NRC Expectations when Addressing Chemical Effects, Downstream Effects, and Coatings

Dr. Brian Sheron

Associate Director for Project Licensing and Technical Analysis - NRR

6/30/05

1

Staff Expectations

- Chemical Effects
- Downstream Effects
- Coatings

2

Addressing Chemical Effects

- The staff expectation is that chemical effects must be addressed when responding to GL 2004-02
- Initial results from ICET indicate that chemical effects may be a real issue with the potential to influence sump head loss values

3

Addressing Chemical Effects

- Licensees are expected to account for chemical effects in sump design:
  - Need to address chemical effects apparent from
    - Regulatory Guide 1.82, Draft Issuance: 2/03, Final Issuance: 11/03
    - Generic Letter 2004-02, Draft Issuance: 4/04, Final Issuance: 9/04
  - NRC staff expectation elaborated upon in 8/25/2004 letter from B. Sheron to A. Pietrangelo
  - NRC SE states that if chemical effects are observed during ICET, the licensee needs to evaluate sump screen head loss consequences
  - NRC SE states chemical effects should be addressed on a plant - specific basis
    - Differences in plant materials, quantities and sump pool environment and those used in ICET must be addressed

4

Addressing Chemical Effects

- Staff is not issuing design guidance to address chemical effects or the associated head loss consequences
  - licensee is responsible for determining potential head loss and necessary margins (e.g., - remove problematic insulation)
  - licensee is required to provide technical justification for chemical effects and associated head loss consequences

5

Addressing Chemical Effects

- Methods and technical justification used to evaluate chemical effects are expected to be included in the September 2005 licensee submittals
- Licensees may address chemical effects in their September 2005 response by adding head loss margin to their analysis. If a licensee expects to perform further testing to support their head loss margin, the staff will accept updates to the September 2005 submittal that reflect new information resulting from additional testing and analysis.
- If a licensee plans additional testing and analysis, the staff expects a detailed description of those actions and a timeline for completion of those actions to be included in the September 2005 response.
- If a licensee does not address chemical effects in September 2005 submittal, the staff will conclude the design has not been sufficiently shown to comply with 10 CFR 50.46 with regard to long term cooling.

6

Chemical Effects: Additional Confirmatory Research Activities

- The NRC has initiated confirmatory research activities to understand implications associated with chemical effects in the following areas.
  - Head loss implications: Head loss associated with ICET chemical by-products and the effect of important environmental variables (time, temperature, containment materials, etc.) is being investigated.
  - Chemical speciation prediction: Analytical tools for predicting the chemical products which may form in specific sump environments are being evaluated.
- These activities are supporting the staff's evaluation of licensee responses to GL 2004-02.
  - Results will not be used to modify the SE
- More information on these activities will be provided subsequently by RES.

7

Addressing Downstream Effects

- Licensee is expected to account for downstream effects in sump design:
  - Downstream effects a recognized part of GSI-191 since August 2002 public meeting
  - Downstream effects addressed in Bulletin 2003-01, which addressed interim compensatory measures
  - Staff emphasized at August 2003 Industry Sump Workshop that generic letter would include downstream effects
  - Downstream effects included in April 2004 draft generic letter and final version in September 2004
  - NRC SE states that licensees should evaluate downstream effects

8

Addressing Qualified Coatings

- When crediting qualified coatings, the staff expects that a licensee will be able to demonstrate that those coatings will remain adherent during a LOCA
  - NRC SE requires assessment of coatings
    - Need to determine if degraded qualified coatings exist and amount
  - Licensees must have a surveillance program to periodically monitor & assess the coatings
    - Ensures the assertion that qualified coatings will continue to meet intended function
    - Ensures that quantities of degraded & unqualified coating used in analysis remains bounding over time
  - Demonstration cannot rely only on visual assessment
    - Expect licensee will provide the Methods, Criteria and Technical Justification used for demonstrating the coating will meet its intended function
    - If degradation is identified the methods and criteria must also be capable of determining the extent of condition

9

Addressing Qualified Coatings

- Where a licensee does not demonstrate the coating will remain adherent in event of LOCA
  - Staff expects the licensee to assume all coating will fail
    - NRC SE specifies that all degraded qualified coatings are assumed to fail
    - Account for the transport and potential impact of this debris in containment sump design
    - Technical justification will need to be provided for assertions regarding coating debris characteristics and associated transport that deviate from NRC SE

10

Generic Letter 2004-02

GL 2004-02 expected completion date including chemical and downstream effects

12/07

11

NRC Expectations when Addressing Chemical Effects, Downstream Effects, and Coatings

Dr. Brian Sheron

Associate Director for Project Licensing and Technical Analysis - NRR

6/30/05

1

Staff Expectations

- Chemical Effects
- Downstream Effects
- Coatings

2

Addressing Chemical Effects

- The staff expectation is that chemical effects must be addressed when responding to GL 2004-02
- Initial results from ICET indicate that chemical effects may be a real issue with the potential to influence sump head loss values

3

Addressing Chemical Effects

- Licensees are expected to account for chemical effects in sump design:
  - Need to address chemical effects apparent from
    - Regulatory Guide 1.82, Draft Issuance: 2/03, Final Issuance: 11/03
    - Generic Letter 2004-02, Draft Issuance: 4/04, Final Issuance: 9/04
  - NRC staff expectation elaborated upon in 8/25/2004 letter from B. Sheron to A. Pietrangelo
  - NRC SE states that if chemical effects are observed during ICET, the licensee needs to evaluate sump screen head loss consequences
  - NRC SE states chemical effects should be addressed on a plant - specific basis
    - Differences in plant materials, quantities and sump pool environment and those used in ICET must be addressed

4

Addressing Chemical Effects

- Staff is not issuing design guidance to address chemical effects or the associated head loss consequences
  - licensee is responsible for determining potential head loss and necessary margins (e.g., - remove problematic insulation)
  - licensee is required to provide technical justification for chemical effects and associated head loss consequences

5

Addressing Chemical Effects

- Methods and technical justification used to evaluate chemical effects are expected to be included in the September 2005 licensee submittals
- Licensees may address chemical effects in their September 2005 response by adding head loss margin to their analysis. If a licensee expects to perform further testing to support their head loss margin, the staff will accept updates to the September 2005 submittal that reflect new information resulting from additional testing and analysis.
- If a licensee plans additional testing and analysis, the staff expects a detailed description of those actions and a timeline for completion of those actions to be included in the September 2005 response.
- If a licensee does not address chemical effects in September 2005 submittal, the staff will conclude the design has not been sufficiently shown to comply with 10 CFR 50.46 with regard to long term cooling.

6

Chemical Effects: Additional Confirmatory Research Activities

- The NRC has initiated confirmatory research activities to understand implications associated with chemical effects in the following areas.
  - Head loss implications: Head loss associated with ICET chemical by-products and the effect of important environmental variables (time, temperature, containment materials, etc.) is being investigated.
  - Chemical speciation prediction: Analytical tools for predicting the chemical products which may form in specific sump environments are being evaluated.
- These activities are supporting the staff's evaluation of licensee responses to GL 2004-02.
  - Results will not be used to modify the SE
- More information on these activities will be provided subsequently by RES.

7

Addressing Downstream Effects

- Licensee is expected to account for downstream effects in sump design:
  - Downstream effects a recognized part of GSI-191 since August 2002 public meeting
  - Downstream effects addressed in Bulletin 2003-01, which addressed interim compensatory measures
  - Staff emphasized at August 2003 Industry Sump Workshop that generic letter would include downstream effects
  - Downstream effects included in April 2004 draft generic letter and final version in September 2004
  - NRC SE states that licensees should evaluate downstream effects

8

Addressing Qualified Coatings

- When crediting qualified coatings, the staff expects that a licensee will be able to demonstrate that those coatings will remain adherent during a LOCA
  - NRC SE requires assessment of coatings
    - Need to determine if degraded qualified coatings exist and amount
  - Licensees must have a surveillance program to periodically monitor & assess the coatings
    - Ensures the assertion that qualified coatings will continue to meet intended function
    - Ensures that quantities of degraded & unqualified coating used in analysis remains bounding over time
  - Demonstration cannot rely only on visual assessment
    - Expect licensee will provide the Methods, Criteria and Technical Justification used for demonstrating the coating will meet its intended function
    - If degradation is identified the methods and criteria must also be capable of determining the extent of condition

9

Addressing Qualified Coatings

- Where a licensee does not demonstrate the coating will remain adherent in event of LOCA
  - Staff expects the licensee to assume all coating will fail
    - NRC SE specifies that all degraded qualified coatings are assumed to fail
    - Account for the transport and potential impact of this debris in containment sump design
    - Technical justification will need to be provided for assertions regarding coating debris characteristics and associated transport that deviate from NRC SE

10

Generic Letter 2004-02

GL 2004-02 expected completion date including chemical and downstream effects

12/07

11

Options to Address Margin for Chemical Effects

NEI

Objective

- Identify "target margins" and options for addressing chemical effects in September response
- Discuss planned vendor activities to address impact of chemical effects on strainer performance

NEI

Target Margin Table

- Intended to provide interim guidance for level of margin to address chemical effects on strainer performance
  - Information is preliminary, based on limited test data
  - Guidance will be supplemented (where schedule allows) with subsequent test data
- "Target Margin" guidance represents a baseline
  - Application of target margin supported by options that include both quantifiable and qualitative margin sources
  - "Target Margin" adjusted up or down based upon plant features, anticipated design changes
- Margin assessments to be confirmed or superseded by ongoing and follow on test results and evaluation

NEI

3

Adjustment Factors for Test 1

Chemical Effect or Product	Draft Adjustment Factor (Headloss)	Basis
• Sediment particulate	• 10% from initiation of recirculation from containment sump	• The quantity of sediment formed is relatively small, but contains large coagulated particles. Settling period was in first 36 hours. Since coagulation has occurred, transportability of latent debris and fiberglass shards should be considered significantly reduced from no chemical effects case.
• Precipitate particulate	• 0 at 60C to 10% at 23C, increasing from 0 at time 0 to 10% at 20 days and beyond	• Run data indicates precipitate is formed as sump solution cooled. Amount of dissolved material available to form precipitate is a function of test exposure time (corrosion rate for Al * time).
• Kinematic viscosity increase	• From 1.0 to 1.6 mm2/sec as T reduced from 60C to 23C	• Preliminary data from ICET run 1 indicates an apparent increase in viscosity as solution cooled.
• Sump solution deposition in or reaction with fiberglass	• 0 at initiation of recirculation to 5% at day 5 to 10% at day 15 and beyond	• SEM images indicates deposition of material on external fiberglass, increasing with test or loop exposure time.

