

Trial of Amended Silicates™ for Mercury Control at Miami Fort Station

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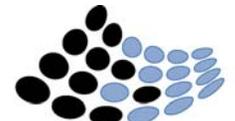
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Presentation Outline

- Background and Trial objectives
- Team members
- Host site and sorbent characteristics
- Injection system design and operation
- Balance-of-plant impacts
- Mercury capture
- Impact on fly ash salability
- Economic analysis
- Conclusions



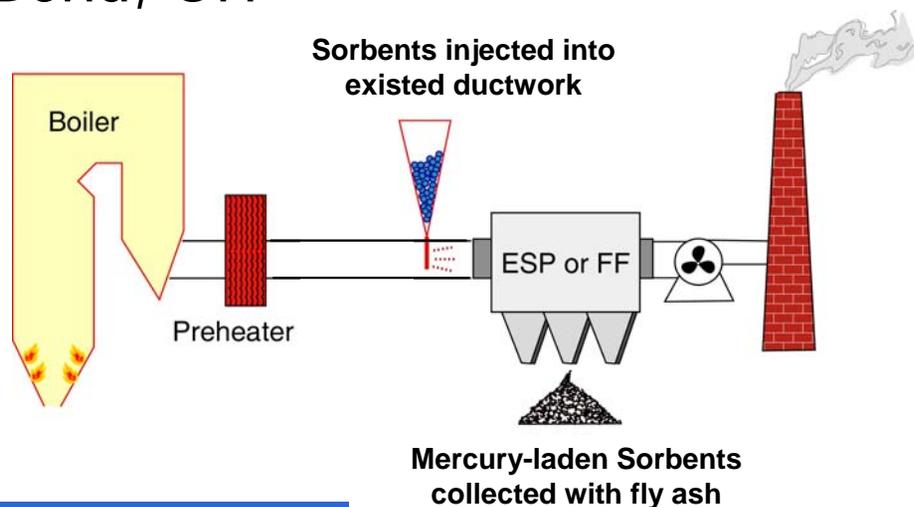
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Background

- Trial of novel sorbent for mercury capture at coal-fired utility boilers
- Funded under Cooperative Agreement with US DOE as part of NETL Mercury Control Program
- Hosted by Duke Energy (Cinergy) at Miami Fort Station, North Bend, OH



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Trial Objectives

- Demonstrate Amended Silicates™ sorbent at full-scale for an extended test period
- Verify collected fly ash plus sorbent remains suitable for use in concrete
- Confirm sorbent injection has no detrimental impact on balance of plant operations
- Estimate cost to implement Amended Silicates mercury control



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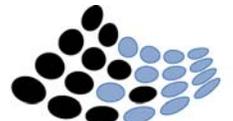


Project Team

- Amended Silicates, LLC
 - ADA Technologies, Inc.
 - CH2M HILL
- Duke Energy (Miami Fort Station)
- Engelhard Corporation (now part of BASF)
- UNDEERC
- University of Western Kentucky
- Boral Material Technologies, Inc.
- Separation Technologies LLC

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Miami Fort Station



- Located on the Ohio River, down river from Cincinnati
- Burns eastern bituminous, run-of-the-river coal
 - Typical values during test: 11% ash, 2.3% sulfur, 12,000 BTU/lb, 0.11 ppm Hg
- Trial performed on Unit 6
 - 175 MW with cold-side ESP
 - Cycling operation (Low-load overnight)

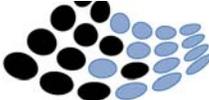
Amended Silicates™ Sorbent

- Powdered, dry-injection sorbent
- Chemically amended silicate substrate, non-carbon based
- Developed and tested through funding from EPA, EPRI, DOE, and Amended Silicates, LLC
- Patented formulation



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Amended Silicates

Demonstration Timeline

Three-Phase Project:

1. Planning & Installation (April 2004 – Jan 2006)
 - Duct modeling and injection system design
 - Site preparation
 - ES&H and Trial Plans
 - Sorbent manufacturing
2. Trial Operations (Jan-March, 2006)
 1. Baseline
 2. Parametric
 3. 30-day Amended Silicates injection
 4. PAC injection
3. Sample and Data Analysis (April 2006 to Dec 2006)

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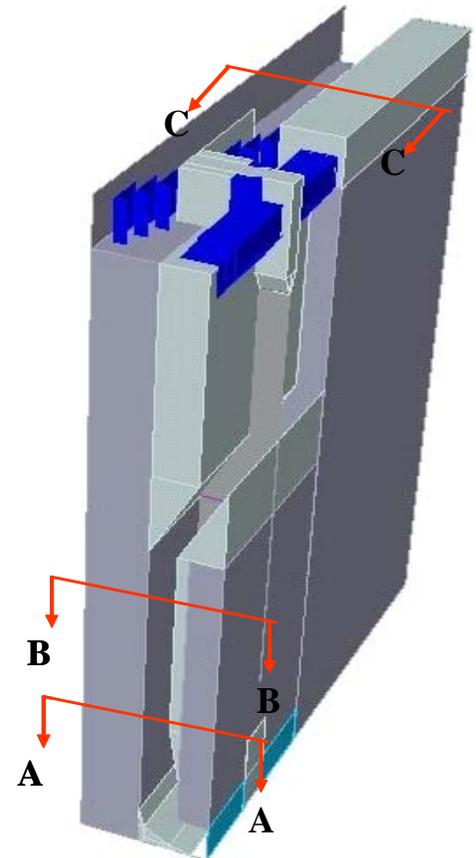
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Injection System Design

- Ductwork and lances modeled using computational fluid dynamics
- Four-lance system selected to span 40' x 5' duct
- Sorbent delivered by a Norit PortaPAC sorbent feeder
- Sorbent was provided in 1200 lb "Super Sacks"
- Sorbent delivery system operated by host site personnel



