ArevaEPRDCPEm Resource

From:	WILLIFORD Dennis (AREVA) [Dennis.Williford@areva.com]
Sent:	Thursday, May 30, 2013 10:16 PM
To:	Snyder, Amy
Cc:	Ford, Tanya; ANDERSON Katherine (EXTERNAL AREVA); DELANO Karen (AREVA); HONMA George (EXTERNAL AREVA); LEIGHLITER John (AREVA); LEWIS Ray (EXTERNAL AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); SHEPHERD Tracey (AREVA); VANCE Brian (AREVA); NOXON David (AREVA); GUCWA Len (EXTERNAL AREVA); RITCHEY Calvin (AREVA)
Subject:	Advanced Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Question 19-341
Attachments:	Advanced Response RAI 455 Q19-341 US EPR DC.pdf

Amy,

Attached is an Advanced Response for RAI 455, Question 19-341 in advance of the July 30, 2013 final date.

As discussed with NRC staff on May 29, 2013, the fragility evaluation and critical section work supporting the Fuel Building fragility analysis has not been completed at this time. Upon completion of the fragility analysis for the Fuel Building, U.S. EPR FSAR Tier 2, Table 19.1-106 will be revised to include this result and will be presented with the final RAI 455 response. The Fuel Building fragility analysis will be completed and available for inspection prior to the scheduled SMA audit.

To keep our commitment to send a final response to this question by the commitment date, we need to receive all NRC staff feedback and comments no later than **July 16, 2013**.

Please let me know if NRC staff has any questions or if the response to this question can be sent as final.

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Wednesday, June 06, 2012 9:23 AM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 9

Getachew,
AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455 on January 25, 2011. AREVA submitted Supplement 1 on April 20, 2011, and Supplement 2 on June 17, 2011, providing a revised schedule for the one question. AREVA submitted Supplement 3 on June 24, 2011 to provide an interim response to the one question. Supplement 4 sent on October 18, 2011, Supplement 5 sent on November 17, 2011, Supplement 6 sent on December 13, 2011, and Supplement 7 sent on January 24, 2012 provided a preliminary revised schedule for the one question. Supplement 8 sent on February 26, 2012 provided a revised schedule for the one question.

The schedule for a technically correct and complete response to the remaining question has been changed as provided below. This schedule was transmitted to the NRC in AREVA NP letter NRC:12:024 dated May 10, 2012.

Question #	Response Date
RAI 455 — 19-341	**July 30, 2013**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Sunday, February 26, 2012 7:06 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 8

Getachew,
AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455 on January 25, 2011. AREVA submitted Supplement 1 on April 20, 2011, and Supplement 2 on June 17, 2011, providing a revised schedule for the one question. AREVA submitted Supplement 3 on June 24, 2011 to provide an interim response to the one question. Supplement 4 sent on October 18, 2011, Supplement 5 sent on November 17, 2011, Supplement 6 sent on December 13, 2011, and Supplement 7 sent on January 24, 2012 provided a preliminary revised schedule for the one question.

The schedule for a technically correct and complete response to the remaining question has been changed as provided below. This schedule was transmitted to the NRC in AREVA NP letter NRC:12:008 dated February 21, 2012.

Question #	Response Date
RAI 455 — 19-341	**August 30, 2013**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, January 24, 2012 8:43 AM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB);

Michael.Miernicki@nrc.gov; tanya.ford@nrc.gov
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 7

Getachew,
AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455 on January 25, 2011. AREVA submitted Supplement 1 on April 20, 2011, and Supplement 2 on June 17, 2011, providing a revised schedule for the one question. AREVA submitted Supplement 3 on June 24, 2011 to provide an interim response to the one question. Supplement 4 sent on October 18, 2011, Supplement 5 sent on November 17, 2011, and Supplement 6 sent on December 13, 2011 provided a preliminary revised schedule for the one question.

The preliminary schedule for a response to this question has been revised and is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by February 21, 2012.

Question #	Response Date
RAI 455 — 19-341	**February 21, 2012**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, December 13, 2011 4:41 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 6

Getachew,
AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455 on January 25, 2011. AREVA submitted Supplement 1 on April 20, 2011, and Supplement 2 on June 17, 2011, providing a revised schedule for the one question. AREVA submitted Supplement 3 on June 24, 2011 to provide an interim response to the one question. Supplement 4 sent on October 18, 2011, and Supplement 5 sent on November 17, 2011 provided a revised schedule for the one question.

A preliminary revised schedule for a technically correct and complete response to the one question is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by January 25, 2012.

Question #	Response Date
RAI 455 — 19-341	**January 25, 2012**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager

AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Thursday, November 17, 2011 6:31 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 5

Getachew,
AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455 on January 25, 2011. AREVA submitted RAI 455, Supplement 1 on April 20, 2011, and Supplement 2 on June 17, 2011, providing a revised schedule for the one question. AREVA submitted RAI 455, Supplement 3 on June 24, 2011 to provide an interim response to the one question. Supplement 4 sent on October 18, 2011 provided a revised schedule for the one question.

A preliminary revised schedule for a technically correct and complete response to the one question is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by December 14, 2011.

Question #	Response Date
RAI 455 — 19-341	**December 14, 2011**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, October 18, 2011 5:05 PM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 4

Getachew,
AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455 on January 25, 2011. AREVA submitted RAI 455, Supplement 1 on April 20, 2011, and Supplement 2 on June 17, 2011, providing a revised schedule for the one question. AREVA submitted RAI 455, Supplement 3 on June 24, 2011 to provide an interim response to the one question.

A preliminary revised schedule for a technically correct and complete response to the one question is provided below. This schedule is being reevaluated and a new supplement with a revised schedule will be transmitted by November 17, 2011.

Question #	Response Date
RAI 455 — 19-341	**November 17, 2011**

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Friday, June 24, 2011 11:20 AM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 3

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455 on January 25, 2011. AREVA NP submitted Supplement 1 on April 20, 2011, and Supplement 2 on June 17, 2011, to provide a revised schedule for the single question.

The attached file, "RAI 455 Supplement 3 Response US EPR DC-INTERIM.pdf" provides a technically correct INTERIM response to Question 19-341. 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 455 Question 19-341.

The following table indicates the pages in the response document, "RAI 455 Supplement 3 Response US EPR DC-INTERIM.pdf" that contain AREVA NP's INTERIM response to the subject question.

Question #	Start Page	End Page
RAI 455 — 19-341	2	7

The schedule for a technically correct and complete final response to this question is unchanged as provided below.

Question #	Interim Response Date	Response Date
RAI 455 — 19-341	**June 24, 2011 (Actual)**	October 19, 2011

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: RYAN Tom (RS/NB)
Sent: Friday, June 17, 2011 9:45 AM
To: 'Tesfaye, Getachew'
Cc: NOXON David (RS/NB); BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); WILLIFORD Dennis (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 2

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455

on January 25, 2011. Supplement 1 to RAI 455 provided a revised schedule on April 20, 2011.

The schedule for a technically correct and complete response to this question has been changed and is provided below.

Question #	Response Date
RAI 455 — 19-341	October 19, 2011

Sincerely,

Tom Ryan for
Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WELLS Russell (RS/NB)
Sent: Wednesday, April 20, 2011 10:26 AM
To: Tesfaye, Getachew
Cc: NOXON David (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. 455, FSARCh. 19, OPEN ITEM, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI 455

on January 25, 2011.

Additional time is required to interact with the NRC staff.

The schedule for a technically correct and complete response to this question has been changed and is provided below.

Question #	Response Date
RAI 455 — 19-341	June 17, 2011

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)
434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: BRYAN Martin (External RS/NB)
Sent: Tuesday, January 25, 2011 4:48 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); NOXON David (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 455 Response US EPR DC.pdf," provides the schedule for technically correct and complete responses to these questions.

The following table indicates the respective pages in the response document, "RAI 455 Response US EPR DC.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 455 — 19-341	2	3

The schedule for technically correct and complete response to the one question is provided below.

Question #	Response Date
RAI 455 — 19-341	April 21, 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: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Tuesday, December 21, 2010 4:44 PM
To: ZZ-DL-A-USEPR-DL

Cc: Xu, Jim; Hawkins, Kimberly; Ford, Tanya; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 455(4911), FSARCh. 19, OPEN ITEM

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on October 29, 2010, and discussed with your staff in December 2010. No change is 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, excluding the time period of **December 24, 2010 thru January 3, 2011, to account for the holiday season** as discussed with AREVA NP Inc. For any RAIs that cannot be answered **within 45 days**, it is expected that a date for receipt of this information will be provided to the staff within the 40-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: 4521

Mail Envelope Properties (554210743EFE354B8D5741BEB695E65617C2D1)

Subject: Advanced Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Question 19-341
Sent Date: 5/30/2013 10:16:29 PM
Received Date: 5/30/2013 10:16:47 PM
From: WILLIFORD Dennis (AREVA)

Created By: Dennis.Williford@areva.com

Recipients:
"Ford, Tanya" <Tanya.Ford@nrc.gov>
Tracking Status: None
"ANDERSON Katherine (EXTERNAL AREVA)" <katherine.anderson.ext@areva.com>
Tracking Status: None
"DELANO Karen (AREVA)" <Karen.Delano@areva.com>
Tracking Status: None
"HONMA George (EXTERNAL AREVA)" <George.Honma.ext@areva.com>
Tracking Status: None
"LEIGHLITER John (AREVA)" <John.Leighliter@areva.com>
Tracking Status: None
"LEWIS Ray (EXTERNAL AREVA)" <Ray.Lewis.ext@areva.com>
Tracking Status: None
"ROMINE Judy (AREVA)" <Judy.Romine@areva.com>
Tracking Status: None
"RYAN Tom (AREVA)" <Tom.Ryan@areva.com>
Tracking Status: None
"SHEPHERD Tracey (AREVA)" <Tracey.Shepherd@areva.com>
Tracking Status: None
"VANCE Brian (AREVA)" <Brian.Vance@areva.com>
Tracking Status: None
"NOXON David (AREVA)" <David.Noxon@areva.com>
Tracking Status: None
"GUCWA Len (EXTERNAL AREVA)" <Len.Gucwa.ext@areva.com>
Tracking Status: None
"RITCHEY Calvin (AREVA)" <Calvin.Ritchey@areva.com>
Tracking Status: None
"Snyder, Amy" <Amy.Snyder@nrc.gov>
Tracking Status: None

Post Office: FUSLYNCMX03.fdom.ad.corp

Files	**Size**	**Date & Time**
MESSAGE	16766	5/30/2013 10:16:47 PM
Advanced Response RAI 455 Q19-341 US EPR DC.pdf		1175364

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal

Expiration Date:
Recipients Received:

Advanced Response to

Request for Additional Information No. 455, Question 19-341

12/21/2010

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: FSAR Chapter 19

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

Question 19-341:

OPEN ITEM

Follow-up to Open Item RAI No 234, Question 19-304

In 10 CFR 52.47, "Contents of applications; technical information," there is a requirement that each application for design certification (DC) must include a "description of the design-specific probabilistic risk assessment (PRA) and its results" (§ 52.47(a)(27)).

To address the seismic risk for the standard design, the staff proposed a position in SECY-93-087, which the Commission approved, as modified, in a Staff Requirements Memorandum (SRM) dated July 21, 1995, the use of a PRA-based seismic margins analysis for assessing the seismic risk for the design. As stated in the SRM, the seismic margins analysis should use a plant-level seismic margin of 1.67 times the design-basis safe shut earthquakes (SSE). To provide detailed guidance on this analysis, the staff developed Interim Staff Guidance (ISG-20), "Implementation of a Probabilistic Risk Assessment-Based Seismic Margin Analysis (SMA) for New Reactors." ISG-20 provides an implementation process acceptable to the staff for performing the PRA-based SMA and identifies the information to be included in an application needed to support the staff's review and safety findings. The staff needs this information to confirm that adequate seismic margin has been demonstrated or will be established for the standard design.

Tier 2, Chapter 19 of the Final Safety Analysis Report (FSAR) provides a description and results of the PRA-based SMA for the U.S. EPR design certification. Revision 2, of the FSAR Section 19.1.5.1.1.4 provides a description of the system and accident analysis, which includes both the full-power and lower-power shutdown modes. However, with respect to seismic initiating events, the staff noticed that only the small Loss-of-Coolant Accident (LOCA) was included in the seismic initiating events as opposed to various sizes of LOCAs as indicated in ASME/ANS RA-Sa-2009, Table 5-2.3-2(a), SPR-A1 Note (1)(b). Revise Section 19.1.5.1.1.4 of the FSAR to provide a description of the design-specific plant system and sequence analysis consistent with the guidance of ISG-20, Section 5.1.1. It is important that key assumptions utilized are highlighted such that a respective COL applicant can verify their applicability with respect to its site- and plant-specific features.

Revision 2, of the FSAR Section 19.1.5.1.1.5 provides a description of the seismic fragility analysis which, according to AREVA's response to RAI No. 234, Supplement 2, Question 19-304, was performed using the EPR Certified Seismic Design Response Spectra (CSDRS). The staff noticed that Figure 19.1-31 of Revision 2, of the FSAR Section 19 did not include the high-frequency hard rock spectra, which were added to the CSDRS. Revise Section 19.1.5.1.1.5 of the FSAR to provide a description of the seismic fragility evaluation consistent with the guidance of ISG-20, Section 5.1.2. Given that traditional fragility calculations are performed with respect to a single spectrum shape, the FSAR description should discuss the approach utilized to determine the fragility of an SSC for multiple spectral shapes as in the EPR CSDRS. In addition, for active SSCs identified in the cutsets, the FSAR description should discuss the use of generic data for fragility of active components qualified by tests consistent with the guidance given in the 3rd paragraph of Section 5.1.2 of ISG-20. Also, revise the FSAR to include the results of the fragility evaluation in terms of the median capacity and uncertainties.

To ensure that the COL applicants are able to meet Section 52.79(a)(46) and §52.79(d)(1), revise the COL information items 19.1-6 and 19.1-7 to require: 1) COL applicants to update the DC's PRA-based SMA to address plant- and site-specific features, and 2) COL holders (licensees) to perform as-built verifications of the plant level HCLPF capacities. The COL applicants should identify plant-specific vulnerabilities and confirm the key assumptions and bases of the DC's SMA applicable to the site. If the plant-level HCLPF is less than the target value of 1.67 times the site-specific GMRS, the applicant should perform a full convolution of sequence fragility for all sequences with a potential to lead to core damage to demonstrate that the seismic risk is acceptably low for the licensed plant. ISG-20 provides guidance on this process in Section 5.1.4, and the detailed guidance for COL updating is provided in Section 5.2.

ISG-20, Section 5.4, “Position on Documentation,” provides a list of information regarding the documentation in the FSAR that would be sufficient to allow the staff to confirm the acceptability of the PRA-based SMA.

Response to Question 19-341:

U.S. EPR FSAR Tier 2, Section 19.1.5.1 will be revised to consider the updated PRA model, and to address audit findings from the September 2011 SMA audit. The revisions provide a description of the design-specific plant system and sequence analysis consistent with the guidance of ISG-20 Section 5.1.1. The revised analysis specifically considers small LOCA, medium LOCA and large LOCA initiating events. U.S. EPR FSAR Tier 2, Table 19.1-37 will be revised to include seismic related cutsets based on the at-power and shutdown PRA models from the latest PRA update.

The SMA methodology described in U.S. EPR FSAR Tier 2, Section 19.1.5.1.1.1 will be revised along with U.S. EPR FSAR Tier 2, Section 19.1.9 to reflect the latest codes and standards.

