Large Scale Mercury Control Field Testing – Phase II

"Advanced Utility Mercury-Sorbent Field-Testing Program"

Progress Report - July 2004

DOE National Energy Technology Laboratory
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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

Two Long-Term Test Sites

Detroit Edison

1 → St. Clair Station
Subbituminous (85%)

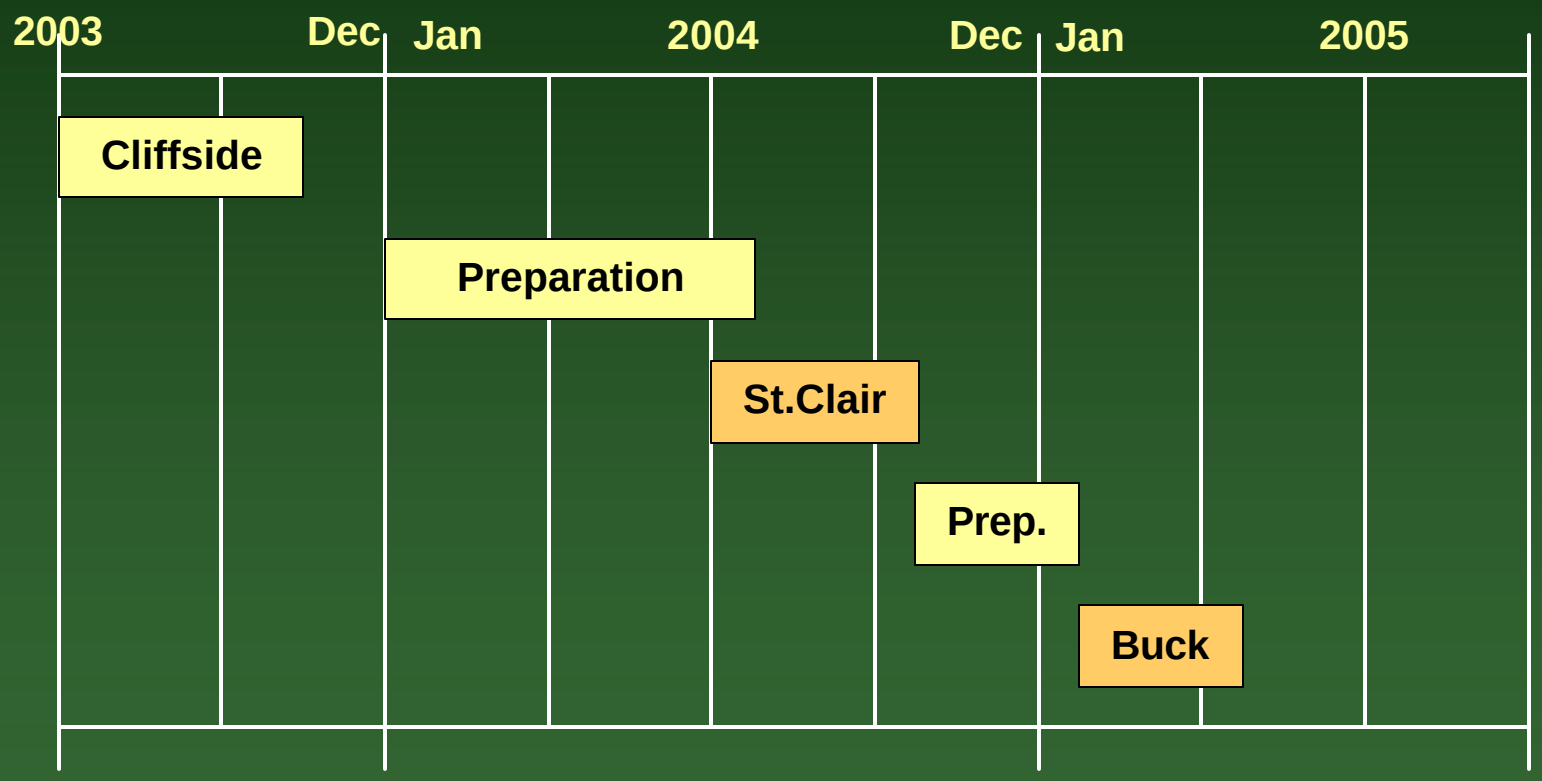
Duke Energy

Trial → 2 → Buck Plant
Hot-Side ESP/Bitum.

2 → (Allen Plant)
(Low SCA/Bitum.)

Cliffside Plant
Hot-Side ESP

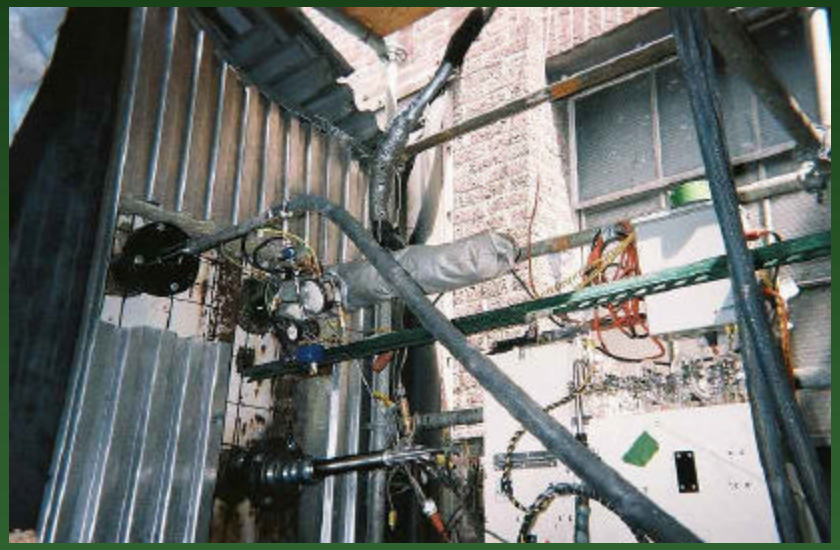
Schedule


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

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°F
SCA :	240 ft^2/K acfm
Avg. Coal Hg:	0.08 ppm
Avg. Coal Cl:	500 ppm

