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Field Test Program to Develop Comprehensive Design, Operating and Cost Data for Mercury Control

DOE/NETL's Mercury Control Technology R&D Program Review

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Project Team

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- Southern Research Institute
- URS Corporation
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ADA-ES Hg Control Program

- Full-scale field testing of sorbent-based mercury control on coal-fired boilers.
- Primary funding from DOE National Energy Technology Laboratory (NETL).
- Cofunding provided by:
  - Southern Company;
  - We Energies;
  - PG&E NEG;
  - EPRI;
  - Ontario Power Generation;
  - TVA;
  - First Energy;
  - Hamon Research Cottrell
  - Kennecott Energy; and
  - Arch Coal.

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DOE/NETL Test Sites

Test Site	Coal	APC	Variables
Alabama Power Gaston	Bit	HS ESP COHPAC FF	
We Energies Pleasant Prairie	PRB	CS-ESP	T, Sorbent, Rate
PG&E NEG Brayton Point	Bit	CS-ESP	Sorbent, Rate, Lance, In-flight
PG&E NEG Salem Harbor	Bit	CS-ESP SNCR	T, Rate, SNCR

Outline

Support preliminary conclusions from four full-scale field tests with supplemental data from other field tests on the following issues:

- Mercury species
- Residence time
- ESP Performance
- Temperature
- Injector Design
- Effect of Chlorine
- Sorbent Characteristics
- Effect of SNCR
- Ash Issues

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Issue

Conclusion*:

Questions?

- *"***What we believe to be most likely to be true based upon what we know today about mercury. This is the opinion of ADA-ES and not that of DOE, NETL, EPRI or any of the co-funding power companies.***"

Mercury Speciation

Conclusion*:

- Powdered activated carbon is effective on both bituminous and subbituminous coals and captures both elemental and oxidized mercury.

Questions?

- Documented performance on a wider variety of sites.

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Removal of Mercury Species with PAC on Bituminous and Subbituminous Coal

Bituminous with FF

	PARTICULATE	OXIDIZED	ELEMENTAL	TOTAL
PAC Injection	µg/m^3	µg/m^3	µg/m^3	µg/m^3
COHPAC Inlet	0.23	6.37	4.59	11.19
COHPAC Outlet	0.12	0.91	0.03	1.05
Removal Efficiency	45.6%	85.7%	99.3%	90.6%

Subbituminous with ESP

	PARTICULATE	OXIDIZED	ELEMENTAL	TOTAL
PAC Injection	µg/m^3	µg/m^3	µg/m^3	µg/m^3
ESP Inlet	0.98	1.73	14.73	17.44
ESP Outlet	0.00	0.44	4.27	4.71
Removal Efficiency	100.0%	74.5%	71.0%	73.0%

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Residence Time

Conclusion*:

1. The in-flight sorption of oxidized mercury is faster than predicted by current models.
2. There should be sufficient residence time in most power plants for ACI to be effective.

Questions?

- Is the rate for in-flight sorption of elemental mercury comparable to that of oxidized mercury?

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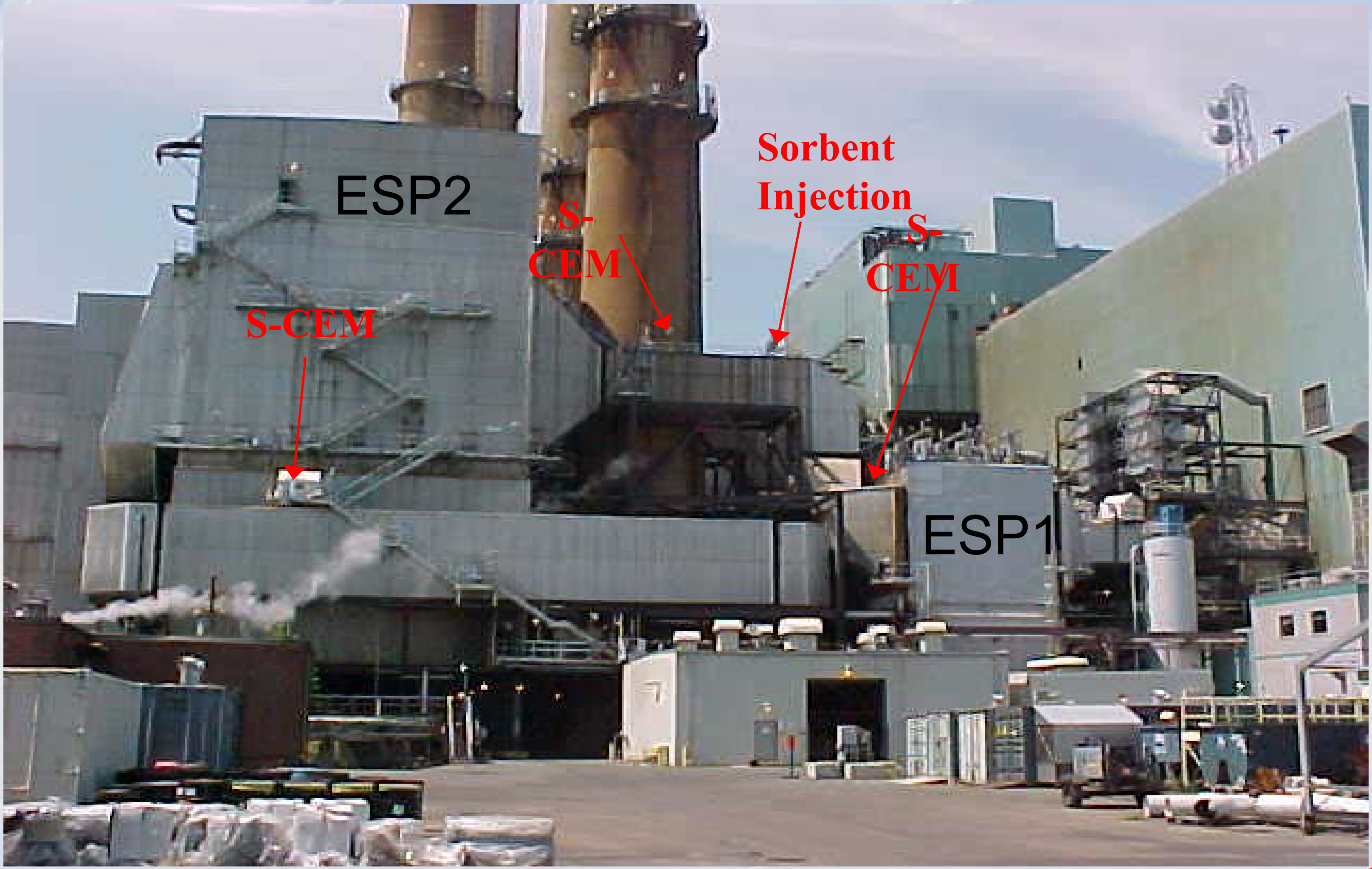
Brayton Point Configuration



