Results from Four Full-Scale Field Tests of ACI for Control of Mercury Emissions

Presentation to

Utility MACT Working Group

March 4, 2003

Washington D.C.

Michael D. Durham, Ph.D., MBA

ADA Environmental Solutions

8100 SouthPark Way B-2

Littleton, CO 80120

303 734-1727

Outline

- Background on DOE NETL Program
- Background on Sorption of Hg on Solid Sorbents
  - Implications on variability of ICR results
- Details of Salem Harbor Program
- Summary of other three field tests
- Conclusions on ACI

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
  - Hamon
  - NORIT

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	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

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

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

Activated Carbon Storage and Feed System

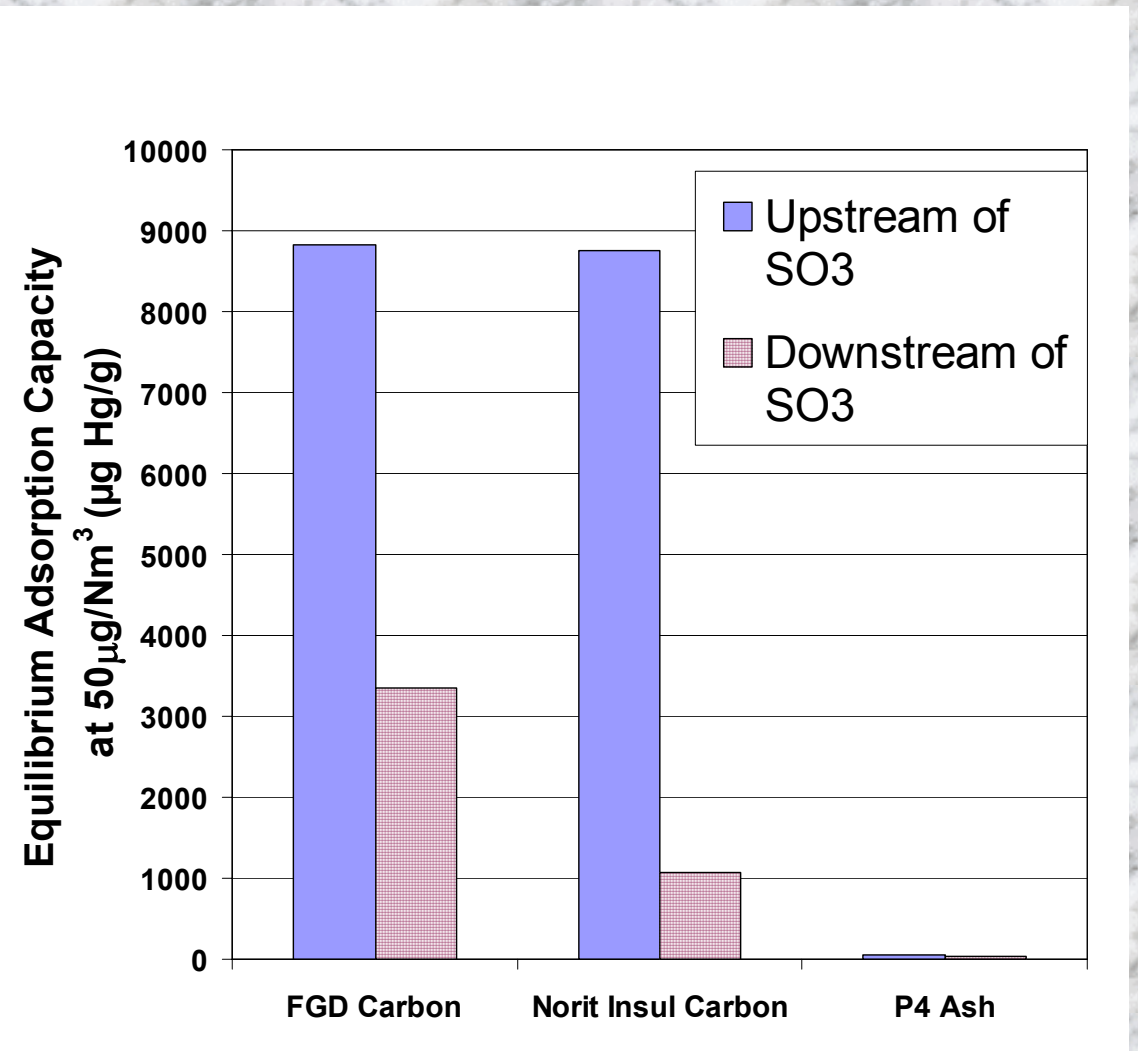
Powdered Activated Carbon Injection System