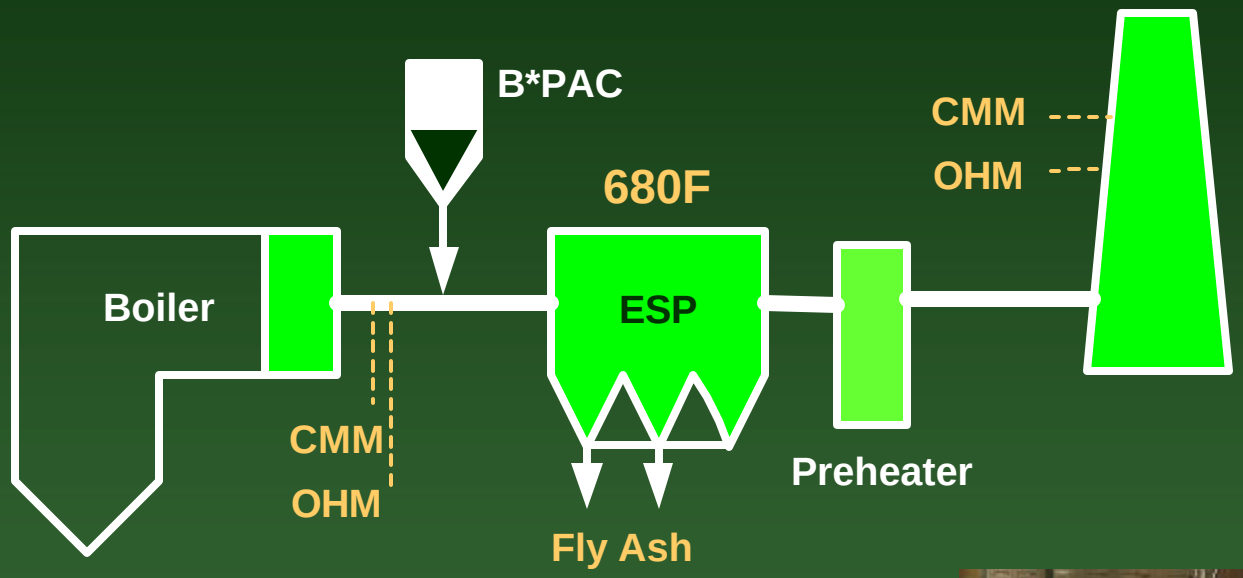
Cramped Retrofit & Uneven Flow



Test Plan

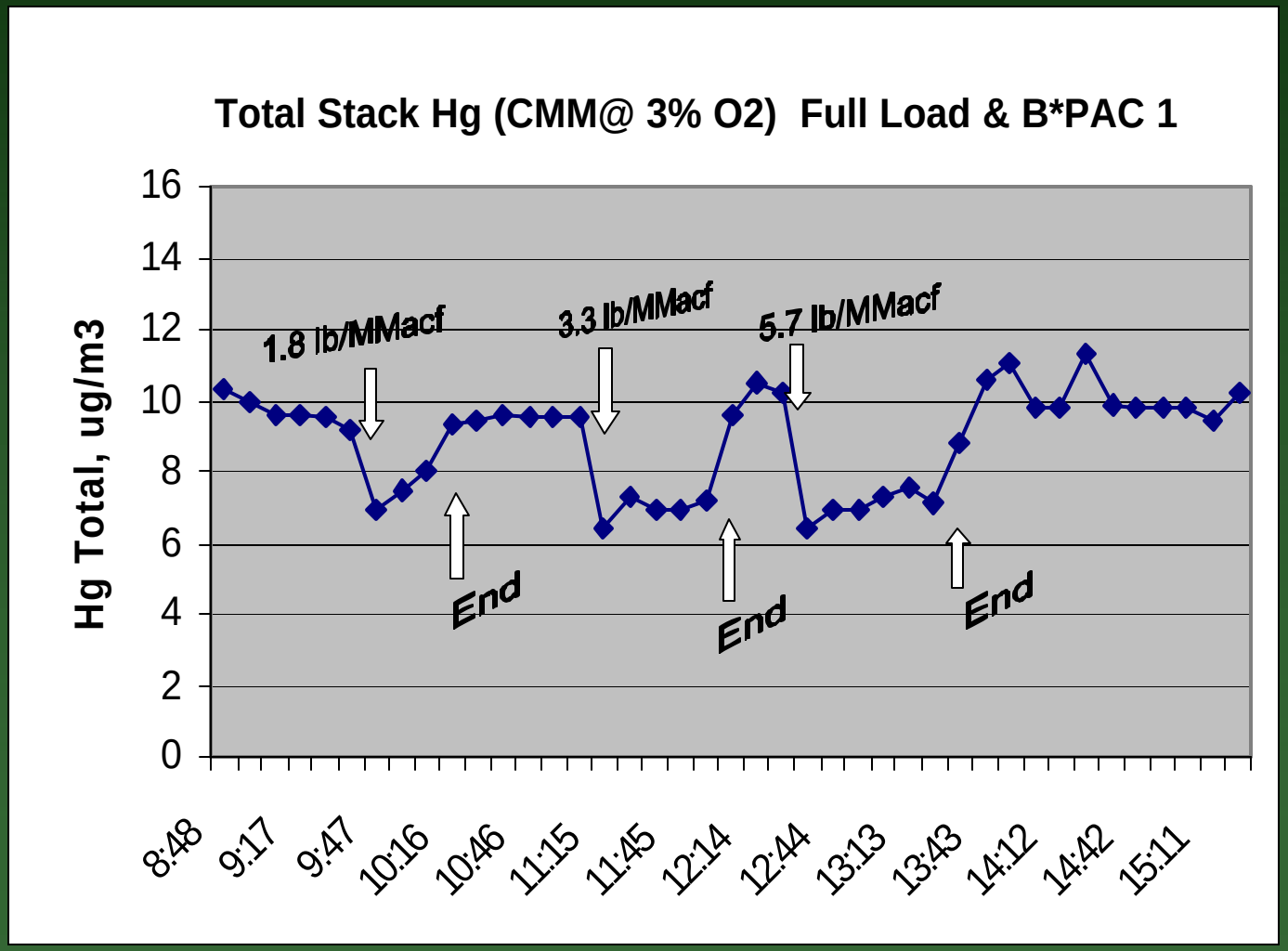
- Baseline Hg removal
- Parametrics with B-PAC™
  - variations in B-PAC production
  - injection rates
  - plant operating conditions
- Consistent coal & conditions
- Very short-term “qualification” tests
- Also looked at Plant Effects
  - ESP performance, opacity, LOI, leachates

