EVALUATION OF LOW-ASH IMPACT SORBENT INJECTION TECHNOLOGIES AT A TEXAS LIGNITE/PRB FIRED POWER PLANT

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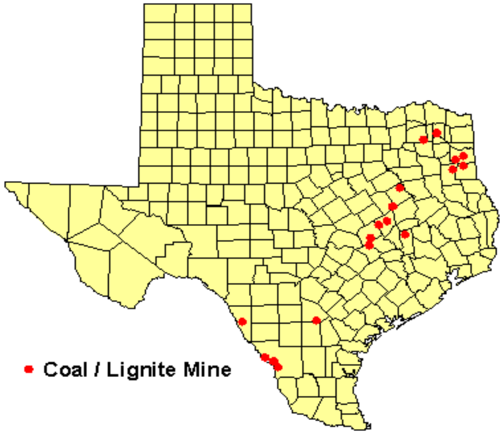
Background – Texas Lignite

- TxL accounts for ~5% of U.S. coal fired
  - ~10% of U.S. utility Hg emissions
- Challenges for Hg control
  - Fuel properties can be quite variable
    - Fluctuating flue gas Hg levels
    - TxL/PRB blends
  - Relatively low fuel chlorine levels
    - Flue gas Hg oxidation typically 25 – 50%
  - Low heating value
    - High gas volumes
    - Relatively high flue gas temperatures
  - Sorbent impact on fly ash is a concern



Background – Texas Lignite

- **Needed information:**
  - **What sorbents are effective in TxL-derived flue gas?**
  - **Can ACI be effective while preserving fly ash resale?**

Host Site – NRG Texas Limestone Electric Generating Station (LEGS): Jewett, TX

- **Unit 1**
  - **Unit 1: 890 MW**
  - **Split tangential boiler**
- **Fuel**
  - **Blend of Texas lignite and PRB coal**
    - **Typically fires 70/30 TxL/PRB blend**

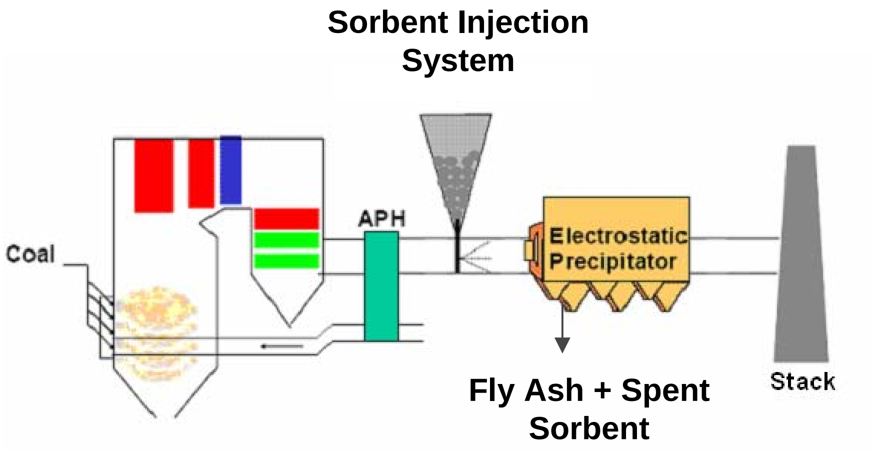
Fuel Type	Texas Lignite	PRB
HV (Btu/lb as-recd)	5500 – 6900	7900 – 8300
Ash (%)	15 – 27	4 – 8
Sulfur (%)	1	0.4
Water (%)	30	30
Hg (ppmd)	0.15 – 0.22	0.06 – 0.10
Cl (ppmd)	50 – 100	25 – 60

Background – Low Ash Impact Sorbent Injection

Ash sample undergoing foam index titration

- Carbon competitively adsorbs the air-entraining admixtures (AEAs) added for air entrainment and stabilization
- Foam index test measures AEA demand
- Results in a larger amount and more variability of AEA needed
- $$ (lost fly ash sales and disposal) >> $$ (carbon sorbent)

Background – Low Ash Impact ACI

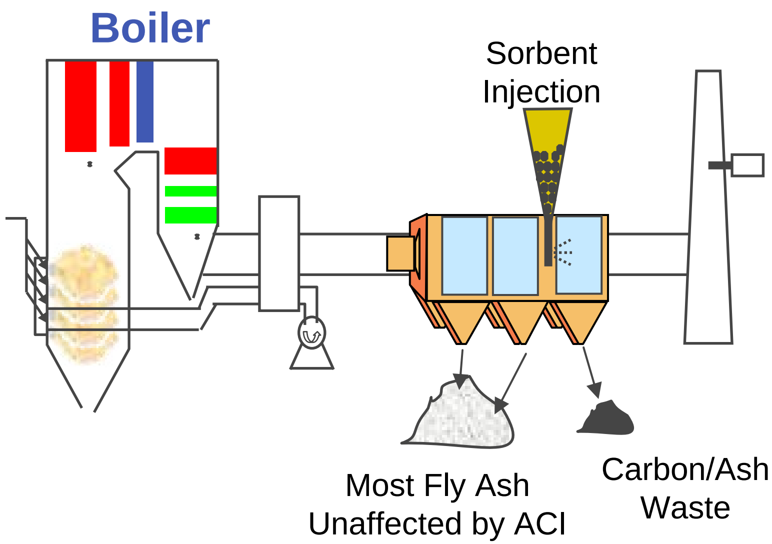


Traditional Sorbent Injection

- Possible Low Ash Impact Implementations
  - Minimize amount of activated carbon to maintain AEA to within acceptable levels
  - Maintain consistent sorbent/ash ratio to make AEA requirement consistent
  - Apply surfactant at plant to passivate the carbon; ash arrives ready-to-use at concrete manufacturer

Background – Low Ash Impact ACI

- Toxecon II™
  - Inject sorbent mid-stream of ESP
  - Bulk of fly ash collected upstream of injection point
  - Carbon/ash mixture collected downstream of injection point is waste
  - Has been demonstrated at only a few sites
  - Concerns about achieving required Hg removal, carbon breakthrough, ESP effects



