

Update on Activated Carbon for Hg Control



**Ralph Altman and
Ramsay Chang**

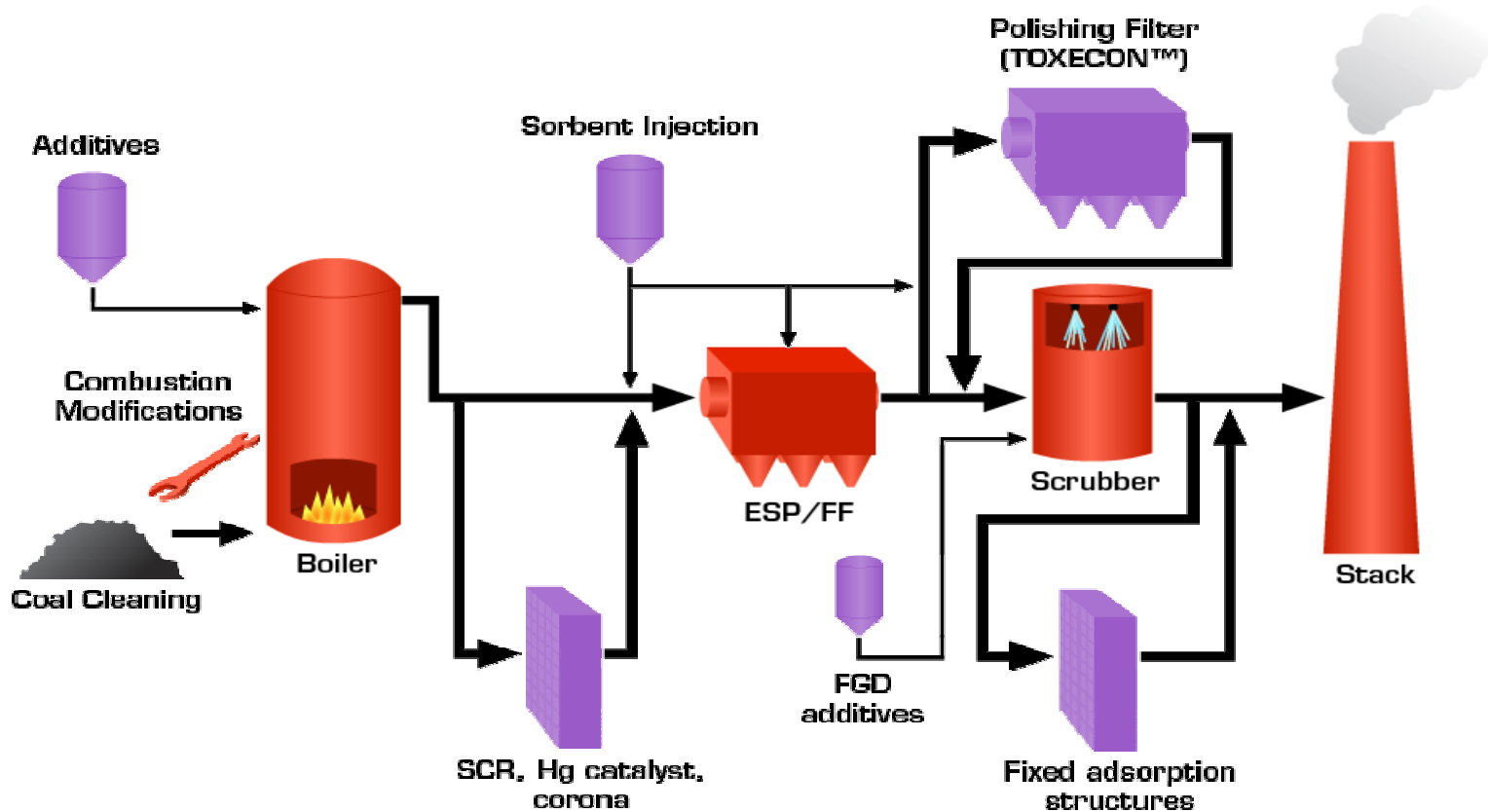
**2005 APC Round Table &
Expo**

**July 26, 2005
Tampa, Florida**

Presentation Outline

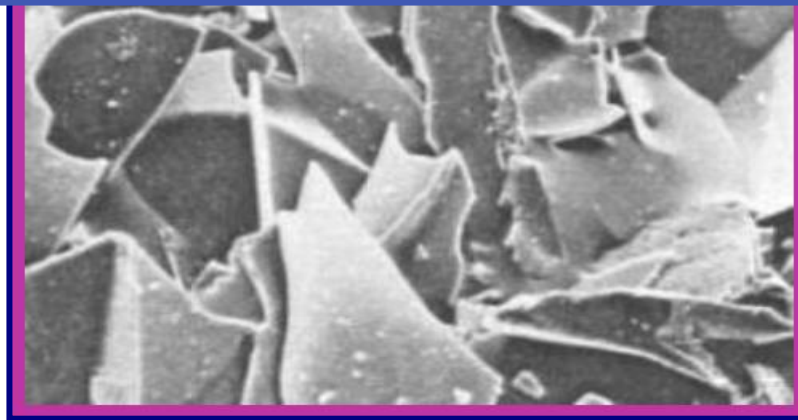
- **ACI full-scale test data and trends**
- **AC cost projections**
- **Plans for 2005 and beyond**

