## ArevaEPRDCPEm Resource

**From:** WILLIFORD Dennis (AREVA) [Dennis.Williford@areva.com]
**Sent:** Friday, June 24, 2011 11:20 AM
**To:** Tesfaye, Getachew
**Cc:** BENNETT Kathy (AREVA); DELANO Karen (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); NOXON David (AREVA)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 3
**Attachments:** RAI 455 Supplement 3 Response US EPR DC - INTERIM.pdf

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:** 3157

**Mail Envelope Properties** (2FBE1051AEB2E748A0F98DF9EEE5A5D47AEF16)

**Subject:** Response to U.S. EPR Design Certification Application RAI No. 455, FSARCh. 19, OPEN ITEM, Supplement 3
**Sent Date:** 6/24/2011 11:20:09 AM
**Received Date:** 6/24/2011 11:21:44 AM
**From:** WILLIFORD Dennis (AREVA)

**Created By:** Dennis.Williford@areva.com

**Recipients:**
"BENNETT Kathy (AREVA)" <Kathy.Bennett@areva.com>
Tracking Status: None
"DELANO Karen (AREVA)" <Karen.Delano@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
"NOXON David (AREVA)" <David.Noxon@areva.com>
Tracking Status: None
"Tesfaye, Getachew" <Getachew.Tesfaye@nrc.gov>
Tracking Status: None

**Post Office:** auscharmx02.adom.ad.corp

| **Files** | **Size** | **Date & Time** |
|---|---|---|
| MESSAGE | 6080 | 6/24/2011 11:21:44 AM |
| RAI 455 Supplement 3 Response US EPR DC - INTERIM.pdf | | 803962 |

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

**Response to**

**Request for Additional Information No. 455(4911), Revision 0, Supplement 3**

**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:**

LOCA of various sizes are considered in the U.S. EPR PRA-based SMA. This includes small LOCA (SLOCA), medium LOCA (MLOCA) and large LOCA (LLOCA) initiating events. MLOCA and LLOCA seismic cutsets identify no additional seismic equipment list (SEL) equipment or operator actions. The SEL already includes equipment that could rupture causing an MLOCA or LLOCA. This includes reactor vessel supports, reactor coolant pump supports, steam generator supports, pressurizer, and reactor coolant system piping as shown in U.S. EPR FSAR Tier 2, Table 19.1-106.

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. In response to the RAI, AREVA NP will revise U.S. EPR FSAR Tier 2, Figure 19.1-31 to show the CSDRS that include the high-frequency hard rock spectra.

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.

A total of eight soil-structure interaction (SSI) analysis cases are considered for the U.S. EPR NI structures for different soil and rock conditions. Five of these are encompassed by the EUR design spectra for soft, medium, and hard soil conditions; and three are associated with the HF design spectra. A total of 16 SSI analyses are performed (i.e., eight different site conditions with uncracked and cracked concrete cases considered for each of the eight cases). Enveloping responses of all 16 SSI analyses are considered for the design of the NI structures, systems and components (SSC). Seismic fragility calculations of the NI structures will be performed using the enveloping global responses.

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, $\beta_R$ and $\beta_U$ 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 of the 16 SSI analyses is used in the seismic fragility derivation, this seismic margin is applicable to all four spectral shapes of the CSDRS

Figure 19-341-02 shows plots of the EUR control motion anchored to 0.3 g, the horizontal HF, target seismic margin earthquake (i.e.,1.67*CSDRS), and calculated seismic margin earthquake of Safeguard Building 1. The HCLPF of the Safeguard Building 1 west wall (No. 6) in the NI structure is 0.65 g, PGA>0.5 g goal, at a combined standard deviation of $\beta_c = 0.44$. 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 SSC seismic fragilities using the U.S. EPR CSDRS, and U.S EPR FSAR Tier 2 Table 19.1-107 will be deleted.

U.S. EPR FSAR Tier 2, Table 19.1-106 contains the SEL developed from the PRA event tree. Therefore, it is the list of equipment for which HCLPF values are needed. For structures on the SEL, HCLPF values will be calculated to support the design certification application.

