Ensuring Spent Fuel Pool Safety

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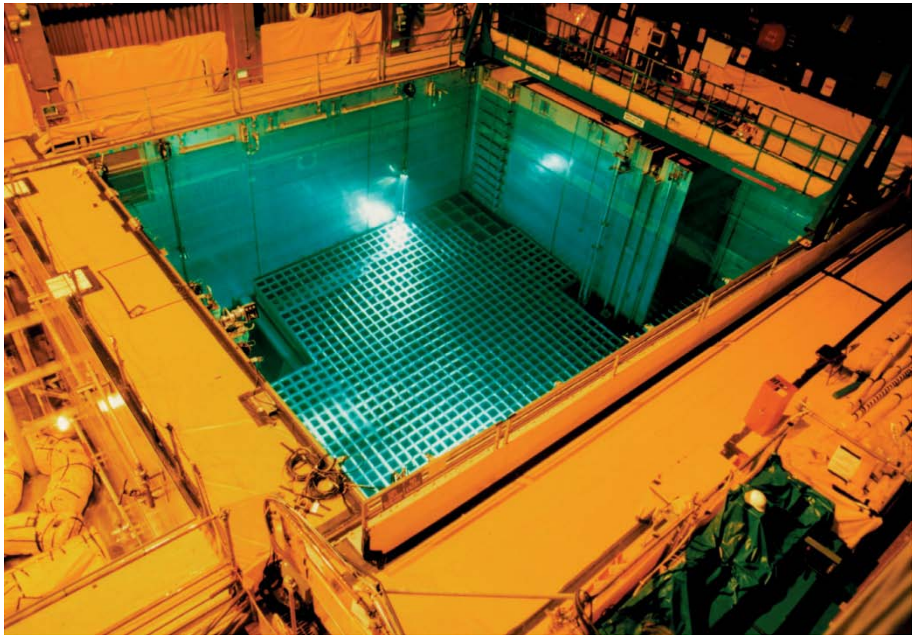
Insights from Fukushima

- Nuclear emergency at Fukushima-Daiichi
  - 3 nuclear reactors
  - 4 reactor spent fuel pools
  - 1 common spent fuel pool

U.S. Spent Fuel Pools



- Spent fuel rods stored in spent fuel pools (SFPs) under at least 20 feet of water
- Typically ~1/4 to 1/3 of fuel in reactor replaced with fresh fuel every 18 to 24 months
- Spent fuel stored in pools minimum of 5 years

U.S. SFP Safety

- Spent Fuel Pools (SFP) originally designed for limited storage of spent fuel until removed off-site
- Safety of spent fuel in pools achieved primarily by maintaining water inventory, geometry, and soluble boron (PWRs)
- Drain down can lead to uncovered fuel, heat-up, and the release of radionuclides

Risk of Large Release

- SFP risk is low, due to the low frequency of events that could damage the thick reinforced pool walls
  - Frequency of fuel uncovery; 6E-7 to 2E-6/yr. – NUREG-1738
  - Consequences have been assessed to be large due to the potential for heatup of all the fuel in the pool
  - Heatup of the fuel in the pool can lead to “zirconium fire” initiation and propagation
  - Large inventory of Cs-137