Key Hg Control Options & Development



Sorbent Injection

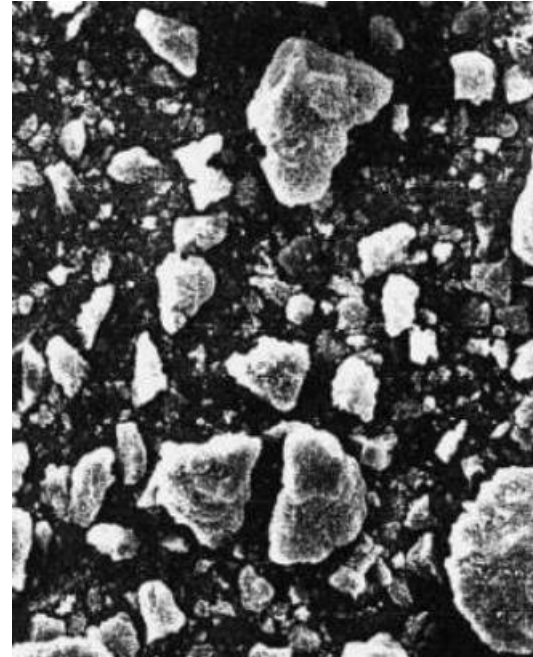
- Activated carbon, halogenated carbon, “concrete friendly” sorbents, “Thief”, high temperature sorbents
- TOXECON® type approaches
- Combustion modifications, modify unburned carbon amount and characteristics



