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Date: Wed, Mar 29, 2000 4:10 PM
Subject: Some thoughts on draft technical document & truncation

Goutam - attached are some comments on the draft technical document. Included in the text is a discussion on the effect of the attenuation model random uncertainty term. I was able to analytically model a point source and show the effect of how changes in sigma change the probability of exceedance at various ground motion levels. The bottom line is that at high ground motions, the probability of exceedance is driven by the extreme tail of the distribution.

What it all comes down to is good judgement. At low probability levels, both deterministic and probabilistic information needs to used - as a reality check.

Open to suggestions.

Tom O'Hara

(See attached file: sfphaz4.doc)

4147

Comments on NRC "Draft Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Plants" – February 15,2000

Summary of NRC Draft

To increase the efficiency and effectiveness of decommissioning regulations, the NRC staff has engaged in rulemaking activities that would reduce the need to routinely process exemptions once a plant is permanently shut down. Reference 1 provides the technical basis for determining the regulatory requirements for decommissioning plants using risk-informed decision making. Table 3.1 (Reference 1) provides a summary of the annual frequency of fuel uncovery associated with internal and external initiating events. Based on Table 3.1 it is estimated that the frequency of a zirconium fire is less than 3×10^{-6}, with the dominant contribution coming from seismic events. The seismic contribution is estimated to be less than 3×10^{-6}, while the contribution from all other initiating events is estimated to be 4×10^{-7}. As described by the staff, other considerations indicate that the seismic contribution may be considerably lower. Assumption of the generic frequency of events leading to a zirconium fire at decommissioning plants to be less than 3×10^{-6} per year is based on a plant satisfying the design and operational characteristics assumed in the risk assessment performed by the staff.

Comments on Appendix 2b Structural Integrity of Spent Fuel Pools Subject to Seismic Loads (Reference 1)

1. Introduction

No significant comments on this section other than to concur that spent fuel pools (SFPs) at operating nuclear power plants <u>and at decommissioning NPPs</u> are inherently rugged in terms of being able to withstand loads substantially beyond those for which they were designed. Consequently, SFPs have significant seismic capacity.

2. Seismic Checklist

It is not clearly noted in this section, but the important point is that successful application of the revised seismic checklist provides a high degree of assurance that the SFP HCLPF is 0.5g or greater. The comments on the conservatisms (in paragraph 2) associated with the design basis earthquake at licensed NPPs should be moved to a separate section. Furthermore, the deterministic method should be contrasted with the probabilistic method. This contrast is important because the deterministic method provides a powerful counter to the probabilistic results at low probability levels.

Deterministic Methods vs Probabilistic Methods

Deterministic Methods

The design basis earthquake ground motion, or the SSE ground motion, for NPPs were based on the assumption of the largest event geophysically ascribable to a tectonic province or to a capable structure at the closest proximity of the province or fault to the site. In the case of the tectonic province in which the site is located, the event is assumed to occur at the site. For the Eastern seaboard, the Charleston event is the largest magnitude earthquake and current research has established that such large events are confined to the Charleston region. The New Madrid zone is another zone in the Central US where very large events have occurred. Recent research has identified the source structures of these large New Madrid earthquakes. Both of these earthquake sources are fully accounted for in the assessment of the SSE for currently licensed NPPs. The SSE ground motions for NPPs are based on conservative estimates of the ground motion from the largest earthquake estimate to be generated from the current tectonic regime. For CEUS sites the typical NPP is designed for about a magnitude 5.3 to 5.5 (about 0.15g). The largest design basis earthquake for a CEUS site, based on detailed seismological, geological, and geophysical investigations, is magnitude 6.0 (about 0.25g). In no EUS licensing proceeding has there been compelling data to require design to an earthquake of a magnitude which would challenge the seismic capacity of an SFP that satisfies the seismic checklist. For WUS sites the design basis ground motion is generally governed by known active faults at known distances. Based on fault length and other deterministic factors the maximum earthquake potential can be estimated.

