Screening of SSCs to Streamline Fragility Calculations in a SPRA

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Dominion Generation

Screening of SSCs - Contents

- Purpose
- Discussion of Various Screening Methods
- Development of Screening Criteria
- **Preliminary** Results

Screening of SSCs

- **Background/Purpose**
  - Screening criteria are developed to provide uniform guidance for SPRAs and to ensure that proper focus is given to those SSCs that have the potential to be risk-significant
  - Criteria will establish which SSCs require explicit calculation of fragility parameters for inclusion in the plant logic models.
  - SSCs that are screened out will not have any significant impact on the seismic PRA analyses, ranking of accident sequences or the seismic CDFs of sequences or the plant.
  - Once screening criteria are established, engineers will be able to utilize previous calculations and reports (e.g. design basis, IPEEE, USI A-46 analyses and tests etc.) to determine and judge if the seismic capacity of a component or structure for the new seismic hazard is such that no further calculation of fragility parameters is warranted (Training may be provided, with examples).

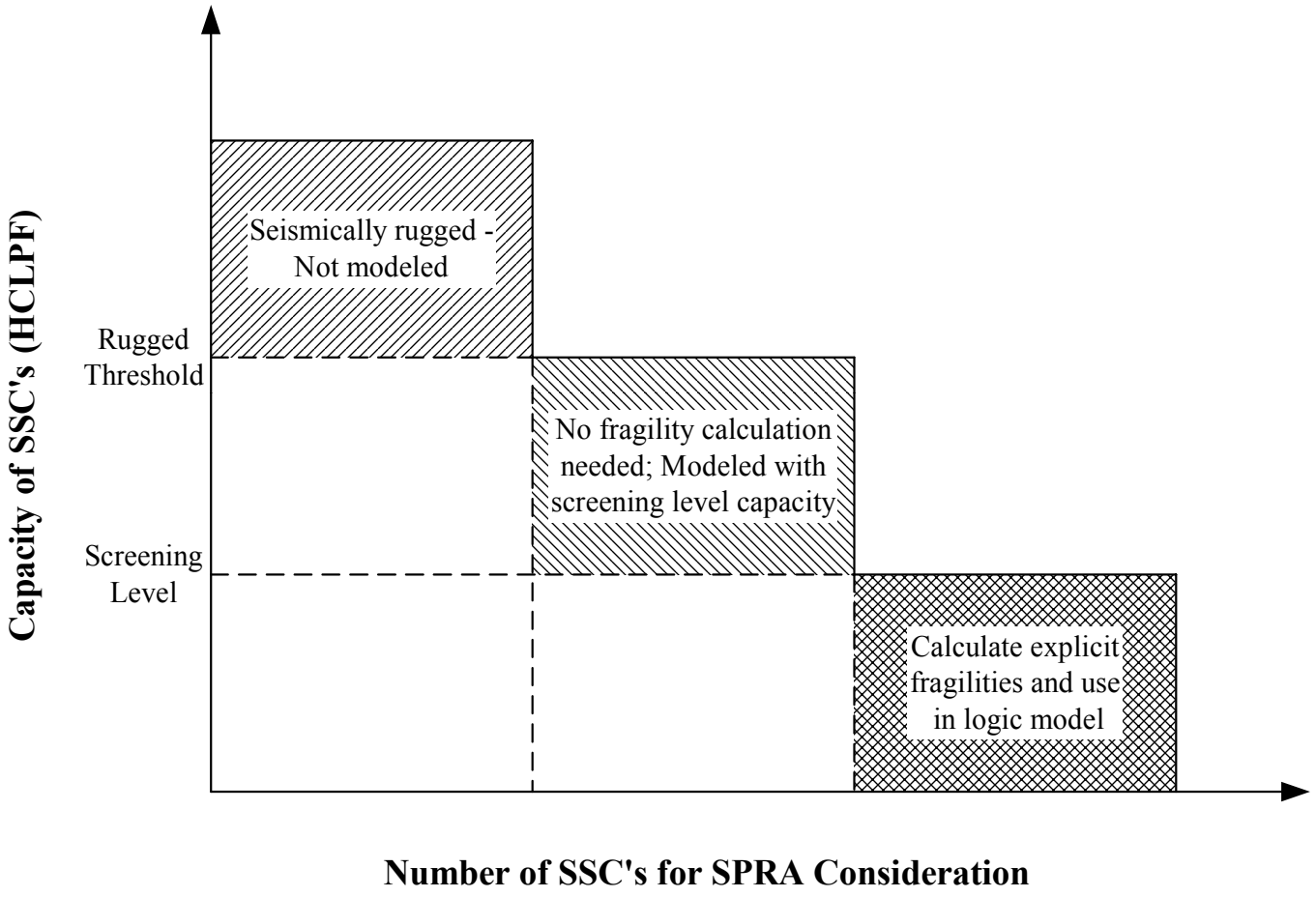
Methods of Screening SSCs

- Certain SSCs are inherently rugged and consequently have a very low probability of failing as a result of a seismic event. Consistent with longstanding practice in seismic PRAs, seismic failure of such SSCs need not be included in the PRA logic models. Exclusion of such SSCs from the logic models does not affect the seismic core-damage frequency or the insights derived from the seismic PRA.
- Insights from logic models can be used to prioritize fragility calculations of SSCs. Screening or ranking of SSCs from a preliminary plant logic model for an SPRA can be done by performing parametric sensitivity analyses with assumed initial fragilities and ranges of fragility values. Those SSCs that do not contribute significantly to the SCDF of an accident sequence may be screened out from having to perform detailed fragility calculations.

Methods of Screening SSCs (Contd.)

