PMSTPCOL PEmails

From: Tai, Tom
Sent: Tuesday, August 07, 2012 4:26 PM
To: Chappell, Coley; Tomkins, James
Cc: STPCOL
Subject: FW: Downstream Fuel Effects Tests
Attachments: Chapter 6 Followup Presentation JUne Action Items Only- NRC.pdf

Coley, Jim,

It's the last slide in the attached.

Tom Tai
DNRL/NRO
(301) 415-8484
Tom.Tai@NRC.GOV

From: Gilmer, James
Sent: Tuesday, August 07, 2012 4:18 PM
To: Tai, Tom
Subject: Downstream Fuel Effects Tests

Tom-----The proposed wording on Slide 35 is different than in COLA Rev.7, App. 6C (although similar). My question is…..is the Rev.7 wording the final version?

Jim Gilmer

Hearing Identifier: SouthTexas34Public_EX
Email Number: 3433

Mail Envelope Properties (0A64B42AAA8FD4418CE1EB5240A6FED1A1212CD06E)

Subject: FW: Downstream Fuel Effects Tests
Sent Date: 8/7/2012 4:26:05 PM
Received Date: 8/7/2012 4:26:09 PM
From: Tai, Tom

Created By: Tom.Tai@nrc.gov

Recipients:
"STPCOL" <STP.COL@nrc.gov>
Tracking Status: None
"Chappell, Coley" <ccchappell@STPEGS.COM>
Tracking Status: None
"Tomkins, James" <jetomkins@STPEGS.COM>
Tracking Status: None

Post Office: HQCLSTR02.nrc.gov

Files	**Size**	**Date & Time**
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Chapter 6 Followup Presentation JUne Action Items Only- NRC.pdf	717664	

Options
Priority: Standard
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Sensitivity: Normal
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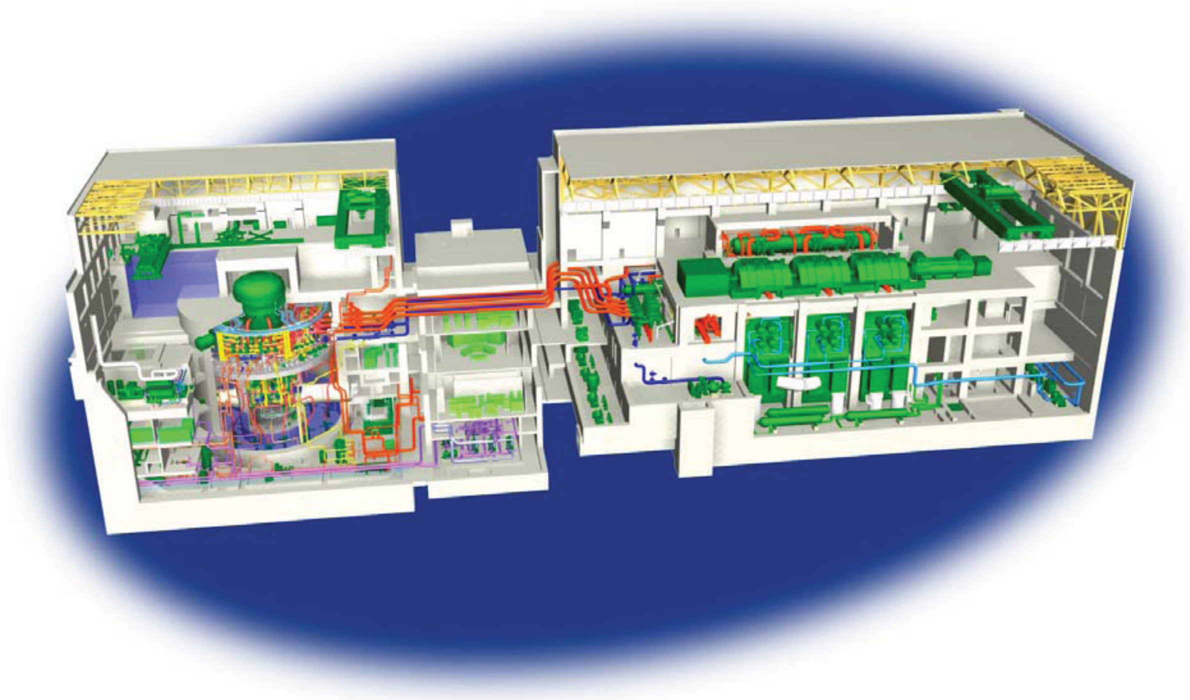
South Texas Project Units 3 & 4 Presentation to ACRS Subcommittee

