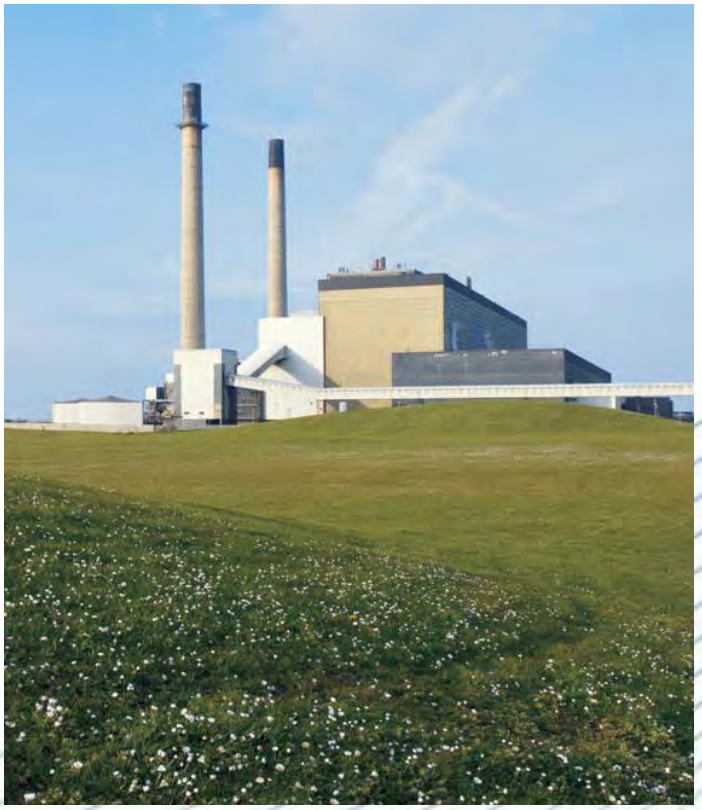
REINHOLD ENVIRONMENTAL Ltd.

2013 APC Round Table & Expo Presentation

July 8-9, 2013, in St. Louis, MO / Hosted by Ameren

Optimization of Mercury Control Strategies



JOHN MEIER

Global Product Line Manager
Air Protection Technologies

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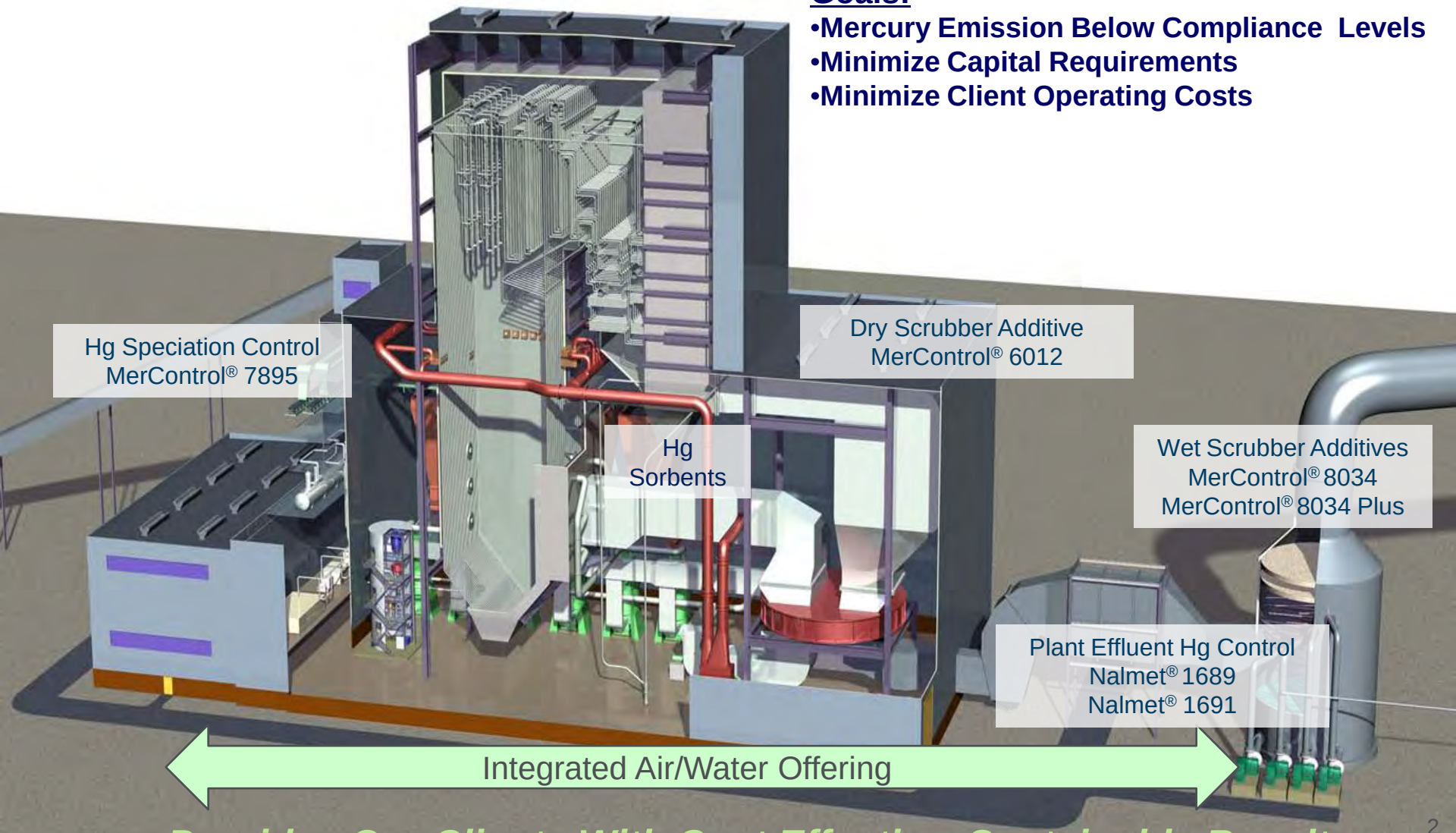
Nalco Air Protection Technologies Portfolio

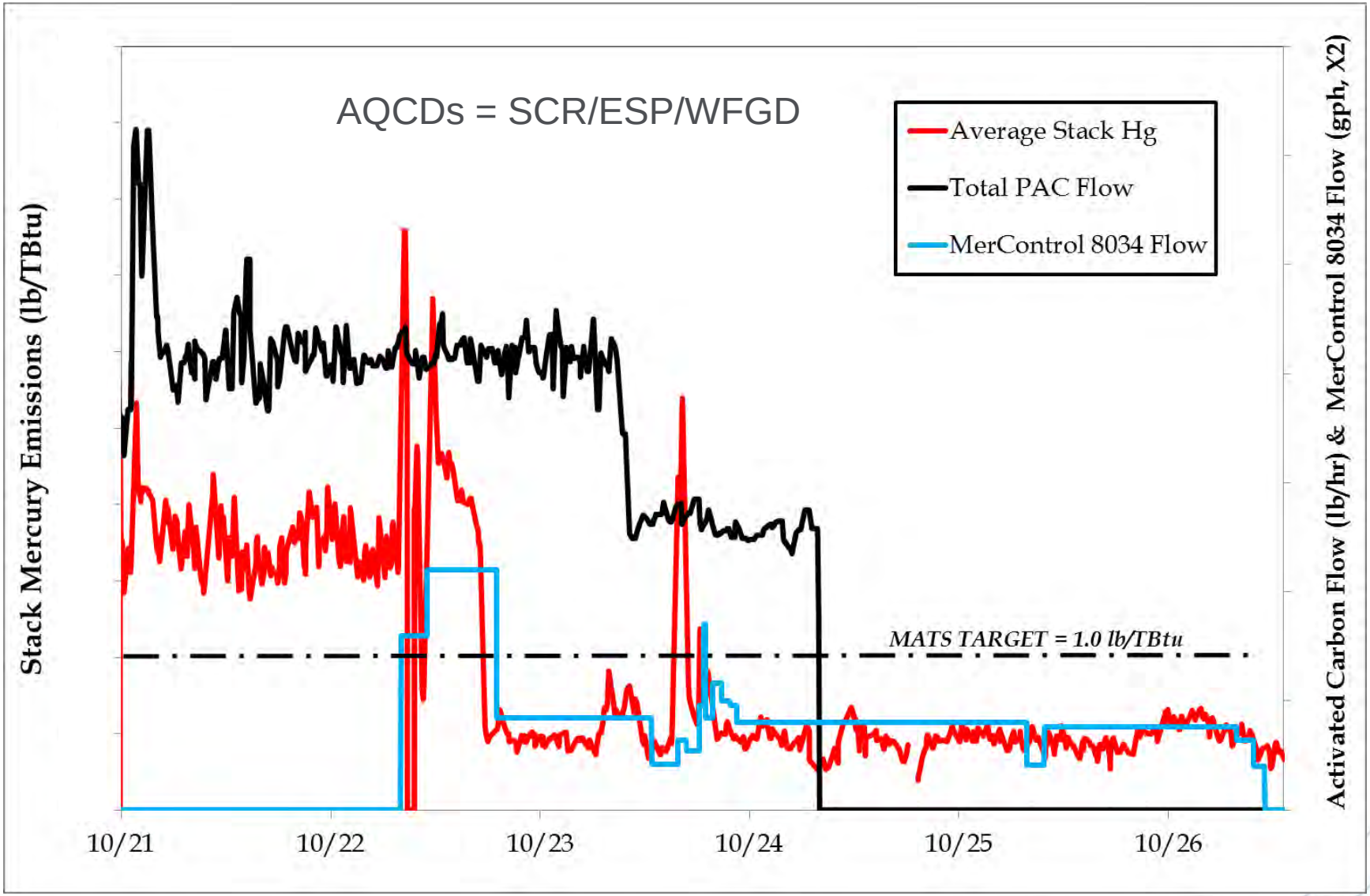
Goals:

