BWROG Leadership Introduction

Sam Harvey (TVA)
BWROG Vice Chairman

NRC - BWROG ECCS SS Meeting
April 30, 2014
Washington D.C.

Overview

Recent BWROG Leadership Changes

- BWROG Executive Chairman – Dennis Madison (SNC)
- BWROG Executive Vice Chairman – TBD by May 8, 2014

Recent ECCS SS Committee Leadership Changes

- Vice Chairman – Greg Broadbent (Entergy)
- DSE - Fuels Subcommittee Leader – Greg Broadbent (Entergy)

Overview (cont.)

Submittals Since Last Public Meeting (December 4, 2013)

- BWROG-14003: BWR Material Dissolution Test Plan, BWROG-ECCS-WP-4-1 R4 (January 23, 2014)
- BWROG-14004: 2014 BWROG Submittal Intentions and Summary of the December 4, 2013 NRC-BWROG Public Meeting (ML13309A287) (January 23, 2014)

Overview (cont.)

Submittals Since Last Public Meeting (December 4, 2013) (cont.)

- BWROG-14006: BWROG Request for Closure of ECCS Suction Strainer Issues: Latent Debris Issue #6; Zone of Influence (ZOI) Adjustment for Air Jet Testing (AJT) Issue #7; and Spherical Zone of Influence (ZOI) Issue #12 (February 14, 2014)
  - April 24, 2014 teleconference
    - Additional discussion on Latent Debris
- BWROG-14015: BWROG ECCS Strainer Bypass Test Report, BWROG-ECCS-TA13-004 R0 (March 20, 2014)

Overview (cont.)

Additional Submittals Pending Review / Commentary

- BWROG-13058: Summary of Member Responses to BWROG Survey on Strainer Head Loss and Near-Field Effects, BWROG-ECCS-WP-3-1 R4 (October 31, 2013)
  - Draft NRC comments received January 8, 2014
  - Final version of NRC comments pending
  - BWROG prepared to respond to comments once final version is posted to ADAMS
- BWROG-13032: Responses to Supplemental RAIs Associated with Boiling Water Reactor Owners' Group (BWROG) Licensing Topical Report NEDC 33608P (June 28, 2013)
  - Original SE delivery estimate: December 31, 2013
  - Revised SE delivery estimate: June 30, 2014

Meeting Objectives

Updates

- Recent submittals
- Subcommittee updates (DSE-Fuels; DSE-Source Term; DSE-Components; Head Loss)
  - Testing programs
  - Work-in-progress updates
  - Q&A opportunity

Project Alignment Discussion / Negotiation

- Minor adjustments to 2014 submittal schedule
- NRC reviewer resources
- BWROG 2014 / 2015 priorities
- Project end date proposal: In 2020 versus 2018
  - Supports submittal backlog reviews
  - Committee operation with ~25% fewer resources

Pre-schedule Next Public Meetings for 2014

- Week of September 8th
- Week of November 10th

Committee Organization Overview

Key BWR Utility Representatives		
Utility	**Role / Responsibility**	**Name**
Energy Northwest	ECCS SS Committee Chairman	Steve Scammon
Exelon	ECCS SS Vice Chairman / DSE-Components Subcommittee Leader	Bradley Tyers
PP&L	ECCS SS Vice Chairman / DSE-Debris Source Term Subcommittee Leader	Tony Borger
SNC	ECCS SS Vice Chairman / Head Loss Subcommittee Leader	Phil Grissom
Entergy	ECCS SS Vice Chairman / DSE-Fuels Subcommittee Leader	Greg Broadbent
SNC	BWROG Executive Chairman	Dennis Madison
SNC	BWROG Chairman	Lesa Hill
TVA	BWROG Vice Chairman	Sam Harvey

Committee Organization Overview (cont.)

ECCS Suctions Strainers Project Management		
Organization	**Role / Responsibility**	**Name**
BWROG - GE Hitachi	ECCS SS Committee Project Manager	Michael Iannantuono
ANATECH	Lead Technical Contractor	Robert Choromokos
BWROG - GE Hitachi	BWROG Program Manager	Ken McCall

ECCS SS Project Technical Contributors		
Organization	**Role / Responsibility**	**Name**
Alden Lab	Fuels Testing	Ludwig Haber
Alden Lab	Fuels Testing	Matthew Horowitz
GE Hitachi	Project Nuclear Fuels Engineer	Jose' Casillas
GE Hitachi	Project Mechanical Engineer	Lawrence Fleischer
NWT Corporation	Chemical Effects Testing	Stephen Sawochka
ANATECH	Project Chemical Engineer	James Furman
ANATECH	Project Fuels Testing Engineer	Michael Kennard
ANATECH	Project Fuels Testing Engineer	Dan Fouts

Committee Organization Overview (cont.)

ECCS SS Project Technical Contributors		
Organization	**Role / Responsibility**	**Name**
Alion Science & Technology	Bypass Testing Coatings Zone of Influence	Megan Stachowiak

- Vendor selection for upcoming strainer head loss testing has not been completed as of yet
- Head loss test facilities will be an experienced vendor that has performed head loss testing for PWR strainers
- Also, potential exists for each of the strainer vendors to participate in strainer head loss testing (GEH, PCI, Enercon and Westinghouse)

Summary

BWROG Takeaways

- Fuels Testing LTR review status / ETA of SER
- Benchtop Test reviews status / comments
- Review status / comments of YTD 2014 submittals
- Agreement with 2014 submittal plan revision
- Agreement with overall project extension to 2020 from 2018
- Teleconference follow-up

Review of Recent NRC Submittals / Forecast for Remaining 2014 Submittals

Steve Scammon (Energy Northwest)
ECCS SS Committee Chairman

NRC - BWROG ECCS SS Meeting
April 30, 2014
Washington D.C.

2014 BWROG Submittals to NRC to Date

3 of 12 as Scheduled for 2014 – Delivered

- BWROG-14003: BWR Material Dissolution Test Plan, BWROG-ECCS-WP-4-1 R4 (January 23, 2014)
- BWROG-14006: BWROG Request for Closure of ECCS Suction Strainer Issues: Latent Debris Issue #6; Zone of Influence (ZOI) Adjustment for Air Jet Testing (AJT) Issue #7; and Spherical Zone of Influence (ZOI) Issue #12 (February 14, 2014)
- BWROG-14015: BWROG ECCS Strainer Bypass Test Report, BWROG-ECCS-TA13-004 R0 (March 20, 2014)

Remaining 2014 BWROG Submittals to NRC – Update

Adjustments to Date as a Matter of Course

- BWROG-14015: BWROG ECCS Strainer Bypass Test Report, BWROG-ECCS-TA13-004 R0 (March 20, 2014)
  - Delivered in 1Q versus 2Q, as originally communicated / agreed to at 12/4/13 meeting
- BWROG-140XX: Assessment of Coatings Report, BWROG-ECCS-TP-5-1
  - Rescheduled from 1Q, as originally communicated / agreed to at 12/4/13 meeting, to 2Q
  - Time used to improve station survey granularity

Remaining 2014 BWROG Submittals to NRC – Update (cont.)

Adjustments to Date as a Matter of Course (cont.)

- BWROG-140XX: Responses to BWR Material Dissolution Test Plan, BWROG-ECCS-WP-4-1 R4 (January 23, 2014)
  - Received draft comments from NRC on April 3, 2014; awaiting final comments posting to ADAMS
  - BWROG ECCS SS would like to formally reply with responses / cover letter in 3Q 2014
  - To align scope with BWROG Chairman's project extension request from 2018 to 2020, responses would displace the following on the 2014 submittals list:
    - Coatings Zone of Influence Calculation and Closure Letter, BWROG-ECCS-TP-8-3
    - Assessment of Coatings, BWROG-ECCS-TP-5-1

Remaining 2014 BWROG Submittals to NRC – Update (cont.)

Adjustments to Date as a Matter of Course (cont.)

- Coatings Zone of Influence Calculation and Closure Letter, BWROG-ECCS-TP-8-3 & Assessment of Coatings, BWROG-ECCS-TP-5-1
  - Request formal removal from 2014 NRC submittal schedule
  - Work to continue in 2014 at a reduced pace
  - Stretch goal for submittals based on impact of BWROG resource realignment: 4Q 2014
  - If not submitted in 2014, both to be considered for submittal in 1Q 2015
    - 2015 NRC Submittals Schedule to be communicated at our tentatively scheduled November 13, 2014 public meeting (third of three public meetings expected in 2014)

Remaining 2014 BWROG Submittals to NRC – Update (cont.)

Adjustments to Date as a Matter of Course (cont.)

- Fuel Test Plan for Tests 3 & 4, BWROG-ECCS-TP-2-1
  - Rescheduled from 2Q, as originally communicated / agreed to at 12/4/13 meeting, to 3Q, based on test lab challenges
    - Prototype / specialized instrumentation
    - Test Standard hydraulics

Remaining 2014 BWROG Submittals to NRC – Update (cont.)

Current Status of Remaining 2014 NRC Submittals (2Q)

- BWROG-ECCS-TP-3-2, Debris Head Loss Thin Bed Test Plan
  - Draft test plan provided to BWROG for commentary and review in mid-May
  - Currently on-target for 2Q NRC submittal

Remaining 2014 BWROG Submittals to NRC – Update (cont.)

Current Status of Remaining 2014 NRC Submittals (3Q)

- BWROG-ECCS-TP-4-1-1, Material Dissolution Test Plan (BWROG-14003) Comments
  - New submittal scope as of April 3, 2014 following draft NRC comments
  - Awaiting final comments posting to ADAMS
  - Currently on-target for 3Q NRC submittal
- BWROG-ECCS-TP-9-X, Debris Transport and Erosion Position Paper
  - Currently on-target for 3Q NRC submittal
- BWROG-ECCS-TP-2-X, Transit Time Calculations Report
  - Currently on-target for 3Q NRC submittal

Remaining 2014 BWROG Submittals to NRC – Update (cont.)

Current Status of Remaining 2014 NRC Submittals (3Q) (cont.)

- BWROG-ECCS-TP-2-X, Fuel Test Plan for Tests 3 & 4
  - Currently on-target for 3Q NRC submittal
  - Submittal expectations delayed; rescheduled from 2Q
- BWROG-ECCS-TP-2-X, Debris Source Term Specification
  - Currently on-target for 3Q NRC submittal
- BWROG-ECCS-TP-2-X, Benchtop Testing Results – BT1-BT4
  - Currently at-risk for 3Q NRC submittal
  - Risk-mitigation to be based on information obtained from NRC at 4/30/14 public meeting; BT1-4 review commentary

Summary

Good progress with 2014 ECCS SS NRC submittals YTD

2014 ECCS SS NRC Submittals originally totaled 12; currently expecting a 2014 total of 11

- Coatings Zone of Influence Calculation and Closure Letter, BWROG-ECCS-TP-8-3 & Assessment of Coatings, BWROG-ECCS-TP-5-1 requested to be moved to 2015 due to BWROG resource realignment

NRC review of NEDC-33608-P / Benchtop Testing / SE generation impacting schedule

- BWROG-ECCS-TP-2-X, Benchtop Testing Results – BT1-BT4; 3Q NRC submittal at risk

Submittal schedule adjustment aligns well with BWROG Chairman's proposal for protracting project completion from 2018 to 2020

Downstream Effects (DSE) – Fuels Subcommittee Update Presentation

Steve Scammon (Energy Northwest)
ECCS SS Committee Chairman

NRC - BWROG ECCS SS Meeting
Washington, DC
April 30, 2014

Fuels Testing Program Update

Submittals Status / NRC Feedback

- BWROG-13032: Responses to Supplemental RAIs Associated with Boiling Water Reactor Owners' Group (BWROG) Licensing Topical Report NEDC 33608P (June 28, 2013)
  - Attachment B provides description of Benchtop Test Program (originally, January – May 2014)
  - Original SE delivery estimate: December 31, 2013
  - Revised SE delivery estimate: June 30, 2014
  - BWROG requesting confirmation of current NRC forecast for SE delivery
    - Protracted SE delivery impacts upon critical path (full scale bundle testing scheduled for 3Q 2014)
    - Challenges in maintaining BWROG resources in comparison to urgency of Fukushima Response Committee (FRC) scope and other emergent industry issues

Fuels Testing Program Update (cont.)

