Incorporation of Additional Plant Inputs in the Chemical Effects Spreadsheet PA-SEE-0354

NRC Observation at Fauske & Associates
3/8/07

Meeting Agenda

• Introductions	5 min
• Project Overview	15 min
• Test Observation	60 min
• Review of Test Plan	30 min
• Discussion of Preliminary Results	60 min
• Break	
• NRC Feedback	30 min
• Concluding Discussion	15 min

Project Overview

Project Overview

- **Objective**: Incorporate plant-specific inputs to address conservatisms without changing the base chemical model
- **Benefit**: Reduction of predicted precipitate generation to aid evaluation of sump screen head loss and chemical effects on fuel
- **Approach**: Use existing WCAP-16530 methodology with the addition of plant-specific inputs where conservative assumptions had been made
- **Participation**: Not all plants participating in this work scope
- **Project Duration**: 12/15/2006 through 5/15/2007

Project Schedule

Milestone:		Forecast/ Actual Date:
1.	Project Start	12/15/06 (A)
2.	Issue Draft Test Plan for Industry Review	12/27/06 (A)
3.	Receive Industry Comments on Test Plan	01/08/07 (A)
4.	Issue Final Test Plan/Begin Testing	01/19/07 (A)
5.	Completion of Bench Scale Tests	03/30/07 (F)
6.	Issue Draft Topical Report	04/16/07 (F)
7.	Receipt of Industry Comments on Draft Report	04/30/07 (F)
8.	Issue Final Report/Final Chemical Model	05/15/07 (F)

Project Scope

- Several areas of testing identified:
  - Silicate and phosphate inhibition of corrosion for both submerged and sprayed on Al metal
  - Differences in corrosion for Al alloys in containment vs. commercially pure Al used in testing
  - Consideration of solubility limits in order to reduce amount of precipitation from material releases
    - Large quantities of dissolved material were observed in the ICET program which did not form precipitate
- Results of testing to be used to refine the existing chemical model spreadsheet in order to allow for plant-specific inputs to the model

Program Benefits
(Estimates based on comparison of spreadsheet results to ICET data)

Refinements	Estimated Plant-Specific Precipitate Reduction	Considerations
Silicate inhibition of aluminum corrosion	50-90% reduction	Applicable for “high silica” plants
Corrosion for plant-specific aluminum alloys	60-80% reduction	Need to identify alloy types in containment
Phosphate inhibition of aluminum corrosion	70-90% reduction	Applicable for plants with TSP buffer
Evaluation of solubility limits for key precipitates	Potentially >50%	Dependent upon specific chemistry conditions, applicable for plants with low-to-moderate precipitate burdens

Project Status

- Initial scoping tests for each of the areas of testing are being conducted to gauge potential benefit
  - Scoping tests have been completed except for the short term solubility testing of AlOOH and $Ca_3(PO_4)_2$
  - These tests are underway this week
- Parametric testing is undertaken based on the results of the initial scoping tests
  - Parametric testing has been conducted for the effect of phosphate on silicate inhibition of Al corrosion

Test Plan

Test Plan

- Testing to evaluate effect of plant-specific inputs on conservatisms in chemical model
- Initial scoping tests to gauge degree of influence of each effect
- Follow-on parametric testing to fully quantify effect over the range of temperature and chemistry conditions
- Test plan developed with flexibility to adjust test parameters as obtain results
- Testing is applicable to plants with TSP, NaOH, and borate buffers

Task 1: Silicate Inhibition of Al Corrosion

- Scoping Test – determine silicate inhibition threshold at pH 8.0
  - Expose Al coupons to range of silicate concentrations in pH 8.0 solution to determine concentration at which inhibition occurs
  - If sufficient number of plants reach threshold concentration, proceed with parametric testing
- Parametric testing 1.1 – determine silicate inhibition as a function of temperature and pH
  - Repeat testing at temperatures of 150°F and 200°F and pH values of 6.0, 8.0 and 11.0
- Parametric testing 1.2 – determine effect of phosphate on silicate inhibition

