3.4.1 Seismic Events

When performing the evaluation of the effect of seismic events on spent fuel pools, it became apparent that the staff does not have detailed information on how all the spent fuel pools were designed and constructed. Therefore, the staff originally performed a simplified bounding seismic risk analysis in our June 1999 draft risk assessment to help determine if there might be a seismic concern. The analysis indicated that seismic events could not be dismissed on the basis of a simplified bounding approach. After further evaluation and discussions with stakeholders, it was determined that it would not be cost effective to perform a plant-specific seismic evaluation for each spent fuel pool. Working with our stakeholders, the staff developed other tools that help assure the pools are sufficiently robust.

Spent fuel pool structures at nuclear power plants are seismically robust. They are constructed with thick reinforced concrete walls and slabs lined with stainless steel liners 1/8 to 1/4 inch thick[1]. Pool walls vary from 4.5 to 5 feet in thickness and the pool floor slabs are around 4 feet thick. The overall pool dimensions are typically about 50 feet long by 40 feet wide and 55 to 60 feet high. In boiling water reactor (BWR) plants, the pool structures are located in the reactor building at an elevation several stories above the ground. In pressurized water reactor (PWR) plants, the spent fuel pool structures are located outside the containment structure supported on the ground or partially embedded in the ground. The location and supporting arrangement of the pool structures determine their capacity to withstand seismic ground motion beyond their design basis. The dimensions of the pool structure are generally derived from radiation shielding considerations rather than structural needs. Spent fuel structures at operating nuclear power plants are able to withstand loads substantially beyond those for which they were designed. Consequently, they have significant seismic capacity.

In a letter dated August 18, 1999 (See Appendix 5), NEI proposed a checklist intended to assure any plant could show robustness for a seismic ground motion with a peak ground acceleration (PGA) of approximately 0.5g. This checklist was reviewed and enhanced by the NRC (task force???) staff. The staff has concluded that plants that satisfy the seismic checklist have demonstrated with reasonable assurance a high-confidence low-probability of failure (HCLPF)[2] value of 0.5g.

U.S. nuclear power plants, including their spent fuel pools, were designed such that they can be safely shutdown and maintained in a safe shutdown condition if subjected to ground motion of a specified amplitude. This design basis ground motion is referred to as the safe shutdown earthquake (SSE). The SSE was determined on a plant specific basis consistent with the seismicity of the plant's location. In general, plants located in the eastern and central parts of the US, had lower magnitude SSEs established for their designs than the plants located in the western parts of the US, which had significantly higher SSEs established for them because of the higher seismicity for locations west of the Rocky Mountains. As part of this study, the staff with assistance from Dr. Kennedy (See Appendix 5), reviewed the potential for spent fuel pool failures due to seismic events with ground motion amplitudes exceeding established SSE

[1] Except at Dresden Unit 1 and Indian Point Unit 1, these two plants do not have any liner plates. They were decommissioned more than 20 years ago and no safety significant degradation of the concrete pool structure has been reported.

[2] The HCLPF value is defined as the peak seismic acceleration at which there is 95% confidence that less than 5% of the structure, system, or component will fail.

428

values to occur in various regions in the U.S. Based on this review, and a review of the conservative nature of the SSE ground motion at most of the sites, it was determined that for sites east of the Rocky Mountains, seismic events with amplitude of ground motion 3 times as large as the SSE values are considered to be as high as physically possible, considering the current tectonics. For plants west of the Rocky Mountains, which have higher SSE design values then those in the Central and Eastern U.S., it was determined that the maximum credible earthquake ground motions would be approximately twice their SSE value. These estimates of the maximum credible earthquake ground motion levels are based on the tectonics that exist in the different parts of the U.S., show extremely low probabilities associated with ground motions of these higher levels. Therefore, for the purpose of this study, it was assumed that seismic events with ground motion 3 times the SSE design values at lower seismicity locations (Eastern and Central U.S. sites) and the 2 time the SSE design values at higher seismicity locations (West Coast sites) are good estimates of the maximum credible seismic ground motions for these sites.

The seismic hazard component of the risk statement thus can be set aside if it can be demonstrated that there is a high confidence in a low probability of failure for seismic ground motion, greater than or equal to 2 times the SSE at higher seismicity sites and at 3 times the SSE at lower seismicity sites. Implicit in this is the assumption that pool structures are free from pre-existing degradation or other seismic vulnerabilities. The enhanced checklist seeks to assure there are no weaknesses in the design or construction of the pools that might make them vulnerable under earthquake ground motions several times higher than those in the site's safe shutdown earthquake (SSE). We note that spent fuel pool configuration, layout, and structural details vary considerably from one plant to another. For sites that fail the seismic check list or have a ground motion goal appropriate for the area of the US the pool is situated in, greater than 0.5g, the utility would need to conduct a detailed assessment of the seismically induced probability of failure of its spent fuel pool structures and components.

The staff concludes that the frequency of spent fuel pool failure for a CEUS plant is acceptably low if 3 times the plant's SSE value is less than 0.5g and the plant satisfies the seismic checklist proposed in their December 13, 1999 letter (See Appendix 5). Although the risk has not been regionally calculated for these sites, deterministic consideration lead the staff to conclude that peak ground acceleration in excess of 3 times SSE are not credible. For these sites the frequency of failure is bounded by $3x10^{-6}$ per year, and other considerations indicate the frequency may be significantly lower.

For those sites where the ground motion at 3 times the SSE exceeds 0.5g peak ground acceleration, this also means that the seismic checklist requirement for HCLPF will not be met. Therefore, a detailed evaluation of HCLPF will be necessary.

For those CEUS sites at which the ground motion at 3 times the SSE exceeds 0.5g PGA, a detailed evaluation of HCLPF would be necessary. Similarly, a detailed HCLPF would be necessary for all western plants. For all CEUS plants which can demonstrate a HCLPF equal to 3 times SSE, the risk is judged to be bounded by $3x10^{-6}$ per year. Similarly, for western sites which can demonstrate a HCLPF equal to 2 times SSE, the risk is judged to be bounded by $3x10^{-6}$ per year.