Large Scale Mercury Control Field Testing – Phase II

"Advanced Utility Mercury-Sorbent Field-Testing Program"

Progress Report - July 2005

DOE National Energy Technology Laboratory
Lynn Brickett, Project Officer

Sorbent Technologies Corporation
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Project Participants

Host Sites

- Duke Energy
- Detroit Edison

Project Contractors

- W. Kentucky Univ., (CMMs)
- Fuel Tech Inc. (CFD)

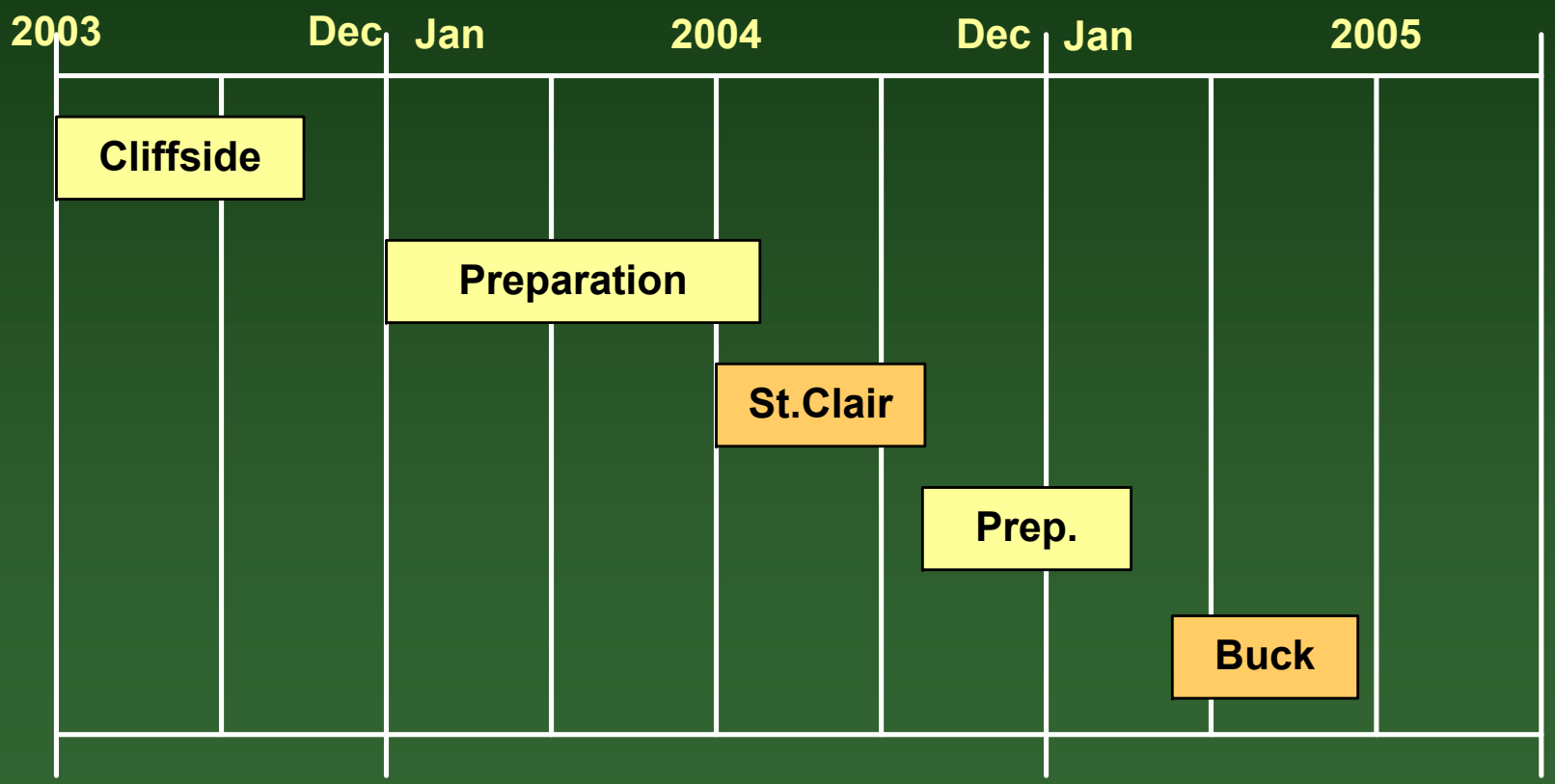
Field Test Partners

- PS Analytical Ltd. (Dry Converter)
- Spectra Gases (Hg Standards)
- Headwaters Clean Coal (Byproducts)

Unique Features

- Brominated PAC (B-PAC™)
- Subbituminous (85%) Blend
- Hot-Side ESP
- Field-Testing Partners

Schedule


2003
Dec
Jan
2004
Dec
Jan
2005
Cliffside
Preparation
St.Clair
Prep.
Buck

Detroit Edison – St. Clair Station

Southeast Michigan
Cold-Side ESP
290^{o}F
85 Sub/15 Bitum. Blend
80 MW
700 (580) ft^{2}/K acfm
0.06 ppm
Mostly Hg$^{(0)}$

Continuous Mercury Monitors (CMMs)

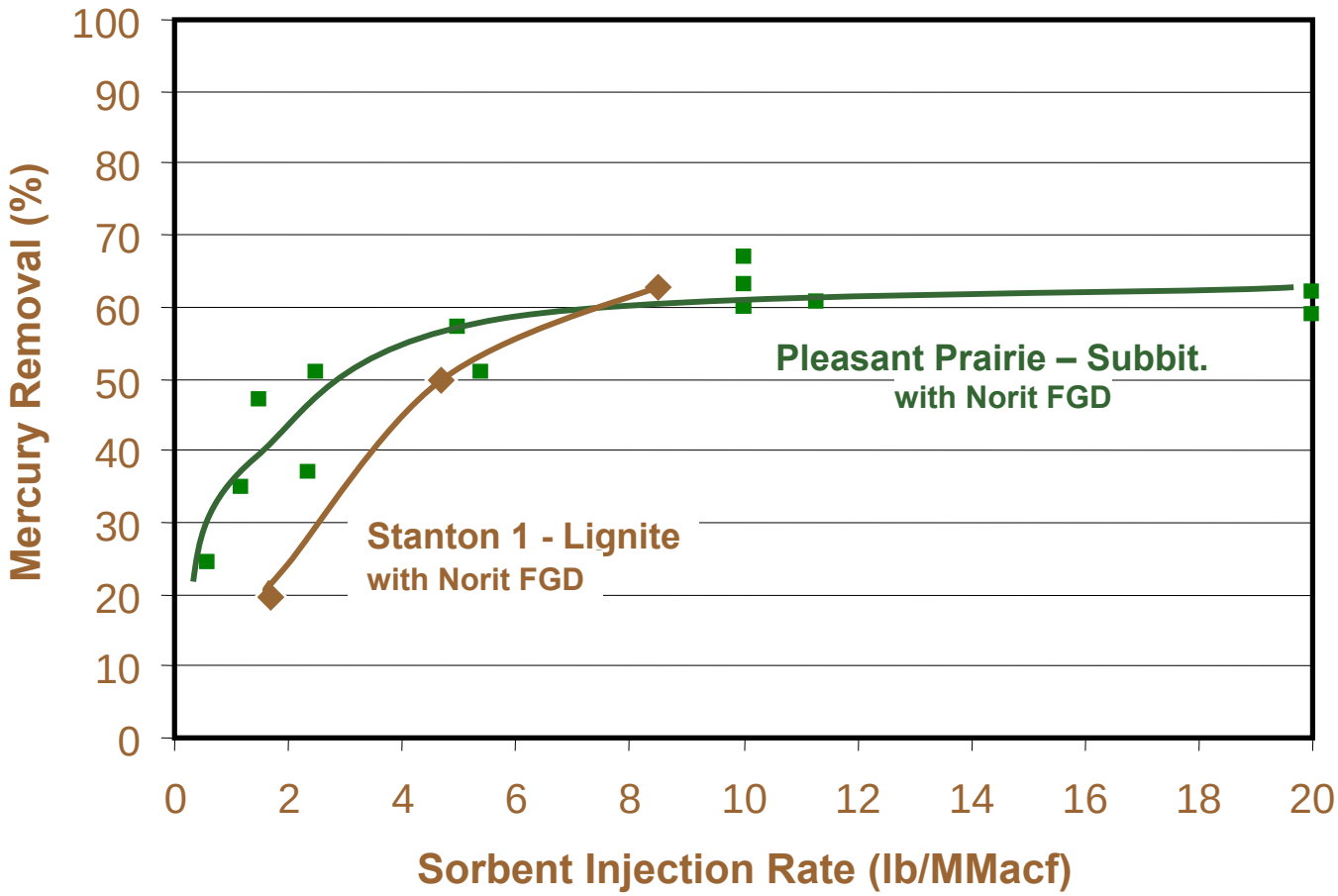
- 2 Latest PS Analytical Ltd. CMMs
  & an experimental Ohio Lumex unit
- Dual Wet/Dry $Hg^{(+2)}$ Converters
- Baldwin & Apogee Inertial Separators
- Also Ontario Hydro &
  Method 324 Hg Sampling
- Baseline Native Hg Removal: 0%–~30%