NEI

4

Adjustment Factors for Test 2

Chemical Effect or Product	Draft Adjustment Factor (Headloss)	Basis
• Sediment	• 2% from initiation of recirculation from containment sump	• Run 2 material did not seem to coagulate, and latent debris and fiberglass shards should be assumed to be highly transportable. A small head loss increase allowance is made for a small amount of reaction product
• Sump solution deposition in or reaction with fiberglass	• 0 at initiation of recirculation to 2% at day 5 to 6% at day 15 and beyond	• SEM observations of material in fiberglass

NEI

5

Adjustment Factors for Test 3

Chemical Effect or Product	Draft Adjustment Factor (Headloss)	Basis
• Sediment	• 5% from initiation of recirculation from containment sump	• Some precipitation occurred shortly after TSP was injected, forming a small amount of light, white material. It should be assumed that the TSP and other debris is highly transportable.
• Sump solution deposition in or reaction with fiberglass	• 0 at initiation of recirculation to 2% at day 5 to 6% at day 15 and beyond	• Similar run 2 TSP.

NEI

6

Adjustment Factors for Tests 4 & 5

- Awaiting release of test data

NEI

Options for Addressing Chemical Effects

- Incorporation as part of new Design
- Analysis Conservatism
- Procedural/Operational Changes

NEI

Design Change/Features

- Screen area
  - Flow area margin in base design
- Active design factors
  - Self Cleaning design
  - Backwash capabilities
  - Sacrificial screen surface area
- Conservatism in pump performance capability
  - Capability of pumps to operate at lower NPSH
- Exemption to 50.46 (large break LOCA redefinition; License change)

NEI

Design Change/Features

- Change pH buffering agent
  - NaOH to TSP
- Reduce design flow
  - Containment spray flow
  - ECCS flow
- Reduction of debris sources
  - Insulation change-out
  - Debris reduction strategies
  - Reduce unqualified coatings
- Pump internals change-out

NEI

Analysis Conservatisms

- Conservatism in methodology
  - Quantification of debris sources
  - Coatings ZOI
  - Coatings size distribution
  - Treatment of unqualified coatings
- Transient effects
  - Sump fluid temperature history
  - Transient NPSH vs. Bounding NPSH
  - Containment Backpressure
- Chapter 6 "Alternate Evaluation" of NEI 04-07

NEI

Procedural/Operational Changes

- Reduction of submerged Aluminum
- Increase to pool depth
  - Replenish RWST/BWST inventory
- Throttle flow/Secure a train
  - Containment spray flow
  - ECCS flow

NEI

Hardware Vendor Activities to Address Chemical Effects on Strainer Performance

- Cooperative Activities Planned by 3 Vendor Teams
  - Alion/Enercon/Westinghouse
  - Framatome/PCI
  - CCI
- General Electric
- AECL

NEI

NRC Expectations For Chemical Effects Evaluations

Paul Klein
Shanlai Lu
Office of Nuclear Reactor Regulation
6/30/2005

Outline

- Chemical Effects History
- ICET Test Result Implications
- Sample Chemical Effects Evaluation Roadmap
- NRC Expectations Summary

GSI-191 Chemical Effects History

- 2003 - ACRS Expresses Chemical Effects Concern
- Nov. 2003, LANL Report Issued:

  "Small Scale Experiments: Effects of Chemical Reactions on Debris Bed Head Loss
- March 2004 - Draft GL Issued For Public Comment
- August 2004 - Letter from NRC (B. Sheron) to NEI
- September 2004 – GL 2004-02 Issued
- November 2004 – ICET Test #1 Initiated
- December 2004 – NRC Safety Evaluation Issued
- January, April, June, 2005 - Public Meetings

ICET Test Result Implications

- Variations in ICET parameters (Tests 1-4) produced significantly different chemical effects:
  Plant specific conditions may lead to different products than those observed in the ICET tests.
- Chemical product constituents vary within the ICET series:
  Important to understand how changes in important chemical effects variables apply to plant specific environments.
- Chemical products formed at different times:
  Timing of chemical product formation affects head loss consequences.
- Temperature dependence of Test#1 amorphous precipitant:
  Considered in analysis of head loss & downstream effects for applicable plants.

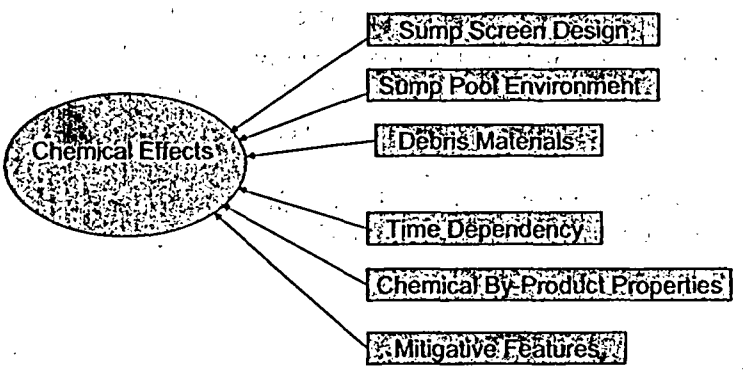
ICET Test Result Implications

– Formation of amorphous chemical products, insulation deposits in certain ICET environments: Testing is needed to determine head loss consequences.

5

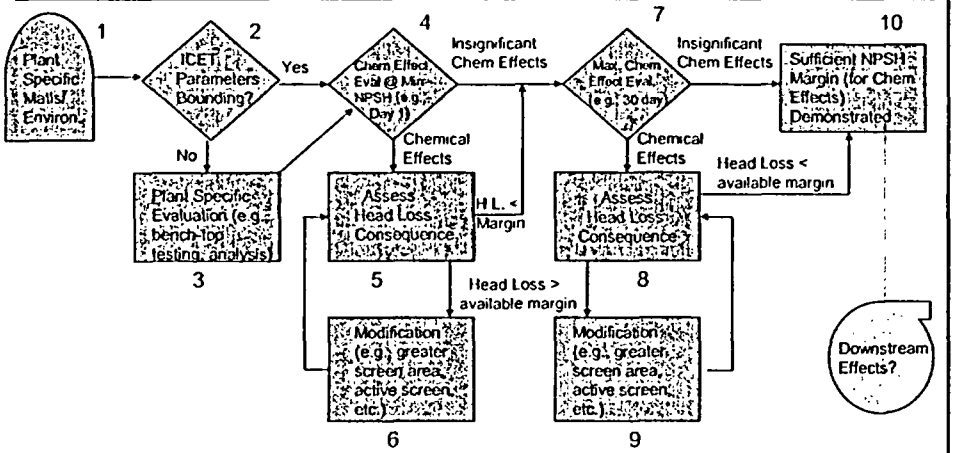
Chemical Effects Evaluations

- Many factors involved in chemical effects evaluation
- Chemical Effects are one part of GSI-191 evaluation
- For some by-products, potential for significant head loss



6

Sample Chemical Effects Evaluation Flowchart



7

Chemical Effects Flowchart

Plant Specific Materials-Sump Pool Environment Comparison to ICET Parameters (Block 2)

- Materials – type and amounts (e.g., metallic, insulation, concrete)
- Sump Pool Env. – pH and buffering agent (e.g., TSP, NaOH)
- Crystal River audit report provides some items for consideration.
- ICET results indicate key contributors to chemical by-products are test specific.
- Bench-top testing may be needed to compare plant specific materials-sump pool environment to ICET results.

8

Chemical Effects Flowchart

Time Dependent Consideration of Chemical Effects To Demonstrate Adequate Head Loss Margin (Blocks 4, 7)

Chemical Effects Evaluation @ Minimum NPSH Margin Conditions (Block 4)

- Point during recirculation phase when plant conditions, including chemical effects, provides for least NPSH margin

Maximum Chemical Effects Evaluation (Block 7)

- Evaluation of Total Head Loss at the point of maximum chemical effects (e.g., greatest head loss contribution from chemical products)

Chemical Effects Flowchart

Assess Head Loss Consequences (Blocks 5, 8)

- Per the NRC SE, if chemical effects are observed during ICET, licensees need to evaluate the sump screen head loss consequences.
- Testing will support a realistic chemical effects evaluation
  - Address head loss consequences for ICET chemical products
  - Address uncertainties in plant specific environments
- Without a sound technical basis, a more conservative evaluation will be necessary.

Summary

- Staff expectation is that chemical effects must be addressed when responding to GL 2004-02.
- If a licensee plans additional testing and analysis to support assumptions in the GL response, the staff expects a detailed description and timeline for those actions.

