REINHOLD ENVIRONMENTAL Ltd.

2014 APC Round Table
& Expo Presentation

July 14-15, 2014, in Louisville, KY / Hosted by LG&E/KU

O&M Issues DSI Systems
Startup, Shutdown & Cycling Loads

Tony Licata – Licata Energy
Curt Biehn – Mississippi Lime

APC Roundtable July 14, 2014
Workshop 7

EPA Requested Comments on Proposed New Rules Startup-Shutdown-Maintenance (SSM)

- Request published on 6/25/13 based on rules proposed 12/30/12
- Reopened comment period limited to 3 questions
- Institute of Clean Air Companies (ICAC) submitted comments on 8/26/13 addressing
  - SCRs & SNCR
  - ESPs
  - Baghouses
  - Wet and Dry FGD
  - DSI & carbon injection

O&M Issues Coal Fired Plants

- Startup – Shutdown Rules
- Start averaging time using a default electrical production
  - 25% of nameplate capacity plus 3 hrs. or
  - the start of electricity generation plus 6 hrs., whichever comes first;
- Other Industry Challenges Cycling Loads
- "Green" Energy and gas price: coal plant cycling
  - Shutdowns: hours to a few days
- Low load operations
- Improved heat rate for CO_2 Rule

DSI Challenges

- How soon can we turn or turn off on hydrated lime & carbon systems.
- Prevent deposits forming in ductwork.
- Sorbent contact with acid gases/Hg at low flow conditions -**mass transfer**
- Does the chemistry work at lower temperatures seen during startup/shutdown?
- Contact time
- Impacts on balance of plant

What Can We Do?

- Modeling - most modeling for flow distribution and deposition done at full load conditions.
- Need to model at low flow conditions
- Inspections of ductwork after cycling operations
- Use CEMS when possible to optimize sorbent injection.
- Other
  - Better distribution
  - More frequent tuning
  - Frequent cleaning of catalyst & airheater
  - DSI injection ahead of airheater

Benefits of DSI Injection During Start/Shutdown and Cycling Operations

- With increased cycling operations we expect to see increased corrosion along the flue gas path. Lime injection could mitigate corrosion that will develop with these operating conditions
- Allow SCRs to startup earlier (lower operating temp.)
  - Startup - Shutdown Conditions
  - Turn on ammonia $\approx$ 600 °F
    - Actual depends on fuel primarily sulfur
  - SCRs are temperature driven – no relationship to MW generation

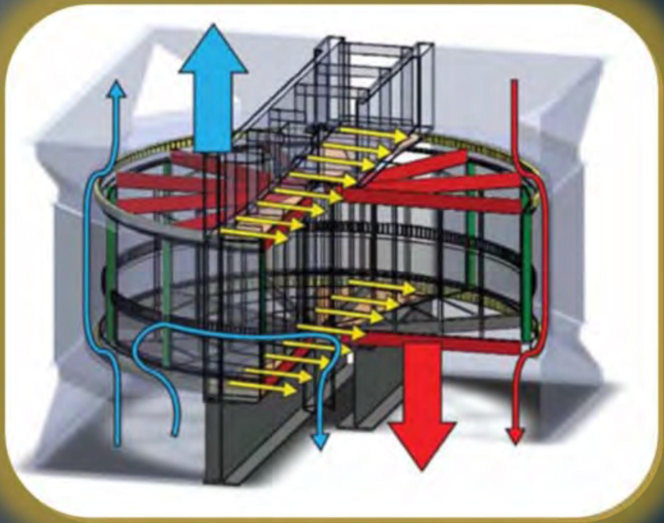
Typical SCR Startup & Shutdown

- Startup - Shutdown Conditions
  - Temperature limited by ABS formation that fouls airheater
  - ABS needs SO_3 and NH_3
  - Take SO_3 out and you can start injecting NH_3 sooner which will result in reducing NOx and being in compliance sooner
  - Inject lime before catalyst or airheater
    - May be able to lower startup temperature from 600 ⟶ 540 °F

Benefits of SO_3 Removal prior to the APH

[8]**APH operations**

- Eliminate ABS buildup from ammonia slip
- Reduce dP growth over time
- Eliminate outages for cleaning



