Reinhold Environmental Ltd.

2009 APC Round Table & Expo Presentation

July 12-14, 2009, in The Woodlands, TX

Discovering what's possible with calcium™

Long Term Pre-Air Preheater Injection of Hydrated Lime and Potential Co-benefits

Curt Biehn & Dan Okenfuss
Mississippi Lime Company

Tony Silva
The Babcock & Wilcox Company

Jeff Wilson
Southern Company

APC/PCUG Conference
July 13-14, 2009

Agenda

- Benefits of SO_3 Mitigation
- Pre-APH removal of SO_3
- The case for hydrated lime
- Injection Program
- Results
  - APH operation and condition
  - SO_3 removal
    - Extended runs
    - Test programs
  - Testing methodology
- Conclusions

SO_3 Mitigation Benefits

- Regulatory-based
  - Reduce plume touchdown concerns
  - Achieve SO_3 & opacity reductions
  - Mercury
    - Removal of SO_3 improves Hg capture with ACI
- Operational-based
  - Reduce system corrosion
  - Improve operational conditions

Pre-APH Removal of SO_3
Hydrated Lime Extended Injection Program

- Follow-up to one day MLC trial in Oct 08
- Begin several weeks prior to planned outage
- Use temporary injection equipment
- Partner with other interested parties
  - Involvement in program and conclusions
  - Conduct test programs
  - Verify equipment and methods

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SOUTHERN COMPANY

Energy to Serve Your World®

B&W

the babcock&wilcox company

a McDermott company

BULK CONVEYOR SPECIALIST, INC.

Breen Energy Solutions

Southern Company's Interest

Sorbent Injection Systems may be the key to not only mitigating the blue plume…..

- But also the key to fuel flexibility
- The solution to APH issues
- And may have co-benefits

Benefits of Injecting Prior to the APH

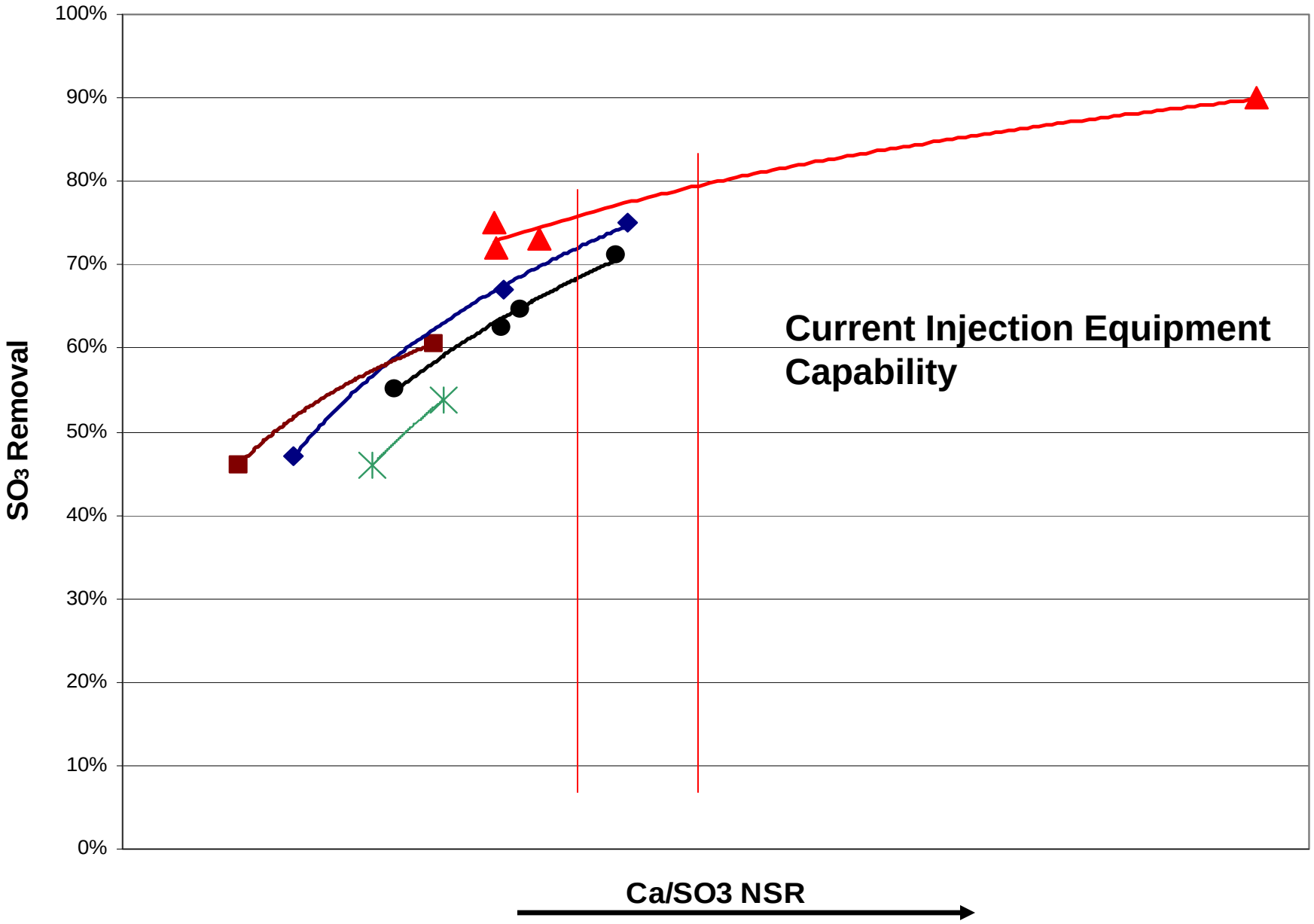
- Adds Residence Time
- Corrosion prevention of downstream equipment
  - Ductwork
  - Fans
  - Particulate Collection
- Increases Mixing
- Allows For Less Complex Design of Injection Equipment
- Possibly Prevents ABS
- Attainable operational improvements
  - Heat rate improvement
  - SCR operation – Ammonia Slip

