

Characterization of Fly Ash from Full-Scale Testing of Sorbent Injection for Mercury Control on Coal-Fired Power Plants

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ADA-ES Hg Control Program

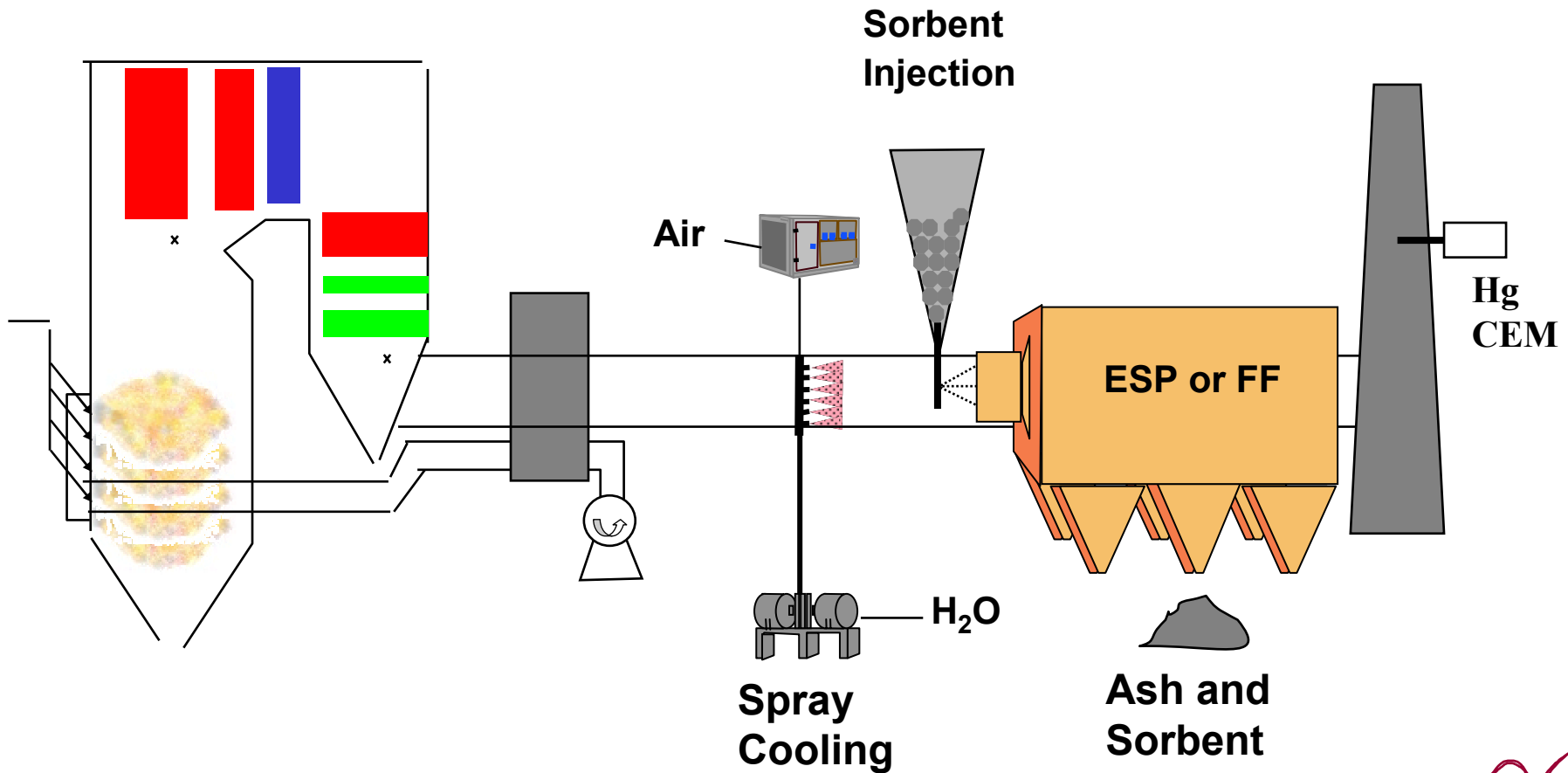
- Full-scale field testing of sorbent-based mercury control on non-scrubbed coal-fired boilers
- Primary funding from DOE National Energy Technology Laboratory (NETL)
- Co-funding provided by:
 - Southern Company
 - Wisconsin Electric
 - PG&E NEG
 - EPRI
 - Ontario Power Generation
 - First Energy
 - TVA
 - Kennecott Energy

Project Overview

- Perform first full-scale evaluations of mercury control on coal-fired boilers (up to 150 MW equivalent).
- Evaluate effectiveness of sorbent-based Hg control (activated carbon).
- Test several different power plant configurations.
- Document all costs associated with Hg control.