Chemical Effects: Recent ICET Results & Implications and NRC Confirmatory Research Activities

Rob Tregoning
Paul Klein
BP Jain
Nuclear Regulatory Commission

Bruce Letellier
Jack Dallman
Los Alamos National Laboratory

Kerry Howe
Arup Maji
University of New Mexico

Public Meeting on GSI-191 Resolution Status
June 30, 2005
NEI Headquarters, Washington, DC

NRC Chemical Effects Research

- Integrated Chemical Effects Testing.
  - Jointly managed with EPRI.
  - Conducted by LANL at the University of New Mexico.
  - NRC Project Manager: B.P. Jain

<u>Confirmatory Activities</u>

- Chemical Effect Head Loss Testing.
  - Conducted by Argonne National Laboratory.
  - NRC Project Manager: Paulette Torres
- Chemical Speciation Analysis.
  - Conducted by the Center for Nuclear Waste Regulatory Analysis
  - NRC Project Manager: B.P. Jain

Integrated Chemical Effects Testing (ICET)

- **Motivation:** Little information on chemical product formation in representative plant sump environments.
- **Objective:**
  - Determine and characterize chemical reaction products that may develop in representative post-LOCA PWR containment sump/spray environments.
  - Licensees utilize results to determine if chemical reaction products may develop in their containment pool environment.
- **Results Communication & Implications:**
  - NRR/Public: NRC Office of Research (RES)
  - Industry: EPRI

ICET: Test Plan Development

- Jointly developed by NRC, LANL, EPRI, and WOG.
- Tests targeted to be representative of important sump pool environmental variables.
  - Metallic and non-metallic containment materials and latent debris loading determined from industry survey and provided by industry.
    - Al, Zn, Cu, Carbon Steel, Concrete, Insulation Materials.
    - Submerged and unsubmerged areas scaled to plant conditions.
  - Test Temperature: 60C (140°F).
  - Test Pressure: Ambient.
  - Flow Velocity over Submerged Coupons: 0 – 3 cm/s.
  - B Concentration: 2800 ppm
  - HCl Concentration: 100 mg/l.
  - LiOH Concentration: 0.7 ppm of lithium.

ICET: Test Description

- Tests simulate five unique chemical environments.
- Primary Variables: pH (buffering agent) and insulation materials.
- Testing initiated in November 2004.
- Scheduled completion in August 2005.

Test Number	Buffering Agent	Insulation Material	Completion Date
1	Sodium Hydroxide: pH ~ 10	100% Fibrous (NUKON)	12/20/04
2	Tri-sodium Phosphate: pH ~ 7	100% Fibrous (NUKON)	3/7/05
3	Tri-sodium Phosphate: pH ~ 7	80% Particulate (CalSil) 20% Fibrous (NUKON)	5/5/05
4	Sodium Hydroxide: pH ~ 10	80% Particulate (CalSil) 20% Fibrous (NUKON)	6/23/05
5	Sodium Tetraborate: pH ~ 9.5	100% Fibrous (NUKON)	8/05

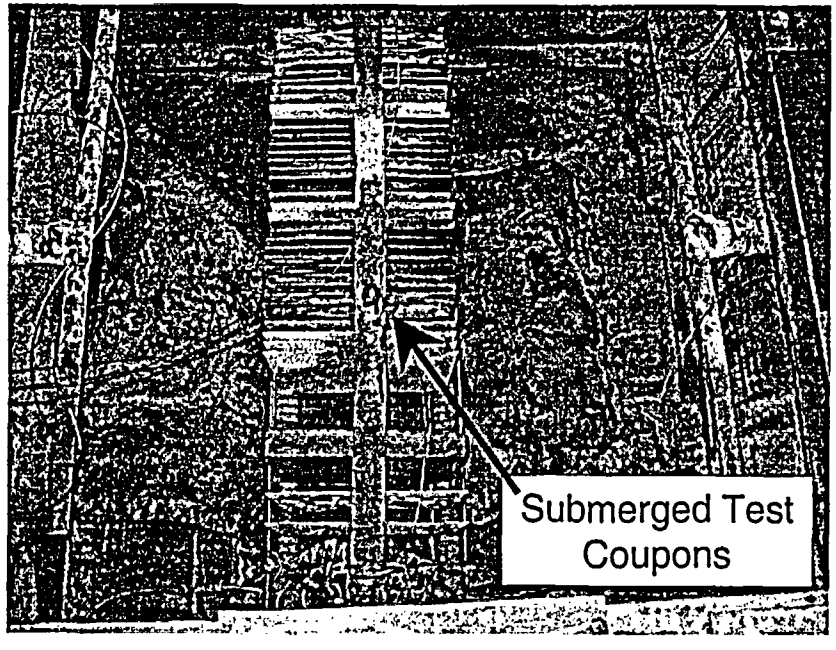
ICET Test 3 General Observations

- White Precipitate
  - **20 minutes into TSP injection**: White flocculent material was visible in fairly large quantities and in large particle sizes. Material entrained in chamber flow.
  - **3 hours**: Size of white material much smaller, but finer and denser.
  - **1 day**: White deposit observed on submerged stainless- steel insulation mesh and galvanized steel coupons.
  - **After testing**: White shiny substance (face cream texture) present in the top layer of sediment, on insulation sample bags, and other test chamber surfaces.

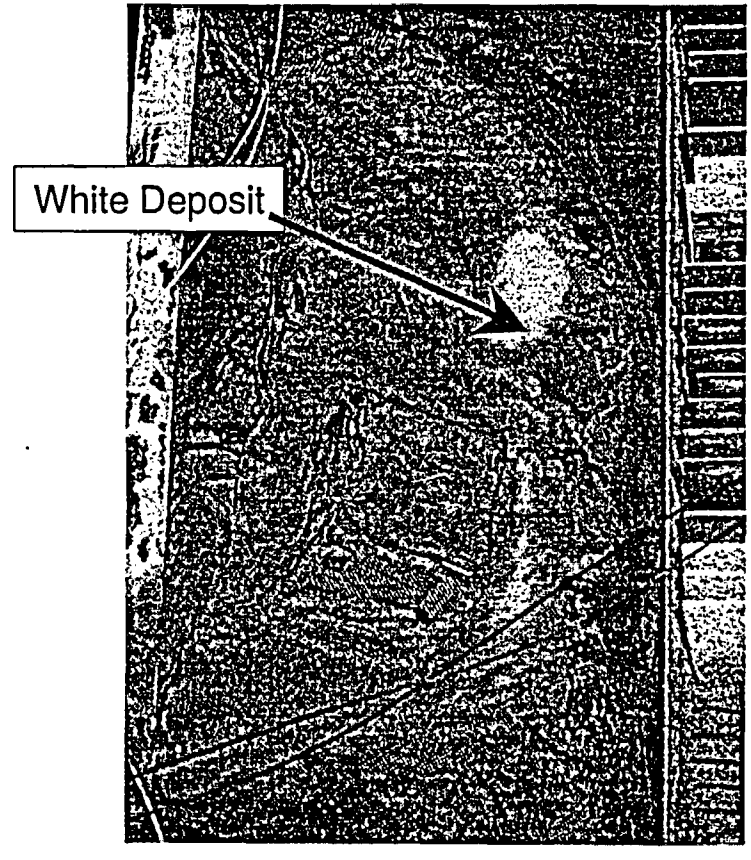
- Flow Meter
  - Stopped working on **Day 8**.
  - Inspection revealed scale and precipitation deposits on flow meter turbine.
  - After cleaning and reinstallation, flow meter operated without failure for remainder of test.
  - No additional deposits apparent at end of test.

ICET Test 3 General Observations

Test Chamber:
Top View after Draining



Close-up of Insulation Bag



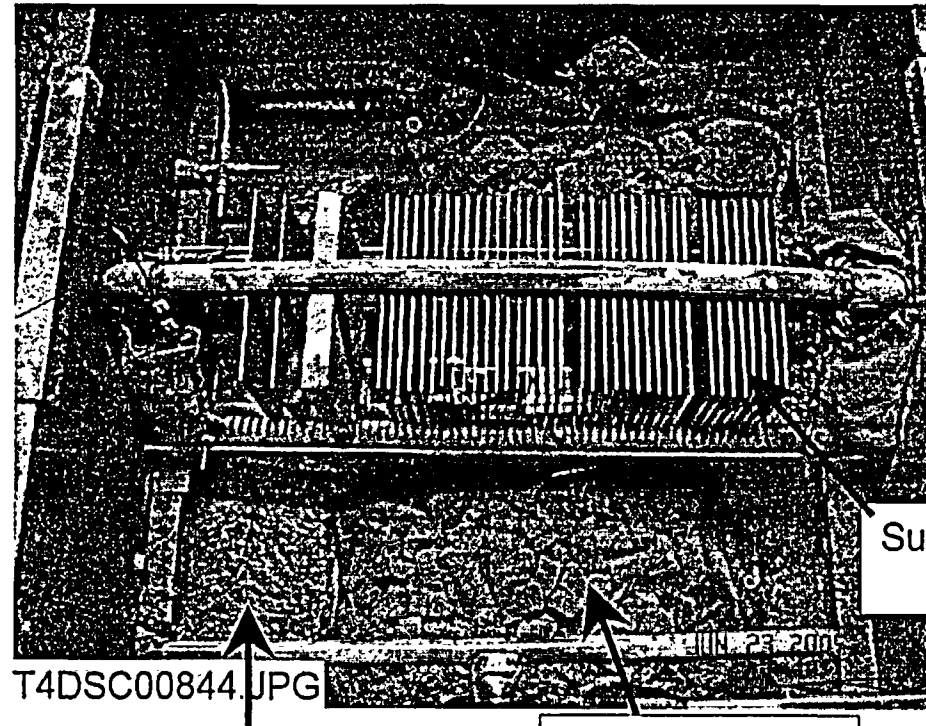
ICET Test 4 General Observations

- **Day 1**: No deposits on coupon racks or insulation, most Cal-Sil had settled.
- Test Observations:
  - Excluding Day zero, tank clarity and color remained constant.
  - No corrosion products are apparent on the submerged coupons.
  - No obvious chemical by-products present in the tank.
  - No precipitates visible in water samples.
- Post-Test Observations.
  - Very little corrosion apparent on submerged specimens, in contrast to Test #1.
  - More corrosion evident of unsubmerged specimens than submerged specimens (especially Al and Zn).
  - Some apparent chemical by-products evident in insulation samples (webbing), but not as prevalent as in Test #1.

ICET Test 4 General Observations

- Less scale in tank after draining compared to Test #3.
- Insulation samples clearly visible in bags.