Benefits of Pre-APH Removal of SO_3

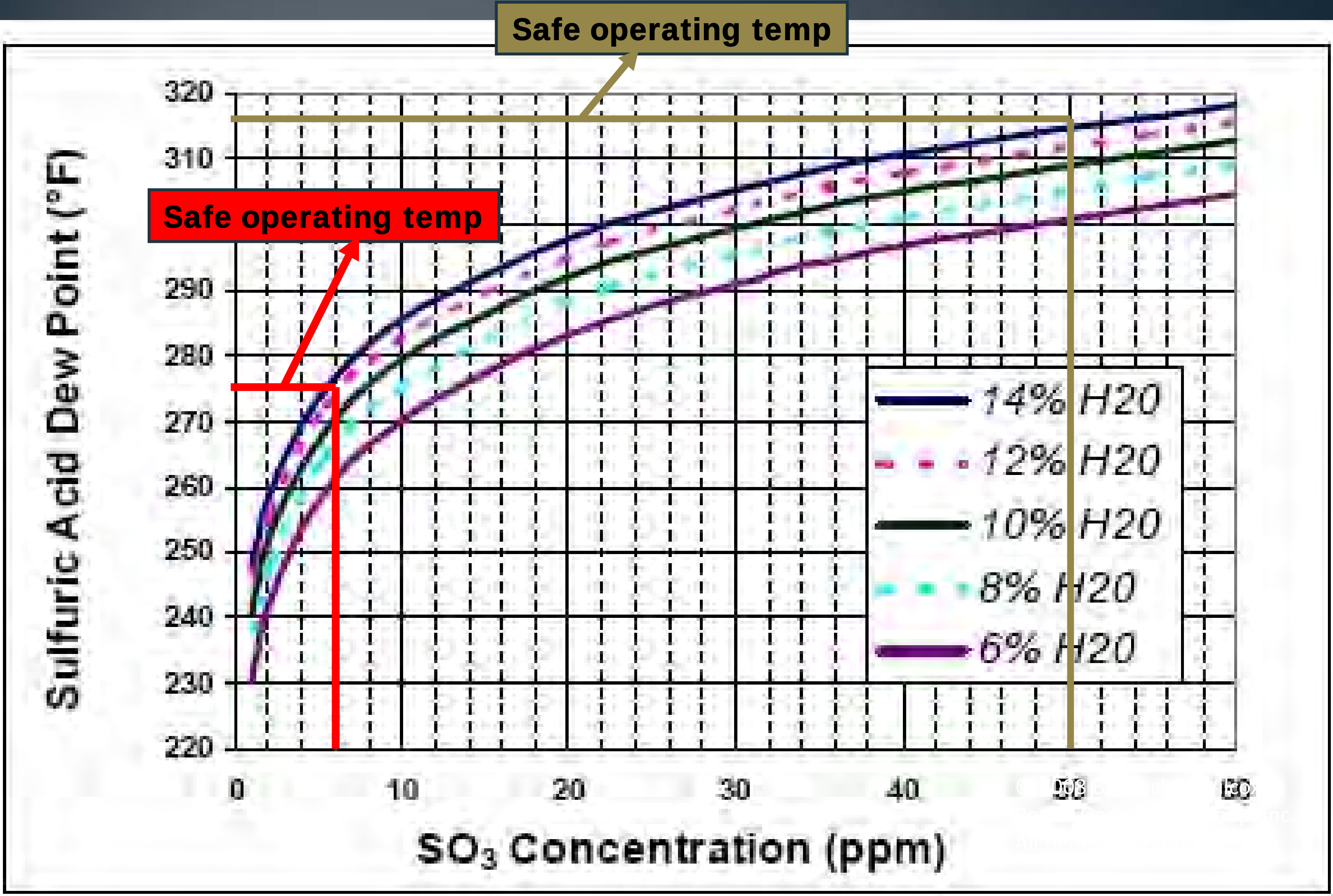
Improve Heat Rate/Reduce CO_2 Emissions

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

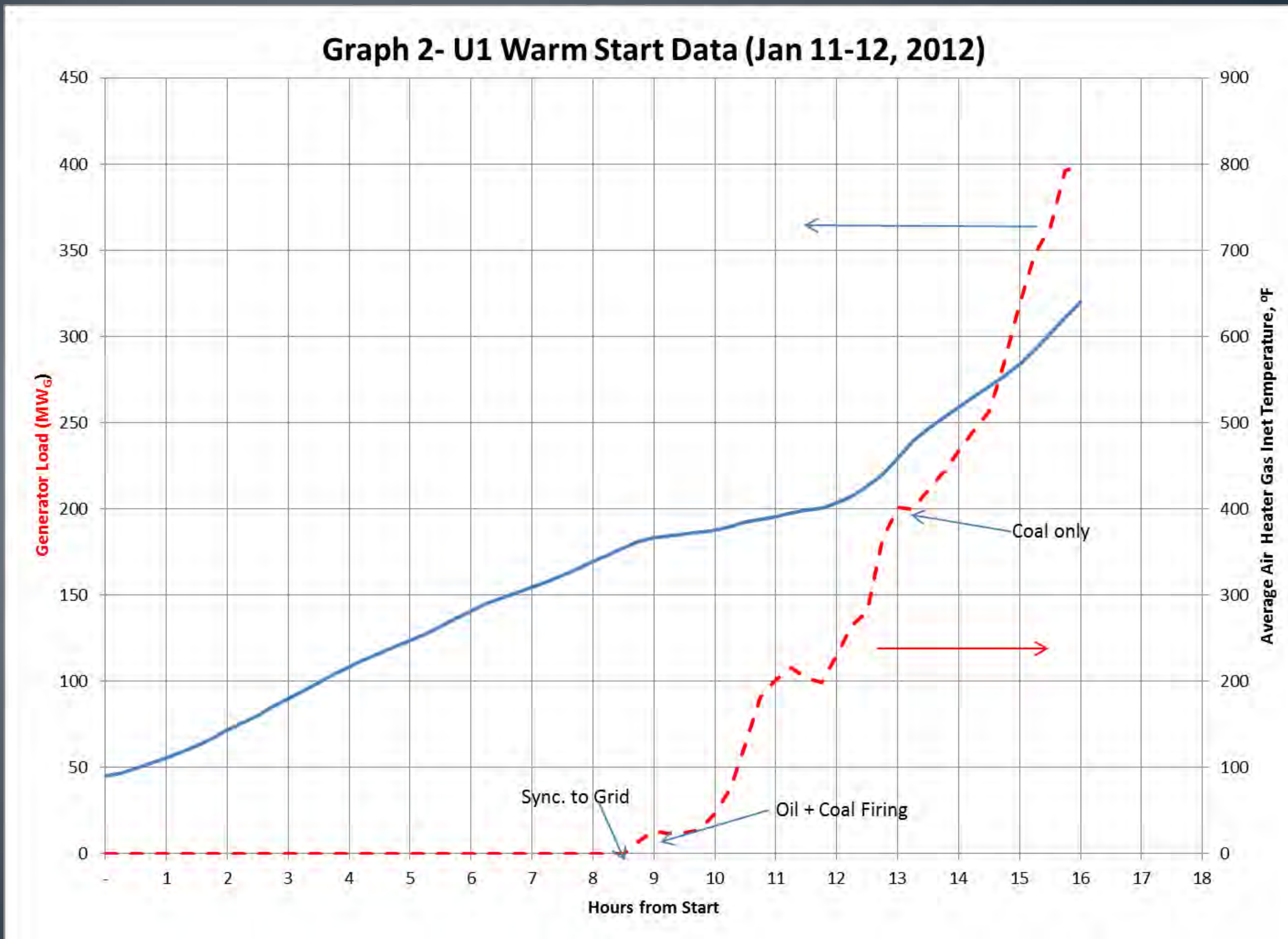
40°F reduction → 1% heat rate improvement → 1% savings on fuel budget

