EDO and DEDO BRIEFING
ON
THE PRELIMINARY TECHNICAL ASSESSMENT OF SPENT FUEL POOL ACCIDENTS FOR DECOMMISSIONING PLANTS

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INTRODUCTION

- Licensees are requesting exemptions from EP and other regulations to reduce unnecessary costs at decommissioned plants.
- To date, the staff has reviewed the licensee's EP requests on a case-by-case basis using criteria that a zircaloy fire will not occur or sufficient time is available to take ad hoc protective measures.
- Technical Working Group was formed to establish a predictable, risk-informed approach for addressing SFP accidents at these plants.
- The staff considers that such an approach would contribute to safety and reduce unnecessary regulatory burden.
- The staff is sensitive to the need to improve efficiency and effectiveness and increase public confidence.

OVERVIEW

- Working Group performed both deterministic evaluations and risk assessments.
- The Working Group has not completed its assessment. However, these preliminary results discussed today provide a trigger for further stakeholder interaction.
- Preliminary findings show that SFPs at decomissioned are not the same as operating plants due to changes in equipment and personnel.
- Preliminary findings also show there is not one dominant event for SFP accidents, as will be discussed later
- Staff expects that interaction with stakeholders can better define some accidents sequences

DETERMINISTIC ASSESSMENT FINDINGS

- **Existing generic studies identified that the likelihood of a zircaloy fire was extremely dependent on decay power and fuel storage configuration.**

SUMMARY OF HEATUP RESULTS
FOR PWR SPENT FUEL

(Annotations give storage configuration
and baseplate hole size)

from NUREG/CR-0649
based on 33 GWD/MTU,
17 x17 pin array, &
well-ventilated room

DETERMINISTIC ASSESSMENT FINDINGS (cont.)

- Changes in operating practices have effected both parameters non-conservatively.

  - Increase in fuel burnup
  - Denser fuel storage racking

- Previous studies underestimate the decay time required to preclude zircaloy oxidation for today's plants.

- Staff evaluated generic, near-bounding thermal hydraulic spent fuel heatup calculations and determined that 3 to 5 years are needed to preclude a zircaloy fire for today's plants.

- For spent fuel heatup analyses, the maximum allowable temperature could be as high as 800 °C, rather than 565 °C, if certain conditions are complied with.

- Two previous EP exemptions were granted based on the finding that 10 hours was sufficient time to take ad hoc offsite protective measures.

Staff performed generic, bounding calculations to correlate decay time since final shutdown (decay power) to heatup time (time available for ad hoc actions). The calculations were based on adiabatic conditions involving one fuel rod heating up from 30 to 900 °C.

Generically, to ensure at least 10 hours are available for ad hoc measures, 2 years of decay time since final shutdown is needed for a BWR and 2.5 years for a PWR.

SFP RISK AT DECOMMISSIONED PLANTS

- It is commonly believed that the risk at decommissioned reactors must be very low compared to operating reactors

- The staff performed a broad analysis of the risk that spent fuel pools at decommissioned plants represent to the public. The analysis considered a wide range of initiating events

- We found that previous analyses had underestimated the effect of denser spent fuel pool reracking, higher burnup, and equipment removal/abandonment under the 50.59 process.

SFP RISK AT DECOMMISSIONED PLANTS (Cont.)

- Risks from spent fuel pool accidents are comparable to those in operating reactors for the first three to five years after last fuel transfer, while operating reactors are at risk for 40 to 60 years.

- Risk is driven by lack of redundancy and diversity of spent fuel pool cooling capability at spent fuel pools.

SCENARIOS EVALUATED IN RISK ANALYSIS

Case 1 - The spent fuel pool and its cooling system are configured and operated in a manner similar to that found by the staff in its site visits. Last fuel transferred one year previously.

Case 2 - Same configuration as Case 1, but the last fuel was transferred one month previously.

Case 3 - The spent fuel pool and its cooling system are configured slightly better than the minimal allowed by NRC regulations. Last fuel transferred one year previously.

FREQUENCY OF FUEL UNCOVERY (per year)

INITIATING EVENT	CASE 1	CASE 2	CASE 3
Loss of Offsite Power - Plant centered and grid related events	1.3E-06	4.2E-06	8.0E-05
Loss of Offsite Power - Events initiated by severe weather	1.4E-06	9.4E-06	1.4E-05
Internal Fire	4.2E-06	5.2E-06	4.5E-05
Loss of Pool Cooling	1.5E-07	2.4E-07	2.3E-05
Loss of Coolant Inventory	2.9E-06	6.0E-05	1.3E-04
Seismic Event	2.0E-06	2.0E-06	2.0E-06
Cask Drop	2.5E-06	2.5E-06	1.5E-05
Aircraft Impact	4.0E-08	4.0E-08	4.0E-08
Tornado Missile	5.6E-07	5.6E-07	5.6E-07
Total	1.5E-05	8.4E-05	3.1E-04

