Update on Full-Scale Activated Carbon Injection for Control of Mercury Emissions

Presentation to

Utility MACT Working Group

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Outline

- ADA-ES DOE/NETL Hg Control Program
- Summary of Previous Results from PAC with a FF and an ESP
- Preliminary results from Brayton Point
- Conclusions and Future Plans

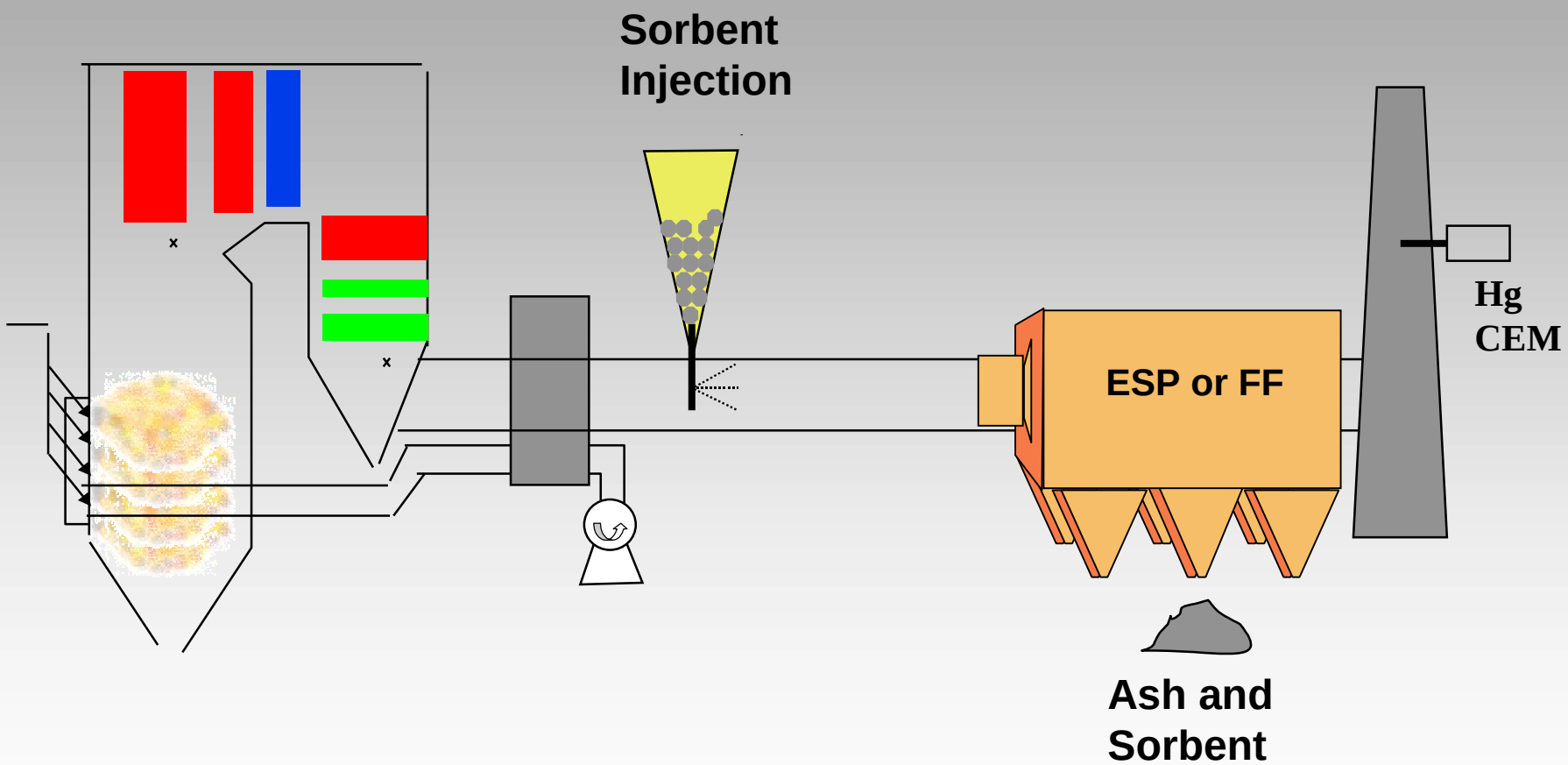
ADA-ES Hg Control Program

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

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



DOE/NETL Test Sites

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

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Description of Typical Test Plan

Tests are conducted in three distinct phases:

- **Baseline: Document mercury concentration at several locations with no ACI**
  - **Ontario Hydro and S-CEM**
- **Parametric: A series of 8 hr. tests at different parametric conditions (sorbent, feedrate, operating conditions)**
  - **3 weeks: S-CEM only**
- **Long-term: Ten day run at constant conditions using optimum sorbent and feedrate**
  - **Ontario Hydro and S-CEM**