Test Chamber: Top View during Draining

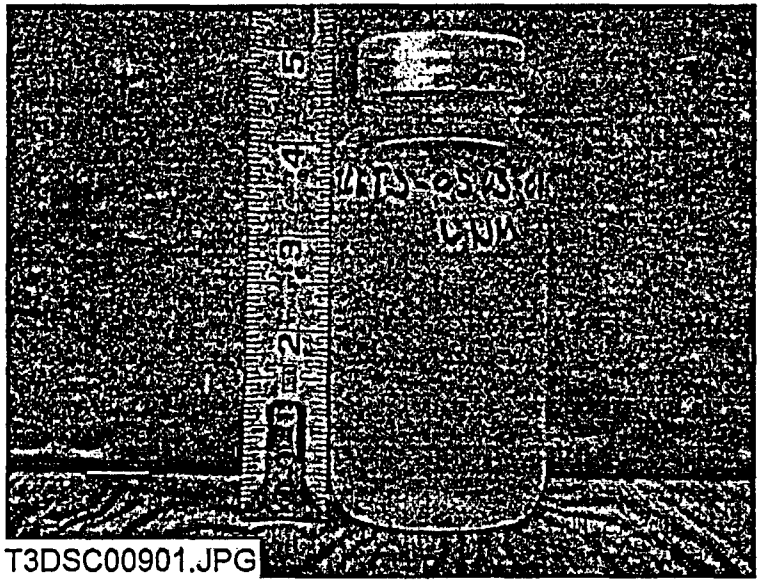


ICET: Findings

- Four test products examined for indication of chemical by-product formation.
- Water sample analysis
- Sediment deposits.
- Insulation samples.
- Test coupon samples: metallic and non-metallic.

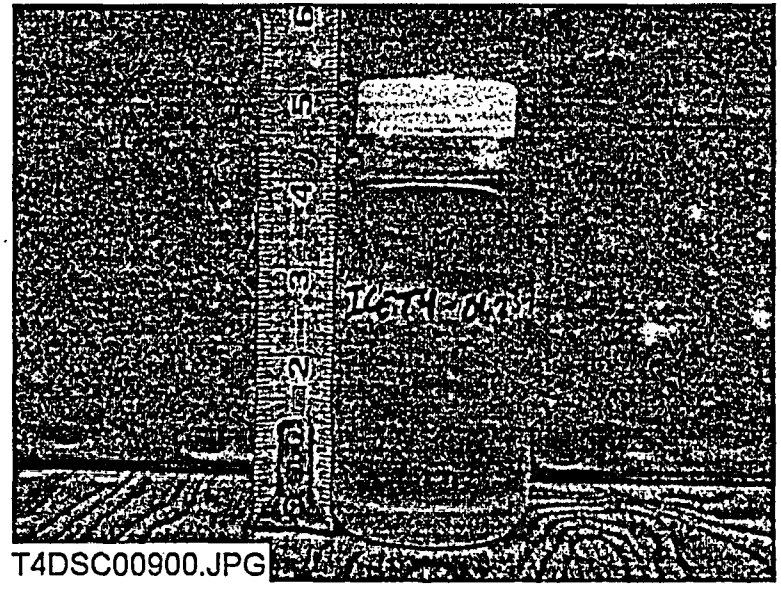
ICET Findings: Water Samples

Test #3



T3DSC00901.JPG

Test #4



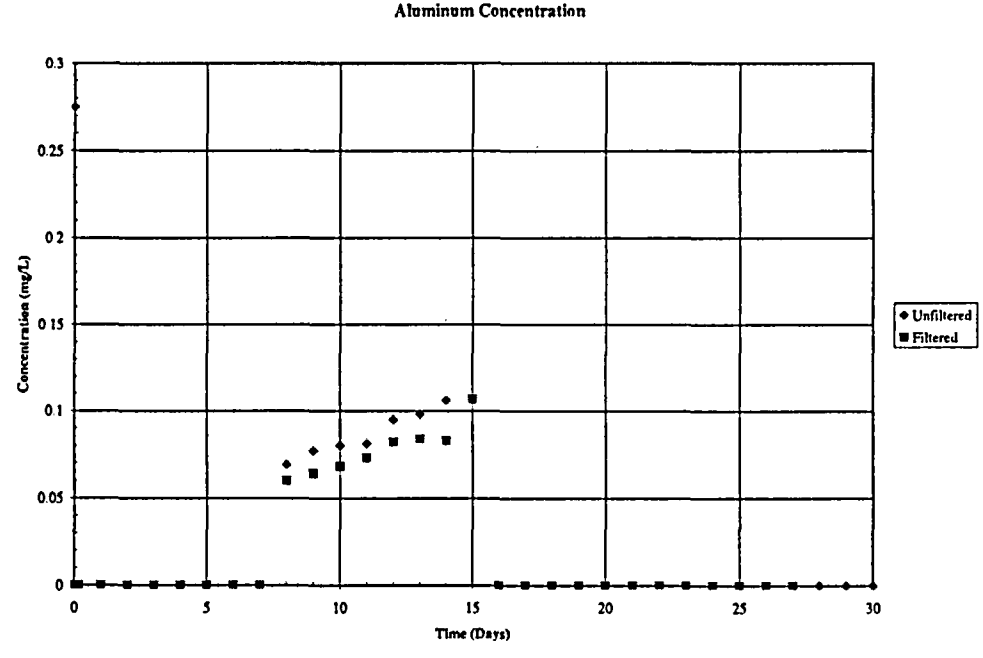
T4DSC00900.JPG

- No precipitants visible at either test temperature or room temperature.
- Precipitants have not appeared as the water samples have aged after the test.
- Test #4 water sample has darkest hue of all environments thus far.

ICET Findings: Aluminum

- Test #3
  - Minimal aluminum concentration.
  - Increase between day 8 and 15, while unexplained, is not expected to be significant.
  - Results are similar to Test #2.
- Test #4
  - Lack of visible corrosion of aluminum samples implies that concentration will be much less than Test #1 (350 mg/L).
  - Corrosion may be inhibited by formation of calcium-carbonate passivation layer.

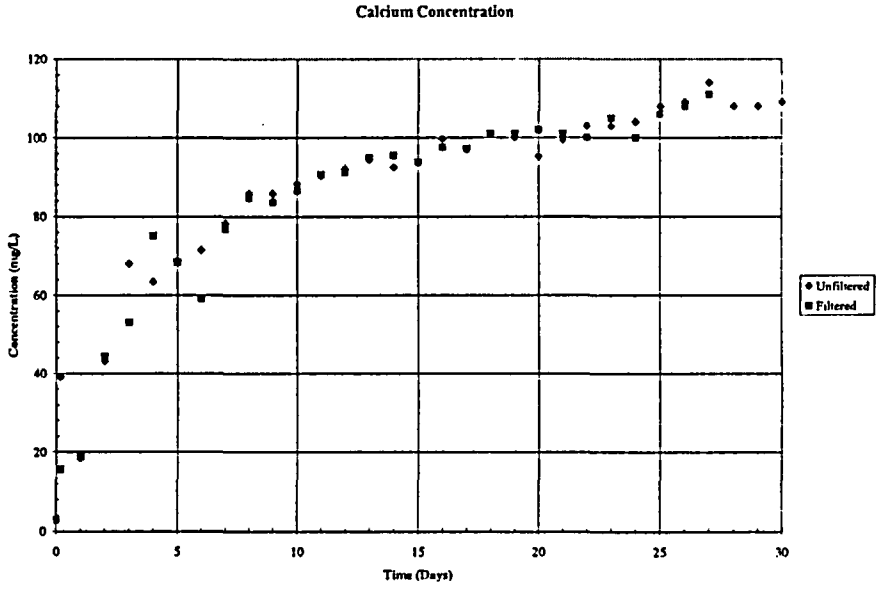
Test #3



ICET Findings: Calcium

- Test #3
  - Substantially higher (factor of i 8) than Tests #1 and #2 due to presence of Cal-Sil
  - Concentration monotonically increases with time.
  - While rate of concentration decreases with time, saturation is not apparent.
- Test #4
  - Chemical analysis for calcium not yet completed.
  - Expected concentrations to be more comparable with Test #3 than Tests #1 and #2 concentrations.

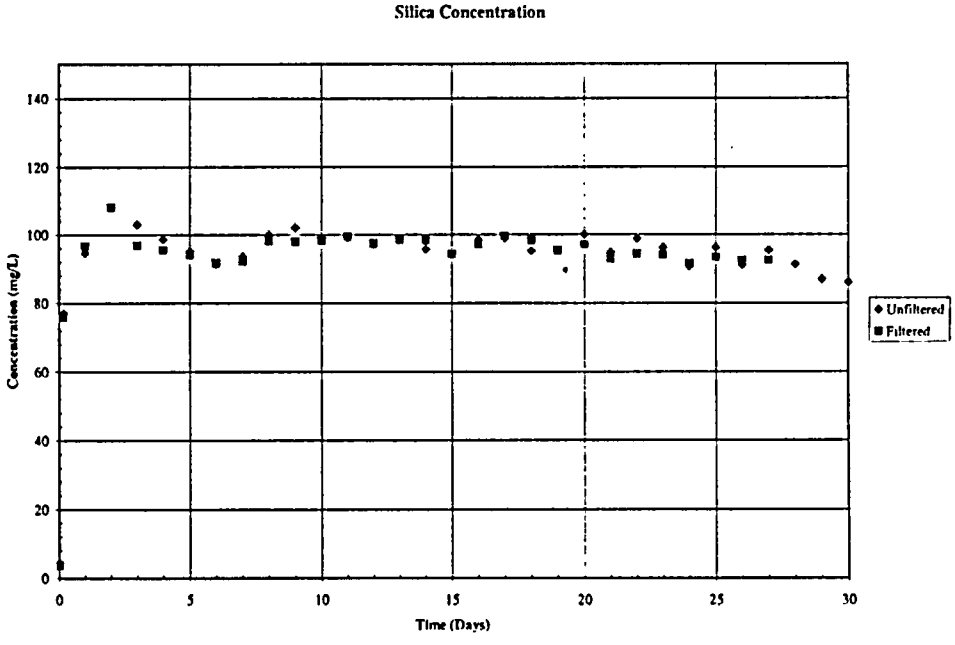
Test #3



ICET Findings: Silicon

- Test #3
  - Silicon concentrations are high and relatively stable after one day.
  - Concentration is only 10% higher than Test #2 saturation concentration after 20 days.
  - Some decrease after day 20 is evident.
- Test #4
  - Chemical analysis for silicon not yet completed.
  - Test #4 concentrations should be most comparable to Test #3 values although differences resulting from test pH may be important.