Measurements & Baseline

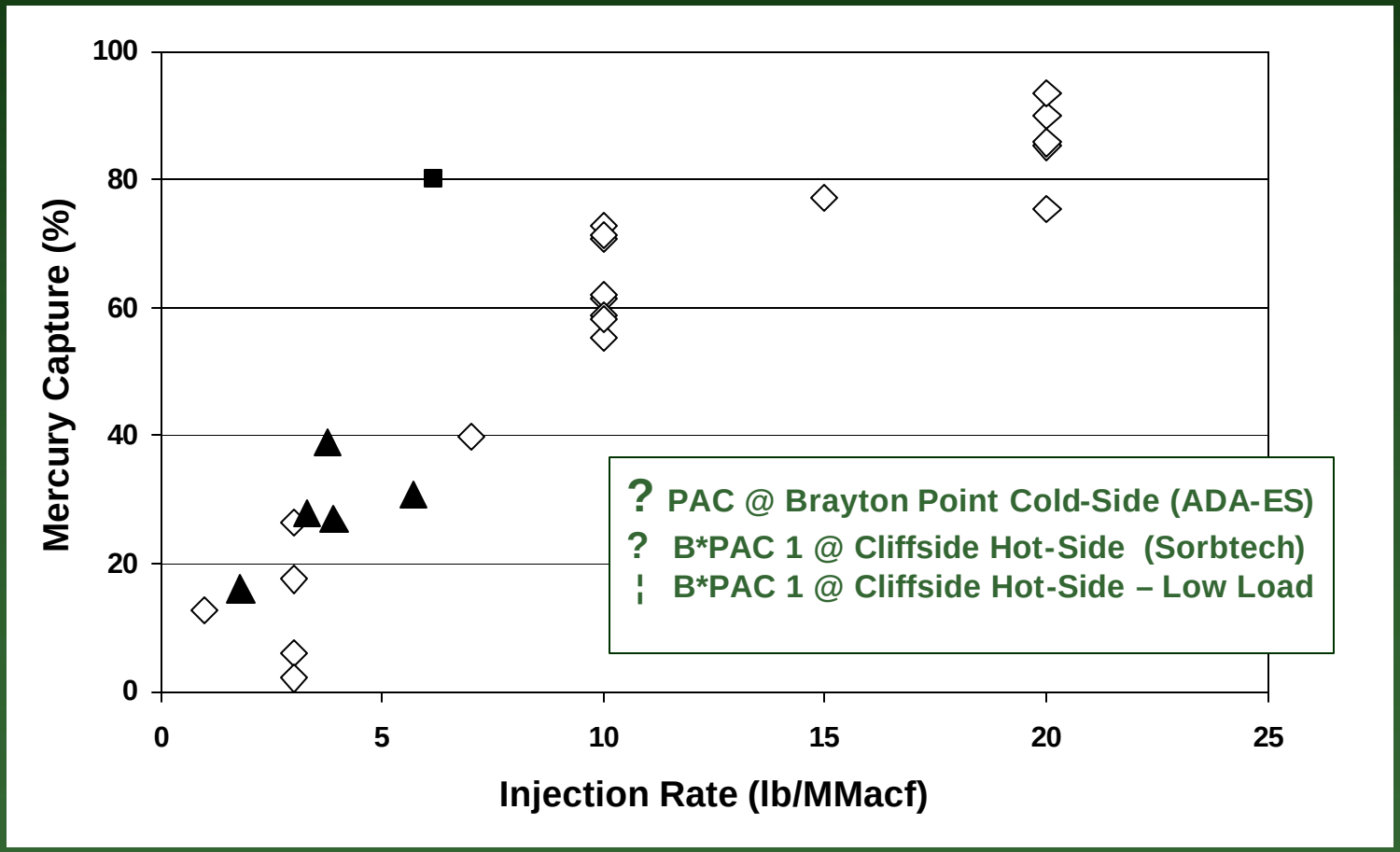


Baseline Mercury:	~9 ug/Nm3 Hg(+2)
	~1 ug/Nm3 Hg(0)
	0 ug/Nm3 Hg(p)
Baseline Hg Removal:	0% - 4%
PAC (Norit FGD) @ 11 lb/MMacf	0%