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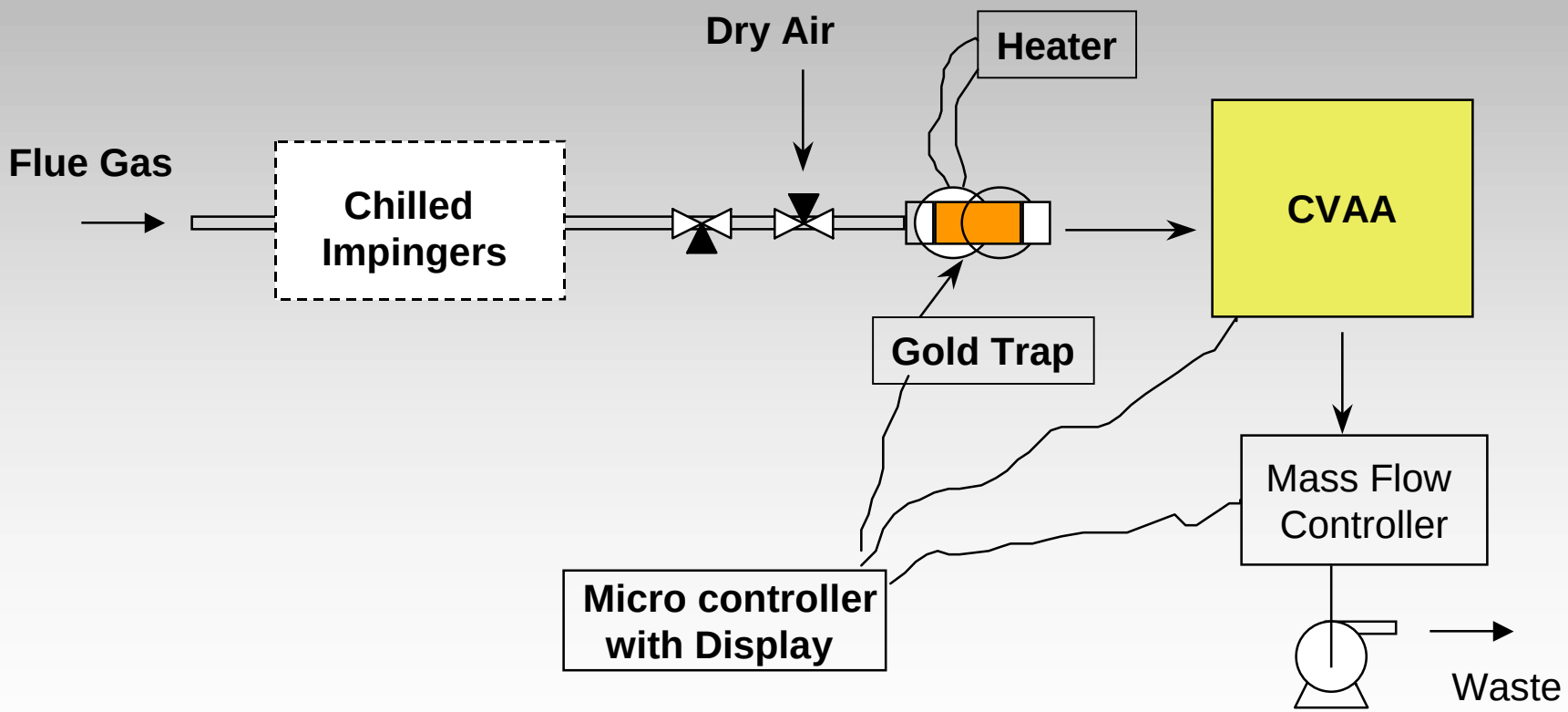
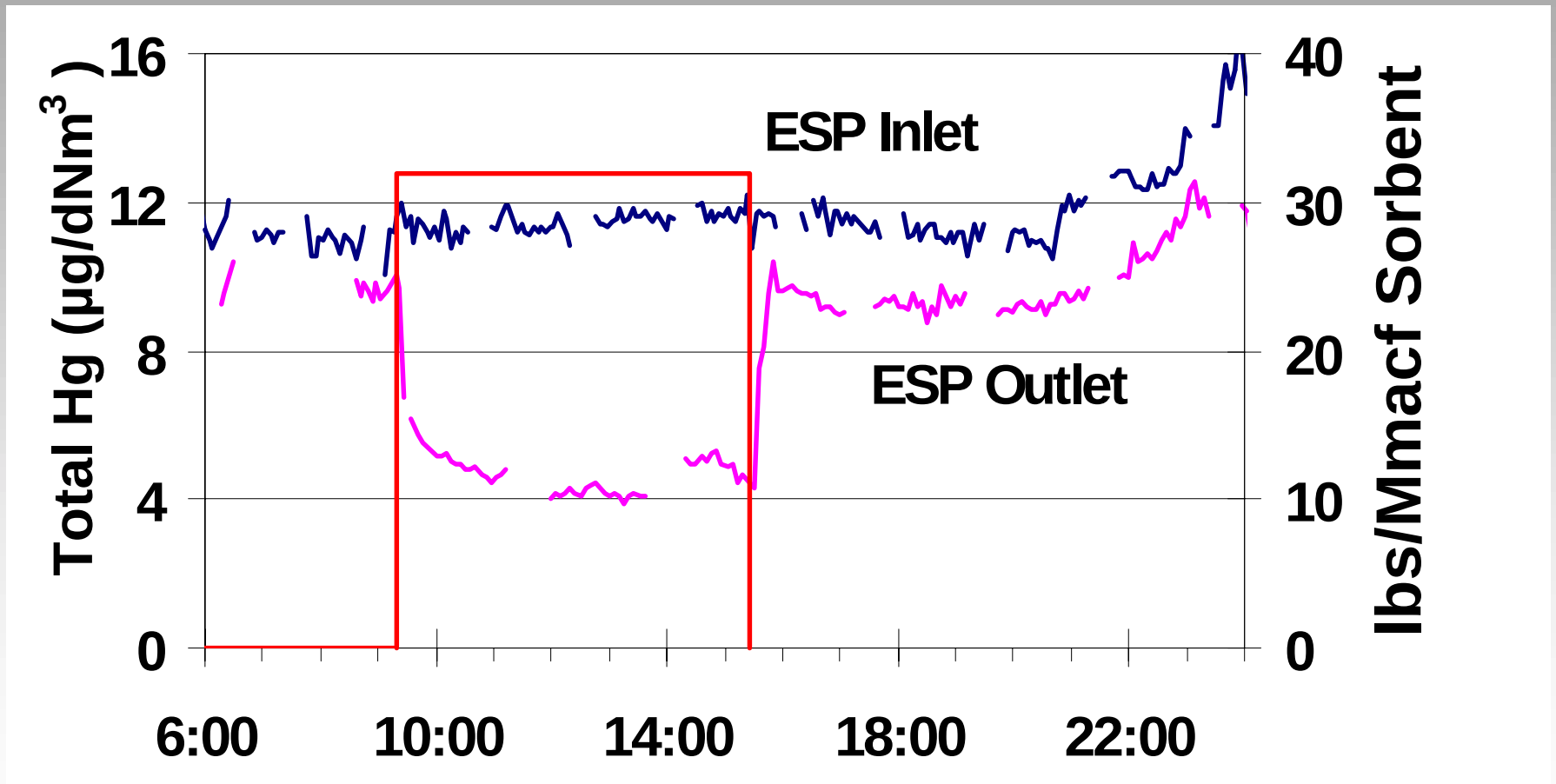
Semi-Continuous Mercury Analyzer

Status: Manual operation; data every ten minutes



Response Time for PAC Injection on an ESP



Alabama Power E.C. Gaston Unit 3

- 270 MW Wall Fired Boiler
- Particulate Collection System
  - Hot-side ESP, SCA = 274 ft^2/1000 acfm
  - COHPAC baghouse supplied by Hamon Research-Cottrell
- Washed Eastern low-sulfur bituminous coal
  - 11,902 Btu/lb
  - 1.2% S
  - 14.7% ash
  - 0.14 ppm Hg
  - 0.017 % Cl
- Baghouse Temperature: 250-270 ^oF