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

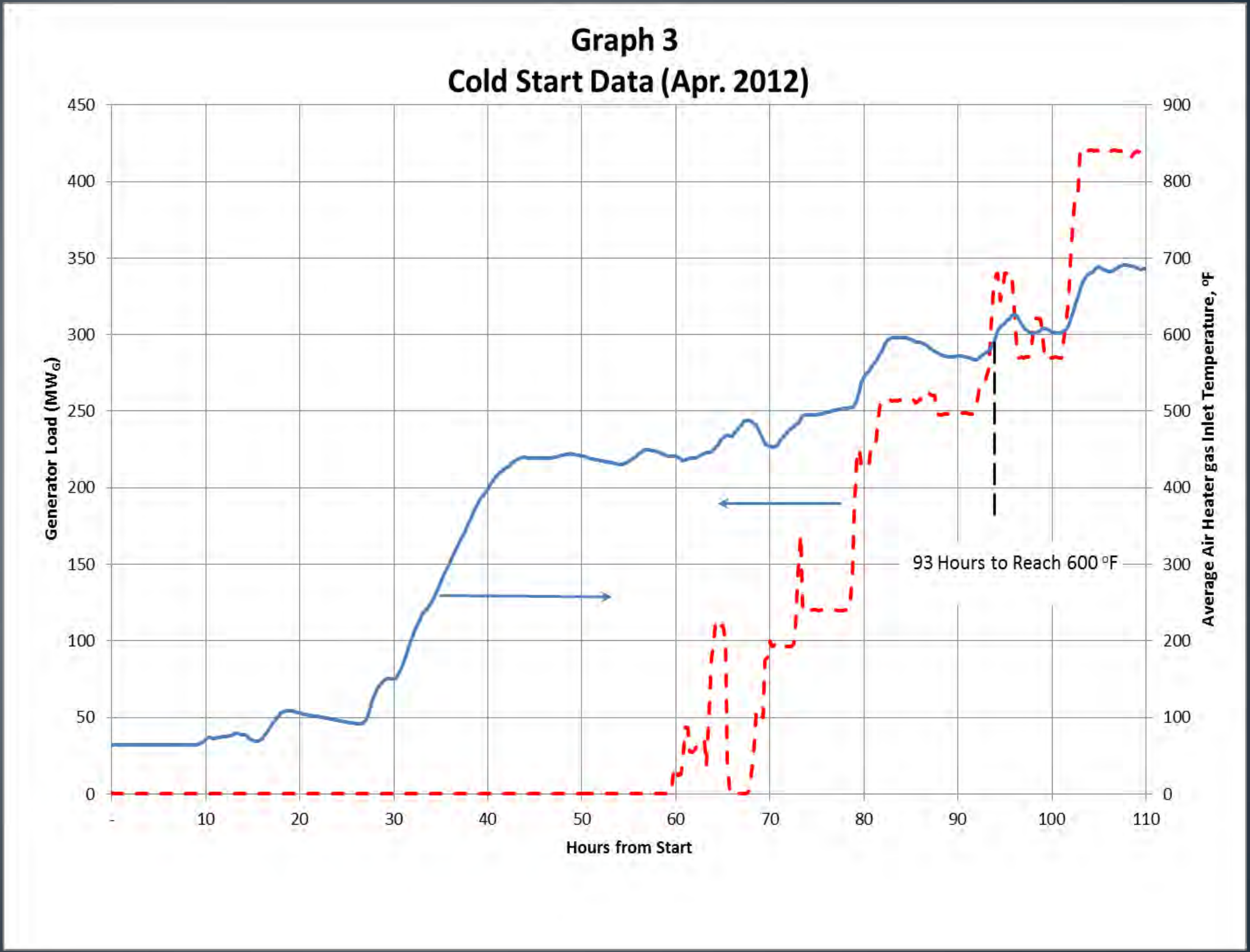
SO_3 Acid Dew Point Curve



Warm Startup



Cold Startup



DSI Challenges

- Emissions Control
- Operate over wide range of load conditions
- Can it play a role in heat rate improvement
- "Net" low cost sorbents that minimize impact on other APC equipment performance and ash management