Sorbent Injection

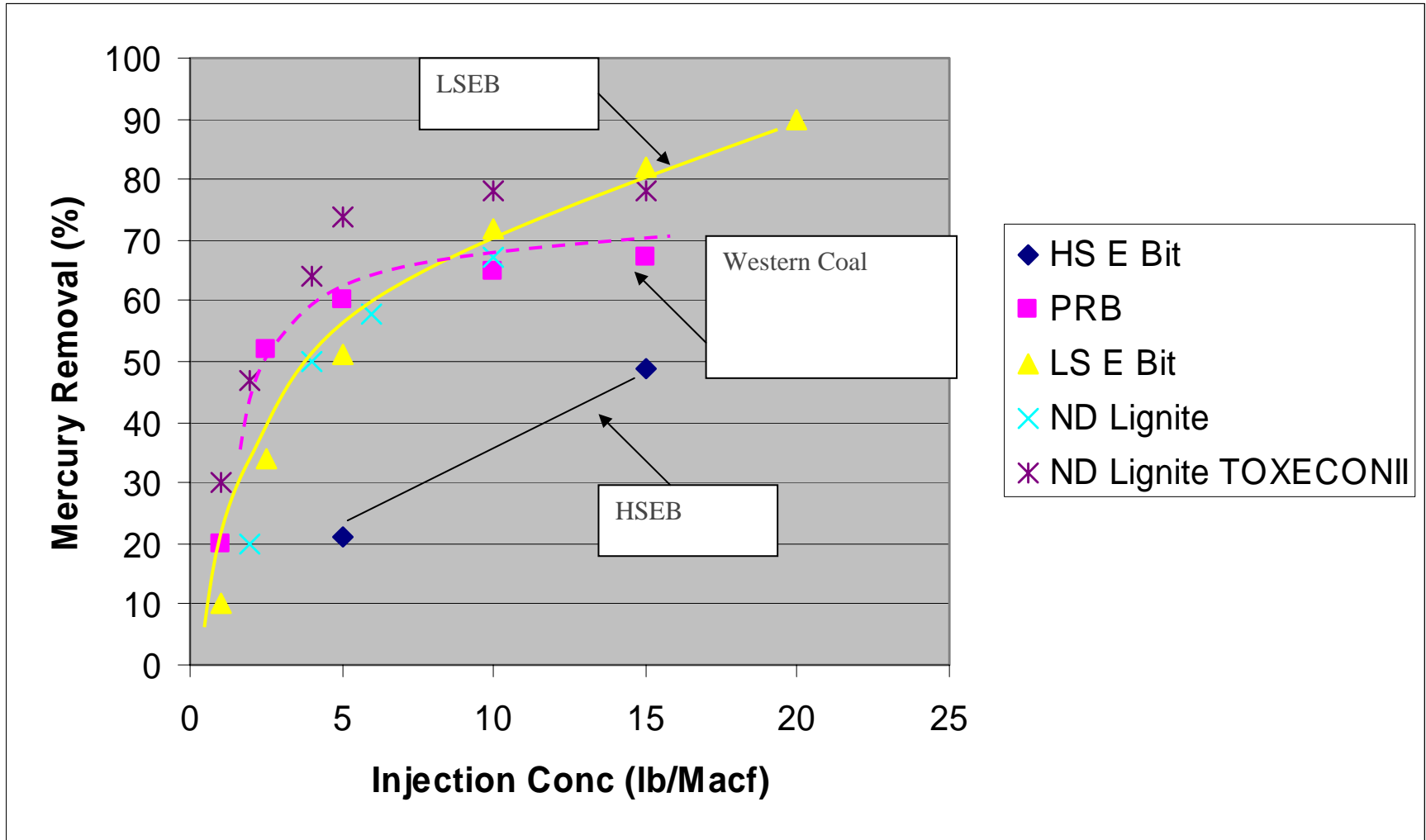


Silo

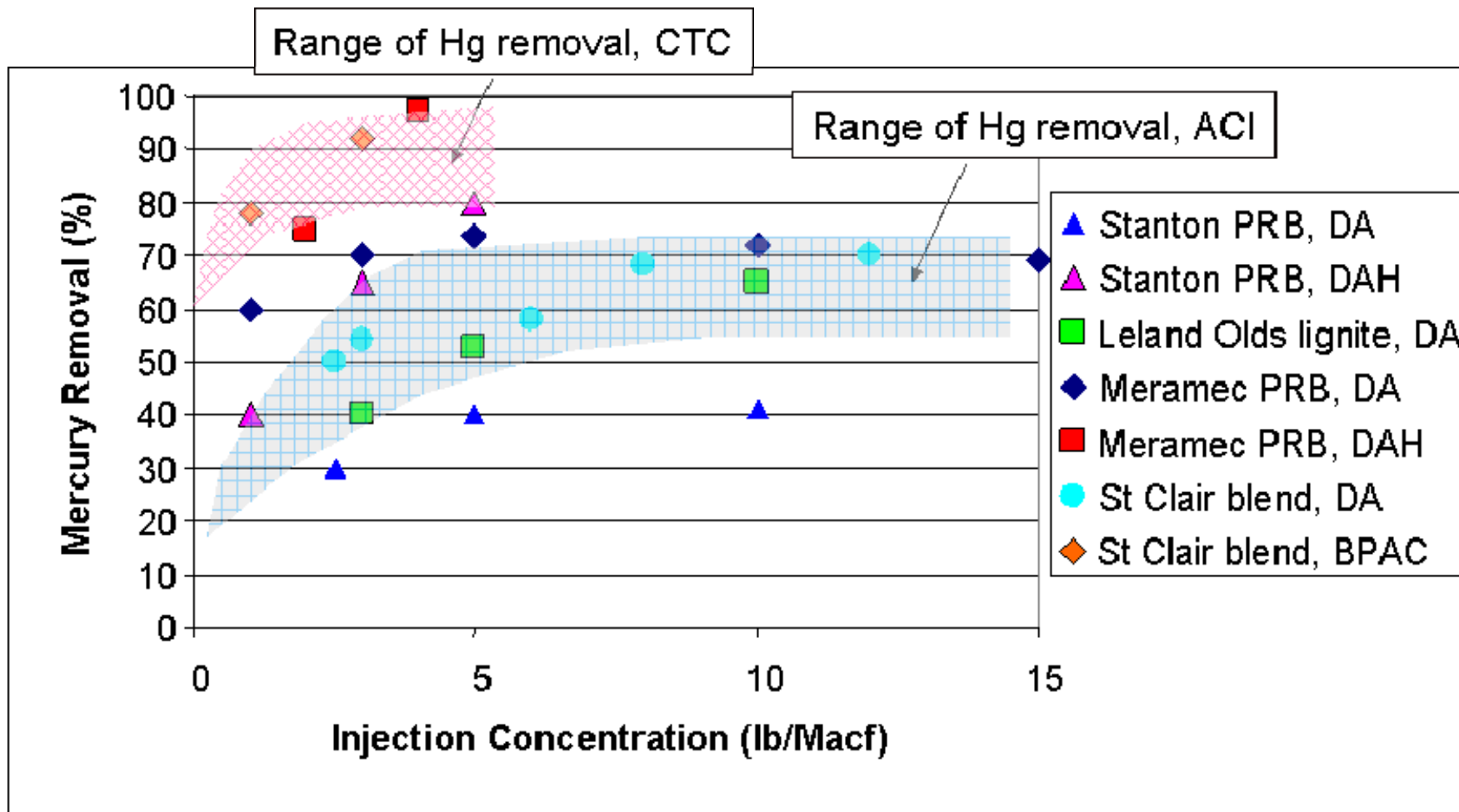


Activated carbon

ACI Performance for ESP and Different Coals

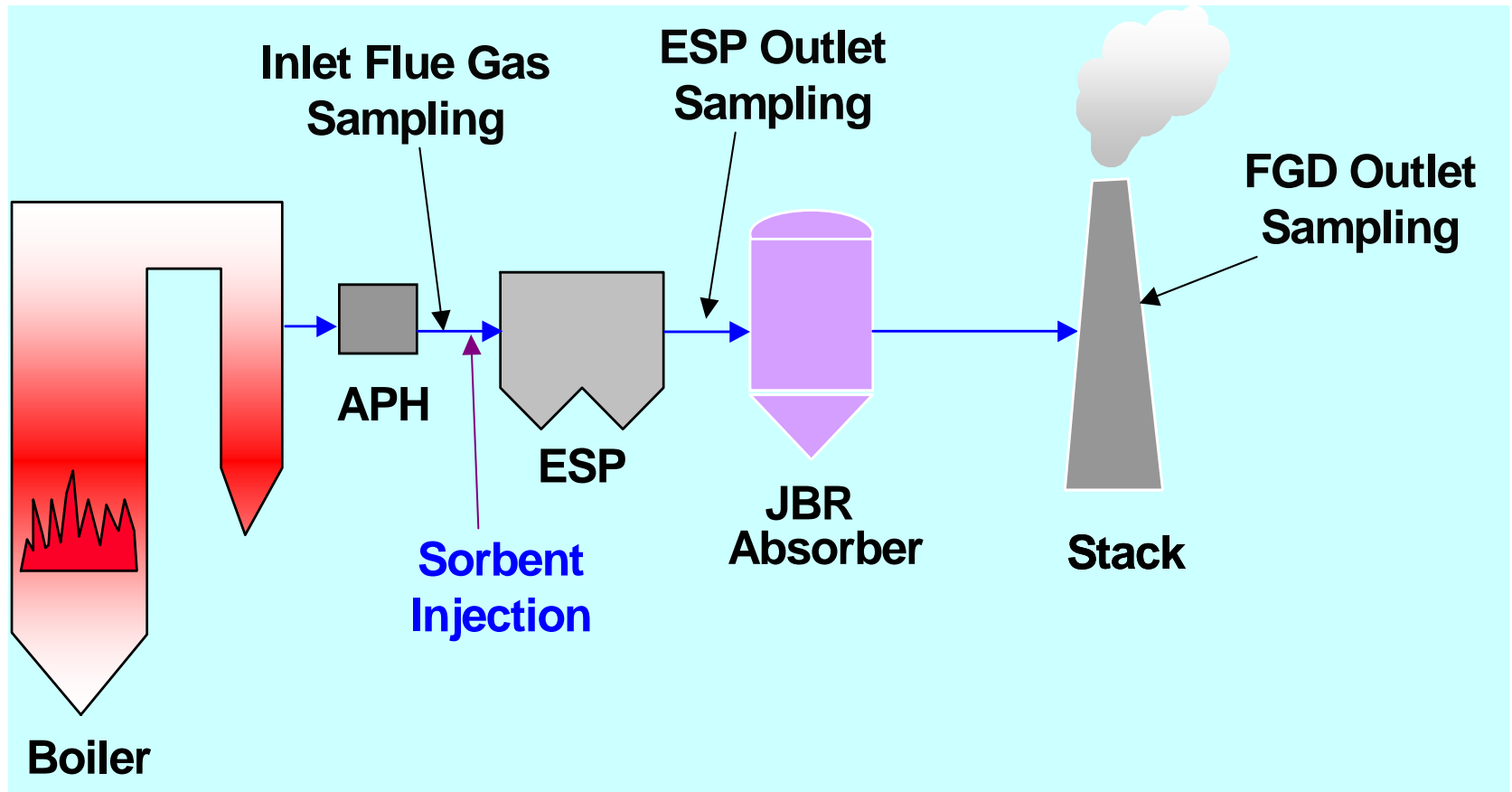