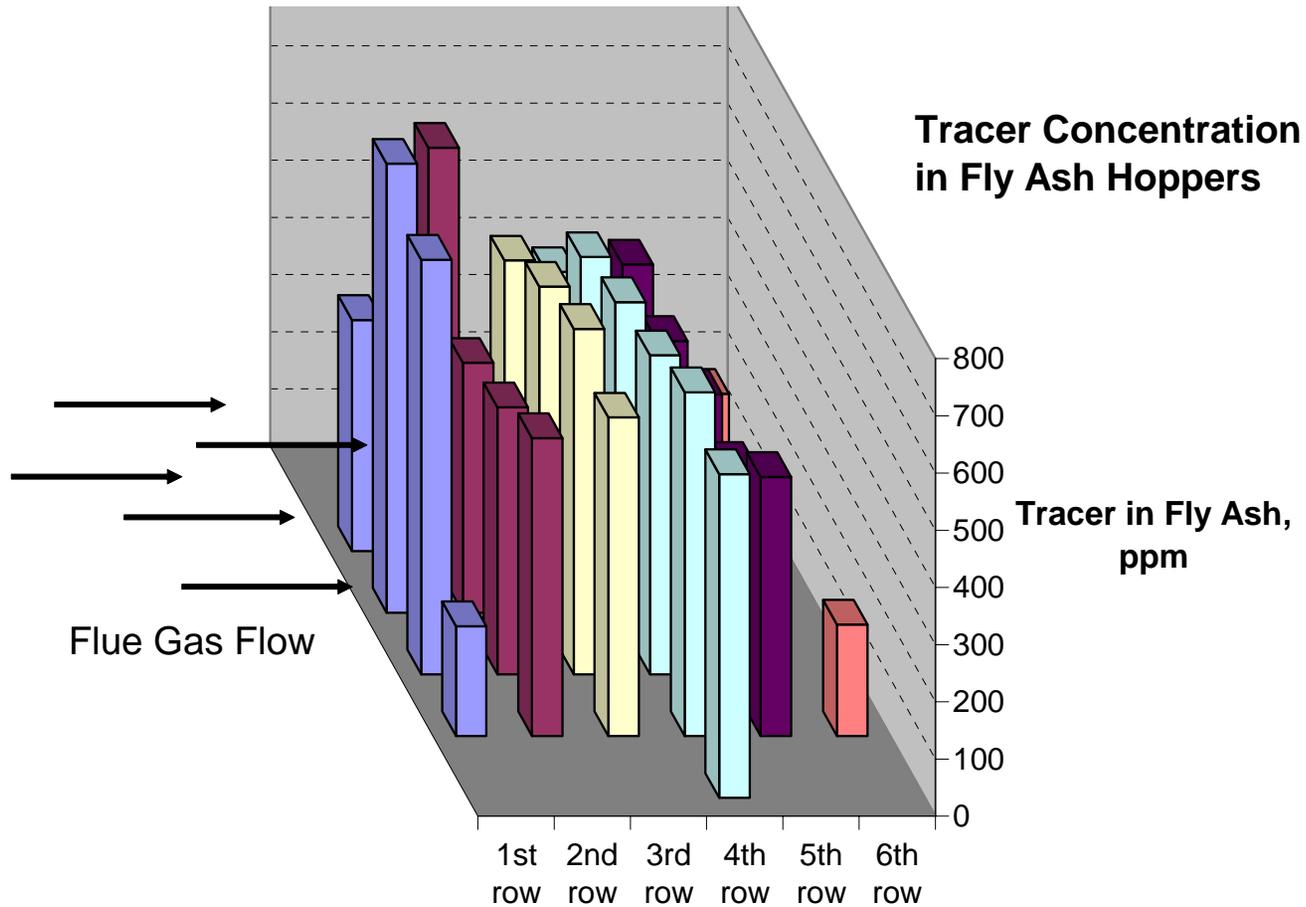
Injection System Operations Summary

Task Name	January 2006				February 2006				March 2006			
	1/1	1/8	1/15	1/22	1/29	2/5	2/12	2/19	2/26	3/5	3/12	3/19
Baseline Hg Measurements			■									
Parametric Tests with Amended Silicates				■								
30-day Trial with Amended Silicates						■						
PAC Injection											■	

- Overcame feeder clogging problems early in program
 - Attributed to agglomeration in the sorbent from the mfr.
 - Eliminated reducer fittings in supply piping and installed ¼" screen in eductor throat
- Analyzed fly ash samples from each hopper for tracer metal to investigate distribution of sorbent in flue gas



Tracer Element Analysis on Fly Ash



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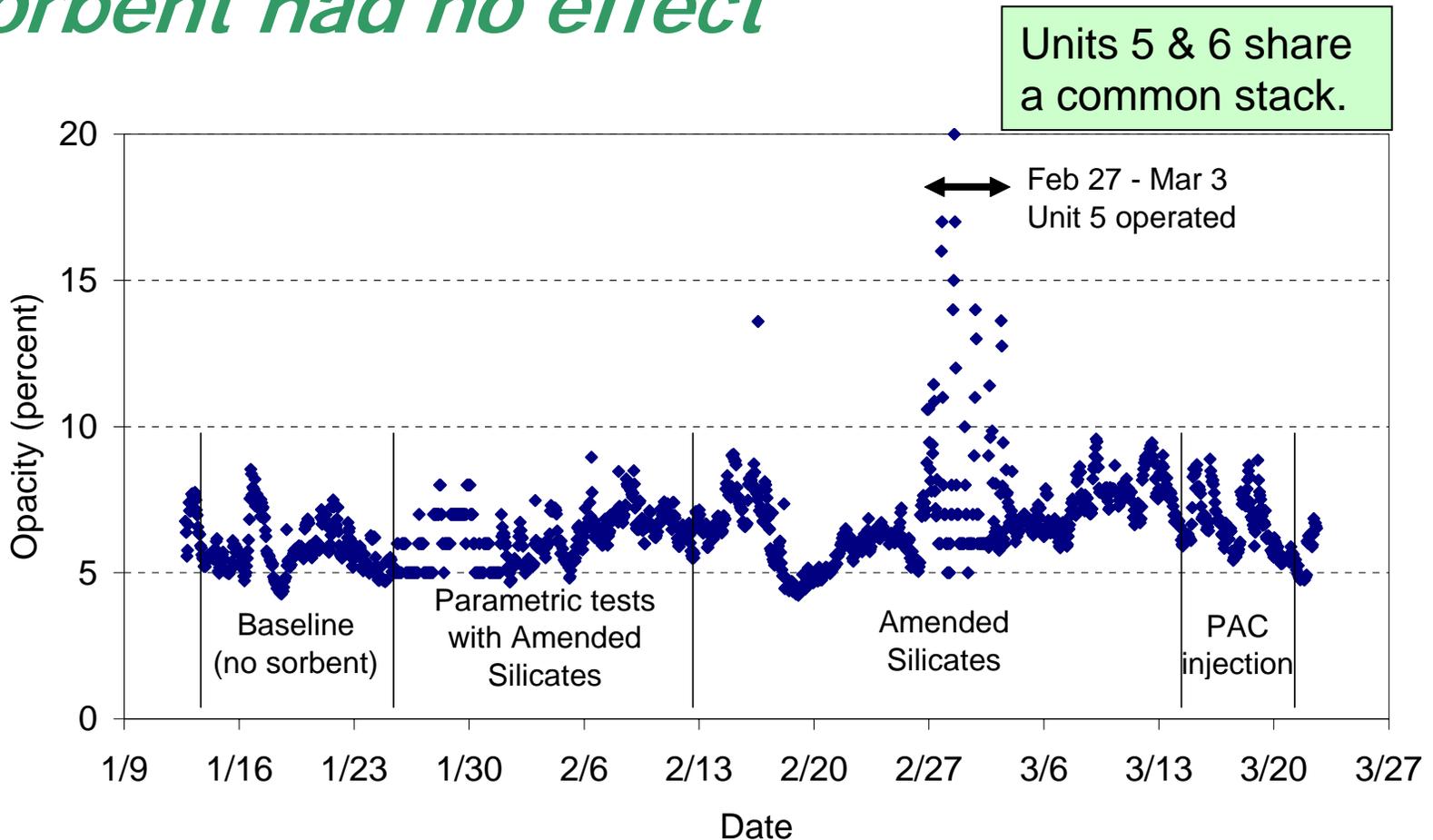
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ESP Performance Evaluation – sorbent had no effect

