BWROG ECCS Suction Strainers Project NRC Update Meeting

Sam Harvey (TVA)
BWROG Vice Chair

NRC - BWROG ECCS SS Meeting
December 4, 2013
Washington D.C.

BWROG Chair Introduction and Remarks

Recent BWROG leadership changes

- BWROG Chair – Lesa Hill (SNC)
- BWROG Vice Chair – Sam Harvey (TVA)

BWROG Letter 13050 (September 11, 2013)

- Requested Option 1: Full LTR review
- Requested Option 2: Review of Benchtop Testing (LTR Attachment B)
  - Benchtop testing perceived as a higher priority versus full LTR review

Submittals Pending Review

- Acceptance Letter for Technical Issue No. 7, "ZOI Adjustment for Air Jet Testing"
- Licensing Topical Report NEDC 33608P, "Boiling Water Reactor Emergency Core Cooling Suction Strainer In-Vessel Downstream Effects"

BWROG Chair Introduction and Remarks (cont.)

Submittals Pending Review (cont.)

- BWROG-ECCS-WP-3-1, "Summary of Member Responses to BWROG Survey on Strainer Head Loss and Near-Field Effects"

Near-term Submittals for NRC Review (1Q 2014)

- BWROG-ECCS-TP-4-1, "BWR Material Dissolution Test Plan"
- BWROG-ECCS-TP-5-1, "Assessment of Coatings"
- BWROG-ECCS-TP-6-X, "85 / 15 Latent Debris Characteristics"

BWROG Chair Introduction and Remarks (cont.)

Additionally Expected 2014 Submittals for NRC Review:

- BWROG-ECCS-TP-2-X, "Bypass Test Report" (ETA 2Q 2014)
- BWROG-ECCS-TP-2-X, "Transit Time Calculations Report" (ETA 3Q 2014)
- BWROG-ECCS-TP-2-X, "Fuel Test Plan for Tests 3 & 4" (ETA 2Q 2014)
- BWROG-ECCS-TP-2-X, "Debris Source Term Specification" (ETA 3Q 2014)
- BWROG-ECCS-TP-2-X, "Benchtop Testing Results – BT1 through BT4" (ETA 3Q 2014)

BWROG Chair Introduction and Remarks (cont.)

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- BWROG-ECCS-TP-8-X, "Coatings Zone of Influence Calculation and Closure Letter" (ETA 2Q 2014)
- BWROG-ECCS-TP-9-X, "Debris Transport and Erosion Position Paper" (ETA 3Q 2014)
- BWROG-ECCS-TP-10-X, "Debris Characteristics" (ETA 3Q 2014)

Summary

BWROG Letter 13050 Agreement

- Request for Option 2: Review of Benchtop Testing (LTR Attachment B) as the BWROG perceives it as a higher priority versus full LTR review

Mitigation Strategies Directorate (MSD)

- Understanding the current date for Stewart Bailey's return to the ECCS SS project; NRC review activities resumed

Understanding of NRC Position to Support Expected 2014 BWROG Submittals

- Twelve (12) issue-related submittals mainly in support of DSE testing programs
- Initial discussions related to planning 1Q 2014 NRC Meeting in Washington DC

BWROG ECCS Suction Strainers – 2014 Schedule / Expected Submittals Overview

Sam Harvey (TVA)
BWROG Vice Chair

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1Q 2014 Expected BWROG Submittals for NRC Review

BWROG-ECCS-TP-4-1, "BWR Material Dissolution Test Plan"

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BWROG-ECCS-TP-9-X, "Debris Transport and Erosion Position Paper" (ETA 3Q 2014)

BWROG-ECCS-TP-10-X, "Debris Characteristics" (ETA 3Q 2014)

BWROG ECCS Suction Strainers Project – Fuels Testing Update

Matt Horowitz (Alden)
Ludwig Haber (Alden)

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December 4, 2013
Washington D.C.

Fuels Testing Program

- LTR describes fuels testing to validate analysis:
  - Attachment A
- Submitted LTR resulted in RAIs
  - Responses to RAIs identified need for Benchtop test program
- Commissioning of facility ongoing
  - Expected completion February 2014
- Awaiting SER of LTR (with Attachment A)
  - Including submitted RAI responses and Benchtop test program

Fuel Test Program - Outline

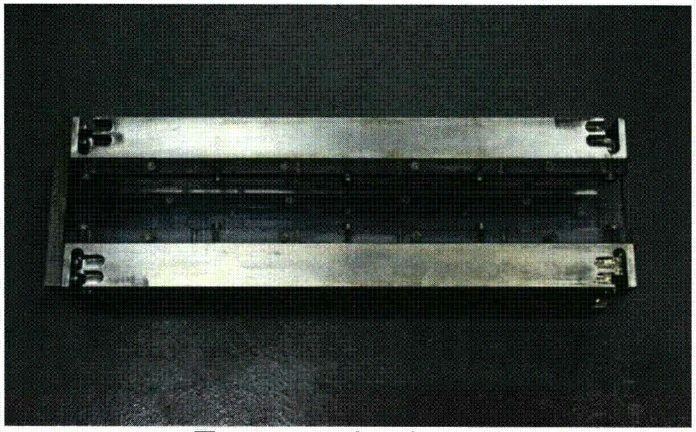
Completed work

- Test standard design & construction
- Loop design & construction
- Commissioning test procedures & inspections

Work in progress

- Facility shakedown
- Computational fluid dynamics validation
  - Draft calculations completed

Fuel Test Program – Test Standard


Test standard section

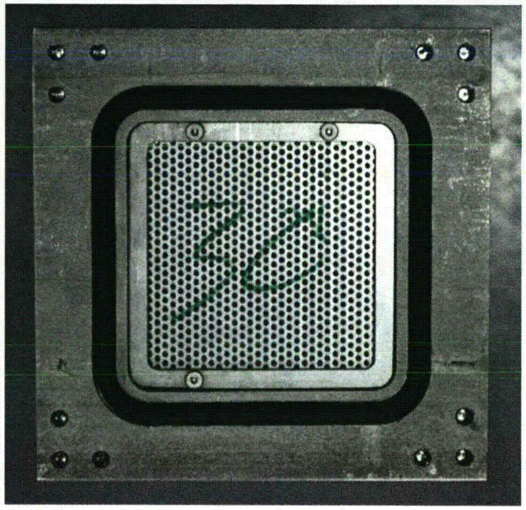
Purpose:

- Verification:
  - Facility configuration
  - Facility performance (incl. M&TE)
    - Throughout test program duration
    - Between tests, common to all vendors
- First prototype of clear fuel channel approach
- Shakedown testing:
  - Surrogate for fuel bundle
  - Clean and debris-laden water operation

Fuel Test Program – Test Standard

Geometry:

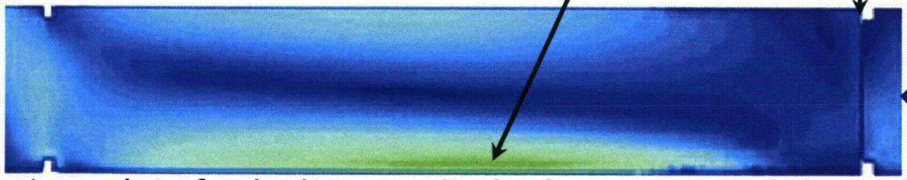
- Square cross-section
- Each spacer represented:
  - Perforated plates of various open areas
  - Designed to test range of M&TE



30% open test standard flange

Design validation:

- Computational fluid dynamics

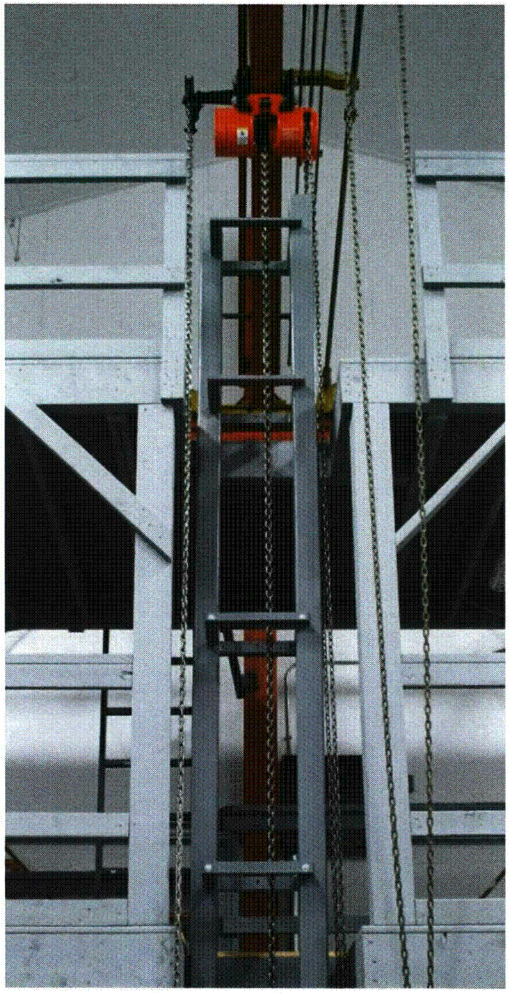


Contour plot of velocity magnitude downstream of skew plate

Fuel Test Program - Facility

- Fuel storage cabinets
- Boiler infrastructure
- Observation deck
- Lifting crane

Boiler units


Test stand & Observation decks


Fuel bundle storage

Fuel Test Program – Facility

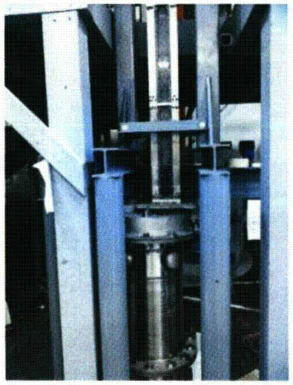
Remaining work:

- Fuel bundle up-ender
  - Wash trough already constructed
- Installation of debris storage
  - Humidity controlled
- Waste tank installation
  - Interfaces with test loop

Wash trough

Debris storage

Fuel Test Program – Test Loop



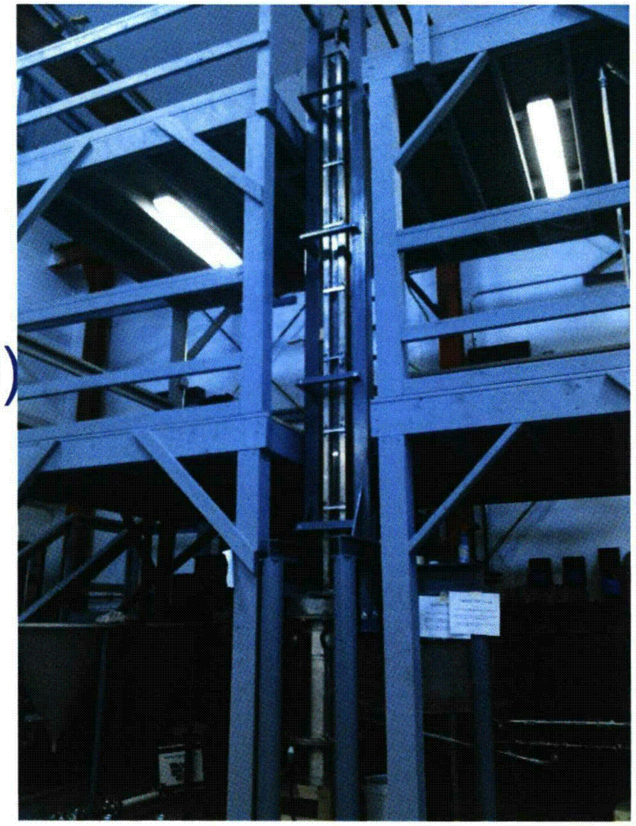
CRGT / Test standard interface

Construction:

- 80% complete
- Remaining elements:
  - Bypass channel representation
  - Clear fuel channel construction (2014)

Commissioning:

- Test 3 & 4 shakedown ongoing
  - Leads to operational loop inspection
- Component inspections ongoing



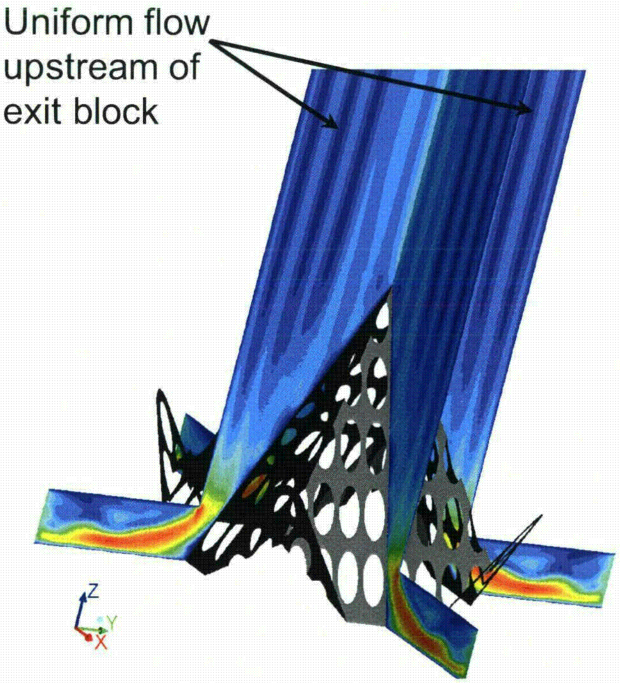
CRGT / Test standard interface
(water flowing)

Fuel Test Program – Test Loop

Computational fluid dynamics validation:

- Completed:
  - Test 3 exit contraction (part of test standard CFD model)
  - Test 4 outlet above LTP

Contraction flow field
(Contour plot of velocity magnitude)

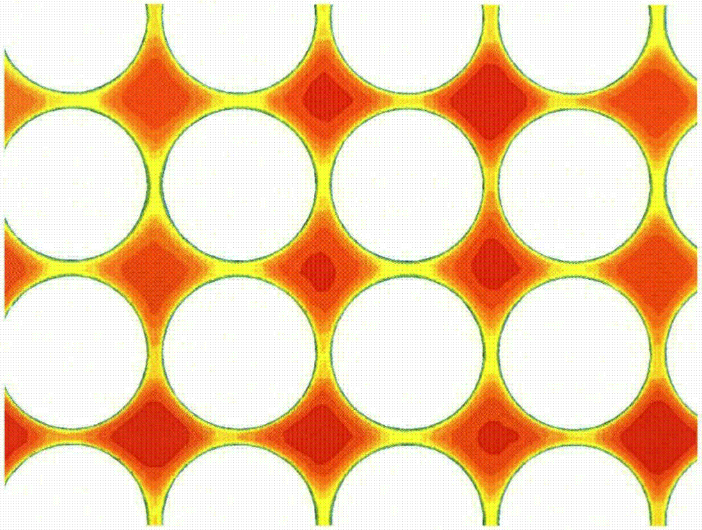


Test 4 – Outlet geometry
(Contour plot of velocity magnitude)

Fuel Test Program – Test Loop

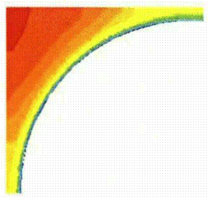
Computational fluid dynamics validation:

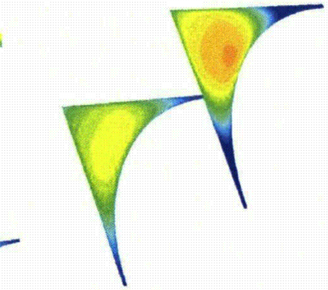
- Ongoing:
  - Inlet plenum geometry
  - Evaluation of prototypical flow below core plate



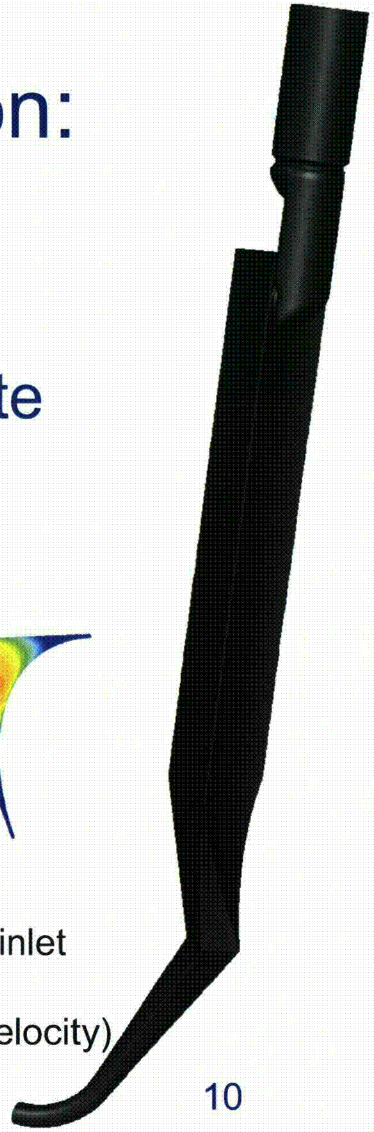
Lower plenum flow distribution
(Contour plot of velocity middle of lower plenum)