SFP Safety and Security

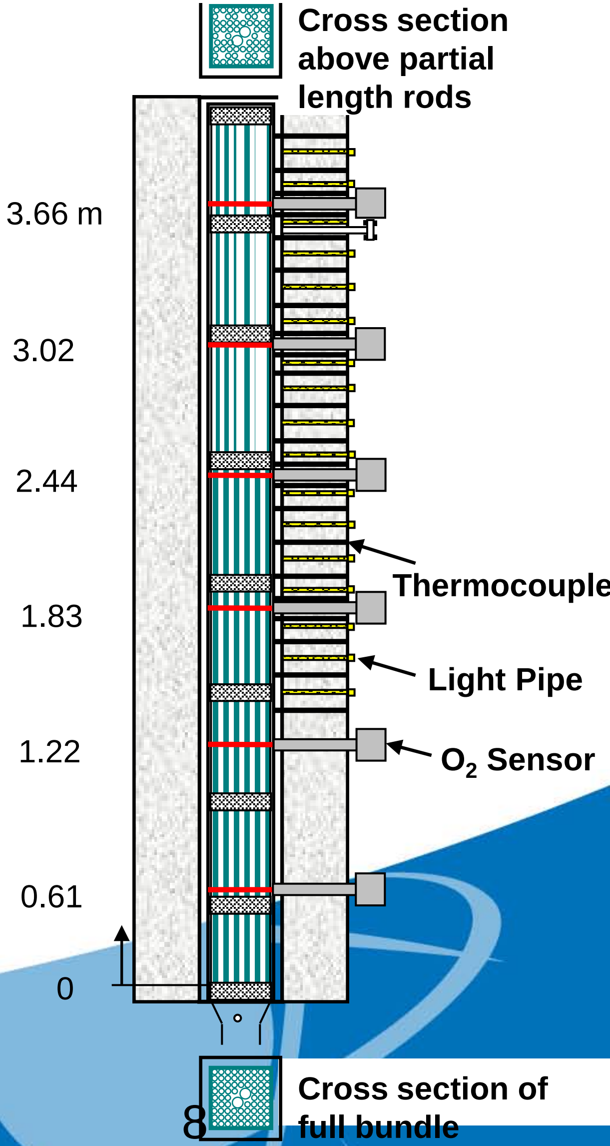
- NRC extensively reexamined pool safety and security after 9-11 attacks
  - Vulnerability to attack
  - Significantly improved analysis of fuel coolability / heatup
  - Assessment of mitigation measures to improve coolability of fuel
    - Improved fuel configuration within the pool achieves substantially greater passive cooling capability by natural convection

SFP Safety and Security

- Additional analyses of a spray system for spent fuel pool cooling
- NRC required spray capability for each site to improve active cooling capability
- Licensees performed site-specific assessments; NRC inspected
- Coolability of fuel within pools has been enhanced by measures identified and assessed as part of post-9/11 research
- Conducting research to confirm understanding and validate analytical modeling

Zirconium Fire Investigations During SFP Loss of Coolant Accident (LOCA)

- Prototypic full length 9×9 BWR hardware
  - Single pool rack cell
  - Upper & lower tie plates with seven spacers
  - Water tubes and channel box
  - 74 electric heater rods with Zr-2 cladding (eight partial length)
  - 5000 W simulating a 100 day old assembly
- Measurements
  - Temp profiles: Axial and radial
  - Induced flow: Effect of ignition on flow
  - O_2 concentration: Determine depletion
  - Nature of fire: Initiation location & axial burn rate



