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Arkansas Nuclear One (ANO)
Resolution of In-Vessel Downstream Effects
Pre-Submittal Meeting with NRC

November 17, 2020

Agenda

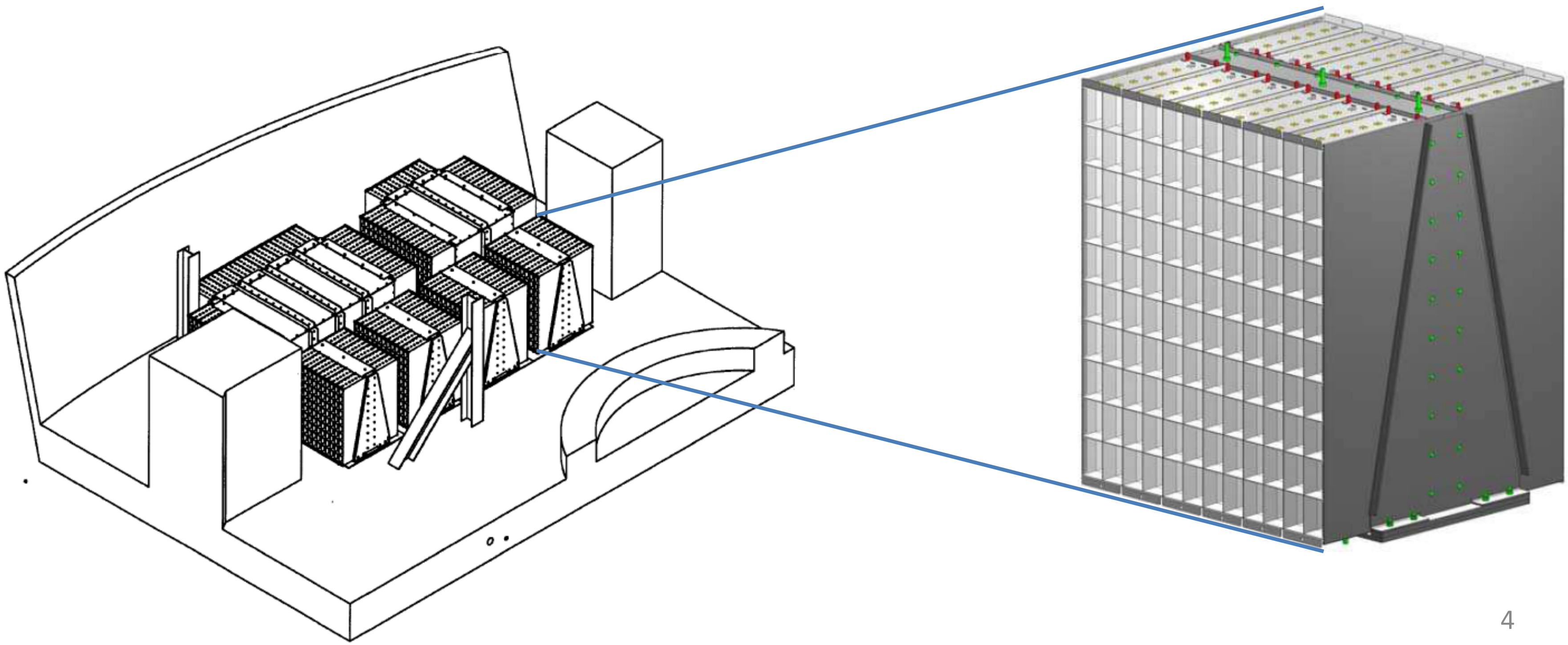
- Meeting Objectives
- Overview of ANO Sump Strainers
- ANO Current Generic Letter 2004-02 Resolution Status
- Overview of ANO Approach for Resolving In-Vessel Downstream Effects
  - ANO Fiber Bypass Testing
  - ANO In-Vessel Fiber Load Analysis
  - Applicability of WCAP-17788 AFP Analysis for ANO
- Submittal Format and Schedule

