

Seismic Screening Criteria
for
Assessing Potential Fuel Pool Vulnerabilities
at
Decommissioning Plants

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Background

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. With this goal in mind, members of the NRC staff, industry representatives and other stakeholders held a two-day workshop on risk related spent fuel pool accidents at decommissioning plants.

At this workshop, based upon presentations by the NRC staff (Goutam Bagchi et al.) and the nuclear industry (T. O'Hara - DE&S), it was concluded that a large seismic event (in the range of three times the design level earthquake) would represent a risk of exceeding the structural capacity of the spent fuel pool and thus potentially result in draining the pool.

Although the methodologies presented by the NRC staff and the industry differed somewhat, they both concluded that, in general, spent fuel pools possess substantial capacity beyond their design basis but that variations in seismic capacity existed due to plant specific details (i.e. "Differences in seismic capacity due to spent fuel location and other details.").

Rather than haggle over the exact magnitude of the risk potential of a greater-than-design-basis seismic event, (i.e. Is the calculated risk in the 10E-06 or 10E-07 range), it was recommended that a simple check list be developed to screen out plants with no seismic structural vulnerabilities. The following pages provide the proposed structural vulnerability check list/screening criteria.

Spent Fuel Pool Seismic Vulnerability Check List

Purpose:

As discussed briefly in the "Background" section, the purpose of this checklist is to identify and evaluate specific seismic characteristics which might result in a specific spent fuel pool from not being capable of withstanding a beyond-design-basis seismic event equal in magnitude to approximately three times its design basis.

1. Assure Adequate Ductility of Shear Wall Structures

The expert panel involved with the development of Reference 1 concluded that, "For the Category 1 structures which comply with the requirements of either ACI 318-71 or ACI 349-76 or later building codes and are designed for an SEE of at least 0.1g pga, as long as they do not have any special problems as discussed below, the HCLPF capacity is at least 0.5g pga." This conclusion was based upon the assumption that the shear wall structure will respond in a ductile manner. The "special problems" cited deal with individual plant details which could prevent a particular plant from responding in the required ductile fashion. Examples cited in Reference 1 included an embedded structural steel frame in a common shear wall at the Zion plant (which was assumed to fail in brittle manner due to a potential shear failure of the attached shear studs) and large openings in a "crib house" roof (also at the Zion plant) which could interrupt the continuity of the structural slab.

Other examples which could impact the ductility of the spent fuel pool structure include large openings which are not adequately reinforced or reinforcing bars that are not sufficiently embedded to prevent a bond failure before the yield capacity of the steel is reached.

2. Assure Design adequacy of Diaphragms (including roofs)

In the design of many nuclear power plants, the seismic design of roof and floor diaphragms has often not received the same level of attention as have the shear walls of the structures. Major cutouts for hatches or for pipe and electrical chases may pose special problems for diaphragms. Since more equipment tends to be anchored to the diaphragm compared to shear walls, moderate amounts of damage may be more critical for the diaphragm compared to the same amount of damage in a wall.

Based upon the guidance provided in Reference 1, diaphragms for Category I structures designed for a SSE of 0.1g or greater do not require an explicit evaluation provided that: (1) the diaphragms loads were developed using dynamic analysis methods; (2) they comply with the ductility detailing requirements of ACI 318-71 or ACI 349-76 or later editions. Diaphragms which do not comply with the above ductility detailing or which

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did not have loads explicitly calculated using dynamic analysis should be evaluated for a beyond-design-basis seismic event in the 0.45-0.5g pga range.

3. **Verify the Adequacy of Structural Steel (and Concrete) Frame Construction**

At a number of older nuclear power plants, the walls and roof above the top of the spent fuel pool are constructed of structural steel. These steel frames were generally designed to resist hurricane and tornado wind loads which exceeded the anticipated design basis seismic loads. A review of these steel (or possibly concrete) framed structures should be performed to assure that they can resist the seismic forces resulting from a beyond-design-basis seismic event in the 0.45-0.5g pga range. Such a review of steel structures should concentrate on structural detailing at connections. Similarly, concrete frame reviews should concentrate on the adequacy of the reinforcement detailing and embedment.

Failure of the structural steel superstructure should be evaluated for its potential impact on the ability of the spent fuel pool to continue to successfully maintain its water inventory for cooling and shielding of the spent fuel.

4. **Verify the Adequacy of Spent Fuel Pool Penetrations**

The seismic and structural adequacy of any spent fuel pool (SFP) penetrations whose failure could result in the draining of the SFP must be evaluated for the forces and displacements resulting from a beyond-design-basis seismic event in the 0.45-0.5g pga range. Specific examples of low elevation SFP penetrations include the fuel transfer chute/tube and possibly piping associated with the SFP cooling system. Failures which could lead to draining or syphoning of the SFP should be considered.

5. **Evaluate the Potential for Impacts with Adjacent Structures**

Structure-to-structure impact may become important for earthquakes significantly above the SSE, particularly for soil sites. Structures are usually conservatively designed with rattle space sufficient to preclude impact at the SSE level but there are no set standards for margins above the SSE. In most cases, impact is not a serious problem but, given the potential for impact, the consequences should be addressed. For impacts at earthquake levels below 0.5g pga, the most probable damage includes the potential for electrical equipment malfunction and for local structural damage. As cited previously, these levels of damage may be found to be acceptable or to result in the loss of SFP support equipment. The major focus of this impact review is to assure that the structure-to-structure impact does not result in the inability of the SFP to maintain its water inventory.

6. **Evaluate the Potential for Dropped Loads**

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A beyond-design-basis seismic event in the 0.45-0.5g pga range has the potential to cause the structural collapse of masonry walls and/or equipment supports systems. If these secondary structural failures could result in the accidental dropping of heavy loads into the SFP, then the consequences of these drops must be considered. As in previous evaluations, the focus of the drop consequence analyses should consider the possibility of draining the SFP. Additionally, the evaluation should evaluate the consequences of any resulting damage to the spent fuel or to the spent fuel storage racks.

7. Other Failure Modes

Experienced seismic engineers should review the geotechnical and structural design details for the specific site and assure that there are not any design vulnerabilities which will not be adequately addressed by the review areas listed above. Soil-related failure modes including liquefaction and slope instability should be screened by the approaches outlined in Reference 1 (Section 7 & Appendix C).

References:

1. "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)," (EPRI NP-6041-SL), August 1991
2. "Seismic Discussion Session," Workshop on Risk Related to Spent Fuel Pool Accidents at Decommissioning Plants, Stuart Richards, Goutam Bagchi and Gareth Parry, July 16, 1999
3. "Draft Technical Study of Spent Fuel Pool Accidents for Decommissioning Plants," by USNRC Technical Working Group - Vonna Ordaz et al., dated June 1999
4. "Risk Informed Decommissioning Emergency Planning," EPRI/NEI Project by Tom O'Hara (presented July 16, 1999)