SFP RISK

	CASE 1	CASE 2	CASE 3
Risk Totals			
Early Fatalities	1.0E-5	8.1E-5	2.1E-4
Latent Cancers	3.3E-2	1.9E-1	6.8E-1
Initiator	% of Risk from initiator	% of Risk from initiator	% of Risk from initiator
Loss of Offsite Power - Plant centered and grid related events	9	5	26
Loss of Offsite Power - Events initiated by severe weather	9	11	5
Internal Fire	28	6	15
Loss of Pool Cooling	1	0.3	7
Loss of Coolant Inventory	19	71	42
Seismic Event	13	2	0.6
Cask Drop	17	3	5
Aircraft Impact	0.3	0.05	0.01
Tornado Missile	4	0.7	0.2

RISK ASSESSMENT FINDINGS

- The interim risk assessment shows spent fuel pool risk at decommissioned plants to be comparable to operating reactor risk for the first 3 - 5 years

- The interim results are driven by modeling assumptions on initiating event characteristics, plant configuration, and operator recovery actions. A more detailed investigation of a "generic" plant would be driven by similar assumptions

- Land interdiction costs as a result of any zircaloy cladding fire in the spent fuel pool would be high. This does not affect Emergency Preparedness (EP), but does affect indemnity insurance.

RISK ASSESSMENT FINDINGS
(Cont.)

- There appears to be sufficient time to respond to most initiators so that the existence or non-existence of EP planning would make little difference to the population.

- This is not necessarily true for heavy load drops, aircraft crash, and very large seismic events that have the potential to rapidly drain the SFP and uncover the fuel. If one of these initiators were to occur during the first year or two after the last fuel was transferred from the reactor to the spent fuel pool, it appears that there would be only five to seven hours available for ad hoc emergency response. This might be too short for effective ad hoc evacuation.

STAFF'S CURRENT PLAN

- Developing interim criteria and recommendations based on the findings to have a more uniform exemption process for decommissioned SFP requirements.

- Requesting independent, quality reviews on the interim assessment from the following groups or organizations:

  - Advisory Committee on Reactor Safeguards (ACRS)
  - Committee to Review Generic Requirements (CRGR)
  - Nuclear Energy Institute (NEI)
  - Idaho National Engineering and Environmental Laboratory (INEEL)
  - Solicit comments from the Stakeholders (public, licensees, etc.)

CURRENT SCHEDULE

- Staff's interim response to the SRM with plans and schedules to the Commission - 6/18/99
- Staff's interim technical assessment paper issued for independent review in parallel to the groups or organizations listed above - 7/30/99
- Independent, quality reviews to be completed - 12/31/99
- Staff to complete final technical assessment - 3/31/00

RECOMMENDED CRITERIA, APPROACHES, AND METHODS

EP Deterministic Assessment Criteria:

1. If 2 years has elapsed for a BWR or 3 years for a PWR since final reactor shutdown, then SFP accidents are not a concern for offsite EP based on the staff's generic finding that at least 10 hours is available and is sufficient time for mitigative actions, and if necessary, offsite protective measures. No analysis is required by the licensee.

2. If a licensee requests a shorter period of time than stated in Item 1., then the licensee may perform a site-specific spent fuel heatup analysis to demonstrate that the spent fuel will not exceed 800° C, if cooled by air only. The analysis should demonstrate that:

   ◊ gap release is not a concern,
   ◊ the analysis models zircaloy oxidation in air & additional flow losses to model blockage due to clad ballooning & rupture, &
   ◊ calculation uncertainties are less than the available margin between the calculated temperature and 800 °C.

   If the design of the SFP is vulnerable to a partial draindown of the SFP, then this configuration would also be analyzed. If the licensee can demonstrate these items, then spent fuel pool accidents are not a concern for offsite EP.

3. If a licensee requests a shorter period of time than stated in Item 1., then the licensee may perform a fuel-specific calculation using the most limiting combination of fuel assembly configuration and fuel burnup. If adiabatic heatup conditions are used, a maximum temperature of 900 °C can be used. If more than 10 hours are available during the time of heatup from 30 °C to 900 °C, then the staff believes that sufficient time would be available to take ad hoc offsite emergency actions.

RECOMMENDED CRITERIA, APPROACHES, AND METHODS (continued)

EP Risk Assessment Approaches and Methods:

1. Refinement of the heavy load drop risk assessment for SFPs at decommissioned plants or limitations on heavy load movements between 2-3 years after final reactor shutdown may be necessary to preclude heavy load drops from being a significant contributor to risk.

   Licensees would need to submit a description of what measures (e.g., installed crane stops, improved procedures, added restrictions on movement of casks until fuel is greater than some specified age) it has taken to adequately reduce heavy load drop concerns. The staff would review the measures and determine their acceptability.

2. Decommissioned plants should have:

   ◊ adequate instrumentation to track and alarm temperature rise and level changes in the SFP.
   ◊ Technical Specification requirements for diesel-driven fire pump, spent fuel pool level instrumentation, spent fuel pool temperature instrumentation, and spent fuel pool area radiation monitors to protect theSFP until the decay heat level in the pool until 3-5 years after final reactor shutdown.
   ◊ Two reliable sources of makeup to the spent fuel pool.