The CSDRS of the U.S. EPR standard plant consists of three EUR control motions anchored to 0.3 g peak ground acceleration, and a fourth high-frequency (HF) control motion. The vertical EUR control motions are the same as the horizontal EUR motions. The high frequency horizontal (HFH) and the high frequency vertical (HFV) control motions are anchored to 0.21 g and 0.18 g peak ground accelerations, respectively. The horizontal and vertical CSDRS are provided in Figure 19-341-01. For design certification, the CSDRS is the safe shutdown earthquake (SSE) per RG 1.208. U.S. EPR FSAR Tier 2, Figure 19.1-31 will be deleted and a reference to the CSDRS description in U.S. EPR FSAR Tier 2, Section 3.7.1 will be added.

Per ISG-20, Section 5.1.2, two methods are acceptable for determining seismic fragility: separation of variable and conservative deterministic failure margin methods. The separation of variable method is used for the U.S. EPR PRA-based SMA of structures in accordance with ISG-20, Section 5.1.2.

Seismic analysis and foundation design for the standard plant are performed for multiple soil profiles including high frequency soil profiles as described in U.S. EPR FSAR Tier 2, Section 3.7.1.3. Fragilities are calculated based on the highest seismic demand for all the soil profiles. The methodology used is described in U.S. EPR FSAR Tier 2, Section 19.1.5.1.1.

The high confidence, low probability of failure (HCLPF) capacity, expressed in terms of peak ground acceleration (PGA), will be calculated from the median capacity (Am) and the associated logarithmic standard deviations, β_R and β_U using the relationship indicated in U.S. EPR FSAR

Tier 2, Section 19.1.5.1.1, equation (A). The seismic margin, which is defined by the ratio of the HCLPF capacity to the CSDRS PGA of 0.3 g, will be shown equal to or greater than the 1.67 value noted in ISG-20. Because the enveloping seismic response for all the soil profiles is used in the seismic fragility derivation, this seismic margin is applicable to the spectral shape of the CSDRS.

In response to this RAI, AREVA NP will update U.S. EPR FSAR Tier 2, Section 19.1.5.1 to describe the development of the structures, systems and components (SSC) seismic fragilities using the U.S. EPR CSDRS.

U.S. EPR FSAR Tier 2, Table 19.1-106 will be revised to contain the seismic equipment list (SEL) developed based on the latest PRA update. The SEL is the list of SSC credited in the SMA to support achieving a plant and sequence level HCLPF of 1.67 times the SSE.

For structures on the SEL, HCLPF values are calculated to support the design certification application. U.S. EPR FSAR Tier 2, Table 19.1-106 will be revised to update the structure related HCLPF. The fragility evaluation and critical section work supporting the Fuel Building fragility analysis has not been completed at this time. Upon completion of the fragility analysis for the Fuel Building, U.S. EPR FSAR Tier 2, Table 19.1-106 will be revised to include this result and will be presented with the final RAI 455 response. The Fuel Building fragility analysis will be completed and available for inspection prior to the scheduled SMA audit.

For mechanical and electrical components, the fragility analysis assigns a minimum HCLPF of 0.5 g to support achieving a plant and sequence level HCLPF of 1.67 times the SSE. U.S. EPR FSAR Tier 2, Section 19.1.5.1.1.3 will be revised to describe the process by which HCLPF are achieved for mechanical and electrical components during the seismic qualification. A COL item will be added to U.S. EPR FSAR Tier 2, Section 19.1.5.1.1.3 and Table 1.8-2 to confirm that an acceptable seismic margin is achieved through the seismic qualification implementation program.

No generic data (e.g., test data, generic seismic qualification test data, and test experience data) are used in developing seismic fragility for the components. The seismic qualification process for components is described in U.S. EPR FSAR Tier 2, Section 3.10.

U.S. EPR FSAR Tier 2, Sections 19.1.5.1.2.4 and 19.1.5.4, and Table 1.8-2 were previously revised to show that the COL applicant is committed to updating the PRA-based SMA to address site-specific features, which includes identifying site-specific SSC and incorporating site-specific soil effects.

This COL commitment covers actions as stated in DC/COL-ISG-20 to:

1. Update the design-specific plant system and accident sequence analysis to incorporate site-specific effects (e.g., soil liquefaction, slope failure) and plant-specific features (e.g., safety-related, site-specific structures), as applicable.
2. Update the SEL with HCLPF values and associated failure modes to adequately reflect the site-specific effects and plant-specific features of the COL site (for soil-related failure modes, the site-specific GMRS can be used for HCLPF calculations).
3. Demonstrate that the design-specific, plant-level HCLPF capacity is maintained in the COL application.

U.S. EPR FSAR Tier 2, Section 19.1.2.2 includes a commitment for the COL applicant to review as-designed and as-built information to confirm that PRA assumptions remain valid, including PRA-based SMA fragilities, and to verify PRA-based SMA after the issuance of the COL.

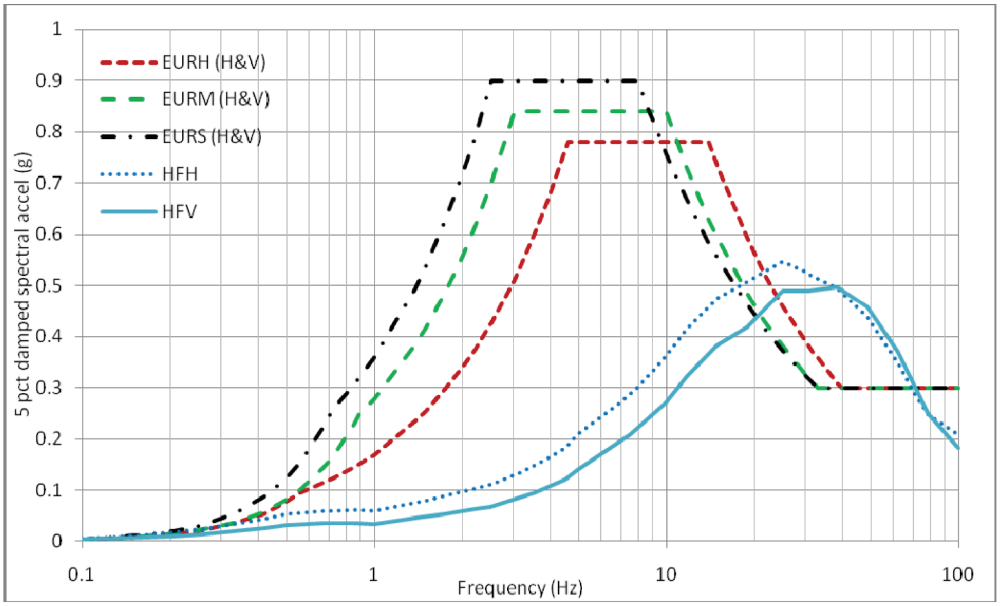
FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 19.1.5.1, and 19.1.9 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Table 1.8-2, Table 19.1-37 and Table 19.1-106 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR, Tier 2, Figure 19.1-31 will be deleted as described in the response and indicated on the enclosed markup.

Figure 19-341-01—U.S. EPR CSDRS



U.S. EPR Final Safety Analysis Report Markups

Table 1.8-2—U.S. EPR Combined License Information Items
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Item No.	Description	Section
19.1-5	A COL applicant that references the U.S. EPR design certification will describe the applicant's PRA maintenance and upgrade program.	19.1.2.4.1
19.1-6	A COL applicant that references the U.S. EPR design certification will confirm that the U.S. EPR PRA-based seismic margin assessment is bounding for their specific site, and will update it to include site-specific SSC and soil effects (including sliding, overturning liquefaction and slope failure).	19.1.5.1.2.4
19.1-7	A COL applicant that references the U.S. EPR design certification will perform the site-specific screening analysis and the site-specific risk analysis for external events applicable to their site.	19.1.5.4
19.1-8	A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of site-specific design programs and processes during the design phase.	19.1.1.1
19.1-9	A COL applicant that references the U.S. EPR design certification will describe the process to review as-designed and as-built information and conduct walk-downs as necessary to confirm that the assumptions used in the PRA (including PRA inputs to RAP and SAMDA) remain valid with respect to internal events, internal flood and fire events (routings and locations of pipe, cable and conduit), and HRA analyses (development of operating procedures, emergency operating procedures and severe accident management guidelines and training), external events including PRA-based seismic margins HCLPF fragilities, and LPSD procedures.	19.1.2.2
19.1-10	A COL applicant that references the U.S. EPR design certification will, for equipment on the SEL, confirm that an acceptable seismic margin is achieved through the seismic qualification implementation program.	19.1.5.1.1.3
19.2-1	A COL applicant that references the U.S. EPR design certification will develop and implement severe accident management guidelines ~~prior to fuel loading~~ using the Operating Strategies for Severe Accidents (OSSA) methodology described in U.S. EPR FSAR Section 19.2.5.	19.2.5
19.2-2	AREVA Technical Report ANP-10329 discusses the Phase 1, Phase 2, and Phase 3 actions that are performed to mitigate an ELAP event. A COL applicant that references the U.S. EPR design certification will address the actions listed in Table 19.2-6. The COL applicant will also address obtaining sufficient offsite resources to sustain core cooling, containment, and spent fuel pool cooling functions indefinitely.	19.2.8

Other phenomenological challenges were not identified as leading to significant probabilities of large release. In particular, it is noted that while some challenges were assessed as having a significant probability under certain circumstances, they did not show up as important once the probability of these circumstances was taken into account. One example is the phenomena of thermally-induced steam generator tube rupture, which was assessed as having a large probability for two-inch equivalent LOCA events (or seal LOCA of equivalent flow rate) in conjunction with a depressurized secondary side and an absence of feedwater to the steam generators. Sensitivity studies showed that these events would have been visible LRF contributors without the EPR design provisions for manual RCS depressurization or if the two-inch LOCA sequences entered Level 2 with feedwater unavailable. However, even combined unavailability of both functions is not sufficient to increase LRF by a factor of two.

19.1.5 Safety Insights from the External Events PRA for Operations at Power

19.1.5.1 Seismic Risk Evaluation

Evaluation of the risk due to seismic events was performed using a PRA-based seismic margins approach. Section 19.1.5.1.1 describes this approach and outlines the manner in which it was applied. Section 19.1.5.1.2 summarizes the results obtained from the PRA-based seismic margins evaluation.

19.1.5.1.1 Description of the Seismic Risk Evaluation

19.1.5.1.1.1 Methodology

The PRA-based Seismic Margins Analysis (SMA) was performed in accordance with the applicable NRC guidance documents ISG-020 (Reference 60), and SECY-93-087 (Reference 2), and in accordance with the applicable guidance in Part 5 of ASME-ANS Ra-Sa-2009 Level 1 /LRF Standard (Reference 61) as endorsed by Regulatory Guide 1.200 (Reference 63). As discussed in ISG-020 the purpose of a PRA-based seismic margins analysis is to provide an understanding of significant seismic vulnerabilities and other seismic insights to demonstrate the seismic robustness of a standard design. ISG-020 requires that the SMA analysis be performed relative to a Review Level Earthquake of 1.67 times the Safe Shutdown Earthquake (SSE). The PRA-based seismic margin analysis includes the following key elements:

- Define the seismic hazard input (Section 19.5.1.1.2).
- Perform the Seismic Fragility Evaluation (Section 19.5.1.1.3).
- Evaluate the design specific system and accident sequences considering the impacts of the Fragility Analysis (Section 19.5.1.1.4).
- Evaluating the Plant Level HCLPF (Section 19.5.1.1.5).

The U.S. EPR PRA model developed for internal initiating events (Section 19.1.4) and the U.S. EPR PRA Model for Shutdown Initiating Events (Section 19.1.6) provides the framework for addressing potential failures induced by seismic events. These PRA models also provide the primary basis for establishing the seismic equipment list (SEL), which identifies equipment and structures for seismic fragility analysis. Because this assessment is being conducted early in the plant design, fragility assumptions are documented to support seismic design development in the detailed design phase.

~~The PRA-based seismic margin assessment employed an approach described in SECY-93-087 (Reference 2). This assessment also followed guidance provided in ANSI/ANS-58.21 (Reference 7), particularly Section 3.7 and Appendix B, as applicable to seismic margin assessment. The PRA-based seismic margin assessment allows potential vulnerabilities in the design (relative to margin above the safe shutdown earthquake (SSE)) to be identified so that measures could be taken to reduce the risk associated with seismic events.~~

~~The primary tasks in the PRA-based seismic margin assessment are as follows:~~

- ~~Identify the seismic hazard.~~
- ~~Evaluate the seismic fragility to obtain high confidence of low probability of failure (HCLPF) capacities for SSC.~~
- ~~Incorporate seismic failures into the system and sequence models to identify their significance with respect to the potential for core damage.~~
- ~~Assess an overall HCLPF capacity at a sequence level to identify the SSC that are limiting with respect to the potential for core damage.~~

~~The U.S. EPR PRA model developed for internal initiating events provides the framework for addressing potential failures induced by seismic events. This model also provides the primary basis for establishing the seismic equipment list (SEL), which identifies equipment and structures for seismic fragility analysis. Because this assessment is being conducted early in the plant design, fragility assumptions are documented to support seismic design development in the detailed design phase.~~

19.1.5.1.1.2 Seismic Hazard Input

The Certified Seismic Design Response Spectra (CSDRS) of the U.S. EPR design consists of three European Utility Requirements (EUR) control motions anchored to 0.3 g peak ground acceleration (PGA), and a fourth high-frequency control motion. The vertical EUR control motions are the same as the horizontal EUR motions. The high frequency horizontal (HFH) and the high frequency vertical (HFV) control motions are anchored to 0.21 g and 0.18 g peak ground accelerations, respectively. The horizontal and vertical CSDRS are provided in Figure 3.7.1-1. For the U.S. EPR design, the CSDRS is the safe shutdown earthquake (SSE) per RG 1.208.

The PRA-based seismic margin assessment follows the guidance in SECY 93-087 and demonstrates that there is a minimum seismic margin of 1.67 times the CSDRS for the U.S. EPR, not including an analysis site-specific of soil effects, which is the responsibility of the COL applicant, as noted in Section 19.1.5.1.2.4. See Section 3.7.1 for a description of the CSDRS for the certified design. The 1.67 times the CSDRS is referred to as seismic margin earthquake (SME) in design certification. ~~Figure 19.1-31 shows the CSDRS and the SME.~~

19.1.5.1.1.3 Seismic Fragility Evaluation

The fragility analysis results in the generation of HCLPF capacities for SSC expressed in terms of PGA. The systems and accident sequence analysis determine the scope of the fragility analysis by specifying a SEL. The SEL establishes the set of SSC for which HCLPF capacities are needed. The SEL is provided in Table 19.1-106. Seismic fragility analysis is based on input from the seismic qualification and analysis described in Section 3.7 and Appendix 3E for structures, and the seismic qualification process described in Section 3.10 for mechanical and electrical components.

For structures on the SEL, HCLPF calculations ~~for the structures~~ are performed using a separation of variable method based on the methodology outlined in EPRI TR-103959 (Reference 38). The structural fragility analysis is performed using the seismic qualification and analysis shown in Section 3.7 and Appendix 3E, and using the U.S. EPR CSDRS as seismic input. Seismic analysis and foundation design for the standard plant are performed for multiple soil profiles including high frequency soil profiles as described in Section 3.7.1.3. Fragilities are calculated based on the highest seismic demand for all the soil profiles. The resulting fragilities are characterized by the median capacity, logarithmic standard deviations that account for randomness and uncertainty, and HCLPF capacity. The HCLPF capacity is a measure of a component seismic capacity. The HCLPF capacity is the acceleration below which there is 95 percent confidence that the failure probability is less than 5 percent. This value can be calculated from the median capacity (Am) for the component and two logarithmic standard deviations, accounting for variability due to uncertainty and randomness (β_U and β_R, respectively). This relationship is as follows:

$$HCLPF = A_m \exp\left[-1.65\left(\beta_R + \beta_U\right)\right] \qquad \text{(A)}$$

The assigned structure-related HCLPF are shown in Table 19.1-106. The HCLPF for the structures excludes analysis of site-specific soil effects, which are the responsibility of the COL applicant, as described in Section 19.1.5.1.2.4.