Probabilistic Methods

References 2 and 3 describe the Lawrence Livermore National Labs (LLNL) and Electric Power Research Institute (EPRI) seismic hazard methodologies. A seismic hazard analysis (SHA) estimates the seismic hazard at a site due to the potential occurrence of earthquakes in the region surrounding the site. Importantly, the historic seismic data is insufficient, at least for the CEUS, to use as the sole source of information for estimating the various parameters of the overall probability model. Therefore, it is necessary to rely on "expert opinion" to supplement the data. One fundamental expert opinion input to the SHA is the upper bound magnitude distribution for each earthquake source. Figure 1 contrasts the distribution of upper bound magnitude estimates assessed by the experts in the LLNL study for the host zones containing a New England NPP with the SSE determined by the 10CFR Part 100 Appendix A process. This distribution of upper bound magnitude is typically based on "expert opinion" – not on any known structure in each host zone description that could cause earthquakes this large. Within this context, the assessed seismic hazard will generally be higher – because less is known and the distribution has more probability associated with extreme outcomes, **or, outcomes that in fact cannot occur**. The effect of including these extreme outcomes is to predict incredible ground motions at credible probability levels. Expert opinion on the distribution of upper bound magnitude is but one of the many opinions rendered in the LLNL and EPRI studies that have profound effects on the perceived seismic hazard at low (10^{-6}) probability levels.

The LLNL methodology was initially developed in 1979 to determine SSE values for older NPPs in the Systematic Evaluation Program. The methodology was further developed to address the Charleston Issue (SECY-91-135, Reference 4), i.e., to evaluate the contribution to the seismic hazard from large earthquakes along the eastern seaboard outside the Charleston region. It should be noted that the focus of these studies was on the relative contribution of large earthquakes to the overall seismic hazard, not on the absolute effect. Also, comparisons between the LLNL and EPRI results was typically made at the SSE level (0.15g to 0.25g - annual probability of 10^{-3} to 10^{-4}), not at the ground motion level associated with a HCLPF of 0.5g. It is noted that given a HCLPF of 0.5g the median capacity (A_m) of an SFP is about 1.0g (A_m = HCLPF/$e^{-1.65(Bc)}$) – far from typical SSE values. Realistically, only large Charleston like earthquakes can generate ground motions of the amplitude, frequency content, and duration to challenge the seismic capacity of spent fuel pools. However, at high ground motion values (1000 cm/sec^2), the tail of the attenuation random uncertainty distribution (sigma) allows, with some non-negligible probability, relatively small events to contribute to the probability of exceeding a ground motion of 1000 cm/sec^2. Figure 2 shows the effect of changing sigma for a point source at a given distance. These results were analytically determined. As can be seen, at low ground motions (125 cm/sec^2), changes in sigma have a small effect on the probability of exceedance. However, at high accelerations (1000 cm/sec^2) the effect of changes in sigma is profound. The high probability of exceeding 1000 cm/sec^2 based on use of a sigma of 0.6g in Figure 2, is driven by the tail of the attenuation random uncertainty term. For example, 1000 cm/sec^2 is about 3 standard deviations above the expected ground motion from a magnitude 6.5 earthquake at 100 km. Deterministically, these results don't make sense and provide a basis for truncating the tail of the random uncertainty term at high ground motion values. Use of a smaller sigma value is a form of truncation. As can be seen on Figure 2, the probability of exceeding 1000 cm/sec^2 is reduced by about a factor 600 by simply changing sigma from 0.6 to 0.4. EPRI results are based on use of a sigma of 0.5. Based on this information and information previously described in Reference 5, use of the LLNL probabilistic estimates at low probability values may not be credible. EPRI results are also likely to be overly conservative at high ground motion values.

3. Seismic Risk - Catastrophic Failure

The staff concludes that for those CEUS plants where 3 X SSE is less than or equal to the NEI screening criterion of 0.5g, then the seismic risk is acceptable low. A similar conclusion is reached for those WUS plants where 2 X SSE satisfies the screening criterion. For CEUS plants that exceed the 3 X SSE screening criterion, a detailed SFP assessment will be required to demonstrate the SFP HCLPF equals 3 X SSE. A similar conclusion is reached for those WUS plants where 2 X SSE exceeds the screening criterion. This requirement that some plants with higher SSE values perform detailed HCLPF assessments of their SFPs may not be warranted. The assumption of this requirement is that the SSE is correlated with seismic hazard, in other words, the higher the SSE the higher the seismic hazard. Previous studies have shown that the SSE is poorly correlated with the seismic hazard (see Figure 3). In particular, there are many 0.25g SSE sites with lower seismic hazard estimates than 0.15g SSE sites. SSE tends to be more correlated with plant vintage than seismic hazard. **Based on this information, we believe that there should be no SFP screening level distinctions based on plant SSE for the CEUS.** For the WUS, it is reasonable to require that certain plants demonstrate a HCLPF of 2 X SSE.

