REINHOLD ENVIRONMENTAL Ltd.

2012 APC Round Table
& Expo Presentation

July 16-17, 2012, in Baltimore, MD / Hosted by Duke Energy, Entergy, FirstEnergy, Southern Company & TVA

URS

"Wet Sorbent Injection Experience: Past, Present, and Future"

Sterling Gray, URS Corporation

Reinhold Environmental APC Conference
Baltimore, MD – July 17, 2012

Outline

- Technology
- Installations
- Performance
- Operational Issues - Past
- Hoosier Merom - Present
- Co-Benefits - Future
- Summary

SBS Injection™ Technology

Features

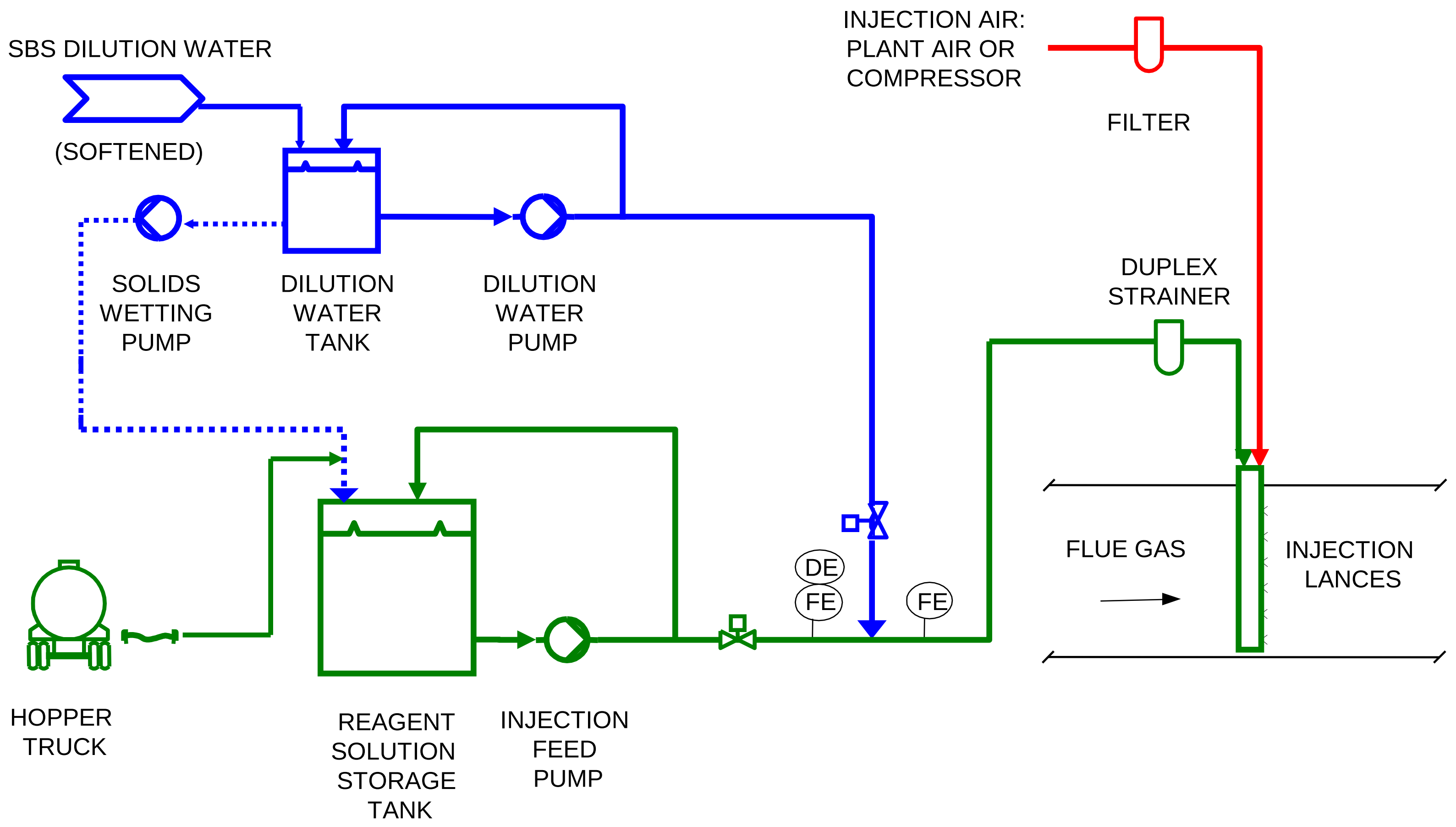
- Patented Technology
- Simple Solution Injection
- Sodium-Based Reagent
- Dual-Fluid Atomization
- Selective Reactions
- High SO_3 Removal
- Low Injection Rate
- Product Collected with Ash

Benefits

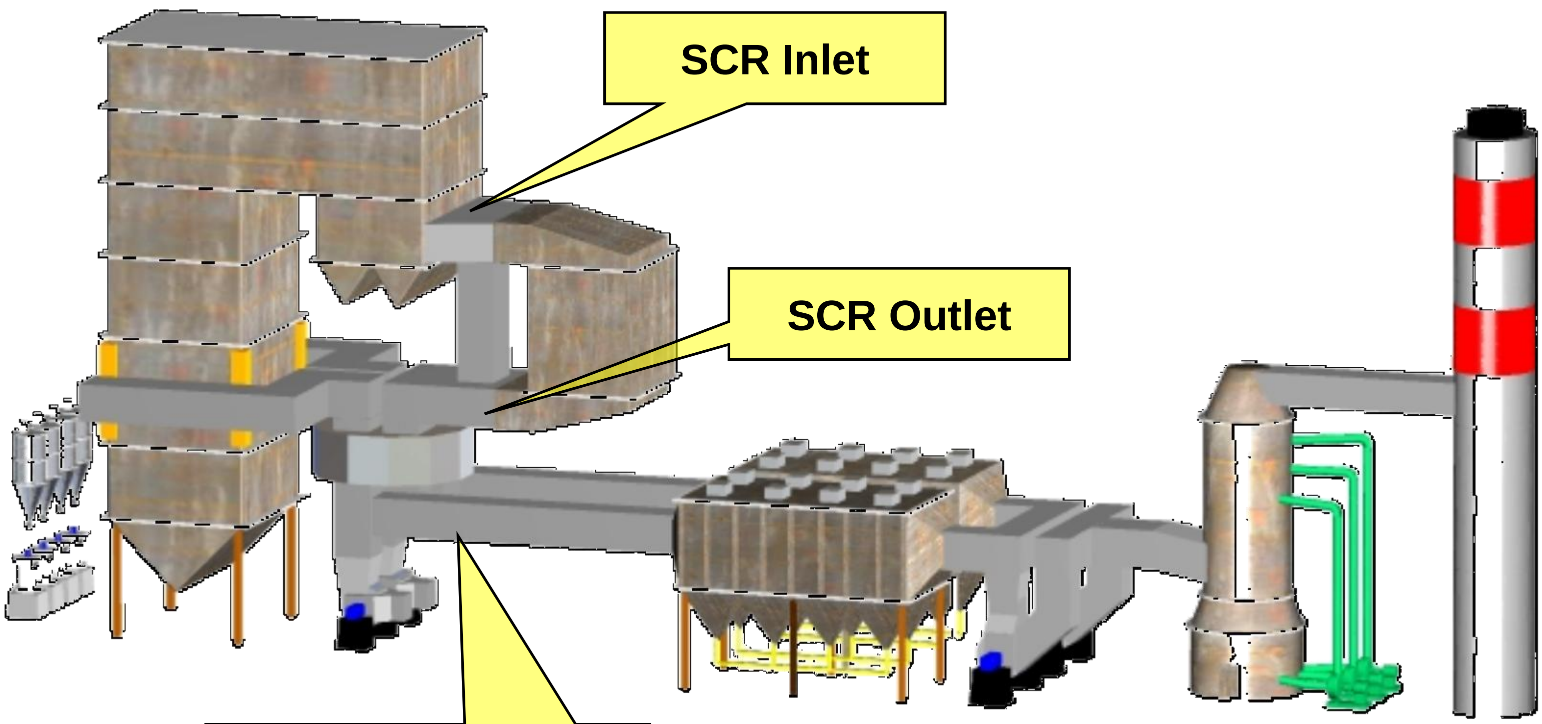
- Opacity Elimination
- Corrosion Reduction
- ESP Enhancement
- HCl and Se Removal
- Potential Heat Recovery
- SCR/SNCR Flexibility
- Hg Capture Enhancement
- CO_2 Reduction

Maximum Benefits with "Upstream" Injection

Simplified SBS Flow Diagram



SBS Injection Locations



SBS Injection Installations

Utility	Plant	State	MW	Design SO_3	Injection Location	Reagent	Startup Date
FirstEnergy	Mansfield 1-3	PA	3 x 860	80	Air Heater Inlet	Sodium Sulfite	2003
TVA	Widows Creek 7	AL	550	54	Air Heater Inlet	Sodium Sulfite	2003
NIPSCO	Bailly 8	IN	365	59	Air Heater Outlet	Sodium Carbonate	2004
Vectren	Culley 3	IN	287	48	SCR Outlet	Sodium Carbonate	2004
PPL	Montour 1-2	PA	2 x 765	42	Air Heater Outlet	Sodium Carbonate	2004
Duke Energy	Gibson 1-5	IN	5 x 650	110	Air Heater Outlet	Sodium Carbonate	2005
DP&L	Killen 2	OH	635	34 / 36	Econ Outlet / SCR Outlet	Sodium Carbonate	2007
IP&L	Harding St 7	IN	465	58	SCR Outlet	Sodium Carbonate	2007
NIPSCO	Bailly 7	IN	180	59	SCR Outlet	Sodium Carbonate	2008
DP&L	Stuart 1-4	OH	4 x 620	90	SCR Inlet	Sodium Carbonate	2008
Duke Energy	Gibson 1-3, 5	IN	4 x 650	110	SCR Inlet	Sodium Carbonate	2009-2011
Allegheny Energy	Pleasants 1-2	WV	2 x 700	74	SCR Outlet	Sodium Carbonate	2012
Hoosier Energy	Merom 1-2	IN	2 x 540	100	SCR Inlet	Sodium Carbonate	2012

15,000 MW Installed on 24 Boilers

Sulfuric Acid Emission Results

Plant	Inlet SO_3 (ppmvd - 3% O_2)	Stack SO_3 (ppmvd - 3% O_2)	SO_3 Removal (%)	H_2SO_4 Emissions (lb/MMBtu)	Particulate Control Device	SO_2 Control Device
A	32	1.3	95.9%	0.0038	ESP	WFGD
B	65	1.6	97.5%	0.0046	Venturi Scrubber	WFGD
C	36	1.3	96.4%	0.0038	ESP	None
D	66	1.2	98.2%	0.0035	ESP	WFGD
E	45	0.2	99.6%	0.0006	ESP	WFGD
F	15	0.6	96.0%	0.0017	ESP	WFGD
G	44	0.5	98.9%	0.0015	ESP	WFGD

Recent installations demonstrate <1 ppm SO_3 and <0.004 lb/MMBtu SAM

URS

Why is WSI so Effective?

Location, Location, Location

- Particle Size
- Distribution
- Mixing

Why is Particle Size Important?

