Callaway Energy Center Strainer Testing for GSI-191

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Nuclear Regulatory Commission
Rockville, MD

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DESIRED OUTCOMES

- Generate a mutual understanding of testing to resolve GSI-191
- Keep staff informed of Callaway Energy Center GSI-191 Resolution Project progress

OVERVIEW

- Risk-Informed Approach
- Plant Characteristics
- Debris Loads
  - Fiber
  - Particulates
- Solution Chemistry
- Testing Process
  - Overview
  - Specific Approach
- Staff Feedback

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PRIORITIES FOR UNDERSTANDING

Test Process Steps

1. Form chemical surrogate in laboratory grade water
2. Determination of thin-bed condition by visual inspection
3. Strategies for reducing Non-Q coating burden

Test Attributes

1. Treatment of “small” debris
2. Strainer geometry (no curb around test module)
3. Flow history with respect to spray and precipitates
4. Particulate surrogate

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Risk-Informed Approach

TWO TEST SERIES FOR STRAINER PERFORMANCE

- Head loss testing
- Fiber penetration testing
- All test procedures, instrumentation, and materials are developed and procured/dedicated Safety Related to support deterministic portion of RoverD

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INFORMATION PROVIDED

- Information provided for NRC review
  - Test specification
  - Test plan
  - Presentation

TEST SCHEDULE

• Shakedown	June 7, 13
• Head loss tests 1, 2 and 3	June 20, 27 July 5
• Fiber penetration tests 1 and 2	July 11, 18
• NRC staff observation	Recommend 2nd head loss test (June 27)

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Plant Characteristics

PLANT CHARACTERISTICS

- Nukon fiberglass on RCS and equipment
- RMI on steam generators
- Non-Q coatings
- TSP dry buffer system
- PCI strainer modules in vertical stacks
- EOP used to ensure submergence
- Full strainer area ~3300ft^2
- Test module scale ~10.5%