For mechanical and electrical components, the fragility analysis assigns a minimum HCLPF of 0.5 g to support achieving a plant and sequence level HCLPF of 1.67 times the SSE. Based on industry experience, most commercial equipment and distributive systems are inherently rugged as long as they are adequately supported or anchored

(Reference 63). To address supports and anchorage, Section 3.10.3 describes a process by which conservatism is introduced into the design in the form of a performance-based factor applied to the qualification process for critical equipment during severe accident scenarios. As described in Section 3.10, the seismic qualification of electrical and mechanical systems and components conforms to the guidance of Regulatory Guide 1.100; and Section 3.10.1.4 describes the process by which a Required Response Spectra (RRS) is established for the U.S. EPR design.

One of the key elements in establishing seismic margin for systems and components on the SEL is to establish an RRS that is appropriately factored throughout the frequency range. Therefore, to provide further confidence that the assigned generic HCLPFs for systems and components on the SEL are achievable, appropriate RRS multiplication factors will be established prior to equipment qualification based on the guidance provided in Reference 63 and on conservatism in the in-structure response spectra. This additional measure when applied to the qualification process for the systems and components on the SEL provides reasonable assurance that a plant and sequence level HCLPF equal to 1.67 times the CSDRS is achievable.

A COL applicant that references the U.S. EPR design certification will, for equipment on the SEL, confirm that an acceptable seismic margin is achieved through the seismic qualification implementation program. The plant and sequence level HCLPF capacities will be verified by the COL applicant during the PRA verification process, as described in Section 19.1.2.2.

~~For mechanical and electrical components on the SEL, the actual HCLPF of components will not be known until the components are procured and evaluated in the installed location. Therefore, for mechanical and electrical components the fragility analysis assumes a minimum reasonably achievable HCLPF of 0.5 g (1.67 times the SSE). The seismic qualification process for these components is described in Section 3.10. The minimum required reasonably achievable HCLPF capacities will be confirmed by the COL applicant during the PRA verification process, as described in Section 19.1.2.2.~~

The COL applicant is also responsible for identifying site-specific SSC and their impact on the HCLPF analysis, as described in Section 19.1.5.1.2.4.

19.1.5.1.1.4 Systems and Accident Sequence Analysis

A seismic-margins model was developed from the event trees and fault trees that comprise the model for internal initiating events so that potentially important accident sequences were considered. So that the relationships among seismic failures and other failure modes could be captured, the seismic-margins model also retains random failures and human failure events from the internal events PRA.

Initiating Events Analysis:

Initiating events in the at-power and shutdown internal events models were reviewed to determine those events that need to be included in the SMA model and to provide input to the SEL. Where initiating events were not explicitly modeled in the PRA, it was because SSC in the mitigating systems perform the same functions identified in initiating events already modeled and, therefore, have already been considered for inclusion in the SEL. SSC were identified and added to the SEL when their failure would cause the initiating event.

The following summarizes this review of initiating events:

Transient Initiators and Loss of Offsite Power

Loss of offsite power (LOOP) is included as a transient initiating event. LOOP is expected to be the dominant contributor to risk from transient initiating events, based on historical PRA insights. Based on U.S. EPR Level 1 PRA results, LOOP is a dominant contributor to risk for internal events. LOOP dominates this category of failures because it disables non-safety equipment and challenges the emergency diesels. Offsite power is expected to have a capacity lower than the SME. Loss of offsite power is assumed to occur for all seismic initiating events in the SMA quantification. This is conservative because if offsite power is available then the safety systems are not dependent on the emergency diesel generators to start, or dependent on the I&C systems to start and load the emergency diesel generators, etcetera. However, it is noted that in some cases the availability of offsite power will make certain scenarios worse. For example, a loss of condenser vacuum ATWS is more limiting than a loss of offsite power ATWS. Where this situation was noted (e.g., on the ATWS scenarios), the importance of the reactor trip function (and maintaining core geometry so that rod drop is ensured) was qualitatively evaluated based on the limiting scenario rather than relying on the occurrence of a loss of offsite power.

Small LOCA, Medium LOCA, and Large LOCA

All LOCA initiating events (SLOCA, MLOCA, and LLOCA) are included as seismic initiating events. Equipment that may fail and cause a SLOCA, such as multiple sensing lines, are expected to have a capacity less than the SME. The RCS piping, major RCS components and the associated supports are included on the SEL (so that no major LOCA event would be expected to occur as a result of a seismic event). Nonetheless, it is conservatively considered that a significant LOCA event could occur as a result of a seismic event (as per the requirements of Reference 61). Excessive LOCA (e.g., Reactor pressure vessel ruptures) are not specifically addressed in the SMA analysis, but because major RCS components (e.g., reactor vessel) are included on the SEL, the probability of such an event will be acceptably small (and because the excessive LOCA goes directly to core damage no additional mitigation equipment would be identified from evaluating these events further).

Steam Generator Tube Rupture

SGTR initiating events are not considered as an initiating event in the SMA. The components that could fail and result in a SGTR such as the steam generators, the steam generator tubes and associated components are included on the SEL. Additionally the major equipment such as the MSIVs, MSRTs, FWIVs and steamline activity instruments are included on the SEL to provide mitigation capability.

Secondary System Breaks

Breaks/Ruptures in the secondary piping are not explicitly modeled as an initiating event because the equipment required to mitigate these events is already required to mitigate other initiating events that are modeled. Leaks in the secondary piping are expected to have a capacity lower than the SME. Plant arrangement is s that leaks in the secondary piping areas do not impact mitigating equipment (e.g., Emergency Feedwater and Safety Injection). Equipment added to the SEL to mitigate the impacts of secondary breaks includes steam generators and piping, feedwater isolation valves, main steam isolation valves, and steam generator pressure signals.

Failures of Class 1E Structures:

Structure failures are not explicitly modeled as initiating events because the Seismic Category I structures that contain equipment credited in the PRA, and Category II structures that can impact structures that contain equipment credited in the PRA, are added to the SEL qualitatively. Failure of a structure is assumed to result in failure of the components in that building. For Seismic Category I and II structures on the SEL, failure of the structure is assumed to lead directly to core damage.

Interfacing Systems LOCAs

Interfacing system LOCAs (ISLOCA) are modeled as a shutdown SMA initiating event because failure modes were identified whereby a seismic event could cause an interfacing system LOCA (e.g., rupture of the RHR piping in the Safeguard Building for an in-service RHR train, or the letdown piping downstream of the low pressure reducing station could fail and the isolation valves could fail to close). For the at-power PRA, the only interfacing system break that was identified as being potentially caused by a seismic event was a letdown line break (downstream of the class break where the piping is non-seismically qualified). The letdown line isolation valves are included on the SEL to protect against this at-power initiating event. Additionally, the coolant purification isolation valves from the RHR trains to the CVCS (JNA30AA004, JNA30AA103; JNA40A004, JNA40AA103) are included on the SEL to provide a means to isolate flow through the low pressure reducing station.

Shutdown Initiating Events

Initiating events in the shutdown internal events model were also reviewed to determine those events that need to be included in the PRA model and to provide input to the SEL.

The following initiating events are therefore considered in the Shutdown SMA:

Loss of Residual Heat Removal (RHR) – Loss of RHR is modeled as an initiating event.

LOCA in Shutdown – LOCA in Shutdown is modeled as an initiating event (both small break and large break LOCA are considered in the analysis).

Uncontrolled Level Drop (ULD) – ULD is considered as a potential shutdown initaiting event in the SMA. The coolant purification isolation valves from the RHR trains to the CVCS (JNA30AA004, JNA30AA103, JNA40A004, JNA40AA103) are included on the SEL to provide a means to isolate flow to the low pressure reducing valves (including consideration of the possible rupture of the letdown piping downstream of the seismic class break).

Interfacing System LOCA – ISLOCA RHR LOCA during shutdown operation is specifically modeled as an SMA initiating event. Equipment added to the SEL includes the Low Pressure Reducing Station Letdown Isolation Valves.

Based on this review, the SMA model includes the following initiating events:

- Seismic LOOP.
- Seismic SLOCA.
- Seismic MLOCA.
- Seismic LLOCA.
- Seismic Loss of RHR in Shutdown.
- Seismic LOCA in Shutdown.
- Seismic ULD in Shutdown.
- Seismic ISLOCA in Shutdown.

Each of these initiators was quantified using the internal events event tree (from Appendix 19A for the at-power PRA or Appendix 19B for the Low Power Shutdown PRA). The SMA model is evaluated (quantified) with the seismic initiating event frequency set to 1.0. For the at-power model, the initiating event frequencies (IE LOOP, IE SLOCA, IE MLOCA and IE LLOCA) are directly set to 1.0. For the shutdown initiating events, the initiating event frequencies are set to 1, and additionally Boundary Condition Sets are utilized such that each seismic initiating event of interest is assumed with a probability of 1.

Plant Response and Mitigation Systems Review

Accident responses in the at-power and shutdown PRA models were used to develop the SMA model and the resulting SEL.

SMA Simplifying Assumptions and Modeling Seismic-Induced Failure of Non-Seismic Components

- All systems that depend on normal AC power such as main feedwater, main condenser, Startup and Shutdown System (SSS) pump and their support systems are set to failure in the SMA analysis by failing the offsite power supply. In the at-power model, this is accomplished by setting house event PWR and basic event LOOP24+REC to true (additionally, in the IE LOOP quantification, it is necessary to set REC OSP 1HR, and REC OSP 2HR to true to prevent power recovery from being considered in the LOOP event tree analysis). In the Shutdown model, it is accomplished by setting house event SD and basic event SD LOOP24+REC to true.

- All SSC that are not on the SEL with a commitment to maintain their function for the Review Level Earthquake (1.67 * CSDRS = 0.5g pga) are set to failure in the SMA analysis. (Category II seismic equipment on the list is assumed to functionally fail, but is also assumed not to result in failure of any adjacent seismic category I SSC). Seismic categories were determined based upon Table 3.2.2-1.

Non-Seismic Systems\Components that are Important to the Level 1 PRA

- Chemical and Volume Control System (CVCS) – CVCS is not credited in the SMA for the purposes of supplying flow to the RCS. The coolant purification isolation valves from the RHR trains to the CVCS (JNA30AA004, JNA30AA103; JNA40A004, JNA40AA103) and the associated category I piping are included on the SEL to provide a means to isolate flow through the LP Reducing Valves. CCW is credited for RCP thermal barrier cooling, and medium head safety injection (MHSI) / low head safety injection (LHSI) are credited for RCS Inventory control. Additionally, auxiliary pressurizer spray is not included nor is it required to mitigate a seismic event.

- SBO Diesels – SBO Diesels are not credited in the SMA. Because the EDGs are the emergency power supply that are designed to withstand seismic forces, the EDGs are the emergency power source that is credited in the SMA analysis (and failure of all 4 EDGs due to random causes is very unlikely). In some seismic PRAs, the results show these backup power supplies have reduced the risk associated with non-seismic random failures of emergency diesels subsequent to lower level earthquakes (higher frequency) that cause a LOOP. Because the U.S. EPR design has four EDGs, the probability of failure because of random causes (non-seismic failure) is less likely.

- Primary Depressurization System (PDS) Valves – PDS valves are not credited in the SMA. These valves are powered by non-seismic AC/DC power supplies located in non-seismic buildings.

- Severe Accident Heat Removal System (SAHRS) – SAHRS and the Closed Cooling Water support to SAHRS are not credited in the SMA. SAHRS depends on electrical equipment in the non-seismic conventional switchgear room.

- Process Information Control System (PICS) – PICS is not credited in the SMA. Operator displays and digital controls and screens in the main control room are not Seismic Category I, but certain portions may be qualified as Seismic Category I.

- Non-Safety Batteries – Non-safety batteries (12 hour and 2 hour) in the Switchgear Building were not credited by failing the buses they supply (with LOOP guaranteed, this effectively fails the PDS valves and the RCP Stand Still Seal System).

- RCP Motors – Oil Collection System – This system is not credited in the SMA. The fire portion of the PRA implicitly credits this system and screens out fires in this system and fires in containment in general.

- Fire Water Distribution System (FWDS) and Sprinkler System – These systems are not credited in the SMA. Fire protection piping in the vicinity of safety-related equipment will be required to maintain structural integrity during a seismic event.

- Non-Class 1E Electrical – Non-class 1E electrical systems are not credited in the SMA.

- Process Automation System (PAS) – PAS is not credited in the SMA.

- Diverse Actuation System (DAS) – DAS is not credited in the SMA.

- Demineralized Water Distribution System (DWDS) – This system is not credited in the SMA. Refilling from the DWDS requires an operator action, and all operator actions are assumed to fail after a seismic event.

- Safeguard Building Ventilation System (SAC) – The SAC maintenance trains are not credited in the SMA. The maintenance train fans as well as the Operational Chilled Water Chillers that supply the cooling are powered from a non-class IE power supply.

- Certain Equipment Identified as Seismic Category II is included on the SEL where significant seismic interaction issues were identified. This is done when potential system interaction issues are identified. Examples include the Refuel Machine or the polar crane toppling off its rails, or an adjacent structure failing in a manner that an adjacent safety-related structure may be compromised.

- Offsite power – Offsite power is assumed to be lost and remain unavailable following a seismic event, and the offsite power non-recovery probabilities are set to true in the LOOP analysis. Additionally, the EDG mission time has been set to

24 hours, consistent with the standard PRA mission time of 24 hours. Although longer EDG mission times could be postulated, the results of this analysis (identifying SEL equipment, and identifying the SSC most important to seismic accident sequence mitigation) are insensitive to the assumed EDG mission time.

Evaluation of Safety Functions

The Major safety functions considered in the SMA accident sequence analysis are described below:

Reactivity Control (Reactor Trip)

The following equipment is included on the SEL and required to operate to support the scram function:

- Reactor internals (do not prevent rod drop).
- Control rods (drop into the core).
- Fuel assemblies (do not prevent rod drop).
- Reactor protection system (RPS) instrumentation, input signals, logic and cabinets.
- RPS I&C power supplies.
- Reactor Trip Breakers.

ATWS events are considered as a potential at-power initiating event in the SMA analysis. The following equipment is included on the SEL to provide for ATWS mitigation:

Pressurizer Safety Valves (PSV) are required to operate following an ATWS event to mitigate the RCS pressure increase. Therefore, the PSVs are included on the SEL.

CVCS and Extra Borating System (EBS) can be used to mitigate ATWS. CVCS is not included on the SEL because the system is non-seismic category. This is not a concern because the EBS pumps are Seismic Category I and supplied with emergency power. The EBS system, including supporting systems is included on the SEL.

The remaining systems and functions in the ATWS model (e.g., secondary cooling, reactor makeup and containment heat removal) are addressed below for their respective functions.

Secondary Cooling Emergency Feedwater, Main Steam Relief Valve, Main Safety System Valve

As described in the initiating event analysis, the steam generator and connected piping systems, including isolation valves have been included in the SEL. Also, as described above, the SSS, main feedwater, and condenser systems are not available as they depend on offsite power and are non-seismic. The following remaining Seismic Category I systems are included in the SMA model and SEL:

- Four EFW trains and their support systems including auto-actuation.
- Four MSRV trains (one on each SG) and their support systems including auto-actuation.
- Eight MSSV (two on each SG).

