PMSTPCOL PEmails

From: Joseph, Stacy
Sent: Monday, June 20, 2011 7:18 AM
To: Gilmer, James; Wagage, Hanry; Makar, Gregory; Le, Tuan
Cc: Donoghue, Joseph; Norato, Michael; Hsia, Anthony; STPCOL
Subject: FW: ACRS Presentation
Attachments: Chapter 6 Followup Presentation JUne Rev.3-NRC.pdf

Attached is STP's draft presentation for tomorrow's ACRS meeting.

From: Tomkins, James [mailto:jetomkins@STPEGS.COM]
Sent: Thursday, June 16, 2011 10:16 PM
To: Joseph, Stacy
Subject: ACRS Presentation

Here is the draft of the NRC Presentation we intend to send to ACRS.

Hearing Identifier: SouthTexas34Public_EX
Email Number: 2902

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Subject: FW: ACRS Presentation
Sent Date: 6/20/2011 7:18:10 AM
Received Date: 6/20/2011 7:18:12 AM
From: Joseph, Stacy

Created By: Stacy.Joseph@nrc.gov

Recipients:
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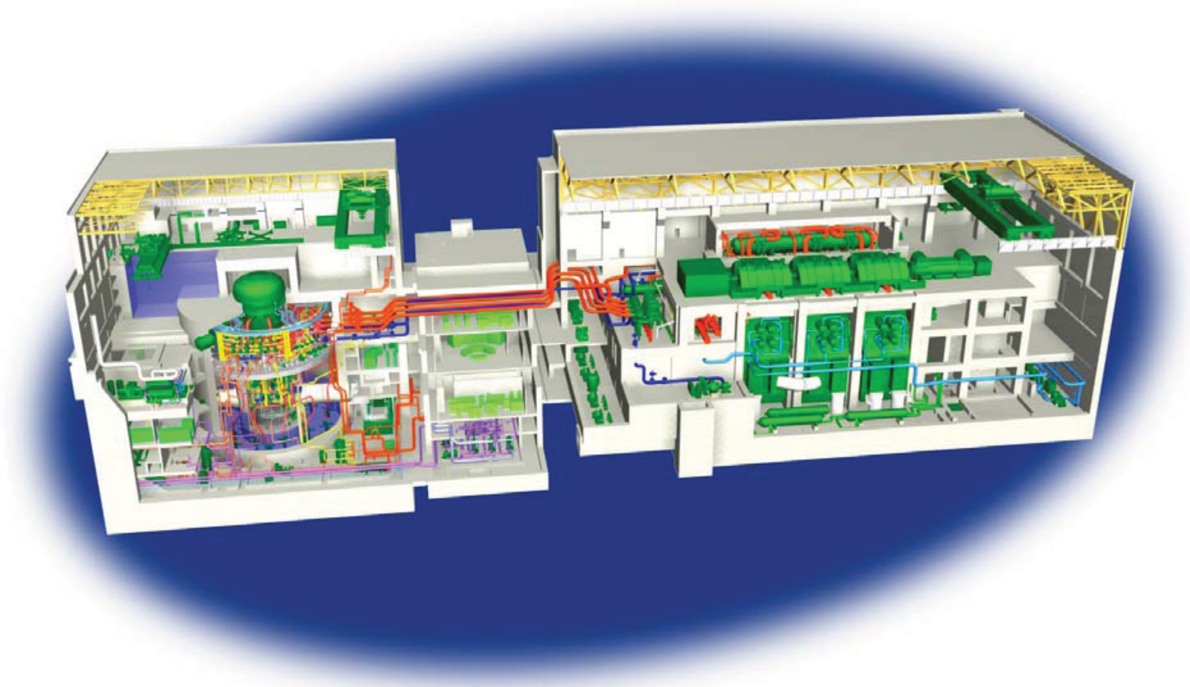
South Texas Project Units 3 & 4 Presentation to ACRS Subcommittee

Chapter 6 Follow-up



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Attendees

Scott Head	NINA Manager, Regulatory Affairs, STP 3&4
James Tomkins	NINA Licensing, STP 3&4
Tom Daley	NINA Engineering, STP 3&4
Caroline Schlaseman	MPR/TANE
Ryuji Iwasaki	Toshiba
Martin Van Haltern	Westinghouse
Tim Andreychek	Westinghouse

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Desired Outcomes

- Review the action items from the previous meeting
- Discuss our response to each item
- Explain the actions we are taking