Coal-Fired Boiler with Sorbent Injection and Spray Cooling



DOE/NETL Test Sites

Test Site	Coal	Particulate Control	Test Dates
Alabama Power Gaston	Bituminous	HS ESP COHPAC FF	Spring 2001
Wisconsin Electric Pleasant Prairie	PRB	CS ESP	Fall 2001
PG&E NEG Brayton Point	Bituminous	CS ESP	Summer 2002
PG&E NEG Salem Harbor	Bituminous	CS ESP	Fall 2002

Solid Samples

- Coal feeder samples and ash hopper samples taken periodically
- Coal analysis (Microbeam Technologies)
 - Standard (ult/prox/ash)
 - Hg and Cl content
- Ash analysis (Microbeam Technologies)
 - LOI
 - Hg content
 - Special tests as required (Surface area, PSD, leaching)



Leaching Studies

- Performed by D. Hassett (EERC)
- TCLP
- SGLP
- Special Studies:
 - Long term SGLP (60, 90 days) for PRB ash
 - Sulfuric acid (pH=2) for bituminous ash

Fuel Characteristics

	Gaston	Pleasant Prairie
Rank	Bituminous	PRB
Sulfur, wt%	1.24	0.32
Ash, wt%	14.78	5.10
Moisture, wt%	6.85	30.69
HHV, Btu/lb	11,902	8,385
Hg, ug/g	0.136	0.109
Cl, ug/g	169.0	8.1

Gaston Site Description

- Alabama Power Company E.C. Gaston Electric Generating Plant Unit 3, Wilsonville, AL
- 270 MW Firing a Variety of Low-Sulfur, Washed Eastern Bituminous Coals
 - Tests conducted on $\frac{1}{2}$ of Unit 3 gas stream (135 MW)
- Particulate Collection System
 - Hot-side ESP, SCA = 274 ft²/1000 acfm
 - COHPAC baghouse supplied by Hamon Research-Cottrell
- Wet Ash Disposal to Pond