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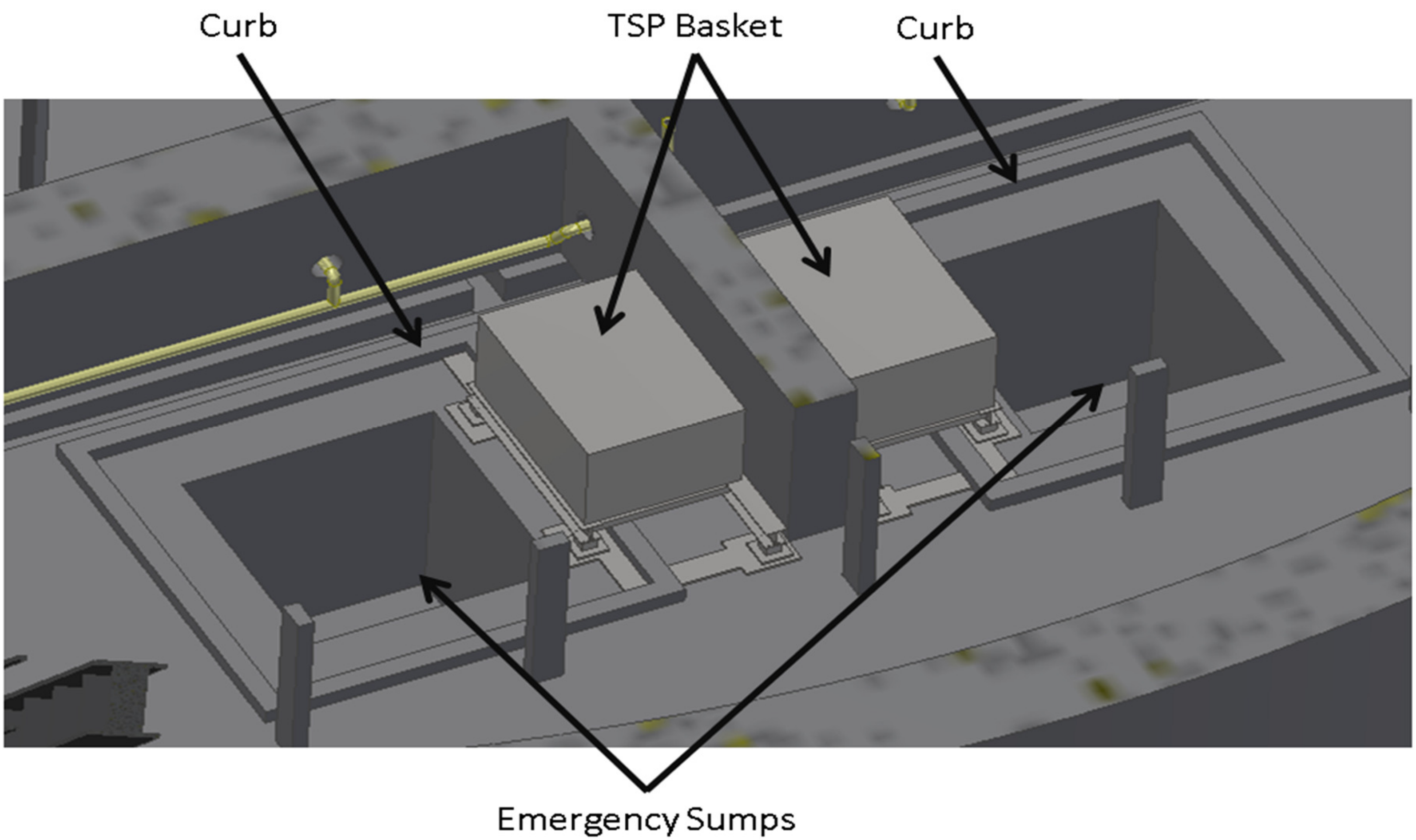
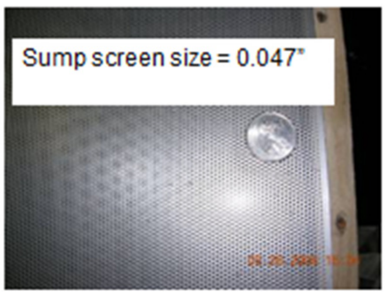
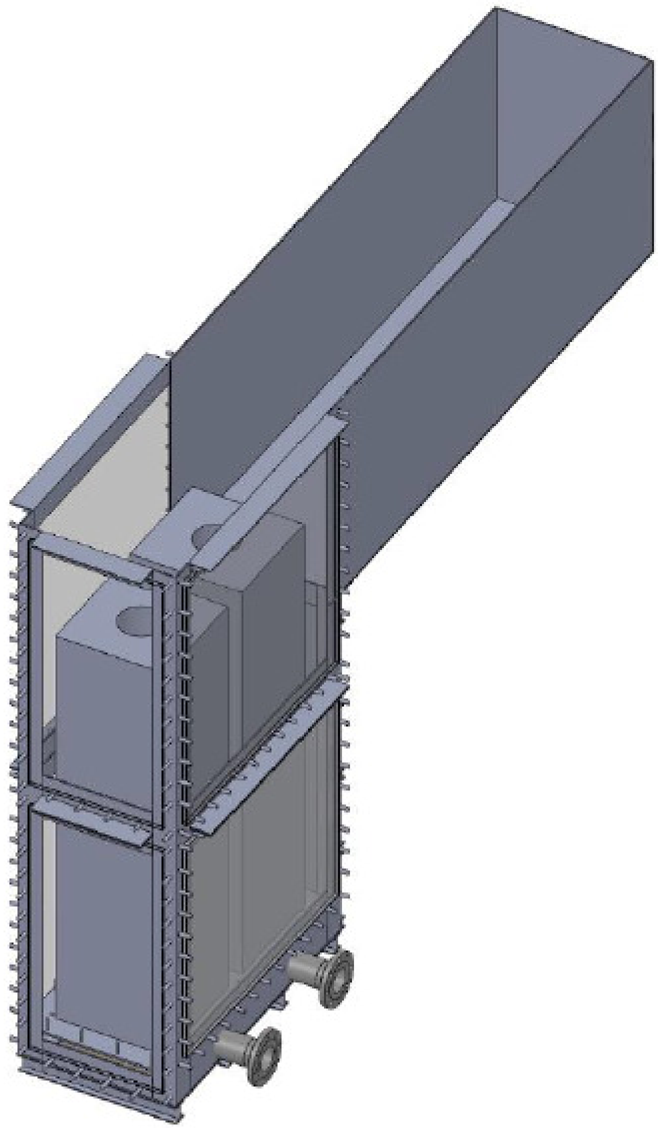
INDEPENDENT SUMP TRAINS