Toxecon II™

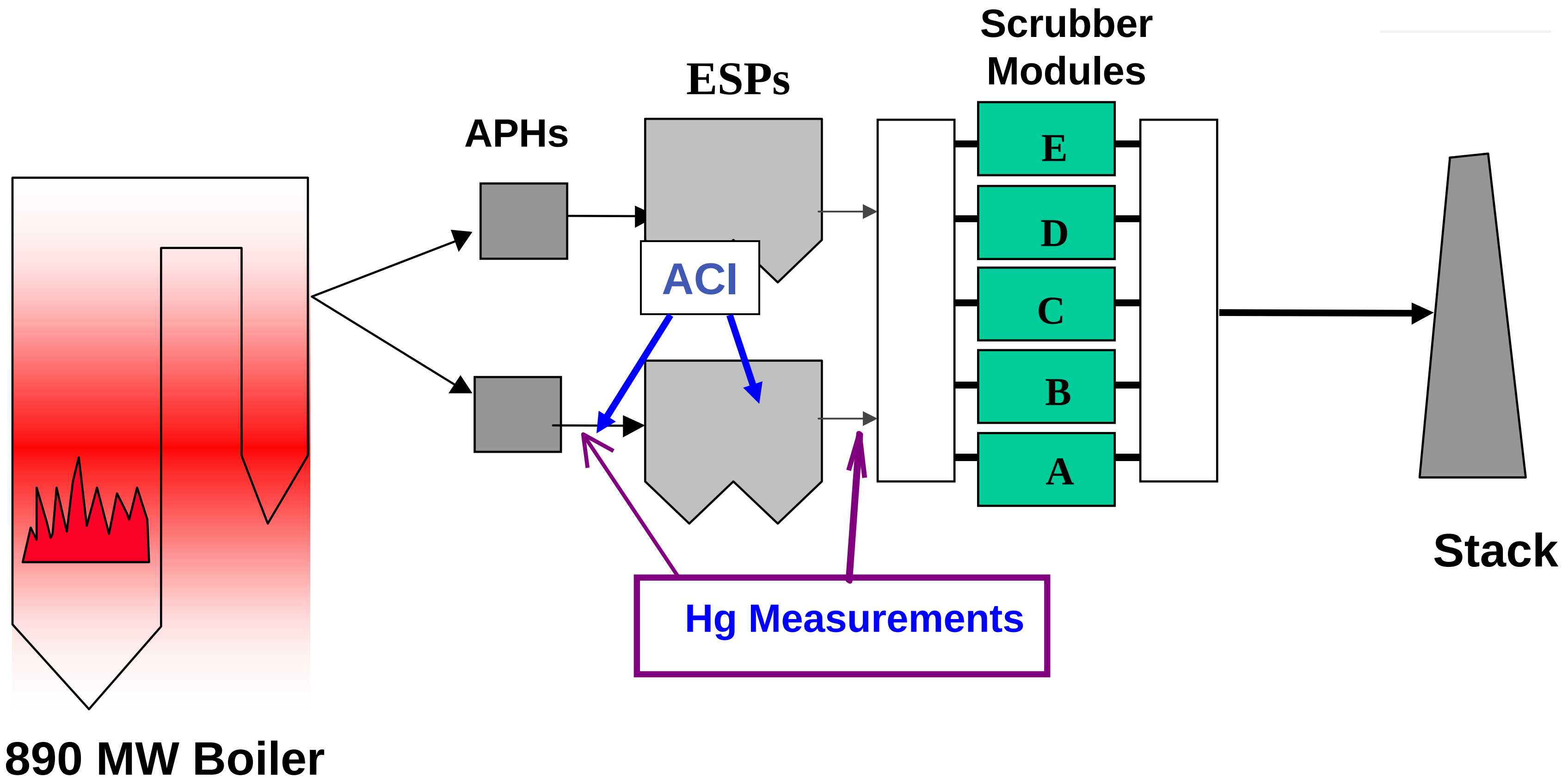
Background – Low Ash Impact Sorbents

- Sorbent Technologies C-PAC™
  - – Passivate the carbon so that it adsorbs mercury but does not adsorb the AEA
  - – Demonstrated in 30-day test at Midwest Generation's Crawford Power Plant
    - **81% removal at 4.5 lb/Macf**
    - **C-PAC containing ash required more AEA, but it was very consistent in AEA requirements**
- BASF Catalysts, LLC
  - – Mineral based sorbent – may adsorb less AEA
  - – Tested at pilot scale and in limited full-scale tests at PRB sites

