RISK CONSIDERATION IN SEISMIC SAFETY REGULATION

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OUTLINE

- Safety goals for seismic safety
- Basis for a probabilistic determination of the SSE
- NRC position on using seismic PRA for regulatory decision making
- Seismic PRA Standard

SAFETY GOALS

- The safety goals proposed in the Commission's Safety Goal Policy Statement apply to the sum of all risk contributors
- There is no partitioning of the goals among different risk contributors

APPROACHES TO DETERMINING THE SSE

- For existing plants SSE determined using a deterministic approach based on the largest historical event with margin to accommodate limited data
- For new plants Regulatory Guide 1.165 describes an approach to determining the SSE ground motion

RG 1.165 APPROACH

- Based on development of a probabilistic seismic hazard curve
- Uses a reference probability of exceedance of 1E-5/yr to determine the SSE response spectrum (spectral acceleration vs. frequency of ground motion)

BASIS FOR REFERENCE PROBABILITY

- Reference probability is the the probability such that 50% of a set of currently operating plants has an annual median probability of exceeding the SSE that is below this level
- The reference probability is determined for the annual probability of exceeding the average of the 5 and 10 Hz SSE response spectrum ordinates associated with 5% critical damping

PERFORMANCE BASED APPROACH

- Industry has proposed an alternative, “performance based” approach
- Base the SSE on a probability of unacceptable performance of 1E-05 per year, where unacceptable performance is the onset of inelastic deformation
- The frequency of the earthquake is backed out from this on the basis of assumptions about structural capacities
- This is under review by NRC

USE OF SEISMIC PRA IN REGULATORY DECISION-MAKING

- RG 1.174 requires that all contributors to risk be addressed when making regulatory decision on changes to the licensing basis
- The phased approach to PRA quality requires that, when a PRA standard exists for a contributor to risk, when that contributor is significant to a decision, it should be addressed using a PRA that meets the appropriate standard
- The ANS standard for external events includes a seismic PRA

ANS External Events PRA Methodology Standard BSR/ANS 58.21

- **Objective is to set forth requirements for external-event PRA used to support risk-informed decisions for commercial NPPs**
- **Includes Seismic Probabilistic Risk Assessment (SPRA), Seismic Margin Assessment (SMA), High Winds, External Flooding and "Other" External Events**
- **Seismic PRA format similar to ASME-RA-S-02 for Internal Event PRA**
- **Three Capability Categories for graded approach to risk assessment**

ANS External Events PRA Methodology Standard BSR/ANS 58.21

- Limited to Level 1 analysis of CDF during full power operation and limited Level 2 analysis of LERF.
- Also includes requirements for SMA.
- Requirements, not procedures.
- Requirements based primarily on state-of-the-art in external event PRA as practiced in IPEEE and earlier PRAs.

High Level Requirements for Seismic Hazard Analysis

- **A – SCOPE (HLR-HA-A): The frequency of earthquakes at the site SHALL be based on a site-specific probabilistic seismic hazard analysis (PSHA) (existing or new) that reflects the composite distribution of the informed technical community. The level of analysis SHALL be determined based on the intended application and on site-specific complexity.**

- **B – DATA COLLECTION (HLR-HA-B): To provide inputs to the PSHA, a comprehensive up-to-date data base including: geological, seismological, and geophysical data; local site topography; and surficial geologic and geotechnical site properties, SHALL be compiled. A catalog of historical, instrumental, and paleoseismicity information SHALL also be compiled.**

High Level Requirements for Seismic Hazard Analysis

- **C – SEISMIC SOURCES AND SOURCE CHARACTERIZATION (HLR-HA-C): To account for the frequency of occurrence of earthquakes in the site region, the PSHA SHALL consider all credible sources of potentially damaging earthquakes. Both the aleatory and epistemic uncertainties SHALL be considered in characterizing the seismic sources.**
- **D – GROUND MOTION CHARACTERIZATION (HLR-HA-D): The PSHA SHALL account for all credible mechanisms influencing estimates of vibratory ground motion that can occur at a site given the occurrence of an earthquake of a certain magnitude at a certain location. Both the aleatory and epistemic uncertainties SHALL be considered in characterizing the ground motion propagation.**
- **E – LOCAL SITE EFFECTS (HLR-HA-E): The PSHA SHALL account for the effects of local site response.**

High Level Requirements for Seismic Hazard Analysis

- **F – AGGREGATION AND QUANTIFICATION (HLR-HA-F): Uncertainties in each step of the hazard analysis SHALL be propagated and displayed in the final quantification of hazard estimates for the site. The results SHALL include fractile hazard curves, median and mean hazard curves, and uniform hazard response spectra (UHS). For certain applications, the PSHA SHALL include seismic source deaggregation and magnitude-distance deaggregation.**

- **G – SPECTRAL SHAPE (HLR-HA-G): For further use in the SPRA, the spectral shape SHALL be based on a site-specific evaluation taking into account the contributions of deaggregated magnitude-distance results of the PSHA. Broad-band, smooth spectral shapes, such as those presented in NUREG/CR-0098 (Newmark and Hall, 1978) (for lower-seismicity sites such as most of those east of the U.S. Rocky Mountains) may also be used taking into account the site conditions. The use of UHS may also be appropriate if it reflects the site-specific shape.**

High Level Requirements for Seismic Hazard Analysis

- **H – USE OF EXISTING STUDIES (HLR-HA-H): When use is made of an existing study for PSHA purposes, it SHALL be confirmed that the basic data and interpretations are still valid in light of current information, the study meets the requirements outlined in A through G above, and the study is suitable for the intended application.**

- **I – OTHER SEISMIC HAZARDS (HLR-HA-I): A screening analysis SHALL be performed to assess whether, in addition to the vibratory ground motion, other seismic hazards, such as fault displacement, landslide, soil liquefaction, or soil settlement need to be included in the SPRA for the specific application. If so, the SPRA SHALL address the effect of these hazards through assessment of the frequency of hazard occurrence and/or the magnitude of hazard consequences.**

- **J – DOCUMENTATION (HLR-HA-J): The PSHA SHALL be documented in a manner that facilitates applying the PRA and updating it, and that enables peer review.**

NRC Regulatory Guidance on Standards

- **RG 1.200**
  - **This regulatory guide describes one acceptable approach for determining that the quality of the PRA, *in toto* or of those parts that are used to support an application, is sufficient to provide confidence in the results such that the PRA can be used in regulatory decision making for light-water reactors.**
  - **It is also intended to reflect and endorse guidance provided by standards-setting and nuclear industry organizations.**

- **NUREG Report**
  - **The objectives of this document are to provide guidance on the use of alternate methods and the treatment of uncertainties in risk-informed decision making. Guidance is provided on, for example:**
    - **Acceptable approaches to supplement a PRA that is not of a full scope, or has deficiencies in some of the individual PRA elements.**
    - **Specifically, guidance is provided on seismic margin assessment and the screening and bounding assessment for external events**