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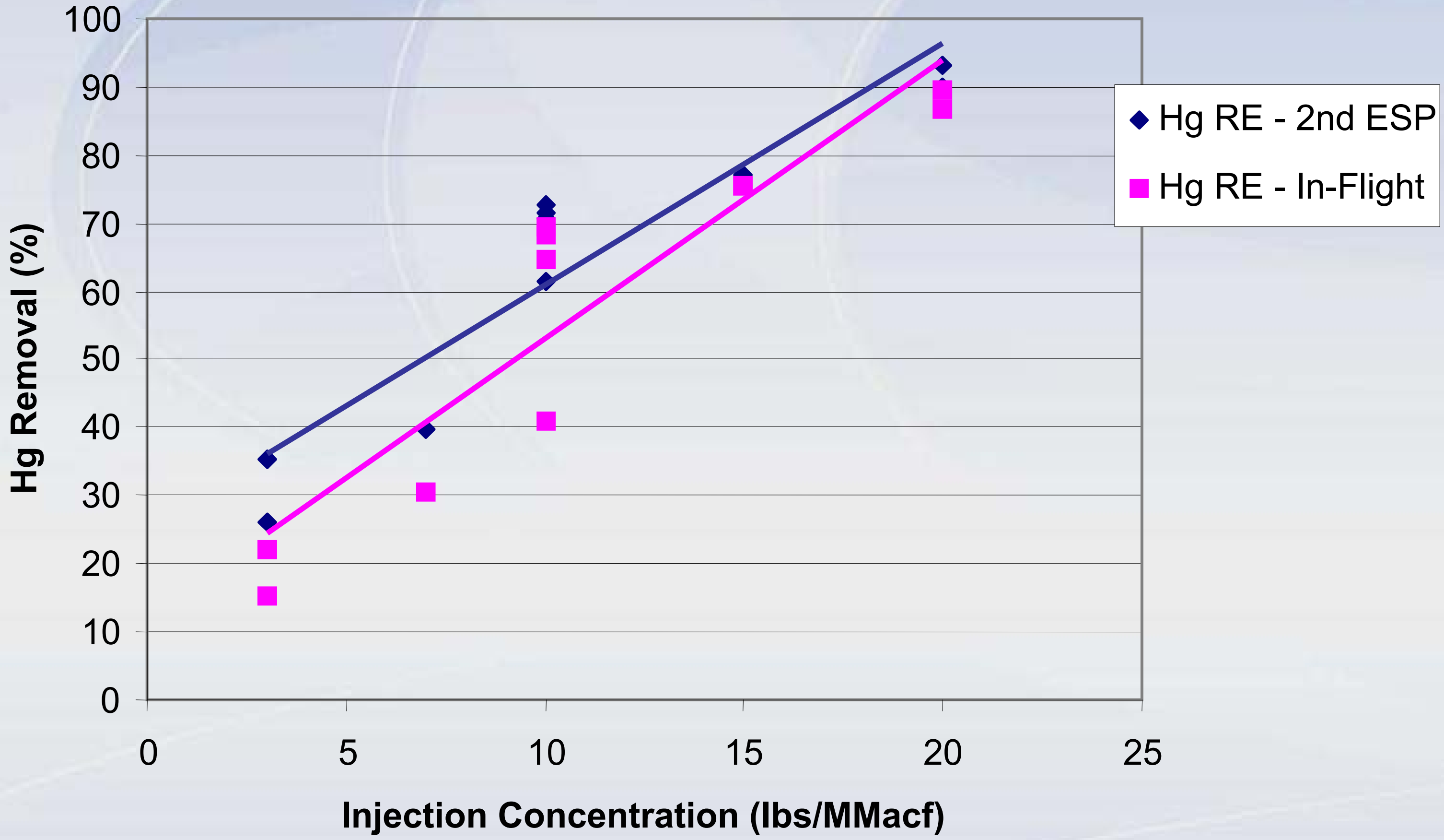
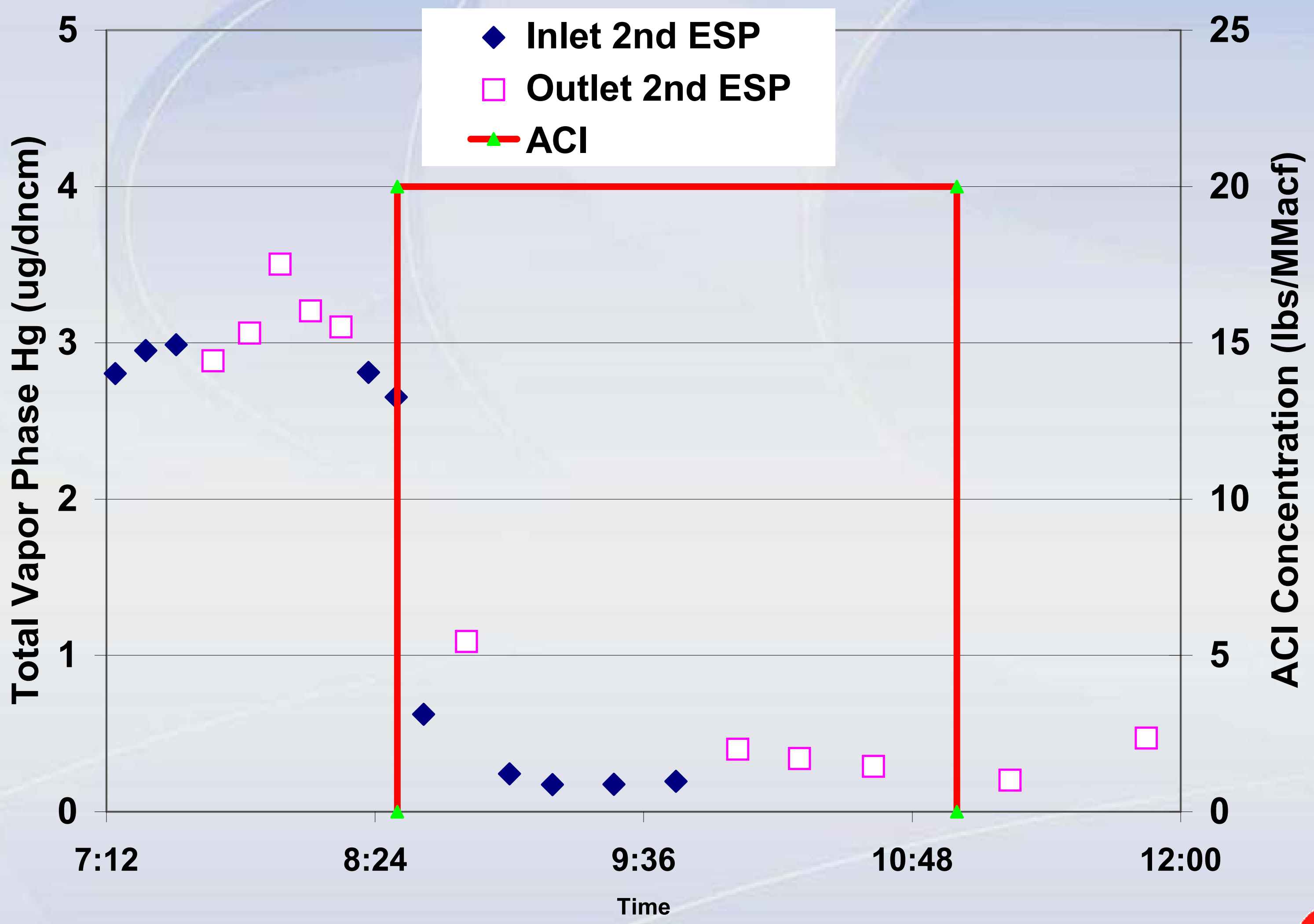
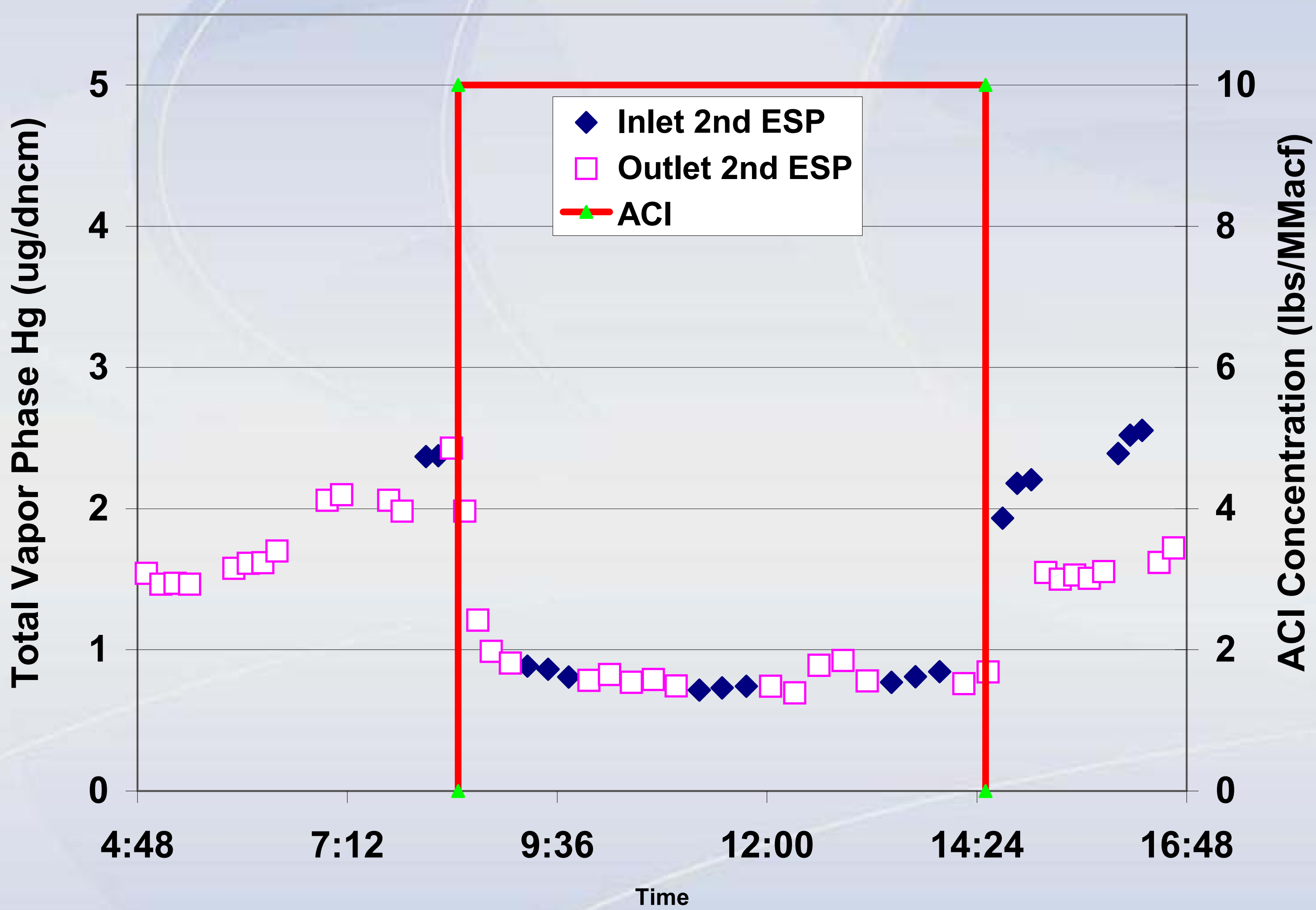
In-Flight Sorption of Vapor Phase Mercury



In-Flight Mercury Sorption



In-Flight Mercury Sorption



Residence Time Estimates

Plant	In-Duct (Sec.)	ESP Cone (Sec.)	ESP Box (Sec.)
Brayton Point	0.54	1.5	12
Salem Harbor	0.9	1.6	18
Pleasant Prairie	0.75	3.1	14.7

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ESP Performance

Conclusion*:

1. ACI does not impact the fundamental performance of an ESP
2. A large ESP (SCA > 400 ft^2/kacfm) should be able to effectively capture injected sorbents

Questions?

- Will a smaller ESP (SCA < 250 ft^2/kacfm) be able to adequately capture injected sorbents

ESP Performance – Brayton Point

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SCA at Test Sites

Plant Site	SCA (ft^2/1000 ACFM)
Pleasant Prairie	468
Brayton Point	403
Salem Harbor	474

Temperature

Conclusion*:

- At temperatures below 350 °F, spray cooling will provide no benefit to ACI.
- At temperatures above 350 °F, on a flue gas stream with predominately oxidized mercury, some form of cooling will be required for ACI to be effective.

Questions?

- Maximum temperatures for ACI on a flue gas with predominately elemental mercury .