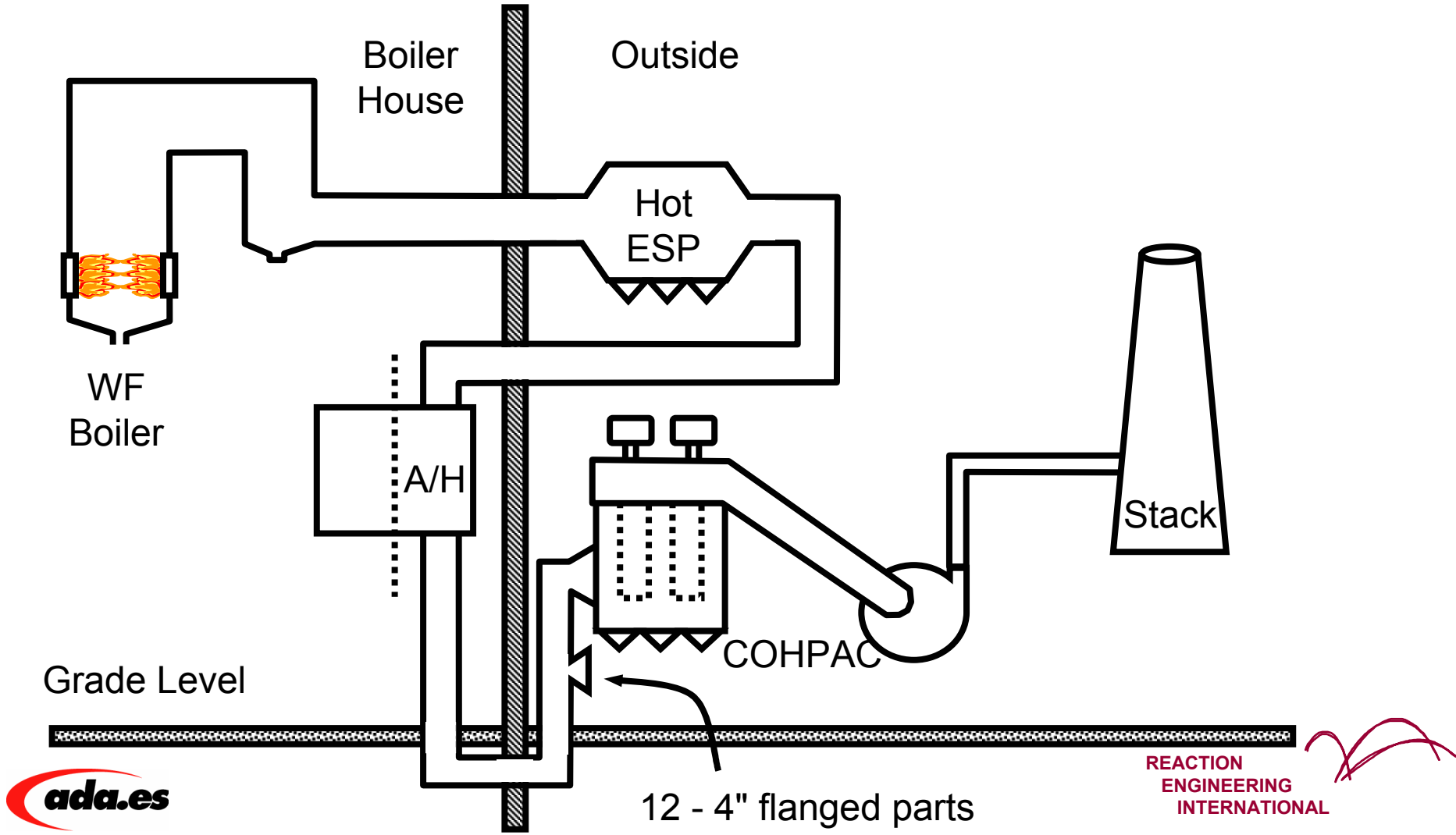


COHPAC Baghouse

- EPRI Patented Technology
 - High A/C Pulse-Jet Baghouse Installed Downstream of Existing ESP
 - Low Inlet Mass Loading
- Hamon Research-Cottrell Pulse-Jet Baghouse
- Testing conducted on B-Side
 - 4,352 bags per side
- Ryton/Ryton™ Felt Fabric