Zirc Fire Investigations During SFP LOCA – Postmortem

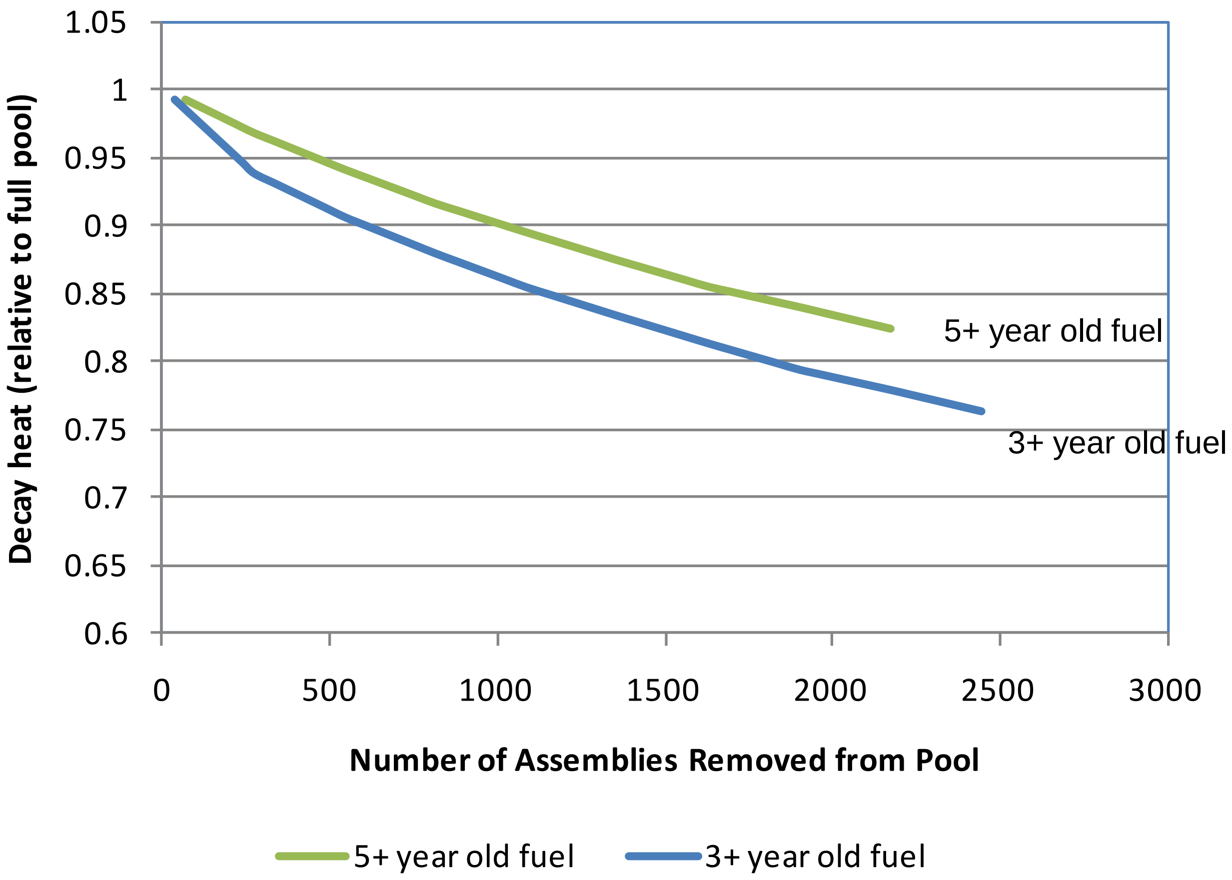
Full Length Single Assembly Ignition Movie

Removing Fuel from Pools

- NRC has considered benefits of removal of fuel from the pool and returning to a low density racking type configuration
- There are competing factors in such a consideration
  - Storage in dry casks must be consistent with certificate
  - Discharging of fuel increases the risk of cask drops and worker doses
  - Removal of fuel will decrease the inventory of Cesium-137
  - Removal of fuel does not appreciably reduce decay heat (most of the decay heat is from recently discharged fuel)
  - Reduction in potential land contamination and economic impacts, if a large release occurred

Impact of Removing Assemblies

Reduction of pool thermal heat load



Comparative Consequence Study

- NRC is initiating an updated SFP study
- Estimate the change in accident consequences associated with removing older fuel from the SFP and placing it in dry storage
- Limited scope analysis (e.g., single SFP/operating cycle for low/high density racking)

Comparative Consequence Study for SFP

- Technical approach relies on realistic analysis using expedient but technically-defensible deterministic methods and assumptions.
- Elements of study include
  - Information gathering
  - Seismic and structural assessment
  - Accessibility, decay heat, and radionuclide inventory assessment
  - Accident progression (MELCOR) and offsite consequence analysis (MACCS2)
  - Emergency planning assessment

Conclusions

- No immediate safety concerns based on Fukushima nuclear emergency
- Confirmed the existing safety measures for SFPs
- Examining both the near-term and long-term reviews
- Spent fuel needs to be managed safely and securely