areas around large penetrations or a cluster of small penetrations and other areas where heavy loads are transferred to the containment structure. Visual inspection of these selected areas will be completed during the pressure tests while the containment is at its maximum test pressure. Samples of the exposed portions of the tendon anchorage assembly hardware will also be included in the visual inspections. The tendon anchorage assemblies utilized for the greased tendons will be representative of the grouted tendons except that provisions will be provided to allow force measurement by lift-off or load cells. The sample size of tendon anchorage assemblies will comply with the requirements of RG 1.90, Revision 1.

  Access to perform the visual inspections is provided from the tendon gallery, annular space between the containment building exterior wall and the reactor shield building wall, and the annular space between the containment building dome and reactor shield building dome shown in U.S. EPR FSAR Tier 2, Figure 3B-12. Figure 03.08.01-50-1 shows the dimensions of the space around the containment ring girder. There is approximately 18 inches between the containment ring girder and the Reactor Shield Building.

The ISI Program will also include a fourth component for the inspection of the test tendons filler grease. The inspection of filler grease will be performed consistent with the guidance in RG 1.35, R3, Regulatory Position 6.

Three greased tendons of each type; vertical, gamma and horizontal hoop will be provided for force monitoring. These test tendons are included in the number of tendons required by design and will be subjected to force measurement by lift-off or load cells to assess the effects of concrete shrinkage and creep and relaxation of the tendon steel. The nine greased tendons are the sample size for load cell or lift-off testing.

In accordance with the Alternative B of RG 1.90, Revision 1, the points to be instrumented for measurement of radial displacements under pressure will be located in six horizontal planes in the cylindrical portion of the shell with a minimum of four points in each plane.

The points to be instrumented for measurement of vertical (or radial) displacements under pressure will be located at the top of the cylinder relative to the base, at a minimum of four approximately equally spaced azimuths. Locations will also be selected at the dome apex and one intermediate point between the apex and the springline on at least three equally spaced azimuths.

U.S EPR FSAR Tier 2, Table 1.9-2 and Table 3.8-7 as well as the text in U.S EPR FSAR Tier 2, Sections 3.8.1.1.2, 3.8.1.2.5, 3.8.1.6.3, 3.8.1.7.2 and Section 5.5 of the Technical Specifications will be updated to include this information.

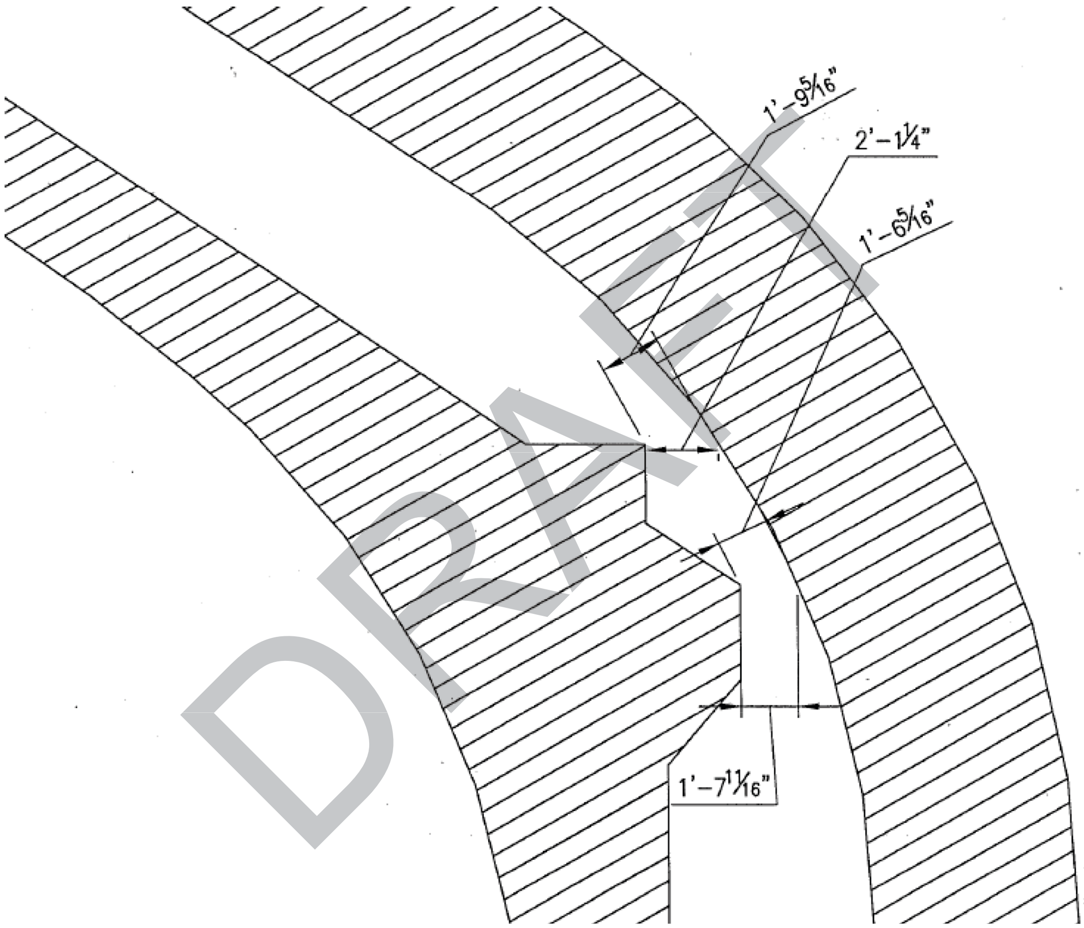
Item c:

The requested information has been added to the U.S. EPR FSAR Tier 2, Table 3.8-7.

FSAR Impact:

The U.S. EPR FSAR, Tier 2, Tables 1.9-2 and 3.8-7, Sections 3.8.1.1.2, 3.8.1.2.5, 3.8.1.6.3, 3.8.1.7.2 and Section 5.5 of Chapter 16, Technical Specifications will be revised as described in the response and indicated on the enclosed markup.

Figure 03.08.01-50-1—Dimensions between Containment and Shield buildings at Ring Girder



U.S. EPR Final Safety Analysis Report Markups

Table 1.9-2—U.S. EPR Conformance with Regulatory Guides
Sheet 3 of 19

RG / Rev	Description	U.S. EPR Assessment	FSAR Section(s)
1.29, R4	Seismic Design Classification	Y	3.2.1
1.30, 08/1972	Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment	N/A-COL	N/A
1.31, R3	Control of Ferrite Content in Stainless Steel Weld Metal	Y	3.6.3 5.2.3 6.1.1
1.32,R3	Criteria for Power Systems for Nuclear Power Plants	Y	6.3 Table 8.1-1 8.2 8.3.2.2.3
1.33,R2	Quality Assurance Program Requirements (Operation)	N/A-COL	N/A
1.34, 12/1972	Control of Electroslag Weld Properties	Y	5.2.3.4
1.35, R3	Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containments	N/A-~~OTHER (No ungrouted tendons)~~	N/A
1.35.1, 07/1990	Determining Prestre 03.08.01-50 ion of Prestressed Concrete Containments	<u>Y</u> ~~N/A-OTHER (No ungrouted tendons)~~	<u>3.8.1.2.5</u> ~~N/A~~
1.36, 02/1973	Nonmetallic Thermal Insulation for Austenitic Stainless Steel	Y	5.2.3.4.3 6.1.1
1.37, R1	Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants	Y	3.13 5.2.3 5.3.1 5.4.2 6.1.1 17.5 10.3
1.38, R2	Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants	N/A-COL	N/A
1.39, R2	Housekeeping Requirements for Water-Cooled Nuclear Power Plants	N/A-COL	N/A