Halogen Additives Improved AC Hg Removal Across ESP for Western Coals

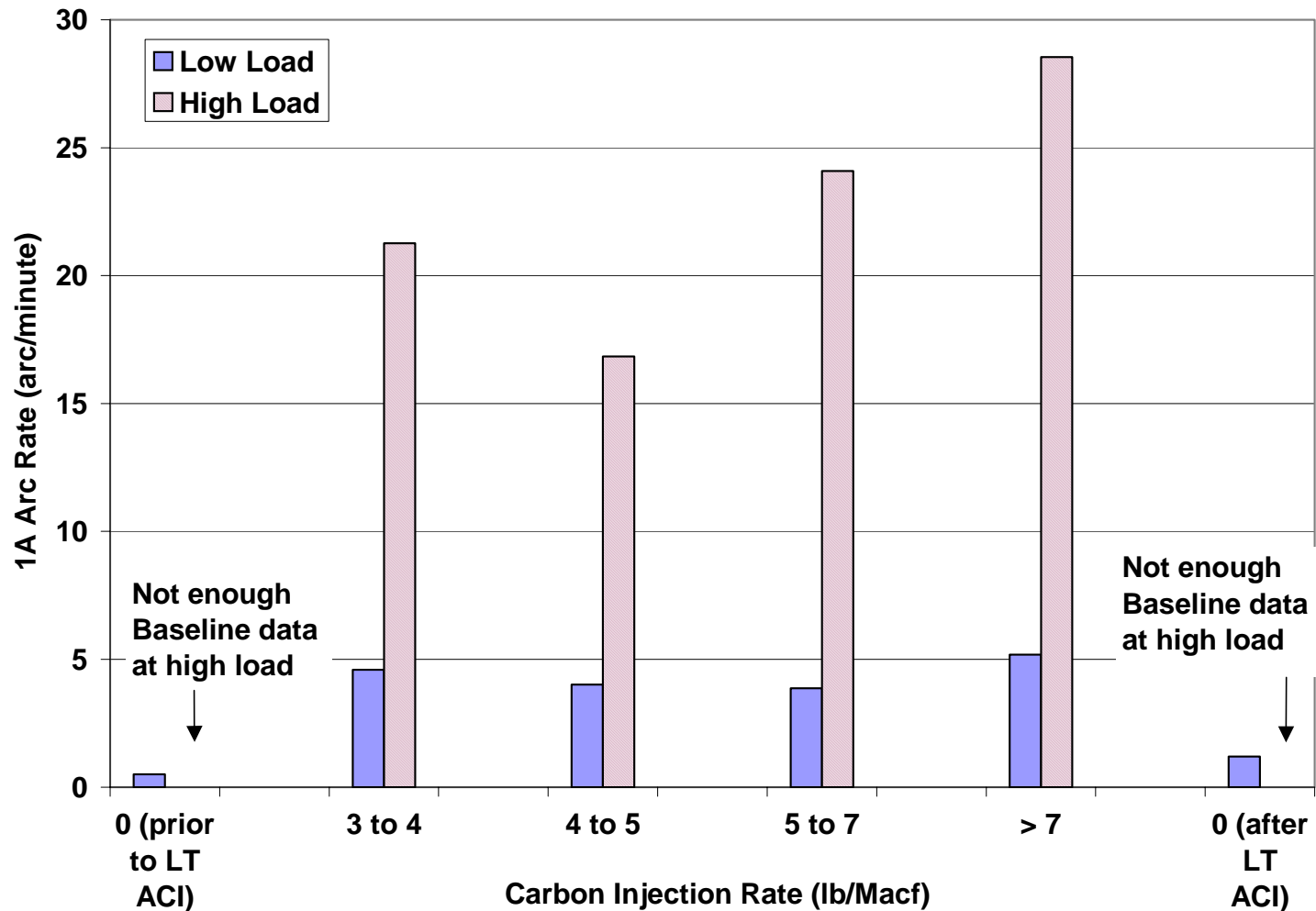


DA = untreated carbon, all others bromine impregnated from Norit (DAH) and Sorbent Technologies (BPAC)