Meeting Objectives

- Communicate ANO's approach for resolving in-vessel downstream effects
- Communicate content and schedule of upcoming supplemental GL 2004-02 response
- Obtain staff feedback on the technical approach
- Identify areas of concern from the NRC

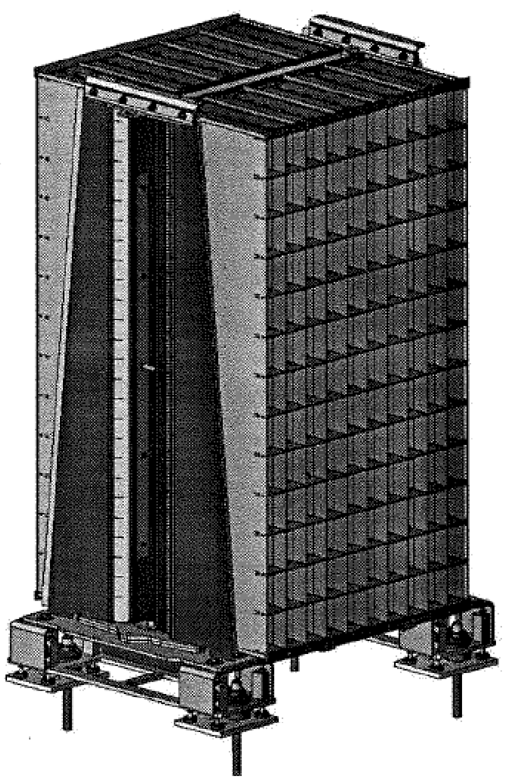
Overview of Sump Strainers (Unit 1)

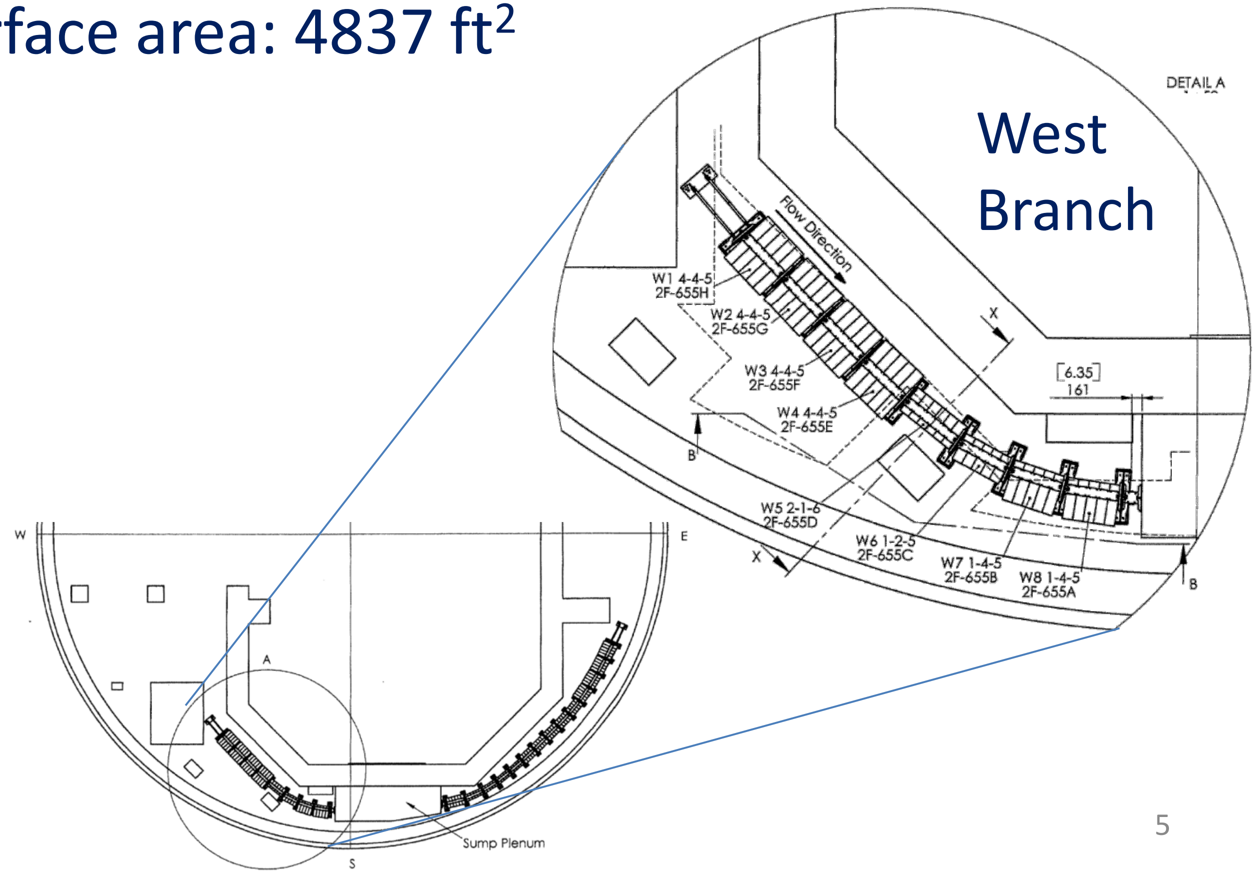
- Unit 1 strainer features multiple modules of filtering cartridges installed on top of containment sump
- Cartridge lengths: 300 mm and 400 mm
- Total strainer surface area: 2715 ft^2