SBS

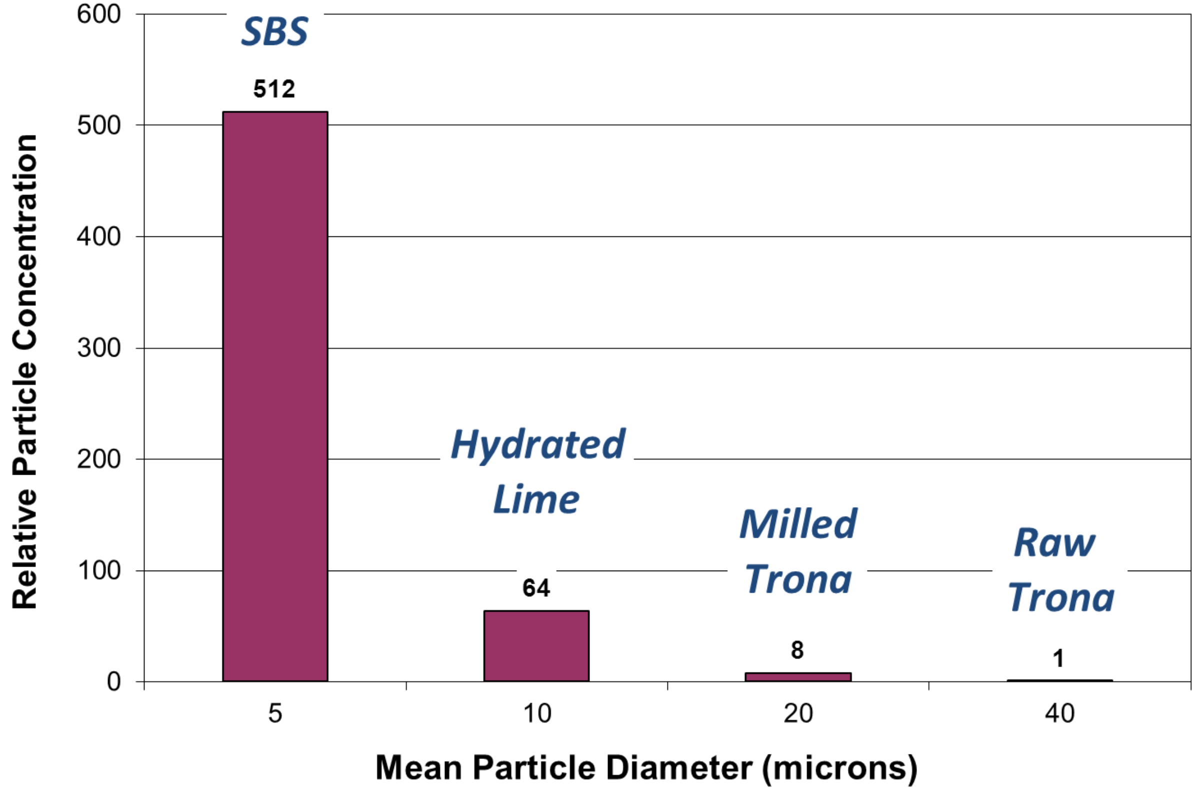
Hydrated Lime

Milled Trona

Raw Trona

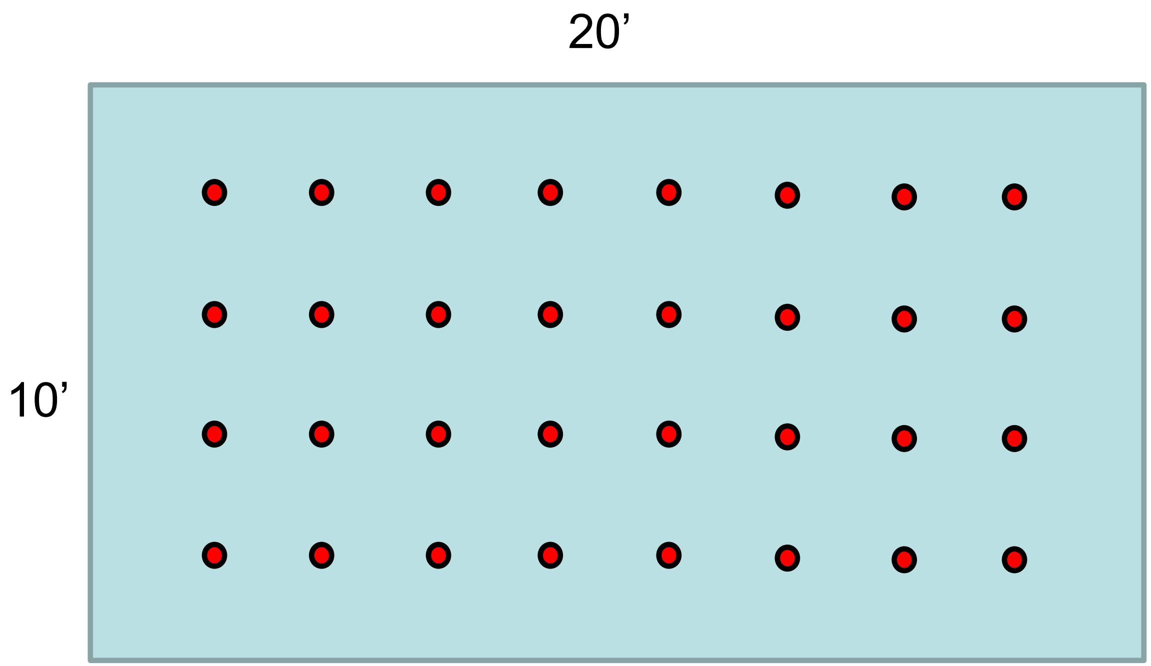
Smaller particle size means greater quantity of particles for given mass of sorbent

Why is Particle Size Important?



More SBS particles means less distance to SO_3 molecule and faster reaction

Typical SBS Distribution



8 Lances x 4 Nozzles = 32 Injection Points (~ 6 ft^2/nozzle)
Lance and Nozzle Flow Deviation ~ +/- 5%

Ensures good distribution of sorbent and contacting with flue gas and pollutant

Past

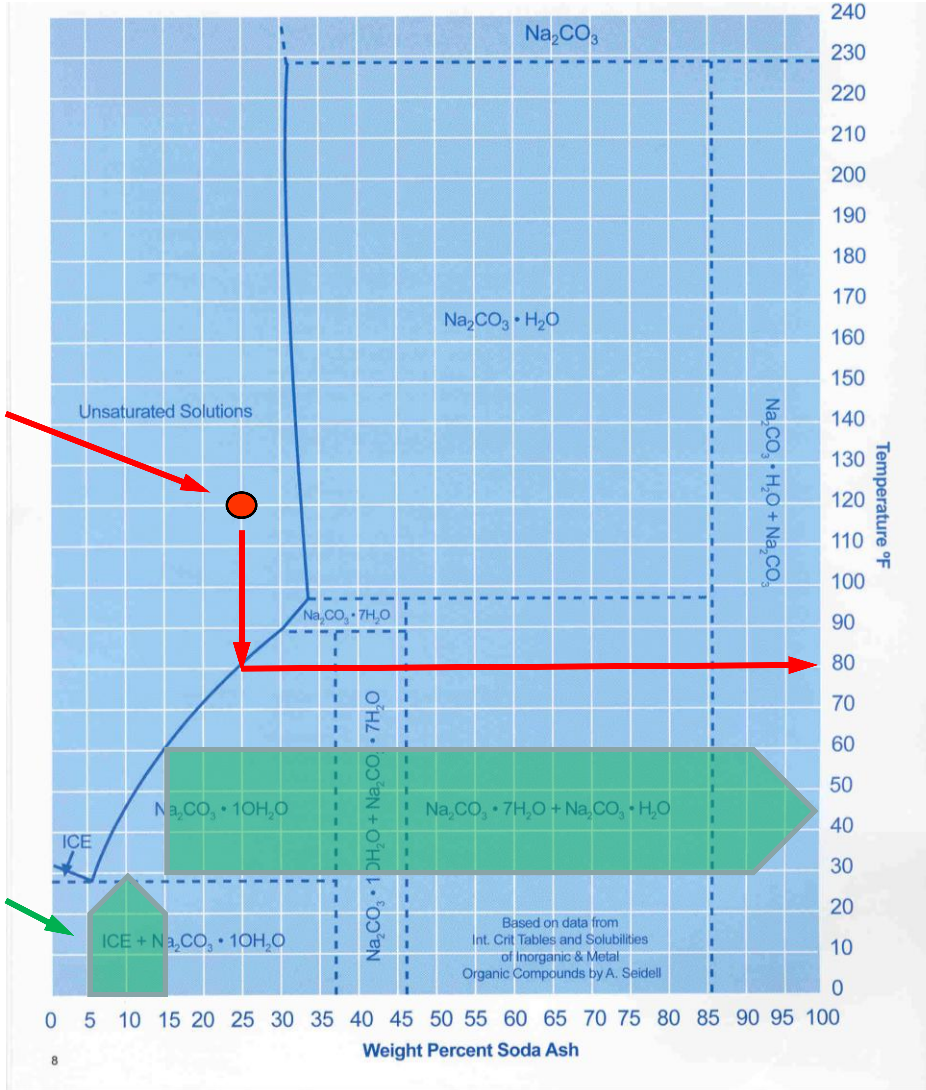
Operational Issues

- Soda Ash Salting
- Poor Atomization
- Nozzle Pluggage
- Strainer Pluggage
- Air Heater Fouling

Soda Ash Solubility Diagram

Design Storage Conditions

Typical Injection Conditions



"Salting" Temperature

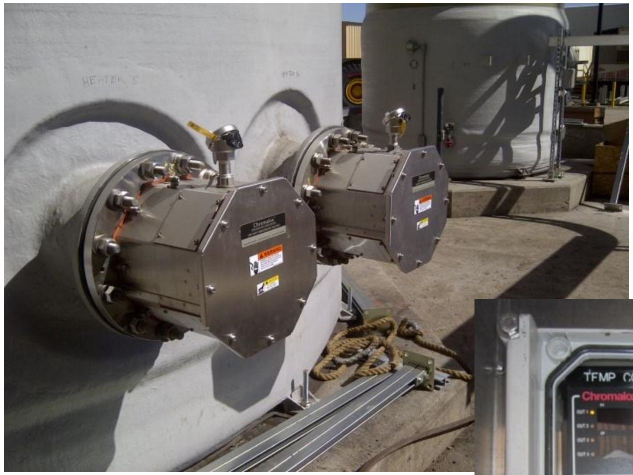
25 wt% ~ 80°F

5-15 wt% ~ 30-60°F

“Salting Out” Examples

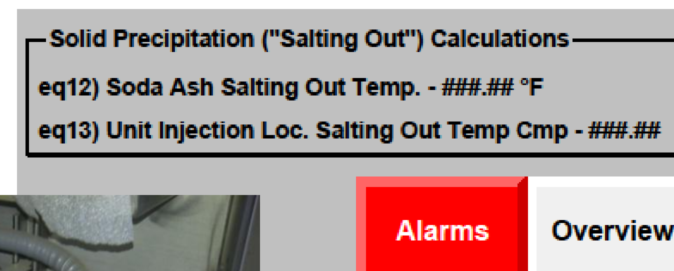
Design Preventative Measures

- Redundant heaters in reagent storage tank
- Insulation and heat-tracing of all liquid piping
- Automatic flush sequences for shutdown



