

# Spent Fuel Pool Seismic Evaluations

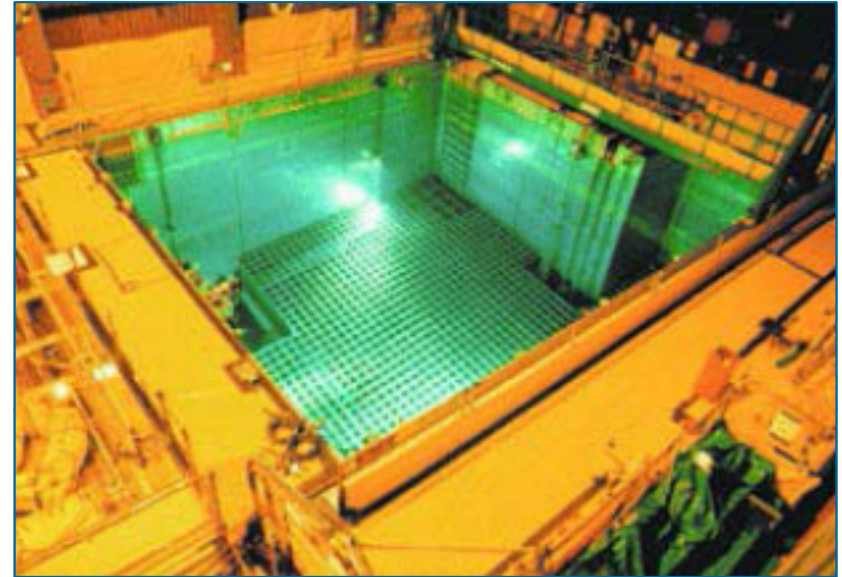
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**NRC Meeting on Recommendation 2.1**  
September 3, 2015



# SFP Seismic Evaluation Criteria

- Graded approach to SFP seismic evaluations
  - For plants with GMRS peak spectra accelerations ( $S_a$ )  $\leq 0.8g$ 
    - NP-6041 criteria for the SFP structure
    - Generic assessments for non-structural elements
  - For plants with GMRS peak spectra accelerations ( $S_a$ )  $> 0.8g$ 
    - Simplified analysis of SFP walls and floors applying insights from the NRC SFP scoping study
    - Criteria for non-structural elements to be developed



## SFP Evaluation Criteria – $S_a \leq 0.8g$

- SFP structural criteria
  - Seismic adequacy assessment using NP-6041 criteria
  - White paper provided to NRC and discussed at the July 15, 2015 public meeting
- SFP non-structural criteria
  - SPID identifies the following issues that need to be evaluated
    - Penetration assessment
    - Siphoning assessment
    - Sloshing assessment (perhaps point to an Attachment)
    - Evaporative loss assessment
  - White paper with generic assessment criteria provided to NRC for review
  - Industry has evaluated these 4 issues and concluded that these non-structural elements do not pose a significant risk at plants with  $S_a \leq 0.8g$
- Submittal template will incorporate these generic conclusions for plants with  $S_a \leq 0.8g$

## SFP Evaluation Criteria – $S_a \leq 0.8g$

### ■ Piping Penetrations

- Industry survey shows that not many plants have penetrations below about 10 ft above top of fuel
- Past SFP risk assessments (NUREG/CR-5176) concluded that HCLPF capacities of piping systems are estimated to be in excess of 0.5g PGA
- NRC Scoping Study concluded piping would remain functional and leak tight for the spent fuel pool at Peach Bottom (peak  $S_a$  of 1.8 g)
- SFP piping is considered rugged if evaluated to the SSE and GMRS peak  $S_a \leq 0.8g$

