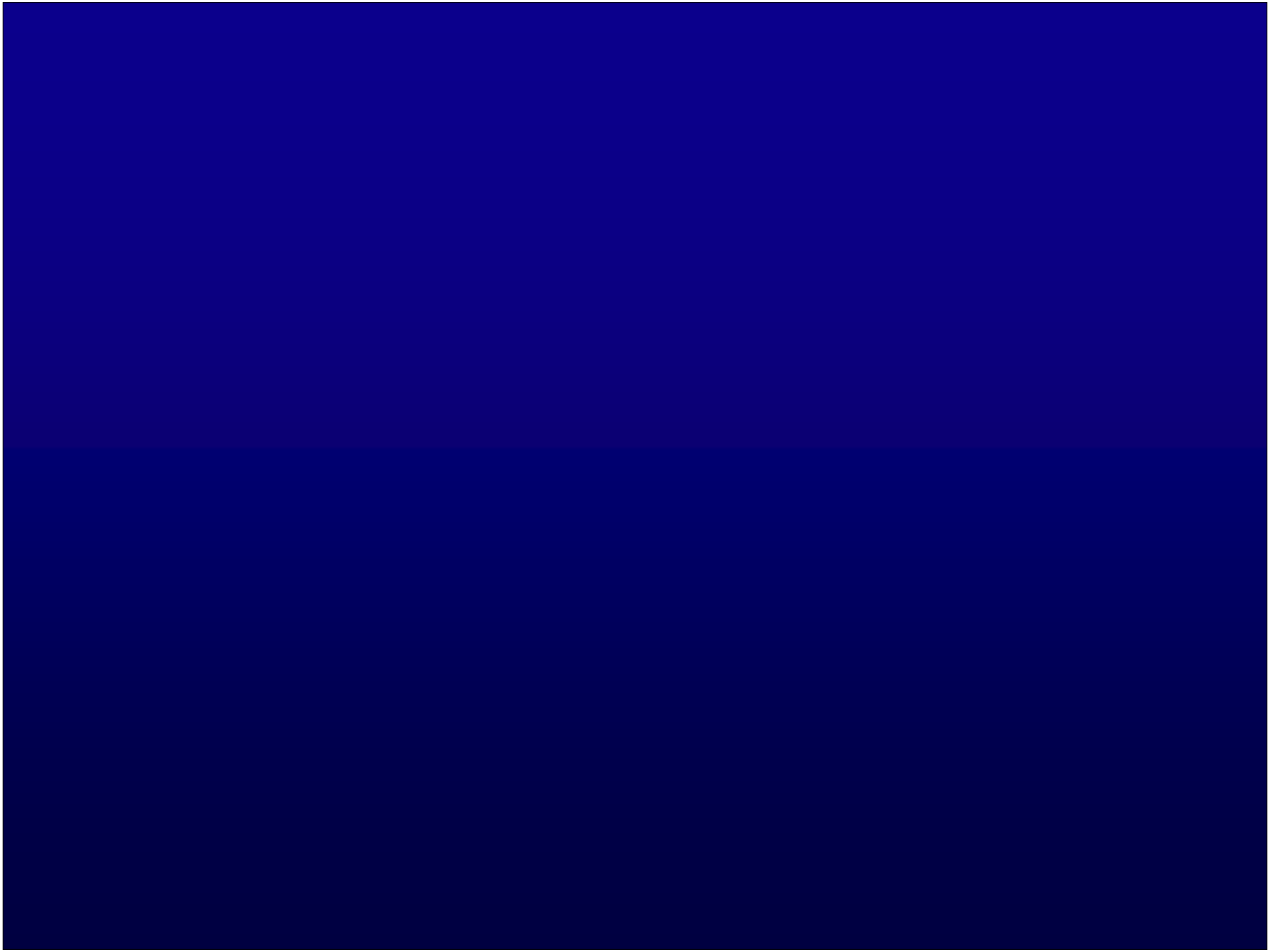
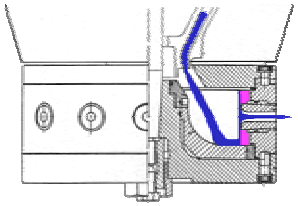
Reinhold Environmental Ltd.

2007 APC Round Table & Expo Presentation

July 8-10, 2007
Chattanooga, TN
Hosted by TVA

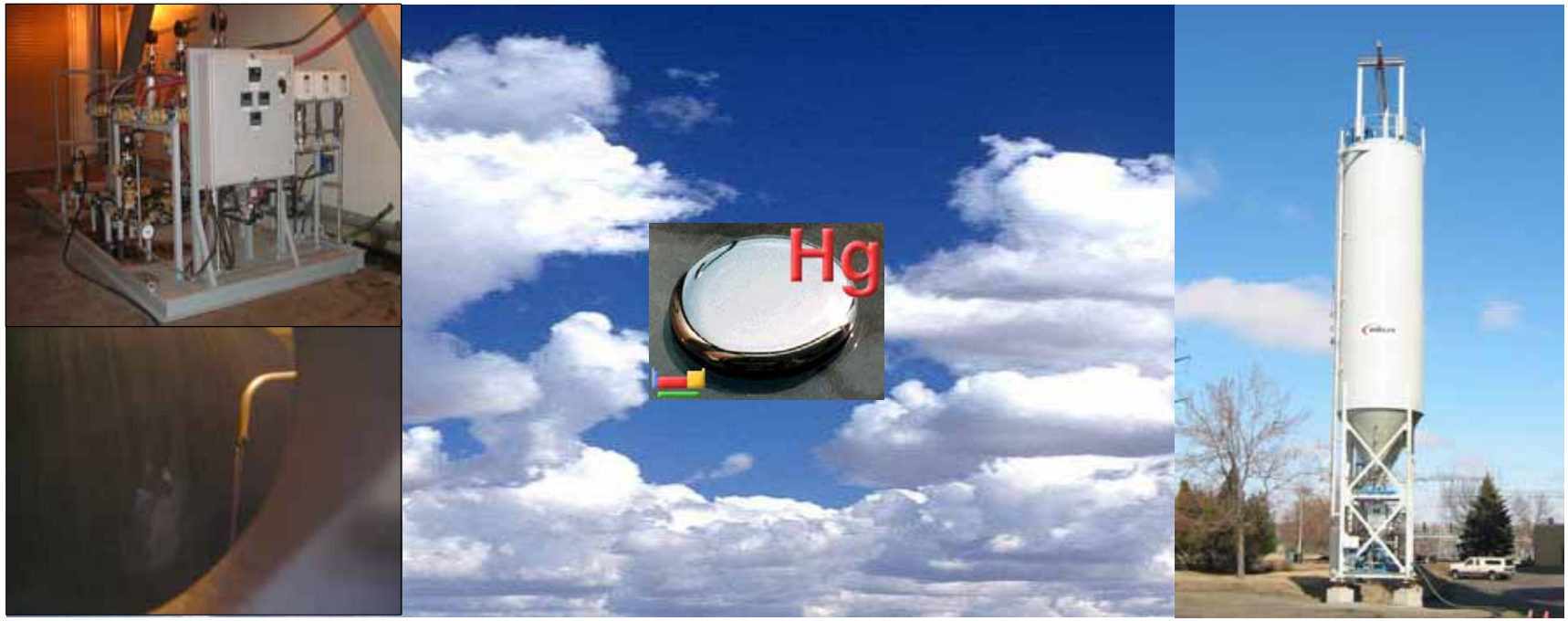


DFGD and Mercury Workshop



Bryan Jankura

The Babcock and Wilcox Company



July 9, 2007
Reinhold 2007 APC Exposition

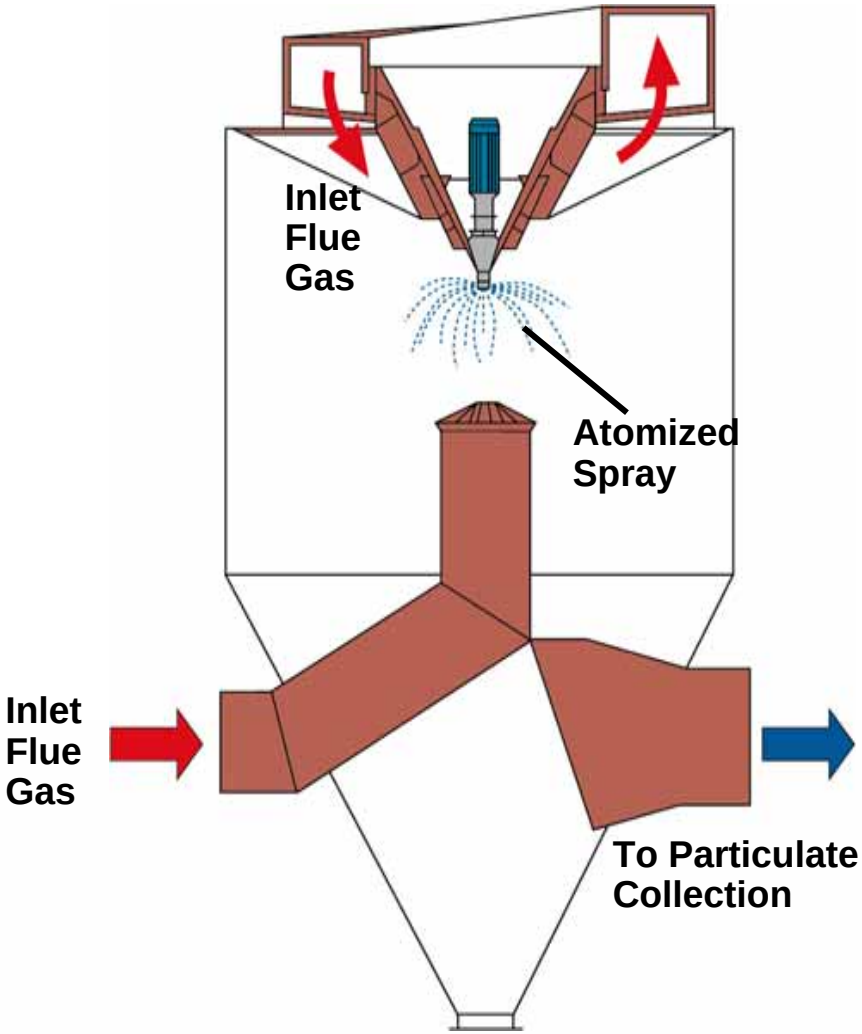
Workshop Key Topics

- ***Dry Scrubbing FGD Primer.***
- ***Mercury Emission Air Permit Limits.***
- ***DFGD Mercury Emission Control Options.***
- ***Mercury Emission Reduction Performance Data.***
- ***Balance of Plant issues.***
- ***How Much Could it Cost ??***

?? Q&A ??