For components on the SEL, the actual PRA-based SMA of equipment and components will not be known until the equipment is procured. U.S. EPR FSAR Tier 2, Table 19.1-106 provides the minimum required reasonably achievable HCLPF capacities for these components to be confirmed by the COL applicant. No generic data (e.g., test data, generic seismic qualification test data, 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 will be 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, 19.1.5.4, Table 1.8-2, and Figure 19.1-31 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Table 19.1-106 will be revised to update the structure related HCLPF upon completion of the fragility analysis.

U.S. EPR FSAR, Tier 2, Table 19.1-107 will be deleted as described in the response and indicated on the enclosed markup.

**Figure 19-341-01—U.S. EPR CSDRS**

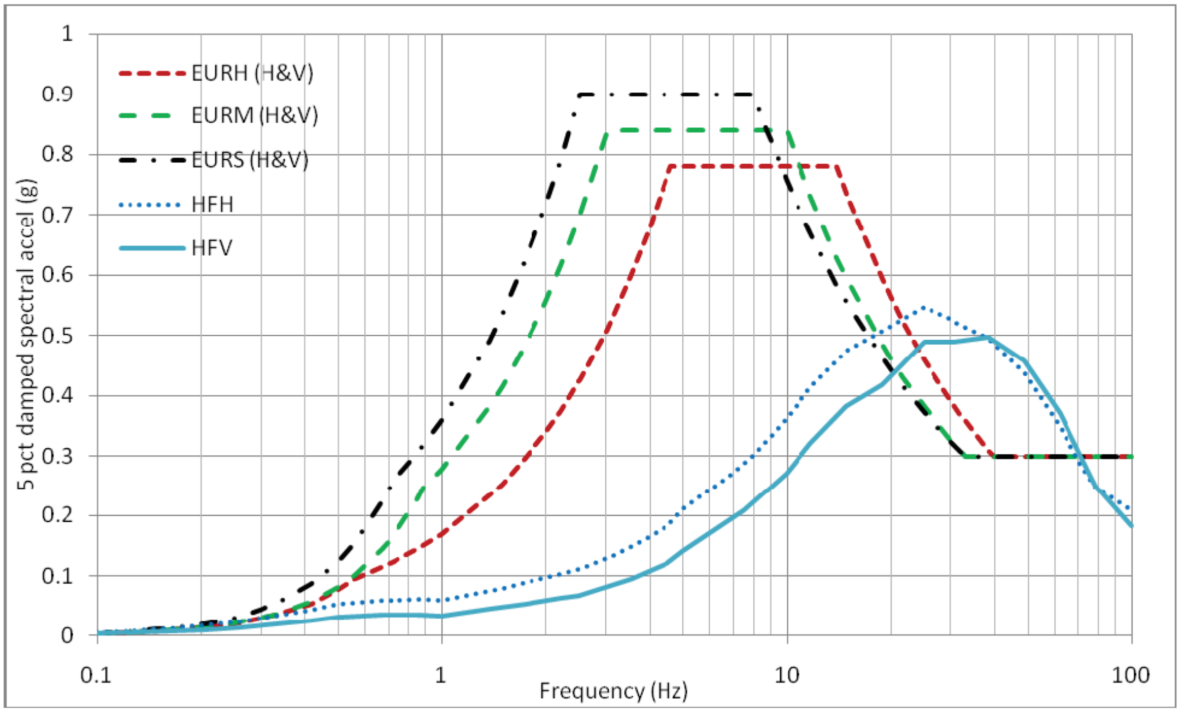
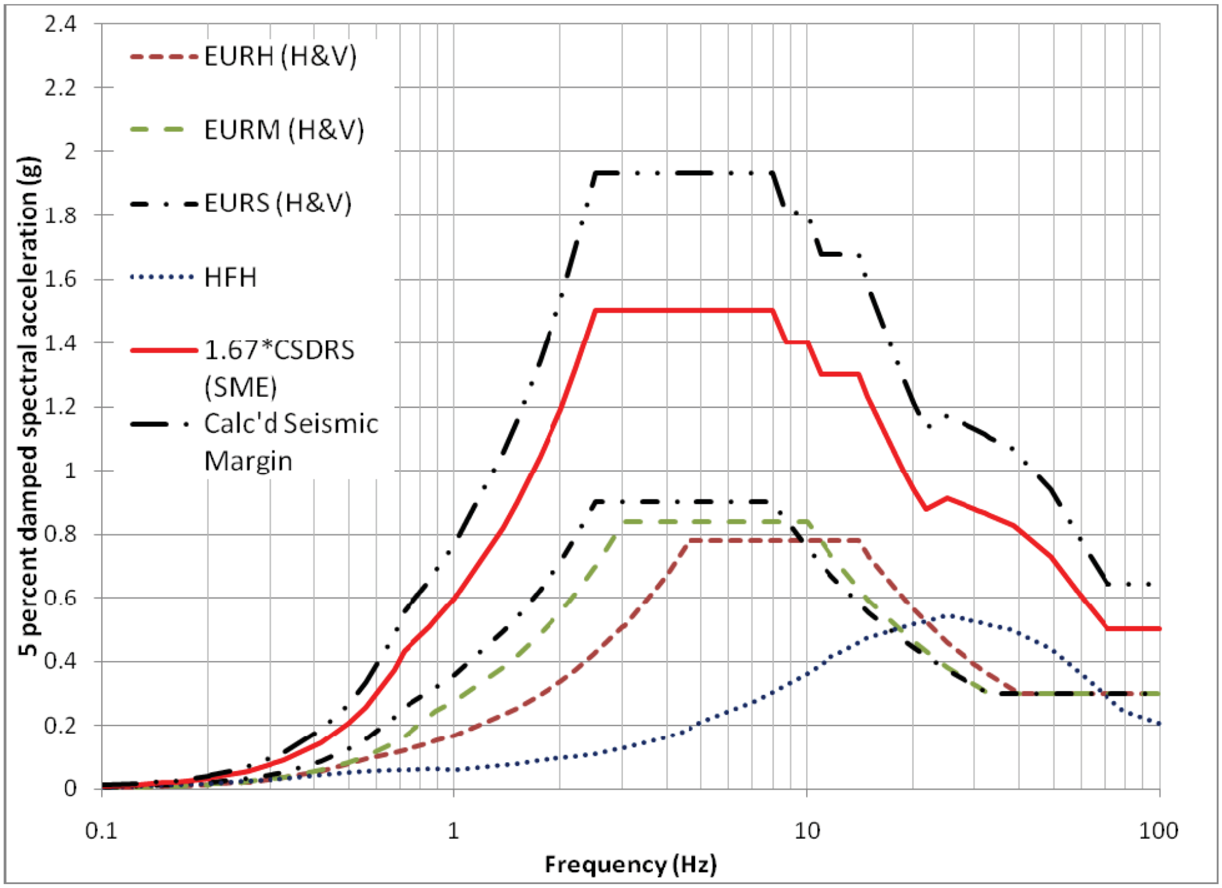