Capture of Vapor Phase Hg by Solid Sorbents

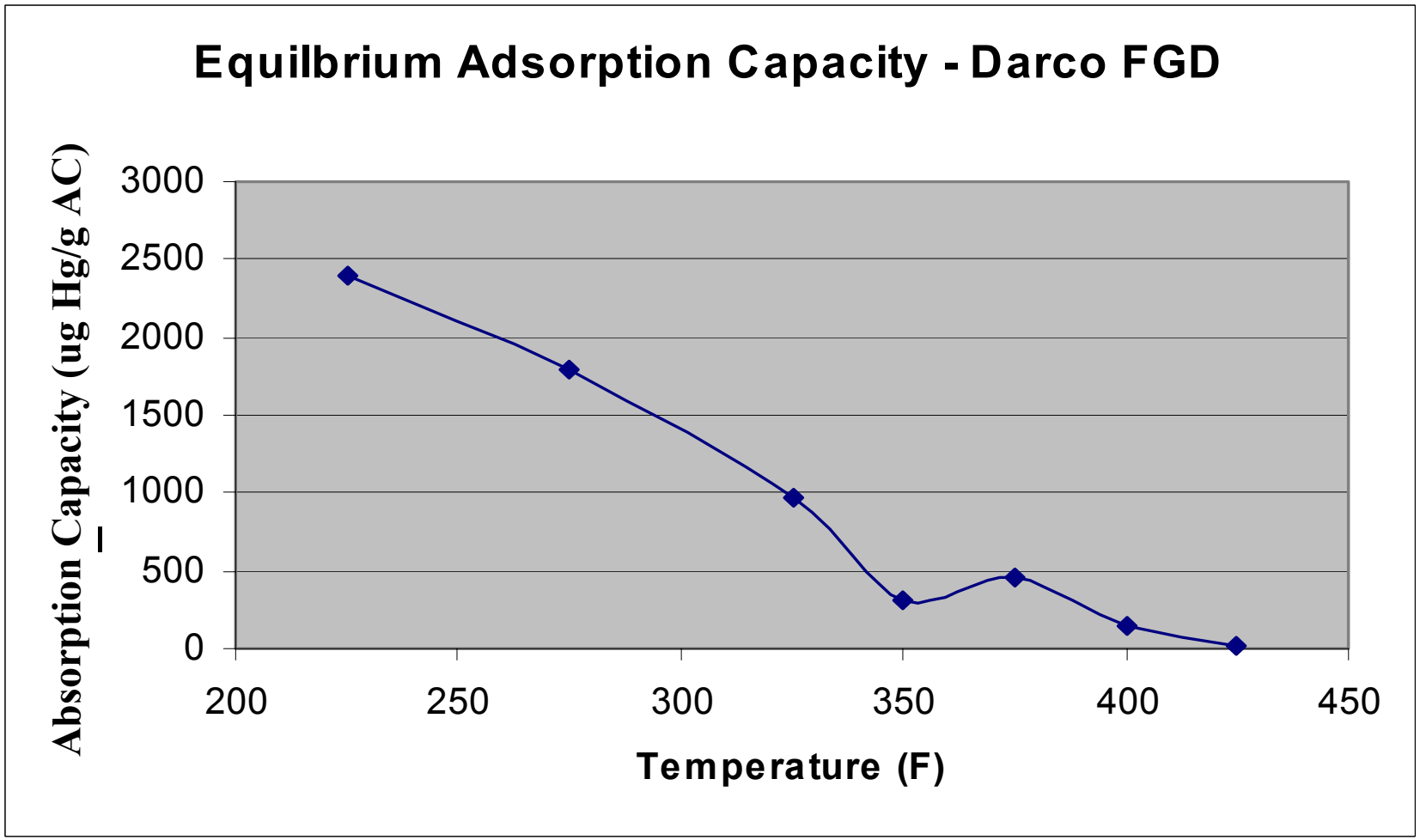
- **Mass Transfer Limits (getting the Hg to the sorbent):**
  - Removal increases with particle concentration
    - » Optimize by increasing mass loading and decreasing particle size
  - Produces percentage removal independent of concentration; and
  - Particle control device (FF vs ESP) is a critical parameter.

- **Sorbent Capacity (ability to retain Hg) depends upon:**
  - Sorbent characteristics such as surface area, capacity, and reactivity
  - Temperature: decreases at higher temperatures
  - Mercury concentration; and
  - Concentrations of SO_3 and other contaminants.

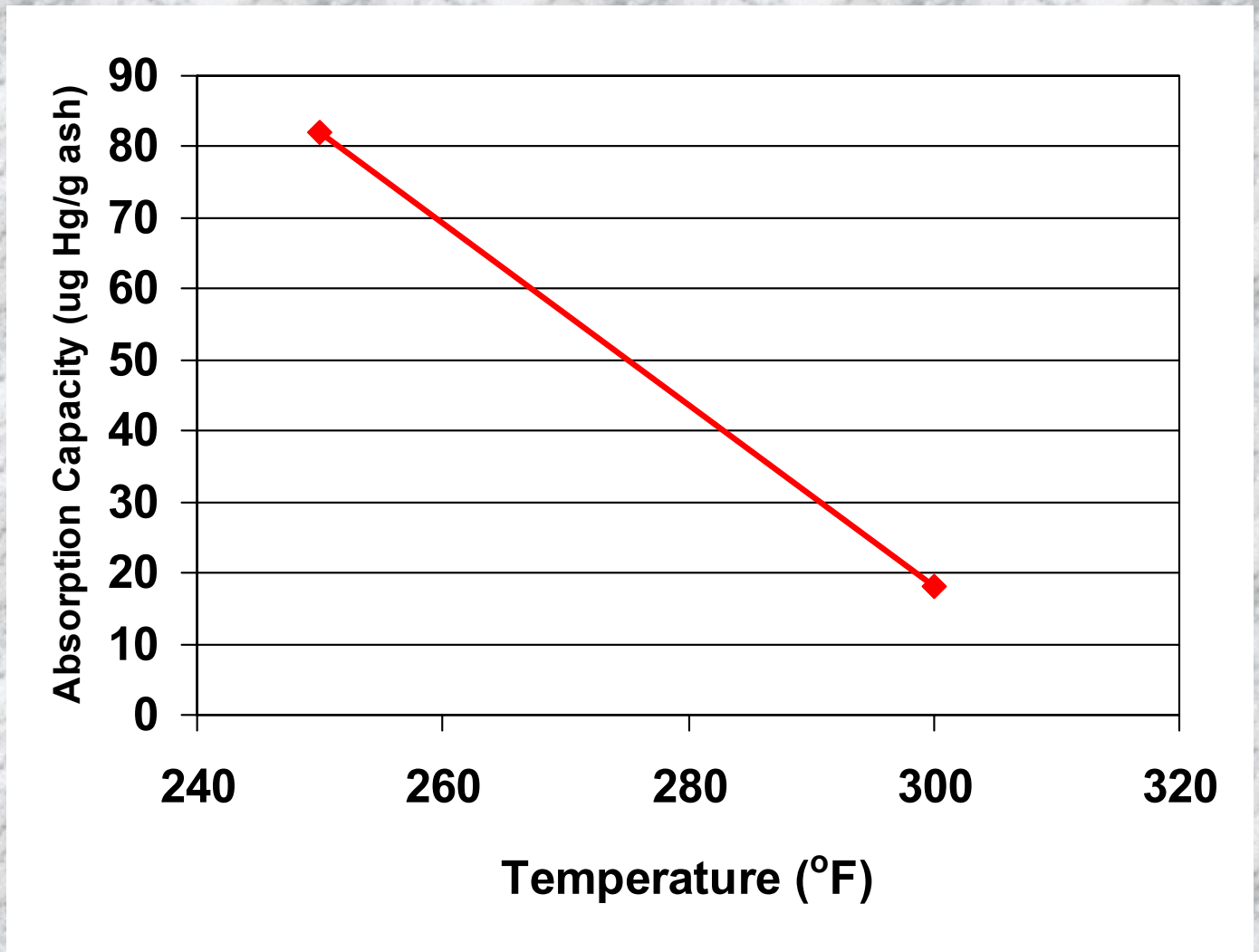
Equilibrium Adsorption Capacities at 250°F Upstream and Downstream of SO_3 Injection