Dry Scrubbing FGD Primer

B&W/Niro Spray Dryer Vessel Design

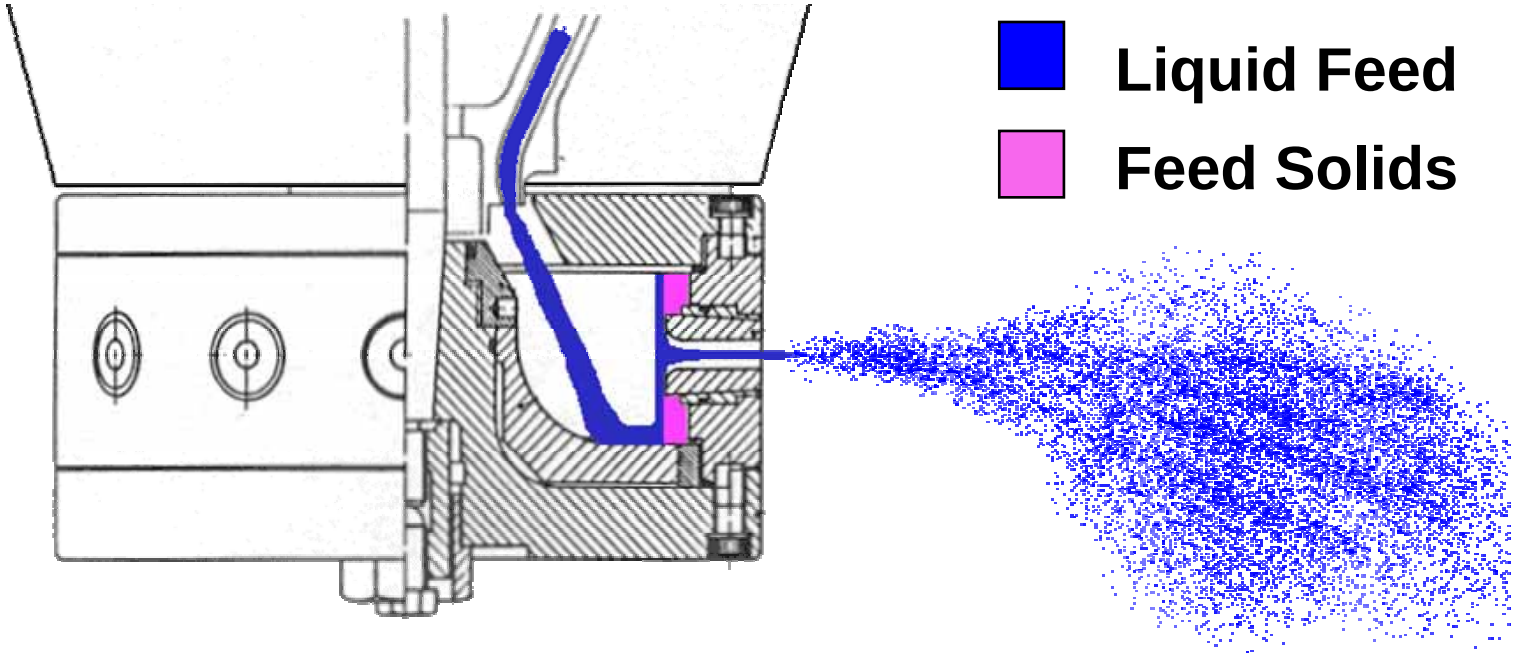


43 ft – 65 ft
Diameter

DFGD Rotary Atomizer

DFGD Rotary Atomizer

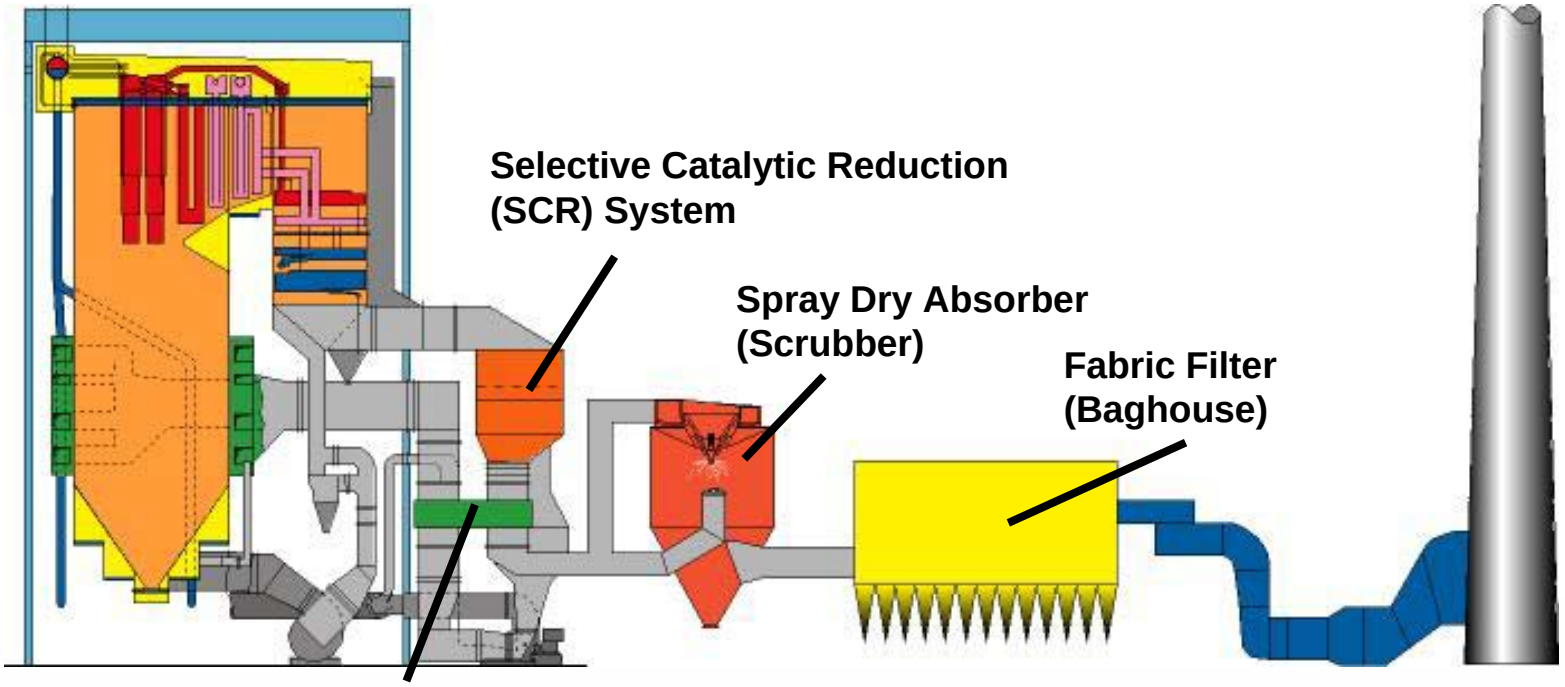
DFGD Rotary Slurry Atomization



- 14 inches Diameter
- 9,500 RPM
- 100 - 1,400 Hp
- Up to 450 GPM of Slurry

Typical Coal-Fired Boiler with DFGD

Steam Generator



- *Add reagent slurry*
- *Dry slurry*
- *Humidify gas*

- *Collect solids*
- *Continue reactions*

??? Dry FGD Myth ???

Dry Scrubbing is NOT "DRY"

"Spray Dryer" + "Pollutant Absorption"

Spray Dry Absorption = SDA

Spray Dry FGD Characteristics

Typical Application

- ≤ ~1.5 to 2% Sulfur Coal
- ≤ ~95% Sulfur Dioxide Removal

Advantages (compared to WFGD)

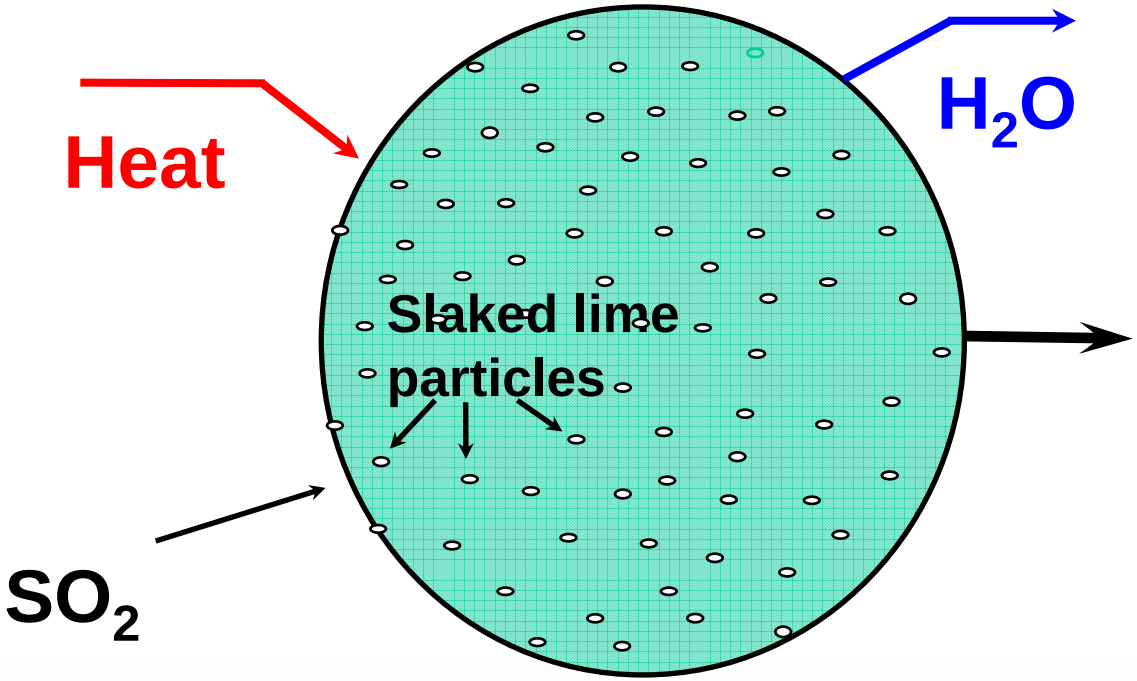
- Lower Capital Cost
- Lower Power Consumption
- Lower Water Consumption
- Dry Solids Byproduct
- Carbon Steel Construction
- System Simplicity

Other Considerations

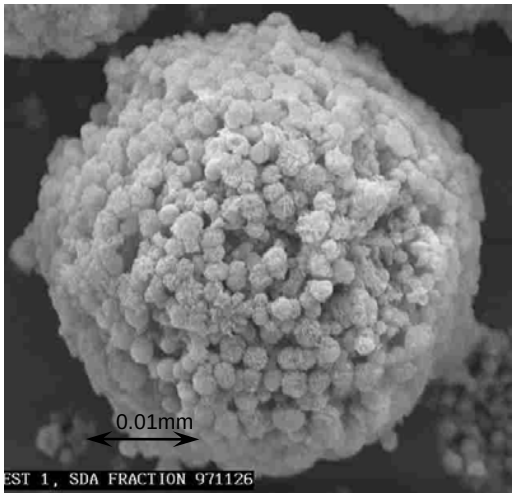
- More Expensive Reagent
- Disposal Product with Limited Market Potential

DFGD Air Pollutant Reductions

Spray Dry Absorption (SDA)