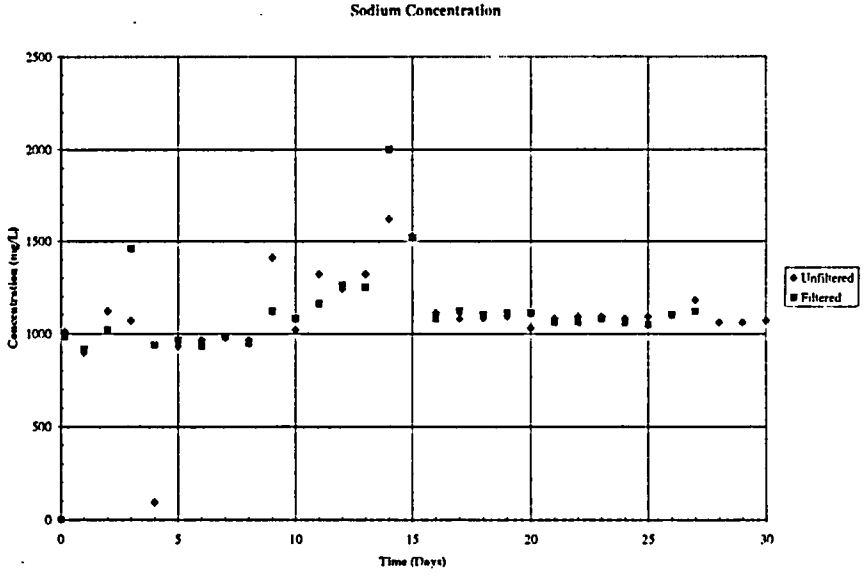
Test #3



ICET Findings: Sodium

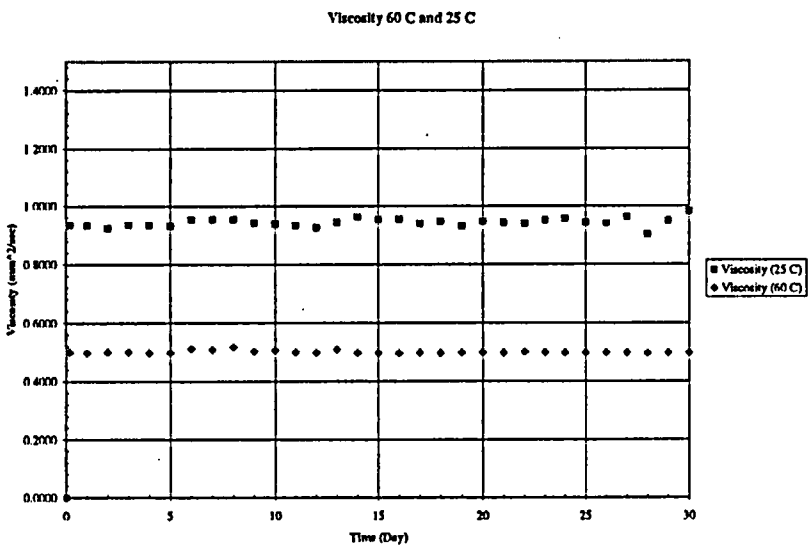
- Test #3
  - Tests #2 and #3 (TSP) concentrations are similar.
  - Test #3: Increase in sodium between days 10 and 15, then back to baseline values.
- Test #4
  - Test #1 buffering agent (NaOH) and initial concentration is similar to Test #4.
  - Sodium concentration expected to be similar to Test #1 (4000 – 5000 mg/L).
  - The Test #1 concentration is approximately 5 times greater than Tests #2 and #3.

Test #3

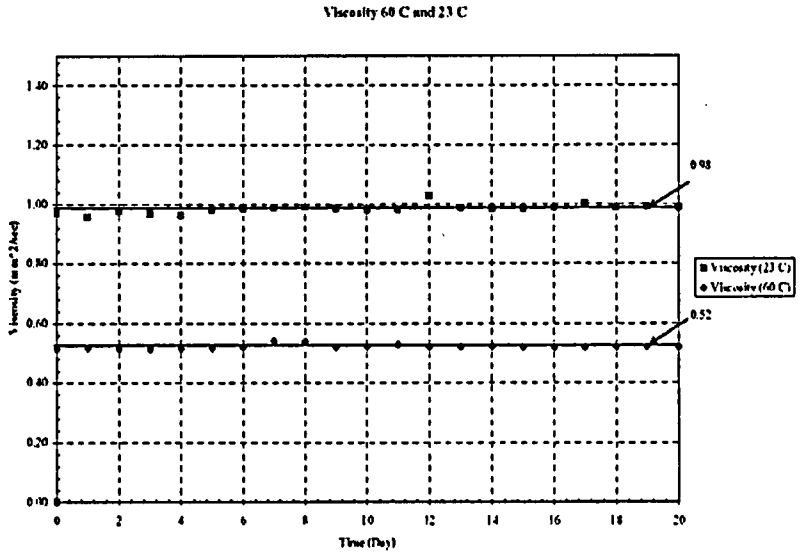


ICET Findings: Kinematic Viscosity

Test #3



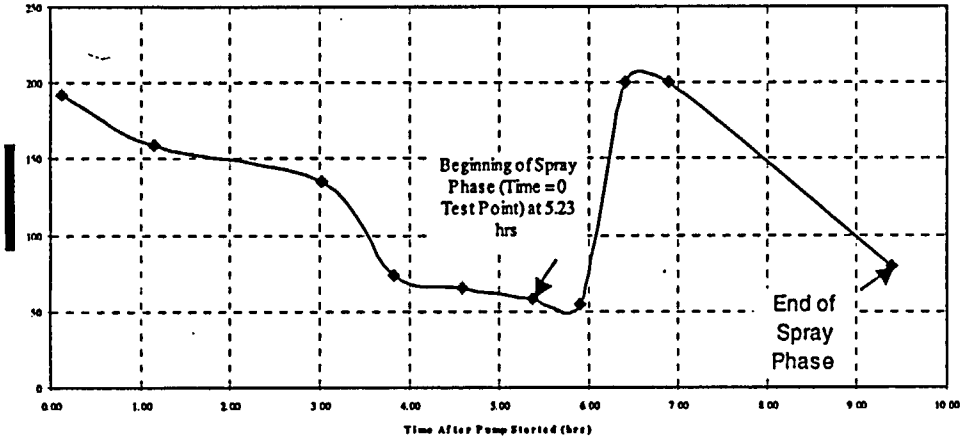
Test #4



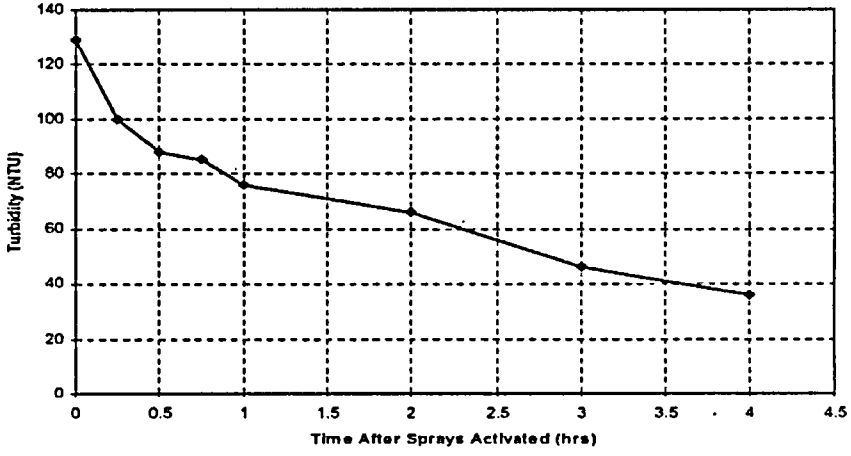
- Test #3 and #4 kinematic viscosities at room temperature and 140°F are similar.
- Results consistent with Test #2 and Test #1 140°F results.
- Bulk viscosity change not sensitive to Test #3 deposit formation.