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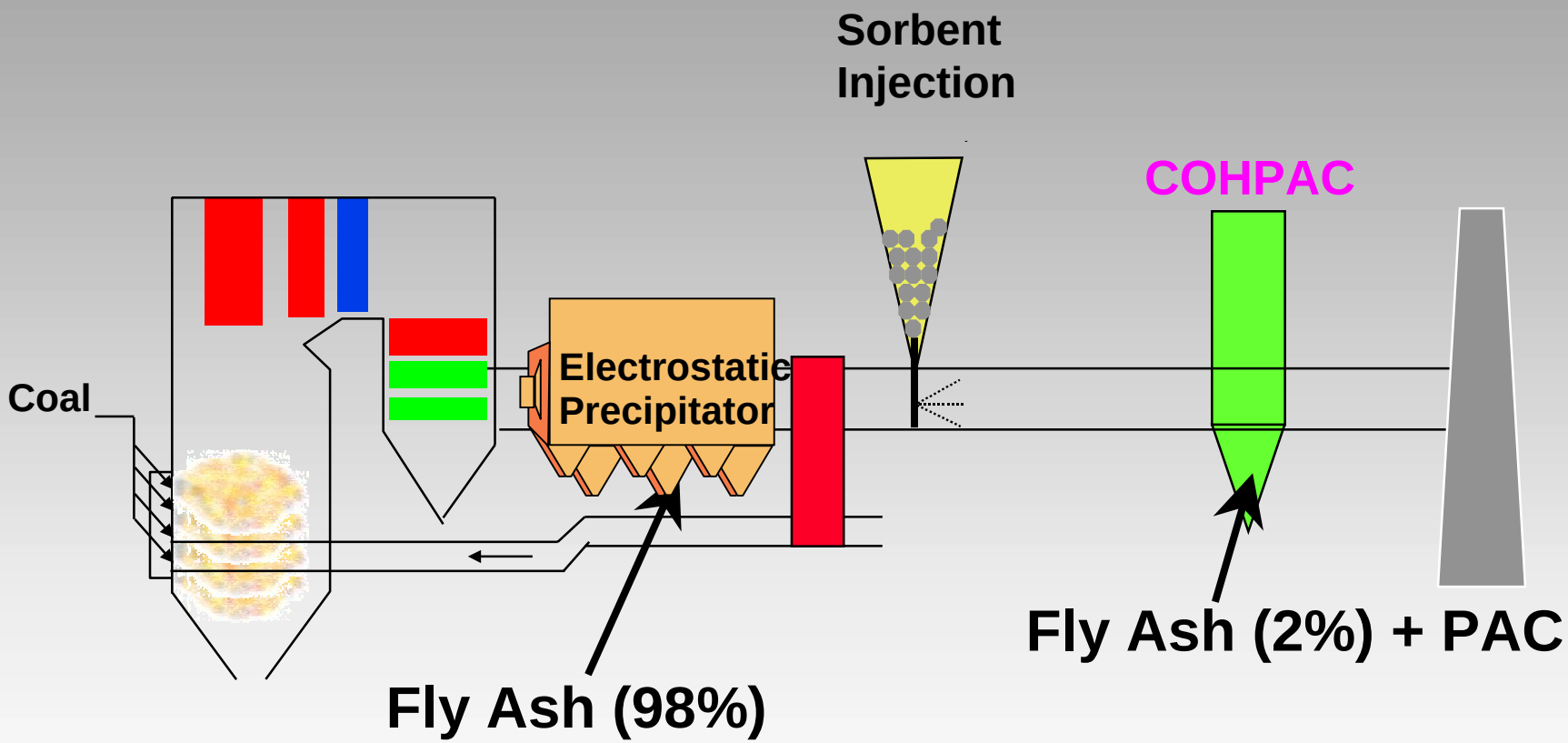
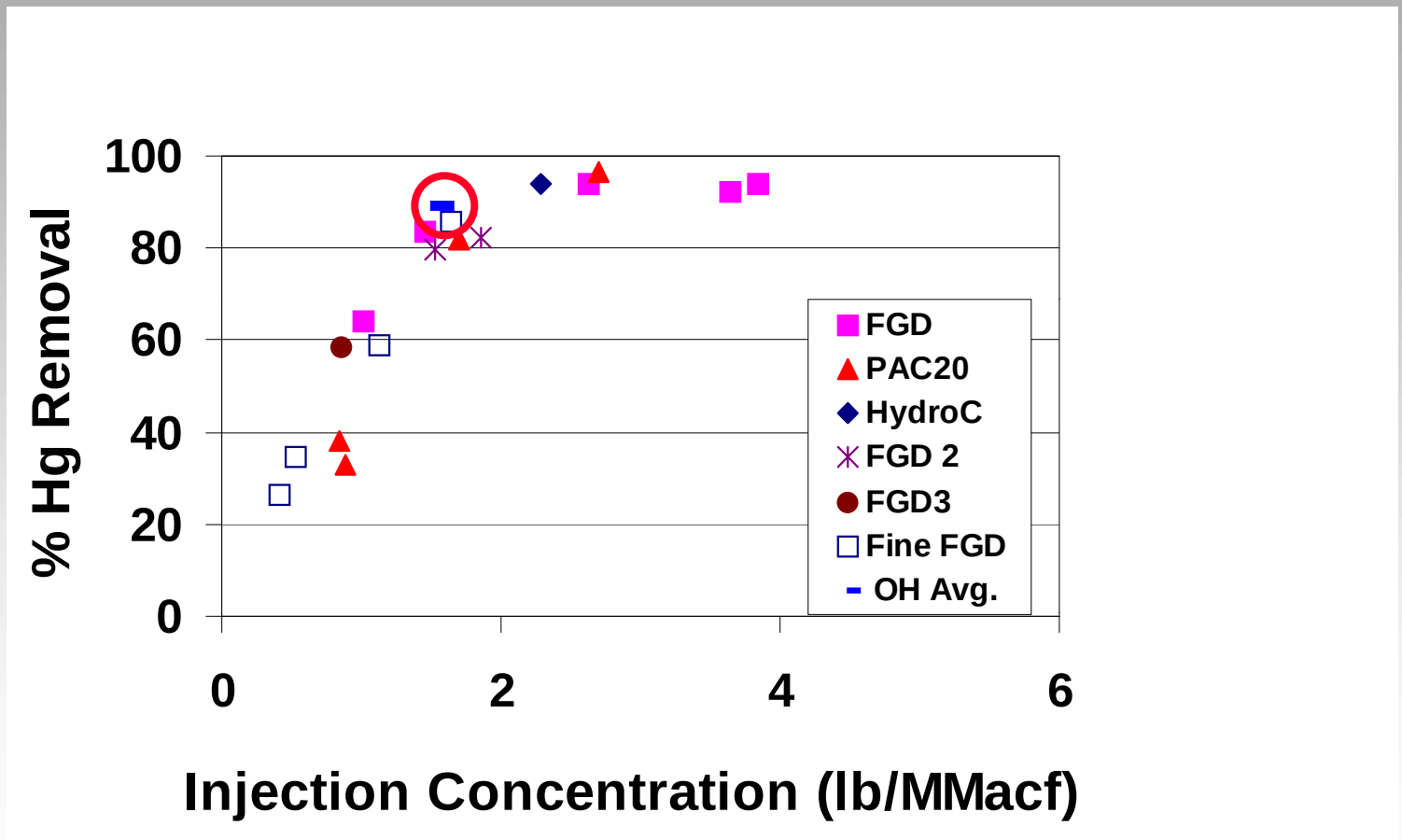
Site Test Configuration at Alabama Power Plant Gaston