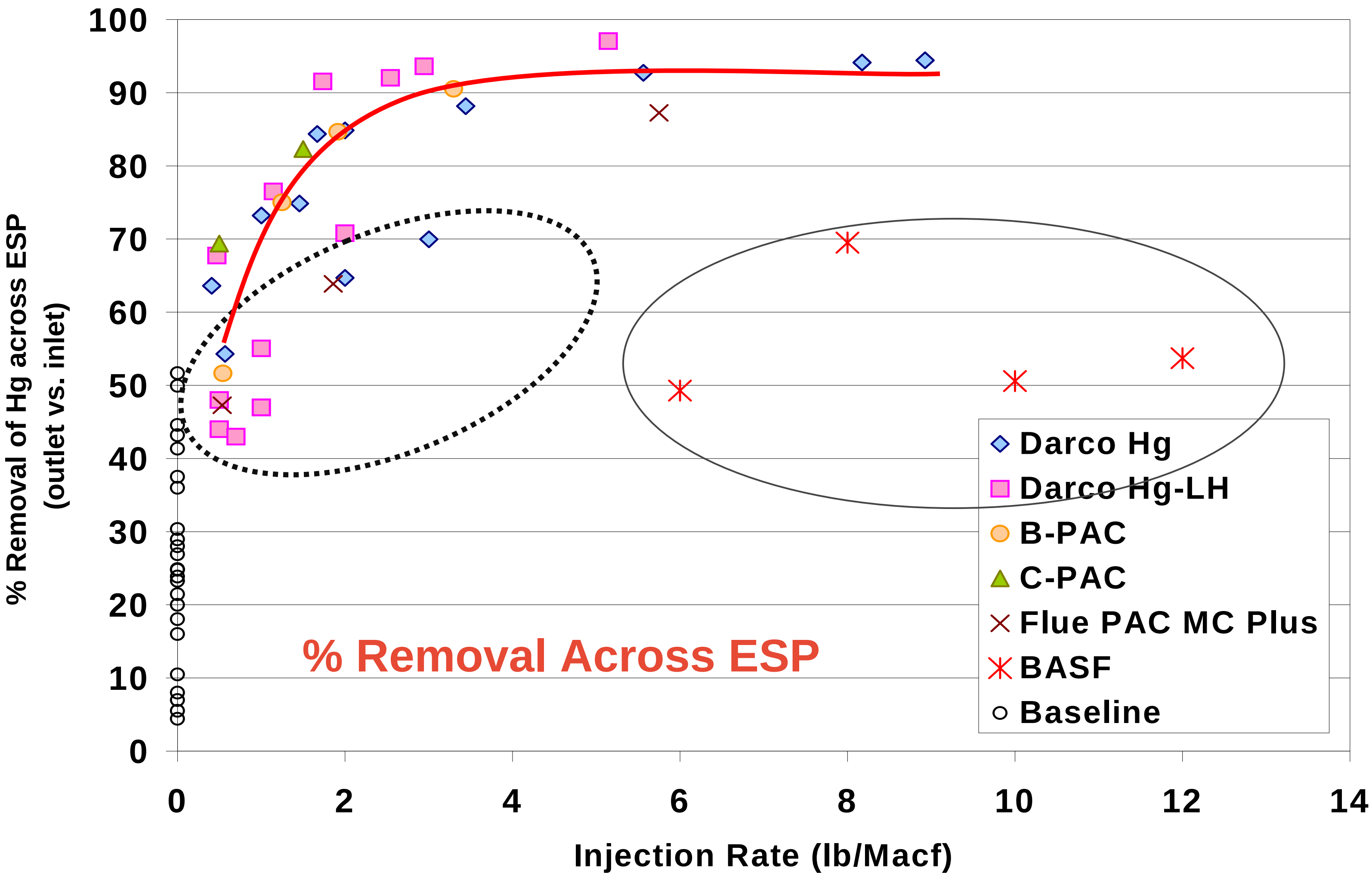
Sorbents Tested

Sorbent Name	Manufacturer	Manufacturing Location	Price ($/lb, FOB)	Sorbent Description	d_{50} (µm)
Darco Hg	Norit Americas	Marshall, TX	$0.50	Texas lignite derived activated carbon	19
Darco Hg-LH	Norit Americas	Marshall, TX	$0.85	Texas lignite derived activated carbon, treated with bromine	19
B-PAC™	Sorbent Technologies	Twinsburg, OH	$0.85	Activated carbon, treated with bromine	20
C-PAC™	Sorbent Technologies	Twinsburg, OH	$1.20	Activated carbon treated with bromine and passivated to be low-ash impact	20
Flue PAC MC Plus	Calgon Carbon	Pittsburgh, PA	$0.90-$0.95	Activated carbon, treated with bromine	unknown
MS200	BASF	Gordon, GA and Attapulgus, GA	$0.90	Enhanced molecular sieve material	15-20

Limestone Unit 1 Configuration



Parametric Results - Sorbent Injection Upstream of ESP



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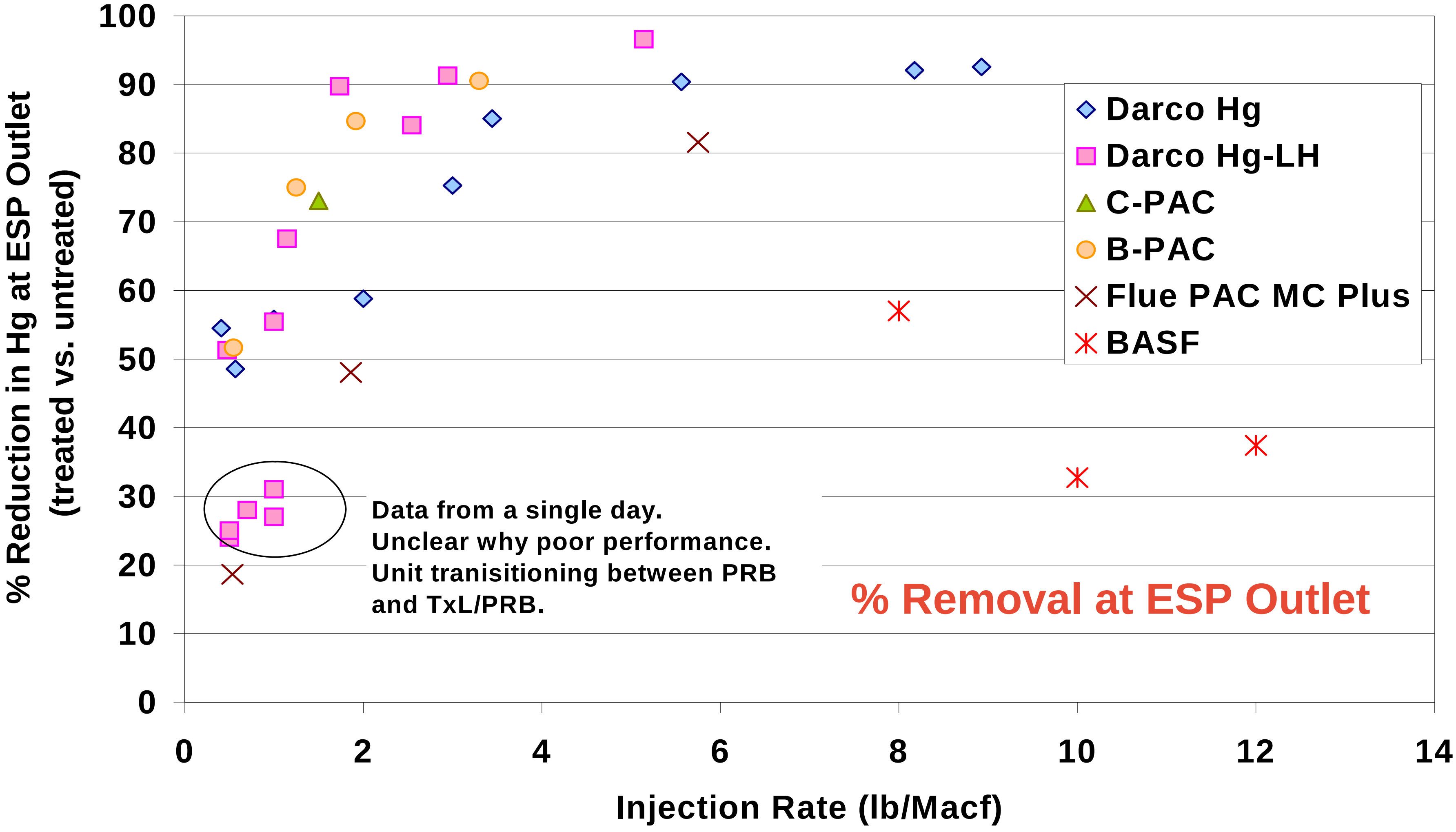
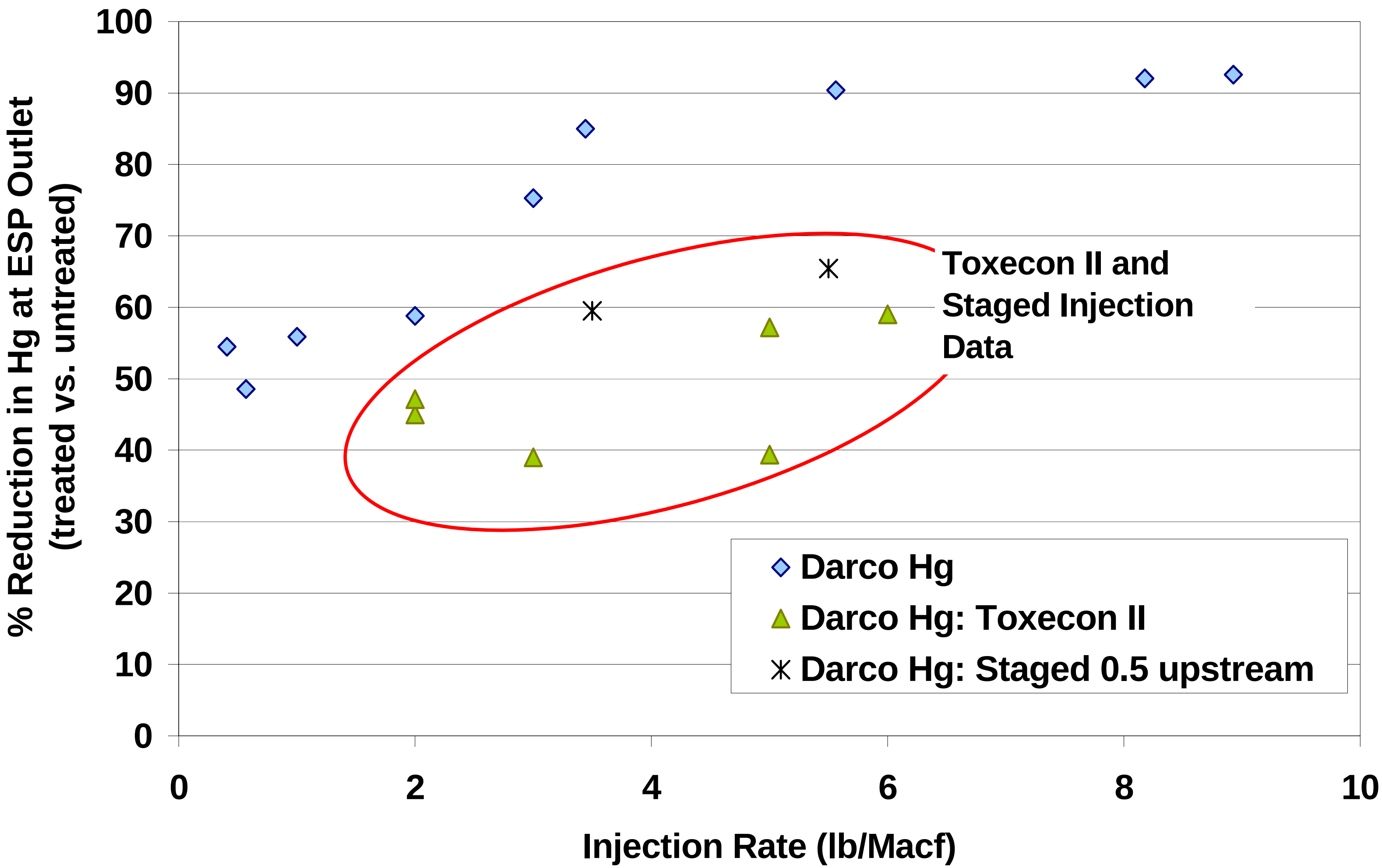
Parametric Results - Sorbent Injection Upstream of ESP