ICET Findings: Turbidity for First Day of Test

Test #3



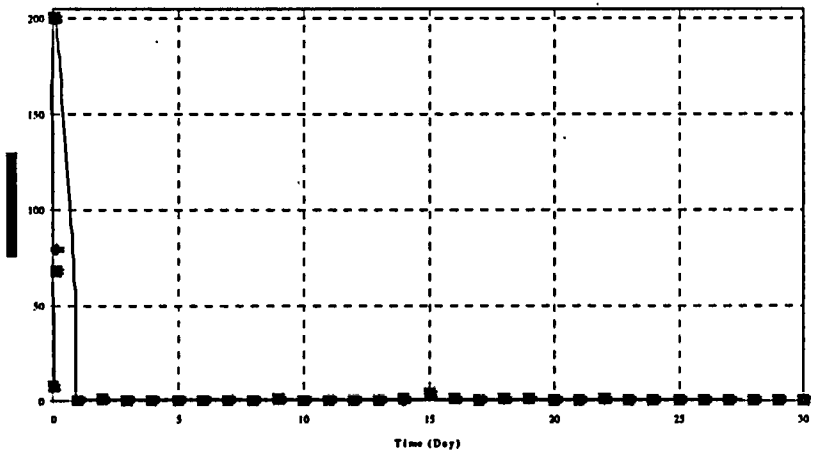
Test #4



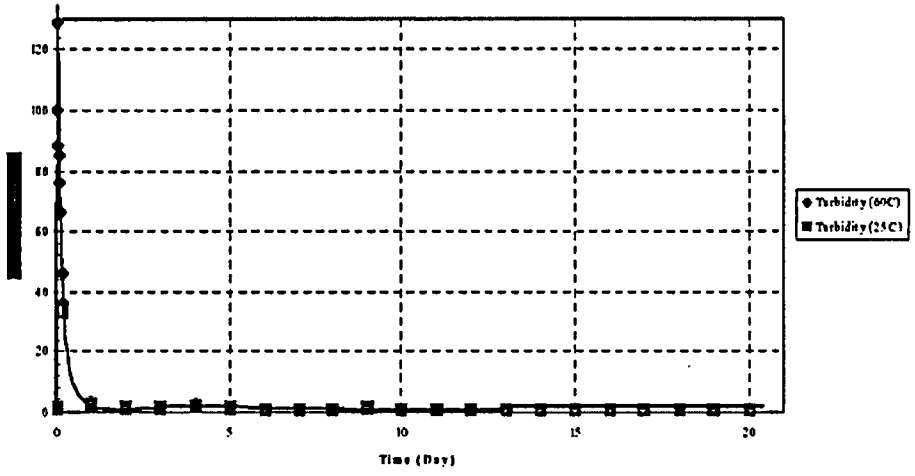
- Test #3 Turbidity.
  - Monotonically decreases until TSP is initially metered into solution.
  - Increases substantially at point when white flocculent material is evident.
  - Decreases over remaining spray phase when metering is complete.
- Test #4 turbidity monotonically decreases as Cal-Sil settles.

ICET Findings: Long-Term Turbidity

Test #3



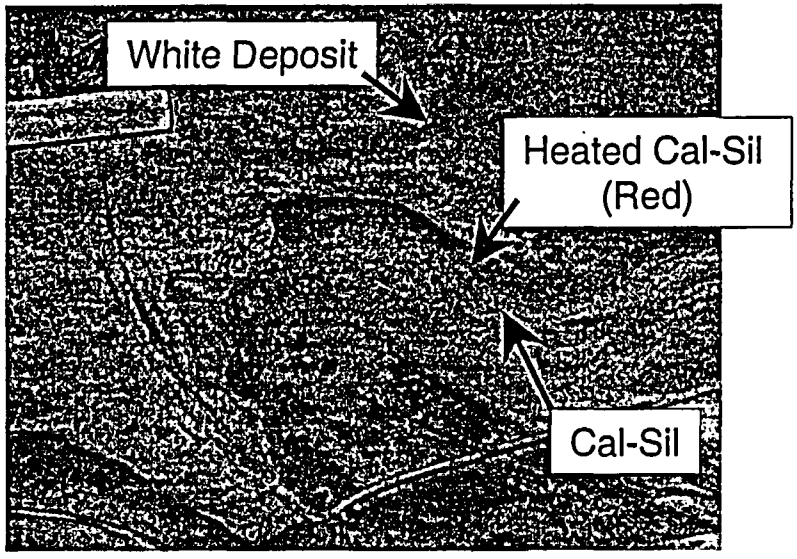
Test #4



- Long-term results similar for tests 3 and 4.
- After a day, turbidity decreased substantially from initial values.
- Turbidity relatively low and constant over bulk of test.
- Test and room temperature values similar.
- Small increases due to periodic water additions.
- Total suspended solids values exhibit similar trends, but are more variable.

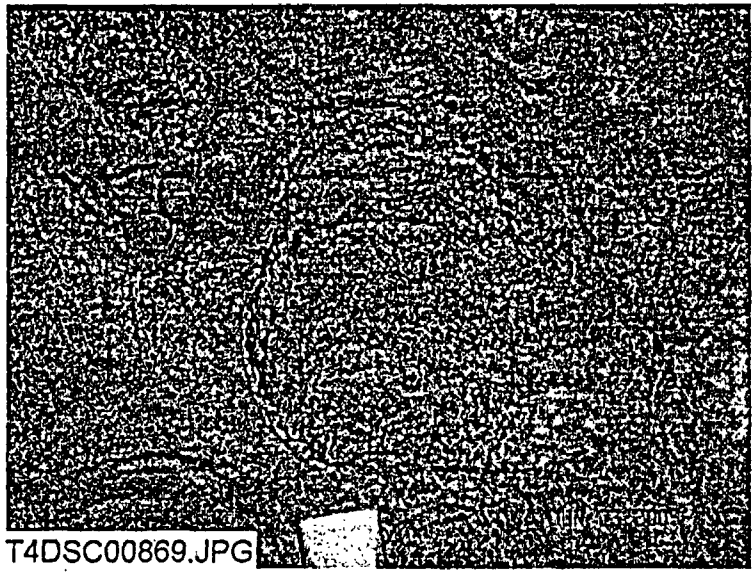
ICET Findings: Sediment

Test #3



- Sediment appears segregated.
- Coating of white chemical by-product on top of sediment is apparent.

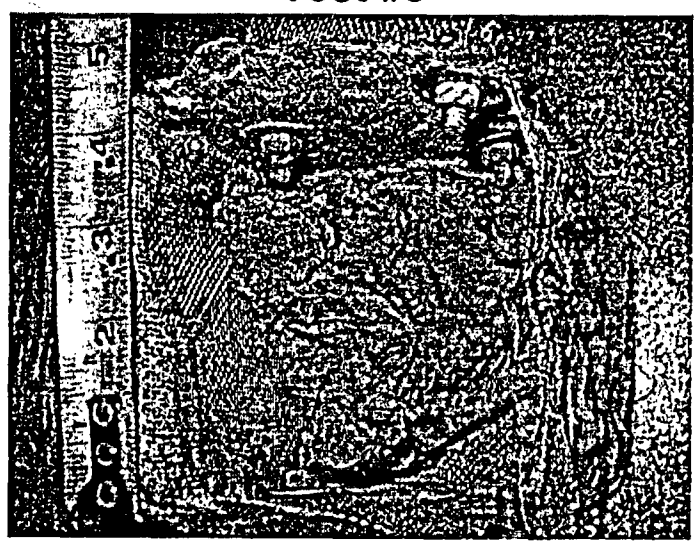
Test #4



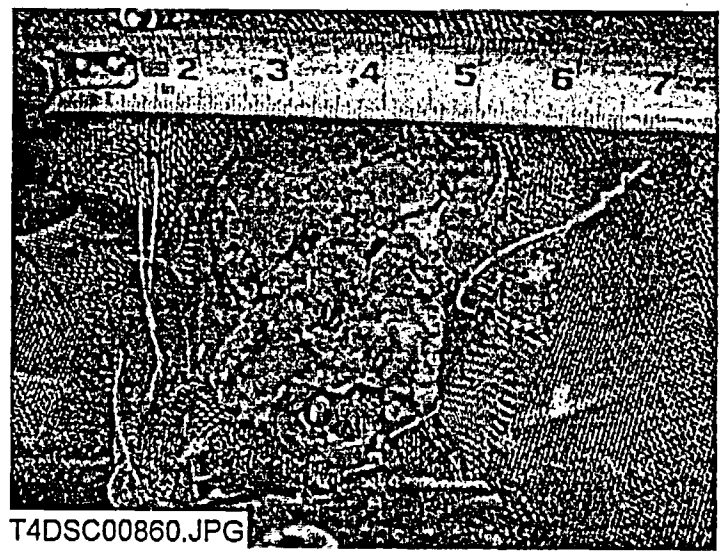
- Sediment mixed more uniformly.
- No unique chemical by-product apparent on top surface.

ICET Findings: Insulation Samples

Test #3



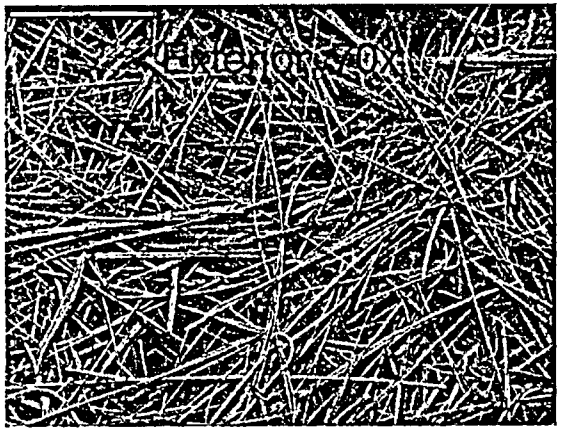
Test #4

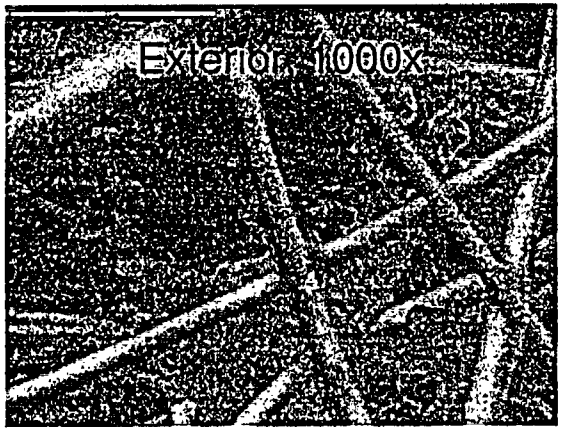


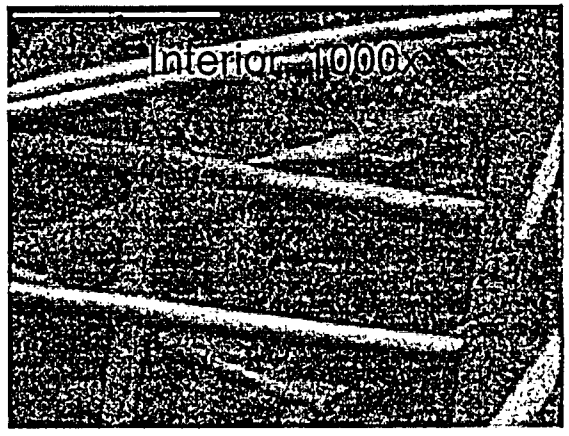
- White substance (appearance similar to sediment coating) coats exterior insulation surfaces within sample bags.
- Substance apparent on mesh insulation bag surface.
- No chemical by-products visibly apparent on insulation surface.
- Mesh insulation holders also do not exhibit any obvious by-products.

