ArevaEPRDCPEm Resource

From: Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent: Monday, August 17, 2009 4:50 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); NOXON David B (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 257, FSARCh. 19
Attachments: RAI 257 Response US EPR DC.pdf

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 257 Response US EPR DC.pdf" provides technically correct and complete responses to 2 of the 3 questions, and a partial response to 1 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 responses to RAI 257 Questions 19-316 and 19-317.

The following table indicates the respective pages in the response document, "RAI 257 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 257 — 19-316	2	12
RAI 257 — 19-317	13	14
RAI 257 — 19-318	15	16

A complete answer is not provided for one part of Question 19-316. The schedule for a technically correct and complete response to this part of the question is provided below.

Question #	Response Date
RAI 257 — 19-316, Part I	September 1, 2009

Sincerely,

Ronda Pederson
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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Thursday, July 16, 2009 3:16 PM
To: ZZ-DL-A-USEPR-DL
Cc: Clark, Theresa; Phan, Hanh; Fuller, Edward; Mrowca, Lynn; Chowdhury, Prosanta; Colaccino, Joseph;

ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 257 (3288), FSARCh. 19

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on July 7, 2009, and on July 15, 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. 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: 734

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Response to

Request for Additional Information No. 257 (3288), Revision 1

7/16/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation
Application Section: 19.1

QUESTIONS for PRA Licensing, Operations Support and Maintenance Branch 1 (AP1000/EPR Projects) (SPLA)

Question 19-316:

(Follow-up to Question 19-166) Following the submission of Final Safety Analysis Report (FSAR) Revision 1, the staff has reviewed the various tables of design features, insights, and assumptions in Chapter 19. Specifically, these tables are Table 19.1-2—Features for U.S. EPR that Address Challenges for Current PWRs [pressurized water reactors], Table 19.1-5—Systems Analyzed in U.S. EPR PRA [probabilistic risk assessment], Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk, Table 19.1-108—U.S. EPR PRA-Based Insights, and Table 19.1-109—U.S. EPR PRA General Assumptions. The staff's objective was to confirm that the design details match descriptions elsewhere in the FSAR and that the assumptions are reasonable. The staff found several apparent inconsistencies and areas needing clarification. Please address each of the following and revise the FSAR as appropriate.

a. In Table 19.1-2, the entry on station blackout (SBO) refers to "cross-ties available for selected loads important to the PRA." It is unclear whether this statement refers to the alternate feed connections described in FSAR Section 8.3.1.1.1 or to other electrical cross-ties.

b. In Table 19.1-2, the entry on response to loss-of-coolant accidents (LOCA) refers to the capability to perform fast cooldown (FCD) using the main steam relief trains (MSRT). Although this operation is described in Chapter 19 and the response to Question 19-60, there appears to be no discussion of FCD elsewhere in the FSAR (e.g., in Chapter 10). If FCD is part of the plant design, it should not be described only in Chapter 19.

c. In Table 19.1-2, the entry on potential for reactor coolant pump (RCP) seal failure refers to an automatic trip of the RCPs given total loss of seal cooling. FSAR Section 5.4.1.2.1 also refers to a trip on loss of cooling. The response to Question 19-206 provides the logic for standstill seal system (SSSS) actuation and indicates that the process automation system (PAS) generates a sequence including an RCP trip. However, other FSAR Sections (e.g., Tier 1, Section 2.4.1 and Tier 2, Section 7.3.1.2.15) describe only the protection system (PS) RCP trip on stage two containment isolation or a safety injection (SI) signal combined with a 75-percent pressure difference across two RCPs. If the SSSS sequence including RCP trip is part of the plant design, it should not be described only in Chapter 19 and a single reference in Section 5.4.1.2.1.

d. In Table 19.1-5, the entry on the safety chilled water system (SCWS) states that SCWS provides "direct room cooling to the EFWS [emergency feedwater system] pump rooms." The first bullet on FSAR page 10.4-86 also refers to SCWS room cooling. This function is not included in the Tier 1 or Tier 2 descriptions of SCWS or in the list of major SCWS users provided in response to Question 09.02.02-41. If SCWS provides direct room cooling of the EFWS pump rooms, the function should not be described only in Chapters 10 and 19.

e. The first bullet in item 5 of Table 19.1-102 provides a disposition for full load rejection. This function is also described in Tier 2, Sections 7.7.2.3.4, 10.2.2.7, and 14.2.12.21.4. References to these portions of the FSAR (and others as appropriate) should be added for completeness.

f. Item 8 of Table 19.1-102 provides several references for a medium head safety injection (MHSI) shutoff head lower than the main steam safety valve (MSSV) setpoint. These values are presented in Tier 1, Tables 2.2.3-3 and 2.8.2-3. References to these portions of the FSAR (and others as appropriate) should be added for completeness.

g. The third portion of item 9 in Table 19.1-102 refers only to Tier 2, Section 7.1.1.4.1. The diverse reactor trip devices are described in Tier 2, Section 7.2.1.1. Functional diversity is discussed in Section 10 of topical report ANP-10281P. These references (and others as appropriate) should be added for completeness.

h. Item 10 of Table 19.1-102 refers to Tier 2, Section 9.2.8.2.2. Diversity of the SCWS refrigeration units is stated more clearly in Tier 2, Section 9.2.8.4. This reference (and others as appropriate) should be added for completeness.

i. Item 14 of Table 19.1-102 refers to Tier 2, Section 19.2.3.3.3.1. Passive cooling by the severe accident heat removal system (SAHRS) is described more fully in Tier 2, Section 19.2.3.3.3.2. This reference (and others as appropriate) should be added for completeness.

j. Item 15 of Table 19.1-102 describes the use of SAHRS for backup cooling of the in-containment refueling water storage tank (IRWST) if low head safety injection (LHSI) fails. Although Figure 19.2-2 shows a loop from the IRWST to the SAHRS heat exchanger, this function is not explicitly listed in the Tier 1 or Tier 2 descriptions of SAHRS. Tier 2, Section 6.2.1.1.1 only describes LHSI heat removal from the IRWST, not the SAHRS backup. If the use of SAHRS as a backup source of IRWST cooling is part of the plant design, it should not be discussed only in the description of the Level 1 PRA.

k. Item 20 of Table 19.1-102 refers to Tier 2, Section 5.3.3.1.1. Absence of penetrations in the lower vessel head is stated more clearly in Tier 2, Section 5.3.3.1.3. This reference (and others as appropriate) should be added for completeness.

l. Item 3 in Table 19.1-108 indicates that the current PRA models one component cooling water system (CCWS) header supplying two RCP thermal barriers. The design has been changed to supply all four RCPs from a single header. Until this design change is incorporated in the PRA, the table should acknowledge the difference; once it is incorporated, the table will need further revision.

m. Item 9 in Table 19.1-108 describes automatic isolation of the essential service water system (ESWS) and demineralized water system (DWS) on high sump level. ESWS isolation is described in Sections 3.4.3.4, 9.2.1.3.5, and 9.3.3.3, but appears not to be included in Chapter 7. Fuel building (FB) level measurements and alarms are described in FSAR Sections 3.4.3.6 and 9.2.1.3.5, but automatic isolation of DWS appears not to be included in these sections or in Chapter 7. In addition, the bounding FB flood source identified in Section 3.4.3.5 is the fire water distribution system (FWDS), not DWS. These inconsistencies should be corrected as needed, and the isolation functions should be considered for inclusion in Chapter 7.

n. Item 16 in Table 19.1-108 refers to Tier 2, Section 9.3.4.2.2. Reactor coolant system (RCS) loop level limitation is described more fully in Tier 2, Section 7.7.2.3.13. This reference (and others as appropriate) should be added for completeness.

o. Item 17 in Table 19.1-108 refers to Tier 2, Section 5.4.7.2.1. Reactor coolant system (RCS) loop level control is described more fully in Tier 2, Section 7.7.2.2.3. This reference (and others as appropriate) should be added for completeness.

p. Item 18 in Table 19.1-108 refers to "Insight #3," but the referenced insight is now the third item in Table 19.1-102.