Design Preventative Measures

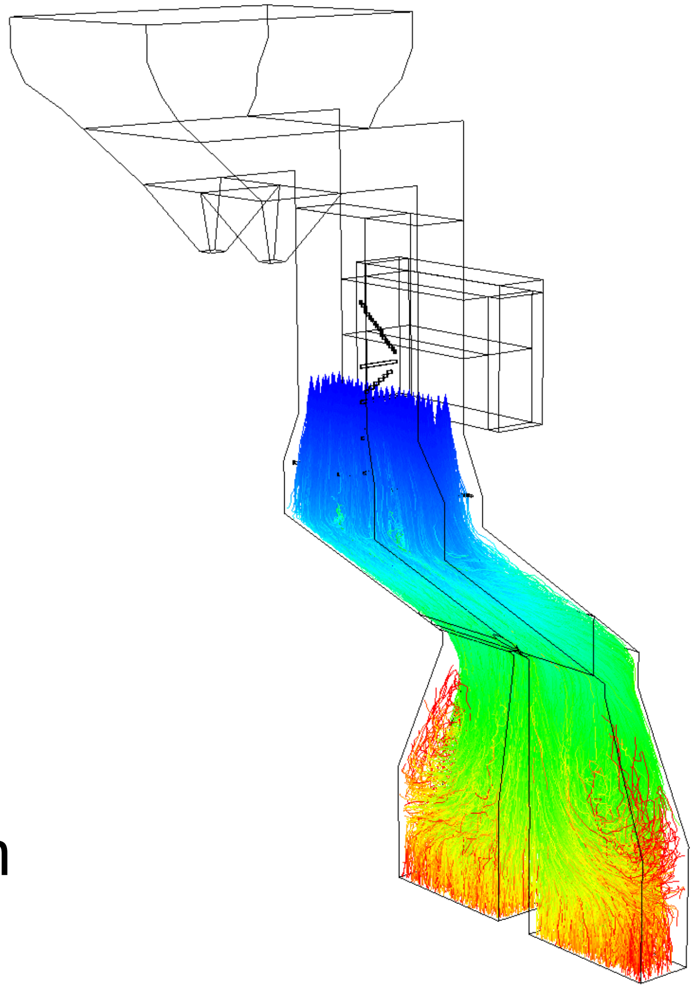
- Solution temperature monitoring (at injection lance supply piping)
- Low temperature alarms (calculated “salting” temp)
- Heat-tracing monitoring alarms



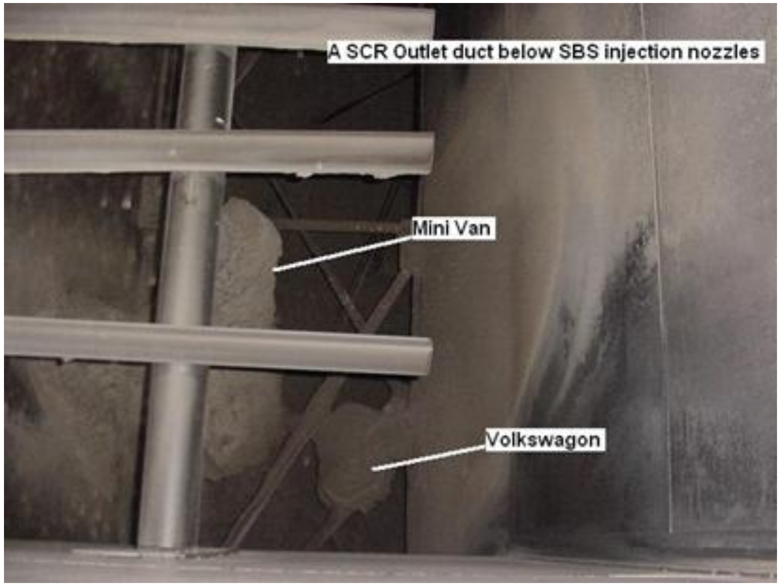
Poor Spray Atomization

Southeastern Utility

- Installed 2003
- 550 MW
- SCR – ESP - WFGD
- Inject at APH Inlet
- 50-55 ppm Inlet SO_3
- 1.5-2.0 sec Res Time
- <5 ppm SO_3 at APH-I
- Ozone season operation



Injection Duct/APH – Oct 2003

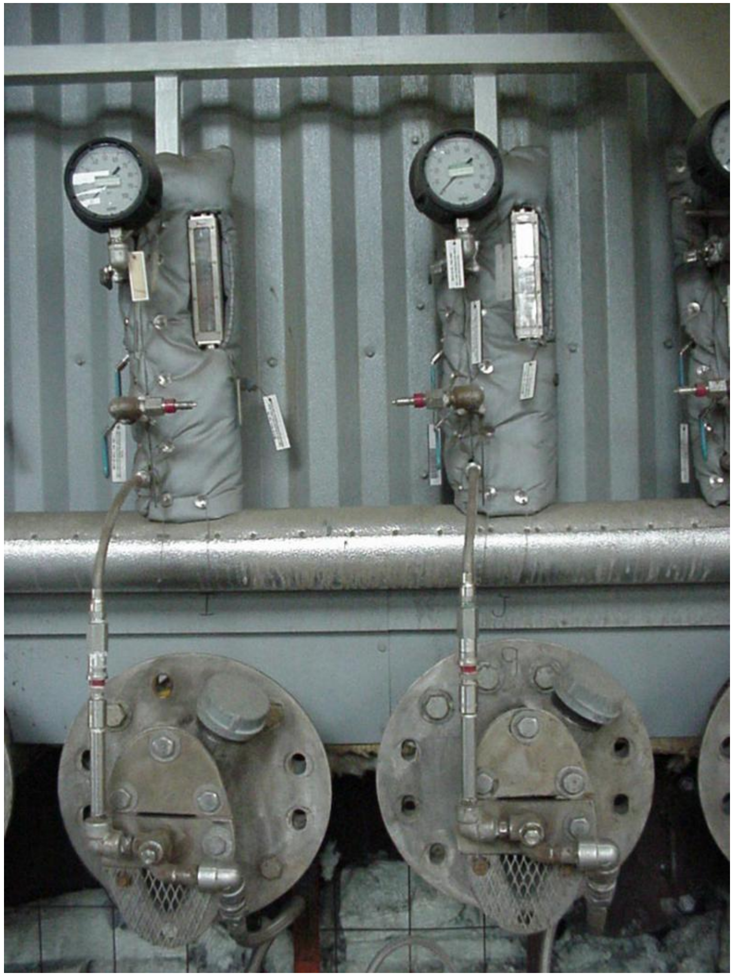


Issue: Observed large “clinkers” in vertical ductwork and small “gravel” deposits on top of APH elements.

Cause: Atomizing air supply to one or more injection lances inadvertently turned off for two-week period.

Contributing Factors

- Local lance flow indication only
- Difficult to read lance flow
- Difficult access to injection lance area (two ladders, scaffold platform)
- Operators not taking regular daily shift log readings



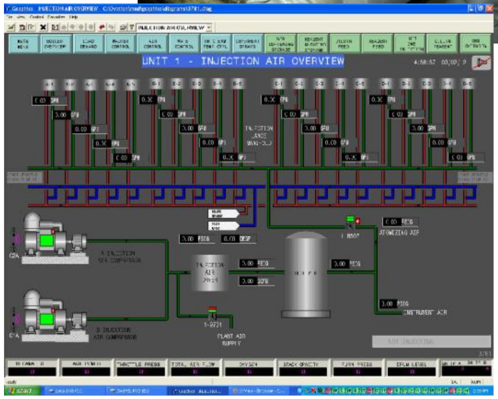
Injection Duct/APH – Oct 2004

Action: Implemented better operational practices and review of daily operating results.

Result: No significant deposition observed in ductwork and small gravel deposits on APH significantly reduced.

New Design Approaches

- Change to mag flow meters on lances
- Lance flows incorporated into control system



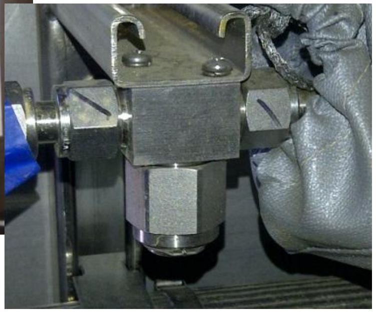
- Lance flow alarms implemented
- Atomizing air pressure interlocks implemented
- Improved access to injection lance area

Lance Nozzle Pluggage

Issue: Early installations saw some pluggage of injection lance nozzles due to foreign debris.

Solutions:

- Implemented two stage filtration of liquid
  - Duplex basket strainer on common line
  - Small inline strainer on injection lance feed
- Implemented strainers on atomizing air stream and flush water stream



Strainer Pluggage

Issue: Observed intermittent strainer pluggage – worse after system shutdown and restart.

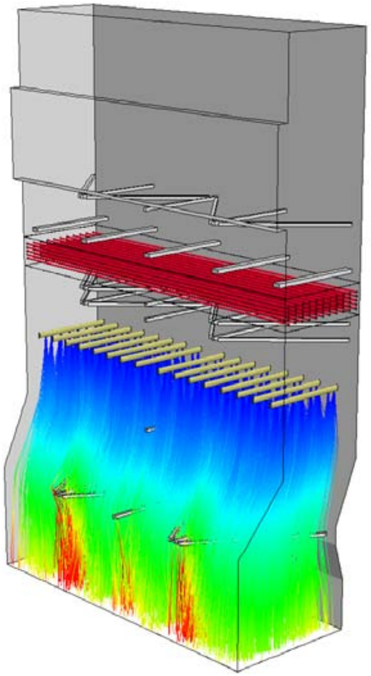
Cause: Wear/degradation of soda ash unloading hose.

Fix: Replacement with stainless steel hose design.

Air Heater Fouling

Northeastern Utility

- Installed 2003
- 860 MW
- SCR/ESP/WFGD
- ~65 ppm Inlet SO_3
- <0.7 sec Res Time
- 10-20 ppm SO_3 AH-I



Issue: *Observed gradual increase in APH pressure drop during operation of SCR.*

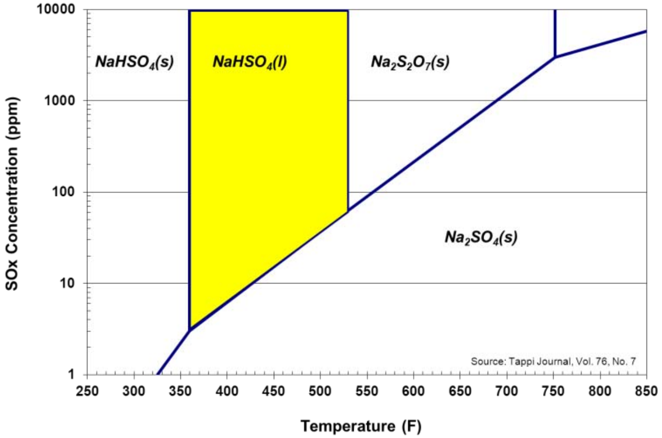
Air Heater Fouling

Observation:
Deposition of sodium salts in middle layer of air heater.

Cause:
Inadequate SO_3 removal resulting in liquid sodium bisulfate formation (NaBS).

Design Solution:
Ensure adequate reaction time and mixing to achieve required APH inlet SO_3 conc via CFD modeling.

