Luminant

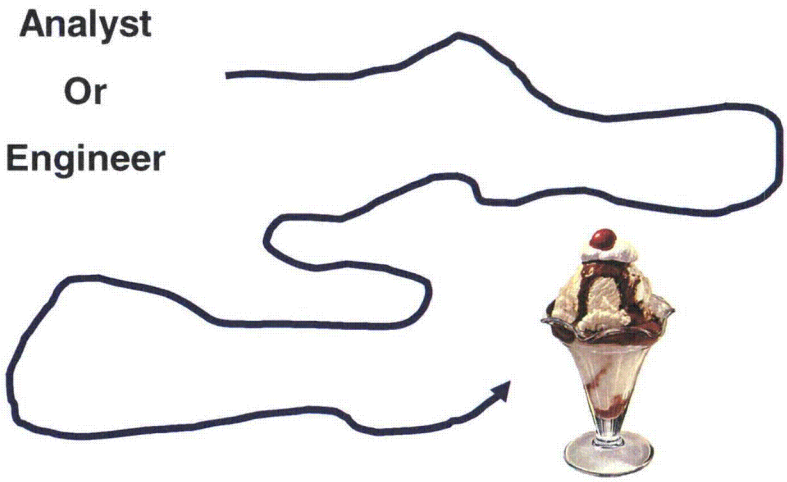
NRC – Luminant Power Public Meeting

Comanche Peak Nuclear Power Plant
Emergency Sump Performance
July 9th
2009

Overview

- This presentation provides clarifications and additional information to support the supplemental response to GL 2004-02
- Focused on the NRC draft request for additional information [RAI #s noted]
- Conservatisms which offset uncertainties are noted in bold
- Supplemental response will be revised

GSI-191 Challenge



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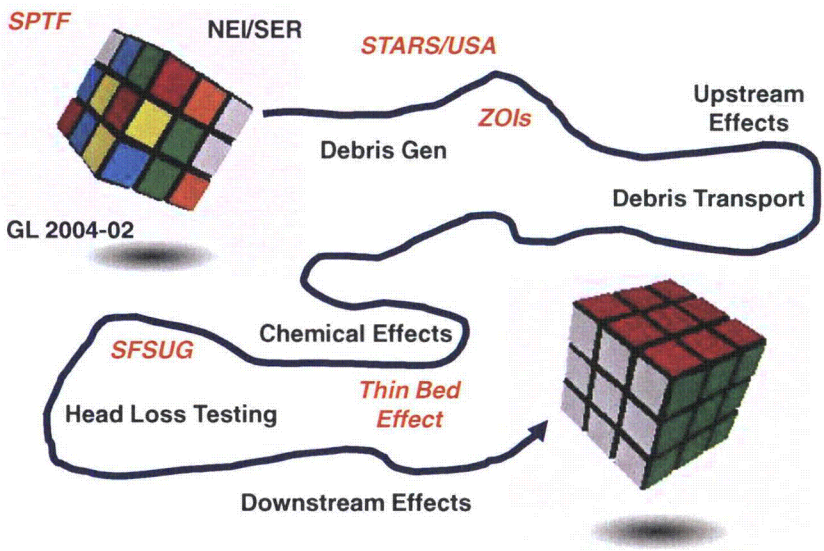
GSI-191 Sumpology 101



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Modifications

- Flat sump screens replaced with large complex strainers
- Sump switchover setpoints lowered
- Motor operated isolation valves replaced
- Debris screens and strainers provided for drains in the refueling cavity
- Drain holes added to the reactor vessel head stand shield wall
- Modified features to minimize water holdup
- Debris interceptor (curb) provided around strainers
- Water control feature added to optimize sump performance
- ECCS and CSS pump suction pressure monitoring instrumentation upgraded to meet Regulatory Guide 1.97, Revision 2.

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Schedule – Specify, design, build and install new strainers before completion of analyses

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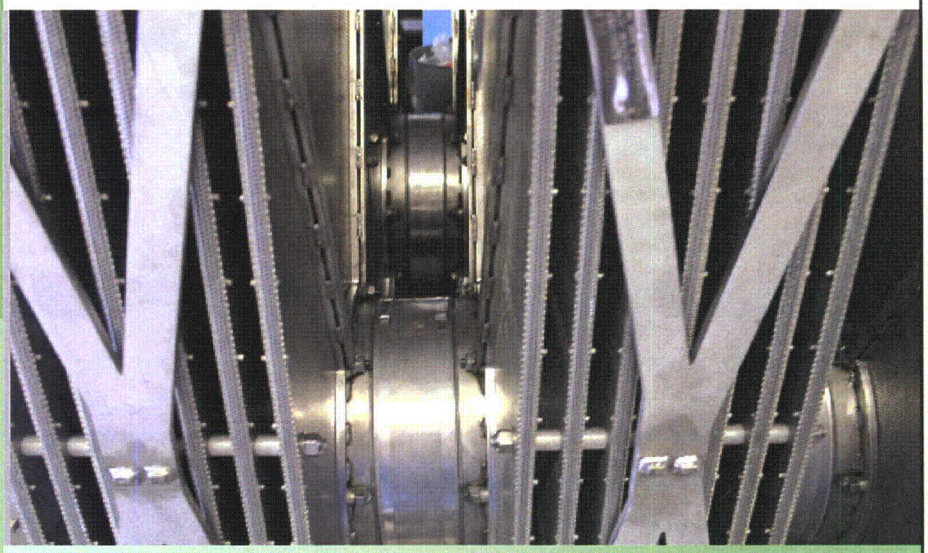
Core Tube Designed for Switchover Transient



RAI 22 and 23

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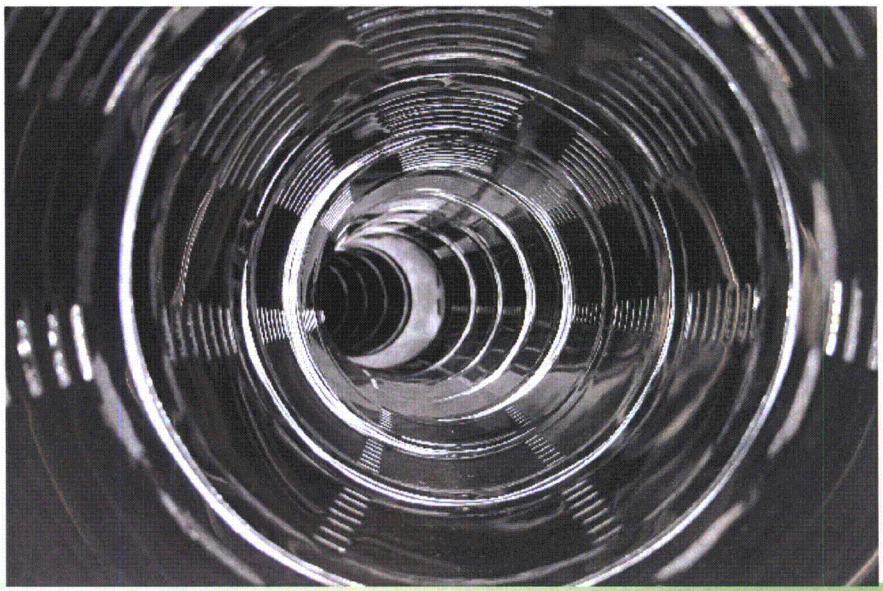
Flow Control Core Tube



RAI 22 and 23

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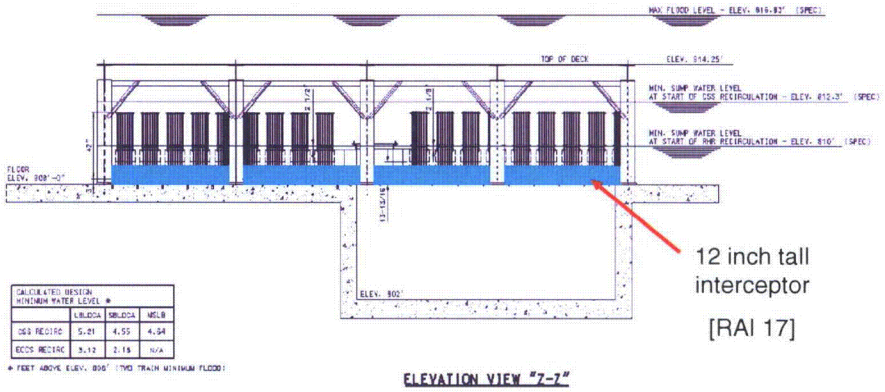
Strainer and Interceptor Layout

The sump pit is self venting through the strainers. There are no vents to containment above the top of the strainers. [RAI 21]

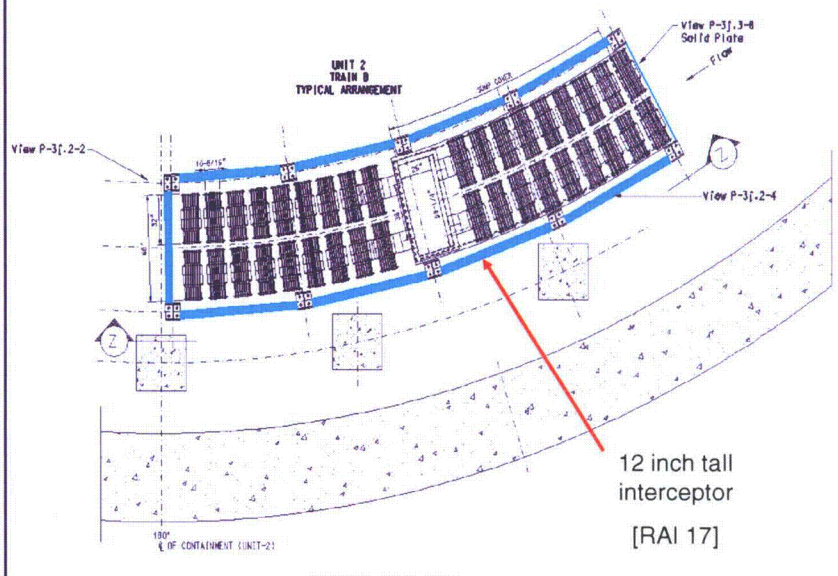


CALCULATED DESIGN MINIMUM WATER LEVEL *			
	LBLOCA	SBLOCA	MSLB
CSS RECIRC	5.21	4.55	4.54
ECCS RECIRC	3.12	2.15	N/A

* FEET ABOVE ELEV. 806' (TWO TRAIN MINIMUM FLOOD)