q. Item 19 in Table 19.1-108 describes residual heat removal (RHR) isolation on high safeguard building (SB) sump level. Although this function appears in the referenced

FSAR section, it appears not to be described in Chapter 7. If this isolation function is part of the plant design, it should not be described only in Chapter 19 and the list of mid-loop design features in Section 5.4.7.2.1.

r. Item 20 in Table 19.1-108 refers to Tier 2, Section 5.4.7.2. These two MHSI actuation signals are also presented in Tier 1, Table 2.4.1-4. This reference (and others as appropriate) should be added for completeness.

s. Item 21 in Table 19.1-108 refers to “Insight #20,” but the referenced insight is now the fourth item in Table 19.1-108.

t. Item 22 in Table 19.1-108 addresses feed and bleed during shutdown, but refers to the FSAR section related to overpressure protection. The pressurizer safety relief valves (PSRV) and severe accident depressurization valves (SADV) are described more fully in Tier 1, Section 2.2.1 and Tier 2, Sections 5.4.13 and 19.2.3.3.4.1. These references (and others as appropriate) should be added for completeness.

u. Item 23 in Table 19.1-108 refers to “Insight #2,” but the referenced insight is now the second item in Table 19.1-102.

v. Item 24 in Table 19.1-108 refers to the thermal barrier cooling design documented in Tier 2, Section 9.2.2.1. This reference (and others as appropriate) should be added for completeness.

w. Item 20 in Table 19.1-109 refers to “EDWS.” This abbreviation is undefined and may be a typographical error meaning DWS, ESWS, or another system.

x. As in part (d) above, item 36 in Table 19.1-109 refers to local room cooling of the EFWS pump rooms. If revisions are made in response to part (d), this assumption may also need clarification.

y. Item 57 in Table 19.1-109 states that the equipment hatch is open in shutdown plant operating states (POS) CA, CB, and E and closed in D. This statement is consistent with Table 19.1-110 and Section 19.1.6.3.1.4, but is not consistent with Table 19.1-89, which states that the hatch is closed in POS CA and CB. The assumed containment status should be verified and made consistent throughout Chapter 19.

Response to Question 19-316:

Response to Question 19-316 (a):

The “cross-ties” discussed in U.S. EPR FSAR, Tier 2, Table 19.1-2 do not refer to the alternate feed connections described in FSAR Section 8.3.1.1.1. Rather they refer to the ability to supply power to a limited number of important loads in Division 2 and Division 3 in case of a loss of emergency onsite power in these divisions, including the Class 1E uninterruptible power supply (EUPS) bus and the heating, ventilation, and air conditioning (HVAC) loads. Power can be supplied from either the Division 1 or 4 station blackout diesel generator or emergency diesel generator.

The way these cross-ties are established has been changed since the U.S. EPR FSAR probabilistic risk assessment (PRA) model completion. This design change is described in Item 5 of U.S. EPR FSAR, Tier 2, Section 19.1.2.4.

FSAR Impact:

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

Response to Question 19-316 (b):

The following text will be added to U.S. EPR FSAR, Tier 2, Section 10.3.2.2:

> "The main steam system provides a non-safety-related redundant means to depressurize SGs (i.e., achieve fast cooldown) to depressurize the RCS during beyond design basis events to allow for RC makeup to mitigate ICC and avoid a severe accident."

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 10.3.2.2 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (c):

The following text will be added to U.S. EPR FSAR, Tier 2, Section 5.4.1.2.1:

> "In the event of a simultaneous loss of seal injection and thermal barrier cooling (all seal cooling lost) or a simultaneous failure of RCP No. 1 and 2 seals, the associated RCP is automatically tripped. After the RCP has stopped rotating the pressure boundary is maintained by automatic closure of the non-safety-related standstill seal and associated leak-off lines to and from each seal stage."

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 5.4.1.2.1 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (d):

The safety chilled water system (SCWS) supplies chilled water to the safety-related heating, ventilation and air conditioning (HVAC) systems and to the low head safety injection system (LHSI) pumps and motors located in Safeguard Buildings (SB) 1 and 4. The rooms that contain the EFWS pumps are cooled by the electrical division of the Safeguards Building ventilation system (electrical) (SBVSE). This system is one of several safety-related HVAC systems that have room coolers supplied by the SCWS. Other HVAC systems supplied by the SCWS are the Main Control Room air conditioning system (CRACS), the Safeguard Building controlled-area ventilation system (SBVS), and the Fuel Building ventilation system (FBVS). The EFWS pump rooms are just some of the rooms that contain a SBVSE room cooler that receives SCW. U.S. EPR FSAR, Tier 2, Section 10.4.9.3 indicates the EFW pump room coolers are cooled by the SCWS. This is correct and is consistent with the information contained in U.S. EPR FSAR, Tier

2, Section 9.2.8. This function is included in the Tier 1 and Tier 2 descriptions of the SCWS. Specifying coverage to the individual room is a level of detail not intended or included in the main Tier 1 and Tier 2 SCWS sections. In the response to Question 09.02.02-41, a list of major SCWS users was not provided. U.S. EPR FSAR, Tier 2, Table 19.1-5 summarizes the SCWS functions credited in the PRA, which is why the EFW room is specifically mentioned therein.

In order to clarify the selection of the HVAC subsystems discussed in U.S. EPR FSAR, Tier 2, Table 19.1-5, the entry under "Safety chilled water system", Bullet 2 will be revised to state: "Provides cooling to the SB HVAC, which includes cooling to ac and dc switchgear rooms and the EFW pump rooms." The Main Control Room HVAC systems will be deleted, since they are not explicitly modeled in the probabilistic risk assessment.

In addition, U.S. EPR FSAR, Tier 2, Table 19.1-5, Bullet 3 will be revised to change "CCW CHs" to "CCW Common Headers."

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-5, will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (e):

Reference to U.S. EPR FSAR, Tier 2, Sections 7.7.2.3.4, 10.2.2.7 and 14.2.12.21.4 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 5.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-102 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (f):

There is no reference to the MHSI shutoff head in U.S. EPR FSAR, Tier 1, Tables 2.2.3-3. The MHSI shutoff head is shown in U.S. EPR FSAR, Tier 2, Table 6.3-3. Reference to U.S. EPR FSAR, Tier 1, Table 2.8.2-3 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 8.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-102 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (g):

Reference to U.S. EPR FSAR, Tier 2, Section 7.2.1.1 and ANP-10281P, Section 10 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 9.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-102 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (h):

Reference to U.S. EPR FSAR, Tier 2, Section 9.2.8.4 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 10.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-102 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (i):

Reference to U.S. EPR FSAR, Tier 2, Section 19.2.3.3.3.2 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 14.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-102 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (j):

As discussed in Item 15 of Table 19.1-102, the severe accident heat removal system (SAHRS) is a non-safety system used to mitigate beyond design basis events. The system is discussed in U.S. EPR FSAR, Tier 1, Section 2.3.3 and in more detail in Tier 2, Section 19.2.3.3.3.2. The system alignment credited in the PRA level 1 analysis for cooling of the IRWST in case of a loss of all four low head safety injection (LHSI) trains is addressed in Tier 1, Section 2.3.3 by the function of active recirculation cooling of the core melt stabilization system (CMSS) and containment.

FSAR Impact:

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

Response to Question 19-316 (k):

Reference to U.S. EPR FSAR, Tier 2, Section 5.3.3.1.3 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 20.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-102 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (l):

A response to this question will be provided by September 1, 2009.

Response to Question 19-316 (m):

Automatic isolation of the DWS is not discussed in U.S. EPR FSAR, Tier 2, Section 3.4.3.5 or Section 9.3.3.3 because it is a non-safety-related actuation. In the flooding probabilistic risk assessment (PRA), for a Safeguards Building (SB) flood, automatic isolation is only important for the essential service water system (ESWS), as a large ESWS flood could affect multiple Safeguard Buildings (an event which is not modeled in the PRA). The DWS flooding potential is not enough to reach ground level in a SB. A DWS flood could reach ground level in the FB, but given the assumptions made in the PRA for a flood in the FB; this is without consequence, as discussed below.