Mercury Removal vs. Injection Rate

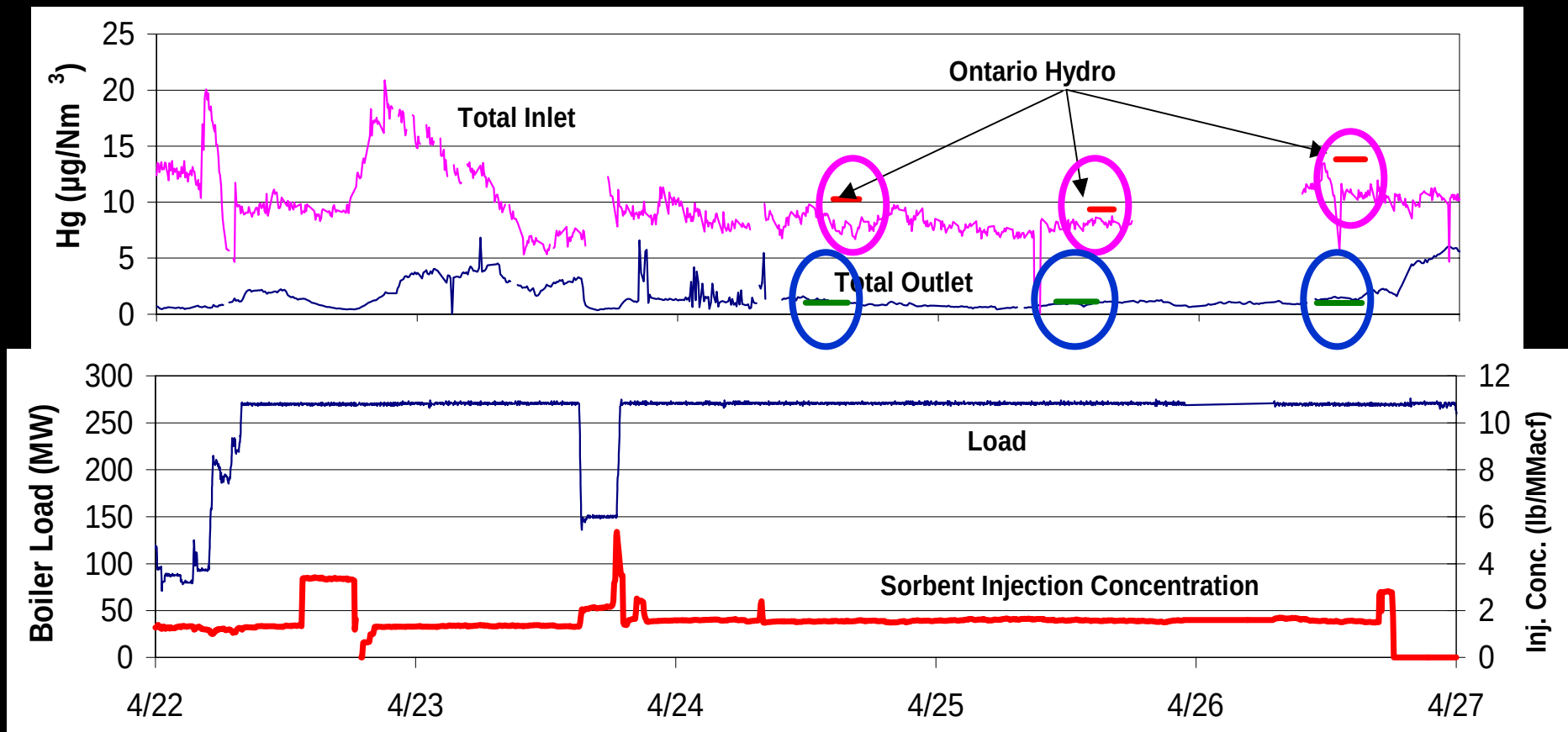


Ontario Hydro Measurements at Gaston

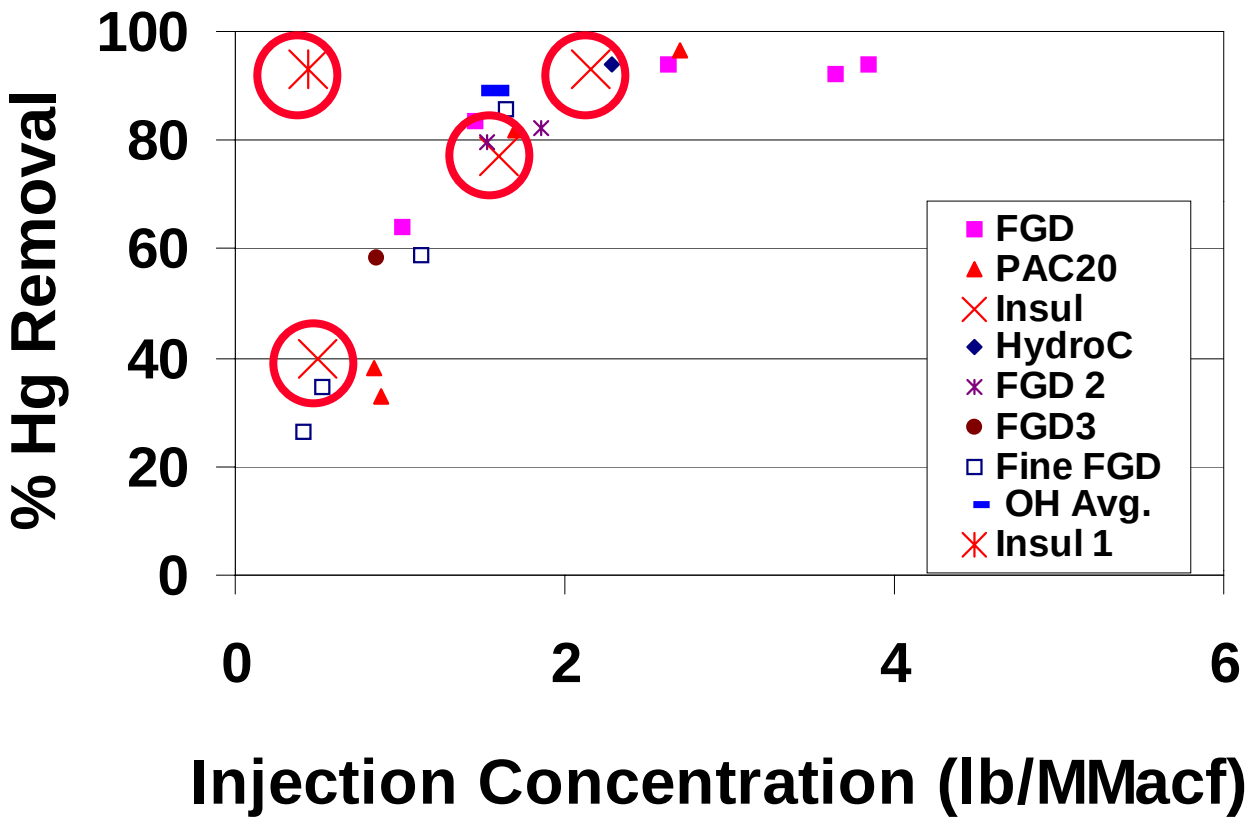
(microgram/dncm)

	PARTICULATE	OXIDIZED	ELEMENTAL	TOTAL
Baseline (no ACI)				
COHPAC Inlet	0.09	9.54	5.97	15.60
COHPAC Outlet	0.01	11.19	3.34	14.54
Removal Efficiency	89.1%	-17.3%	44.1%	6.8%
PAC Injection				
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%

5-Day Continuous Injection

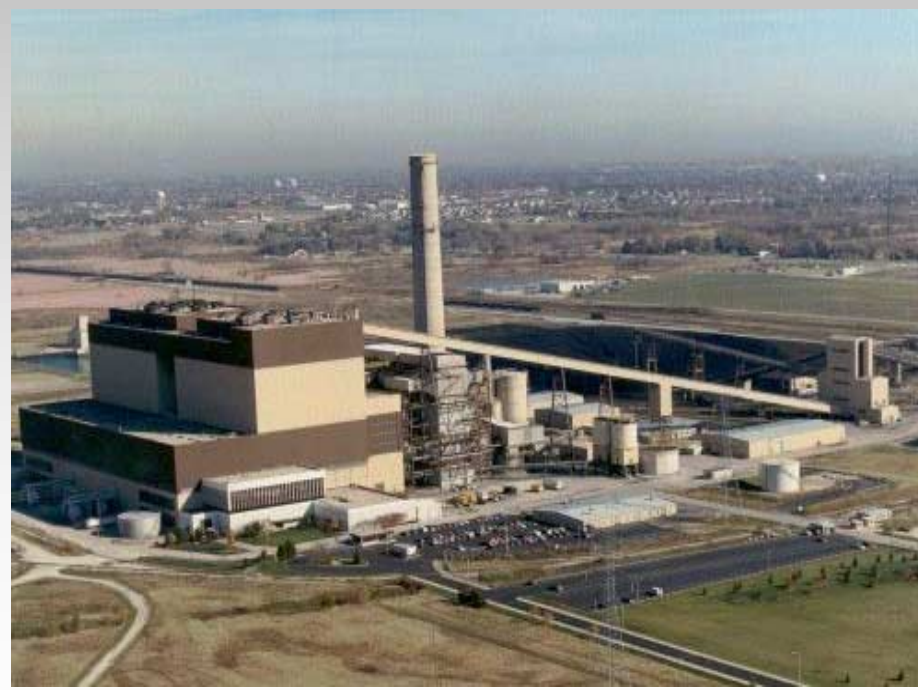


Misleading Short-Term Test



We Energies Pleasant Prairie Unit 2

- 600 MW Turbo Fired Boiler
- Particulate Collection System
  - Cold-side ESP, SCA = 468 ft^2/1000 acfm
  - Wahlco SO_3 System
- Powder River Basin, subbituminous
  - 8,385 Btu/lb
  - 0.3% S
  - 5.1% ash
  - 0.11 ppm Hg
  - 0.0008 % Cl
- ESP Temperature: 290 ^oF