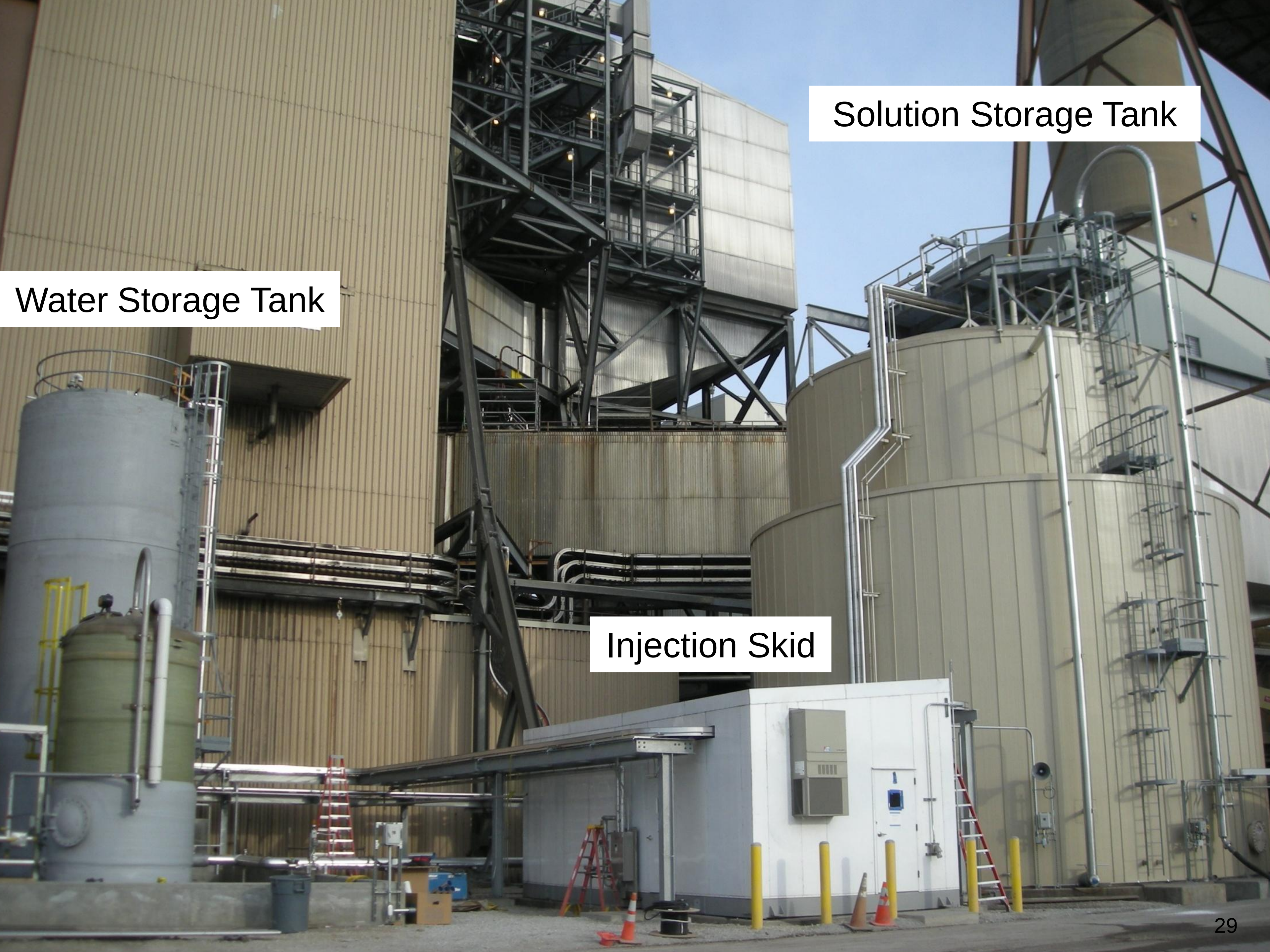
Sodium Sulfate Phase Diagram

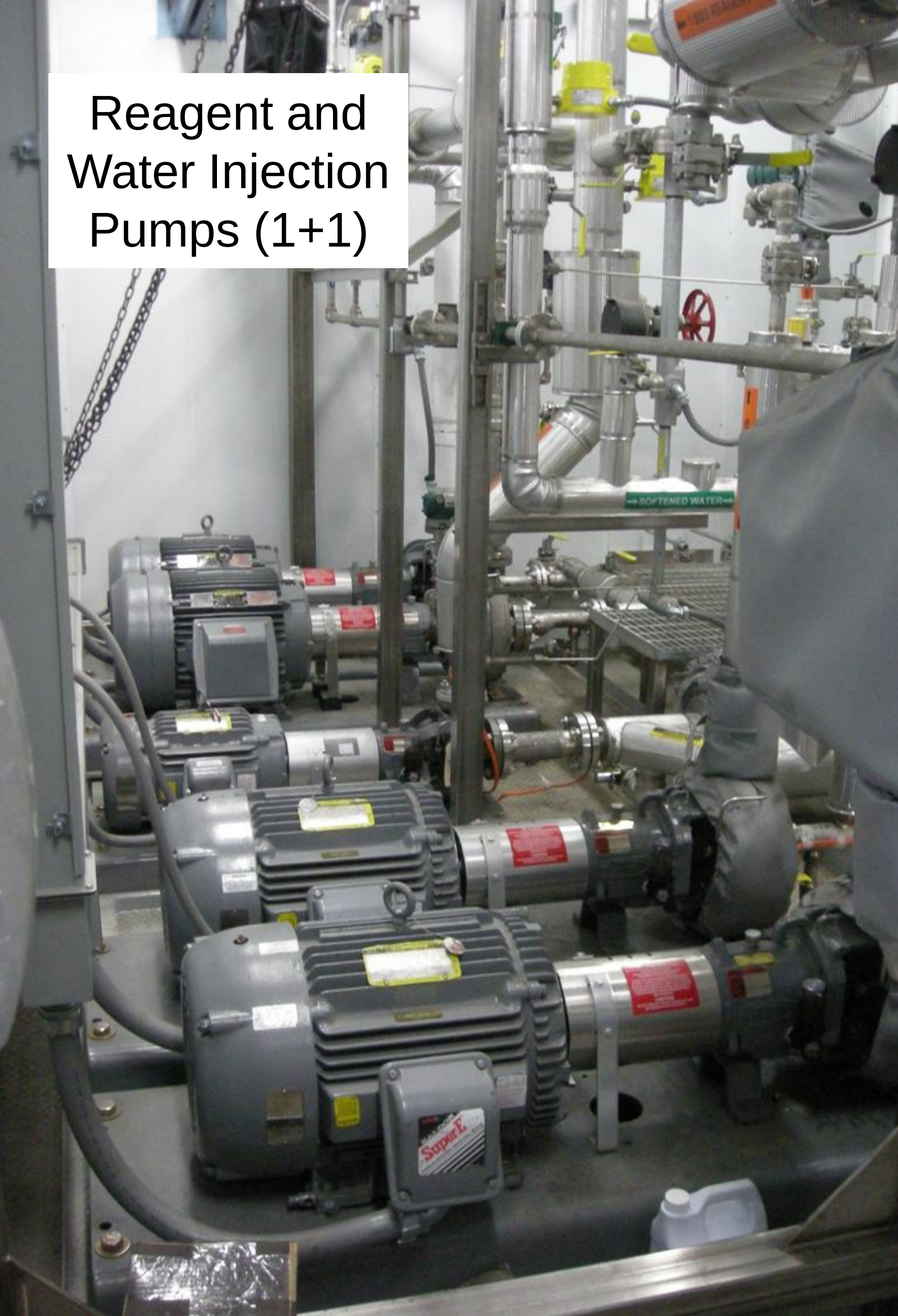


Present

Hoosier Energy Merom SBS

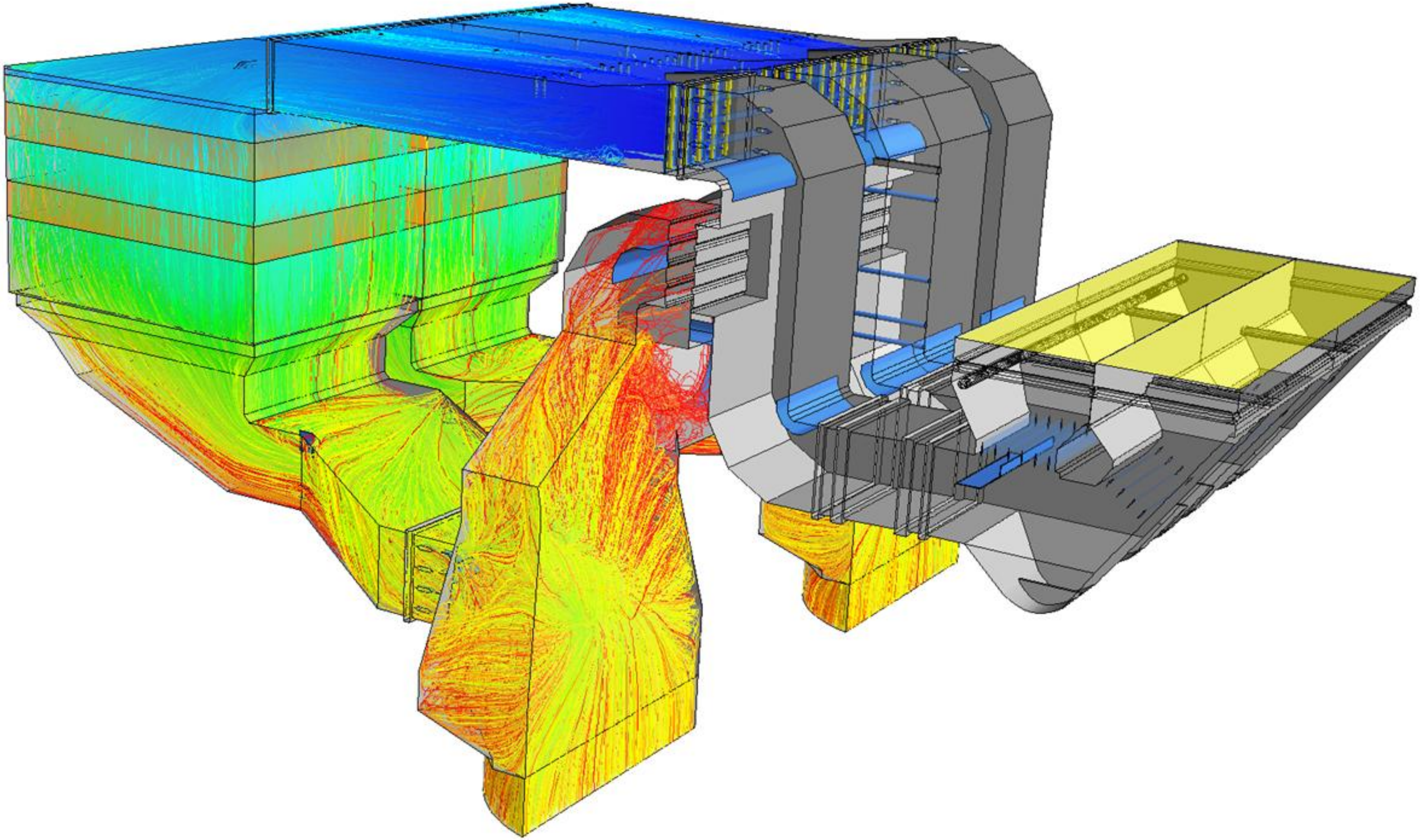
- Sullivan, IN
- 2 x 540 MW
- SCR / APH / ESP / WFGD
- 5 lb SO_2/MMBtu Fuel
- 100 ppm design SO_3
- ~ 70 ppm actual SO_3
- SCR inlet injection location


Solution Storage Tank
Water Storage Tank
Injection Skid



Reagent and Water Injection Pumps (1+1)