The above systems alone ensure a success state in the at-power PRA if there is no LOCA. Makeup to the EFW pools is non-seismic and the demineralized water makeup pumps are powered by normal AC power. However, there is enough EFW storage capacity to support the PRA success criteria because the RCP pumps are tripped on a LOOP. There is an operator action to isolate a leaking EFW pool supply, but the probability of this failure mode is low. Although the internal events PRA does not model Residual Heat Removal (RHR) shutdown cooling as a long term alternative to EFW secondary cooling, the four trains of Low Head Safety Injection (LHSI) equipment and their supports systems are included in the SMA model and on the SEL.

RCP Seal Cooling

RCP seal cooling is included in the SMA model and included on the SEL to provide a means to maintain cooling to the RCP seals (and thereby maintain the integrity of the RCS). RCP seal injection with CVCS is assumed to be lost because of the seismic event (because the charging pumps are non-class powered). Therefore, thermal barrier cooling with CCWS is required following a seismic event to protect the RCP seals. To maintain the RCP thermal barrier cooling function following a seismic event, components necessary to maintain CCWS thermal barrier cooling are included on the SEL

Primary Feed & Bleed (F&B)

Feed and Bleed Cooling is included in the SMA model to provide accident mitigation in the event that secondary cooling is unavailable. The following equipment is included on the SEL to provide for Feed and Bleed capability:

- Three PSV opening on demand and their support equipment.
- Safety injection signal (I&C) and supporting equipment.
- Four Medium Head Safety Injection (MHSI) trains and their support systems.
- Four Accumulators and associated MOV and support equipment.

- Four LHSI trains and their support systems (feed and In-Containment Refueling Water Storage Tank (IRWST) cooling).

The following operator action is required:

- Initiate Feed and Bleed - Although SIS occurs automatically when these bleed valves are opened, it is assumed the operators also start the pumps by procedure before opening the valves.

SLOCA Considerations

The SSC required to mitigate a SLOCA is similar to the SSC identified for the transient accident sequence. The success criteria are slightly different, but since F&B was included in the transient accident response model most of the equipment required for SLOCA has been identified. The following additional equipment was identified for inclusion in the SMA model and SEL:

- Actuation of Safety Injection and partial cool down (PCD). PCD actuates and opens MSRV trains at a lower pressure to allow MHSI makeup to the RPV.

MLOCA and LLOCA Considerations

The systems and components necessary to mitigate a MLOCA or LLOCA are similar to the equipment required to mitigate the small LOCA (although secondary cooling is not required, and accumulators are required to mitigate larger breaks).

CVCS Letdown (potential loss of inventory path)

The charging pumps and the associated piping outside of containment are not seismically qualified; therefore, charging was not credited in the SMA. However, the CVCS letdown isolation valves are Category I and are credited in the SMA as a means to prevent an uncontrolled loss of inventory. This loss of inventory could be through the containment isolation valves in the case of an abnormal alignment or break during at-power operations, or through the low pressure reducing station during shutdown.

Stuck Open PSV (potential loss of inventory)

Normally, the PSVs are not challenged. Therefore, the possibility of their challenge and then the subsequent failure to close is unlikely and not modeled, except in the case of ATWS and for a loss of RHR during plant operating states (POS) C. The same equipment required to mitigate a small LOCA would mitigate a stuck open PSV.

Supporting Structures

Major structures not included above where failure could impact Level 1 SSC on the SEL are added qualitatively and include:

- Nuclear Auxiliary Building.
- Access Building.
- Turbine Building.

Components Required to Support Effective Operations Control

To support survival of the operators and their ability to mitigate a seismic event, the following SSC are added to the SEL

- Control room and ceiling.
- Control room emergency ventilation.
- SICS.
- Radiation Monitoring Sensors, Skids, Cabinets.

Modeling of Seismic Induced Failures

System fragility basic events were added to the model with a probability of 0.1. The same basic event is used for all trains to conservatively correlate seismic failure as a common cause for identical equipment. Fragility basic events were added for the following:

- AC Power (all 4 emergency switchgear trains 31/32/33/34 BDA).
- Accumulators (all 4 trains).
- 1EUPS (the 4 Class 1E Uninterruptable power sources including the inverters and the BRA buses).
- DC Power (the 4 Class 1E Batteries and the associated DC buses).
- CCWS (all 4 trains).
- EBS (both trains).
- EDG (all 4 emergency diesels).
- EFW (all 4 trains).
- ESWS (all 4 trains).
- I&C (all 4 divisions).
- LHSI (all 4 trains).
- MHSI (all 4 trains).

- MSRT (all 4 SGs).
- PSRVs (all 3 trains).
- Reactor Internals (RT failure).
- SAC (all 4 trains and the QKA trains).
- Seal LOCA (all 4 RCPs).

Seismic Equipment List (SEL)

A list of SSC has been developed based on the SMA model development in the previous section using the internal events PRA model for at-power and shutdown operations. The equipment credited in the SMA for accident mitigation, is included on the SEL (Table 19.1-106). In addition, P&IDs, electrical one-line diagrams, plant arrangement drawings and other plant systems descriptions were reviewed so that highly reliable passive components that may not be explicitly modeled in the PRA are identified. In accordance with Section 5.1.1 of ISG-020 (Reference 60), equipment important to maintain containment integrity is also included on the SEL (Table 19-106). The SEL provides the list of SSC for which fragility analysis is required to determine plant-level HCLPF.

Containment Performance

An evaluation of containment performance is included so that the appropriate Level 2 SSC are included on the SEL as required by Section 5.1.1 of ISG-020 (Reference 60). The following SSC are included in the SEL:

- Reactor Building, including Penetrations (containment).
- Containment Isolation valves and supporting equipment.
- Core Melt Retention Structure (the melt discharge channel is Seismic Category II, the remainder of SSC are non-seismic).
- Passive flooding line to the core melt stabilization system (CMSS) cooling structure up to and including MOV JMQ42AA004/0006 (the piping line must maintain structural integrity such that IRWST inventory is not depleted).
- Combustible Gas Control System: The Passive Autocatalytic Recombiners and the associated foils and Dampers are included on the SEL list, and will be designed and constructed to maintain a minimum HCLPF of 0.5g pga. The PARS are included on the SEL based on consideration of their importance in maintaining containment integrity following a severe accident.

Low Power and Shutdown

The LPSD configurations, models, and systems were evaluated to determine whether any components should be added to the SEL. The Shutdown PRA model (fault trees and event trees) was utilized to identify the systems, structures, and components (SSC) that would be required to mitigate a seismic event that occurs during shutdown operation. The Shutdown PRA model (described in Section 19.1.6) addresses the various Plant Operating States (POS) that occur from Shutdown into Refueling and back to Startup (transition from State C into refueling and back to startup. Each transition POS that differs significantly from normal at-power operation is evaluated for risk in the Shutdown PRA, and each of these shutdown operating states is evaluated in the SMA. POS A and B are covered by the at-power PRA. Many of the same systems and components identified for power operation are also modeled in the LPSD model. A key difference is that loss of LHSI in the RHR mode of operation is a new initiating event, but this system is already included on the SEL. Similarly, loss of offsite power is an important initiating event, but it also has been identified as an important initiator for power operation. However, there are SSC that need to be added to the SEL based on this evaluation as summarized below:

- Reactor Cavity and connected pools (both empty and full).
- Fuel Transfer Tube and Gate Valve.
- Refuel Gates.
- Refueling Machines and Cranes (must not tip over onto fuel assemblies).
- Polar Crane (e.g., must not tip over, drop heavy loads).
- Spent Fuel Pool.
- Spent Fuel Pool Cooling System and supporting equipment.
- Pressurizer vent valves (10JEF10AA501 and 10JEF10AA502).
- The coolant purification isolation valves from the RHR trains to the CVCS (JNA30AA004, JNA30AA103; JNA40A004, JNA40AA103.

Relay Chatter

Generally, it is expected that solid state relays are used to support the operation of equipment credited on the SEL. Solid state relays are inherently immune to chatter. Electro-mechanical relays, where used, are analyzed as part of the HCLPF capacity determination.

Random Failures and Human Actions

As required by Section 5.2.3 of Reference 3, the U. S. EPR SMA considers both random failures and human errors. Because the SMA uses the event tree models and fault tree models from the PRA (both the at-power models and the Shutdown models), random failures are considered just as they are in the Internal Events analysis and in the Shutdown PRA analysis. Operator Errors were conservatively set to a value of 1.0 in the SMA analysis so that required operator actions are identified in the analysis. No credit is taken for any recovery actions associated with seismic failures.

Summary of the U.S. EPR SMA Approach

The U.S. EPR Seismic Margins Analysis is performed in accordance with the ISG-020 guidance (Reference 60) for performing a PRA-Based Seismic Margins Analysis. ISG-020 endorses Part 5 of the 2009 ASME/ANS PRA Standard (Reference 61) in guiding the SMA approach. The Systems analysis portion of the SMA was therefore performed in accordance with the applicable requirements of 5.2-3 of the 2009 ASME/ANS PRA standard:

- It is conservatively assumed that a seismic event will cause one or more events requiring reactor shutdown including:
  - Loss-of-coolant accidents of various sizes and in all relevant locations.
  - Transients, of which loss of off-site power (LOSP) is usually the most important.

  In the U.S. EPR approach, it is conservatively assumed that LOCAs of various sizes may be induced concurrent with a loss off offsite power and a failure of all equipment not included on the SEL.
- The event trees and fault trees from the internal-event at-power PRA model and from the Low Power Shutdown PRA are used directly in the SMA as the basis for evaluating the seismic accident sequences.
- The PRA-based SMA models consider seismically induced failures as well as random (seismically independent) failures and human errors that are required for accident mitigation.
- System recoveries credited in the internal events model that may not be feasible following a major earthquake are not credited in the SMA model (e.g., nonrecovery of offsite power has been conservatively set to 1 for seismic events, and the diesel generator mission time was increased to 24 hours).
- Seismic related failures are assumed to be non-recoverable.
- The PRA accident sequence analysis and the associated systems analysis was used as the primary input for developing the seismic equipment list.

All (post-accident) human error probabilities have been conservatively set equal to 1.0 in the SMA model, so that human actions required to mitigate seismic induced accident scenarios will be highlighted. The purpose of the SMA is to identify those seismic failures, human errors and random failures that are of primary importance to the seismic risk. It is not the purpose of the SMA to quantitatively estimate the seismic risk (nor is this any feasible, since in design certification, there is no single seismic hazard that would apply to all possible sites).

The solution of the integrated fault-tree and event-tree models to evaluate the seismic margin is addressed in Section 19.1.5.1.2.

~~The initiating events and event trees in the at-power and shutdown internal events model were reviewed to identify which events needed to be included in the seismic model to account for the types of sequences that could be important following an earthquake. The following consequential initiating events were identified and included in the seismic model:~~

- ~~Seismic loss of offsite power (S LOOP).~~
- ~~Seismic small LOCA (S SLOCA).~~
- ~~Seismic medium LOCA (S MLOCA).~~
- ~~Seismic large LOCA (S LLOCA).~~
- ~~Seismic loss of residual heat removal (RHR).~~
- ~~Seismic LOCA in shutdown.~~
- ~~Seismic uncontrolled level drop (ULD).~~
- ~~Seismic interfacing systems LOCA (ISLOCA) in shutdown.~~

~~LOOP is the most likely plant initiating event that would result from a seismic event. The LOOP event tree developed for internal events was modified for use in the seismic model. In particular, events related to the restoration of offsite power and events that reflected the use of systems that are not seismically qualified were removed. For further completeness in defining the SEL and modeling of potential sequences, the LOOP model retained a transfer to an ATWS event tree for sequences involving failure of the reactor to trip. The S LOOP event tree is shown in Figure 19.1-10—Event Tree for Seismic Loss of Offsite Power (S LOOP).~~

~~The S SLOCA event tree accounts for LOCA sequences that could result from a seismic event (e.g., due to failure of multiple instrument impulse lines). The event tree for internal events was modified to develop the S SLOCA event tree. The capacity of the RCS may be substantially higher than the SME, but the SLOCA model was developed~~

~~to enhance completeness of the SEL and of the sequences considered. The S SLOCA event tree is shown in Figure 19.1-11—Event Tree for Seismic Small LOCA (S SLOCA).~~

~~The MLOCA and LLOCA event trees (see Appendix 19A) were used directly. The internal events shutdown event trees (Appendix 19B) were utilized directly in the shutdown SMA analysis.~~

~~Structures and other passive components not typically included in the internal events PRA were added to the SEL. Containment performance was considered and resulted in additions to the SEL.~~

~~Fault trees developed in the internal events PRA were modified to investigate system failure modes and dependencies, and to establish the SEL for fragility analysis. Seismic failures were addressed as follows:~~

- ~~Basic events representing seismic failures of SSC for which fragility evaluations were performed were added at appropriate points in the fault trees.~~
- ~~Seismic failures were treated as common events for all trains of a system. For example, the same basic event representing seismic failure of a pump was applied for all similar trains of a system. Complete correlation in that manner assumes that redundant components fail if one component fails.~~
- ~~Systems not qualified for seismic loadings were set to a failure probability of 1.0. Thus, for example, the seismic model treats both offsite power and the SBODGs as unavailable following a seismic event. No credit is given for recovery of offsite power. Removal of these non-qualified systems allowed simplification of the models.~~
- ~~Human failure events were retained in the fault-tree models, but were set to failure with a probability of 1.0. This allowed any potentially important events to be visible during the quantification process.~~

~~The solution of the integrated fault-tree and event-tree models to evaluate the seismic margin is addressed in the next section.~~

19.1.5.1.1.5 HCLPF Sequence Assessment

The seismic margin assessment evaluates the impact of seismic initiators by determining whether there is adequate margin. This is done by searching for scenarios in which combinations of seismic failures, random events, and failures of human actions could result in an effective seismic capacity less than the SME.

To make this evaluation, seismic failures were added to the fault-tree models developed for internal initiating events, as discussed in the previous section.

The "MIN-MAX" method of evaluating accident sequences at the cut-set level was used to assess the plant-level HCLPF capacity. The MIN-MAX method assesses the accident sequence HCLPF by taking the lowest HCLPF capacity for components analyzed under OR-gate logic and the highest HCLPF capacity for components analyzed under AND-gate logic. Random component failures and human actions are also considered in the evaluation.

The product of this evaluation is identification of the structures and components that arise in the core damage cutsets and that limit the plant-level HCLPF capacity.

19.1.5.1.2 Results from the Seismic Risk Evaluation

19.1.5.1.2.1 Risk Metrics

The PRA-based seismic margin assessment investigated the margin incorporated into the design of the U.S. EPR. This entailed evaluating the plant-level HCLPF, and comparing it to the SME, which is defined as a factor of 1.67 times the design-basis SSE. That is, the assessment focused on identifying any potential vulnerabilities in the design, defined as components that would not meet the criterion of 95 percent confidence that the probability of failure would be less than 5 percent at the SME. This requirement has been met as described below.

19.1.5.1.2.2 Significant Initiating Events and Sequences

Summary of the At-power SMA results

At-power event trees that were quantified to support the SMA analysis are included in Appendix 19A. The at-power event trees quantified to support the SMA analysis include LOOP, ATWS, SLOCA, MLOCA, and LLOCA. The at-power PRA event trees as were utilized directly to perform the SMA accident sequence quantification for each of these initiating events. The SMA cutsets are reviewed to identify those combinations of seismic failures, random failures and operator error that are most limiting with respect to seismic risk. Since at this stage of the design, detailed fragility evaluations are not available for equipment on the SEL, the SSC on the SEL have been assumed to have a HCLPF greater than or equal to 0.5g. Since there is no differentiation of HCLPF for the various components on the SEL, there is no effort to conclude that certain seismic failures are more likely than others. Rather, since all components on the SSC have the same assumed HCLPF, the limiting seismic cutsets are those cutsets containing the fewest seismic failures. By examining cutsets greater than 1E-3 all cutsets with 3 or less seismic failures are identified (recall that each seismic failure event is assigned a value of 0.1). The at-power SMA cutsets are summarized in Table 19.1-37.