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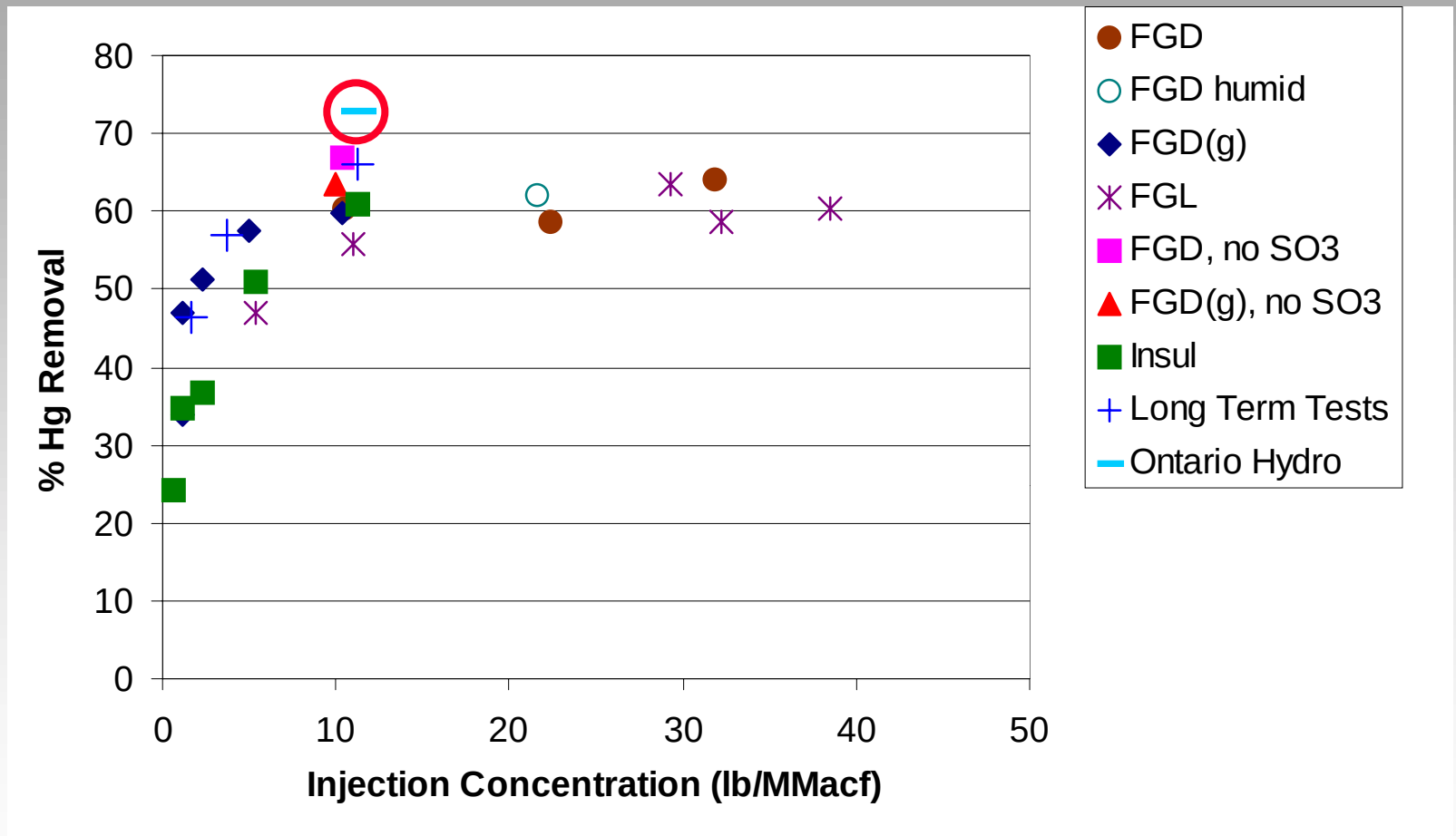
Carbon Injection Performance on a PRB Coal with an ESP



Speciated Mercury Measured by Ontario Hydro Method (10 lbs/MMacf)

(microgram/dncm)

	PARTICULATE	ELEMENTAL	OXIDIZED	TOTAL
Baseline (no ACI)				
ESP Inlet	1.97	12.22	2.51	16.71
ESP Outlet	0.01	9.80	6.01	15.82
Removal Efficiency	99.5%	19.8%	-139.3	5.3%
PAC Injection				
ESP Inlet	0.98	14.73	1.73	17.44
ESP Outlet	0.00	4.27	0.44	4.71
Removal Efficiency	100.0%	71.0%	74.5%	73.0%

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PG&E NEG Brayton Point Unit 1

- 245 MW Tangential Boiler
- Particulate Control System
  - Two ESPs in series with combined SCA of 559 ft^2/kacfm
  - EPRICON SO_3 system
- Eastern low-sulfur bituminous coal
  - 12,319 Btu/lb
  - 0.7 % S
  - 11% ash
  - 0.03-0.05 ppm Hg
  - 0.1-0.4 % Cl
- ESP Temperature: 280-340 ^oF

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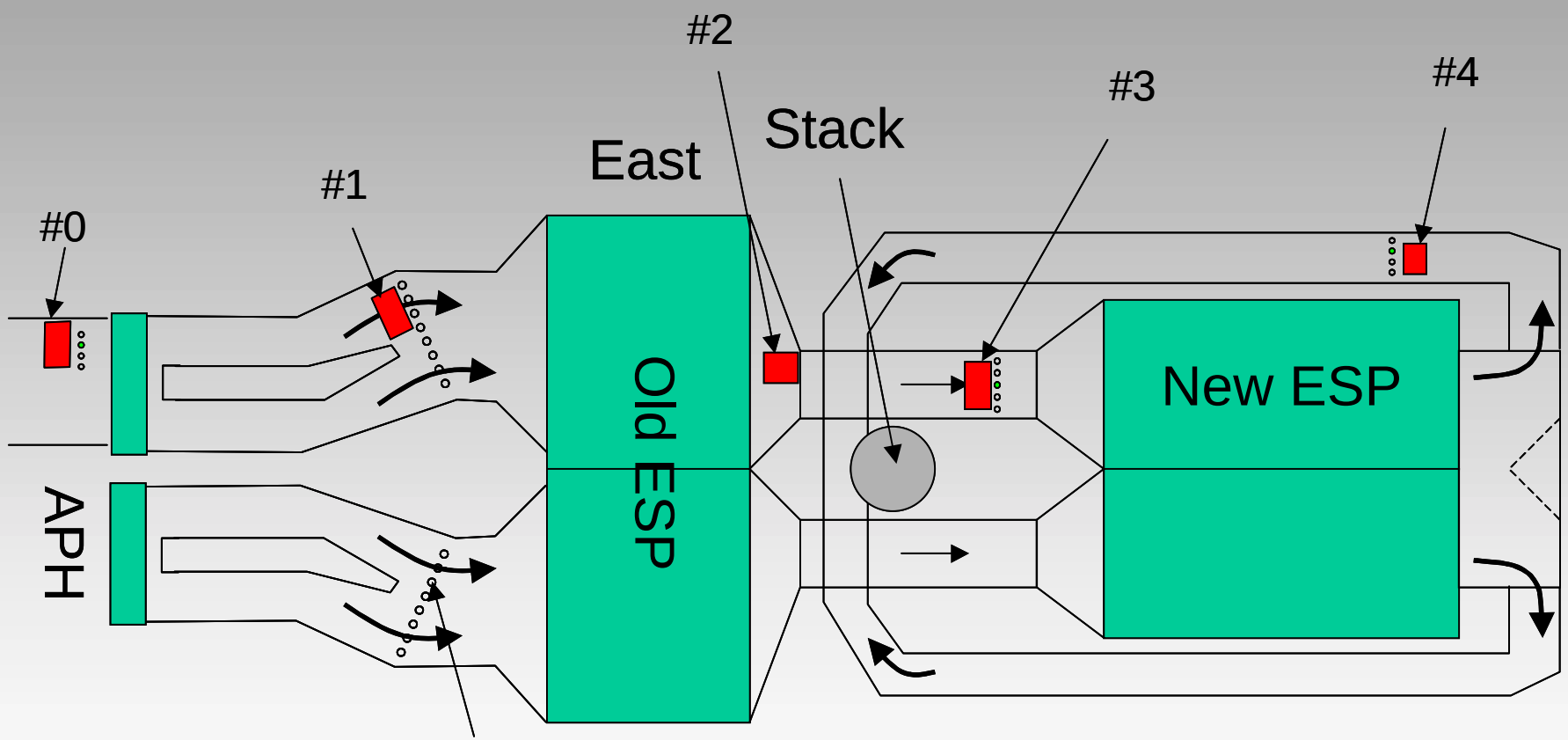
Sampling Locations