Injection Trailer & Instruments in Place

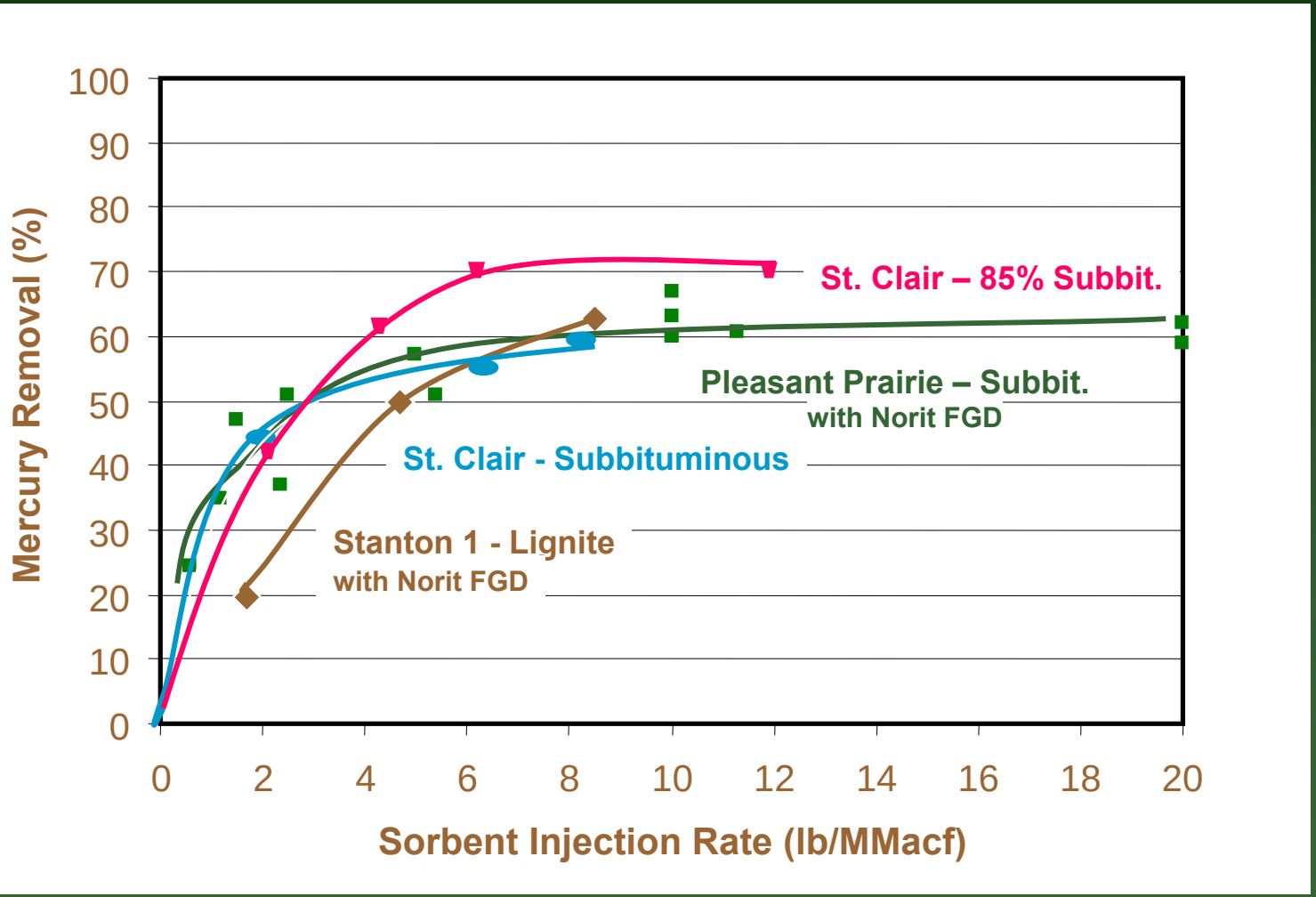
Mobile injection trailer (patent pending) in place.

ESP outlet Hg measurement.