SMA At-power LOOP Sequences

The LOOP SMA cutsets are included in Table 19.1-37 and the most limiting sequences from an SMA perspective are summarized below:

Single-element seismic sequences: Seismic failure of AC power cabinets, I&C cabinets, EDGs, DC Buses (including Batteries), ESW, and Class 1E UPS represent single-element cutsets

Cutsets with combinations of seismic failures and random failures:

- Seismic failure of CCWS and failure of the RCP seals due to random failure.
- Seismic failure of EFW, failure of one EDG train.

Cutsets with combinations of seismic failures and human actions:

- Seismic failure of EFW and operator failure to start feed and bleed.
- Seismic Failure of either SB HVAC or SCWS and operator failure to open doors and align portable ventilation.
- Seismic failure of reactor trip (due to either reactor trip failures or due to core geometry issues) and operator failure to start Emergency Boration.
- Seismic failure of I&C (either due to I&C seismic failure, or seismic failure of the I&C power supply) and failure to manually trip reactor.

SMA at-power LOCA Sequences

The LOCA SMA cutsets are included in Table 19.1-37 (for SLOCA, MLOCA and LLOCA initiating events) and the most limiting from an SMA perspective are summarized below:

Single-element seismic sequences:

- Seismic failure of AC power cabinets, I&C cabinets, EDGs, DC Buses, ESW, HVAC, CCWS, Class 1E UPS, or LHSI represent single-element cutsets. For large LOCA, the Accumulators represent an additional single element seismic sequence.

Cutsets with combinations of seismic failures and random failures or operator actions:

- Seismic failure of EFW or MSRT; and failure of one EDG train.
- Seismic failure of EFW or MSRT; and operator failure to start feed and bleed.
- Seismic Failure of SB HVAC (either SAC or SCWS) and operator failure to open doors and align portable ventilation.

- Seismic failure of MHSI and operator failure to initiate fast cooldown.

MLOCA and LLOCA cutsets were also inspected and the results are also included in Table 19.1-37. The SSCs and operator actions important to mitigating MLOCAs and LLOCA are similar to the equipment required to mitigate SLOCAs, with the primary exception that the accumulators are identified as an additional single-element cutset for the LLOCA initiating events.

Seismic failures of key structures that house safety-related systems are also considered as events that are assumed to result in core damage. All Structures housing equipment included on the SEL are included on the SEL so that equipment operation is not compromised because of building failure

Summary of the Low Power Shutdown SMA results

The Shutdown events trees from the Low Power Shutdown Analysis were used directly for the Shutdown SMA Analysis. The Shutdown event trees were obtained directly from the Low Power Shutdown PRA model (Section 19.1.6 and Appendix 19B). The Shutdown SMA cutsets are reviewed to identify those combinations of seismic failures, random failures, and operator error that are most limiting with respect to seismic risk. Because at this stage of the design, detailed fragility evaluations are not available for equipment on the SEL, the SSC on the SEL have been assumed to have a HCLPF greater than 0.5g. Because there is no differentiation of HCLPF for the various components on the SEL, there is no effort to conclude that certain seismic failures are more likely than others. Rather, since all components on the SSC have the same assumed HCLPF, the limiting seismic cutsets are those cutsets containing the fewest seismic failures. By examining cutsets greater than 1E-3, all cutsets with 3 or less seismic failures are identified (recall that each seismic failure event is assigned a value of 0.1). The Shutdown SMA cutsets are summarized in Table 19.1-37.

Shutdown SMA single-element seismic cutsets are summarized below:

- For various shutdown POS initiators, single element seismic cutsets include AC power cabinets, instrumentation and controls (I&C) cabinets, emergency diesel generators (EDGs), Class 1E DC Buses or Batteries, and essential service water (ESW)

- For a seismic LOCA or uncontrolled level drop in POS C, seismic failure of component cooling water (event component cooling water system) represents a single element cutset.

- For a seismic LOCA in POS C, seismic failure of LHSI is a single element cutset.

Shutdown SMA cutsets with combinations of seismic failures and random failures are summarized below:

- For loss of RHR in POS C, seismic failure of CCWS and failure of the RCP seals due to random failure.
- For seismic LOCA or an uncontrolled level drop in POS C, seismic failure of MHSI and any EDG fails due to random failures.

Shutdown SMA cutsets with combinations of seismic failures and human actions are summarized below:

- For POS C, D and E loss of RHR or LOCA initiating events, seismic failure of SB HVAC (either SAC or SCWS) and operator failure to open doors and align portable ventilation.
- For seismic loss of RHR in POS D, seismic failure of CCWS and operator failure to start LHSI.
- For seismic LOCA or uncontrolled level drop in POS C, seismic failure of either emergency feedwater (EFW) (event EFW) or main steam relief train (MSRT), combined with operator failure to restart RHR after a LOCA, and operator failure to start feed and bleed.
- For seismic LOCA or uncontrolled level drop in POS C, seismic failure of MHSI and failure to initiate feed and bleed using LHSI.
- For seismic LOCA or uncontrolled level drop in POS C, seismic failure of class 1E UPS and failure to restart RHR.
- For seismic LOCA in POS D or E, seismic failure of CCWS and operator failure to start LHSI.
- For seismic uncontrolled level drop in POS D, seismic failure of either CCWS or MHSI, and Failure to start LHSI.

Shutdown SMA cutsets with combinations of seismic failure, random failures, and human actions are summarized below:

- For POS C, seismic failure of CCWS or LHSI results in loss of RHR, any DG fails due to random causes (results in failure of feed and bleed due to loss of power to at least 1 PSRV) and failure to supply the EFW in the failed train to an operating EFW pump results in late failure of EFW.
- For POS C, seismic failure of CCWS results in loss of RHR, EDG1 fails due to random causes, and failure to align portable ventilation in Safeguards Building 2.
- For seismic LOCA in POS C, seismic failure of EFW or MSRT, failure of train of power, and operator failure to restart RHR after a LOCA.
- For POS C a seismic LOCA or an uncontrolled level drop, with seismic failure of EFW or MSRTs, concurrent with failure to restart RHR after the initiating event (uncontrolled level drop or LOCA) and 1 EDG fails due to random causes.

- For an uncontrolled level drop in POS Cbd, seismic failure of LHSI, any EDG fails due to random causes, and failure of the operators to align the EFW inventory from the failed EFW train results in late failure of EFW.

- For an uncontrolled level drop in either Cbd or Dud, seismic failure of 1EUPS, random failure of EDG3 and failure of the operator to locally isolate the low pressure reducing station.

- For an uncontrolled level drop in either Cbd or Dud, seismic failure of 1EUPS, random failure of EDG4 and failure of the operator to locally isolate the low pressure reducing station and operator failure to align portable ventilation.

- For an uncontrolled level drop in Dud, seismic failure of CCW, random failure of EDG4 and failure of the operator to locally isolate the low pressure reducing station and operator failure to align portable ventilation.

Shutdown SMA RHR LOCA cutsets are summarized below:

- RHR piping fails (assumed in initiating event) and operator failure to isolate the LOCA (automatic isolation is non-seismic).

- RHR piping fails (assumed in initiating event) and DC fails (results in loss of power to all RHR isolation valves).

- RHR piping fails (assumed in initiating event), seismic failure of Class 1EUPS, and random failure of the EDG in the train with the ruptured RHR piping (results in loss of power to all RHR suction isolation valves).

Shutdown SMA Cutsets with no seismic failures (combinations of random failures and/or operator errors only):

- An uncontrolled level drop via the low pressure reducing station, automatic isolation of the ULD fails due to the seismic event (since the automatic isolation signal is dependent on non-seismic I&C), and operator fails to manually isolate the leak.

- In POSs Cau and Cbu when only RHR pumps 2 and 3 are assumed initially operating, random failure of the two EDGs supplying the operating RHR pumps results in loss of the running RHR, and operator failure to start standby RHR trains fails the standby RHR (EFW fails due to loss of power to MSRTs and Feed and Bleed fails due to loss of power to one or more PSRVs).

- Seismic LOCA or Uncontrolled level Drop in POS C, one EDG fails due to random causes, operator fails to restart RHR pumps, and operator failure to crosstie EFW inventory from the failed train results in late failure of EFW.

- Seismic LOCA or Uncontrolled level Drop in POS C, one EFW fails due to random causes, operator fails to restart RHR pumps, and operator failure to crosstie EFW inventory from the failed train results in late failure of EFW.

- Seismic LOCA or Uncontrolled level Drop in POS C, (EDG1 or EDG2 fails due to random causes) AND (EDG3 or EDG4 fails due to random causes), and operator fails to restart RHR pumps.
- Seismic LOCA or Uncontrolled level Drop in POS C, EDG1 and EDG2 fails due to random causes, and operator fails to restart RHR pumps.
- An Uncontrolled Level Drop in POS C or D, EDG3 and EDG4 both fail due to random causes, and operator fails to locally isolate the low pressure reducing station and also fails to align portable HVAC.

~~Loss of offsite power is the most important initiating event because equipment needed for offsite power to function (e.g., ceramic insulators) typically has low seismic capacity and its failure has effects on safety and non-safety systems. Loss of offsite power results in the loss of main and startup feedwater, the main condenser as a heat sink, and maintenance ventilation systems. The LOOP also presents a demand for the EDGs to supply power to the safety systems. The next section discusses the expected dominant seismic and non-seismic failures that contribute to the LOOP accident sequences.~~

~~For purposes of the seismic margins assessment, it is also assumed that a seismic event would lead to leakage from the RCS equivalent to an SLOCA. This assumption is made even though the RCS is expected to have a sufficiently high seismic capacity such that a failure resulting in an SLOCA would be unlikely. The seismically induced SLOCA is included so that a broader set of equipment will be considered in the SEL and associated fragility evaluations than would be the case if only systems needed to respond to a LOOP were included. The primary difference with respect to the cutsets obtained for the S-LOOP sequences and those for S-SLOCA was the requirement for cooling of the IRWST for the latter. This requirement added cutsets relating to seismic failure of the CCWS and LHSI/RHR to those obtained for LOOP scenarios.~~

~~Seismic failures of key structures that house safety-related systems are also considered as initiating events that are assumed to result in core damage. Structures were assessed to have relatively high capacities and were assigned HCLPF capacities larger than the SME based on calculations and generic information.~~

19.1.5.1.2.3 Significant Functions, SSC, and Operator Actions

Summary of the Limiting At-Power SMA Functions and SSC

The results of the at-power SMA demonstrate that the plant-level HCLPF is equal to or greater than 1.67 times the CSDRS (provided the HCLPF commitments in Table 19-106 are achieved). The following SSC are limiting in determining the plant-level HCLPF capacity:

- The class 1E electrical distribution power cabinets.

- DC – Class 1E Batteries and associated DC Buses.
- Component cooling water (CCWS).
- Emergency diesel generators (EDGs).
- Emergency feedwater (EFW).
- Essential service water (ESW).
- Instrumentation and controls (I&C) cabinets.
- Low head safety injection (LHSI).
- Main head safety injection (MHSI).
- Accumulators (ACC).
- Main steam relief train (MSRT).
- Class 1E UPS – Class 1E Inverters and associated BRA buses.
- Safeguards Building (SBs), heating, ventilation, air conditioning (HVAC) – The safety chilled water System (SCWS) and SB ventilation system electrical division (SAC).
- The associated structures housing this equipment (e.g., the Safeguards Buildings, the Emergency Power Generating Buildings, and the Essential Service Water Pump Buildings).
- Reactor Trip (and maintenance of core geometry such that rod drop is not impeded).

Summary of the Limiting Low Power Shutdown SMA Functions and SSC

The results of the Low Power Shutdown SMA demonstrate that the plant-level HCLPF is equal to or greater than 1.67 times the CSDRS (provided the HCLPF commitments in Table 19-106 are achieved). The following SSC are limiting in determining the plant-level HCLPF capacity:

- AC – The class 1E electrical distribution power cabinets.
- DC – Class 1E Batteries and associated DC Buses.
- EDGs.
- Component cooling water.
- EFW.
- Emergency service water.

- I&C cabinets.
- Class 1E UPS – Class 1E Inverters and associated BRA buses.
- MSRTs.
- Safeguards Building (SB) heating, ventilation, air conditioning (HVAC) (safety chilled water and SB ventilation system electrical division).
- LHSI/RHR.
- MHSI.
- Low pressure reducing station valves.
- The associated structures housing this equipment (e.g., the Safeguards Buildings, the Emergency Power Generating Buildings, Essential Service Water Pump Building, and the Fuel Building).
- Reactor Trip (and maintenance of core geometry such that rod drop is not impeded).

Significant Operator Actions

A number of operator actions are identified in the SMA results (Table 19.1-37) as being important to mitigating seismic accident sequences:

- Isolate the Low Pressure Reducing Station in the event that a seismic event occurs when the low pressure reducing station is in service (automatic isolation is a non-safety function).
- Isolate any RHR LOCA that occurs outside containment: In the event that the seismic category 1 RHR piping fails due to the seismic event, operator action is required to manually isolate the break (automatic isolation is a non-safety function).
- Feed and Bleed: This operator action is required within about 2 hours after a seismic LOOP if it is assumed that EFW fails at time zero. This allows for sufficient time to perform the action, even allowing for the fact that operator response may be degraded due to the seismic event. Feed and Bleed is also required after a LOCA during POS C and for SLOCA and MLOCA when secondary cooling fails.
- Fast Cooldown: Given a LOCA with MHSI failure, the operators would initiate a fast cooldown to allow LHSI injection with accumulators.
- Ventilation Recovery: Operator action is credited to open doors and align portable ventilation following a failure of SAC or QKA to maintain temperatures in the Safeguards Building that will support operation of the vital equipment. More than

4 hours is required before any critical equipment reaches temperatures that would compromise equipment functionality.

- EBS Start for an ATWS event: This operator action is assumed to be required in less than 30 minutes.

- RHR Restart after a LOCA in POS C: The RHR pumps may be required to trip on a LOCA due to low coolant level, therefore requiring a manual restart. Additionally if a significant LOCA occurs during shutdown, operator action may be required to manually trip the pumps (the LHSI pump trip on low RCS level is a non-safety function).

- LHSI Start after a loss of RHR in POS D: Provides inventory control after a loss of RHR during mid-loop.

- LHSI Start after a LOCA in POS D or E: Provides inventory control after a LOCA during POS with LHSI pumps not aligned for RHR.

- Open EFW suction crosstie valves to allow EFW inventory in EFW trains that are failed or unavailable to be utilized by EFW trains that are available (OPF-EFW-6H): There is ample time to perform the required action (greater than 6 hours when one train of EFW is available, and greater than 12 hours when 2 trains of EFW are available).