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Agenda

- Introduction
- Summary of Key Points from Previous meeting
- Action Item Summary
- Proposed COLA Changes
- Response to Action Items from meeting
- Conservatisms in Test Protocol and Acceptance Criteria
- Summary

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Summary of Key Points from Previous Meeting

- We believe there is reasonable assurance that STP 3&4, including the licensed fuel, will meet Long Term Cooling (LTC) requirements based on:
  - Minimal post-LOCA debris (especially fiber and chemicals)
  - Significant margin in ECCS strainer head loss
  - Diversity of water delivery to the core
  - Defense in depth provided by fuel assembly bypass and HPCF, either of which can provide cooling even if assemblies plug completely
- Post-COL downstream effects testing of the fuel to be used in the initial cycle will verify that flow will remain adequate to ensure long term cooling

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Action Items Summary

# 72	Strainer Hydrodynamic Load Development
# 73	Is Thin Bed Effect Bounded by Japanese Testing
# 74	Nukon Fiberglass Fiber Diameter
# 75	Is ALOOH the Appropriate Surrogate for Zinc Oxide

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Action Item Summary

# 76	Is Zinc Addition Planned for Use at STP
# 77	Justify Use of Partial Length Assembly
# 78	Address the Effects of Temperature
# 79	Use of NRC Approved Debris Addition Protocol
# 80	Basis for Debris bed DP vs. flow exponent of 2.0

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Action Item Summary

# 81	Multiple Tests to Establish Uncertainty
# 82	Justify Shorter Test Loop Transit Time
# 83	Justify the 1.7 Inlet Flow Distribution Factor
# 84	Parametric Study of K-Factor vs. Flow
	Surrogate for real fiber

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Summary of Actions

- Modify COLA to make commitment that we will reflect industry experience with downstream fuel tests in the final testing procedure provided to the NRC
- Run multiple tests to ensure we understand test variability

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Proposed COLA Markup

The following changes (shown in blue) will be made to FSAR Appendix 6C :

6C.3.1.9 Downstream Fuel Effects Test

Prior to the initial fuel load, a downstream effects test for the fuel is performed to ensure that small debris passing through the suction strainers does not impair the flow to the core. The detailed test procedure will be provided to the NRC at least six months prior to performing the test and will reflect industry experience with performance of such tests, for example consideration of fuel assembly geometry, debris addition and test protocol, number of tests, and provisions for assessing test variability (COM 6C-2). The following discusses the test plan, the analysis basis, and the debris assumptions used for this test.

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ACRS Action Items

- Action Item # 72
  - *ACRS asked about how the hydrodynamic load definition are developed and evaluated for the strainers*

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Strainer Structural Analysis

- Additionally, ACRS asked: What testing was done to ensure that the complex geometry of the CCI cassette-type strainers is properly accounted in the structural analysis of these strainers under hydrodynamic suppression pool loading?
- Geometry-dependent drag coefficient and acceleration drag volume determined by testing for CCI cassette-type strainers
  - Drag coefficient and acceleration drag volume are key parameters for determining the magnitude of several hydrodynamic loads:
    - C_D used in Vent Clearing and Fall Back loads
    - C_D and V_A used in Air Bubble Drag and SRV Discharge Bubble Drag loads
    - V_A used in Condensation Oscillation load

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Strainer Structural Analysis *(continued)*

- Hydrodynamic loads for each strainer size (RHR, HPCF and RCIC) defined by Toshiba in ASME Design Specification
  - Methodology for load development in accordance with DCD:
    - Vent Clearing load defined in accordance with NUREG-0487
    - LOCA Air Bubble drag load and SRV Quencher Air Bubble drag load both defined in accordance with NEDE-21471
    - Condensation Oscillation load and Chugging load both defined in accordance with NEDO-25153
- Loads combined in accordance with DCD Tier 2 Table 3.9-2, and applied to Finite Element model of strainer to determine stresses in perforated sheets, flange plate, internal ribs

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Strainer Structural Analysis *(continued)*

- Resulting membrane, local membrane, membrane + bending stresses compared to applicable ASME B&PV Code Section III Service Level A, B, C & D allowables for limiting load combinations
- ITAAC 3.0-14 will confirm an acceptable ASME Code Design Report exists for all ASME components, including these ECCS strainers

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ACRS Action Items *(continued)*

- Action Item # 73
  - *ACRS asked if the analysis performed for the Japanese plants bounds thin bed effects*