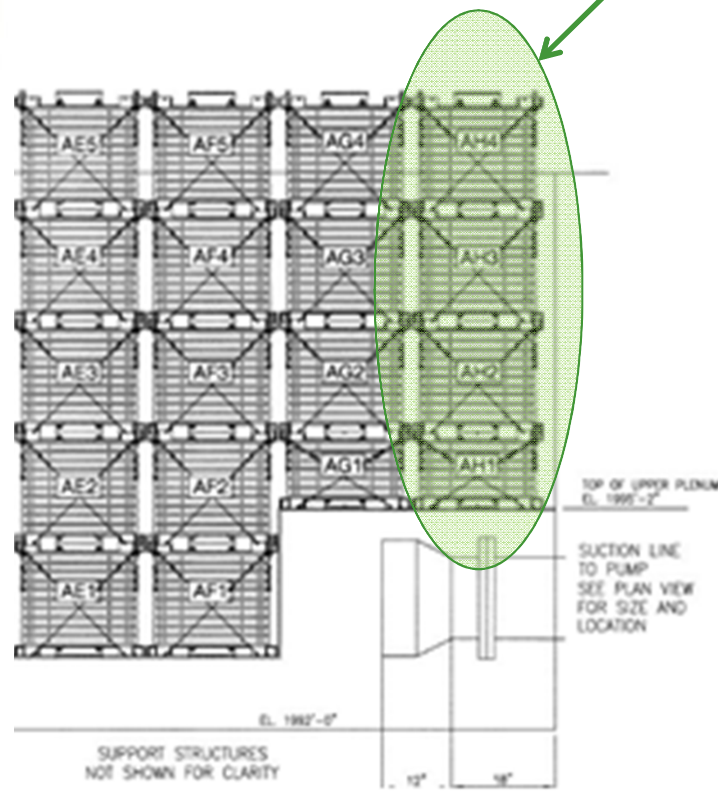
RECESSED STRAINER MANIFOLD

72 of these modules require





Test module equals full “short stack”



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Debris Loads

(Fiber)

BASIC TREATMENT OF FIBER

- ZOI consistent with approved methodology
- Erosion consistent with approved methodology
- Transport consistent with guidance and Drywell Debris Transport Study (DDTS)
  – All fines assumed to transport
- Small Fiber
  – Add small-fiber (as small fiber) after all fines
- NEI guidance for fiber debris preparation and handling