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
Kenji Arai	Toshiba
Martin Van Haltern	Westinghouse
Nirmal Jain	Westinghouse
Tim Andreychek	Westinghouse

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Agenda

- Introduction
- Summary of key points from previous meeting
- Response to Action Items
- Proposed COLA Changes to Address ACRS Comments

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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, <u>either of which</u> 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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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 fiber (Japanese mineral wool) reduced to match predicted (analytical) thin bed maximum pressure drop resulted in measured pressure drop 3 to 4 times lower than measured pressure drop at full-fiber thickness
  - Tested thicknesses were 0.31-0.39 in (8-10mm) for thin bed; 1.26-1.30 in (32-33 mm) for full-fiber load
- STP 3&4 latent fiber would result in thickness ~0.01 in, assuming no fiber bypasses 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
- Action: None, 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

- Per NEI 04-07, fiberglass filaments range from 0.276 to 0.325 X 10^{-4} inches in diameter
- Based on the area of the STP 3&4 strainers, and assuming a uniform distribution, the calculated fiber bed thickness of fiberglass for 1 cubic foot of fiberglass debris is approximately 0.01 inches
- The "thin-bed" effect has historically occurred at about 0.125 inches for fiberglass, although it has been observed recently at somewhat smaller thicknesses
- STP 3&4 calculated thickness is more than an order of magnitude less than the historical "thin-bed" thickness for fiberglass
- Action : None

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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

- Zinc Oxide is virtually insoluble in water (1.6 ppm)
- ALOOH forms a particulate-like gelatinous substance in water
- ALOOH in this form is far more likely to cause flow blockage and its use is therefore conservative
- Action : No action 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 may be used on STP 3&4 to minimize Co-60 due to Hydrogen Water Chemistry
- Per the ABWR DCD, maximum zinc injection concentration is 10 ppb
- Based on total ABWR RCS capacity, total zinc in RCS is less than 18 g ($<0.04\ lb_m$)
- Compared to the conservatively assumed zinc in the STP 3&4 debris of 47 lb_m, this amount is insignificant
- Action : None

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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
- Examination of two tests from the AP1000 testing indicates that testing with the same total amount of debris, comparable flow rates and different temperatures provides a comparison of distributed vs. concentrated debris
  - These results show that distributed debris produces a lower overall hydraulic resistance than concentrated debris
- Since assemblies are a closed channel, focusing a finite amount of debris in a limited axial region is conservative compared to distributing the debris over several different axial regions
- Action: Current 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
- 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
- Action : 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 observe a range of pressure drops, including several higher values, with a different debris addition protocol
- It is judged that this difference is within the uncertainty of this type of testing
- Action : Use NRC mandated protocol unless future industry downstream testing experience dictates otherwise

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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
- Action : Use exponent of 2

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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 Uncertainty

- We agree with this recommendation
- Action : Perform multiple tests to establish uncertainty
  - Based on industry experience, we currently intend to perform up to 6 tests to establish test uncertainty
    - 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 will be performed at expected post-LOCA flow rates in the fuel
- Test loop has sufficient liquid volume to ensure clumping of debris does not occur
- Test loop is smaller, resulting in a more rapid turnover of the liquid volume and the debris being exposed to the debris-capturing features of the fuel faster and more frequently
- The test and acceptance criteria are based on the end state of maximum blockage, and not on how fast the blockage occurs
- Action : None

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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 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
- Action : Use 1.7 factor