- Some SSCs may be less rugged but would still have sufficient capacity such that their failures would be unlikely to contribute significantly to the seismic core-damage frequency. Failures of SSCs in this category are retained in the seismic PRA logic model (with capacity equal to the screening level), but detailed fragility calculations are not warranted. Retention of such failures ensures that future changes or sensitivities that could increase their importance are not overlooked.
- **Criteria for defining screening capacity of SSCs for this method are developed using a parametric analysis**

Screening of SSCs



Development of Screening Criteria

The steps in the parametric analysis are as follows:

A. Select Several Hazard Curves:

- Rock Site:
  - Updated SOG / EPRI 04/06 Mean PGA, 5HZ and 10HZ hazard curves
  - USGS-2008 / EPRI 04/06 Mean PGA, 5HZ and 10HZ hazard curves, (North Anna Site), EPRI, December 2011
- Soil Site:
  - Updated SOG / EPRI 04/06 Mean PGA, 5HZ and 10HZ Hazard curves
  - USGS-2008 / EPRI 04/06, Mean PGA, 5HZ and 10HZ hazard curves, (Surry site) EPRI, December 2011

A total of 12 seismic hazard curves are evaluated in this sensitivity analysis (More curves may be considered)

Development of Screening Criteria

B. Select Initial Target Screening Criteria (adjust later if needed):

1. Fragility of a single component is convolved with a hazard curve, one at a time, such that the point estimate target value of the seismic CDF is 1E-7, 5E-7 or 1E-6. This is done by trial and error runs in a SPRA quantification code (e.g. "SEISMIC") as follows:

Assume $\beta r=\beta u=0.283$ (i.e., $\beta_c=0.4$) and adjust A_m until the CDF is equal to the target value. Then, HCLPF = A_m x e^(-1.65($\beta_r + \beta_u$)). **This is the screening HCLPF acceleration**. Note: The selected criterion will be eventually compared to the calculated plant CDF, e.g., review the screening CDF as a percent of the expected plant seismic CDF (possibly less than about 1%).

2. Check HCLPF of 2.0xGMRS, 2.5xGMRS and 3.0xGMRS etc. as possible alternate screening criteria.

Development of Screening Criteria

C. Select Logic Model and SSCs:

We used the composite plant equation from a recent SPRA. The selected boolean equation contains 55 SSCs. To determine the cumulative effect if several SSCs were screened out, parametric analyses are performed for the following cases:

- With 10 risk-significant SSCs that contribute to the seismic CDF.
- With 5 risk-significant SSCs that contribute to the seismic CDF.

