

Reinhold Environmental Ltd.



2008 APC Round Table
& Expo Presentation

July 13-15, 2008, in Savannah, GA

Codan Development LLC



“Hg, HCl & Se Co-Removal with SO₃ Control”

**2008 APC/PCUG Conference
Savannah, Georgia
July 13-18, 2008**

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URS Corporation**



Presentation Outline

- SBS Technology Description
- Impacts of SO₃ & Benefits of Control
- SBS Development Programs
 - ✓ Mercury control testing at the Mercury Research Center
 - ✓ HCl & Selenium removal via SBS
- Summary

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SBS Technology Description

Features

- Patented Technology
- Clear Solution Injection
- Sodium-Based Reagent
- Dual-Fluid Atomization
- Selective Reactions
- High SO₃ Removal
- Low Injection Rate
- Product Collected in ESP

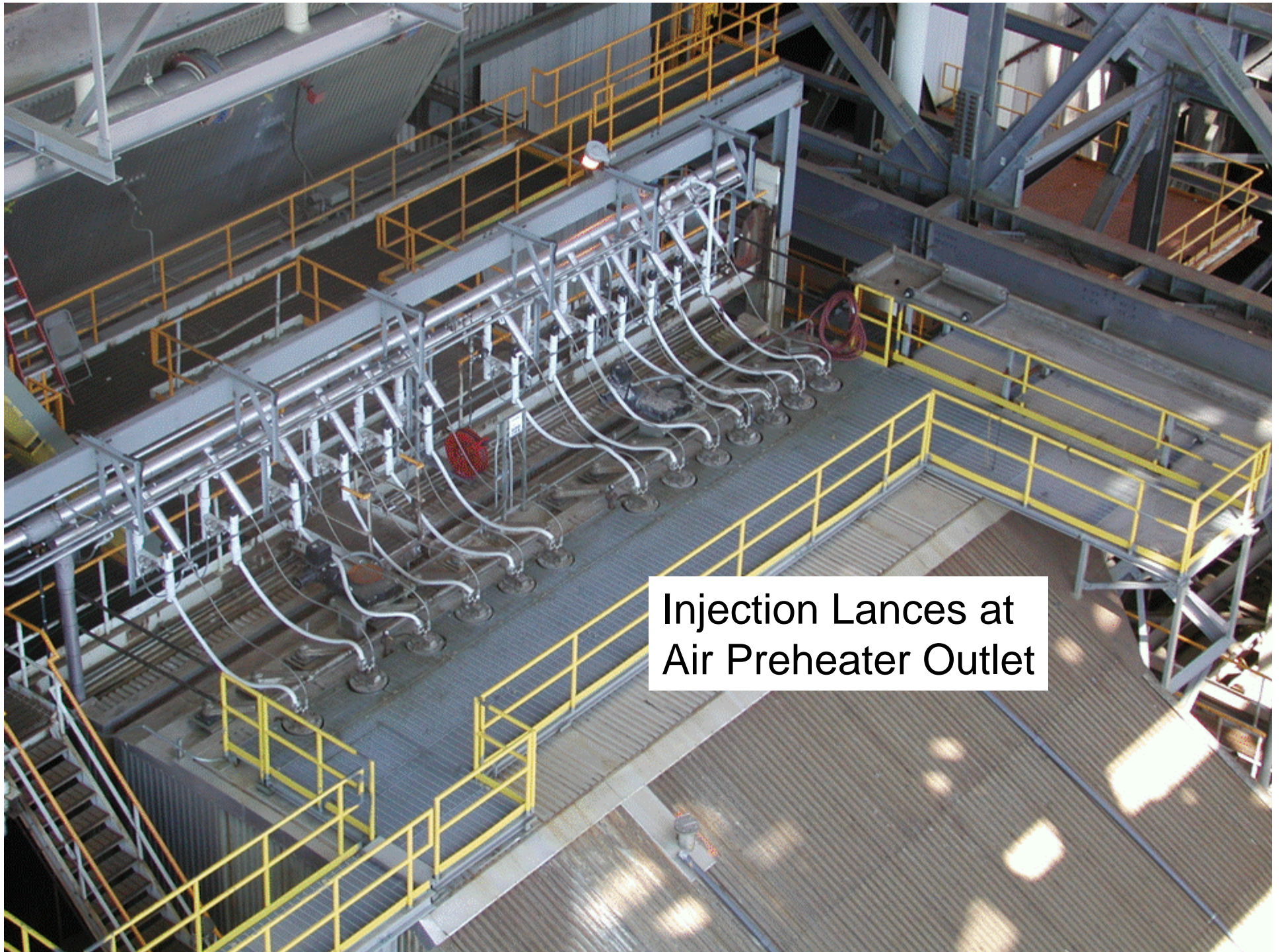






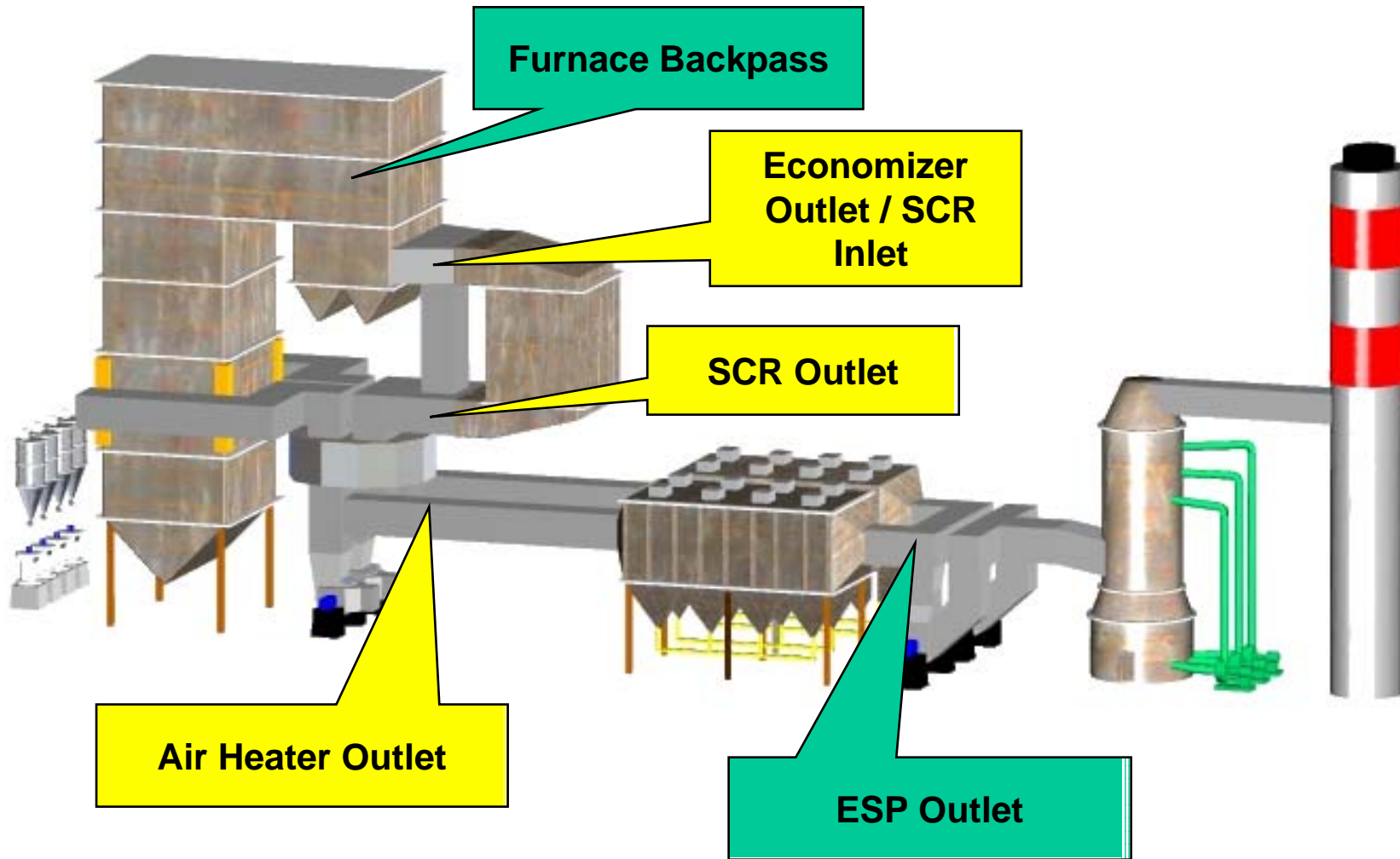
Vertical Injection
Lances at SCR
Outlet





Injection Lances at
Air Preheater Outlet

Potential SBS Injection Locations



Commercial SBS Installations

Utility	Plant	Location	MW	Design SO3	Injection Location	Reagent	Operating Season	Startup Date
FirstEnergy	Mansfield 1-3	Shippingport, PA	3x860	80	Air Heater Inlet	Sodium Sulfite	Year-round	March 2003
TVA	Widows Creek 7	Stevenson, AL	550	54	Air Heater Inlet	Sodium Sulfite	Ozone	April 2003
NIPSCO	Bailly 8	Porter, IN	365	59	Air Heater Outlet	Sodium Carbonate	Ozone	April 2004
Vectren	Culley 3	Newburgh, IN	287	48	SCR Outlet	Byproduct SBS	Year-round	July 2004
PPL	Montour 1-2	Washingtonville, PA	2x765	42	Air Heater Outlet	Sodium Carbonate	Ozone	Aug 2004
Duke Energy	Gibson 1-5	E. Mt. Carmel, IN	5x650	110	Air Heater Outlet	Sodium Carbonate	Ozone	May 2005