- **Mercury Emission Below Compliance Levels**
- **Minimize Capital Requirements**
- **Minimize Client Operating Costs**



……Provides Our Clients With Cost Effective, Sustainable Results

MerControl 8034 *versus* ACI Pre-ESP



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MerControl 8034
Hg Re-emission Control

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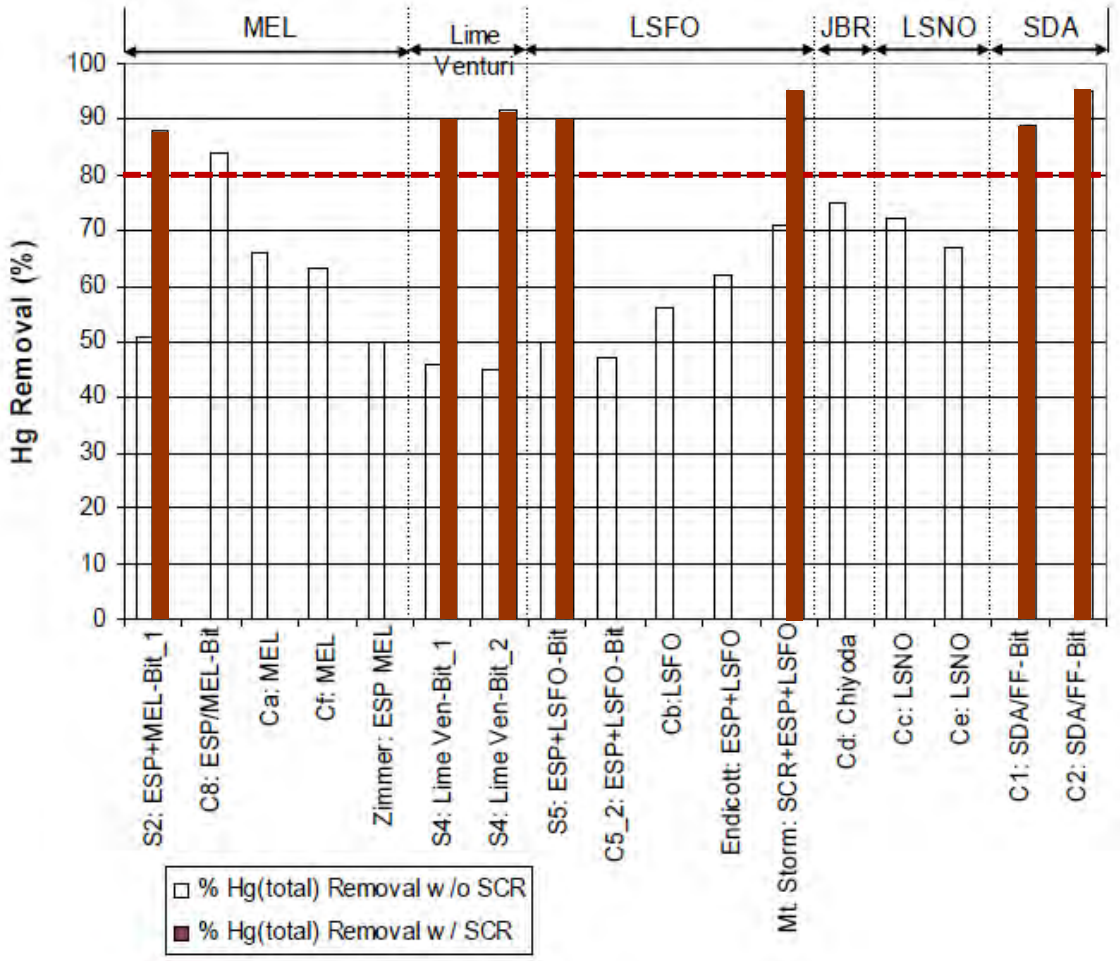
Impact of Type/Chemistry of Scrubber



KEY:

MEL=Magnesium Enhanced Lime
LSFO=Limestone Forced Oxidation
JBR=Jet Bubbler Reactor
LSNO=Limestone No Oxidation
SDA=Spray Dryer Absorber

Coal-to-Stack Mercury Capture:

50 – 80%

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R. Strivastava, "Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update," EPA/600/R-10/006, February 2010.

WFGD Mercury Emission Control

- **What Limits Compliance of EGUs with WFGDs?**

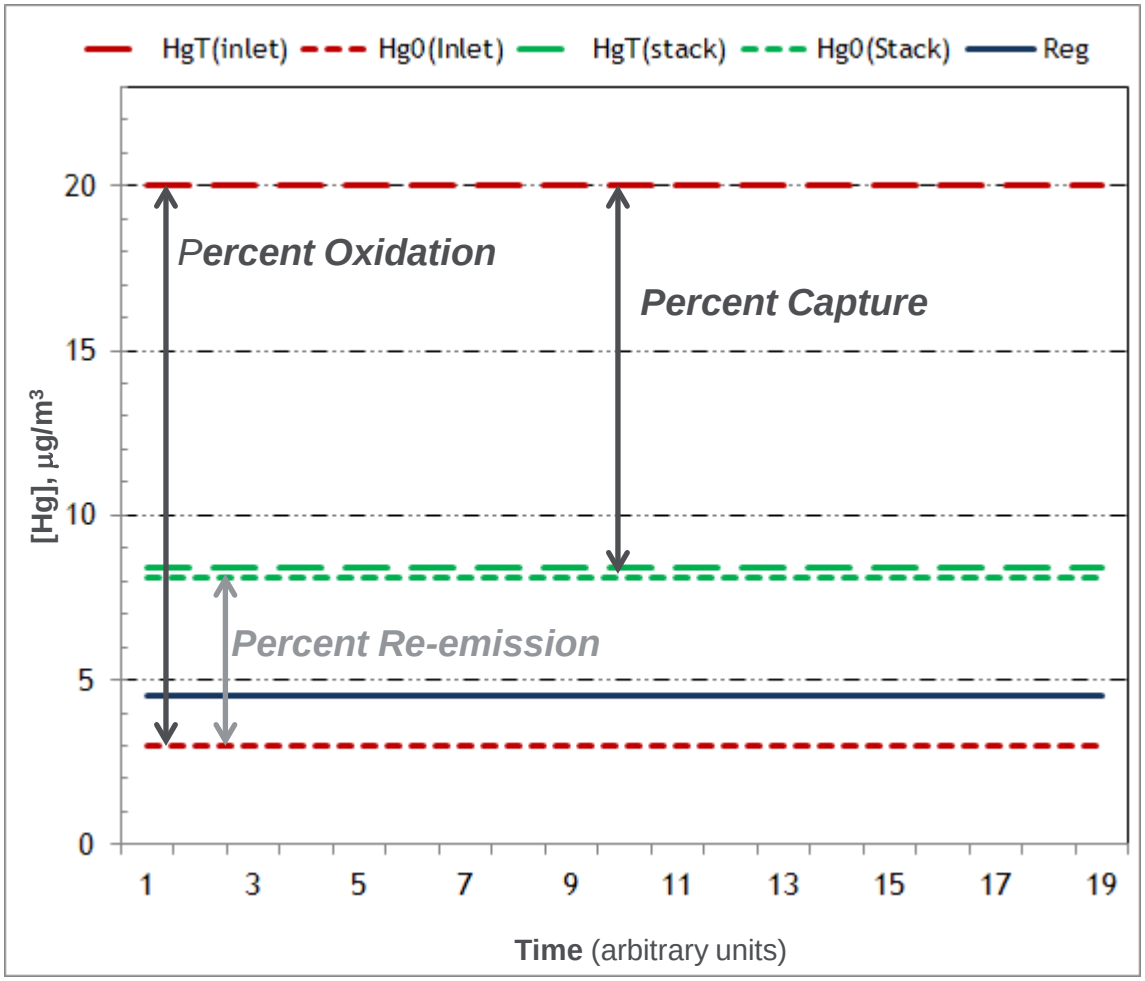
1. Mechanical
2. Chemical ***Mercury Re-emission***

$$[Hg^0]_{stack} > [Hg^0]_{WFGD\ inlet}$$

$$Hg^{2+}_{(aq)} \rightarrow Hg^0_{(g)} \uparrow$$

$$HgSO_3 + H_2O \rightarrow Hg^0 + H_2SO_4$$

Hg Re-emission Example/Definitions



$$\%\ \text{Hg Oxidation} = \left(\frac{Hg^{T}_{Inlet} - Hg^{0}_{inlet}}{Hg^{T}_{Inlet}} \right) \times 100$$

$$\%\ \text{Hg Capture}^{*} = \left(\frac{Hg^{T}_{Inlet} - Hg^{T}_{outlet}}{Hg^{T}_{Inlet}} \right) \times 100$$

$$\%\ \text{Hg Re - emission} = \left(\frac{Hg^{0}_{outlet} - Hg^{0}_{inlet}}{Hg^{T}_{Inlet} - Hg^{0}_{Inlet}} \right) \times 100$$

$$\%\ \text{WFGD Efficiency} = \left(\frac{Hg^{T}_{inlet} - Hg^{T}_{outlet}}{Hg^{T}_{Inlet} - Hg^{0}_{Inlet}} \right) \times 100$$