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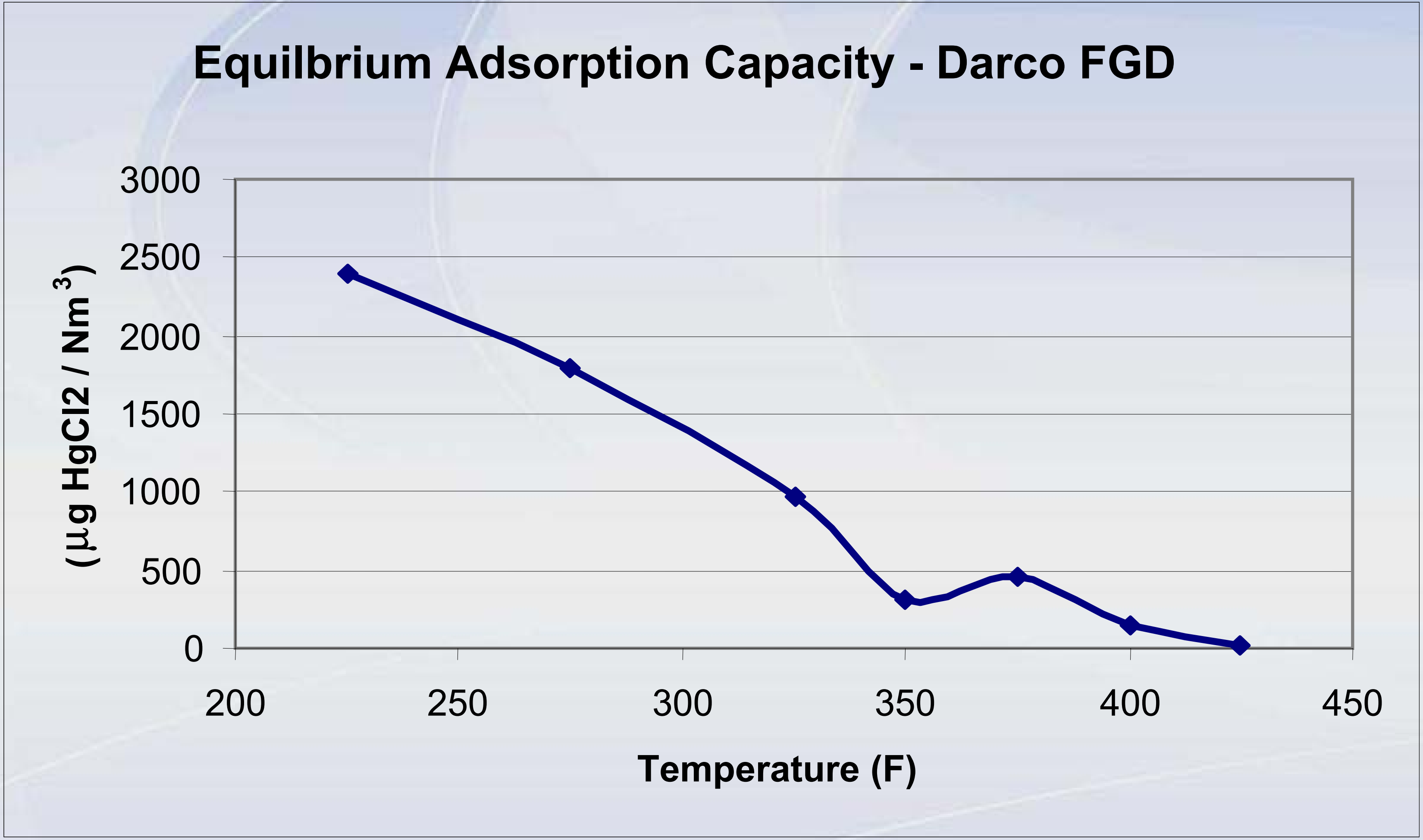
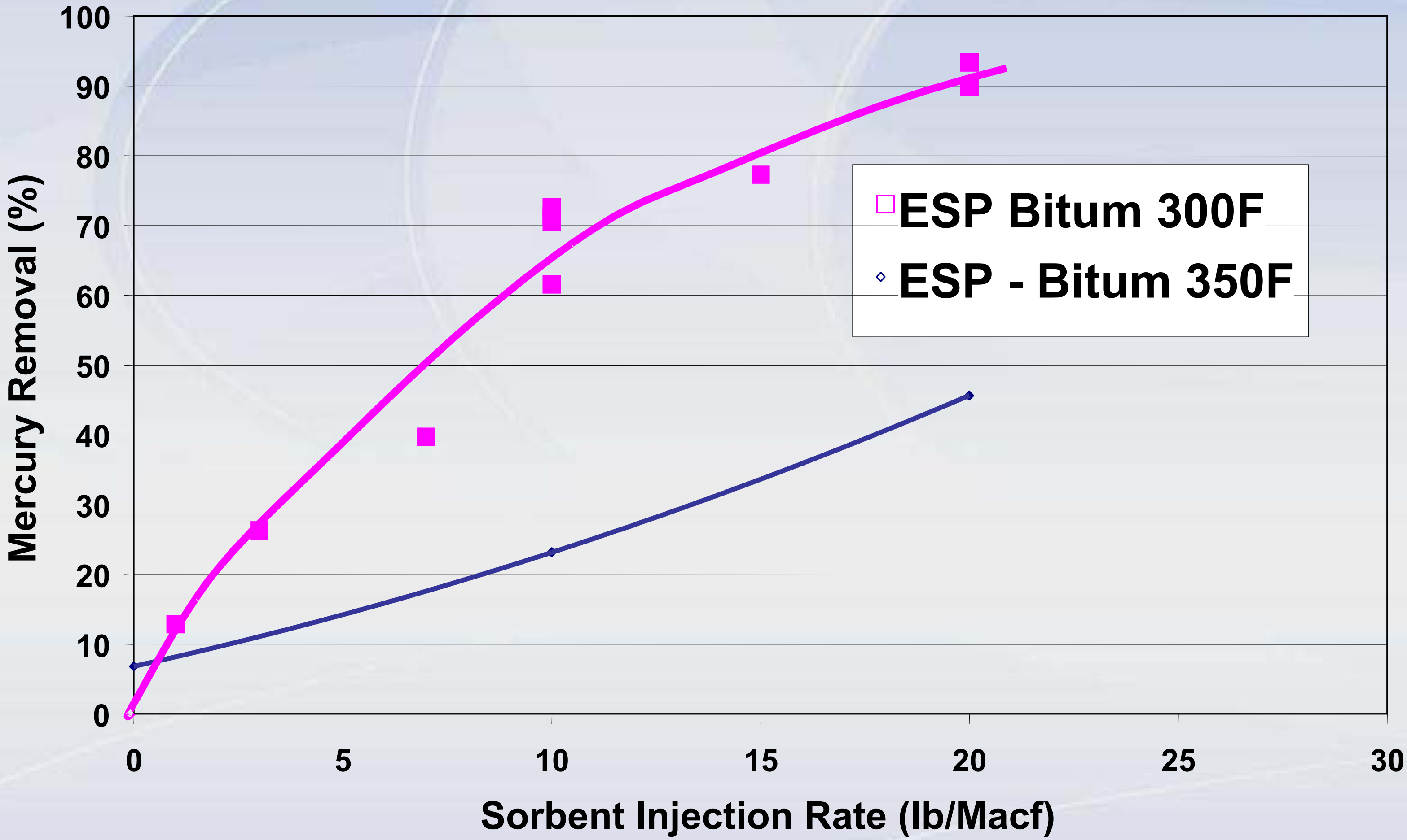
Adsorption Capacity vs. Temperature



Hg Capture vs. Temperature (w/ ACI)