- Statistical analysis – used t-test to determine if the sorbent injection T/R set data was significantly different from baseline measurements
- Results – no difference in ESP operation within a 95% level of significance
 - Voltage difference no more than 0.5 kV
 - Amperage difference no more than 25 mA (<5%)



Stack Opacity Evaluation – sorbent had no effect



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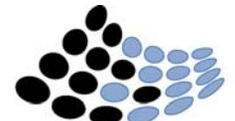
Mercury Capture: Summary of Baseline Hg Removals by the native fly ash

Date/Time	Ontario-Hydro Data	Coal/Fly Ash mass balance
1/17/06 15:00	6.7%	6.3%
1/18/06 9:30	11.6%	10.0%
1/18/06 12:30	6.6%	
1/18/06 15:00	14.7%	
1/19/06 9:00	11.9%	8.9%
Averages	10.3%	8.4%



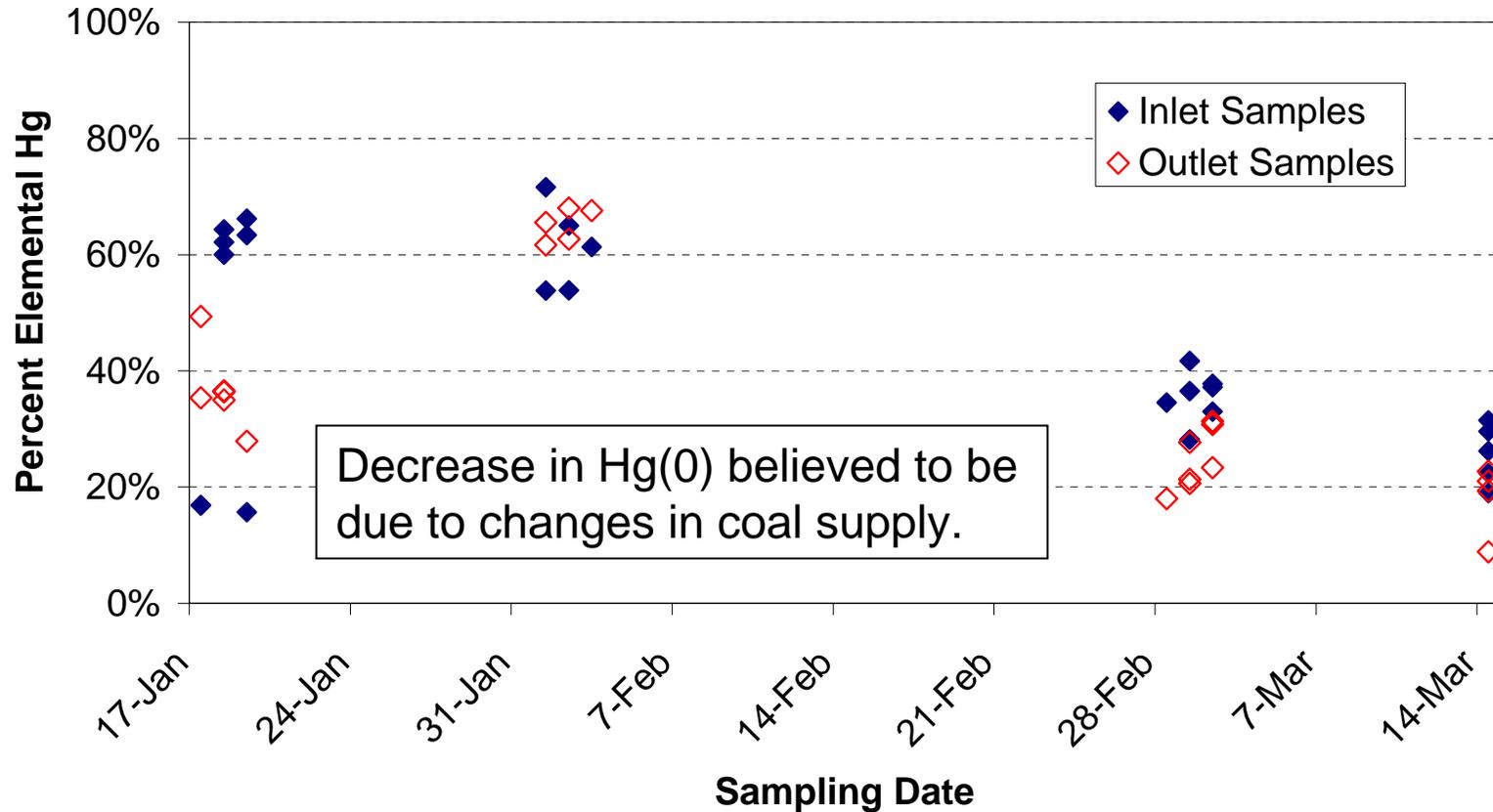
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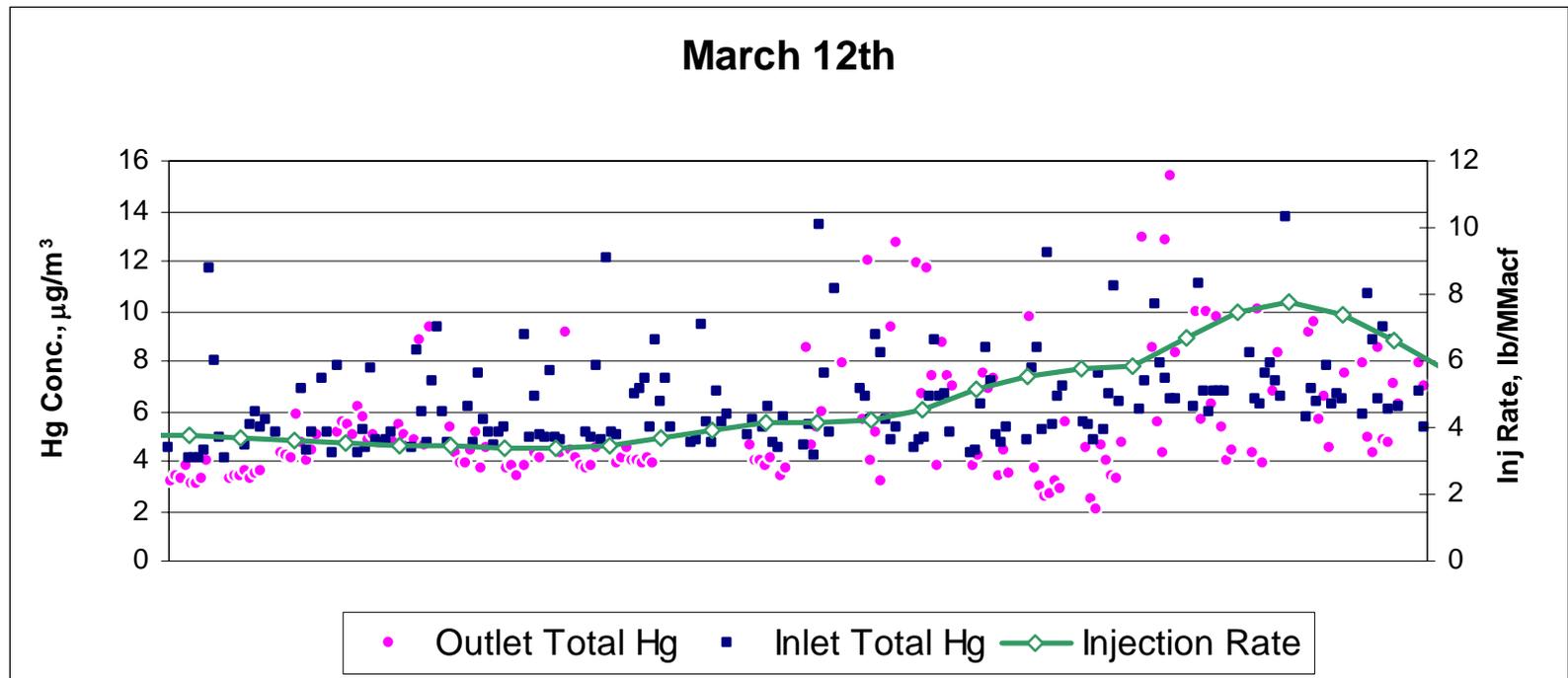
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Mercury Speciation by Ontario-Hydro Method