Parametric Results – Toxecon II™



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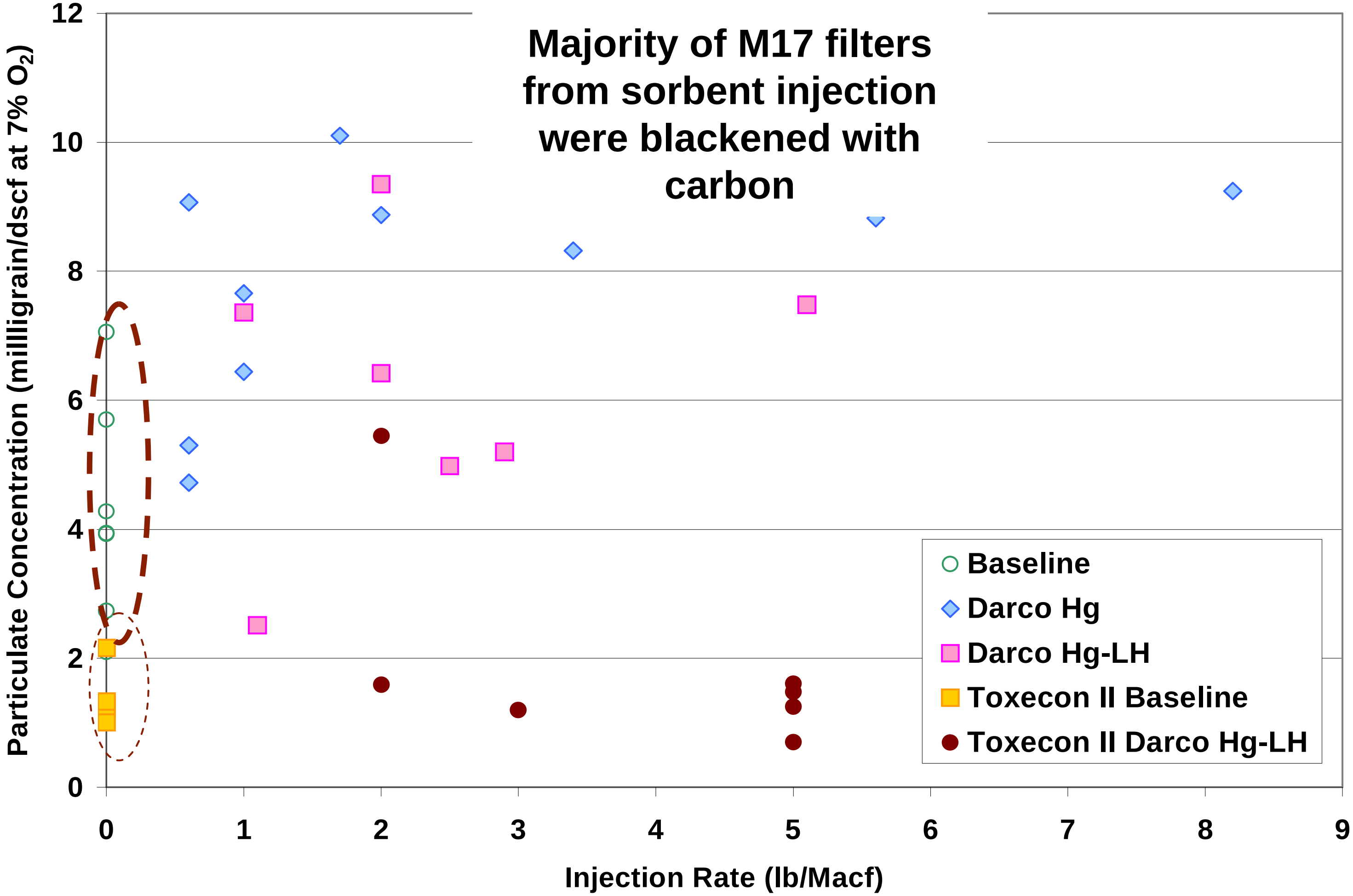
Parametric Results – Particulate Breakthrough