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Thin Bed Effect

- RJ-ABWR strainers sized based on head loss due to full fiber load
  - Small-scale testing with analytically-predicted thin-bed fiber quantity resulted in measured pressure drop 3 to 4 times lower than measured pressure drop at full-fiber thickness
- STP 3&4 latent fiber uniformly spread over strainers would result in thickness ~0.01 in, assuming no fiber passes through the strainer holes
- Since RJ-ABWR and STP 3&4 strainers are sized based on full-fiber thickness for RJ-ABWR, STP 3&4 strainers are adequately sized
- Thin bed effect bounded

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ACRS Action Items *(continued)*

- Action Item # 74
  - *ACRS asked about the Nukon fiberglass fiber diameter*

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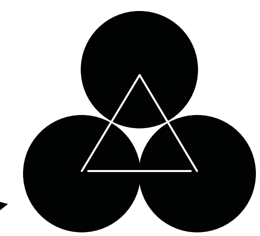
Nukon Fiber Diameter

- Diameter of fiberglass filaments
  - Range from 0.276×10^{-4} to 0.325×10^{-4} inches in diameter
  - Source: NEI 04-07
- Assuming;
  - Area of the STP 3&4 strainers = ~ 1000 ft^2
  - Fibrous debris = 1 ft^3
  - Fiberglass as surrogate fibrous debris
  - Uniform distribution of fibers over the strainer surface
  - "Worst case" (most dense) fiber packing (see diagram)



- Calculated bed thickness of fiberglass = ~ 0.01inches
- "Thin-bed" effect for fiberglass
  - Historically observed at a bed thickness for (NUREG/CR-6442) = ~ 0.125 inches
  - STP 3&4 calculated thickness is more than an order of magnitude less than the historical "thin-bed" thickness for fiberglass

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ACRS Action Items *(continued)*

- Action Item # 75
- *ACRS questioned whether aluminum oxy-hydroxide is an appropriate surrogate for zinc oxide*

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Aluminum Oxy-Hydroxide (ALOOH) as Surrogate for Zinc Oxide

- ALOOH
  - Forms a particulate-like gelatinous substance in water
  - Known to collect on fiber beds; is likely to cause head loss
  - Has been identified by NRC as the “worst” of the chemical surrogates evaluated
- Zinc Oxide
  - Exists in low concentration due to limited amount of zinc
  - Is virtually insoluble in water (1.6 ppm)
- Therefore, use of ALOOH provides reasonable assurance of conservative head loss results
- Use ALOOH unless future industry experience dictates otherwise

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ACRS Action Items *(continued)*

- Action Item # 76
- *ACRS asked if STP is planning to use zinc injection to perform hydrogen water chemistry and if this would impact the zinc precipitates*

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Zinc Addition

- Zinc Addition is not included in the current COL application
- Zinc Addition is an option that may be used in the future
  - No decision will be made to implement Zinc Injection at STP until after several cycles of operation
- If that decision is made, the effects of Zinc Addition on formation of post-accident zinc precipitates would be evaluated as part of that decision
  - Available industry resources would be used to support that evaluation
  - For example, use would be made of EPRI's ongoing zinc addition evaluations
- Such a change to the licensing basis would be evaluated under applicable regulatory change rules

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ACRS Action Items *(continued)*

- Action Item # 77
- *ACRS asked for justification for the use of a partial length fuel assembly*

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Partial Length Fuel Assembly

- Partial length is consistent with previous industry testing
- Industry experience indicates that depositing a finite amount of debris in a limited axial region is conservative (yields a higher pressure drop) compared to distributing the same debris over several axial regions
- The potential for debris forming blockages in the boiling region has been shown to be unlikely in tests by another advanced reactor design
- Plan is to use a partial fuel assembly, unless future industry downstream testing experience dictates otherwise

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ACRS Action Items *(continued)*

- Action Item # 78
- *ACRS asked about addressing the effects of temperature*

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Effects of Temperature

- Room temperature results in a higher water viscosity than would be the case for elevated temperatures
  - Viscosity is higher by a factor of 2.2 at 70 deg F compared to 150 deg F
- Higher viscosity results in greater drag on debris, making it more likely to be transported to the fuel for debris bed formation
- Higher viscosity also results in higher pressure drop for a given debris bed
- There has been no evidence that debris deposition in fuel results in a higher hydraulic resistance at higher temperatures
- Test at room temperature, unless future industry downstream testing experience dictates otherwise

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ACRS Action Items *(continued)*

- Action Item # 79
- *ACRS challenged the use of the NRC-accepted protocol for addition of debris. It was stated that introduction of debris in different sequences may provide a worse result*