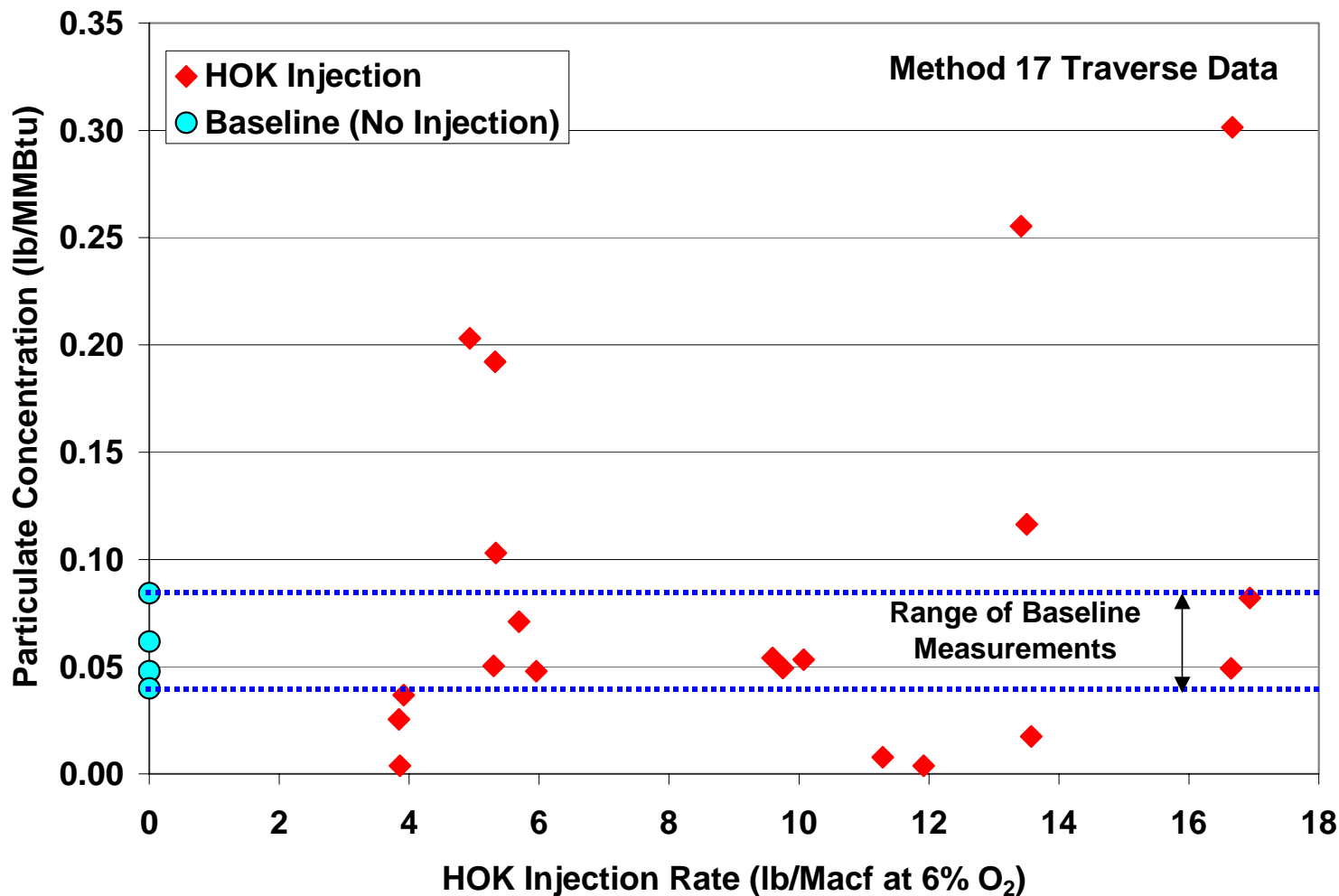
Plant Yates Unit 1 Configuration



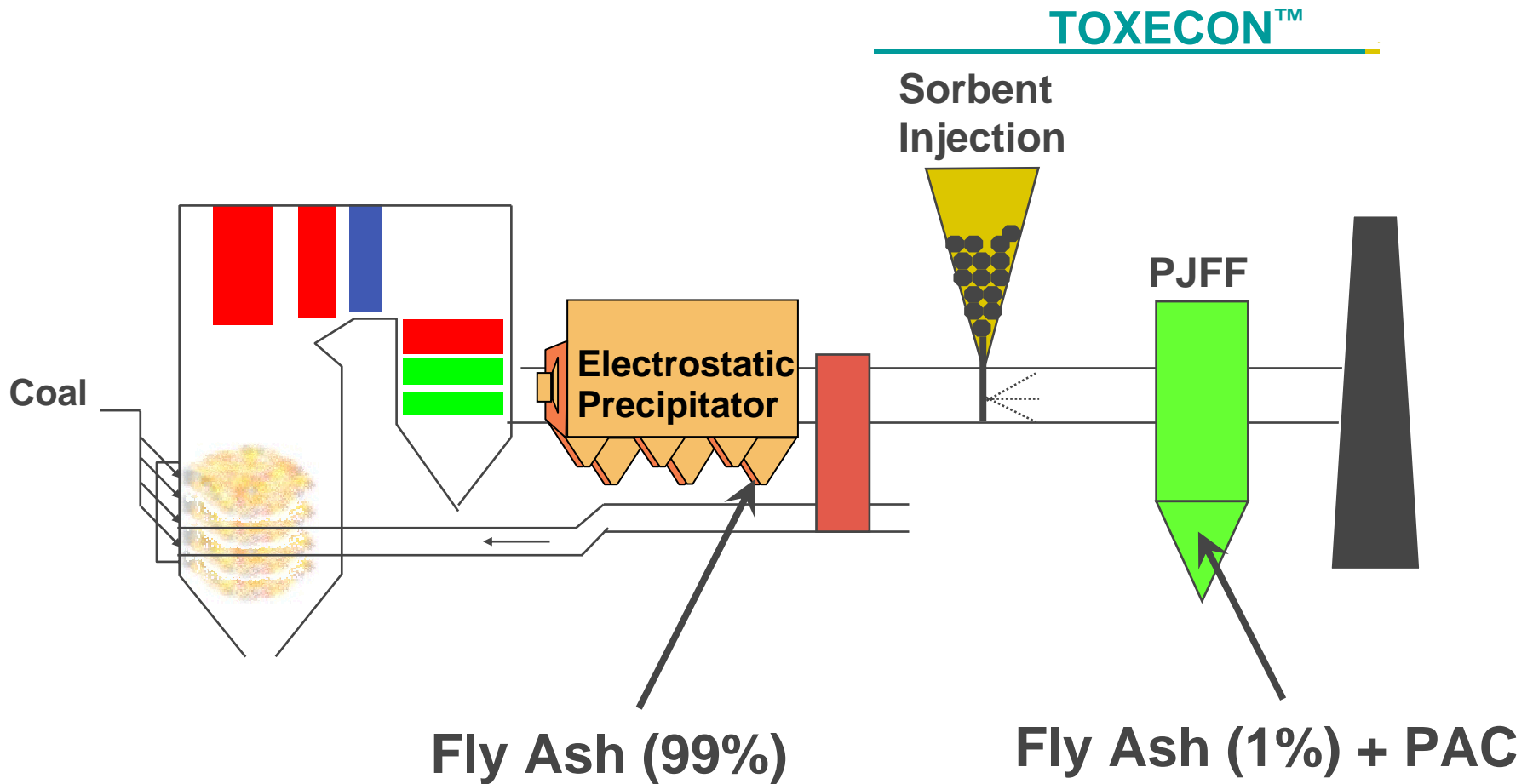
Average ESP Arc Rates Higher during Long-Term ACI



