Wolf Creek

Fiber Penetration and Head Loss Testing Approach

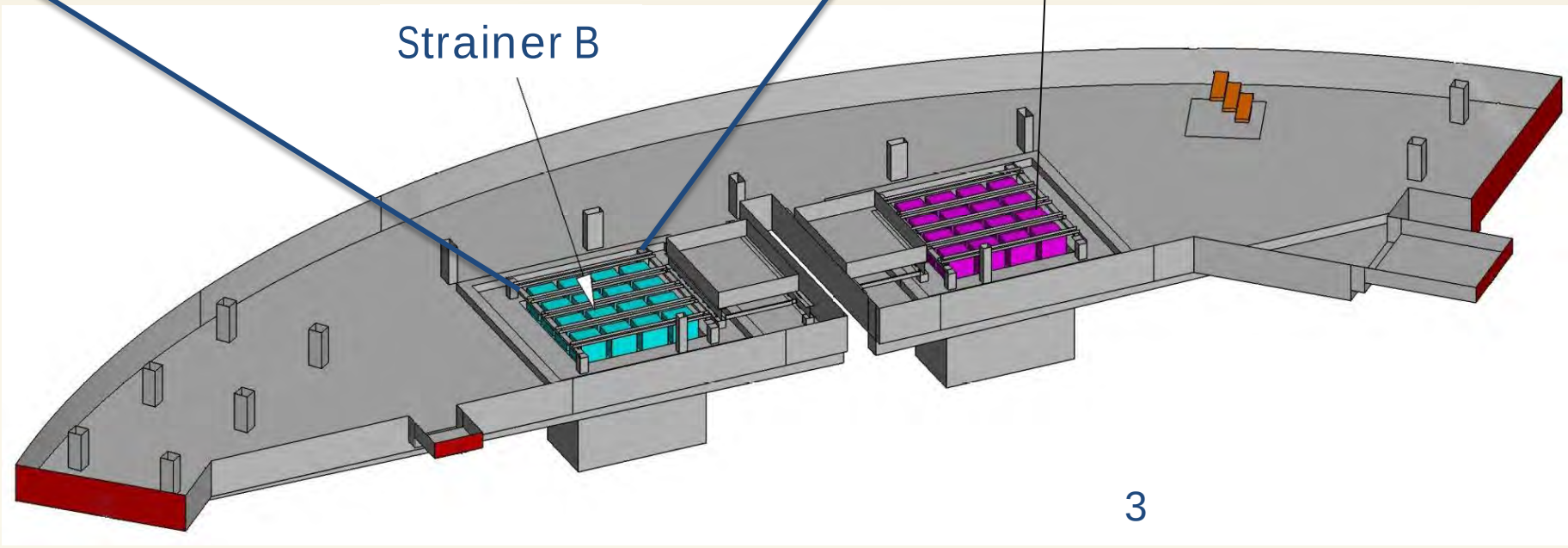
Meeting with NRC

April 12, 2016

Outline

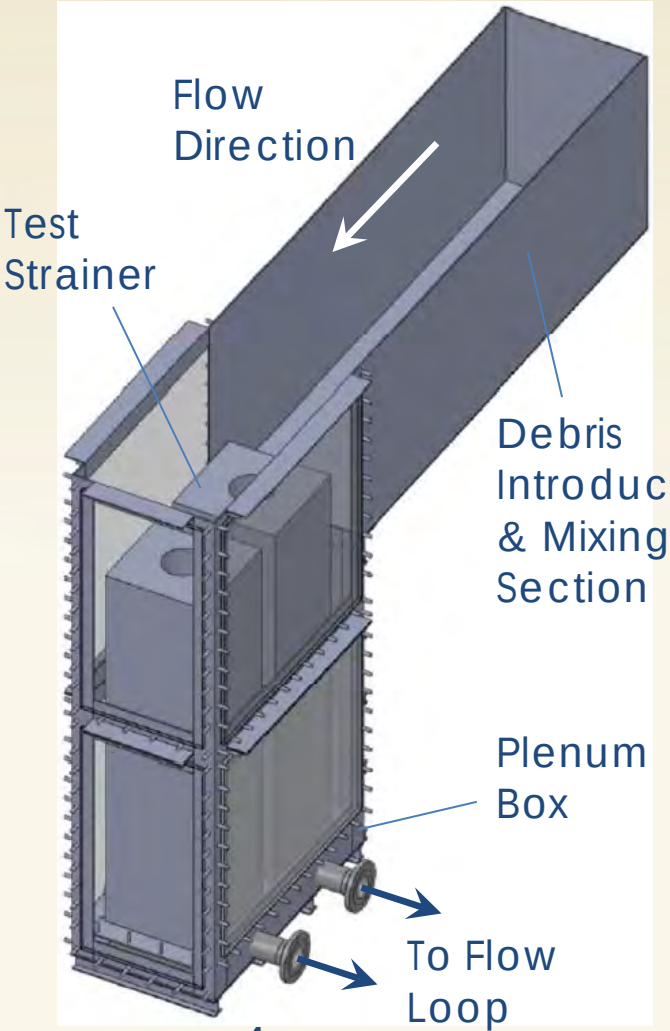
- Purpose of Meeting
  - Communicate Wolf Creek testing approach for fiber penetration and strainer head loss
- Agenda
  - Overview of Wolf Creek Testing Program
  - Fiber Penetration Testing Approach
  - Strainer Head Loss Testing Approach