ELEVATION VIEW "7-7"

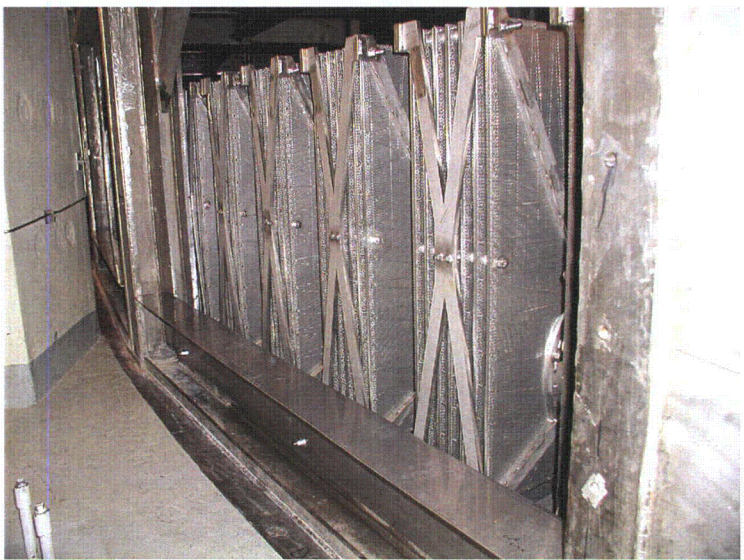
Revised calculation for ECCS Recirc for SBLOCA – 810.56 ft. [RAI 19/22/23]



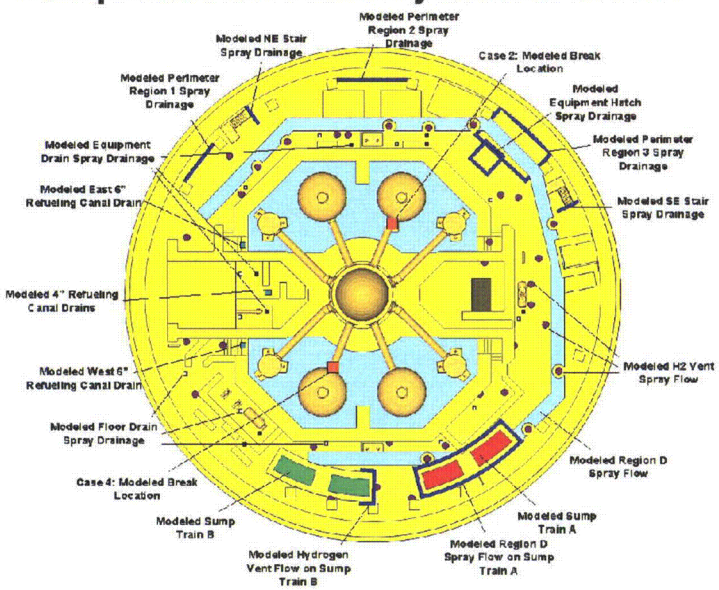
PARTIAL PLAN VIEW

New Sump Strainer with Debris Interceptor and Trash Rack

New Sump Strainer



Computational Fluid Dynamics Model

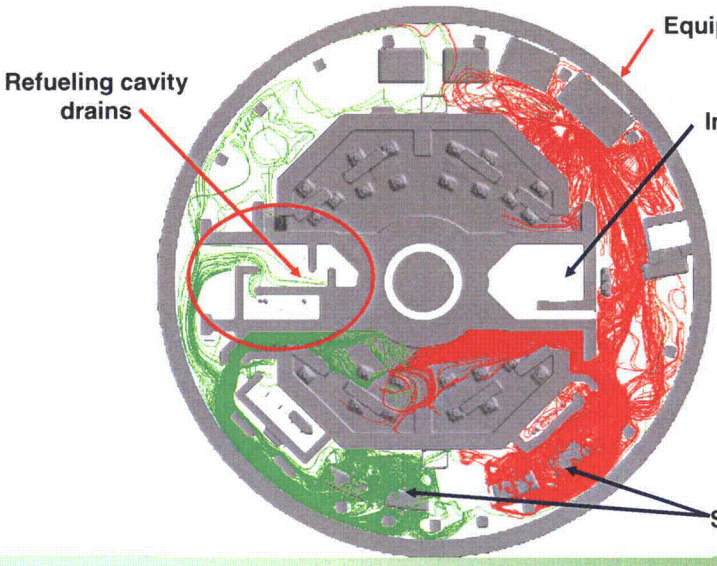


Capped Equipment Drain near sumps

Normal sump drain near strainer

Flashing Mod

Streamline for Loop 4 LOCA (2-train)



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Solid plate on sump outboard ends

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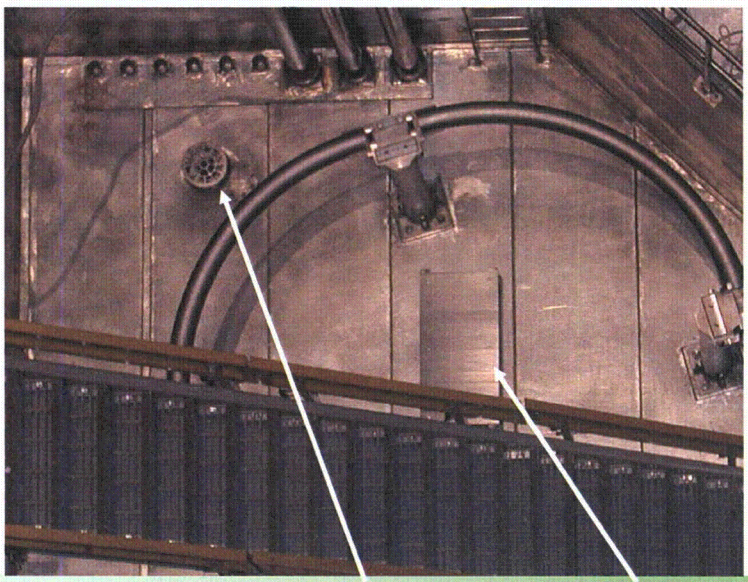
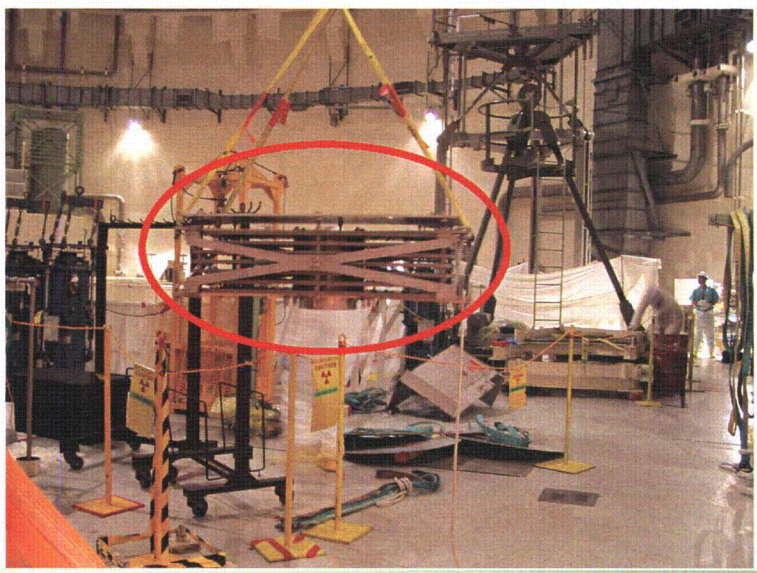
Refueling Cavity Drains