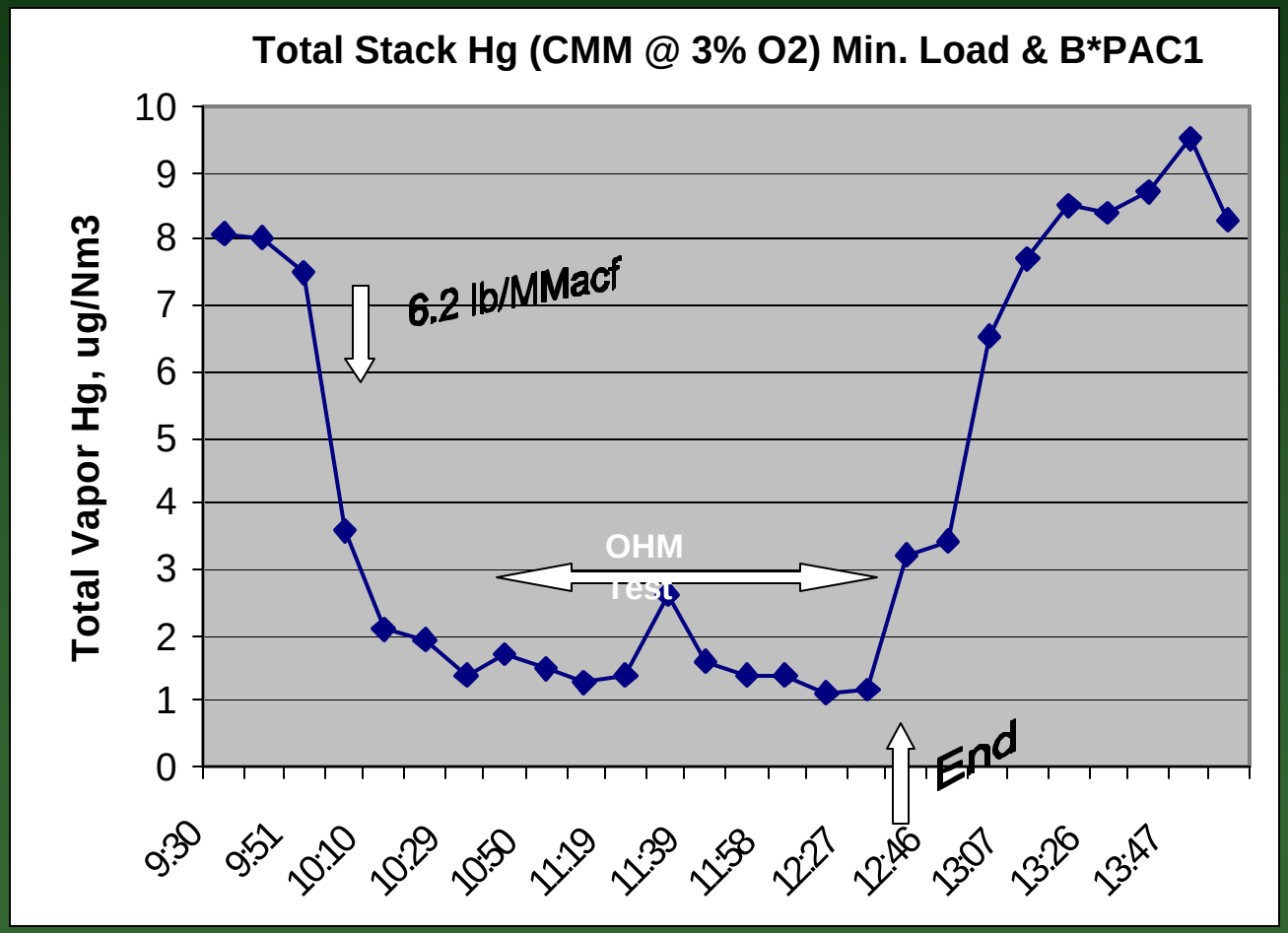
WKU's PS Analytical CMM Results



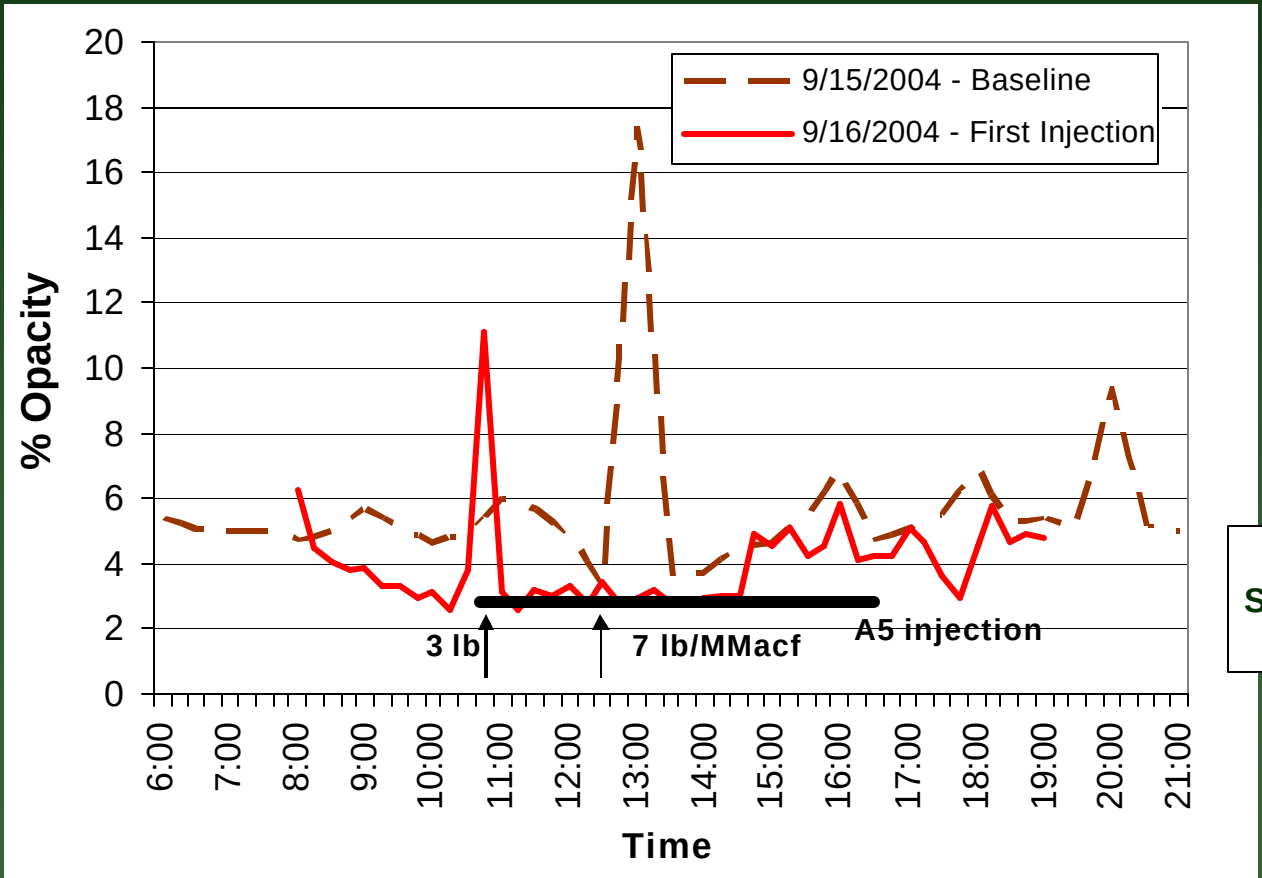
Performance Similar to a Cold-Side



Operating Condition Variation



Balance-of-Plant Effects: Opacity



SCA=240 ft2/K acfm

Balance-of-Plant Effects: Wastes

Toxic Characteristic Leaching Procedure
(fly ash with 620 ppb Hg – 80% removal)

Fly Ash + B*PAC 1	0.49 µg/L Hg
Extraction Solution Blank	0.42 µg/L Hg
EPA Drinking Water Std.	2.00 µg/L Hg

Sluice Water to Ash Pond
(during run with 80% Hg removal)