~~The following addresses the accident sequences, which reflect seismic fragilities of systems and equipment, non-seismic failure of equipment, and operator actions.~~

~~Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)Summary of Cutsets for Seismic Sequences with LOOP summarizes the S-LOOP cutsets; these are limiting with respect to the plant-level HCLPF capacity. These cutsets reflect the following contributions:~~

- ~~Seismic failure of AC power cabinets (event AC), I&C cabinets (event I&C), emergency diesels generators (event EDG), batteries (event BAT), ESW (event ESWS) or room cooling (event SAC) represent single element cutsets that limit the plant level HCLPF.~~

- ~~Seismic failure of emergency feedwater (event EFW) and failure of the operators to initiate feed-and-bleed cooling (event OPE-FB-90M) constitute the first two-element cutset.~~

- ~~Seismic failure of CCW (event CCWS) and a consequential RCP seal LOCA (event PROB SEAL LOCA) comprise the next two-element cutset.~~

- ~~The next two cutsets include two seismic failures and failure of an operator action. One of the operator actions is to perform fast cooldown (failure event OPE-FCD-40M) to permit injection by LHSI following a seal LOCA and MHSI failure, and the other is to initiate feed-and-bleed cooling (event OPE-FB-40M).~~

- ~~The last three cutsets include seismic failure of emergency feedwater (event EFW) and non-seismic failures of equipment and failure of operator action.~~

~~The seismic SLOCA results are similar to those presented in Table 19.1-37 for seismic LOOP sequences. These cutsets also include two types of single-element cutsets that reflect seismic failures; these include failure of CCWS and failure of LHSI. Either failure results in a loss of IRWST cooling, which is required in the long term following a LOCA. Since the HCLPF for the SLOCA initiating event is much higher than that for LOOP, these sequences are less significant and are not discussed further.~~

~~The S-LOOP event tree includes a transfer to the ATWS event tree for scenarios involving failure of the reactor to trip. All ATWS cutsets include seismically induced binding of the control rods, such that they failed to insert. The most important cutset includes operator failure to initiate the EBS, which results in core damage. Since seismic failures leading to ATWS have capacities greater than the SME, these are not discussed further.~~

19.1.5.1.2.4 Key Assumptions and Insights

Assumptions and insights from the PRA-based seismic margin assessment are as follows:

- Plant level HCLPF – Based on the seismic margin assessment , it is concluded that the U.S. EPR HCLPF capacity will be equal to or greater than 1.67 times the CSDRS (0.5g pga). This conclusion is dependent on achieving the HCLPF commitments in Table 19.1-106 and additional activities after Design Certification as discussed in ISG-020.

- Seismic PRA model – The SMA analysis considers seismically induced LOOP, SLOCA, MLOCA, LLOCA, ATWS, and various shutdown initiating events. Equipment and structures that are not seismically qualified are not credited in the model. This treatment is judged conservative for a seismic margin assessment because of inherent seismic capacity and ruggedness that exists in non-seismic structures and equipment.

- The operator is important in protecting against a seismic event in shutdown conditions when the low pressure reducing station is in service (especially in reduced inventory conditions such as mid-loop). The automatic signal that closes the reducing valves on low RCS level is a non-safety signal, and the valves that are typically utilized to control letdown flow through the low pressure reducing station (the low pressure reducing station valves) are provided with a power supply that is not seismically qualified such that a significant seismic event will require operator action to isolate the LP reducing station, and will disable the equipment that is typically utilized to isolate low pressure reducing station flow. Therefore, a seismic event could both cause an uncontrolled level drop event, result in failure of the I&C control signals (the low RCS level signal that automatically closes the low pressure reducing valves is a non-class signal), and significantly degrades the ability of operations staff to respond to the event.

- ~~Plant level HCLPF – Based on the seismic margin assessment performed, the plant level HCLPF capacity is greater than SME, not including an analysis of soil effects.~~
- ~~Seismic PRA model – The seismic PRA models seismically induced LOOP, SLOCA, MLOCA, LLOCA, ATWS, and shutdown initiating events. Equipment and structures that are not seismically qualified are not credited in the model. This treatment is judged conservative for a seismic margin assessment because of inherent seismic capacity and ruggedness that exists in non-seismic structures and equipment.~~

A COL applicant that references the U.S. EPR design certification will confirm that the U.S. EPR PRA-based seismic margin assessment is bounding for their specific site, and will update it to include site-specific SSC and soil effects (including sliding, overturning liquefaction and slope failure).

19.1.5.1.2.5 Sensitivities and Uncertainties

Uncertainties are taken into account explicitly in the fragility development and in evaluating non-seismic failures of equipment. Because the seismic margin assessment is primarily qualitative, no sensitivity studies are conducted.

19.1.5.2 Internal Flooding Risk Evaluation

19.1.5.2.1 Description of Internal Flooding Risk Evaluation

19.1.5.2.1.1 Methodology

Based on good spatial separation between safety buildings containing safety trains in the U.S. EPR, a bounding internal flooding analysis method is used to evaluate risk from the internal flooding events. The aim of this bounding analysis is to show that the CDF/LRF, as a result of a more detailed internal flooding evaluation, will not change the conclusion that the overall CDF/LRF meets the U.S. EPR design objective.

The bounding internal flooding analysis method implies that the floods are analyzed for the entire building, that the worst PRA scenario resulting from the failure of all SSC in the building is modeled, and that the total building flooding frequency is applied to that scenario. Based on this approach, for each building containing SSC credited in the PRA, the internal flooding evaluation is performed in the following steps:

- Calculate flooding frequency based on the flooding sources and piping segments. Where detailed design information is not available, use conservative estimates of flooding frequency from available industry references.
- Analyze possible flooding scenarios for each location and, based on the PRA model, select the worst scenario.

47. NUREG-1524, "A Reassessment of the Potential for an Alpha-Mode Containment Failure and a Review of the Current Understanding of Broader Fuel Coolant Interaction Issues: Second Steam Explosion Review Work Group Workshop," U.S. Nuclear Regulatory Commission, 1996.

48. Deleted.

49. Deleted.

50. Deleted.

51. Deleted.

52. Deleted.

53. Deleted.

54. EMF-2110(NP)(A), Revision 1, "TELEPERM XS: A Digital Reactor Protection System," Siemens Power Corporation, July 2000.

55. IEC-62340, "Nuclear Power Plants – Instrumentation and Control Systems Important to Safety – Requirements to Cope with Common Cause failure (CCF)," Edition 1.0, International Electrotechnical Commission, 12-7-2007.

56. IEC-60880, "Nuclear Power Plants – Instrumentation and Control Systems Important to Safety – Software Aspects for Computer-Based Systems Performing Category A Functions," Edition 2.0, International Electrotechnical Commission, 5-9-2006.

57. IEC-61508, "Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems," International Electrotechnical Commission.

58. ANP-10304, Revision 5, "U.S. EPR Diversity and Defense-in-Depth Assessment Technical Report," AREVA NP Inc., May 2012.

59. ANP-10290, Revision 1, "Environmental Report Standard Design Certification," AREVA NP Inc., September 2009.

60. DC-COL-ISG-020, "Interim Staff Guidance on Implementation of a Probabilistic Risk Assessment-Based Seismic Margin Analysis for New Reactors."

61. ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008: Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications."

62. Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of PRA Results for Risk-Informed Activities, Rev 2, March 2009.

63. EPRI, "Seismic Fragility Application Guide," EPRI Report 1002988, Palo Alto.

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
Sheet 1 of 15

Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
LOOP	AC	---	---	No secondary cooling (SC) and F&B
LOOP	I&C	---	---	No automatic actuation or instrumentation for operators (including no auto-start of the EDGs)
LOOP	EDG	---	---	No AC power
LOOP	DC	---	---	No DC (fails diesels)
LOOP	ESWS	---	---	No service water (fails diesels)
LOOP	1EUPS	---	---	EFW fails due to loss of power to the SG level control valves, PSRVs are also dependent on 1EUPS so feed and bleed also fails
LOOP	HVAC (SAC)	---	OPF-SAC-2H	No room cooling (fails AC & I&C)
LOOP	EFW	---	OPE-FB-90M	Secondary Cooling (SC) failure (EFW) and operator fails F&B
LOOP	CCWS	PROB SEAL LOCA	---	CCWS challenges RCP seals, seal LOCA occurs (0.2 probability) and there is no IRWST cooling.
LOOP	CCWS	QKA40 PM4 "OR" EDG 4 fails to start/run	OPF-EFW-6H OPF-SAC-2H	Loss of HVAC results in loss of divisions 3 and 4, EFW fails long-term as EFW Pools 1 and 2 eventually deplete, Feed and Bleed fails due to loss of divisions 3 and 4.
LOOP	---	CCWS/ESWS PM2 and EDG1, EDG3 or EDG4 fails to start/ run,	OPF-EFW-6H	EFW fails long term as 2 EDGs fail and operator fails to align stranded EFW inventory to an operable train; Feed and Bleed fails due to loss of power to one or more PSRVs
LOOP	---	CCWS/ESWS PM3 and EDG1, EDG2 or EDG4 fails to start/ run,	OPF-EFW-6H	EFW fails long term as 2 EDGs fail and operator fails to align stranded EFW inventory to an operable train; Feed and Bleed fails due to loss of power to one or more PSRVs

All indicated changes are in response to RAI 455, Question19-341

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~

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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
LOOP	EFW	Any EDG fails to run/start	---	EFW fails due to the seismic event and single EDG failure and operator failure results in loss of DC at two hours which fails one or more PSVs which fails feed and Bleed (F&B)
LOOP	CCWS	EDG1 fails to start/run	OPF-EFW-6H OPF-SAC-2H	Loss of HVAC results in loss of divisions 1 and 2, EFW fails long-term as EFW Pools 3 and 4 eventually deplete, Feed and Bleed fails due to loss of divisions 1 and 2.
LOOP	---	EDG1 fails to start/run and QKA20 PM2	OPF-EFW-6H OPF-SAC-2H	EDG and HVAC faults result in loss of divisions 1 and 2, EFW fails long-term as EFW Pools 3 and 4 eventually deplete, Feed and Bleed fails due to loss of divisions 1 and 2.
LOOP	---	EDG3 fails to start/run and QKA40 PM4	OPF-EFW-6H OPF-SAC-2H	EDG and HVAC faults result in loss of divisions 3 and 4, EFW fails long-term as EFW Pools 1 and 2 eventually deplete, Feed and Bleed fails due to loss of divisions 3 and 4.
LOOP	---	(EDG1 or EDG2 fails) and (EDG3 or EDG4 fails)	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
LOOP	---	(EDG1 and EDG2) or (EDG 3 and EDG4)	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
LOOP	---	EDG1 fails and maintenance unavailability of an EDG or EFW pump in divisions 2,3 or 4	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
LOOP	---	EDG2 fails and maintenance unavailability of an EDG or EFW pump in divisions 1,3 or 4	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~

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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
LOOP	---	EDG3 fails and maintenance unavailability of an EDG or EFW pump in divisions 1,2 or 4	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
LOOP	---	EDG4 fails and maintenance unavailability of an EDG or EFW pump in divisions 1,2,or 3	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
LOOP	RT	---	OPF-EBS-30M-	No reactivity control. LOOP is not a limiting ATWS event and therefore it is recommended that RT (and maintenance of core geometry) be considered as an important function for seismic events (SMA and/or SPRA).
ILOOP	I&C	---	OPF-RT-6M	Reactor Trip Fails due to seismically induced I&C failures, and no power (EDG start dependent on Protection System)
LOOP	DC	---	OPF-RT-6M	Reactor Trip Fails due to seismically induced DC failures (loss of power to RPS), and no power to support accident mitigation (EDG start and load dependent on DC)
SLOCA	AC	---	---	No secondary cooling (SC) and F&B
SLOCA	I&C	---	---	No automatic actuation or instrumentation for operators (including no auto-start of the EDGs)
SLOCA	EDG	---	---	Fails all AC power (ESWS and CCWS)
SLOCA	DC	---	---	No DC (fails diesels)
SLOCA	ESWS	---	---	Fails EDGs (and AC power since offsite power and SBO DGs are assumed unavailable)
SLOCA	SAC	---	OPF-SAC-2H	No room cooling (fails AC & I&C)

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
Sheet 4 of 15

Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
SLOCA	CCWS	---	---	Fails MHSI and containment heat removal
SLOCA	LHSI	---	---	Containment heat removal fails due to LHSI failure (SAHRS fails due to non-seismic).
SLOCA	EFW or MSRT	---	OPE-FB-40M	PCD failure (EFW or MSRT) and operator fails F&B
SLOCA	MHSI	---	OPE-FCD-40M	PCD success, but MHSI fails and operators fail fast cooldown (FCD)
SLOCA	1EUPS	---	---	Fails EFW, MSRTs and PSRVs
SLOCA	EFW	Any EDG fails to run/start	---	EFW fails due to the seismic event and F&B fails due to loss of power to one or more PSVs.
SLOCA	MSRT	Any EDG fails to run/start	---	PCD fails due to MSRT failure, and F&B fails due to loss of power to one or more PSVs.
SLOCA	---	CCWS/ESWS PM2 "AND" (EDG1, EDG3 or EDG4 fails to start/run)	OPF-EFW-6H	EFW fails long term as 2 EDGs fail and operator fails to align stranded EFW inventory to an operable train; Feed and Bleed fails due to loss of power to one or more PSRVs
SLOCA	---	CCWS/ESWS PM3 "AND" (EDG1, EDG2 or EDG4 fails to start/run)	OPF-EFW-6H	EFW fails long term as 2 EDGs fail and operator fails to align stranded EFW inventory to an operable train; Feed and Bleed fails due to loss of power to one or more PSRVs
SLOCA	---	EDG1 fails to start/run and QKA20 PM2	OPF-EFW-6H OPF-SAC-2H	EDG and HVAC faults result in loss of divisions 1 and 2, EFW fails long-term as EFW Pools 3 and 4 eventually deplete, Feed and Bleed fails due to loss of divisions 1 and 2.
SLOCA	---	EDG3 fails to start/run and QKA40 PM4	OPF-EFW-6H OPF-SAC-2H	EDG and HVAC faults result in loss of divisions 3 and 4, EFW fails long-term as EFW Pools 1 and 2 eventually deplete, Feed and Bleed fails due to loss of divisions 3 and 4.

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~

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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
SLOCA	---	(EDG1 or EDG2 fails) and (EDG3 or EDG4 fails)	---	MSRTs fail as they have a long term dependency on power (and need train 1 &2 or 3&4 power). F&B fails due to loss of power to one or more PSVs.
SLOCA	---	(EDG1 and EDG2) or (EDG 3 and EDG4)	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
SLOCA	---	EDG1 fails and maintenance unavailability of an EDG or EFW pump in divisions 2,3 or 4	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
SLOCA	---	EDG2 fails and maintenance unavailability of an EDG or EFW pump in divisions 1,3 or 4	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
SLOCA	---	EDG3 fails and maintenance unavailability of an EDG or EFW pump in divisions 1,2 or 4	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
SLOCA	---	EDG4 fails and maintenance unavailability of an EDG or EFW pump in divisions 1,2,or 3	OPF-EFW-6H	EFW fails long term due to depletion of pools for operable EFW pumps due to operator inaction; F&B fails due to loss of power to one or more PSVs
MLOCA	AC	---	---	No AC power results in failure of secondary cooling (SC) and F&B
MLOCA	I&C	---	---	No automatic actuation or instrumentation for operators (including no auto-start of the EDGs)
MLOCA	EDG	---	---	Fails all AC power
MLOCA	DC	---	---	No DC (fails diesels)

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~

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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
MLOCA	ESWS	---	---	Fails EDGs (and AC power since offsite power and SBO DGs are assumed unavailable)
MLOCA	SAC	---	OPF-SAC-2H	No room cooling (fails AC & I&C)
MLOCA	CCWS	---	---	Fails MHSI and containment heat removal
MLOCA	LHSI	---	---	Containment heat removal fails due to LHSI failure (SAHRS fails due to non-seismic).
MLOCA	MHSI	---	OPE-FCD-30M	PCD success, but MHSI fails and fast cooldown (FCD) fails due to operator inaction
MLOCA	1EUPS	---	---	Fails MSRTs and PSVs
MLOCA	MSRT	---	OPE-FB-30M	PCD fails due to MSRT failure, and F&B fails due to operator inaction
MLOCA	MSRT	Any EDG fails to run/start	---	PCD fails due to MSRT failure, and F&B fails due to loss of power to one or more PSVs.
MLOCA	---	(EDG1 and EDG2) or (EDG 3 and EDG4)	---	MSRTs fail as they have a long term dependency on power (and need train 1 &2 or 3&4 power). F&B fails due to loss of power to one or more PSVs.
LLOCA	AC	---	---	No AC power results in failure of secondary cooling (SC) and F&B
LLOCA	I&C	---	---	No automatic actuation or instrumentation for operators (including no auto-start of the EDGs)
LLOCA	EDG	---	---	Fails all AC power
LLOCA	DC	---	---	No DC (fails diesels)
LLOCA	ESWS	---	---	Fails EDGs (and AC power since offsite power and SBO DGs are assumed unavailable)

All indicated changes are in response to RAI 455, Question19-341

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
LLOCA	SAC	---	OPF-SAC-2H	No room cooling (fails AC & I&C)
LLOCA	CCWS	---	---	Fails containment heat removal (two LHSI are cooled by SCWS)
LLOCA	ACC	---	---	LLOCA requires accumulators
LLOCA	LHSI	---	---	RCS inventory control and Containment heat removal fails due to LHSI failure.
LLOCA	---	EDG2 and EDG3 both fail to start/run "OR" EDG2 or EDG 3 both fail due to one unavailable for maintenance and the other fails due to start/run	---	For Large LOCA the PRA model assumes that trains 1 and 4 are ineffective (one directly from flow diversion via the break and the adjacent train from steam entrainment). Therefore failures of LHSI 2 and 3 results in inadequate RCS inventory control.
IE SD RHR (POS C)	AC or DC or EDG or ESWS	---	---	Station Blackout
IE SD RHR (POS C)	I&C	---	---	No automatic actuation or instrumentation for operators
IE SD RHR (POS C)	SAC	---	OPF-SAC-2H	Loss of HVAC event eventually morphs into a loss of all AC power event if operator action is not credited
IE SD RHR (POS C)	CCWS	PROB SEAL LOCA	---	RHR fails on loss of CCW, and if seal LOCA occurs LTC is guaranteed failure (due to CCW failure).
IE SD RHR (POS C)	CCWS or LHSI	Any DG fail to run	OPF-EFW-6H	RHR Fails due to LHSI or CCWS seismic failure, EFW fails due to inadequate inventory (one EDF and OPF-EFW-6H), Primary Bleed Fails due to EDG failure (DRVs assumed unavailable due to non-seismic design).