Process Instrumentation and Control Valves



Injection Location – SCR Inlet


Injection Location – SCR Inlet

Injection Manifold

Injection Lance

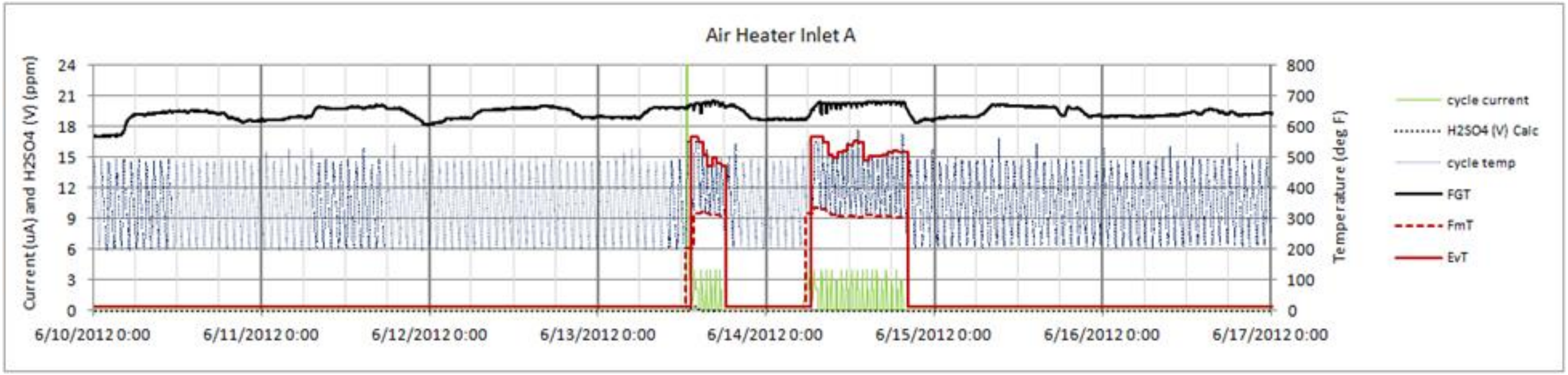

Before SBS Injection

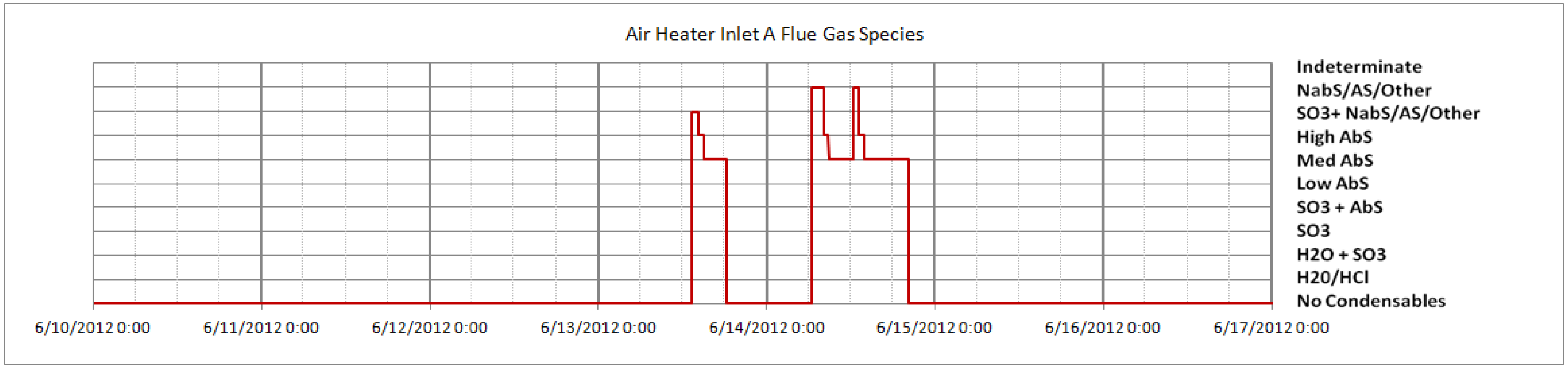

After SBS Injection


Before SBS Injection


After SBS Injection

Breen "Condensible" Results





SBS in Service: No condensables detected

SBS Out of Service: ABS detected

SBS in Service: No condensables detected

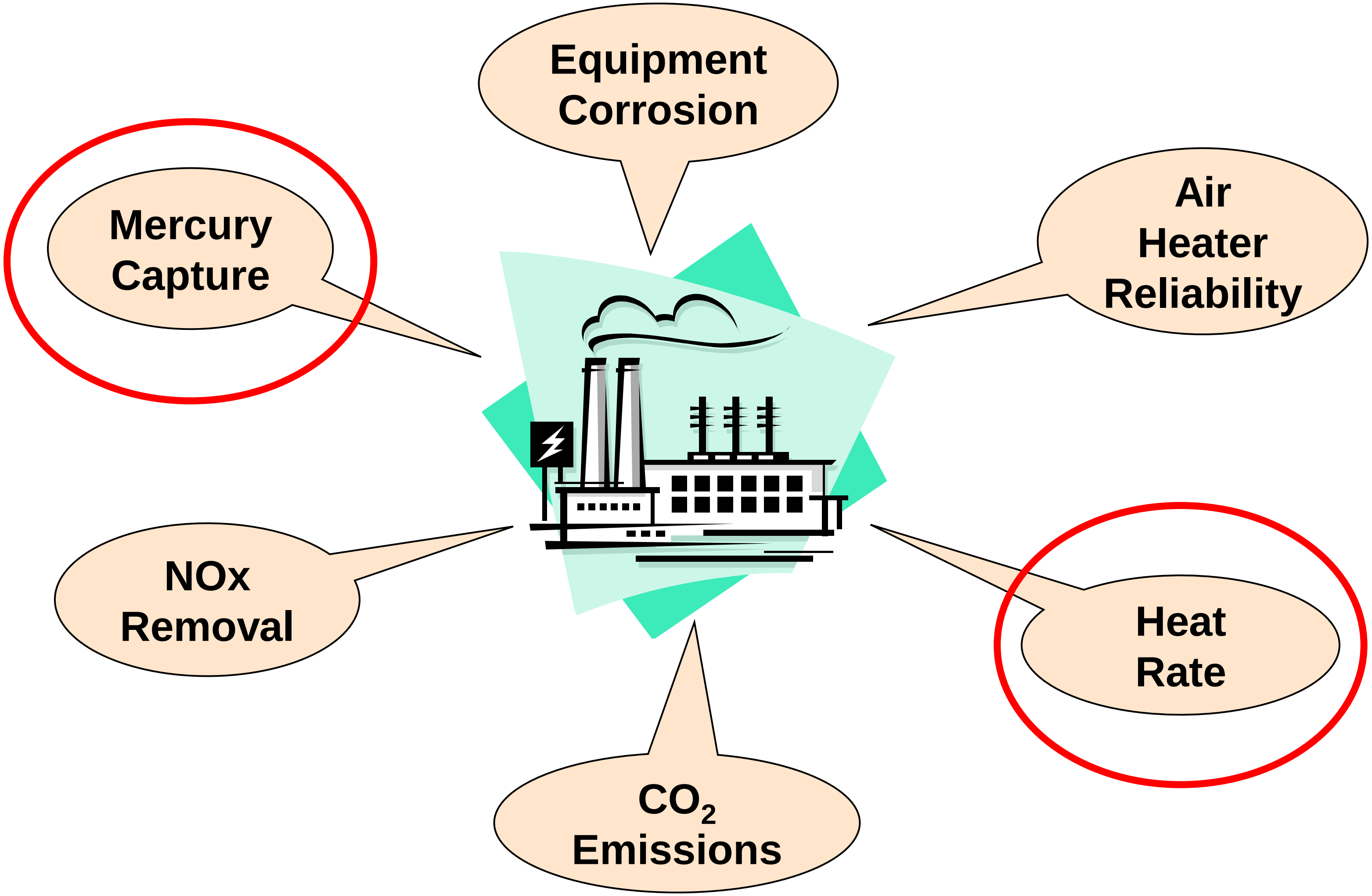
Injection Duct (Harding Street) – After 8 Months of Operation

Future

Opacity is most visible issue…

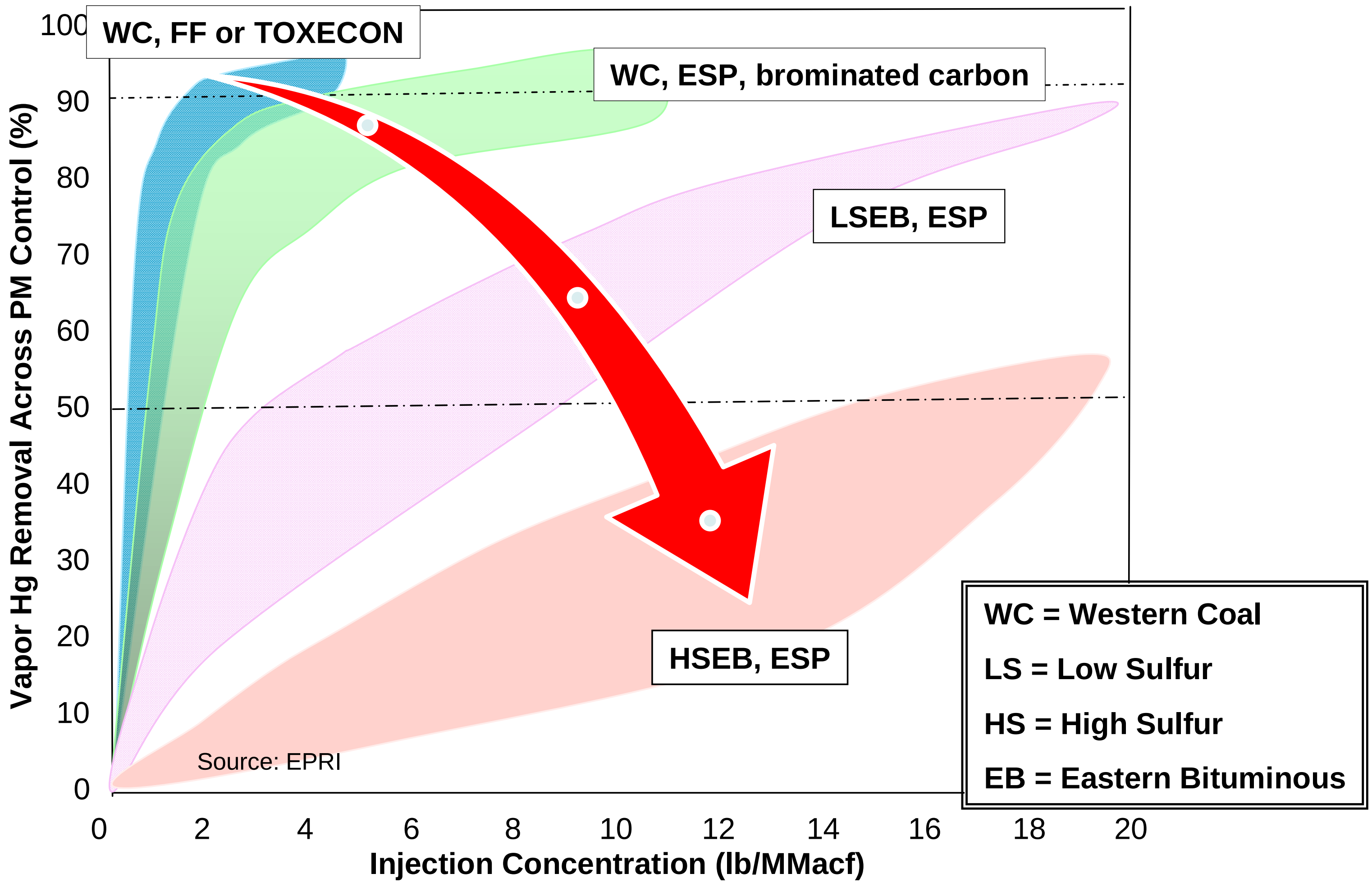
Sulfuric acid opacity typically visible when SO_3 > 5ppm