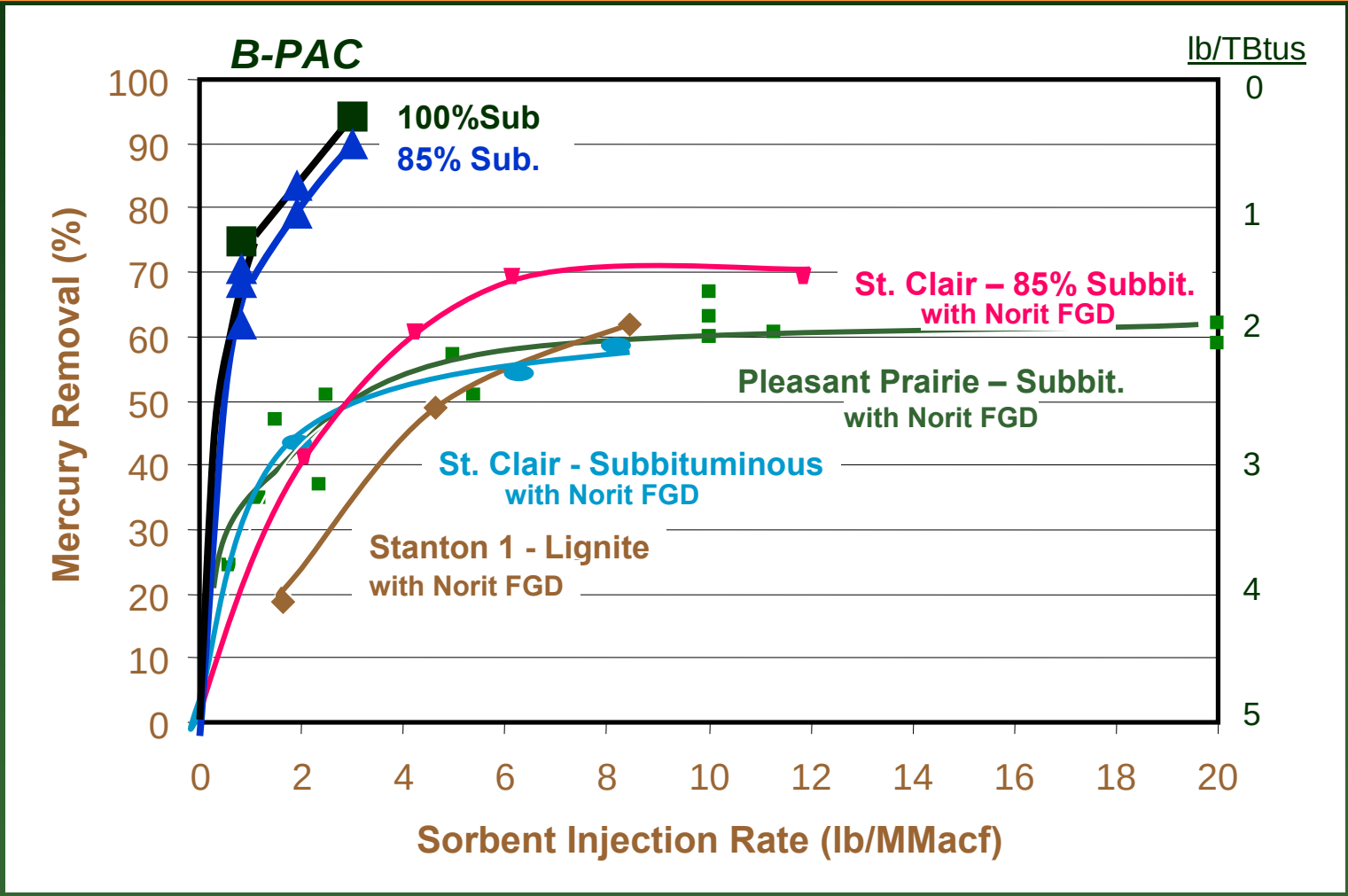
Western Coals with ESPs – Full-Scale



Western Coals with ESPs – Full-Scale

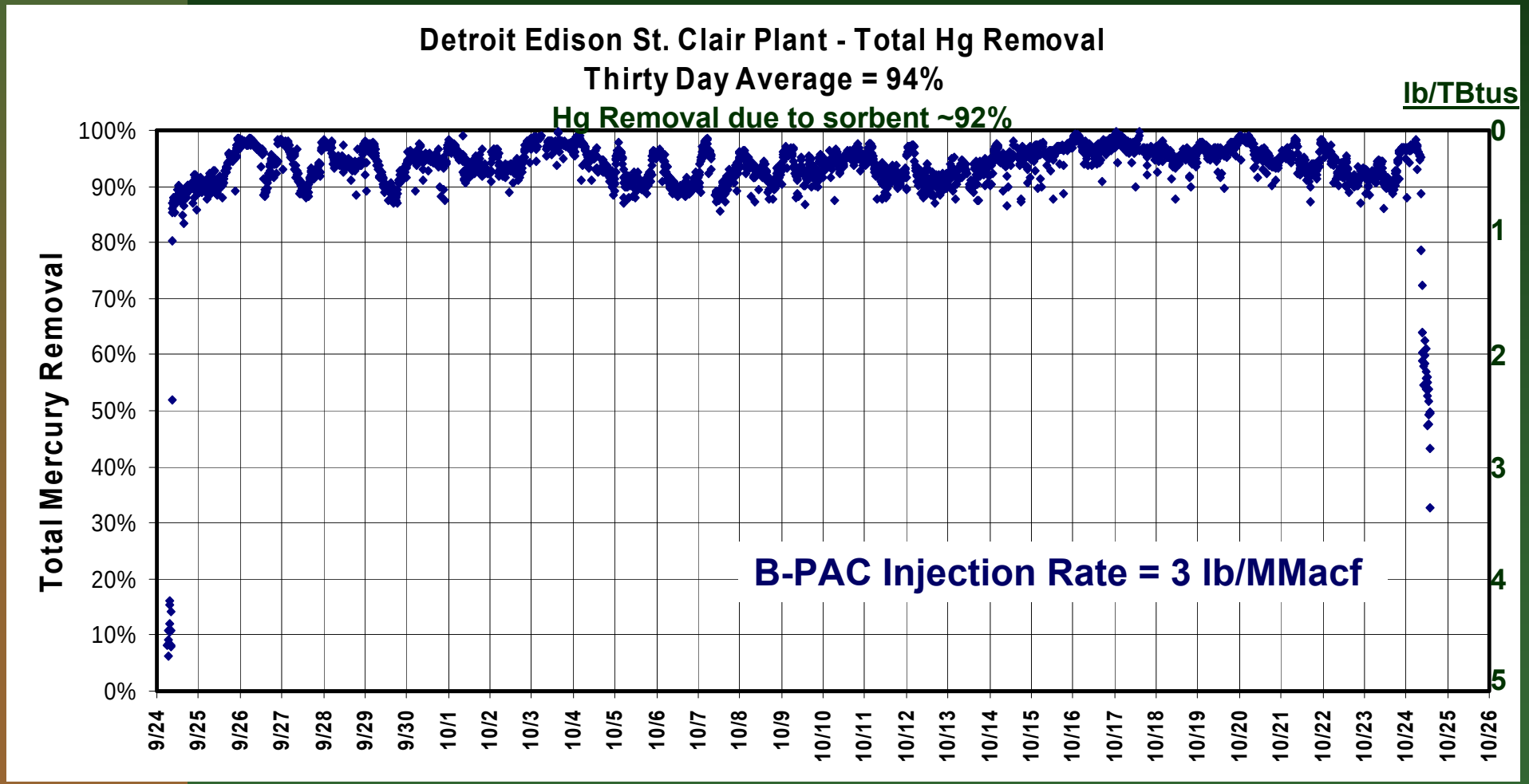


Western Coals with ESPs – Full-Scale

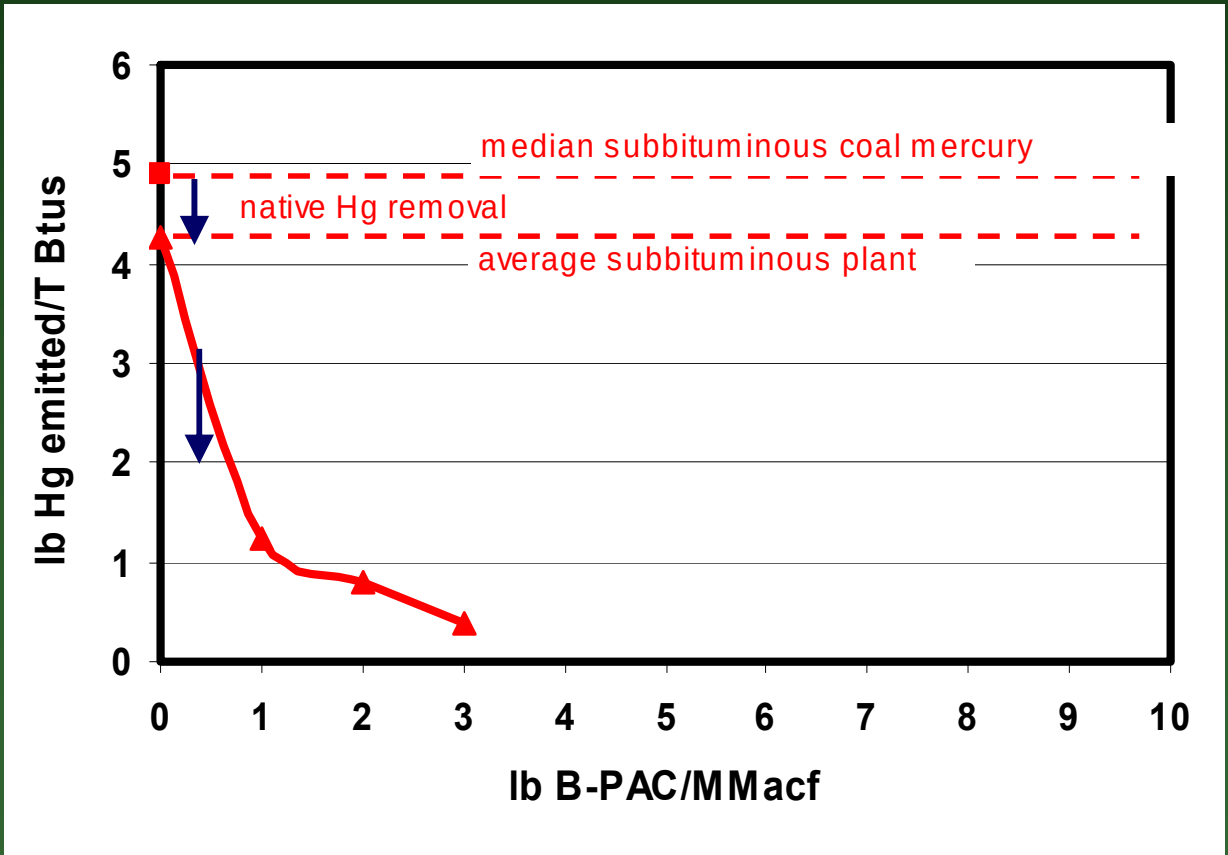


Long-Term Continuous B-PAC Run at St. Clair

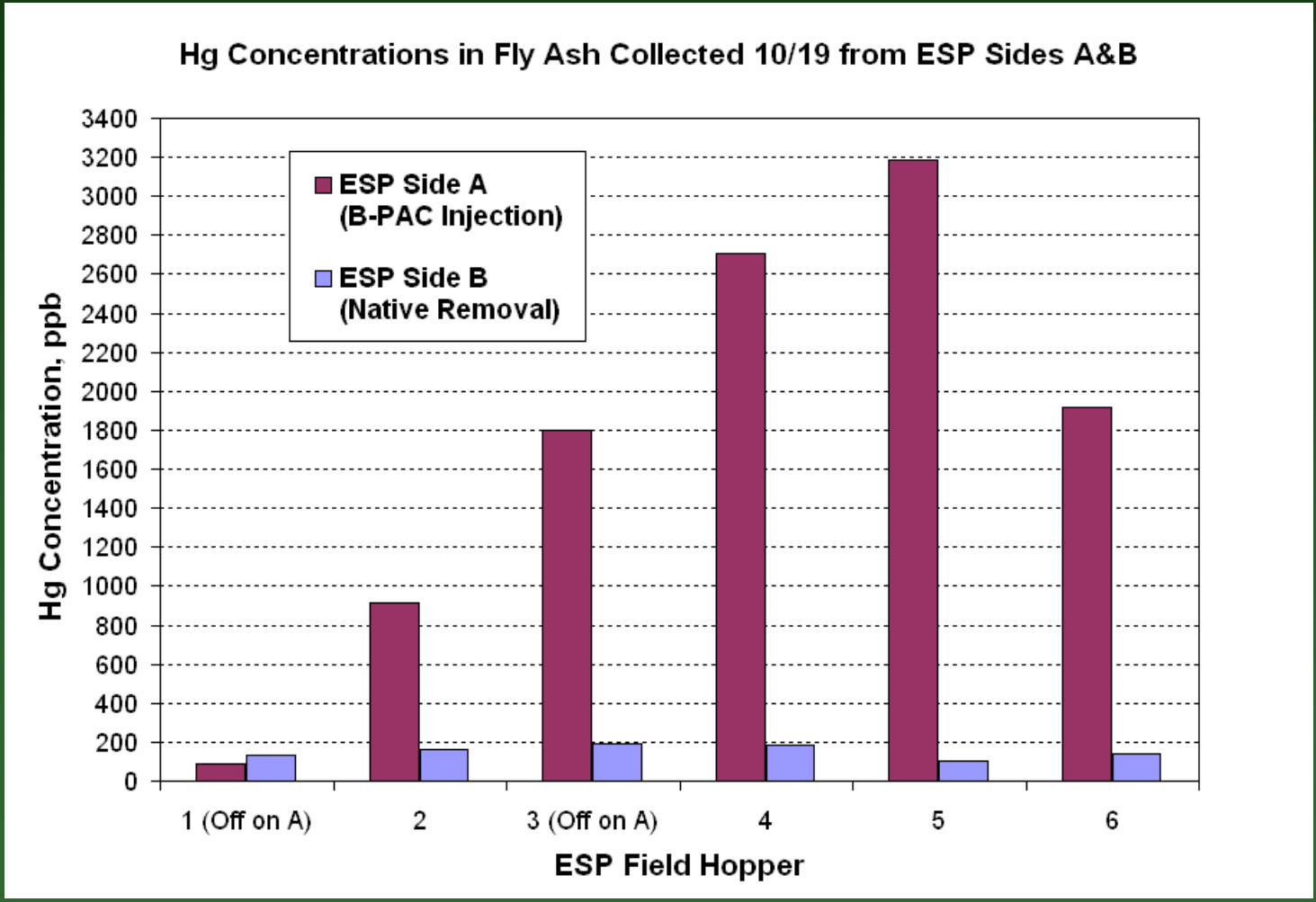
Thirty Day Average Mercury Removal = 94%