ICET Findings:
Test #3 Day 30 Insulation Samples

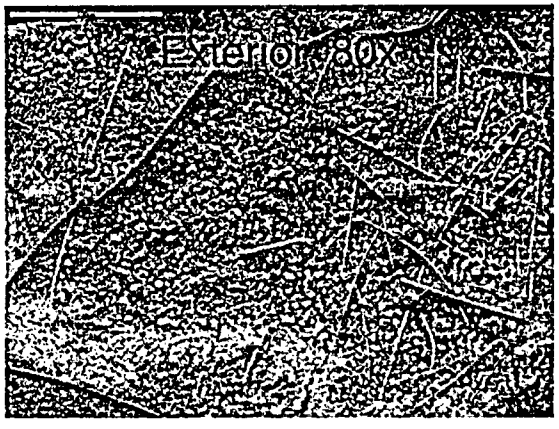
"Low Flow" Samples

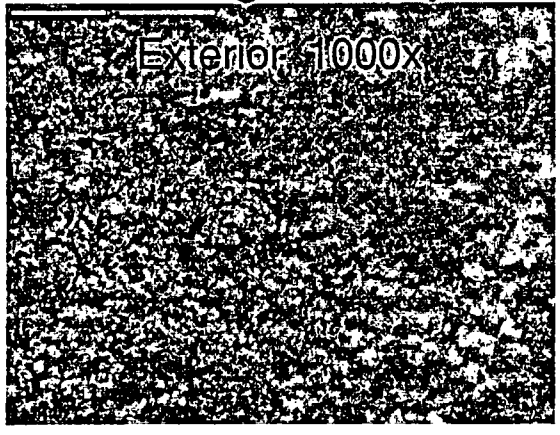


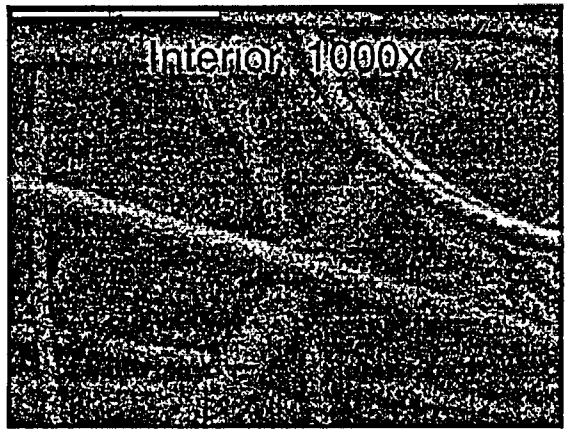




"Bird Cage" Samples

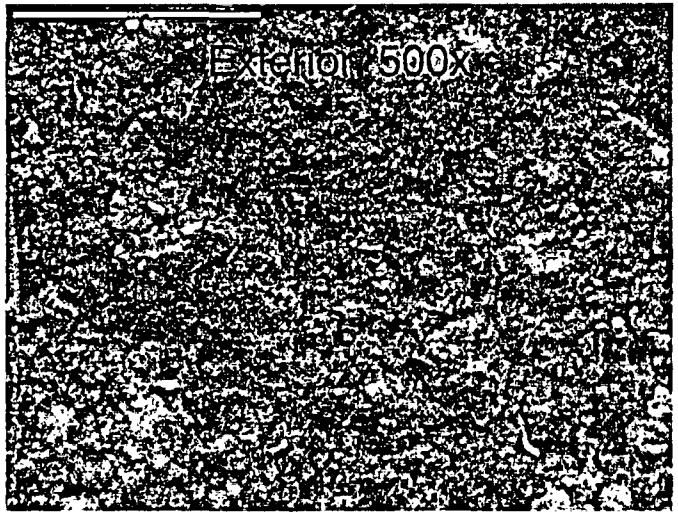


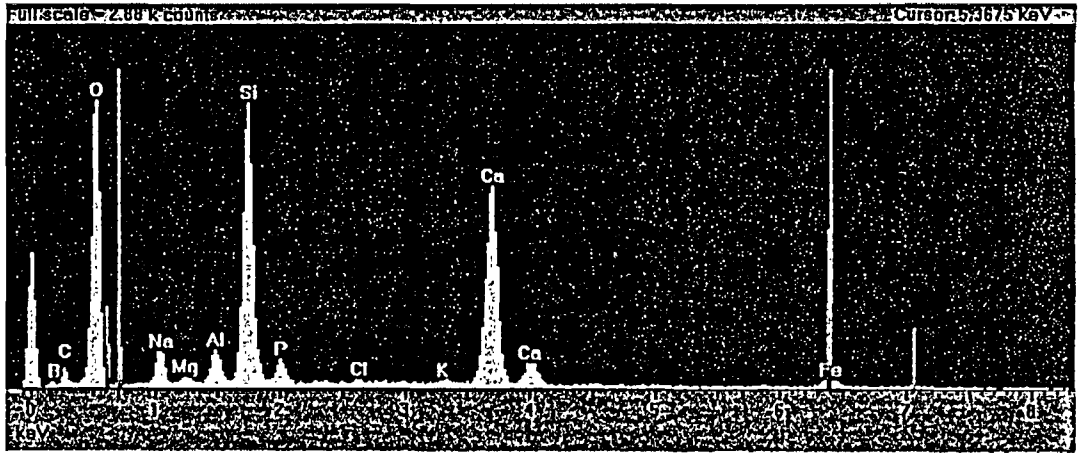




ICET Findings:
Test #3 Day 30 Bird Cage Insulation

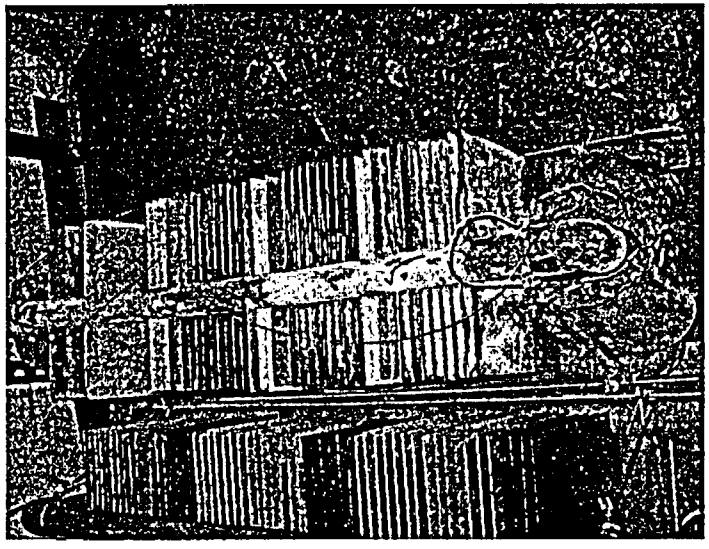
- EDS Counting Spectra
  - Most prevalent: silicon, calcium, phosphorus.
  - Less prevalent: aluminum, magnesium, sodium.
- Both "wet" and "dry" samples contain similar elements and amounts of these elements.





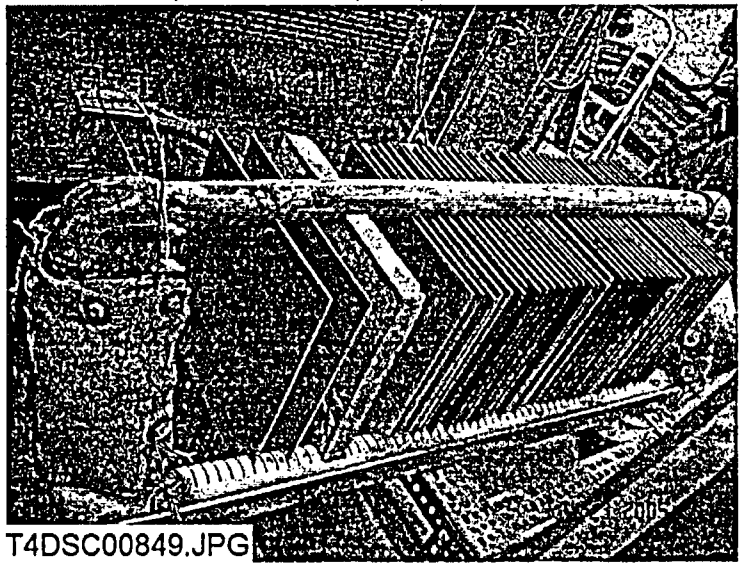
ICET Findings: Test Coupon Corrosion

Test #3



- Corrosion products appear similar to Test #2 coupons.
- Cu evident on Al samples appears as if electroplating has occurred.
- No other unusual corrosion products evident.

Test #4



T4DSC00849.JPG

- Submerged coupons exhibit less corrosion than unsubmerged coupons.
- Much less Al weight loss than in Test #1.
- Faint white product on Al and Zn coupons.

ICET Implications for Tests 3 and 4

- Test #3: Head Loss Implications.
  - Head loss due to white shiny substance.
  - Head loss as a function of time and temperature.
  - Head loss in the presence of debris and across a bare sump strainer screen.
- Test #3: Downstream Chemical Effects Implications.
  - Effect on reactor core cooling.
  - Possibility that additional solids could travel back to the sump strainer screen upon recirculation.
  - Possible contributions to downstream blockage.
- Test #4.
  - Currently, head loss and downstream implications associated with this environment are less than first three test environments.
  - Unknown how much Cal-Sil is necessary to inhibit metallic coupon corrosion.
  - Important to understand if NaOH plants are closer to Test #1 or Test #4 environments.