Adsorption Capacity vs. Temperature



Adsorption Capacity of LOI Carbon



Equivalent Mass of Carbon Basis

LOI %	Flue Gas Concentration (lb/MMacf)
15	36
20	48
25	60
30	72
35	84

PG&E NEG Salem Harbor Unit 1

- 85 MW B&W Radiant Boiler
- NOx Control: SNCR
- PM Control: ESP with an SCA of 474 ft^2/kacfm
- Coal: South American Bituminous
  - Sulfur (%): 0.63
  - Mercury: 0.03 – 0.08 ug/g
  - Chlorine: 206 ppm
- LOI (Loss on Ignition, Carbon Content): 25-35%

Baseline Results

Location	Particle Bound	Oxidized, Hg^{2+}	Elemental, Hg^{0}	Total, Hg
Inlet – Location #1 (μg/dscf)*	9.27	0.08	<0.23	9.58
Outlet – Location #3 (μg/dscf)*	<0.23	0.27	<0.38	<0.88
RE (%)	97.14	-211.65	-75.27	90.81

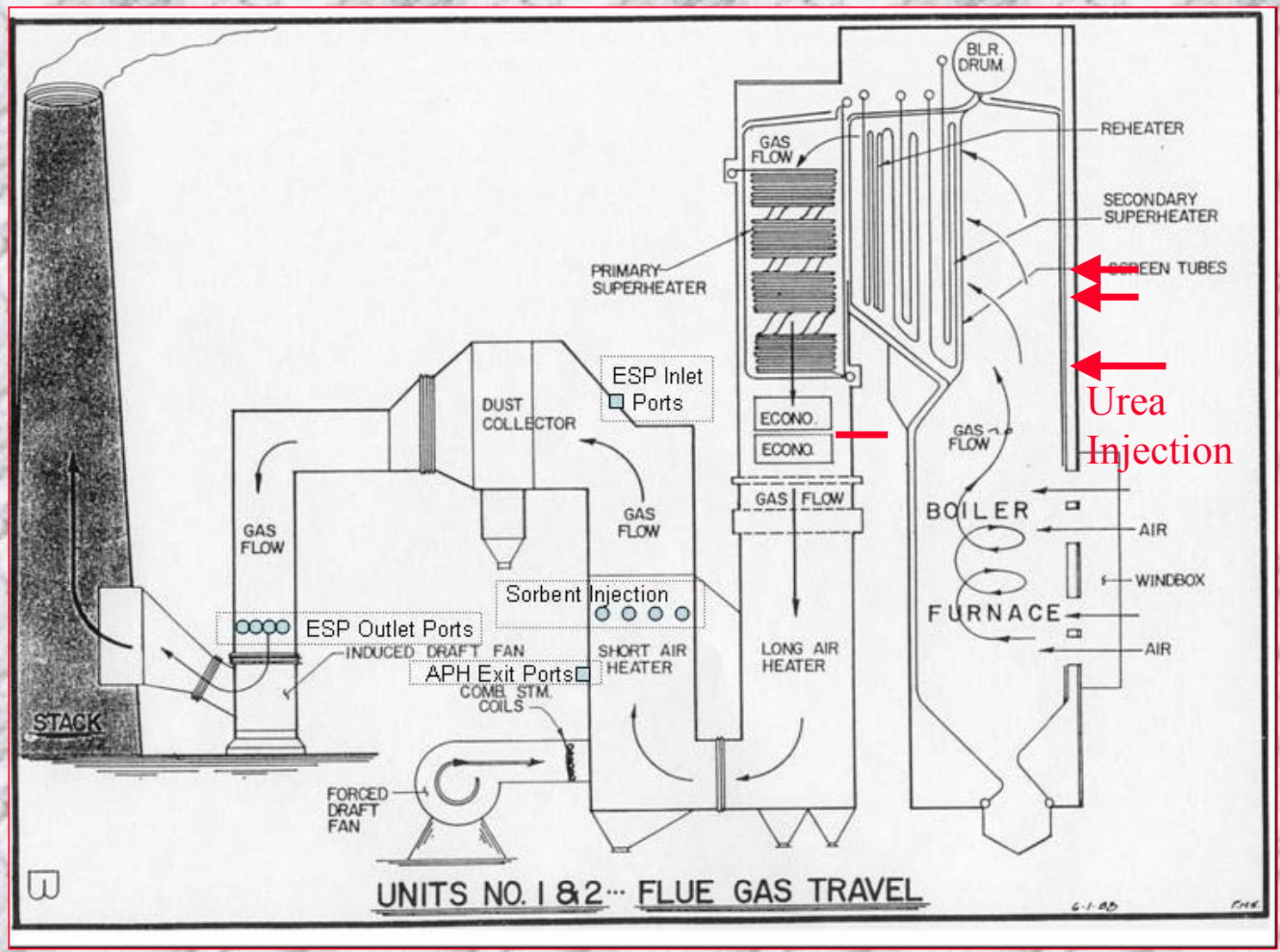
Objectives of Hg Test Program at Salem Harbor

- Understand the reasons that high Hg removal levels occurred under baseline (no ACI) conditions
- Document the impact of the SNCR system on Hg control
- Document the impact of LOI on Hg control
- Document impact of temperature on Hg control
- Evaluate impact of ACI