Removal Requirements at Pre FGD Injection Location

- A 1.5% sulfur coal requires 50% removal
- A 2.0% sulfur coal requires 65% removal
- A 2.5% sulfur coal requires 75% removal
- A 3.0% sulfur coal requires 83% removal

* Assumes an 11500 Btu coal and one second residence time

Hydrated Lime Injection at Yates



ABS Accumulation Hot Layer

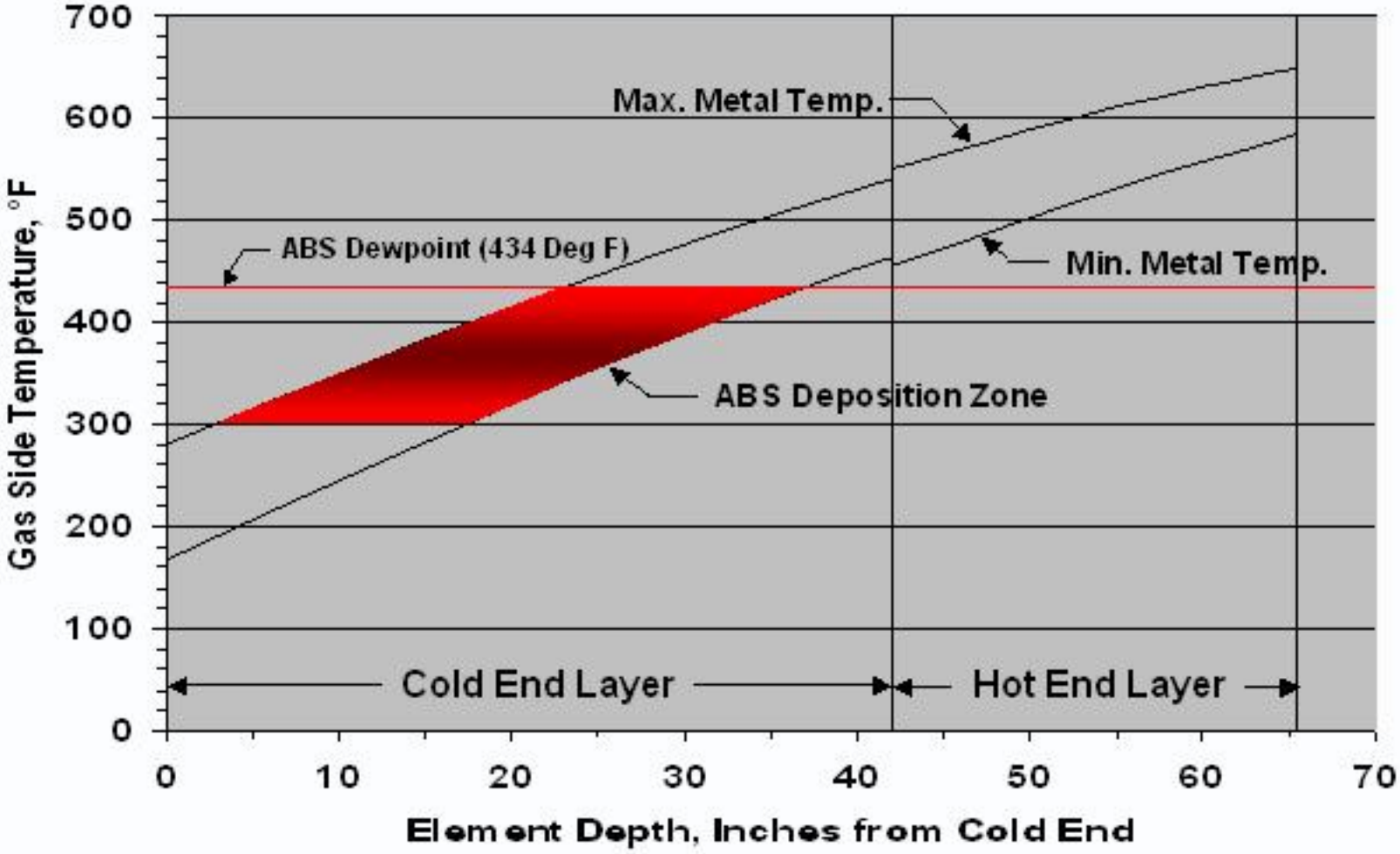
ALSTOM

Ash Fouling in Cold Layer

ALSTOM

ABS Deposition Zone, LAP3038

(A1) 23.5" DN7™ / 42" DNFa®



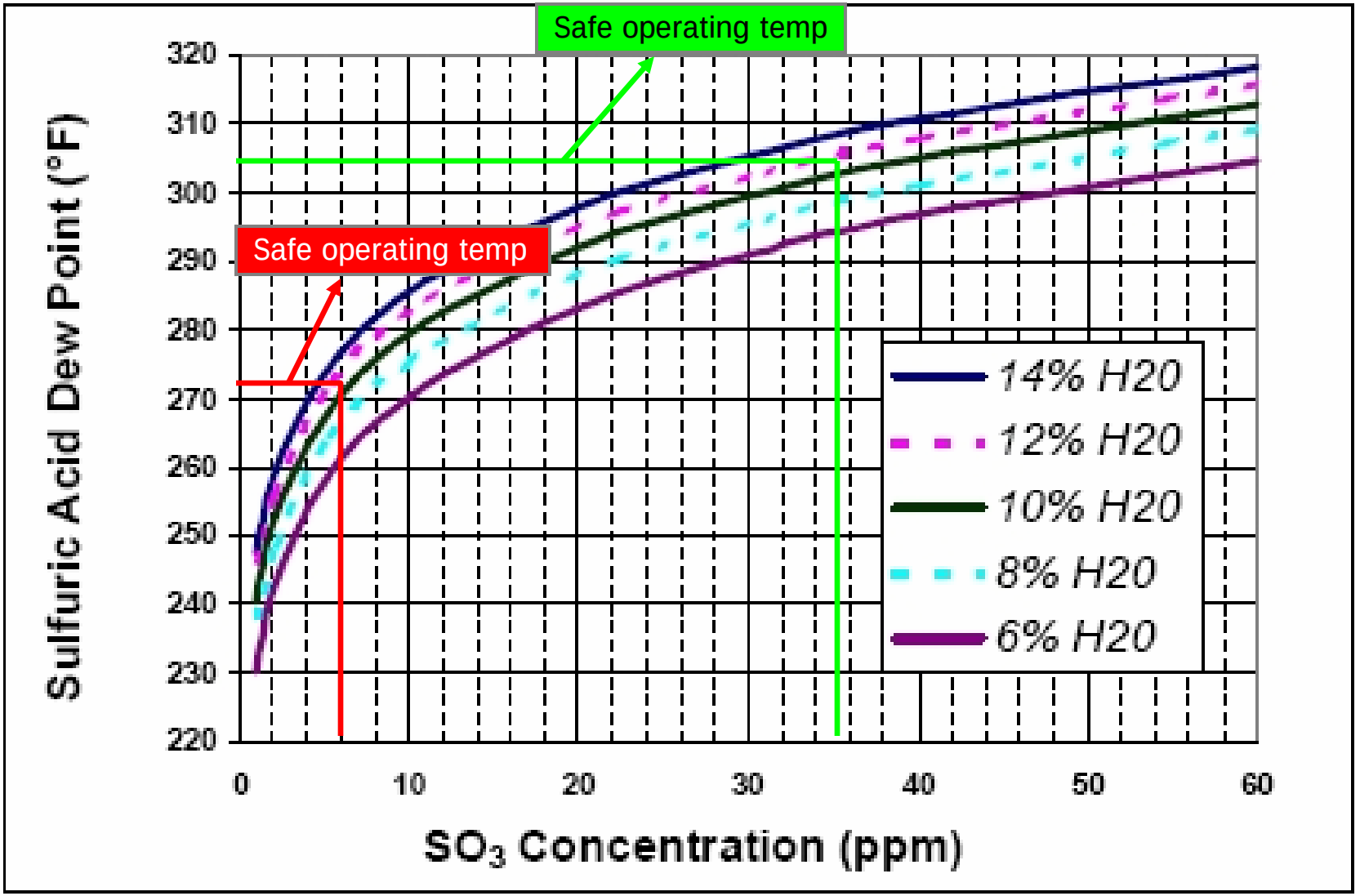
Benefits of Pre-APH Removal of SO_3
Heat Rate Improvement

- Reduce SO_3 Dew Point prior to APH
- Reduce operating temperature of APH

40°F reduction → 1% heat rate improvement → 1% savings on fuel budget

- Reduction in CO_2 emissions
  - 1 lb coal → 2.5 lb CO_2

SO_3 Acid Dew Point Curve



Key Sorbent Criteria
Available Calcium and Surface Area

Property	Industry Typical	Flue Gas Grade
Surface Area, m^2/g	14 – 23	≥ 21
Avail. Calcium Hydroxide, %wt	89 - 97%	> 95%
Total Calcium Hydroxide, %wt	92 - 99%	92 - 99%
Porosity, cm^3/g	0.07 – 0.14	0.12
Particle Size, -325 mesh, %wt	~ 92%	~ 92%
Moisture, %wt	≤ 1.0%	≤ 1.0%
*Typical** Usage, lb Ca/lb SO_3	> 5	2.5 - 4