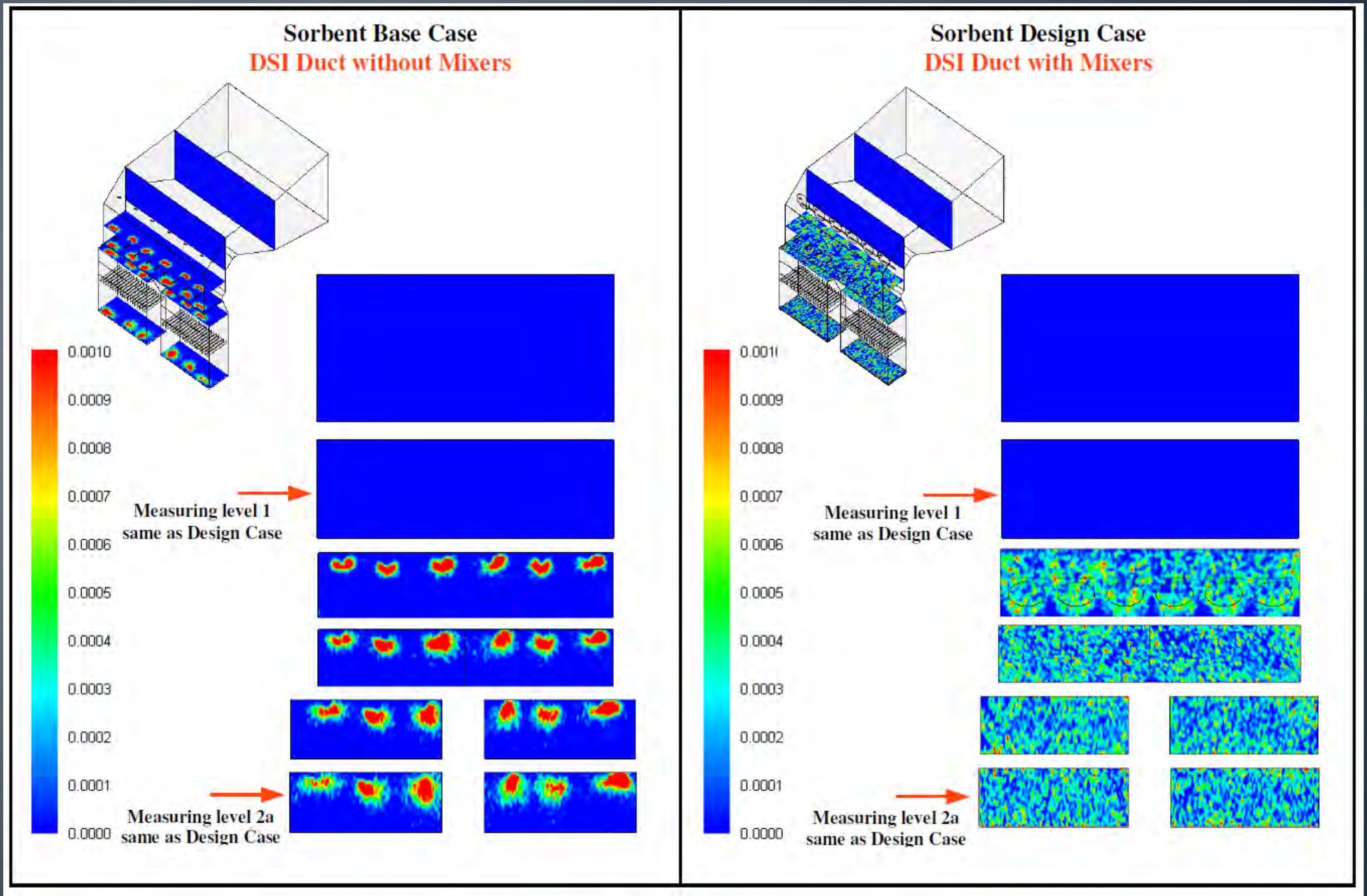
DSI Design

- Periods of operation, especially for boiler startup, characterized by rapid transient changes in flue gas composition, quantity, temperature, and moisture conditions.
- The problems are aggravated with installation of multiple APC equipment and processes, especially those required to achieve MATs compliance.
- Minimize Sorbent usage
  - Cost
  - Ash
  - Other APC equipment

Key To DSI Design

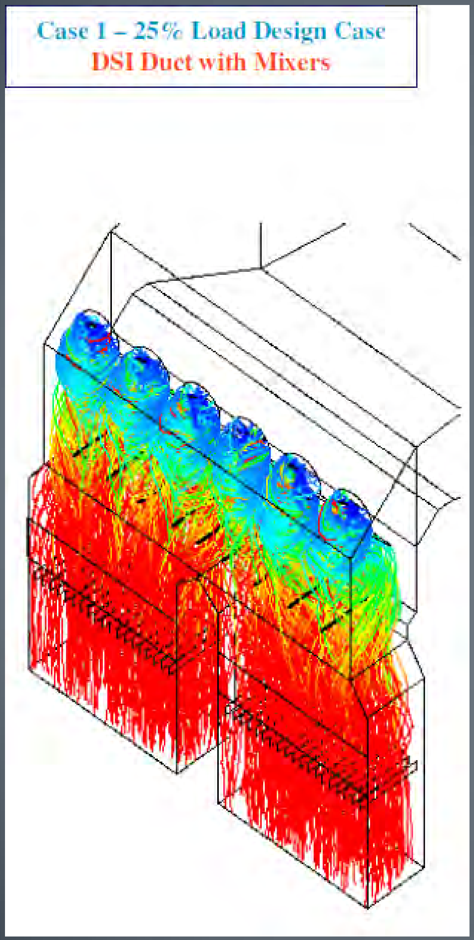
- Distribution of sorbent
- Get the sorbent to the pollutant in the flue gas
- Adjustable feed rate – don't overfeed or underfeed
- Modeling
- Mixing
- Maintain Calcium/air ratio in transport pipe and injectors (>0.4 lbs hydrate: lb air)
  - High air (low ratio) -> tendency toward scale
  - Low air (high ratio) -> stay above saltation velocity