Overview of Sump Strainers



Overview of Testing Program

- Perform tank tests at Alden for fiber penetration and strainer head loss
- Use prototypical strainer modules for head loss testing
- Modify prototypical strainer modules for penetration testing to eliminate bridging
- Test strainer modules have same disk size, perforation size and core tube diameter as the plant strainer
- Maintain turbulence level for complete transport of fine debris



Overview of Testing Program (cont'd)

- Use methods previously reviewed by the NRC
  - Similar to recent tank tests for Florida Power & Light at Alden witnessed by the NRC staff
- Follow NEI guidance on fibrous debris preparation*
- Determine threshold debris load that meets in-vessel and head loss criteria using test results
- Projected test start date: May 9, 2016

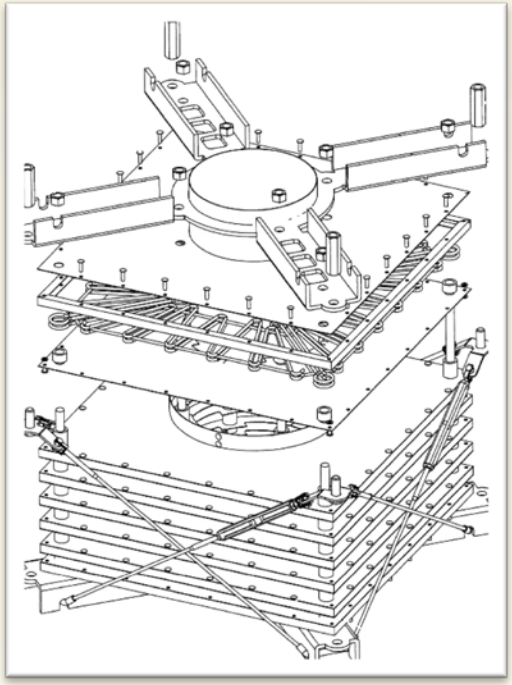
❖ *ZOI Fibrous Debris Preparation: Processing, Storage and Handling, Rev. 1, Jan 2012* (ADAMS Accession No. ML120481057)

Fiber Penetration Testing Approach

- Perform a fiber-only penetration test
- Collect time-dependent fiber penetration data considering prompt and long-term penetration
- Develop a curve fit from testing data to characterize rates of prompt and long-term penetration
- Apply curve fit to quantify total fiber penetration for the fiber load of each break at bounding plant conditions
- Determine compliance with the in-vessel fibrous debris quantity limit (WCAP-17788)
- Perform 30-day extrapolation for total fiber penetration as input to ex-vessel downstream effects analysis

Prevent Bridging for Penetration Testing

- Modified prototype strainer to eliminate possible bridging of fiber between adjacent disks, and between the strainer and its surrounding walls
- Preventing bridging in fiber-only penetration testing allows fiber to reach the perf plates and is conservative
- Test strainer module modification
  - Remove every other disk
  - Remove seismic cables
  - Increase distance between edges of test strainer and surrounding walls
- Measured fiber penetration per unit area will be applied to the plant strainer surface area