4. Seismic Risk - Support System Failure

No comments.

5. Conclusion

The staff concludes that for SFPs in the CEUS with HCLPF values of 3 X SSE or 0.5g whichever is greater and for WUS SFPs with HCLPF values of 2 X SSE or 0.5g, whichever is greater, the SFP failure frequency due to seismic is bounded by 3 x 10^{-6} per year. As stated by the staff, "other considerations indicate that the frequency may be significantly lower."

For CEUS plants that satisfy the seismic checklist and 3 X SSE is less than 0.5g, the seismic risk is considered by the staff to be acceptably low and no additional work is required. According to the staff, those CEUS sites (about 27) for which 3 X SSE exceeds 0.5g and 2 WUS sites for which 2 X SSE exceeds 0.5g would have to perform additional plant specific analyses to demonstrate a HCLPF value for their SFPs of 3 X SSE and 2X SSE respectively in order to demonstrate acceptably low seismic risk.

The conclusion that the SFP failure frequency is bounded by 3 x 10^{-6} per year can be found in previous submittals. In particular, it was shown that using the 0.5g HCLPF and applying Dr. Kennedy's conservative methodology to estimate SFP failure frequency at all CEUS sites using both the LLNL and EPRI seismic hazard results, the SFP failure frequency is bounded by 3 x 10^{-6} per year. It is noted that no distinction was made in the previous analysis concerning cases where 3 X SSE was greater than 0.5g. The basis for requiring a higher HCLPF value for plants with 3 X SSE greater than 0.5g is neither clear nor compelling. If the basis for requiring a higher HCLPF value for plants with high SSEs is that the SSE is assumed to be correlated with hazard it can readily be shown that seismic hazard and SSE are poorly correlated (Figure 2). Furthermore, it can be also be shown, using just the LLNL results and Dr. Kennedy's methodology, that there are many sites where 3 X SSE is greater than 0.5g **AND** the SFP failure frequency is well below 10^{-6} per year.

It was noted previously that a 0.5g HCLPF relates to about a 1 g median SFP capacity. When rigorously convolving a typical mean seismic hazard curve with the SFP fragility curve associated with a 0.5g HCLPF, the dominant contribution to the seismic risk occur above about 0.7g. Based on this information, only large earthquakes can generate ground motions of the amplitude, frequency content, and duration to challenge the seismic capacity of spent fuel pools. However, at high ground motion values (1g), the tail of the attenuation random uncertainty distribution (sigma) allows, with some non-negligible probability, relatively small events to contribute to the probability of exceeding a ground motion of 1g. Deterministic evaluation performed in the licensing of CEUS NPPs have not identified any sources near NPPs that are capable of generating earthquake ground motions of this magnitude. Therefore, these probabilistic results don't make sense and provide a basis for truncating the tail of the random uncertainty term at high ground motion values or using a smaller value for the random uncertainty term at high ground motions.

Based on the results of both probabilistic and deterministic evaluations, it is concluded that for all CEUS and some WUS NPPs, regardless of SSE value, satisfaction of all the requirements of the seismic checklist provides sufficient documentation of an acceptably low level of seismic risk. For the 2 WUS plants at known high seismic hazard locations, a HCLPF value of 2 X SSE should be demonstrated.

References:

1. USNRC, Draft for Comment Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, February, 2000.

2. NUREG/CR-5250, Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains, Lawrence Livermore Nation Laboratory, January, 1989.

3. EPRI NP-6396-D, Probabilistic Seismic Hazard Evaluations at Nuclear Plant Sites in the Central and Eastern United States: Resolution of the Charleston Issue, Electric Power Research Institute, April 1989.

4. SECY-91-135, Conclusions of the Probabilistic Seismic Hazard Studies Conducted for Nuclear Power Plants in the Eastern United States, May 14, 1991.