Submittals Status / NRC Feedback (cont.)

- BWROG-13050: Communicated Delay of Approximately Six Months in Reviewing BWROG Submittal Associated with NEDC-33608P S2 RAI Responses (September 11, 2013)
  - Requested Option 1: Full LTR review
  - Requested Option 2: Review of Benchtop Testing (LTR Attachment B)
  - Follow up to 9/11/13 letter: BWROG-14004: 2014 BWROG Submittal Intentions and Summary of the December 4, 2013 NRC-BWROG Public Meeting (ML13309A287) (January 23, 2014)
    - Attachment B (Benchtop Tests) order of review
      - BT4→BT2 →BT1 →BT3
      - Mitigates protracted delivery of overall SE

Fuels Testing Program Update (cont.)

Summary / Key Aspects

- Fuels Testing LTR review status / ETA of Safety Evaluation Report (SER)
- Benchtop Test reviews status / comments
  - Requested Review Order
    - BT4→BT2 →BT1 →BT3
- Recovery Plan in response to Mitigation Strategies Directorate (MSD) resource needs
  - Request concurrence on trajectory change for overall project completion in 2020 versus 2018

Head Loss Subcommittee Update Presentation

Phillip Grissom (SNC)
ECCS SS Committee Vice Chairman
Head Loss Subcommittee Leader

NRC - BWROG ECCS SS Meeting
April 30, 2014
Washington D.C.

Head Loss Survey Report - October 31, 2013

BWROG Conclusions

- Only ENERCON strainers took credit for settling in testing
- Analytical debris transport / settling characteristics need to be reviewed if used to reduce debris quantity at strainer
- Assumptions used with correlations need to be reviewed
- Characteristics of failed paint (chips or particulate) need to be reviewed
- Thin bed effects test program needed to properly characterize associated head losses
- Previous debris preparation and introduction was acceptable for thick debris bed tests

Appendix A

- Flow chart for evaluating strainer head loss (after URG supplement)

NRC Draft Responses to Head Loss Survey Report - January 8, 2014

For BWROG Consideration

- NRC staff agreed with 5 of 6 report conclusions
- NRC took exception to conclusion that previous debris fiber preparation / introduction was acceptable for thicker debris bed testing
  - Justification that test debris characteristics are prototypical to that found in representative BWR suppression pools

Appendix A Specific Feedback

- NRC does not want Appendix A to be used with previous URG guidance

Comments Related to Strainer Vendors

Applicable to All Strainer Vendors

- Test debris and surrogate properties should be reviewed and justified
- Head loss test termination criteria needs to be justified or extrapolated

Vendor Specific Comments

- Enercon – Justification of flow velocity and turbulence
- ABB – Performance of flow sweeps to justify temperature scaling
- PCI – Addressing NUREG-6224, in that there may have been an under-predicted head loss for certain debris physical characteristics
- GE – Further justification of bump-up factors

BWROG Responses to NRC Comments

Course of Action

- BWROG – NRC alignment regarding debris characteristics / debris preparation
- BWROG thin bed effects test plan to be submitted to NRC for comments
- BWROG to consider prior NRC comments during thin beds effects test plan development
- Acceptability of previous BWR thick bed tests with previous fiber preparation to be addressed in the thin beds effects test program or in a future head loss testing program
- BWROG to submit responses to vendor-specific NRC comments

Thin Bed Effects Testing Program

Objectives

- Determine if thin bed effect occurs on complex geometry strainers used in BWRs
- Define BWR debris compositions and strainer geometries that will not experience the thin bed effects phenomenon
- Where supported by test data, provide justification that previous BWR thick bed tests are an acceptable basis for strainer design

Thin Bed Effects Testing Program (cont.)

Approach

- Use prototypical stacked disk strainer
- Use short duration Design of Experiments tests
- Use range of plant flow velocities based on survey results
- Use various mixtures of Nukon, sludge and problematic debris in tests based on survey results
- Test for various thicknesses from 1/16" to 1/2" or more – each test with unique thickness (don't just add fiber)
- NRC review and concurrence with test plan prior to testing

DSE – Components Update Presentation

Brad Tyers (Exelon)
ECCS SS Committee Vice Chairman
DSE-Components Subcommittee Leader

NRC - BWROG ECCS SS Meeting
Washington D.C.
April 30, 2014

DSE - Components Subcommittee

Objectives

- 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
- To determine the impact of the fibrous debris that can pass through the suction strainer after a LOCA on the downstream components (e.g. pump impellers, pump seals, valves)
- Obtain results that can be applied to the BWR fleet

Actions Completed Since 12/4/13 Meeting

For NRC Submittal

- BWROG-14015: BWROG ECCS Strainer Bypass Test Report, BWROG-ECCS-TA13-004 R0 (March 20, 2014)

Current Activities

Enercon

- Obtaining quote for strainer bypass test support

Westinghouse

- Work in progress to receive WCAP-16406-P by BWROG Utilities (those that previously did not have access - Columbia, Susquehanna, Fermi, and Cooper)
  - Initial gap analysis cannot commence until this occurs

Debris Source Term Subcommittee Update Presentation

Tony Borger (PPL)
ECCS SS Committee Vice Chairman
Debris Source Term Subcommittee Leader

NRC - BWROG ECCS SS Meeting
April 30, 2014
Washington D.C.

Debris Source Term – Associated Issues

Issue 4:	Chemical Effects
Issue 5:	Coating Assessment
Issue 6:	Latent Debris
Issue 7:	Zone of Influence (ZOI) Adjustment for Air Jet Testing
Issue 8:	Coating Zone of Influence (ZOI)
Issue 9:	Debris Transport & Erosion
Issue 10:	Debris Characteristics
Issue 11:	Near Field Scaling
Issue 12:	Spherical Zone of Influence (ZOI)

Debris Source Term – Update

Issue 4: Chemical Effects

- BWROG-14003, "BWR Material Dissolution Test Plan," BWROG-ECCS-WP-4-1 R4, for NRC Information and Commentary (January 23, 2014)
- Independent 3rd party review of ALION dissolution test results performed
- Perform Integrated Material Dissolution Testing

Issue 5: Coating Assessment

- Survey data provided by utilities
- Results to be processed and summarized in BWROG-ECCS-TP-5-1 submittal report

Debris Source Term – Update (cont.)

Issue 6: Latent Debris

- Adopted 85% Particulate / 15% Fiber or plant-specific ratio with justification
- BWROG-14006: BWROG Request for Closure of ECCS Suction Strainer Issues: Latent Debris Issue #6; Zone of Influence (ZOI) Adjustment for Air Jet Testing (AJT) Issue #7; and Spherical Zone of Influence (ZOI) Issue #12 (February 14, 2014)

Debris Source Term – Update (cont.)

Issue 7: ZOI Adjustment for Air Jet Testing

- BWROG-14006: BWROG Request for Closure of ECCS Suction Strainer Issues: Latent Debris Issue #6; Zone of Influence (ZOI) Adjustment for Air Jet Testing (AJT) Issue #7; and Spherical Zone of Influence (ZOI) Issue #12 (February 14, 2014)
- NRC Feedback of BWROG-ECCS-TA-08-001, ML13280A347 (November 2013)
  - *"Therefore, the staff concluded that the ZOIs determined in the report are representative of destruction pressures consistent with those used for PWRs and that the ZOI sizes are properly defined for BWR conditions"*

Debris Source Term – Update (cont.)

Issue 8: Coatings Zone of Influence

- BWROG-ECCS-TP-8-3, Coatings ZOI Calculation and Issue Closure Letter
  - Modeled two Mk I and two Mk II containments (representative)
  - Identified limiting break for conservative coatings values
  - Restrained Break analysis results < 85 lbm

Debris Source Term – Update (cont.)

Issue 9: Debris Transport and Erosion

- BWROG-ECCS-TP-9-X, Debris Transport and Erosion Position Paper
  - Identifies / resolves any significant differences between URG and GSI-191 guidance

Issue 10: Debris Characteristics

- BWROG-ECCS-TP-10-X, Debris Characteristics Position Paper
  - Justification that debris characteristics are prototypical

Debris Source Term – Update (cont.)

Issue 11: Near Field Effects and Scaling

- Survey complete; included in Head Loss survey
- Initial analysis performed
- Will be addressed with Head Loss Issue

Issue 12: Spherical ZOI

- BWROG-14006: BWROG Request for Closure of ECCS Suction Strainer Issues: Latent Debris Issue #6; Zone of Influence (ZOI) Adjustment for Air Jet Testing (AJT) Issue #7; and Spherical Zone of Influence (ZOI) Issue #12 (February 14, 2014)

Fuels Testing / Alden Lab Update Presentation

Matthew Horowitz, Ph.D. (Alden)

NRC - BWROG ECCS SS Meeting
April 30, 2014
Washington D.C.

Fuels Testing Program

Overview

- LTR describes fuels testing to validate analysis
  - Attachment A
- Submitted LTR resulted in RAIs
  - Responses to RAIs identified need for Benchtop test program (June 28, 2013)
- Commissioning activities of facility in progress
- Awaiting SER of LTR (with Attachment A)
  - Including submitted RAI responses and Benchtop test program

Fuels Testing Program (cont.)

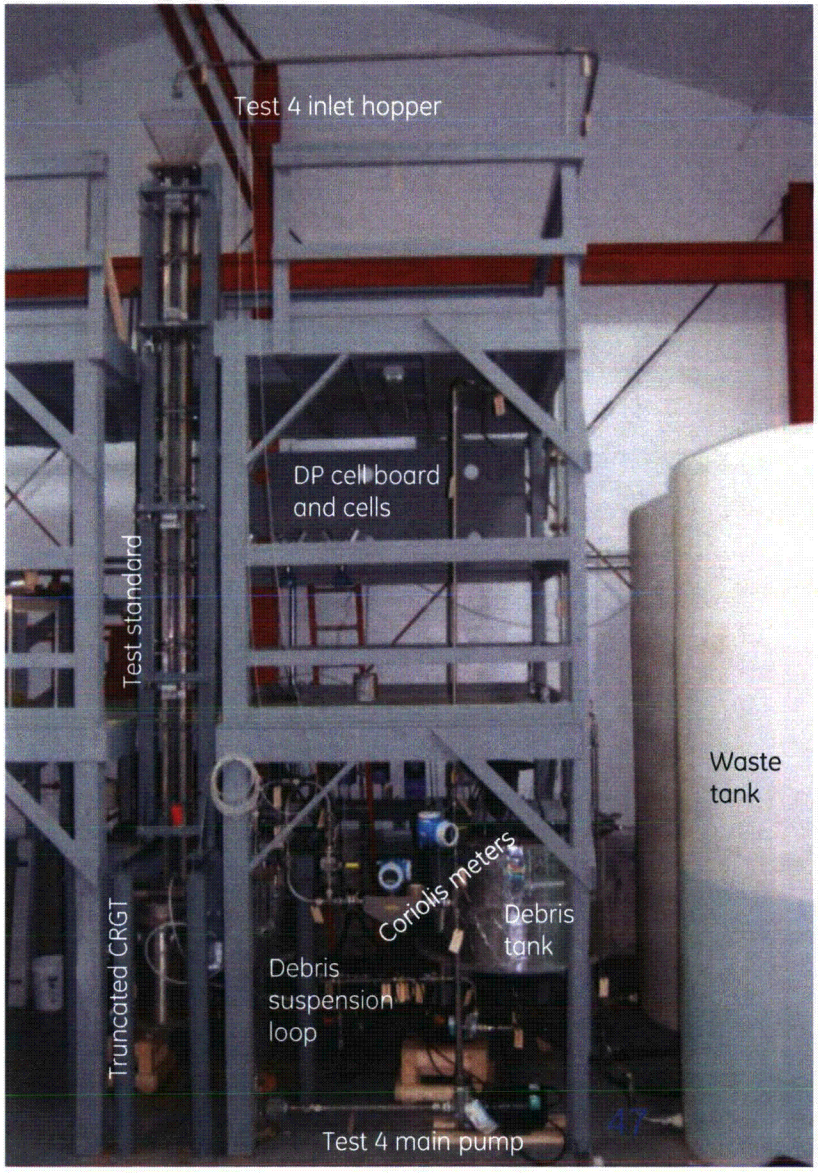
Outline

- Completed work
  - Loop design & construction
  - Test standard design & construction
  - Commissioning test procedures & inspections
  - Test 4 operational inspection completed informally
- Work in progress
  - Formal shakedown / inspection
  - Computational fluid dynamics validation
  - Draft calculations completed

Fuels Testing Program (cont.)