DP&L	Killen 2	Manchester, OH	635	34 / 36	Econ Outlet SCR Outlet	Sodium Carbonate	Year-round	Oct 2007
IP&L	Harding St 7	Indianapolis, IN	465	58	SCR Outlet	Sodium Carbonate	Year-round	Nov 2007
NIPSCO	Bailly 7	Porter, IN	180	59	SCR Outlet	Sodium Carbonate	Year-round	April 2008
DP&L	Stuart 1-4	Aberdeen, OH	4x620	90	Econ Outlet	Sodium Carbonate	Year-round	July 2008

10,000 MW Installed; 2500 MW Under Contract; ~3000 MW Planned

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Gibson June 2004 – No Treatment



Gibson June 2005 – SBS Injection

Impacts Created by Presence of SO₃

- Plume Effects: Opacity & Buoyancy Issues
- Acid Dew Point: Corrosion, Heat Rate & Baghouse Impacts
- Reaction with NH₃: Air Heater Fouling
- SCR Operation: Minimum Operating Temperature Constraints
- Mercury Control: Reduced Mercury Retention by Fly Ash & Activated Carbon
- ESP Performance: Improves ESP Particulate Removal Efficiency

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Benefits of SO₃ Control

- Opacity Elimination
- Corrosion Reduction
- Hg, HCl & Se Control
- Potential Heat Recovery
- CO₂ Reduction
- SCR/SNCR Flexibility
- Fuel Flexibility
- Reduce SCR Minimum Operating Temperature

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Technology Development Activities

- Hg, HCl & Se Co-Removal Testing
- Alternative Reagent Evaluation
- “Pre-SCR” SBS Injection Evaluation
- SCR/SNCR Optimization Demonstration
- Pilot Baghouse Demonstration
- Single-Fluid, High-Pressure Injection
- Reagent Crystal Bed Storage Tank

Technology Development Activities

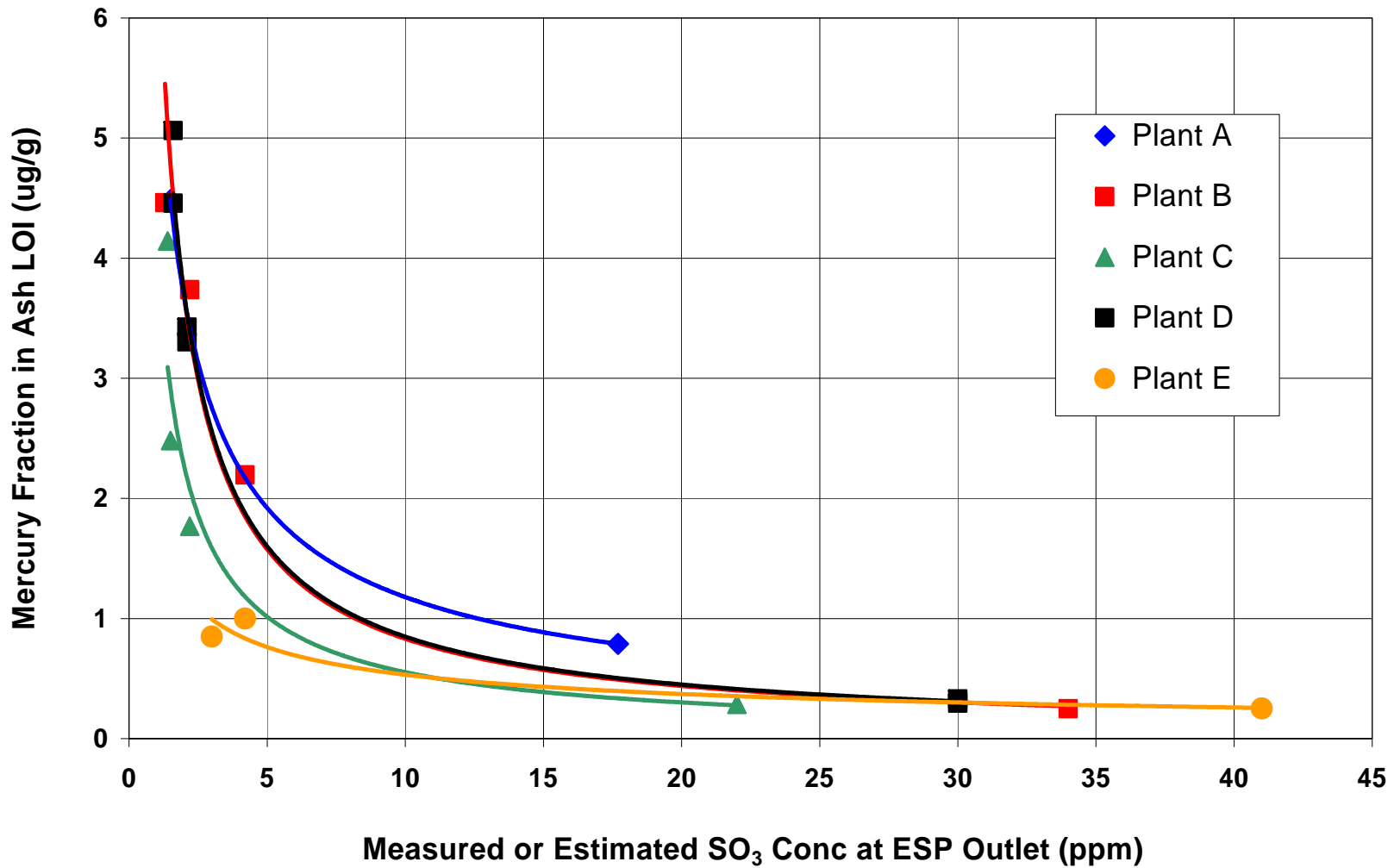
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Mercury Co-Removal with Ash/ACI