5. Appendix 5e, USNRC, Draft for Comment Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, February, 2000.

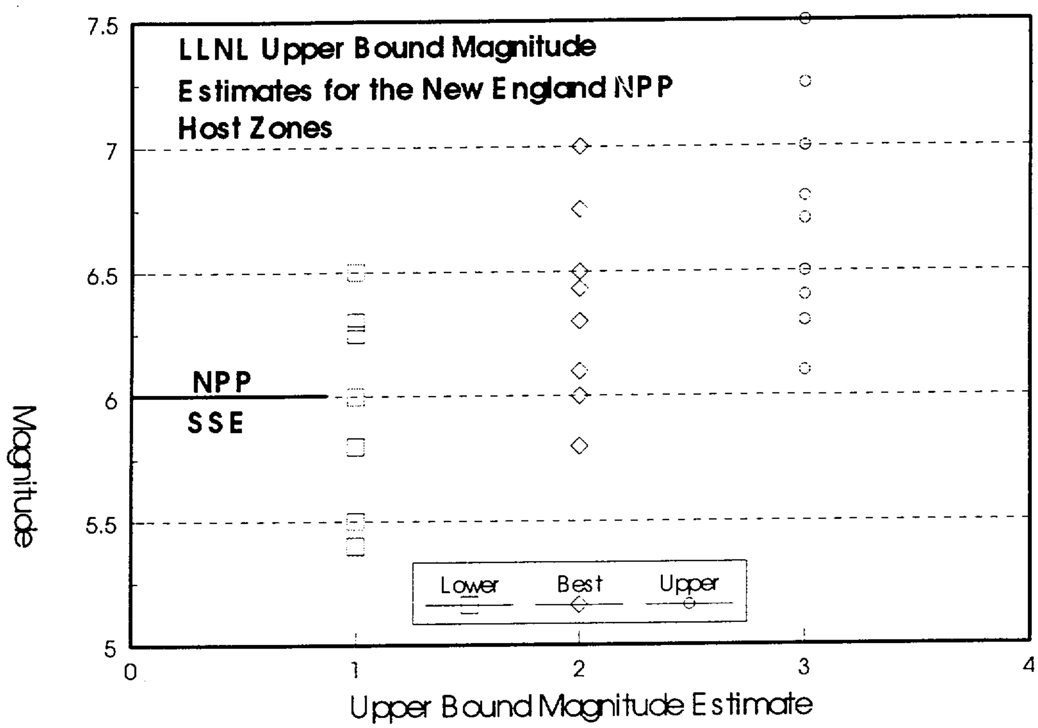

Figure 1 – Distribution of Upper Bound Magnitude Estimates from Reference 1 for a New England site.