Task 2: Aluminum Alloy Corrosion Rates

- Scoping Test – determine corrosion rates at pH 8.0
  - Based on plant feedback, selected Al Alloys 3003, 5005, and 6061 for testing
  - If significant reduction in corrosion observed from Alloy 1100, proceed with parametric testing
- Parametric testing – determine corrosion rates as a function of temperature and pH
  - Repeat testing at temperatures of 150°F and 200°F and pH values of 4.5, 8.0 and 11.0

Task 3: Phosphate Inhibition of Al Corrosion

- Scoping Test – determine phosphate inhibition of Al corrosion
  - Expose Al coupons to boric acid solution buffered with TSP to pH 8.0 at 200°F
  - If observe reduction in corrosion of Al coupons in the presence of phosphate, proceed to parametric testing
  - Testing underway to obtain results of scoping test
- Parametric testing – determine impact on Al corrosion rates of phosphate inhibition as a function of temperature and pH
  - Repeat testing at temperatures of 150°F and 200°F and pH values of 6.0, 8.0 and 9.0

Task 4: Solubility of Al and Ca Precipitates

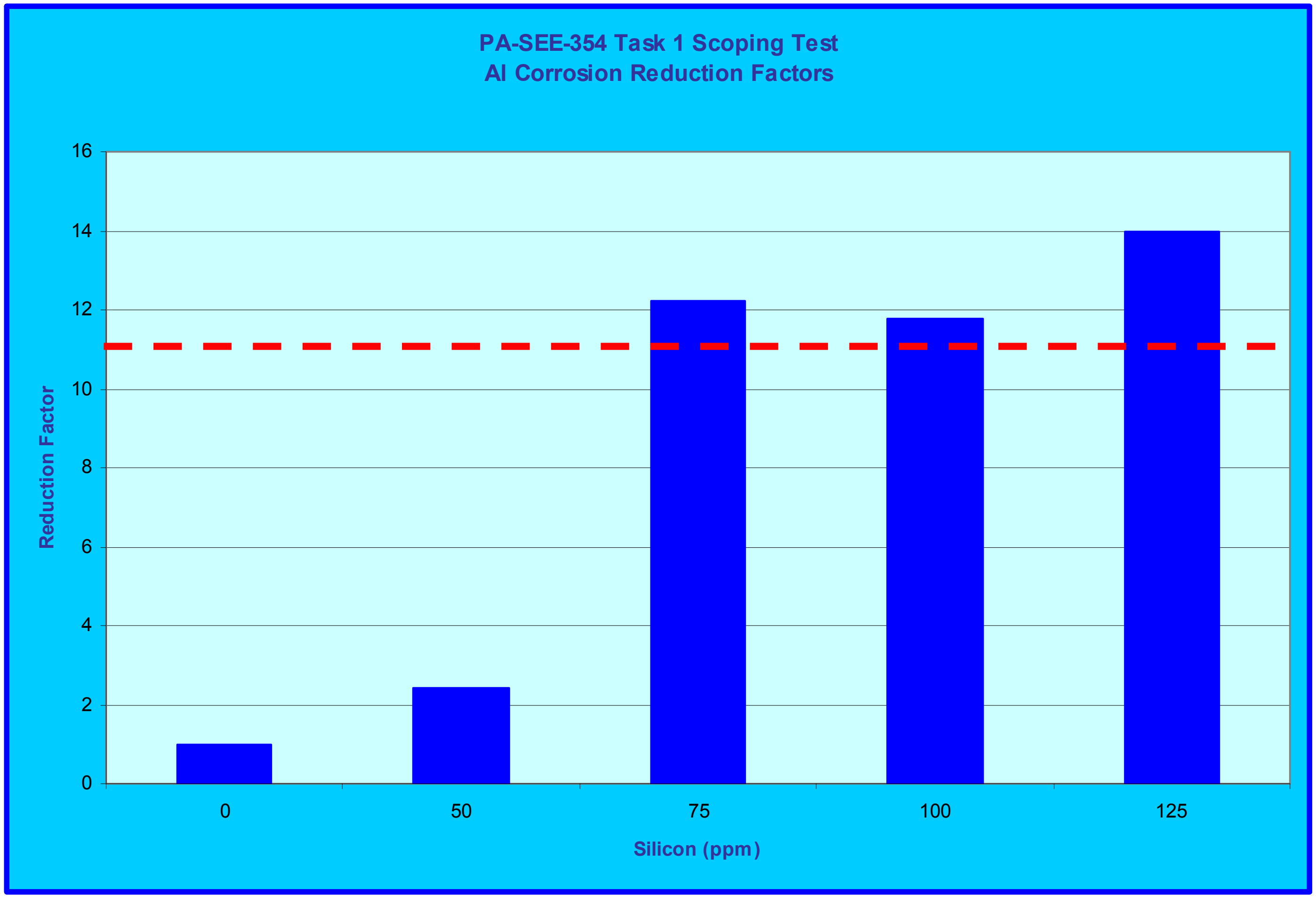
- Tests performed at 140°F and 200°F to represent equilibrium sump temperatures
- Limited testing planned at ambient temperature (80°F)
- Testing for each precipitate: sodium aluminum silicate, aluminum oxyhydroxide, and calcium phosphate
- Scoping Test – evaluate precipitate solubility
  - Short term test to evaluate concentration of precipitates at the point of precipitate formation
  - If sufficiently high concentration before precipitation, perform long term solubility test
- Long term solubility testing – observe solution over one week for precipitate formation