Plant flow for quarter cell





Lower plenum inlet
& flow field
(Contour plot of velocity)



Fuel Test Program – Summary

2013 remaining activities:

- Completion of Test 3 & 4 operational inspection
- Completion of component inspections
- Receipt of test fuel bundle

2014 commissioning activities:

- Clear fuel channel design & construction
- Debris-laden shake-down with test standard
- Up-ender and fuel bundle related procedures
- Completion of Test plan & test procedures

Fuel Test Program – Summary

- Submittals:
  - 1Q 2014: Test plan for Test 3 and Test 4
  - Feedback requested by 3Q 2014
    - Targeting Test 3 start in Q4 2014
- Invitation:
  - Debris-laden test demonstration using test standard
    - March or April 2014 at the staff's convenience

Benchtop Test Program - Overview

Four test groups:

- BT1: Effects of debris concentration by boil-off
- BT2:

  Potential effects of fuel rod surface conditions on debris bed formation and tenacity
- BT3: Possibility of thermal adhesion
- BT4:

  Non-uniformity of debris beds

  Debris wash-down

  Debris blockage measurement techniques

Benchtop Test Program - Plan

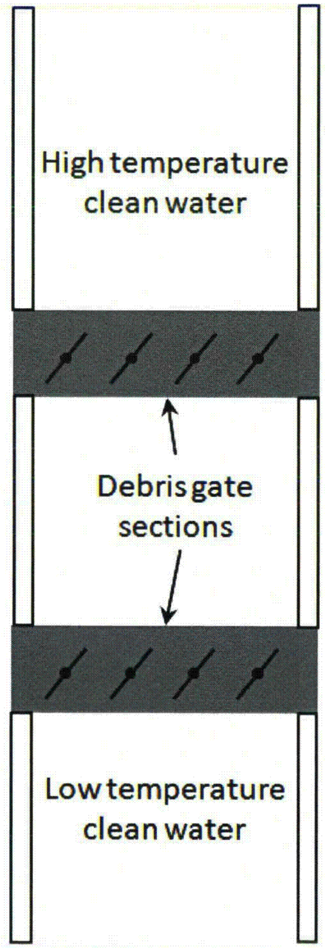
Benchtop test prioritization:

- BT4
  - Possible impact to parent analysis by having to consider non-uniform blockage in greater detail.
- BT2
  - Can affect the test fuel rod surface requirements and invalidate any conducted testing.
- BT1
  - The effects of concentration through boil-off are expected to only affect the later periods of LTCC where risks are relatively lower. Test 3 is not affected at all. BT 1 consequences can be re-evaluated after the completion of Test 3.
- BT 3
  - Thermal adhesion is unlikely and even then is only an issue for non-jet pump plants (only plants with T_{clad} > ~1500 ˚F softening point)

Benchtop Test Program – BT1

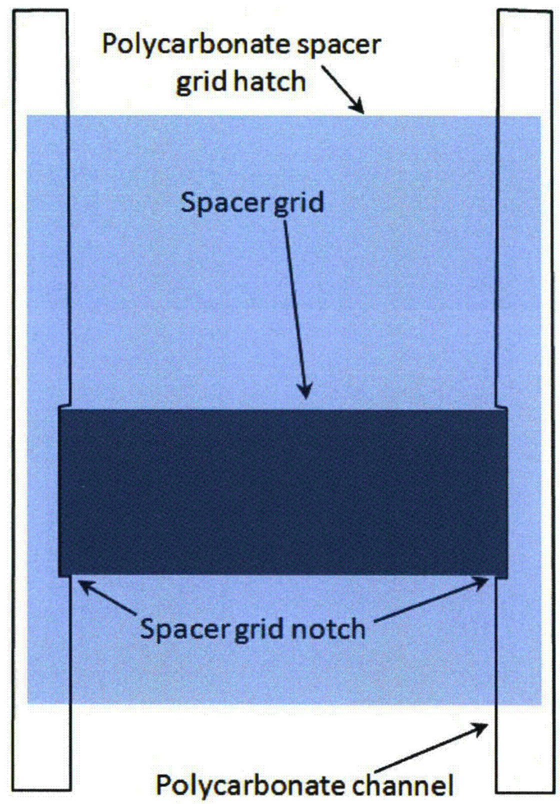
Effects of debris concentration due to boil-off

- Goal:
  - Show response can be bounded in concentration parameter space
- Replicate relevant processes
  - Are effects measurable ?
- Concentration control:
  - Implement through boiling
- Single spacer grid flow
  - Pump through spacer to control flow



Benchtop Test Program – BT1

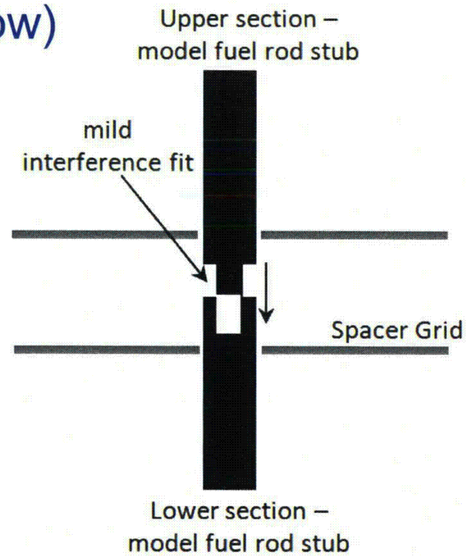
- Measure:
  - Differential pressure
  - Temperature
  - Flow
- Parameters:
  - Flow
  - Debris quantity
  - Concentration:
    - Initial concentration
    - Concentration ratio
    - Tests conducted in pairs



Benchtop Test Program – BT2

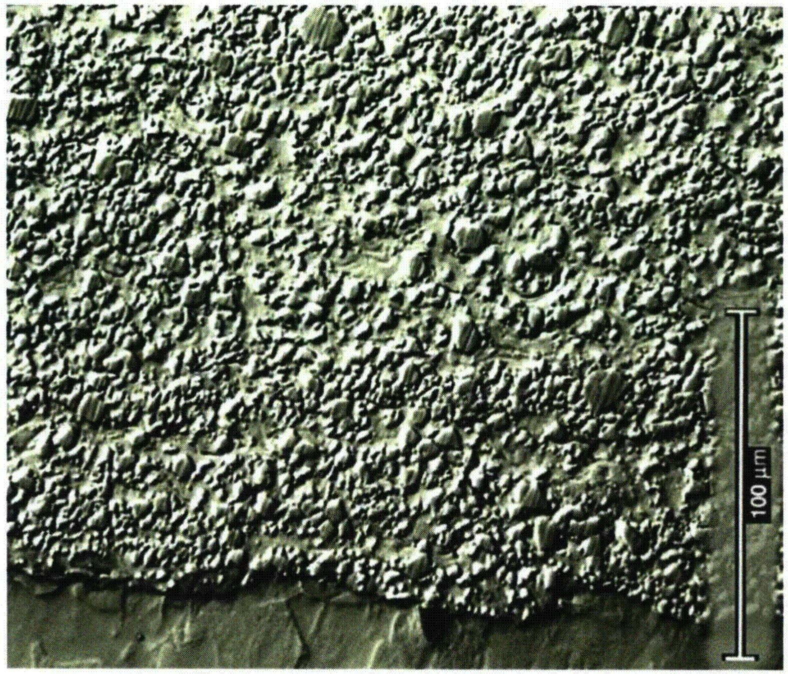
Effects of fuel rod surface roughness:

- Goal:
  - Show fuel rod surface characteristics do not affect
    - Debris retention (quantity of debris on spacer)
    - Debris bed build-up (uniformity of debris bed on spacer)
    - Debris bed tenacity (resistance to removal by air flow)
- Use BT1 set-up
- Overtly modify surface characteristics
  - Different surrogate rod materials
  - Different roughening techniques



Benchtop Test Program – BT2

- Measure:
  - Differential pressure
  - Temperature
  - Flow
  - Surface characteristics
    - Use microscope
- Parameters:
  - Flow
  - Debris concentration
  - Counter-current steam (air)
    - Tenacity of debris bed
  - Debris quantity

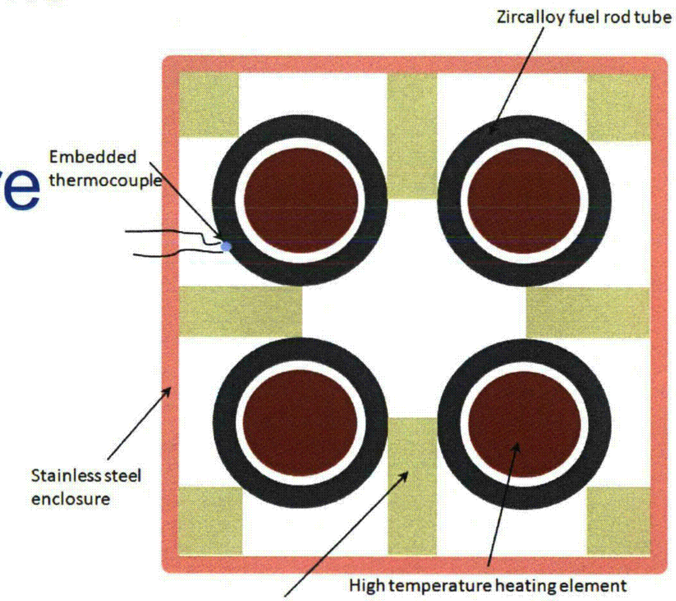


Example surface coating method

Benchtop Test Program – BT3

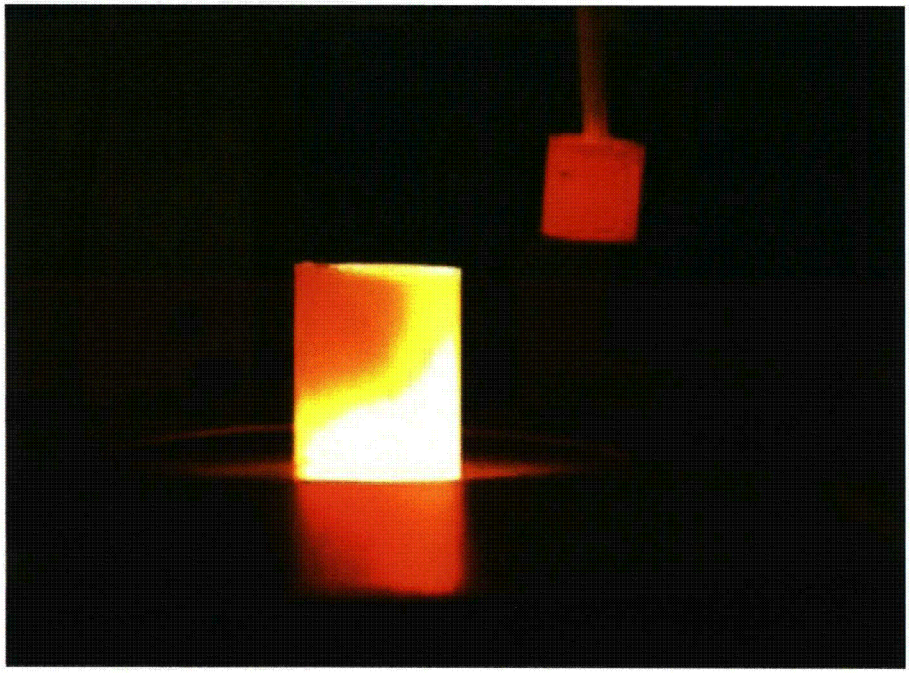
Possibility of thermal adhesion:

- Goal:
  - Demonstrate that thermal adhesion of fiberglass is not possible under prototypical conditions
- Construct small fuel bundle cell
- Heat surfaces to T_{clad} temperature
- Spray water with debris
- Examine surface of fuel rods



Benchtop Test Program – BT3

- Measure:
  - Temperature
    - Network of thermocouples
  - Spray flow
  - Surface conditions
    - Pre and post test
  - Debris outflow
    - All exit flows will be filtered
- Parameters:
  - Debris quantity
  - Surface temperature
  - Spray flow rate



MIT test of new fuel cladding architecture

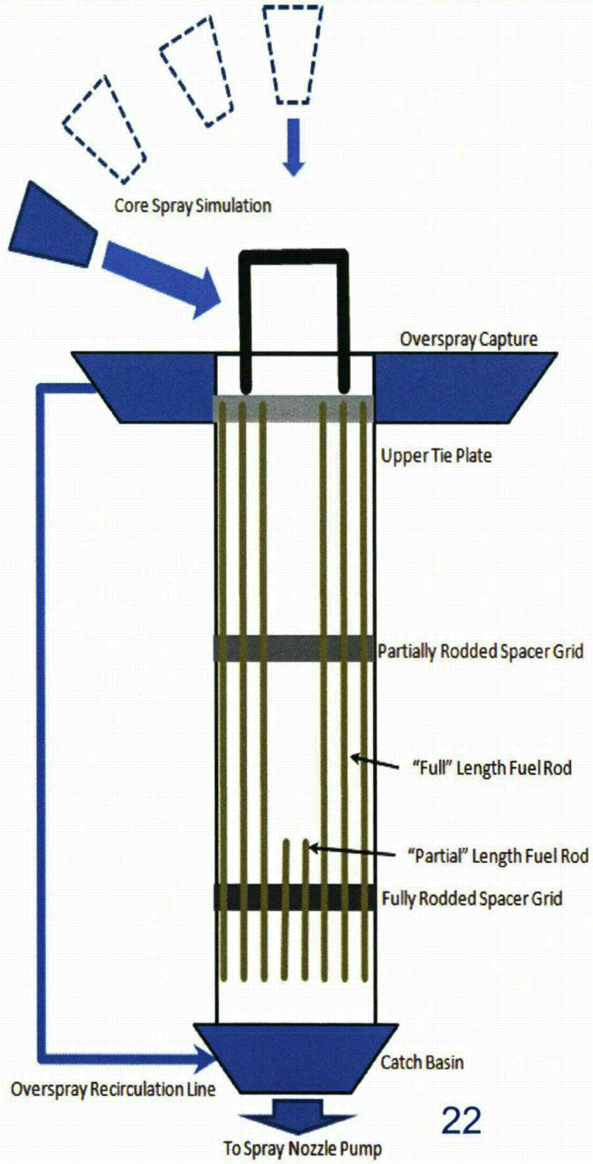
Benchtop Test Program – BT4

Non-uniform debris accumulation:

- Goal:
  - Demonstrate that debris deposition is not significantly non-uniform
  - Evaluate blockage assessment methods
- Construct a short fuel bundle test bed
  - Represent upper fuel bundle spacer grid configuration:
    - upper tie plate
    - upper spacer
    - fully rodded spacer
- Evaluate effect of spray flow configuration

Benchtop Test Program – BT4

- Measure:
  - Temperature
  - Spray flow & pressure
  - Spacer grid DP & blockage
  - Flow rate
- Parameters:
  - Spray angle & momentum
  - Debris concentration & composition
  - Counter-flow stream (air)
    - Flow rate & introduction method



Benchtop Test Program - Summary

- Benchtop program directly targets staff concerns
- Phenomena are evaluated in simplest environment
- Smaller test configurations allow higher test count
  - Greater parameter variation
  - Greater confidence in results
- Top priority for staff review is fuels test program:
  - Within fuels program, benchtop test program is key
  - Within benchtop test program, BT4 is first priority
  - GOAL:
    - Improve targeting of staff concerns
    - Execute program without do-loops

BWROG ECCS Suction Strainer Coatings Zone of Influence

Rob Choromokos (SI)

NRC – BWROG ECCS SS Meeting
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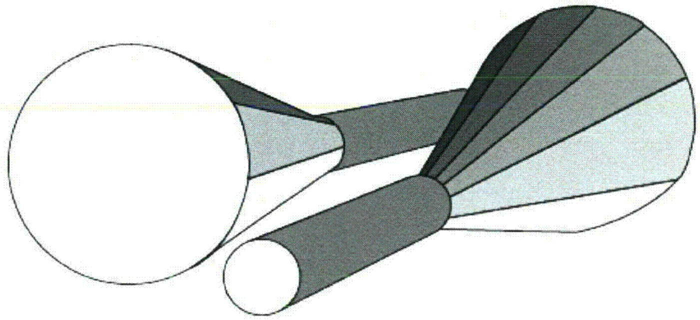
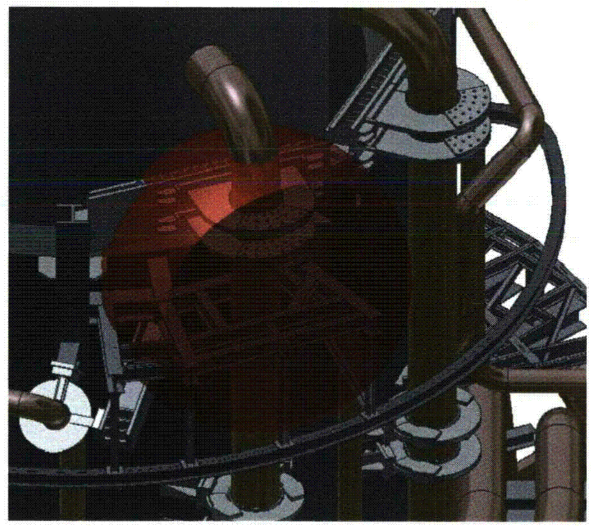
Issue 8 – Coatings ZOI Recap

- URG Guidance provides a generic value of 85 lbs based on a conical directed jet impinging on a wall 20 ft away.
- NEI-04-07 PWR methodology determines the quantity of coating inside a spherical coatings ZOI – similar to insulation destruction. This becomes a plant specific number.
- What is the impact of a change in method on the 85 lbs value presented in the URG?