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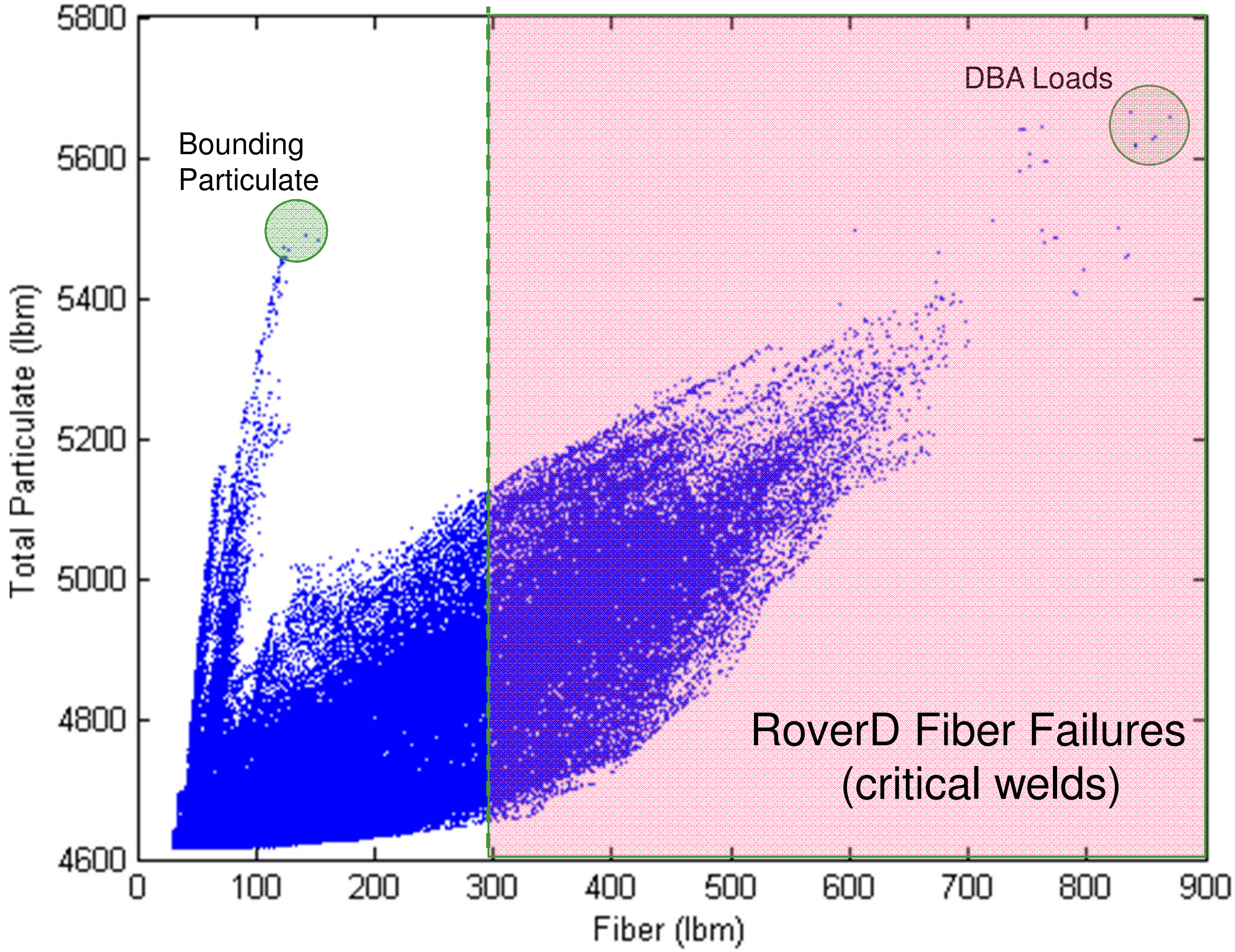
CEC BREAK SPECTRUM

- Every break has unique debris
- Every break has a frequency
- ~600k weighted samples of size and direction at all welds
- About 4600 lbm of Non-Q coating
- Traditional DBA loads near upper right
- RoverD fiber goal near 300 lbm



Debris Loads

(Test Particulates)

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Coating Debris Quantity

MAX CEC COATING DEBRIS (FOR TEST PLANNING)

Coating Type	Total Debris Volume (ft^3)	Test Mass Typical 2008 Surrogate (lbm)	Test Mass SiO2 Surrogate (lbm)
Acrylic/Epoxy	21.8	435	379
IOZ	13.1	629	228

- Estimates based on max DEGB at independent locations
- Present test load larger than 2008 test load
- High particle-to-fiber mass ratios for most breaks

STRATEGIES TO REDUCE PARTICULATE IMPACT

1. Test particulate loads that bound RoverD critical welds
2. Choose a second "RoverD-type" limit for particulates (next slide)
3. Reduction of coating particulate
4. Justify some Non-Q failure as chips

