SUGGESTED CHANGES 8/25/00 8/29/00

Beyond Design Basis Accidents in Spent Fuel Pools," and other studies of operating reactor spent fuel pools concluded that existing requirements for operating reactor spent fuel pools are sufficient. During this study, the staff evaluated one additional issue concerning the drop of a cask on the spent fuel pool floor. As noted above, due to the industry's commitment to Phase II of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants, Resolution of Generic Technical Activity A-36," this is not a concern for decommissioning reactors.

Operating reactors are not required to implement Phase II of NUREG-0612. The risk for spent fuel pools at operating plants is limited by the lower expected frequency of heavy load lifts as compared to decommissioning plants. Nonetheless, this issue will be further examined as part of the Office of Nuclear Regulatory Research's prioritization of Generic Safety Issue 186, "Potential Risk and Consequences of Heavy Load Drops in Nuclear Power Plants," which was accepted in May 1999.

3.4.7 Spent Fuel Pool Uncovery Frequency at 2, 5, and 10 Years After Shutdown

[MIKE'S INPUT]

3.5 Beyond Design Basis Spent Fuel Pool Accident Scenarios (External Events)

The following is a description of how each of the external event initiators was modeled, a discussion of the frequency of fuel uncovery associated with the initiator, and a description of the most important insights regarding risk reduction strategies for each initiator.

3.5.1 Seismic Events

The staff performed a simplified bounding seismic risk analysis in its June 1999 preliminary draft risk assessment to gain initial insights on seismic contribution to SFP risk. The analysis indicated that seismic events could not be dismissed on the basis of a simplified bounding approach. The additional efforts by the staff to evaluate the seismic risk to spent fuel pools are addressed here and in Appendix 2b.

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[5]. Pool walls are about 5 feet thick 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 ~~largely~~ determine their capacity to withstand seismic ground motion beyond their design basis. The dimensions of the pool structure are generally derived from radiation

have an influence on

[5]Except at Dresden Unit 1 and Indian Point Unit 1, these two plants 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.

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shielding considerations rather than seismic demand needs. Spent fuel structures at nuclear power plants are able to withstand loads substantially beyond those for which they were designed.

To evaluate the risk from a seismic event at a spent fuel pool, one needs to know both the likelihood of seismic ground motion at various g-levels (i.e., seismic hazard curves) and the conditional probability that a structure, system, or component (SSC) will fail at a given acceleration level (i.e., the fragility of the SSC). These curves are convoluted mathematically to arrive at the likelihood that the spent fuel pool will fail due to a seismic event. In evaluating the effect of seismic events on spent fuel pools, it became apparent that although information was available on seismic hazard curves for nuclear power plant sites, the staff did not have fragility analyses of the pools, nor generally did licensees. The staff recognized that many of the spent fuel pools and the buildings housing them were designed by different architect engineers. Some buildings and pools were built to the Uniform Building Code and others were built to different standards.

To overcome lack of knowledge of the capacity of the spent fuel pools, the staff and NEI developed a seismic check list and used generic fragility analyses (one for PWRs and one for BWRs) corresponding to the capacity of the spent fuel pool assured by the seismic checklist. During stakeholder interactions, the staff proposed the use of a seismic checklist, and in a letter dated August 18, 1999, NEI proposed a checklist that could be used to show a spent fuel pool would retain its structural integrity at a peak spectral acceleration of about 1.2 g. This value (1.2 g peak spectral acceleration) was chosen in part due to existing databases that could be used in the checklist but that only went up to 1.2 g peak spectral acceleration. The checklist was reviewed and enhanced by the staff (See Appendix 2b). 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, but are less than the 1.2 g peak spectral acceleration. The staff has concluded that plants that satisfy the revised seismic checklist can demonstrate with reasonable assurance a high-confidence low-probability of failure (HCLPF)[6] at a ground motion that has a very small likelihood of exceedence. Convolution of the site-specific seismic hazard curves with the generic fragility curves results in annual probabilities of a zirconium fire from seismic events ranging from less than $1x10^{-7}$ per year to over $1x10^{-5}$ per year, depending on the site and the hazard curves used.