E.C. Gaston

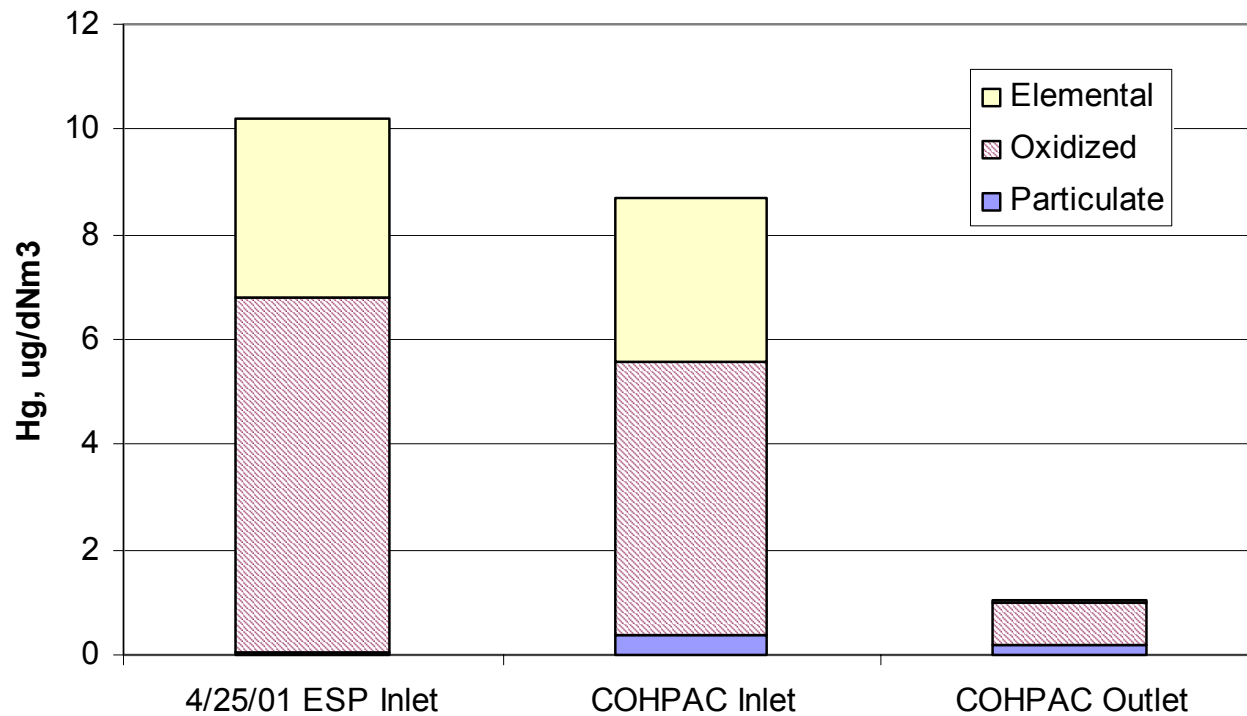


PAC Injection Conditions: Gaston

- Baseline ash ~15% LOI
- Commercial sorbent (Norit Americas FGD Carbon):
 - **600 m²/g, 18 microns MMD**
- Injected in B-side of COHPAC
 - **1.5 lb/MMacf**



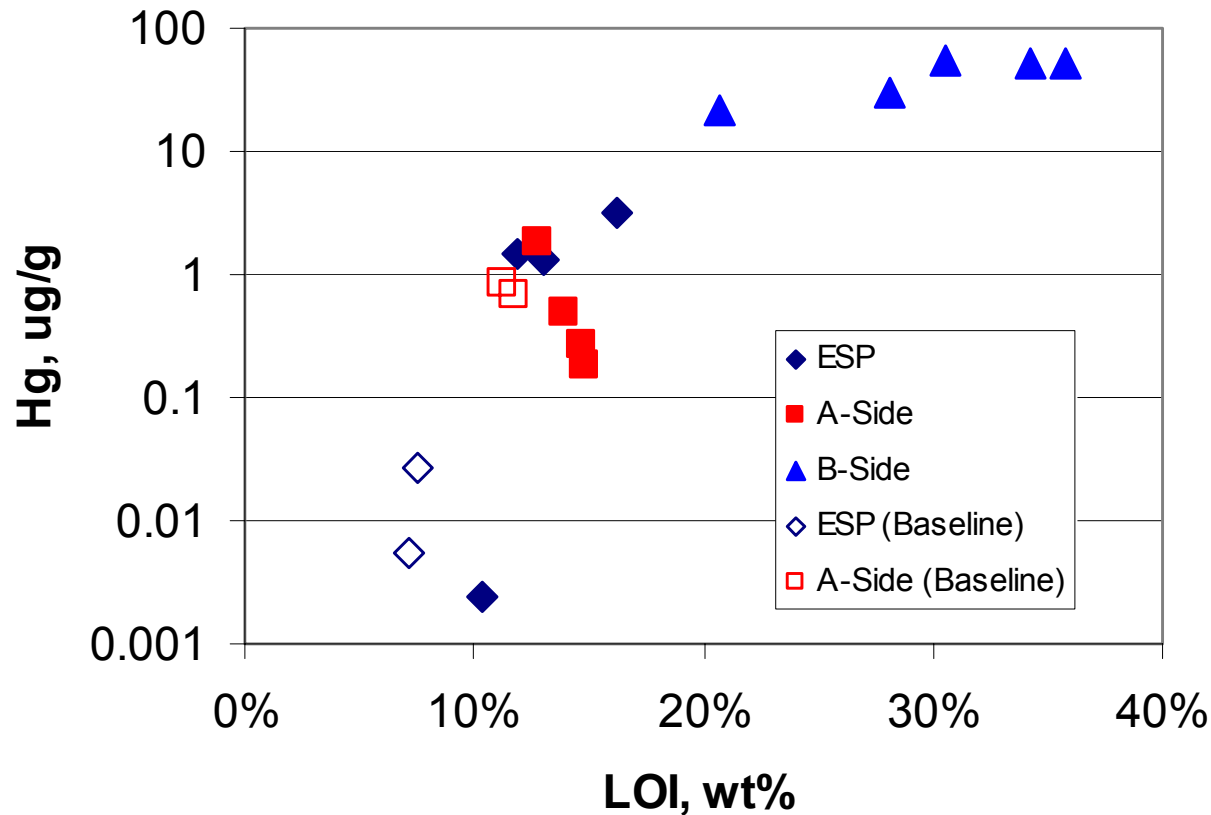
Mercury Speciation: Gaston



Ontario Hydro results during long term testing



Gaston Ash Characteristics



A-side:

- no sorbent
- 10-15% LOI
- Hg similar to HESP

B-side:

- PAC @ 1.5 lb/MMacf
- 20-35% LOI
- 10-50 ug/g Hg



Conclusions from Gaston Tests

- Effective mercury control, up to 90% efficiency, was obtained with Darco FGD
- Significant increase in cleaning frequency with carbon injection (COHPAC configuration)
- On average during long-term test, 80-85% mercury removal was obtained
- Actual and theoretical removals were in reasonable agreement
- Tests provide data for design of future COHPAC (TOXECON) baghouses

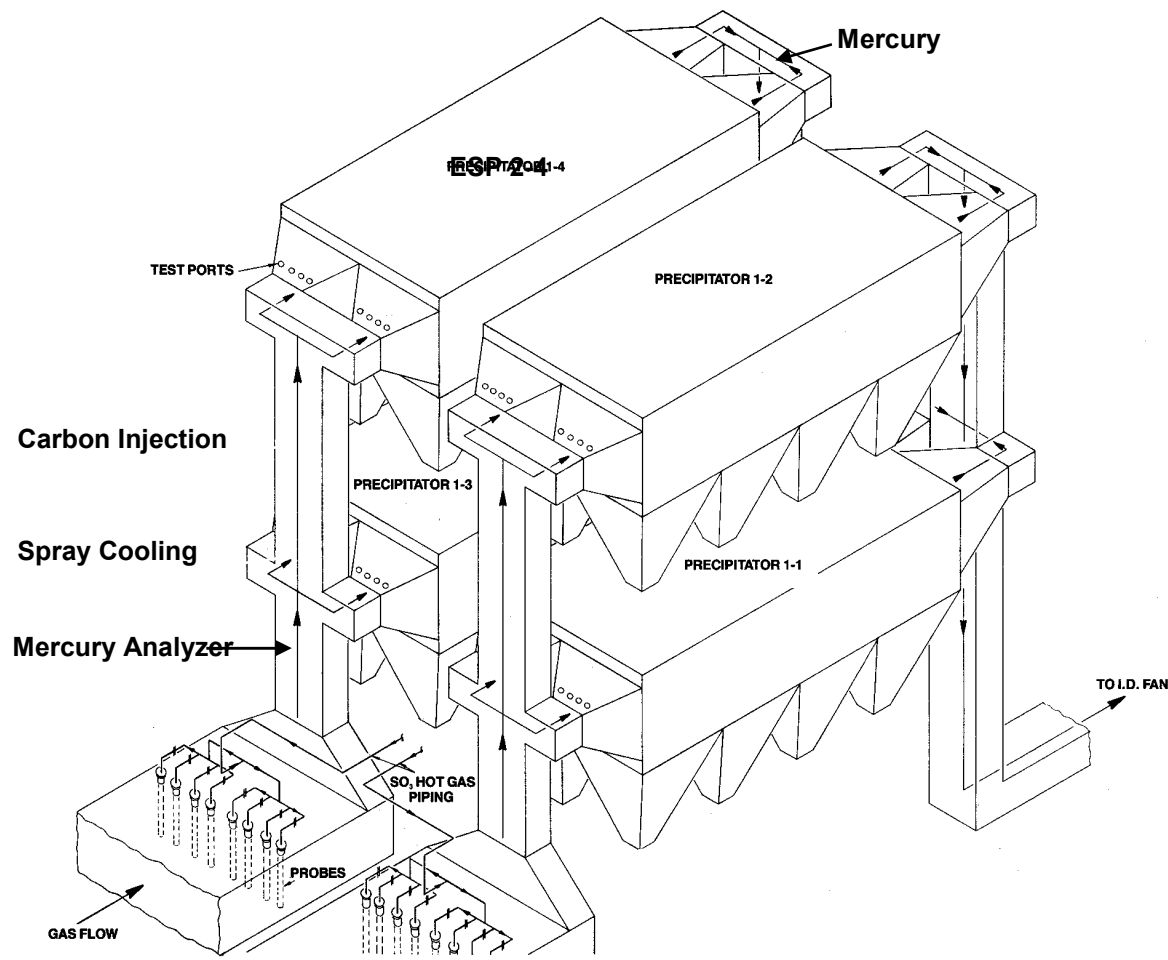


PPPP Site Description