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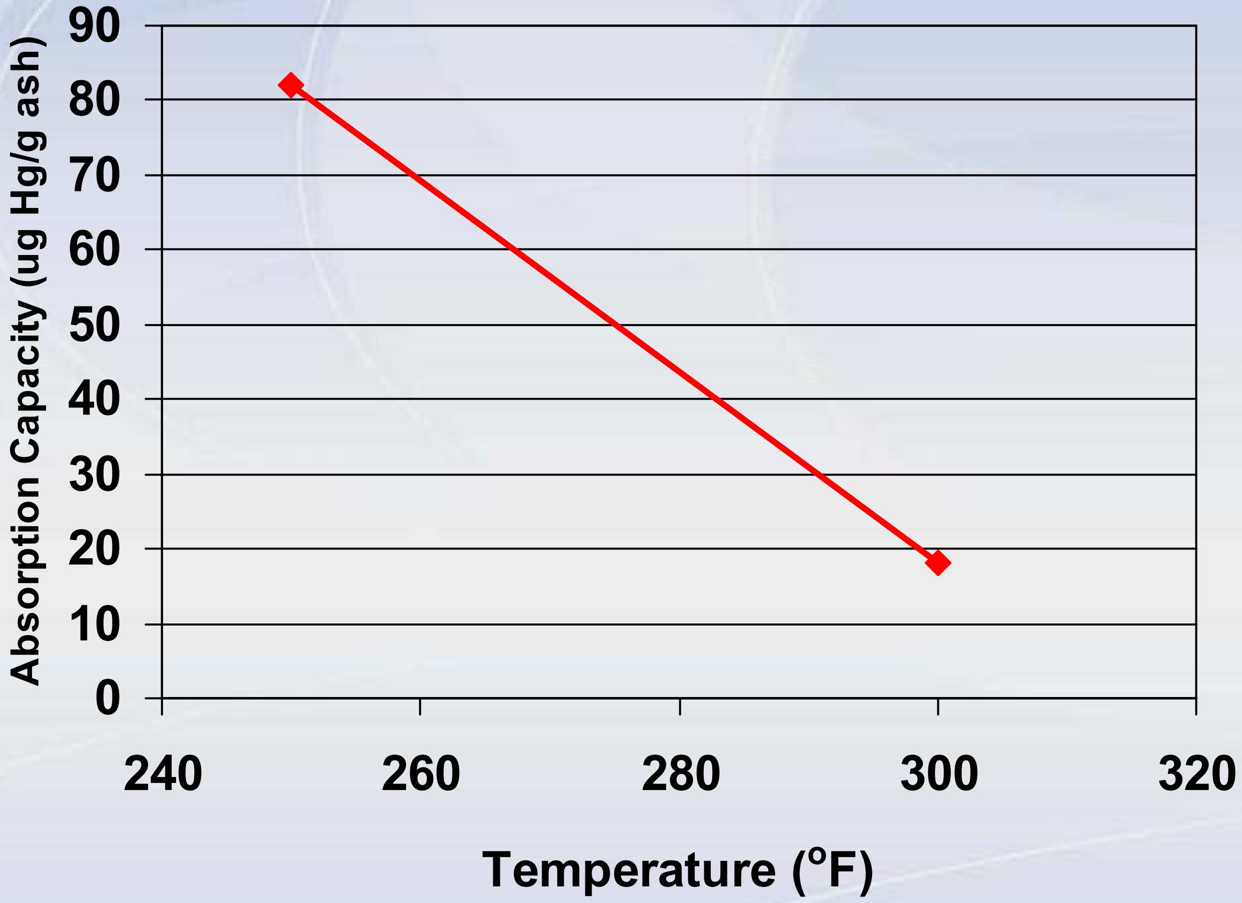
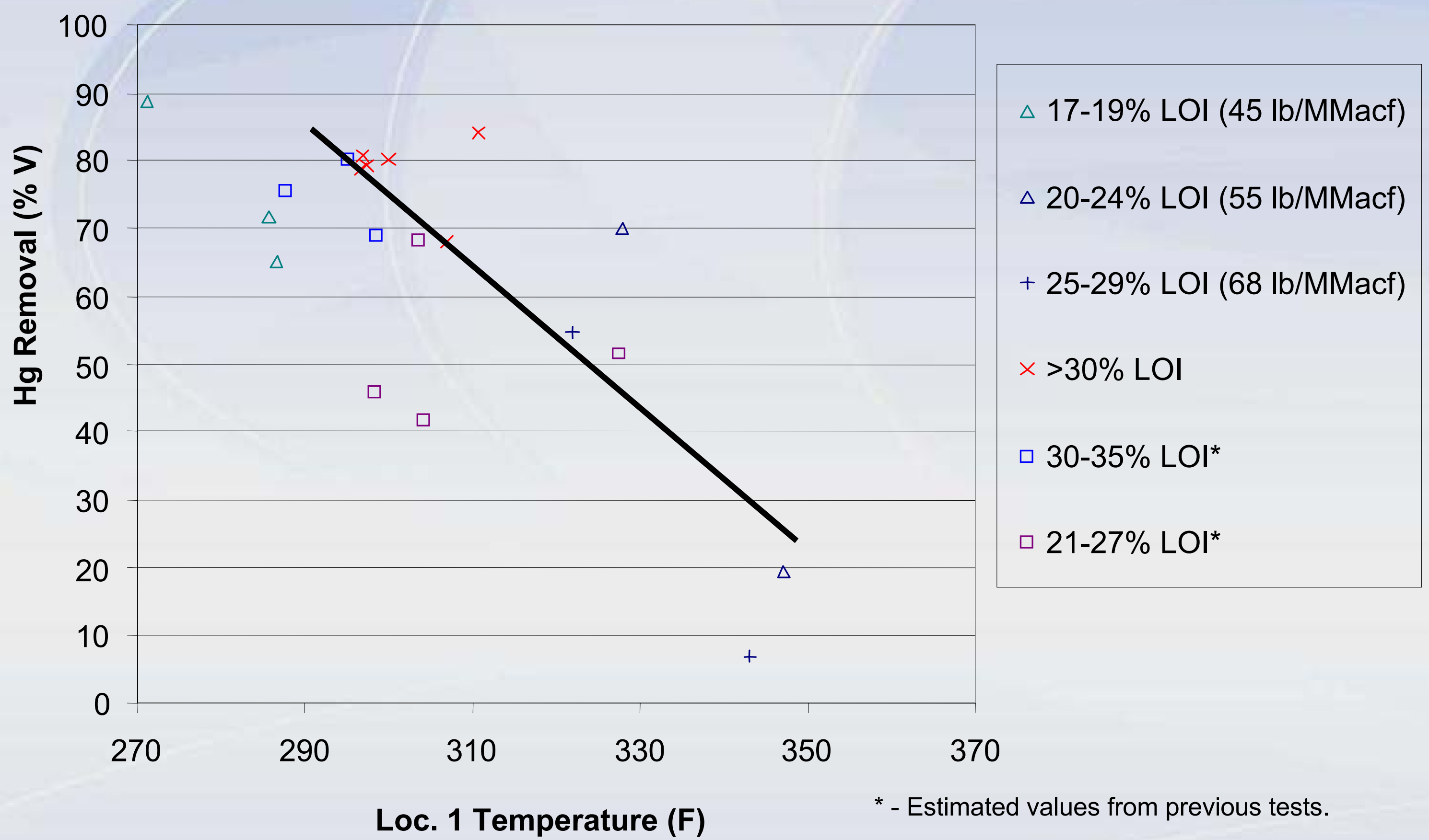
Adsorption Capacity of LOI Carbon



Hg Capture vs. Temperature (No ACI)



* - Estimated values from previous tests.

Injection Equipment

Conclusion*:

- Sorbent injection equipment capable of treating power plant sized gas streams was demonstrated in this program.
- Distribution of sorbent in the system is adequate as evidenced by > 90% removal.

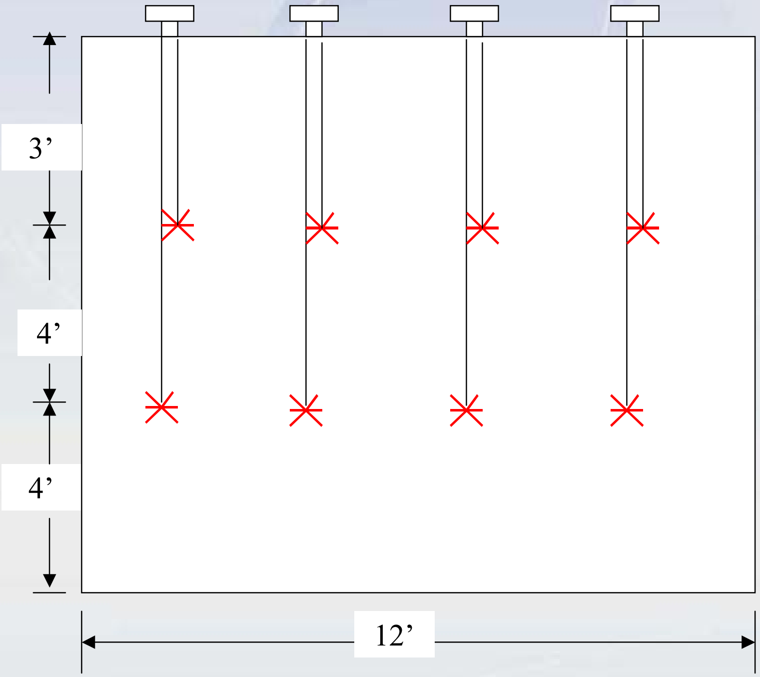
Questions?

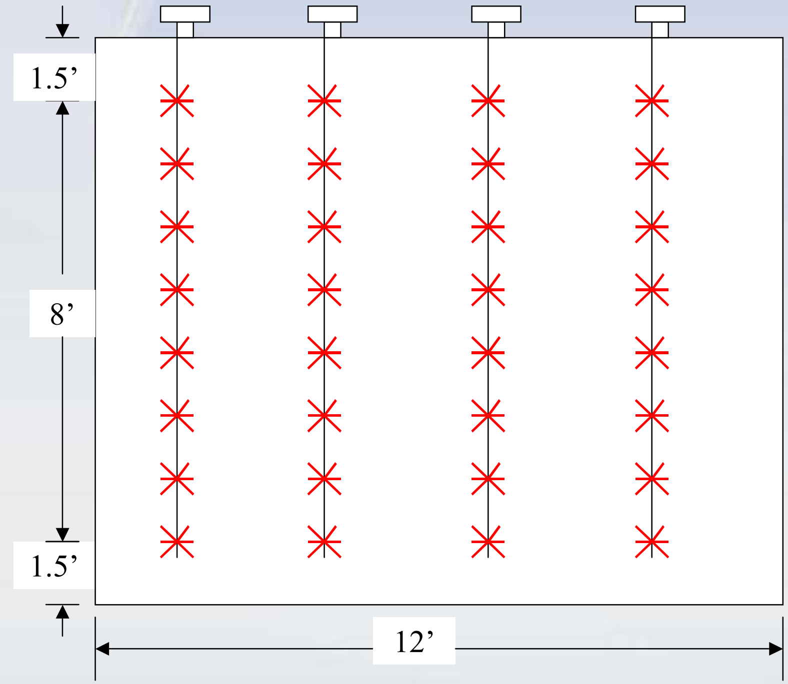
- Long-term reliability

Activated Carbon Storage and Feed System

Powdered Activated Carbon Injection System

Lance Designs





No difference in performance with the two lance configurations

Effect of Chlorine

Conclusion*:

- Chlorine plays a significant role in the performance of PAC

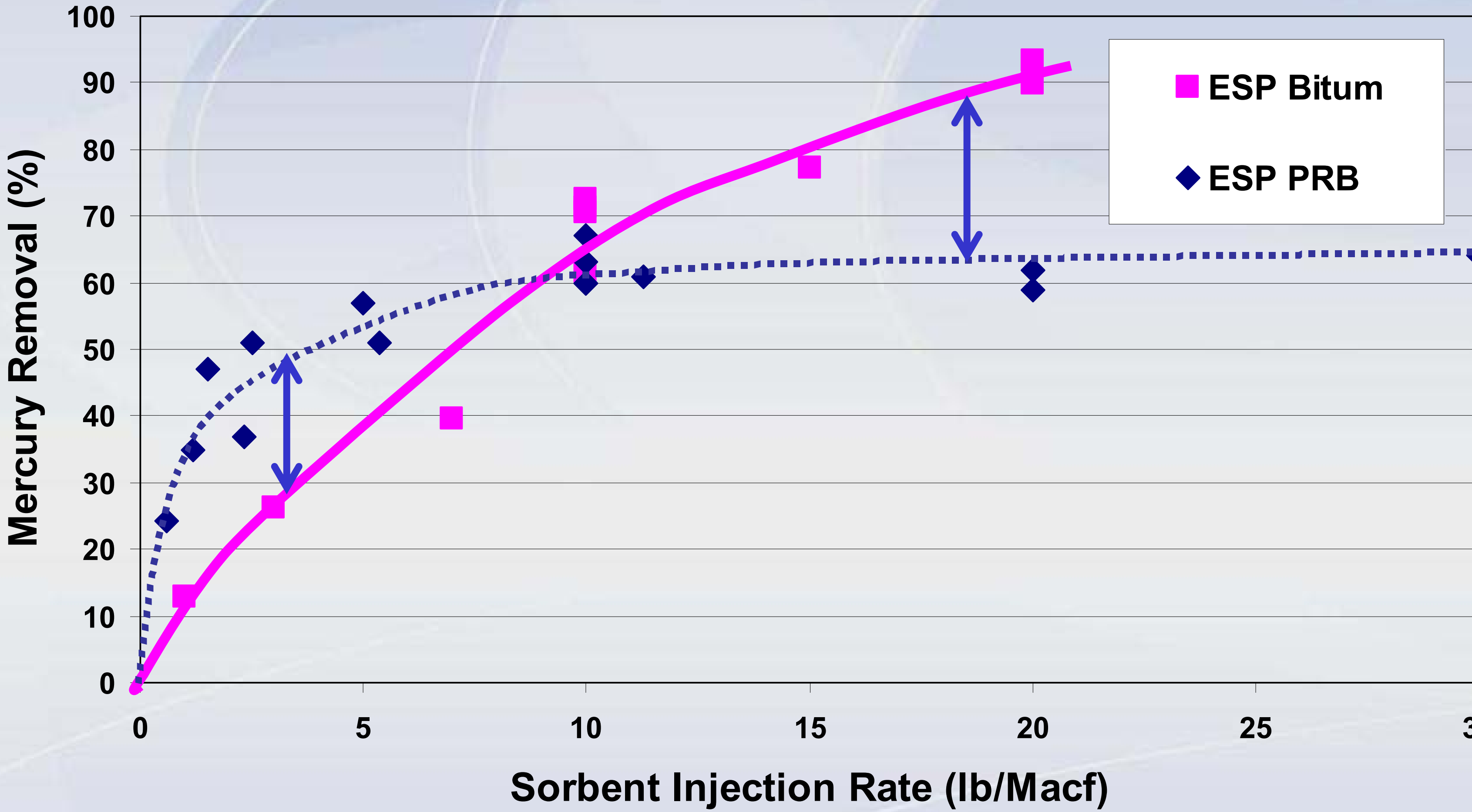
Questions?

- Can halogenated sorbents (other than iodated carbon) produce acceptable performance in an HCl deficient gas stream.

Differences in Coal and Flue Gas Characteristics for the Four DOE Sites

Plant	Coal	Hg (ppm)	Chlorine (ppm)
Alabama Power Gaston	Washed Eastern Bit	0.14	169
We Energies Pleasant Prairie	PRB	0.11	8
PG&E NEG Brayton Point	Eastern Bit	0.03	2000-4000
PG&E NEG Salem Harbor	South Amer. Bituminous	0.03-0.08	206

PAC Performance with ESPs: Bituminous vs. PRB



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Native Mercury Removal for Western Coals

Plant	ESP/FF	Coal	Carbon in Ash	Mercury Removal
Comanche 2	FF	PRB[1]	0.4	61%
Arapahoe 4	FF	PRB[1]	14.4	62%
Cherokee 3	FF	Colowyo[2]	7.6	98%
Valmont	FF	20 Mile[2]		86%

1: < 50 ppm Cl   2: 400 ppm Cl

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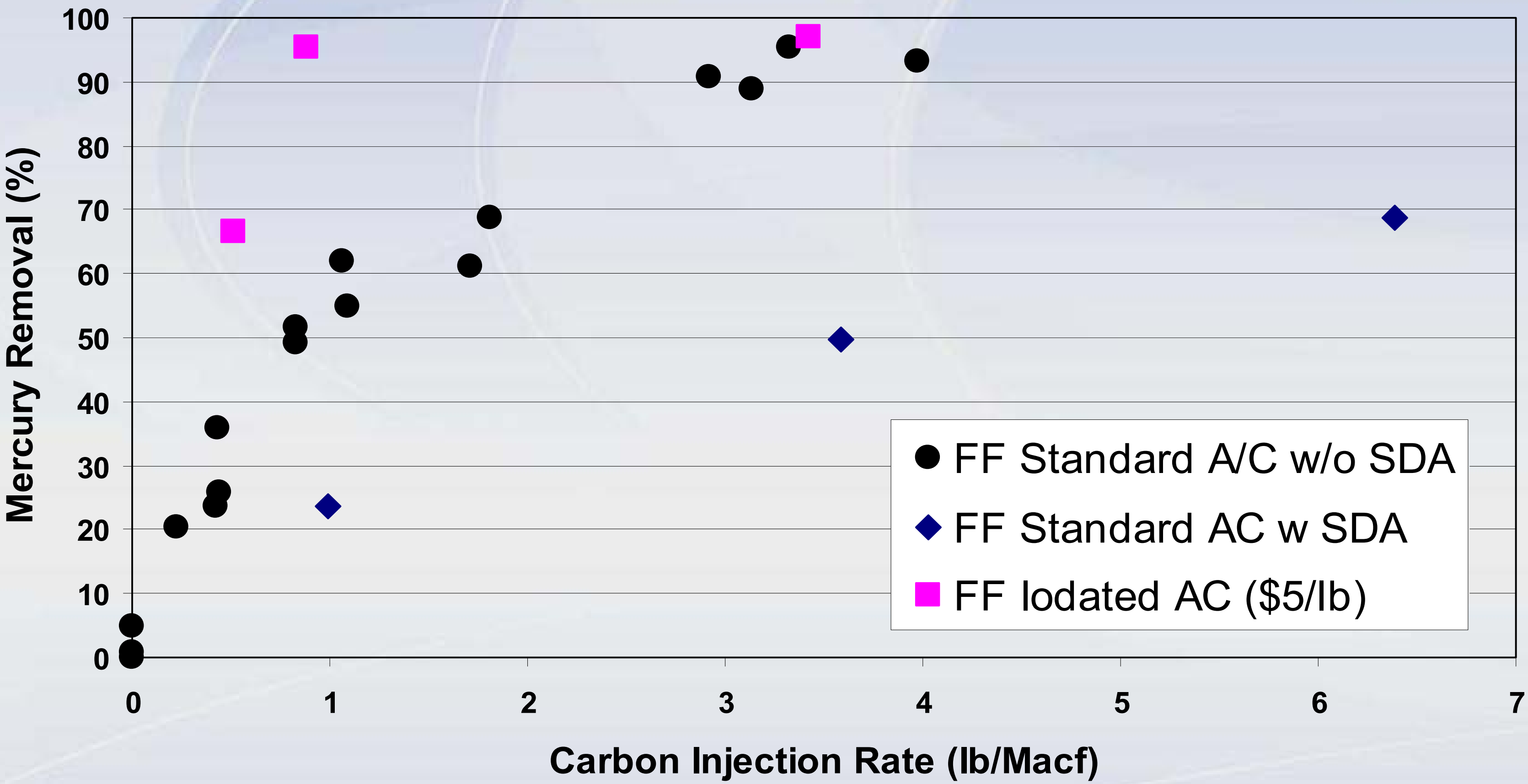
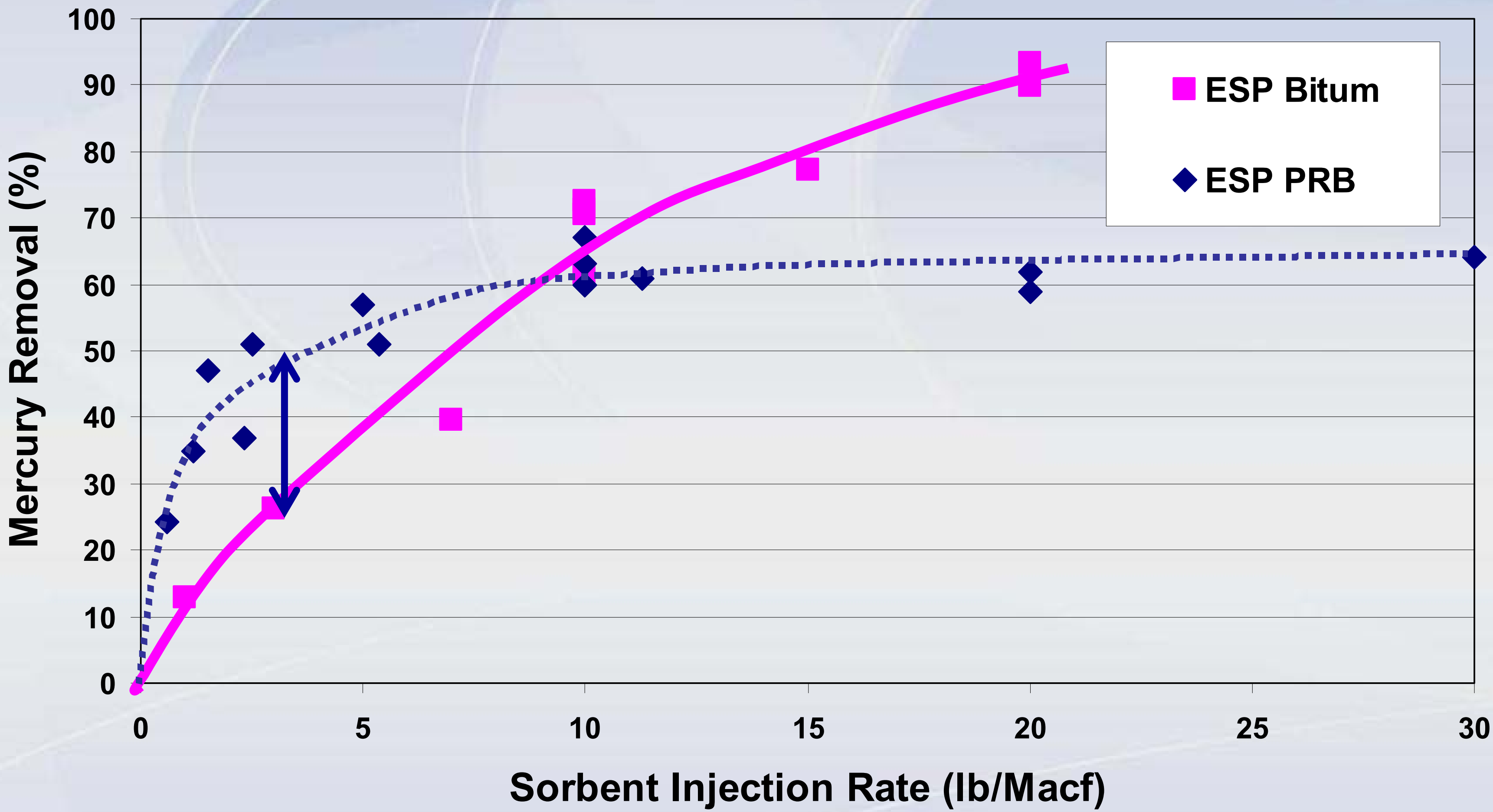
Hg Removal with Spray Dryers on Western Coals (EPRI Data)