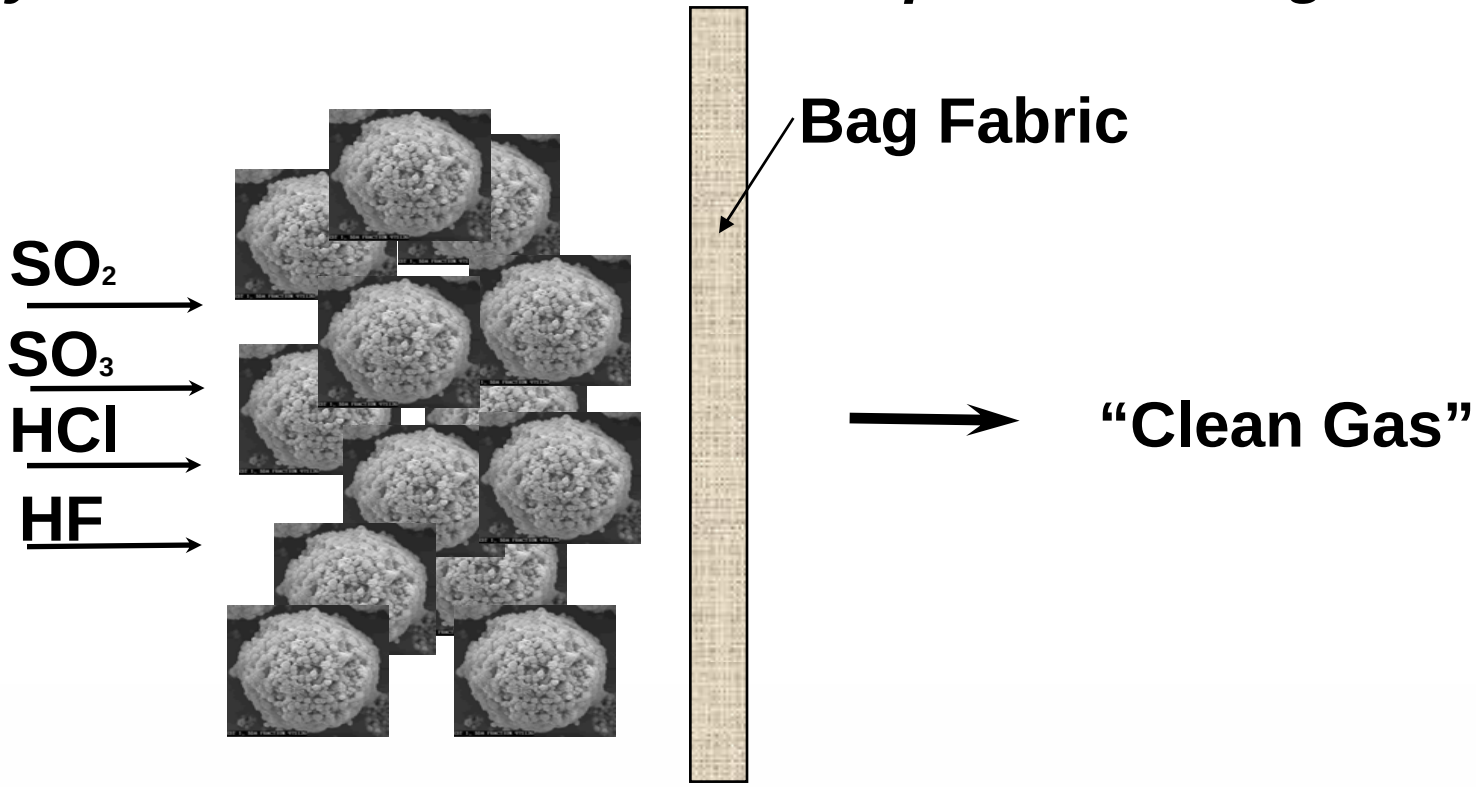
"Dry" Reaction Product



Average Spray Droplet (65 microns)

SO_2 Absorption Continues in Baghouse

Dry Solids from the SDA build up on filter bag.



A Baghouse removes 30 to 60% of the incoming SO_2

Mercury Emission Air Permit Limits

Federal Clean Air Mercury (CAMR} Rule

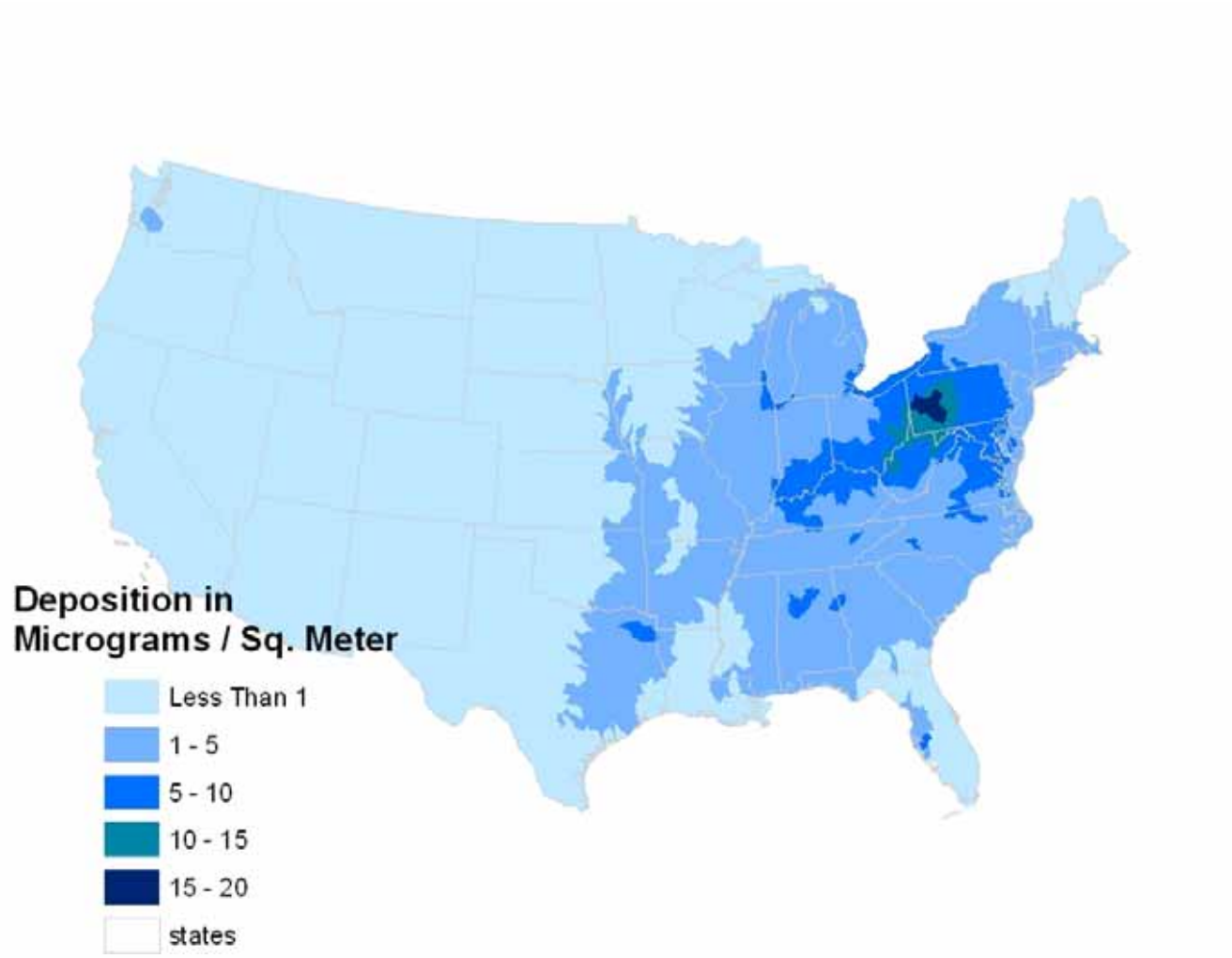
(May, 2006 "Reconsideration")

Coal Rank	2005 CAMR NSPS (lb x 10^{-6}/MW.hr)
Bit	20
SubBit WFGD	66
SubBit DFGD	97
Lignite	175

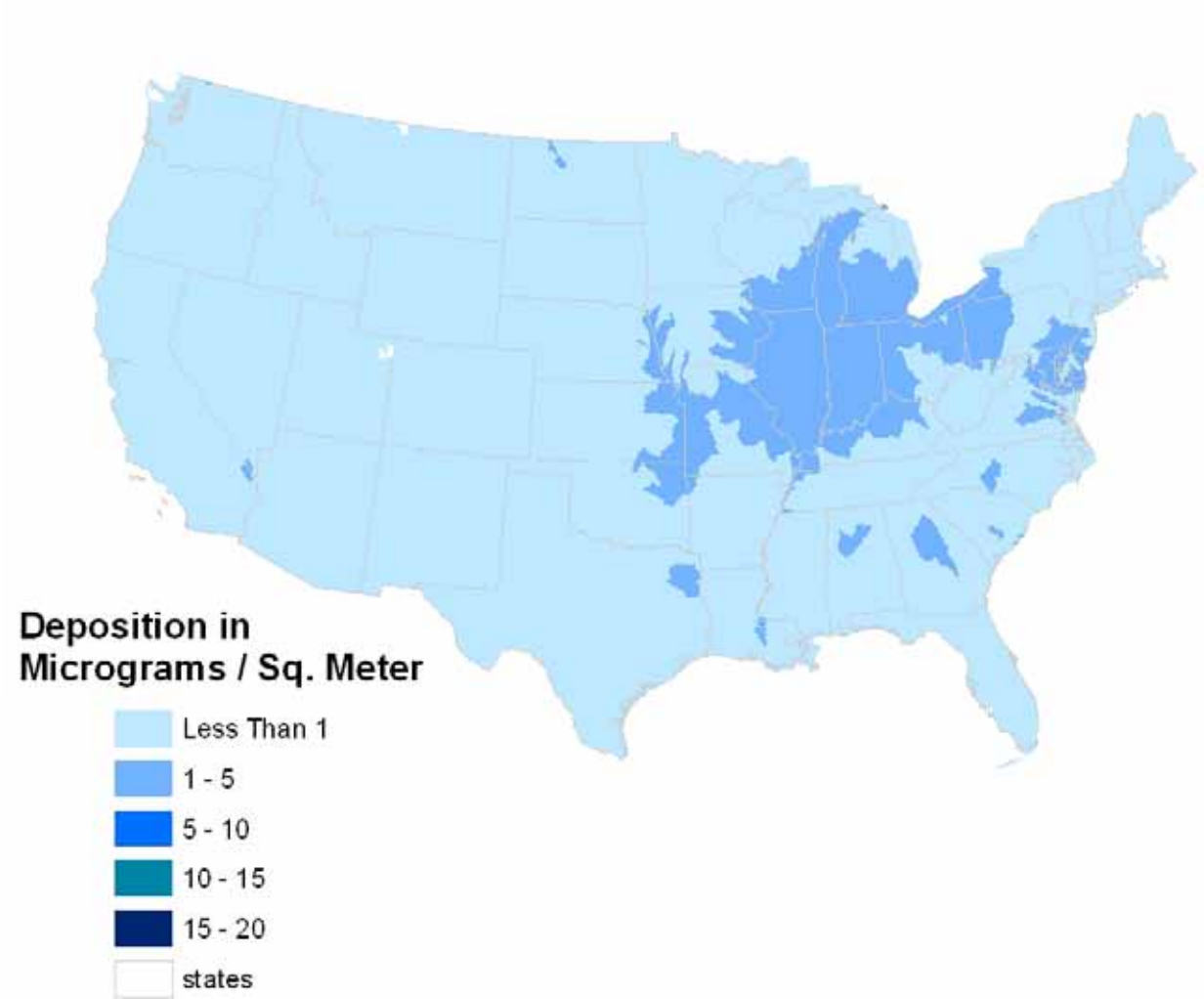
CAMR sets an emission reduction requirement for each State and Indian country