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
Sheet 8 of 15

Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD RHR (POS C)	CCWS	EDG1 fail to run	OPF-SAC-2H	RHR Fails due to CCWS seismic failure, EFW1 fails due to power failure, EFW2 failed by loss of HVAC SB2 (QKA10 failed by power, QKA20 failed by loss of CCW, and alternate HVAC failed by OPF-SAC-2H)), EFW3 and 4 assumed unavailable for maintenance, and FB is guaranteed failure (DRVs and at least 1 PSV failed)
IE SD RHR (POS C)	---	EDG2 and EDG3	OPF-RHR-Cau (state Cau) "OR" OPF-RHR-Cbu (State Cbu)	In operating states with two RHR pumps initially operating (Cbu, Cau) failure of EDG2 and 3 fails the two operating RHR pumps, EFW fails due to failure of the MSRTs when class batteries 2 and 3 deplete, and bleed is failed due to insufficient PSRVs)
IE SD RHR (POS D)	AC or DC or EDG or ESWS	---	---	Station Blackout
IE SD RHR (POS D)	I&C	---	---	No automatic actuation or instrumentation for operators
IE SD RHR (POS D)	CCWS	---	OPF-LHSIRHR	Loss of MHSI (due to failure of CCW) and failure to start LHSI results in inadequate RCS inventory control
IE SD LOCA (POS C)	AC or DC or EDG or ESWS	---	---	Station Blackout
IE SD LOCA (POS C)	I&C	---	---	No automatic actuation or instrumentation for operators
IE SD LOCA (POS C)	CCWS	---	---	Failure of CCW results in failure of MHSI and although LHSI is successful CHR is unavailable (SAHRS unavailable due to non-seismic).

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~

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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD LOCA (POS C)	LHSI	---	---	Although RCS inventory control can be achieved with MHSI success, containment heat removal requires LHSI for success (SAHRS assumed failed for seismic event).
IE SD LOCA (POS C)	SAC	---	OPF-SAC-2H	Loss of HVAC event eventually morphs into a loss of all AC power event if operator action is not credited
IE SD LOCA (POS C)	EFW or MSRT	---	OPF-RHRLOCA-Cxx and OPF-FB-Cxx	Failure to restart RHR after a LOCA, failure to start feed and bleed, and failure of EFW or MSRT causes loss of secondary cooling (Note 2)
IE SD LOCA (POS C)	MHSI	---	OPF-FB-Cxx (Note 5)	Failure of MHSI on small LOCA event tree requires feed and bleed utilizing LHSI which fails due to operator error (Note 2)
IE SD LOCA (POS C)	1EUPS	---	OPF-RHRLOCA-Cxx	Small LOCA, RHR fails due to operator error, and failure of the 1EUPS results in failure of EFW (via MSRTS) and failure of feed and bleed (PSRVs require 1EUPS power). Note (2)
IE SD LOCA (POS C)	---	One EDG fails to start/run (Note 3)	OPF-EFW-6H OPD-EFWRF/XTIE OPF-RHRLOCA-Cxx	Small LOCA with 1 EDG failure, the operators fails to supply the EFW inventory in the failed train to an operating pump resulting in long term failure of EFW, RHR cooling fails due to operator inaction,
IE SD LOCA (POS C)	---	One EFW pump fails to start/run (Note 4)	OPF-EFW-6H OPD-EFWRF/XTIE OPF-RHRLOCA-Cxx OPE-FB-Cxx	Small LOCA with 1 EFW failure, the operators fail to supply the EFW inventory in the failed train to an operating pump resulting in long term failure of EFW, and RHR and Feed and Bleed fail due to operator inaction,

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~

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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD LOCA (POS C)	MHSI	One EDG fails to start/run (Note 3)	---	Failure of MHSI on small LOCA event tree requires feed and bleed utilizing LHSI which fails due to loss of power to one or more PSVs
IE SD LOCA (POS C)	EFW or MSRT	One EDG fails to start/run (Note 3)	OPE-RHRLOCA-Cxx	Failure to restart RHR after a small LOCA, failure of EFW or MSRT causes loss of secondary cooling and feed and bleed fails due to loss of power to one or more PSVs
IE SD LOCA (POS C)	---	(EDG1 or EDG2 fails) and (EDG3 or EDG4 fails)	OPE-RHRLOCA-Cxx	Failure to restart RHR after a small LOCA, the MSRTs fail due to the EDG failures resulting in loss of secondary cooling, and feed and bleed fails due to loss of power to one or more PSVs
IE SD LOCA (POS C)	---	EDG1 and EDG2	OPE-RHRLOCA-Cxx	Failure to restart RHR after a small LOCA, Both EFW pumps that are credited in the shutdown analysis fail due to loss of power resulting in loss of secondary cooling, and feed and bleed fails due to loss of power to one or more PSVs
IE SD LOCA (POS D/E)	AC or DC or EDG or ESWS	---	---	Station Blackout
IE SD LOCA (POS D/E)	I&C	---	---	No automatic actuation or instrumentation for operators
IE SD LOCA (POS D/E)	SAC	---	OPF-SAC-2H	Loss of HVAC event eventually morphs into a loss of all AC power event if operator action is not credited
IE SD LOCA (POS D/E)	CCWS or MHSI	---	OPF-LHSILO-xx	Loss of MHSI (due to either loss of CCW or MHSI) and failure to start LHSI results in inadequate RCS inventory control

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
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Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD ULD C	---	---	OPF-ISOCSLPRS-CR	Operator action is required to terminate the draindown following a seismic event (automatic actuation is non-safety and non-seismic).
IE SD ULD C	AC or DC or EDG or ESWS	---	---	Station Blackout
IE SD ULD C	I&C	---	---	No automatic actuation or instrumentation for operators
IE SD ULD C	CCWS	---	---	Failure of CCW results in failure of MHSI and although LHSI is successful CHR is unavailable (SAHRS unavailable due to non-seismic).
IE SD ULD C	SAC	---	OPF-SAC-2H	Loss of HVAC event eventually morphs into a loss of all AC power event if operator action is not credited
IE SD ULD C	EFW or MSRT	---	OPF-RHRULD-Cbd and OPF-FB-Cbd	Failure to restart RHR after a ULD, failure to start feed and bleed, and failure of EFW or MSRT causes loss of secondary cooling (Note 2)
IE SD ULD C	MHSI	---	OPF-FB-Cbd	Failure of MHSI requires feed and bleed utilizing LHSI which fails due to operator error (Note 2)
IE SD ULD C	1EUPS	---	OPF-RHRULD-Cbd	RHR fails due to operator error, and failure of the 1EUPS results in failure of EFW (via MSRTS) and failure of feed and bleed (PSRVs require 1EUPS power). Note (2)
IE SD ULD C	---	One EDG fails to start/run (Note 3)	OPF-EFW-6H OPD-EFWRF/XTIE OPF-RHRULD-Cbd	ULD with 1 EDG failure, the operators fails to supply the EFW inventory in the failed train to an operating pump resulting in long term failure of EFW, RHR cooling fails due to operator inaction,

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
Sheet 12 of 15

Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD ULD C	---	One EFW pump fails to start/ run (Note 4)	OPF-EFW-6H OPD-EFWRF/ XTIE OPF-RHRULD-Cbd OPE-FB-Cbd	ULD with 1 EFW failure, the operators fail to supply the EFW inventory in the failed train to an operating pump resulting in long term failure of EFW, and RHR and Feed and Bleed fail due to operator inaction.
IE SD ULD C	MHSI	One EDG fails to start/run (Note 3)	---	Failure of MHSI after a ULD event requires feed and bleed which fails due to loss of power to one or more PSVs
IE SD ULD C	EFW or MSRT	One EDG fails to start/run (Note 3)	OPE-RHRULD-Cbd	Failure to restart RHR after a ULD, failure of EFW or MSRT causes loss of secondary cooling and feed and bleed fails due to loss of power to one or more PSVs
IE SD ULD C	LHSI	Any EDG Fail to Run	OPF-EFW-6H OPD-EFWRF/ XTIE	RHR fails due to seismic induced failure of LHSI/RHR pumps, the operators fails to supply the EFW inventory in the failed train to an operating EFW pump resulting in long term failure of EFW, and feed and bleed fails due to loss of power to one or more PSRVs.
IE SD ULD C	---	(EDG1 or EDG2 fails) and (EDG3 or EDG4 fails)	OPE-RHRULD-Cbd	Failure to restart RHR after a small LOCA, the MSRTs fail due to the EDG failures resulting in loss of secondary cooling, and feed and bleed fails due to loss of power to one or more PSVs
IE SD ULD C	---	EDG1 and EDG2	OPE-RHRULD-Cbd	Failure to restart RHR after a ULD, Both EFW pumps that are credited in the shutdown analysis fail due to loss of power resulting in loss of secondary cooling, and feed and bleed fails due to loss of power to one or more PSVs

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~

Sheet 13 of 15

Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD ULD C	1EUPS	EDG3	OPE-ISOCSLPRS-L	Isolation of CVCS reducing station, and isolation of RHR train 3 fails due to 1EUPS and EDG3 failure, and local isolation of CVCS piping fails
IE SD ULD C		EDG3 and EDG4	OPF-SAC-2H OPE-ISOCSLPRS-L	HVAC fails in SB 3 and 4, results in failure to isolate letdown from the control room, and local isolation also fails (UPS powered isolation valves are conservatively modeled as depedendent on HVAC)
IE SD ULD C	1EUPS	EDG4	OPF-SAC-2H OPE-ISOCSLPRS-L	HVAC fails in SB 3 and 4, results in failure to isolate letdown from the control room, and local isolation also fails (UPS powered isolation valves are conservatively modeled as depedendent on HVAC)
IE SD ULD C	SAC	EDG2	OPF-EFW-6H OPD-EFWRF/XTIE	RHR trains 1 and 4 fail from loss of QKA, RHR 2 fails from loss of power and RHR 3 unavailable to allow RHR3 isolation to isolate CVCS break, , the operators fails to supply the EFW inventory in the failed train to an operating EFW pump resulting in long term failure of EFW, and feed and bleed fails due to loss of power to one or more PSRVs
IE SD ULD D	---	---	OPE-ISOCSLPRS-CR	Operator action is required to terminate the draindown following a seismic event (automatic actuation is non-safety and non-seismic).
IE SD ULD D	AC or DC or EDG or ESWS	---	-	Station Blackout
IE SD ULD D	I&C	---	-	No automatic actuation or instrumentation for operators
IE SD ULD D	SAC	---	OPF-SAC-2H	Loss of HVAC event eventually morphs into a loss of all AC power event if operator action is not credited

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
Sheet 14 of 15

Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD ULD D	CCWS or MHSI	---	OPF-LHSIULD-Du	Loss of MHSI (due to either loss of CCW or MHSI) and failure to start LHSI results in inadequate RCS inventory control
IE SD ULD D	1EUPS	EDG3	OPE-ISOCSLPRS-L	Isolation of CVCS reducing station, and isolation of RHR train 3 fails due to 1EUPS and EDG3 failure, and local isolation of CVCS piping fails
IE SD ULD D	CCWS	EDG4	OPF-SAC-2H OPE-ISOCSLPRS-L	HVAC fails in SB 3 and 4, results in failure to isolate letdown from the control room, and local isolation also fails (UPS powered isolation valves are conservatively modeled as dependent on HVAC)
IE SD ULD D		EDG3 and EDG4	OPF-SAC-2H OPE-ISOCSLPRS-L	HVAC fails in SB 3 and 4, results in failure to isolate letdown from the control room, and local isolation also fails (UPS powered isolation valves are conservatively modeled as dependent on HVAC)
IE SD ULD D	1EUPS	EDG4	OPF-SAC-2H OPE-ISOCSLPRS-L	HVAC fails in SB 3 and 4, results in failure to isolate letdown from the control room, and local isolation also fails (UPS powered isolation valves are conservatively modeled as dependent on HVAC)
IE SD ULD D	---	KBA14AA106EFC	OPE-ISOCSLPRS	RHR fails due to failure of the LP Reducing Station isolation valve to close, and operator inaction to close other isolation valves
IE SD RHR LOCA (POS C\D)	RHR piping	---	OPF-ISORHRBRK	In the event that the seismic 1 RHR piping fails due to the seismic event, operator action is required to manually isolate the break (auto isolation is a non-safety function). RHR piping break assumed in initiating event

Table 19.1-37—Summary of SMA Cutsets (from the at-power and shutdown PRA)~~Summary of Cutsets for Seismic Sequences with LOOP~~
Sheet 15 of 15

Initiating Event	Seismic Failures[1]	Random / Non-Seismic Failures	Operator Actions[5]	Description
IE SD RHR LOCA (POS C\D)	DC and RHR piping failure (assumed in initiating event)	---	---	DC seismic failure prevents start/load of the EDGs and fails the 1EUPS powered RHR isolation valve. RHR piping break assumed in initiating event.
IE SD RHR LOCA (POS C\D)	1EUPS and RHR piping failure assumed in IE	Failure of the EDG in the train with the ruptured RHR train	---	Seismic failure of the 1EUPS fails the UPS powered MOV, and the EDG failure results in failure to close the non-UPS powered MOV. RHR piping break assumed in initiating event.