PAC Performance with ESPs: Bituminous vs. PRB



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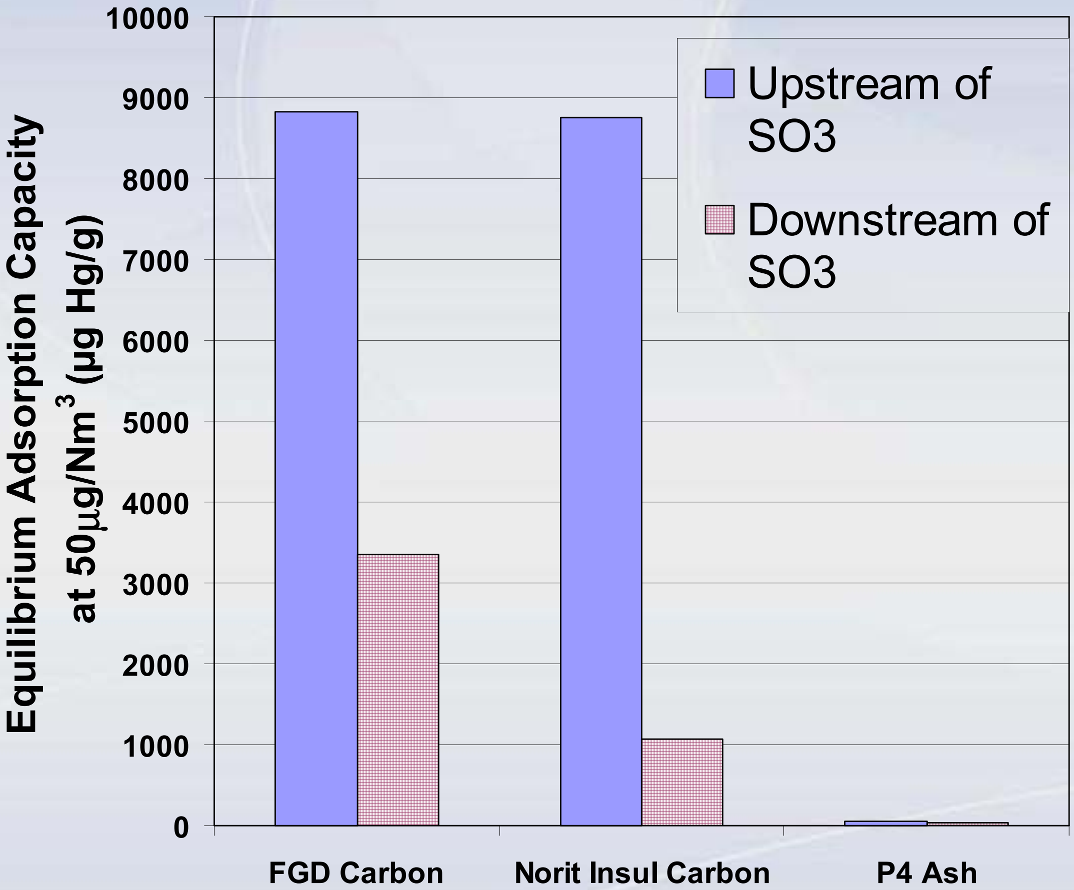
Equilibrium Adsorption Capacities at 250°F Upstream and Downstream of SO_3 Injection



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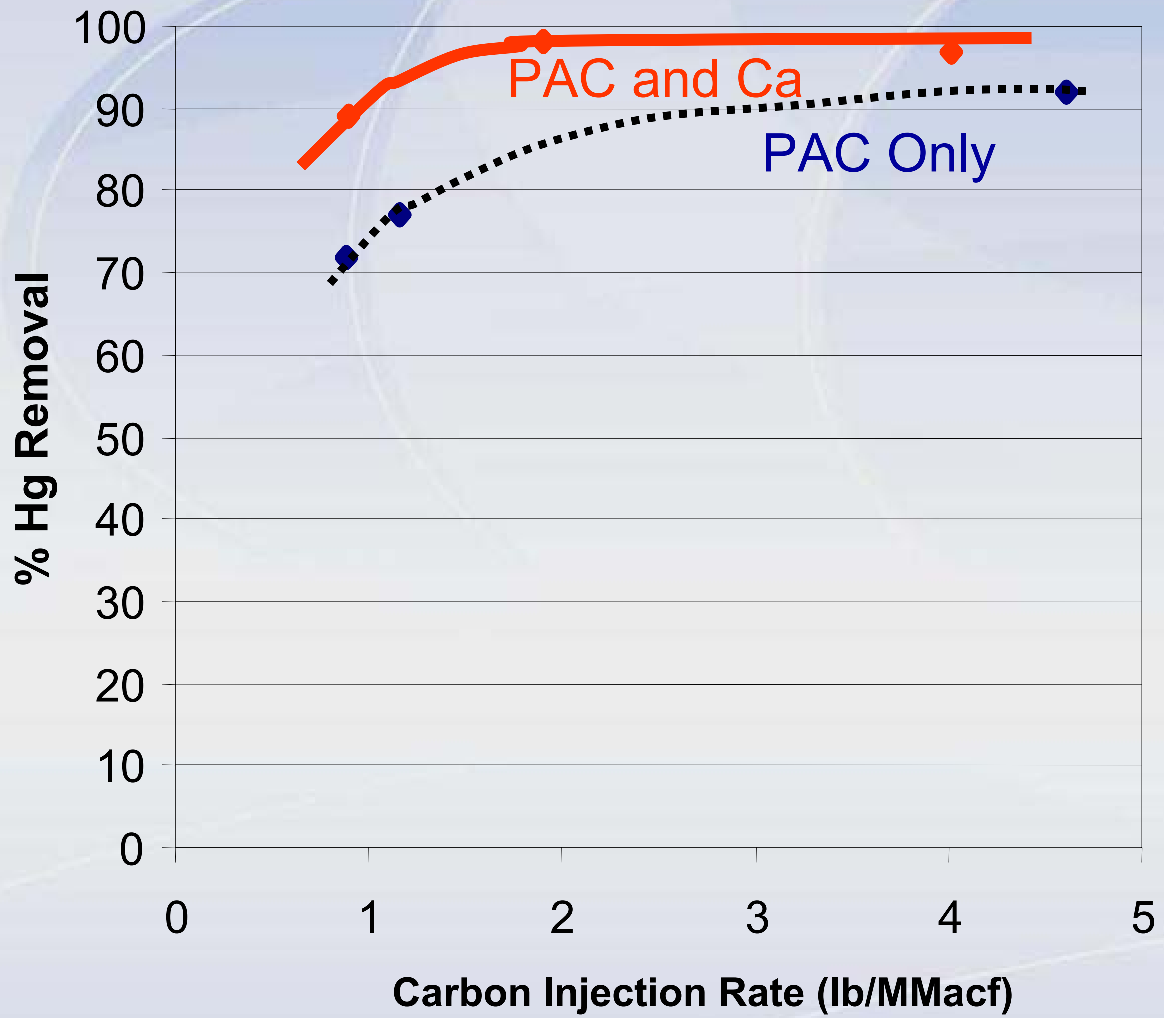
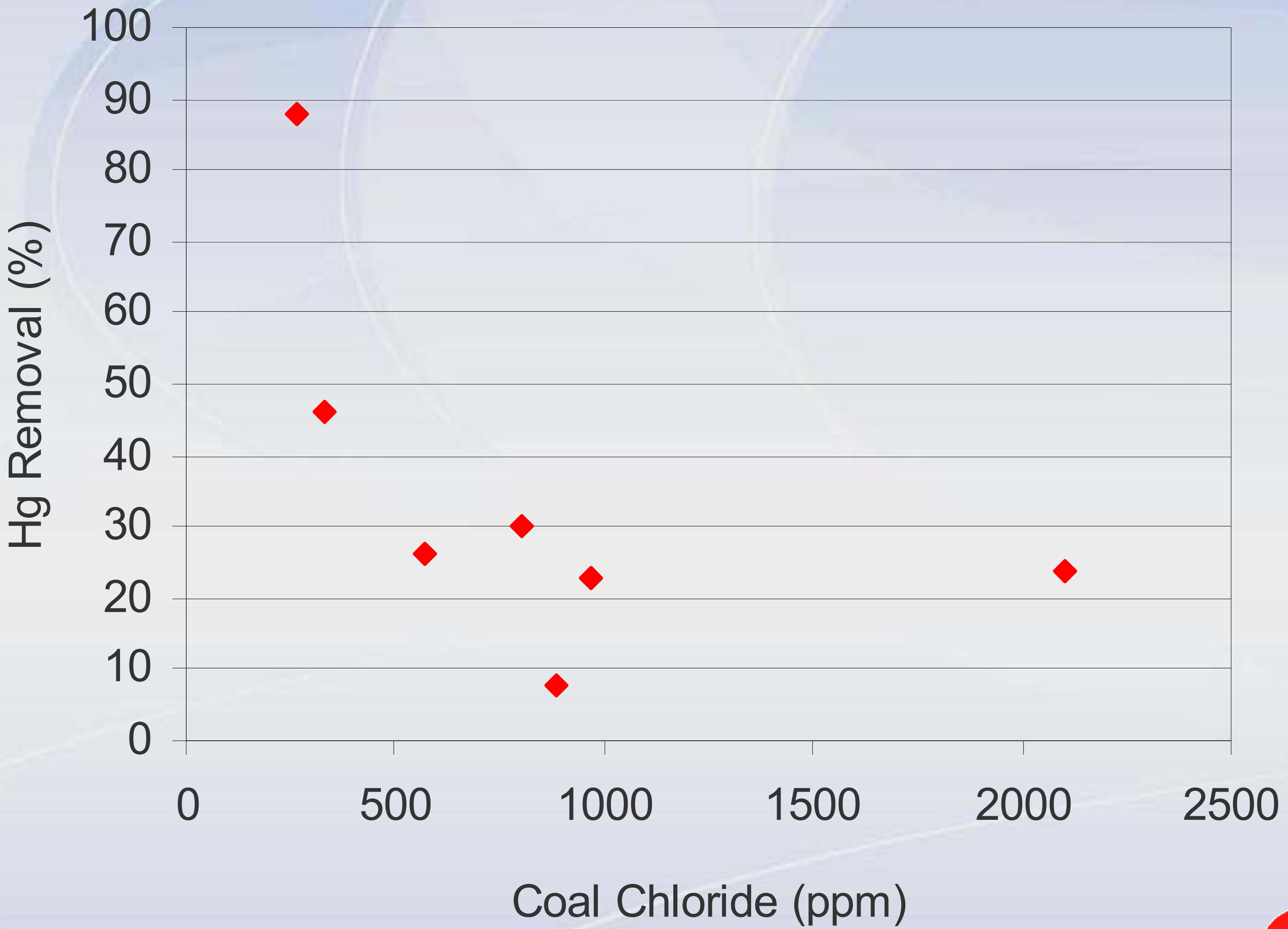
Impact of Ca Injection on PAC Performance on a High HCl Flue Gas: EPRI COHPAC Testing at Hudson