SO_3 Mitigation requires high surface area hydrated lime

**Typical usage is based upon a variety of unit-specific factors, including residence time, system design, etc.*

Pre-APH Removal of SO_3
Use of Hydrated Lime

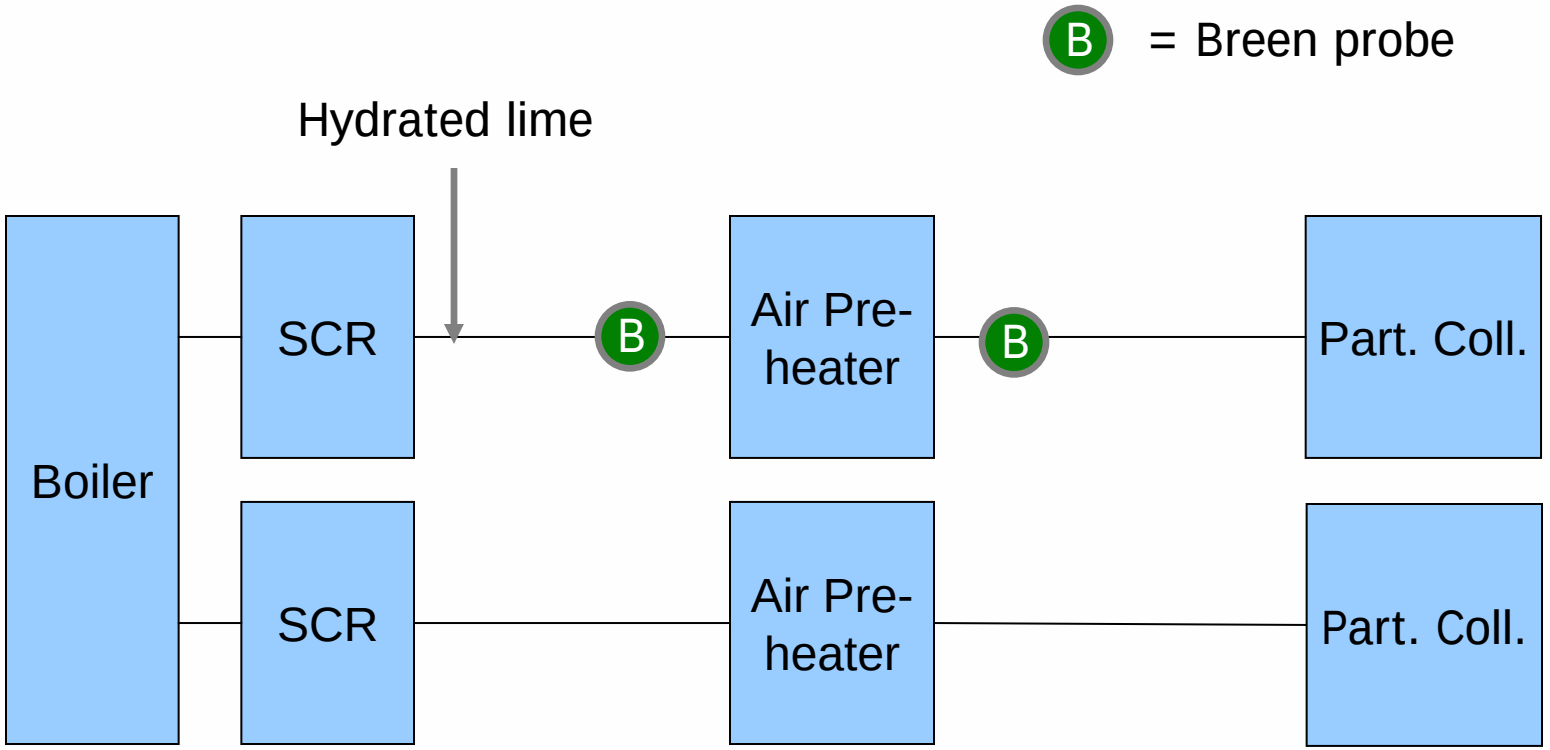
- Reactivity
  - MLC trial in 2008 showed good removal
    - 66-92% SO_3 removal when tested at APH *outlet*
      - **In flight removal**
    - Ca/SO_3 wt ratios = 2.1 – 3.3

- Nature of any Ca-based byproduct buildup on internals
  - Elevated APH pressure differential
  - Ease of removal from APH
  - Problematic intermediates at varying SO_3 removal levels?

Test Program Goals
Eight Week Trial

- Determine effects of hydrate lime injection on APH operation
  - Pressure differential
  - Identify any deposition on APH at the end of the trial
- Capability to reduce SO_3 content prior to APH
  - Potential for heat rate improvement
- SO_3 measurement
  - Breen probe
  - Controlled Condensate/Inertial Separation probe
- In-flight removal of HCl

Test Unit Overview
Injection and Test Locations



- 250 MW Unit
- Injection location → Breen probe ~ 75ft
- Breen probe → APH ~ 45ft

APH Operation

- Differential pressure
  - Maintained similar performance to untreated side of the process
- Inspection results after 8 weeks of hydrated lime injection
  - No unusual solids buildup noted
  - Light ash on gas side
  - Clean on air side
  - Similar appearance between treated and untreated side APHs

Treating with hydrated lime <u>did not</u> cause operational issues with APH during the trial.