Many States have Hg Regulations

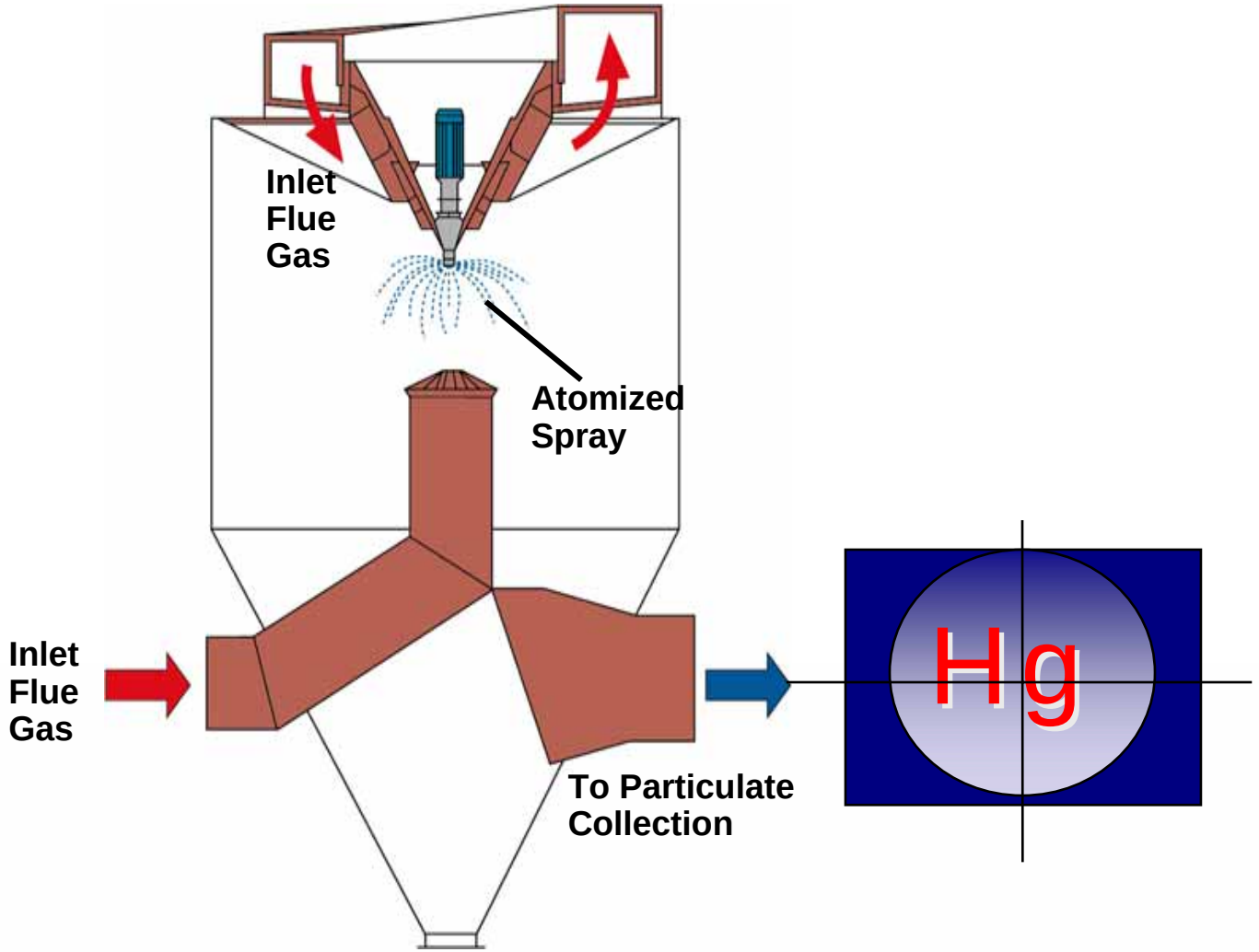
Mercury Deposition – "NOW"



Mercury Deposition – Future??



DFGD Mercury Emission Control Options



Boiler Side

Coal Selection (source and cleaning)

Coal Combustion (fly ash, UBC)

Selective Catalytic Reduction

Coal Additives (Halogens)

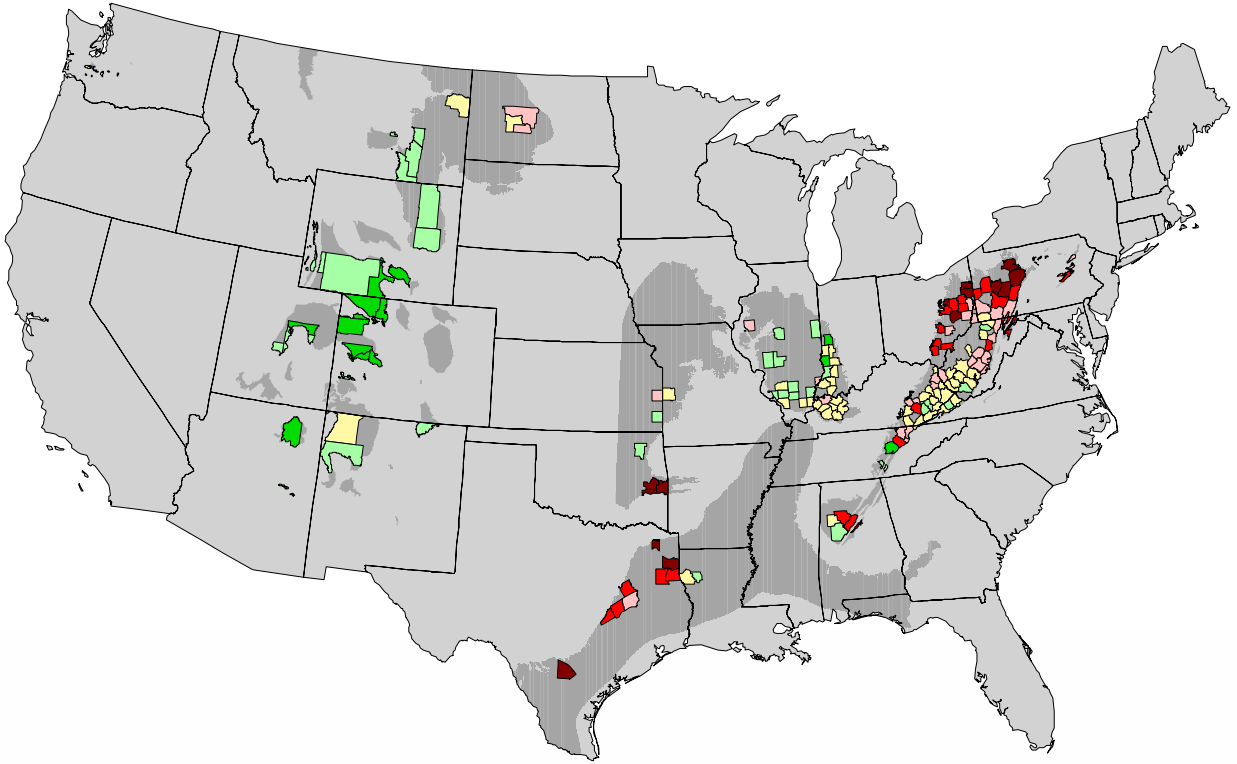
AQCS Side

Fly Ash Collection (ESP or BGH)

SDA operation (Recycle, Baghouse)

Flue gas additives (Powdered Activated Carbons)