Sample Average	< 0.005 µg/L Hg

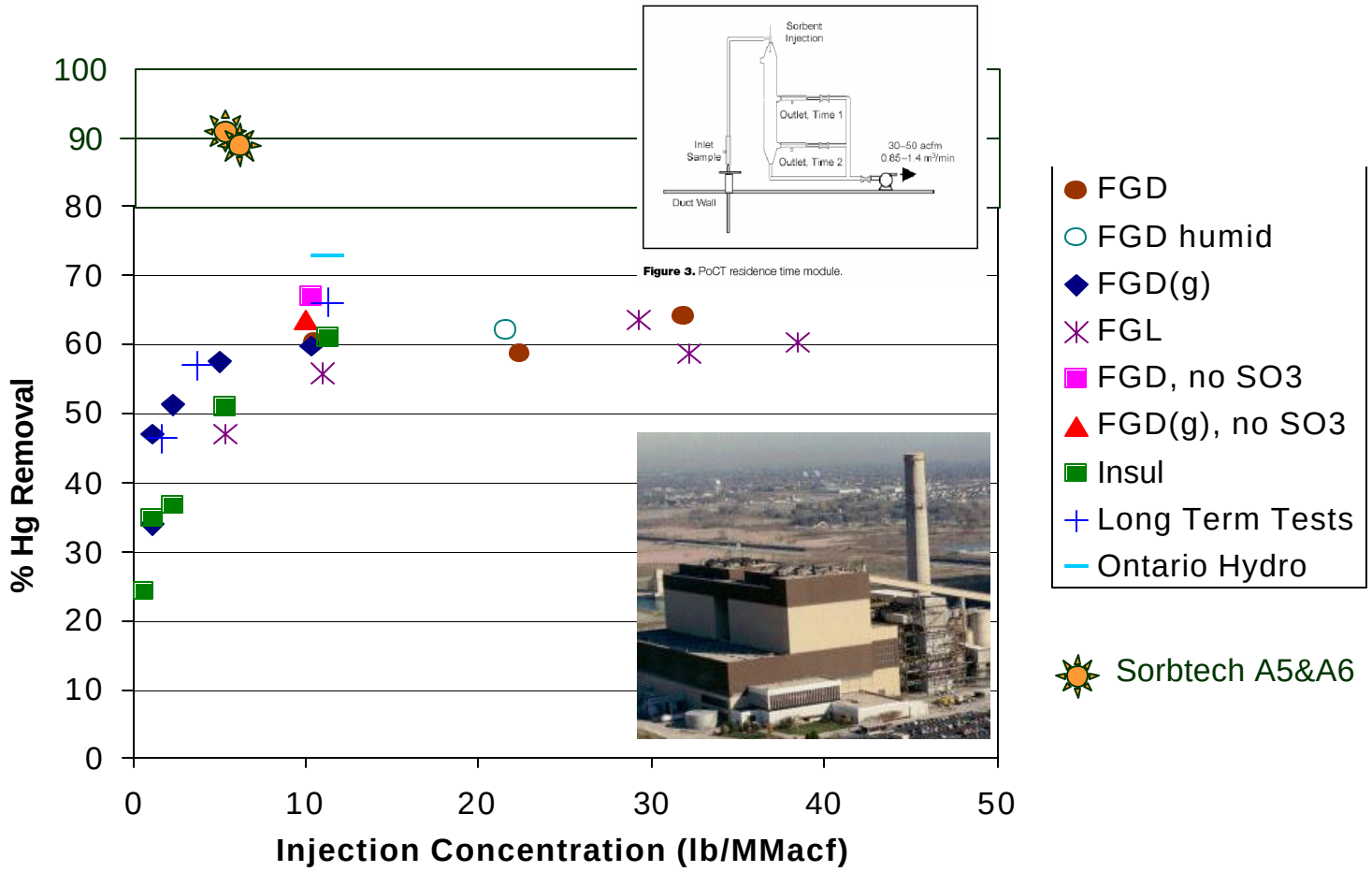
Duke Energy – Buck Plant – Hot-Side ESP

North Carolina
Hot-Side ESP
700°F Inlet
Low-S Bituminous
140 MW (~200MW)
240 ft^{2}/K acfm SCA
0.06 ppm Hg
Mostly $Hg^{(+2)}$

Cold-Side Testing at DTE Energy's St. Clair

- Qualification Testing
- Baseline Testing
- Parametric Testing
- Long-Term Testing (24 x 30)
- Support Activities

Qualification Testing
Pleasant Prairie – ADA-ES & Recent Apogee



B-PAC Cost Effectiveness

- For Subbituminous & Lignite with an ESP:

If 4 lb/MMacf of $0.75/lb Brominated PAC injected into Pleasant Prairie's 12 µg Hg/Nm^3 similarly provided 90% Hg removal with just an ESP:

$$\left(\frac{4 lb\ sorbent}{1{,}000{,}000 acf}\right)\left(\frac{Nm3}{(90\%)12 mg\ Hg}\right)\left(\frac{\$0.75}{lb\ sorbent}\right)\left(\frac{1.5\ acf\ @\ 300F}{1\ scf}\right)\left(\frac{35.3 scf}{Nm^3}\right)\left(\frac{10^9\ mgHg}{2.2\ lb\ Hg\ removed}\right) = \$6{,}700/\ lbHg.$$

Avg. Control Cost: ~<u>$7,000 /lb Hg removed.</u>

(85% less than $50,000-to-$70,000 baseline)

Full-Scale at Stanton 10 SD/FF with Lignite

Look for B-PAC Results in URS DOE Project "Enhancing C Reactivity in Lignite Systems."

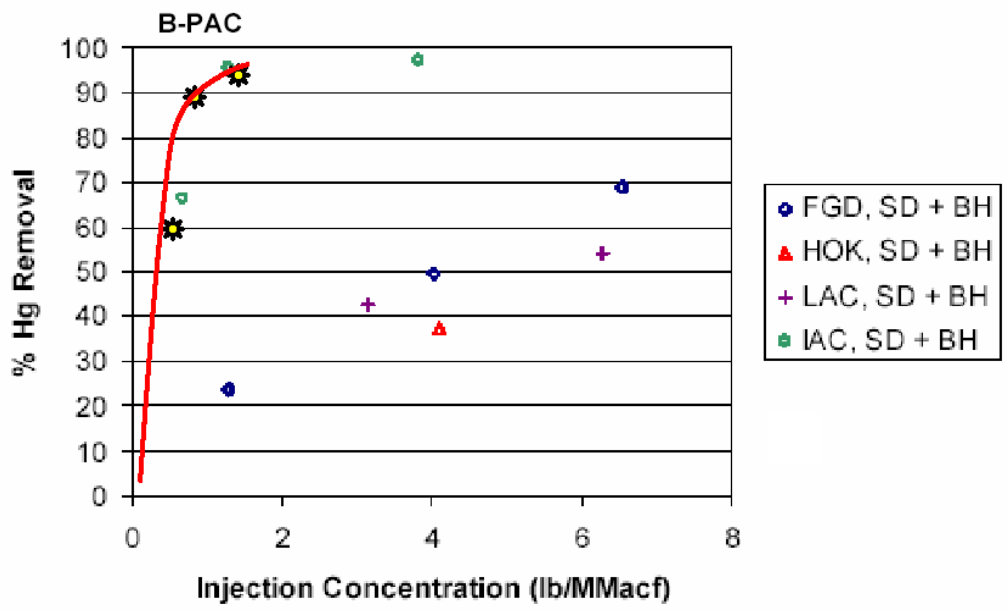
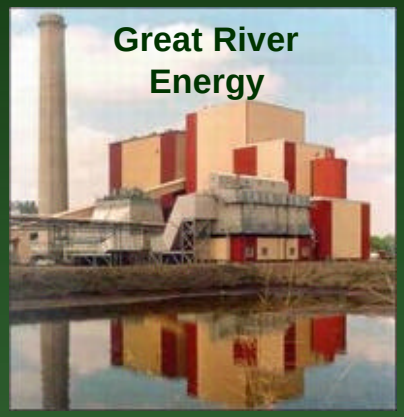


Figure 4. Mercury removal measured across the spray dryer and baghouse at Stanton Station during parametric testing..