Test 4 Loop Operational Inspection

- Completed informally
  - Two separate sets of piping required for Test 4
  - Informally inspected both sets
- Loop can achieve required flow rates for Test 4
  - Total flow through bundle
  - Debris introduction flow



Fuels Testing Program (cont.)

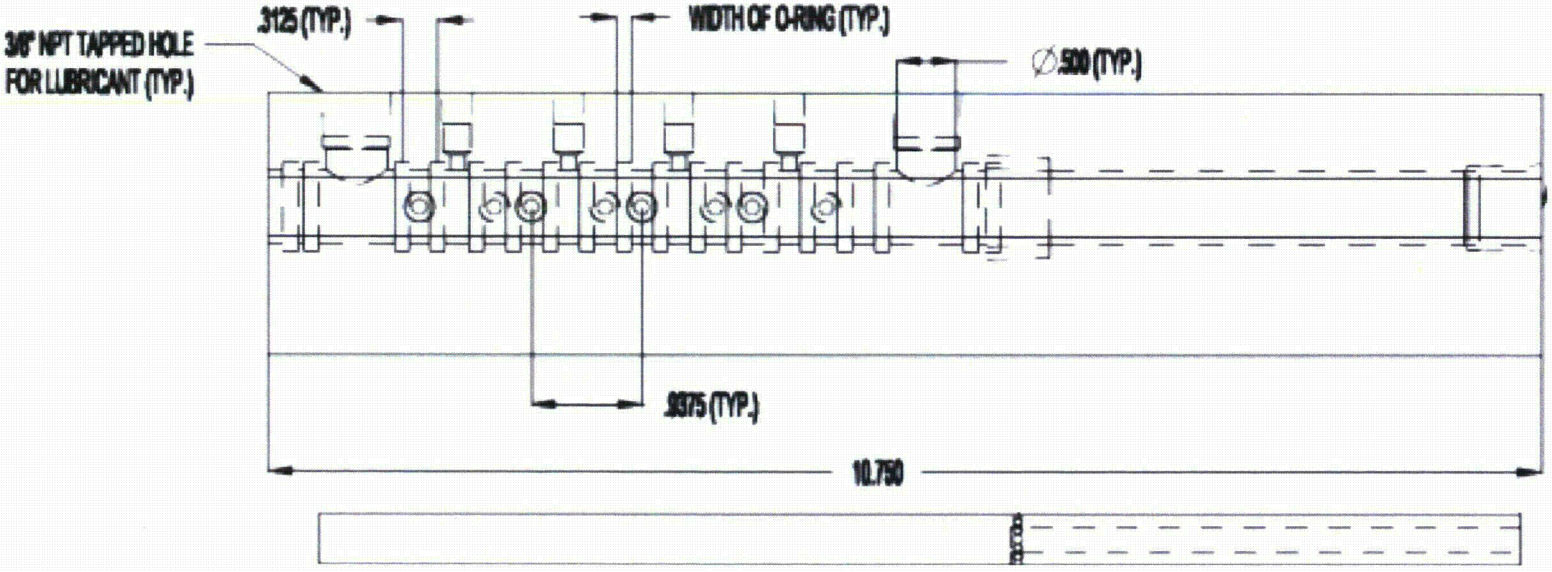
Test 4 Loop Operational Inspection (cont.)

- Challenges
  - Coriolis meter used to measure debris introduction flow rate
    - Returned to manufacturer for electronics repair
    - Recalibrated by Alden after being repaired
  - Pressure measurement
    - Need to sample pressures at 8 spacer grid locations, UTP, and be able to measure skewed flow (3 extra measurements on different sides of spacer)
    - Must sample 12 differential pressures
      - Separate samplers required to route pressures to high and low sides of the DP cells

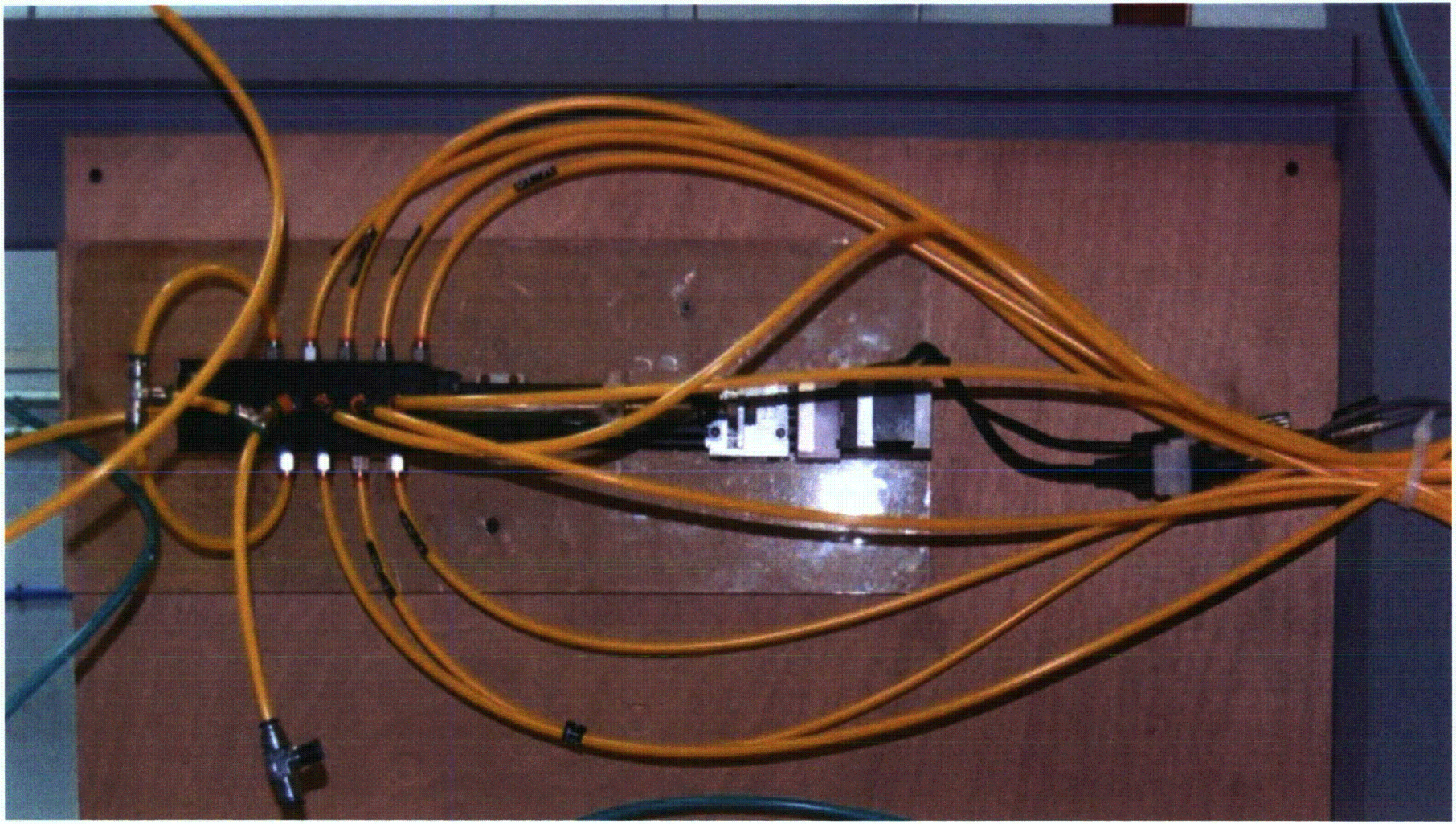
Fuels Testing Program (cont.)

Test 4 Loop Operational Inspection (cont.)

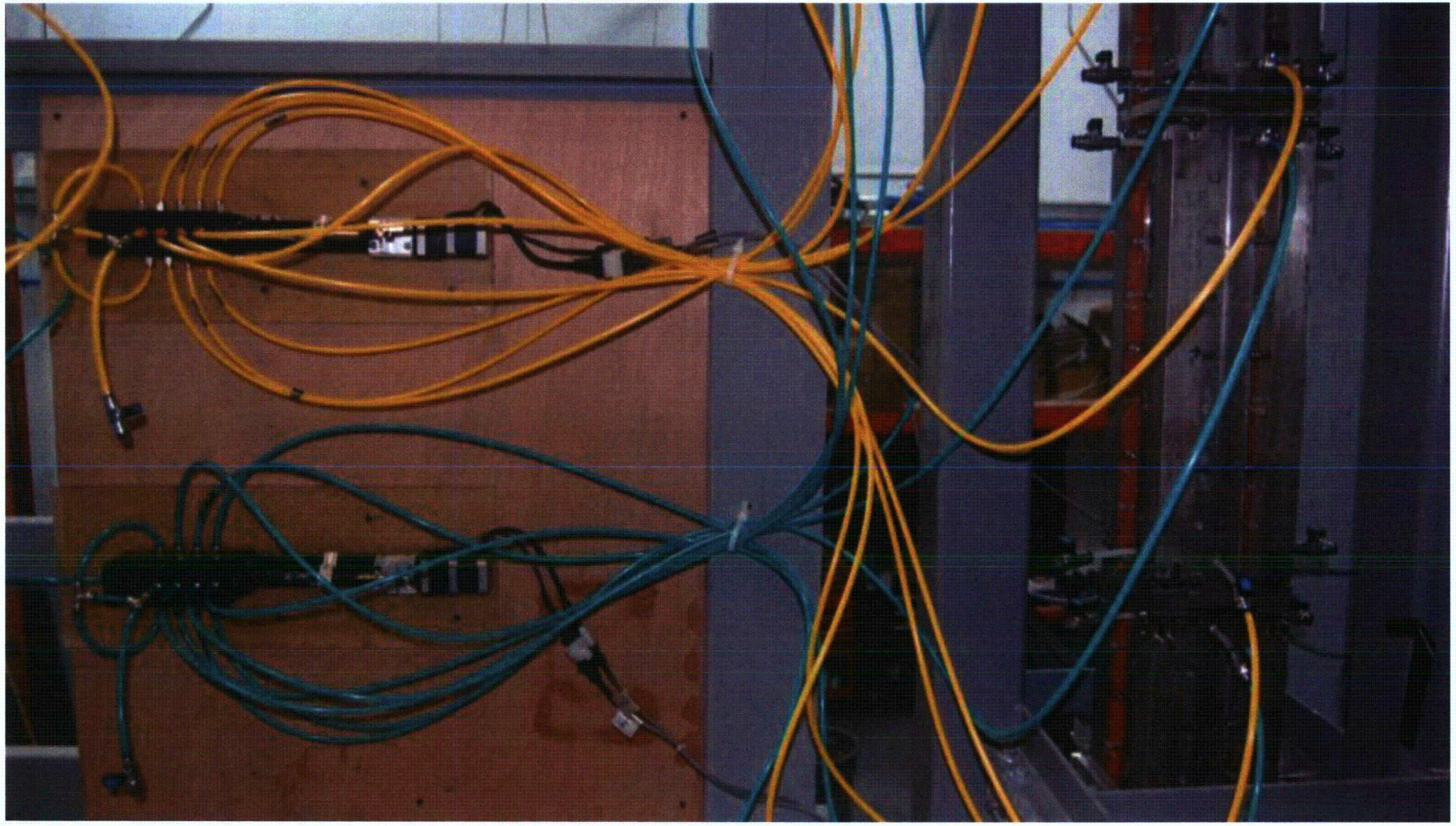
- Pressure Sampling
  - Manifold
    - 12 ports isolated from each other with O-rings
  - Motorized Traverse
    - Moves hollow shaft inside a manifold
    - Transverse holes in shaft align with manifold ports transmit pressure to output line connected to shaft