Coal Mercury Concentration

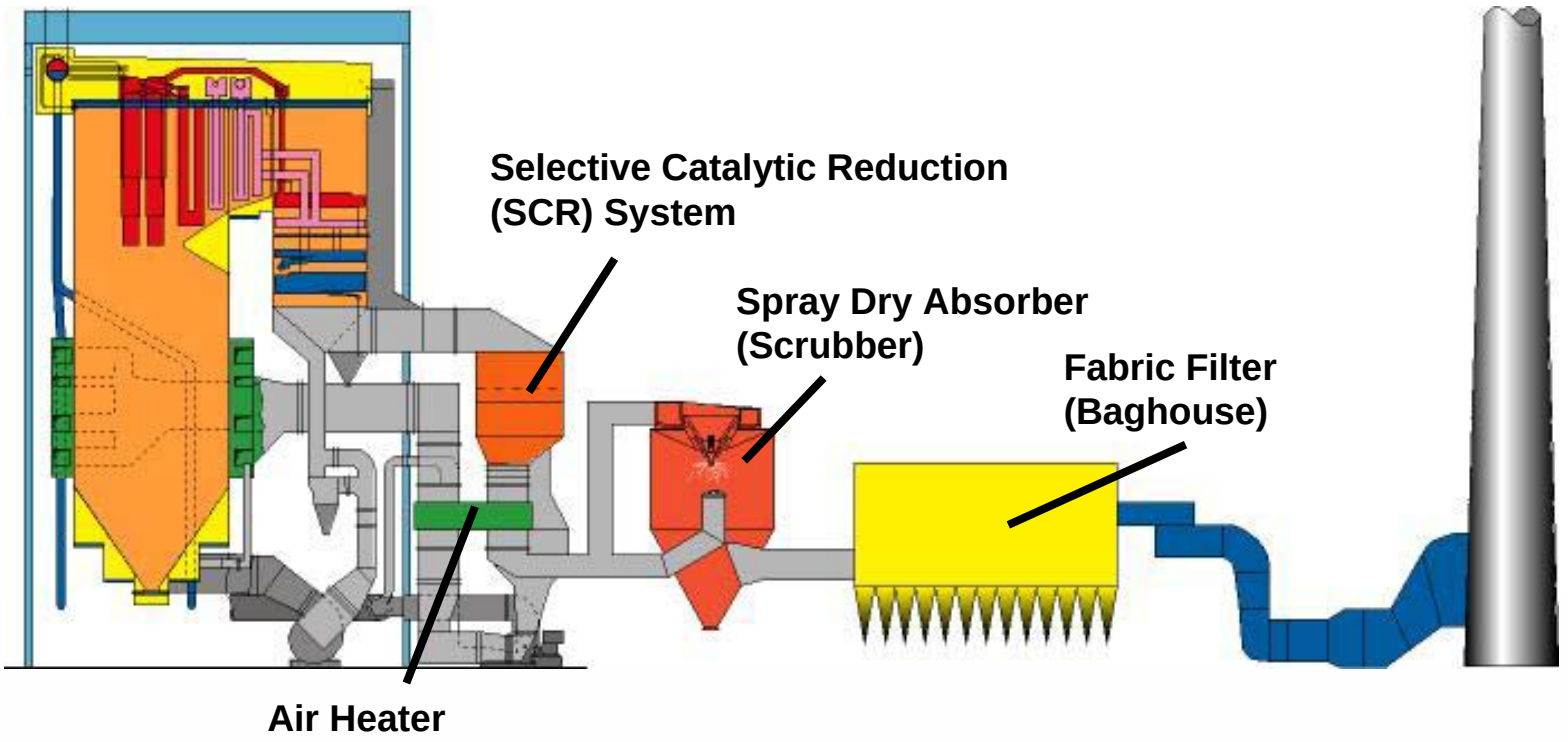


lbs Hg/TBtu

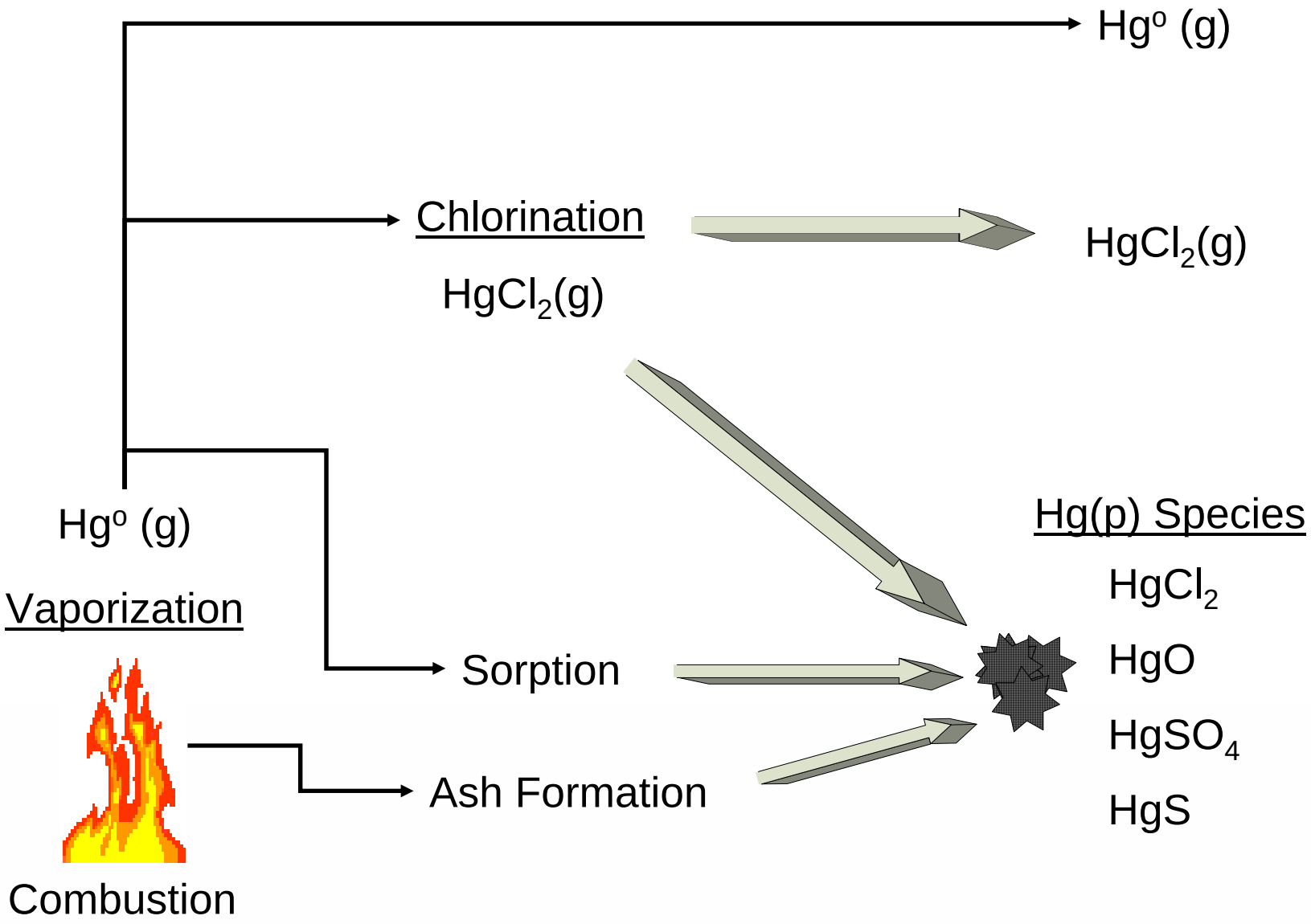
	2 - 4
	4 - 6
	6 - 9
	9 - 15
	15 - 30
	30 - 52

1999 coal production, ICR 2 data, by county

Typical Coal-Fired Boiler with DFGD



Fate of Hg in Coal Combustion

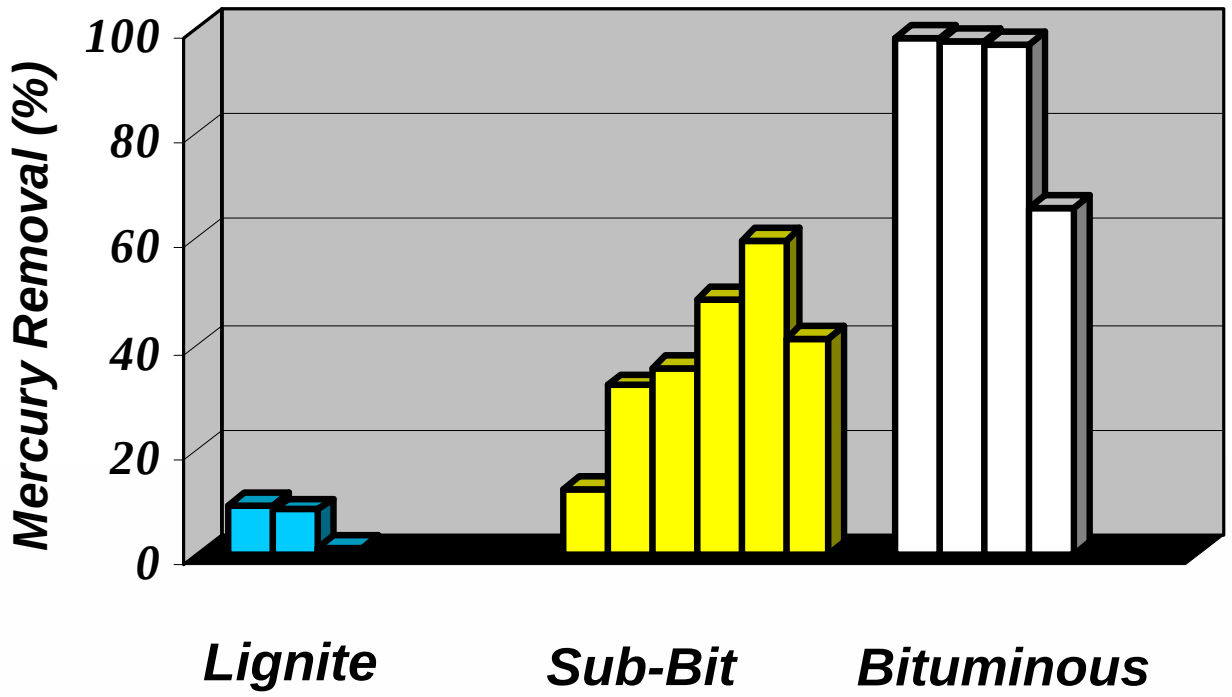


Coal-Fired Boiler Mercury Emissions

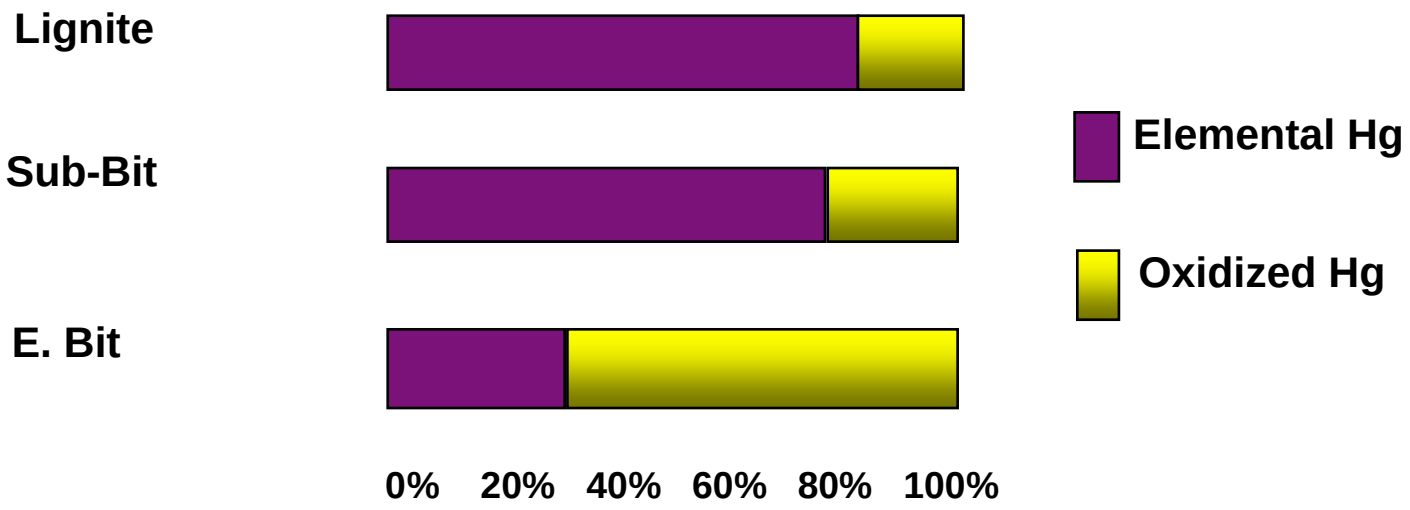
Spray Dry Mercury Control - EPA ICR Data

Plant Site Valid Test Averages

Total Mercury Removal

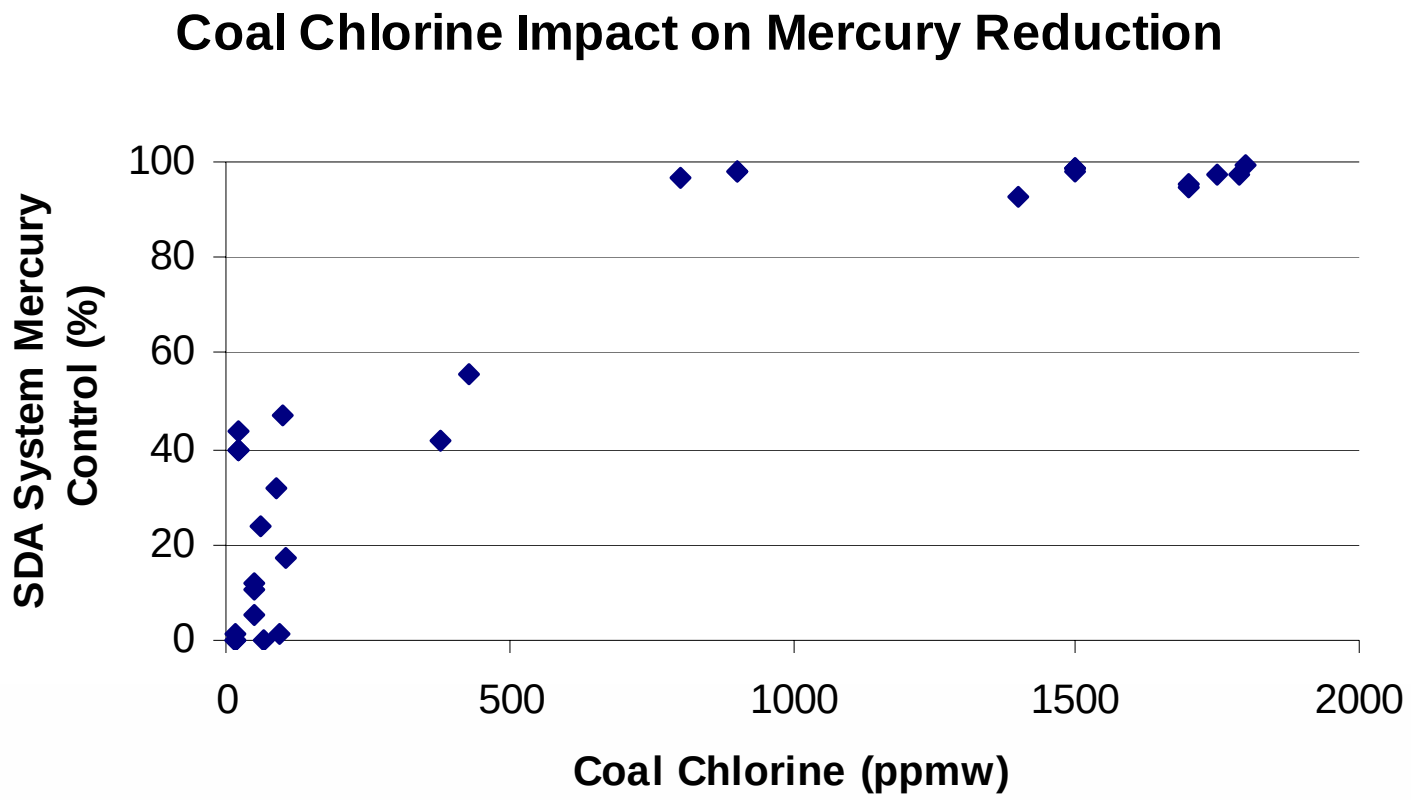


Typical Mercury Speciation vs. Coal Types

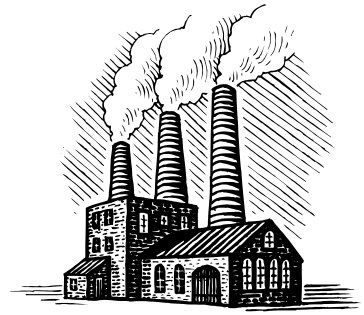


Oxidized Hg = $HgCl_2$

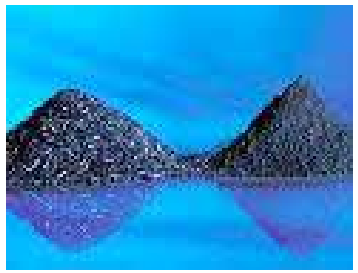
ICR SDA Test Data – SDA Total Mercury Control