**Table 1.9-2—U.S. EPR Conformance with Regulatory Guides
Sheet 7 of 19**

RG / Rev	Description	U.S. EPR Assessment	FSAR Section(s)
1.82, R3	Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident	Y	6.3
1.84, R33	Design, Fabrication, and Materials Code Case Acceptability, ASME Section III	Y	3.8.1
			3.8.2
			4.5.2
			5.2.1
			5.4.2.4.1
			10.3
1.86, 06/1974	Termination of Operating Licenses for Nuclear Reactors	N/A-COL	N/A
1.87, 06/1975	Guidance for Construction of Class 1 Components in Elevated-Temperature Reactors	N/A-OTHER	N/A
1.89, R1	Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants	Y	3.11
			Appendix 3D Attach C
1.90, R1	Inservice Inspection of Prestressed Concrete Containment Structures with Grouted Tendons 03.08.01-50	Y ~~EXCEPTION (No forced monitoring)~~	3.8.1.2.5 3.8.1.7.2 ~~5.3.1.6 3.8.1.2.5 and 3.8.1.7.2~~
1.91, R1	Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants	N/A-COL	N/A
1.92, R2	Combining Modal Responses and Spatial Components in Seismic Response Analysis	Y	3.7.2
			3.7.3
			Appendix 3D Attach E
1.93, 12/1974	Availability of Electric Power Sources	Y	16.B3.8
1.94, R1	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants	Y	3.8.1.2.5
1.96, R1	Design of Main Steam Isolation Valve Leakage Control Systems for Boiling Water Reactor Nuclear Power Plants	N/A-BWR	N/A

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.

03.08.01-50

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. <u>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.</u>~~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.

<u>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.</u>

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.

- Article CC-3000 of the ASME Code, 2004 Edition, Section III, Division 2 (GDC 1, GDC 2, and GDC 16).
- ASME Code 2004 Edition, Section XI, Subsection IWL, Requirements for Class CC Concrete Components of Light-Water Cooled Plants.
- ASME Code 2004 Edition, Section XI, Subsection IWE, Requirements for Class MC and Metallic Liners of Class CC Concrete Components of Light-Water Cooled Power Plants.

3.8.1.2.4 Regulations

- 10 CFR 50 – Licensing of Production and Utilization Facilities.
- 10 CFR 50, Appendix A – General Design Criteria for Nuclear Power Plants (GDC 1, 2, 4, 16, and 50).
- 10 CFR 50, Appendix J – Primary Reactor Containment Leakage Testing for Water Cooled Power Reactors.
- 10 CFR 100 – Reactor Site Criteria.

3.8.1.2.5 NRC Regulatory Guides

Regulatory Guides applicable to the design and construction of the RCB:

03.08.01-50

- RG 1.7, Revision 3.
- RG1.35.1, July 1990.
- RG 1.84, Revision 33.
- RG 1.90, Revision 1 ~~(exception described in 3.8.1.7)~~.
- RG 1.94, Revision 1.
- RG 1.107, Revision 1.
- RG 1.136, Revision 3 (exception described in 3.8.1.3).
- RG 1.199, November 2003 (exception described in 3.8.1.4).
- RG 1.216, August 2010.

3.8.1.3 Loads and Load Combinations

The U.S. EPR standard plant design loads envelope includes the expected loads over a broad range of site conditions. Loads and load combinations for the RCB are in accordance with the requirements of Article CC-3000 of the ASME Code, Section III, Division 2, Code for Concrete Containments and ACI Standard 359, and RG 1.136

Fabrication and Placement

Fabrication and placement of reinforcing bars for the RCB are in accordance with Subarticle CC-4300 of the ASME Code, Section III, Division 2.

3.8.1.6.3 Tendon System Materials

Tendons

The post-tensioning tendon system consists of load-carrying and non-load-carrying components. The load-carrying components include the post-tensioning wires that make up the tendons, and anchorage components composed of bearing plates, anchor heads, wedges, and shims. Non-load-carrying components include the tendon sheathing (including sheaths, conduits, trumpet assemblies, couplers, vent and drain nipples, and other appurtenances) and corrosion prevention materials.

Materials used for the RCB post-tensioning system (including post-tensioning steel, anchorage components, and non-load-carrying and accessory components) meet the requirements of Subarticle CC-2400 of the ASME Code, Section III, Division 2.

The Freyssinet C-range post-tensioning system has the following properties:

- ASTM A416 (Reference 36), Grade 270, low-relaxation tendon material.
- Tendon ultimate strength $F_{pu} = 270$ ksi
- Tendon minimum yield strength $F_{py} = (0.9)(270) = 243$ ksi
- Modulus of elasticity of tendon material $E_{ps} = 28{,}000$ ksi
- Number of strands per tendon $N_{strands} = 55$
- Total area of each tendon $A_p = 12.76$ in^2

The materials used for the anchorage components are compatible with the tendon system. Tendon raceways consist of corrugated steel ducts and rigid metal conduit. These components are non-structural and are sealed to prevent the intrusion of concrete during construction.