100% pipe separation, and 100% offset



Action Plan

1. Determine equivalent BWR ZOI from PWR ZOI
2. Apply BWR ZOI and coatings debris generation at several plants
3. Compare results to URG value of 85 lbs
4. If results support the use of 85 lbs, no further action
5. If results indicated destroyed coatings are substantially greater than 85 lbs and impact is significant, revise guidance

Determine BWR Coatings ZOI

- BWROG-ECCS-TA08-001 calculation developed BWR coating ZOIs for Recirc and MS of:

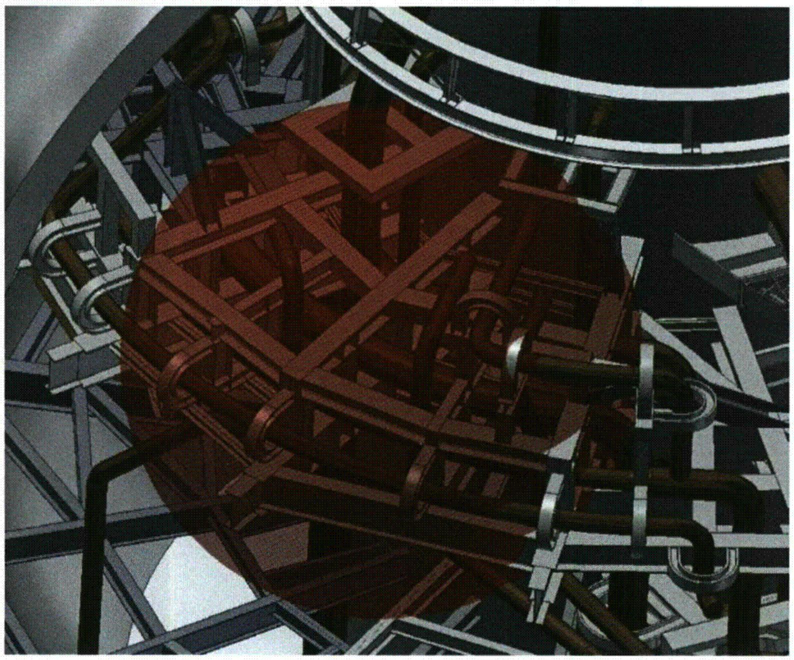
Case	Coating Type	Destruction Pressure	BWR ZOI
Recirculation Line	Epoxy	39.91 psi	2.4 D
	Other Qualified	12.30 psi	6.1 D
Main Steam Line	Epoxy	39.91 psi	3.4 D
	Other Qualified	12.30 psi	7.4 D

- NRC staff reviewed and accepted BWROG coating ZOIs – see ML13280A347, dated November 5, 2013.

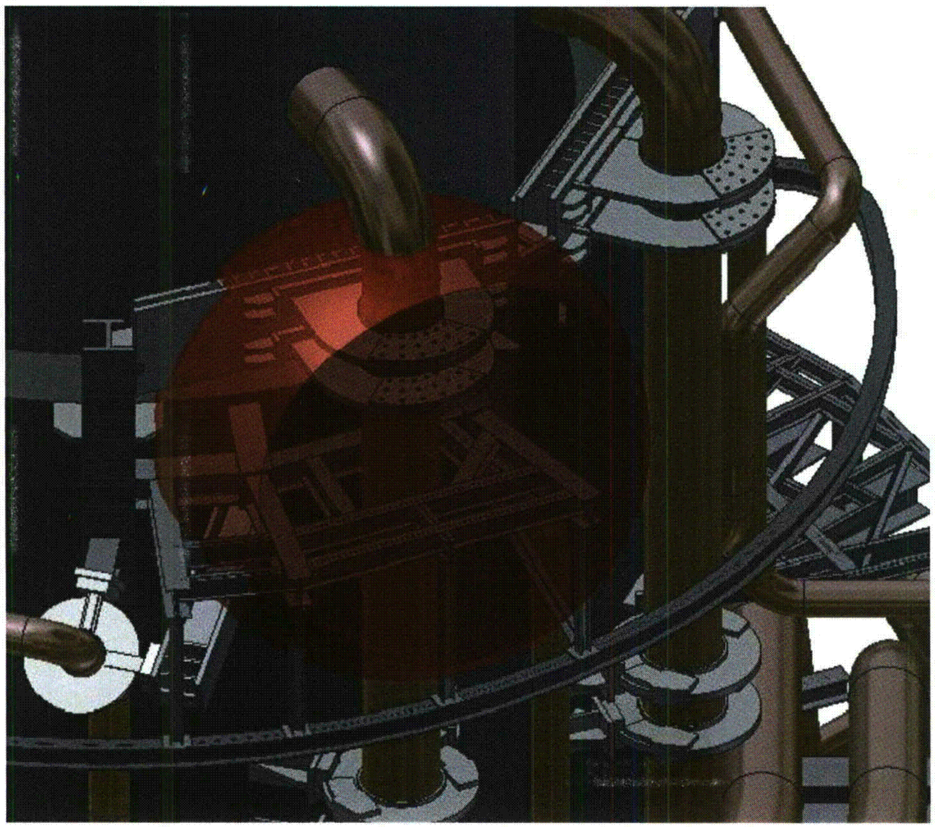
Apply BWR Coating ZOI to Pilot Plants

- Selected 4 plants (2 Mark I's and 2 Mark II's) to evaluate amount of coatings debris generated using spherical ZOI methodology with BWR ZOIs.
- Developed detailed CAD models from plant documentation. Includes:
  - Concrete
  - Equipment
  - Piping and Structural Supports
  - Steel liner
- Performed conservative unrestrained fully offset break ZOI for all 4 plants and sensitivity for restrained (more realistic) break for 1 plant.
- Restrained break follows URG method for ZOI resizing.

Apply BWR Coating ZOI to Mark I



Apply BWR Coating ZOI to Mark II



Compare Coatings Quantity Results

- Resulting coating debris amounts generated
- Conservative fully offset DEGB generates greater than 85 lbs for three of the four plants.
- More realistic break offset due to structural steel, whip restraints or other physical boundaries significantly reduces the coatings quantity generated.

Plant	Unrestrained Break Quantity	Restrained Break Quantity
Mark II	155 lbs	Not Performed
Mark II	128 lbs	Not Performed
Mark I	154 lbs	57 lbs
Mark I	73 lbs	Not Performed

Summary

- A detailed break specific analysis substantiates a coatings debris load of less than 85 lbs (URG value)
- Submit analysis summary in the form of a BWROG letter to close Issue 8 retaining the 85 lbs value (ETA 2Q 2014)

BWROG Downstream Effects Bypass Fiber

Brad Tyers (Exelon)
DSE-Components Subcommittee
Vice Chair

NRC – BWROG ECCS SS Meeting
Washington D.C.
December 4, 2013

Objective

1. To determine the mass, size characteristics and timing of fibrous debris that can pass through the suction strainer after a LOCA for input into the fuels testing program
2. Results can be applied to the BWR fleet

BWROG Design Diversity

- Individual variables were adjusted to determine which attributes impact fiber bypass quantity.
- Plots of bypass quantity vs. mass of fiber transported to strainer were developed for each test series.
- Resulting correlations can be used in combination with plant design data to determine bypass quantity vs. time.

Parameters Varied to Test Impact on Bypass Quantity

- Fiber Quantity
- Fiber Concentration
- Fiber Type
- Approach Velocity
- Strainer Design
- Strainer Hole Size

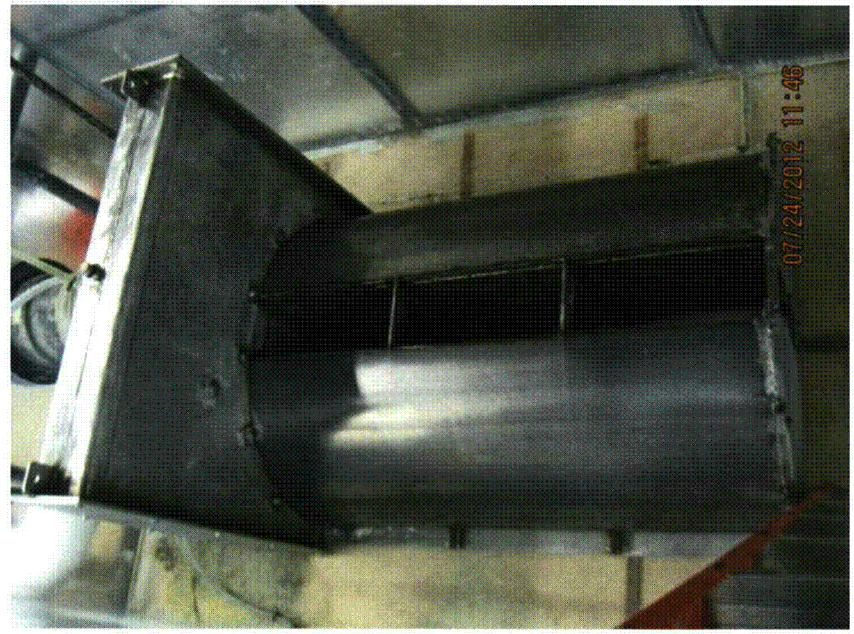
Assumptions and Limitations

To limit the number and duration of tests, variables were selected to represent a range of conditions.

- Strainer design selections were limited to:
  - Complex geometry (PCI stacked disk design)
  - Simple geometry (Enercon)
- Fiber selections were limited to:
  - Low Density Fiberglass (NUKON)
  - Rockwool
  - Temp-Mat
- Approach velocities are limited to 0.02 ft/sec, 0.04 ft/sec, 0.06 ft/sec.

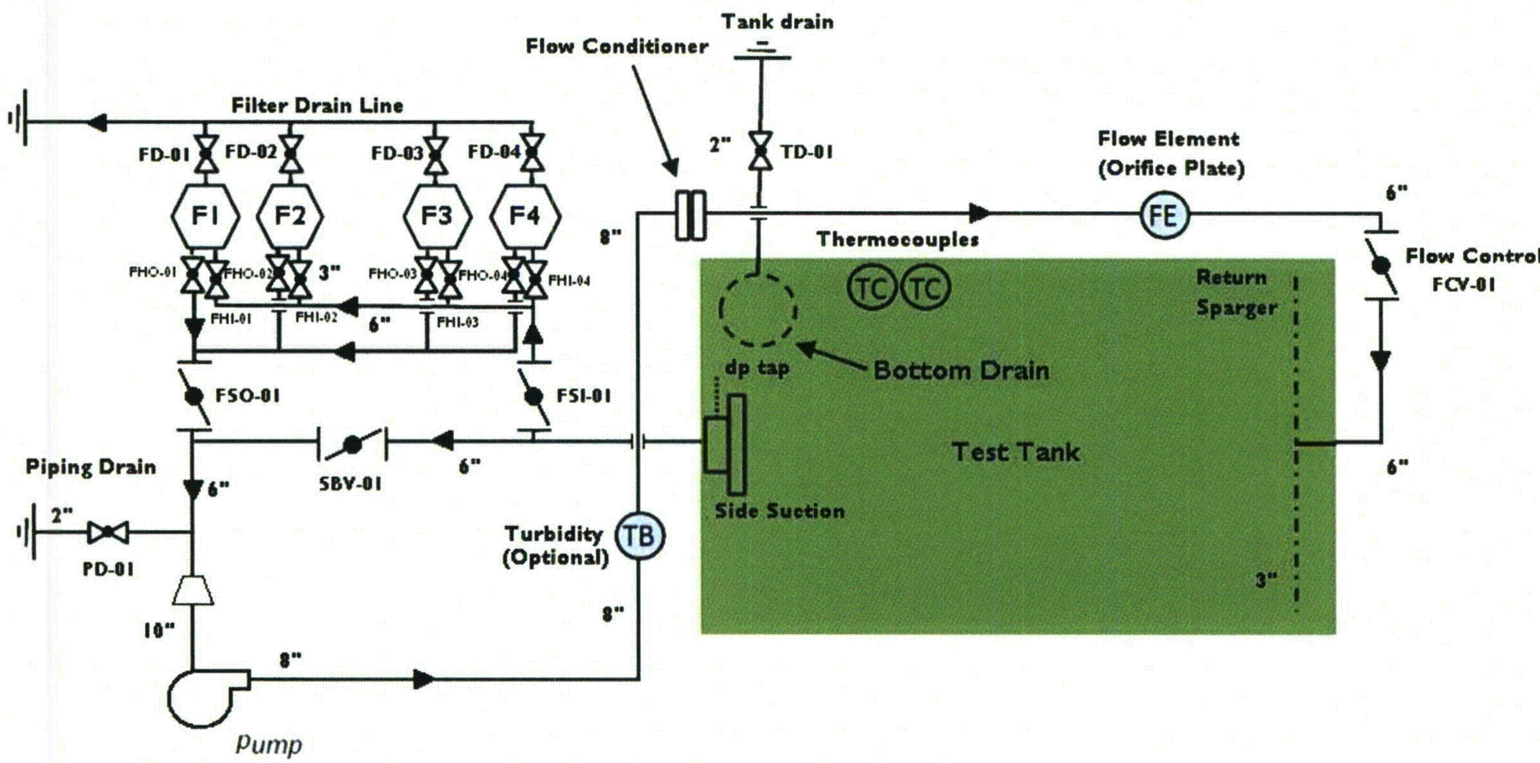
Strainer Geometries

PCI Stacked Disk Strainer



Enercon Strainer

Testing Apparatus



Testing Apparatus

- Strainer modules submerged in 2500 gal tank
- Strainer outlet piping connected to four parallel 5 micron filters to collect and measure all bypassed fiber
- All flow passed through filters
- Pump suction connected to filter bags, discharge into tank

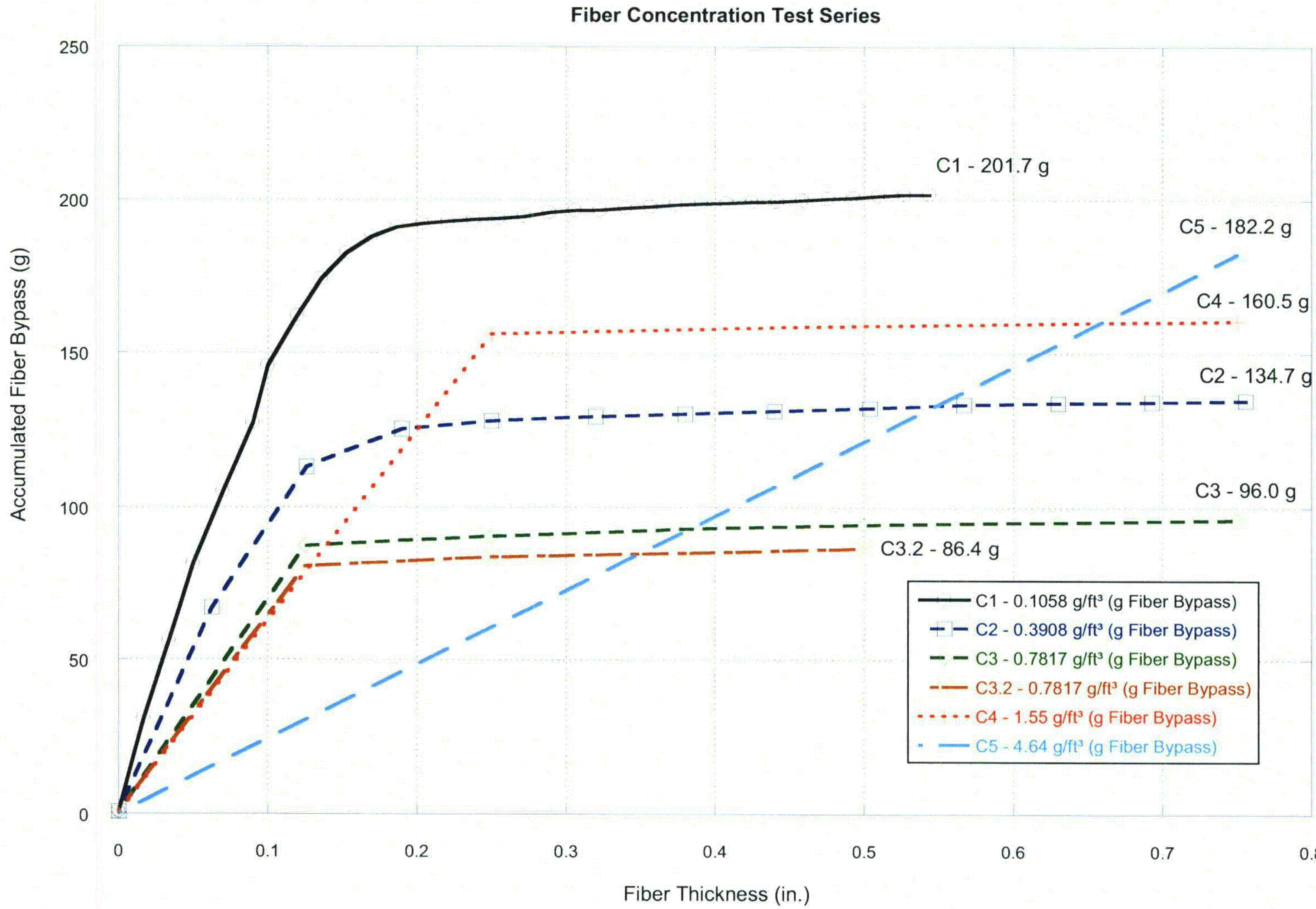
Debris Preparation Method

- Fiber fines were prepared to be in accordance with NUREG/CR-6808 Classes 1-3
- Fiber fines were boiled for 10 minutes, then processed using motorized paint stirrers
- Fiber was re-suspended with paint stirrers prior to introduction into the test tank