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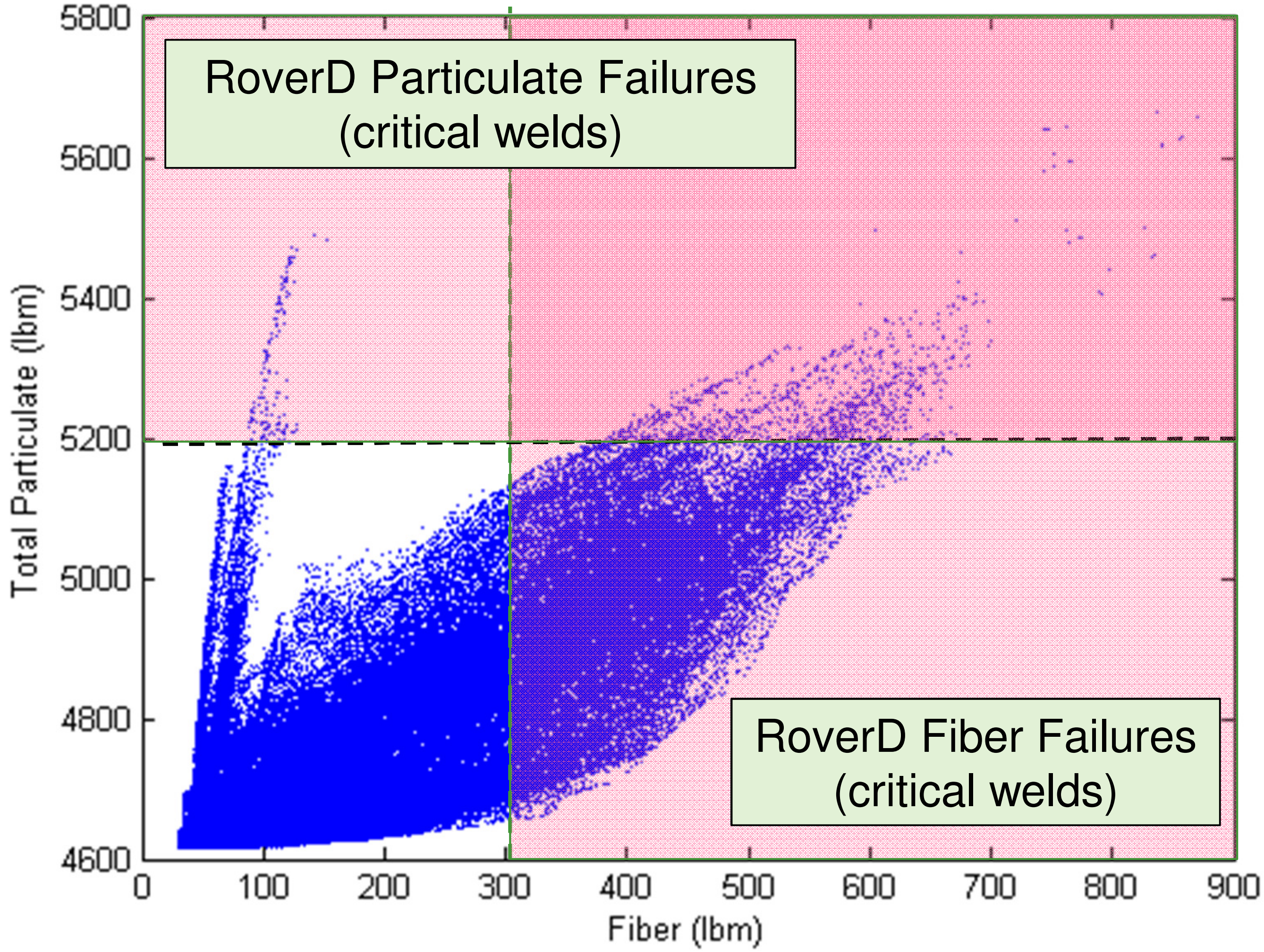