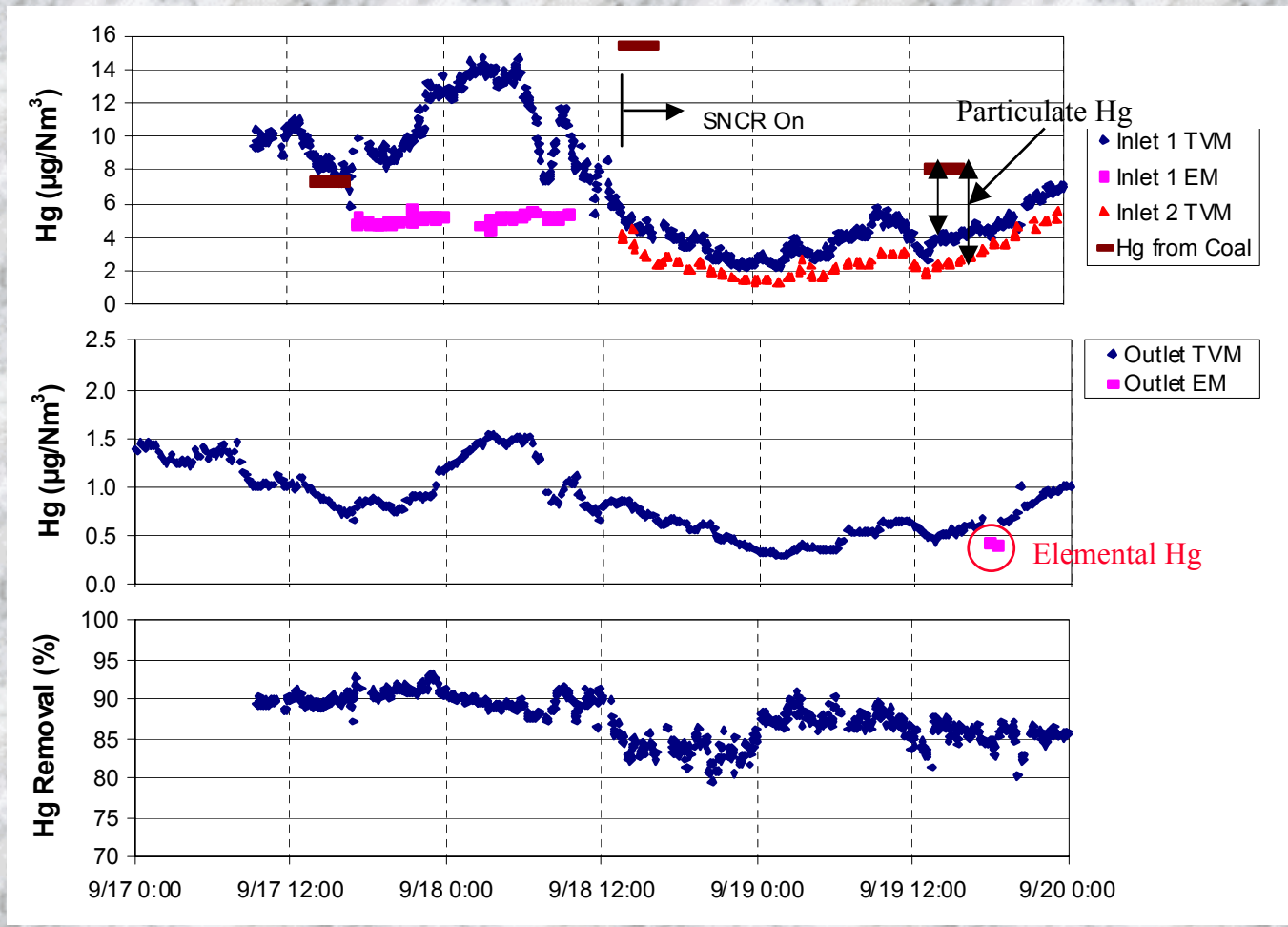
Operating Parameters

- **SNCR operation:**
  - On/off tests by turning off injection of urea
- **LOI:**
  - Decrease LOI by operating at high excess air at low load
- **ESP Temperature:**
  - Increase temperature by using steam coils to increase temperature of air entering air preheater