SO_3 Adversely Impacts …

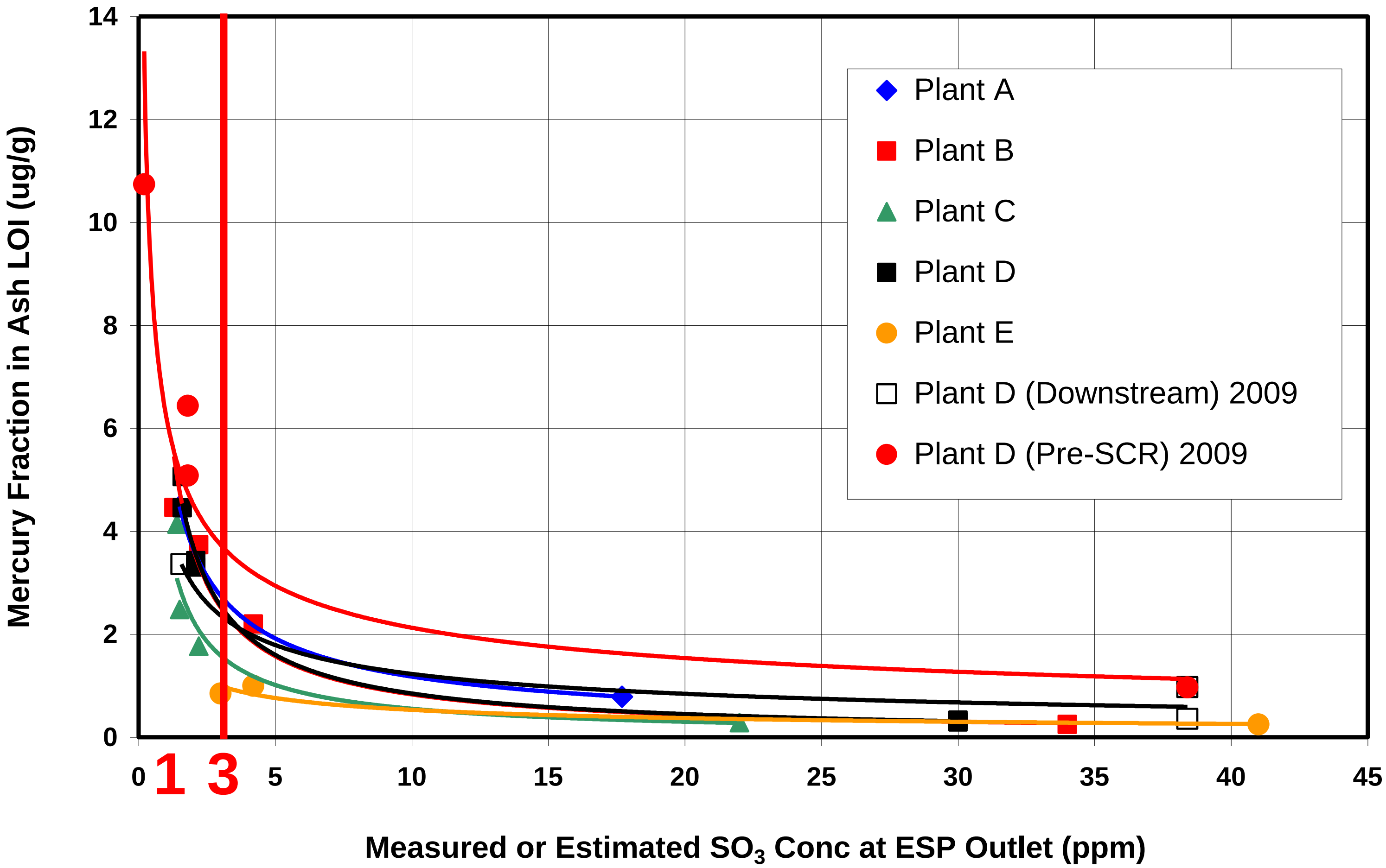


Mercury Co-Benefit

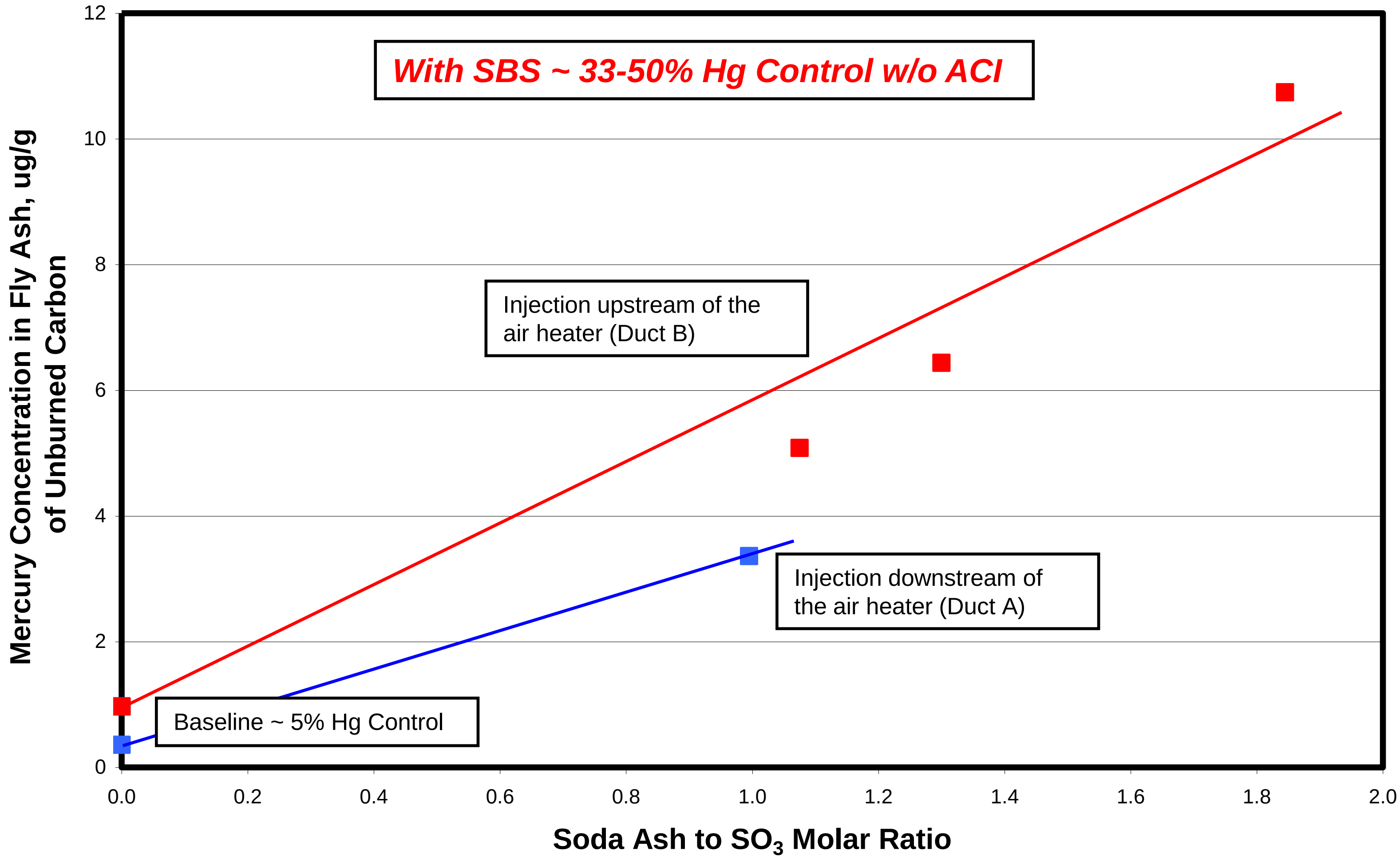
Impact of SO_3 on ACI Performance



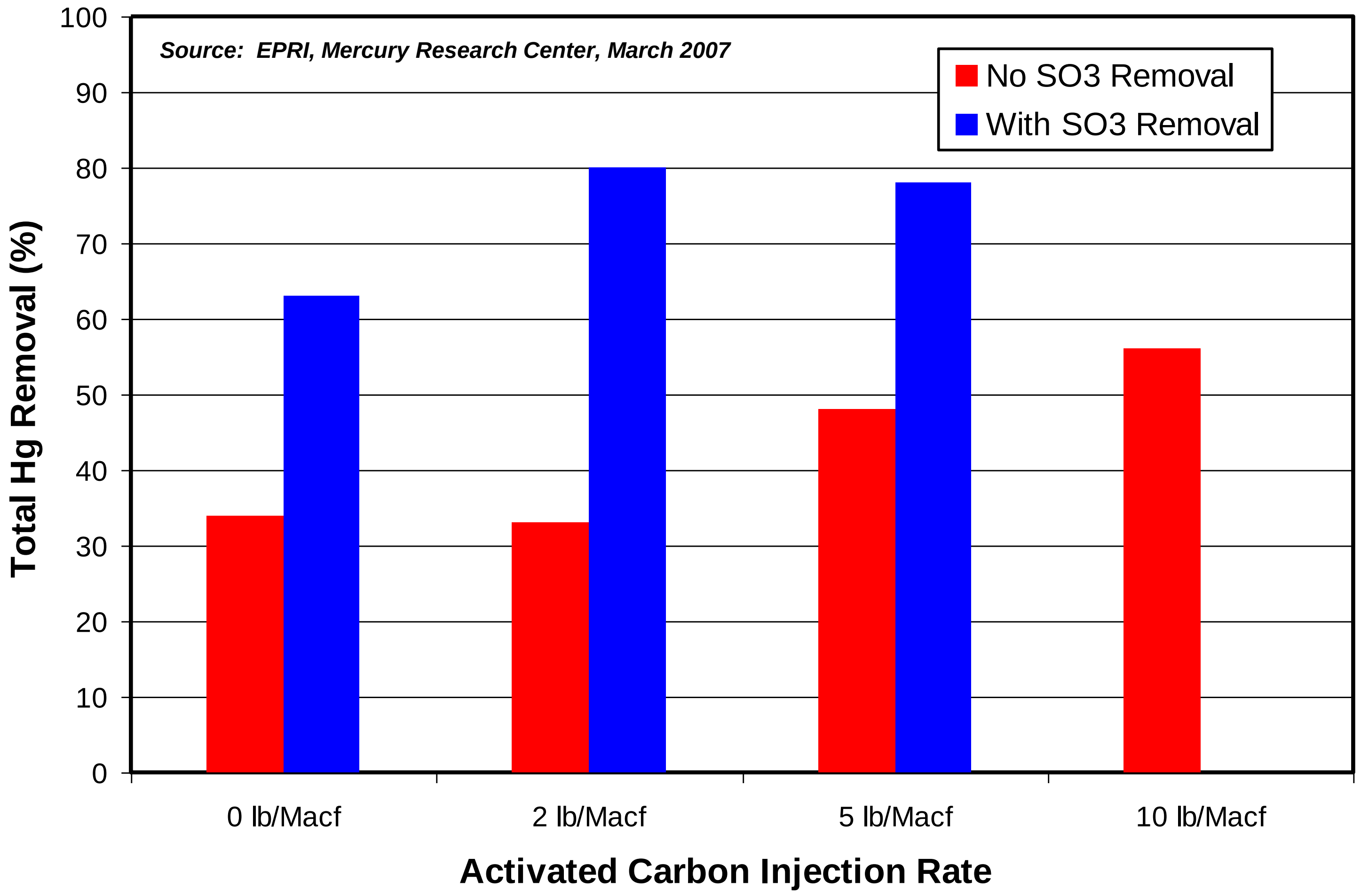
SO_3 Impact on Ash Hg Capture



Mercury Co-Removal Results

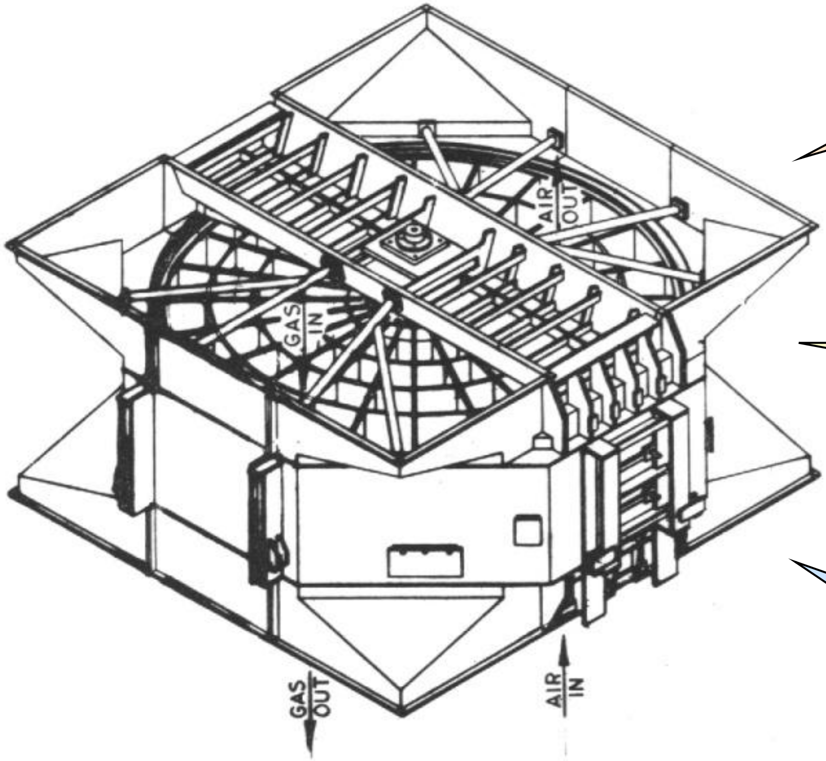


Impact on Hg Removal with ACI



Heat Rate Co-Benefit

Air Heater Fouling Agents