Treated gas side

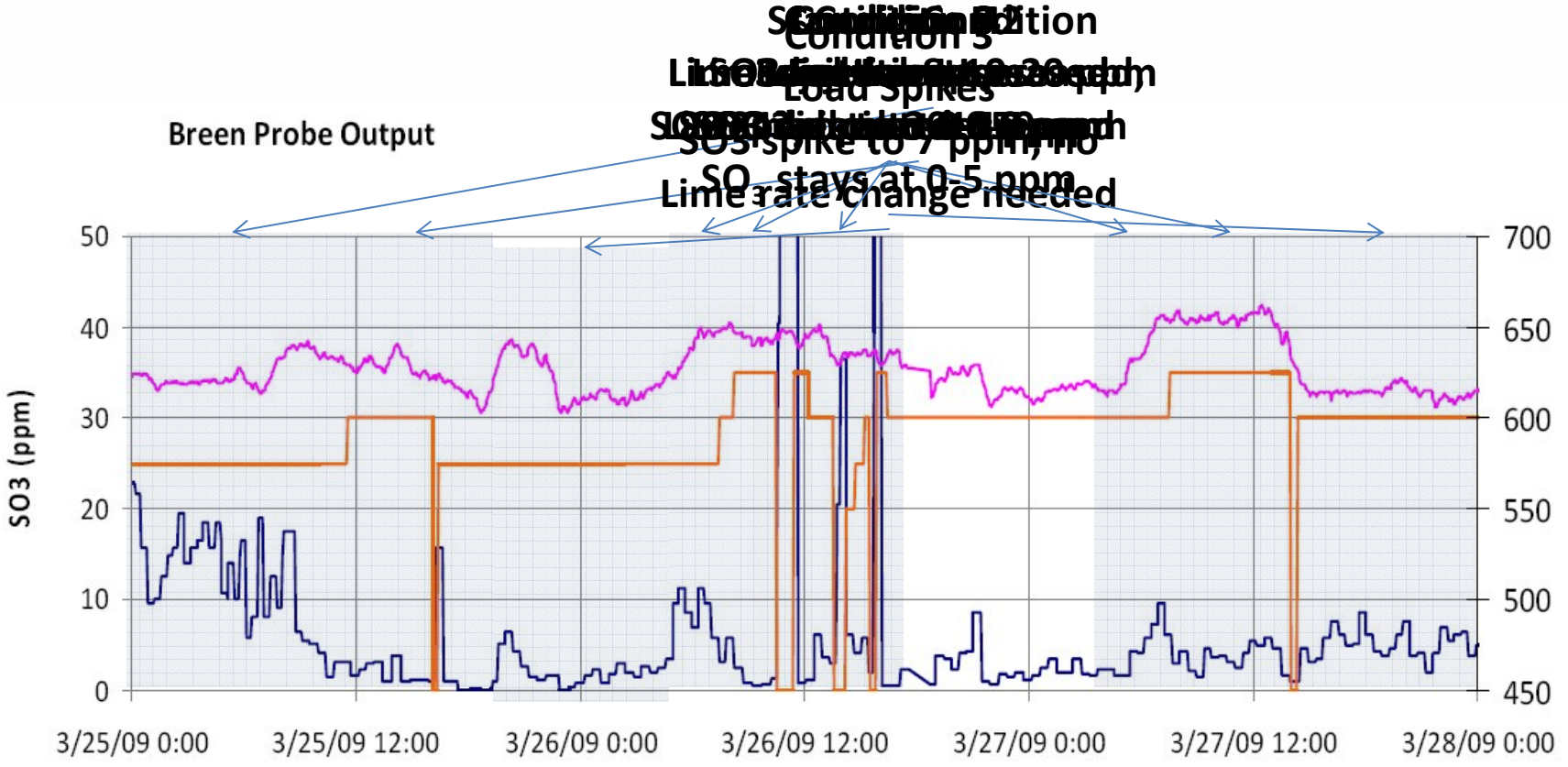
Treated air side

APH Operation with Hydrate Injection Byproducts

- Byproduct(s) did not build up on internals
- SO_3 removal rates varies during the 8 week trial
  - Planned and unplanned
- These variations did not have an effect on operation

SO_3 Removal Sample Performance

Blue: SO_3 at APH inlet (y axis)
Orange: Feed setting as % (y axis)
Pink: Flue gas temp (secondary y axis)

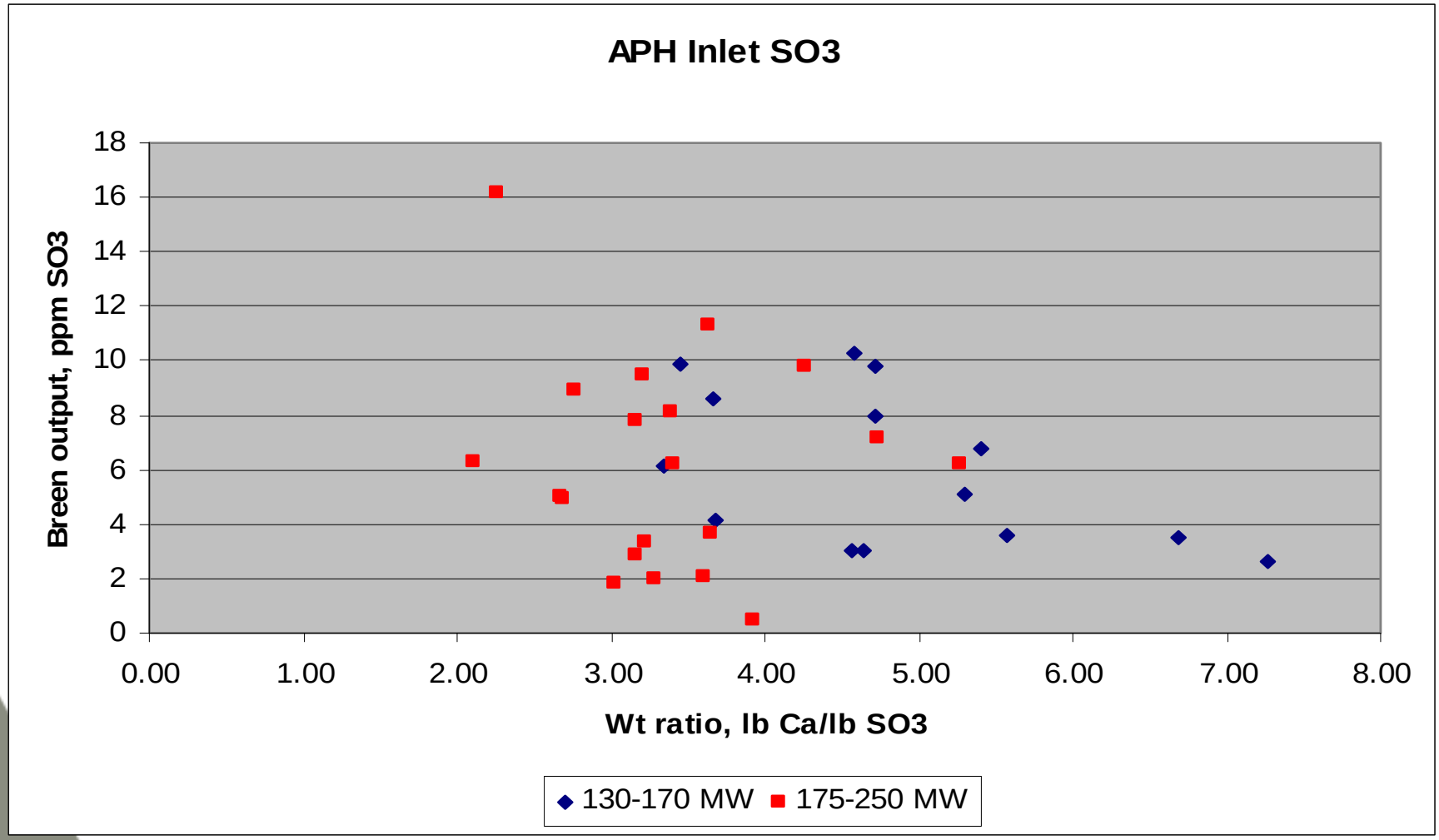


- Ability to control SO_3 below 10 ppm
  - Testing port ~45 ft prior to APH
  - Reflects in-flight removal of SO_3
- Weight ratio (lbs Ca/lbs SO_3) typically $\leq$ 4.0