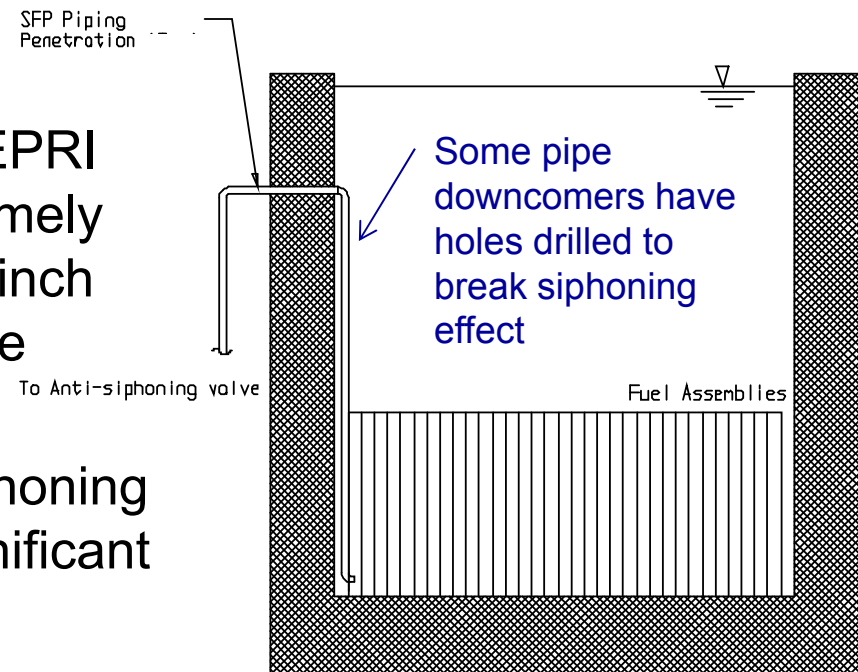
### ■ Refueling Gates

- Designs have high ductility and seismic loads do not dominate the design
- NRC SFP Scoping Study concluded that for Peach Bottom, the refueling gate and seal was not damaged (peak  $S_a$  of 1.8 g)
- Combined median horizontal impulsive, horizontal convective, and vertical pressures are less than the hydrostatic pressure at mid-height of the SFP
- SFP refueling gates will remain functional in cases where the GMRS peak  $S_a \leq 0.8g$

# SFP Evaluation Criteria – $S_a \leq 0.8g$

## ■ Siphoning

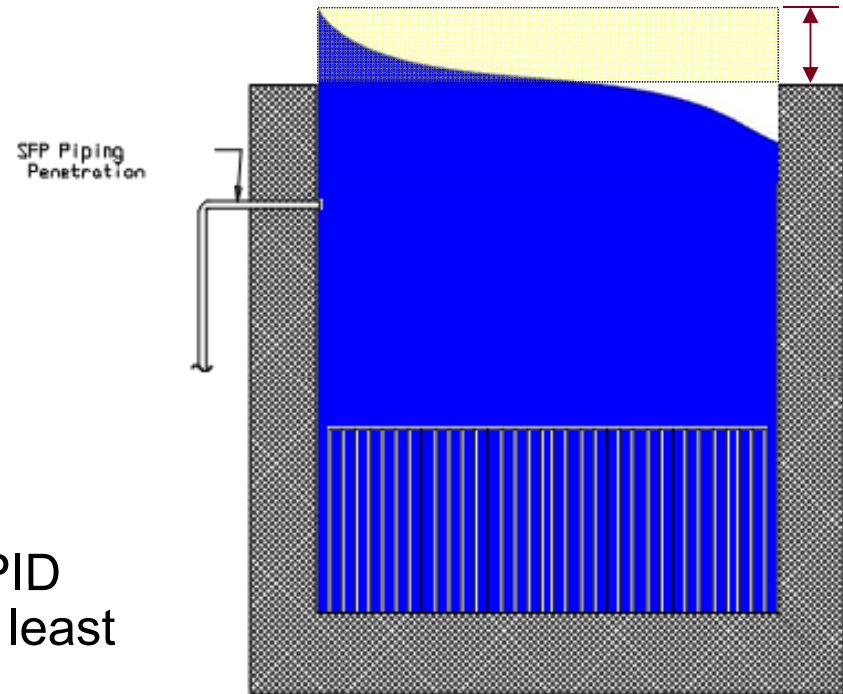
- Most SFPs have anti-siphoning devices
- Anti-siphoning valves are typically passive mechanical devices that permit flow in one direction or break the vacuum
  - Passive valves are rugged in accordance with EPRI NP-6041 (Table 2-4)
  - Active valves will require confirmation accordance with EPRI NP-6041 (Table 2-4) that extremely large extended operators on 2-inch or smaller piping have adequate lateral support
- If GMRS peak  $S_a < 0.8g$ , anti-siphoning devices are rugged and not a significant source of rapid drain-down



# SFP Evaluation Criteria – $S_a \leq 0.8g$

## ■ Sloshing

- Seismic ground motion can induce sloshing motions in SFPs
- SPID provides guidance for estimating sloshing frequencies and heights
- SPID guidance is conservative for estimating sloshing heights
- Comparison to NRC SFP Scoping Study and Fukushima indicates SPID over-predicts sloshing height by at least a factor of three
- Based on the conservative SPID guidance, industry SFP survey results, and reevaluated GMRS, median slosh heights for SFPs are 3.7 ft
- Assume at least 1 ft of freeboard, use sloshing losses of 3 ft for all plants with GMRS peak  $S_a < 0.8g$
- These results are used in the assessment of SFP evaporation effects