Water from a large DWS flood event could reach ground level only if it was contained in one FB division. In that case, water could spread to the neighboring Safeguard Building (SB 1 or 4), to the other FB division, or to the Nuclear Auxiliary Building.

- Propagation to the neighboring SB is already assumed in the FB flood scenario because the PRA assumes that the door separating the FB from the SB at Elevation -31 ft fails.
- Propagation to the other FB division is already included in the scenario because all equipment in the FB is conservatively assumed to fail.
- Propagation to the Nuclear Auxiliary Building would not adversely affect the systems needed to mitigate the flood in the FB.

Therefore, the assumption that a DWS flood is automatically isolated and would be contained below ground level is not important to the flooding PRA.

U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 9 will be reworded so that the assumption only applies to the ESWS.

A description of the automatic isolation of the ESWS will not be included in Chapter 7. The description of this function is included in U.S. EPR FSAR, Tier 2, Sections 9.2.1.3 and 9.3.3 which describe the functionality of the ESWS and the vent and drain system, respectively. Chapter 7 of NUREG 0800 ("Standard Review Plan") contains specific guidance that defines the I&C functionality to be described in Chapter 7 of the Design Certification application. The function in question, automatic ESWS isolation, is not appropriate for inclusion in Chapter 7 based on this NUREG 0800 guidance.

In addition, the FWDS is identified as the bounding system (based on the released inventory before isolation) in Section 3.4.3.5. Its maximum flooding potential (based on available water inventory in the system) is less than the DWS and is not enough to flood the FB up to ground level. The deterministic flooding analyses credit manual isolation after a certain period of time and the FWDS flow rate is higher than the DWS, thus the inventory released in that time is higher.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (n):

Reference to U.S. EPR FSAR, Tier 2, Section 7.7.2.3.13 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 16.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (o):

Reference to U.S. EPR FSAR, Tier 2, Section 7.7.2.2.3 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 17.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (p):

U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 18 will be revised to correctly reference U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 3.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (q):

A description of the RHR isolation function on high Safeguard Building (SB) sump level will not be included in U.S. EPR FSAR, Tier 2, Chapter 7. The description of this function is included in U.S. EPR FSAR, Tier 2, Section 5.4.7.2.1, which describes the functionality of the residual heat removal system. Chapter 7 of NUREG-0800 ("Standard Review Plan") contains specific guidance that defines the I&C functionality to be described in Chapter 7 of the Design Certification application. The function in question, isolation of the RHR on high SB sump level, is a beyond design basis function associated with risk reduction, and is not appropriate for inclusion in Chapter 7 based on the NUREG-0800 guidance.

FSAR Impact:

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

Response to Question 19-316 (r):

The two medium head safety injection (MHSI) actuation signals are presented in U.S. EPR FSAR, Tier 1, Table 2.4.1-3. Reference to U.S. EPR FSAR, Tier 1, Table 2.4.1-3 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 20.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (s):

U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 21 will be revised to correctly reference U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 4.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (t):

References to U.S. EPR FSAR, Tier 1, Section 2.2.1; Tier 2, Section 5.4.13; and Tier 2, Section 19.2.3.3.4.1 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 22.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (u):

U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 23 will be revised to correctly reference U.S. EPR FSAR, Tier 2, Table 19.1-102, Item 2.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (v):

The thermal barrier cooling design is documented in U.S. EPR FSAR, Tier 2, Section 9.2.2.1. Reference to U.S. EPR FSAR, Tier 2, Section 9.2.2.2.1 will be added to U.S. EPR FSAR, Tier 2, Table 19.1-108, Item 24.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-108 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (w):

The item 20 reference to EDWS in U.S. EPR FSAR, Tier 2, Table 19.1-109, will be revised to reference the demineralized water system (DWS) makeup water to feedwater tank supply for the startup and shutdown system (SSS).

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-109 will be revised as described in the response and indicated on the enclosed markup.

Response to Question 19-316 (x):

See the response to Question 19-316 (d) above. Table 19.1-109, Item 36 does not require revision as the content is correct as stated.

FSAR Impact:

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

Response to Question 19-316 (y):

U.S. EPR FSAR, Tier 2, Table 19.1-89 will be modified to be consistent with the current "U.S. EPR General Assumptions" presented in Table 19.1-109, Item 57. The equipment hatch status in POS CA and CB will be shown as "Open."

The Shutdown Level 2 PRA model assumes that the hatch is initially closed in POS D. Based on information on the U.S. EPR shutdown schedule, this assumption may not be valid. This assumption will be re-evaluated as necessary in a PRA update after the U.S. EPR shutdown schedule becomes available. A sensitivity study was performed with the equipment hatch open in plant operating state D.

Hatch re-closure is assumed possible before boiling in case of a loss of residual heat removal with power available. Given the short time available, the human error probability is estimated to be 0.3. Hatch re-closure is not credited for loss of coolant accidents, nor is it credited if power is unavailable. The results of the sensitivity case are shown in Table 19-316y. With the hatch initially open, large release frequency (LRF) in POS D becomes 7.0E-09/year. The resulting increase in total (at power and shutdown) LRF is 21%.

Table 19-316y: Sensitivity Analysis: Large Release Frequency in Function of Hatch Status in POS D

	LRF with Hatch Initially Closed in POS D (per yr)	**LRF with Hatch Initially Open in POS D (per yr)**
At power	2.6E-08	2.6E-08
State C	4.3E-09	4.3E-09
State D	3.6E-10	7.0E-09
State E	1.0E-09	1.0E-09
Total	**3.2E-08**	**3.8E-08**

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-89 will be revised as described in the response and indicated on the enclosed markup.

Question 19-317:

(Follow-up to Question 19-275) In a teleconference on June 30, 2009, the applicant indicated that in POS CBD, the RCS is at mid-loop and vented via four valves: the pressurizer degas line (30JEF10AA503 and 30JEF10AA504) and the nitrogen supply connection (30JEF10AA501 and 30JEF10AA502). The staff's understanding is that no other RCS penetrations (e.g., pressurizer manway) are assumed to be open. Are all connections to the RCS in this state (e.g., the connection to the nitrogen system) designed to withstand the pressure increase required for steam generator heat removal, indicated as 175 psi in the response to Question 19-133? Please discuss the assumption that the only RCS openings (even after pressurization) are the four vent valves described above. Because this information is important for concluding that the containment environment will support closure within the stated times, the assumption should be documented in the FSAR.

Response to Question 19-317:

The 175 psi referred to in the question should be 145 psi, as shown in the Table 19-133.1 of the response to RAI 14, Question 19-133, and indicated in a clarification from the NRC[1].

Also, the assumption that the reactor coolant system (RCS) is at mid-loop during plant operating state (POS) CBD (U.S. EPR FSAR, Tier 2, Table 19.1-109, Item 50) is a conservative PRA assumption made to simplify time-to-boil calculations; a minimum level is selected for each POS. Since POS CBD represents a draining-down phase in shutdown, the actual RCS level varies during POS CBD and it will be greater than mid-loop level until the end of this POS.

It is unlikely that the pressurizer manway will be opened at any time during a shutdown. Before the reactor head is removed, the pressurizer manway would only be opened, in the case that the pressurizer safety relief valves or primary depressurization valves are not operable as a vent path.

As stated in the question, during POS CBD, pressurizer degas line valves (30JEF10AA503 and 30JEF10AA504) and nitrogen supply connection valves (30JEF10AA501 and 30JEF10AA502) may be open. The pressurizer degas line valves are designed to be open during normal operations and have a design pressure of 2535 psig. The nitrogen supply connection valves are connected through a check valve to the nitrogen gas supply system, and through a closed isolation valve to the Nuclear Island drain and vent system (vacuum pump). This check valve and isolation valve have a design pressure of 710 psig.