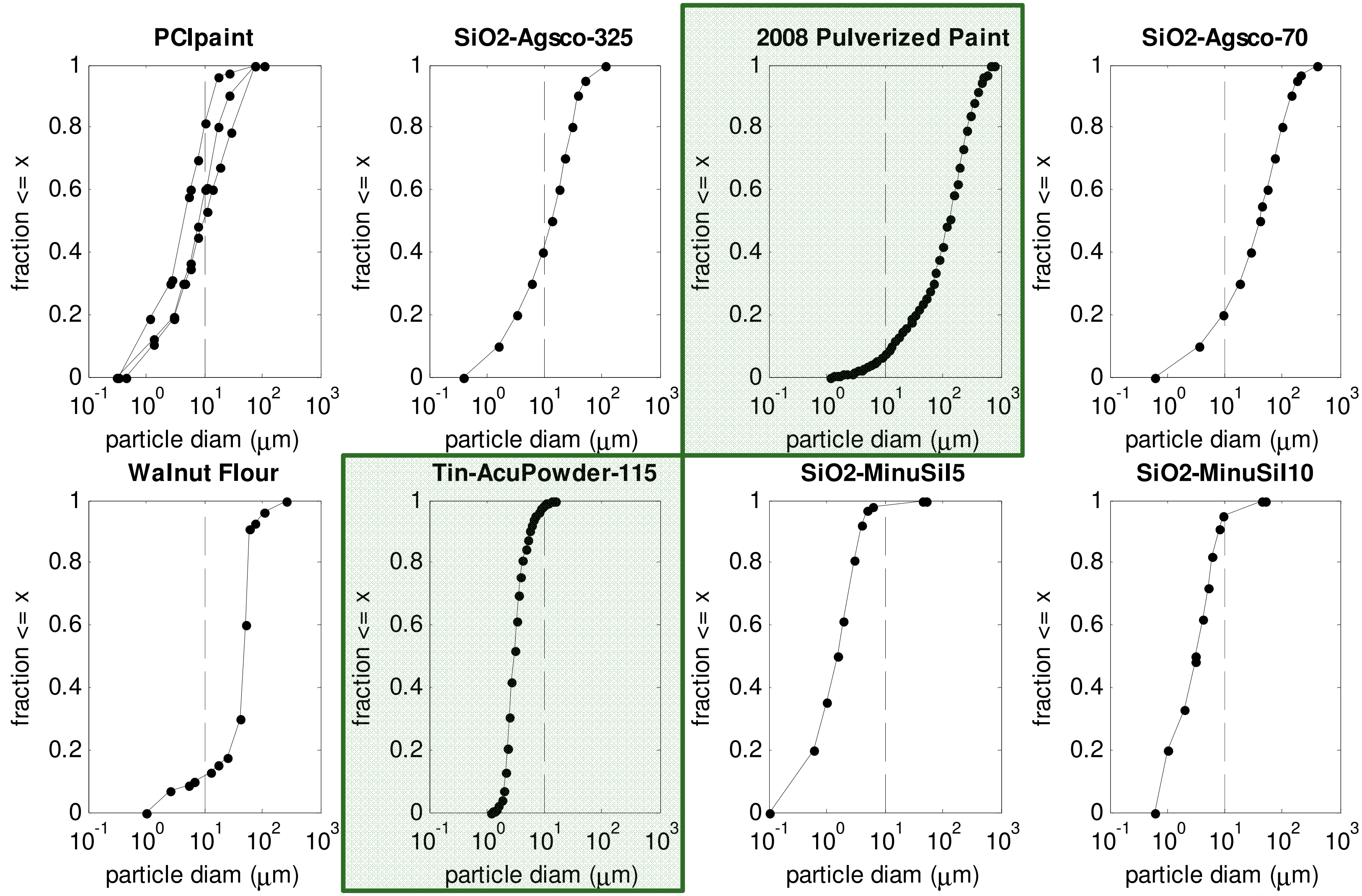
ROVERD-TYPE LIMIT FOR PARTICULATES