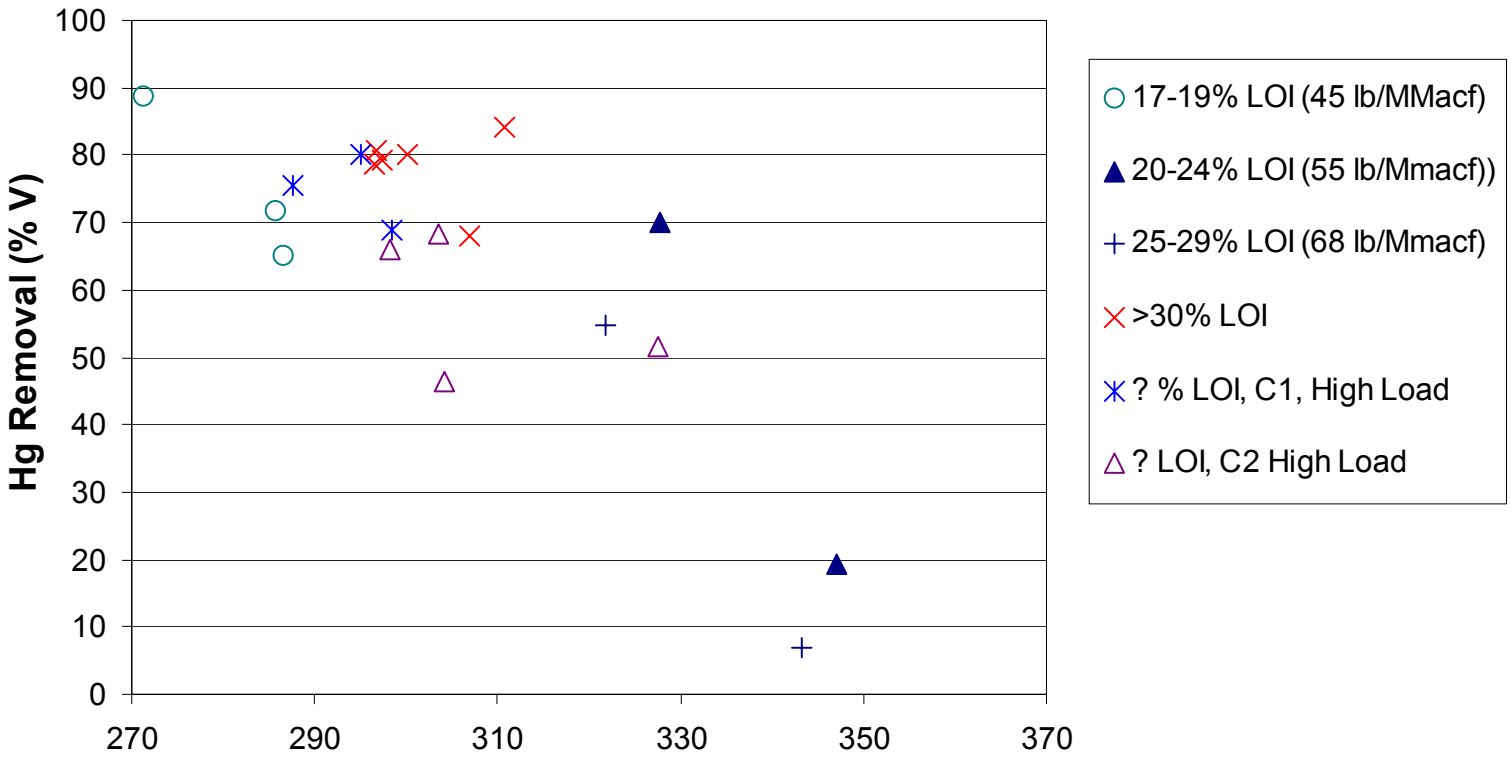
Flue Gas Path



SNCR On/Off

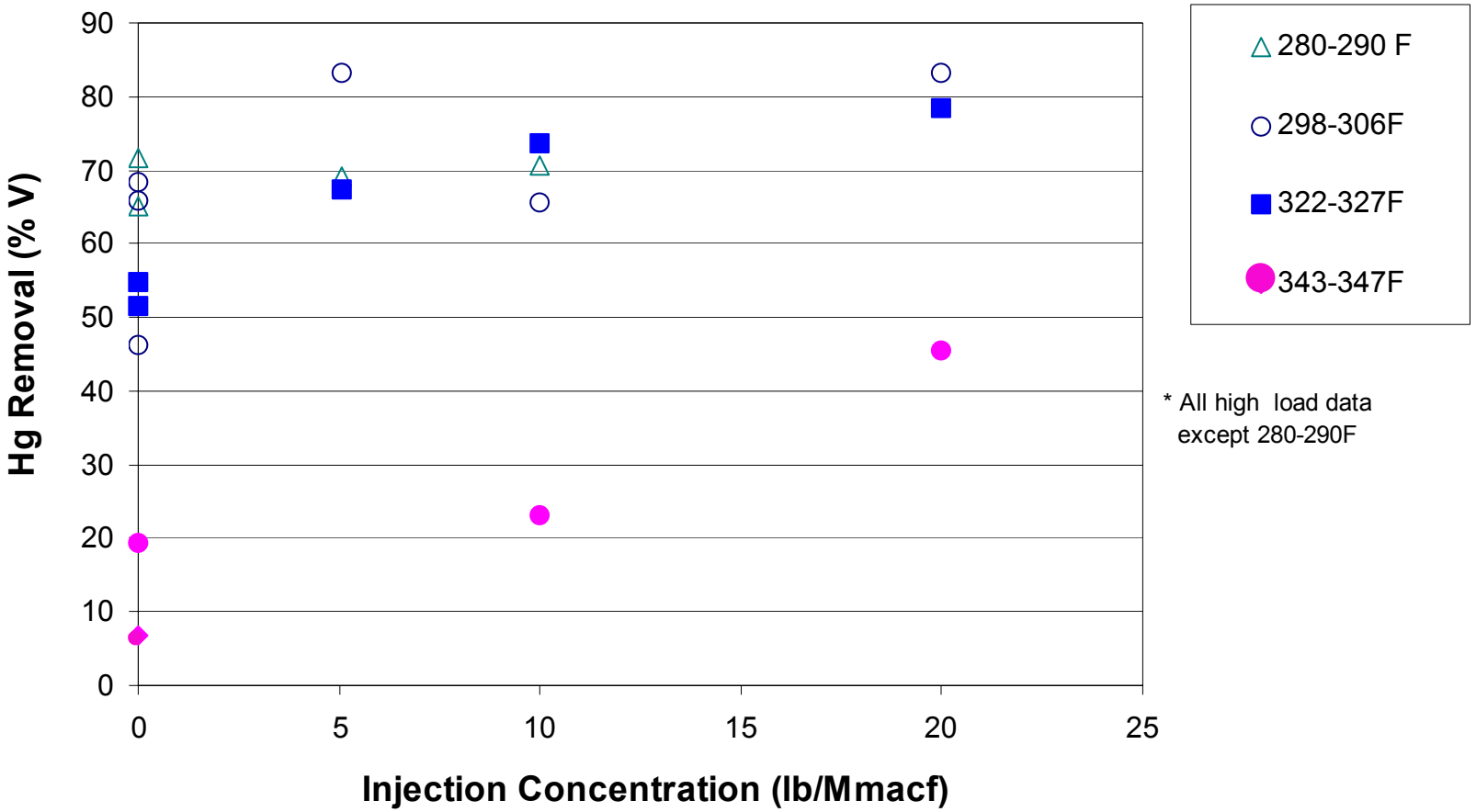

Hg (µg/Nm3)
16
14
12
10
8
6
4
2
0
SNCR On
Particulate Hg
Inlet 1 TVM
Inlet 1 EM
Inlet 2 TVM
Hg from Coal
Hg (µg/Nm3)
2.5
2.0
1.5
1.0
0.5
0.0
Outlet TVM
Outlet EM
Elemental Hg
Hg Removal (%)
100
95
90
85
80
75
70
9/17 0:00
9/17 12:00
9/18 0:00
9/18 12:00
9/19 0:00
9/19 12:00
9/20 0:00

Hg RE% vs. Temperature (No ACI)



C1 LOI during high load typically 30 - 35%
C2 LOI during high load typically 21 - 27%
with some low (18%) and some high (41%)