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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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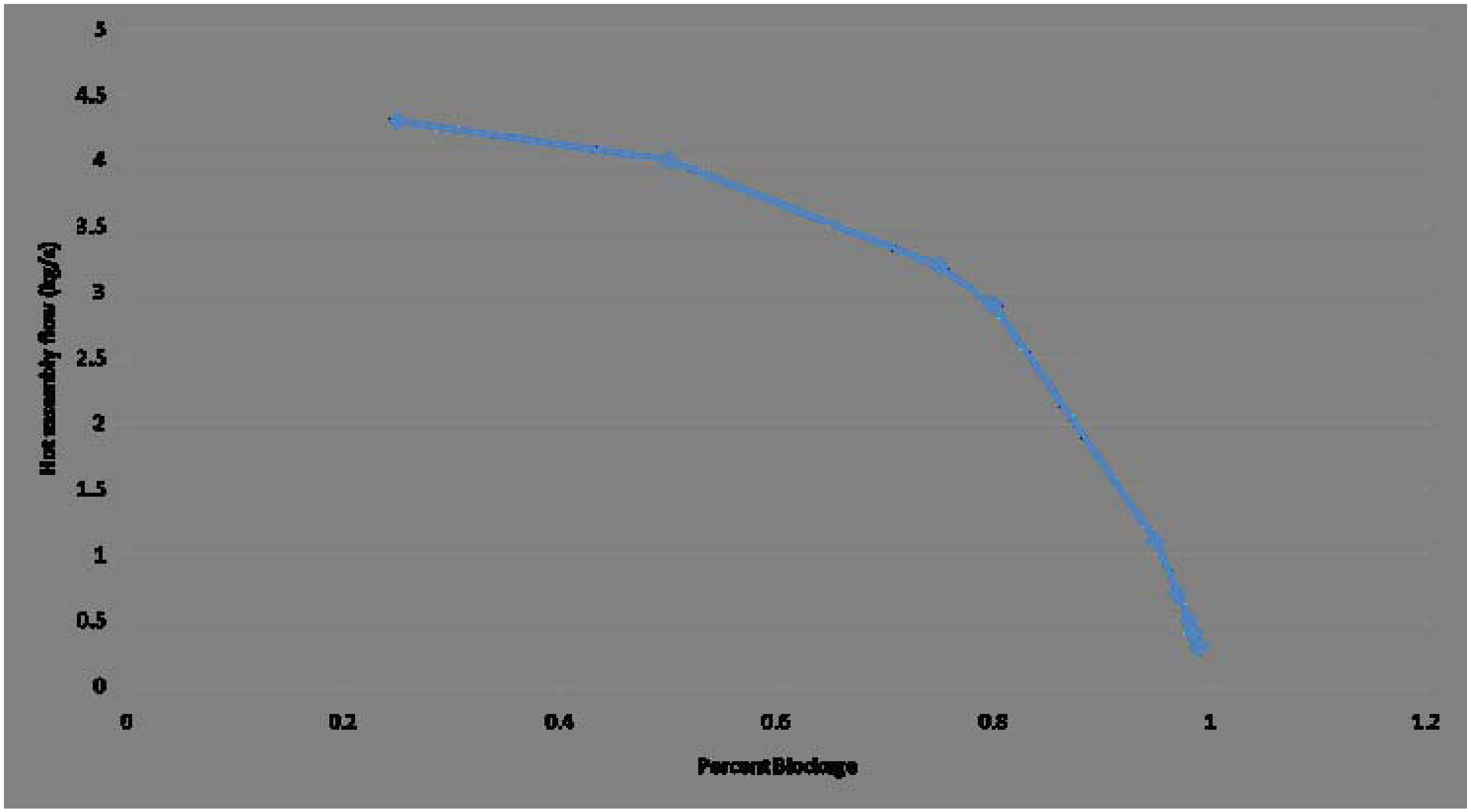
Hot Assembly Flow vs. Blockage Factor