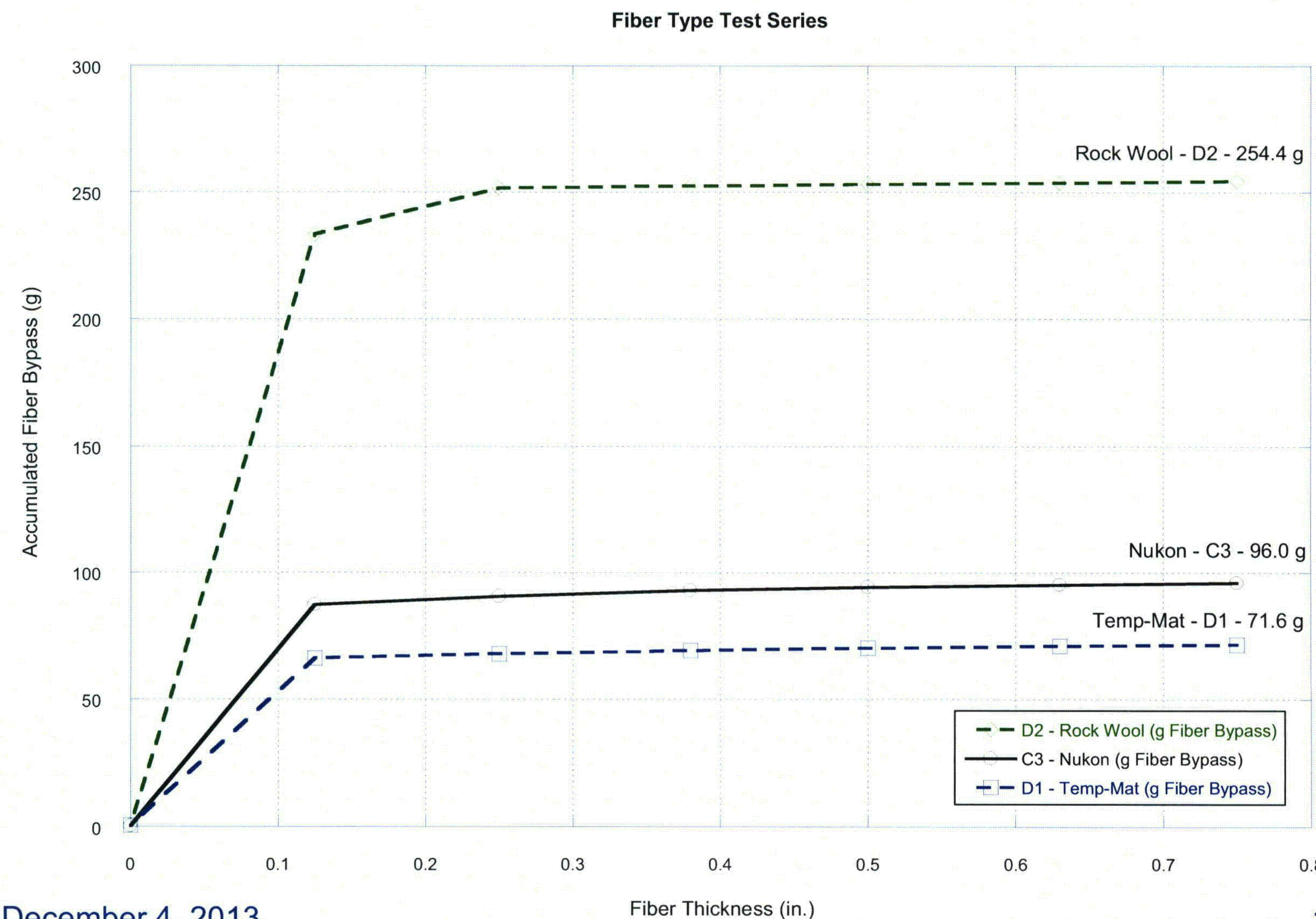
Test Results

Test Label	Fiber Type	Approach V (ft/s)	Hole (in)	Fiber Conc. (g/ft³)	Strainer Type	Fiber Bypass (Total, g/ft²)
C1	NUKON	0.04	1/8	0.1058	PCI	8.77
C2	NUKON	0.04	1/8	0.3908	PCI	5.86
C3	NUKON	0.04	1/8	0.7817	PCI	4.17
C3.2	NUKON	0.04	1/8	0.7817	PCI	3.75
C4	NUKON	0.04	1/8	1.547	PCI	6.98
C5	NUKON	0.04	1/8	4.641	PCI	7.92
D1	Temp-Mat	0.04	1/8	3.8411	PCI	3.11
D2	Rock-Wool	0.04	1/8	1.5607	PCI	11.06
F1	NUKON	0.02	1/8	0.7817	PCI	2.67
F2	NUKON	0.06	1/8	0.7817	PCI	6.80
S1	NUKON	0.04	3/32	0.7817	PCI	3.60
S2	NUKON	0.02	3/32	0.7817	Enercon	4.89

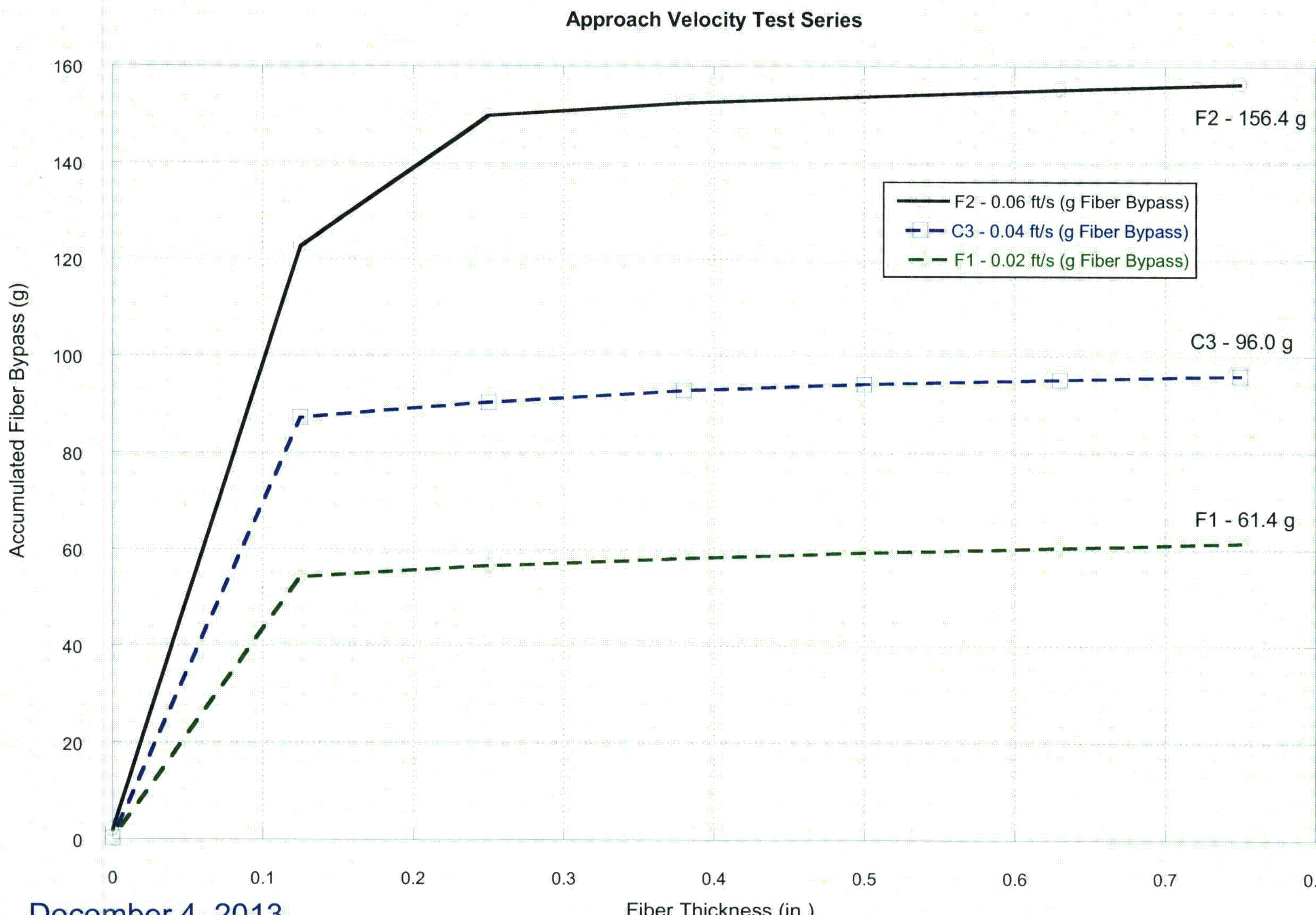
Test Results – Fiber Concentration Series