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Debris Addition Protocol

- PWR sump screen replacement testing indicated that the debris addition sequence of particulate first, fiber next, and chemical surrogates last was appropriate for testing for thin bed effects and produced the highest pressure drop across sump screens
- This protocol was mandated by the NRC for sump screen testing
- Since fuel is effectively another screen, this same protocol has been adopted for downstream fuel testing by the industry
- Another reactor design did test with concurrent addition of particulate and fiber
  - Observed pressure drops were within the range of test variability
  - It is concluded that this difference is within the variability of this type of testing
- Use NRC mandated protocol unless future industry downstream testing experience dictates otherwise

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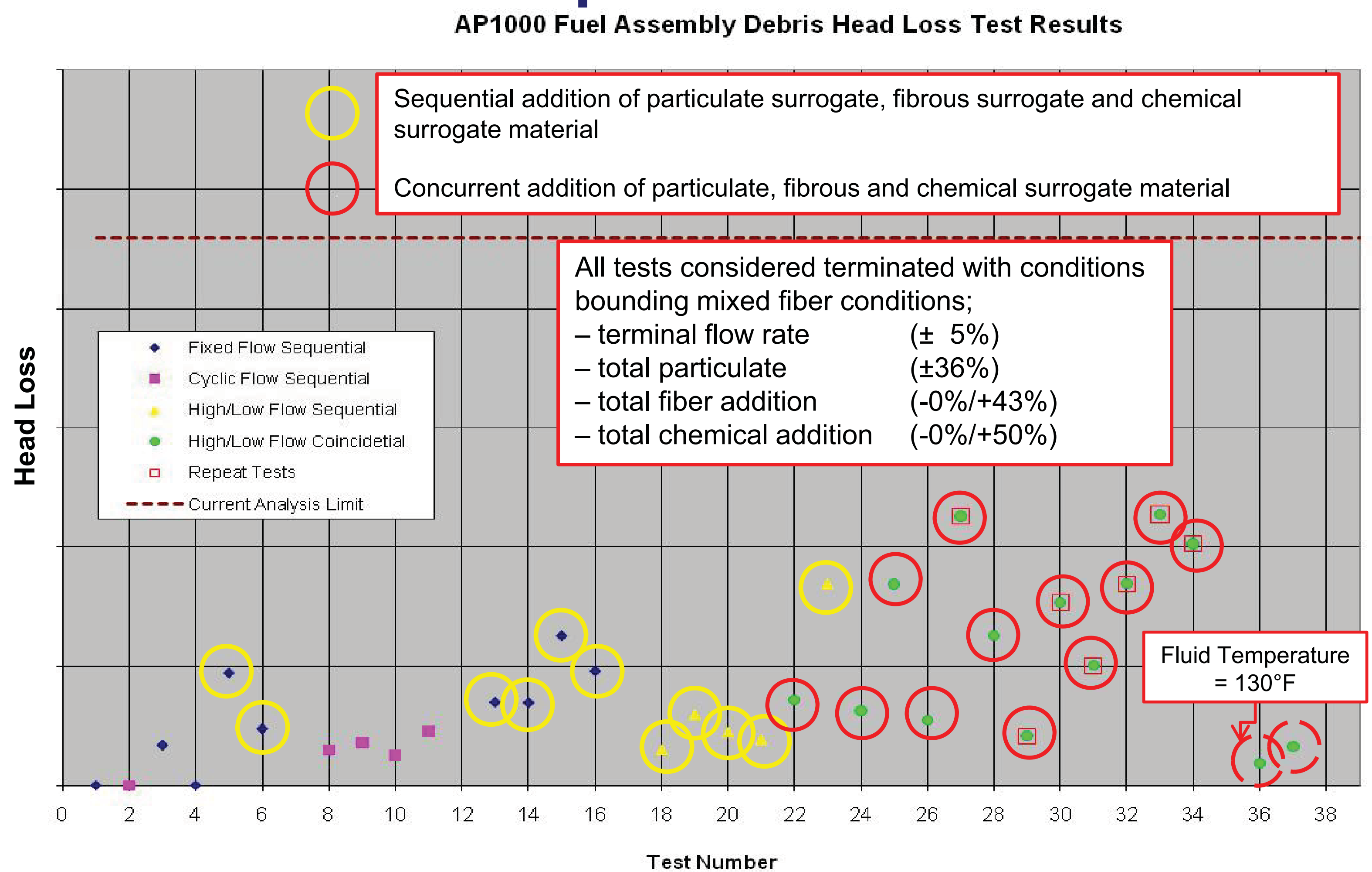
Effect of Fiber Types on Head Loss