Older Data from: Sjostrom, S., et al., "Full-Scale Evaluation of Mercury Control at Great River Energy's Stanton Generating Station Using Injected Sorbents and a Spray Dryer/Baghouse," Air Quality III, Sept. 2002.

$$\left(\frac{1.0\ lb\ sorbent}{1{,}000{,}000\ acf}\right)\left(\frac{Nm3}{(88\%\ removed)12mg\ Hg}\right)\left(\frac{\$0.75}{lb\ sorbent}\right)\left(\frac{1.5\ acf\ @\ 300F}{1\ scf}\right)\left(\frac{35.3scf}{Nm^3}\right)\left(\frac{10^9\ mg}{2.2\ lb}\right)=\$1{,}700\ /\ lbHg\ .$$

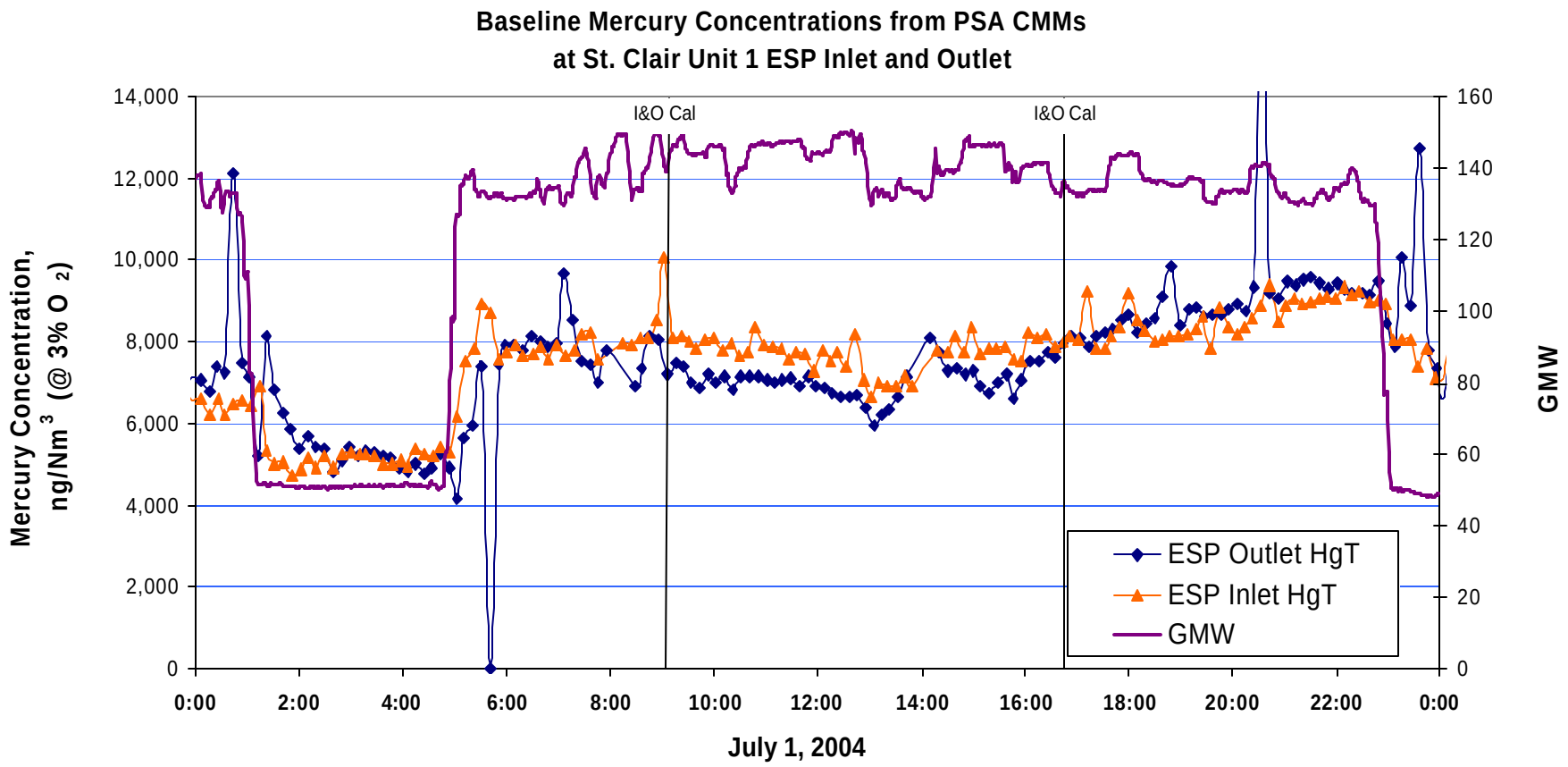
Detroit Edison – St. Clair Station