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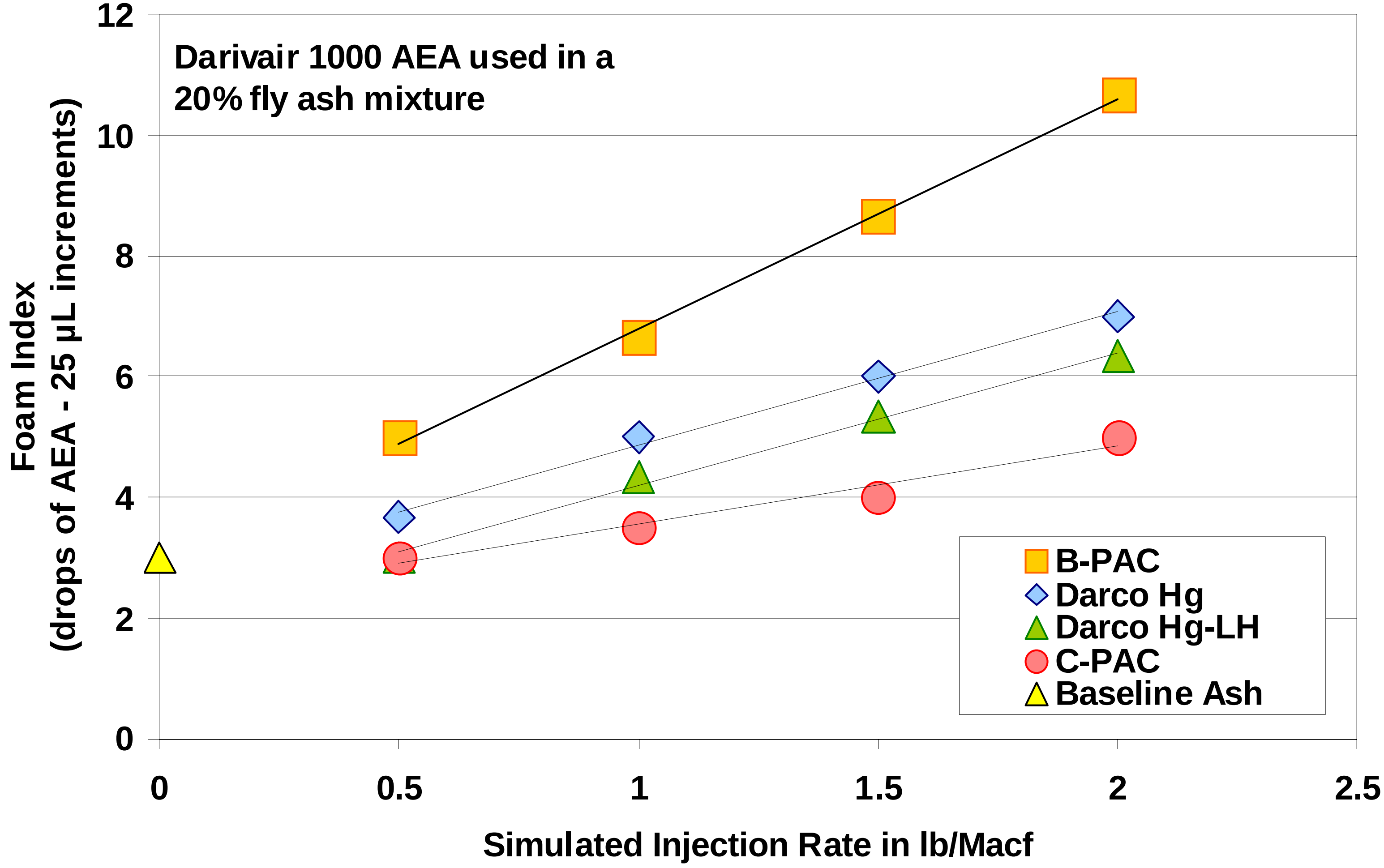
Parametric Results – Concrete Testing

- Baseline ash - 3 to 4 drops AEA
- 0.6 lb/Macf injection of Darco Hg (24-hour period of injection) - 3 to 4 drops
- Simulated ash/carbon mixtures
  - **DARCO Hg**
  - **DARCO Hg-LH**
  - **B-PAC**
  - **C-PAC**

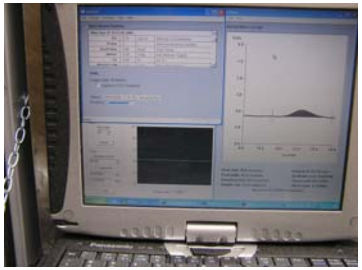
Foam Index Results for Simulated Ash/Carbon



Long-term Sorbent Injection Test

- Test conditions determined from parametric results (performance and cost analysis)
  - Injection upstream of ESP
  - Darco Hg-LH
  - 2 lb/Macf

- Continuous injection test
  - 60-day test
  - Evaluate process performance & variability
  - Balance of plant impacts
    - Fly ash concrete testing
    - ESP electrical performance