From ICAPP 2011 Paper #11371



ACRS Action Items *(continued)*

- Action Item # 80
- *ACRS asked NINA to provide the basis for test acceptance criteria utilizing square relationship, vs. use of some other exponent such as 1.2 for debris bed*

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Exponent in Fuel Test Acceptance Criteria

- Acceptance criteria based on the assumption that pressure drop is proportional to flow squared (i.e. Pressure Drop = K x Flow^2)
- Acceptance criteria for the test is stated in terms of an increase in the "K" factor (ratio of final to initial)
- The test data will be converted to an equivalent "K" factor increase on the same basis (i.e. proportional to flow squared)
- The use of an exponent of 2 in conjunction with factor of 4 margin in acceptance criteria provides adequate conservatism
- The flow relationship will be confirmed as part of the test

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ACRS Action Items *(continued)*

- Action Item # 81
- *ACRS stated that multiple tests at the same conditions would be needed to establish the uncertainty in the testing*

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Multiple Tests to Establish Range of Variability in Experimental Results

- We agree with this recommendation
- We plan to perform multiple tests to establish variability
  - Based on industry experience, we currently intend to perform 3 to 6 tests to establish test variability
    - Each test would have the same debris loading, debris addition protocol, and flow rate
  - This plan will be revised if necessary to reflect future industry experience with these tests

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ACRS Action Items *(continued)*

- Action Item # 82
- *ACRS asked for justification of the shorter transient loop time in the test vs. actual debris deposition time in the plant*

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Shorter Test Loop Transient Time

- Test loop has sufficient liquid volume to ensure clumping of debris does not occur
- Test will be performed at expected post-LOCA flow rates in the fuel
- Test loop volume is smaller than the plant:
  - There is a more rapid turn-over in the test than the plant
  - The test liquid volume and the debris is exposed to the debris-capturing features of the fuel more quickly and frequently than the plant recirculating liquid volume
  - The debris bed in the fuel is formed more quickly in the test than in the plant
- The test and acceptance criteria:
  - Based on the end state debris bed
  - Not on how fast the debris bed forms occurs

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ACRS Action Items *(continued)*

- Action Item # 83
- *ACRS asked for justification that the 1.7 factor is bounding considering potential for uneven distribution of debris in the lower plenum, possibility of injection from HPCF flowing down through the core*

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Inlet Flow Distribution

- Conservatism factor of 1.7 for debris is based on peak assembly power of 1.7
- Computer analyses have shown that flow is greater in the higher power assembly by a factor of ~ 1.45 (on an integral flow basis)
- HPCF provides flow to the upper plenum which may result in flow down the peripheral lower power assemblies
  - Even if HPCF completely stopped upward flow in peripheral assemblies, this would result in a 10% increase in the flow (and debris) to the hot assembly
  - Net Debris ratio to the hot assembly will be limited to 110% of 1.45
- Factor of 1.7 still bounds worst case flow with margin

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ACRS Action Items *(continued)*

- Action Item # 84
- *ACRS requested a parametric study of k-factor vs. flow rate*

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Parametric Study of K-Factor

- Parametric study using the GOBLIN model employed for the acceptance criteria determination
- The inlet area of the hot assembly was reduced in stages to simulate blockage and the flow in the hot assembly was recorded (first plot)
- The second plot provides flow versus an equivalent K-factor
- There was no increase in PCT for any of these blockages