Impact of SO₃ on Mercury Control

- SO₃ Competes with Mercury for Carbon Adsorption Sites
 - ✓ Reduced mercury co-removal with fly ash
 - ✓ Increased activated carbon consumption and/or reduced mercury removal efficiencies
- Consequences:
 - ✓ Increased mercury emissions
 - ✓ Need for add-on mercury control process
 - ✓ Higher operating costs for activated carbon

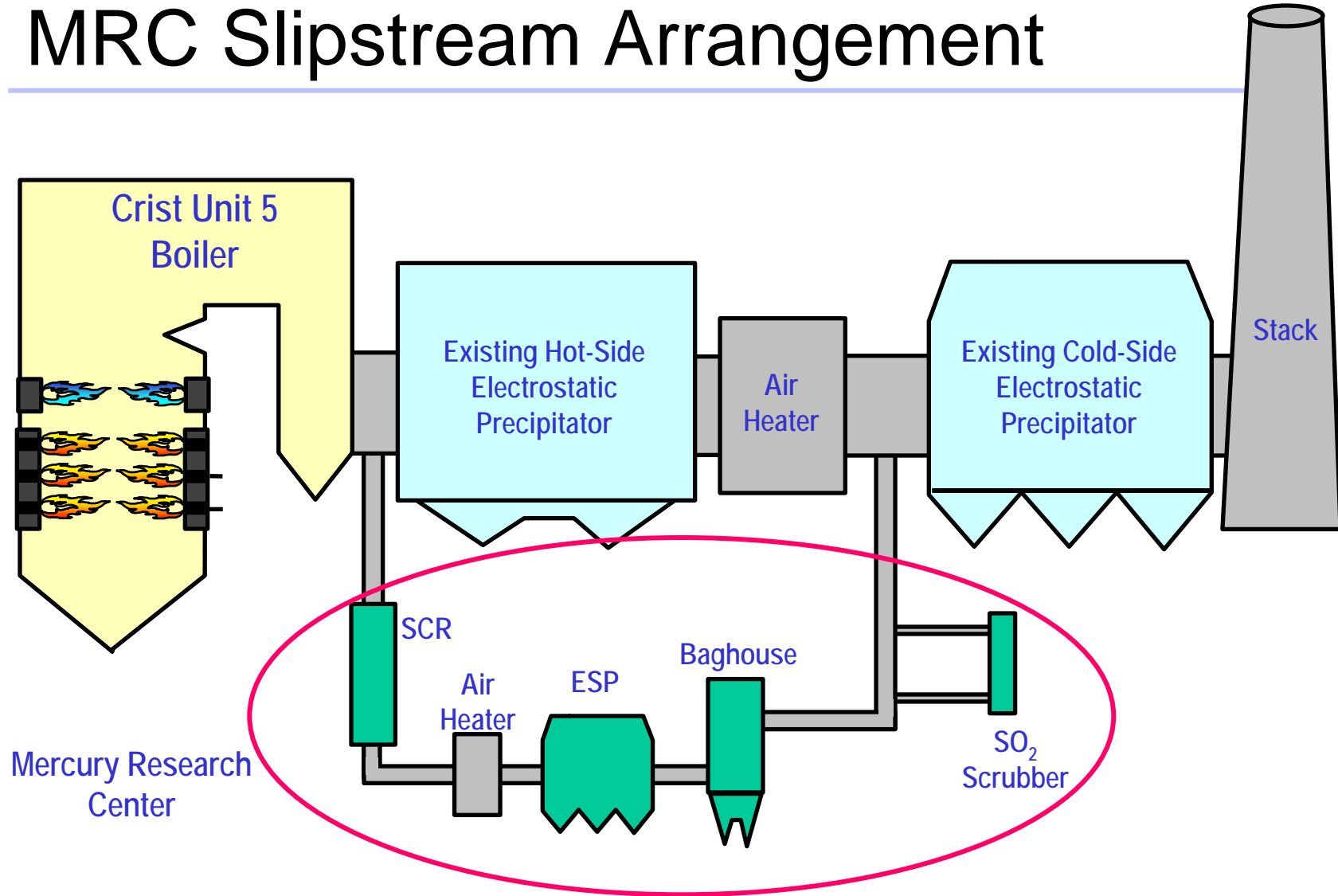
Impact of SO₃ on Hg Capture in Ash



Mercury Research Center ACI Testing

- Purpose:
 - ✓ Quantify the Benefit of SO₃ Reduction on Mercury Co-Removal with Fly Ash & Activated Carbon
 - ✓ For SO₃, define how low is “low enough”
- Test Duration – 1 Week
 - ✓ Added SO₃ control to on-going EPRI testing with activated carbon
- Participants
 - ✓ EPRI, Southern Company, Southern Research Institute, URS