~~Seismic Failures[1]~~	~~Non-Seismic Failures of Equipment~~	~~Human Failure Events~~	~~Description~~
~~AC~~	—	—	~~Total loss of AC power, leading to loss of secondary cooling and failure of feed and bleed cooling.~~
~~I&C~~	—	—	~~No auto actuation or instrumentation for operators.~~
~~EDG~~	—	—	~~Total loss of AC power, leading to loss of secondary cooling and failure of feed and bleed cooling.~~
~~BAT~~	—	—	~~Failure of DC power, causing unavailability of diesel generators, and total loss of AC power.~~
~~ESWS~~	—	—	~~Failure of ESW causing unavailability of diesel generators, and total loss of AC power.~~
~~SAC~~	—	—	~~Failure of room cooling, leading to total loss of AC power and failure of I&C.~~
~~EFW~~	—	~~OPE-FB-90M~~	~~Failure of secondary cooling due to seismic failure of EFW, and failure of operators to effect feed and bleed cooling.~~
~~CCWS~~	~~PROB SEAL LOCA~~	—	~~Seismic failure of CCWS causes loss of cooling for RCP seals, and a seal LOCA results. Unavailability of CCWS precludes cooling of IRWST.~~
~~SEAL LOCA and MHSI~~	—	~~OPE-FCD-40M~~	~~Seismically induced seal LOCA and failure of MHSI, with failure of the operators to perform a fast cooldown to permit use of LHSI.~~
~~SEAL LOCA and (MSRT or EFW)~~	—	~~OPE-FB-40M~~	~~Seismically induced seal LOCA and failure of secondary cooling, with failure of the operators to effect feed and bleed cooling.~~
~~EFW~~	~~EDG1or EDG2 or EDG3 or EDG4~~	~~OPF-XTDIV-NSC~~	~~Seismic failure of EFW and failure of an emergency diesel generator with failure of operator action to cross-tie AC division. Battery depleting causes loss of DC power at 2 hours, leading to closure of a PSV and failure of feed and bleed cooling.~~

~~Seismic Failures[1]~~	~~Non-Seismic Failures of Equipment~~	~~Human Failure Events~~	~~Description~~
~~EFW~~	~~CCWS/ESWS PM2 or CCWS/ESWS PM3~~	~~OPF-XTDIV-NSC~~	~~Seismic failure of EFW and failure of cooling for emergency diesel generator with failure of operator action to cross-tie AC division. Battery depletion causes loss of DC power at 2 hr, leading to closure of a PSV and failure of feed-and-bleed cooling. Note that CCWS/ESWS Divisions 1 and 4 have the same non-seismic failure impact as Divisions 2 and 3, but do not show up because they are assumed to be normally running in the model (no maintenance, PM).~~
~~EFW~~	~~SAC PM1 or SAC PM2 or SAC PM3 or SAC PM4~~	~~OPF-SAC-2H~~	~~Seismic failure of EFW and failure of room cooling, leading to loss of DC power at 2 hr, which causes the PSV to close, resulting in failure of feed-and-bleed cooling.~~

Note:

(1) Only single element seismic failure cutsets are shown except as required to show random equipment failure and human action failure contributions.

(2) For POS C the sequence results for operating state Cad are shown as representative (For operating states Cau, Cbd, Cbu the operators errors appropriate for those states are utilized in the accident sequence analysis rather than the Cad operator actions).

(3) Basic Events contributing to EDG failure in include EDG fail to start, EDG fail to run, ESW pump fail to start, offsite power supply breakers fail to open due to priority module fault, EDG circuit breaker fails to close due to priority module fault, and ESW pump breaker fails to close due to priority module fault.

(4) Basic Events contributing to EFW failure include EFW pump fail to start, EFW pump fail to run, EFW flow control valve fails to control flow, SG level control valve fails to control flow, flow control valve fails due to priority module fault, level control valve fails due to priority module fault, EFW pump fails due to priority module fault or EFW fails due to loss of HVAC (SAC fan priority module fault and OPF-SAC-2H).

(5) Where the cutsets for various states that are combined in Table 19.1-37 have essentially the same form except that they utilize separate basic event names such that differences in operator timing can be accounted for in the Shutdown PRA, the general form of the operator error basic event is shown. For example the 4 State C states (Cad, Cbd, Cau, and Cbu) have been combined into a single Table entry and the operator error OPF-FB-Cxx is utilized to represent OPF-FB-Cad, OPF-FB-Cbd, OPF-FB-Cau, or OPF-FB-Cbu depending on the operating state being evaluated. (For the SMA all operator errors have been set to 1.0, so all operator errors have the same basic event probability).

Table 19.1-106—SSC HCLPF Capacities
Sheet 1 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
Structures	
Reactor Containment Building	1.12
Reactor Shield Building	0.85
Reactor Building Internal Structure	0.73
Safeguard Building 1	0.54
Safeguard Building 4	0.59
Safeguard Buildings 2 & 3	0.57
Emergency Power Generating Buildings	0.75
Essential Service Water Pump Building (and Cooling Tower Structure)	0.62
Fuel Building	-
Vent Stack	0.54

Table 19.1-106—SSC HCLPF Capacities
Sheet 2 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
~~Containment & Annulus~~	~~0.5~~
~~Containment Penetrations (e.g., Piping, Hatches)~~	
~~Reactor Building Internal Structure~~	
~~IRWST~~	
~~Core Melt Retention Structure~~	
~~IRWST Drain Valve to Core Catcher~~	
~~Combustible Gas Control~~	
~~Reactor Cavity, Seal and Pools~~	
~~Fuel Transfer Tube~~	
~~Refuel Gates~~	
~~Refuel Machine~~e[1]	
~~Polar Crane~~[1]	
~~Safeguard Buildings 1 & 4~~	
~~Safeguard Buildings 2 & 3~~	
~~EFW Pools~~	
~~CCW Surge Tanks~~	
~~EBS Boric Acid Tanks~~	
~~Control Room & Ceiling~~	
~~Fuel Building~~	
~~Spent Fuel Pool~~	
~~Emergency Power Generating Buildings~~	
~~Cable Duct & Shaft~~	
~~Nuclear Auxiliary Building[1]~~	
~~Essential Service Water Cooling Tower Structure~~	
~~Essential Service Water Pump Building~~	

Table 19.1-106—SSC HCLPF Capacities
Sheet 3 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
Reactor Coolant System, Control Rods & Reactor Internals	
Reactor Vessel & Supports	0.5
Reactor Internals (do not prevent rod drop)	
Core Assemblies (do not prevent rod drop)	
Control Rod Drives (e.g., Guide Tubes)	
Steam Generators & Supports	
Reactor Coolant Pumps & Supports	
Pressurizer & Supports	
Pressurizer Relief Valves (JEF10AA191 including SOV JEF10AA717)	
Pressurizer Vent MOVs (JEF10AA501 and 502)	
Piping, Manual Valves, Check Valves	
Steam Generator Tubes including Tube to Tube Sheet Weld	
Secondary Coolant System	
Feedwater Piping downstream of FWIV	0.5
Main Steam Piping upstream of MSIV	
MSIVs ~~Oleo Pneumatic~~ (LBA10AA002 and SOVs LBA10AA712)	
FWIVs MOVs (LAB60AA002)	
High Range FWIVs Hydraulic-Pneumatic) ~~Full and Low Load Oleo Pneumatic~~ (LAB60AA001 and associated SOVs,) ~~LAB64AA102)~~	
Low Range Feedwater Control Valves (LAB64AA102)	
MSRVs Control MOV (LBA13AA101)	
MSRIVs Steam-Operated (LBA13AA001 and associated SOVs)	
MSSVs (LBA11AA191)	
Emergency Feedwater System	
Pumps (LAS11AP001)	0.5
Isolation MOVs (LAR11AA006)	
Flow Control Valves (LAR11AA105)	
Limitation Control Valves (LAR11AA103)	
Piping, Manual Valves, Check Valves	

Table 19.1-106—SSC HCLPF Capacities
Sheet 4 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
Medium Head Safety Injection	
Pumps (JND10AP001)	0.5
MOVs (JND10AA002 / 004 / 005)	
IRWST	
Piping, Manual Valves, Check Valves, Motor-Operated Check Valve	
Safety Injection Accumulators	
Accumulator (JNG13BB001)	0.5
Piping, MOV, Manual Valves, Check Valves	
Low Head Safety Injection / Residual Heat Removal	
Pumps (JNG10AP001)	0.5
Heat Exchangers (JNG10AC001)	
CCWS LHSI HX Supply Valve (KAA12AA005)	
MOVs (i.e. JNG, JNA10AA001, JNA10AA003, JNA10AA101)	
IRWST	
RHR system coolant purification isolation valves to the CVCS (JNA30AA004, JNA30AA103; JNA40A004,JNA40AA103)	
Piping, Safety, Manual & Check Valves, Motor-Operated Check Valve	
Extra Borating System	
Pumps (JDH10AP001 and JDH40AP001)	0.5
MOVs (i.e., JDH10AA006/008/015)	
Piping, Safety, Manual & Check Valves	
EBS Boric Acid Tanks	
Building Ventilation (e.g., Fans, Dampers, Ducts, Coolers, Filters)	
Component Cooling Water	
Pumps (KAA10AP001)	0.5
Heat Exchangers (KAA10AC001)	
MOVs (i.e., KAA10AA112, KAA12AA005/013)	
Common Header Supply and Return Valves (KAA10AA006/010/032/ 033)	
Piping, Safety, Manual & Check Valves	
NAB Isolation Valves (KAB50AA001,002and 004; KAB80AA015,016 and 019)	

Table 19.1-106—SSC HCLPF Capacities
Sheet 5 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
Essential Service Water	
ESWS Pumps ~~(PEB10AP001)~~ (PEB10AP001	0.5
MOVs (PEB10AA005~~.~~)	
Cooling Tower Fans & Equipment	
Piping, Manual Valves, Check Valves, Filters and Strainers	
Building Ventilation (e.g., Fans, Dampers, Ducts, Coolers, Filters)	
Emergency Diesels	
Diesel Generator and Controls (XJA10)	0.5
Fuel Oil Day Tanks	
Fuel Oil Storage Tanks	
Air Start Compressors (XJX10AN001)	
Air Start Receivers	
Diesel Heat Exchangers	
Building Ventilation (e.g., Fans, Dampers, Ducts, Coolers, Filters)	
Safeguards Building Ventilation	
Supply Fans (SAC01AN001)	0.5
Exhaust Fans (SAC31AN001)	
Chillers (QKA10AH112)	
Pumps (QKA10AP107)	
Motor-Operated Dampers (e.g., SAC31AA002)	
Piping, Ducting, Manual and Check Dampers (Valves QKA)	
EFW Ventilation Chiller (SAC01AH001)	
Control Room Emergency Ventilation	
Pre, HEPA, Carbon filters SAB11AT001, 2, 3, 4	0.5
Fan (SAB11AN001)	
Chiller Cooling Coil (SAB01AC001)	
Fan (SAB01AN001)	
HEPA Filter (SAB01AT005)	

Table 19.1-106—SSC HCLPF Capacities
Sheet 6 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
Fuel Pool Cooling	
Pumps (FAK11AP001, FAK12AP001, FAK21AP001, FAK22AP001)	0.5
Heat Exchangers (FAK10AC001, FAK20AC001)	
MOVs (FAK10AA601, FAK10AA001)	
Piping, Manual Valves, Check Valves	
Building Ventilation (e.g., Fans, Dampers, Ducts, Coolers, Filters)	
Emergency AC & DC	
~~6.9 kV Switchgear (31BDA, BDB, BDC)~~Electrical Change 6.9kv switchgear (31BDA,BDB,BDC,BDD)	0.5
Transformers (31BMT01, 02, 03, 04)	
Transformer, Voltage-Regulated (31BNT01)	
4~~80 V Load Center (31BMA, B, C)~~480 V Load Center Chnage (31BMB, BMC, BMD)	
480 V MCC (31BNB01, 31BNB02, 31BNB03, 31BNA01, 31BNA02, 31BNC01, 31BND01)	
480 V Uninterruptible MCC (31BRA)	
Electrical Panel Boards (e.g., 120V AC Panelboards Associated with Equipment Credited in the SMA)	
Batteries & Racks (31BTD01)	
Chargers (31BTP01, BTP02)	
Inverters with Electronic Bypass Switch in Same Cabinet (31BRU01)	
AC/DC Converters & DC power supplies (BRV, BRW)	
EDG Breaker (Qualified as Part of Cabinet)	
Cable Trays (Associated with Equipment Credited in the SMA)	
Miscellaneous Equipment	
Containment Penetrations (e.g., Piping, Hatches)	0.5g
Reactor Cavity, Seal and Pools	
Fuel Transfer Tube	
Refuel Gates	
Refuel Machine[1]	
Polar Crane[1]	
Control Room & Ceiling	
Cable Duct & Shaft	
Nuclear Auxiliary Building[1]	

Table 19.1-106—SSC HCLPF Capacities
Sheet 7 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
I&C / Relays / Sensor & Transmitters	
Steam Generator Level (JEA10CL809/10/11/12)	0.5
Steam Generator Pressure (LBA10CP811/21/31/41)	
Pressurizer Pressure (JEF10CP801/03/05/07)	
Pressurizer Level (JEF10CL802/04/06/08)	
Steamline Activity (30LBA10CR811)	
EFW Pump Flow (LAR11CF801)	
RCP Speed	
Cold Leg Temperature Elements (JEB10CT811)	
Hot Leg Temperature Elements (JEB10CT805)	
RCS Loop Level	
Self-Powered Neutron Sensor	
RCCA Rod Position Reactor Trip Check Back (CRDM)	
Reactor Protection Cabinets, Racks, Modules, Fiber Optics (TXS)	
Reactor Trip Cabinets (Breakers, Contactors) (TXS)	
PACS Cabinets (ESF, Priority Module Actuators, Solid State Modules) (TXS)	
SAS Cabinets (EFW, RHR Controls) (TXS)	
RCSL Cabinets (Reactor Control) (TXS)	
SICS (Backup to PICS – Solid State Display) (TXS)	
Incore Instrumentation and Cabinets (TXS)	
Excore Instrumentation and Cabinets (TXS)	
Rodpilot Cabinets (TXS)	
Radiation Monitoring Sensors, Skids, Cabinets (TXS, T3000)	
Instrumentation (Operator Support Other than Above Sensors)	
LHSI Heat Exchanger Temperature (JNG10CT001 and 002)	
ESWS Flow Rate (PEB10CF001)	
CCWS Flow Rate (KAA10CF023)	
CCWS Temperature (KAA10CT092/93)	
CCWS / ESWS Start (KAA10EC001)	
EFW Flow to Steam Generator (LAR11CF802)	
EFW Pool Level (LAR10CL001)	

Table 19.1-106—SSC HCLPF Capacities
Sheet 8 of 8

SSC as a Function of Event Tree Node[2]	HCLPF (g) (pga)
Containment Systems and Containment Isolation (CI) Valves	
Core Melt Retention Structure	0.5
Passive flooding line to the core melt stabilization system (CMSS) up to and including MOV JMQ42AA004/006	
Combustible Gas Control (Including the Passive Autocatalytic Recombiners)	
Ventilation (KLA10AA001, 003 etc including SOVs)	
~~Gaseous Waste (e.g., KPL84AA003 and 003)~~ Gaseous Waste (e.g., KPL84AA002, and 003)	
Reactor Building Primary Drain (e.g., KTA10AA017 and 018)	
Containment Area Sump, Floor Drain (e.g., KTC10AA005 and 006)	
Leakage Monitoring (e.g., JMM10AA006 and 007)	
Letdown Isolation Valves (e.g., KBA14AA002 and 003)	
Steam Generator Blowdown (LCQ10AA003, LCQ51AA002 and 003, LCQ52AA001 and 002)	

Notes:

1. The HCLPF capacity of this SSC is the capacity to not disable the safety functions of SSC credited in the PRA-based SMA. This SSC is not credited in the PRA-based SMA.

2. Train 1 Component IDs are listed as representative.

Table 19.1-107—Deleted

Figure 19.1-31—Deleted~~Seismic Margin Earthquake for Soft, Medium, Hard and High Frequency Soil Sites~~