ICR Data on Chlorine in Bituminous Coals Impact on Mercury Removal in ESP



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Sorbent Characteristics

Conclusion*:

- Similar performance from several high-capacity carbons
- R&D to improve sorbents should be directed toward lower-capacity, cheaper products
- Questions?
- Can performance be improved by reducing particle size?

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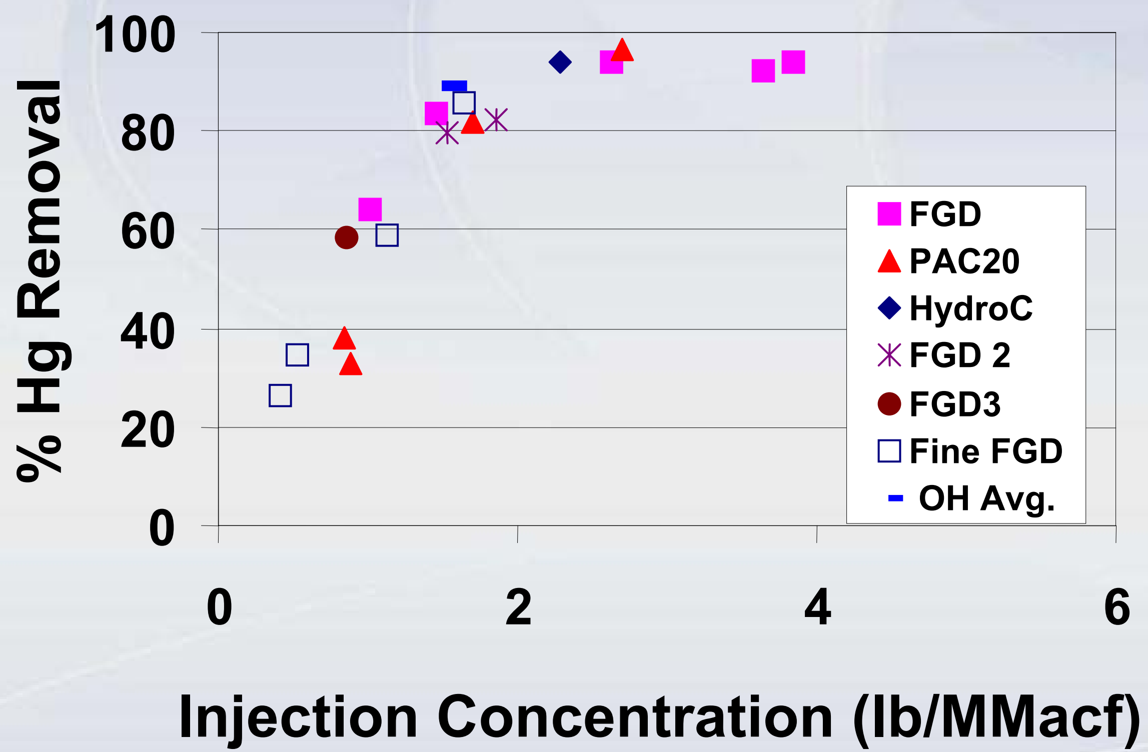
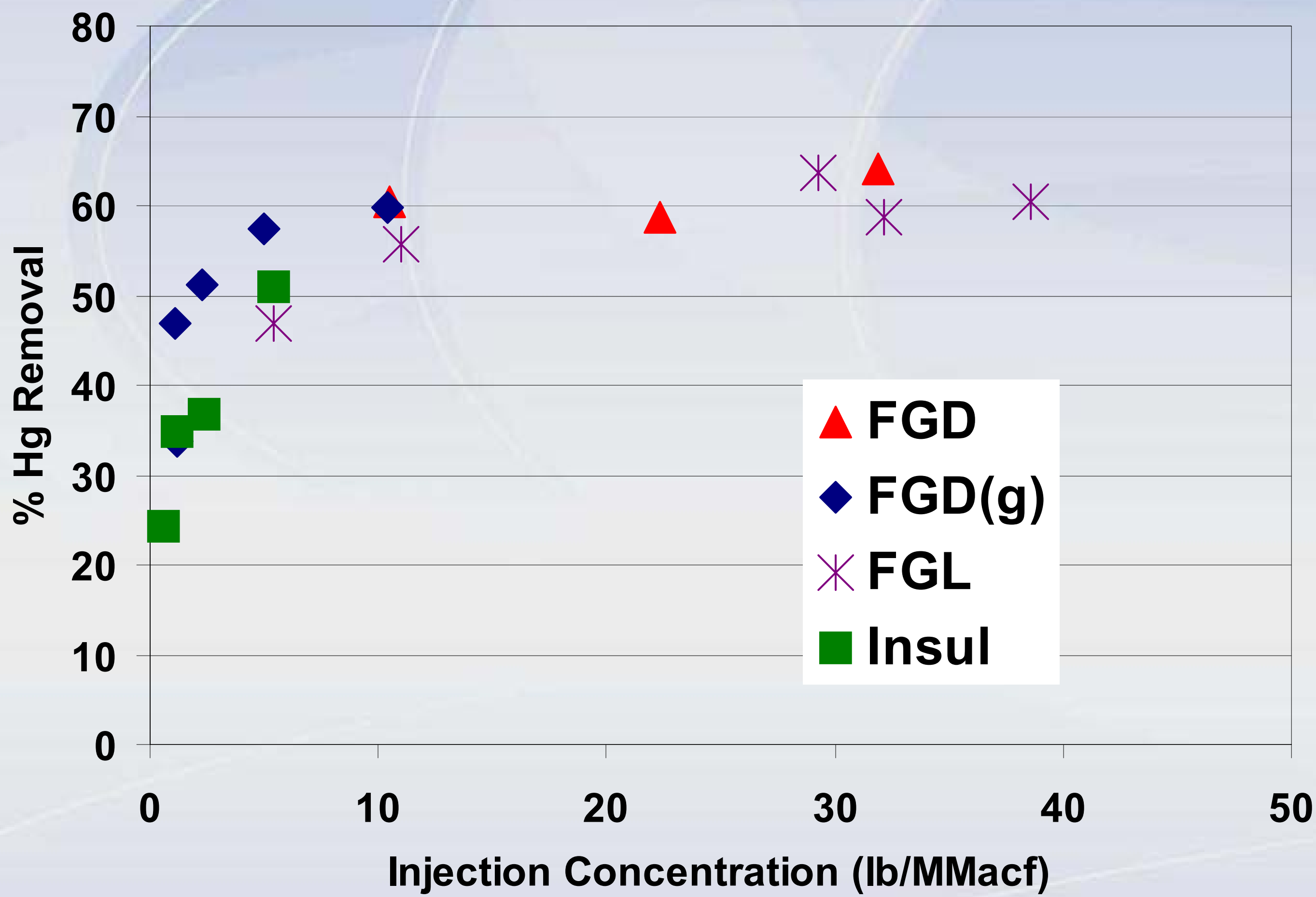
Mercury Removal with Different NORIT PACs (Gaston)



Mercury Removal with Different NORIT PACs (Pleasant Prairie)