Hg RE% vs. Injection Concentration



Conclusions of Hg Control Testing at Salem Harbor

- No impact of SNCR operation on Hg removal
- At standard operating temperatures (300°F), reducing LOI from 30-35% to 15-20% has minimal impact on Hg removal
- At Salem Harbor, temperature has greater impact on mercury removal than LOI
- LOI has minimal capacity and is impacted by temperature and the presence of acid gases
- Activated carbon has excess capacity at moderate temperatures and less sensitive to changes in coal and flue gas conditions
- Activated carbon was less effective capturing mercury at higher temperatures (> 340°F)

Summary of Results from Other Three Field Tests

Removal of Mercury Species with PAC on Bituminous and Subbituminous Coal

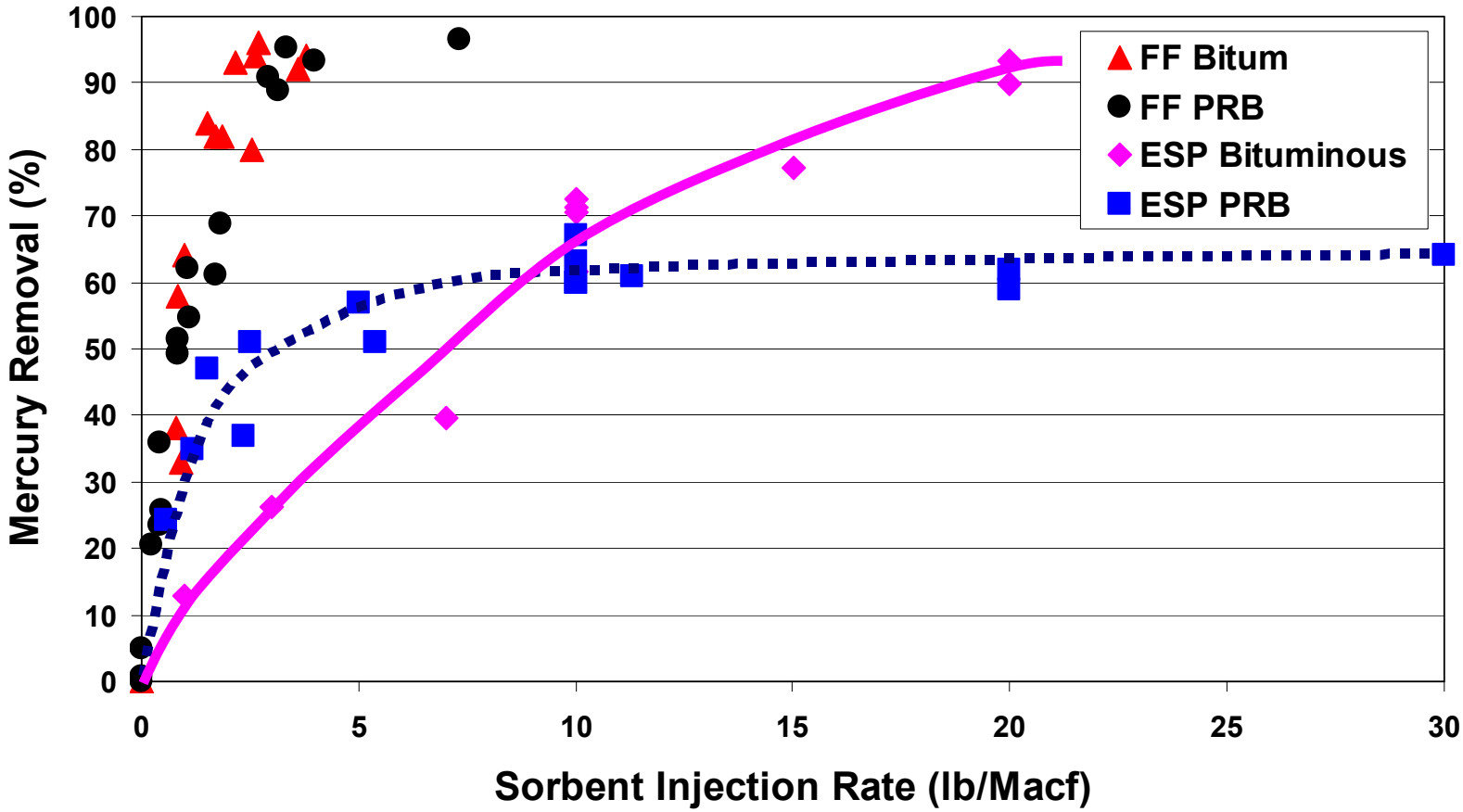
Bituminous with FF

	PARTICULATE	OXIDIZED	ELEMENTAL	TOTAL
PAC Injection	µg/m³	µg/m³	µg/m³	µg/m³
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