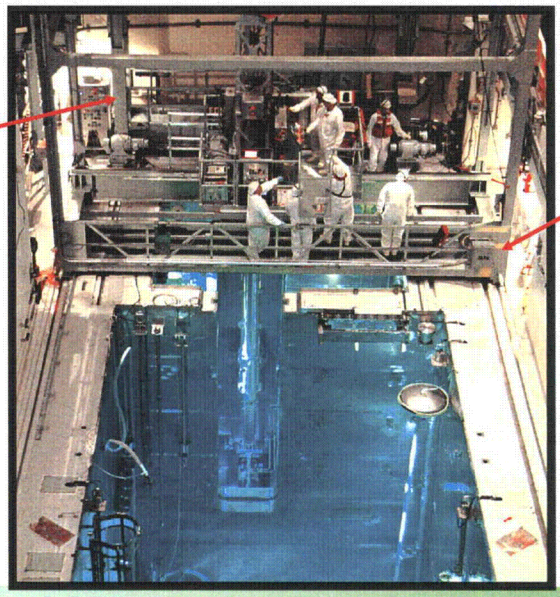
Debris Screen and Drain Strainer

Drain Strainer

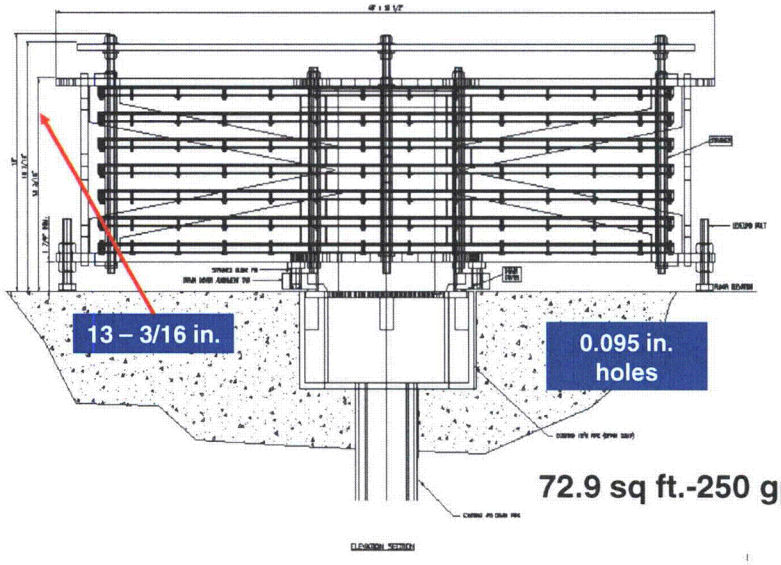


RAI 32

Upender Area



Refueling Cavity Drain Strainer



Upender Area Drainage

- Maximum spray flow into the upender area (1.7% of upper containment) is 185 gpm. Strainer is 1.8% size of sump strainer. Debris load on the drain strainer would be bounded by the debris load on the sump strainer.
- The flooding calculation assumed 2 ft of holdup (< 400 ft^3) The CSHL at 250 gpm is 0.042 ft.
- 10.8" submergence - the 30 day debris laden head loss for the sump strainers is approximately 7.2 inches
- **No credit for the drain strainers were taken to reduce sump debris loads**

Strainer Prototype Testing

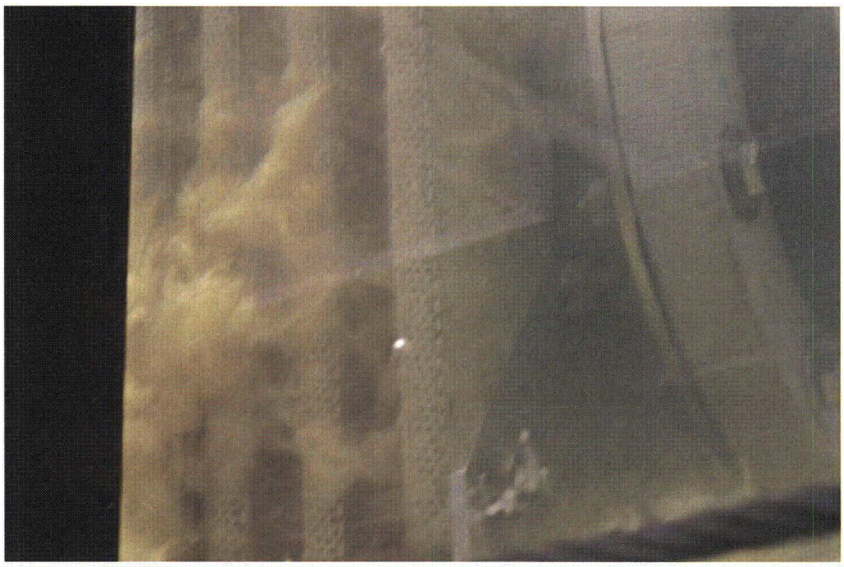
- Informative testing based on BWR protocol
- Demonstrated LBLOCA ECCS switchover with partial submergence
- Demonstrated relationship of LOCA versus Secondary Line Breaks
- Demonstrated settling is prototypical and would occur for most debris

Prototype (small flume) Testing

- Ultra-Conservative test temperature - < 50 F
- **Fiberglass fibers settle in 20 to 60 minutes in 50 F water versus 20 to 30 seconds in 120 F water [NUREG/CR-2982, "...water temperature has a paramount effect on buoyancy..."]**
- **Tests conducted at 128 F and 169 F confirmed the effect on settling of fiberglass [Test Report No. ITR-92-03N]**
- Fibrous debris was consistent with NUREG/CR-6808.
- Demonstrated settling with low approach velocity is prototypical and would occur for fines

Prototype Fiber Testing

Free Floating Fines and Smalls



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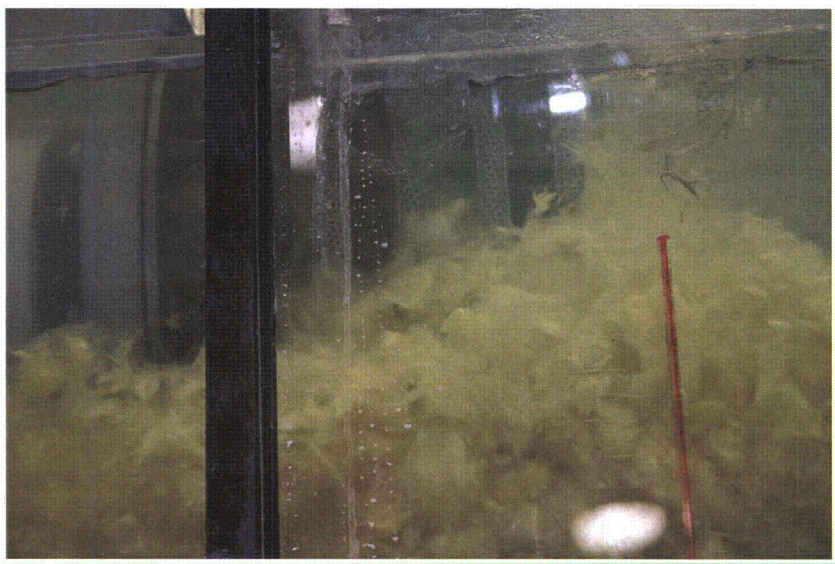
Settled Fibers



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Settled Debris During Head Loss Test

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Recirculation with partial submergence

- The strainer was designed for a transient water level during switchover
  - LBLOCA 3.12 ft. At 4900 gpm
  - SBLOCA 2.56 ft. at 400 to 1200 gpm
- The core tube would have > 9 inches of submergence at initiation
- Water level would be rising at over 1 inch per minute for all break sizes
- The strainer would be fully submerged in less than 15 minutes (0ne train)

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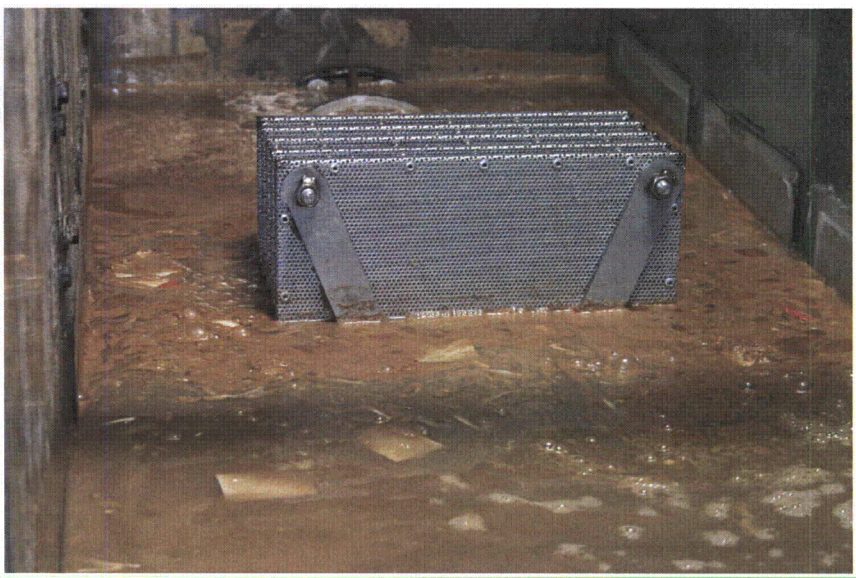
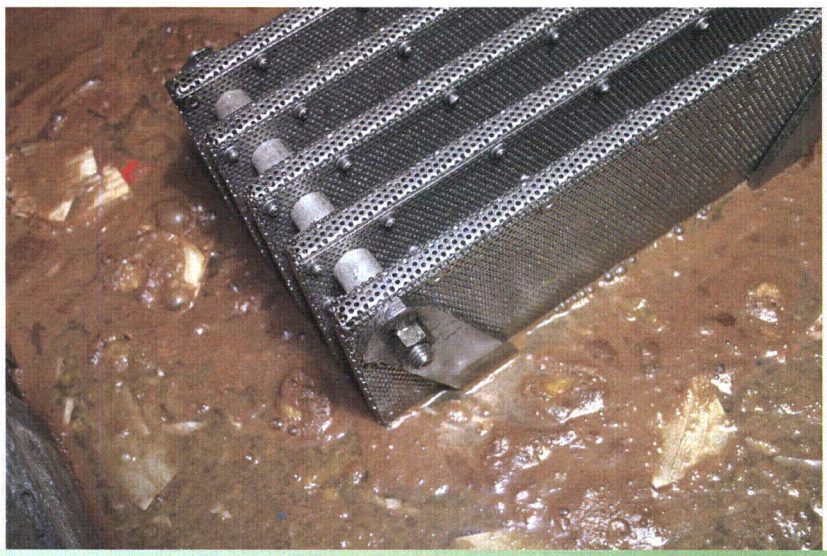
Flood Up Transient

- **Water level at ECCS switchover. All debris introduced at the prototype prior to pump start. Debris mixed at start.**
- Initial flow at maximum ECCS (39.5% of design flow)
- Flood up at minimum flood rate was 25 min. (< 1 pool turnover).
- 100% flow at CSS switchover flood level.