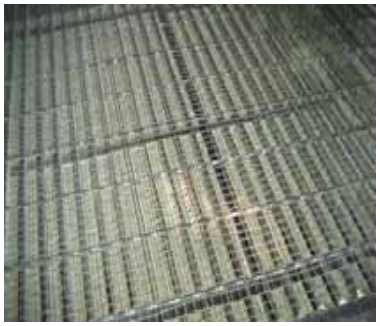
Flue Gas Mercury Speciation Factors



Gas Composition
(i.e., Chloride)



Unburned Carbon (UBC)



Catalysts
(i.e., SCR, Ash, Boiler Metals)

Key Points For Hg Removal

The form of mercury in the flue gas is critical to performance of emissions control systems

- **Particulate vs. Vapor**
- **Elemental Mercury - Hg^0**
- **Oxidized or Ionic Mercury - Hg^{++}**

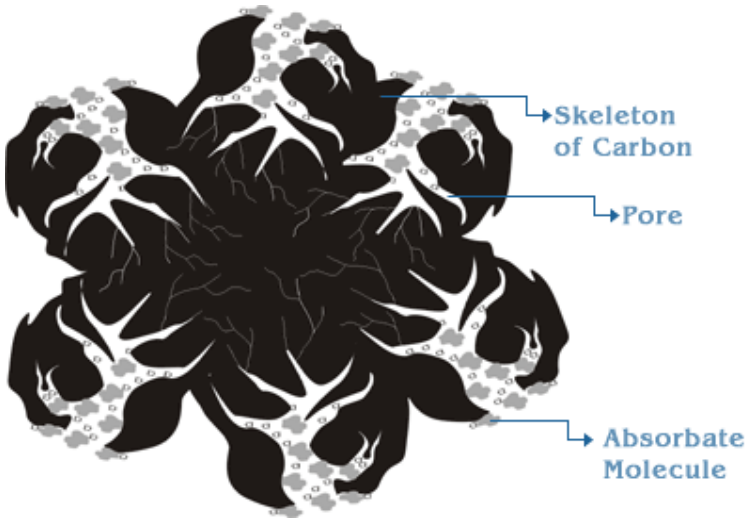
Coal Chlorine Plays a Significant Role

Typical PRB Power Plant Hg Emissions

- ***90 – 900 MWgross Plant***
- ***0.10 – 0.30 ppm PRB coal Hg***
- ***10 - 30 ppm Coal Chlorine***
- ***SDA + Baghouse***
- ***SCR (Maybe)***

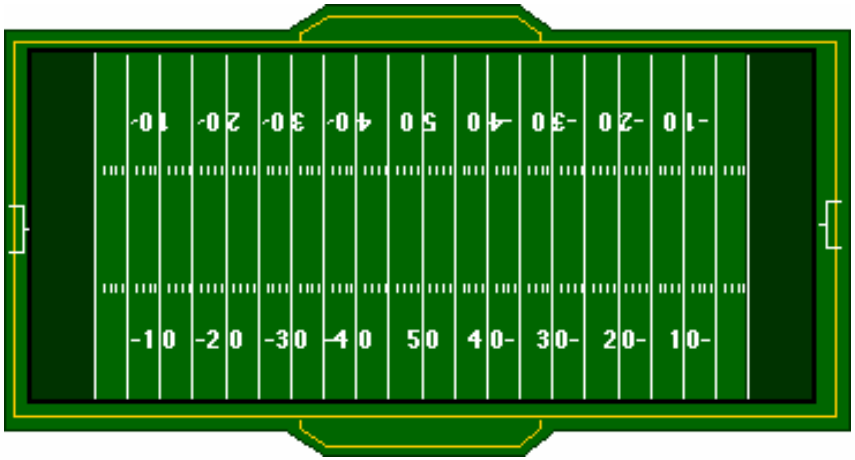
- ***Stack Hg Emissions can be <of 95 x10^{-6} lb/MW.hr***
- ***Stack Hg emissions of 0.20 lb/day (100 MW)***
- ***~70% of coal Hg exits the Stack***

Powdered Activated Carbon Injection For DFGD Mercury Control



40 microns MMD

Surface Area of 9 grams =



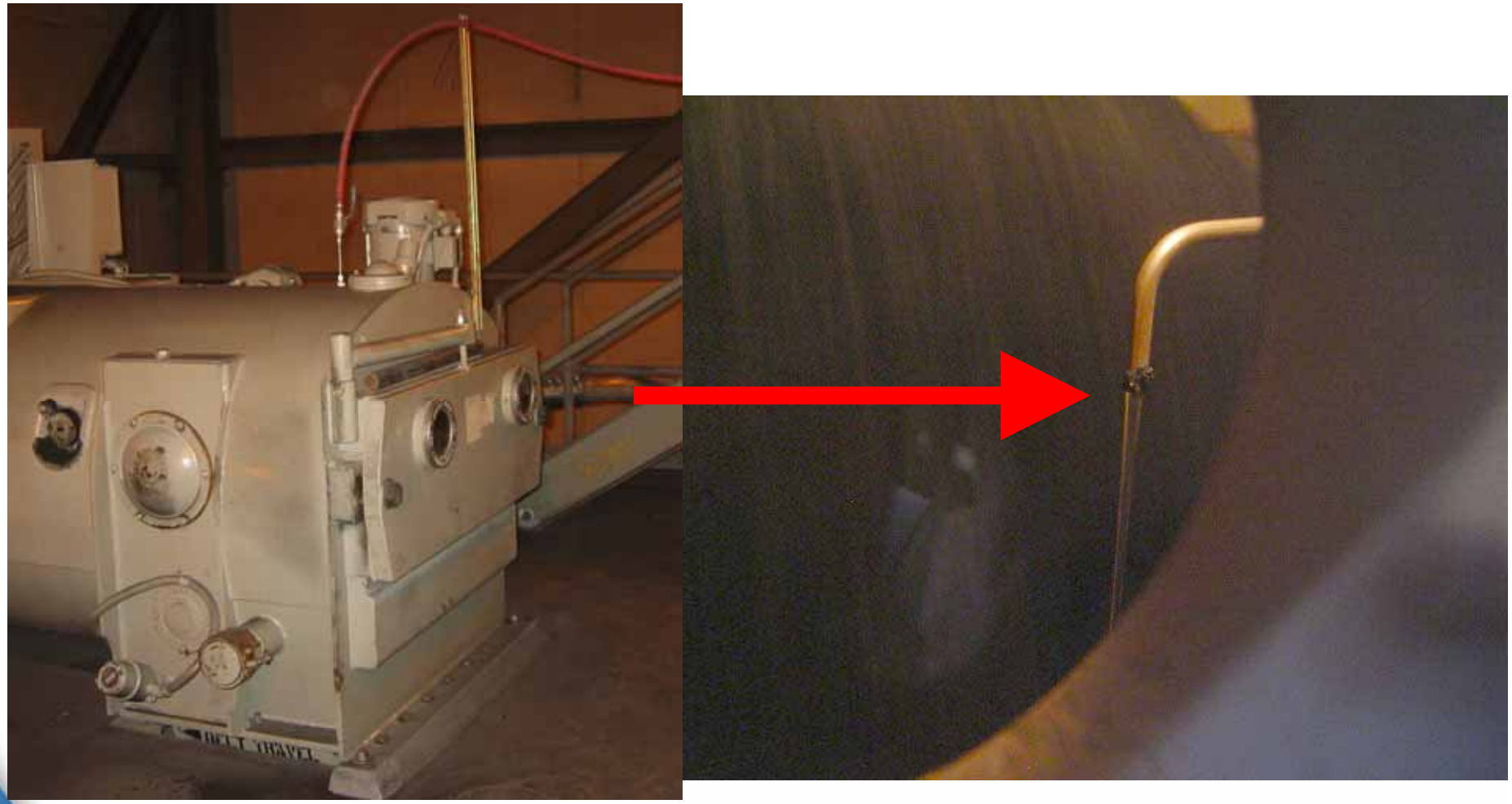
PAC Storage and Delivery Equipment

PAC Flue Work Injector Equipment

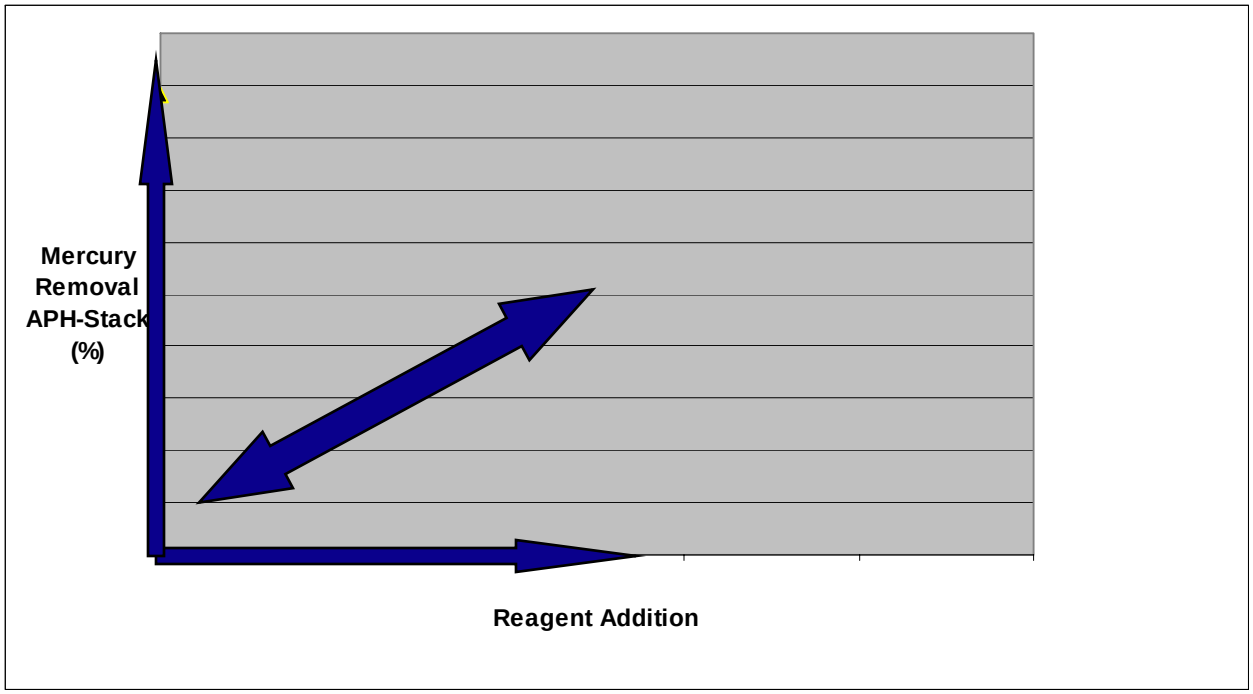
Calcium Chlorides Solution Injection For DFGD Mercury Control