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Continuous Mercury data exhibited a high degree of scatter...

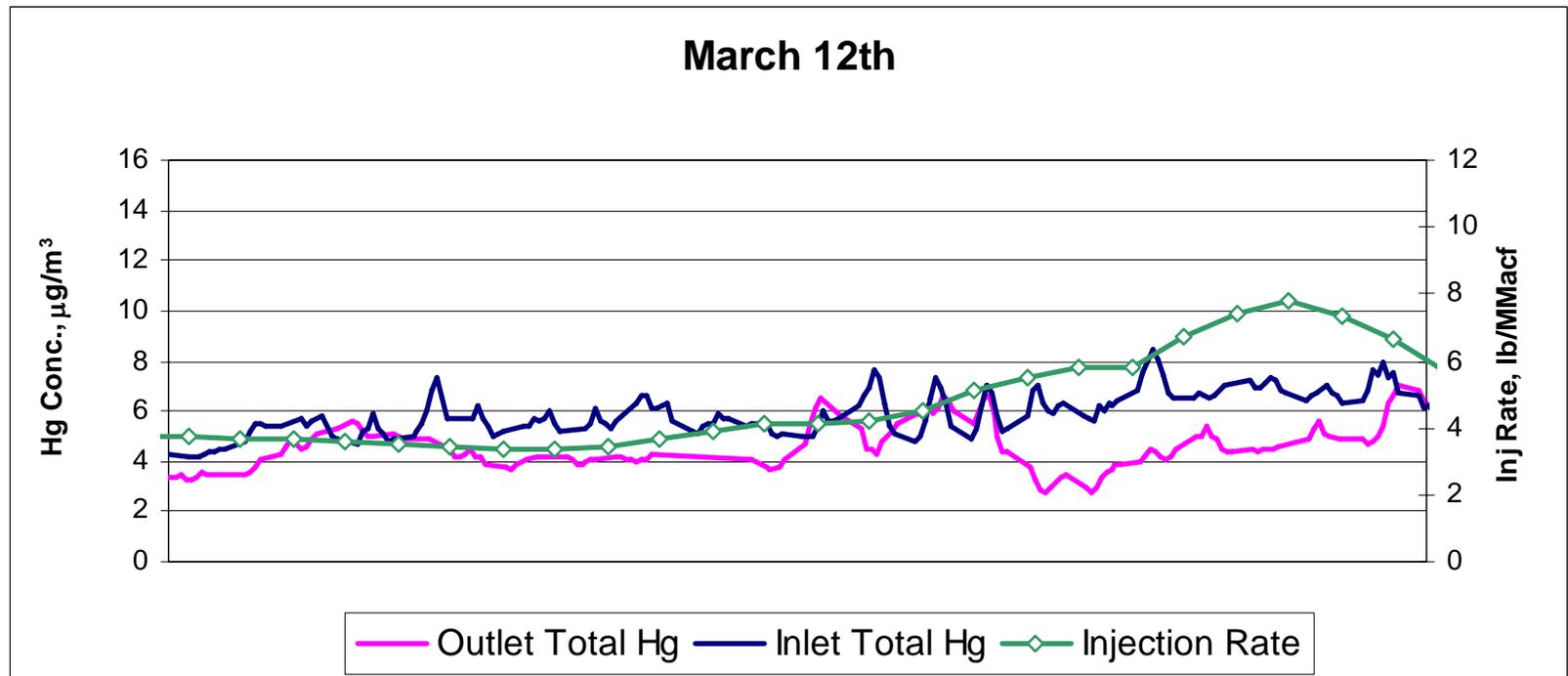


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...Statistical filter method was used to screen and smooth raw data