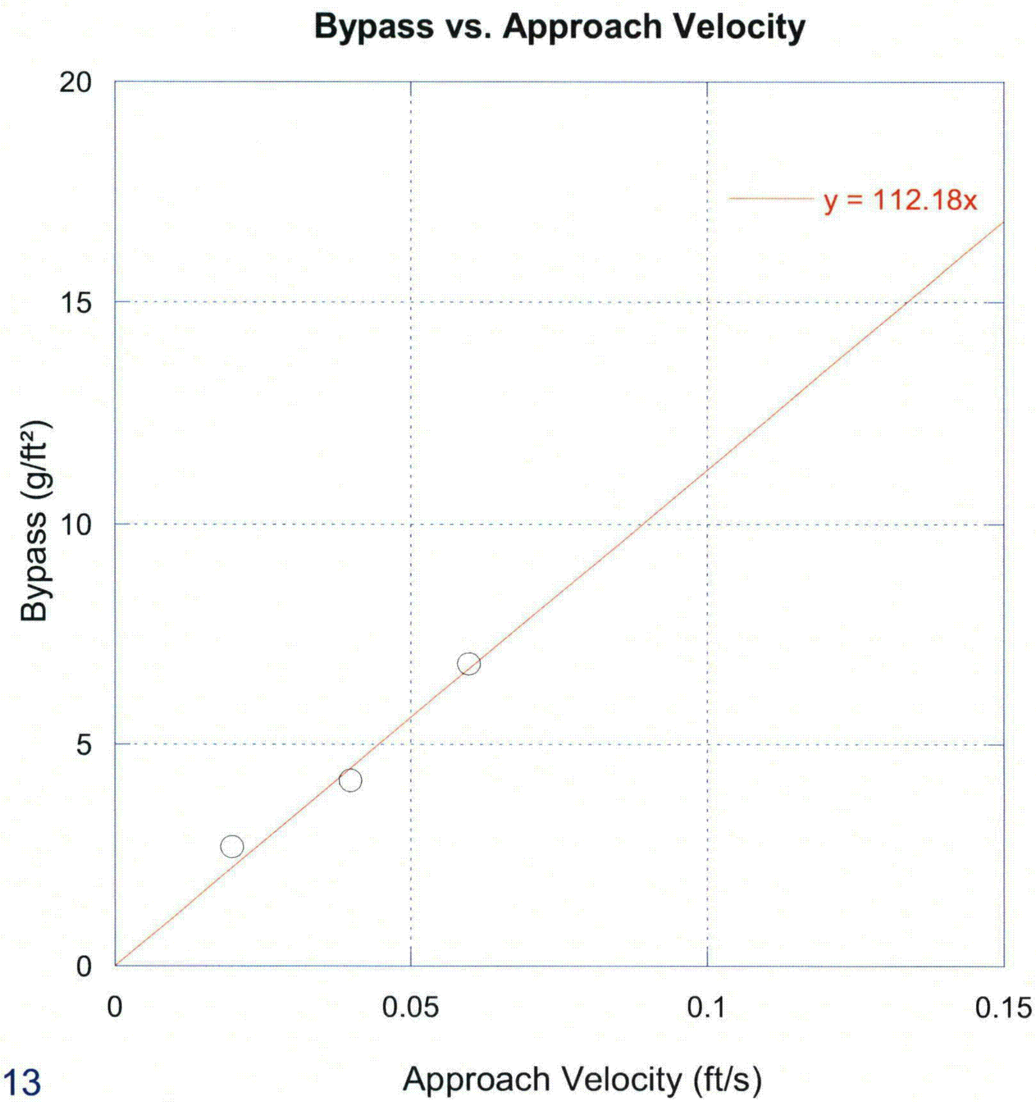
Test Results – Fiber Type Series



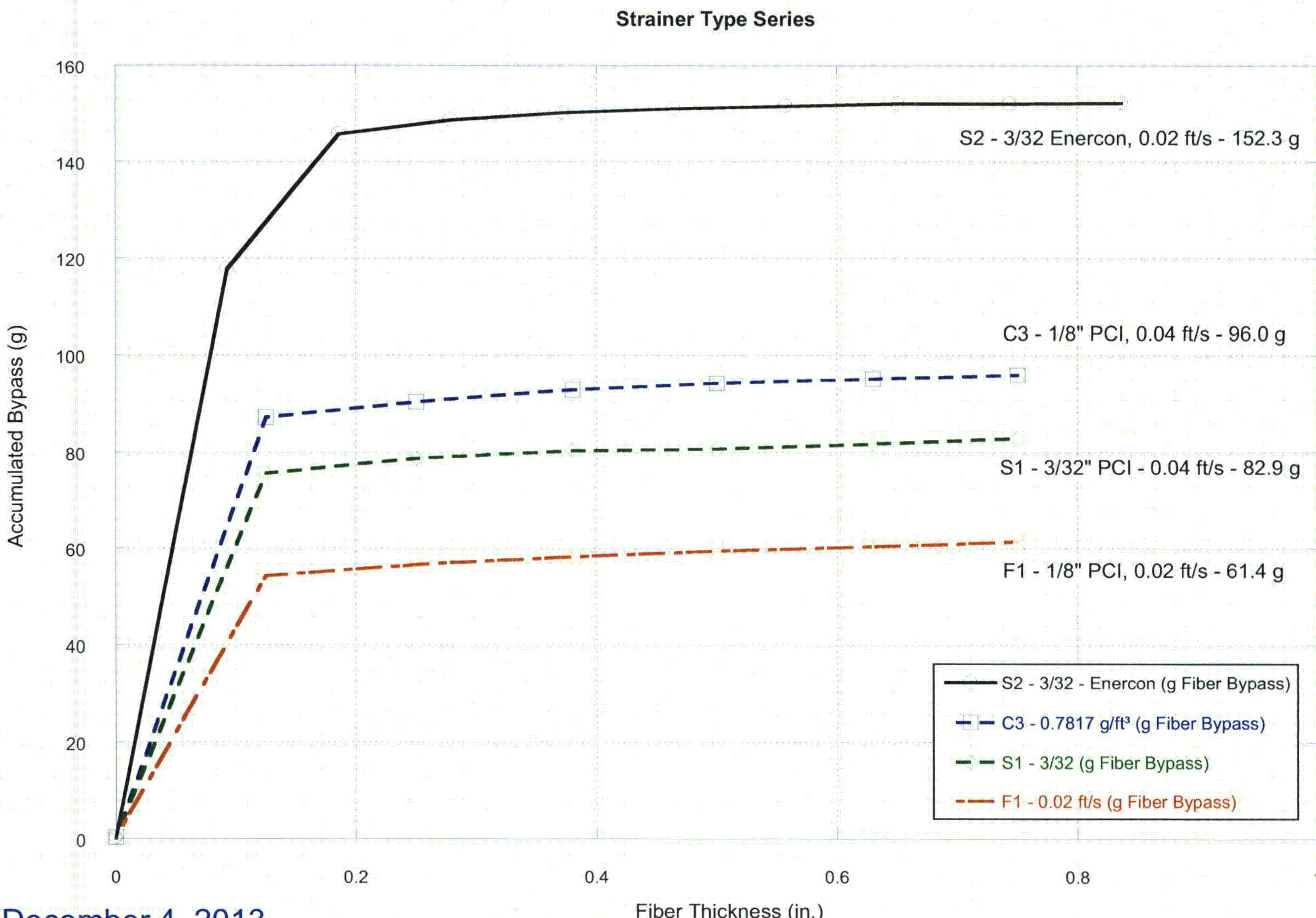
Test Results – Approach Velocity Series



Fiber Bypass vs. Approach Velocity



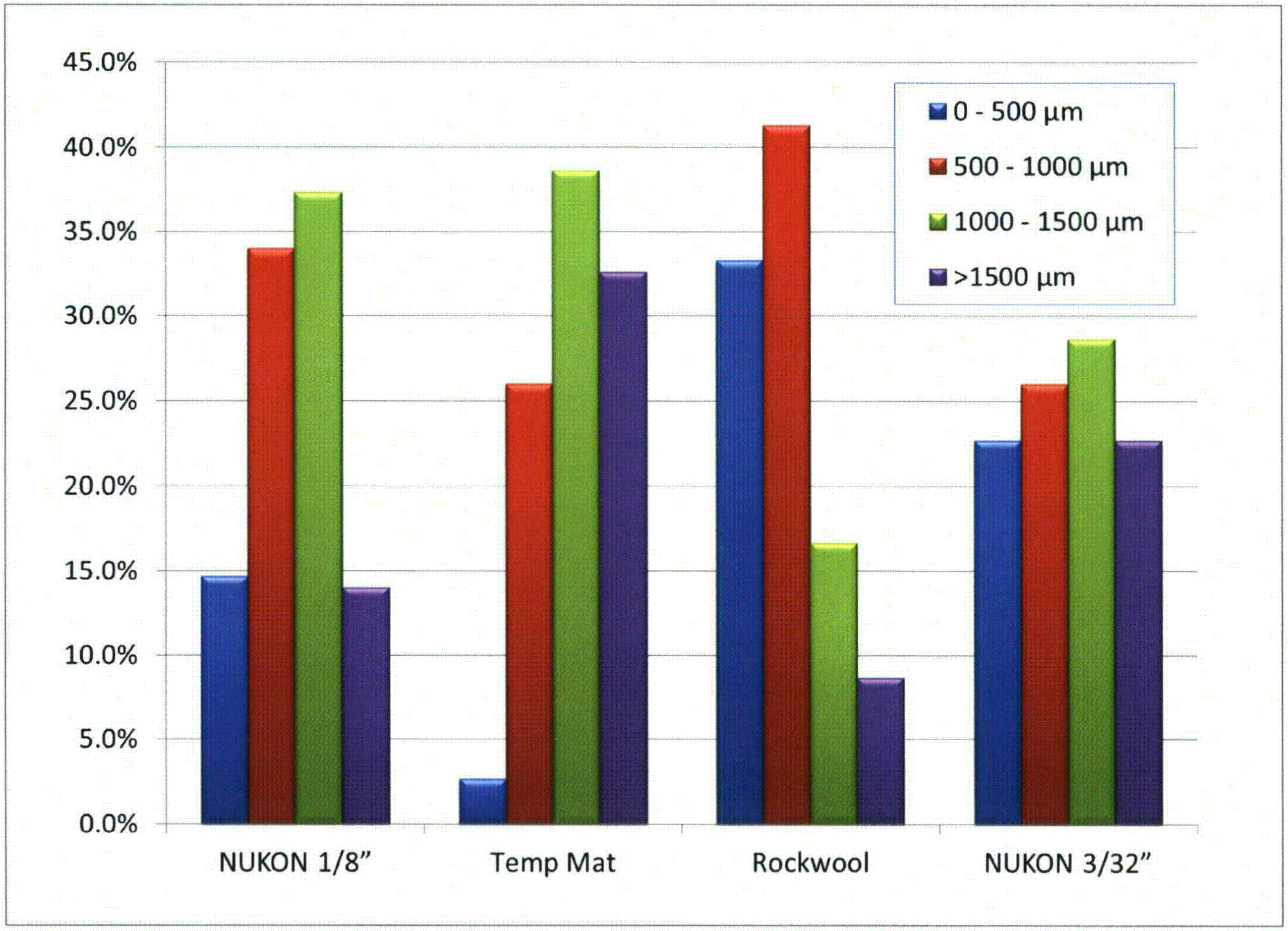
Test Results – Hole Size/Strainer Type Series



Test Results – Conclusions

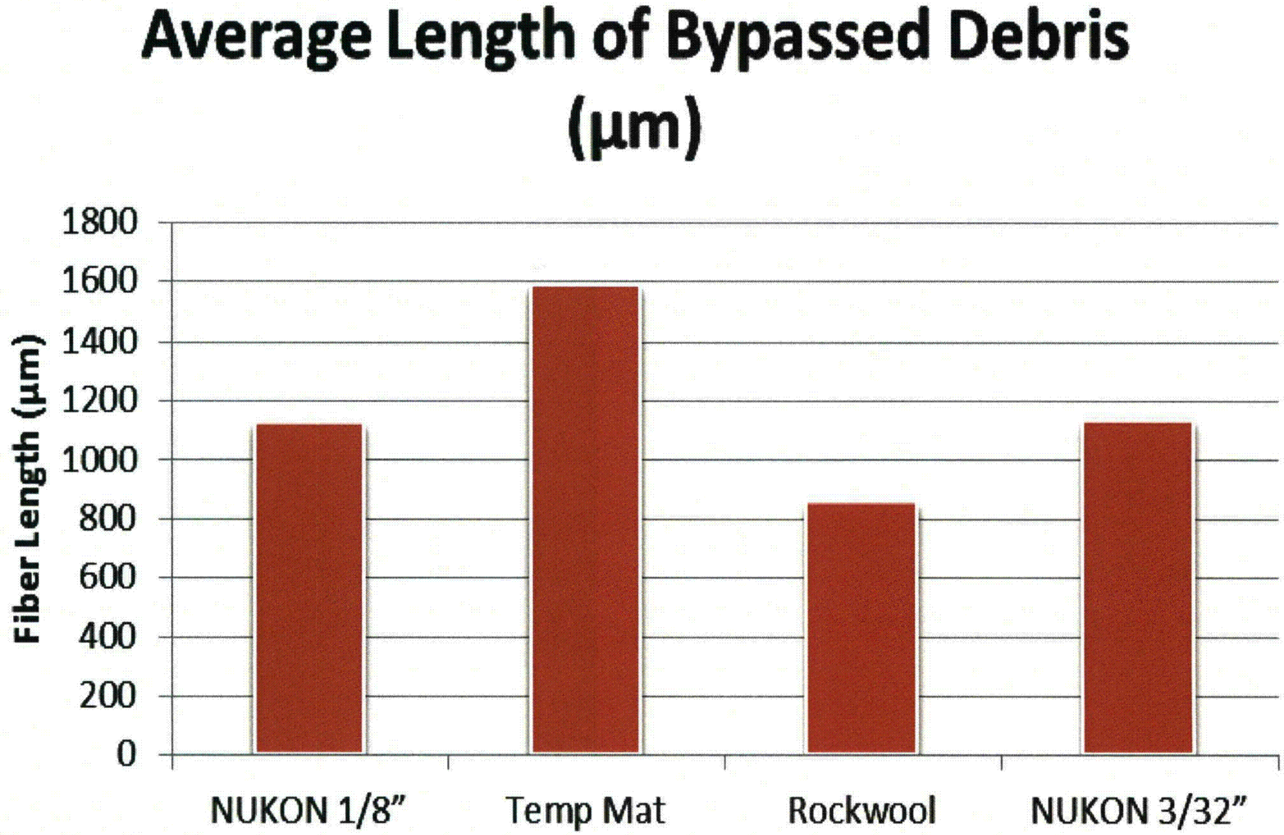
- Fiber bypass is highest between 0 and 0.25 in. of deposited nominal fiber thickness
- Bypass fiber quantity is dependent upon fiber concentration, although the relationship is not monotonic.
- Rockwool results in the highest bypass quantity, followed by NUKON and Temp-Mat
- Bypass increases monotonically with velocity, and can be modeled with an essentially linear correlation.
- Bypass increases with hole size – with all other parameters held constant, the 3/32nd in. hole size bypassed 3.6 g/ft^2 and the 1/8th in. hole size bypassed 4.2 g/ft^2.

Test Results – Fiber Length Distribution



- ❑ Majority of the bypassed fibers lengths are in 500 to 1500 μm range

Test Results – Fiber Length Distribution



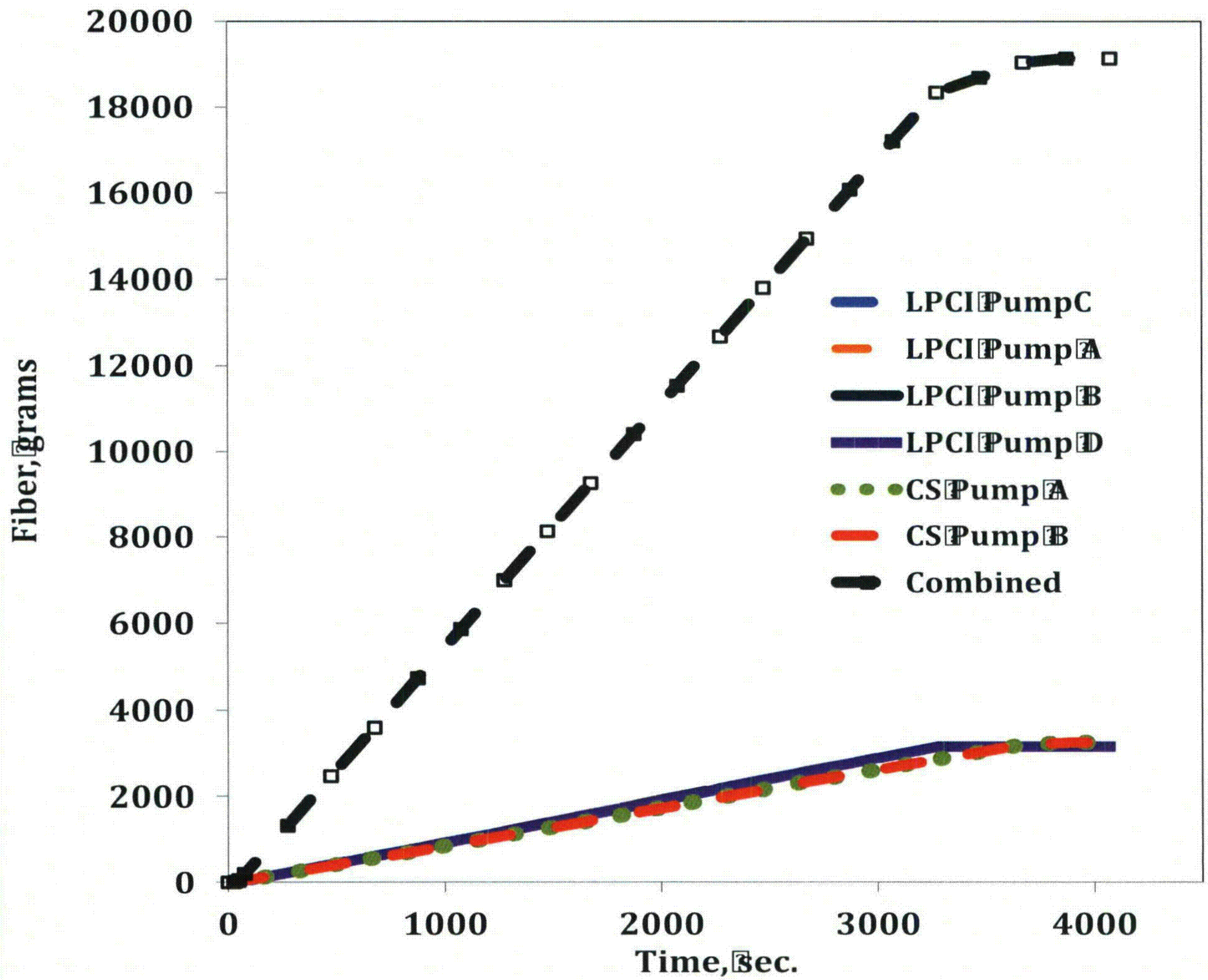
Transit Time Methodology

- Develop a conservative estimate of the plant specific transit time of fibrous debris to the fuel channel after a LOCA.
- Using plant P&IDs and isometric drawings of piping and equipment, calculate fluid volume between strainer and reactor.
- Based on the post-LOCA ECCS flow rates, calculate the transit-time for fiber from the strainer to the reactor core.
- Using the bypass test report results for downstream fiber concentration and total bypass fiber quantity, calculate the maximum possible accumulation rate of fiber within the core.

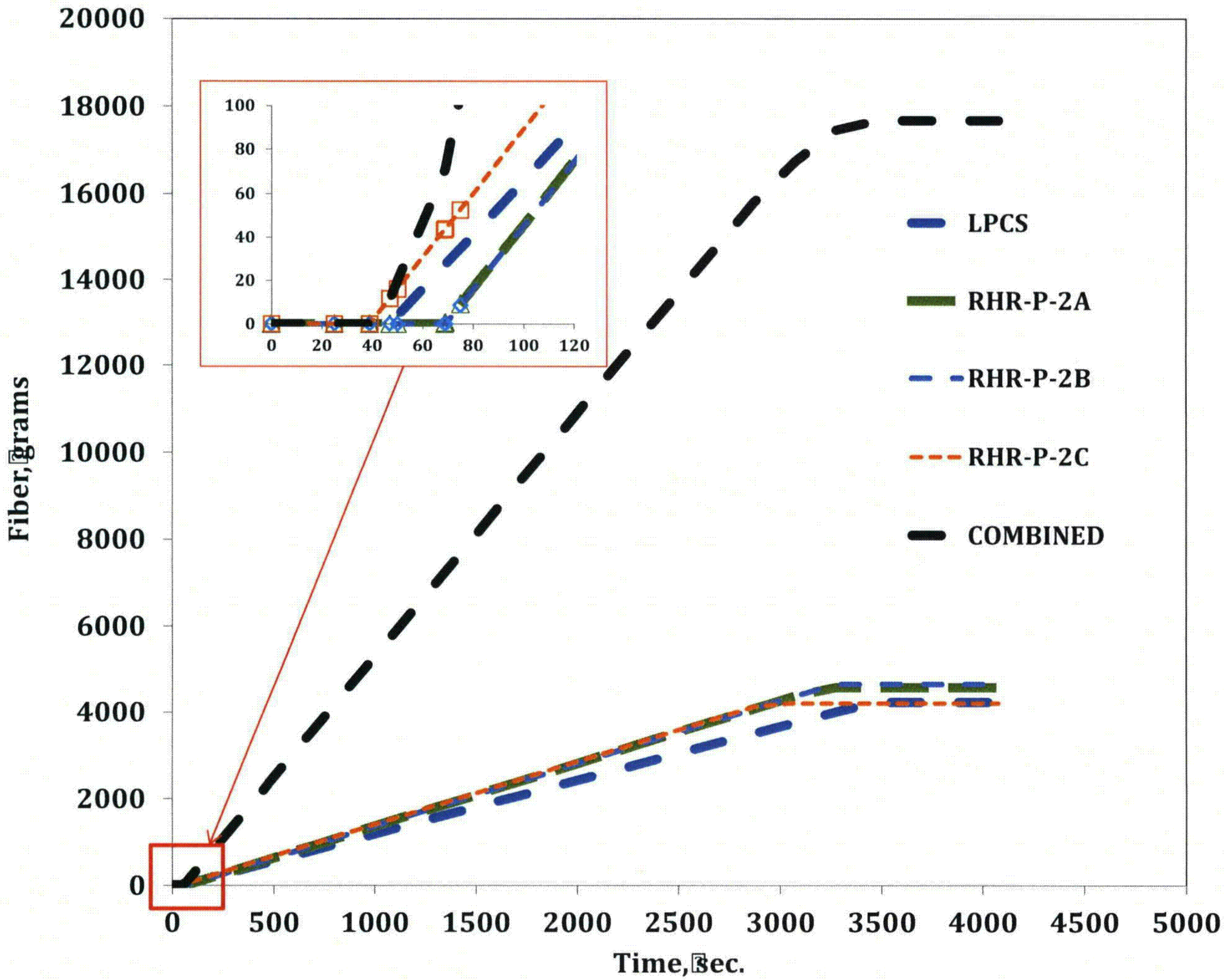
Transit Time Methodology

- After a LOCA, HPCI initially draws from the condensate storage tank, so HPCI is not included in this analysis.
- Rated flows are assumed for all pumps.
- 100% fiber in the pool at pump start
- The maximum downstream fiber concentration measured during bypass testing was used to calculate fiber accumulation.