- Second RoverD-type criterion for coatings (ex 5200 lbm)
- Preliminary risk estimate of ΔCDF = 3.3e-7 per yr
- No increase in critical weld count (approx 55 welds)



Particle Surrogate

CANDIDATE PARTICULATES



SURROGATE SELECTION PROCESS

1. Calculate the CEC particulate volume for damaged organic and damaged IOZ coatings (Q and Non-Q)
2. Examine the corresponding particle distribution obtained using typical 2008 surrogates
3. Match the particle distribution using available silicates
4. Confirm the “small” and “large” diameter components with physical descriptions consistent with guidance

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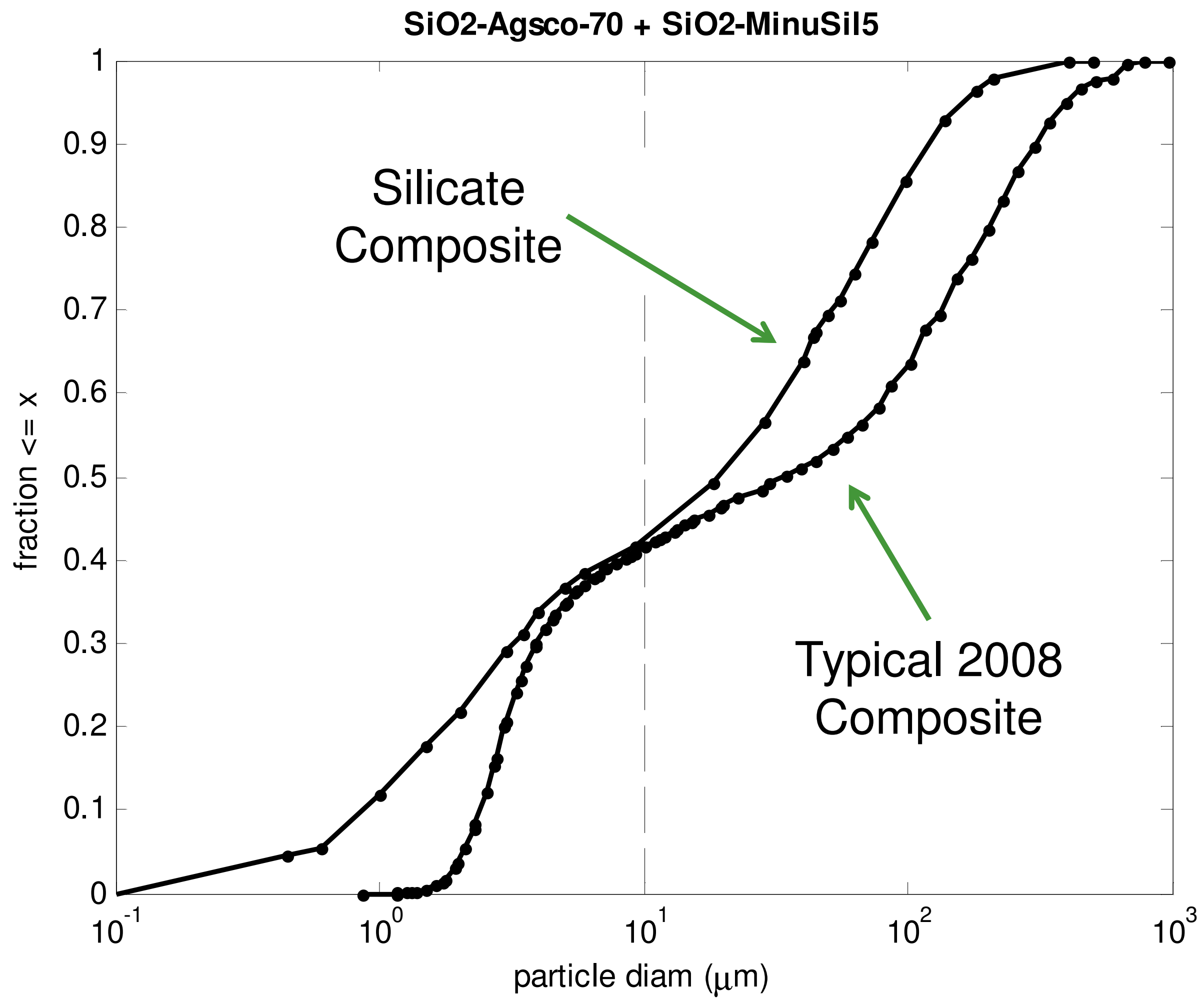
CLOSE COMPOSITE



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Solution Chemistry

TEST SOLUTION

- Penetration test solution
  - pH during early fiber ingestion (first pool turn over)
    - Quickest TSP dissolution is ~105 min

Condition	Initial pH	Max Steady State pH	Estimated TSP basket s wetted at start of recirc	Time to recirculation	Estimated turn over time
SBLOCA	4.6-4.7	4.7 – 7.5	Less than 10 min	133 min	~2 hours
LBLOCA	4.6-4.7	7.1 -7.3	Less than 5 min	12.5 min	~0.5 hour

- Headloss test solution
  - Solution pH determined by RoverD fiber target (likely LBLOCA)

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PRECIPITATE

- Precipitate type
  - AlOOH and $Ca_3(PO_4)_2$
- Precipitate quantity
  - Multiple batches that range from 24-hr chemical to NPSH failure

Testing Process

FACILITY DESCRIPTION

- Tank test configuration to maximize transport
- NEI fiber debris preparation
- WCAP-16530 chemical surrogate preparation
- Alden debris introduction
- Time-lapse video
- ΔP, level, T (120F), pH spot checks