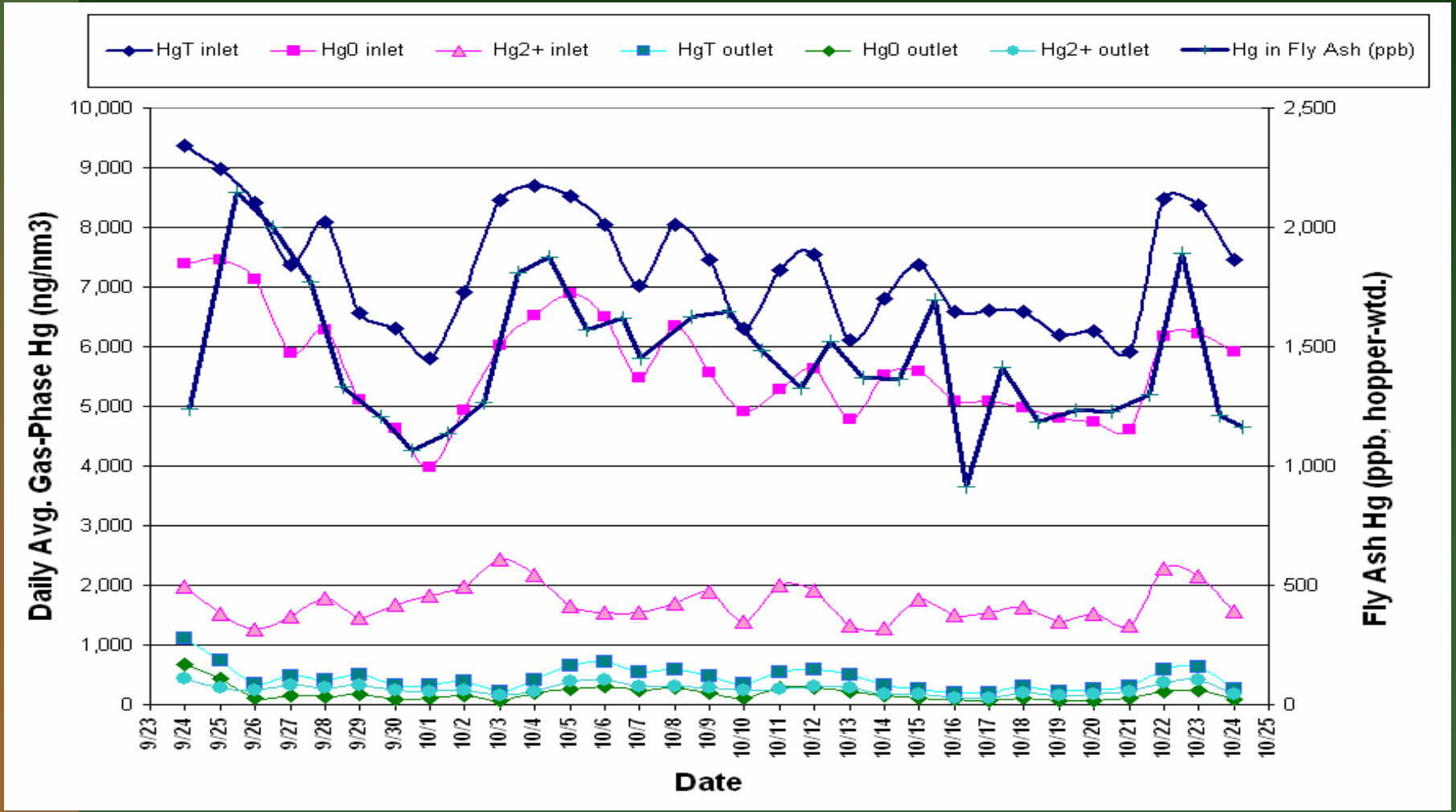
1-2 lb B-PAC/MMacf Gets to 1 lb Hg/T Btus



Mercury Sequestered in the Fly Ash

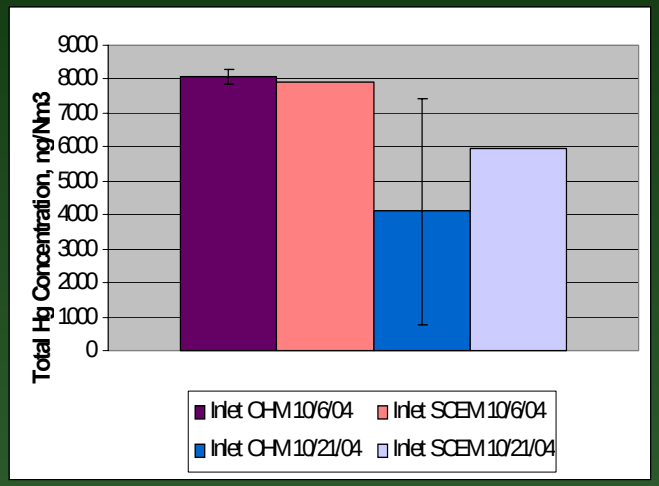


Fly Ash Hg Tracked CMM Hg Closely

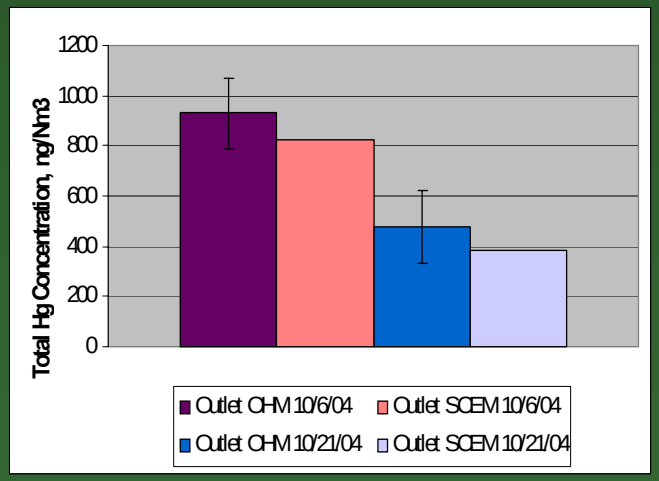


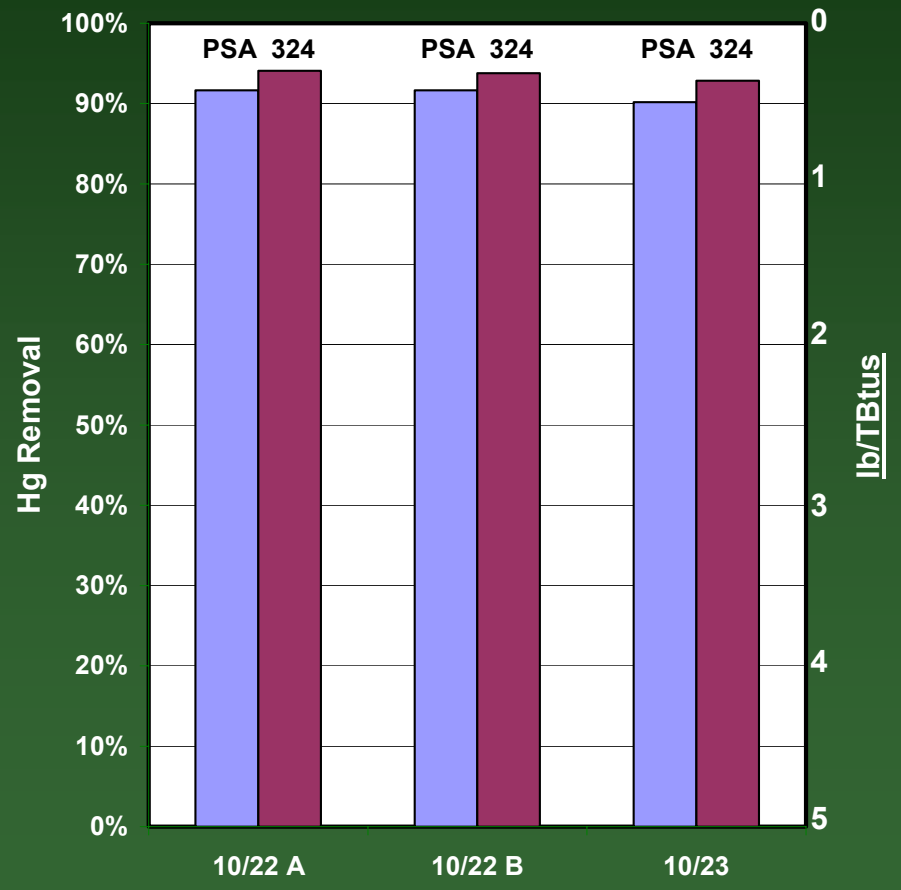
Ontario Hydro & Method 324 Verification

Inlet – Twice in Long-Term Run



Outlet – Twice in Long-Term Run





Cost Effectiveness with PRB at St. Clair

If 1 lb/MMacf of $0.75/lb B-PAC is injected into a CS-ESP with 7 µg Hg/Nm^3 provides 70% Hg removal:

$$\left(\frac{1lb\ sorbent}{1{,}000{,}000\ acf}\right)\left(\frac{Nm3}{(70\%)\,7\,\mu g\ Hg}\right)\left(\frac{\$0.75}{lb\ sorbent}\right)\left(\frac{1.5\ acf\ @\ 300F}{1\ scf}\right)\left(\frac{35.3scf}{Nm^3}\right)\left(\frac{10^9\ \mu gHg}{2.2\,lb\ Hg\ removed}\right)=\$3{,}700\,/\,lbHg.$$

Cost < $4,000 /lb Hg removed,

>90% cost reduction from the current technology baseline.

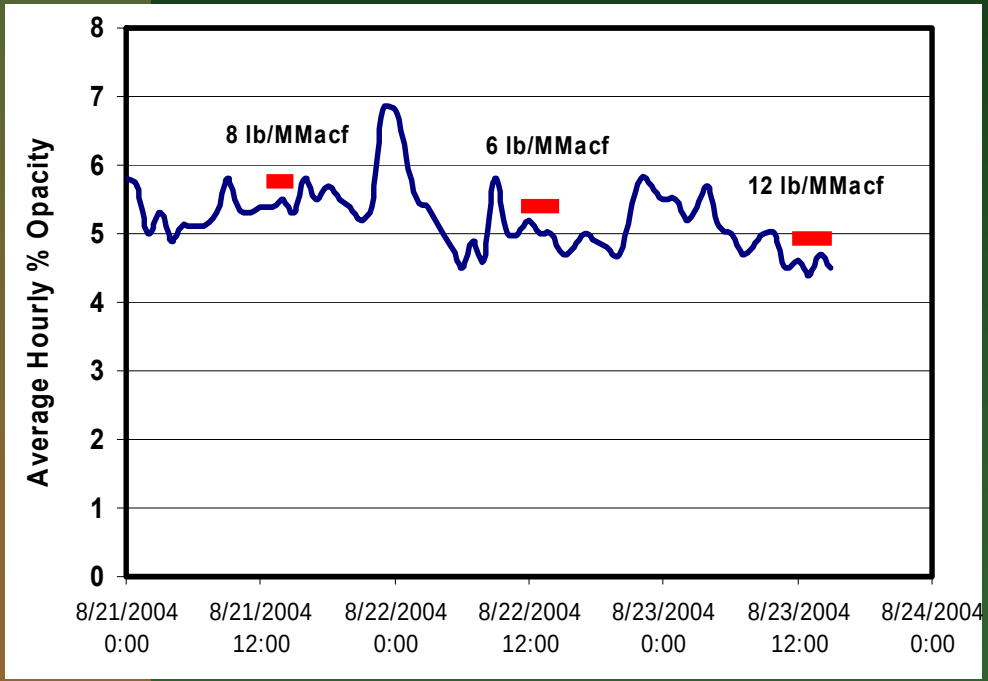
Similarly, if 3 lb/MMacf of B-PAC is injected into a cold-side ESP provides 90% Hg removal:

Cost < $10,000 /lb Hg removed,

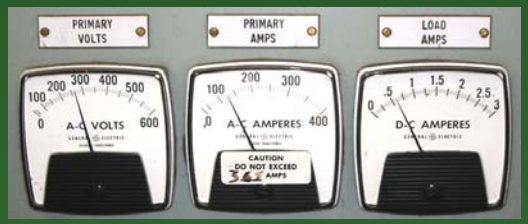
85% cost reduction from the current technology baseline.

No Balance-of-Plant Effects Observed

No Changes in ESP Performance



Never any Sparking. All Data at High Load.	Field	G-R Set Primary Volts Before	G-R Set Primary Volts During	Load on Wire Primary Amps Before	Load on Wire Primary Amps During	Load on Plate Load Amps Before	Load on Plate Load Amps During
B-PAC	2	220	210	100	80	0.35	0.35
6 lb/MMacf	4	290	290	150	150	0.80	0.80
85% Subbituminous	5	250	250	140	140	0.75	0.75
8/10/2004	6	270	270	150	150	0.75	0.75
Plain PAC	2	225	230	40	40	0.15	0.15
8 lb/MMacf	4	300	300	110	110	0.60	0.60
100% Subbituminous	5	220	220	90	90	0.35	0.35
8/21/2004	6	290	290	150	150	0.75	0.75



No Leachate Hg

B-PAC in the fly ash had net adsorption of Hg from the leaching solutions

No Balance-of-Plant Effects Observed

Very low off-gassed bromine.

Method 26A Results – All data in ppm.

No Br_2 was ever detected.

Without Sorbent	Baseline 07/28	Inlet–Long-Term 10/21
HF	1.0	0.4
HCl	8.1	3.6
Cl_2	<0.1	0.3
HBr	0.1	<0.1

B-PAC 3lb/MMacf	Parametric 09/09	L-T 10/06	L-T 10/21
HF	2.2	0.1	0.4
HCl	5.9	6.0	4.3
Cl_2	0.1	0.2	0.4
HBr	1.0	0.3	0.2