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Grouting of Tendons

Cement grout for the grouted tendons in the prestressing system in the RCB is selected based on the testing and material requirements of the ASME Code, Section III, Division 2, as amended by RG 1.136, which endorses the Regulatory Positions of RG 1.107, Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures.

Greasing of Tendons

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Grease for the greased test tendons in the prestressing system in the RCB is selected based on the testing and material requirements of the ASME Code, Section III, Division 2.

3.8.1.6.4 Liner Plate System and Penetration Sleeve Materials

The 0.25 inch thick liner plate is SA-516, Grade 55, 60, 65 or 70 material, which conforms to Subarticle CC-2500 of the ASME Code, Section III, Division 2 (GDC 16). Thickened liner plates are used at penetrations, brackets, and embedded assemblies.

Penetration assemblies and appurtenances that are either not backed by concrete or are embedded in concrete and surrounded by a compressible material to provide local flexibility conform to the material requirements of Subsection NE of the ASME Code, Section III, Division 1 (GDC 16). Penetration sleeve materials are listed in Table 6.1-1.

Welding materials conform to the requirements of ASME Code, Section II. Welding activities meet the requirements of ASME Code, Sections III and IX.

Materials used for the carbon steel liner plate, carbon steel and low alloy steel attachments, and appurtenances subject to ASME Code Division 2 requirements, meet the fracture toughness requirements of Subsection CC-2520 of the ASME Code, Section III, Division 2.

Materials used in ASME Division 1 attachments and appurtenances meet the fracture toughness requirements of Subsection 2300 of the ASME Code, Section III, Division 1.

3.8.1.6.5 Steel Embedments

Steel embedment materials conform to the requirements of Subsection CC-2000 of the ASME Code, Section III, Division 2.

3.8.1.6.6 Corrosion Retarding Compounds

Corrosion retarding compounds used for the RCB are described in Section 6.1.2.

3.8.1.6.7 Quality Control

In addition to the quality control measures addressed in Section 3.8.1.6, refer to Chapter 17 for a description of the quality assurance program for the U.S. EPR (GDC 1).

3.8.1.6.8 Special Construction Techniques

Special techniques are not used for construction of the RCB. Modular construction methods are used to the extent practical for prefabricating portions of the containment liner, equipment hatch, airlocks, penetrations, reinforcing steel, tendon conduits, and concrete formwork. Such methods have been used extensively in the construction industry. Rigging is pre-engineered for heavy lifts of modular sections. Permanent and temporary stiffeners are used on liner plate sections to satisfy code requirements for structural integrity of the modular sections during rigging operations.

3.8.1.7 Testing and Inservice Inspection Requirements

3.8.1.7.1 Structural Integrity Test

Following construction, the RCB is proof-tested at 115 percent of the design pressure. During this test, deflection measurements and concrete crack inspections are made to confirm that the actual structural response is within the limits predicted by the design analyses (GDC 1).

The SIT procedure complies with the requirements of Article CC-6000 of the ASME Code, 2004 Edition, Section III, Division 2, and with Subsections IWL and IWE of Section XI of the ASME Code.

3.8.1.7.2 Long-Term Surveillance

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The RCB is monitored periodically throughout its service life in accordance with 10 CFR 50.55a and 10 CFR 50, Appendix J, to evaluate the integrity of containment over time (GDC 1 and GDC 16). As part of this monitoring program, containment deformations and exterior surface conditions are determined while the building is pressurized. at the maximum calculated DBA pressure (P_a). Initial conditions, baseline measurements taken at P_a, during depressurization following the SIT are established prior to initial operation. Initial measurements and in-service inspection meet the requirements of the following:

- ASME Code, 2004 Edition, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Subsections IWE and IWL.
- Supplemental Inspection Requirements of 10 CFR 50.55a.
- ASME Code, 2004 Edition, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Subsection IWL, does not contain specifications for inservice inspection of grouted tendons. For inservice inspection of grouted tendons, the guidelines of RG 1.90, Revision 1 are followed, with no exceptions. with the following exceptions:
  - Force monitoring of ungrouted test tendons is not provided:
    - This exception to RG 1.90 is acceptable because all tendons used within the RCB are fully grouted.
  - Pressurization at year one uses P_a instead of P_N:

- This exception is acceptable because the value of P_a is higher than that of P_N.