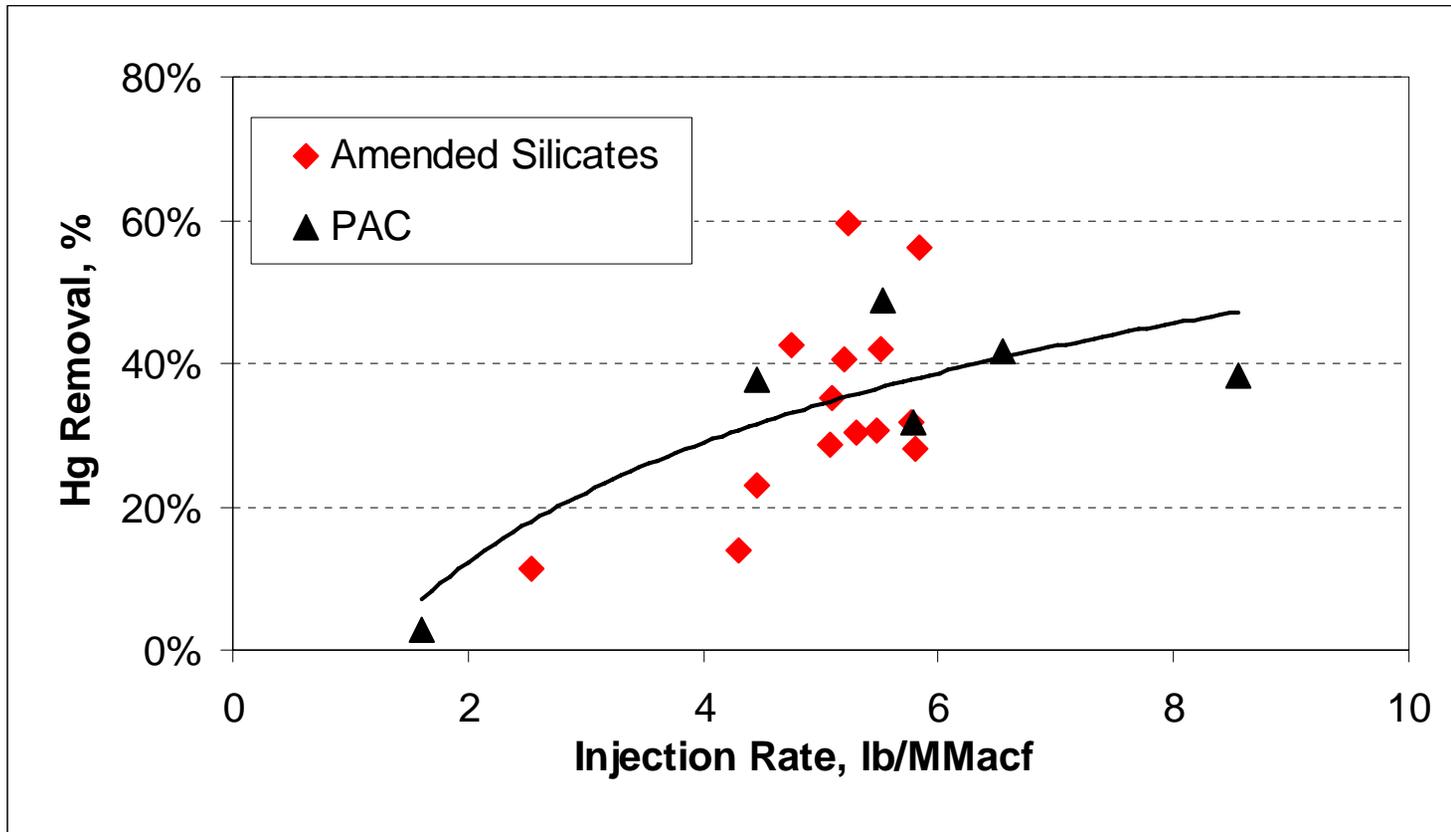


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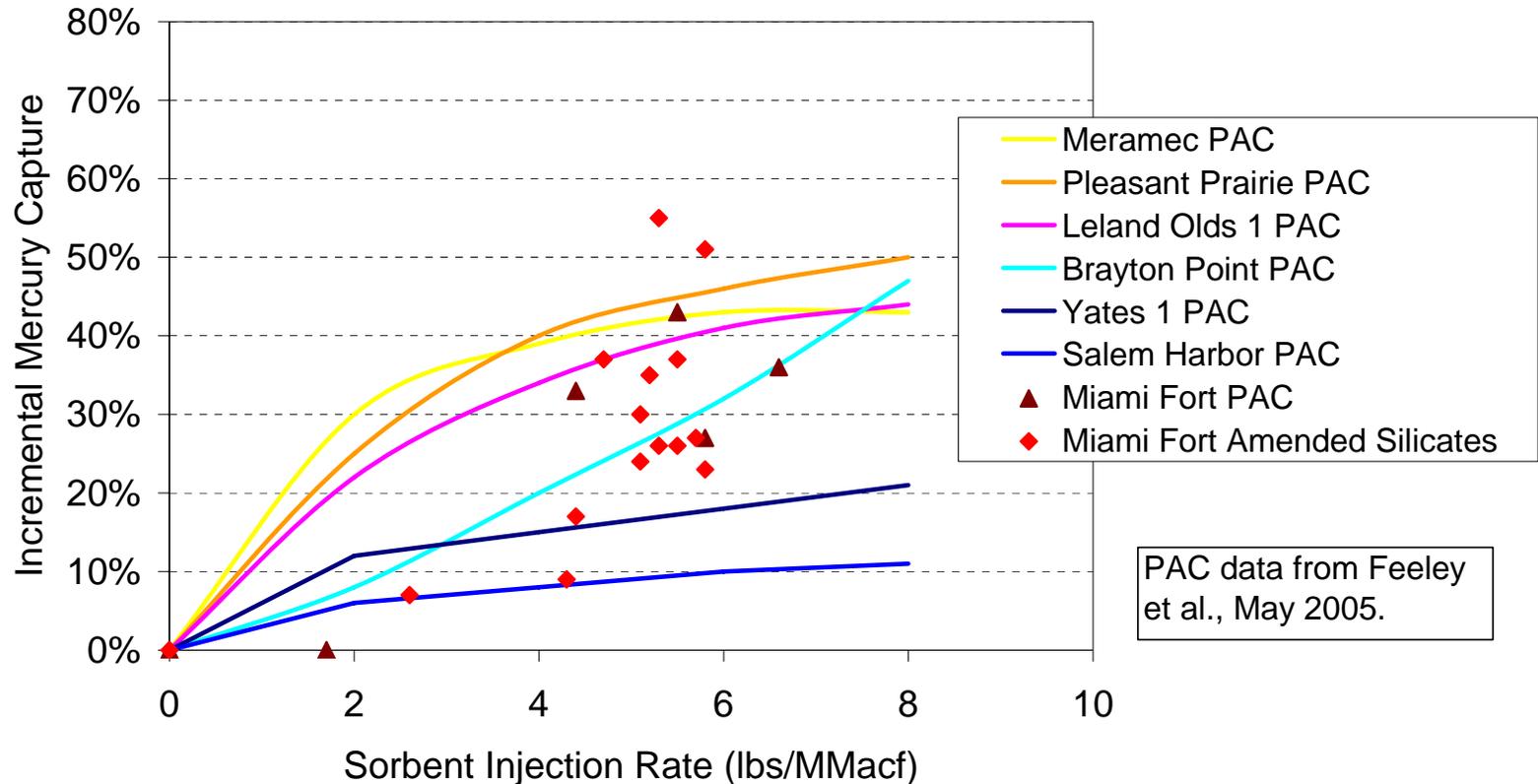