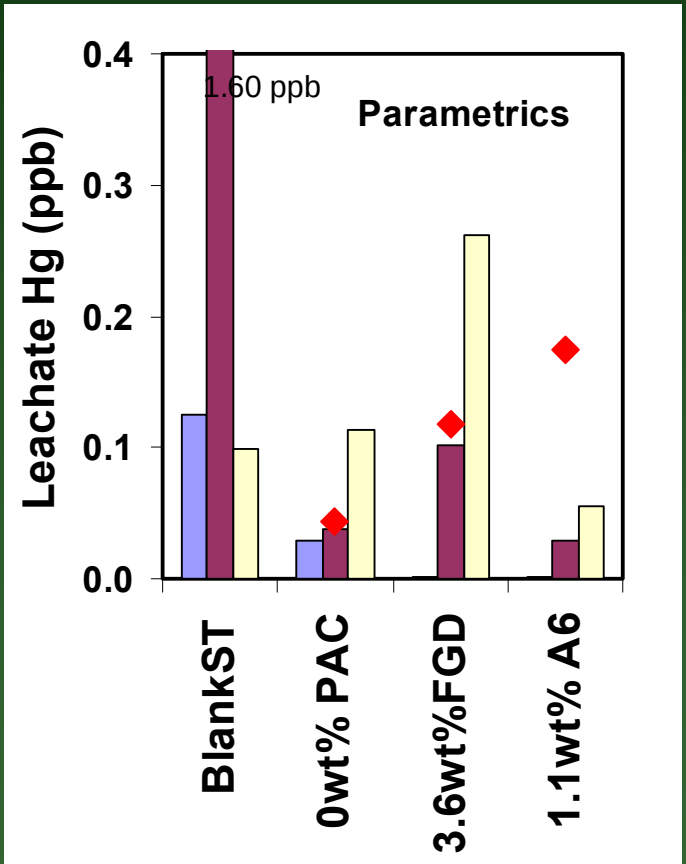
Carbon Steel Corrosion Coupons

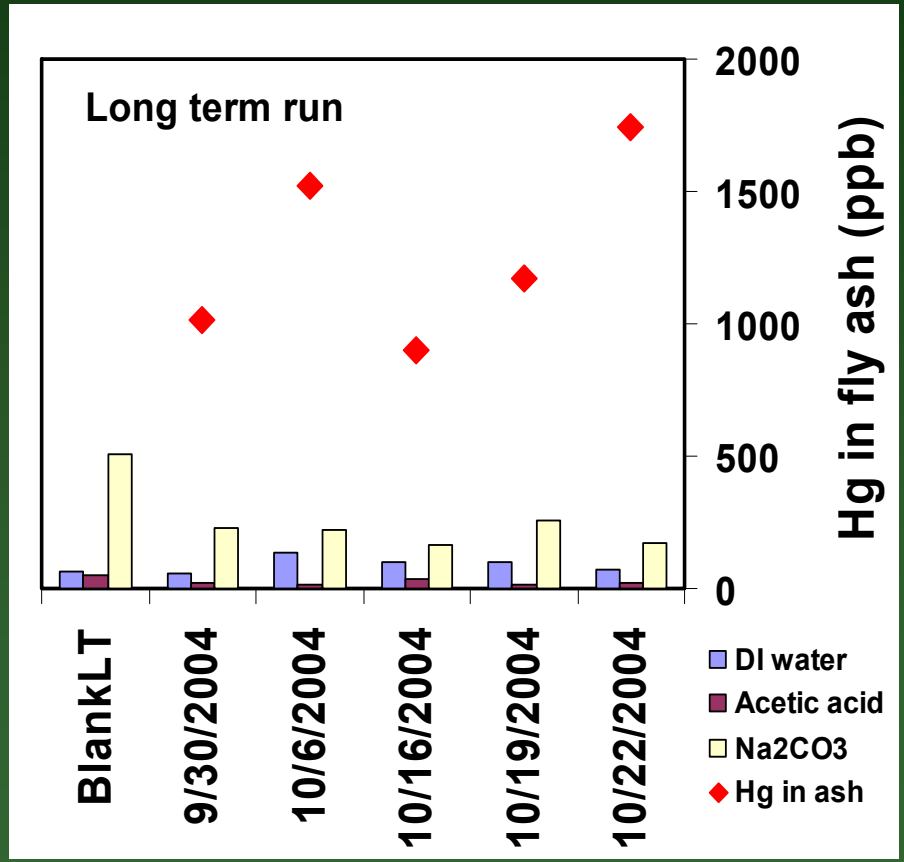
(4 each, 30 days)

	Avg. ∆Wt.
Baseline	**+0.13%**
B-PAC	**+0.13%**

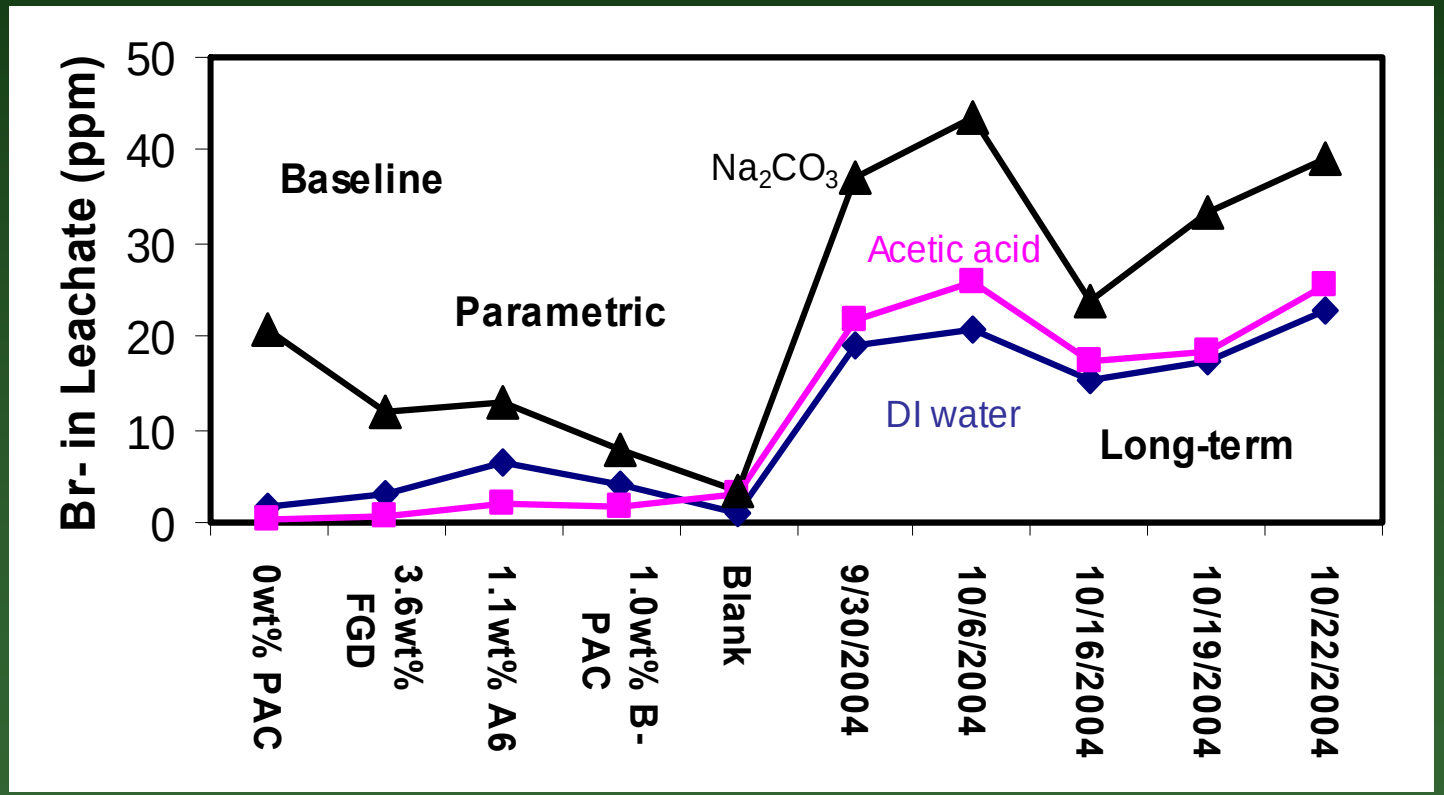
No corrosion detected.