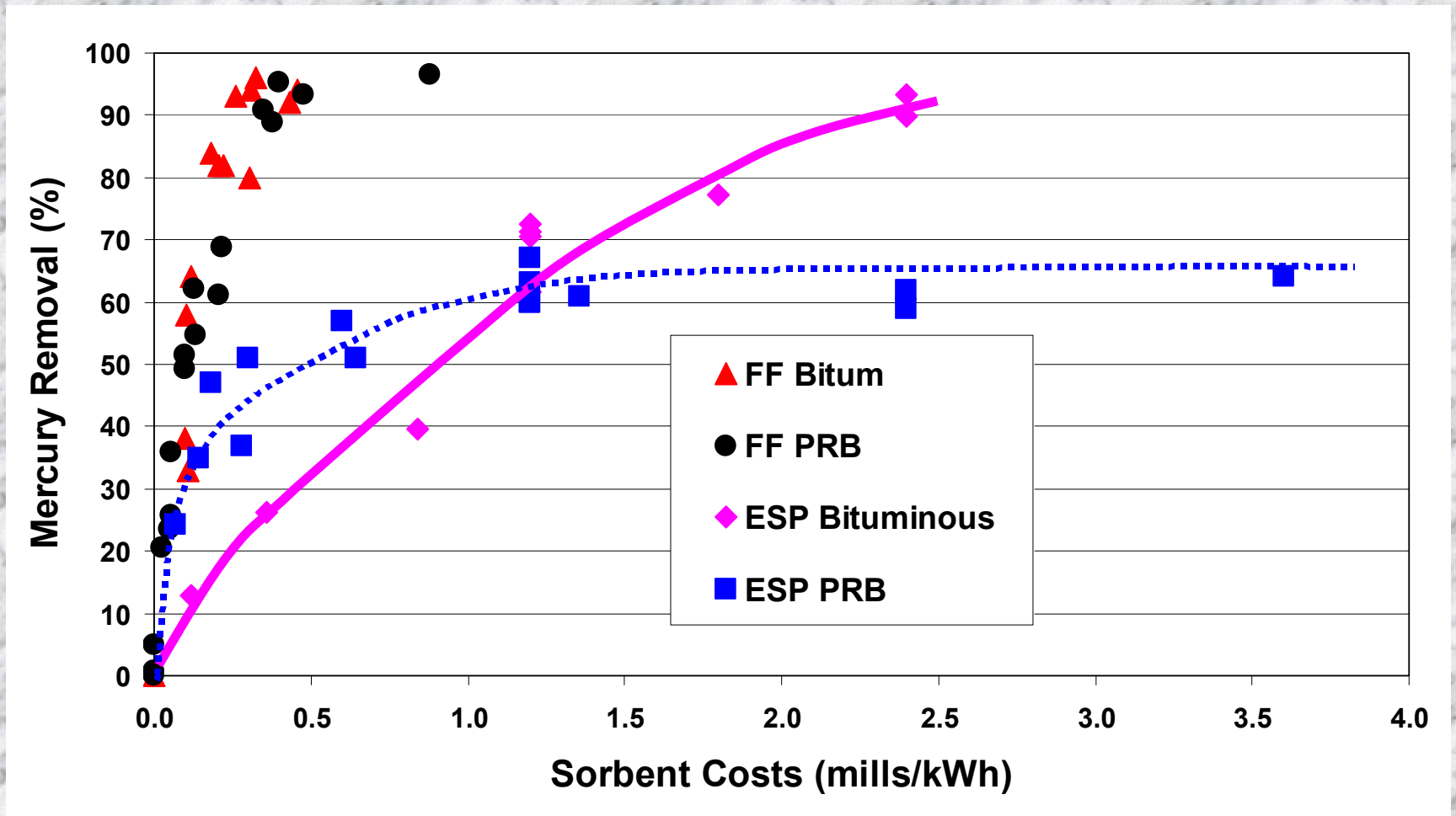
	PARTICULATE	OXIDIZED	ELEMENTAL	TOTAL
PAC Injection	µg/m³	µg/m³	µg/m³	µg/m³
ESP Inlet	0.98	1.73	14.73	17.44
ESP Outlet	0.00	0.44	4.27	4.71
Removal Efficiency	100.0%	74.5%	71.0%	73.0%

Mercury Removal with PAC Upstream of FFS and ESPs



* Includes EPRI data on small-scale PRB/FF tests

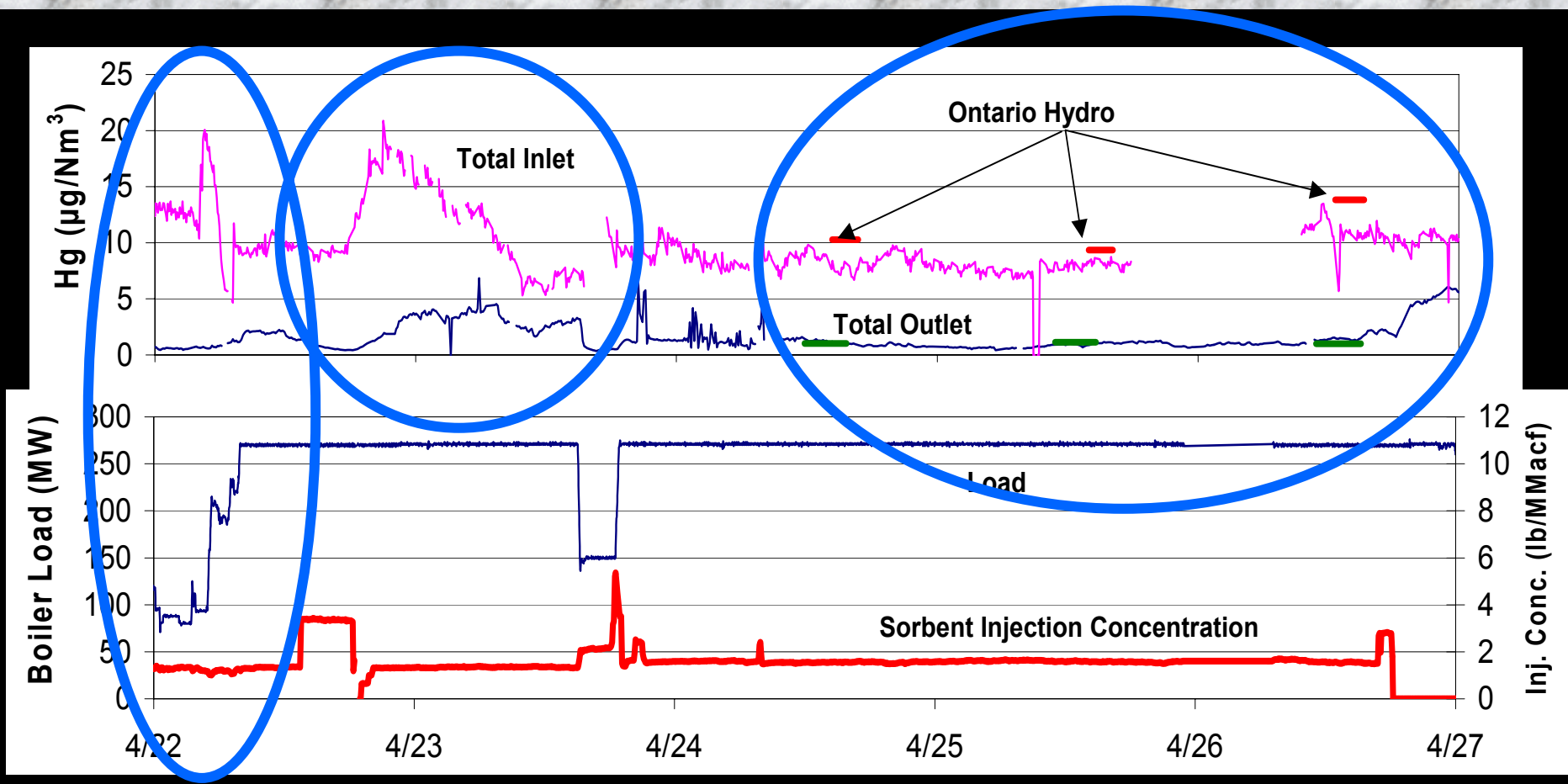
Comparison of Sorbent Costs for a Fabric Filter and ESPs