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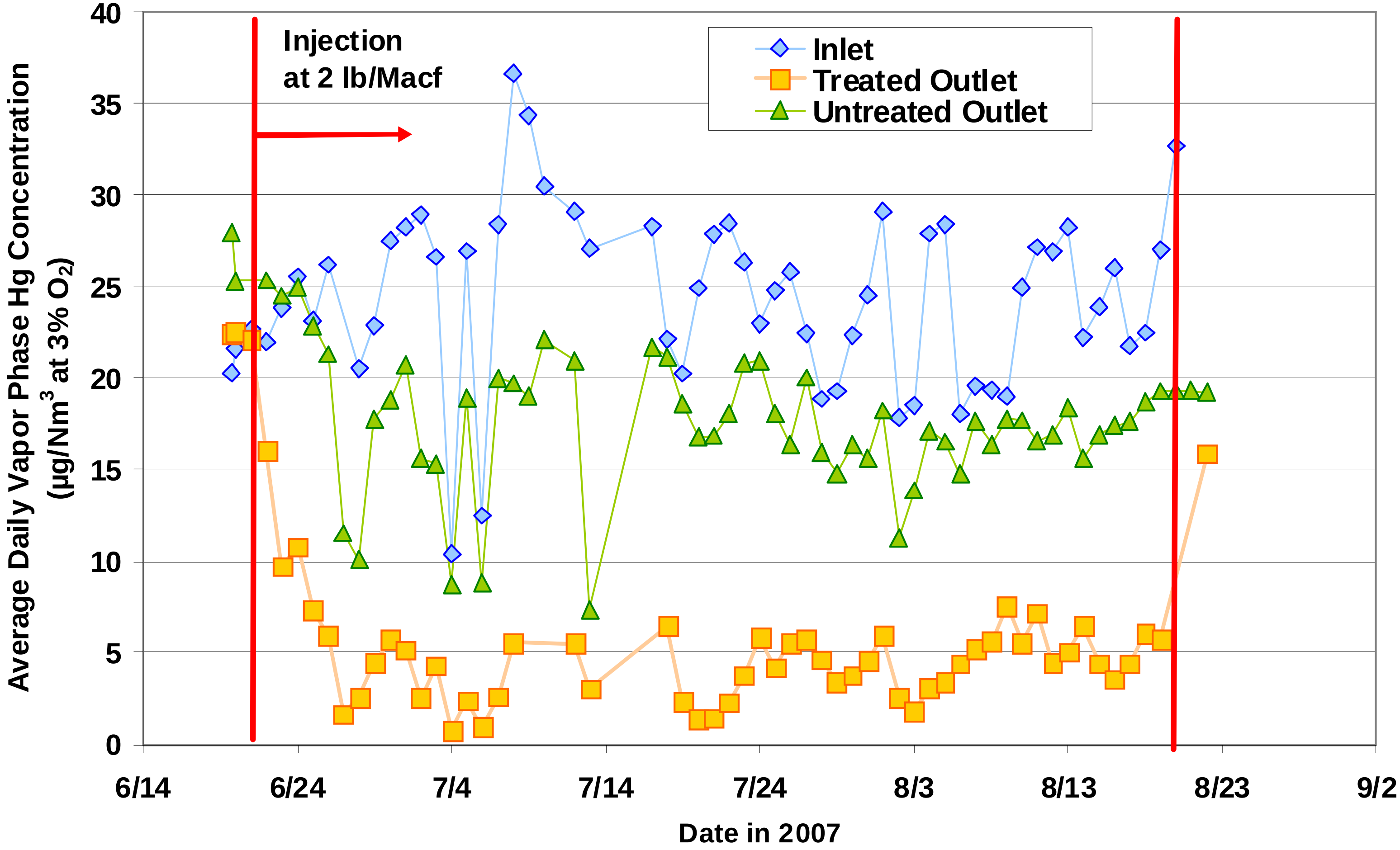
Long-Term Results – Hg Concentrations



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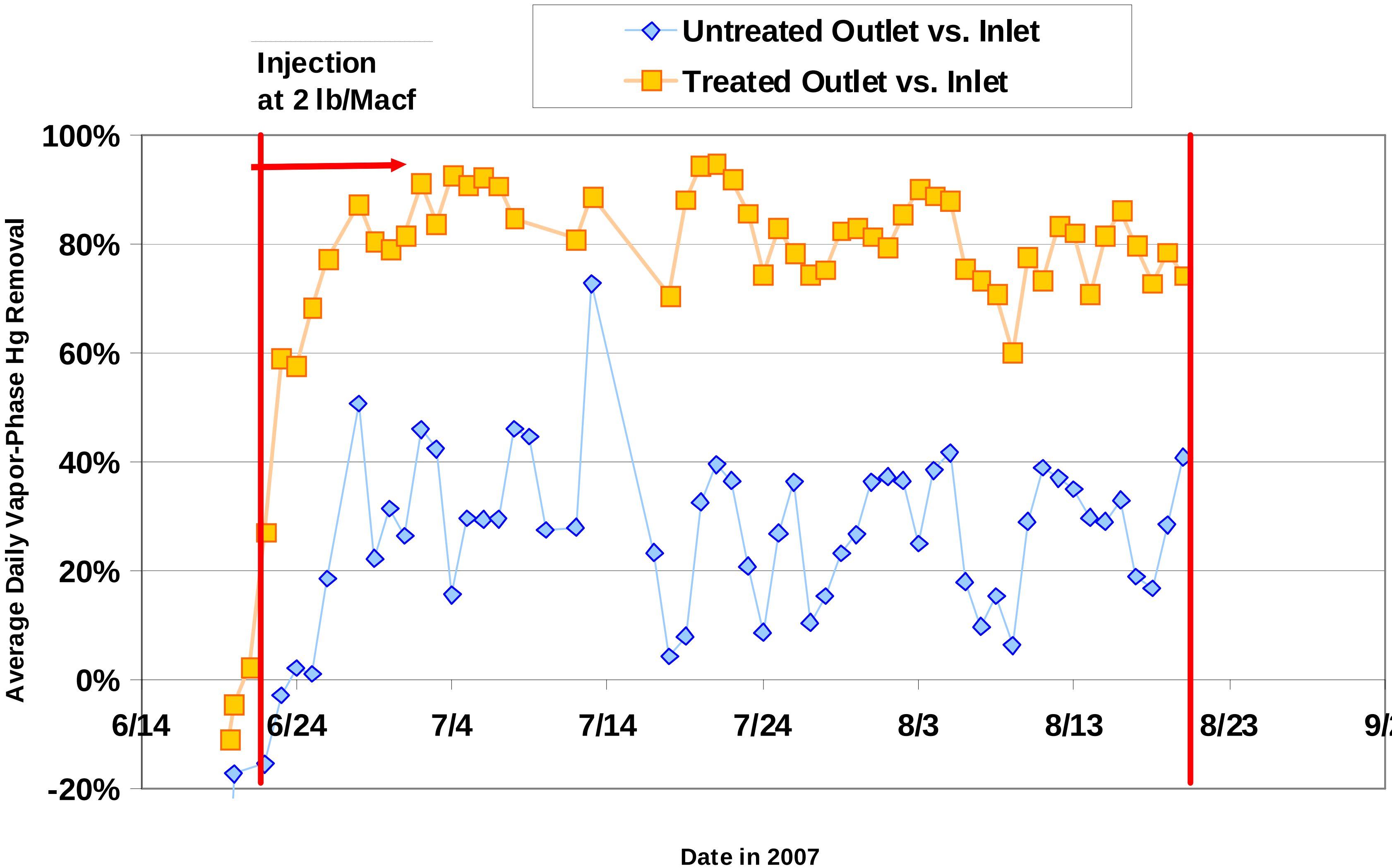
Long-Term Results – Hg Removal