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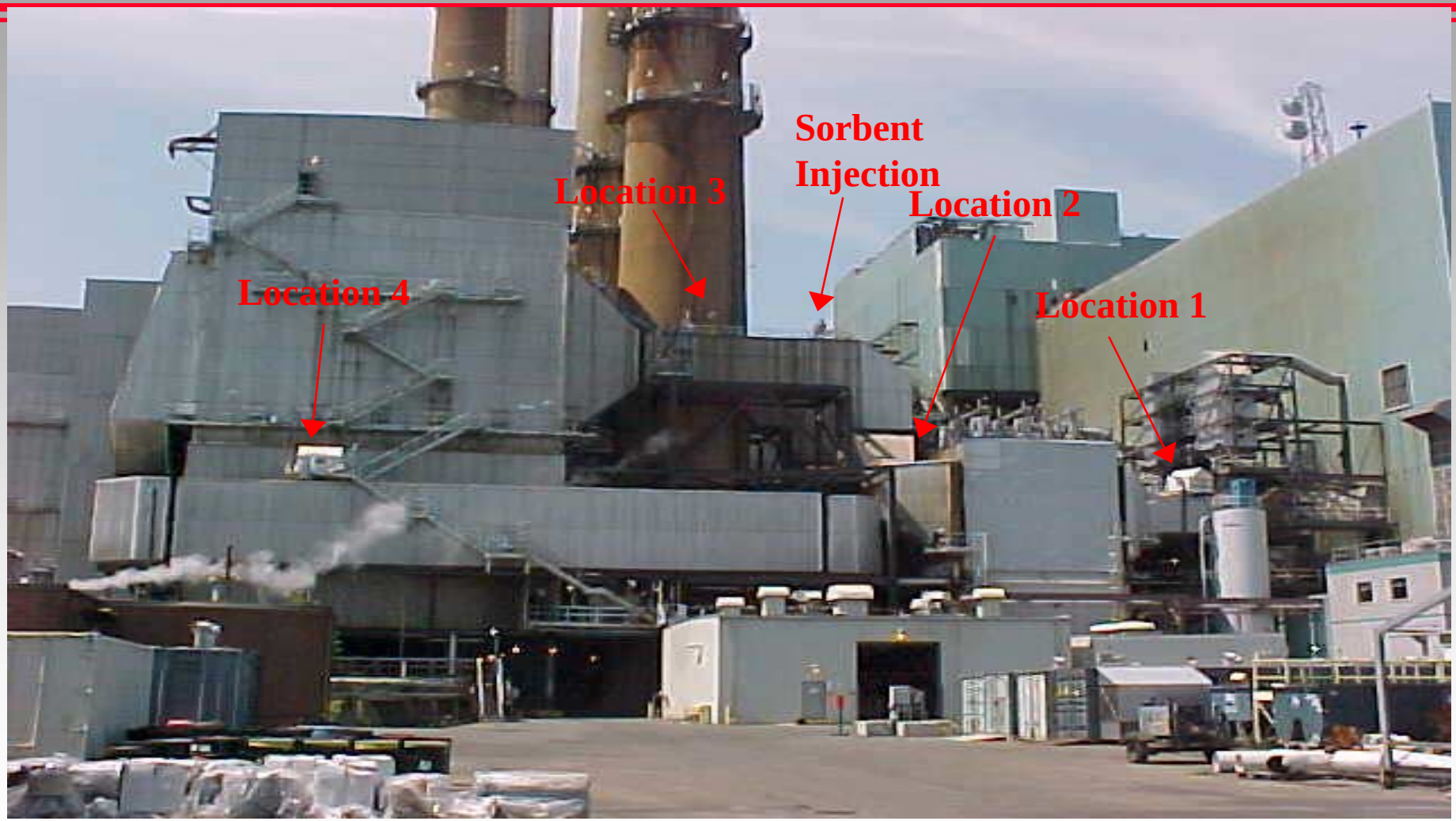

Variability of Baseline (no ACI) Mercury Removal at Brayton Point

Five sets of Ontario Hydro measurements have been made since 1999 documenting baseline mercury removal

- The coal specification for the West Virginia low-sulfur bituminous coal has been the same during this time period
- Measured variability:
  - Mercury in coal: 0.03-0.08 ppm
  - Chlorine in coal: 0.08-0.4 %
  - Mercury in flue gas: 2.9-6.4 ug/m^3
  - Percent of mercury (as oxidized or particulate): 89-95%
  - **Removal across ESP: 30-91%**