ICET: Reporting Schedule

- Data reports available for EPRI/industry review approximately 1 month prior to public release.
- Reports will be made available on the NRC GSI-191 website.
- A NUREG/CR report will also be created to summarize information, but little or no new technical information is planned.

Product	Public Availability[1]
Test #1 Implications Summary (NRC)	June 30, 2005
Test #1 Data Report	June 30, 2005
Test #2 Implications Summary (NRC)	June 30, 2005
Test #2 Data Report	August 9, 2005
Test #3 Implications Summary (NRC)	June 30, 2005
Test #3 Data Report	September 6, 2005
Test #4 Implications Summary (NRC)	July 22, 2005
Test #4 Data Report	October 8, 2005
Test #5 Implications Summary (NRC)	September 12, 2005
Test #5 Data Report	November 29, 2005

[1]Dates are approximate within one week.

Additional RES Chemical Effects Products (since 4/13/05 public meeting)

- ICET Test Plan (Accession # ML051100357).
- Requested Information From Characterization of Materials Associated with Integrated Chemical Effects Tests 1 and 2, letter from R. Tregoning to J. Gisclon, dated 4/25/05 (Accession # ML051150118).
  - Test #1 and #2 sediment characteristics.
  - Test #1 precipitant composition.
  - Description of Test #1 and #2 fiberglass chemical deposits.
- Request for ICET Runs 1 – 3 Archival Material, letter from M. Evans to J. Gisclon, dated 5/19/05 (Accession # ML051400044).
  - Released material for ICET runs 1 – 3 for additional industry characterization.
  - Offered similar amounts and types of material for runs 4 and 5 when available.
- Letter from M. Evans to J. Gisclon, dated 6/27/05 (Accession # ML051740081).
  - Response to additional request for technical information.
  - NRC position on equivalency between sodium tetraborate and sodium hydroxide.
  - ICET reporting schedule.

Confirmatory Chemical Effects Research

- Chemical Effect Head Loss Testing.
  - Objectives: Measure head loss associated with simulated ICET environments; understand effect of important variables on chemical product formation and head loss.
  - Status: Benchtop simulation of ICET products is underway. Loop construction has begun.
- Chemical Speciation Analysis.
  - Objectives: Conduct simulation of ICET results and understand effect of key variables on chemical species formed in these environments.
  - Status: Leaching studies have begun; variety of codes are being evaluated for applicability.
- Results of research will be used to inform NRR evaluation of September GL responses.
- More information on these programs and RES work at PNNL to measure head loss associated with PWR containment particulate debris will be provided at upcoming ACRS meeting (July 20).

Summary

- Integrated chemical effects testing is nearly complete to examine if chemical by-products form in realistic sump environments.
- Testing in all four environments (NaOH and TSP) have identified distinct by-products.
- The ICET results have demonstrated that chemical effects are an important consideration for the GL responses.
- NRC continues to strive for timely communications of the findings.
- Test data and archival test material have been released to the industry for conducting additional studies as desired.
- NRC has initiated confirmatory activities to further examine chemical effects in an effort to support evaluation of the GL 2004-02 responses.

GSI-191 Resolution Status Meeting

U. S. NRC
Pilot Plant Audit Insights
June 30, 2005

Presented By:
Thomas Hafera, US NRC
Office of Nuclear Reactor Regulation

NRC GSI-191 Pilot Program

- Pilot Program Approach
- Review Process Lessons
- Insights for Industry

NRC GSI-191 Pilot Program

Initial Pilot Review – Crystal River Unit 3

- Joint effort
- Chance to exercise the approved methodology
- Identify new/innovative approaches
- Meetings to identify issues
- Permits early problem resolution

3

NRC GSI-191 Pilot Program

Review Process Lessons

- Resources required
- Team approach
- Regional Involvement
- Key areas/issues lacking information
  - Coatings (ZOI & Transport)
  - Debris Transport
  - Head Loss
  - Downstream Effects
  - Chemical Effects

4

NRC GSI-191 Pilot Program

Insights for Industry

- Coatings ZOI data needed
- Margin for Chemical Effects issues
- Downstream Effects – WOG evaluation
- Debris Transport
- Head Loss calculations/tests
- SE method is not the only way
- Engineering judgment can be used, but must have a strong technical justification

5

GL 2004-02 September 2005 Response Expectations

Dave Cullison
Mike Webb
June 30, 2005

September Response Expectations

- Licensees need to identify in the cover letter any milestone that won't be met, particularly the 12/07 date. If the 12/07 date will not be met, the response needs:
  - A detailed description of why the 12/07 date will not be met
  - A description of how the regulatory requirements will be met until the corrective actions are completed (GL 91-18)
- Licensees need to be aware that not meeting the 12/07 date may result in additional regulatory action

September Response Expectations
(cont)

- If any implementation dates are considered company proprietary, it is acceptable to identify those dates as Spring, Fall 200X as appropriate as long as the DLPM project manager is informed of the actual date.

September Response Expectations
(cont)

- As with the 90-day responses, the staff expects licensees to identify the methodology used in their analysis (licensees can reference their 90-day responses). If there are exceptions to the use of the NEI/SE methodology, those exceptions need to be identified, described, and justified to facilitate staff review.
- If a licensee uses a methodology other than the NEI/SE methodology, a detailed description of that methodology should be provided. A licensee using a different methodology should provide justification to facilitate further communications with the staff after the receipt of their response.

September Response Expectations
(cont)

- The description of planned or existing programmatic controls that will ensure that potential sources of debris introduced into containment will be assessed for adverse effects on ECCS/CSS functions needs to specific and in detail. If any analyses, design work, etc. was or will be performed by a contractor, please identify the contractor.

5

September Response Expectations
(cont)

- Overall, the response needs to be complete and detailed enough to show that the licensee adequately exercised the guidance for evaluating sumps
- It is expected that there will not be any areas still requiring evaluation
- Licensees are free to update their responses as necessary if any changes result from confirmation containment walkdowns

6

September Response Expectations
(cont)

- License changes requiring NRC approval via license amendment or exemption or relief need to be submitted on a schedule that provides sufficient time for the NRC staff to complete its review well in advance of December 2007.
- The staff believes that four months following the September 1, 2005 submittals is sufficient time for licensees to submit license changes for prior NRC approval (i.e., submit license changes by 12/31/05).

7

September Response Expectations
(cont)

- Evaluations conducted in accordance with 10 CFR 50.59 to determine if prior NRC approval of a license change is required are to be completed and discussed in the September 2005 submittals.

8

GL 2004-02 Resolution: HPSI Throttle Valve Confirmatory Testing & RES Products

Rob Tregoning
Greg Makar
Nuclear Regulatory Commission

Bruce Letellier
Pratap Sadasivan
Los Alamos National Laboratory

Arup Maji
University of New Mexico

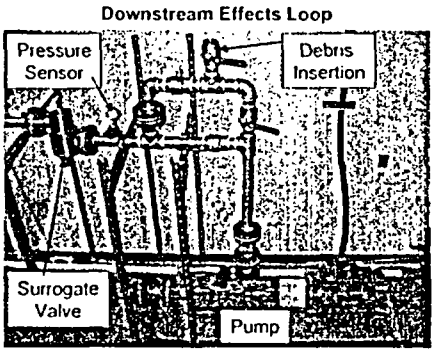
Public Meeting on GSI-191 Resolution Status
June 30, 2005
NEI Headquarters, Washington, DC

HPSI Throttle Valve Evaluation

- **Motivation:** HPSI throttle valves a likely source of performance degradation due to flow restrictions.
- **Objective:** Evaluate effect of insulation debris on blockage and wear for surrogate high pressure safety injection (HPSI) throttle valves.
- **Precursor testing:** Debris types and sizes based on screen penetration study.

HPSI Throttle Valve Evaluation

- Flow rate = 75 gpm.
- Pressures = 400 – 450 psi (upstream)
- Surrogate valve utilized to vary stem configurations.
  - 5°, large seat area (4.0in²).
  - 5°, small seat area (1.8in²).
  - 45°, large seat area (4.0in²).
- Four testing phases.
  - C_v and Shim baseline tests.
  - Single debris-type (RMI, Cal-Sil, NUKON™).
  - Multiple debris-types.
  - Debris accumulation tests.



HPSI Throttle Valve Evaluation: Status

- Confirmatory testing is complete.
- Preliminary findings.
  - RMI can cause flow obstructions when the maximum debris dimension is larger than the throttle valve opening.
  - For RMI debris, the increase in flow resistance through the valve correlates with the number of RMI pieces found in valve body testing.
  - In single-class debris tests, the largest increases in flow resistance were in tests with a large amount (100 g) of NUKON through a small valve opening gap (1/20" & 1/16").
  - CalSil debris did not cause significant blockages by itself.
  - Flow resistance and blockage exhibits a good deal of variability.
  - Still evaluating multiple debris and accumulation test results.
- Preliminary LANL report will be completed in September.

RES Recent and Upcoming Products

- Johns, R.C., et. al., "Small Scale Experiments: Effects of Chemical Reactions on Debris-Bed Head Loss," NUREG/CR-6868, March 2005.
- Shaffer, C.J., et. al., "GSI-191: Experimental Studies of Loss-of-Coolant-Accident-Generated Debris Accumulation and Head Loss with Emphasis on the Effects of Calcium Silicate Insulation," NUREG/CR-6874, May 2005.
- Ding, M., et. al. "Characterization and Head-Loss Testing of Latent Debris from Pressurized-Water-Reactor Containment Buildings," NUREG/CR-xxxx, to be published July 2005.
- Maji, A., et. al., "Screen Penetration Test Report," NUREG/CR-xxxx, to be published September 2005.
- These products supercede LANL technical reports on same subjects which have been previously been made publicly available.