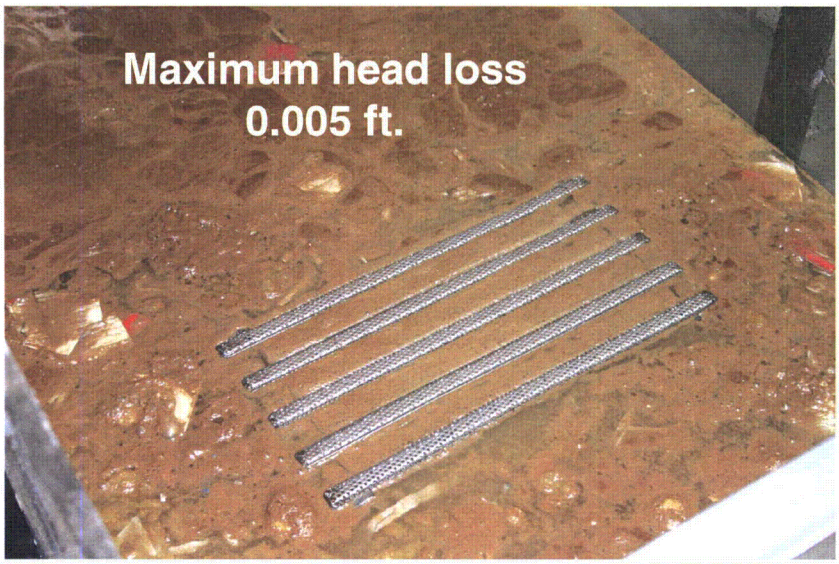
Transient Flood Up Testing



Transient Flood Up Testing



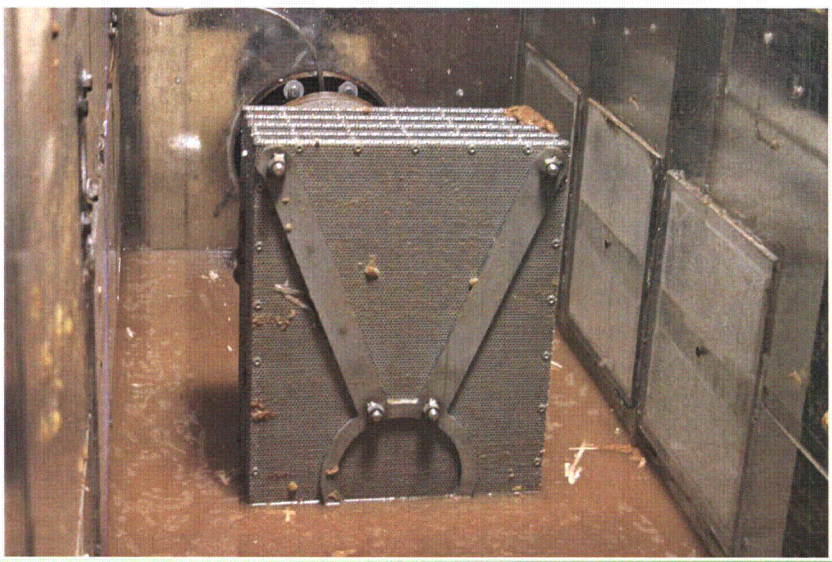
Transient Flood Up Testing



Secondary Line Breaks

- Secondary lines break have a maximum flow rate of 60.5% of design (7520 gpm versus 12,420 gpm)
- The maximum mission time is less than 10 hours versus 30 days for LOCA.
- Debris Head loss was 0.009 ft. vs 0.482 for LOCA

Main Steam Line Break Testing – Drain Down



Reflective Metal Insulation

- Debris Generation and Transport based on Diamond Power Reflective Metal Insulation.
- 11,269 ft^2 small/2,072 ft^2 large Sump A (2 train)
- Unit 1 SG replacement with Transco RMI bounded
- **No credit for the scavenging of fibers by RMI was taken in analysis or testing.**

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Low Density Fiberglass Insulation

- **For debris generation and transport, Nukon low density fiberglass [2.4 lbm/ft3] was assumed to calculate the volume**
- **For strainer design debris load, the maximum density of 4.9 lbm/ft3 was assumed**
- **100% of the LDFG in each loop room was assumed to be within the ZOI**
- **No credit for shadowing by grating and robust structures was taken**

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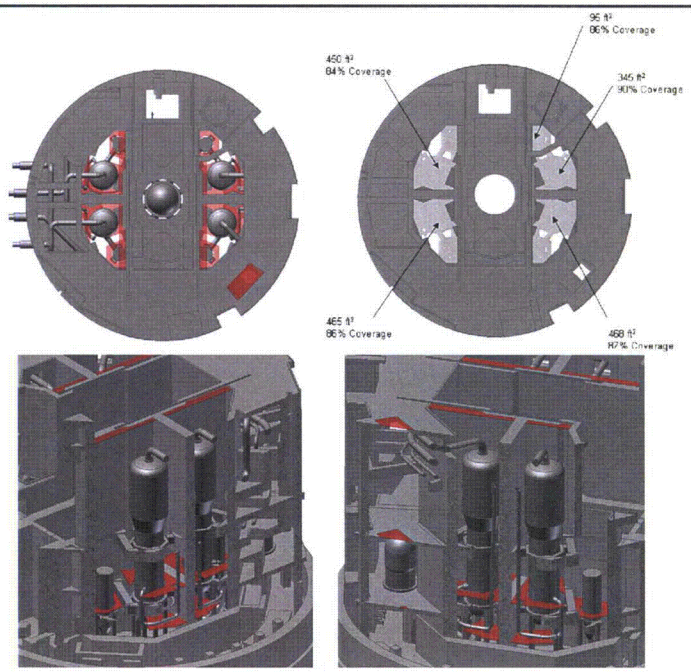
Small Fiberglass Holdup in Upper Containment

- Based on DDTS testing, 10% of the small fiberglass debris in upper containment was credited for holdup on grating (7% debris on grating and 3% washing off operating deck through grating)
- No credit taken for holdup of fiberglass fines, or retention of small pieces on concrete floors, refueling canal, stairs, or any other structures besides RCS loop room grating.
- Removing a small amount of this conservatism would reduce the overall washdown transport fraction even if no credit is taken for holdup on grating.



LOOPS 1 & 4 LOOPS 2 & 3

Low Density Fiberglass Insulation

LDFG	ZOI 42.42 ft^3	Transported* 33.87 ft^3	Case (Loop 4)
Fines	7.16 ft^3	6.66 ft^3 32.6 lbm	Loop 4, 1 train
Smalls	29.01 ft^3	22.63 ft^3 110.9 lbm	Loop 4, 1 train
Large	3.03 ft^3	2.28 ft^3 11.2 lbm	Loop 4, 2 train
Jacketed	3.22 ft^3	2.30 ft^3 11.3 lbm	Loop 4, 2 train

*** (166 lbm) = 69 ft^3 NUKON for testing**

LDFG Debris Preparation

- **NUKON processed into fines representative of either eroded or latent fibrous debris and 'fines/smalls' by recognized mechanical process devices [i.e., chipper (smalls) & Munson shredder machine (fines)]**
- **Sample of latent, fines/smalls, and larges' were provided to the Staff before any Large Flume Testing was initiated and were found to be representative of what the NRC Staff had expected, as long as they are adequately diluted**
- **Fibrous debris has been processed, prepared, and introduced in accordance with the PCI white paper *Sure-Flow Suction Strainer - Testing Debris Preparation & Surrogates*, the PCI/AREVA/Alden Large Flume Test Protocol which have been provided to and discussed with the NRC Staff**
- **Observations and comments by the NRC Staff and lessons learned by PCI/AREVA/Alden during the initial Large Flume Test for Wolf Creek/Callaway were incorporated into all subsequent tests**

Fines diluted per the March 2008 Staff guidance

LDFG Fines

RAI 25 and 26

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Latent Debris

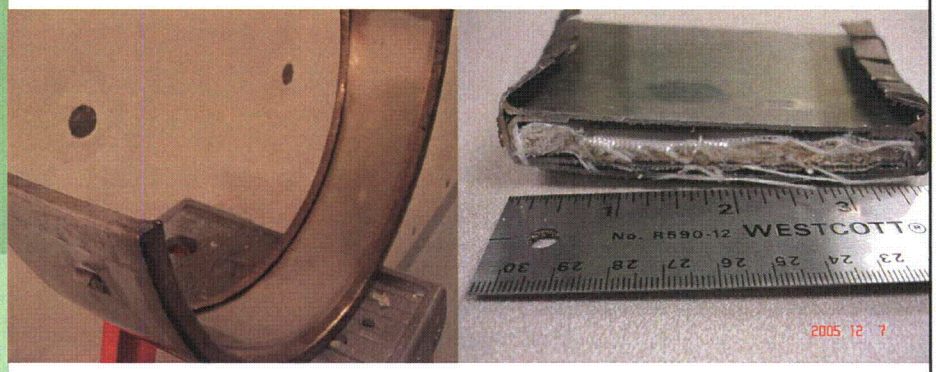
- 200 lbm (70% particulate/30% fiber) conservatively assumed
- No settling in the recirculation pool credited
- **Pool fill transport excluded upper containment.**
  - **inactive sump conservatively limited to 15%**
  - **active sumps evaluated to be 9%**
- **Testing used bounding case of 80% transport to one sump**
- **Latent fibers introduced on surface of test flume 5 minutes prior to start of flow. Head loss prior to first batch was comparable to fiber only test with fines**