– Pressurization at years three and seven uses P_a instead of $1.15P_D$:

- This exception is acceptable because the structural integrity is confirmed at year zero. Additional overpressurization to $1.15P_D$ unduly cycles the structure and interrupts the surveillance tracking of containment response to P_a.

The EPR containment uses fully grouted tendons in each location. This methodology has several advantages:

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- Tendons are surrounded with a cementitious grout injected into the tendon duct; the alkaline composition of the grout mixture, in accordance with RG 1.107, Revision 1 (February 1977), inhibits corrosion of the steel strands and prevents the ingress of corrosive fluids (e.g., water).
- In the event of one or more strand failures during the life of the structure, the bond of the strand with grout and the grout to the concrete wall enables the remaining portion of the post-tensioning to be transmitted to the structure.
- Grouted tendons and tendon anchorages are less vulnerable to local damage than ungrouted tendons. Therefore, if the end anchorages are damaged, for instance by fire or missile impact, the post-tensioning force will be maintained along the effective length of the tendon.
- Grouted tendons increase the overall wall tightness by filling any voids from within the structure. This reduces the risk of water or other contaminates from entering through wall cracks or tendon end caps.
- European experience has found that grouted tendons significantly improve concrete crack distribution when the containment is pressurized to a point where the tensile stress of the concrete is exceeded. Less local large tensile strains are likely to occur thus diminishing the risk of having large concrete cracks behind the containment liner. The absence of large cracks improved the safety margin of the liner with regard to air tightness.

The use of grouted tendons precludes the possibility of directly measuring the post-tension force over time by lifting off at the anchorages. The U.S. EPR mitigates this concern by extensively monitoring the movement of the RCB during 10 CFR 50, Appendix J, leak-rate testing at P_a. The pressure test schedule is a part of the inservice inspection program. Movements obtained from the initial test will be used to baseline a structural analysis that will be used to predict the capacity of the RCB over time. Thirty-six RCB locations will be monitored for radial displacement, 6 for vertical displacement and 13 on the dome for tri-directional displacement. Table 3.8-7—ISI Schedule for the U.S. EPR.

The RCB is fully enclosed by the RSB; therefore, the potential for corrosion of the tendon system is significantly reduced.

The U.S. EPR containment differs in some aspects from the "reference containment" as defined in RG 1.90, Revision 1. The U.S. EPR containment ISI program will be developed using the concepts presented in RG 1.90, Revision 1. In accordance with RG 1.90, Revision 1, the tendons for the U.S. EPR will be included in an ISI program. The program will consist of three items;

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- Force monitoring of ungrouted test tendons.
- Monitoring of deformations under pressure at prescribed locations (Alternative B of RG 1.90, Revision 1).
- Visual inspection of exposed structurally critical areas of the containment and containment prestressing system.

The ISI Program will also include a fourth component for the inspection of the test tendons filler grease. The inspection of filler grease will be performed consistent with the guidance in RG 1.35, R3, Regulatory Position 6.

Three greased tendons of each type (vertical, gamma and horizontal hoop) will be provided for force monitoring. The test tendons are included in the number of tendons required by design and will be subjected to force measurement by lift-off or load cells to assess the effects of concrete shrinkage and creep and relaxation of the tendon steel. The nine greased tendons form the sample size for load cell or lift-off testing,

In accordance with the Alternative B of RG 1.90, Revision 1, the points to be instrumented for measurement of radial displacements under pressure will be located in six horizontal planes in the cylindrical portion of the shell with a minimum of four points in each plane.

The points to be instrumented for measurement of vertical (or radial) displacements under pressure will be located at the top of the cylinder relative to the base, at a minimum of four approximately equally spaced azimuths. Locations will also be selected at the apex of the dome and one intermediate point between the apex and the springline on at least three equally spaced azimuths .

The visual inspections will be performed of representative areas at structural discontinuities, areas around large penetrations or a cluster of small penetrations, and other areas where heavy loads are transferred to the containment structure. Visual inspection of these selected areas will be completed during the pressure tests while the containment is at maximum test pressure. Also included will be samples of the exposed portions of the tendon anchorage assembly hardware. The tendon anchorage

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assemblies utilized for the greased tendons will be representative of the grouted tendons except that provisions will be provided to allow force measurement by lift-off of load cells. The sample size of tendon anchorage assemblies will comply with the requirements of RG 1.90, Revision 1.