* = *Inlet flue gas concentration to stack emission.*

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MerControl 8034 Technology

Simple Application Equipment, Low Capital Cost

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Injection and Sampling Points

Basin Injection

Recirculation Line Injection

Sampling Stream

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Hg Capture via SCR and WFGD

Multiple Boilers

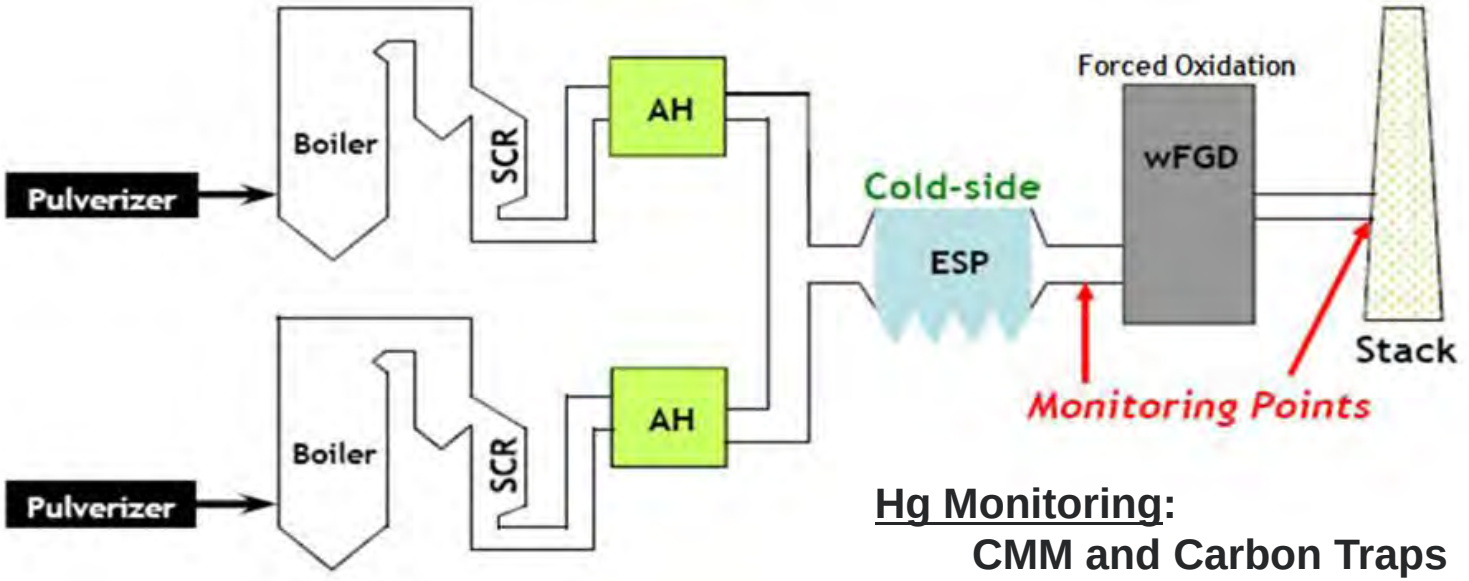
Site Description:

- Chlorine* = 1200 ppm (max = 1400)
- Mercury* = 0.05 ppm (max = 0.06)

*= AR value

- Full Load = N/A
- Fuel = High Chlorine Bituminous
- AQCDs = SCR, cold-side ESP and w-FGD

Goal: Reduce Hg re-emissions to meet MATS limit.



Hg Monitoring:
CMM and Carbon Traps

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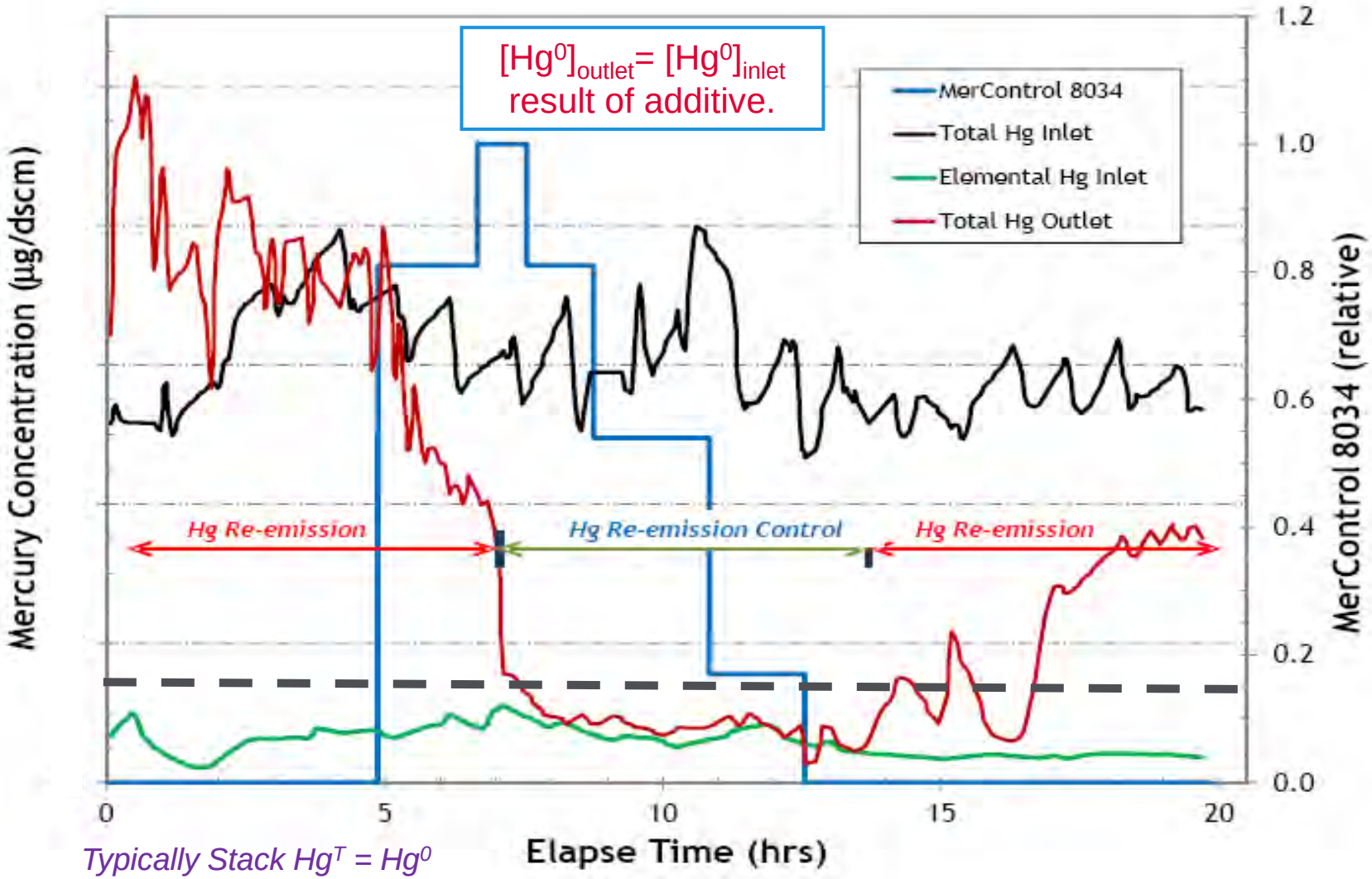
Re-Emission Additive Performance



Typically Stack $Hg^T = Hg^0$

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Performance Summary

Multiple Boilers

Comparison	Elapse (Hrs)	Percent			
		Oxidation	Re-emission	Capture	wFGD Efficiency
Baseline	0-5	90.8 ± 3.3	99.4 ± 35.7	-27.6 ± 29.1	-30.9 ± 33.7
MerControl 8034	10-13.5	90.0 ± 2.4	11.3 ± 31.2	88.2 ± 3.2	98.0 ± 2.9
No additive	18-end	93.0 ± 0.4	30.9 ± 1.9	38.7 ± 4.4	41.6 ± 4.7

During Periods of MerControl 8034 Technology Application, Hg Re-emission Was Near *Zero* and Hg Capture Was *Greater Than 90%*.

wFGD Efficiency Attains 98%

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Mercury Emission Control via WFGDs

Site Description

- Full Load = 513 MWg
- Boiler Type = tangential pulverized coal
- Fuel = bituminous coal
- AQCDs = cold-side ESP, LSFO wFGD