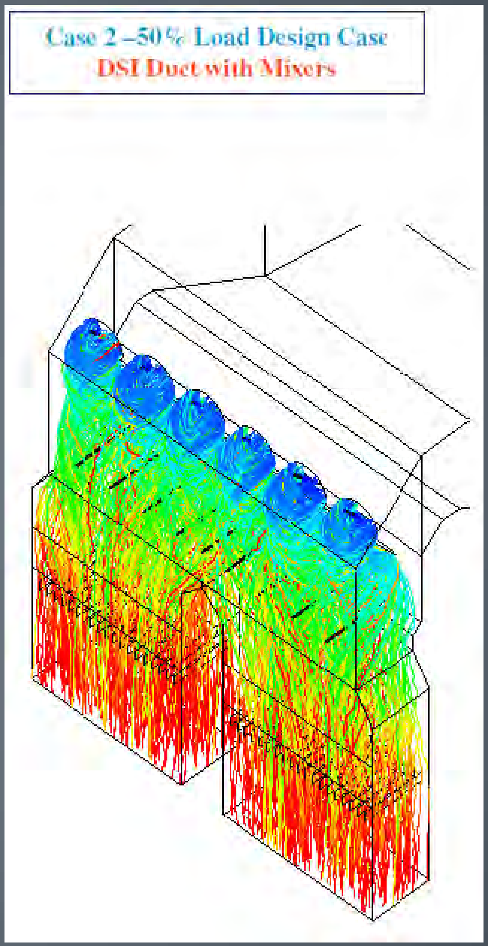
Use of Mixers for Uniform Distribution

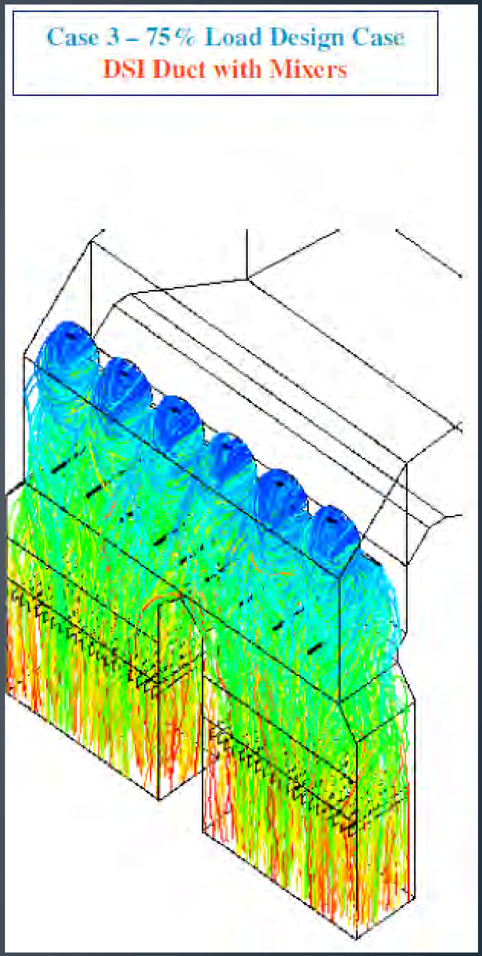


Provided by Babcock Power

Mixing at Various Loads







Provided by Babcock Power

DSI System – Hydrate for SO_3 Control

- Target feed rates established during stack test period
  - Complete load profile, not all at full load
  - Coal sulfur content ranges
- In line monitoring of emissions
  - SO_3 : Breen, SICK, Stack visual
  - SO_2 : CEMS
  - Hg : CEMS (indirect method)