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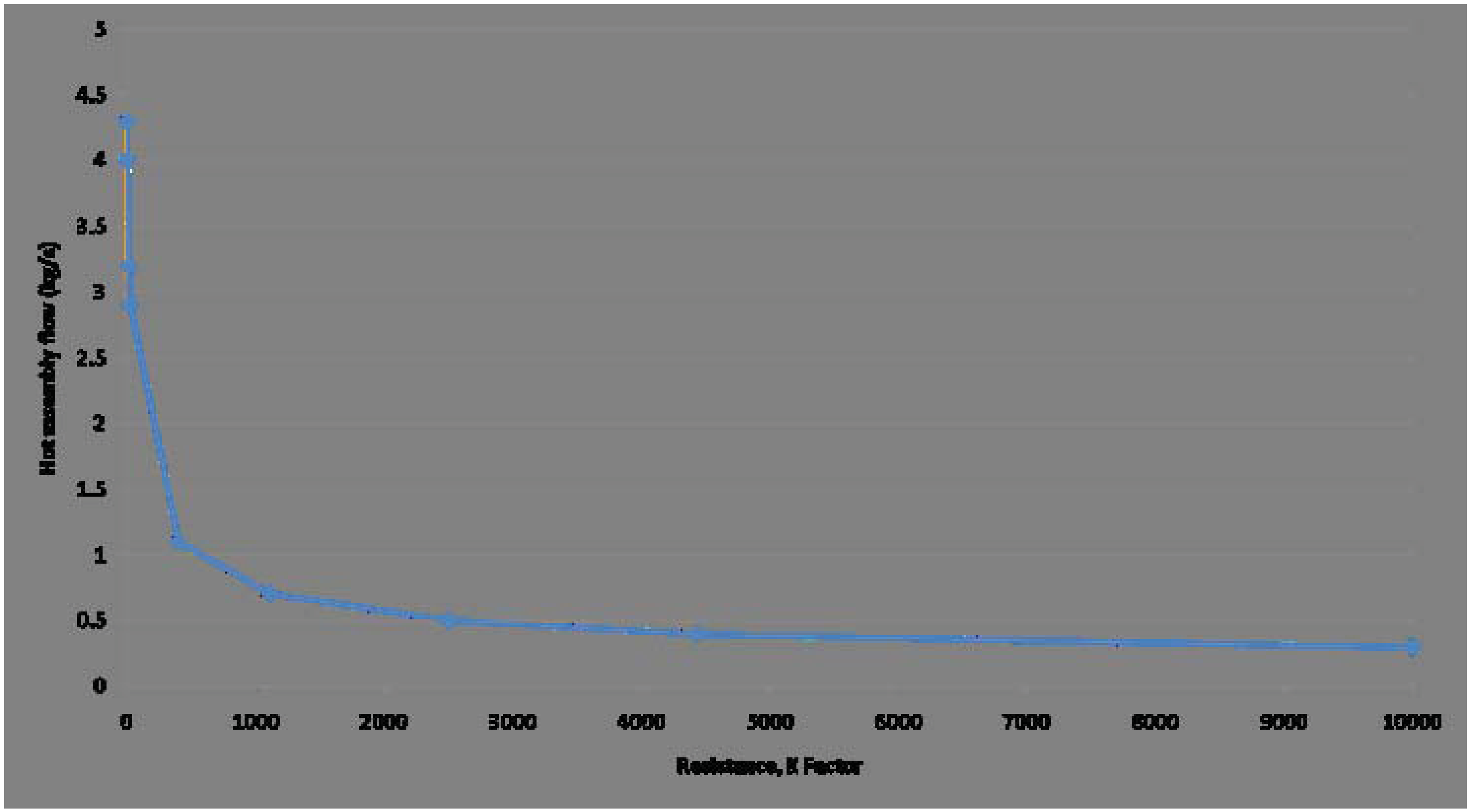
Hot Assembly flow vs. Resistance



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ACRS Action Items *(continued)*

- Action Item # 85
- *ACRS asked about how much hydrogen is released in the zinc reaction, and what is the effect of the hydrogen bubbles on the debris behavior*

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Hydrogen Gas Issue

- Generation of zinc debris from the zinc rich coatings is due to the initial mass and energy release from the RCS
  - Since there is no aluminum, the zinc appears to be a large number
  - However, this amount is small and is conservatively evaluated to be 47 lb_m
- Zinc debris is assumed to be its constituent size and is on the order of 10 microns (3.9×10^{-4} inches)
- Formation of debris bed is expected to occur in several days after the event
- Generation of hydrogen from the oxidation of zinc is a slow process expected to take about two weeks and is expected to result in a total maximum production of less than 1.49 lb_m of hydrogen
- Debris bed formation would take place well before hydrogen is produced in any significant amounts
- Hydrogen formation from the small amount of zinc in STP 3&4 containment is small, occurs over an extended period of time and therefore has an insignificant impact on debris formation
- Action: None

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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
- Action : Use fiberglass as surrogate for “latent fiber”, unless future industry downstream testing experience dictates otherwise

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Proposed FSAR Changes

- Appendix 6C will be revised to state that the detailed downstream test protocol that is to be submitted to the NRC six months prior to performing the downstream test will reflect industry experience with regard to downstream testing including for example such effects as assembly geometry, protocol for sequence of addition of debris, treatment of uncertainties, and identification of margin.
- Markup on following page

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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 debris bypassing 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, e.g. consideration of fuel assembly geometry, debris addition and test protocol, provisions for establishing test uncertainty factors, and identification of margin (COM 6C-2).** The following discusses the test plan, the analysis basis, and the debris assumptions **currently envisioned** for this test.

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