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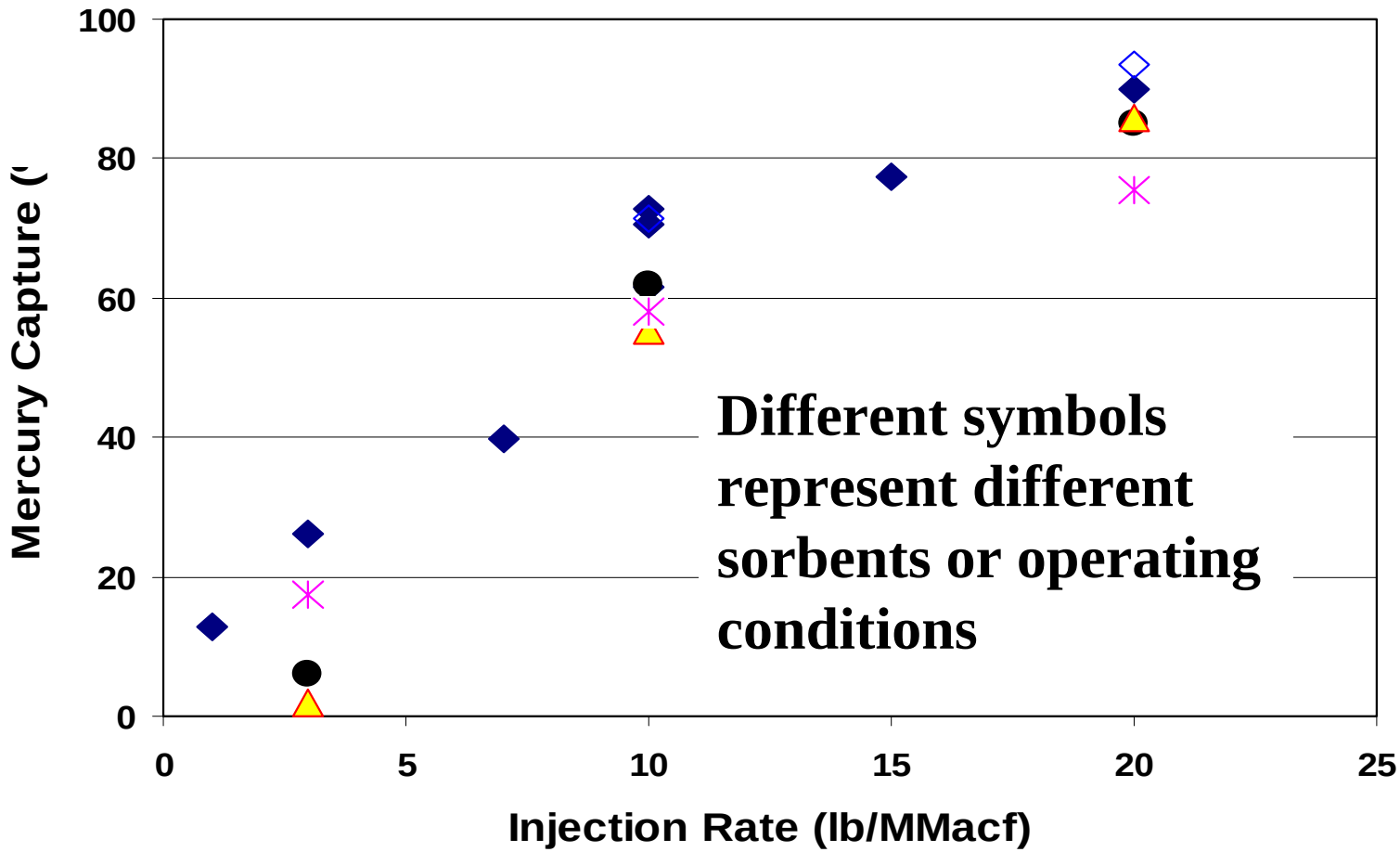
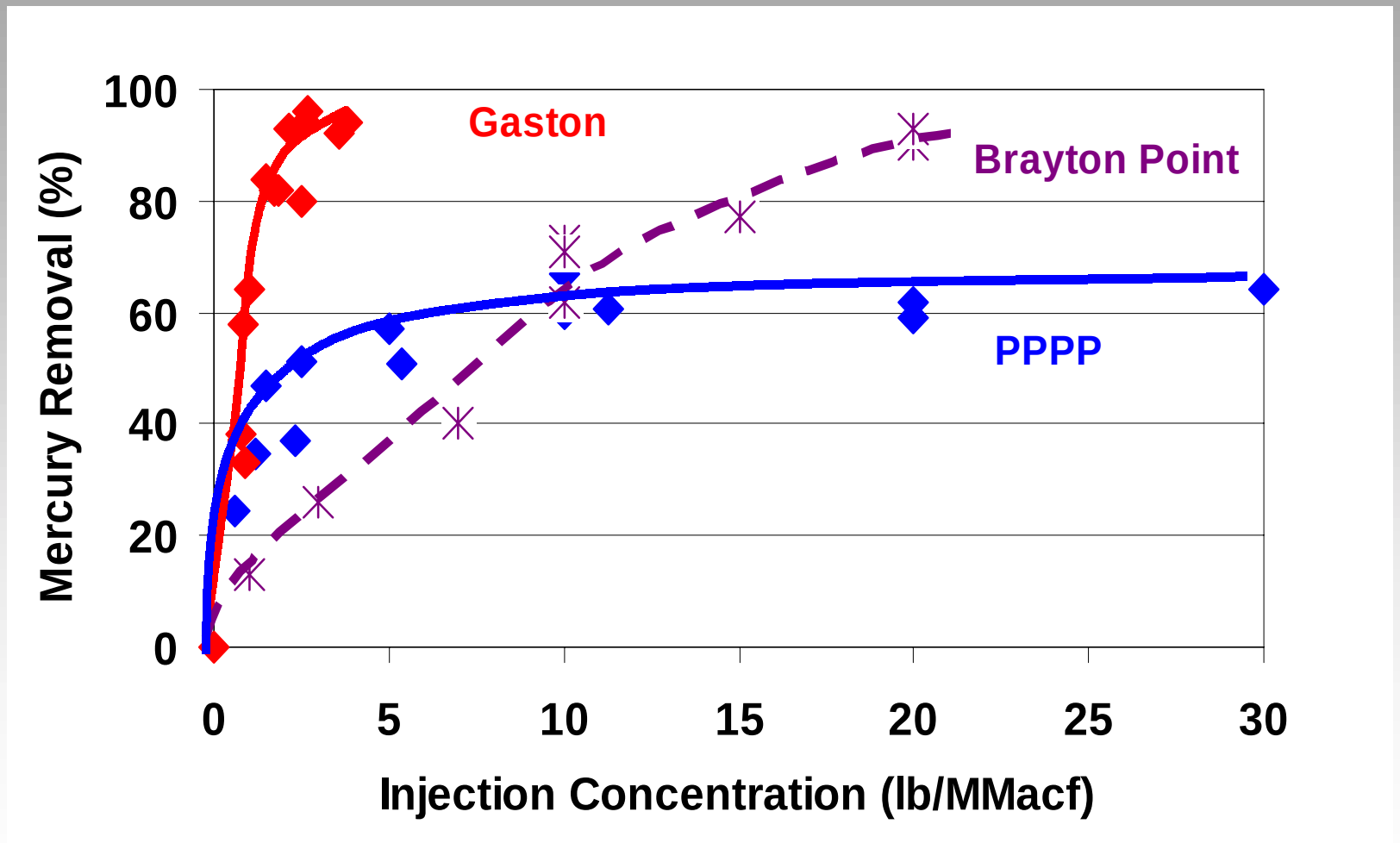
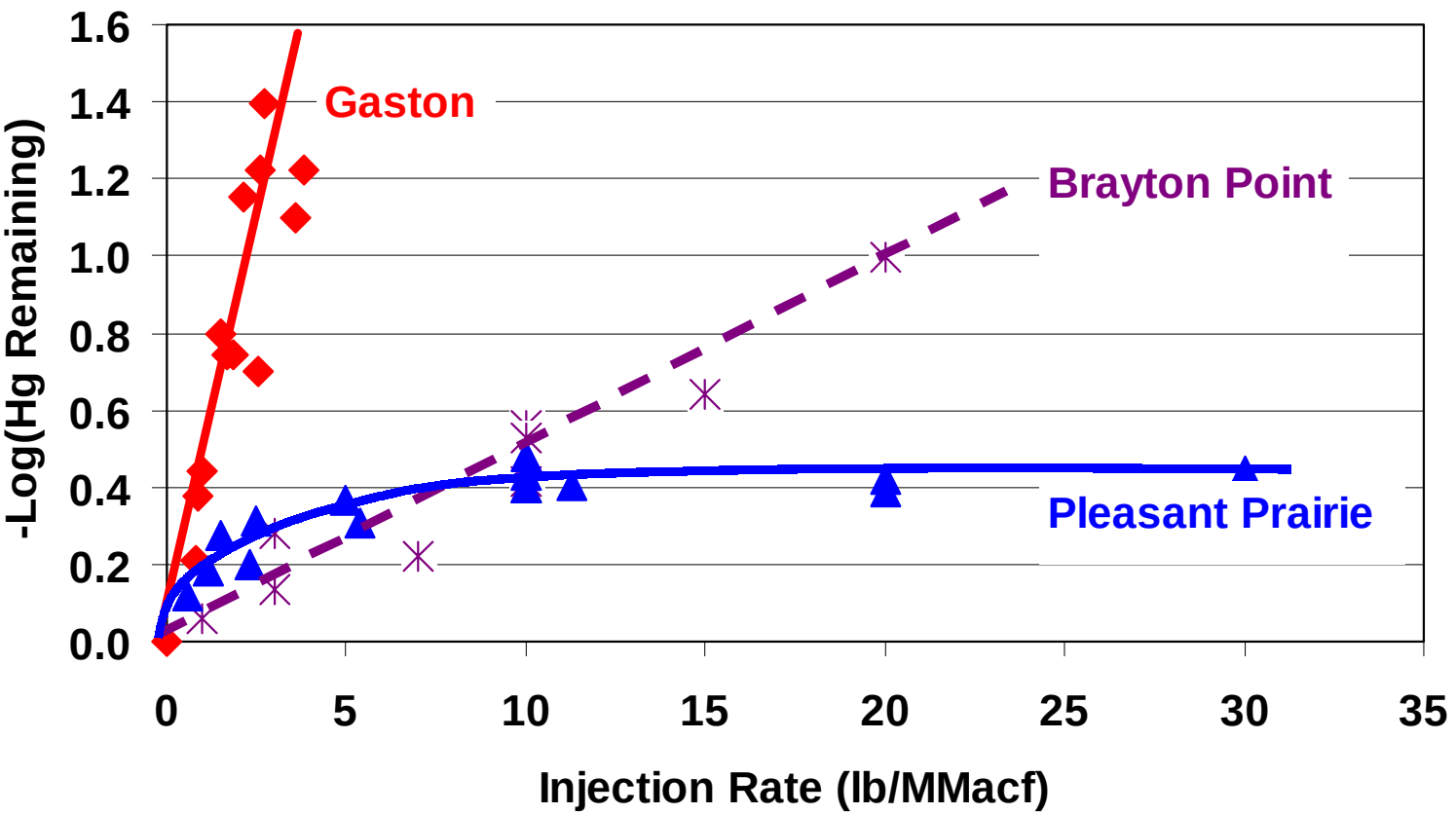
Preliminary Results with ACI from S-CEM Measurements at BP