Source: Alstom Air Preheater Company

Ash

Sulfuric Acid

Ammonium Bisulfate

Strategy: APH Performance

1) Inject Sorbent to Remove SO_3 Prior to Air Heater

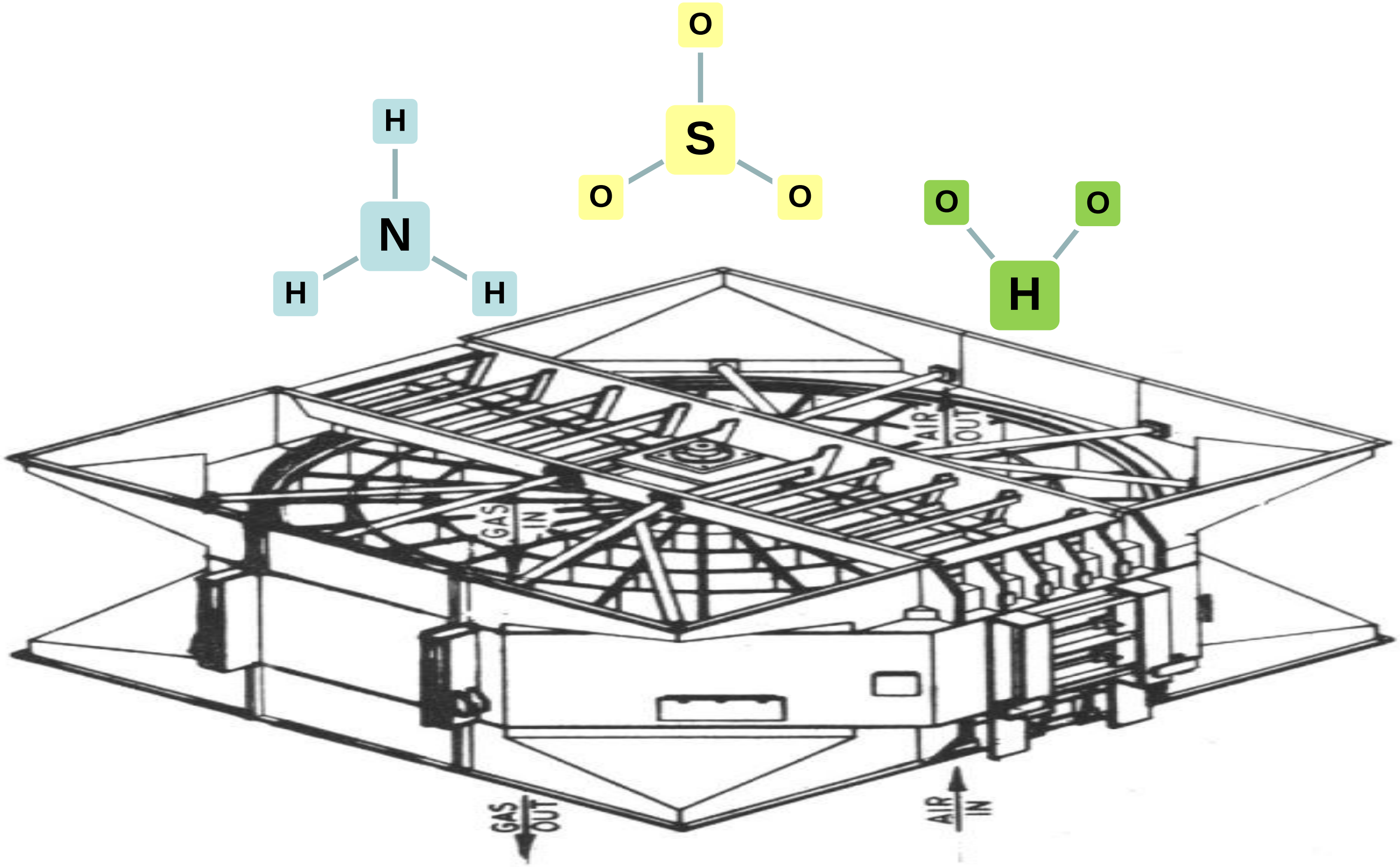
$$NH_3 + SO_3 + H_2O \rightarrow (NH_4)HSO_4$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

2) Reduce Exit Gas Temp from Air Heater

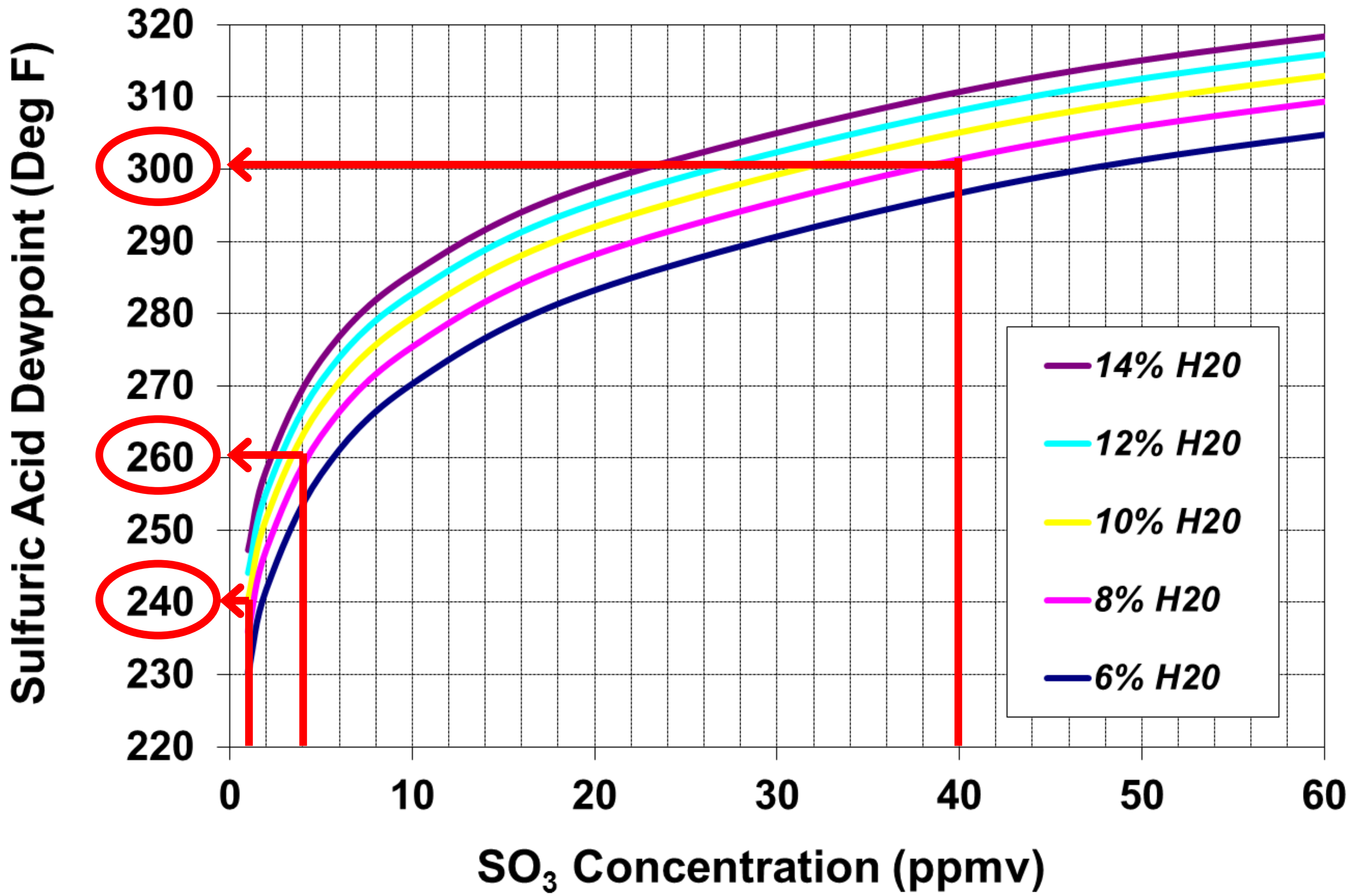
(see Workshop 5 from 2011 APC conference)