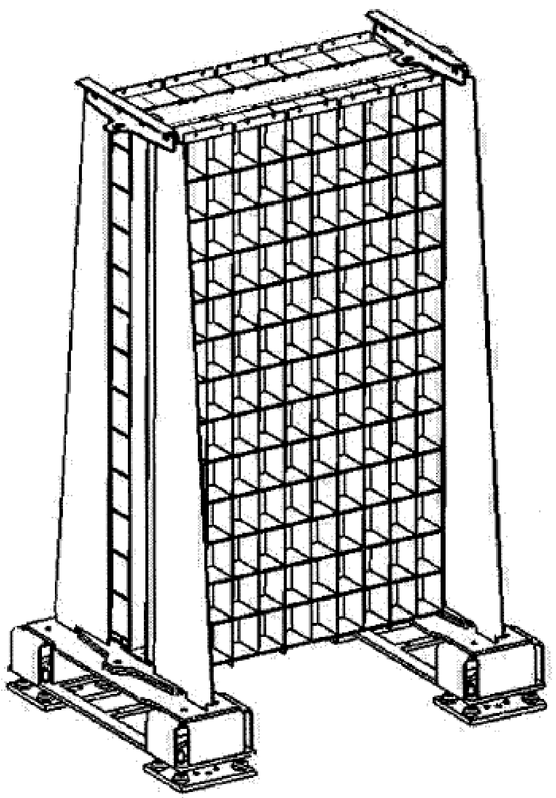
Overview of Sump Strainers (Unit 2)