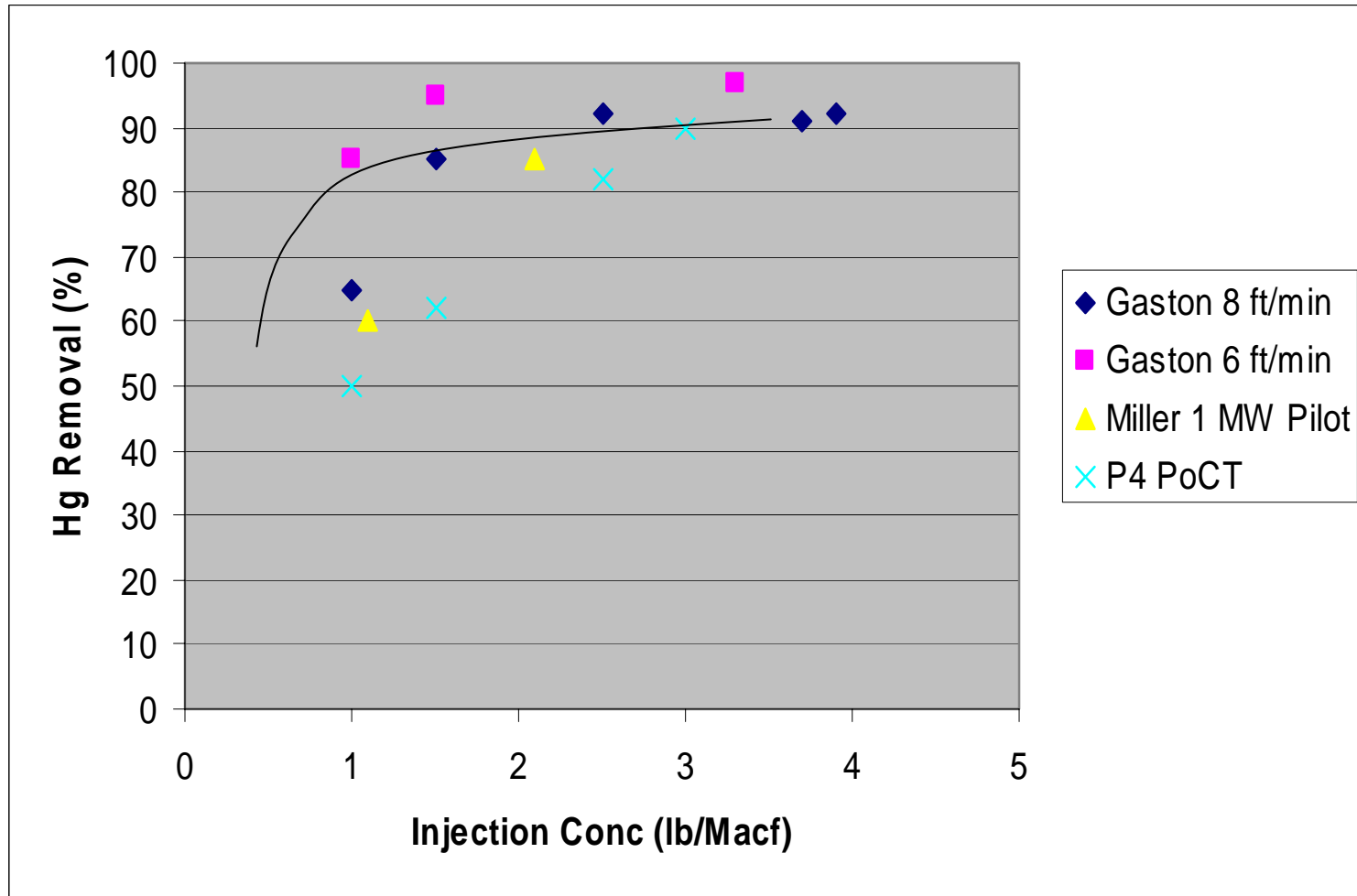
ESP Outlet Particulate Concentrations Higher During ACI