- Wisconsin Electric's Pleasant Prairie Power Plant
Unit 2, Kenosha, WI
- 600 MW Firing a Variety of Powder River Basin, Low Sulfur, Sub-bituminous Coals
 - Test conducted on $\frac{1}{4}$ of Unit 2 gas stream (150 MW)
- Particulate Collection System
 - Cold-side ESP, SCA = 468 ft²/1000 acfm
 - SO₃ flue gas conditioning
- Ash is Sold for Use in Concrete Applications



ESP Configuration, PPPP

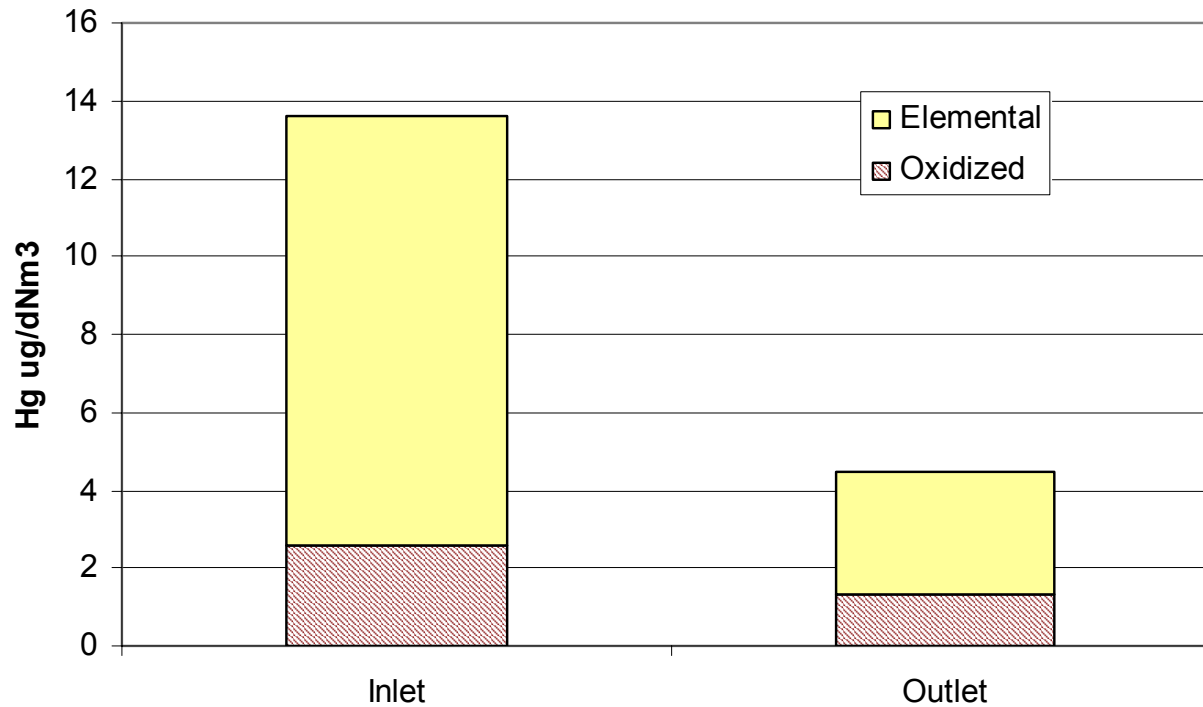


PAC Injection Conditions: PPPP

- Baseline ash ~0.5% LOI
- Commercial sorbent (Norit Americas FGD Carbon):
 - **600 m²/g, 18 microns MMD**
- Injected upstream of ESP
 - **1-10 lb/MMacf**