The pressure test schedule is part of the ISI program and is provided in Table 3.8-7—ISI Schedule for the U.S. EPR.

Section 6.2.6 contains a description of the associated leak-rate test procedure, Containment Integrated Leakage Rate Test (CILRT). Containment pressure testing will occur in conjunction with the CILRT.

Sufficient physical access is provided in the annulus between the RCB and the RSB to perform inservice inspections on the outside of the containment. There is approximately 18 inches clearance between the upper containment ring beam and the RSB. Space is available inside of the RCB to perform inservice inspections of the liner plate. Gaps are provided between the liner and RB internal structures concrete structural elements, which provide space necessary to inspect the liner at wall and floor locations inside containment. Inservice inspection of the embedded portion of the containment liner and the surface of the concrete containment structure covered by the liner are exempted in accordance with Section III of the ASME Code for Class CC components.

3.8.2 Steel Containment

The steel containment section describes major RCB penetrations and portions of penetrations not backed by structural concrete that are intended to resist pressure. Section 3.8.1 describes the concrete RCB.

3.8.2.1 Description of the Containment

Steel items that are part of the RCB pressure boundary and are not backed by concrete include the equipment hatch, airlocks, construction opening, piping penetration sleeves, electrical penetration sleeves, and fuel transfer tube penetration sleeve. Section 3.8.1.1 describes RCB steel items that are backed by concrete, such as the liner plate.

3.8.2.1.1 Equipment Hatch, Dedicated Spare Penetration, Airlocks, and Construction Opening

The equipment hatch, illustrated in Figure 3.8-25 is a welded steel assembly with a double-sealed, flanged, and bolted cover. The cover for the equipment hatch attaches to the hatch sleeve from inside of the RCB. The cover seats against the sealing surface of the penetration sleeve mating flange when subjected to internal pressure inside the RCB. The RCB penetration sleeve and the RSB penetration sleeve are connected by an

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Table 3.8-7—ISI Schedule for the U.S. EPR

	Test Pressure	
Year	**U.S. EPR ISI**	**RG 1.90**
0	$1.15*P_d$ ~~and P_a~~	$1.15*P_d$
1	~~P_a~~ P_N	P_N
3	~~P_a~~ $1.15*P_d$	$1.15*P_d$
7	~~P_a~~ $1.15*P_d$	$1.15*P_d$
Thereafter	P_a	P_a

Notes:

1. ~~At year 0, the baseline measurements will be taken following the SIT, at a test pressure of P_a.~~

P_N – Normal operating pressure or zero.

P_d – Containment design pressure, ~~.~~ P_d = 62 psig.

Pa – Maximum calculated DBA pressure, ~~.~~ P_a = 55 psig.

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5.5 Programs and Manuals

5.5.4 Component Cyclic or Transient Limit

This program provides controls to track the FSAR Section 3.9.1.1, cyclic and transient occurrences to ensure that components are maintained within the design limits.

5.5.5 Pre-Stressed Concrete Containment Tendon Surveillance Program

This program provides for the monitoring of the containment post tensioning force over time. Tendons used in the containment structure are fully grouted and the structure itself is not exposed to the environment during its operational life. The program shall include baseline measurements prior to initial operation. The Tendon Surveillance Program, inspection frequencies, and acceptance criteria shall be in accordance with FSAR Section 3.8.1.7.

The provisions of SR 3.0.3 are applicable to the Tendon Surveillance Program Inspection frequencies.

~~Containment Post Tensioning Surveillance Program~~

~~This program provides for the monitoring of the containment post tensioning force over time. Tendons used in the containment structure are fully grouted and the structure itself is not exposed to the environment during its operational life. The program shall include initial base line measurements prior to initial operation. The Containment Post Tensioning Surveillance Program, inspection frequencies, and acceptance criteria shall be in accordance with Regulatory Guide 1.90, Rev. 1 with the following exceptions:~~

~~-Force monitoring of ungrouted test tendons is not provided~~

~~-Pressurization at year one uses P_a instead of P_N~~

~~-Pressurization at years three and seven use P_a instead of $1.15P_D$~~

~~The provisions of SR 3.0.3 are applicable to the Containment Post Tensioning Surveillance Program inspection frequencies.~~

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