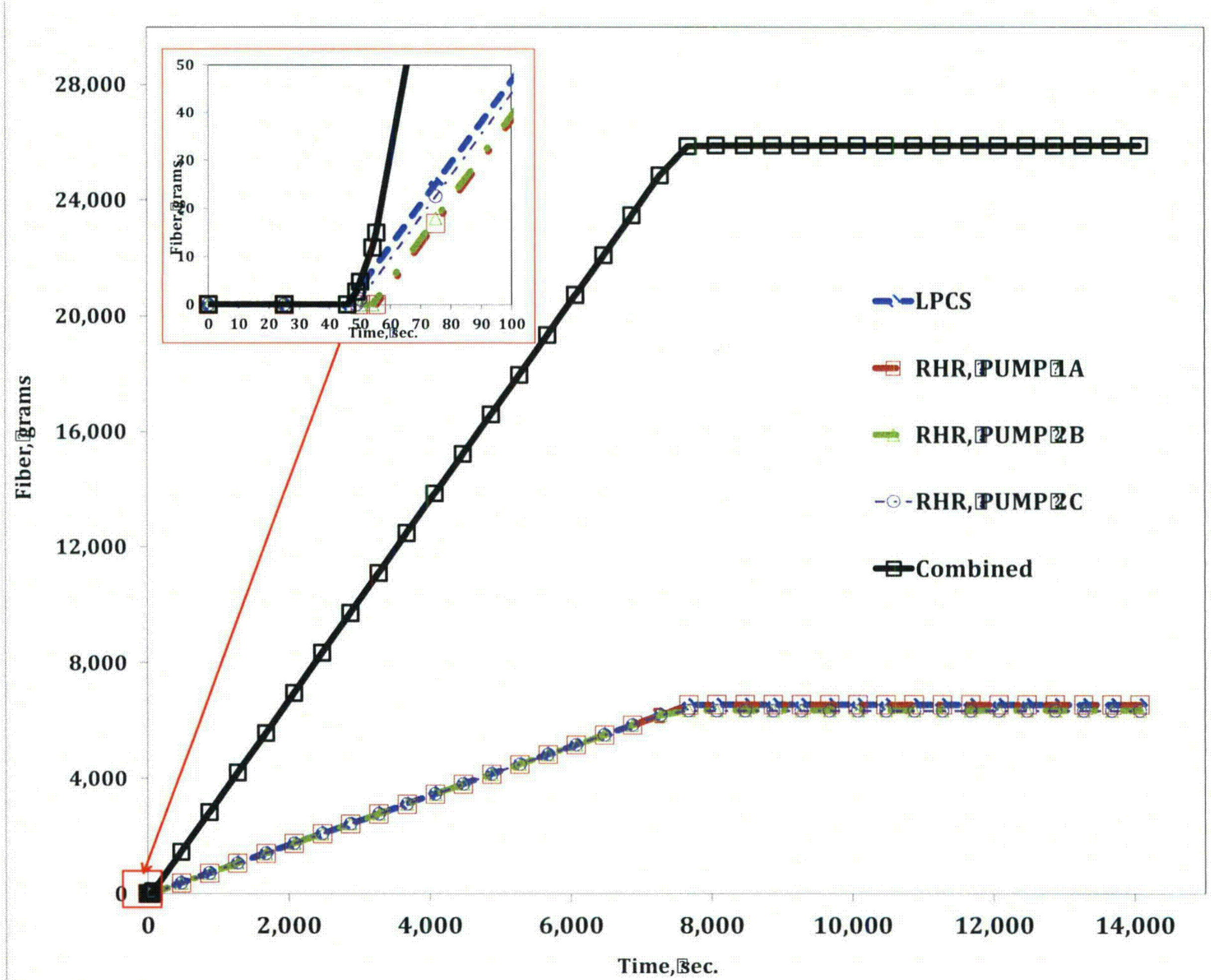
Transit Time Calculation Results Plant A – BWR/3 MK I



Transit Time Calculation Results
Plant B – BWR/5 MK II



Transit Time Calculation Results
Plant C – BWR/6 MK III



Transit Time – Preliminary Conclusions

- Fuel Tests 1, 2 and 3 may not be necessary based on inherent delays associated with:
  - ECCS injection
  - Fiber transport from the break to the suppression pool
  - Transport rate of bypassed debris
- After the first strand of fiber reaches the core, the bypassed fiber accumulates gradually over the next 50 to 100 minutes.

BWROG ECCS Suction Head Loss Issues Update

Phillip Grissom (SNC)
Head Loss Subcommittee Vice Chair

NRC - BWROG ECCS SS Meeting
December 4, 2013
Washington D.C.

Head Loss Issues Update

Completed BWROG member survey on head loss (Issue #4) and near-field effects (Issue #11)

- Compiled survey results by strainer manufacturer into four spreadsheets
- Summarization of survey results
- Submitted report to NRC on October 31
  - Appendix A: Head Loss Assessment Flowchart
- Generic thin bed effects testing to continue as planned

Head Loss Issues Update (cont.)

BWROG developing test plans for thin bed effects testing

- Testing will address range of debris compositions, and flow rates as defined by survey results
- Testing will identify range of conditions under which thin bed effects are possible
- Thin bed head loss data will be provided to BWROG members to address thin bed effect

Summary

- Develop detailed guidance for plants on implementing BWROG-13058 Appendix A flowchart
- Requested review prioritization
  - Can be reviewed by NRC following NEDC-33608-P (fuels testing / benchtop testing) with minimal programmatic impact
  - BWROG project related to thin bed testing can proceed while NRC review is in progress

BWR Debris Source Term Chemical Effects Issues Update

Steve Sawochka (NWT)
Jim Furman (SI)

NRC - BWROG ECCS SS Meeting
Washington D.C.
December 4, 2013

Chemical Effect Testing Update

- BWR material dissolution data developed in 2011/2012 by Alion Science & Technology was evaluated to assist in BWROG chemical effects test plan development.
- Preliminary correlations of release rates developed for non-buffered and buffered solutions
- Post-LOCA simulation tests with mixed materials will be performed with a bounding temperature profile in a recirculating test loop to measure release during the accident and effects on head loss
- Complementary precipitate formation tests will be conducted in bench-top test apparatus.

BWR Dissolution Test Methodology

- Samples exposed in demineralized water (Non-buffered) and sodium pentaborate (Buffered) solutions in polycarbonate flasks at static conditions at temperatures up to 200°F. Temperatures varied during most tests
- Primarily 2 to 3 days tests with single materials. Several 1 to 2 week tests with mixed materials
  - Aluminum
  - Zinc
  - Galvanized Carbon Steel (GCS)
  - Carbon Steel
  - NUKON
- Databank
  - Concentration, solution volumes and temperature vs. time
  - Visual observations of specimen characteristics and solution turbidity

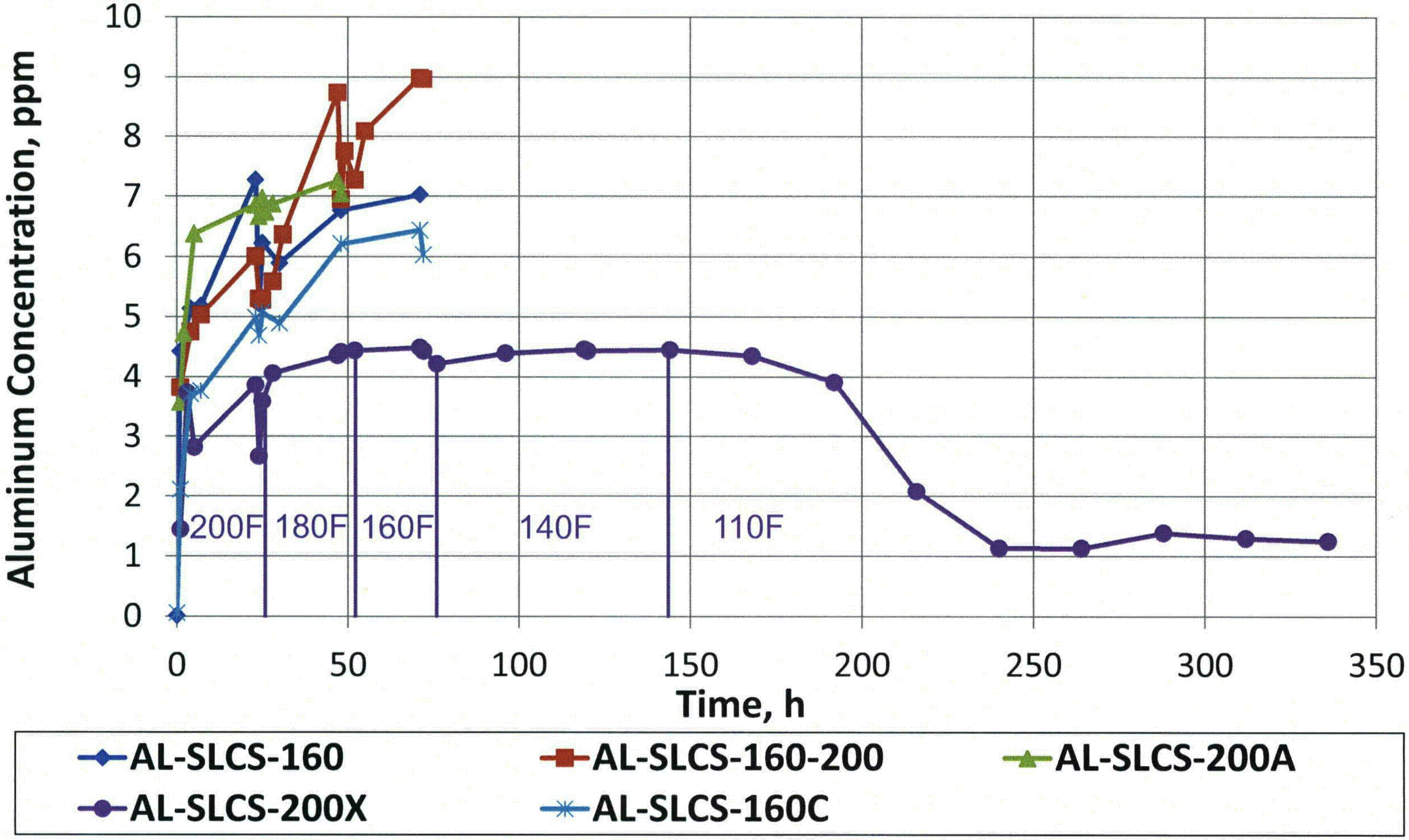
Material Dissolution Test Results

- Release rates from aluminum, zinc, and GCS rapidly decrease with time. Effect appears due to metal passivation.
- Release calculations based on release rates over first several hours of exposure during LOCA event would lead to marked overestimation of total release
- Aluminum release increased significantly with pH. Zinc release was minimal at elevated pH.
- In non-buffered low pH solutions, aluminum release was minimal during single material testing. Release increased during mixed material testing due to sodium and calcium release from NUKON and a corresponding increase in pH.
- Data sufficient to develop preliminary release rate correlations for buffered and non-buffered BWR solutions.

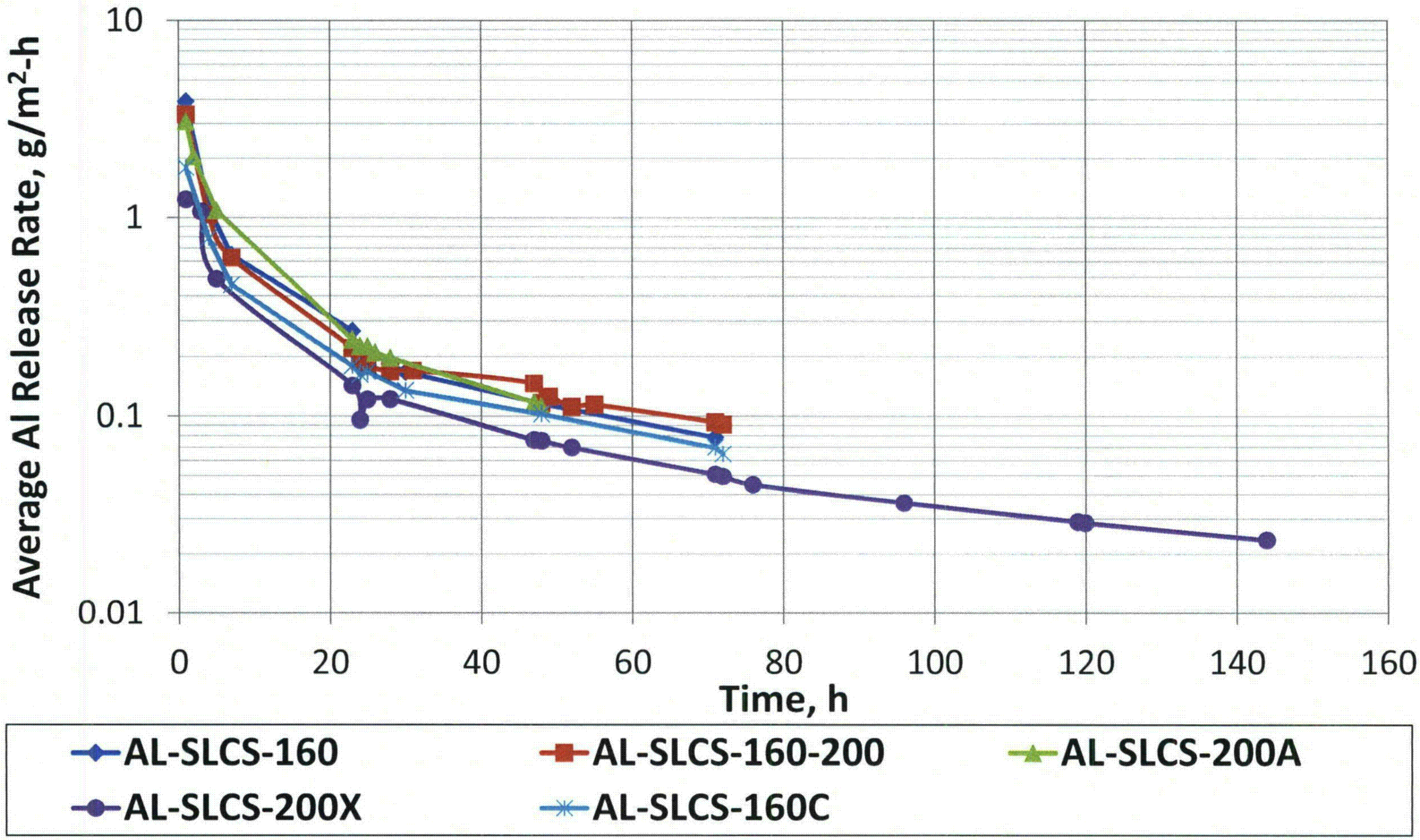
Application of Material Dissolution Data

- Solution concentration and sample volume data used to generate release rate estimates, g/m^2 – hour or g/kg – hour as a function of time.
- Release rates and BWR containment material and liquid volume estimates employed to develop preliminary estimates of total releases and containment solution concentrations vs. time at post-LOCA conditions
- Additional testing will be required to develop improved estimates