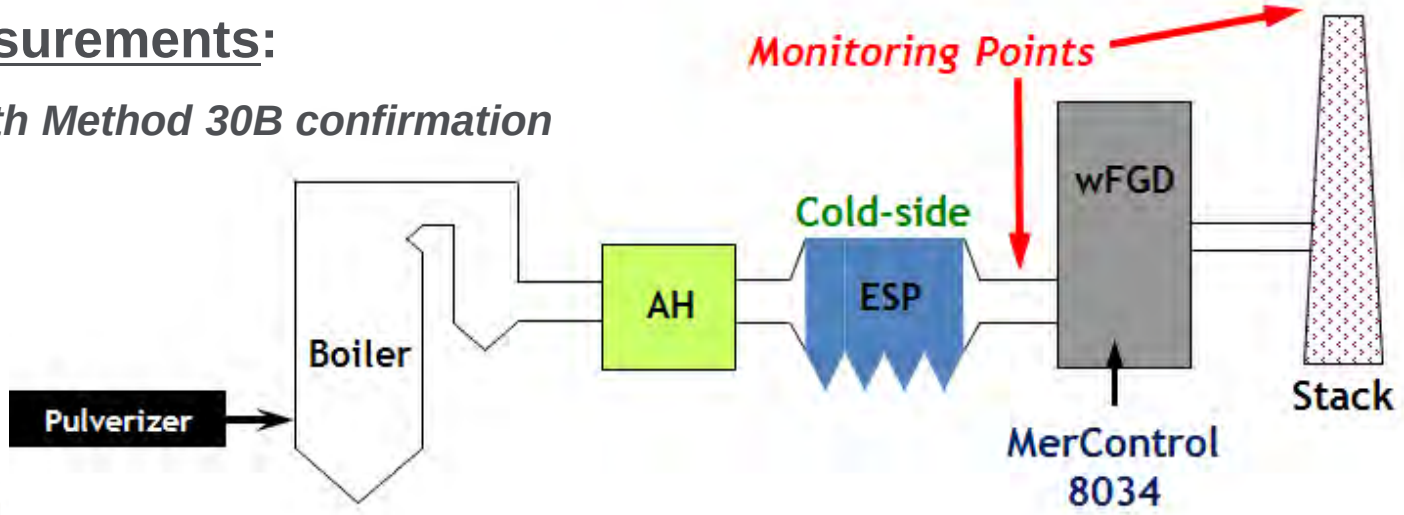
Coal Quality

- Sulfur = 3.06 ± 0.38 % (dry)
- Chlorine = 409 ± 154 ppm
- Mercury = 0.088 ± 0.026 ppm

Goal: Control Mercury Re-emission across the WFGD to maximize mercury capture.

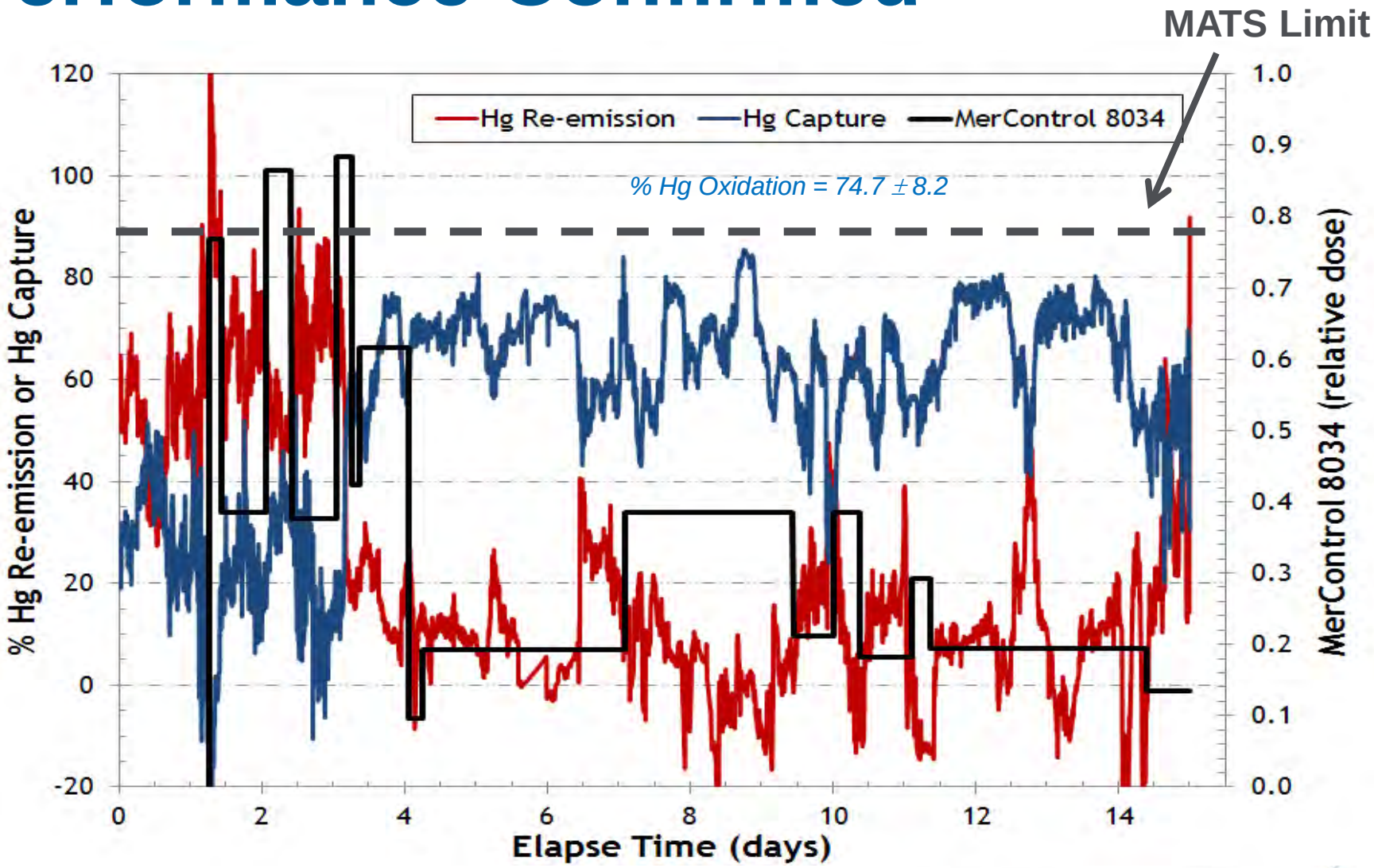
Hg measurements:

CMMs with Method 30B confirmation



LSFO = Limestone forced oxidation

Performance Confirmed



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Summary of Performance:

Comparison	Elapse Days	Percent			
		Oxidation	Re-emission	Capture	FGD Efficiency
Baseline	0-1.4	79.5 ± 4.6	59.3 ± 21.0	23.7 ± 17.2	40.7 ± 21.0
MerControl 8034	4 - 14	73.9 ± 7.9	9.69 ± 10.8	65.5 ± 9.6	90.3 ± 11.0

FGD Efficiency = Percent of inlet flue gas ionic mercury captured by WFGD.

$$\%\,\text{FGD Efficiency} = \left(\frac{Hg^{T}_{inlet} - Hg^{0}_{outlet}}{Hg^{T}_{Inlet} - Hg^{0}_{Inlet}} \right) \times 100$$

MerControl 8034 Application for Re-emission Control Increased WFGD Mercury Capture Efficiency To Greater Than 90%.

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MerControl 8034
Corrosion Mitigation

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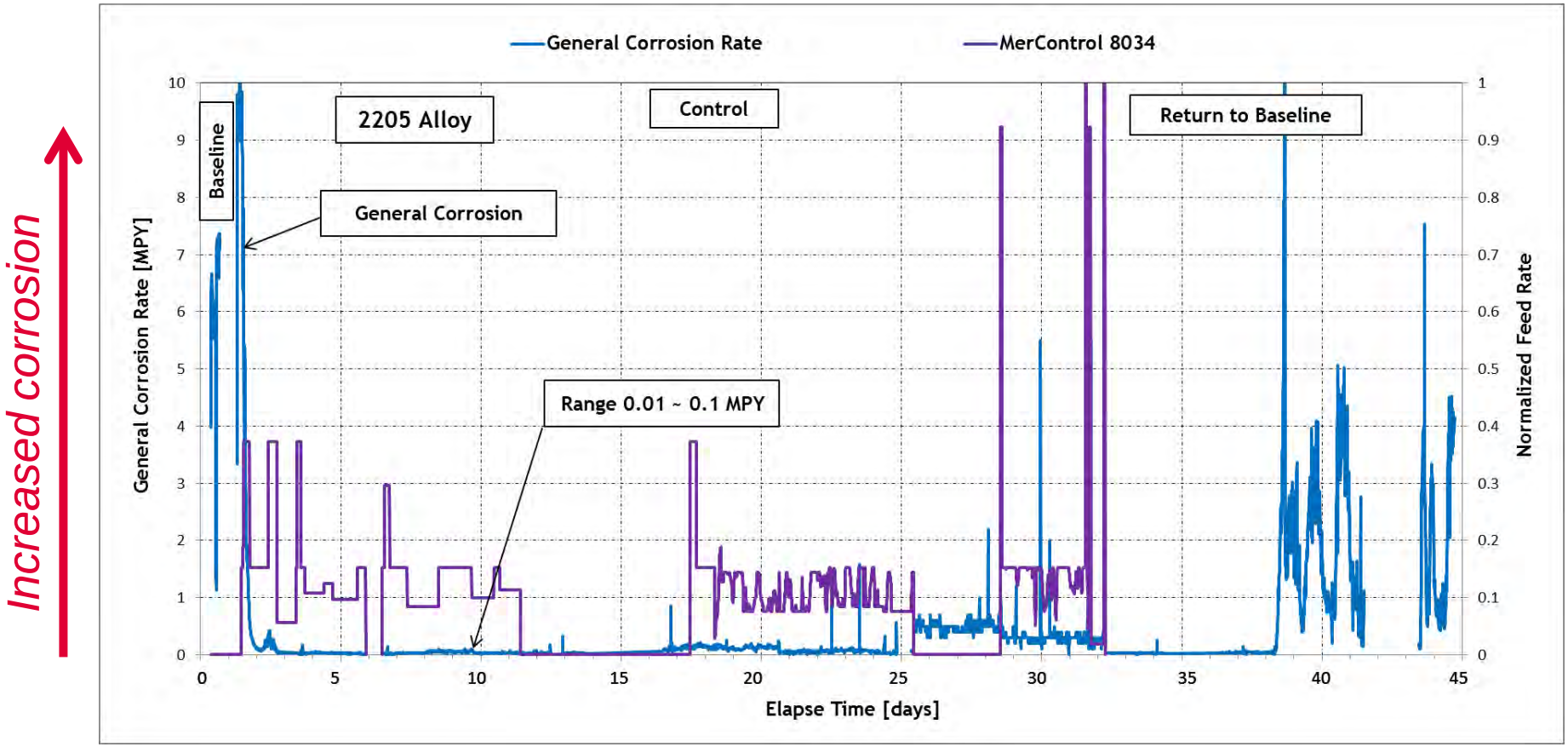
General Corrosion Rate