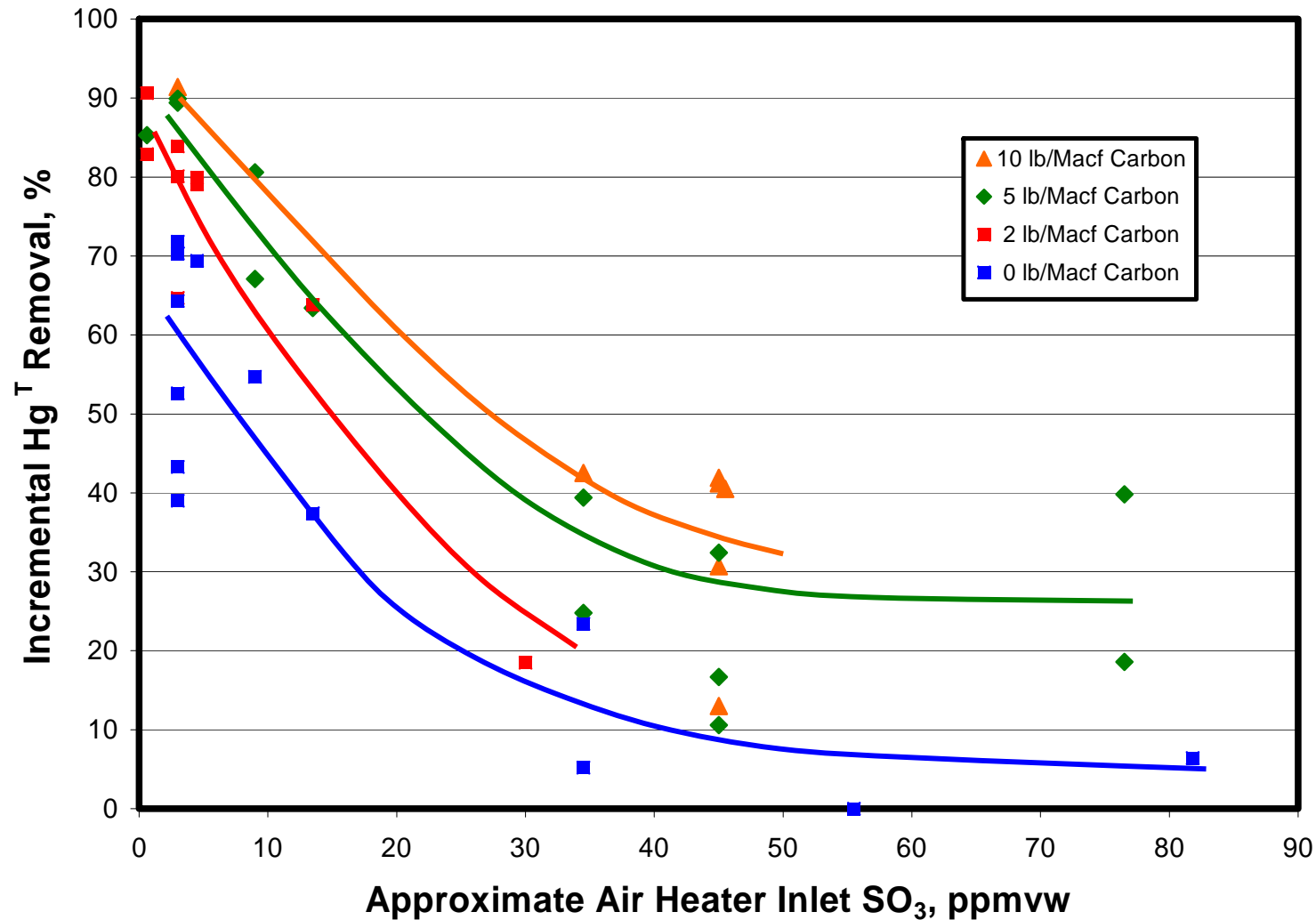
MRC Slipstream Arrangement



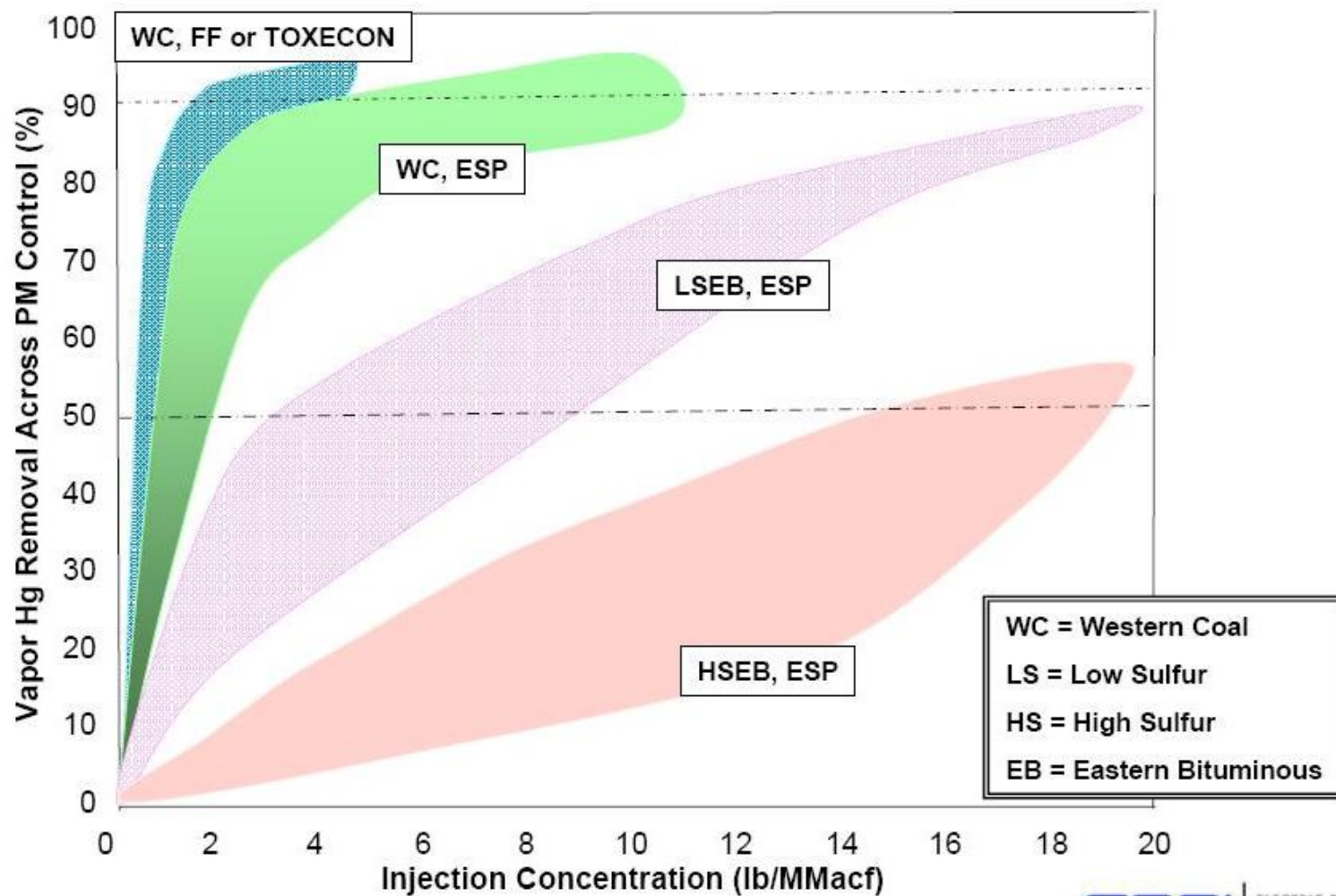
MRC Testing Approach

- Testing Performed w/wo SO₃ Injection
 - ✓ SO₃ Ranged from 3 to 80 ppm
- Testing Performed w/wo SBS Injection
- Carbon Injection Rates from 0 to 10 lb/Macf
 - ✓ Carbon injected at APH outlet upstream of ESP
 - ✓ LOI averaged 6%
- Mercury Measured at ESP Inlet & Outlet
- Results Correlated with Air Heater Inlet & ESP Outlet SO₃