Total Hg Capture averaged about 40% for both sorbent materials



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Comparison of incremental Hg Capture: Plants with cold-side ESPs



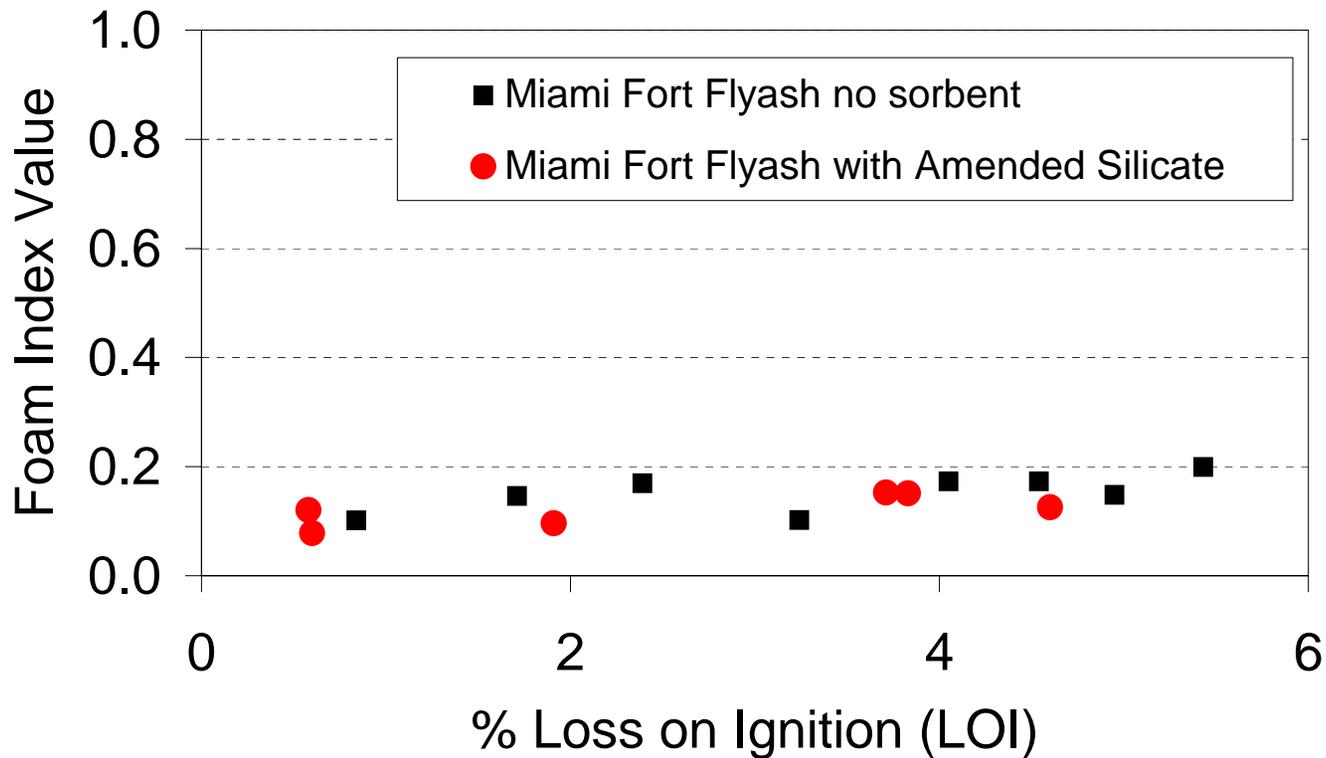
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Fly Ash Analysis

No effect on Foam Index Value



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Fly Ash Analysis

Boral comparison of samples

Description	Sample Number	LOI (%)	Flow (%)	Control Mortar Air (%)	Mortar Air (%)	MAR (%)
Baseline, no sorbent (1/18)	6289-01	4.14	85.0	17.63	14.12	80.09
Amended Silicates (3/14)	6289-02	3.65	89.0	17.63	13.31	75.50
PAC (3/21)	6289-03	5.32	80.0	17.63	5.70	32.33

