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Date: Wednesday, July 26, 2000 03:41 PM
Subject:

L/231

MAIN BODY SEISMIC WRITEUP

3.4.1 Seismic Events

The staff's concern regarding seismic issues at spent fuel pools involves very large earthquakes that can structurally fail the pool. Under this scenario, the pool will suffer a significant breach, it will drain rapidly, and it will be incapable of being refilled. This would lead to rapid cladding heat up followed by a zirconium cladding fire. The staff evaluated how large an earthquake would be required to cause such damage and what would be the return frequency of such large earthquakes.

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.

The staff began to investigate the capacity of spent fuel pools to withstand large earthquakes. While performing the evaluation, it became apparent that the staff does not have detailed information on how all the spent fuel pools were designed and constructed. Detailed fragility analyses of spent fuel pools were only available for a few plants. The staff originally performed a simplified bounding seismic risk analysis in its 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. In addition 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 its stakeholders, the staff developed other tools that help assure the pools are sufficiently robust.

Based on existing spent fuel pool fragility analyses and engineering judgement, the staff determined that a high confidence, low probability of failure HCLPF)[2] value of 0.5 g peak

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[1]Except for Dresden Unit 1 and Indian Point Unit 1, whose spent fuel pools do not have any liner plates. They were permanently shutdown 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 time the structure, system, or component will fail.

ground acceleration (or 1.2 g peak spectral acceleration) probably existed for most SFPs. Given this assumption, with the assistance of Dr. Robert P. Kennedy (See Appendix 2b, Attachment 2), it was determined that the annual frequency of seismically induced failure of spent fuel pool structures varies from less than $1.0X10^{-6}$ to $13.6X10^{-6}$ per year.

In its draft report, the staff proposed to use $3X10^{-6}$ per year as the annual frequency criterion of seismic failure and equivalently the frequency of radioactive release. However, comments from the Advisory Committee on Reactor Safeguards and other stake holders indicated that the proposed criterion and approach were too conservative. Also, the proposed approach contained different assessments for the Eastern and the Western United States and was complicated by the fact that seismic fragility information for ground motion levels beyond 0.5 g is not readily available from a peer reviewed data base.

The staff reexamined the results of Table 3, Appendix 2b, Attachment 2, which estimates the return frequencies of large earthquakes that could fail spent fuel pools. The staff's review indicates that only three operating eastern plant sites have frequencies greater than $4.5X10^{-6}$ per year of having an earthquake with a peak spectral acceleration greater than 1.2 g. The staff finds $4.5X10^{-6}$ per year to be an acceptable criterion for seismic return period for earthquakes that could fail the spent fuel pools since it is a factor of 2 less than the $1x10^{-5}$ per year PPG and the estimated frequency of zirconium cladding fires from other initiators is an order of magnitude lower. Such a margin is warranted due to the uncertainties of the seismic hazard and spent fuel pool fragilities at each site.

The staff determined that absent specific information about SFP seismic capacities, that some plant-specific evaluation of spent fuel pool capacity was warranted. During stakeholder interactions with the staff, the staff proposed the use of a seismic checklist that built on the work done for ..... and could provide assurance of the capacity of spent fuel pools. In a letter dated August 18, 1999, NEI proposed a checklist that could be used to 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 staff (See Appendix 2b, Attachment 1). The seismic checklist was developed to provide a simplified method for demonstrating a HCLPF at an acceptably low value of seismic risk. The checklist includes elements to assure there are no weaknesses in the design or construction nor any service induced degradation of the pools that would make them vulnerable to failure under earthquake ground motions that exceed their design basis ground motion. Spent fuel pools that satisfy the seismic checklist, as written, would have a high confidence in a low probability of failure for seismic ground motions up to 0.5 g peak ground acceleration (1.2g peak spectral acceleration).

The staff recommends that those plants that exceed $4.5X10^{-6}$ per year frequency for exceeding 1.2 g peak spectral acceleration in their spent fuel pool should be required to conduct plant-specific analysis beyond the confirmation of the checklist if they desire to obtain exemptions from EP, indemnification, or security at decommissioning sites. This process results in identification of four sites in the eastern U.S., only three of which are operating reactor sites - Pilgrim, H. B. Robinson, and Vogtle sites, with Maine Yankee the decommissioning site. In the western U.S., the Diablo Canyon and San Onofre sites are also beyond the scope of a simple screening evaluation. Based on the NRC sponsored study, "Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools at Two Representative Nuclear power Plants," NUREG/CR 5176, January 1989, the seismic HCLPF capacity of the H. B. Robinson spent fuel pool has been estimated to be 0.65 g. For the Vogtle, Pilgrim, Diablo Canyon, and San Onofre sites, it may be necessary for the utilities to conduct a detailed site-specific seismic risk

evaluation if they desire an exemption from EP when the site is in decommissioning.
To summarize the staff recommendation for seismic vulnerability of spent fuel pools, (1) all sites must conduct an assessment of the spent fuel pool structures using the revised seismic check list in order to identify any structural degradation, potential for seismic interaction from superstructures and over head cranes, and to verify that they have a seismic HCLPF value of 0.5 g or higher, (2) those sites that cannot demonstrate that a seismic HCLPF value exists, may either under take appropriate remedial action or conduct site-specific seismic risk assessment and (3) Pilgrim, H. B. Robinson, Vogtle, Diablo Canyon and San Onofre sites would have to use the seismic check list to identify any structural degradation or other anomalies and then conduct a site specific seismic risk assessment if they desire an exemption from EP when their sites are in decommissioning.