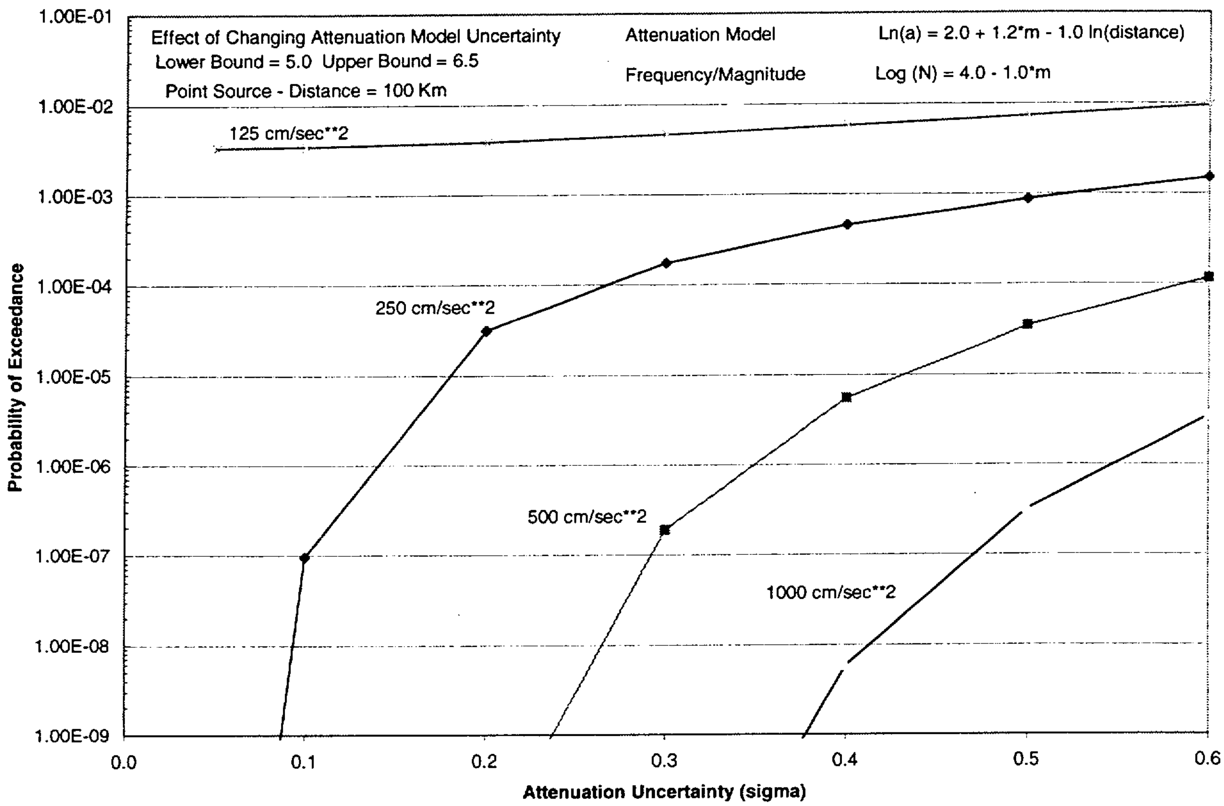

Figure 2 Effect of Attenuation Random Uncertainty on Probability of Exceedance from a Point Source

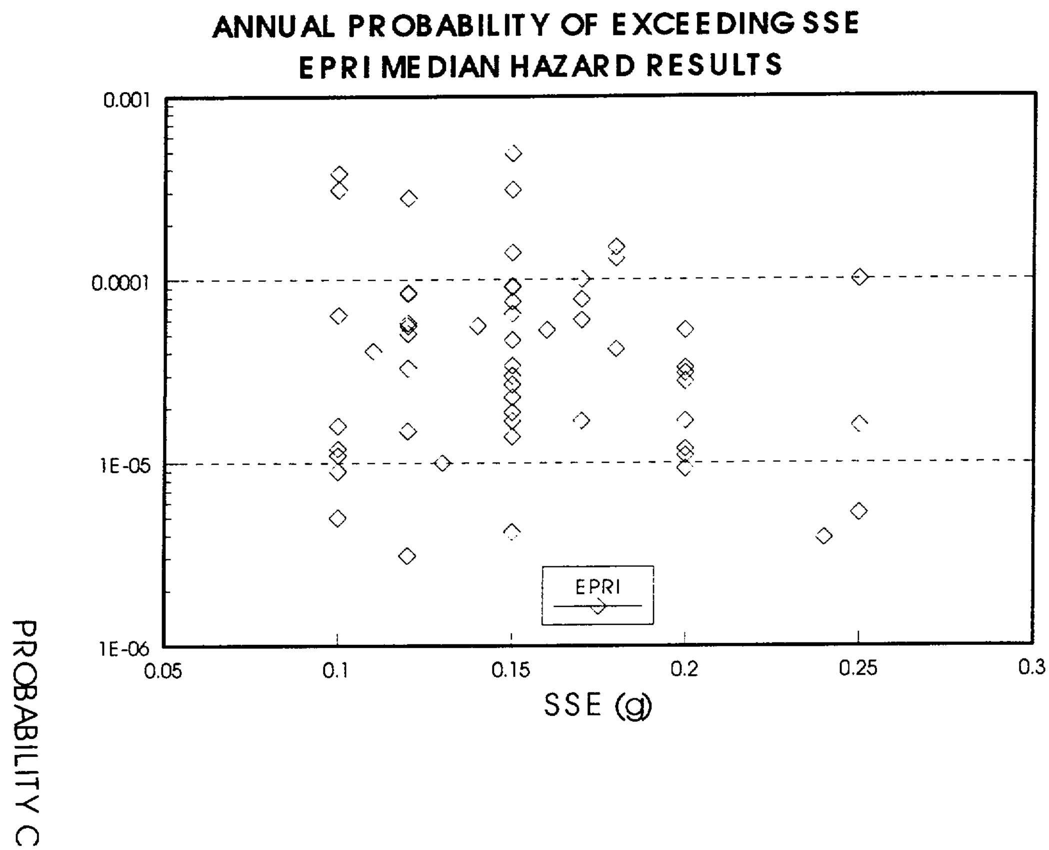

Figure 3 – Annual Probability of Exceeding the SSE at CEUS sites based on EPRI (Reference 3)