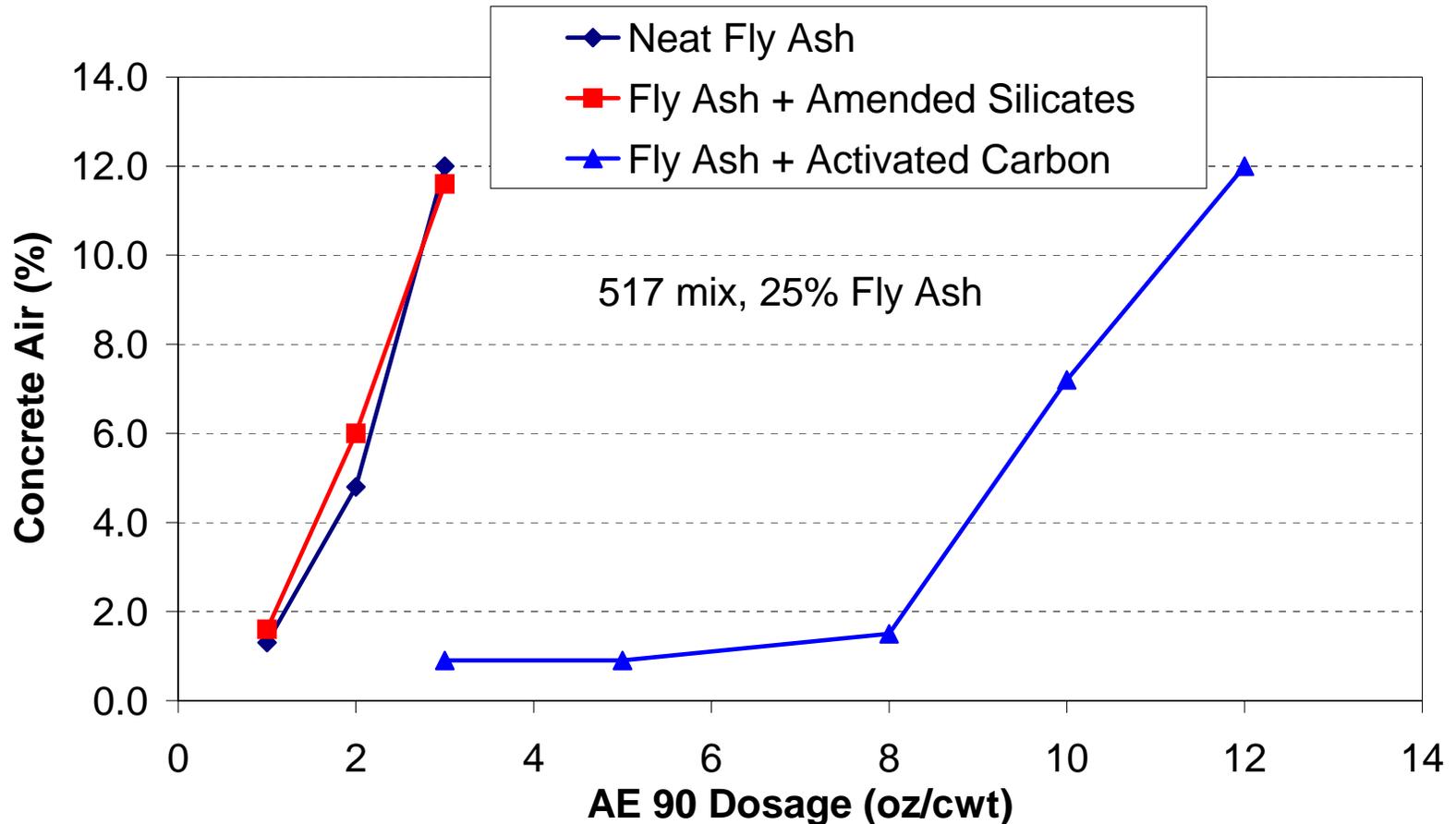
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Fly Ash Analysis

No impact on air entrainment agent



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Fly Ash Analysis

Boral concrete strength

Compressive strength of concrete samples made with Miami Fort fly ash

	7 days	28 days	56 days
Baseline, no sorbent Sample 6289-01	2487 psi	3554	TBD
with Amended Silicates Sample 6289-02	2491 psi	3581	TBD
with PAC Sample 6289-03	2190 psi	3374	TBD

Leaching Results from Sorbent / Fly Ash Mixtures

Sample ID, Collection Date	Total Mercury	Leachable Mercury via TCLP
PAC, Mar 21	470 ppb	7 ppb
Amended Silicates, Feb 20	548 ppb	1.7 ppb
Amended Silicates, Mar 1	589 ppb	1.6 ppb

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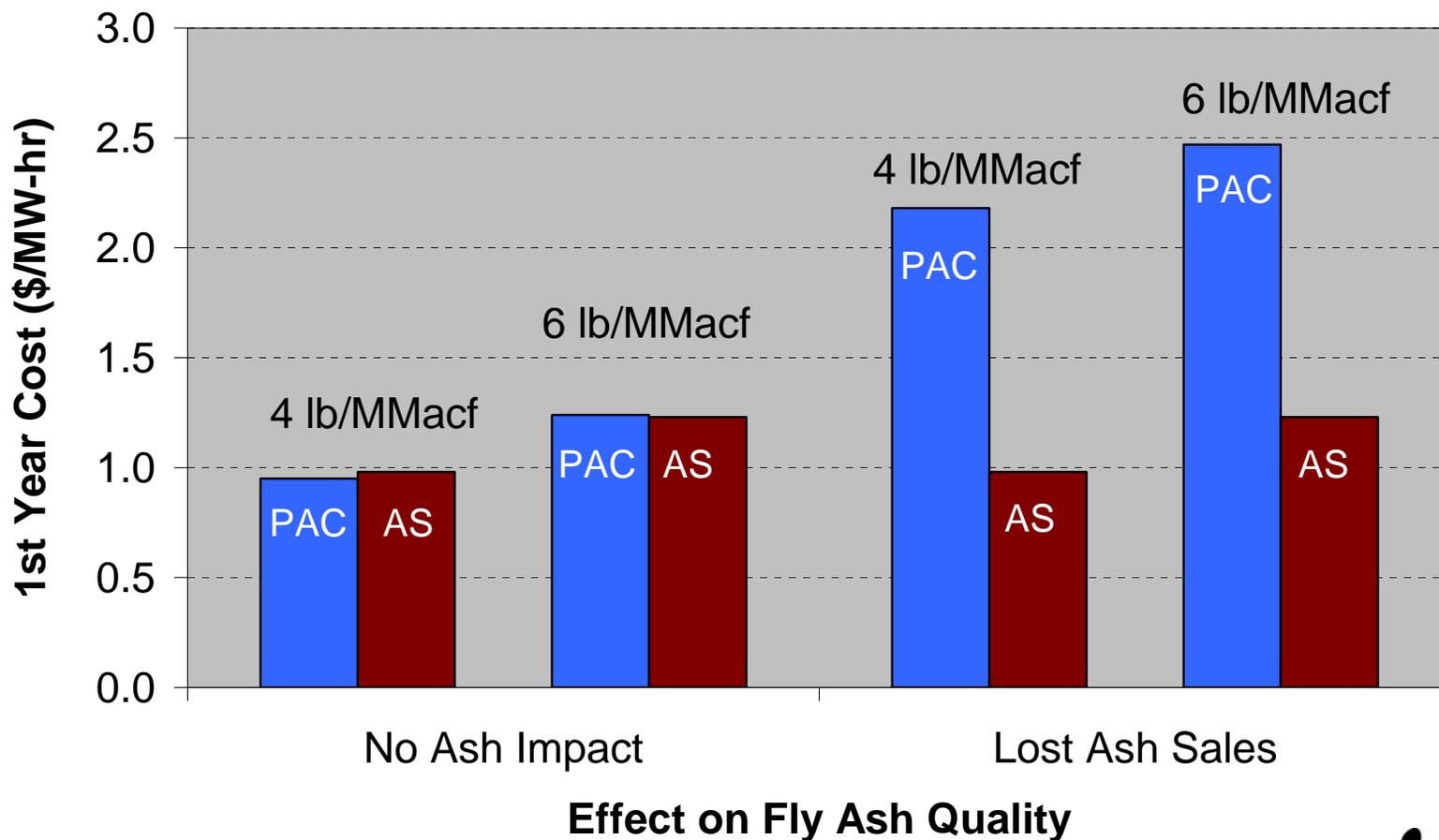