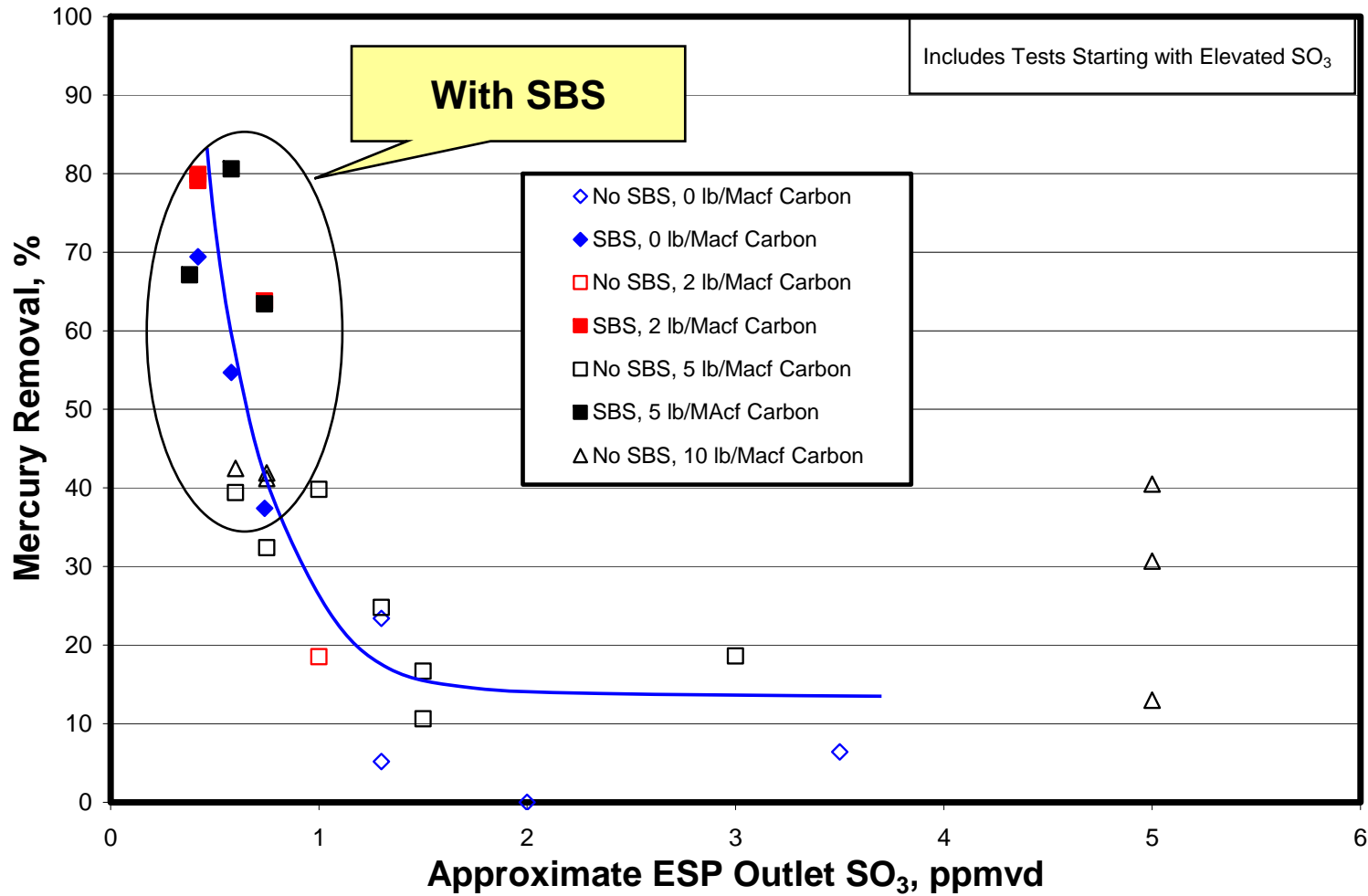
“Incremental” Hg^T Removal vs Air Heater Inlet SO₃