Development of Screening Criteria

D. Perform Sensitivity Analyses (Using risk quantifications for various cases):

- Run the quantification ("SEISMIC") code with sufficiently large Monte Carlo trials with the selected plant equation using previously calculated fragilities of all SSCs convolved with the first hazard curve. Calculate plant CDF (This is called **CDF_a**)
- Select 10 risk-significant SSCs. Assign their Fragility parameters with HCLPF value equal to the screening level. Use βr=βu=0.283 (i.e., $\beta_c = 0.4$) and calculate Am using the equation HCLPF = A_m x e^(-1.65($\beta_r + \beta_u$)). Perform quantification using "SEISMIC" code and calculate plant CDF (This is called **CDF_b**)
- Assign a high Am value (> 3 x Screening A_m) to these 10 components. Perform quantification using the "SEISMIC" code and calculate plant CDF (This is called **CDF_c**)
- Repeat the above steps for each of the 12 hazard curve (and also for a set of 5 SSCs) and prepare tables as follows (**preliminary**):

Development of Screening Criteria

EPRI-SOG PGA Mean Rock Hazard Curve

GMRS PGA = 0.312 g

CASE →	HCLPF capacity based on single element convolved with the hazard curve such that the CDF is 1E-7	HCLPF capacity based on single element convolved with the hazard curve such that the CDF is 5E-7	HCLPF capacity based on single element convolved with the hazard curve such that the CDF is 1E-6
Screening A_m / HCLPF based on the fragility of a single element convolved with the hazard	1.00g (A_m = 2.55g)	0.737g (A_m=1.875g)	0.629g (A_m = 1.60g)
CDF_a: Original fragilities of all components	9.878 E-5 per year	9.878 E- 5 per year	9.878 E-5 per year
CDF_b: Fragilities at screening HCLPF for each of the 10 risk significant SSC	1.087 E-5 per year	1.199 E-5 per year	1.337 E-5 per year
CDF_c: A_m > 3 x screening level A_m for each of 10 risk significant SSC	1.065 E-5 per year	1.065 E-5 per year	1.065 E-5 per year

Development of Screening Criteria

Analysis from the Table on the previous page:

By inspection, $CDF_b << CDF_a$, which implies that the selected 10 components are risk significant and contribute to the seismic risk thus the sensitivity analysis is meaningful (and conservative).

For the 1E-7 Case: $100 \times (CDF_b - CDF_c)/ CDF_b = 2\%$,

Screening criterion as a % of CDF = (1E-7/9.878 E-5)*100 = 0.1%

For the 5E-7 Case: $100 \times (CDF_b - CDF_c)/ CDF_b = 11.2\%$

Screening criterion as a % of CDF = (5E-7/9.878 E-5)*100 = 0.5%

For the 1E-6 Case: $100 \times (CDF_b - CDF_c)/ CDF_b = 20.3\%$

Screening criterion as a % of CDF = (1E-6/9.878 E-5)*100 = 1%

Development of Screening Criteria

E. Establish Criteria:

Since $CDF_b << CDF_a$, it implies that the selected 10 components are risk significant and thus the sensitivity analyses are reasonable (conservative)

The development of criteria assumes that it is acceptable for CDF_c to about 10% to 20% lower than CDF_b. This implies that the screening criterion is reasonable and the cumulative effect of several screened SSCs on the plant CDF is not significant.

Development of Screening Criteria

F. Summary and Criteria Based on Preliminary Results:

Based on the tables prepared for the various soil and rock hazard curves, the following **preliminary** criteria for screening SSCs in logic models are developed:

Screening of SSCs can be set as: HCLPF value based on about 5E-7 CDF or alternatively at 2.5 to 3.0 x GMRS (Note: this is preliminary , also more parametric analyses are planned). In parallel, plants should ascertain that the CDF corresponding to the selected HCLPF screening criterion is less than about 1% of the eventual or expected plant CDF from a seismic PRA. If not, the screening criteria should be adjusted

The overall conclusion is to not select a low screening HCLPF level like the 0.3g used by some plants during IPEEEs. The above criteria will result in sufficiently high screening levels and will reduce the surrogate SCDF contribution (modeled at the screening level). Once a high screening level is selected, the list of SSCs can be ordered so that the ones with the highest SCDF impact are calculated first (approach based on feedback from the initial logic model quantification)

It is noted that use of these screening criteria is optional, SPRAs to address NTTF 2.1 may also refine or develop similar site-specific criteria with justification