General Corrosion Significantly Decreases During MerControl 8034 Injection.

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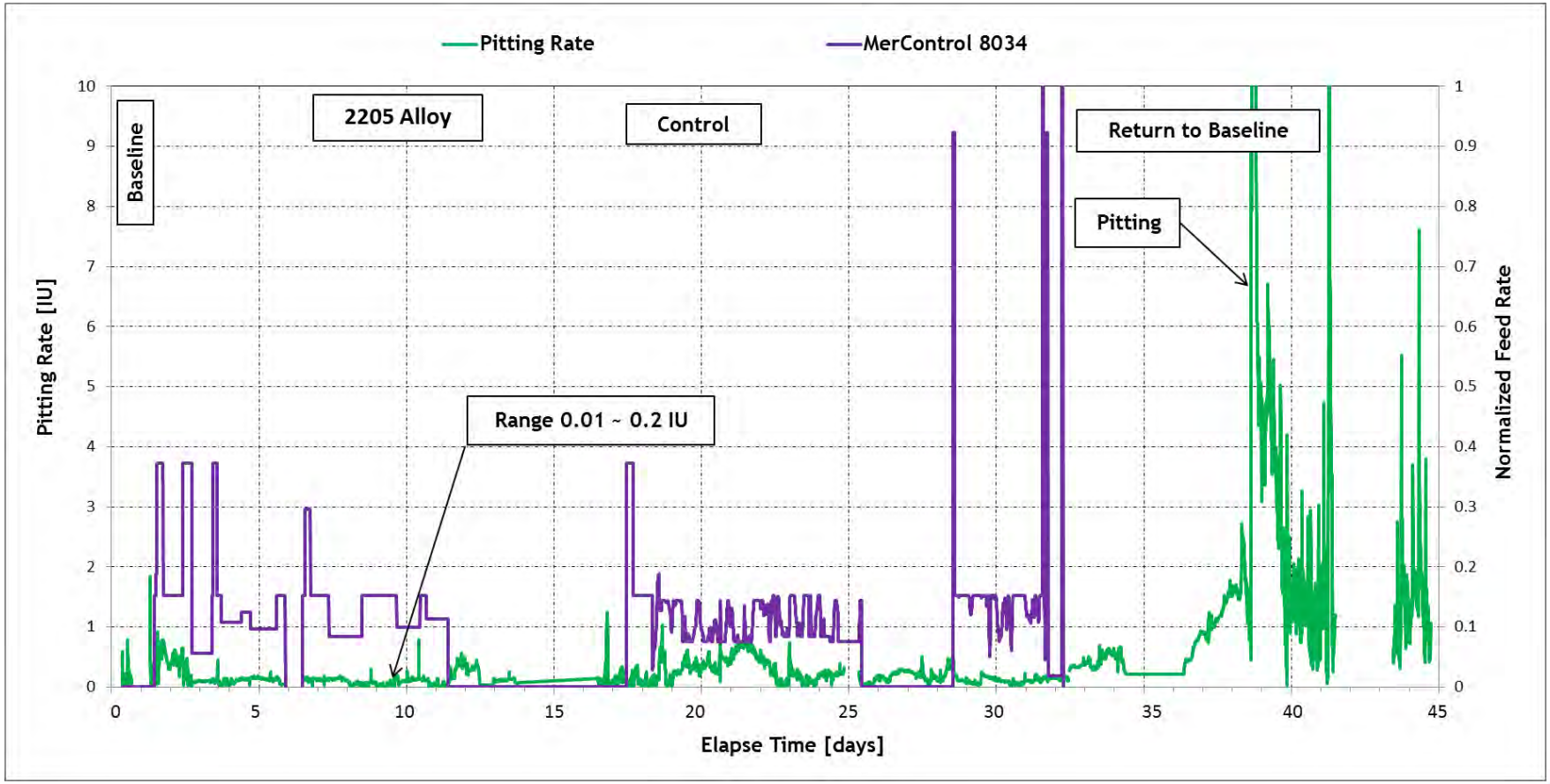
Localized Corrosion Rate



Increased pitting

Pitting of 2205 Alloy decreases during MerControl 8034 Injection.

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MerControl 8034 “Plus”

Next Generation Re-Emission Control

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Benefits of MerControl 8034 “Plus”:

- “Practically non-toxic” as defined by EPA*.
- Manufacturing is a Core Competency
- Patented Technology (composition, application, manufacture)
- Performance
- Improved Product Stability (>1 year)

Demonstrated on Commercial Units Successfully And Currently In Use at Multiple Units.

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*LC50 is >100 ppm.

MerControl 8034 Plus: Very Low Toxicity

Mammalian Testing

- Significantly less toxic and lower environmental impact than competitive technologies
- MSDS NFPA Rating = 1 1 0
- Non-irritating to skin
- Non-mutagenic

Substance/Structure	Acute Oral	Eye Skin Corrosion/ Irritation	Mutagenicity
Nalco's New Technology 8034 Plus	> 2,000 mg/kg	Skin- Non-irritating Eye- Non-irritating	Negative Ames
TMT	>2,000 mg/kg	Skin-Slightly Irritating Eye- Irritating	Negative Ames
Na_2S	LD_{50}- 254 mg/kg	Skin- Corrosive Eye- Corrosive	Negative Ames
DMDTC	LD_{50}- > 2,000 mg/kg	Skin-Severely irritating Eye-Severely Irritating	Positive Ames

Colors represent EPA defined toxicity categories

- Red = highly toxic
- Yellow = moderate to slightly toxic
- Green = practically non-toxic

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Case Studies
MerControl 7895

Hg Oxidation

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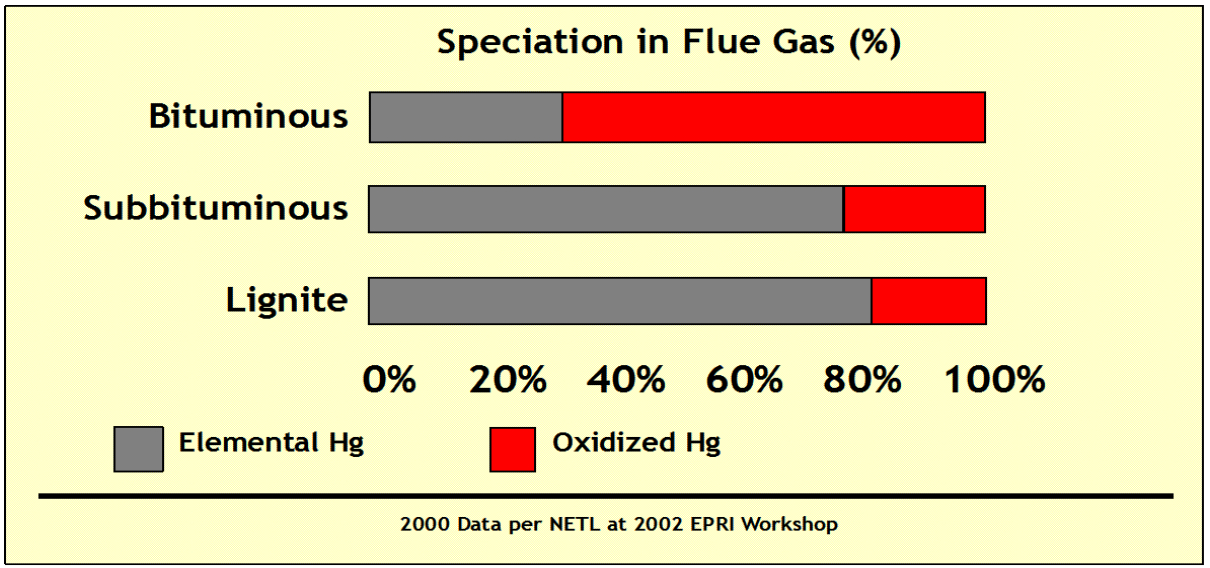
Mercury Speciation Management

$[Hg^{2+}]$ in flue gas correlates with chlorine content of coal.



$$[Hg^0]_{gas} + [Hg^{2+}]_{gas} + [Hg]_{particulate} = [Hg^T]$$

Also in Flue Gas are: CO_2 + SO_2 + SO_3 + HCl + other acid gases and HAPs.