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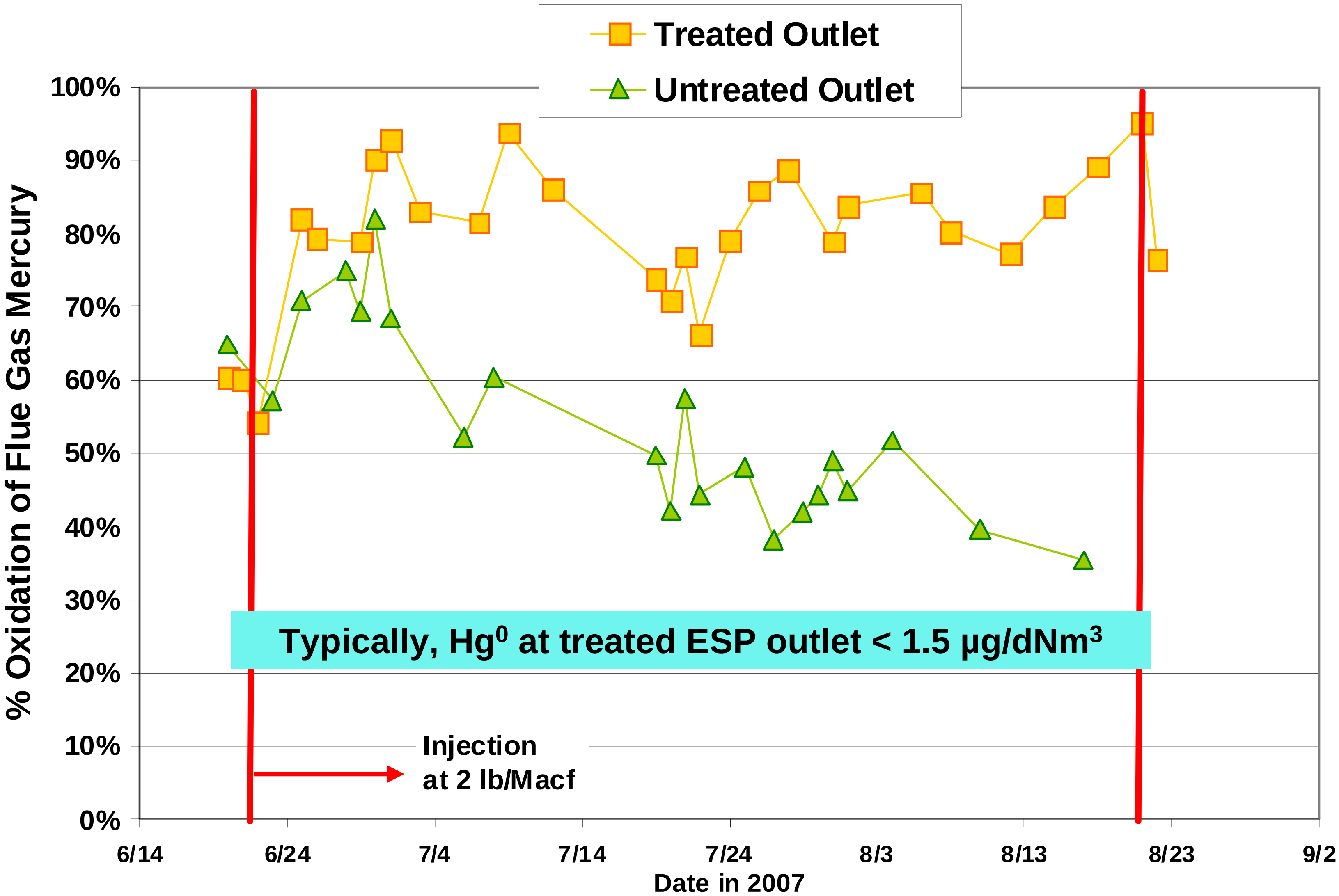
Long-Term Results – Hg Oxidation



Long-Term Results
Summary of Hg Data

- Average Hg Concentrations (µg/dNm^3 at 3% O_2)

	Inlet	Untreated Outlet	Treated Outlet
TxL/PRB	25.7	18.5	5.2
100% PRB	11.7	9.0	1.2

- Average Hg Removal

Removal	Untreated Outlet vs. Inlet	Treated Outlet vs. Inlet
TxL/PRB	26%	80%
100% PRB	27%	92%

- Average Hg Oxidation

Oxidation	Inlet	Untreated Outlet	Treated Outlet
TxL/PRB	37%	49%	81%
100% PRB	30%	54%	N/A