3. For licensees seeking exemptions, the following efforts should be performed to provide confidence that the as-built SFP has a sufficiently robust high confidence low probability frequency (HCLPF).

   Verification of the pool structure and its vicinity to identify:

   a. physical conditions such as cracking, spalling of concrete, signs of leakage or leaching and separation of pool walls from the grade surface,
   b. arrangement and layout of supporting columns and shear walls, assessment of other loads from tributary load areas carried by the supporting structure of the pool, as-built dimensions and mapping of any existing structural cracks,
   c. adjacent structures that can impact the pool structure both above and below the grade surface, supporting arrangement for superstructure and crane and potential for failure of the superstructure and the crane, the weight of the heaviest object that can drop in the pool structure and the corresponding drop height.

Calculate the seismic capacity of the pool structure. Typically such a calculation consists of the following:

a. review existing layout drawings and structural dimensions and reconcile the differences, if any, between the as-built and as designed information and consider the effects of structural degradation as appropriate,

b. from design calculations determine the margin to failure and assess the extrapolated multiple of SSE level that the pool structure should survive, determine whether or not design dynamic response analysis including soil-structure interaction effects are still applicable at the capacity level seismic event, if not, conduct a new analysis using properties of soil at higher strain levels and reduced stiffness of cracked reinforced concrete,

c. determine the loads from pool structure foundation uplift and from impact of pool structure with adjacent structures during the capacity level seismic event, determine loads from the impact of spent fuel rack on the pool floor and the side walls and determine the loads from dropping of heavy objects from the collapse of superstructure or the overhead crane,

d. determine a list of plausible failure modes; failure of side walls due to the worst loading from the capacity level earthquake in combination with fluid hydrostatic and sloshing head and dynamic earth pressure as appropriate, failure of the pool floor slab in flexure and bending due to loads from the masses of water and the spent fuel and racks, local failure by punching shear due to impact between structures and the spent fuel racks or dropping of heavy objects,

e. the calculations to determine the lowest structural capacity can be based on ultimate strength of reinforced concrete structures due to flexure, shear and punching shear. When conducting an yield line analysis, differences in flexural yield capacities in two orthogonal directions and for the negative and positive bending moments influence the crack patterns and several sets of yield lines may have to be investigated to obtain the lowest capacity. For heterogeneous materials, the traditional yield line analysis provides upper bound solutions; consequently, considerable skill is needed to determine the structural capacity based on the yield lines that approximate the lower bound capacity.

RECOMMENDED CRITERIA, APPROACHES, AND METHODS (continued)

Insurance Indemnification Approaches and Methods:

1) After five years have elapsed since the final reactor shutdown, SFP accidents are not an offsite concern for insurance indemnification purposes due to the generic staff finding that zircaloy fire could not occur.

2) The licensee may perform a site-specific spent fuel heatup analysis to demonstrate that the spent fuel will not exceed 800 °C, if cooled by air only. The licensee would have to demonstrate that 1) gap release is not a concern, 2) the analysis includes a model for zircaloy oxidation in air and additional flow losses to model blockage due to clad ballooning and rupture, and 3) the calculation uncertainties are less than the available margin between the calculated temperature and 800 °C. If the design of the spent fuel pool could allow a partial draindown to occur, this configuration would also be analyzed. If the licensee can demonstrate this, then spent fuel pool accidents are not an offsite concern for insurance indemnification.

*All recommendations mentioned above are contigent upon the approval by the EP staff.

FURTHER WORK

- The risk assessment performed for this interim assessment was simplified due to time constraints. The staff recommends further work be performed to verify assumptions, reduce uncertainty, and focus on the risk significant contributors in the assessment.

- The staff needs to assess whether action levels higher than the "alert" level at decommissioned plants is necessary to ensure the timing of the warning is commensurate with the potential consequences of a release followed by evacuation of local residents.

- The staff needs to evaluate strengthening the requirements for spent fuel pool cooling system and support system redundancy and diversity at decommissioned plants.

- The staff needs to reevaluate the 10 CFR 50.59 process for removing safety-related equipment and other equipment at decommissioned plants.

- The staff found that the studies for Generic Safety Issue (GSI) 82, "Severe Accidents in Spent Fuel Pools," may underestimate the time that zircaloy fire would be possible at an operating plant due to higher burnups and denser storage practices. The staff recommends that the NRC Office of Research explore the effect of higher burnups and denser storage practices on the conclusions of GSI 82.

FURTHER WORK (Continued)

- The risk associated with an internal fire was identified as a significant contributor to the overall risk. In addition, a zircaloy clad fire is a concern due to the possible severe offsite consequences. The staff recommends that the use of high-expansion foam or monitor nozzles should be considered further as a means to extinguish plant fires.

- The source term for long-lived radionuclides is not well defined. Additionally, the current source term is not defined of higher burnup fuels. The staff recommends that the source term be updated for high burnup fuel and decayed to include significant contributors for long decay times.