Solution Storage and Delivery Equipment

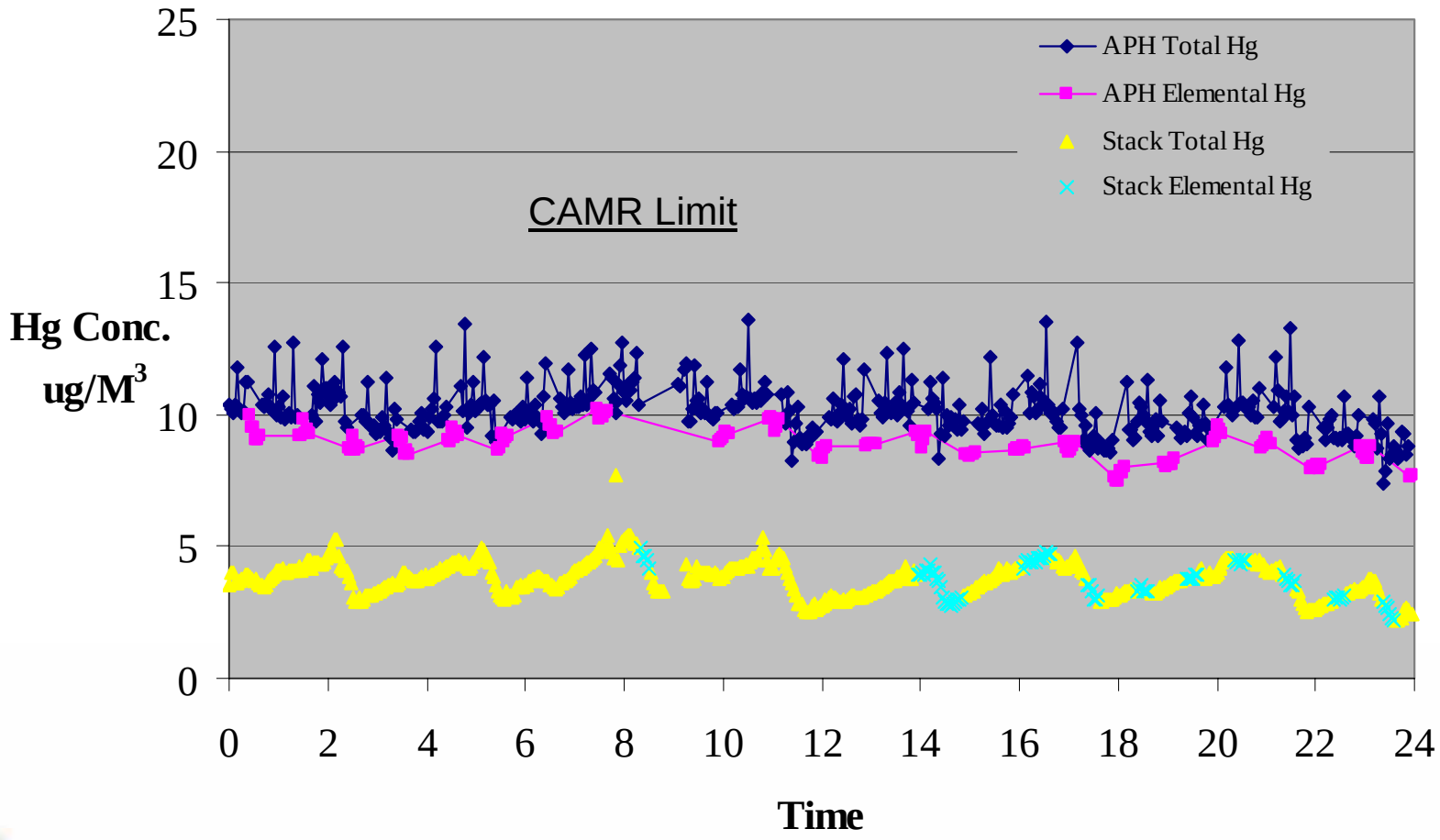
Calcium Chloride Solution Injection Equipment