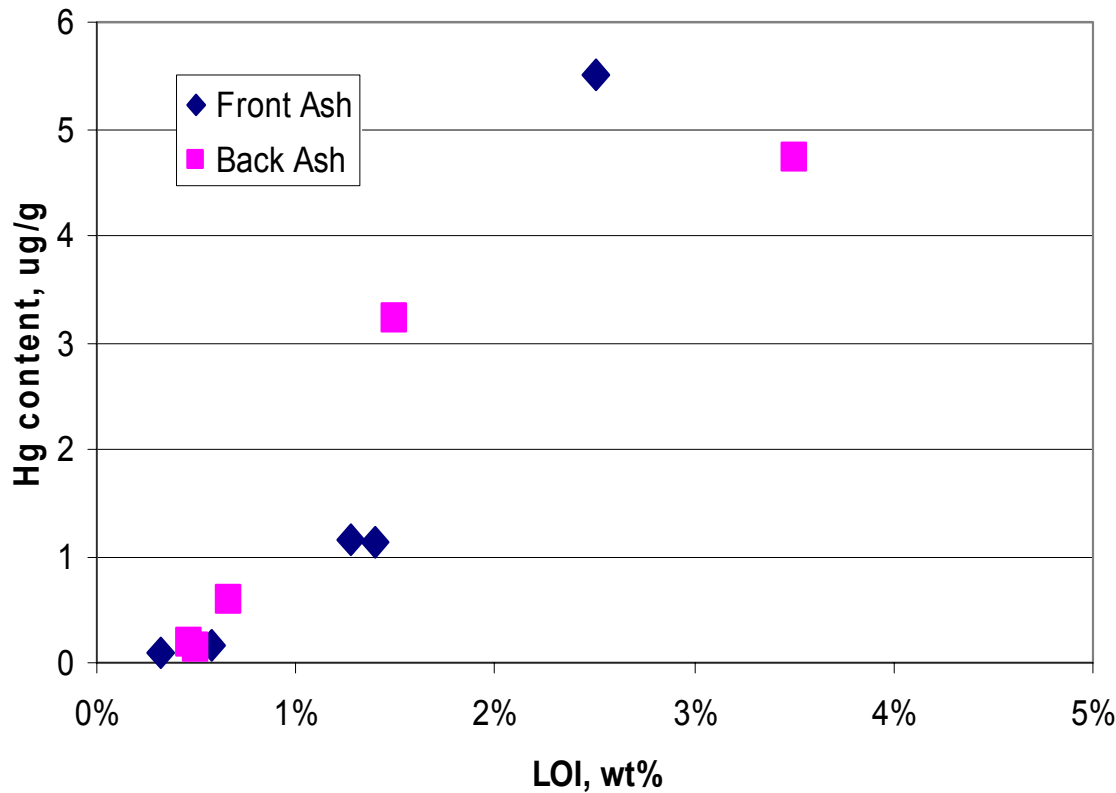


Mercury Speciation: Pleasant Prairie



S-CEM (gas-phase only) results during long term testing at 10 lb/MMacf

Pleasant Prairie Ash Characteristics



Baseline ash ~0.5% LOI
Sorbent injection:
1-10 lb/MMacf
LOI increased to ~5% @
10 lb/MMacf
Linear reln between Hg
and LOI

Conclusions from Testing at PPPP

- Higher removal at lower injections rates than expected from models
- No increased removal at high injection rates
- PAC injection reduced both elemental and oxidized mercury concentrations
- No detrimental impact on ESP performance
- On a PRB ash, if the gas temperature is below 300 °F, it appears that additional cooling does not improve capture of mercury