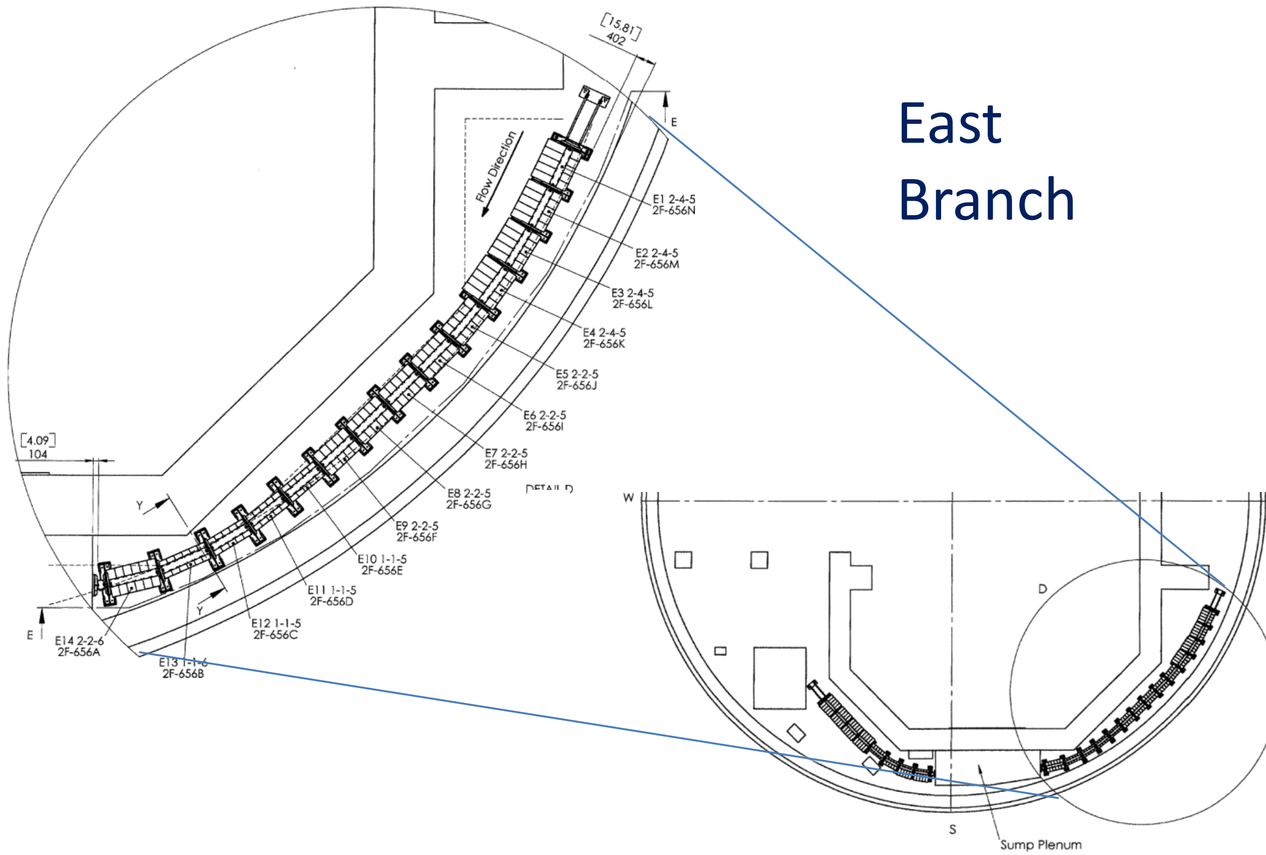
- Unit 2 strainer has modules of filter cartridges along containment wall connected to a suction plenum
- Cartridge lengths: 100 mm, 200 mm and 400 mm
- Total strainer surface area: 4837 ft^2





Overview of Sump Strainers (Unit 2)