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MerControl 7895 Technology

MerControl 7895 = Boiler Additive or BA

Meter addition to coal pulverizers.

Simple application equipment.

Low capital cost.

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Hg Capture via SCR and WFGD

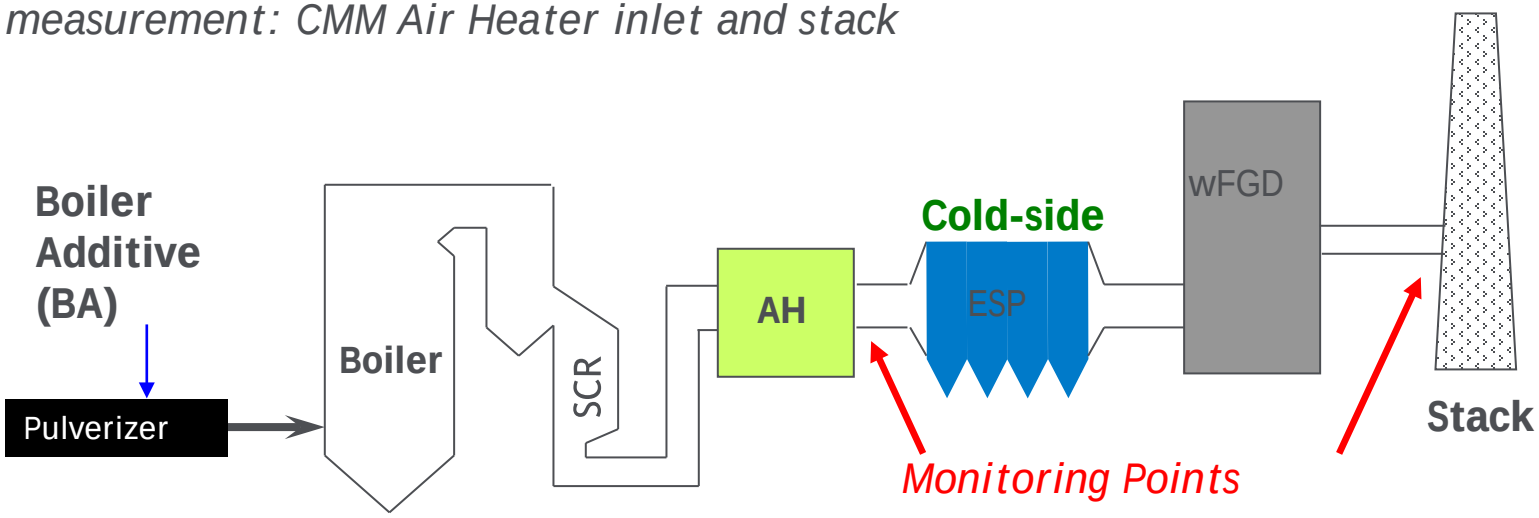
Site Description:

- Chlorine* = 1200 ppm (max = 1400)
- Mercury* = 0.05 ppm (max = 0.06)

- Full Load = 192 MWe
- Boiler Type = PC, Corner Fired
- Fuel = High Chlorine Bituminous
- AQCDs = SCR, cold-side ESP and wFGD

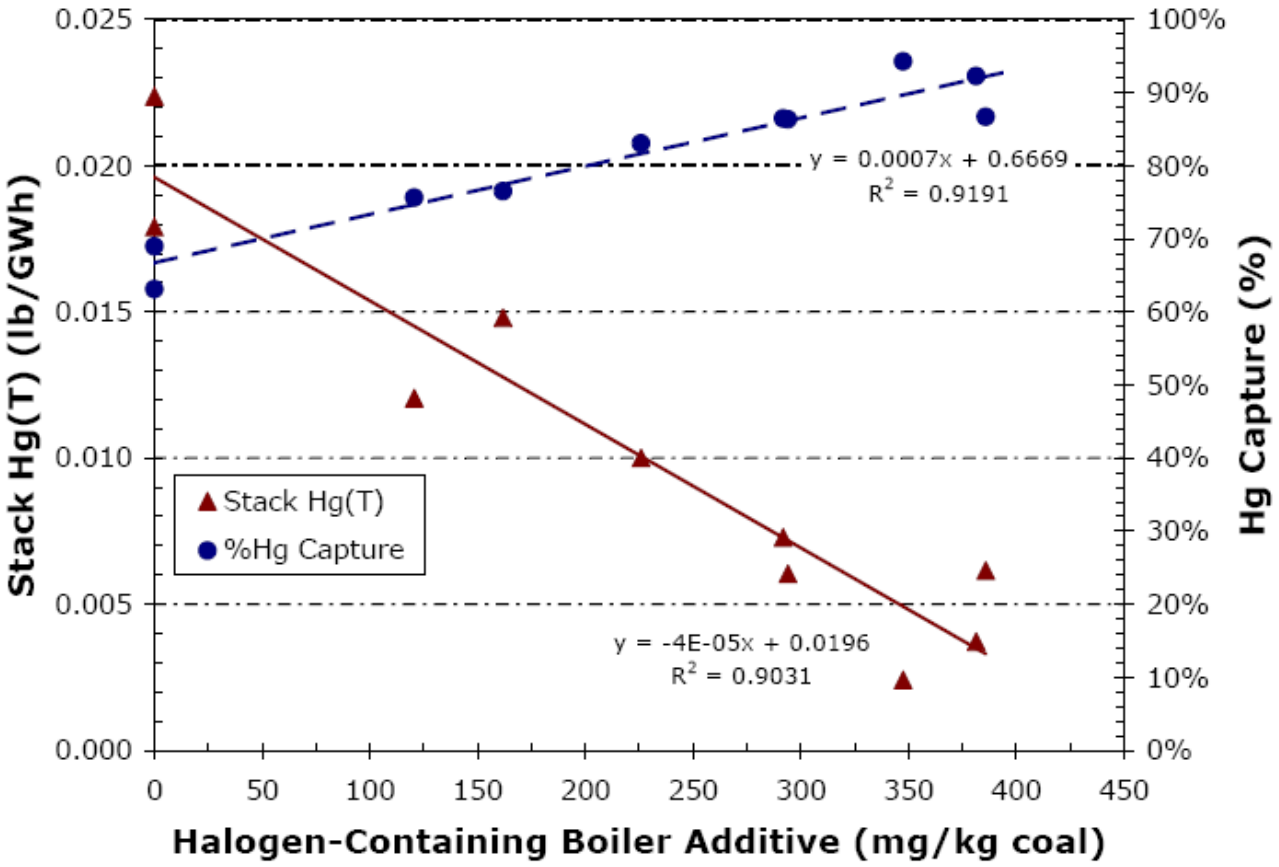
Goal: Achieve 90% Hg Capture[1] *and* meet mercury water discharge regulations.

Hg measurement: CMM Air Heater inlet and stack



[1]Air Heater Inlet to Stack

Mercury Emissions and Capture



Hg Capture %

$$\left(\frac{Hg^{T}_{\text{FGD inlet}}}{Hg^{T}_{\text{stack}}} \right) X\ 100$$

Based on OHM measurements

➢ ***Halogen-containing BA reduces Hg stack emissions.***

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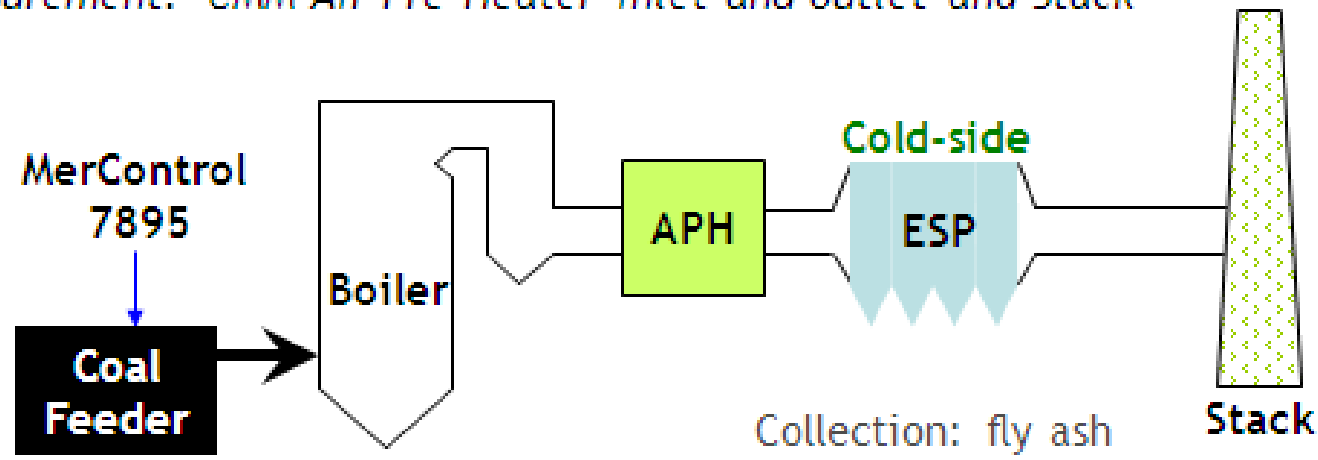
Concrete Compatible Mercury Control