Fuels Testing Program – Pressure Sampling



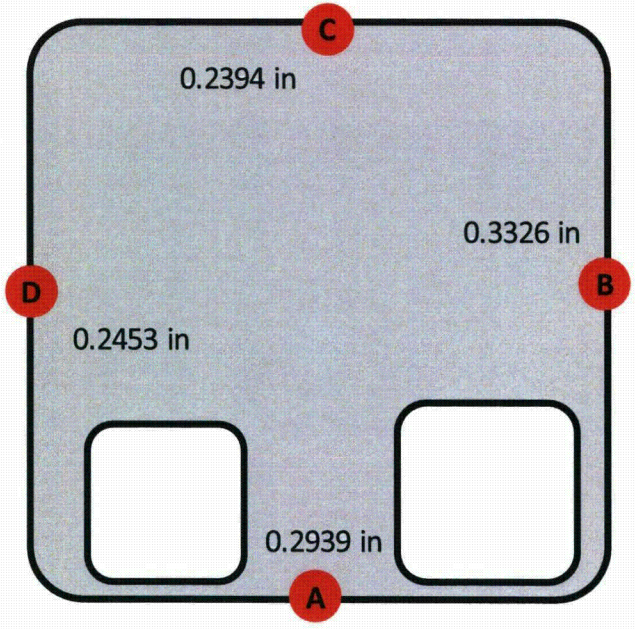
Fuels Testing Program – Pressure Sampling (cont.)



Fuels Testing Program – Pressure Sampling (cont.)

Measurement Example

- Use test standard with skew plate installed
- Plate D/P values measured between a common high (upstream of plate) and four downstream sides
- Larger differential pressures correspond to lower downstream pressure and higher downstream velocity
- Higher velocities near orifices as expected

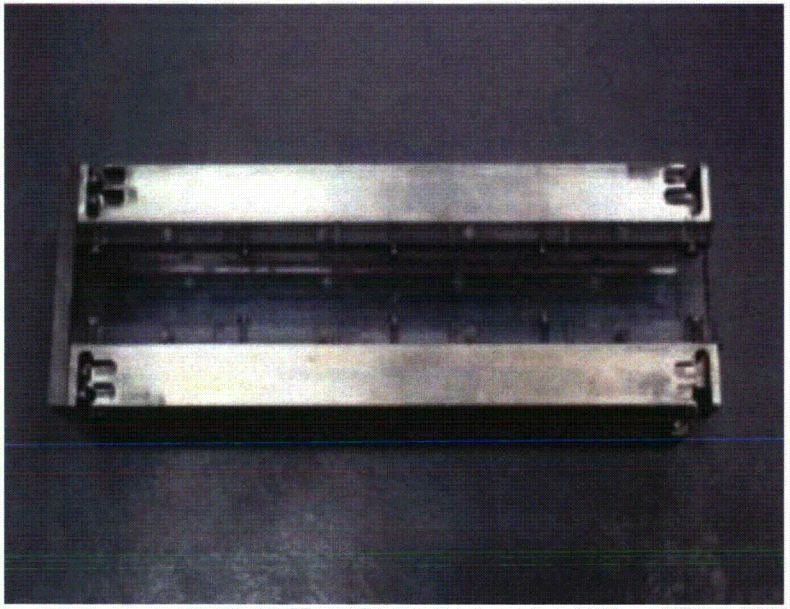


Fuels Testing Program – Test Standard (cont.)

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

Test standard section



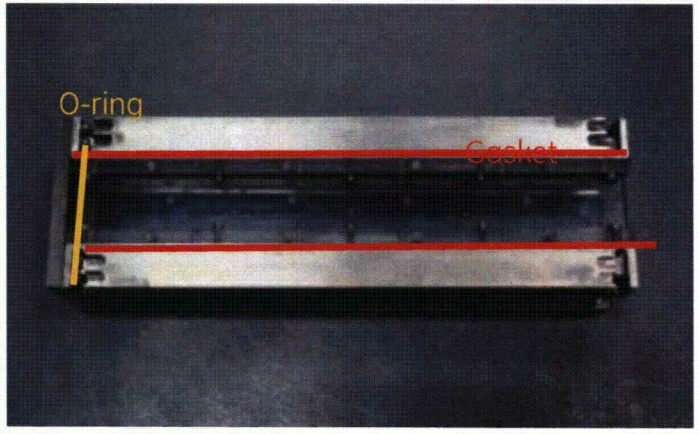
Fuels Testing Program – Test Standard (cont.)

Sealing Difficulties with Test Standard

- Gaskets between stainless steel corners
- O-ring at flange
- Intersection between gasket and O-ring

Test Standard can continue to be used to qualify the facility

30% open test standard flange



Fuels Testing Program – Summary

Test 4 loop is expected to meet requirements based on informal shakedown results

Commissioning Activities to Complete

- Formal execution of Test 4 operational inspection in clean water
- Test 3 operational inspection in clean water
- Debris laden facility qualification – use test standard with preliminary versions of Test 3 and 4 procedures

Remaining Activities in 2014

- Test plan for Tests 3 and 4
- Design and construction of clear fuel channel
  - Incorporate lessons learned from test standard
- Benchtop testing

Benchtop Testing (BT) Program

Overview

- Four Testing Groups
  - BT1 (3rd test in order to be performed)
    - Effects of debris concentration by boil-off
  - BT2 (2nd test in order to be performed)
    - Potential effects of fuel rod surface conditions on debris bed formation and tenacity
  - BT3 (4th test in order to be performed)
    - Possibility of thermal adhesion
  - BT4 (1st test in order to be performed)
    - Non-uniformity of debris beds
    - Debris wash-down
    - Debris blockage measurement techniques
- Testing Preparations / Work in Progress
  - Awaiting review of submittals related to BT 4
  - Acquisition of prototypical components
    - Spacer Grids, UTP, Stub Rods

BWR Debris Source Term Chemical Effects Testing Program

Steve Sawochka (NWT)
Jim Furman (SIA)

NRC - BWROG ECCS SS Meeting
Washington D.C.
April 30, 2014

Chemical Effect Testing Update

Overview

- BWR material dissolution data developed in 2011 / 2012 by Alion Science & Technology were evaluated to assist in BWROG chemical effects test plan development
- Bench-top tests were performed at static conditions primarily with single materials in air saturated demineralized water and Na_2 B_{10} O_{16} Solutions (~100 ppm Na and 230 ppm B)
- Preliminary correlations of release rates were developed from the Alion data and used to develop total release and solution concentration estimates for "Reference BWR"
- Preliminary results were presented at the NRC-BWROG ECCS SS Meeting in Washington on 12/4/2013
- Release rate relations have recently been employed to develop estimates of total releases and solution concentrations based on preliminary BWROG site survey inputs (non-validated)

Chemical Effect Testing Update

Overview (cont.)

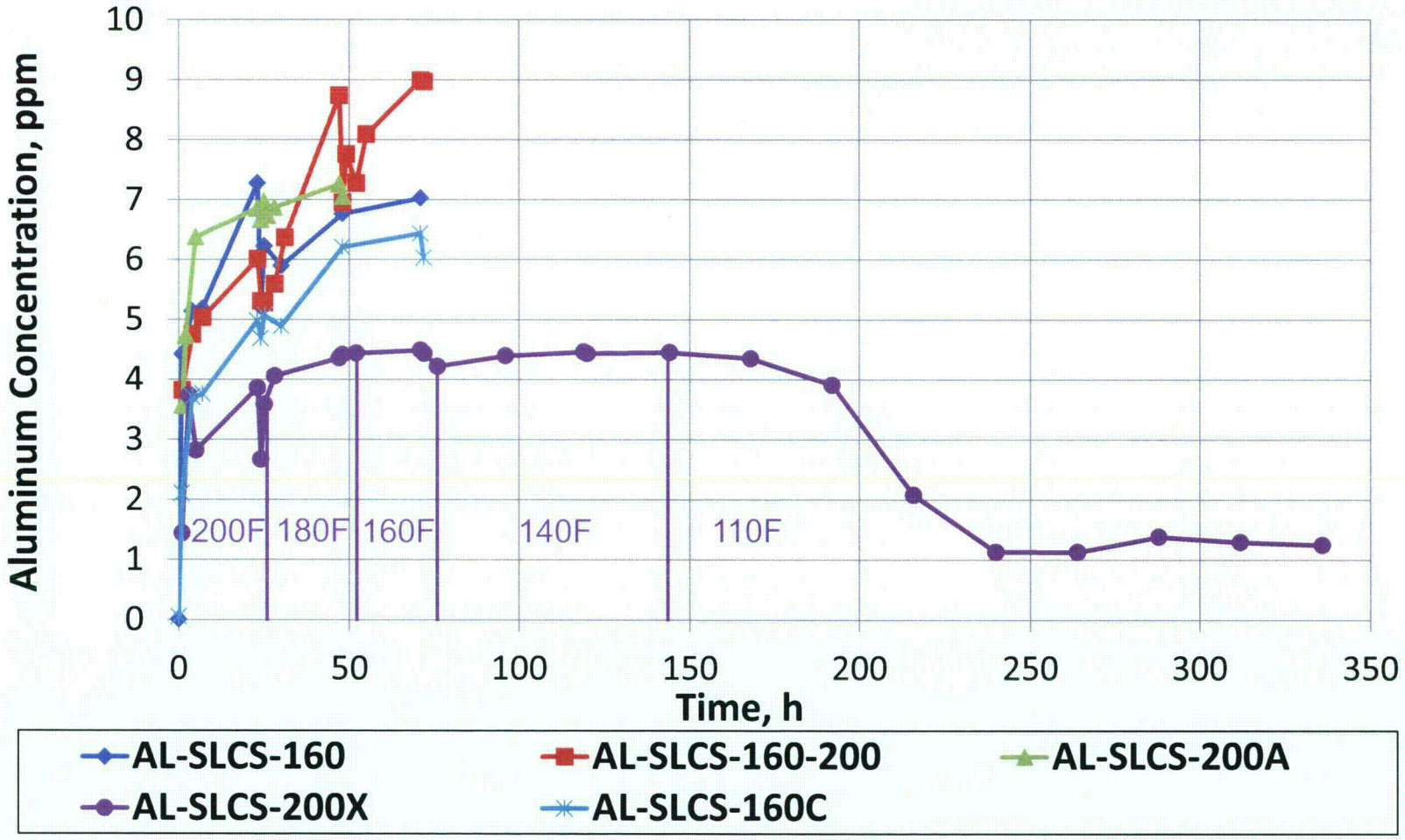
- Post-LOCA simulation tests with mixed materials will be performed in 2014 with a bounding temperature profile in a recirculating test loop to augment release rate data and measure effects on ECCS SS pressure drop
- Ratios of exposed material weights / areas to containment solution volume based on BWROG site survey will be used to develop test plan
- Bench-top precipitate formation tests also will be conducted