During POS CBD, the low pressure reducing station isolation valves may be open to allow for drain-down to mid-loop. As stated in U.S. EPR FSAR, Tier 2, Table 19.1-108, low pressure reducing station auto isolation on low loop level is important to prevent possible RCS flow diversion through the chemical and volume control system. This isolation has a design pressure of 1160 psig.

There are no other RCS penetrations assumed to be open during POS CBD.

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[1] Email from Getachew Tesfaye to Ronda Pederson, 08/06/2009

Based on the above, the conclusions presented in the response to RAI 197, Question 19-275 about the RCS repressurization (related to timing of steaming in the containment and the hatch closure), are valid. The following assumption will be added to the U.S. EPR FSAR, Tier 2, Table 19.1-109 as Item 84:

> "The RCS vents identified in state CB are not considered large enough to prevent RCS repressurization in the case of loss of cooling; therefore RCS repressurization is assumed in the time-to-boil calculation."

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 19.1-109 will be revised as described in the response and indicated on the enclosed markup.

Question 19-318:

(Follow-up to Question 19-291) The response to Question 19-271 indicates that the possible heating, ventilation, and air conditioning (HVAC) dependency “can be addressed through the plant procedures that, on a loss of HVAC for a specific division, instruct operators to make sure that a running CCW[S] pump is not supplied from this division (perform a CCW[S] switchover if necessary.” If the applicant expects the plant to be operated in this way, this assumption should be included in the appropriate table of the FSAR. If the operator succeeds in following this procedure, only one division of equipment (rather than two) would fail following a loss of HVAC to one SB. The staff is concerned that this “conservative” treatment may result in a significant overestimation of the importance of HVAC, losses of offsite power (LOOP), and potentially other systems and operator actions. Unless it can be demonstrated that the risk profile and important PRA insights would not be affected by this conservatism, the model should be updated to reflect realistic plant operations. Please provide a justification for the current treatment or update the PRA and FSAR as appropriate.

Response to Question 19-318:

The probabilistic risk assessment (PRA) model was not updated based on the procedure-related recommendation discussed in the question, because this recommendation is not incorporated into the U.S. EPR documentation. Additionally, the plant operators will have several other methods available to reduce the risk of HVAC-induced component cooling water (CCW) switchover failures. These include design changes (a new HVAC design has been proposed) or by instituting additional administrative controls (e.g., disallow safety chilled water system maintenance on the trains where CCW is supplying flow to the common headers).

A sensitivity case was evaluated which credits operator action to perform a CCW switchover if Division 1 or 4 HVAC is lost when CCW pump 1 or 4 is supplying the associated common header. (The CCW switchover human error probability is evaluated to be 2E-2, and 0.16 is used as a medium dependency value with the operator action to recover HVAC). The results of this core damage frequency (CDF) sensitivity case are presented in Table 19-318.

Table 19-318—Results of a Sensitivity Case with Crediting Operator Performing CCW Switchover given a Loss of HVAC Train

	Base Case CDF (per yr)	Sensitivity Case CDF (per yr)	Relative Change in CDF
Total at-power CDF	5.26E-07	4.23E-07	-19.6%
Internal Events	2.89E-07	2.05E-07	-29.1%
Internal Fires	1.76E-07	1.59E-07	-9.7%
Internal Floods	6.13E-08	6.00E-08	-2.3%

The results show a reduction in the CDF of approximately 20%. PRA insights based on this reduction include:

- Changes in the total CDF distribution between internal, fire and flood events as reported in U.S. EPR FSAR, Tier 2, Figure 19.1-4 are not significant; internal events still dominate with 48% contribution, instead of 55%.
- Changes to the internal event contributors to the significant initiating events (U.S. EPR FSAR, Tier 2, Table 19.1-6) are not significant. The LOOP initiating event still dominates with a contribution of 39% instead of 49%.
- Changes in the internal events important cutset groups (Table 19.1-7) can be summarized as: the contribution from some of the LOOP/HVAC-related cutset groups has changed significantly, but the overall cutsets selection are not significantly affected.
- There are minor changes to the human error risk ranking (U.S. EPR FSAR, Tier 2, Tables 19.1-10 and 19.1-11). For example, the new CCW switchover action is a risk-significant operator action in the sensitivity model, and the importance of the HVAC recovery action (OPF-SAC-2H) is somewhat reduced, although it remains one of the most significant operator actions.
- Changes to the internal events important equipment, common cause, and parameters (Tables 19.1- 8, -9, -12, -13, and -14) are not significant.
- Changes to flood and fire CDF and risk insights are not significant.

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

49. D. A. Powers, “Technical Issues Associated with Air Ingression During Core Degredation”, SAND2000-1935C, June 2000.

50. T. Kärelä et al. “Experiments on the Behaviour of ruthenium in air ingress Accidents,” NKS-151, March 2007.

51. Auvinen et al, “Progress on Ruthenium Release and Transport under Air Ingress Conditions,” European Review Meeting on Severe Accident Research (ERMSAR-2007), Karlsruhe, Germany, 12-14 June 2007.

19-316(g)

52. M. L. Ang et al., “PWR severe accident behaviour and containment response for some sequences initiated at shutdown,” The Nuclear Engineer, volume 38, no. 3, page 79, 1997.

53. ANP-10281P, Revision 0, “U.S. EPR Digital Protection System Topical Report,” AREVA NP Inc., March 2007.

Table 19.1-5—Systems Analyzed in U.S. EPR PRA
Sheet 4 of 4

19-316(d)

System	Comment
Safety chilled water system	• Four independent divisions, each housed within separate SB • Provides cooling to the SB HVAC, that includes cooling to ac and dc switchgear rooms and EFW pump rooms. ~~and Control Room HVAC systems and direct room cooling to the EFW pump rooms.~~ • Trains 1 and 4 of Safety Chilled Water are air-cooled whereas trains 2 and 3 are cooled by the CCW ~~CHs~~common headers. • Trains 1 and 4 provide direct cooling to the LHSI pumps, such that these pumps are supported during a loss of CCW or ESW
Instrumentation & control systems	• Digital I&C systems for different functions (RPS, ESFAS, actuation and control of other safety and non-safety systems)

Table 19.1-89—System Availability During Shutdown
Sheet 1 of 2

19-316(y)

POS	Description	LHSI/RHR Availability				Secondary Cooling Availability		SIS				
		Trains Avail	RHR Run	RHR Stdby	LHSI Stdby	SG with MSRT	EFW	Signal	MHSI	SAHR	Hatch	Comment
CA_d	RHR Heat Removal with Level in PZR (shutting down)	4	4	0	0	2	2 (Trains 1 and 2 w/ P13)	Low delta Psat	4	1	~~Closed~~ Open	MSRT set at 148 psia
CB_d	RHR Heat Removal at mid-LOOP with RPV Head On (shutting down)	4	3	0	1 (Train 1 or 4)	2	2 (Trains 1 and 2 w/ P13)	Low Loop Level	4	1	~~Closed~~ Open	MSRT set at 148 psia
D_d	RHR Heat Removal at mid-LOOP with RPV Head Off (shutting down)	4	3	0	1 (Train 1 or 4)	NA	NA	Low Loop Level	4	NA	Closed	
E	Reactor Cavity Flooded (fuel off load)	3	2 (Train 2 & 3)	0	1 (Train 4)	NA	NA	Low Loop Level	3	NA	Open	
F	Core Off-load	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
E	Reactor Cavity Flooded (fuel load)	3	2 (Train 1 & 2)	0	1 (Train 4)	NA	NA	Low Loop Level	3	NA	Open	
D_u	RHR Heat Removal at mid-LOOP with RPV Head OFF (starting up after refueling)	4	2 (Train 1 & 2)	1 (Train 3)	1 (Train 4)	NA	NA	Low Loop Level	4	NA	Closed	

19-316(y)