PAC Injection Summary

GASTON

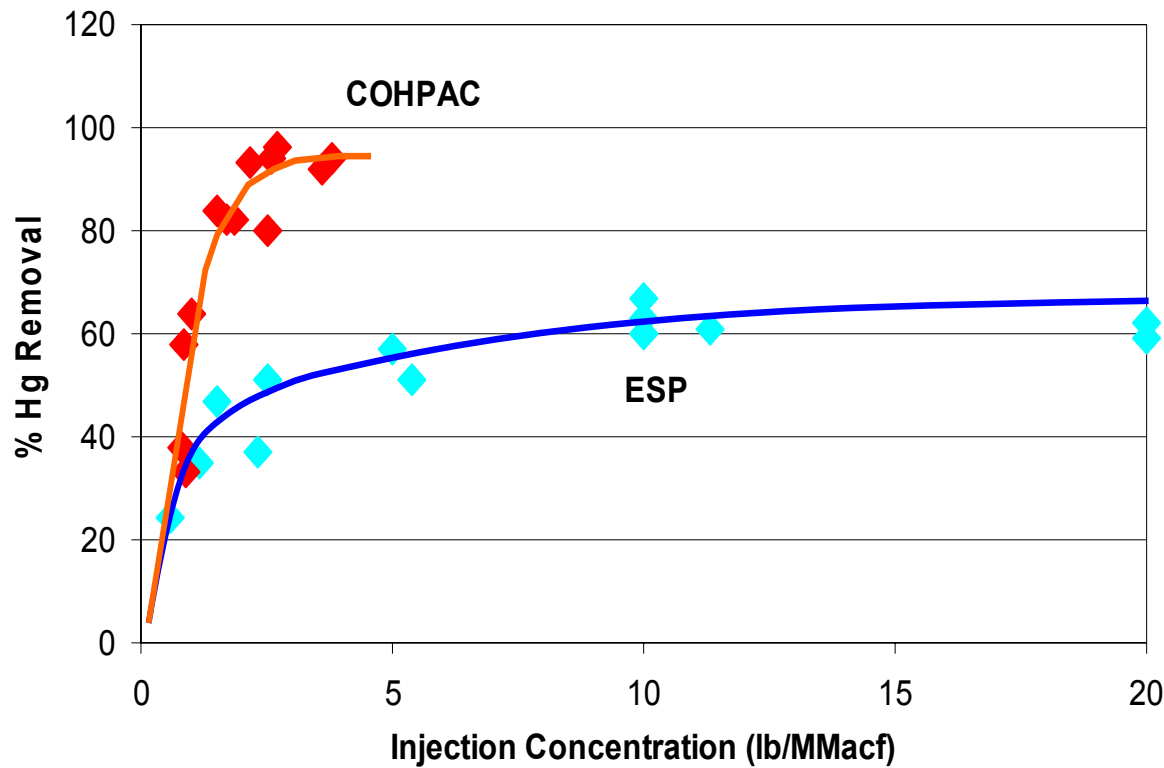
- Darco FGD @ 1.5 lb/MMacf
- Hg removal 78% (10-day average)
- Ash during testing:
 - 20-35% LOI
 - 10-50 ug/g Hg

PLEASANT PRAIRIE

- Darco FGD @
- 1-10 lb/Mmacf
- Hg removal 40-70%
- Ash during testing:
 - LOI increased to ~5% @ 10 lb/MMacf
 - 1-5 ug/g Hg



Mercury Removal Trends from NETL Tests



Pleasant Prairie: ESP

Gaston: COHPAC

Leaching Result (EERC)

Plant	Injection Rate, lb/MMacf	Sample location	Hg content, ug/g	Micrograms Hg per liter (ppbw)		
				TCLP	SGLP	SAL
Gaston	10	B-side	30.6	0.01	<0.01	<0.01
Gaston	10	B-side	21.7	<0.01	<0.01	<0.01
P4	1.5	Front Ash	5.5	<0.01	<0.01	
P4	1.5	Back Ash	4.73	<0.01	<0.01	

Pleasant Prairie Leaching Results (ASTM Water)

Date	Sample Type	Inj.Rate lb/MMacf	Hg, ppbw in soln
baseline	Front Ash	0	<0.028
11/2/2001	Front Ash	1	<0.028
11/2/2001	Front Ash	1	0.033
11/8/2001	Front Ash	3	<0.028
11/14/2001	Front Ash	10	<0.028

Source: Wisconsin Electric Co.



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Pleasant Prairie ASTM C 618 tests

Date	Sample Type	Inj.Rate lb/MMacf	LOI, wt%	7-day strength activity index	water required %of control	Autoclave, % exp.
baseline	Front Ash	0	0.58%	91.3	94.2	-0.06
11/2/2001	Front Ash	1	1.04%	84.3	95	0.01
11/8/2001	Front Ash	3	1.58%	86.8	94.6	0.01
11/14/2001	Front Ash	10	3.57%	84.1	96.2	-0.02
Class C limit			<6%	>75	<105	<0.8

Source: Wisconsin Electric Co.



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Summary

- Preliminary leaching studies completed for Gaston (COHPAC baghouse/bituminous) and Pleasant Prairie (ESP/PRB)
- Little or no detectable Hg leached by ASTM water leach, TCLP, SGLP, sulfuric acid (bituminous ash)
- Long-term SGLP in progress for PRB ash
- PRB ash + sorbent conforms to ASTM C618, but issues with foam index test (air entrainment)