**Figure 19-341-02—Comparison of 1.67*CSDRS (SME) with Calculated Seismic Margin Earthquake of an Example NI Structure**



# U.S. EPR Final Safety Analysis Report Markups

**Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 40 of 40**

19-341

| Item No. | Description | Section |
|---|---|---|
| 19.1-4 | A COL applicant that references the U.S. EPR design certification will conduct a peer review of the PRA relative to the ASME PRA Standard prior to use of the PRA to support risk-informed applications or before fuel load. | 19.1.2.3 |
| 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 design-specific U.S. EPR PRA-based seismic margins assessment is bounding for their specific site.~~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.~~, including a site-specific PRA-based SMA for soil effects (including sliding and overturning, liquefaction, and slope failure).~~ | 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 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 |
| 19.2-1 | 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 |

Next File

## 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 margin assessment employed an approach described in SECY 93-087 (Reference 2). This assessment also followed guidance provided in ANSI/ANS-58.21 (~~Reference 35~~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

19-341

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

19-341

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.

~~For the U.S. EPR standard design, the site-independent broad-band smooth response spectra, based on the European Utility Requirements (EUR) spectral shapes for different site conditions are referred to as certified seismic design response spectra (CSDRS). The CSDRS are anchored to 0.3 g peak ground acceleration (PGA), for both horizontal and vertical ground motion. Section 3.7 discusses the EUR spectral shapes.~~

~~The CSDRS for the U.S. EPR are shown in Figure 3.7.1-1. These are ground response spectra for EUR Control Motions—hard (EURH), medium (EURM), and soft (EURS) soils.~~ 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 of soil effects, which is the responsibility of the COL applicant, as noted in Section 19.1.5.1.2.4. The 1.67 times the CSDRS is referred to as seismic margin earthquake (SME) in design certification. Figure 19.1-31 shows ~~plots of the SME for soft, medium, and hard soil sites~~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. 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 ($\beta_U$ and $\beta_R$, respectively). This relationship is as follows:

$$HCLPF = A_m \exp[-1.65(\beta_R + \beta_U)] \qquad (A)$$

19-341

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 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.

~~The calculations of the seismic margin for different SSC are performed using the seismic fragility analysis method; the median seismic capacity and variability are estimated.  The fragility evaluation characterizes the capacities of SSC to withstand the ground motion due to an earthquake.  Fragility is expressed as the conditional probability of failure of SSC as a function of earthquake size.  The capacity of a component to maintain its function during and following strong ground motion and the uncertainties associated with that capacity were estimated, taking into account the seismic response at the component's location in a structure.  The resulting fragilities are characterized by the median capacity, logarithmic standard deviations that account for randomness and uncertainty, and HCLPF capacity.  Both the median capacity and the HCLPF capacity are expressed in terms of peak ground acceleration (PGA).  The set of SSC for which fragility was estimated was defined through the development of a SEL, as discussed in the next section.~~

~~The seismic assessment included evaluating design information and qualification criteria to estimate the factors of safety (or margin) between the design capacity of a component and its actual capacity.  This margin arises, for example, because the actual stress a component could experience might be much less than the allowable stress level, or because the equipment is tested to an enveloping spectrum while the actual floor response spectrum at that equipment location may be significantly lower. Table 19.1-106 shows HCLPF capacities assigned to structures and equipment modeled in this PRA-based SMA.  An HCLPF capacity of 0.5 g PGA (1.67 times the SSE) is assigned to each SSC, not including an analysis of site-specific soil effects. Table 19.1-107 shows a sample fragility calculation that represents the process for documenting the SSC fragilities.~~

~~Section 19.1.5.4 describes the COL item to perform the site-specific SMA with an analysis of site-specific soil effects.~~

19-341

~~As noted previously, the HCLPF capacity is a measure of a component's 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 ($A_m$) for the component and two logarithmic standard deviations, accounting for variability due to uncertainty and randomness ($\beta_U$ and $\beta_R$, respectively). This relationship is as follows:~~

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

### 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.

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).

19-341

- 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).

19-341 The MLOCA and LLOCA event trees (see Appendix 19A) were used directly. The internal events shutdown event ~~tress~~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.

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 performed, the plant level HCLPF capacity is greater than SME, not including an analysis of soil effects.

19-341

- Seismic PRA model – ~~although the seismic PRA model is quite extensive in that SLOCA and ATWS were included, as well as all success paths in the internal events PRA.~~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 design-specific U.S. EPR PRA-based seismic margin assessment is bounding for the specific site.~~

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.

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 ~~including a site-specific PRA-based SMA for soil effects (including sliding and overturning, liquefaction, and slope failure)~~.

19-341

### 19.1.5.4.1 High Winds and Tornado Risk Evaluation

All U.S. EPR Seismic Category I structures are designed to meet the following standards for high winds and tornadoes.

#### High Winds

The U.S. EPR Seismic Category I structures are designed to withstand high wind load characteristics as specified in NUREG-0800, Section 3.1.1. The EPR Seismic Category I structures are specifically designed for a basic wind speed of 145 mph. This value bounds all locations within the U.S. except the extreme southern tips of Louisiana and Florida (SEI/ASCE 7-05).