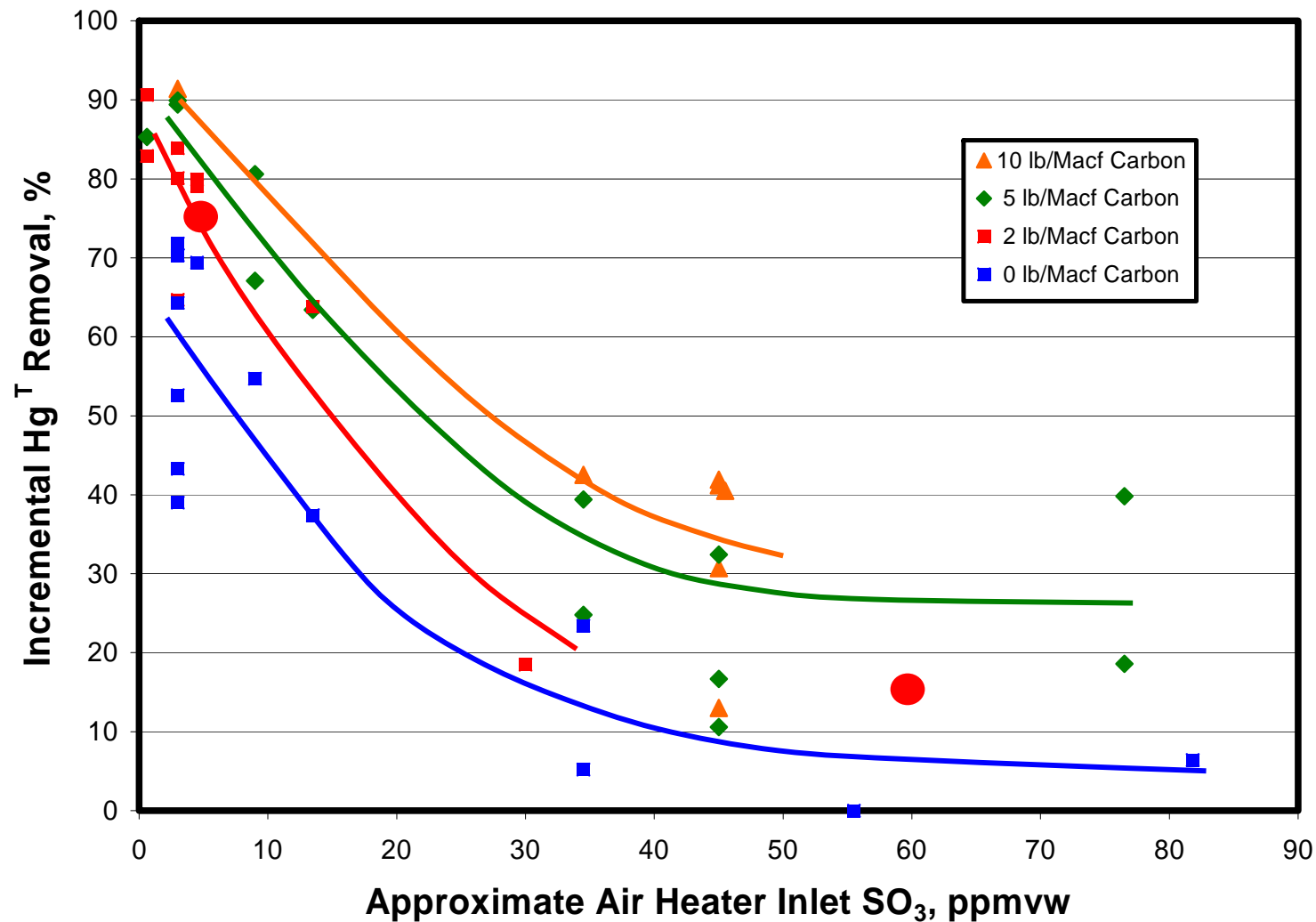
Impact of Coal Type on Hg Removal



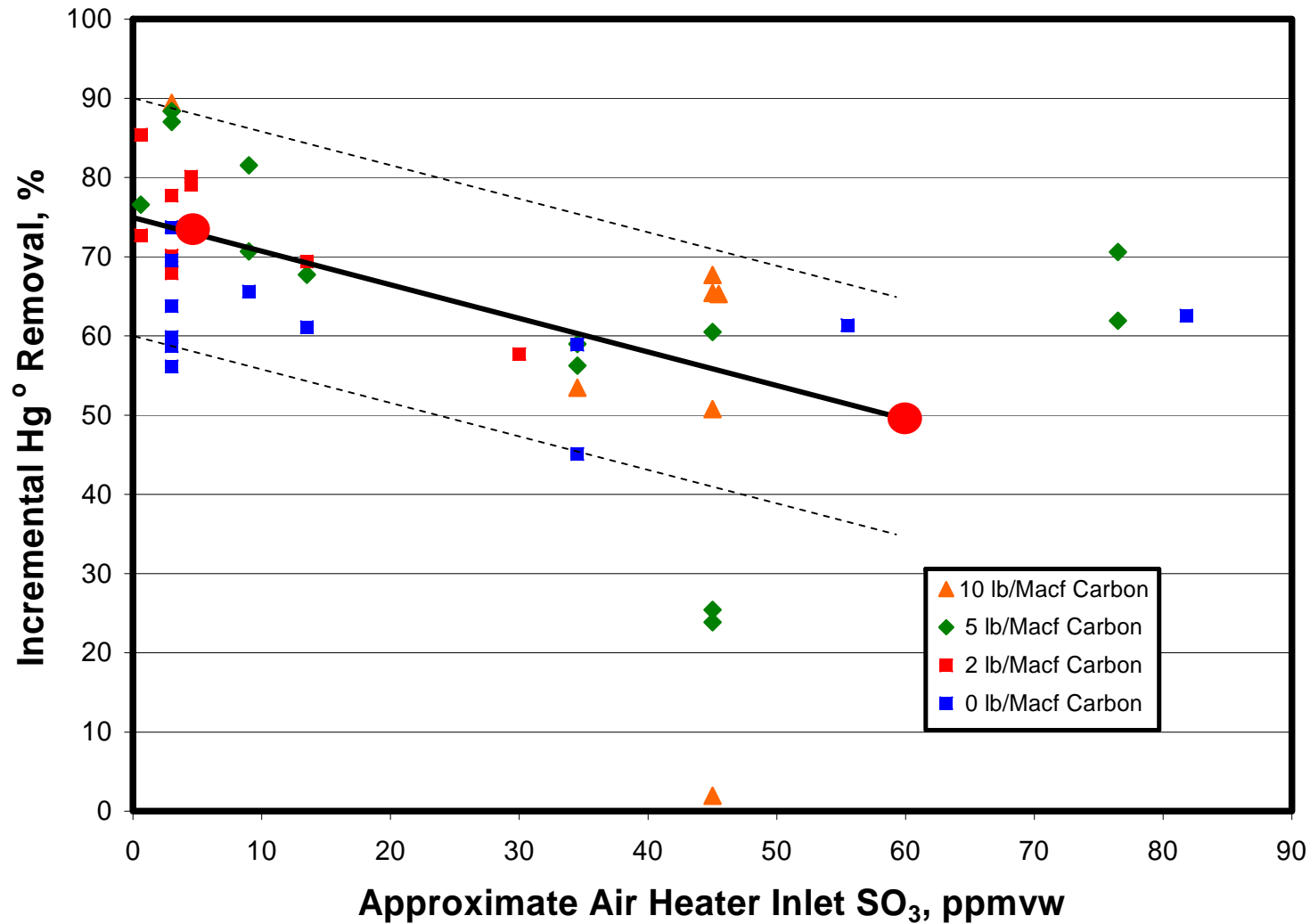
“Incremental” Hg Removal vs ESP Outlet SO₃



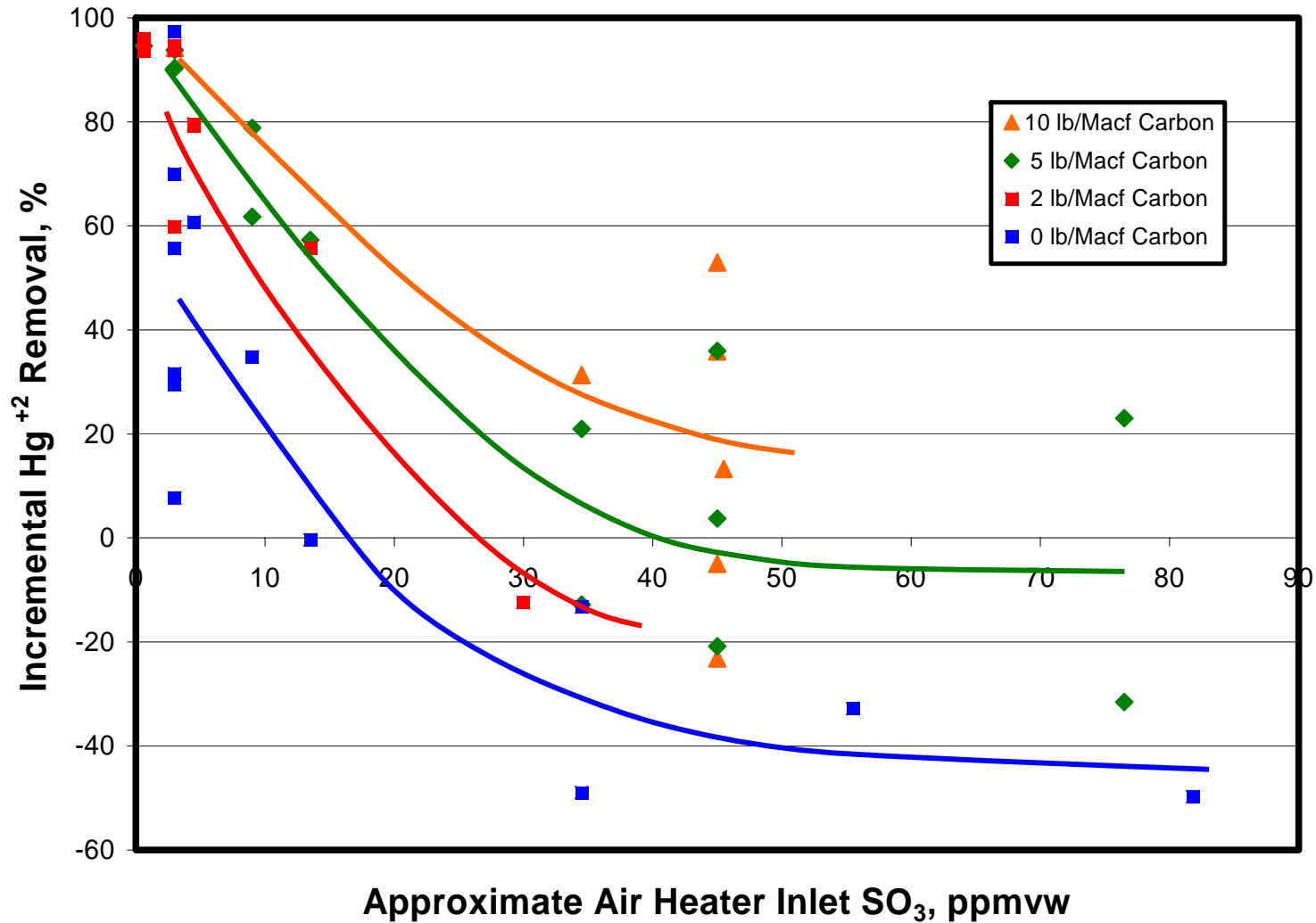
“Incremental” Hg^T Removal vs Air Heater Inlet SO₃