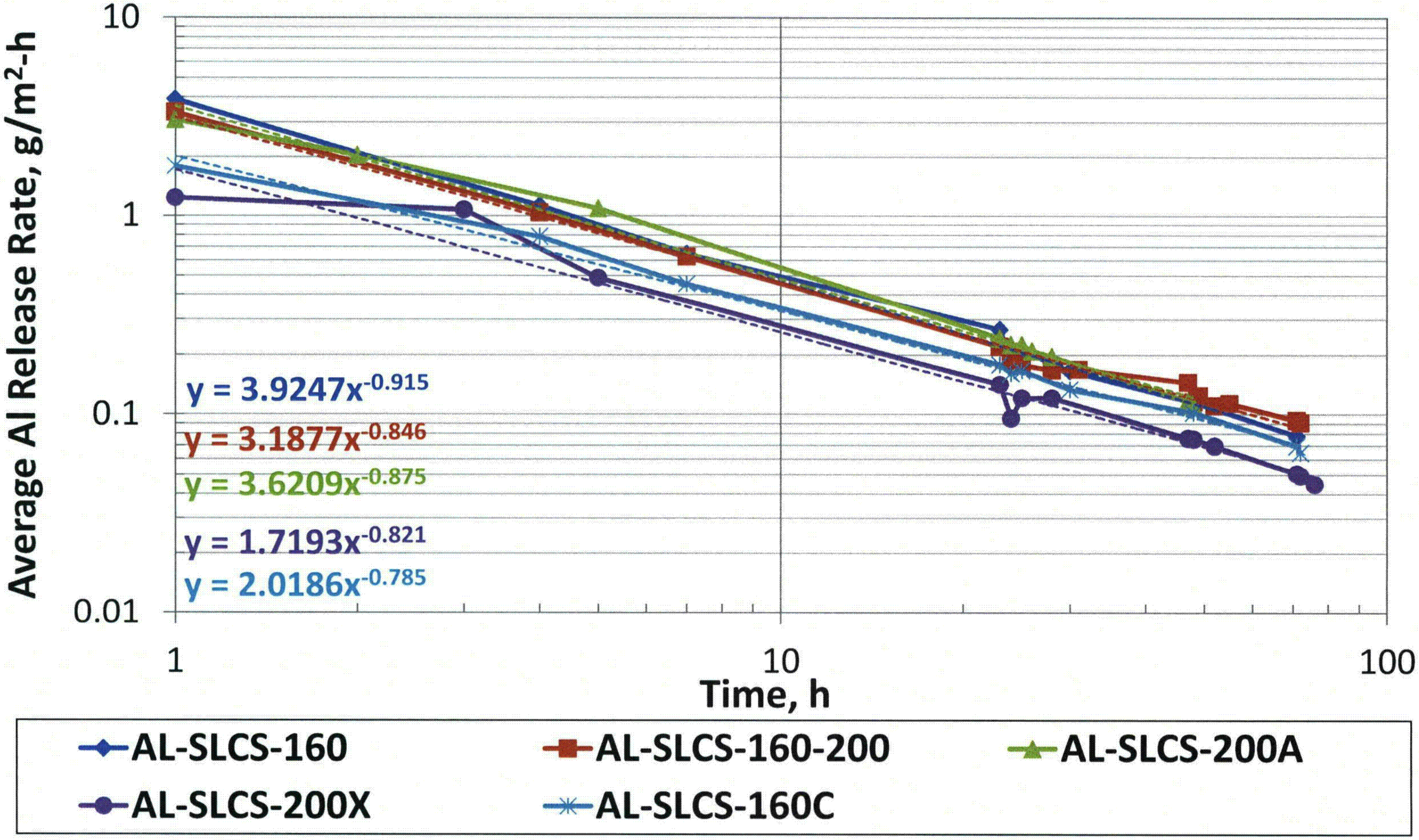
Aluminum Concentrations in Buffered Solutions



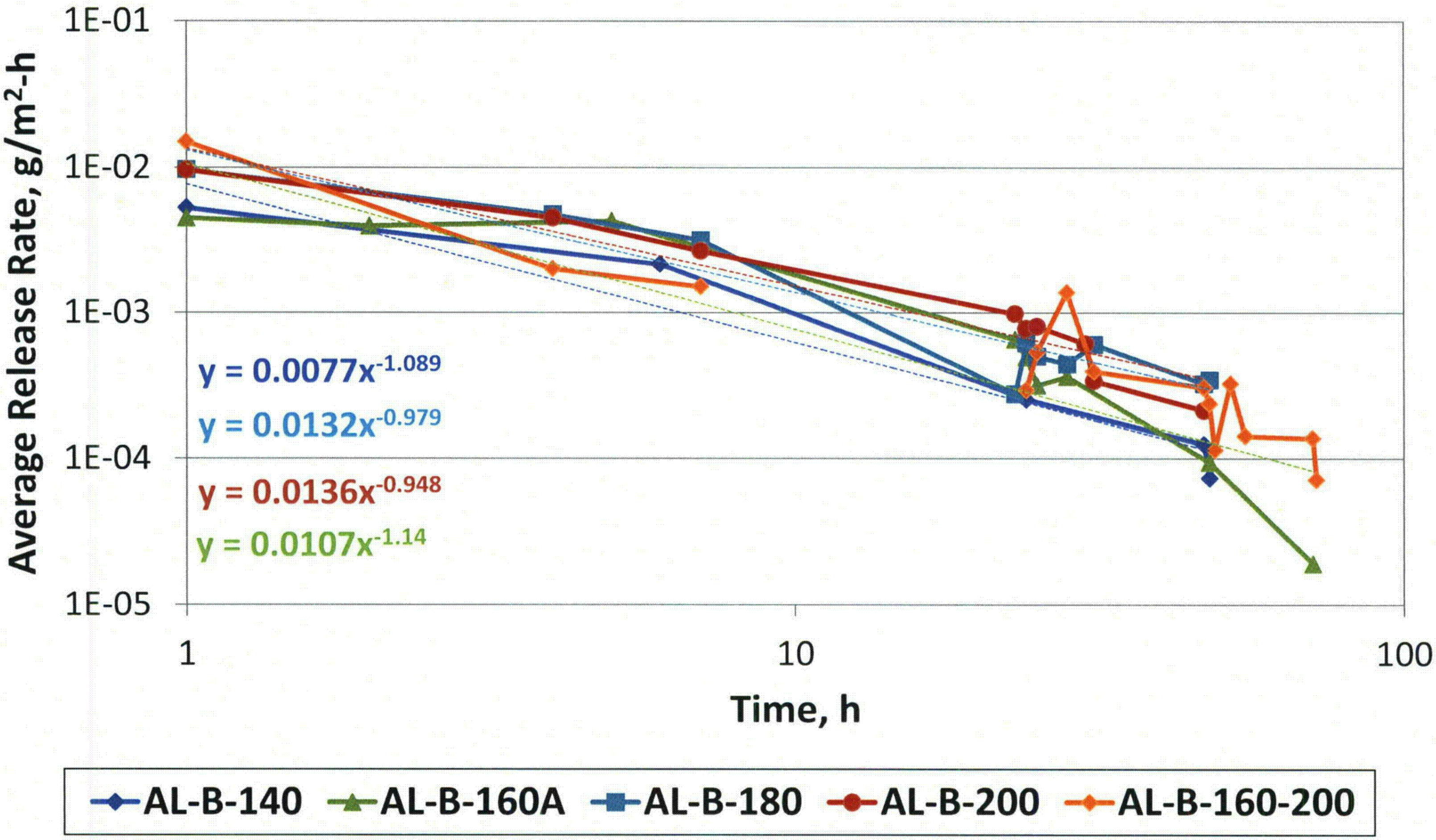
Average Aluminum Release Rates in Buffered Solutions



Correlation of Average Aluminum Release Rates in Buffered Solutions



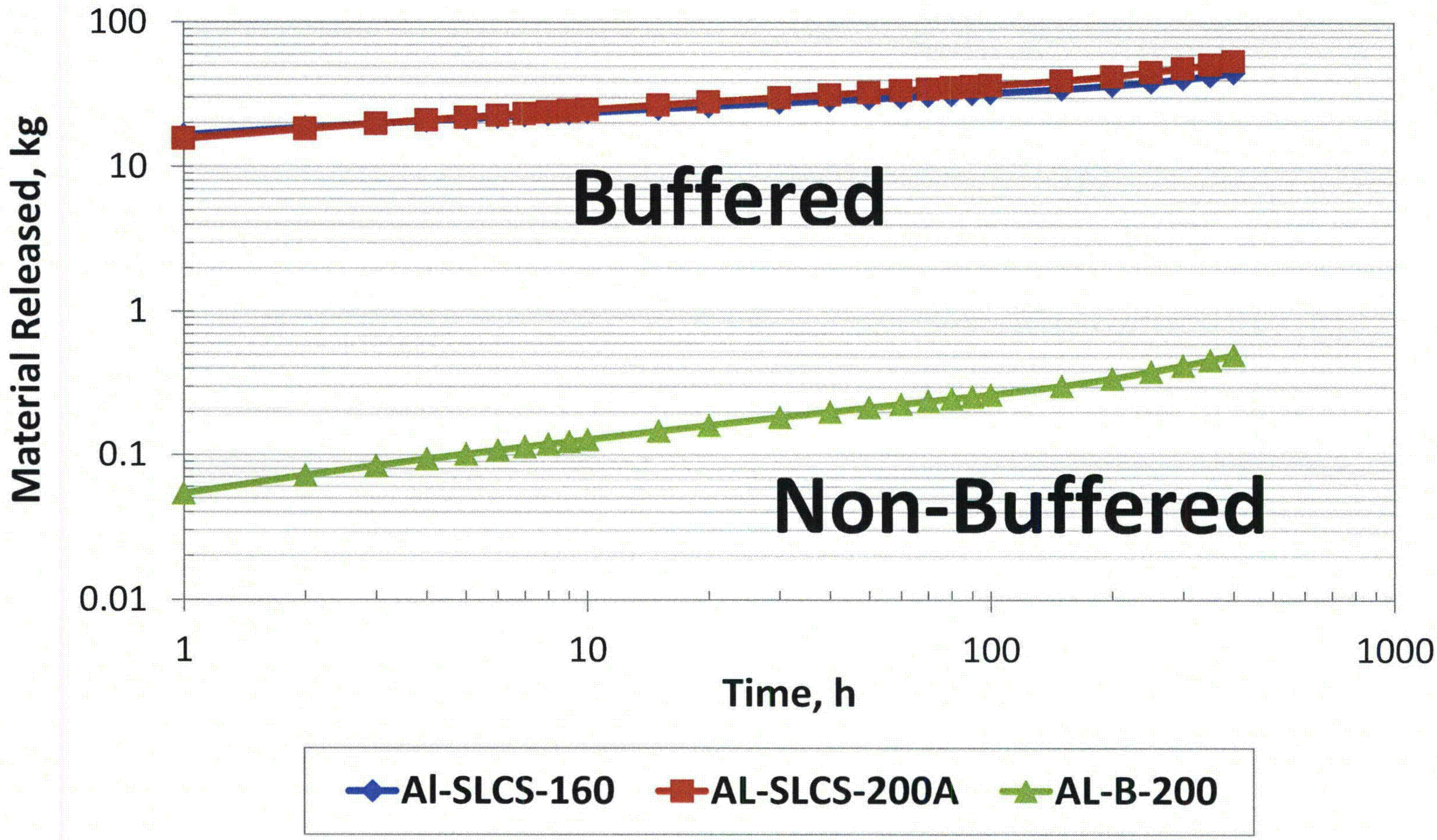
Correlation of Average Aluminum Release Rates in Non-Buffered Solutions



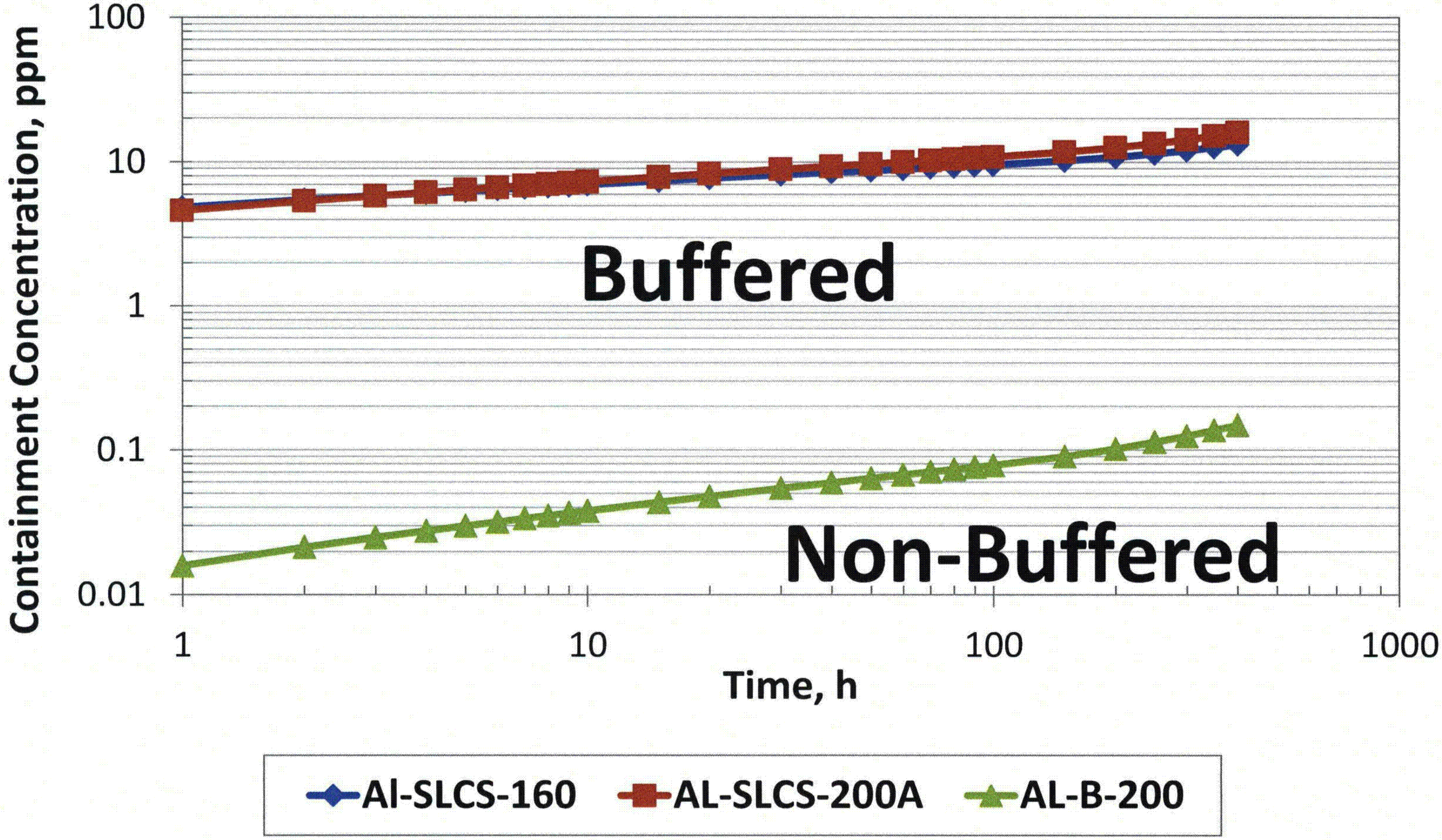
Releases at "Reference" BWR

- Integrate time dependent release rate over mission time
- Time dependent release rate for initial 72 hours obtained from average release rate correlations
- Release rate at 72 hours used for remainder of mission time
- "Reference" BWR Parameters
  - Aluminum Area: 83,072 ft^2
  - Galvanized Carbon Steel Area: 44,312 ft^2
  - Containment Liquid Volume: 119,171 ft^3
- Calculations can be performed using individual plant values.