Table 19.1-89—System Availability During Shutdown
Sheet 2 of 2

		LHSI/RHR Availability				Secondary Cooling Availability		SIS				
POS	Description	Trains Avail	RHR Run	RHR Stdby	LHSI Stdby	SG with MSRT	EFW	Signal	MHSI	SAHR	Hatch	Comment
CB_u	RHR: Mid-loop w/ RPV head on (starting up after refueling)	4	2 (Train 1 & 2)	1 (Train 3)	1 (Train 4)	2	2	Low Loop Level	4	1	~~Closed~~ Open	MSRT set at 148 psia
CA_u	RHR: RCS Normal Level (starting up after refueling)	4	2 (Train 1 & 2)	1 (Train 3)	1 (Train 4)	2 to 4	2 to 4	Low delta Psat	4	1	~~Closed~~ Open	MSRT set at 148 psia

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 2 of 7

No	U.S. EPR Design Feature Description	Disposition
4	**High level of redundancy and independence for onsite power supply system** The U.S. EPR design includes both emergency diesel-generators (EDGs) and station blackout diesel generators that serve as an alternate AC source. These onsite power sources have the following features:	
	• There are four EDGs, one supporting each safety division. This provides substantial redundancy to maintain the function of safety systems following a loss of offsite power.	Tier 1, Section 2.5.4; Tier 2, Section 8.3.1.1.5
	• There are two backup SBO diesel-generators for AAC. The SBO diesel-generators are diverse from the EDGs in design, cooling, actuation and control, fuel oil supply and operating environment. This affords significant defense against potential common-cause failures that might affect all of the diesel generators.	Tier 1, Section 2.5.3; Tier 2, Section 8.4.1
	• The SBO diesel-generators can be aligned to back up two divisions of the safety loads if the EDGs are unavailable, and can be used to support systems provided to mitigate severe-accident conditions.	Tier 1, Section 2.5.3; Tier 2, Section 8.4.1
5	**Reliability of normal AC power supplies** Among the provisions incorporated into the design of the U.S. EPR to provide for improved reliability of the normal supply of AC power, reducing the demand for emergency power from the diesel-generators, are the following:	19-316(e)
	• The design includes the capability to withstand a full load rejection without tripping the reactor. In the event of a load rejection, the reactor and turbine would automatically run back to a power level sufficient to allow the main generator to continue to supply the plant auxiliary loads. This design would reduce the potential for reactor trip and challenge to onsite emergency power systems for grid-centered loss of power events.	Tier 2, Section 8.3.1.1; Tier 2, Section 7.7.2.3.4; Tier 2, Section 10.2.2.7; Tier 2, Section 14.2.12.21.4
	• During normal operation, two auxiliary transformers supply power directly from the switchyard to all four safety-related switchgear divisions. An additional three transformers supply the non-safety-related switchgear. Since the main generator does not normally supply auxiliary loads in this configuration, a reactor trip does not create a demand for fast transfer to an offsite power source. Moreover, there are redundant feeds for each switchgear (safety-related and non-safety-related), so that loss of an individual auxiliary transformer will not affect the continued supply of offsite power to plant loads.	Tier 1, Section 2.5.5; Tier 2, Section 8.2.1.1; COLA Item 8.1-1; COLA Item 8.2-1; COLA Item 8.2-3

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 3 of 7

No	U.S. EPR Design Feature Description	Disposition
6	**Provisions to limit the impact of sequences involving failure to scram** The extra borating system (EBS) provides manual injection capability of highly borated water into the reactor pressure vessel (RPV) in the event that the reactor shutdown system does not function properly. EBS is a two-train system which further reduces the potential contribution of accidents involving a failure to scram	Tier 1, Section 2.2.7; Tier 2, Section 2 6.8
7	**Reduced potential for a small LOCA due to failure of reactor coolant pump (RCP) seals** The potential for RCS leakage or small LOCA (SLOCA) due to failure of reactor coolant pump (RCP) shaft seals has been an important risk contributor for many PWRs. The U.S. EPR design includes a stand still seal for each RCP. The stand still seal is a pneumatic, “metal-to-metal” seal that serves as a back-up seal, and is independent of the normal shaft seal. The stand still seal system reduces the risk of a LOCA event as a result of postulated RCP seal degradation.	Tier 2, Section 5.4.1.2.1 19-316(f)
8	**Reduced potential for release pathway following a steam generator tube rupture (SGTR)** Among the features of the MHSI system is the provision for a shutoff head below the setpoints for the main steam safety valves (MSSV). In the event of an SGTR, the lower MHSI shutoff head limits the pressure differential that forces reactor coolant through the broken tube. The lower MHSI pressure will not challenge the associated MSSV to open (with possible failure to re-close). This reduces the potential for a release pathway from the RCS through the MSSV.	Tier 2, Table 6.3-3; Tier 2, Table 10.3-2; Tier 2, Section 15.6.3.1.1; Tier 1, Table 2.8.2-3
9	**A state-of-the-art digital instrumentation and control (I&C) system** The U.S. EPR uses state-of-the-art digital systems for I&C functions. The reliability of these systems enhances the automatic initiation of functions important to maintaining core cooling, including the following: • Reactor shutdown, • Emergency feedwater, and • Safety injection The man-machine interface implemented through a fully computerized control room also optimizes the information available to the operators.	Tier 1, Section 2.4.1; Tier 2, Section 7.1.1.4.1 Tier 2, Section 7.1.1.1

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 4 of 7

No	U.S. EPR Design Feature Description	Disposition
	Because of the level of redundancy of such systems, concerns regarding the potential for common-cause failures must be addressed. A number of important measures have been taken to limit the potential for CCFs for the digital I&C systems of the U.S. EPR, including the following:	Tier 2, Section 7.1.1.4.1; Tier 2, Section 7.2.1.1; ANP-10281P (Reference 53), Section 10
	• The Protection System employs subsystems called diversity groups to accomplish essential actuations. These subsystems are functionally diverse and independent. The diversity results from the use of different application programs and different parameter/sensor inputs. No information is shared between diversity groups via network connections. • The outputs of the protective system (PS) are connected to diverse reactor trip devices. • The ESF functions are also divided between the diverse subsystems to obtain maximum functional diversity.	19-316(g)
	In addition to the functional diversity provided by the subsystems within the PS and the diversity of the reactor trip devices, there is additional defense-in-depth provided in the I&C architecture. This includes the following:	
	• Trip reduction features of the RCSL and PAS systems, which provide control, surveillance, and limitation functions to reduce reactor trips and PS challenges. Among these features is the automatic power reduction that is not credited in the PRA.	Tier 2, Section 7.1.1.4.5; Tier 2, Section 7.1.1.4.6
	• Backup trip and actuation functions are performed by the non-safety-related I&C system (i.e., the PAS).	Tier 2, Section 7.4.1.1
	The potential for software CCFs is minimized by such measures as the following:	Tier 2, Section 7.1.1.1; Tier 2, Section 7.1.1.2
	• High quality software design tools. • A deterministic operating system. • Built in monitoring and testing. 19-316(h) • Built in functional diversity.	
10	**Diversity of some elements of HVAC** Diversity is incorporated into the design of the safety chilled water system through the use of air cooling for the refrigeration units in Divisions 1 and 4, and CCW cooling for the refrigeration units of Divisions 2 and 3.	Tier 2, Section 9.2.8.2.2; Tier 2, Section 9.2.8.4

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 6 of 7

No	U.S. EPR Design Feature Description	Disposition
14	**Core-melt retention system** A passive device allows water from the IRWST to flood the corium spreading area to remove heat from below the core debris via the cooling water channels. This design limits the potential for core-concrete interactions that could cause pressurization of the containment via the generation of non-condensable gases.	Tier 2, Section 19.2.3.3.3.1; Tier 2, Section 19.2.3.3.3.2 19-316(i)
15	**Severe-accident heat removal system** The severe accident heat removal system (SAHRS) provides a means for removing heat from containment following a severe accident. Feature of the SAHRS that play an important role in the Level 2 PRA include the following: ● The system supports passive cooling of the molten core debris. ● The system includes a containment spray mode that enhances scrubbing of fission products from the containment atmosphere. ● The system provides for active recirculation of cooling water for the molten core debris. ● Active elements of the SAHRS rely on the SBO diesel generators, providing a degree of diversity and independence from the safety systems involved in core cooling. In addition to containment heat removal credited in Level 2, the SAHRS is also credited in some Level 1 sequences for cooling IRWST if the heat removal function of LHSI fails. The demands/ challenges to the SAHRS are relatively low in frequency due to the four train reliability of LHSI heat removal and overall low CDF. The SAHRS is a single train, which has a dedicated CCW and ESW cooling capability. The system is manually initiated.	Tier 1, Section 2.3.3; Tier 2, Section 19.2.3.3.3.2
16	**Main steam relief trains for reliable heat removal** Each main steam line is equipped with a MSRT. To provide for both reliable operation and limited potential for spurious operation, each MSRT is equipped with four solenoid valves.	Tier 2, Section 10.3.2.2