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

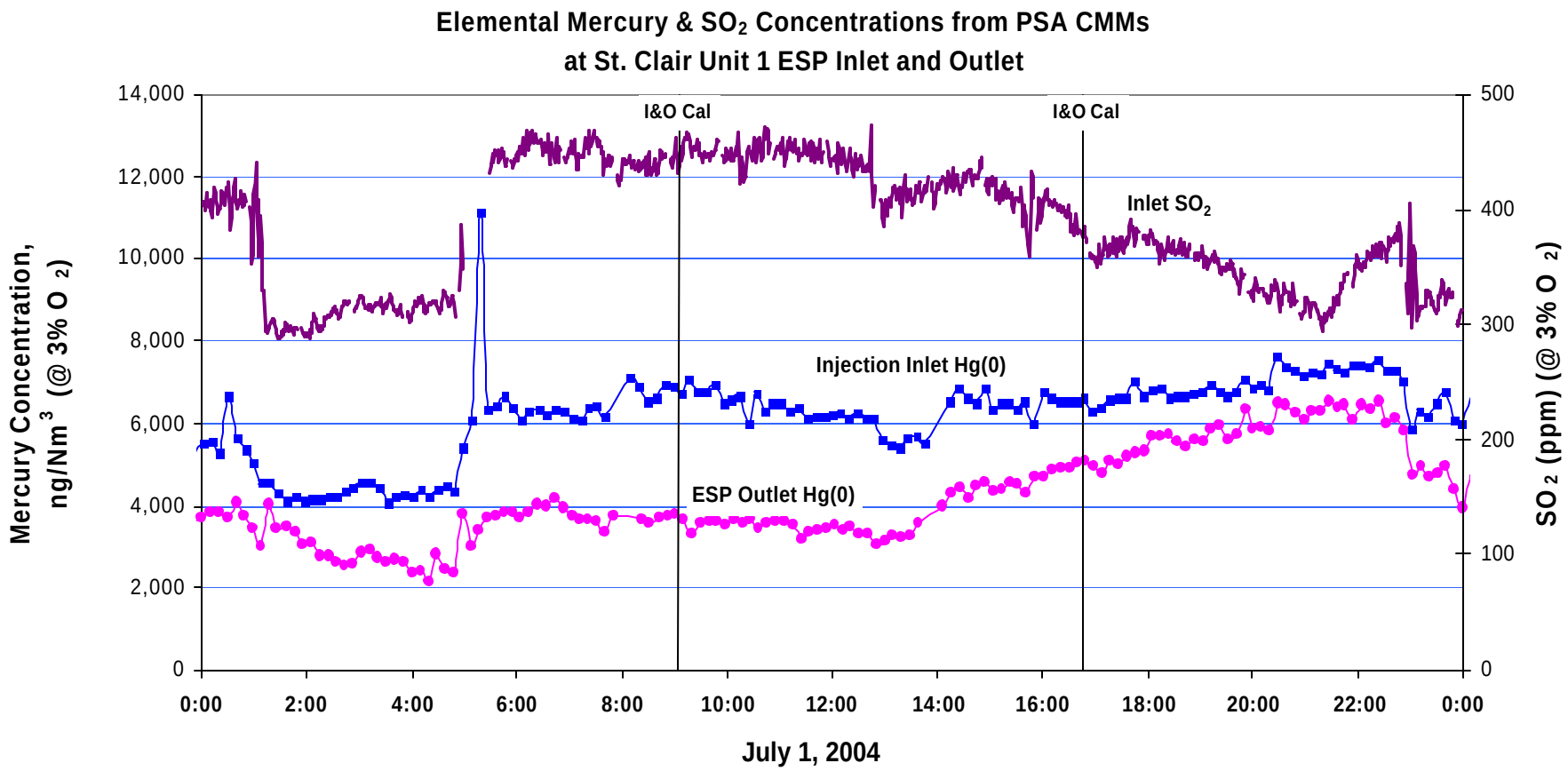
Baseline Measurements

- PS Analytical Mercury Monitors
- Dual Wet/Dry $Hg^{(+2)}$ Converter
- Latest Baldwin Inertial Separators
- Calibration by Dynamic Spiking

Preliminary Initial Baseline Results



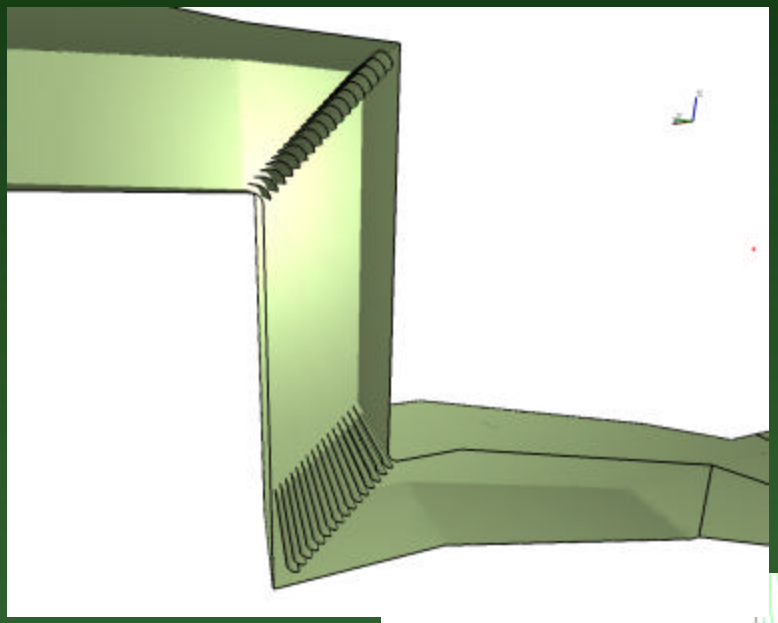
Preliminary Initial Speciation

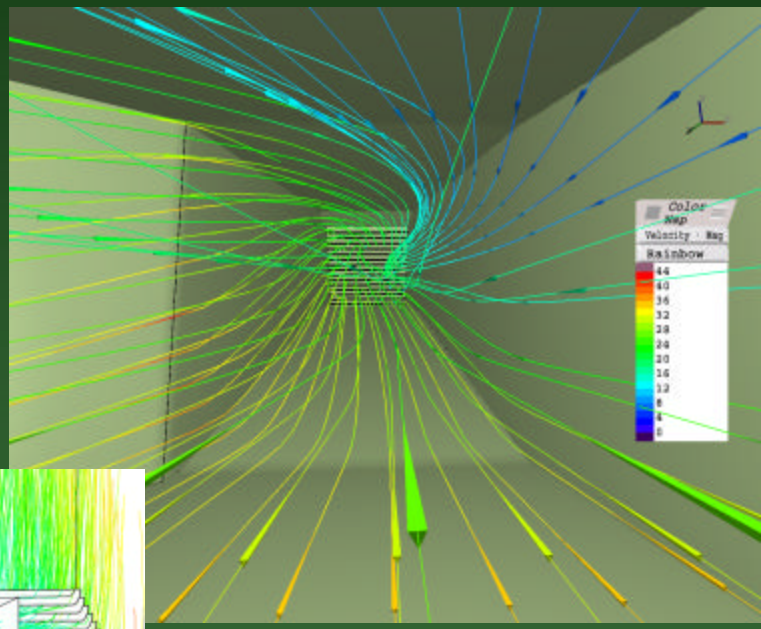


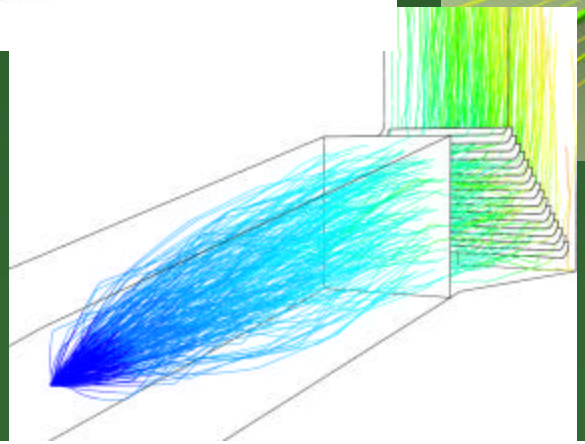
Supporting Activities

- CFD & Injection System Design
- Transportable Sorbent Injection Trailer
- B-PAC Production Plant

