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

Seismic Discussion Session

Stuart Richards, PD IV & Decommissioning, DLPM
Goutam Bagchi, DE
Gareth Parry, DSSA

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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
- 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

at mean level.

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 $2X10^{-5}$ 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 $1X10^{-6}$ 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.

Areas of Concern

- Structural fragilities are a function of site specific design features.

- The fragility used in the evaluation should include all modes that lead to a non-recoverable draining of the spent fuel pool, including:

  - gross structural failure
  - penetration failures
  - impact of adjacent structures
  - dropped loads

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