RAI 9, 12, and 15

44

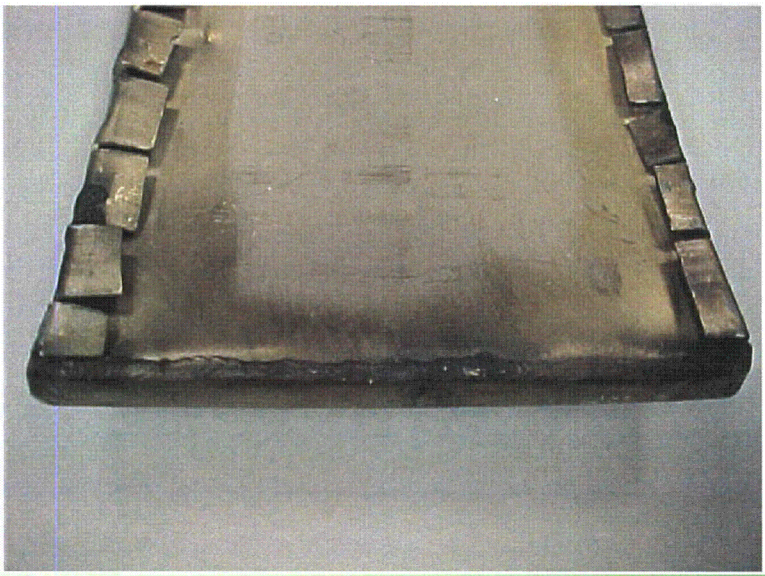
High Efficiency Insulation

Min-K encapsulation is 0.050 inch thick stainless steel



Robust design -Weld are continuous. The end profile is low. Maximum specified Min-K thickness 0.5 inches assumed.

Seamless – no open gaps



NUREG-6808 – Air Jet Impact Testing

- Transco RMI with sheaths half the thickness of 0.050 was tested. No RMI sheath failed during testing. (App. B p. 5)
- The tested Transco RMI had rivets and spot welds (3" max) in lieu of continuous welds
- The RMI failures occurred due to separation of the outer sheath from the ends. RMI testing targeted the seams and joints
- Secondary effects were considered insignificant
- **The ZOI for Transco RMI is conservative for Comanche Peak**

Min-K Insulation

Min-K	ZOI	Transported	Case
Fines	0.56 ft3	0.52 ft3 8.2 lbm	Surge Line, 1 train

100% fines assumed within the ZOI

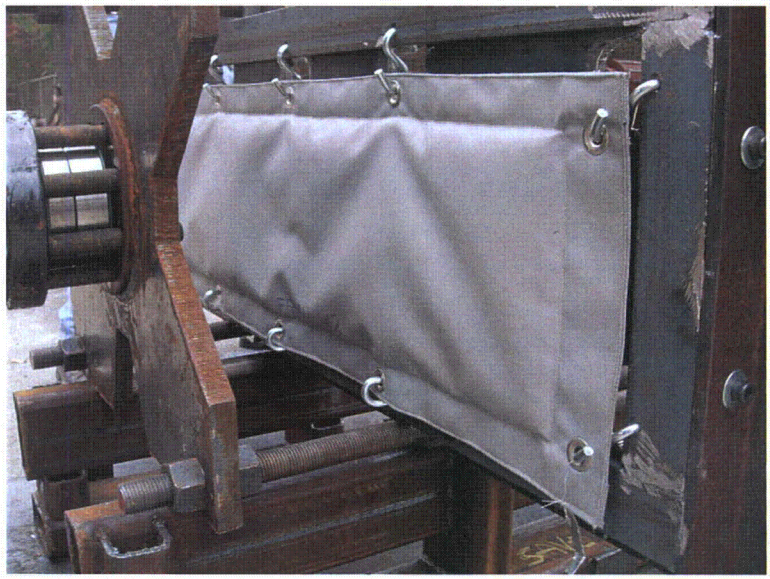
Pulverized Min-K used for testing

Lead Shielding Blankets

- The lead fibers were previously shown to not be transportable in testing and were not tested. **No credit for fiber scavenging was taken.**
- The Comanche Peak permanent lead blankets are the same blankets tested at Wyle.
- Wyle testing bounds the Comanche Peak configuration.

Lead Shielding Blankets – CPNPP

Lead Shielding Blankets – Wyle Test 2



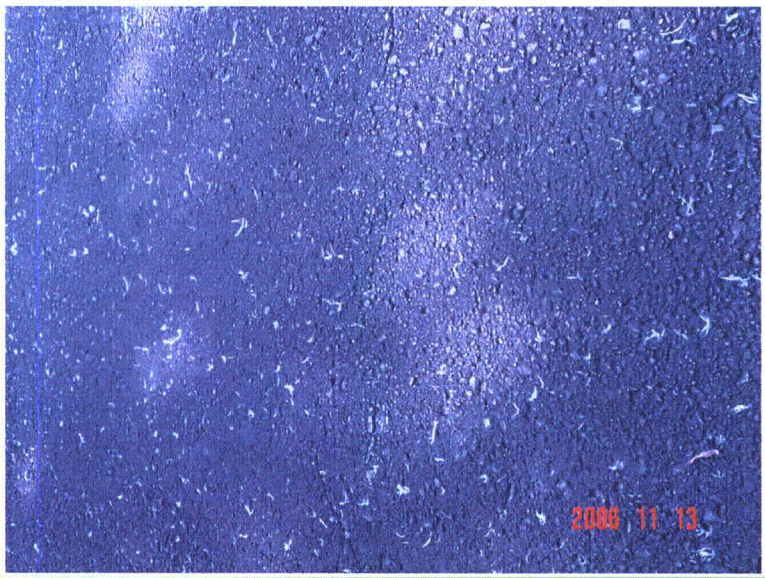
RAI 2 51

Lead Shielding Blankets – Wyle Test 2

RAI 2 52

Lead Shielding Blankets – Wyle Test 2

Lead Shielding Blankets – Wyle Test 2



Lead Blanket Cover Fines

Size consistent with LDFG smalls

Lead Shielding Blankets

- All layers within the ZOI were included.
- The largest break, Loop 1 Cold Leg, was used for testing.
- Fibers from the blanket cover were observed to reach the strainer during fiber bypass testing.
- The fiberglass content was included in the chemical effects analysis.

Coatings

- All containment coatings were applied and maintained under either the Comanche Peak 10 CFR 50, Appendix B QA program or the Comanche Peak Non-Appendix B QA program.
- The reevaluation of all coatings inside containment was based on ASTM D 5144-00, the EPRI Guideline on Nuclear Safety Related Coatings using plant records.
- Where records were insufficient, sampling and testing were performed (e.g. material traceability).

Coatings within the ZOI

- ZOI of 4D used for acceptable concrete epoxy coatings based on WCAP-16568-P and JOGAR testing.
- **ZOI of 10D used for acceptable steel epoxy coatings in lieu of 4D for conservatism.**
- Pulverized acrylic coatings used for testing surrogate for epoxy
- Tin Powder used for IOZ surrogate

Unqualified Coatings

- **Indeterminate coatings classified as unqualified.**
- **Size distribution for analysis and head loss testing based on test data.**
- **Testing proved that paint chips >/= 1/64 inches cannot transport to and block the strainer.**

Chemical Precipitates - Analysis

- **Analysis of chemical effects were completed in accordance with WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191," Revision 0, February 2006.**
- **No WCAP-16785 refinements were used.**
- The current Sodium Hydroxide [NaOH] buffer concentrations were used. There are no current plans to implement the buffer reduction which was previously proposed as a contingency.

RAI 34 and 36

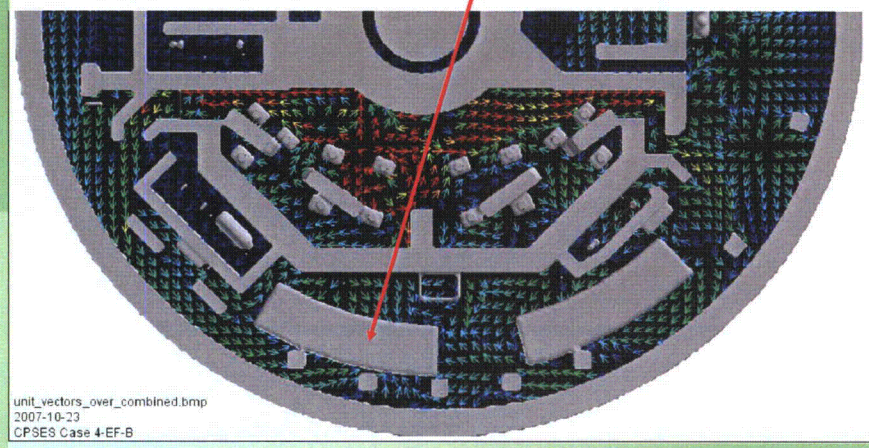
Chemical Precipitates - Testing

- **Although Sodium Aluminum Silicate (NaAlSi3O8) makes up 83% of the precipitate, Aluminum Oxyhydroxide (AlOOH) was used as the surrogate for testing.**
- For head loss testing, WCAP-16530 was applied to generate the AlOOH precipitates. Acceptance criteria for AlOOH batches generated were based on the settling characteristics of chemical precipitates generated at 2.2 g / l.
- AlOOH precipitates generated were introduced within 24 hours of their generation / acceptance for use.