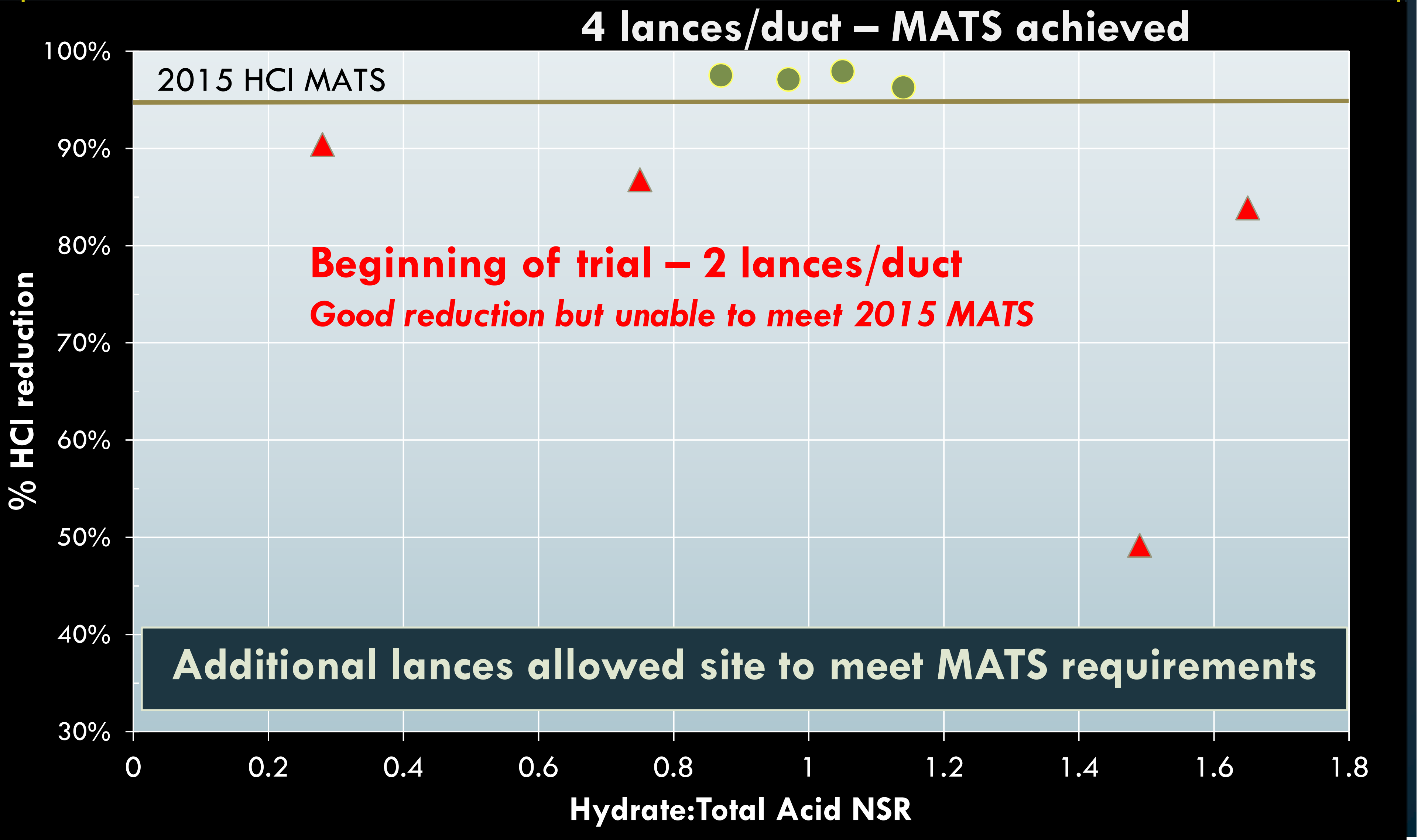
Start-up and Shut-down Events

- Shut-down
  - Main priority: leave the system ready to run
    - Empty rotary feeder, feed lines, splitter(s), and lances
    - Keep the blower running as long as there is a risk of flue gas passing into the DSI system
    - Follow manufacturer's recommendations
  - Manage inventory in silo and air quality to bin activators
- Start-up
  - Sorbent flow: pollutants present and flue gas flow sufficient
  - Baghouse: bag coating
  - Sorbent Cost < Cost of a Fine

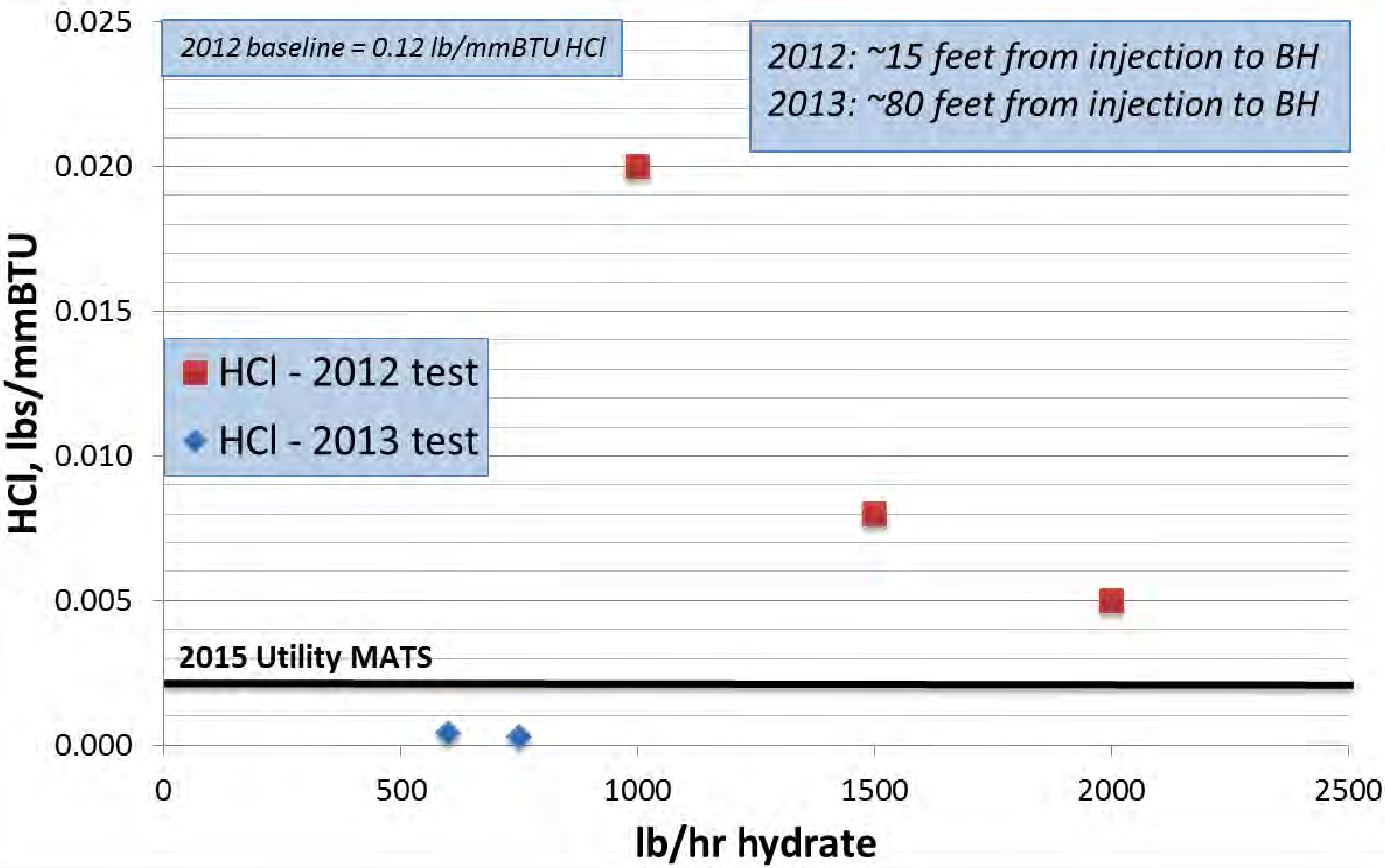
During Operation Maintain Sorbent Flow and Distribution to Duct