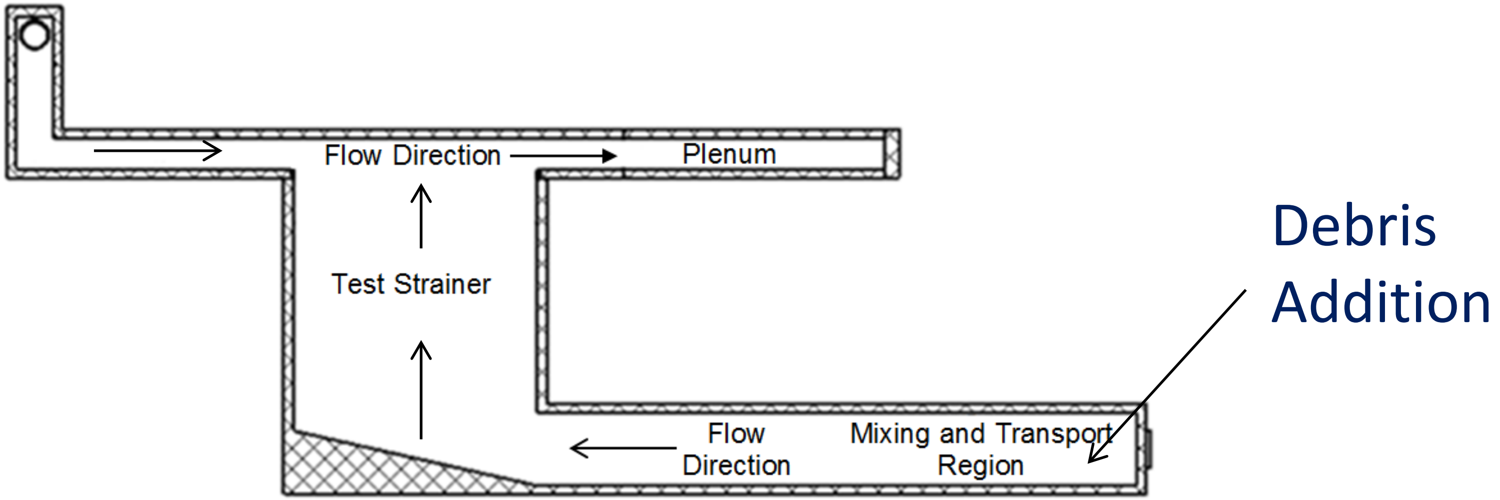


Current GL 2004-02 Resolution Status

- ANO chose a deterministic resolution path (Option 2b) for both strainer head loss and in-vessel effects
- All outstanding issues related to strainer head loss have been resolved as of 2010
- ANO presented the fiber bypass testing approach to the NRC in March 2017
- ANO conducted fiber bypass testing in May 2017
- ANO evaluated in-vessel fiber loads in 2017
  - Evaluation updated in 2020 per latest NRC review guidance
- ANO is working on a supplemental response to GL 2004-02

