Background

Probabilistic evaluation of risk in spent fuel pools (SFPs) is an emerging focus area for nuclear regulatory agencies and plant operators in the United States and Europe.

Several Western European regulatory agencies in France, the United Kingdom, Germany and Finland have increased their focus on probabilistic risk assessment (PRA), leading to the development of some standard requirements for SFP probabilistic risk evaluations during all plant configurations, including at-power and refueling operations.

Based on lessons learned from the Fukushima events, a joint effort from the U.S. industry has led to the development of a strategic response plan that recognizes that timelines for emergency response capability for continued core cooling, containment integrity and SFP cooling must be synchronized to preclude fission product barrier degradation following a loss of AC power. Plants can prevent fuel damage so that plant equipment and strategies are sufficient to maintain or restore core and fuel pool cooling and containment functions, and are of sufficient capacity to place all units in a safe shutdown condition with normal fuel pool cooling restored.

Plans for a geologic repository have gone unrealized, so many operating nuclear power plants have begun storing spent fuel at independent spent fuel storage installations at or near the plants. The U.S. Nuclear Regulatory Commission is investigating the risks associated with such dry-cask storage operations via a human reliability analysis (NUREG-7016 and NUREG-7017). Preliminary insights from the study have identified human performance vulnerabilities.

To address the current requirements for and studies about SFP risk evaluation, Westinghouse has developed an SFP PRA model. The model helps identify the importance of risk in regard to SFP equipment and, consequently, vulnerabilities, and enables Westinghouse to identify improvements such as modifications to equipment and procedures to enhance the overall SFP risk profile.

Description

Westinghouse’s comprehensive SFP PRA model evaluates the yearly frequency of SFP boiling, SFP uncovery and associated releases by analyzing all internal and external events, including seismic events, that can occur at a plant. This analysis helps Western European utilities achieve their overall goals and objectives for PRA model enhancements and development.
Westinghouse uses plant-specific features and characteristics, including technical specifications and procedures, to identify the SFP operational states that plants may encounter during at-power operations and refueling. For each identified operational state, Westinghouse develops accident sequence models that account for the event initiators, mitigating systems and operator actions. Westinghouse also develops system-level models based on success criteria and availability. Then Westinghouse analyzes the data to support the SFP PRA model, taking into consideration equipment requirements during SFP configurations and state-of-the-art methods for quantifying human failure events.

If desired, Westinghouse can perform a qualitative human reliability analysis of the operations that happen during refueling, dry cask storage or decommissioning so that the plant can better understand, for example, how human performance of operations dealing with heavy-load movement can plausibly lead to a drop or a loss of water inventory.

**Benefits**

Westinghouse has the expertise and capability to tailor an SFP PRA model to meet customer needs and industry standards. Utilities can use an SFP PRA model to improve plant safety, address regulatory requirements and justify changes in plant operations. Such benefits can be realized in several areas:

- The viability of the B.5b Phase 2 strategies for SFP cooling and makeup capabilities during emergent issues can be assessed in all plant operating modes. Due to the Fukushima events, these strategies are currently being evaluated as part of the strategic response plan.

- A qualitative human reliability analysis can help build a technical basis for improvements to procedures and practices in order to keep movements over the SFP safe during dry cask or decommissioning operations.

- Westinghouse can perform a seismic PRA of the SFP for facilities that do not comply with industry decommissioning commitments and staff decommissioning assumptions given in NUREG-1738.

- Detailed, state-of-the-art thermal-hydraulic analyses can be performed via MAAP5 code to evaluate molten spent fuel relocation and associated releases for the Level 2 SFP PRA model.

**Experience**

- Westinghouse has developed SFP PRA models in support of shutdown PRAs for both pressurized water reactors and boiling water reactors in Germany.

- Westinghouse has developed an SFP PRA model in support of the AP1000® plant licensing in the United Kingdom.

- Westinghouse has performed thermal-hydraulic analyses to establish system success criteria and operator response timing for assessing plant risk during SFP operations.

- Westinghouse has extensive expertise and experience in all aspects of PRA model development worldwide for all-mode, Level 1, Level 2 and Level 3 PRA models, including fire, flood, seismic and other external events.

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