Alion Material Dissolution Test Results

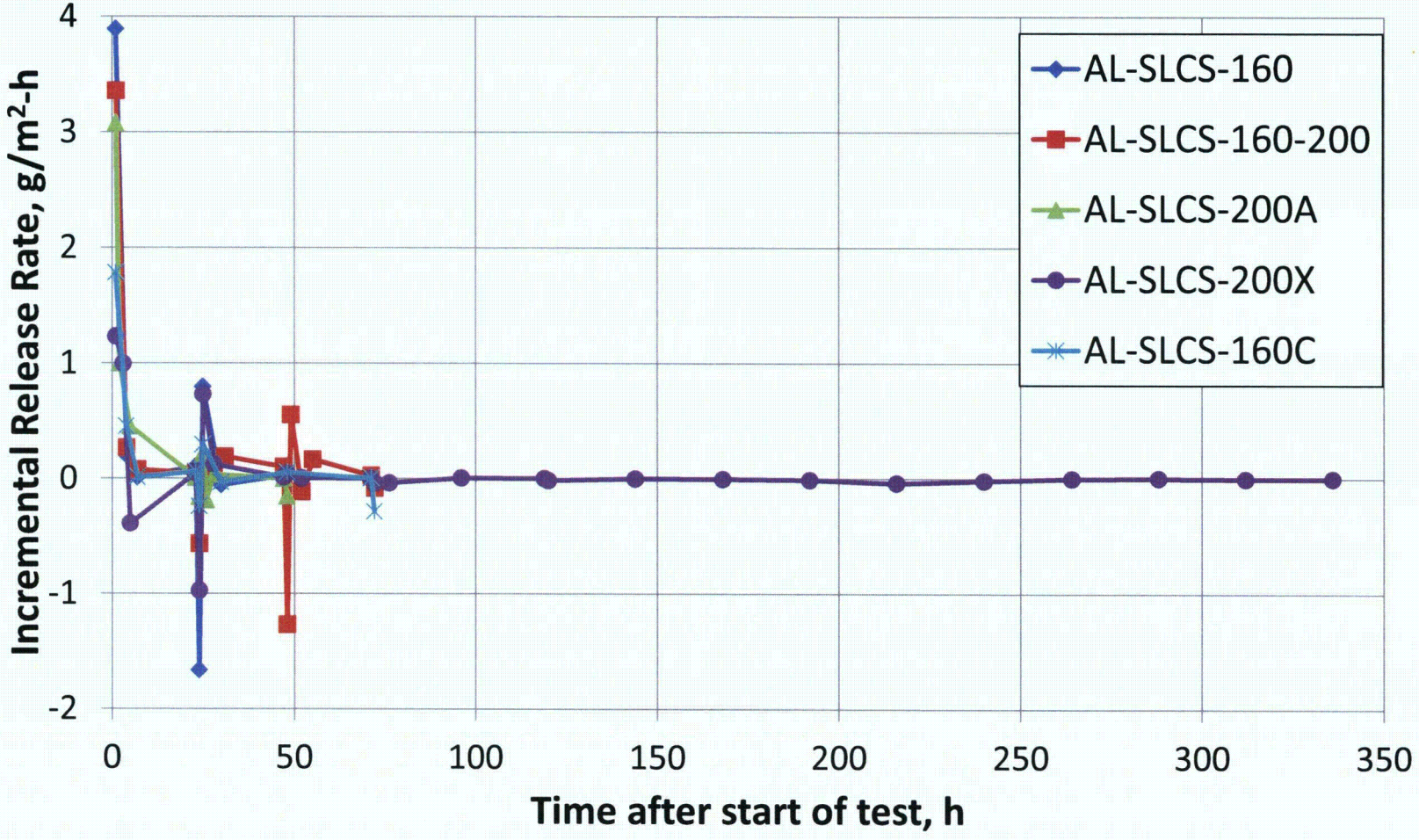
Summary

- Release rates from aluminum, zinc, and GCS rapidly decreased with time. Effect appears due to metal passivation
- Aluminum release rates increased significantly with pH
- Zinc and iron release rates decreased with pH
- Variations were consistent with expectations based on thermodynamics
- 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
- Alion data were sufficient to develop preliminary release rate correlations at static conditions for buffered and non-buffered BWR solutions

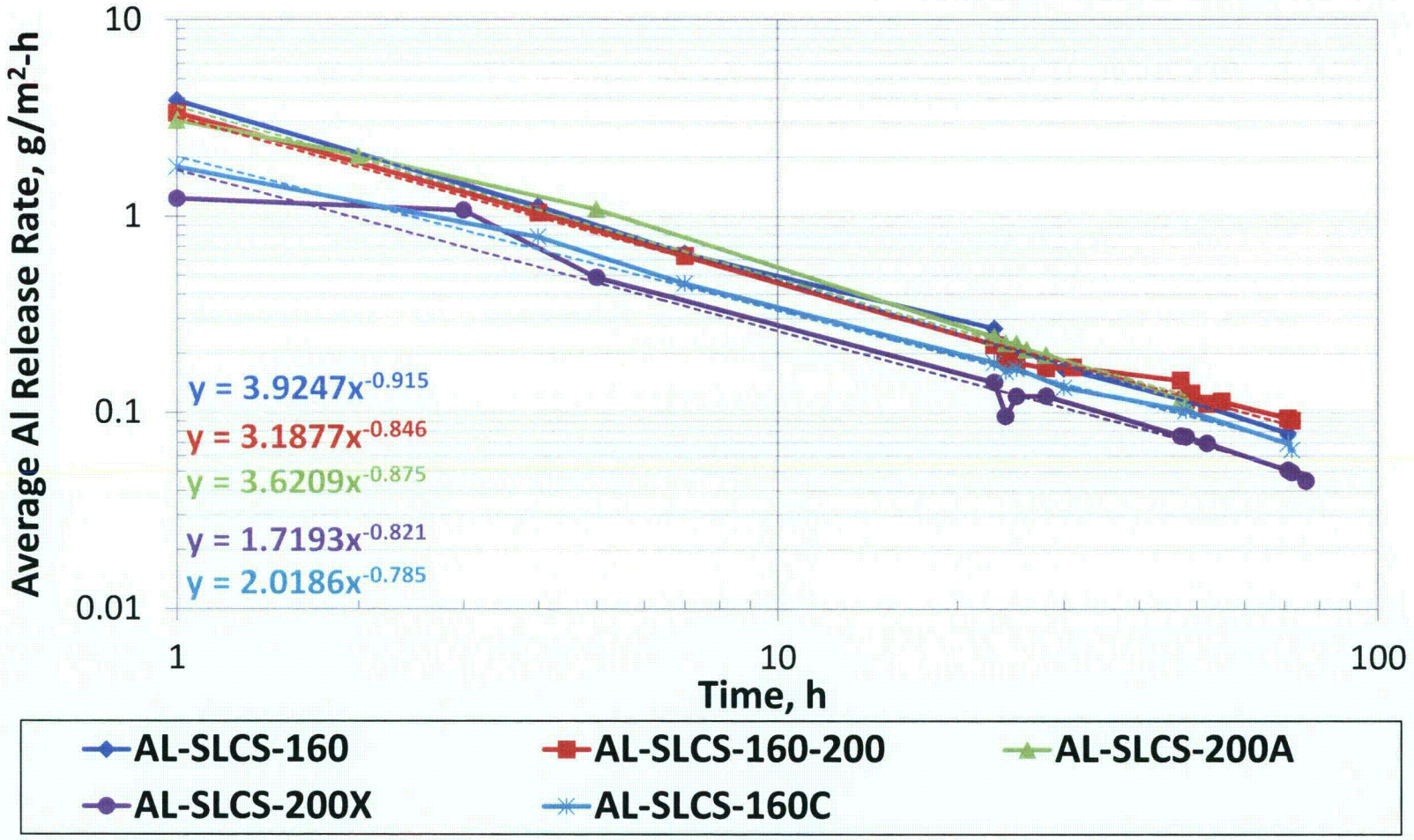
Database Example: Aluminum Concentrations in Buffered Solutions



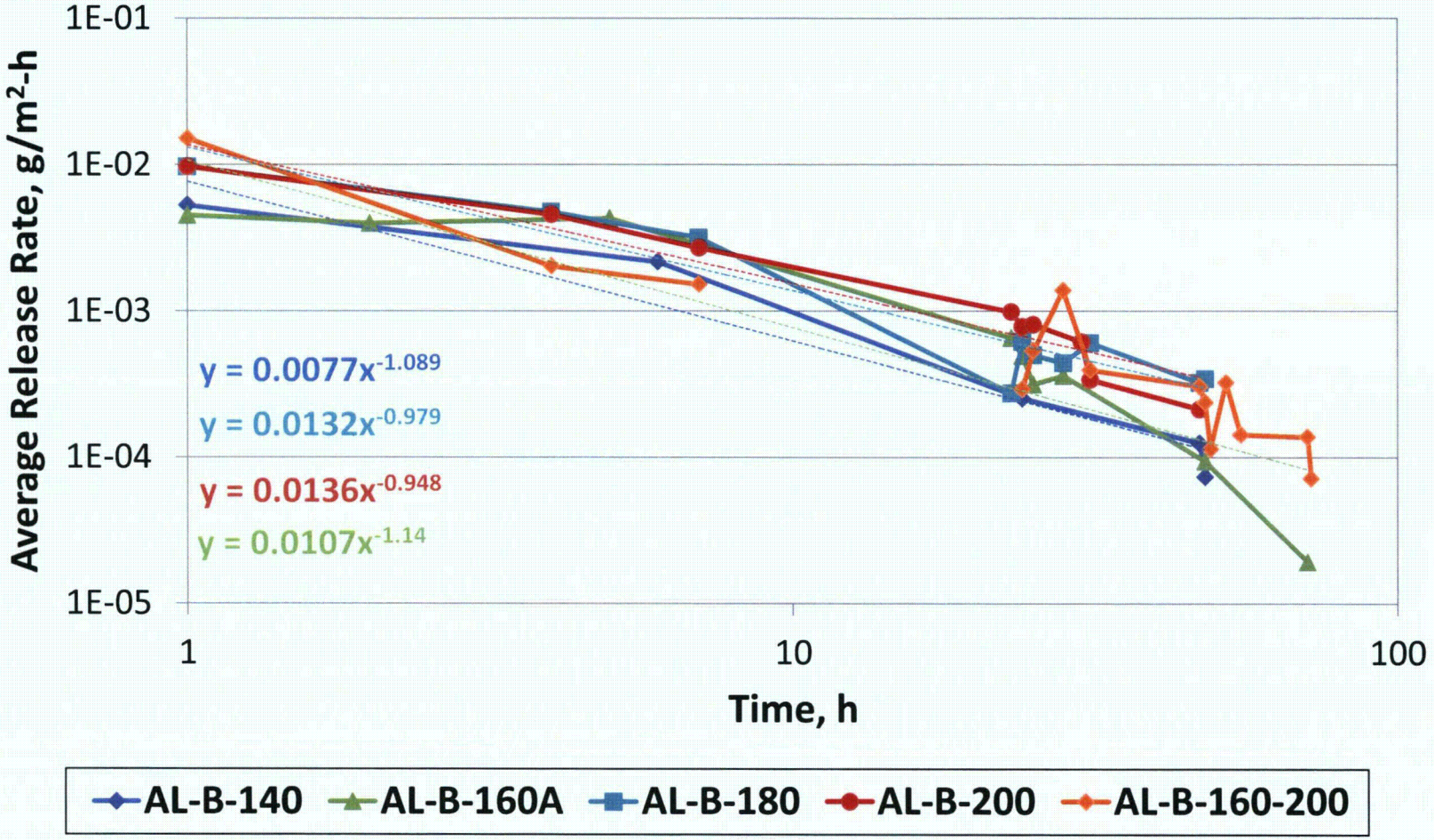
Incremental Aluminum Release Rates in Buffered Solutions