Mercury Removal Trends with ACI



Mass Transfer is a 1st Order Rate Equation



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

	Pleasant Prairie	Gaston	Brayton Point
Coal	PRB	Washed Eastern Bit.	Eastern Bit.
Mercury (ppm)	0.11	.14	0.03
Hg in Flue Gas (ug/m^3)	17	15	1-3
Chlorine (ppm)	8	169	1000-4000
HCl (ppm)	≅1		150

Reasons to be Cautious in Extrapolating Preliminary Results from BP

- Bituminous coals present measurement challenges for S-CEMs
- Very low mercury concentrations in coal and flue gas (sorbent capacity and measurement issues)
- Unusual two ESPs in series configuration
- Exceptionally large ESP
- Documented variability in day to day performance

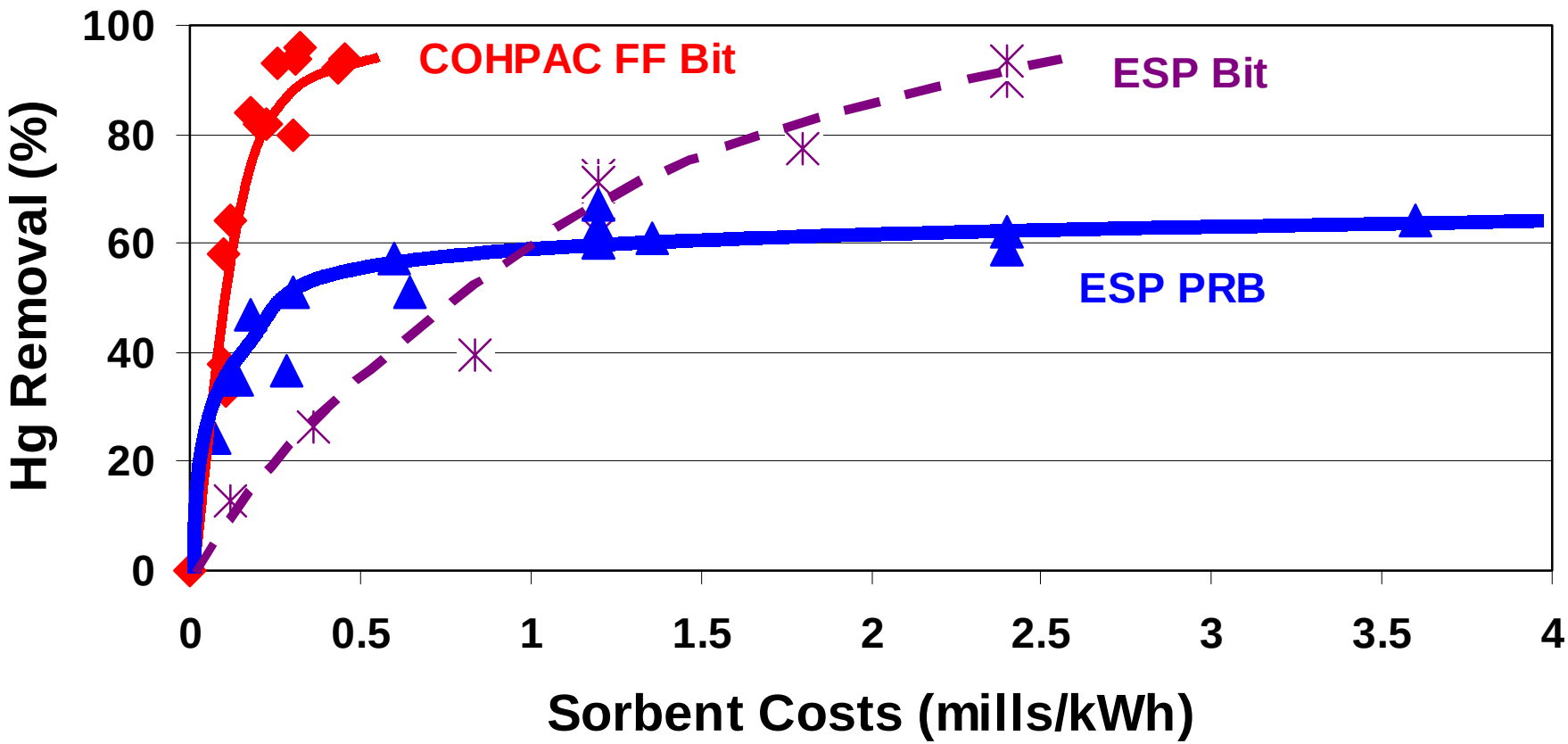
Spray Cooling and ACI

- At Pleasant Prairie, no improvement in mercury removal were observed when spray cooling by 50 ^{o}F
- Sorbents such as activated carbon have excess capacity and therefore are unlikely to benefit from spray cooling
- At Brayton Point, high levels of mercury removal were measured at ESP temperatures of 280-340 ^{o}F without cooling the gas
- Therefore, spray cooling should not be necessary for most applications of PAC injection
- May be beneficial when gas temperature is above 350 ^{o}F (i.e. lignite sites may require spray cooling)

Carbon-in-Flyash Issues

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

Comparison of Sorbent Costs for a Fabric Filter and ESPs



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Conclusions

- PAC injection can effectively capture elemental and oxidized mercury from both bituminous and subbituminous coals
- Additional field tests and long-term demonstrations are necessary to continue to mature the technology
- Fabric filters provide better contact between the sorbent and mercury than ESPs resulting in higher removal levels at lower sorbent costs
- New COHPAC FF's will have to be designed to handle higher loadings of PAC to insure high (>90%) mercury removal
- Coal characteristics appear to effect ACI performance with an ESP

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Future Plans

- **Short-term testing at additional sites**
  - **PG&E Salem Harbor (Bituminous coal, SNCR, large ESP) 9/2002**
- **Long-term testing**
  - **Alabama Power (Bituminous coal, COHPAC FF) 2002-2003**
  - ***CCPI Program (PRB Coal, COHPAC FF) 2004-2006**
  - ***CCPI Program (Bituminous Coal, FF) 2004-2006**

*** Proposed**