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 7 of 7

No	U.S. EPR Design Feature Description	Disposition
17	**The remote shutdown workstation is in a fire and flood area separate from the main control room.** Although a main control room fire may defeat manual actuation of equipment from the main control room, it will not affect the automatic functioning of safe shutdown equipment via the PS or manual operation from the remote shutdown station. Sufficient instrumentation and control is provided at the remote shutdown station to bring the plant to safe shutdown conditions in case the control room must be evacuated. There are no differences between the main control room and remote shutdown workstation controls and monitoring that would be expected to affect safety system redundancy and reliability. The following applies toward transferring control from the MCR to the RSS: • The transfer must be in a different fire area than the MCR and within reasonable walking distance from the MCR. • The transfer must disable the MCR control and provide transfer to the RSS controls without loss of control capability.	Tier 2, Section 3.4.3.4; Tier 2, Section 9.5.1.2.1; Tier 2, Section 7.4.1.3; Tier 2, Section 7.4.2.3
18	**MCR & RSS ventilation systems** The main control room has its own ventilation system, and is pressurized. This prevents smoke, hot gases, or fire suppressants originating in areas outside the control room from entering the control room via the ventilation system. The ventilation system for the remote shutdown workstation is independent of the ventilation system for the main control room.	Tier 2, Section 6.4.2.4; Tier 2, Section 9.4.1.3
19	**Seismic margins analysis** The plant level HCLPF is ≥ 1.67 SSE, where the SSE is defined by the Certified Design Response Spectra (CSDRS), and there are no spatial seismic interaction issues. Differences between the as-built plant and the design used as the basis for the U.S. EPR FSAR seismic margins analysis will be reviewed.	COL Item 19.1-6; COL Item 19.1-9
20	**Instrumentation through RPV top head** The U.S. EPR location of the RPV instrumentation which is through RPV top head not lower head, reduces likelihood of LOCA during maintenance	19-316(k) Tier 2, Section 5.3.3.1.1; Tier 2, Section 5.3.3.1.3

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 2 of 5

No	U.S. EPR PRA Based Insight	Disposition
5	**EDGs and SBO DGs are assigned to different common-cause groups.** This PRA modeling assumption will be confirmed by assuring diversity between EDGs and SBO DGs (multiple diversities that could be accomplished be selecting different model, control power, heating, ventilation and air conditioning (HVAC), engine cooling, fuel systems, and location.	Tier 2, Section 8.4.1
6	**High I&C system reliability** The fault-tolerant design of the TXS platform contributes to high I&C system reliability. Inherent in the modeling of the fault tolerant design is the "coverage" of the self-monitoring features, which determines for a given module the percentage of failure modes that are assumed to be repaired quickly (24 hours) versus the non-self-monitored failure modes that are detected by periodic surveillance tests.	Tier 2, Section 7.1.2.6.26; Tier 2, Section 7.1.2.6.16; Tier 2, Section 7.1.2.6.21; Tier 2, Table 1.8-2, Item 19.1-9
7	**The AV42 priority module is not susceptible to CCF** Software CCF is not a concern for the AV42 priority module because the safety-related functions contain neither software nor an operating system. The AV42 uses a programmable logic device; the functions on the module are implemented in solid state logic gate arrays and are non-user programmable. The AV42 is 100% testable before installation. The device also undergoes rigorous physical testing and qualification (environmental, electrical, seismic, radiation, electromagnetic interference, and radio frequency interference). The AV42 module is designed with features to ensure independence between the safety-related and non-safety-related circuits.	Tier 2, Section 7.1.1.2.1
8	**Risk of losing all instrumentation is negligible** The human machine interface (HMI) design includes both SICS and PICS systems for operator monitoring and controls. Consequently the risk of losing all instrumentation is negligible relative to the human error probability.	Tier 2, Section 7.1.1.3.1; Tier 2, Section 7.1.1.3.2
9	**Floods caused by a break in ~~a system with very large flooding potential (ESWS or DWS)~~the ESWS are assumed to be contained below ground level of the affected ~~buildings (~~SB~~ or FB)~~.** Bases for this assumption are following: 1. ~~Those systems are~~The ESWS is automatically isolated if the building sump detects a large flooding event 2. Expansive time is needed to flood a building up to ground level, so operator isolation is likely to succeed if automatic isolation failed.	Tier 1, Section 2.1.1; Tier 2, Section 3.4.3.1; ~~Tier 2, Section 3.4.3.3;~~ Tier 2, Section 3.4.3.4; ~~Tier 2, Section 3.4.3.5~~Tier 2, Section 9.2.1.3.5; Tier 2, Section 9.3.3.3

19-316(m)

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 3 of 5

No	U.S. EPR PRA Based Insight	Disposition
10	**Isolation of EFW tank leaks or pipe breaks is assumed possible for any break location.** Pipe breaks in the EFWS are treated as flooding events with the potential to drain all four EFW tanks. It is assumed that the operators would have the ability to manually isolate an EFW pipe break occurring in any of the four SB with isolation valves in another unaffected SB and to initiate DWS makeup to the tanks of the intact EFW trains. The severity of a flooding event from an EFW tank leak will be reduced as a result of the design change identified in Section 19.1.2.4, which maintains the EFW suction header isolation valves closed. Manual isolation of an EFW tank leak or pipe break will not be necessary.	Tier 2, Section 3.4.3.4; Tier 2, Section 10.4.9.2.1
11	**Flooding event would not affect the electrical and I&C rooms of a safeguard building.** Flood paths are provided in the safeguard buildings, such that water from a break anywhere in the building would be stored in the lower elevation of the building. In particular, a flooding event would not affect the electrical and I&C rooms of a safeguard building. All electrical / I&C equipment is located above the maximum postulated flood level.	Tier 1, Section 2.1.1; Tier 2, Section 3.4.3.4
12	**Cable separation in the MCR Cable Spreading Area** Due to divisional separation measures in the MCR Cable Spreading Area, a fire in the cable spreading area is assumed to disable only one electrical safety division. Non-safety division cables are also assumed to be separated from the safety divisions.	Tier 2, Section 9.5.1.2.1
13	**Shutdown management guidelines** The shutdown guidelines as described in the Shutdown Management Guidelines, NUMARC 91-06, should be considered when developing the plant specific operations procedures.	Tier 2, Section 13.5.2; COLA Item 13.1-1; COLA Item 13.4-1; COLA Item 13.5-1
14	**The low probability that the IRWST suction strainers are plugged during shutdown.** The IRWST design (e.g., large, separation between suction lines, debris retaining capability) and plant procedures (e.g., foreign material control) are expected to ensure that this probability is low.	Tier 2, Section 6.3.2.2.2; COLA Item 6.3-1
15	**Closing containment hatches and penetrations** The ability to close containment hatches and penetrations during Modes 5 & 6 prior to steaming to containment is important. It is assumed that procedures and training will be de[19-316(n)] encompass this item.	Tier 2, Section 13.5.2; COLA Item 13.1-1; COLA Item 13.4-1; COLA Item 13.5-1
16	**Low pressure reducing station auto isolation** In shutdown operation, low pressure reducing station auto isolation on low loop level is important to prevent possible RCS flow diversion through CVCS.	Tier 2, Section 9.3.4.2.2; Tier 2, Section 7.7.2.3.13