Correlation of Average Aluminum Release Rates in Buffered Solutions



Correlation of Average Aluminum Release Rates in Non-Buffered Solutions

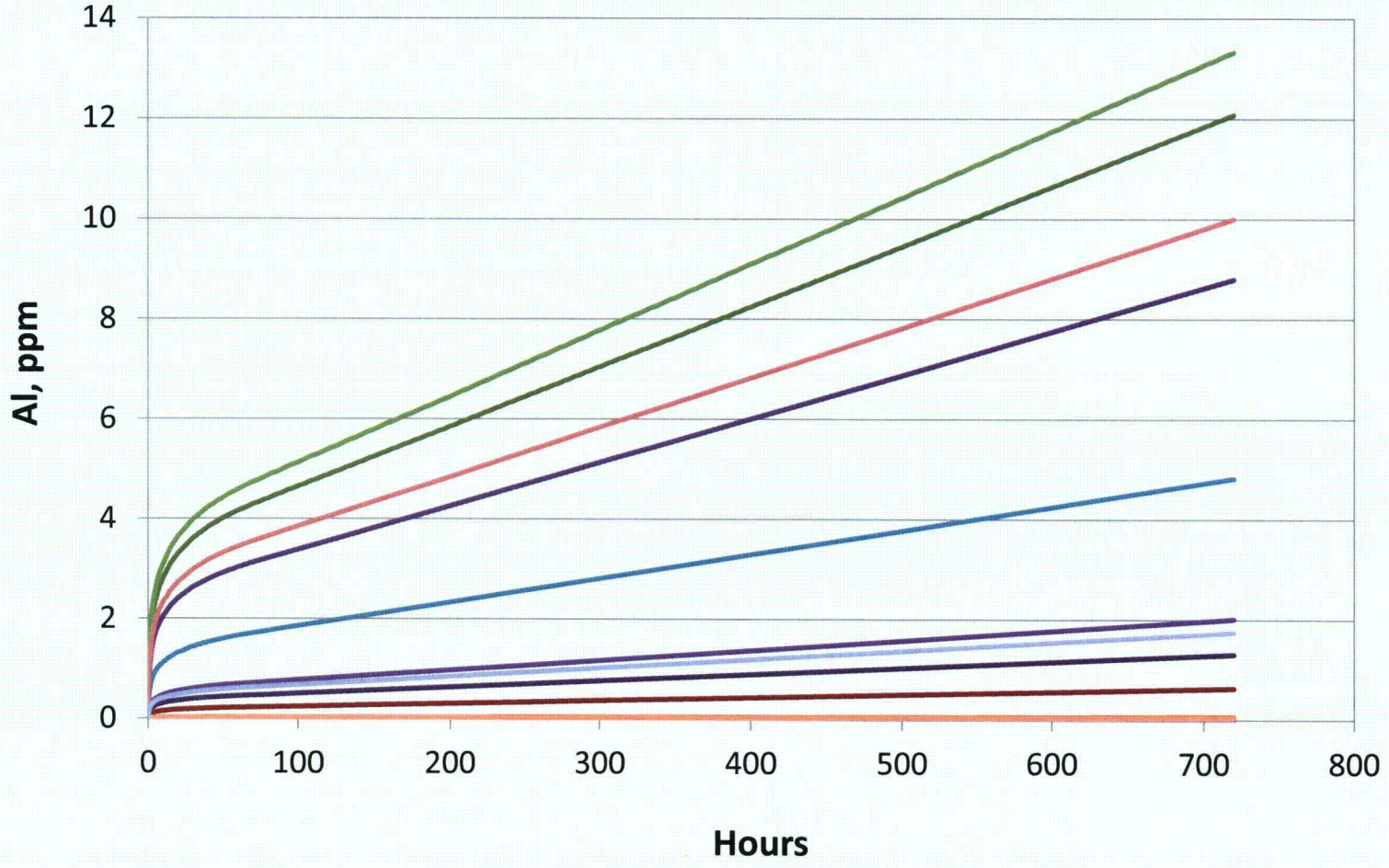


Estimation of Releases During BWR Post-LOCA Event

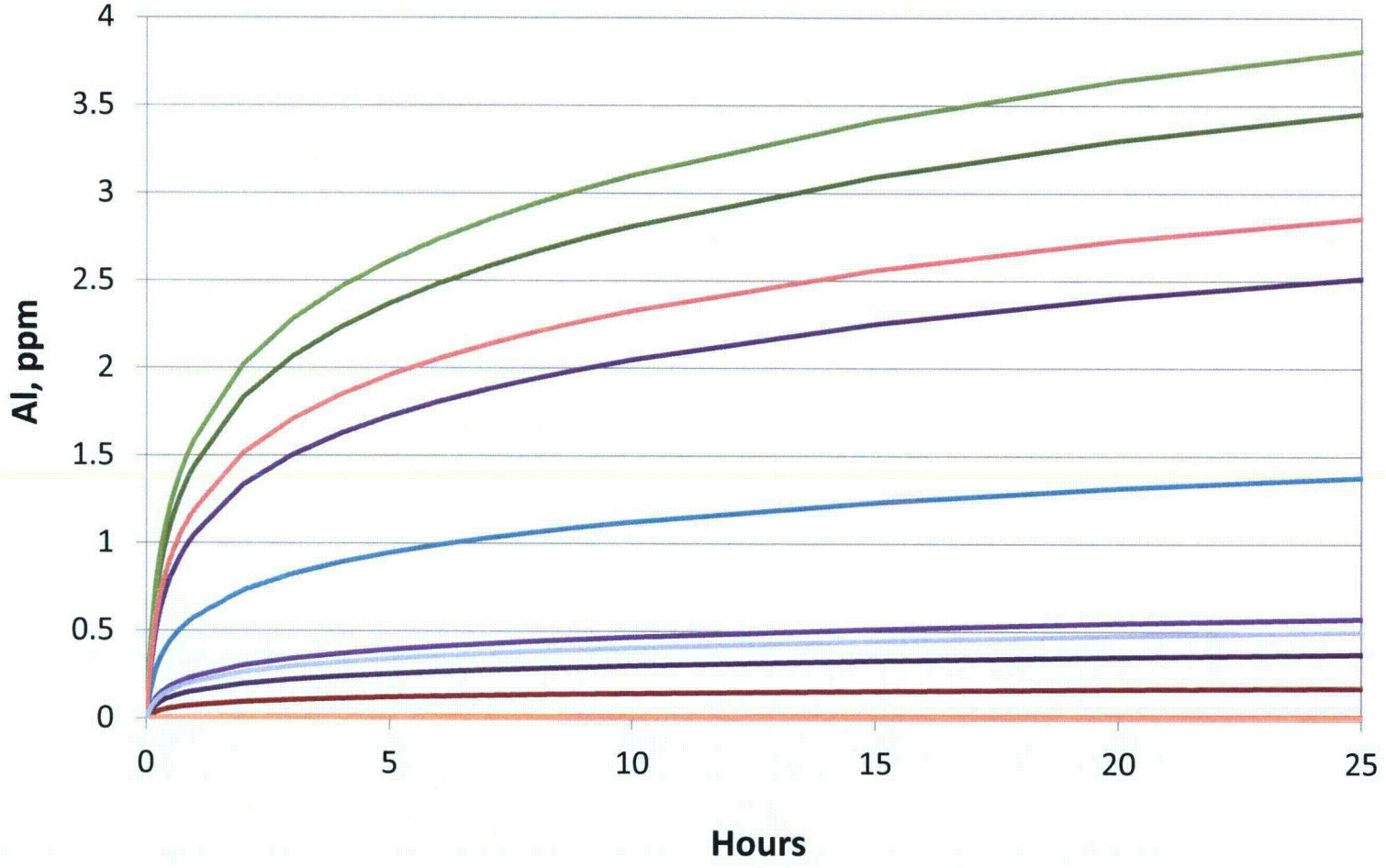
Summary

- Time dependent release rate for initial 72 hours based on average release rate correlations for Al in buffered water
- Release rate at 72 hours used for remainder of mission time
- Total releases estimated by integrating releases over mission time
- Preliminary BWROG site survey data (non-zero values)
- Aluminum Area: 0.0002 to 0.390 ft2 / ft3 Solution
- Containment Liquid Volume ~~(median)~~: 68,000 to 167,000 ft3
- Release and concentration estimates developed using individual plant values

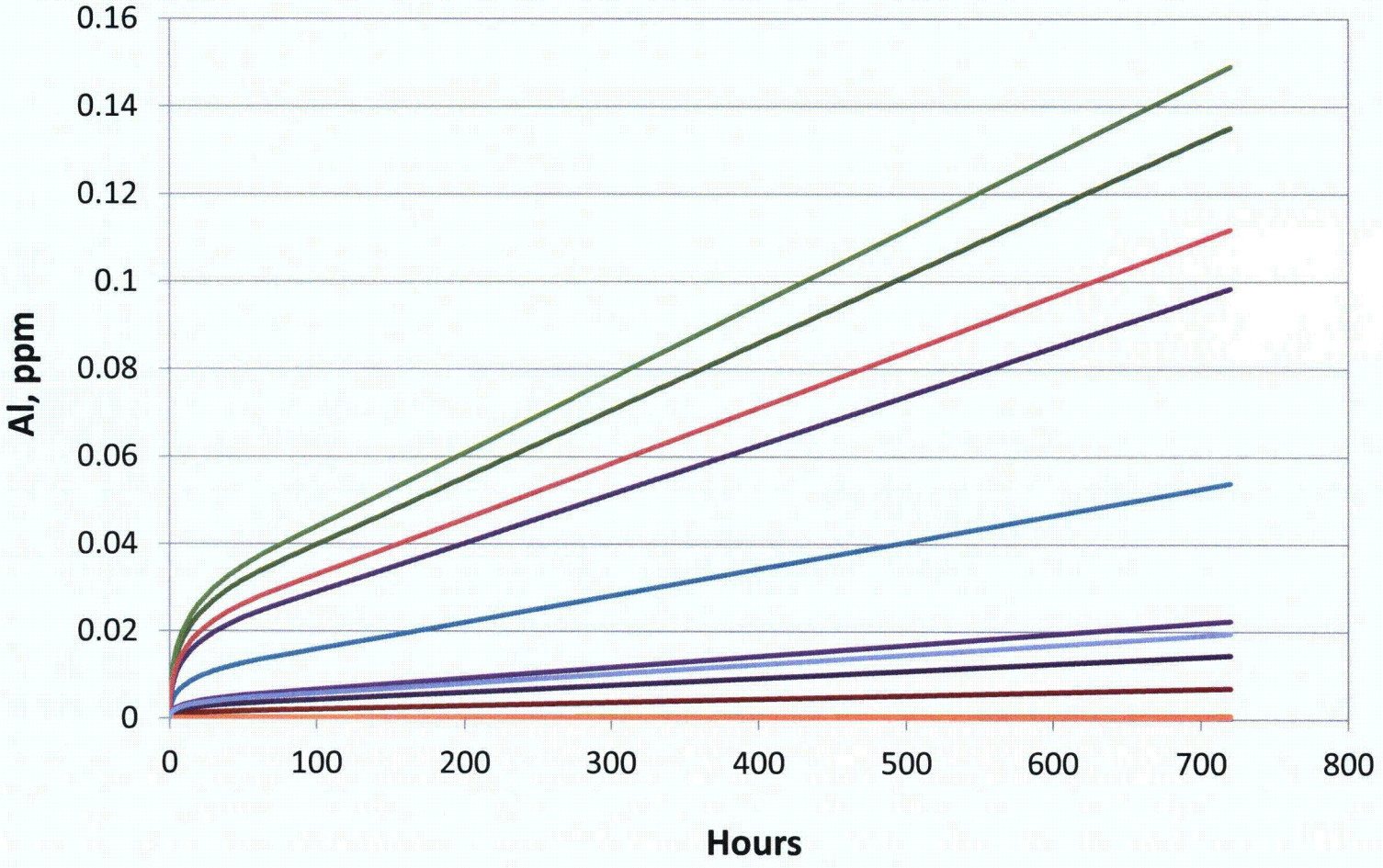
Containment Solution Aluminum Concentrations at Individual Plants (Buffered Solution)



