

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

**Credible Sequences for Long-Term
Mitigation Events Discussion Session**



**Richard Barrett, Branch Chief, SPSB
Glenn Kelly, DSSA/SPSB**

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Approach to Risk-Informed Decommissioning

- ◆ **Examine the full scope of potentially risk-significant issues**

- ◆ **Determine which sequences are credible**
 - ◇ **Loss of heat removal**
 - ◇ **Loss of inventory**
 - ◇ **Heavy Loads**
 - ◇ **Seismic**

- ◆ **Document the preliminary assessment for public review**

Approach to Risk-Informed Decommissioning

- ◆ **Elicit feedback from all stakeholders regarding analysis assumptions and design/operational features**
- ◆ **Conduct a complete and open discussion of the risk assessment**
- ◆ **Modify NRC technical assessment based on feedback**
- ◆ **Develop a consistent and predictable basis for future plant-specific decisions, based on:**
 - ◆ **The most appropriate PRA assessment methodology, and**
 - ◆ **Actual design/operational characteristics of the plant.**

Estimation of the Frequency of Zirconium Fire

In the risk analysis, the frequency of fuel uncover (leading to a zirconium fire) is estimated as follows:

$$F = \sum (IE) \times (\text{mitigating system failure \#1}) \\ \times \dots \times (\text{mitigating system failure \#n})$$

where:

F = frequency of fuel uncover

IE = initiating event frequency

Mitigating System Failures = hardware failures, failures of mitigating systems, or human error.

Summary of Results of Risk Assessment

- ◆ **For long term and intermediate term sequences, the IE frequencies are typically on the order of 0.01 per year.**
- ◆ **The conditional probability of failure to mitigate an initiating event is on the order of 10^{-4} (i.e. 1 in 10,000 times the organization will fail to respond adequately when challenged).**
- ◆ **Therefore, the fuel uncover frequency is typically on the order of 10^{-6} per year.**

Credible Sequences for Long-term Mitigation Events

- ◆ **(loss of offsite power from plant centered or grid related events) x (the diesel fire pump fails to start) x (offsite power is not recovered before fuel uncover) x (no recovery help from offsite sources such as fire engines)**
- ◆ **loss of offsite power from a severe weather event occurs with no recovery) x (the diesel fails to start or run) x (no recovery from offsite sources such as a fire truck)**

Credible Sequences (Cont)

- ◆ **(loss of cooling) x (failure of control room alarms) x (operator failure to notice pool steaming and level drop during walkdowns)**
- ◆ **a fire is not suppressed in the building containing the spent fuel and it is large enough to either fail the offsite power feeds, or the fuel pool cooling pumps) x [(operator fails to refill the pool using the diesel-driven fire pump) or (recovery using offsite sources (e.g., fire engines) fails)]**

Staff Concerns

- 1. Operator Attentiveness**
- 2. Instrumentation in Control Room relaying SFP level, SFP temperature, and radiation in area around the SFP**
- 3. Lack of automatic actions by mitigation systems**
- 4. Specific procedures to deal with significant drop in SFP water level including specific recognition of possible need to use offsite resources**

Staff Concerns (cont.)

- 5. Operability of fire pumps and capability of making up to the SFP**
- 6. Training and experience of future Certified Fuel Handlers**
- 7. Redundancy and defense-in-depth in hardware**

Spent Fuel Pool Cooling Risk Analysis

Frequency of Fuel Uncovery (per year)

INITIATING EVENT - Preliminary Study Results	CASE 1
Loss of Offsite Power - Plant centered and grid related events	1.3E-06
Loss of Offsite Power - Events initiated by severe weather	1.4E-06
Internal Fire	8.6E-06
Loss of Pool Cooling	1.5E-07
Loss of Coolant Inventory	2.9E-06
Seismic Event	2.0E-06
Cask Drop	2.5E-06
Aircraft Impact	4.0E-08
Tornado Missile	5.6E-07
Total	1.2E-05

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**Credible Sequences for Intermediate-Term
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Credible Sequences For Intermediate Mitigation Events

- ◆ **(a “small” loss of inventory event occurs) x (SFP level not restored by makeup pumps or fire pumps because of operator error or hardware failure) x (offsite recovery, such as fire engines, unsuccessful)**
- ◆ **(a “large” loss of inventory event occurs) x (operator does not isolate leak) x (SFP level not restored by makeup pumps or fire pumps because of operator error or hardware failure) x (offsite recovery, such as fire engines, unsuccessful)**

Credible Sequences (Cont.)

- ◆ **(a “small” loss of inventory event occurs) x (failure of control room alarms) x (failure of operators to notice condition during walkdowns)**

Staff Concerns

- ◆ **Same as for long-term events plus the following:**
 1. **Vacuum breakers adequately sized and tested.**
 2. **Large pipes penetrating SFP near or below the level of the fuel.**
 3. **Intermediate to large pipes (permanent and temporary) that extend more than 8 feet into the SFP and can act as siphons.**