Pre-APH SO_3 Capture Extended Run Averages

- Calculated average Unit Load
  - Data covers Gross MW range of 130 – 250 MW
- Hydrate feed set point consistent throughout run
- Determined $Ca(OH)_2$: SO_3 weight ratio
  - Assumed 35 ppm SO_3 exiting SCR
- Calculated average SO_3 concentration from APH inlet Breen probe data
  - Removal rate
- Median wt ratio is 4.0 and median SO_3 is 6.2 ppm

Pre-APH SO_3 Capture – Extended Run Averages Grouped by Unit Load



- Data indicate higher loads may require less hydrated lime
- "Off shift effect" another possibility

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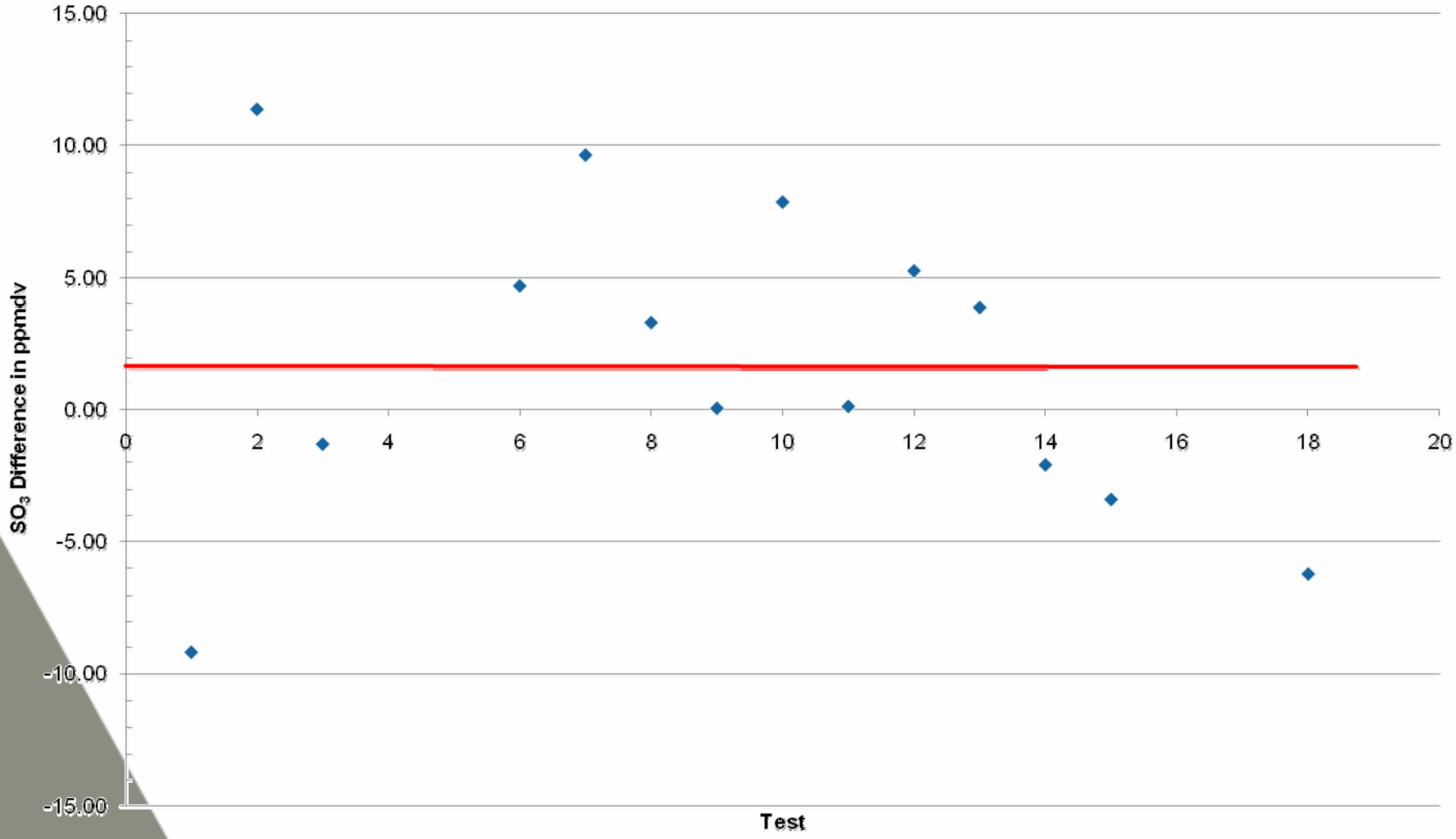
Stack Testing Objectives

- Confirm Breen Probe readings with controlled condensation system (CCS) testing
- Perform parametric testing of injection rates vs. SO_3 using CCS
- Measure HCl during the SO_3 parametric test to determine how much / if any is removed across the system