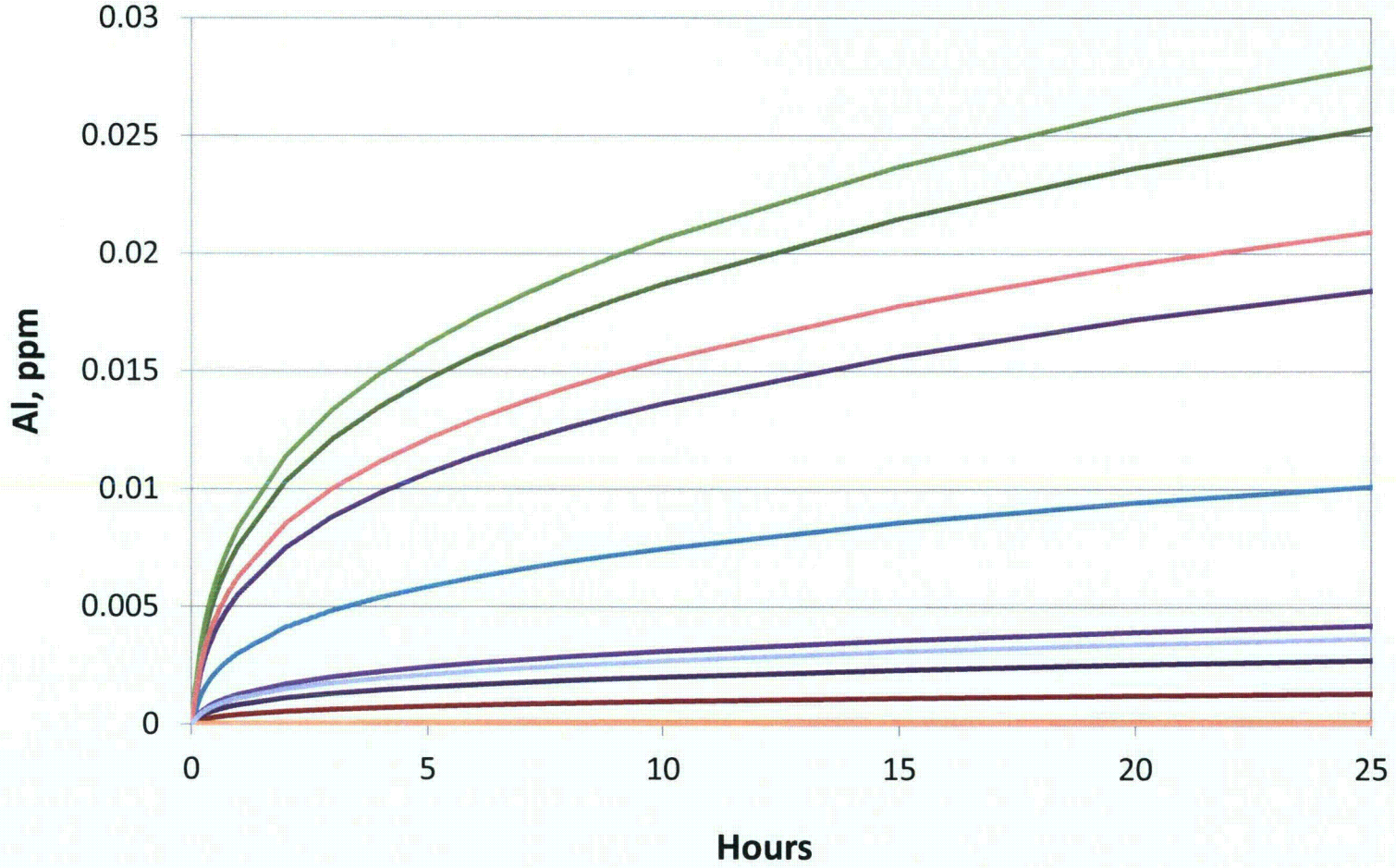
Containment Solution Aluminum Concentrations at Individual Plants (Buffered Solution)



Containment Solution Aluminum Concentrations at Individual Plants (Demin Water)



Containment Solution Aluminum Concentrations at Individual Plants (Demin Water)



Effect Summary of Solution Chemistry on Aluminum Release

Solution	Al, ppm	# of plants
Buffered	<0.1	22
	0.1 to <1	2
	1 to <5	5
	5 to <15	4
Demin water	<0.01	24
	0.01 to <0.15	9

Solution	Al Release, kg	# of plants
Buffered	<0.1	18
	0.1 to <1	4
	1 to <5	4
	5 to <55	7
Demin water	<0.1	28
	0.1 to <0.6	5

Summary

Basis for developing preliminary estimates of plant specific material releases and solution concentrations developed

Qualitative assessments of the tendency of chemical effects on ECCS Suction Strainer pressure drop can be made from such estimates

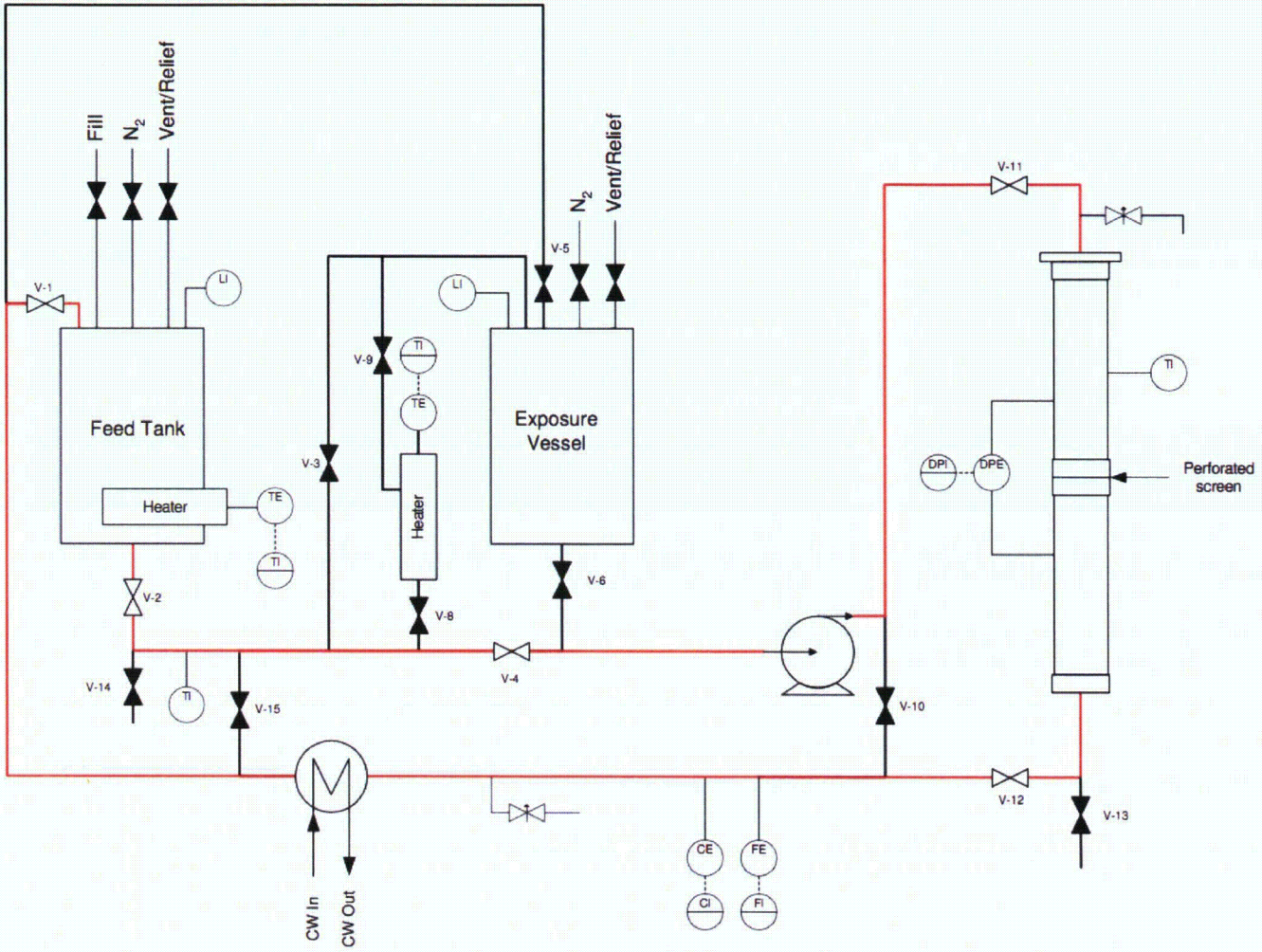
Additional testing planned in 2014 with mixed materials and bounding LOCA event temperature profile to confirm / augment available data

Test plan parameters to be based on tendency for chemical effect

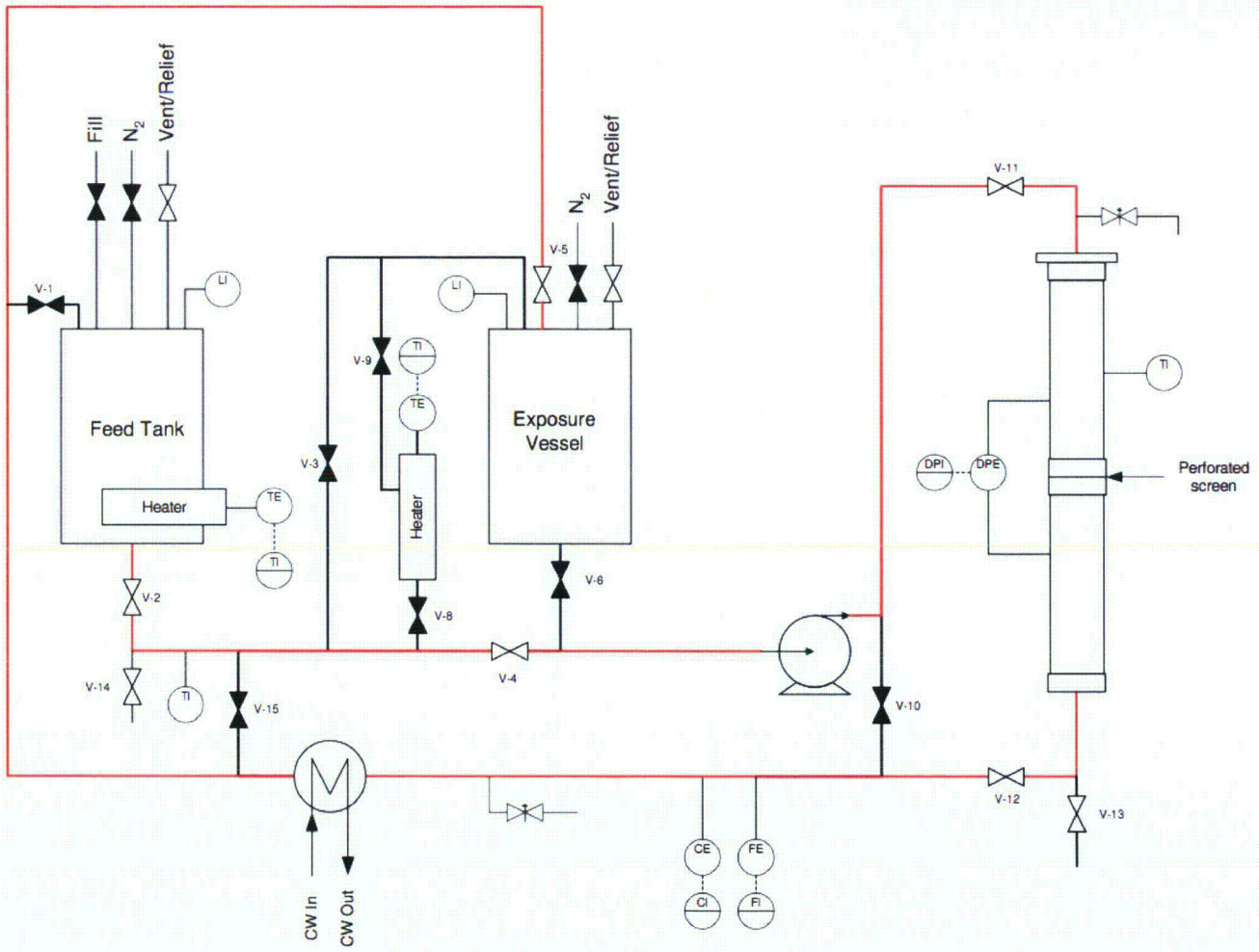
- Minimal tendency at low total releases and concentrations of possible precipitate precursors
- Increased tendency as releases and concentrations increase