- Handling best practices = high system On Stream Times
  - Consistent flow from silo to rotary feeder
  - Manage conveying air balance with sorbent
  - Optimize convey temperature and moisture content
  - Convey line size, length, and pathway
- Cover the flue gas
  - Effective flow split
  - Lance # and depth
  - Distribution in flue gas
    - In-duct mixers
    - Special lances

Improved Distribution to Meet HCl MATS



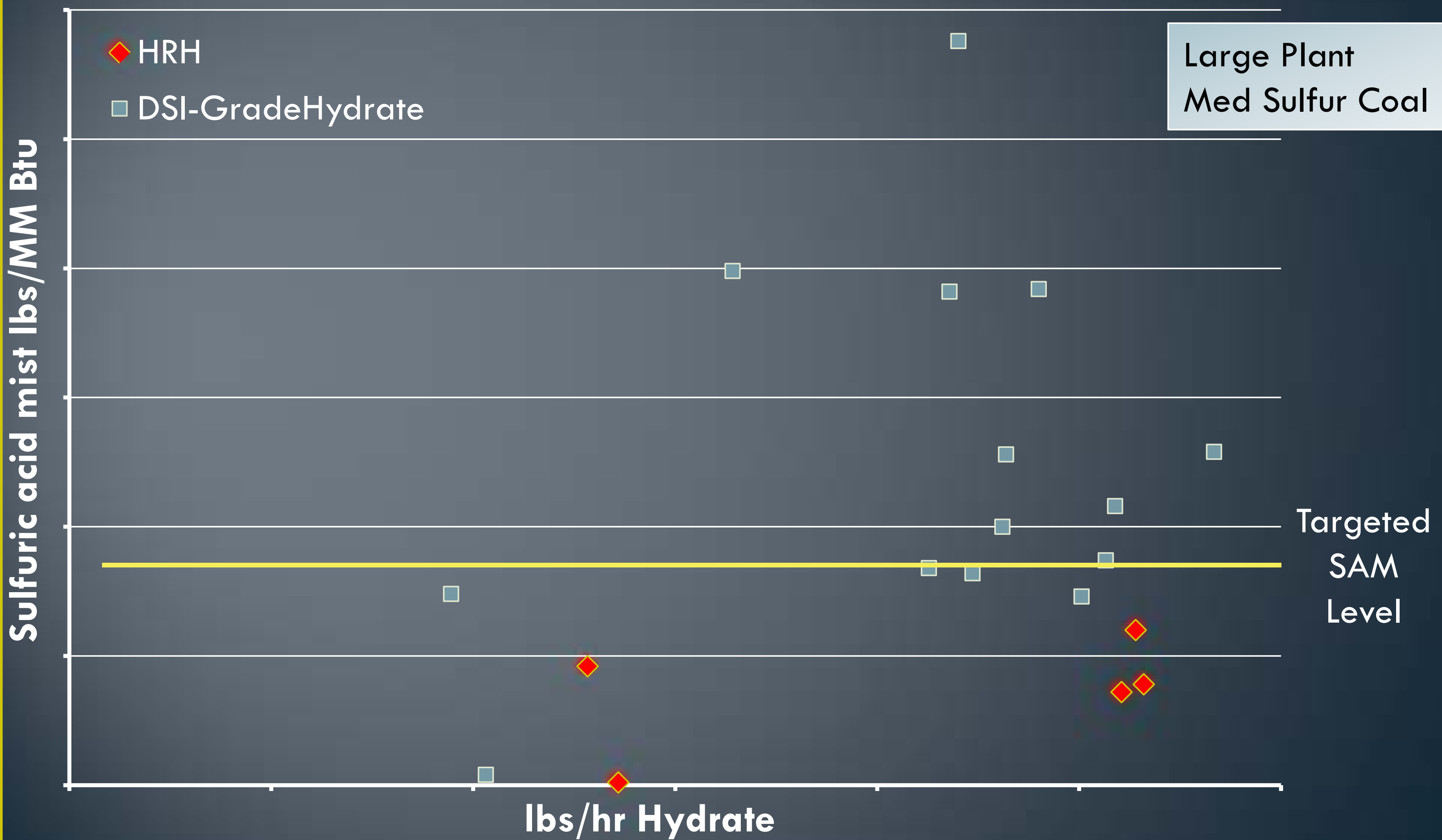
Longer Residence Time Improves HCl Removal



Use a Better Sorbent

- Next generation sorbents available
  - Capability for high level (> 90%) pollutant removal
  - Higher costs offset by lower annual usage
- Additional benefits
  - Lower emissions level – like buying insurance
  - Fewer deliveries
  - Less stress on feed system and other APC equipment
    - ESP
    - Particulate
    - Ash disposal
  - Inventory advantages

