

**Workshop on Risk Related to Spent Fuel Pool
Accidents at Decommissioning Plants**

Seismic Discussion Session



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Beyond Design Basis Seismic Events

Reasons For The Study

- ◆ **Significant reduction in seismic hazard perception between 1989 and 1993**
- ◆ **Differences in seismic capacity due to spent fuel pool location and other details** *site dependent*
plant dependent
- ◆ **Loss of pool integrity is determined by the failure mode that has the least seismic capacity; large variations in seismic capacity can exist from one plant to another**

Seismic Events - Approach For The Study

- ◆ **Plant specific hazard and seismic capacity combination can raise a risk concern**
- ◆ **Opportunity to address this issue in a risk-informed manner**

Seismic Events - Approach For The Study

Objective:

- ◆ **Examine risk-informed methods of assessing plant vulnerability to this issue**
- ◆ **Identify conditions necessary to screen out plants with appropriate seismic demand and capacity combination**

Seismic Events - Approach For The Study

Assumptions:

- ◆ **Seismic fragility evaluations indicate a capacity of about 3 times the seismic design basis level earthquake value unless there is any specific plant-related weakness**
- ◆ **Seismic hazard curves from NRC and independent industry studies yield very similar values as demonstrated in the Duke Engineering report**

Seismic Events Study - What Was Done?

- ◆ **Used the basic plant grouping from NUREG-1407, “Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities” published, June 1991**
- ◆ **Obtained annual probability of exceedance for peak ground acceleration at 3 times and 3.5 times the design level earthquake values for each plant from NUREG-1488, “Revised Livermore Seismic Hazard Estimates for 69 Nuclear power plant Sites East of the Rocky Mountains,” October 1993**

Seismic Events Study - What Was Done?

- ◆ **Except for a few sites, 3 times the design level earthquake has an annual probability of exceedance of a mean value of about 2×10^{-5} per reactor year**

Seismic Events

- ◆ **With a seismic capacity of 3 times the design level earthquake, there is high confidence that the conditional failure probability is about 0.05**
- ◆ **The product of hazard and failure probability (high confidence) is about 1×10^{-6} per reactor year. This is the probability of unrecoverable loss of spent fuel pool integrity and it is about half of the total probability of fuel being uncovered due to a seismic event**

Seismic Events

- ◆ **Report also presents discussions about various failure modes of the spent fuel pool structure and potential changes in structural response at high level earthquake ground motion**
- ◆ **A simple check list can be developed to screen out plants with no structural vulnerability or identify simple compensatory measures**

Evaluation of Frequency of SFP Failure Due to Seismic Events

- ◆ **The most accurate estimate obtained by a convolution of a site-specific hazard curve with a site-specific fragility curve (NUREG/CR-5176).**
- ◆ **The hazard curve expresses the frequency with which the frequency of ground motion acceleration is exceeded.**
- ◆ **The fragility curve expresses the probability of failure as a function of that ground motion acceleration.**

Evaluation of Frequency of SFP Failure Due to Seismic Events

- ◆ **Uncertainties are addressed quantitatively.**
- ◆ **The methodology is relatively mature and has been used for about half of the IPEEEs to address seismic risk for operating plants.**

Sources of Data

- ◆ Hazard curves are available for all sites in the Eastern US (NUREG-1488)
- ◆ Representative fragility curves for gross structural failure of a BWR (Vermont Yankee) and a PWR (H.B. Robinson 2) pool were developed in NUREG/CR-5176
- ◆ System failures evaluated for operating plant configuration but still gave significant failure frequencies (on the order of $1E-04$ /yr) without taking credit for alternate makeup.

Seismic Events Study - What Was Done?

- ◆ **Except for a few sites, 3 times the design level earthquake has an annual probability of exceedance of a mean value of about 2×10^{-5} per reactor year**

Areas of Concern

- ◆ **Impact of changes to fragility characterization are non-linear, e.g.,**
 - ◇ **a reduction in the HCLPF* value of 40% can lead to an increase in frequency of failure of a factor on the order of 5,**
 - ◇ **a reduction in the HCLPF* value of 20% can lead to an increase in frequency of failure of a factor on the order of 2.**

***HCLPF - High Confidence of Low Probability of Failure**