Multi-parameter based assessment needed to assure that test parameters bracket plant parameters

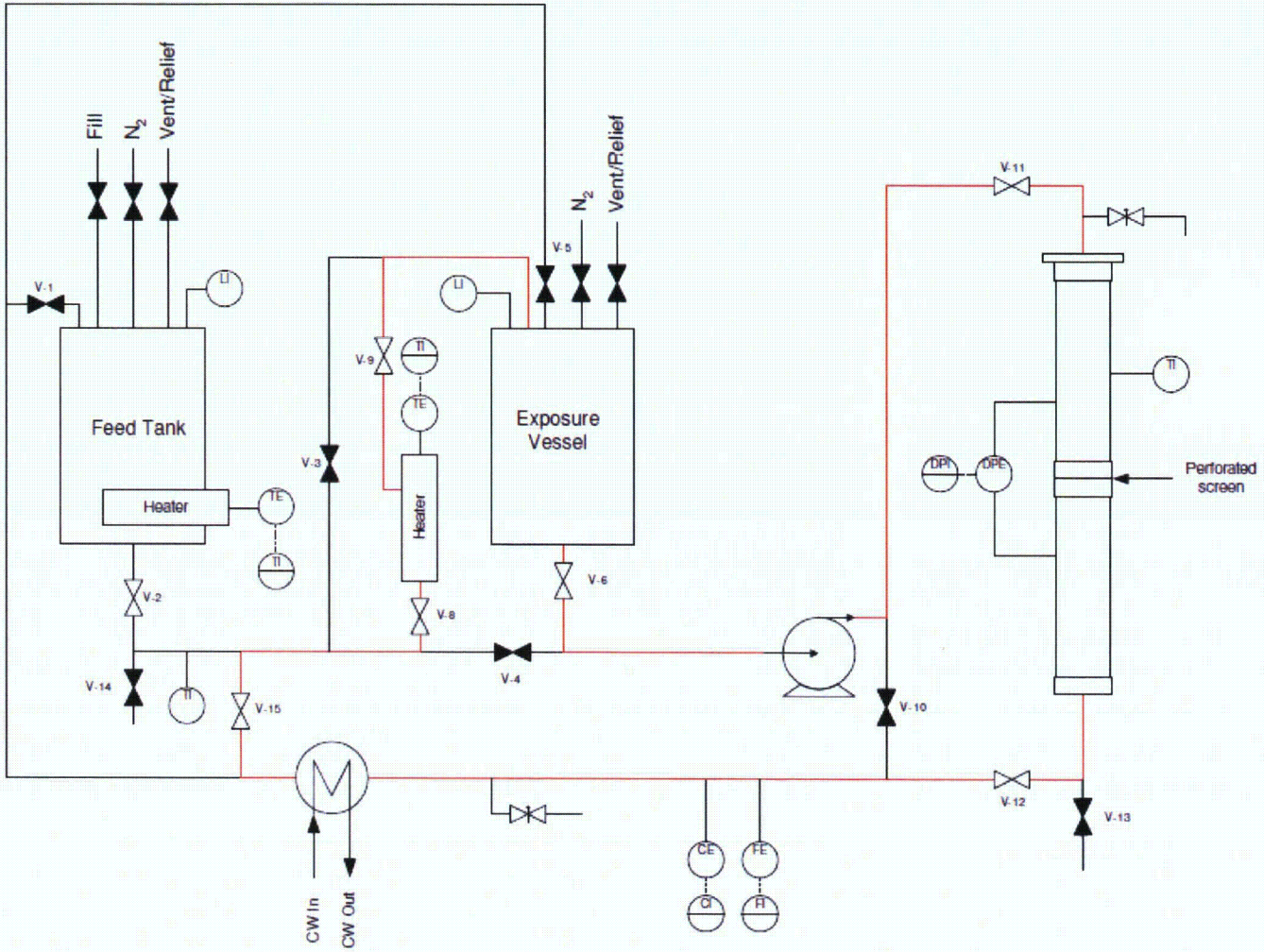
Chemical Effects Testing in 2014
ECCS SS Loop Schematic: Filter Precoat



Chemical Effects Testing in 2014
ECCS SS Loop Schematic: Exposure Tank Fill



Chemical Effects Testing in 2014
ECCS SS Loop Schematic: Normal Operation



Test Loop

Parameters

• Feed Tank Volume	25 Gallons
• Exposure Vessel Volume	17 Gallons
• Filter Vessel ID	4 inches
• Screen Area	0.067 ft2 (3/32 holes; 5/32 spacing)
• Flow Rate	1 to 4 gpm (3 gpm Target)
• Facial Velocity	0.03 to 0.13 fps (0.1 fps Target)
• Materials	304 and 316 SS

Preliminary Test Procedure

Prepare specimens and install in empty exposure vessel

Fill feed tank and remainder of the loop (except exposure vessel) with either demineralized water or NaPB solution

Purge fill and exposure vessels with N2 to an O2 concentration of <5% consistent with BWR containment inerting. The liquid phase will not be degassed

Initiate flow through filter vessel bypassing the exposure vessel

Heat feed tank to ~190 F while continuing recirculation

Initiate sampling and analysis program

Add fibrous material and sludge as dilute slurry to feed tank (no fibrous material will be added to the exposure vessel)

Build filter cake by recirculation from feed tank through filter vessel

Preliminary Test Procedure (cont.)

Divert flow from the filter vessel outlet to the exposure vessel to fill exposure vessel to desired level

Re-route all of the filter vessel outlet flow through the loop heaters to the exposure vessel once the desired exposure vessel water level has been reached

Isolate the feed tank

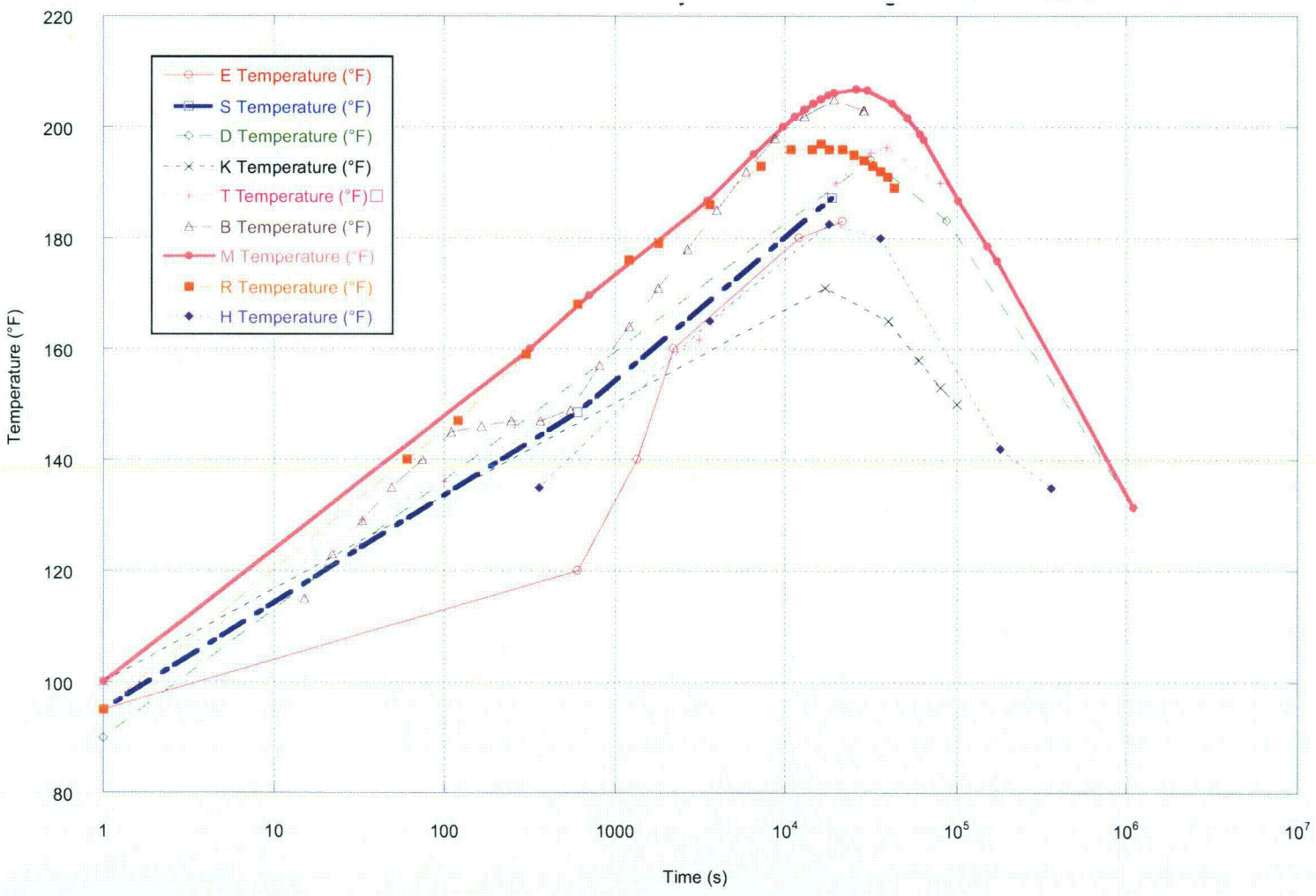
Continue operation following the post-LOCA temperature profile over 15 day period

Add makeup solution as necessary to compensate for sampling losses

Terminate flow through filter vessel

Isolate filter vessel, drain, and remove filter cake for visual inspection and analysis

Chemical Effects Testing in 2014
Integrated Testing Temperature Profile



Chemical Effects Testing in 2014
Precipitate Formation Assessment

Summary

- Potential precipitate formation will be measured during bench-top tests for a variety of reactive material combinations
- Buffered and unbuffered solutions will be tested
- Materials will be exposed for two days at 200°F, cooled to 140°F, held for one day, assessed for precipitate formation, cooled to 110°F, held for one day, and assessed for precipitate formation
- Precipitates will be collected via filtration and characterized using SEM / XRD if sufficient material is collected
- Material dissolution will be measured via GFAA / ICP of solution

Summary

Basis for developing preliminary estimates of containment solution concentrations developed

BWROG plant survey results are currently being validated

Bench-top and loop test parameters will be based on BWROG plant survey results

Plant survey results to be submitted to NRC (currently scheduled for 3Q 2014)

Revised test plan based on survey results to be submitted to NRC (currently scheduled for 3Q 2014)

Integrated material dissolution testing to continue into 2015

Public Meeting Summary

Key Aspects

- Fuels Testing LTR review status / ETA of SER
- Benchtop Test reviews status / comments
- Review status / comments of YTD 2014 submittals
- Agreement with 2014 submittal plan revision
- Agreement with overall project extension to 2020 from 2018
- Latent Debris issue clarity