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 4 of 5

19-316(o)

No	U.S. EPR PRA Based Insight	Disposition
17	**Automatic level control at mid-loop** Automatic level control at mid-loop is important to reduces likelihood of RHR pumps cavitations.	Tier 2, Section 5.4.7.2.1; Tier 2, Section 7.7.2.2.3
18	**In-containment refueling water storage tank/SD** As stated in ~~the Insight #3~~Table 19.1-102 design feature #3, the design of the IRWST eliminates some failure modes that have been important for current-generation plants: in shutdown operation IRWST inside containment reduces impacts of RHR flow diversions which lead to LOCAs inside containment not outside.	Tier 2, Section 6.3.2.2.2
19	**RHR auto isolation on safeguards building sump level** In shutdown operation, RHR auto isolation and pump shutoff on a high safeguards building sump level, divisionally based, is an important protection from RHR LOCAs outside containment.	Tier 2, Section 5.4.7.2.1
20	**Automatic MHSI actuation** In shutdown operation, automatic MHSI actuation on a low RCS (hot leg) loop level or on a low dPsat (for cold shutdown) is important to mitigate losses of RHR, LOCAs and flow diversions.	Tier 2, Section 5.4.7.2; Tier 1, Table 2.4.1-3
21	**Sensitivity to human reliability in shutdown** Similarly to the Insight # ~~20~~4, the shutdown CDF is sensitive to probabilities for human failure events. Important human actions in shutdown: operator isolations of various flow diversions; operator actions to control draindown in midloop and operator manual actuations of RHR/LHSI pumps. It is assumed that instrumentation to support above actions will be available (e.g. loop level and sump level indications and alarms) and that the written procedures covering the above actions will be implemented, and maintained.	Tier 2, Section 18.6
22	**An alternate decay heat removal path** An alternate decay heat removal path in shutdown, can be established by operator action to manually open PSV valves or primary depressurization valves and to initiate MHSI/LHSI injection.	Tier 2, Section 5.2.2; Tier 1, Section 2.2.1; Tier 2, Section 5.4.13; Tier 2, Section 19.2.3.3.4.1
23	**Physical separation of safety systems/SD** As stated in ~~the Insight~~Table 19.1-102 design feature #2, complete physical separation of the U.S. EPR safety systems, significantly reduces the potential for core-damage accidents due to internal or external hazards in shutdown. It is assumed that this separation also makes it possible to implement controls during maintenance in shutdown to protect operating trains. It is also expected that the written procedures will be developed to cover Fire Protection Program implementation.	Tier 2, Section 5.4.7.2; Tier 2, Section 9.5.1.6

19-316(p) 19-316(r) 19-316(s) 19-316(t) 19-316(u)

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 5 of 5

No	U.S. EPR PRA Based Insight	Disposition
24	**Seal Loca contribution to fire and flooding CDF** RCP seal LOCAs are identified as important contributors to both the internal fire and the internal flooding CDF. The design change to thermal barrier cooling, identified in Section 19.1.2.4, exhibits a prospective reduction in seal LOCA contribution to fire and flooding CDF.	Tier 2, Section 19.1.5.2.2.8 Tier 2, Section 19.1.5.3.2.8; Tier 2, Section 9.2.2.2.1

19-316(v)

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 3 of 16

No.	Category[1]	PRA General Assumptions[2]
17	CC	The I&C of the U.S. EPR has not been designed to the point where a formal software reliability analysis is feasible. Therefore, the MGL common cause parameters assigned to I&C components are a rough approximation and are expected to be conservative.
18	CC	The most important common cause event based on RAW importance is the CCF of the safety-related batteries on demand because, in the case of a LOOP event, this event is assumed to lead directly to core damage.
19	PM	Maintenance unavailability in the PRA model is assumed to be a combination of preventive and corrective maintenance. The unavailability time due to preventive maintenance is assumed to be seven days per year. Preventive maintenance is only considered for systems where it is assumed that scheduled maintenance will normally be performed "at power". The unavailability time due to corrective maintenance is assumed to be three days for the running systems, and nine days for the standby systems.
20 19-316(w)	PM	Maintenance unavailability is assumed on a divisional basis; only one division is allowed to have one (or several) of its systems unavailable for maintenance at any given time. In addition: • One EFW train cannot be in maintenance when SSS/~~E~~DWS makeup water to feedwater tank supply for SSS is in maintenance. • One SBO DG and one EDG cannot be out for maintenance at the same time.
21	PM	Maintenance assumptions are not included for operating electrical and I&C equipment. The basis for this assumption is discussed below: • Each Class 1E DC bus has two separate battery chargers and only one of them is credited in the PRA analysis which allows for one battery charger to be unavailable for maintenance. • It is assumed that maintenance unavailability of the battery and the UPS inverter will be small relative to the other failure modes that are included in the model, since preventive maintenance is assumed to be performed during shutdown modes and corrective maintenance is assumed to be negligible. • The maintenance unavailability of a Class 1E AC or DC bus is also assumed to be negligible, given that preliminary design information suggests an eight hour AOT for Class 1E buses and a two hour AOT for the Class 1E dc buses.
22	HRA	The HRA is performed under the assumption that the operating procedures and emergency guidelines will be well written and complete and that the operators will be well trained. Conservative HRA methods are used because the detailed design for the human machine interface (HMI) and corresponding emergency operating guidelines are not completed.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 16 of 16

No.	Category[1]	PRA General Assumptions[2]
81	Seismic	The PRA-based seismic margin assessment assumes that equipment will be installed as designed and that there are no potential spatial interaction concerns in the as-built configuration (e.g., adjacent cabinets are bolted together, collapse of non-seismically designed equipment or masonry wall onto safety-related equipment is precluded, and no likelihood of seismically-induced fire or flood impacting safety-related equipment).
82	LPSD	Nozzle dams are not required during a plant shutdown, but may be used infrequently during mid-cycle maintenance, when full core off-load is not desirable. Appropriate RCS operating conditions will be considered in the specification of nozzle dams to provide reasonable assurance that nozzle dams will not fail. Plant procedures that cover reduced inventory operation will govern the installation of nozzle dams and the establishment of adequate venting to prevent pressurization of the RPV upper plenum due to a postulated loss of decay heat removal. Nozzle dams are the only U.S. EPR related temporary reactor coolant system boundary as specified by NUREG-1449 and NUREG-1512. Freeze seals are not expected to be used; they will not be part of the maintenance procedures for the U.S. EPR.
83	LPSD	The efficiency of the Passive Autocatalytic Recombiners (PAR) during shutdown is assumed to be nominal. Maintenance unavailability, if any, is assumed to be limited to a small fraction of the PARs and would not affect the overall efficiency of the system.
84	LPSD	The RCS vents identified in state CB are not considered large enough to prevent RCS repressurization in the case of loss of cooling; therefore RCS repressurization is assumed in the time to boil calculation.

19-317

Notes:

1. | Category | Description |
|---|---|
| Model | Modeling Assumption |
| IE | Initiating Event |
| CC | Common Cause |
| PM | Preventive Maintenance |
| HRA | Human Reliability Analysis |
| SYS | System Modeling |
| I&C | Instrumentation and Controls |
| LPSD | Low Power/ Shutdown Modeling |
| Flood | Flood Analysis |
| Fire | Fire Analysis |
| Seismic | Seismic Analysis |

2. The PRA assumptions will be reevaluated as part of the PRA maintenance and update process. The PRA maintenance and upgrade process is described in Section

Next File

There are four identical RCP assemblies used in the U.S. EPR plant design. The RCPs are centrifugal, single stage pumps with mechanical shaft seals driven by squirrel-cage type induction motors as shown in Figure 5.4-1. Each RCP assembly has one common vertical shaft line for the pump and motor with main and auxiliary bearings, one single double thrust bearing and a flywheel located at the top of the motor shaft.

5.4.1.2.1 Pumps

All parts of the pump in contact with the reactor coolant are austenitic stainless steel, except for seals, bearings and gaskets.