Site Description:

- **Chlorine* = 100ppm (max = 400)**
- **Mercury* = 0.08ppm (max = 0.21)**
- **Full Load = 600 MWe**
- **Boiler Type = PC, Opposed-Wall Firing**
- **Fuel = PRB, sub-bituminous coal (4 sources)**
- **AQCDs = Low NO_x burners, OFA, cold-side ESP**

Goal: Mercury Achieve 90% Hg Capture while maintaining concrete sales of fly ash

Hg measurement: CMM Air Pre-Heater inlet and outlet and Stack



[1]Air Heater Inlet to Stack

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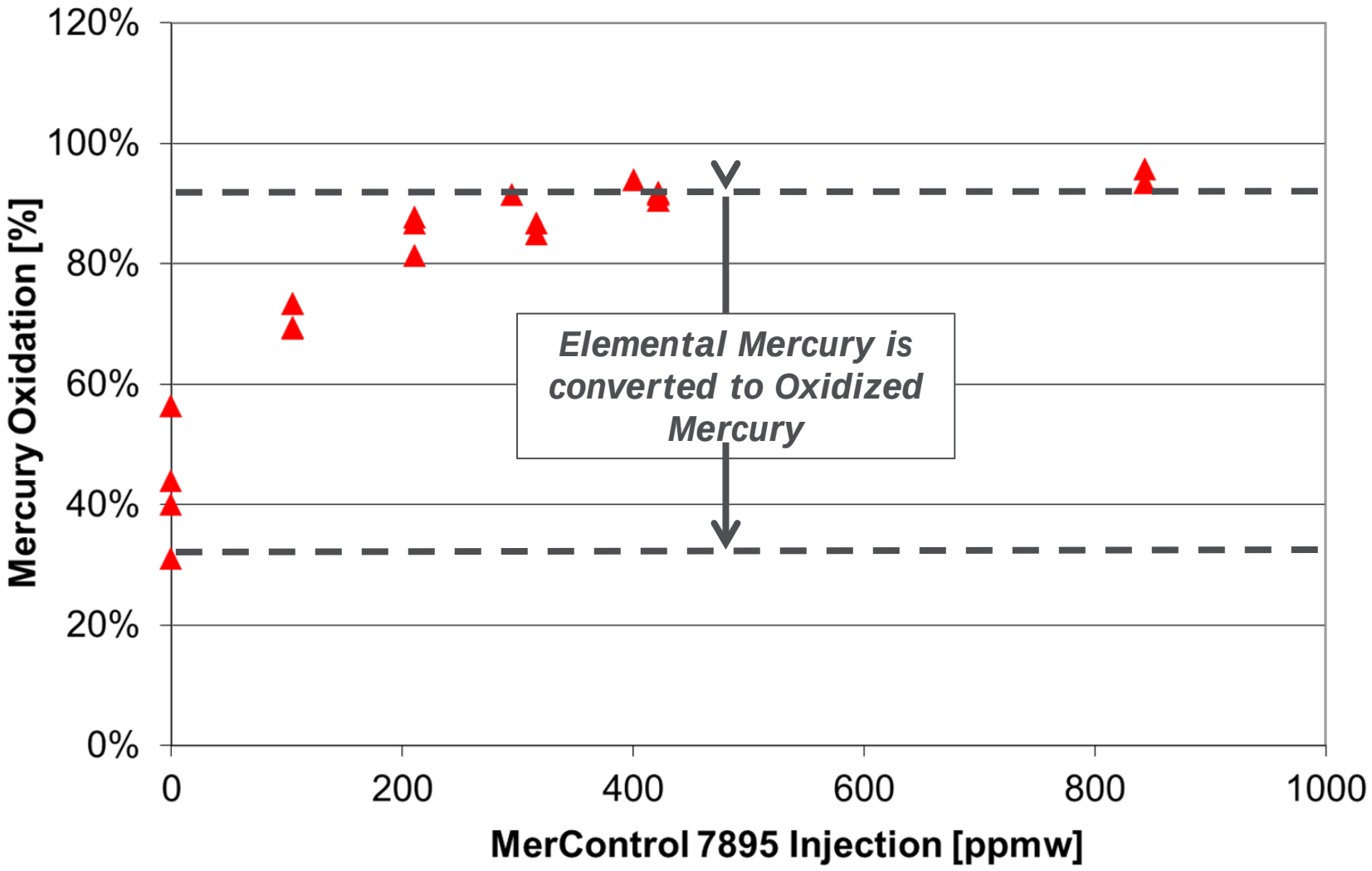
Mercury Oxidation with 7895



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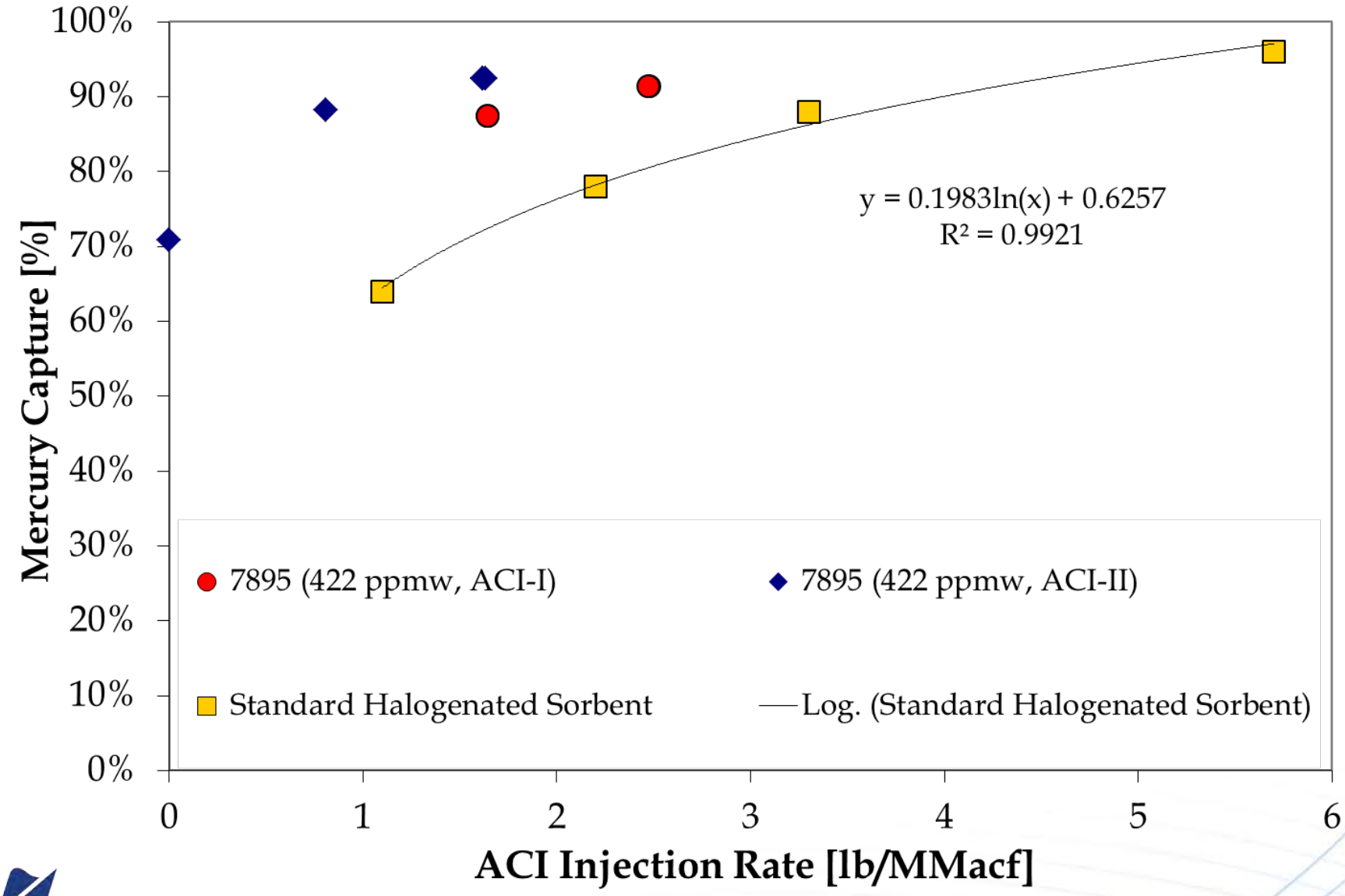
AC Injection (Post Air Heater)