Chemical Precipitates - Testing

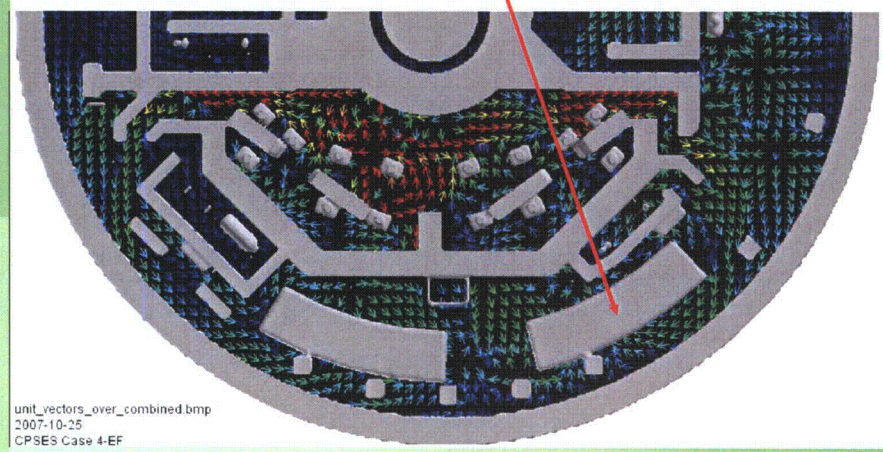
- **The chemical concentration in the test flume was controlled over time so as to prevent the potentially accelerated settling of chemical precipitates from an over concentrated flow stream. This was in accord with the protocol reviewed with the NRC staff prior to testing.**
- **WCAP-16785 was not used.**
- Calculations of head loss including chemical precipitates were performed at both 200 F and 120 F

Supplementary Strainer Testing
Loop 4 LOCA
Train B



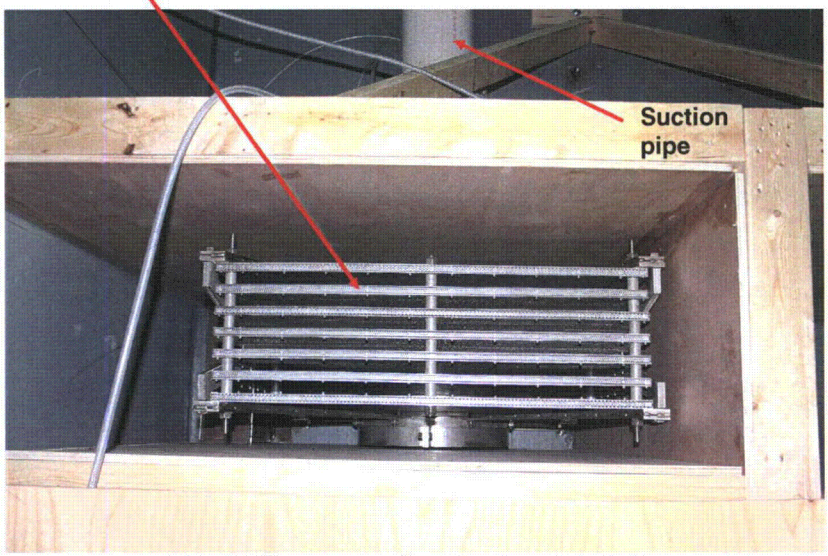
RAI 16 63

Supplementary Strainer Testing
Loop 4 LOCA
Train A



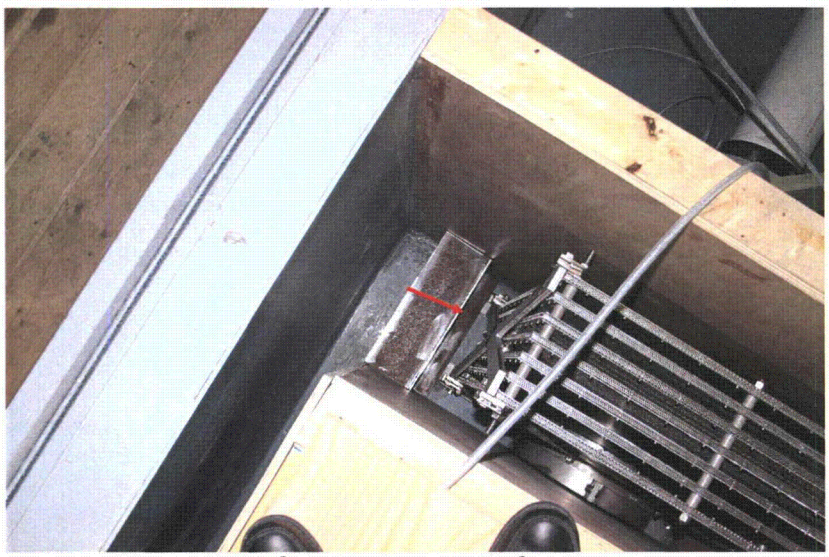
RAI 16 64

Test Module – approach velocity 0.0073 fps



109.5 ft^2, net scaling factor 2.9225%

Debris interceptor – 12 inches tall, 6 inch top



0.18 fps test vs 0.12 fps avg

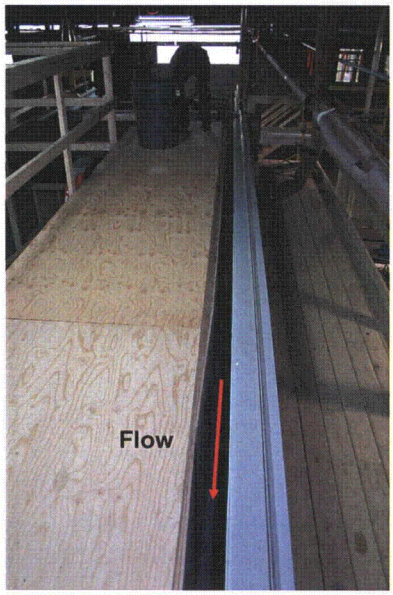
Transport flume –

264 inches

(22 feet)

Max flow –

0.62 fps



RAI 18

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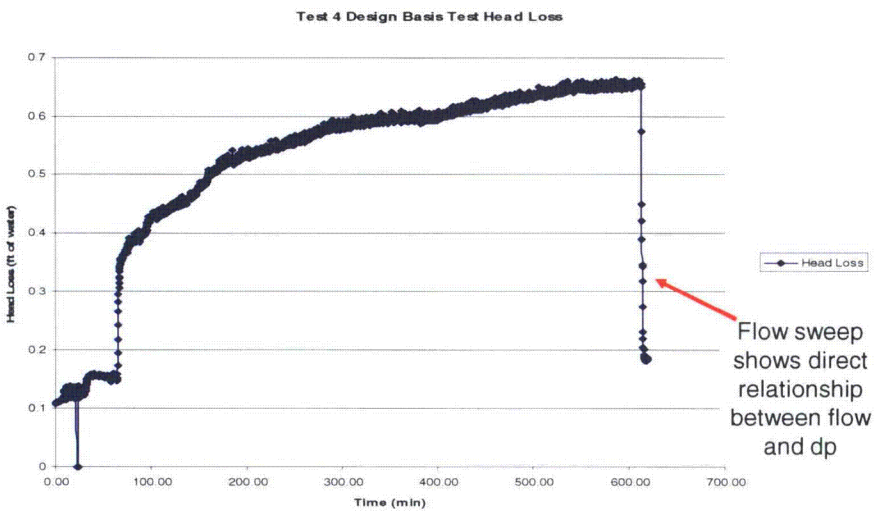
Test Protocol

- **Test debris types were introduced separately with the most transportable first.**
- Although classified as fines, the lead blanket covers were characteristic of smalls but less transportable. Therefore, they were added after LDFG smalls.
- **Particulate fines were introduced before fibrous debris for conservatism.**

RAI 27

68

Head loss test – Debris head loss stable at approximately 0.6 ft



Flow sweep shows direct relationship between flow and dp

RAI 29

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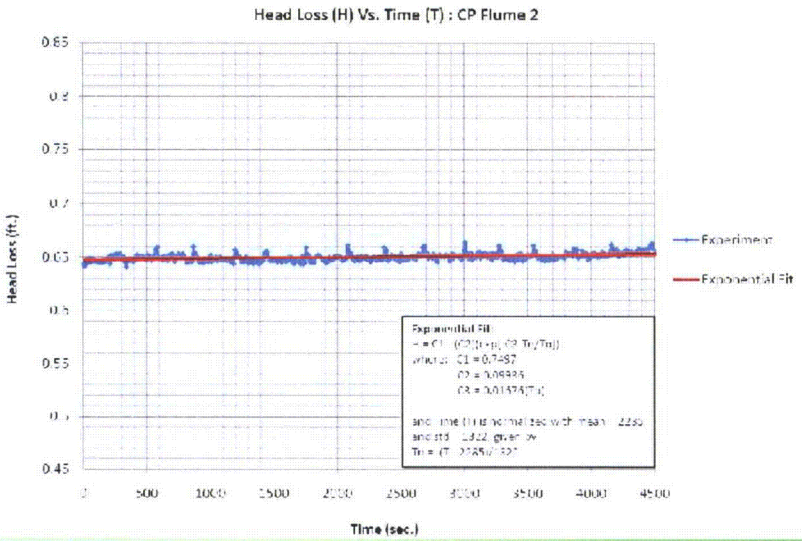
Test 4 Head Loss Extrapolation Curve Exponential – 0.7497 ft.