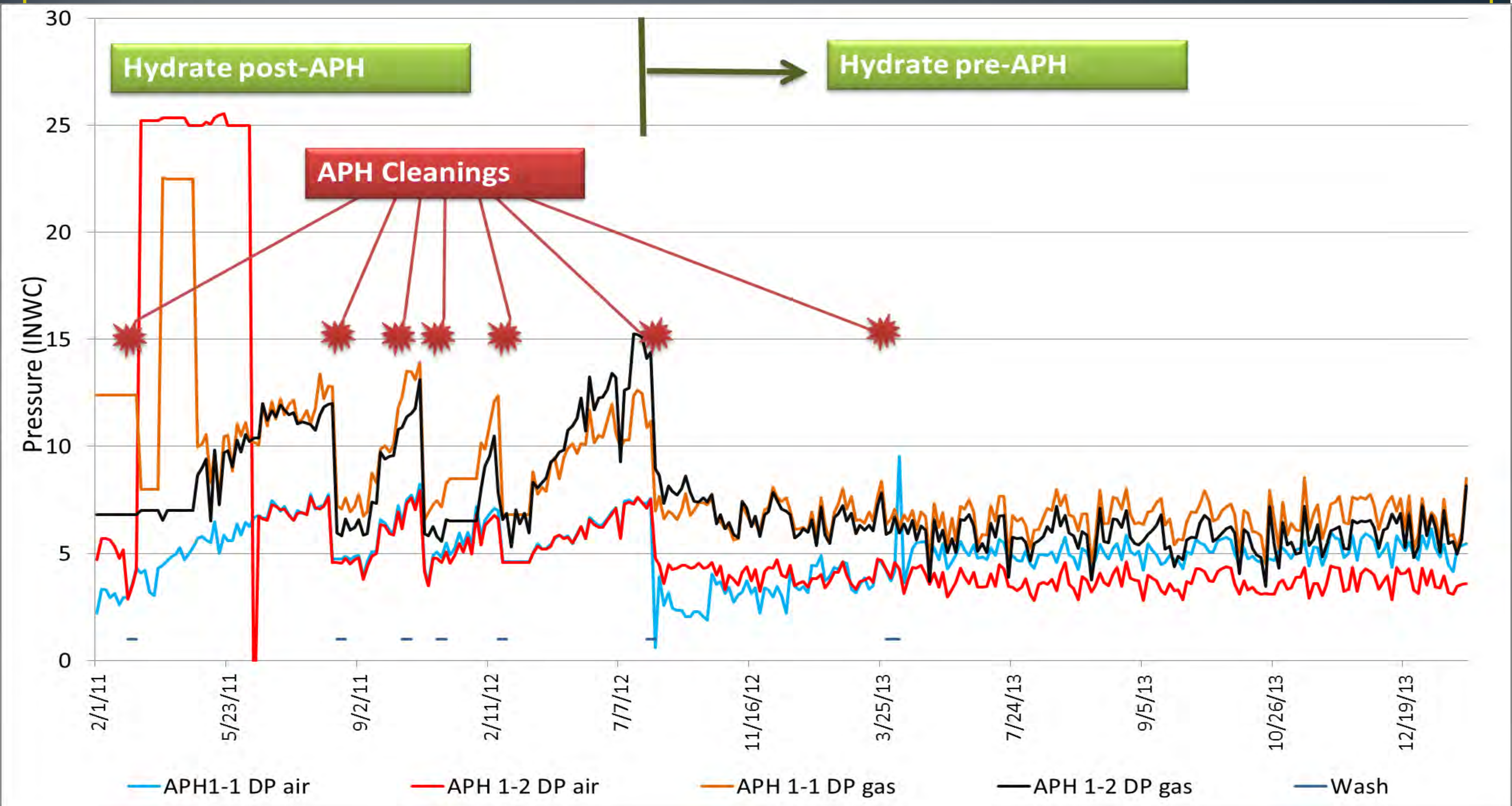
High Reactivity Hydrated Lime Allows a Plant to Meet SAM Requirements



Pre-APH with Hydrated Lime Where are We Now?

- Significant testing, retro-fits, and installations in past 3 years
  - Over 35 units (~23 GW)
- Many units have operated with Pre-APH injection of hydrate for over 12 months and multiple outage cycles
- SO_3 is being controlled
- Air preheaters are staying clean

Hydrated Lime Injection Upstream of APH Example of Recognized Improvement



TVA – Paradise Units 1 & 2
Benefits from Pre-APH Injection of Hydrate

Post-APH Injection of Hydrated Lime (Jan '11 – Mar '13)

- Over **570,000 MWh** were lost as a result of air heater fouling from both units

Pre-APH Injection of Hydrated Lime (Mar '13 – Current)

- **0 MWh** have been lost as a result of air heater fouling
- Have not experienced any APH pluggage attributed to hydrate injection
- Contributing Factors:
  - Air Heater maintenance
  - Combustion Tuning
  - SCR catalyst replacement/ Tuning

Injection of Hydrated Lime Pre-SCR

Benefits

- Earlier control of SO_3
- Longer contact time
- Enhanced mixing

Concerns

- Fouling of catalyst
  - No signs of deactivation on test conducted to date
- Likely need secondary hydrate injection point downstream of SCR
- Implications of HCl removal on Hg

Questions & Answers

Tony Licata
Licata Energy & Environmental Consultants, Inc.
345 Concord Road
Yonkers, NY 10710
Phone 914-779-3451
Email TonyLicataLEEC@aol.com

Curt Biehn
Mississippi Lime
3870 S. Lindbergh Blvd.
St. Louis, MO 63127
Phone 314-543-6309
Email cbiehn@mississippilime.com