“Incremental” Hg⁰ Removal vs Air Heater Inlet SO₃



“Incremental” Hg⁺² Removal vs Air Heater Inlet SO₃



Example Case – Net removal with 2 ACI

Baseline @ 60 ppm SO₃, 2 lb/Macf ACI

<u>ESP Inlet</u>	<u>ESP Outlet</u>	<u>Scrubber Outlet</u>
Hg ⁰ = 5.0	Hg ⁰ = 2.5	Hg ⁰ = 2.5
Hg ⁺² = 5.0	Hg ⁺² = 6.0	Hg ⁺² = 0.3
Hg ^T Removal =	15%	72%
Hg ⁰ Removal =	50%	0%
Hg ⁺² Removal =	-20%	95%

SO₃ Control to 5 ppm

<u>ESP Inlet</u>	<u>ESP Outlet</u>	<u>Scrubber Outlet</u>
Hg ⁰ = 5.0	Hg ⁰ = 1.35	Hg ⁰ = 1.35
Hg ⁺² = 5.0	Hg ⁺² = 1.65	Hg ⁺² = 0.08
Hg ^T Removal =	70%	86%
Hg ⁰ Removal =	73%	0%
Hg ⁺² Removal =	67%	95%

MRC Testing Conclusions

- SO₃ Removal Alone, or Combined with ACl, can be a Cost-Effective Hg Control Strategy
- High SO₃ Removal Efficiencies are Necessary for Effective Hg Control
- SO₃ Must be Removed Prior to the Point of AC Injection
 - ✓ SO₃ will generally need to be removed upstream of the air heater
- SO₃ Control Can Provide a Significant Incremental Reduction in Hg Emissions for Scrubbed Units
 - ✓ Greater benefits in units with lower Hg oxidation levels and scrubbers with higher re-emissions

Selenium Co-Removal with Ash

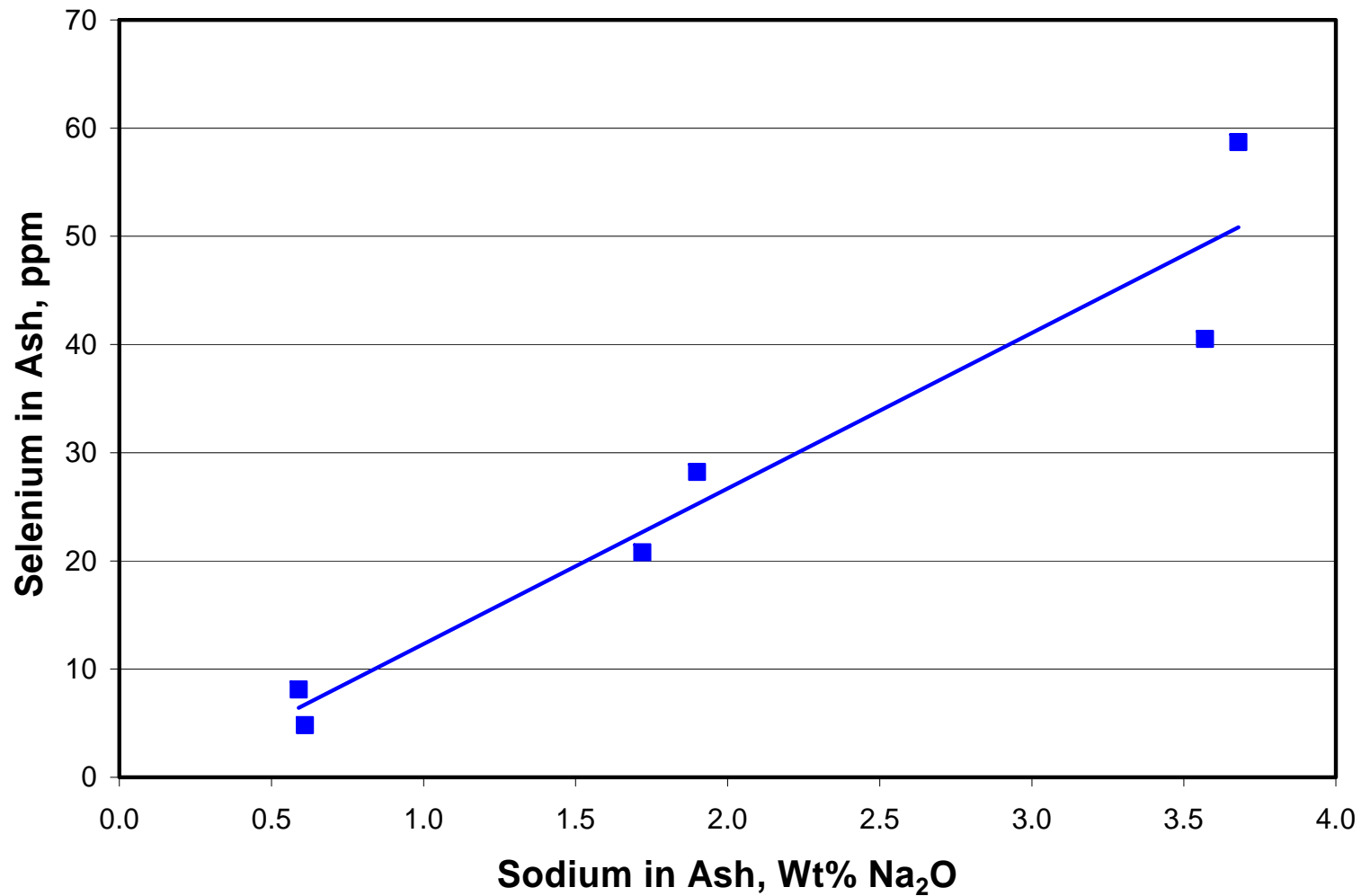
Selenium Impacts

- Selenium Present in Coals at Low Levels
 - ✓ 1 to 5 ppm typical
- Some Selenium is Removed in the ESP
 - ✓ Efficiency varies with ash alkalinity
- Remaining Selenium Removed in the Scrubber
 - ✓ Present as Selenite & Selenate, and in other forms
- Some of the Selenate is Removed with Gypsum
- Remaining Selenium Species are Cycled Up
 - ✓ May require treatment before discharge