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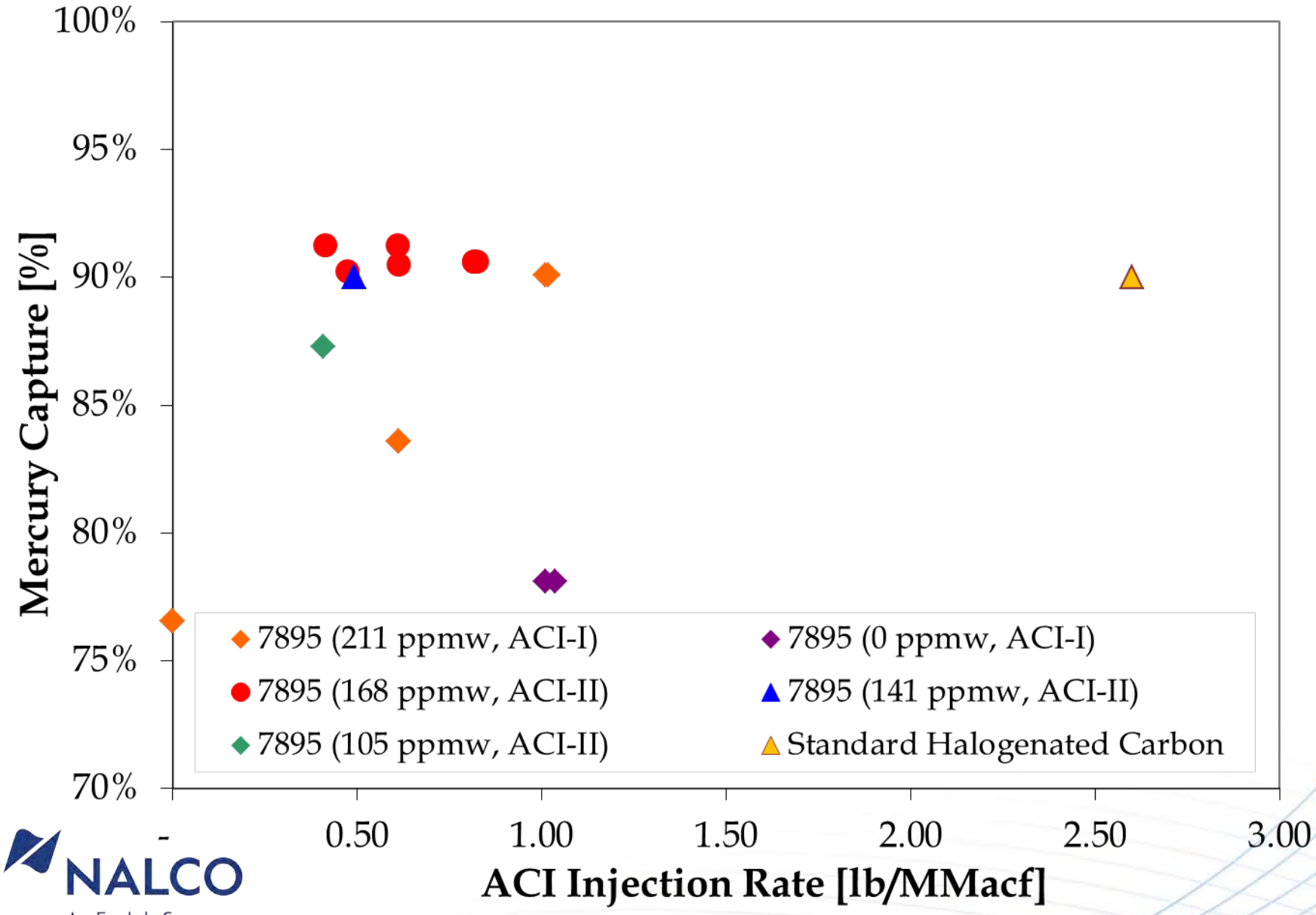
AC Injection (Pre Air Heater)



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Hg Capture via SDA and FF

Site Description:

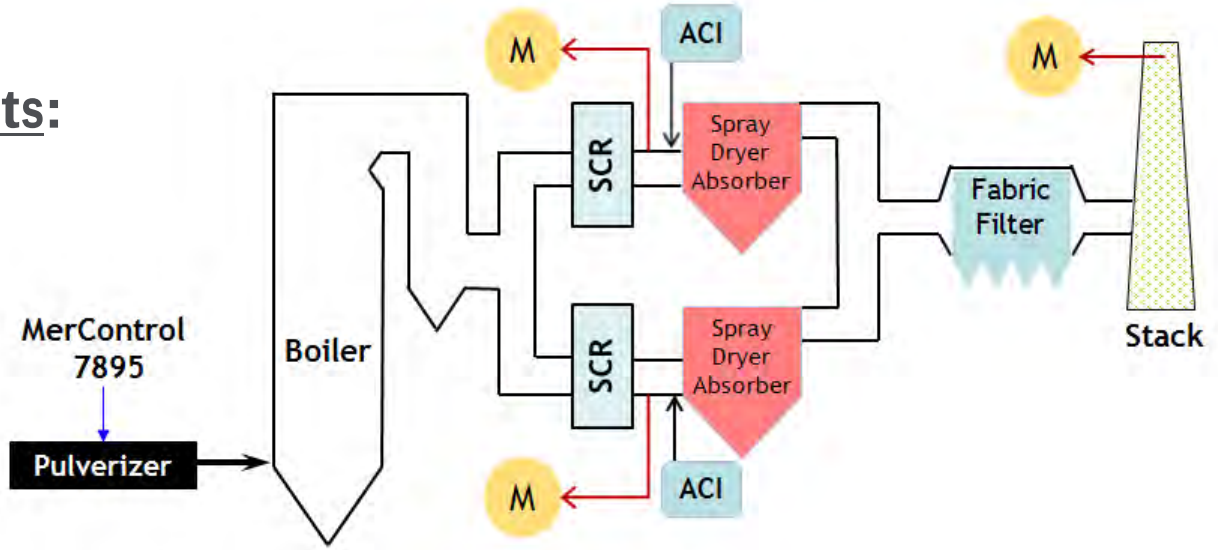
- Chlorine* = 24 ± 14 ppm
- Mercury* = 0.115 ± 0.020 ppm

- Full Load = 580-MWg
- Boiler Type = supercritical PC boiler
- Fuel = Low-sulfur PRB coal
- AQCDs = low-NO_x burners, SCR, SDA, FF

Goal: Mercury emissions less than 1.0 lb /TBtu at minimal cost.

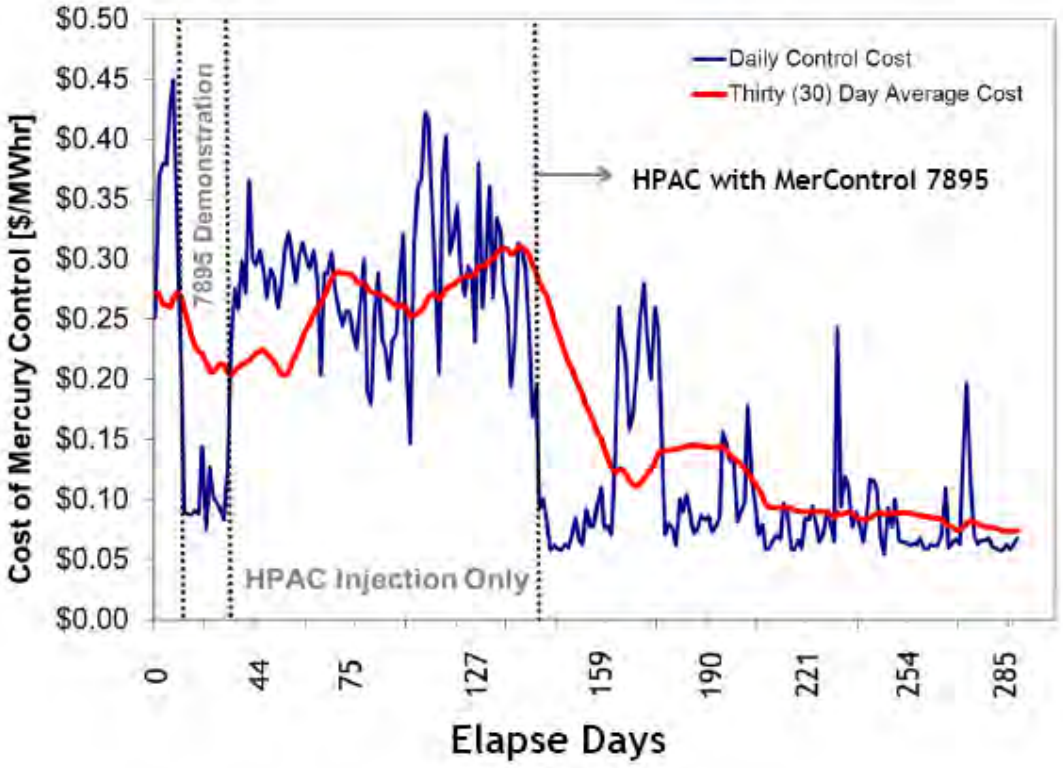
Hg Measurements:

CMM, OHM and carbon traps at locations indicated at right by M



[1]Air Heater Inlet to Stack

Optimized Cost of Hg Emission Control



Condition	HPAC (lb/MMacf)	BA (ppmw)	$/yr
HPAC only	1.65		$1.45MM
HPAC+BA	0.25	28	$0.36MM
Savings			**$1.09MM**

(based on annualized used & 83% Hg capture.)

HPAC alone Hg control was about $0.30/MWhr.

Optimized strategy for Hg control approached $0.07/MWhr.

- **Cost reduction of >75% with Hg emission compliance.**
- **Annual saving of $1.0-1.7MM realized.**

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Recommended Dose MerControl 7895

For MATS compliance

Fuel/AQCDs	MerControl 7895*	Bromine*	Flue Gas (HBr)**
Sub-bituminous	100	40	1.2
Sub-bituminous w SCR	50	20	0.6
Bituminous	485	200	6
Bituminous w SCR	100	40	1.2

*ppm based on coal weight
**ppm based on volume

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Thank You

Questions?