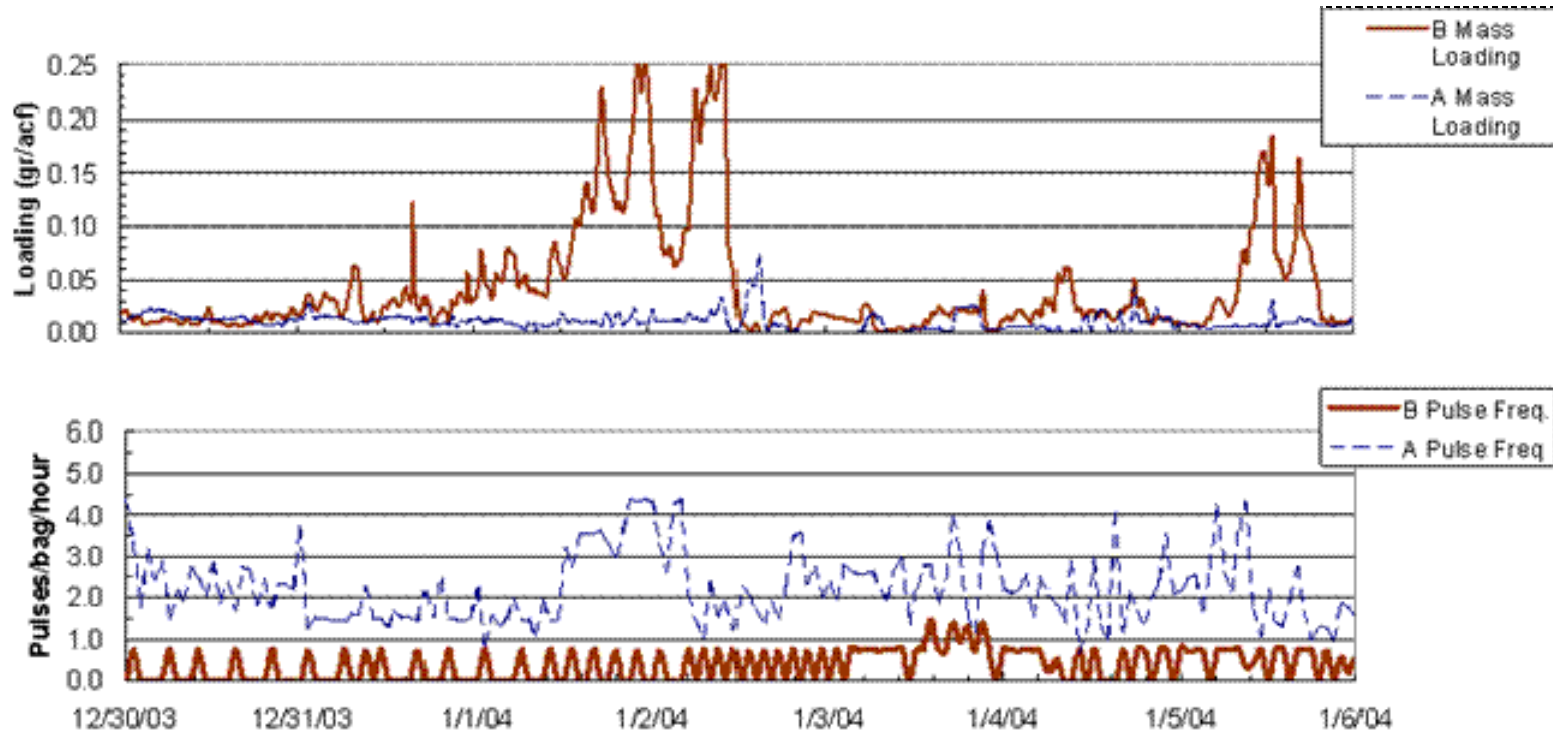
TOXECON™ Configuration



TOXECON™ Performance

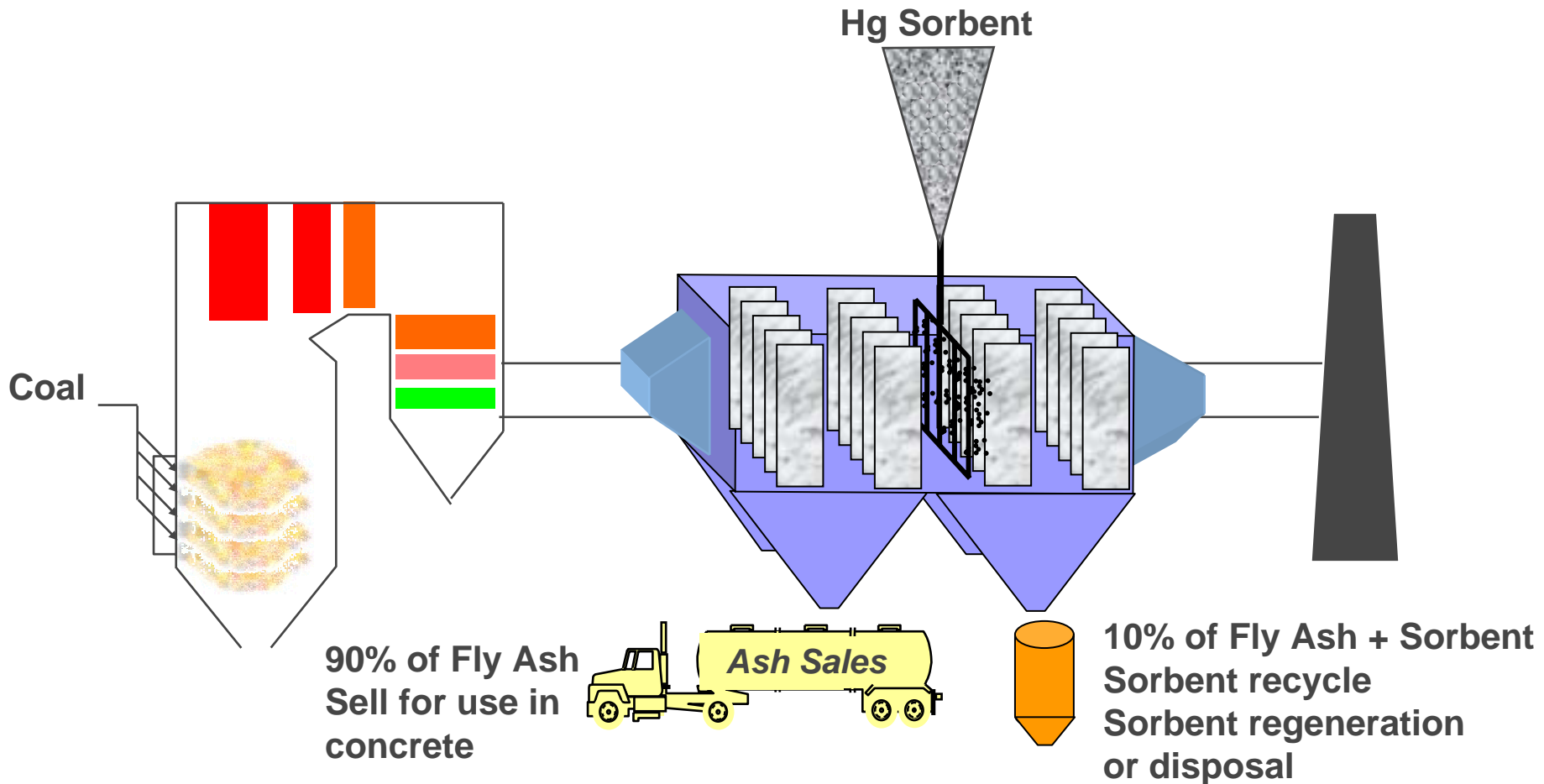


Gaston TOXECON™ Test Showed Reduced Bag Cleaning with High Perm Fabrics



	2.7-denier	7.0-denier
Injection Rate (lbs/h)	20	20
Injection Concentration (lbs/Macf)	0.6	0.6
Mercury Removal (%)	86	87
Cleaning Frequency (pulses/bag/hour)	3.8	0.7
Duration (days)	20	6