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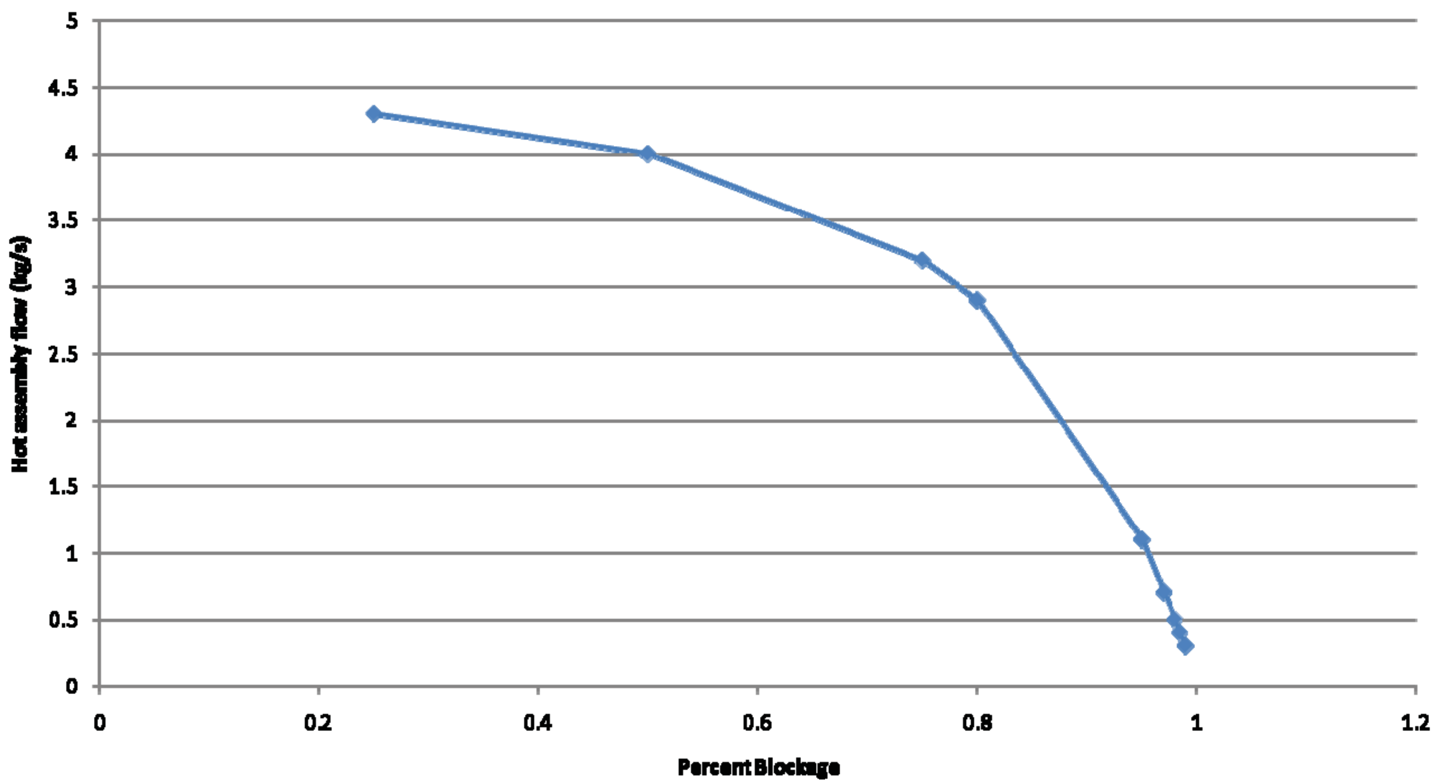
Hot Assembly Flow vs. Blockage Factor