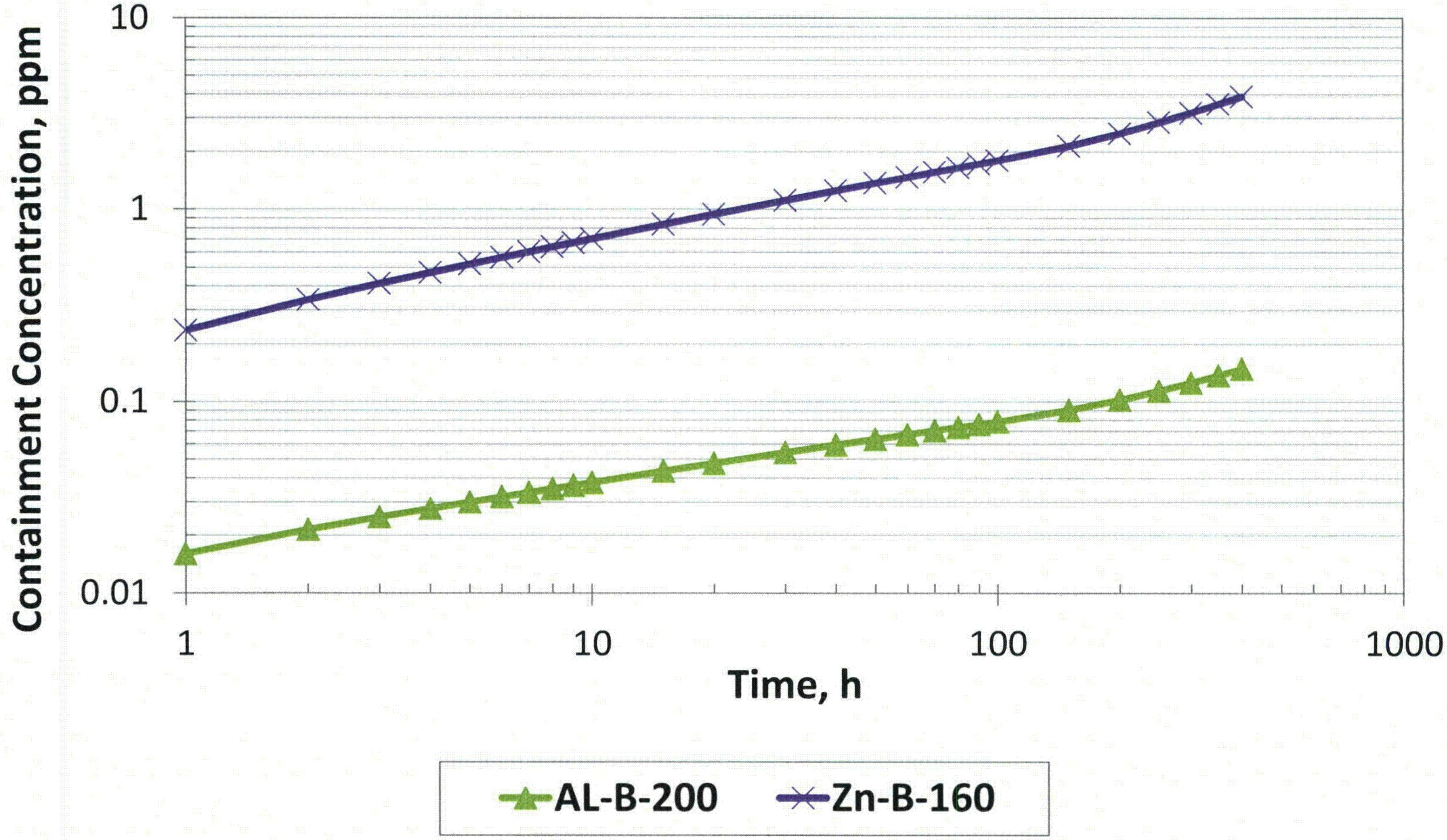
Aluminum Release to Containment Solution at "Reference" BWR



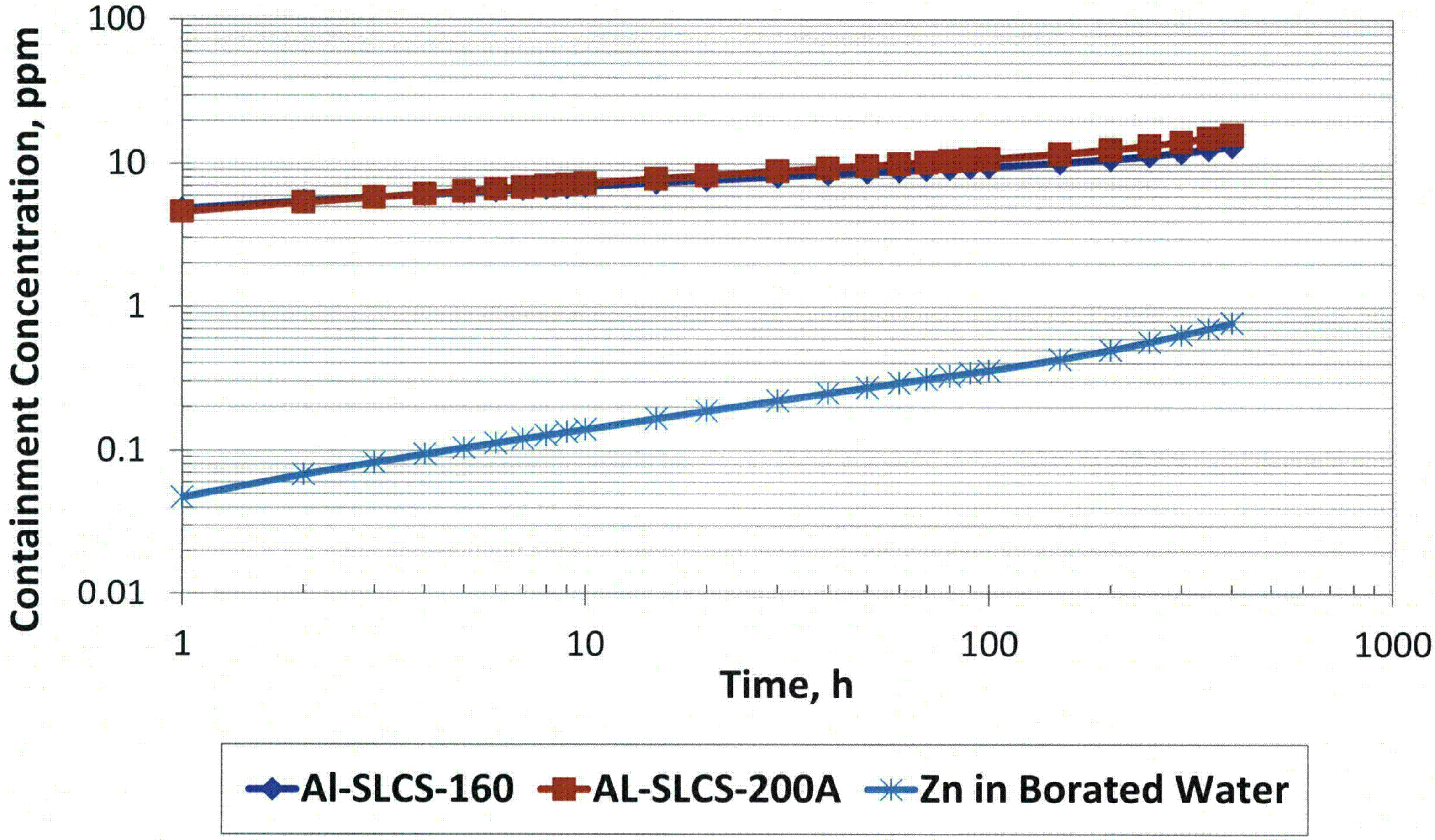
Containment Solution Aluminum Concentrations at “Reference” BWR



Containment Solution Aluminum and Zinc Concentrations (Non-Buffered Solutions) at “Reference” BWR



Containment Solution Aluminum and Zinc Concentrations (Buffered Solutions) at “Reference” BWR



Summary

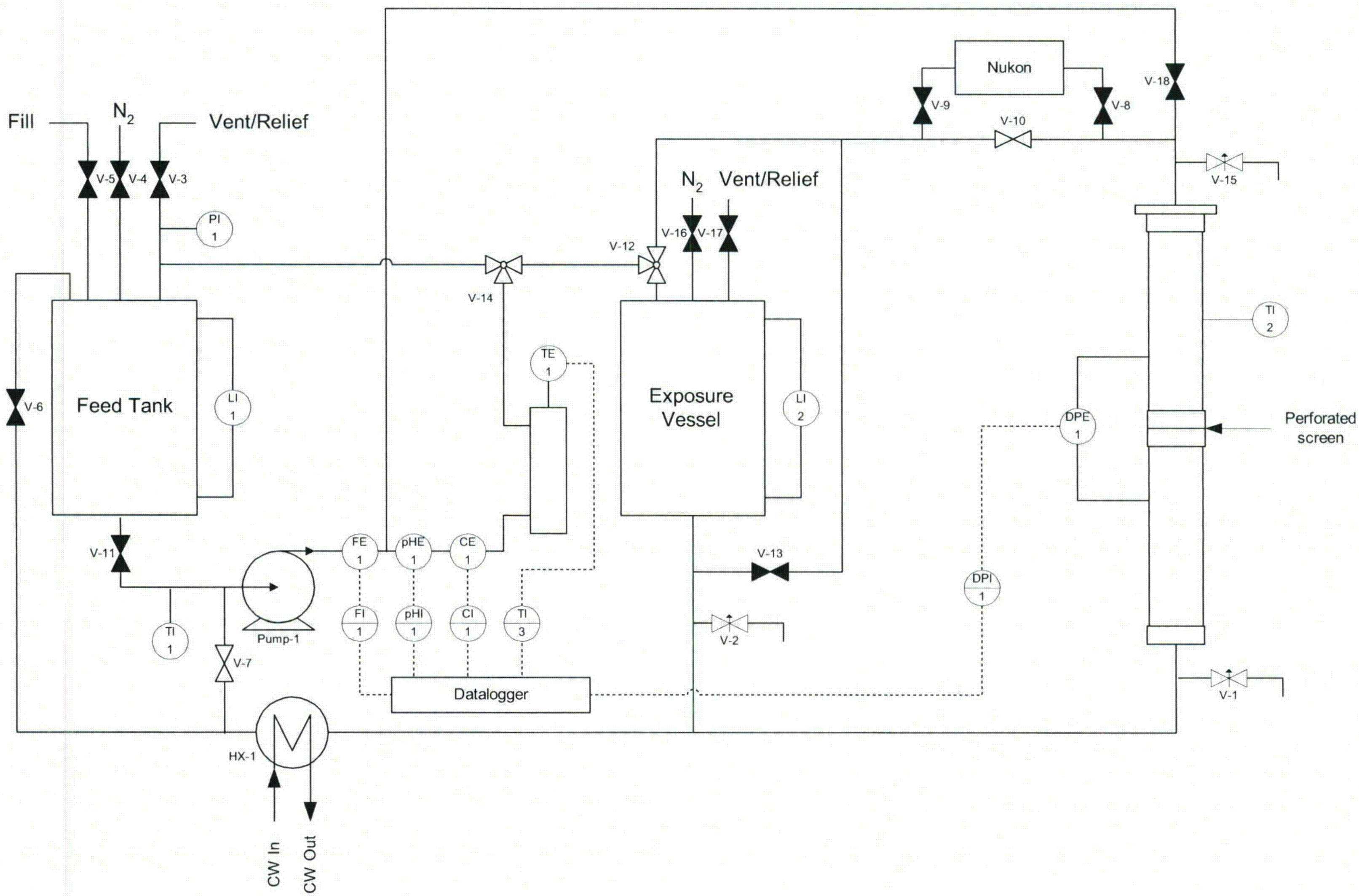
- BWR material dissolution data performed by Alion independently evaluated.
- Release rate correlations developed for buffered and non-buffered solutions. Preliminary correlations based primarily on single material test results.
- Rapid decrease in aluminum, zinc and GCS release rates observed. Effect appears to be a result of surface passivation.
- Effects of passivation must be considered in estimating releases.
- Use of release rate data during first several hours of exposure will lead to marked overestimation of total releases and containment solution concentrations.
- Basis for developing preliminary estimates of material releases and solution concentrations developed.
- Additional testing planned with mixed materials with bounding LOCA event temperature profile to confirm/ augment available data.

Chemical Effects Testing in 2014
Integrated Material Dissolution Testing

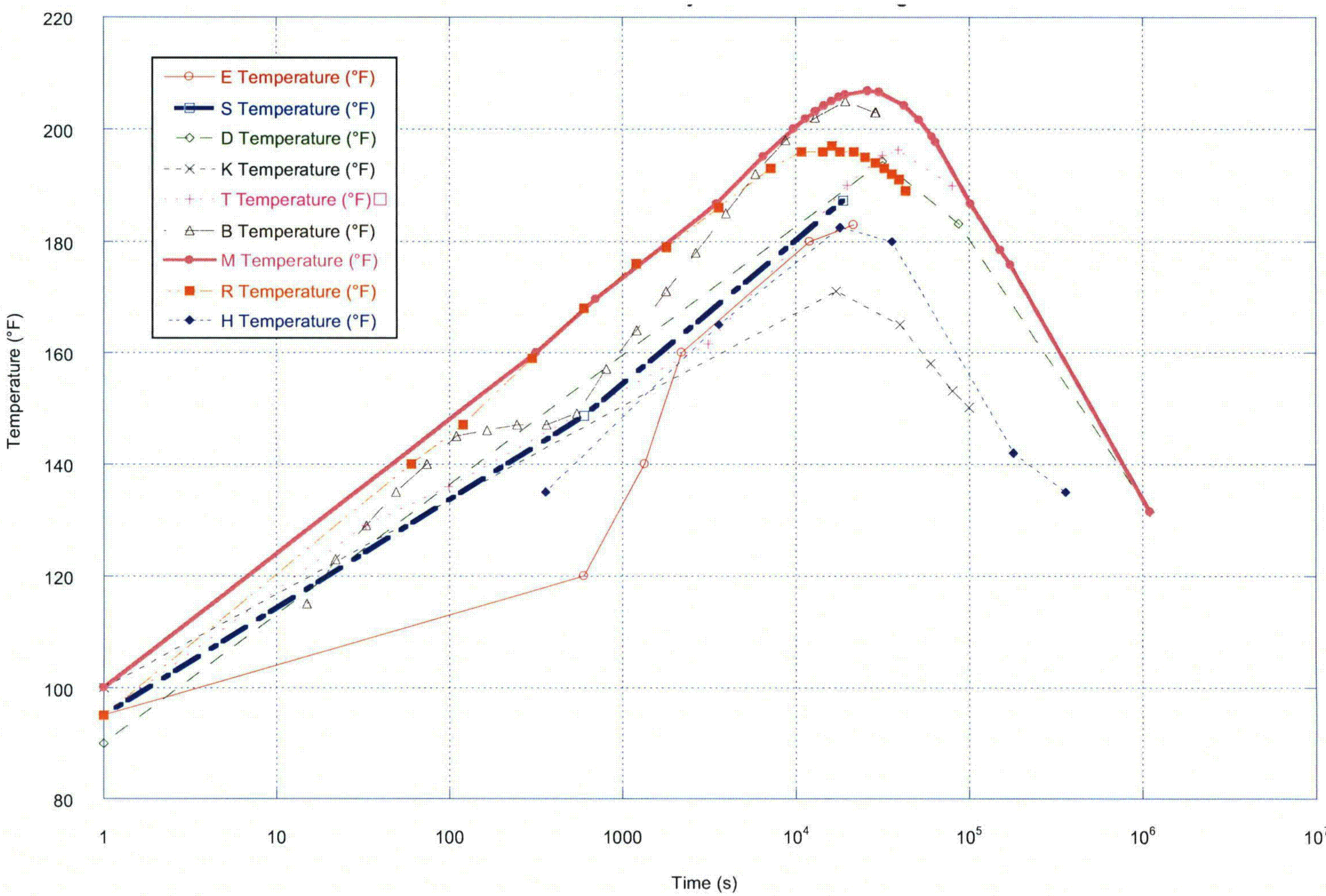
Test		Materials	Solution Chemistry
1-S-B		Al, NUKON®, Galvanized Steel	Borated
2-S-NB		Al, NUKON®, Galvanized Steel	Suppression Pool/Torus
3-S-CS-B		Al, NUKON®, Galvanized Steel, CS	Borated
4-S-CS-NB		Al, NUKON®, Galvanized Steel, CS	Suppression Pool/Torus

- Integrated Material Dissolution Testing is planned for 2014.
- Reactive materials will be exposed to simulated coolant over a bounding representative post-LOCA coolant temperature profile for long term (450 hour) tests.
- Buffered and un-buffered coolant will be tested.
- Flow will be passed through a Nukon debris bed to measure the precipitation of chemical effects via head loss changes.

Chemical Effects Testing in 2014 Integrated Testing Apparatus



Chemical Effects Testing in 2014 Integrated Testing



Chemical Effects Testing in 2014
Precipitation Formation Assessment

- Precipitation Formation Assessment testing will measure the potential precipitation of reaction product for a variety of reactive material combinations.
- Buffered and unbuffered solutions will be tested over two temperature profiles.

Test	Temperature, °F	Materials	Solution
1-PF-B	200 to 140 °F	Al, NUKON®	Borated
2-PF-NB	200 to 140 °F	Al, NUKON®	Suppression Pool/Torus
3-PF-GS-B	200 to 140 °F	Al, NUKON®, Galvanized Steel	Borated
4-PF-GS-NB	200 to 140 °F	Al, NUKON®, Galvanized Steel	Suppression Pool/Torus
5-PF-CS-B	200 to 140 °F	Al, NUKON®, Carbon Steel	Borated
6-PF-CS-NB	200 to 140 °F	Al, NUKON®, Carbon Steel	Suppression Pool/Torus
7-PFC-B	200 to 110 °F	Al, NUKON®	Borated
8-PFC -NB	200 to 110 °F	Al, NUKON®	Suppression Pool/Torus
9-PFC-GS-B	200 to 110 °F	Al, NUKON®, Galvanized Steel	Borated
10-PFC-GS-NB	200 to 110 °F	Al, NUKON®, Galvanized Steel	Suppression Pool/Torus
11-PFC-CS-B	200 to 110 °F	Al, NUKON®, Carbon Steel	Borated
12-PFC-CS-NB	200 to 110 °F	Al, NUKON®, Carbon Steel	Suppression Pool/Torus
13-PF-CAL-B	200 to 110 °F	Al, NUKON®, Calcium Silicate	Borated
14-PF-CAL-NB	200 to 110 °F	Al, NUKON®, Calcium Silicate	Suppression Pool/Torus

Chemical Effects Testing in 2014 Precipitation Formation Assessment

- Precipitate formation assessments will be conducted as bench-top tests.
- Precipitates will be collected via filtration and characterized using SEM/XRD if sufficient material is collected.
- Material dissolution will be measured via ICP/GFAA of solution and sample mass loss measurement.
- Test report combining results of both integrated material dissolution testing and precipitation formation assessments will be prepared 1Q 2015.