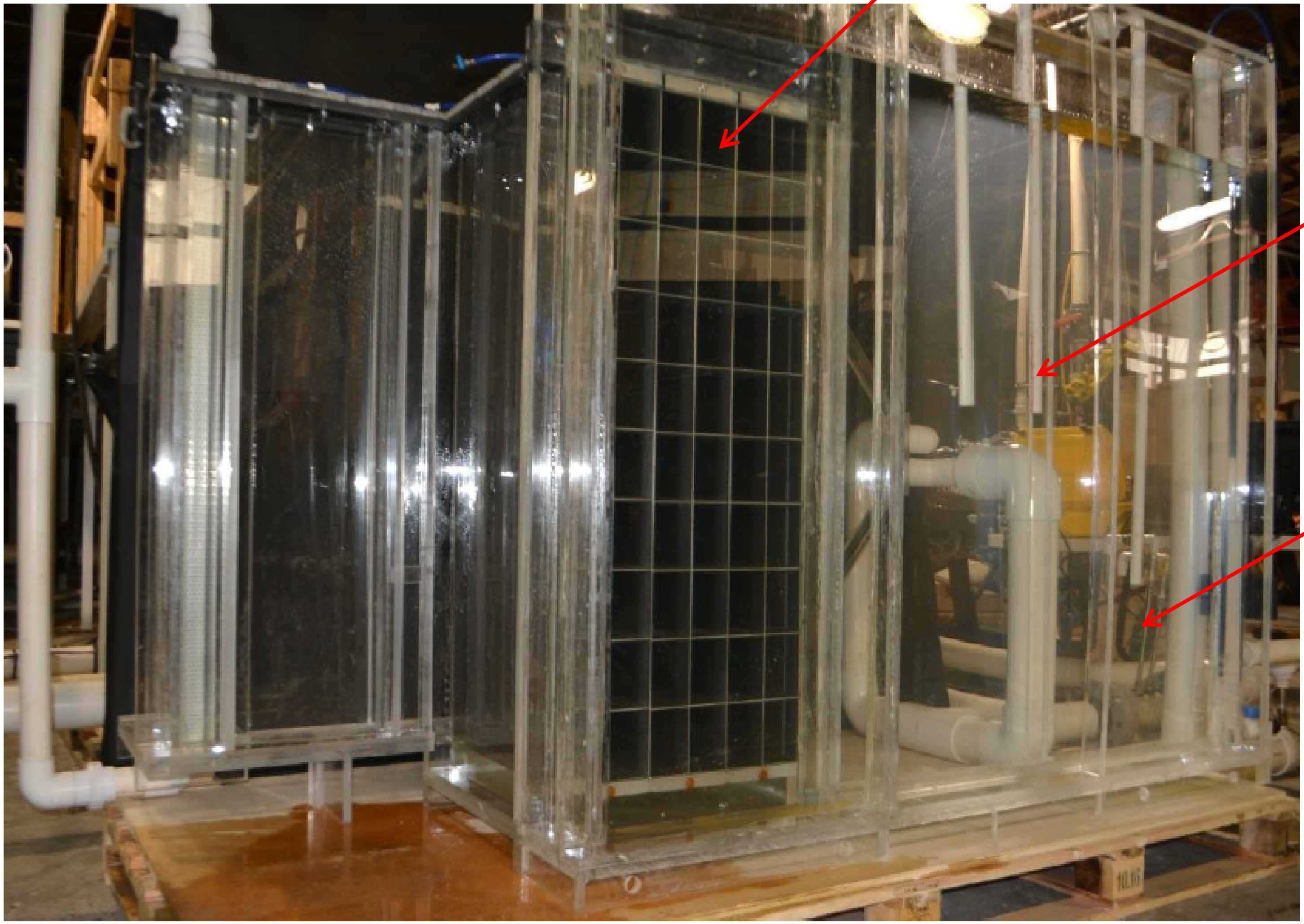
ANO Fiber Bypass Testing

- Performed large-scale bypass tests at Alden
- Used three spare 400 mm cartridges as test strainer with key perforated plate dimensions matching those of plant strainers
- Figure below shows a plan view of test tank



ANO Fiber Bypass Testing

Test
Strainer



Mixing
Lines

Mixing
Region for
Debris
Addition

ANO Fiber Bypass Testing

- Performed two large-scale fiber-only bypass tests
  - Similar to other tank tests observed by the NRC at Alden
- Test parameters represented plant conditions of both units: fiber load, approach velocity and water chemistry (i.e., max pH and buffer type)
- Used only fine heat-treated Nukon fiber for testing
- Followed NEI guidance on fiber debris preparation
- Added debris in 5 batches with increasing batch size
- Prevented settling by mixing from return flow into test tank without disturbing debris bed on test strainer

ANO Fiber Bypass Testing

Prepared Nukon Fiber

Debris Loading on Test Strainer

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ANO Fiber Bypass Testing

- Collected fiber bypass by routing all flow through 5-micron filter bags with retention rate > 97%
  - Parallel filter housings used to facilitate swapping filter bags without disturbing system flow
- Collected time-dependent fiber bypass testing data: bypass vs. fiber load on strainer
  - New filter bags placed online before adding a new batch
  - At least one additional set of filter bags placed online for >30 min to capture shedding fiber for each batch
- Filter bags dried and weighed before and after testing
- Test 2 showed slightly higher bypass and used to develop a curve fit for bypass fraction vs. fiber load on strainer