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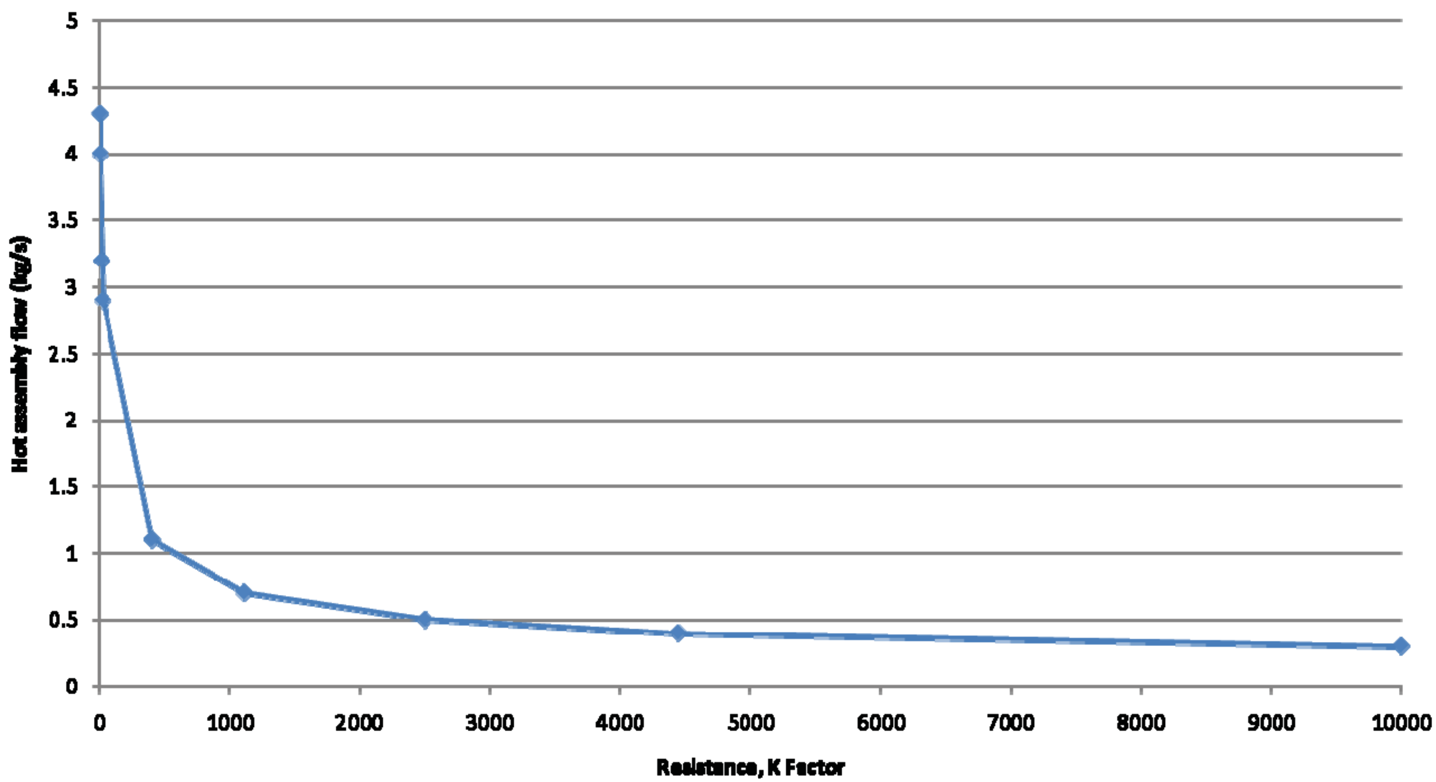
Hot Assembly Flow vs. Resistance