RAI 28

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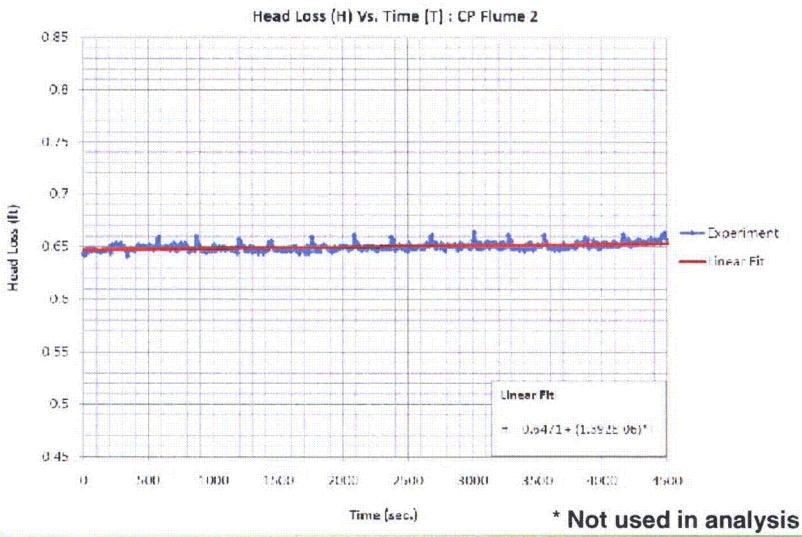
Test 4 Head Loss Extrapolation Curve Linear – 4.2552 ft.*



* Not used in analysis

Head Loss Margins

- **Exponential – Net Positive Suction Head margin 5 Ft. at 30 days**
- **Linear**

	Days	Extrapolation	NPSH Margin
Non-Harsh	14	2.331 ft	3.63 ft
Ambient	25	3.654 ft	2.306 ft

Headloss test – drain down

Test 4 Headloss

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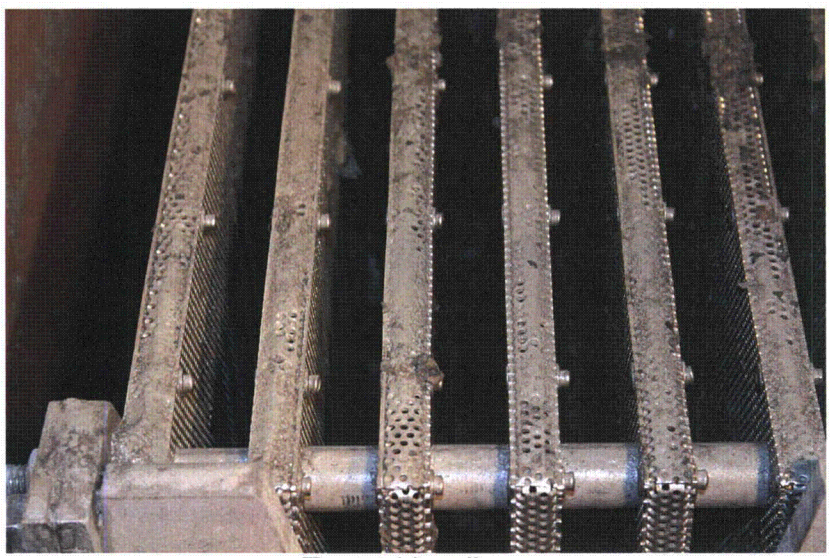
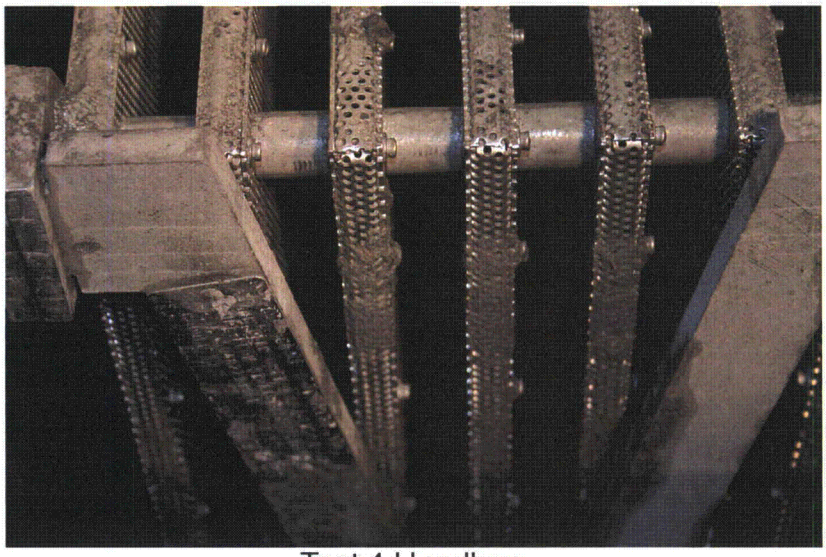
Headloss test – drain down



Test 4 Headloss

74

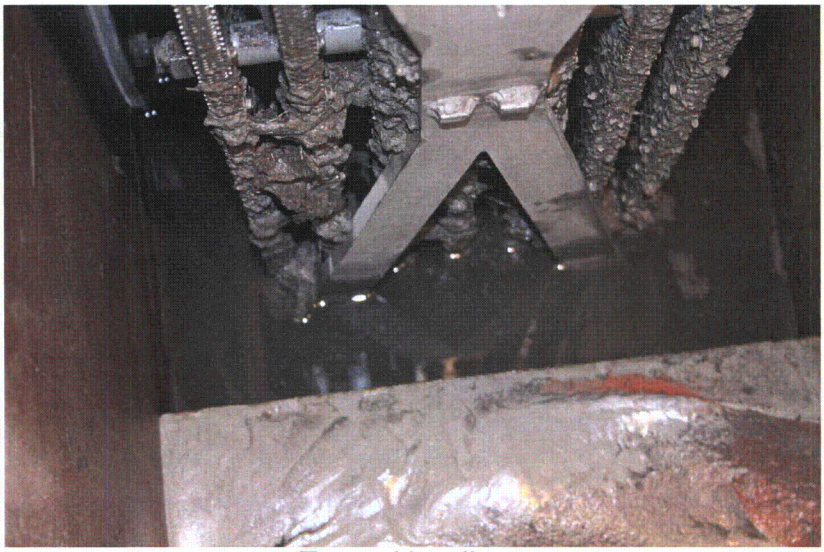
Light debris load/open holes - top half



Test 4 Headloss

75

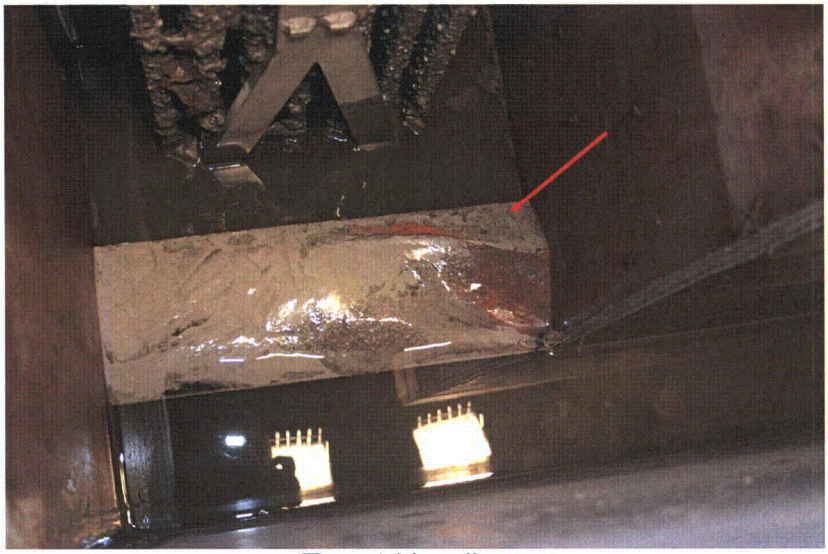
Heavier debris load on bottom half



Test 4 Headloss

76

Settled fines on top of interceptor



Test 4 Headloss

77

Miscellaneous Debris

- Miscellaneous debris was tested for transport at both Alion and Alden test facilities to determine the margin in the 200 ft^2 sacrificial area.
- Electromark Series 1000 and 3000 labels were shown to be **qualified (would not detach)** or **acceptable (would not transport or block the strainer).**
- Other acceptable materials – Lamacoid

RAI 5

78

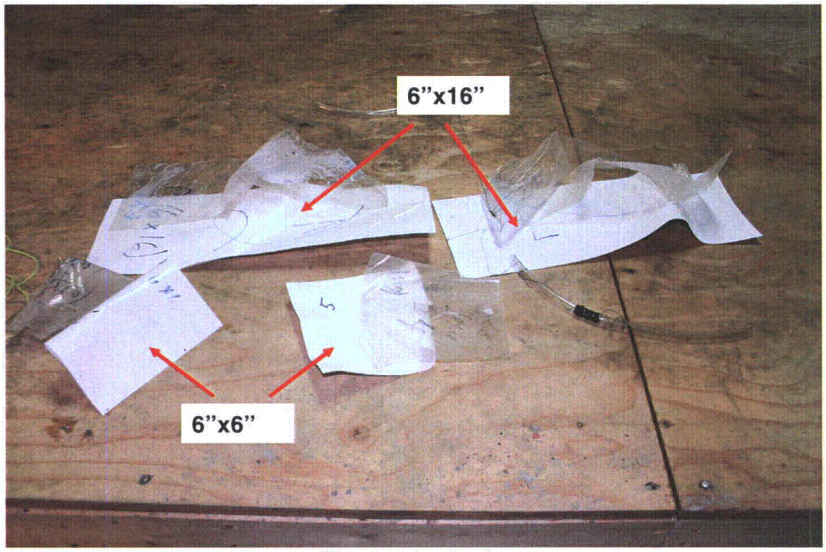
Miscellaneous Debris Testing

- Separate flumes were used for miscellaneous debris testing because the transport over the debris interceptor was 0.18 fps as opposed to 0.12 fps in the plant. The average transport velocity in front of the debris interceptor is 0.08 fps; therefore, a minimum of 0.1 fps was used for testing.
- Some label testing was done in the main flume.