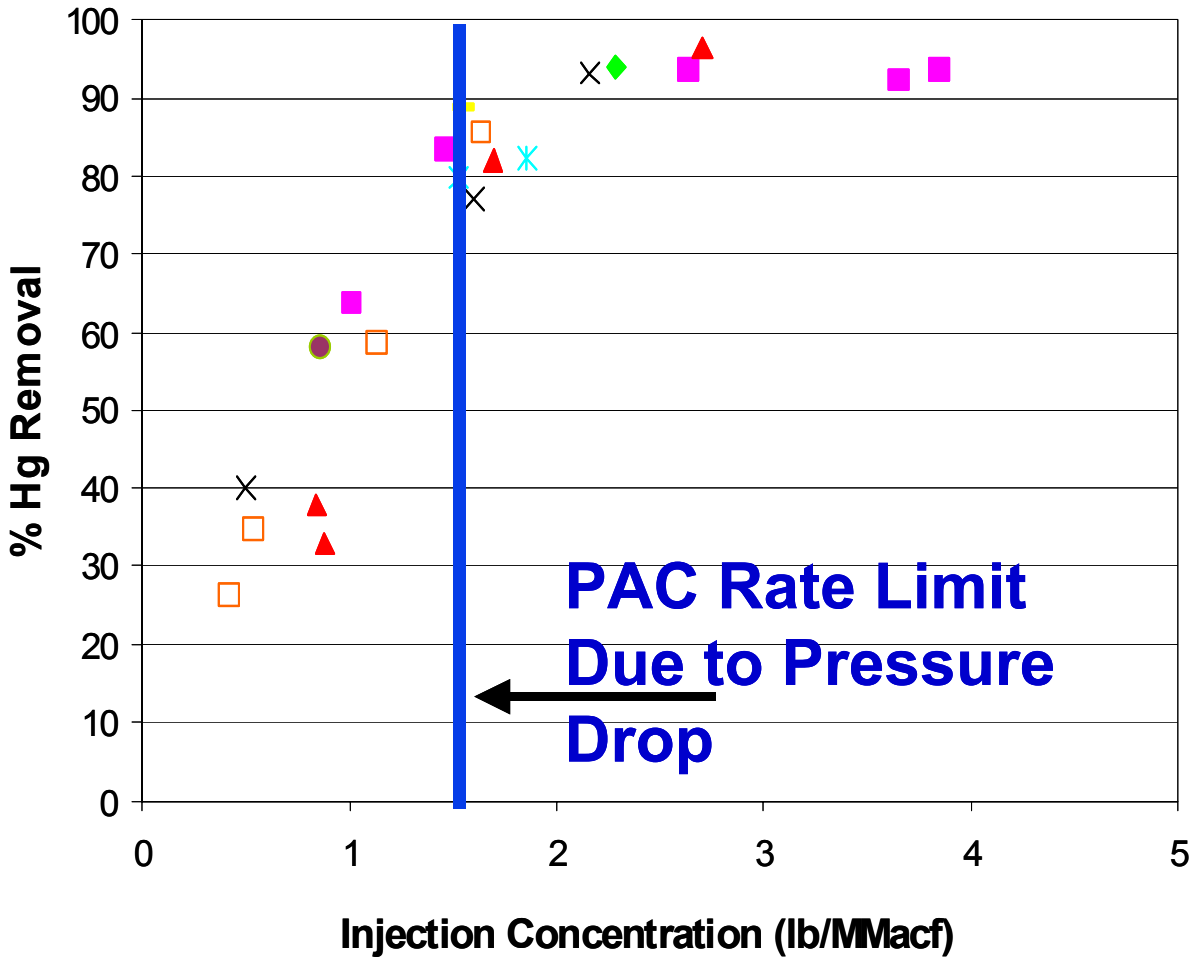
Issues with Variability of Inlet Hg

Short-term vs. Long-term Results

5-Day Continuous Injection



Mercury Removal vs. Injection Rate at Gaston



Conclusions: IPM Model Inputs for ACI on Bituminous and Subbituminous Coals

- 90 % Hg Removal
  - ✓ Bituminous coals: Fabric Filter ($40/kW) , ACI at 3 lb/Mmacf (0.4 mills/kWh)
  - ✓ Subbituminous coals: Fabric Filter, ACI at 3 lb/MMacf
  - ✓ Lignites: Flue Gas Cooling, Fabric Filter, ACI at 3 lb/MMacf
- 60 % HG Removal
  - ✓ Bituminous coals: ESP, ACI at 10 lb/Mmacf (1.2 mills/kWh)
  - ✓ Subbituminous coals: ESP, ACI at 10 lb/MMacf
  - ✓ Lignites: Flue Gas Cooling, ESP, ACI at 10 lb/MMacf
- Impact of Wet and Dry FGD on ACI
  - ✓ Bituminous coals: Reduces sorbent requirements
  - ✓ Subbituminous coals: Higher sorbent feedrate and/or more expensive sorbents
  - ✓ Lignites: Higher sorbent feedrate and/or more expensive sorbents

Future Plans

- **Long-term testing**
  - Alabama Power (Bituminous coal, COHPAC FF) 2003-2004
  - CCPI Program at WE Presque Isle (PRB, COHPAC FF) 2004-2006
- **Short-term testing at additional sites**
  - * TBD Site (PRB with Spray Dryer) 9/2003
  - * TBD Site (PRB with small ESP) 3/2004
  - * TBD Site (Eastern Bituminous with Wet Scrubber) 9/2004

* Proposed