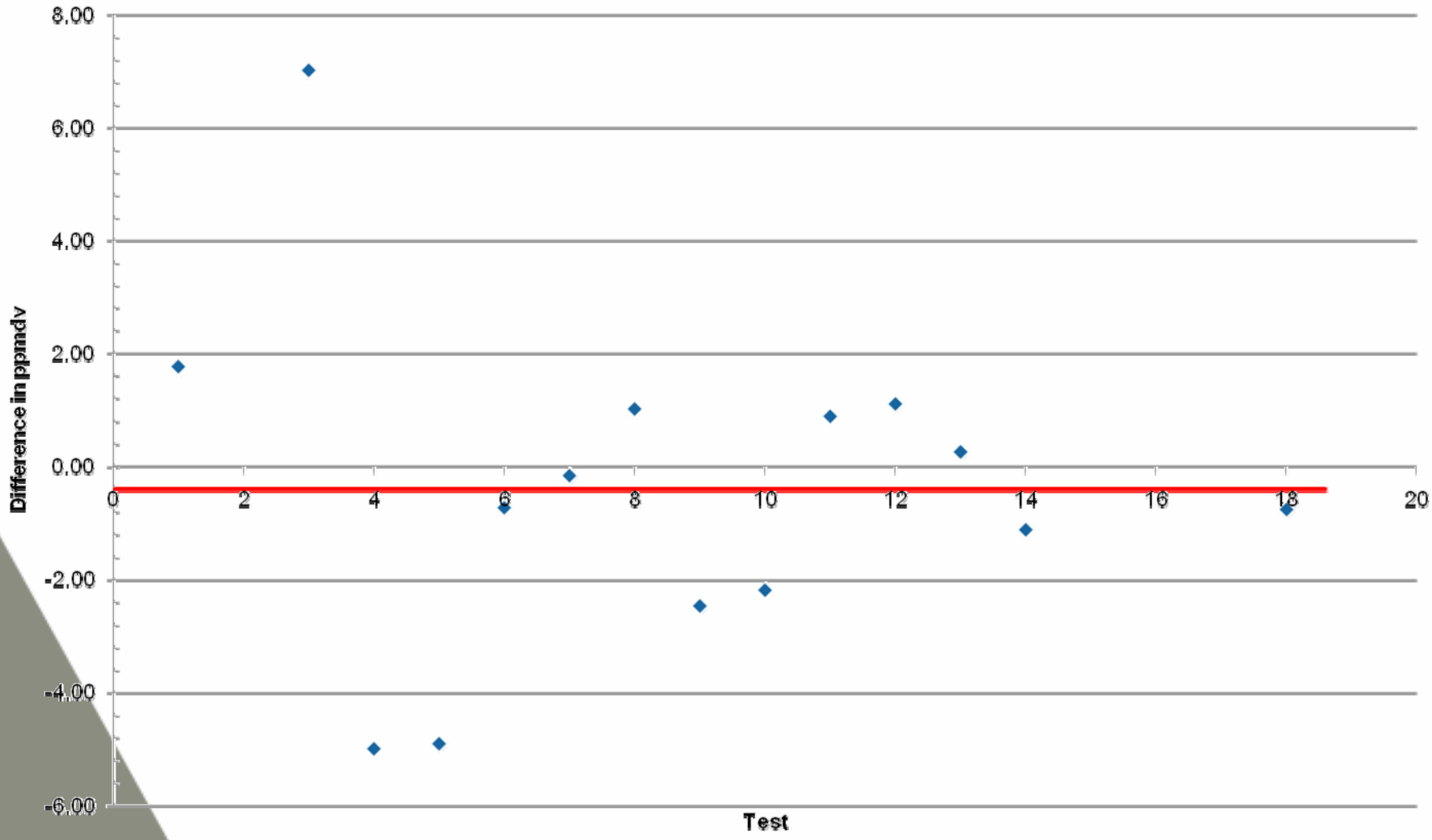
Test Program

- Test program from 3/30 – 4/3, 2009
- Flue gas testing performed by Clean Air Engineering
- Hydrated Lime injected on A duct only
- SO_3 /SO_2 tested at
  - SCR outlet (untreated duct only)
  - AH inlet (treated duct)
  - AH outlet (treated duct)
- HCl tested at
  - SCR outlet (untreated duct)
  - AH out (treated duct)

SO_3 Difference between Stack Testing and Breen Probe (AH inlet)