Strategy: Step 1

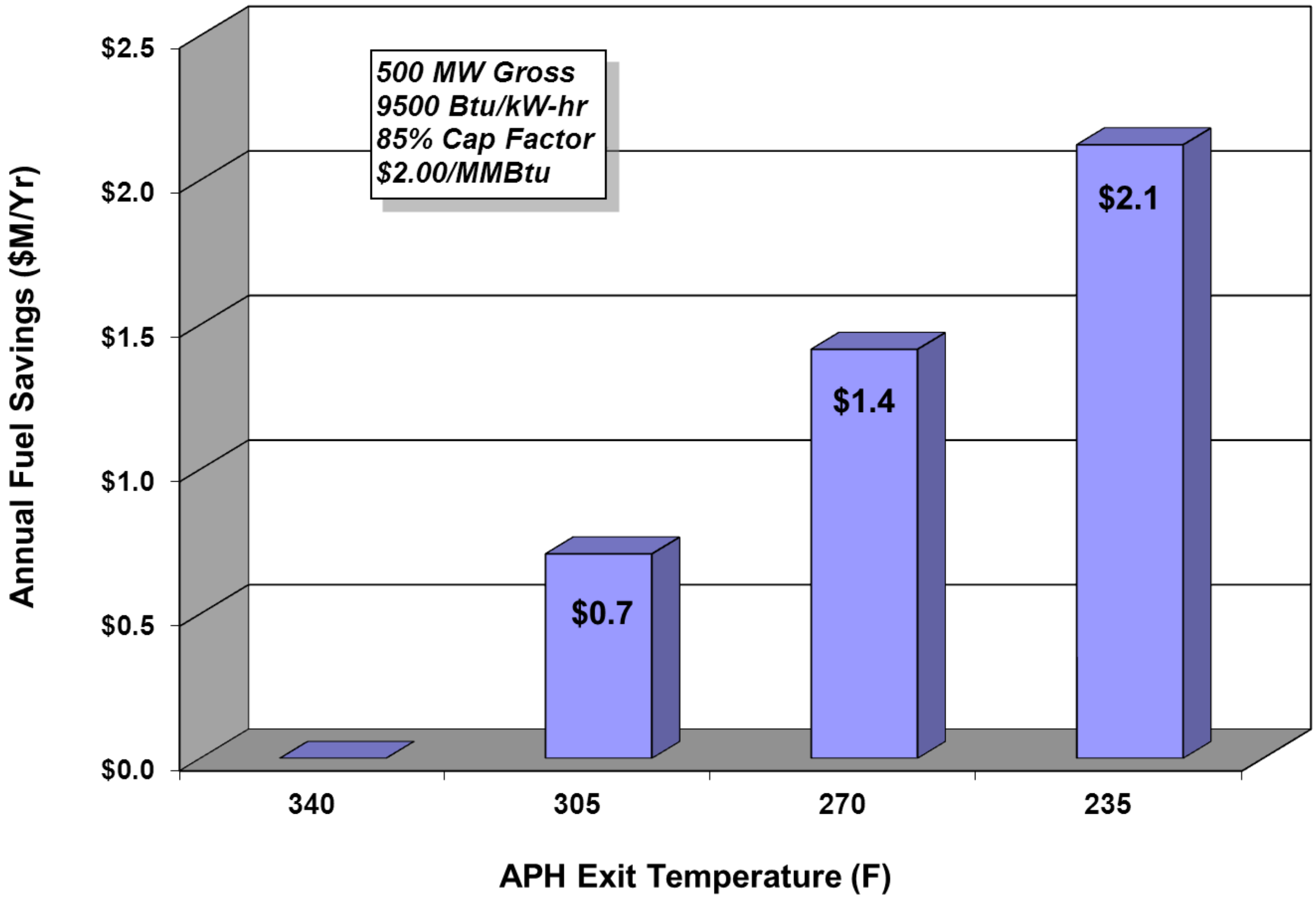


Result: No Fouling of Air Heater

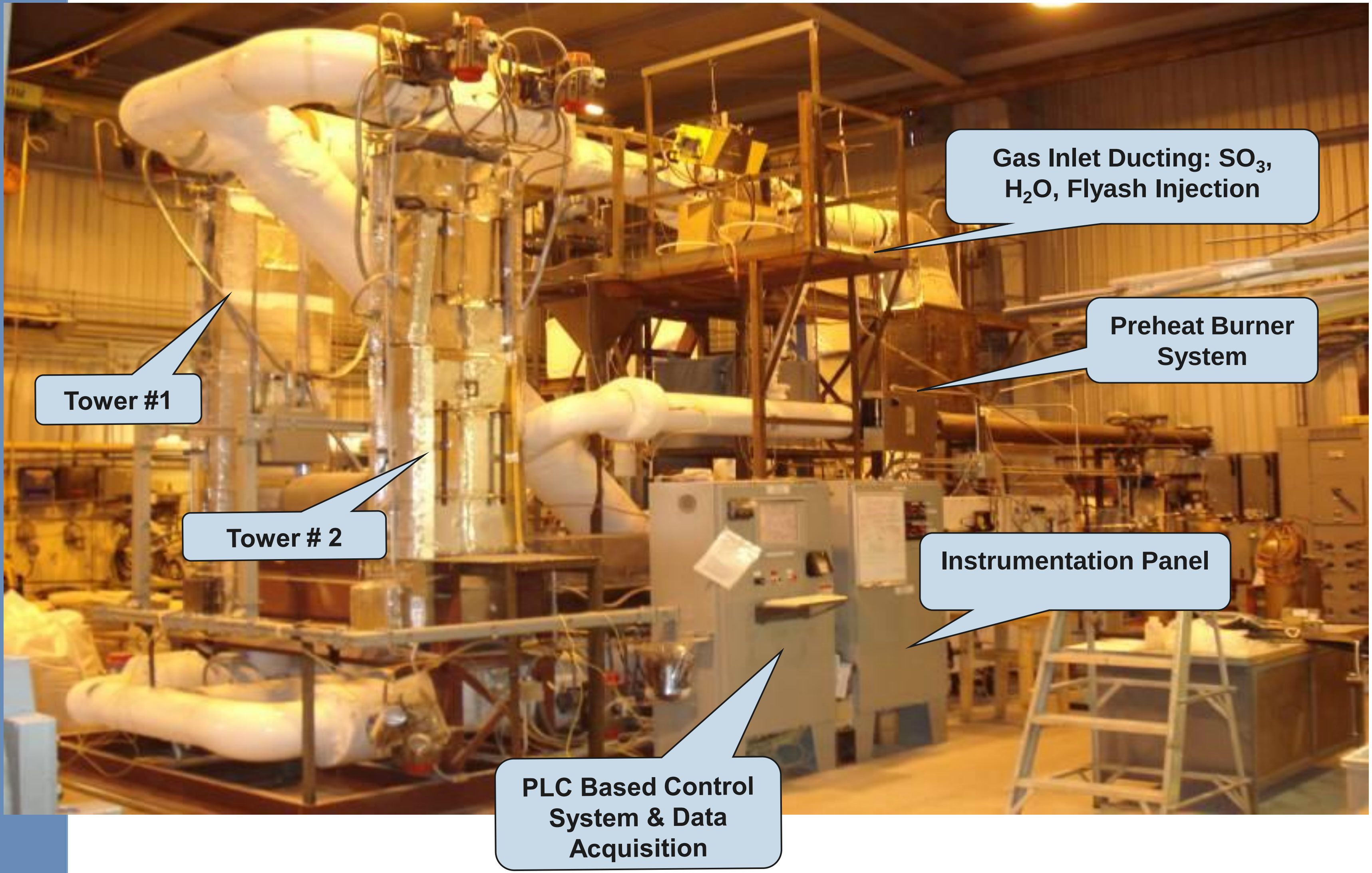
Strategy: Step 2



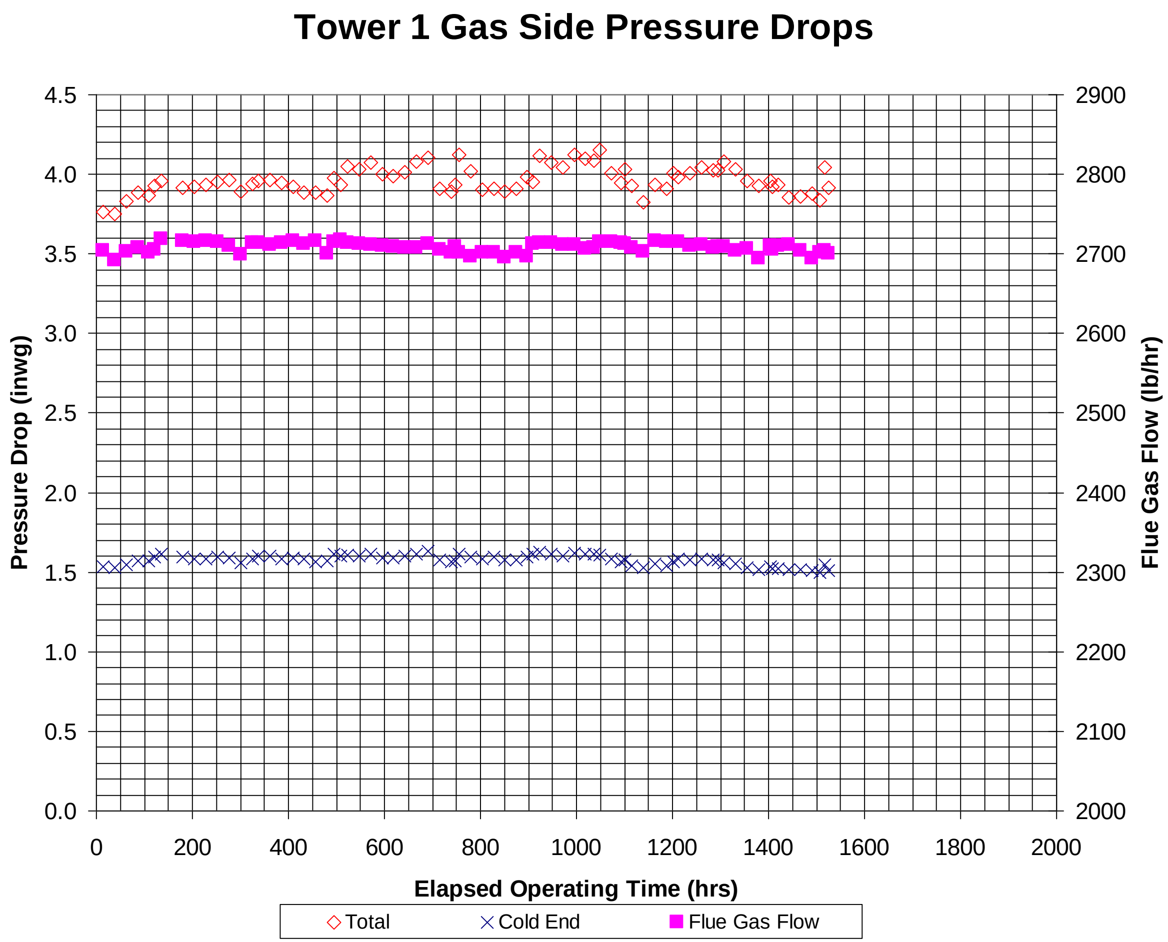
Strategy: Heat Rate Benefit



Alstom Pilot APH Test Facility



Simulated SBS Injection (220°F)



Stable Pressure Drop Response

Simulated SBS Injection (220°F)

No Significant Deposit Thickness Was Found

Strategy: Other Co-Benefits

- Reduced CO_2 Emissions
  - higher unit energy efficiency
- Enhanced Mercury Capture
  - greater carbon absorption capacity
  - less SO_3 interference
- Enhanced ESP Performance
  - lower gas volumetric flow (higher SCA)
  - lower ash resistivity (temp and SO_3 effect)
- Reduced Gas Path Pressure Drop

Summary

- Wet Sorbent Injection is a highly effective process for SO_3 control
- SBS Injection™ installed on 24 boilers (15,000 MW) with nearly 10 yrs continuous operating experience
- Stack emissions can be reduced to <1 ppm SO_3
- Design improvements have eliminated nearly all operational issues
- Significant co-benefits can be realized when SO_3 controlled prior to APH and reduced to low levels

Questions?

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Also at Booth 79