

# Seismic Probabilistic Risk Assessment of Boiling Water Reactor Plants

## Background

Westinghouse and Stevenson & Associates (S&A) have combined their resources to establish a business team with industry expertise that will prove invaluable for all seismic probabilistic risk assessment (S-PRA) projects.

To address the requirements set forward by the U.S. Nuclear Regulatory Commission (NRC) in response to the post-Fukushima Near Term Task Force (NTTF) Recommendation 2.1 on seismic hazard re-evaluation, major efforts will be required to expand the existing plant PRA models to include seismic events. U.S. NRC expectation, discussed in the March 2012, 50.54(f) letters, is for plants to develop seismic PRAs in compliance with the requirements of the American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) combined PRA standard (ASME/ANS RA-Sb-2013). The industry consensus standard includes high-level and supporting technical requirements for modeling seismic (and other) PRAs. Models developed are used to evaluate seismic-induced core damage frequency (CDF) and large early-release frequency (LERF) that can be used to meet the requirements in the 50.54(f) letters.

The CDF and LERF results also can be used in support of utilities' risk-informed applications. The PRA standard requires analysis to be carried out to evaluate the impact of uncertainty in the PRA input data on the PRA results. Also, to meet the requirements of the standard, the seismic PRA models need to undergo a peer review. The seismic PRA technical elements are generally required to meet the ASME/ANS PRA standard supporting requirements at Capability Category II level.

In May 2014, the U.S. NRC prioritized the 59 nuclear sites located in the central and eastern United States and identified the 21 sites that need to conduct in-depth analyses of the plants' updated earthquake risk. The boiling water reactor (BWR) plants in this priority list include Peach Bottom and Pilgrim units, which need to complete seismic PRA by June 2017; and Browns Ferry, Dresden, Hatch, La Salle and Oyster Creek, which need to do the same by December 2019.

## Why Westinghouse?

In a resource-constrained nuclear environment, Westinghouse and S&A have the depth and experience to provide timely, cost-effective, accurate seismic PRA solutions. The Westinghouse team can address the entire spectrum of technical aspects involved in a seismic PRA, including soil-structure interaction, seismic modeling and analysis of buildings and structures, site-specific fragility evaluation for structures and components and complete relay-chatter evaluation. The proven Westinghouse seismic PRA quantification methodology has been recognized during industry peer review as best practice for the most accurate propagation of uncertainties in the seismic PRA.

With over 80 PRA and seismic experts, Westinghouse and S&A have more expertise in seismic PRAs than any other organization.

## Description

Westinghouse and S&A have teamed up to offer utilities comprehensive seismic PRA services. Our team possesses the depth of knowledge to provide seismic analyses tailored to the needs of individual utilities. We can do the following:

- Provide expert resources to develop and maintain a full-scope seismic PRA model that meets the requirements of the new PRA standard

- Perform seismic PRA walkdowns with Seismic Qualification Utility Group qualified engineers and data collection tasks, and identify system interactions to be considered in the analysis
- Develop plant-specific seismic fragility values for structures, systems and components using various techniques, from the Conservative Deterministic Failure Methodology to calculate a High Confidence of a Low Probability of Failure to more refined separation of variables techniques
- Identify critical relays, assess the impact of relay chatter and develop plant-specific fragility values for relays and other chatter-sensitive equipment
- Integrate the seismic hazard and fragility data with the seismic PRA model to evaluate seismic-induced CDF and LERF for the plant
- Perform peer review for the seismic PRA to check conformance to the PRA standard
- Provide on-site consultation services to support development of seismic PRA
- Document the seismic PRA model and its bases in a manner that meets the requirements of the PRA standard

Westinghouse has been providing full S-PRA services, including the development of site-specific seismic hazard curves by partnering with seismic hazard specialists. We have supported numerous utilities in developing seismic hazard evaluations, including site-specific Senior Seismic Hazard Advisory Committee Level 3 hazard studies, assisted, as needed, by site-specific data gathering for a better site characterization.

## Benefits

The following are the benefits of developing a seismic PRA:

- Resolving concerns with the evolving understanding of seismic hazard at nuclear power plant sites around the world
- Meeting the requirements of U.S. NRC NTF Recommendation 2.1 for seismic hazard
- Complying with Regulatory Guide 1.200 and the most recent PRA standard, which allows utilities to submit risk-informed applications to change their licensing basis without compromising plant safety
- Improving plant safety by identifying latent vulnerabilities and establishing risk-informed mitigating strategies for those vulnerabilities
- Minimizing the costly iteration of issue-specific seismic evaluations to address any findings by the U.S. NRC in its investigation of previous seismic hazard data

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## Experience

Westinghouse has extensive expertise in nuclear steam supply system (NSSS) PRA development and applications. S&A is one of the most recognized organizations with extensive seismic fragility experience, having performed many of the industry's early seismic fragility evaluations. Together, Westinghouse and S&A have the following experience:

- Developing site-specific seismic hazard curves
- Evaluating soil-structure interaction
- Developing detailed finite element models of buildings and structures
- Performing seismic margin analyses for the Advanced BWR design re-certification submittal
- Performing seismic margin analyses for over 20 BWRs, globally
- Performing seismic PRAs for **AP1000**<sup>®</sup> and **AP600**<sup>™</sup> advanced reactors
- Performing seismic PRAs compliant with the PRA standard for Palo Verde, Wolf Creek and VC Summer Unit 1
- Performing seismic walkdowns, including seismic-induced flooding and fire walkdowns
- Developing accident sequence event trees and system fault trees
- Developing fragility curves for both NSSS and other components
- Identifying critical relays, developing plant-specific fragilities for the relays and assessing the impact of relay chatter
- Performing seismic margin studies for numerous utilities
- Integrating, quantifying and maintaining PRA models

In addition to our in-house capability in performing thermal-hydraulic analyses, Westinghouse has access to the severe accident analysis capability of our subsidiary, Fauske and Associates and the design-basis analyses performed by our owner, Toshiba Corporation, who has designed and built many BWR plants in Japan, and most recently, completed seismic PRAs as part of the post-Fukushima restart effort.

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