#### Tornado Wind Loads

The U.S. EPR Seismic Category I structures are designed to meet the design-basis tornado wind characteristics of Tornado Intensity Region 1 as specified in NUREG-0800, Section 3.3.2. Tornado Intensity Region 1 is characterized by a maximum tornado wind speed of 230 mph (184 mph maximum rotational speed, 46 mph maximum translational speed). These design-basis tornado wind characteristics are bounding for all U.S. regions within the contiguous 48 states.

#### Tornado Missiles

The U.S. EPR Seismic Category I structures are designed to the design-basis tornado missile characteristics of Region 1 (most limiting U.S. region) as specified in NUREG-0800, Section 3.5.1.4. The design basis missiles include (1) a massive high-kinetic-energy missile that deforms on impact, (2) a rigid missile that tests penetration, and (3) a small rigid missile of a size sufficient to pass through any opening in protective barriers.

U.S. EPR Seismic Category I structures include:

- Reactor Building (RB) and Reactor Building annulus.
- Safeguard Buildings (SBs).
- Emergency Power Generating Buildings (EPGB).
- Essential service water (ESW) Pump Structures.
- ESW Cooling Water Structures.

19-341

Table 19.1-107—Deleted~~Table 19.1-107—Seismic Fragility and HCLPF Capacity for Safeguard Building Division 1~~

| ~~Failure Mode~~ | | ~~Shear Failure of Below grade Wall along Column Line 10~~ | | | |
|---|---|---|---|---|---|
| ~~Factor of Safety~~ | | | ~~Median Value~~ | ~~$\beta_R$~~ | ~~$\beta_U$~~ |
| ~~$F_C$~~ | ~~$F_S$~~ | ~~Strength~~ | ~~2.37~~ | ~~0~~ | ~~0.2~~ |
| | ~~F~~ | ~~Inelastic Energy Absorption~~ | ~~2.26~~ | ~~0.12~~ | ~~0.16~~ |
| ~~$F_{RS}$~~ | ~~$F_{SA}$~~ | ~~Ground Motion~~ | | - | - |
| | | ~~-Response Spectra Shape~~ | | ~~0~~ | ~~0~~ |
| | | ~~-Horizontal Direction Peak Response~~ | | ~~0.13~~ | ~~0~~ |
| | | ~~-Vertical Component Response~~ | | ~~0.05~~ | ~~0~~ |
| | ~~$F_D$~~ | ~~Damping~~ | | ~~0~~ | ~~0~~ |
| | ~~$F_M$~~ | ~~Modeling~~ | | ~~0~~ | ~~0.15~~ |
| | ~~$F_{MC}$~~ | ~~Modal Response Combination~~ | | ~~0.15~~ | ~~0~~ |
| | ~~$F_{ECC}$~~ | ~~Earthquake Component Combination~~ | | ~~0.05~~ | ~~0~~ |
| | ~~$F_{THS}$~~ | ~~Time History Simulation~~ | | ~~0~~ | ~~0.01~~ |
| | ~~$F_{SSI}$~~ | ~~Soil Structure Interaction~~ | | | |
| | | ~~-Ground Motion Incoherence~~ | | ~~0~~ | ~~0~~ |
| | | ~~-Vertical Spatial Variation~~ | | ~~0~~ | ~~0.07~~ |
| | | ~~-SSI Analysis~~ | | ~~0.2~~ | ~~0.05~~ |
| ~~Overall Factor Of Safety F =~~ | | | ~~6.04~~ | ~~0.31~~ | ~~0.31~~ |
| ~~$A_d$ = Peak Ground Acceleration of Design Spectra = 0.3 g~~ | | | | | |
| ~~$A_m$ = Median Peak Ground Acceleration = F* $A_d$ = 1.81 g~~ | | | | | |
| ~~$\beta_C$ = Combined Logarithmic standard Deviation = 0.44~~ | | | | | |
| ~~HCLPF = 0.65g PGA > 0.5g~~ | | | | | |

19-341

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