Preliminary Test Results

Task 1: Preliminary Results

- Scoping Test – determine silicate inhibition threshold at pH 8.0
- Scoping test preliminary results:
  - Al corrosion reduction factor of 11 observed with >75 ppm Si at pH 8.0 and 200°F
  - Minor inhibition observed at 50 ppm Si
- Proceed to parametric testing with an inhibition threshold of 75 ppm silicon

Task 1: Preliminary Results



Task 2: Preliminary Results

- Scoping Test – determine Al alloy corrosion rates at pH 8.0
- Scoping test preliminary results:
  - Al Alloy 3003 corrosion ~68% of corrosion for Alloy 1100
  - For Al Alloys 5005 and 6061 even less reduction in corrosion was observed
- Conclusion: no appreciable reduction in Al corrosion for tested Al alloys versus Alloy 1100
  - Determined not to proceed with parametric testing

Task 2: Preliminary Results

Coupon	Scaled Corrosion (μm)	Corrosion Reduction Factor (w/ respect to Alloy 1100)	Percentage of Alloy 1100 Corrosion
1100	4.47	NA	NA
3003	3.02	1.5	67.6
5005	3.68	1.2	82.3
6061	3.45	1.3	77.2

Results based on coupon weight loss prior to de-scaling after 12 hr of exposure

Task 3: Preliminary Results

- Scoping Test – determine phosphate inhibition of Al corrosion
- Scoping test preliminary results:
  - Phosphate shown to inhibit corrosion of aluminum metal
  - Aluminum corrosion with phosphate present is reduced by factor of 10 based on scoping test conditions
- Proceed to parametric testing to evaluate the influence of phosphate inhibition under a range of pH and temperature conditions

Task 3: Preliminary Results

Coupon	Scaled Corrosion (μm)	Corrosion Reduction Factor (w/ respect to no phosphate)	Percentage of Corrosion without Phosphate
1100 Control	4.47	NA	NA
1100 Phosphate	0.44	10.1	9.8

Results based on coupon weight loss prior to de-scaling after 12 hr of exposure

Task 4: Preliminary Results

- Scoping test to determine the solubility of sodium aluminum silicate was performed
- Scoping test preliminary results for $NaAlSi_3O_8$:
  - Precipitation did not occur at dissolved Al concentrations < 20 ppm and dissolved silicon < 60 ppm
  - If plants have < 20 ppm dissolved Al, do not form $NaAlSi_3O_8$ precipitate under tested conditions
- Made determination to proceed with long term solubility testing for $NaAlSi_3O_8$
- Scoping tests currently underway to determine solubility of AlOOH and $Ca_3(PO_4)_2$ precipitate