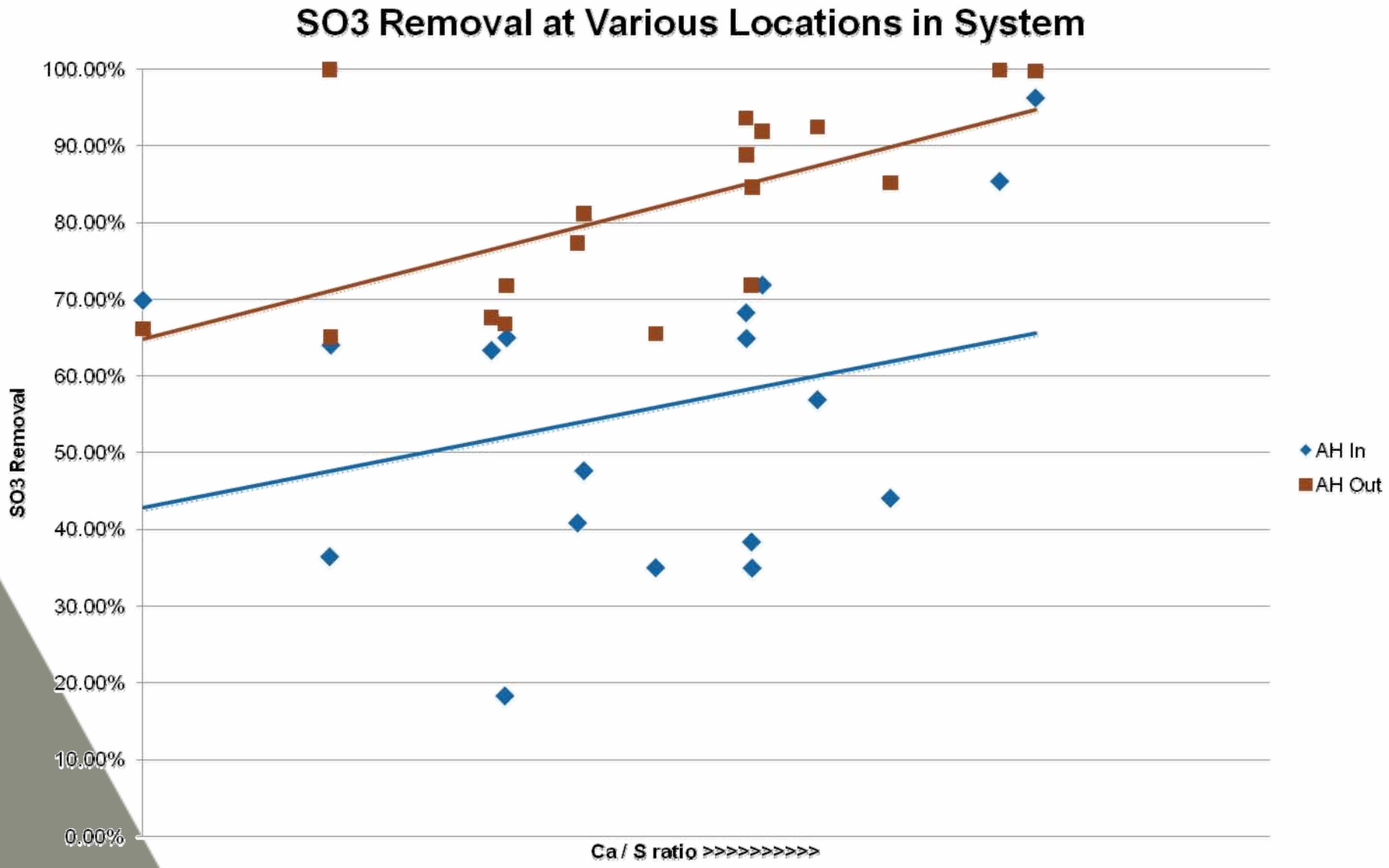


SO_3 Difference between Stack Testing and Breen Probe (AH outlet)



Inlet conditions

- Measured SO_2 ~ 2000 ppmdv
- SCR SO_2 to SO_3 Conversion ~ 0.5 – 0.75%
- Measured SO_3 ~ 30 – 35 ppmdv at full load



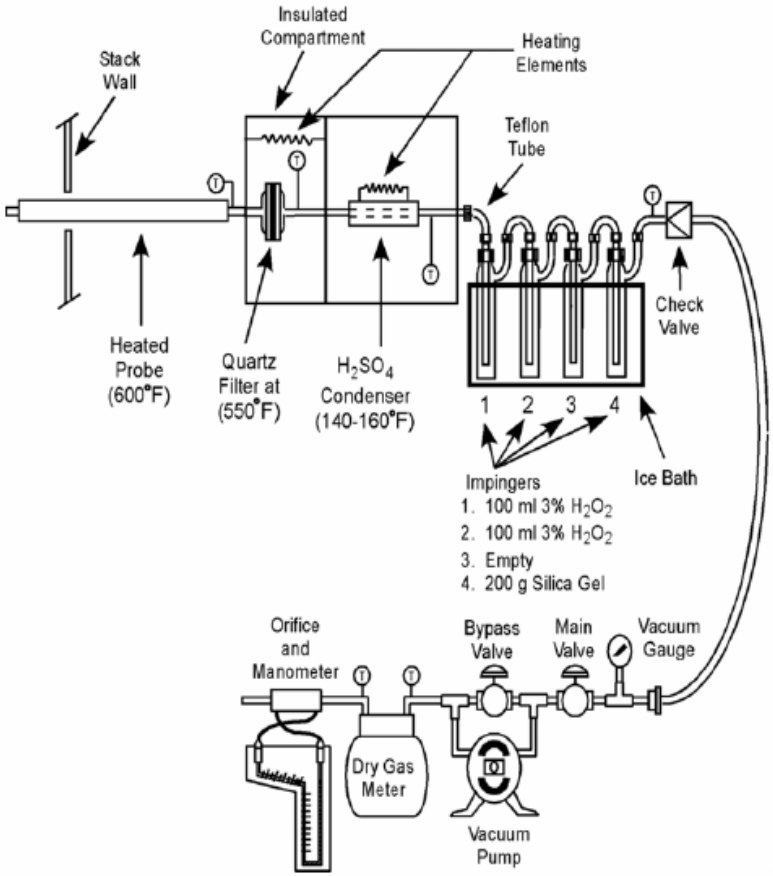
HCl results

- SCR outlet ~ 45 ppm
- Under typical conditions of 3 – 4 Ca / S ratios, no HCl removal was detected
- On over injection conditions (mid-load, high Ca / S ratios) where all SO_3 was mitigated prior to particulate collection device, some HCl removal was detected, about 20 – 30 %.

Test Methods

- SO_3 by Controlled Condensation
- HCl by EPA Method 26A

Controlled Condensation System



CCS

- SCR outlet “B” Duct
  - Dual Trains
- AH inlet and outlet
  - Inertial Probe used in order to mitigate any reaction of sorbent with SO_3 as it passes through the CCS filter
  - QC check - Inertial Probe Filters analyzed for SO_3
    - little to no SO_3 present (<1 ppm)

Inertial probe

Pre-APH Injection of Hydrated Lime Conclusions

- Hydrated lime injected prior to the APH will remove SO_3
- Hydrated lime injection did not negatively affect APH operation
  - No byproduct buildup was noted
  - Sorbent is forgiving at this injection location
- Potential benefits for significant savings by removing SO_3 prior to the APH
  - Utilization for sites with residence time considerations
  - Corrosion
  - ABS
  - Heat Rate

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Thank you

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