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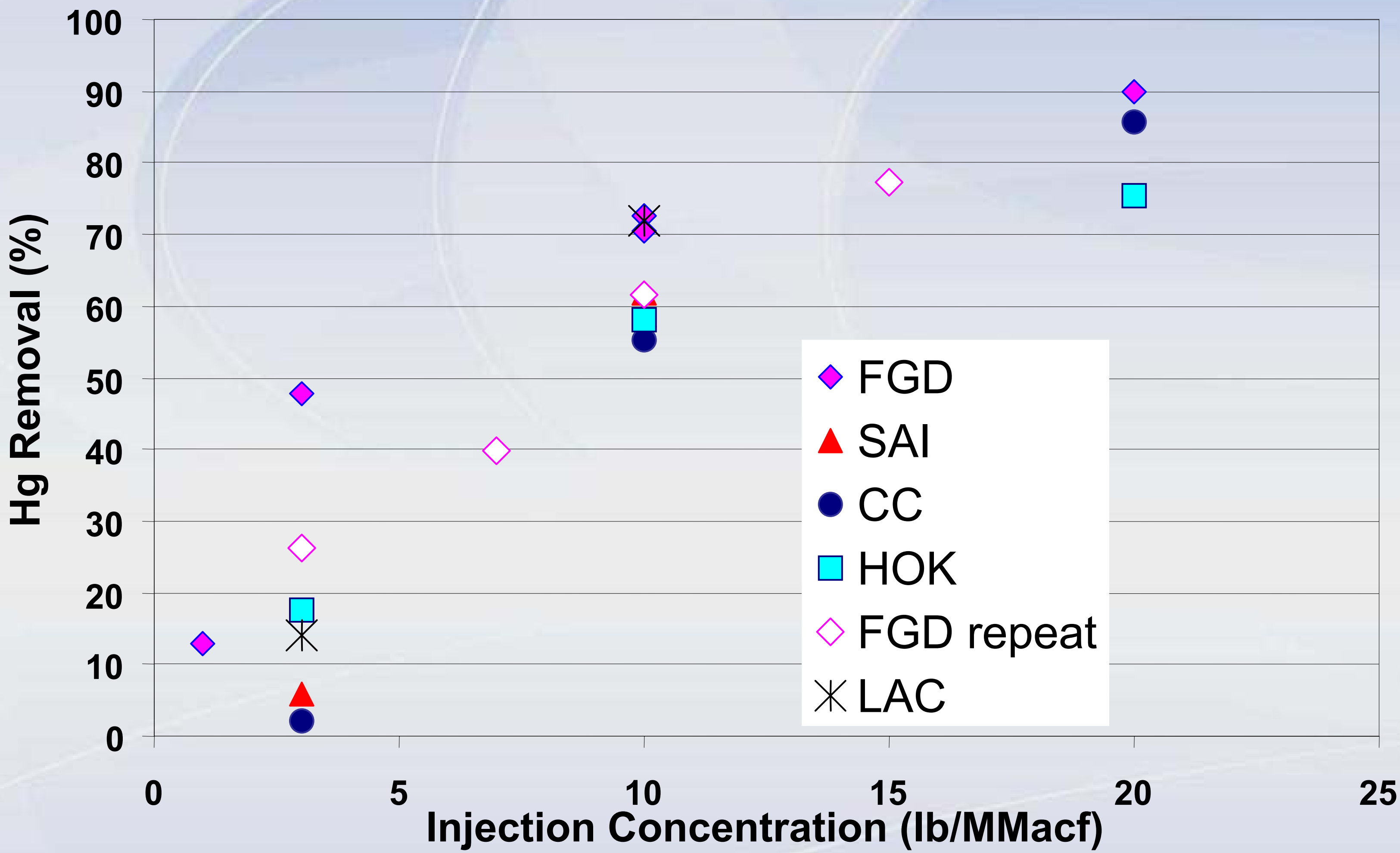
Mercury Removal with PAC from Different Suppliers (Brayton Point)



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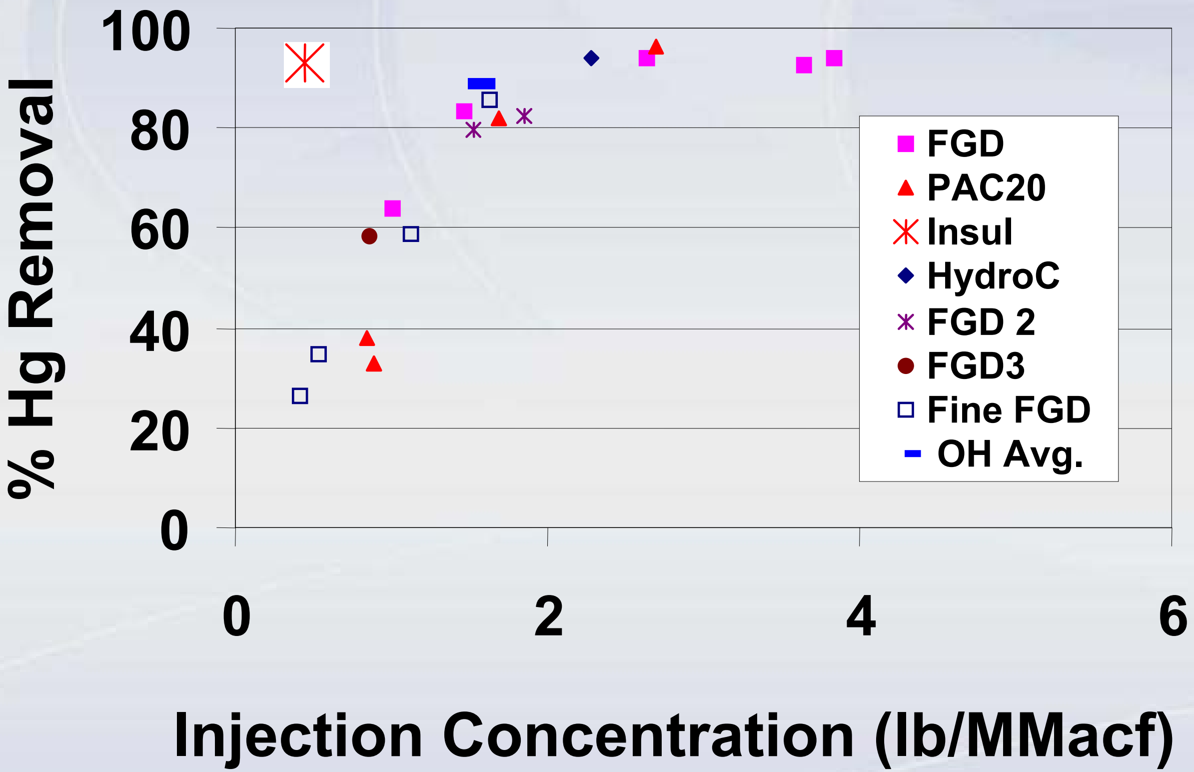
Improved Performance with Reduced Particle Size

Results could not be repeated with two additional tests. In both cases, there was difficulty feeding the finer material.



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Effect of SNCR

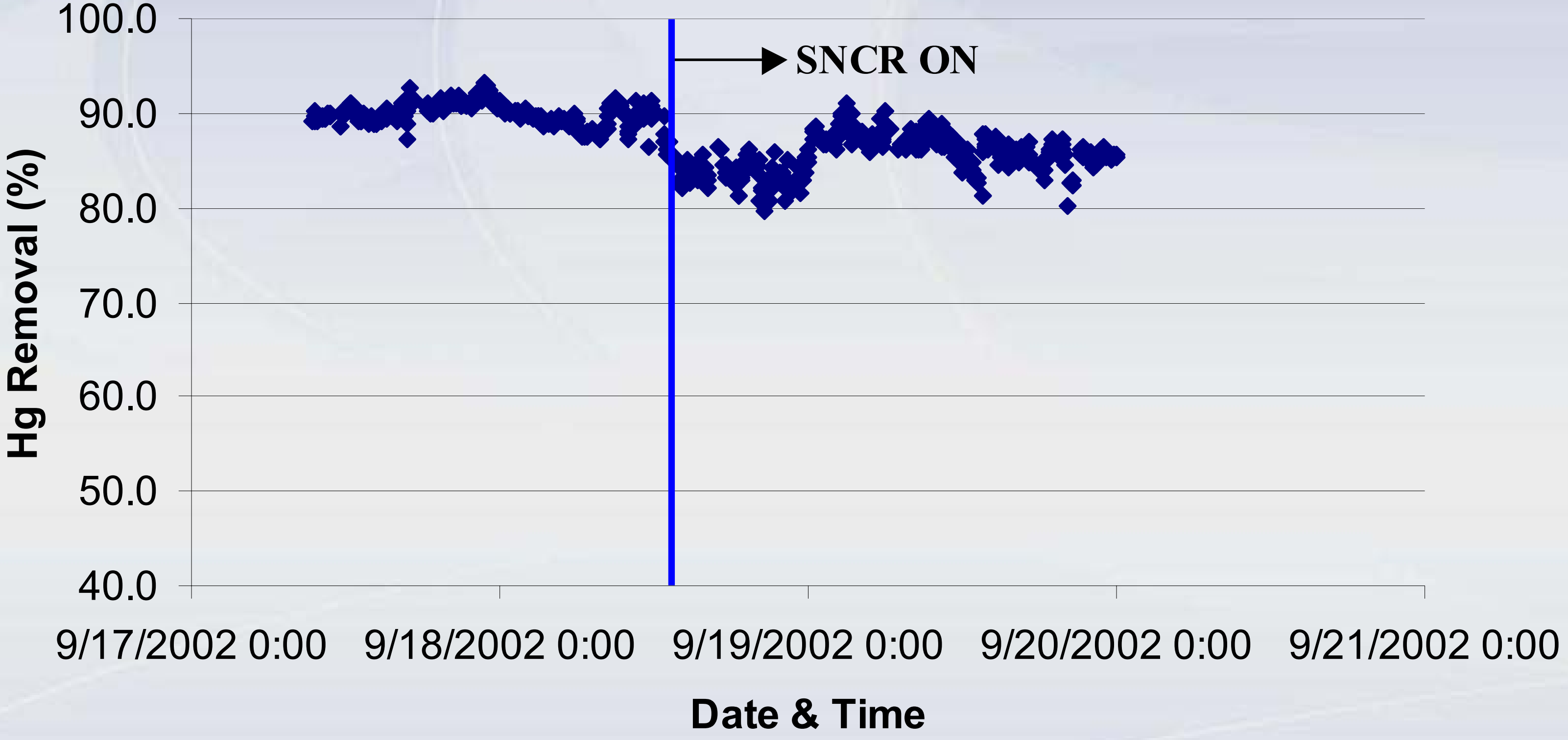
Conclusion*:

- SNCR was not the reason for the high native mercury removal at Salem Harbor.

Questions?

- Does SNCR impact the performance of PAC?

SNCR On/Off Results



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Ash Issues

Conclusion*:

- The mercury captured by PAC, LOI, and ash appears to be very stable and unlikely to reenter the environment.
- The presence of PAC will most likely prevent the sale of ash for use in concrete.

Questions?

- How effective will new technologies be in addressing the ash reuse issue?

Carbon-in-Fly Ash Issues

- Even small amounts of carbon in fly ash can limit use as a cement admixture.
- If currently selling fly ash, must address loss of sales and disposal.
- Several developing technologies to address the problem:
  - Separation;
  - Combustion;
  - Chemical treatment;
  - Non-carbon sorbents; and
  - Configuration solutions such as EPRI TOXECON

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