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ACRS Action Item *(continued)*

- *ACRS questioned the nature of the fiber proposed for the testing*

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Fibrous Insulation as Surrogate for "latent fiber"

- Low-density fiberglass is used by the industry as a surrogate because it has superior strength compared to hair, dust-bunnies, and dust from protective clothing
- It is more likely to form a debris bed that will not collapse or dissolve due to the hydraulic load of flow through the debris bed
- Fiberglass has been observed to produce thin-bed pressure drop effects at small thicknesses compared to other fibrous materials such as mineral wool
- Testing performed for another advanced plant design has shown little difference in testing with fiberglass or with mixed fibers (hair, polyester-cotton, fiberglass) (see graph on following overhead)
- NINA will use fiberglass as surrogate for "latent fiber", unless future industry downstream testing experience dictates otherwise

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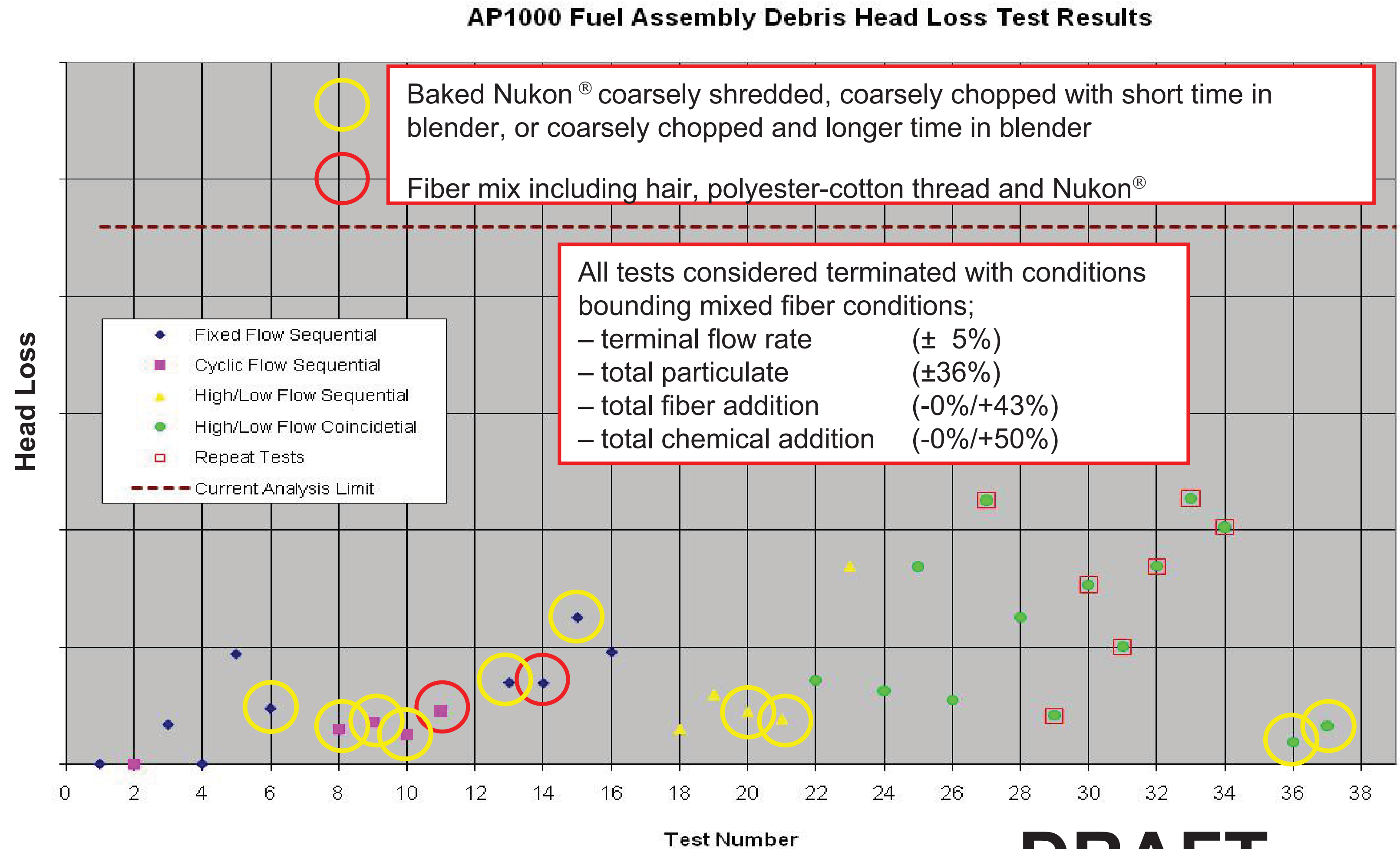
Effect of Fiber Types on Head Loss
From ICAPP 2011 Paper #11371



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Conservatisms in Downstream Test

- There are a number of conservatisms in the test:
  - Debris Assumptions
  - Analysis for Acceptance Criteria
  - Test Performance

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Conservatism in Debris Assumptions

- Chemical amounts assume:
  - No solubility of zinc or aluminum corrosion products in the approximately one million gallon suppression pool
  - All chemical products form precipitates
- No credit for settling of debris in locations where they will not impact the strainers or fuel, such as lower drywell, bottom of suppression pool, and lower plenum
- Latent fiber is all assumed to be fiber fines, with 100 % passing through the strainers
  - Since fibrous materials are prohibited, actual latent fiber in the plant is assumed to be rags and rope left in the upper drywell, which are not likely to pass through the strainer openings

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Conservatisms in Analysis for Acceptance Criteria

- Decay heat held constant at value at 5 minutes after shutdown
- Debris predicted to take more than 2 hours to all reach the strainer the first time, at which point decay heat would be 40% of the value at 5 minutes
  - Chemical precipitates such as zinc oxide are predicted to take about 15 days to reach the values used in the test
- Factor of 4 margin in acceptance criteria (factor of 2 in flow)
- No HPCF or fuel assembly design bypass flow is credited
- Void Fraction of 0.95 at hot assembly exit (flow rate is greater than twice boil-off rate)

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Conservatisms in Test Performance

- Debris added in a manner that:
  - Minimizes clumping
  - Maximizes establishment of a fiber bed, and
  - Provides for the formation of a thin-bed

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Conservatisms in Downstream Test

- The collective conservatisms in the test translate to roughly a factor of 8 in flow margin
  - Analysis based on 5 min decay heat (~ twice the decay heat at the expected debris deposition time)
  - Analysis Acceptance Criteria (0.95 Void Fraction) requires twice the boil-off flow rate
  - Conservatism in criteria results in twice the required flow
- If the downstream test meets the acceptance criteria, we have high confidence that fuel will remain cooled for the debris that would be deposited after a LOCA

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Summary

- There is “Reasonable Assurance” that STP 3&4 ABWR, including the licensed fuel, meets LTC requirements
- We acknowledge there are uncertainties in some of the analyses performed to determine the acceptance criteria and in the debris bed blockage phenomenon itself
- However, the collective conservatisms in the test and the test acceptance criteria provide significant margin and ensure that if the assembly passes the test there will be adequate margin to preclude fuel assembly blockage
- Furthermore, defense-in-depth calculations show that there are two separate means of cooling a fully blocked assembly

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