Hg Is Not Leachable





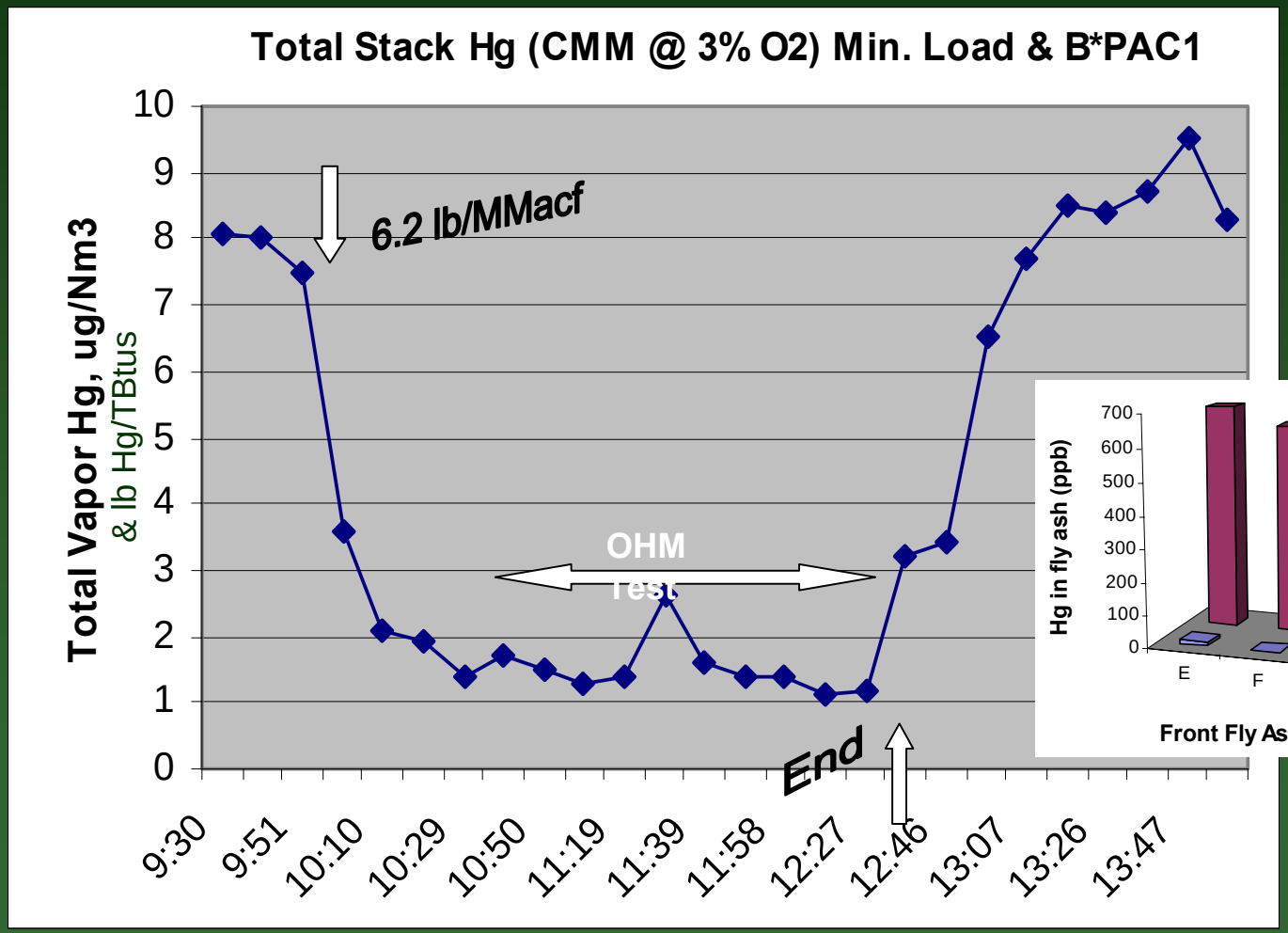
Leachate Br- from St. Clair Fly Ash



Hot-Side Testing at Duke's Cliffside Plant

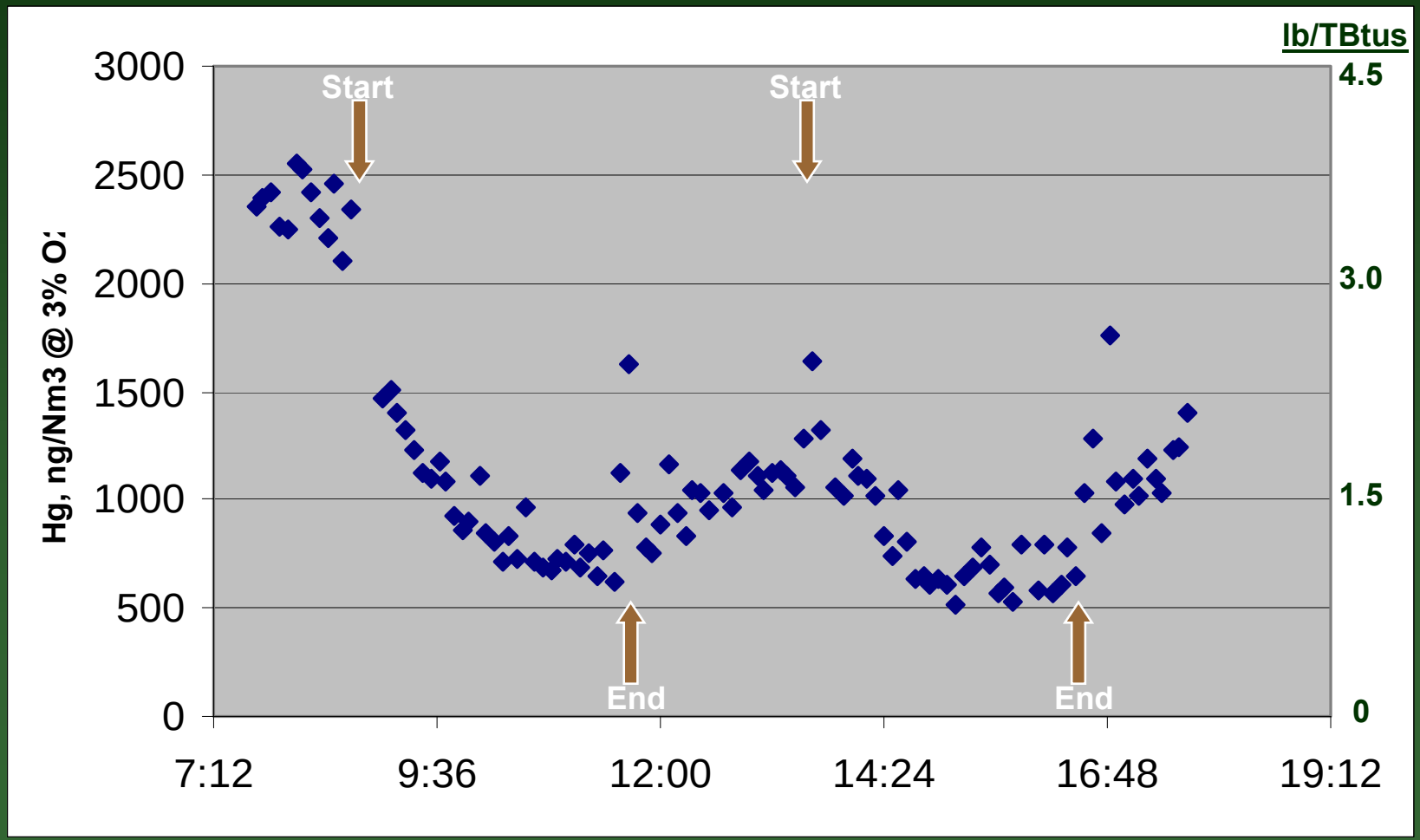
Coal Type:	Low-S Bitumin.
Boiler:	No. 2 (Unit 2)
Boiler Type:	Tangential
Particulates:	Hot-Side ESP
ESP Stream Size:	40 MWe
ESP Inlet Temp.:	700^{o}F
SCA :	240 ft^{2}/K acfm
Avg. Coal Hg:	0.08 ppm
Avg. Coal Cl:	500 ppm

Cliffside 2003 Results
H-PAC at 6.2 lb/MMacf

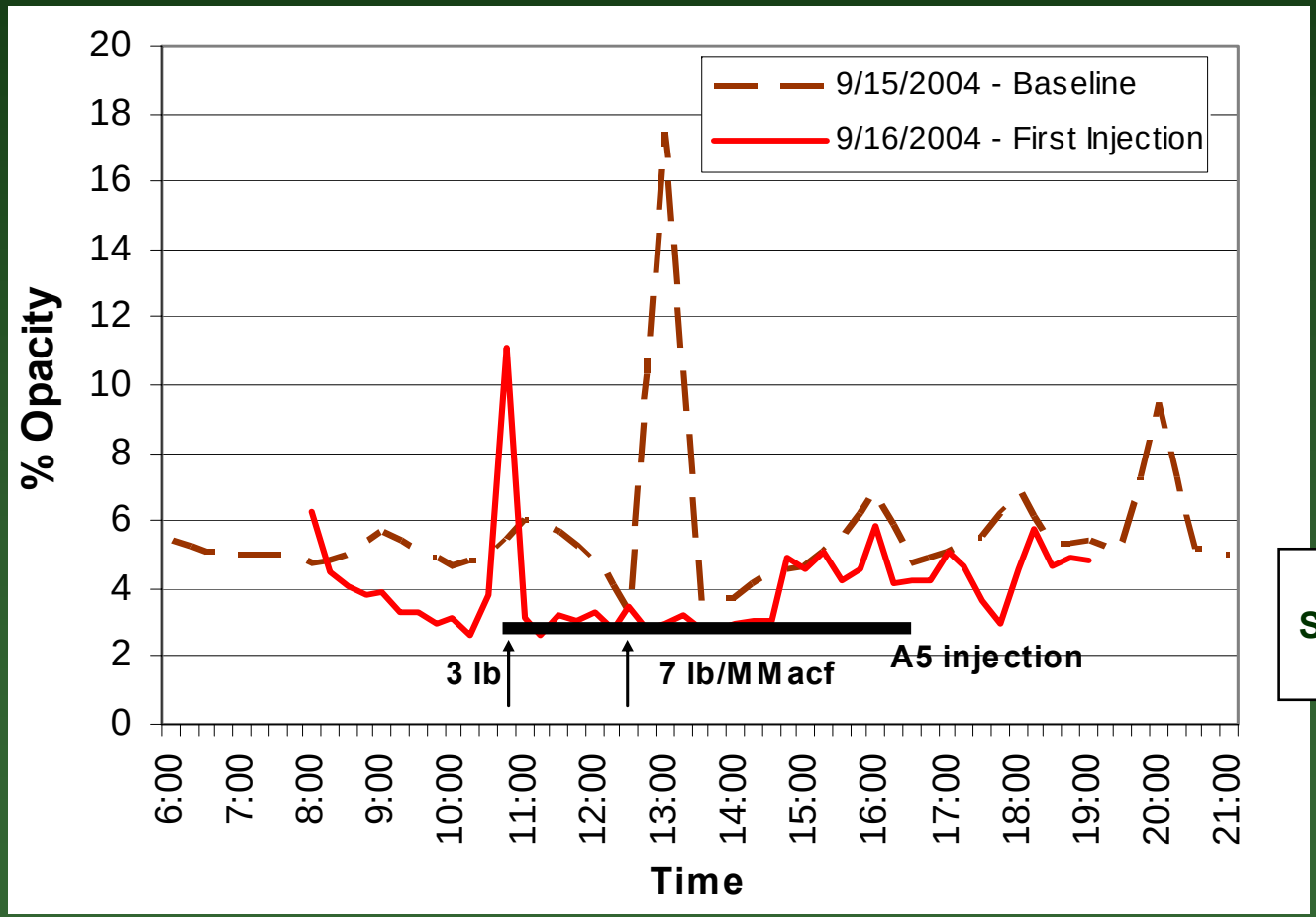


Cliffside 2004 Results – Two B-PAC Sorbents

H-PAC at 5.0 lb/MMacf @ Min. Load



Balance-of-Plant Effects: Opacity



SCA=240 ft2/K acfm

Duke Energy – Buck Plant – Hot-Side ESP

North Carolina
Hot-Side ESP
640^{o}F Inlet
Low-S Bituminous
½ x140 MW (~100MW)
240 ft^{2}/K acfm SCA
~ 0.06 ppm Hg
~ 5.4 µg/Nm^{3} @ O_2
~ 60-80% $Hg^{(+2)}$