The shaft seal system is made up of a series of three seals and a standstill seal. The shaft seal design provides redundancy so that a failure of a single seal stage will not result in an uncontrolled loss of reactor coolant. The standstill seal is a metal-to-metal contact seal that prevents leakage when the RCP has stopped and the three seal leak-off lines have been isolated. The standstill seal is normally used under these conditions:

- In the event of a concurrent loss of injection water (chemical and volume control system (CVCS)) and cooling water for the thermal barrier (component cooling water system (CCWS)).
- In the event of concurrent failure of all three shaft seals.
- In the event of a station blackout.

The standstill seal is activated by compressed nitrogen and is designed to stay closed if the gas pressure is lost, and to remain closed and maintain RCS pressure boundary integrity down to an RCS pressure of approximately 218 psia. If the nitrogen pressure is maintained on the standstill seal, it will maintain RCS pressure boundary integrity down to zero RCS pressure. Position indication is provided for the standstill seal. Standstill seal operability is maintained after a safe shutdown earthquake (SSE).

The temperature of the water within the RCP shaft seal assembly is normally maintained within acceptable limits by seal injection water supplied from the CVCS. Water from the CVCS is injected into the cavity upstream of the number 1 seal, at a pressure slightly higher than the reactor coolant, through a connection on the thermal barrier flange. A portion of this water descends through the thermal barrier heat exchanger (HX) and auxiliary bearing into the RCP casing, while the other portion rises through the shaft seal system.

If seal injection from the CVCS is lost, cooled water from the RCS will enter the shaft seal assembly. The hot RCS water is cooled by the thermal barrier HX before entering the RCP shaft seal assembly. The thermal barrier HX is sized to cool the RCS water below the maximum acceptable shaft seal injection water temperature. Cooling water to the thermal barrier HX is supplied by the CCWS.

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19-316(c)

The RCP shaft seal assembly can therefore withstand the loss of either the CVCS seal injection flow or thermal barrier component cooling water flow, and continue to operate indefinitely.

In the event of a simultaneous loss of seal injection and thermal barrier cooling (all seal cooling lost) or a simultaneous failure of RCP No. 1 and 2 seals, the associated RCP is automatically tripped. After the RCP has stopped rotating the pressure boundary is maintained by automatic closure of the non-safety-related standstill seal and associated leak-off lines to and from each seal stage. During a loss of all cooling to the RCP shaft seal, the pressure boundary is maintained by an automatic trip of the affected RCP with automatic closure of the standstill seal and the associated leak-off lines to and from each seal stage after the RCP has stopped.

Immediately after loss of power to the RCPs, adequate flow is maintained by the inertia of the RCP, including the flywheel-equipped motor.

5.4.1.2.2 Motors

The pump motor is an asynchronous, squirrel cage motor. It is of the open and self-ventilated type. The motor is designed to start and accelerate up to normal operating speed with reverse flow and 80 percent of rated voltage at the motor terminals.

The guide bearings and double thrust bearing are oil lubricated pad bearings. The RCP motor oil lubrication piping and HX are designed to withstand an SSE.

An oil injection device is provided to inject oil into the axial double thrust bearing pads and upper guide bearing during startup and normal shutdown of the RCP. The lower guide bearing is submersed in the lower bearing oil reservoir and is thereby self-lubricating, and does not require oil injection. During normal motor operation and coast down, no external oil pump is needed. Bearing lubrication is accomplished by pumping action of the oil within the bearing.

An oil collection system is provided to collect and drain the motor lube oil (upper and lower bearing lube oil systems) in the event of leakage from the motor lubrication system. The oil collection system is designed in accordance with the fire protection requirements for RCP oil collection systems as presented in RG 1.189. A process and instrumentation drawing of the oil collection system is shown in Figure 5.4-1Figure 5.1-4, Sheet 7 of 7.

An anti-rotation device is mounted on the lower face of the flywheel. The device prevents reverse rotation of the RCP impeller if there is reverse flow in the casing.

The auxiliary boiler system consists of feedwater supply equipment, deaerator, sampling system, water chemistry control equipment and automatic control equipment. Safety relief valves are in accordance with the ASME Boiler and Pressure Vessel (BPV) Code, Section VIII (Reference 16) to protect the system from overpressurization. The auxiliary boiler system does not perform any safety-related functions.

10.3.2.2 Component Description

Table 3.2.2-1 provides the quality group and seismic design classification of components and equipment in the MSSS. Section 3.2 also describes how the guidance in RG 1.26 is implemented for the U.S. EPR. The main steam lines, from the SGs up to and including the fixed restraint downstream of the MSIVs, are designed and constructed in accordance with Quality Group B and Seismic Category I. The remaining piping out to the TG stop valve and second stage reheaters meets ASME Power Piping Code B31.1 (Reference 2). Data related to containment isolation for MSSS valves are listed in Table 6.2.4-1—Containment Isolation Valve and Actuator Data.

Main Steam Safety Valves

Each main steam line has two Reference 1 safety valves, located upstream of the main steam isolation valve (MSIV). The main steam safety valves (MSSV), along with the main steam relief trains (MSRT), provide overpressure protection of the main steam piping and SGs. The safety valves discharge to the atmosphere via directly connected vent stacks. Low-point drains in the vent stacks route any accumulated water to the TB drains.

Table 10.3-2—Design Data for Main Steam Safety Valves, provides design data for the MSSVs.

19-316(b)

Main Steam Relief Trains

Design Bases Events

Each main steam line has one MSRT located upstream of its MSIV. Each MSRT consists of a Reference 1 normally closed, fast opening MSRIV and a downstream, normally open MSRCV. The MSRIVs are designed in accordance with ASME BPV Code, Section III, Division 1, Subsection NC including Article NC-7000 (Reference 3).

The MSRTs are part of the SG secondary side overpressure protection. MSRT setpoint and capacity are such that with consideration of RT, the MSRTs alone prevent system pressure from increasing above 110 percent of design pressure upon full loss of load. The MSRTs discharge to the atmosphere via silencers and have low-point drains in the discharge piping to minimize condensate accumulation.

During mild pressure transients, the MSRIVs automatically open to prevent opening of the MSSVs. If the turbine bypass is unavailable, the MSRIVs vent steam to the atmosphere to remove residual heat.

Controls for the MSRTs are described in Section 7.3.1.2.4, Section 7.3.1.2.5, and Section 7.3.1.2.6.

Each MSRIV is an angle globe valve with a motive steam-operated piston actuator. Each actuator has a piston in the main valve and pilot valves also actuated by the motive steam. The valve is closed by balancing the main piston with steam on both sides. A spring is implemented above the main piston to assist in keeping the valve closed. The valve is rapidly opened by venting steam from above the main piston. The valve is maintained open by keeping both solenoid pilot valves open (energized) in one or both control lines.

The actuator is pilot operated for fast opening with high reliability (redundancy of pilots). There is one set of four solenoid-driven pilot valves (two pilots in series on each of the two redundant control lines, also called manifolds). This arrangement prevents a failure in any pilot valve from causing either a spurious opening (two pilots in series) or a failure to open (two redundant control lines) of the MSRIV. Figure 10.3-2—Main Steam Isolation and Main Steam Relief Isolation Valve Actuators, illustrates MSRIV actuation.

Functional tests of pilot valves may be performed individually during normal operation without impairing power generation.

The MSRCVs provide a safety-related function of controlling MSRT steam flow to prevent over cooling the reactor coolant. The MSRCVs allow mitigation of the effects of a stuck open MSRIV.

The MSRCVs are automatically positioned, based on thermal power, as follows:

- From zero to 20 percent thermal power–40 percent open.
- From 20 to 50 percent thermal power–linear variation between 40 and 100 percent open.
- For greater than 50 percent thermal power–100 percent open.

19-316(b)

Beyond Design Bases Events

The main steam system provides a non-safety-related redundant means to depressurize SG (i.e., achieve fast cooldown) to depressurize the RCS during beyond design basis events to allow for RC makeup to mitigate ICC and avoid a severe accident.