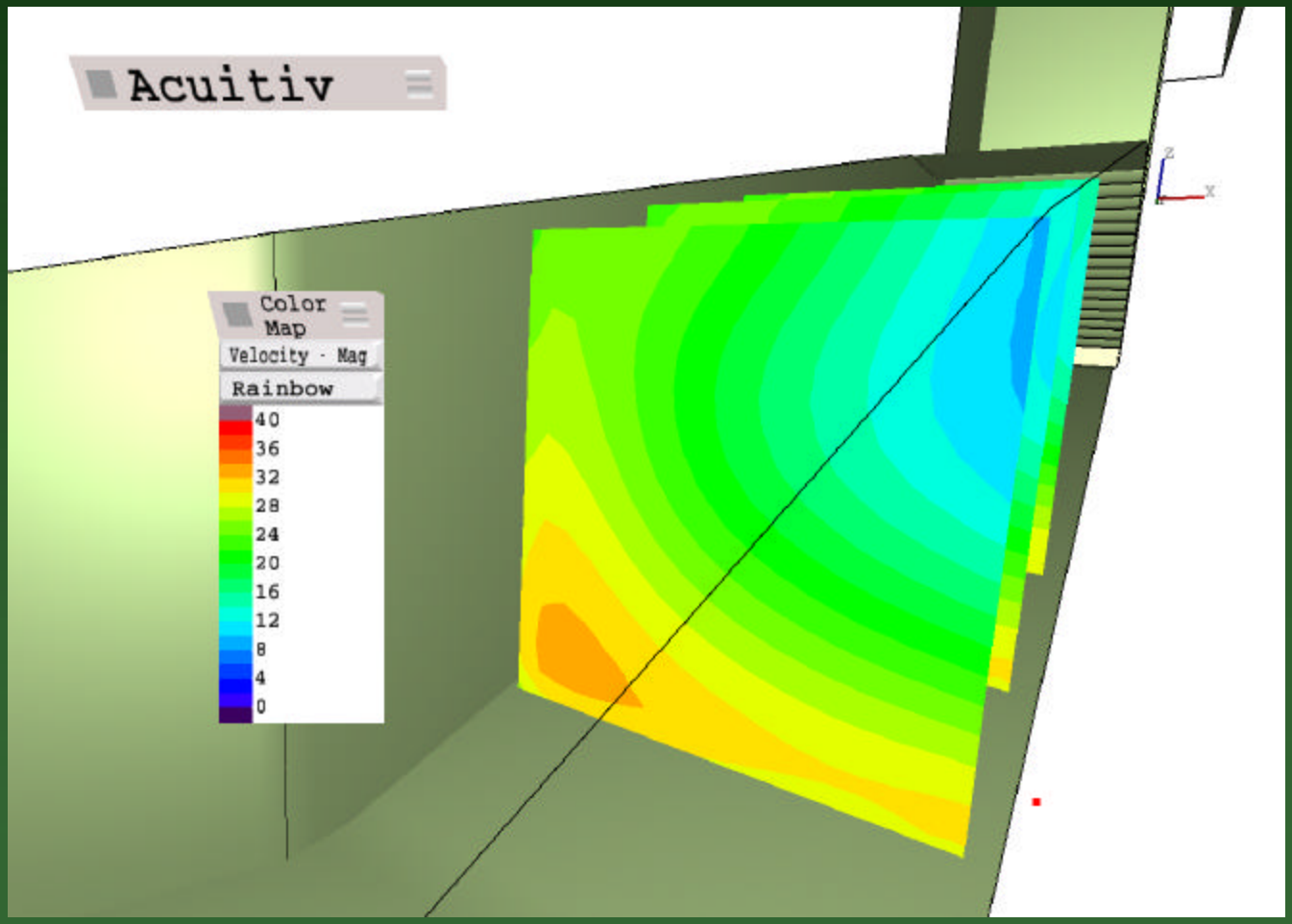
Computational Fluid Dynamics



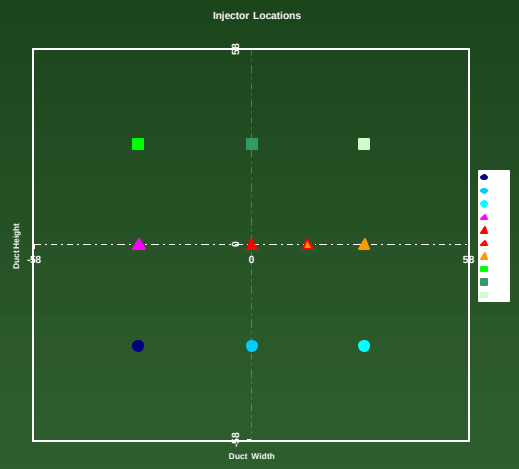


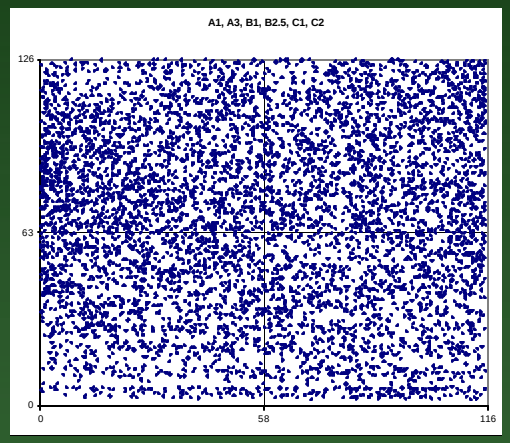


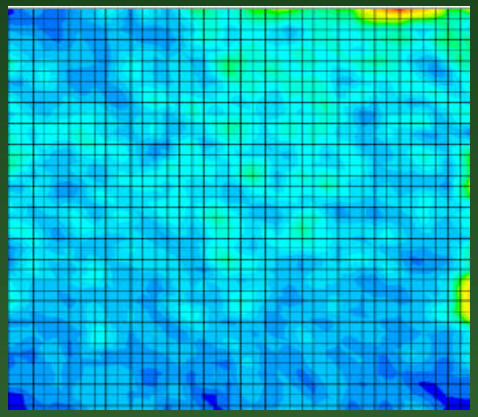
Maldistributed Gas Flow



Designing for Uniform Sorbent Density

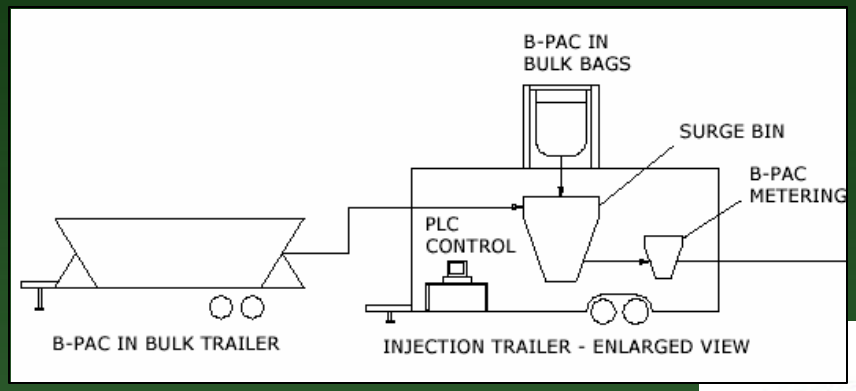






- **End-result here is an asymmetric 6-lance design**

Transportable Injection Trailer



B-PAC Production Plant

- World's first dedicated mercury sorbent production plant
- B-PAC design capacity of 1,500 Tpy (2-shifts)
- Estimated price of $1.00/lb today, $0.75/lb with E-O-S
- Scaleable design
- B-PAC™ is available in quantity for utility trials & commercial use in Aug.