Since our evaluation is intended to apply to all potential decommissioning sites, the generic values for seismic risk will tend to be bounding. Individual sites may have hazard curves that are much lower than the sites with the highest hazard curves.[7] Figures 3.2 and 3.3 show the estimated annual probabilities of a zirconium fire from a seismic event with the probabilities put in order from lowest to highest. Figure 3.2 shows the results of convoluting the site-specific Lawrence Livermore National Laboratory seismic hazard curves (ref. ZZZ) with the generic

ZZZ = NUREG-1488 Revised Livermore Seismic Hazard Estimates for 69 Nuclear Power Plant Sites East of the Rocky Mountains, P. Sobel Oct 1993

[6]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.

[7] At higher accelerations, especially for plant sites east of the Rocky Mountains, there is great modeling uncertainty about the ground motions, return periods, and the possibility of cutoff. There is virtually no data at these acceleration levels, and there is no chance that we will be able to gather such data in the near future (next 100 years).

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spent fuel pool fragility analysis, and Figure 3.3 shows the results convoluting the EPRI site-specific seismic hazard curves (ref. YYYY) in a similar manner[7]. These figures show that for the zirconium fire frequencies using the LLNL curves, the annual probabilities cluster for most sites just above $1x10^{-6}$ per year and for EPRI just below $1x10^{-6}$ per year. Note that the order of the sites differs somewhat between the EPRI and LLNL curves. Given that a utility performs and passes the checklist, the staff finds that the frequency of a zirconium fire from a seismic event will be less than $5x10^{-6}$ per year using the LLNL curves or slightly less than $1x10^{-6}$ per year using the EPRI curves if the below mentioned plants are excluded and perform plant-specific analyses. In looking at these two different sets of hazard curves, the NRC has previously found that both sets are reasonable and equally valid.

In passing the checklist, the staff believes that a spent fuel pool will be assured a HCLPF of at least 1.2 g spectral acceleration. For many sites (particularly PWRs because their SFPs are closer to ground level and receive less amplification), the plant-specific HCLPF may be considerably higher. The only two plant-specific spent fuel pool fragility analyses that the staff is aware of were used in this analysis.

All decommissioning plants that seek to take advantage of exemptions or rule changes with respect to EP, indemnification, or safeguards would need to perform and pass the checklist. In addition to passing the checklist, some decommissioning plant sites that have hazard curves with particularly high relative return periods at a given acceleration would need to perform a plant-specific seismic assessment of their spent fuel pool risk if they wish to gain exemptions from EP, security, or indemnification. Such sites include Robinson, Vogtle, Maine Yankee, and Pilgrim east of the Rocky Mountains and San Onofre, Diablo Canyon, and WPPS west of the Rocky Mountains. These same plants generally are the outliers if one uses either Lawrence Livermore National Laboratory hazard curves or those by EPRI. The staff proposes that these sites would need to show that their frequency of catastrophic failure of the spent fuel pool due to seismic events was less than $5x10^{-6}$ per year using LLNL hazard curves or staff approved site-specific hazard curves, if they wished to take advantage of EP, security , or indemnification exemptions or the rulemaking. The staff finds $5X10^{-6}$ per year to be a reasonable acceptance criterion for seismic return period for earthquake ground motions 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 about 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, and to the small margin between seismic risk results and the Quantitative Health Objectives (QHOs) of the NRC.

3.5.2 Aircraft Crashes

The staff evaluated the likelihood of an aircraft crashing into a nuclear power plant site and seriously damaging the spent fuel pool or its support systems (details are in Appendix 2d). The generic data provided in DOE-STD-3014-96 [Ref. 6] were used to assess the likelihood of an aircraft crash into or near a decommissioning spent fuel pool. Aircraft damage can affect the

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[7] At higher accelerations, especially for plant sites east of the Rocky Mountains, there is great modeling uncertainty about the ground motions, return periods, and the possibility of cutoff. There is virtually no data at these acceleration levels, and there is no chance that we will be able to gather such data in the near future (next 100 years).