Selenium Measurements with SBS

- Coal-Fired Power Plant with SCR/ESP/FGD
- 4-5 lb SO₂ Coal
- SBS Injection After the Air Heater
- Selenium Measurements in the Coal & Ash
- Results:
 - ✓ ~20% Se removal without SBS
 - ✓ Nearly complete Se removal with SBS
- Removal Attributed to Alkaline Reagent Injection

Graph of Se Removal Results



Benefits of Selenium Removal via SBS

- Selenium Captured in Ash
 - ✓ Minimal impact of Se on ash disposal or sales
 - ✓ For wet ash collection, Se present as selenite can be easily treated with ferric chloride
- Avoids Capture in Scrubber
 - ✓ Selenate & other selenium forms more difficult to treat (e.g., ferrous chloride for treatment of selenate)

Chloride Co-Removal with Ash/ACI

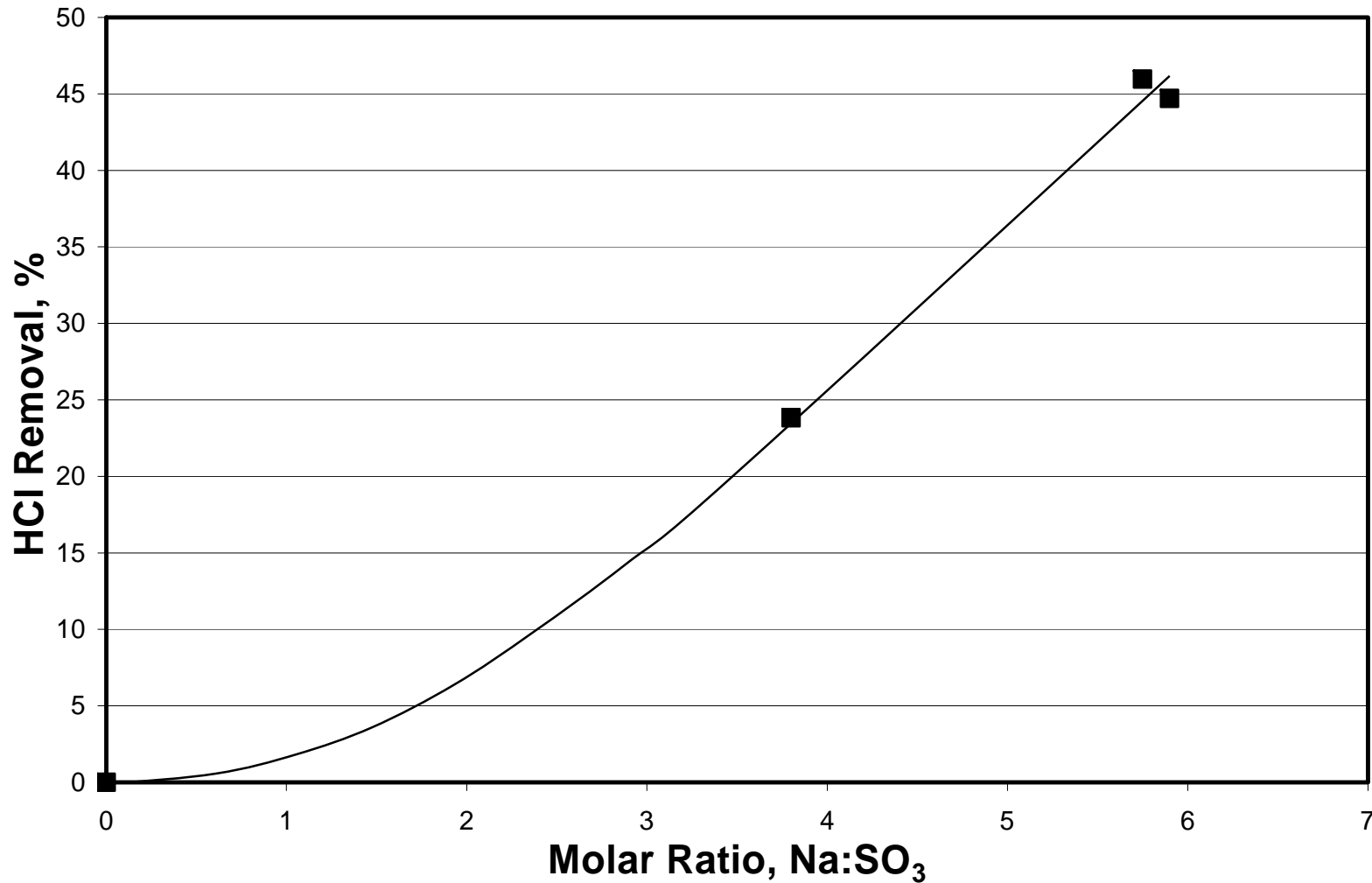
HCl Impacts

- HCl Impacts FGD-Related Costs
 - ✓ Corrosion in existing scrubbers
 - ✓ Higher-grade alloys in new scrubbers
 - ✓ Higher blowdown volumes & treatment costs
- Capital Spending for Chloride Control is Significant and Will Increase

HCl Removal Measurements with SBS

- Coal-Fired Power Plant with SCR/ESP/FGD
- Flue Gas Composition:
 - ✓ 31 ppm SO₃, 55 ppm HCl & 1200 ppm SO₂
- SBS Injection After the Air Heater
- Vapor-Phase HCl Measured at ESP Outlet with Ash Analyzed for Sodium, Chloride & Sulfate
- Elevated Na:SO₃ Molar Ratios (Up to 6.0)
- Results:
 - ✓ ~46% HCl removal at high reagent ratios
 - ✓ HCl removed by “excess” SBS reagent

HCl Removal Measurements with SBS



Summary

- SO₃ Control Reduces Visible Emissions & can Reduce Operating Costs:
 - ✓ Improved heat rate, SCR/SNCR optimization & fuel flexibility
- Additional Environmental Benefits May Also Reduce Capital and/or Operating Costs
 - ✓ Mercury co-removal with ash may reduce or eliminate the need for activated carbon
 - ✓ Selenium co-removal with ash may reduce or eliminate scrubber blowdown treatment requirements
 - ✓ Chloride removal with ash may allow less expensive scrubber materials and/or reduce blowdown treatment costs