Mercury Emission Reduction Performance Data

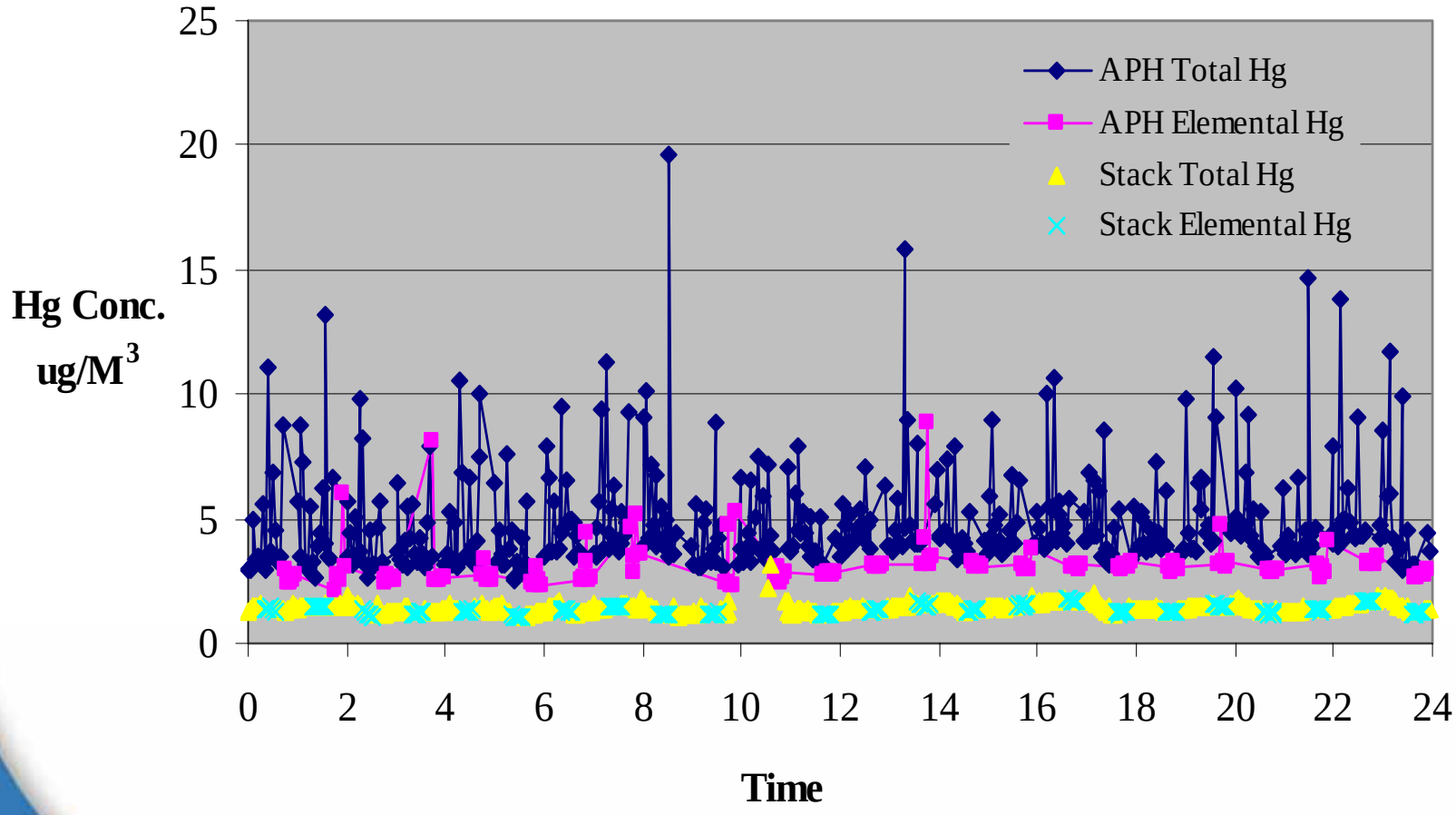


Wygen1 Baseline Mercury Removal and Emissions

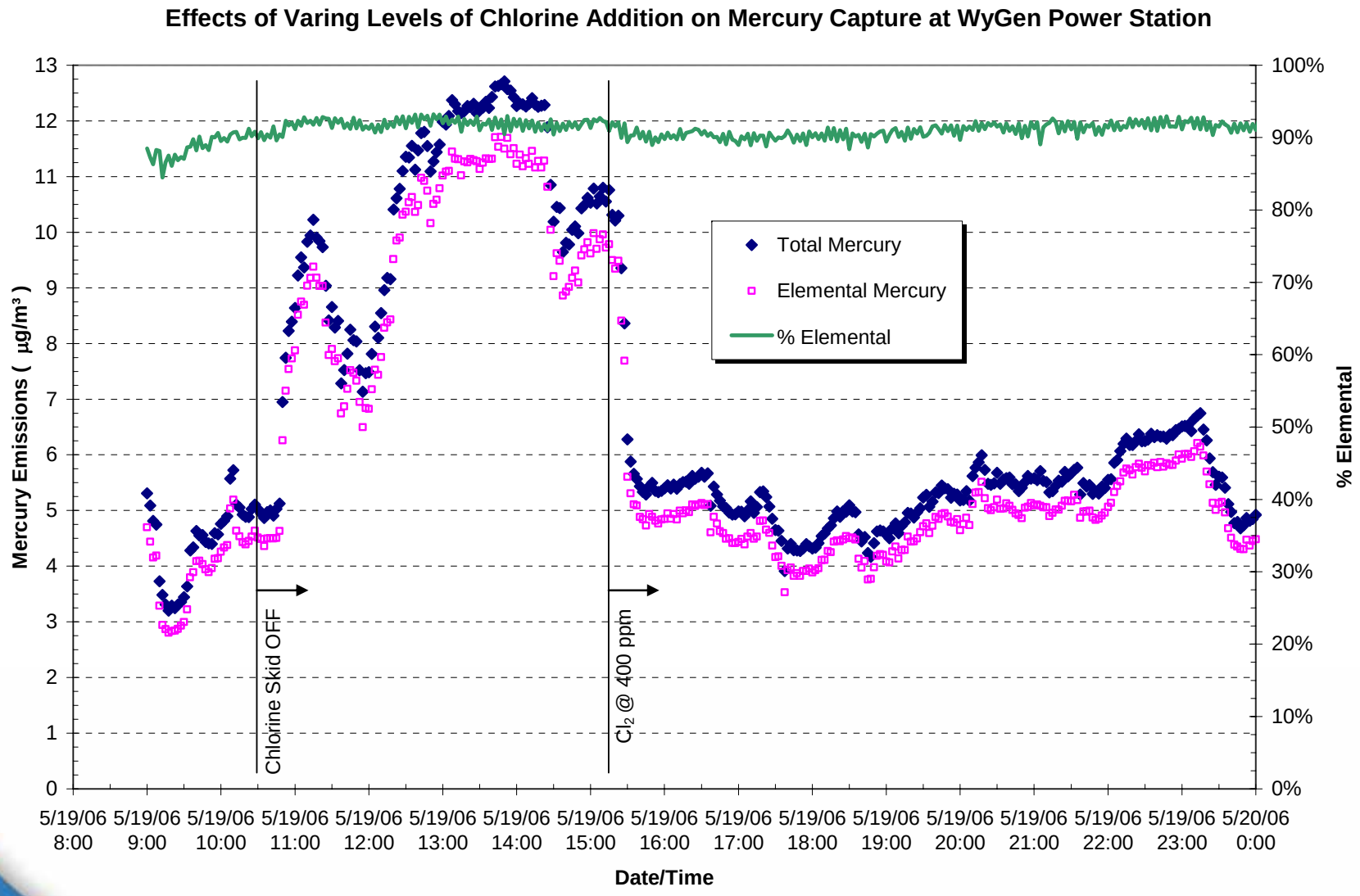


Wygen1 Mercury Removal and Emissions

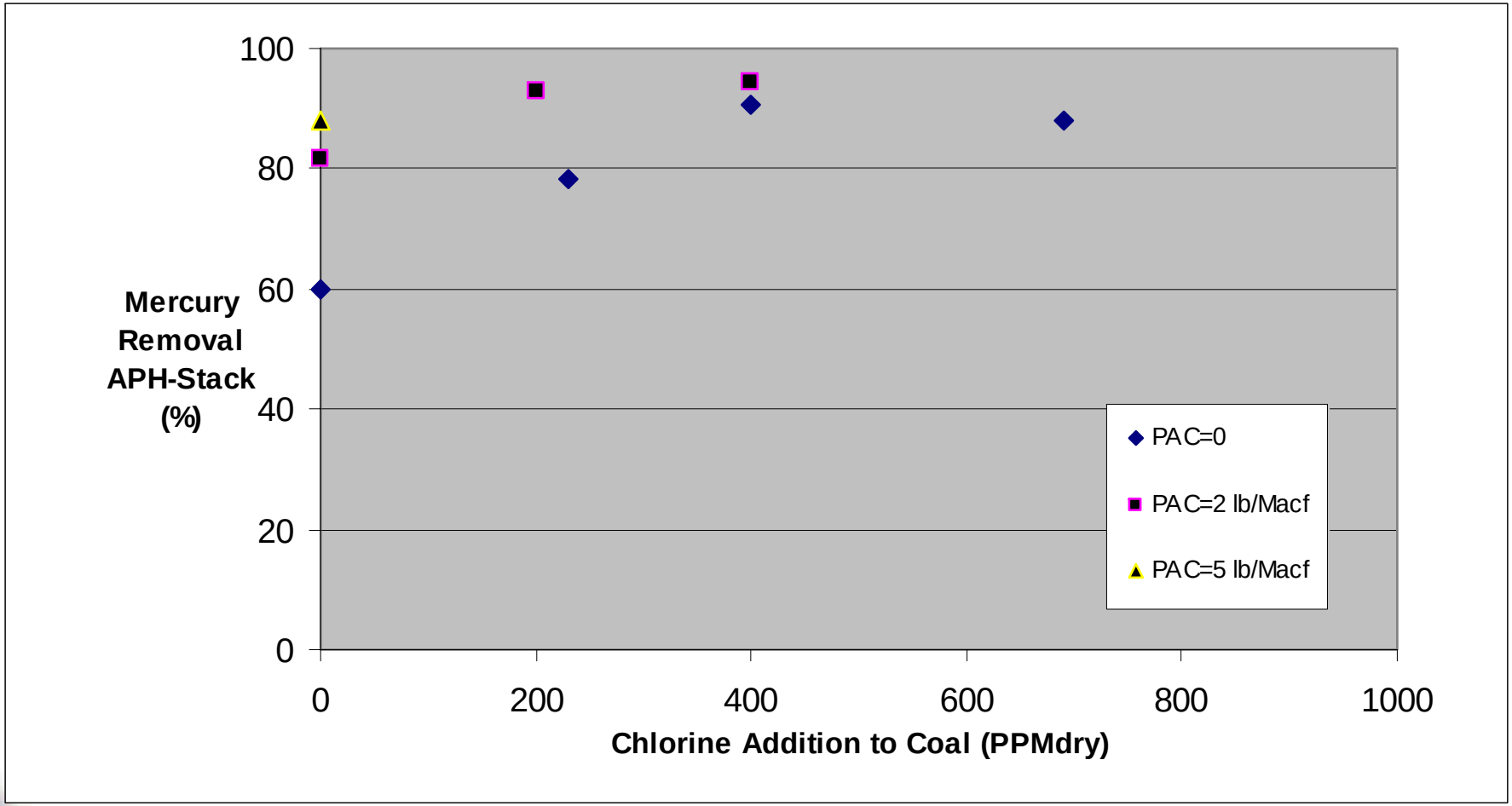
$CaCl_2$ Addition to Coal = 860 ppmdry



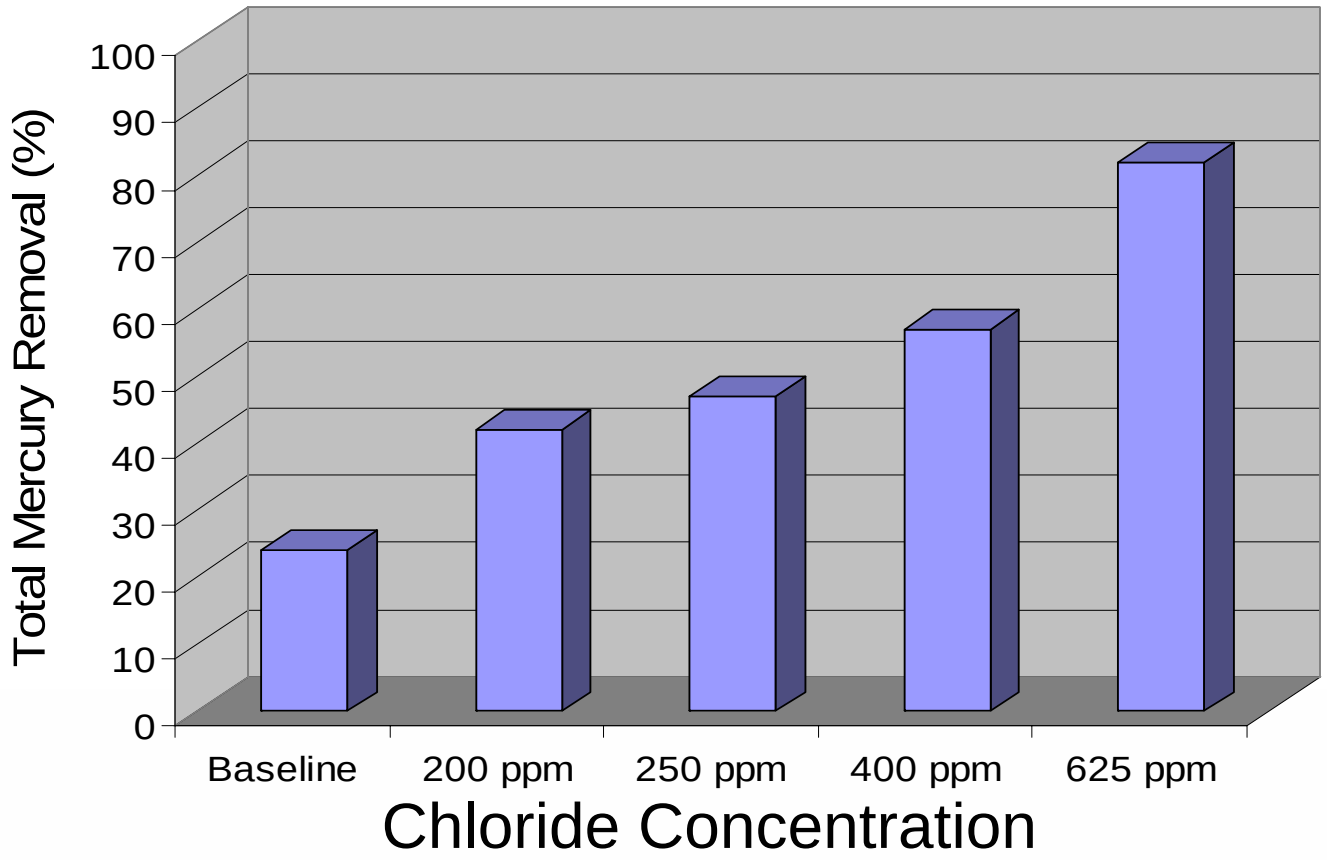
Mercury Emission Response to Coal Additive



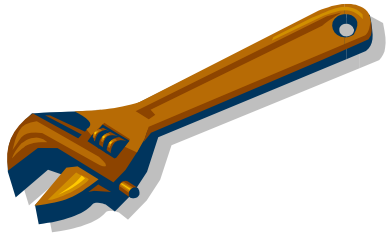
Mercury Emissions with $CaCl_2$ + PAC Addition



Hawthorn5 Mercury Reduction



Balance of Plant Issues



General

- *More Equipment to Operate.*
- *More Equipment to Maintain.*
- *More Truck Chemicals Deliveries.*

PAC

- *Increases Carbon Content in Disposal Ash*
- *Isolated Hopper Fires Have Been Reported.*

Calcium Chlorides

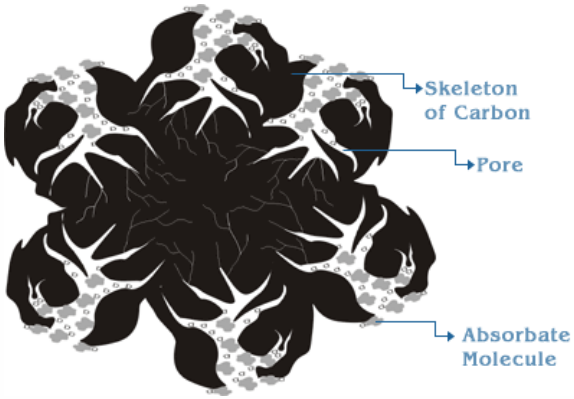
- *May Have Enhanced Boiler Corrosion Above 1000 ppmdry.*
- *Reduces Lime Consumption (benefit)*

? How Much Could it Cost ?

$$$

CaCL2 Solution

PAC



Mercury Emission Control Costs (600 MWg Plant)

	Base Case Norit Hg-LH PAC	Norit Standard PAC & CaCl2 Addition	Norit Hg-LH PAC & CaCl2 Addition
Mercury Removal (% of vapor phase, APH to stack)	90	90	90
Activated Carbon Cost ($/lb delivered)	$1.10	$0.65	$1.10
Activated Carbon Flow Rate (lb/10^6 ACF)	4	3	2
Activated Carbon Flow Rate (lb/hr)	424	318	212
CaCl2 30% Soln ($/gal delivered)	NA	$1.10	$1.10
Cl Addition to Coal (ppmdry)	NA	750	500
CaCl2 flow rate (gpm)	NA	1.36	0.91
Annual Capacity Factor	90%	90%	90%
Annual Operating Hours	7884	7884	7884
Average Annual cost - Activated Carbon	$3,677,098	$1,629,623	$1,838,549
Average Annual cost - CaCL2	$0	$707,668	$473,513
Annual Reagent Cost ($M)	**$3.7**	**$2.3**	**$2.3**
Annual Reagent Cost ($/MW.hr)	**$0.78**	**$0.49**	**$0.49**
Installed Capital Cost ($M)	**$2.1**	**$3.7**	**$2.7**

Thank You !!

a McDermott company

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