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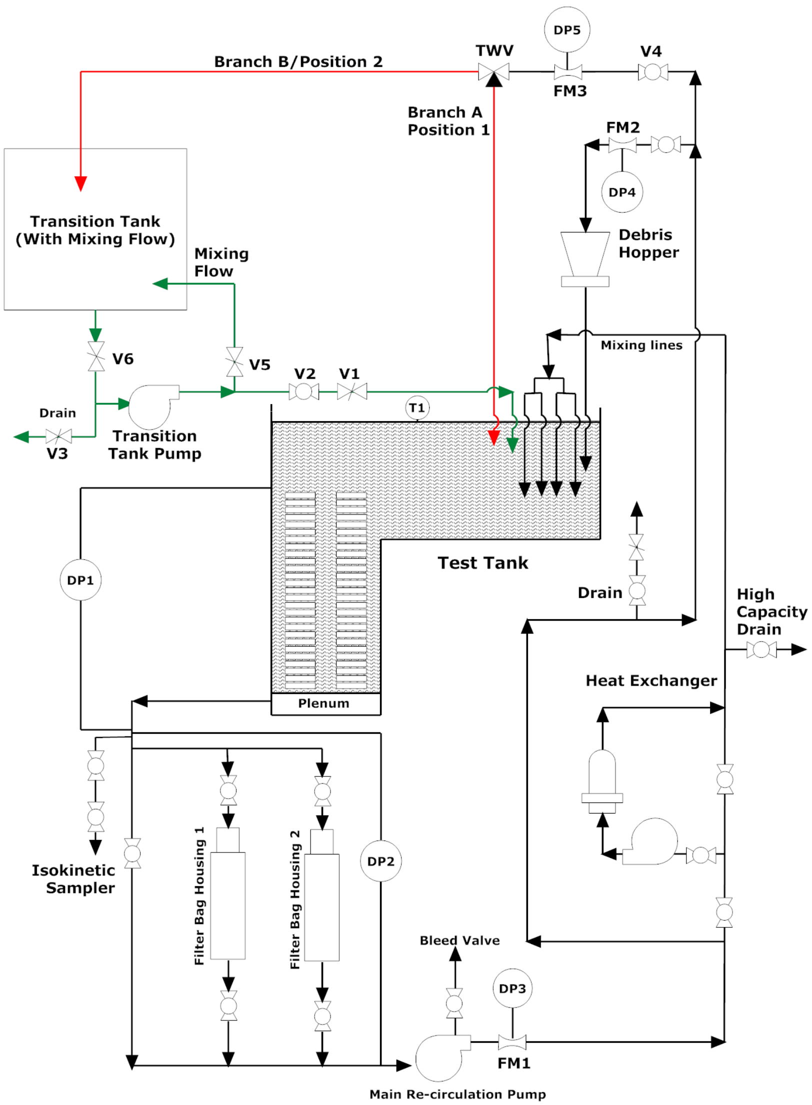
TEST LOOP P&ID



GENERIC HEAD LOSS TEST

Step 1
- Conventional debris up to target (batches)

Step 2
- EOP flow reduction

Step 3
- Bed stability checks

Step 4
- Chemical surrogate add (batches)

GENERIC PENETRATION TEST

- Purpose: Characterize quantity of fiber passing through strainer module as function of load
- Single pass fiber with 100% downstream capture
- Two tests at max velocity for pH effect
- Alden process for sample collection, filter dry, weigh

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TEST SPECIFIC - PRECIPITATE

- Precipitate produced per WCAP-16530 protocol in same laboratory grade water used for borated/buffered solution
- Test velocity and precipitate load addition
  - After fiber/particles, add 24-hour $Ca_3(PO_4)_2$ load, reduce velocity, batch all additional chemicals

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THIN-BED CONFIRMATION BY INSPECTION

- Consistent with Pilot plant 2008 thin-bed confirmation
- Supported by high particle-to-fiber mass ratios
- Supported by experience with thin-bed protocol
- Optional 3rd test for performance characterization or replicate

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OLD TEST VS NEW TEST

2007 Test

- Near-field settling in flume
- Wood chipper fiber
- Walnut flour overestimated required debris volume by 20%
- Tap water
- Debris batches
  - Fiber fines, walnut flour, tin, fiber fines, large debris
  - Batches did not have similar fiber-to-particulate ratios
- Surrogates
  - Walnut shell flour, tin, chips, and fine, small, large LDFG

2016 Test

- Maximum transport in tank
- NEI prep fiber
- Particulate scaling conserves volume
  - Increases IOZ by x3
- Buffered borated water
- Has no epoxy chips
- Particulate and fiber fines introduced simultaneously
  - Batches have similar fiber to particulate ratios
- Surrogates
  - Silicates for all coating, LDFG fines and smalls

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SUMMARY AND FEEDBACK

- Improve quality assurance and repeatability by forming chemical surrogates in laboratory-grade water
- Non-Q coatings are the dominant challenge for successful strainer testing
- Staff invited to attend head loss testing to confirm formation of thin bed at high particulate-to-fiber load

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