Parametric Tests

Preliminary Results

Boiler Load	Inj.Temp.	lb/MMacf	H-PAC1 % Removal	H-PAC2 % Removal
60 MW	540F	4.0	56%	65%
60 MW	540F	7.0	57%	63%
100 MW	590F	2.0	54%	44%
100 MW	590F	5.0	62%	N.D.
100 MW	590F	7.0	63%	62%
140 MW	640F	7.0	64%	54%
140 MW	640F	7.0	3%	Norit FGD

Preliminary Conclusions from Parametrics

- essentially no native Hg removal
- essentially no Hg removal with plain PAC
- generally 50-65% removal at 2-7 lb/MMacf
  with both H-PACs
- gas temperature & load appeared to have little affect
- Hg removal appeared to plateau with injection rate

Long-Term Testing

- 30 days, but periodic shutdowns
  - boiler tube leak, 2 flameouts, etc.
  - coal went to ~20% ash
  - some inertial-separator or analyzer outages

- boiler switched to low-NOx mode/OFA
- switched inlet monitoring to untreated outlet
- difficulty in getting representative ash samples
- M324s + 3 days of Apogee co-measurement + OHMs

Long-Term Test

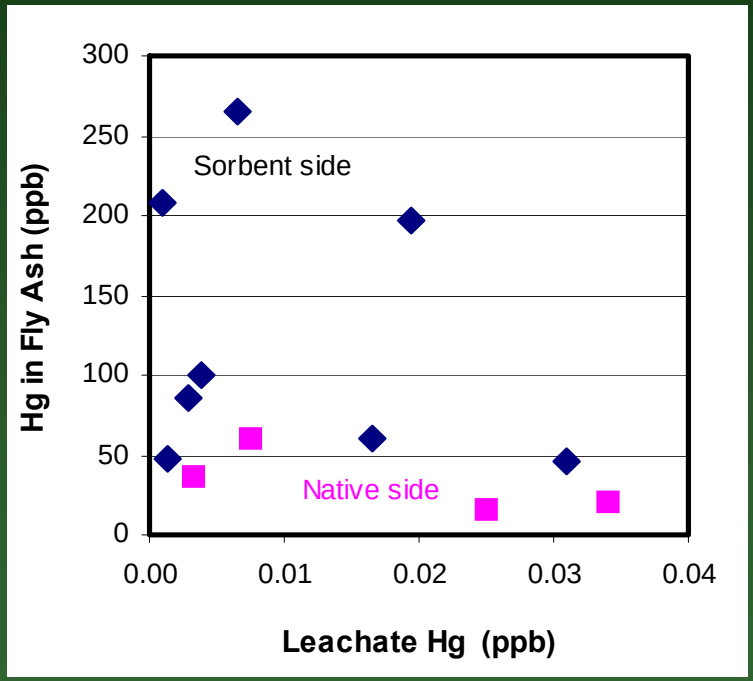
Preliminary Results

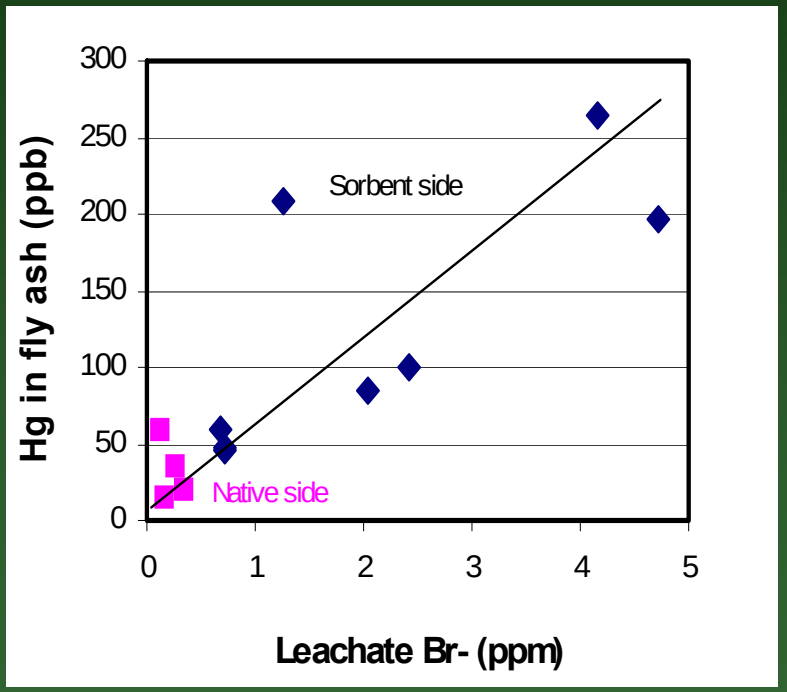
- **H-PAC1 injected at 5 lb/MMacf (~ 3.5 lb/MMacf)**

Load	Inj.Temp.	lb/MMacf	Time Fraction	Wtd.Avg. %Remov.	lb/TBtus
60 MW	~ 540F	5.0	28%	49%	3.0
140 MW	~ 640F	5.0	50%	50%	3.0
60 MW	~ 540F	10.0	22%	71%	1.8

Hg & Br Leachates at Buck

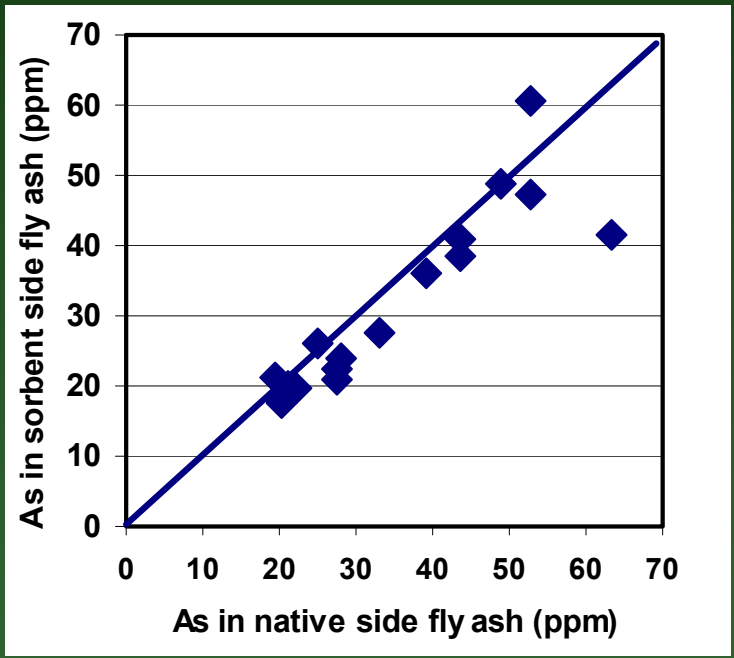
Preliminary Results

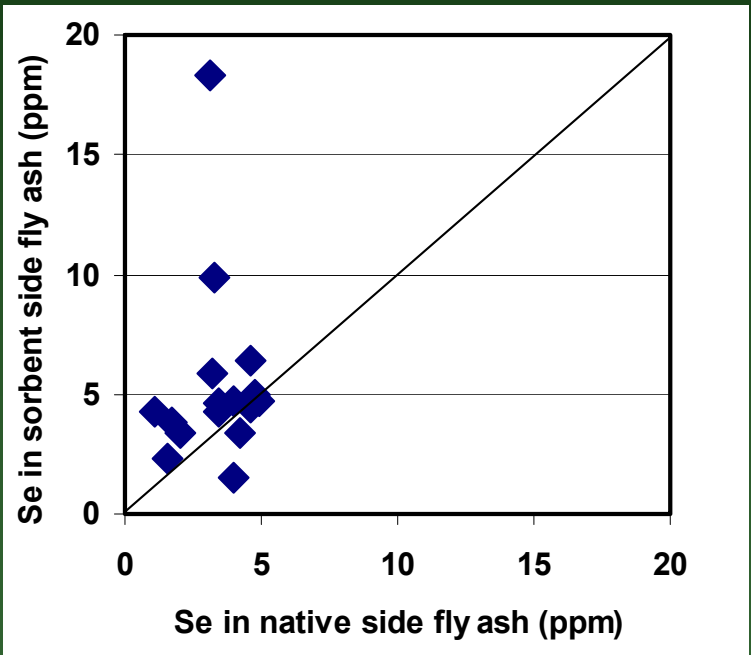




As & Se Concentration at Buck

Preliminary Results





The B-PAC & H-PAC Were Supplied in Bulk

- Our first B-PAC™ plant can serve numerous power plants

Future DOE B-PAC, C-PAC, & H-PAC Demos

(plus additional short-term non-DOE trials at other utility sites)

Conclusions

1. Judging from the 2004 DOE full-scale results at St. Clair (& Meramec, Holcomb, & Stanton 10) – and contrary to regulations & popular belief – a high level of retrofit Hg control with subbituminous coal & N.D. lignites appears relatively easy, inexpensive, & is available today.

2. While ACI is more difficult with hot-side ESPs, with Brominated PAC it is indeed possible.