## SFP Evaluation Criteria – $S_a \leq 0.8g$

- Evaporative loss assessment
  - Evaporative loss estimates calculated using guidance in NUREG-1738, Appendix 2A for heat loads, time to boil, and boil-off rates
  - Using the following inputs
    - Heat load consistent with 60 days after discharge (representative of non-outage period decay power, consistent with NRC Scoping Study)
    - Representative SFP depth
    - Representative SFP surface area
    - 3 ft sloshing losses
  - Time to boiling is 18 hrs
  - Time to uncovering spent fuel to 1/3 of fuel height is 94 hrs
  - Use this result for all plants with GMRS peak  $S_a < 0.8g$

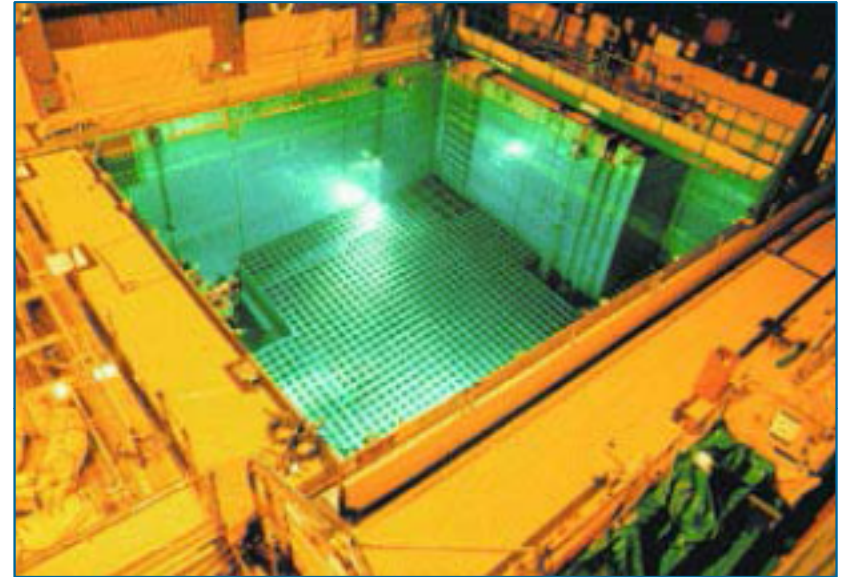
## SFP Evaluation Criteria – $S_a \leq 0.8g$

- Incorporate the criteria into a submittal template for plants with  $S_a \leq 0.8g$
- Proposed template content
  - Plant SFP screening information (GMRS to SSE)
  - Structural assessment showing that the plant SFP meets the parameters necessary to use the NP-6041 screening in Section 2 of the white paper
  - Non-structural assessment using the information in the Section 3 of the white paper
    - Piping is adequately rugged if evaluated to SSE
    - Gates are adequately rugged
    - Confirm existence of anti-siphoning devices and absence of extended operators on small ( $<2''$ ) piping
    - Use conservative 3 ft estimate for sloshing losses
    - Use 94 hrs to boil-off



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  - For plants with GMRS peak spectra accelerations ( $S_a$ )  $> 0.8g$ 
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## SFP Evaluation Criteria – $S_a > 0.8g$

### ■ SFP structural criteria

- Two candidate plants, which have representative SFPs, to be evaluated using detailed seismic inputs (from SPRA models)
- HCLPFs for representative SFPs to be calculated and compared to GMRS demands

### ■ SFP non-structural criteria

- Same rapid draindown mechanisms to be assessed (piping penetrations, refueling gates, sloshing, siphoning, and evaporation).
- Seismic responses (displacements, wall pressures, slosh heights, etc.) will be reviewed to assess applicability of non-structural criteria for plant with  $S_a < 0.8g$ .
- Revised or additional screening criteria to be developed as necessary

## Next Steps

- Evaluation for plants with GMRS peak  $S_a \leq 0.8g$  (2015-2016)
  - Reach agreement on White Paper (November 2015)
  - Develop submittal template based on White Paper (January 2016)
  - Industry submittals (2016)
  
- Evaluation for plants with GMRS peak  $S_a > 0.8g$  (2015-2017)
  - Finalize benchmarking/evaluation (2015-2016)
  - Identify two representative sites for detailed evaluation (2016)
  - Perform analysis when ISRS from the two representative sites are provided from SPRA model(s) (2016-2017)



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