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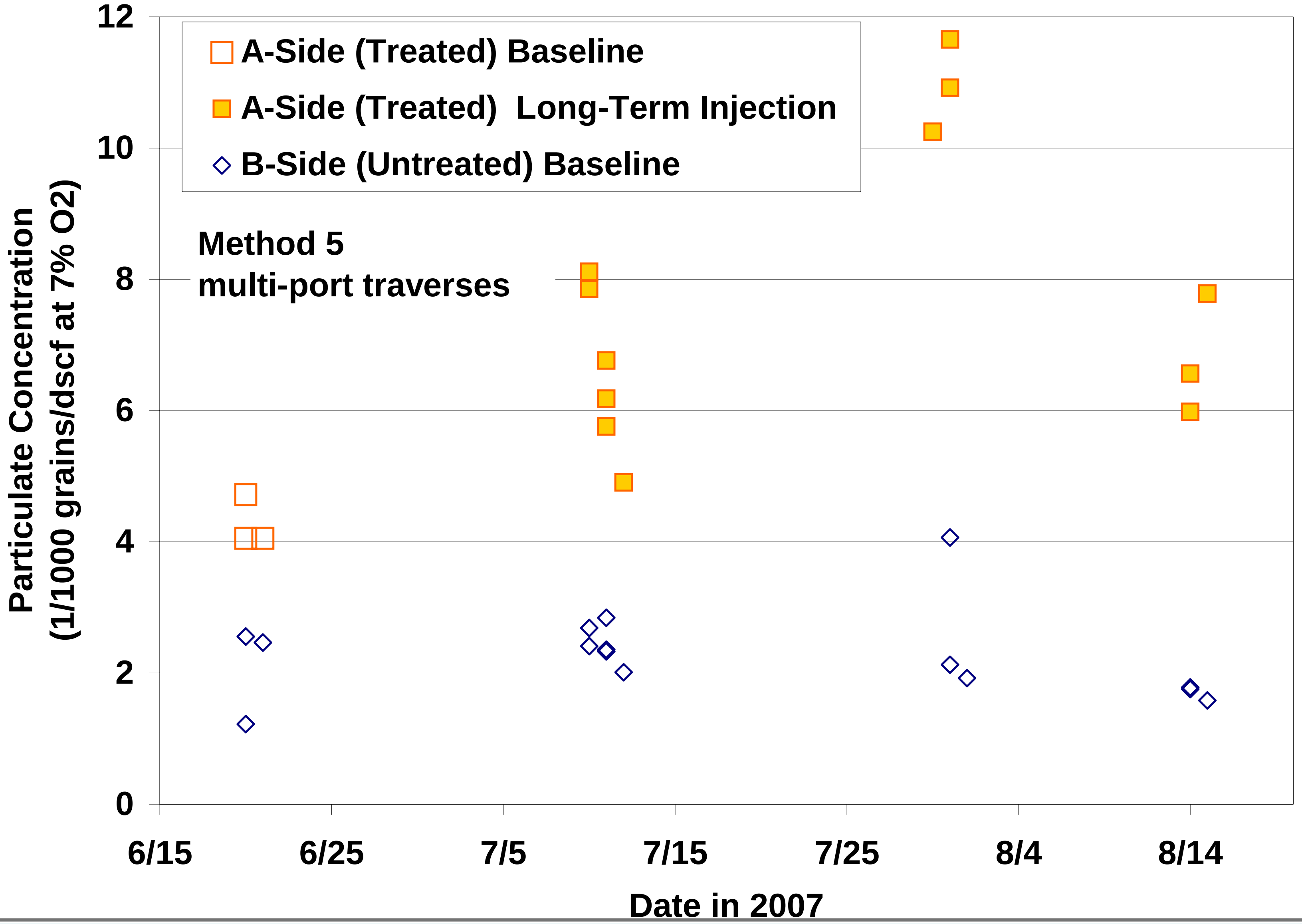
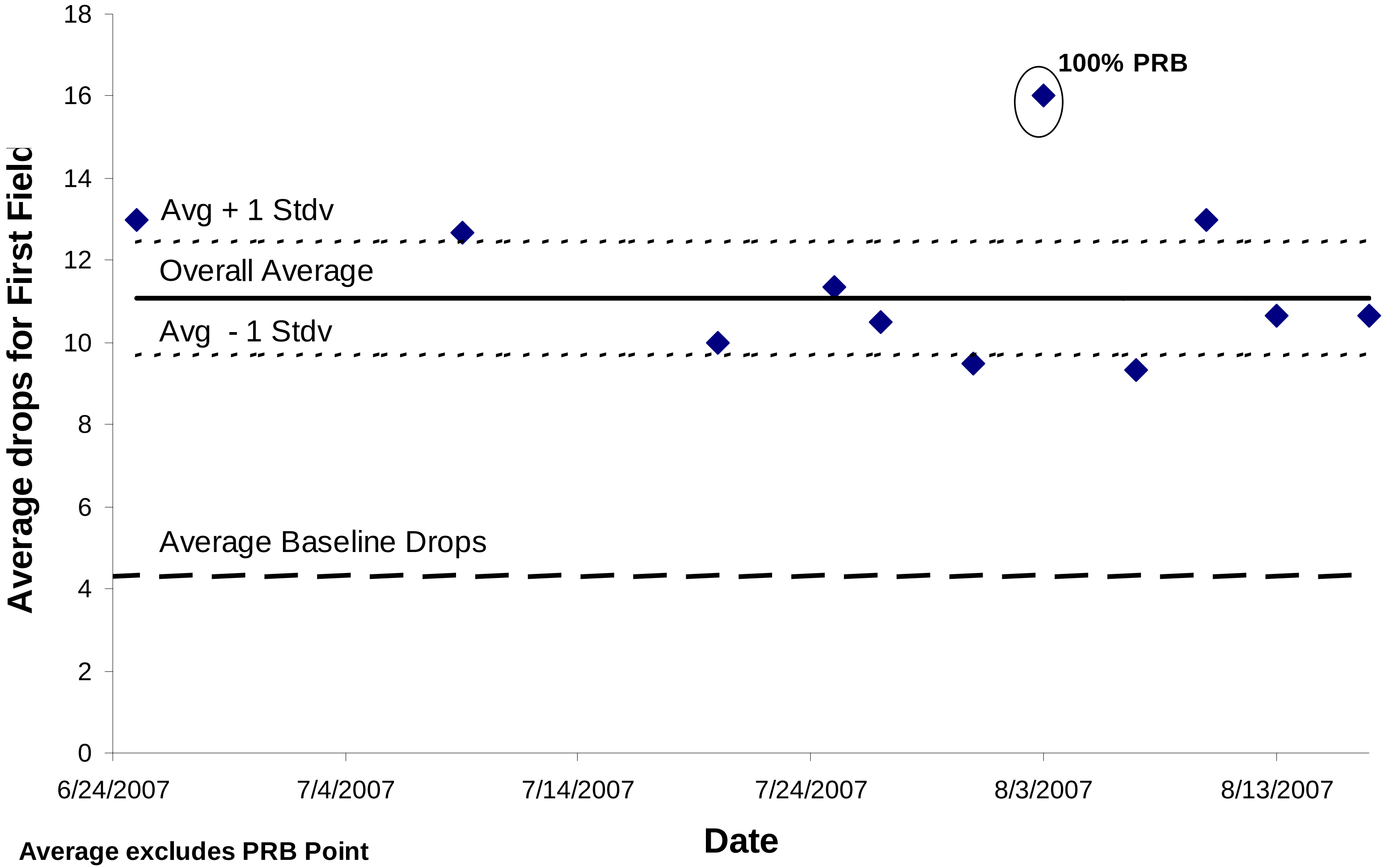
Long-Term Results – Particulate Breakthrough from ESP



Long-term Results – Foam Index from First Field



Average excludes PRB Point

Long-Term Results
Concrete Testing

- **Important Concrete Properties**
  - **Slump (passing 6 ± 1)**
    - **Slump is the workability of the concrete**
    - **Affected by adding chemical admixtures**
  - **Air Pressure (passing 6% ± 1)**
    - **Measured with required AEA**
  - **Compressive Strength**

Long-Term Results
Concrete Testing

- **Concrete made from individual hopper ash from 3rd day of LT injection.**
  - **Comparable to simulated 2.0 lb/Macf concrete in AEA, slump, and air pressure**
  - **Passed all concrete test criteria**
- **Concrete made of injection ash from ESP hoppers to simulate silo ash**
  - **Tested Day 18 and Day 42 of LT injection**
  - **Passed slump and air pressure tests**
  - **Compressive strength results pending**
  - **Results from other injection days pending**

Summary of Results

- Activated carbon injection upstream of the ESP resulted in appreciable Hg removal in TxL/PRB flue gas
  - **Standard activated carbon performed nearly as well as brominated activated carbon**
  - **High levels of mercury oxidation at ESP outlet**
- Toxecon II™ injection did not result in mercury removals high enough to achieve project target of 50% removal
- 60-day injection test performed with 2 lb/Macf Darco Hg-LH upstream of the ESP
  - **Average Hg Removal of 80% (inlet to outlet)**
  - **Sorbent broke through the ESP**
  - **Fly ash may be suitable for concrete use based on preliminary results**

Conclusion

- **Consistency of fly ash is key to use for concrete**
- **Challenges to consistency at Limestone**
  - **Varying carbon injection rate**
  - **Varying fuel blend**
- **Possible ways to implement ACI at Limestone**
  - **Over-control Hg removal**
    - **Inject at a constant rate that guarantees target is met**
  - **Inject small (0.5 lb/Macf) amount of carbon**
    - **Does not significantly affect foam index**
    - **Relies on Hg oxidation and removal across scrubber (not tested)**
  - **Vary injection rate to control Hg removal**
    - **Apply surfactant at plant site to passivate carbon (to be tested)**

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