Economic Analysis

- Performed by engineers at CH2M Hill
- Key assumptions:
 - Used Miami Fort Unit 6 as test case
 - Capital costs estimated following DOE/NETL's Phase II Mercury Control Technology Field Testing Program, April 2006
 - Capital equipment requirements identical for both sorbents
 - Reported costs include annual O&M plus annualized capital (20 year life, 9.2% discount rate)
 - Delivered sorbent cost = \$0.67/lb for PAC (vendor quote), \$0.60-\$0.80/lb for Amended Silicates
 - Ash disposal cost \$17/ton, ash sales credit \$18/ton



Economic Analysis



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Conclusions

- The injection system provided a uniform sorbent distribution in the gas ductwork and was suitable for both sorbents. Sorbent injection was routine and relatively uneventful.
- Without sorbent injection, Unit 6 had very low mercury removal. Data showed 0-10% capture by the fly ash.
- The elemental mercury fraction in the flue gas ranged from 2/3 to 1/3 of the total mercury. Fuel changes likely caused shift.
- ESP operating parameters and stack opacity were not statistically affected by sorbent injection.
- The CMMs required constant attention and generated data with considerable scatter.



Conclusions, cont.

- Amended Silicates™ and PAC sorbent achieved about 40% mercury control at injection rates of 5-6 lbs/MMacf. Higher injection rates did not significantly increase removal.
- Amended Silicates sorbent in the fly ash did not affect the properties of the fly ash / sorbent mixture in typical tests for use as a cement replacement.
- Mercury control cost for the two sorbents is similar in the absence of fly ash re-use.
- The ability to retain fly ash sales makes the overall cost of Amended Silicates approximately half the cost of PAC injection.



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Future Activities

- Final report submittal December 2006
- Short term trial on North Dakota Lignite
- Short term trial at PRB location
- Business planning



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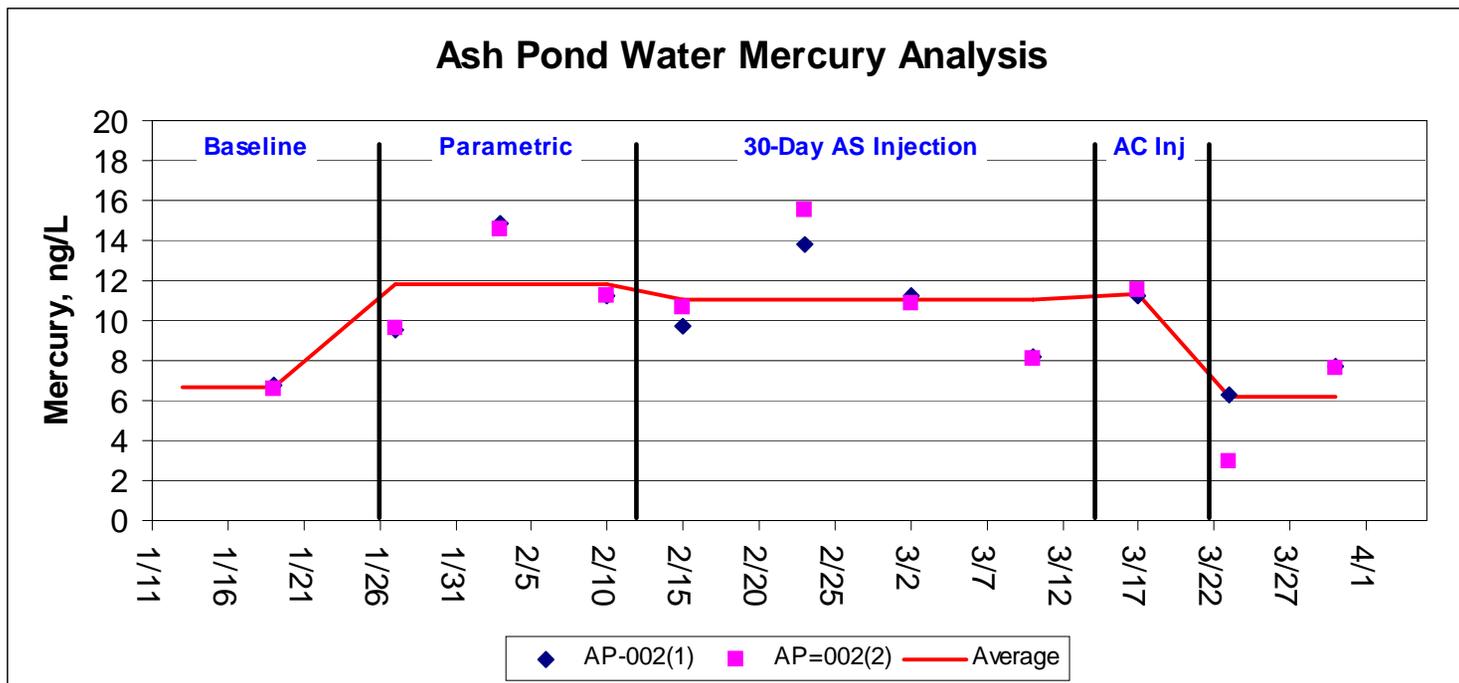


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 - Duke Energy
 - Engelhard Corporation
 - Amended Silicates, LLC
 - Boral Material Technologies Inc.
 - Separation Technologies, LLC



Mercury in Ash Pond Water



Domestic Wastewater >100 ng/L

Ambient Water Quality Criteria ~1 ng/L

Development of Ambient Water Quality Criteria For Mercury, A Report to the Joint Standing Committee on Natural Resources by The Department Of Environmental Protection, State of Maine, January 15, 2001, DELPW2001-4

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