Penetration Testing Conditions

- Prototypical pool chemistry at max pH (9.6)
- Testing temperature 120°F ± 5°F
- Max strainer approach velocity (0.00612 ft/s)
- Prototypical fibrous debris concentrations
  - *Pool fiber concentration defined as total fiber quantity divided by pool volume*
  - *Fiber concentration in test tank maintained at or below the prototypical value to allow debris bed to form slowly*

Fiber Preparation and Introduction

- Only fines will be used for penetration testing
  - Nukon sheets baked single-sided into half thickness and cut into 2” × 2” cubes
  - Debris preparation per the latest NEI Guidance*
- Fiber will be added to the test tank in batches
- Batching size will increase gradually to facilitate fiber bed formation on test strainer
- Total test fiber quantity will bound the max fiber load of largest DEGB

❖ *ZOI Fibrous Debris Preparation: Processing, Storage and Handling, Rev. 1, Jan 2012* (ADAMS Accession No. ML120481057)

Collect Time-Dependent Penetration Data

- Penetrated fiber collected in 5-μm filter bags
- Each batch begins with a set of clean bags
- To measure long-term penetration, extended runtime and multiple bag changes will be done for selected batches
- Total runtime of the test exceeds duration from start of an accident to hot leg recirculation switchover
- A curve-fit will be developed to adequately model and bound testing results
- The curve-fit characterizes both prompt and long-term penetration

Head Loss Testing Approach

- Measure debris bed head loss for debris loading of various break sizes on a prototypical test module
  - No modifications to test modules as done for penetration testing
- Chemical debris will not be added until all conventional debris has been introduced to test tank and head loss allowed to stabilize
- Perform flow sweeps for adjusting measured head losses to plant conditions
  - After adding all conventional debris and at end of test

Head Loss Testing Approach (cont'd)

- Perform temperature sweep after adding all conventional debris to characterize debris bed
- Head Loss Test Conditions:
  - Prototypical sump water chemistry at min pH (8.7)
  - Test temperature approximately 120°F ± 5°F
  - Approach velocity from max strainer flow rate and net strainer surface area (0.00615 ft/s)
- Two head loss tests planned
  - Test 1: Full Debris Load Test
  - Test 2: Thin Bed Test
  - Contingency test may be conducted depending on results of previous tests

Test 1: Full Debris Load Test

- Fibrous and particulate debris batched into test tank as homogeneous mixtures
- Addition of conventional debris ends when head loss is near prescribed value based on pump NPSH margin and strainer structural limit
- No alternating additions of fiber fines and small pieces

Test 1: Full Debris Load Test (cont'd)

- Cumulative conventional debris quantities of intermediate batches match debris loads of multiple break sizes
  - Head loss allowed to stabilize before continuing addition
- Chemical debris batched into test tank after completing all conventional debris addition
  - Head loss allowed to stabilize after each addition

Test 2: Thin Bed Test

- Particulate debris load for Test 2 will be informed by the threshold breaks identified in Test 1
- Particulate debris added to test tank at the beginning of test
- Nukon fiber fines added in batches until thin-bed conditions are met
- Chemical debris batched in afterwards

Test Debris Types

Test Materials	Debris Types at Plant
Nukon	• Nukon Insulation • Latent Fiber • Cerablanket • Fibrous Content of Thermolag
Pulverized Acrylic or Silicon Flour (10 μm)	• IOZ, Epoxy and Alkyds • Foamglas • Particulate Content of Thermolag
PCI PWR Dirt/Dust Mix*	Latent Particulate
Aluminum Oxyhydroxide	Aluminum Precipitate Debris

- The size distribution of "PCI PWR Dirt/Dust Mix" meets requirements in Appendix VII of NEI 04-07 for surrogate of latent particulate debris

Quantity of Chemical Debris

- Evaluated chemical precipitate quantities using deterministic method per WCAP-16530-NP-A
  - Max sump pool mass and temperature to increase aluminum release
  - Max pH to increase aluminum release
  - Conservatively higher aluminum inventory
  - Max quantities of E-Glass of largest DEGB

Closing

- Wolf Creek is planning to use methods previously reviewed by the NRC staff
- Penetration data will be used to develop a curve fit that can be applied to any debris load (up to max for WCNOC)
- Head Loss test results will establish a threshold debris load
- Analysis will determine the threshold debris load that meets both the in-vessel and head loss criteria
- Threshold debris load will determine the break sizes that pass deterministically

Closing

- Questions?