In-Vessel Analysis

- Determined in-vessel fiber load for hot leg breaks (HLBs) using WCAP-17788 methodology
  - Divided recirculation phase into small time steps
  - Calculated debris arrival at sump strainers for each time step based on pool fiber concentration and pump flow rates
  - Evaluated fiber penetration fractions based on strainer fiber load for each time step using curve-fit from testing
  - Analyzed most limiting equipment configurations (both ECCS trains operating with failure of one spray pump)
  - Performed sensitivity to capture the worst combination of inputs (e.g., pool volume, ECCS pump flow rate)
  - Assumed all fiber that reaches reactor accumulates at core inlet with no credit of alternate flow paths (AFPs)

In-Vessel Effects Resolution (Unit 1)

- ANO-1 used "Box 2" path from NRC guidance for B&W plants to resolve in-vessel issue
- Largest in-vessel fiber load of 77.9 g/FA is less than the limit in Section 6.5 of WCAP-17788 Vol 1, Rev. 1
- Boric acid precipitation precluded by inherent design of B&W reactor without requiring operator actions
  - Flow through gaps between reactor vessel outlet nozzles and core support shield dilutes boron concentration
  - This flow path becomes active during reflooding period following an accident
  - Additional operating procedure in place as defense-in-depth measure

In-Vessel Effects Resolution (Unit 2)

- ANO-2 used "Box 4" path from NRC guidance for CE plants to resolve in-vessel issue

Parameters	WCAP-17788 Revision 1 Values	ANO Unit 2 Values
NSSS Design	Various	CE
Fuel Type	Various	Westinghouse 16 x 16 NGF Fuel
Minimum Chemical Precipitation Time (t_{chem})	333 minutes (5.6 hours) (t_{block} from WCAP-17788, Vol. 1, Table 6-1)	24 hours after accident
Max Hot Leg Switchover (HLSO) Time	24 hours after accident	5 hours after accident
Max Core Inlet Fiber Load for HLB	WCAP-17788, Vol. 1, Table 6-3	72.52 g/FA
Max In-Vessel Fiber Load for HLB	WCAP-17788, Vol. 1, Section 6.4	72.52 g/FA
Min Sump Switchover (SSO) Time	20 minutes	30.03 minutes
Max Rated Thermal Power	3458 MWt	3026 MWt
Max AFP Resistance	WCAP-17788, Vol. 4, Table 6-3	WCAP-17788, Vol. 4, Table RAI-4.3-8
ECCS Flow per Fuel Assembly (FA)	3.8 – 11.4 gpm/FA	4.1 – 10.2 gpm/FA

In-Vessel Effects Resolution (Unit 2)

- Chemical precipitation occurs after t_{block} and switchover to hot leg recirculation
  - Chemical precipitation timing based on sump pH, Al concentration from WCAP-16530 evaluation and precipitation boundary equation from WCAP-17788
- Max in-vessel fiber load (72.5 g/FA) exceeds core-inlet fiber limit but bounded by total in-vessel fiber limit
  - WCAP core-inlet fiber limit conservatively low based on assumption of uniform fiber bed at core inlet
  - "Licensees may justify that a non-uniform debris bed will form at the core inlet allowing adequate flow to assume LTCC, even though the average debris load per FA metric is exceeded"

In-Vessel Effects Resolution (Unit 2)

- Earliest ANO-2 sump switchover time (30.03 minutes) is greater than that assumed in the WCAP analysis
- ANO-2 thermal power (3026 MWt) is lower than that analyzed in WCAP-17788 for CE plants (3458 MWt)
- ANO-2 AFP resistance is lower than that analyzed in WCAP-17788 for CE plants
- ANO-2 ECCS flow rate per fuel assembly (4.1 – 10.2 gpm) is within the range tested in WCAP-17788 (3.8 – 11.4 gpm) for CE plants

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Licensing Actions and Submittal

- ANO will update the UFSAR to incorporate in-vessel downstream effects analysis and conclusions before submittal
- No other licensing actions, exemption requests or corrective actions are required
- Submittal will have one enclosure for each unit, focusing on the resolution of in-vessel effects
- Submittal is currently going through ANO licensing review and engineering certification
- Projected submittal date: December 2020

Closing

- Questions?