RAI 14

79

Series 1000 Electromark labels

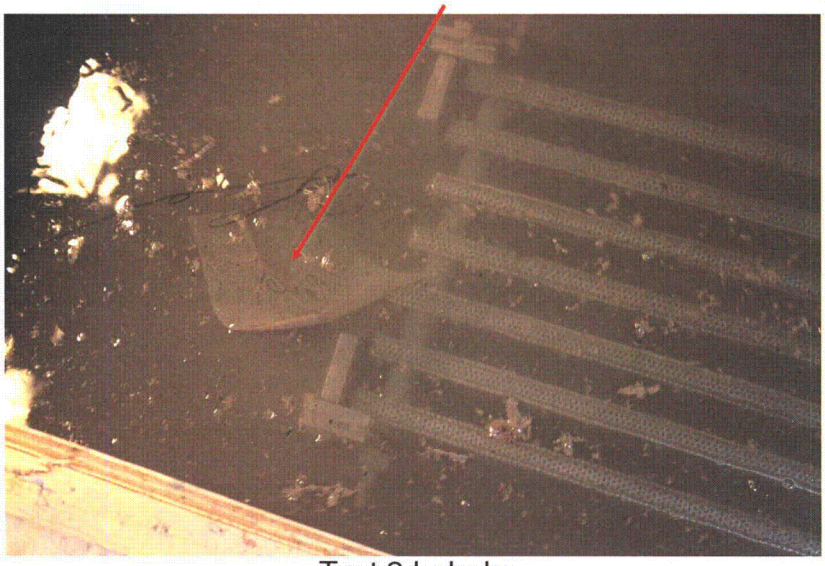


Test 3 Labels

RAI 5

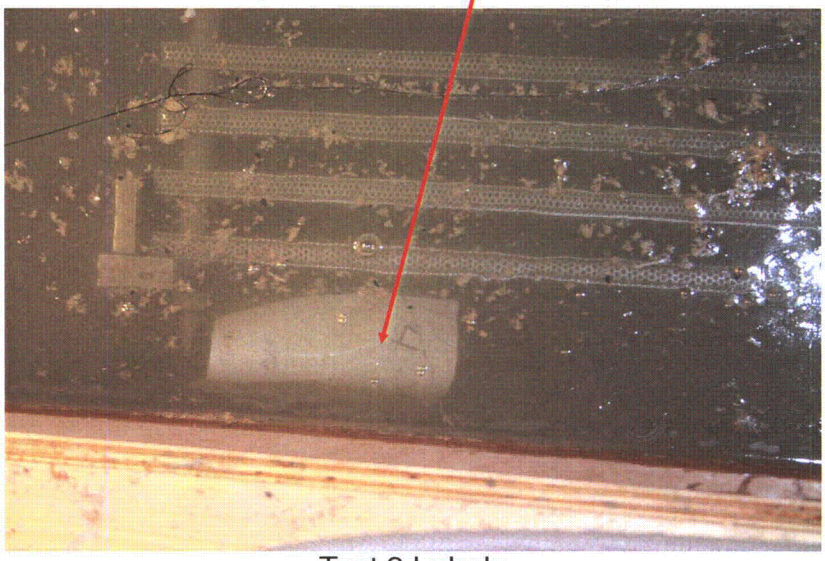
80

Series 1000 Electromark labels, 6"x6" clear vinyl



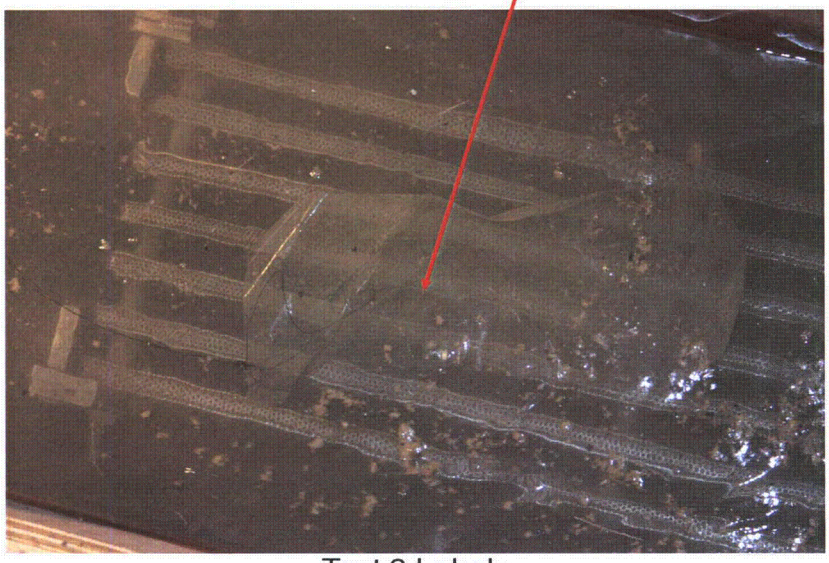
Test 3 Labels

Series 1000 Electromark labels, 6"x6" white vinyl



Test 3 Labels

Series 1000 Electromark labels, 6"x16" clear vinyl



Test 3 Labels

RAI 5

83

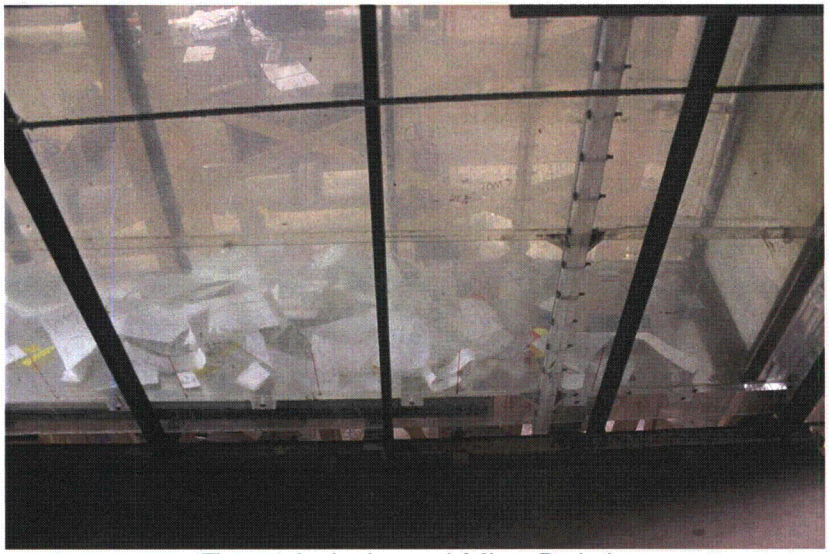
Floating Debris

- Although most miscellaneous debris sank readily in the cold flume water, duct tape, bumper sticker tape and radiation tape floated.
- Based on previous testing of the same duct tape at Alion, it was concluded that the larger pieces of tape could entrain air during boiling.
- The floating debris was considered unacceptable and included in the sacrificial area penalty.

RAI 19

84

Vinyl labels and tags settled at 0.1 fps



Test 6 Labels and Misc Debris

Unacceptable labels, tags, and tape

- The impact on the sacrificial area margin was calculated to be the area equivalent to 75% of the total of the original single sided surface area of the unacceptable labels, tags, and tape (per SER) plus 20% for uncertainty.
- The sacrificial area penalty is 31.9 ft^2 for Unit 1 and 34.6 ft^2 for Unit 2
- Paper tags are less than 22% of this total and represent an insignificant amount of fiber.

In Vessel Downstream Effects

Debris	WCAP-16793-NP, R1	CPNPP
Fiber	0.33 lb	0.02 lb
Particulate	29 lb	98.78 lb
Chemical	13 lb	1.26 lb
Calcium silicate	6 lb	N/A
Microporous Insulation	3.2 lb	0.03

Comparison to the WCAP test data concluded Comanche Peak demonstrates reasonable assurance of Long Term Core Cooling.

Holistic Case

- Conservatisms have been inherent in each phase of the analysis and testing to account for uncertainties
- Debris generation and transport conservatisms assure that only debris that cannot get to the sump is excluded
- Testing conservatisms assure that only debris that DG and DT show cannot get to the sump is excluded from testing

RAI Discussions

- **RAI 9, Debris transport analysis, Pool Fill - Alion**
- **RAI 6, Fiber erosion testing - Alion**
- **RAI 10 and 11, Test Flume, velocity and turbulence questions – Alden**
- **RAI 15, Test protocol, latent fiber issue – PCI**
- **RAI 8, Test protocol, erosion issue - PCI**
- **RAI 20, Test Flume, fiberglass larges question – AREVA**
- **RAI 22 and 23, SBLOCA, vortex, air ingestion, void fraction, and flashing issues – PCI/AREVA**
- **RAI 24 and 37, Secondary line breaks, debris load and testing – Luminant**

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Summary

- Comanche Peak has been a leading participant in the pursuit to resolve GSI-191 since 2000
- Comanche Peak has collaborated with industry groups seeking knowledge and data required to address technical issues.
- Extensive analysis and testing are complete that demonstrate with reasonable assurance that the ECCS and CSS recirculation functions under debris loading conditions are in compliance with the regulatory requirements delineated in Generic Letter 2004-02.

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