EPRI TOXECON II™ Configuration



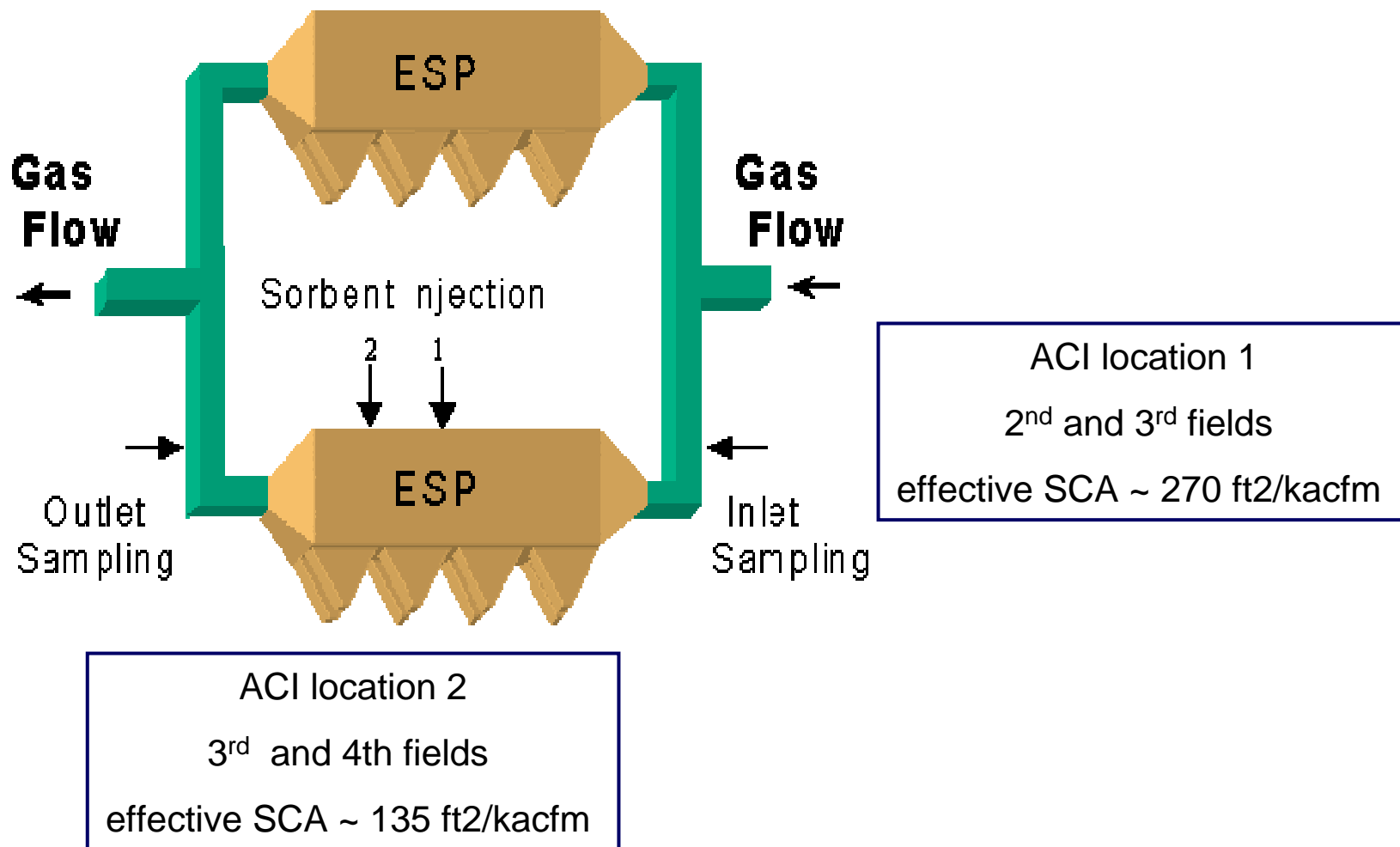


Independence TOXECON II Update

Independence Key Operating Parameters

Unit	2
Size (MW)	842
Test Portion (MWe)	106
Coal	PRB
Heating Value (as received)	8,700
Sulfur (% by weight)	0.32
Chlorine (%)	~0.01
Mercury (µg/g)	0.04
Particulate Control	Cold-Side ESP SCA = 542 ft²/kacfm, 4 fields
Sulfur Control	Compliance Coal (PRB)
Air Pre-Heater	Regenerative
Ash Reuse	Sold

North Half of the Piggyback ESP at Independence Unit 2 and ACI Injection Location (half of ESP box)



Draft Test Plan for TOXECON II Test at Independence

Test Description	Test Week	Measurements, Test Parameters
Baseline	Week 1	ASTM M6784-02 (Ontario Hydro), M26a (halogens), M5 or 17
Parametric testing DARCO Hg	Week 2	DARCO Hg, 1 to 6 lb/MMacf, Location 1 and 2 Monitor particulate emissions (Beta Gauge and one other?) and ESP electrical conditions during all tests
Parametric testing DARCO Hg-LH	Week 3	DARCO Hg LH, 1 to 6 lb/MMacf, Location 1 and 2 Monitor particulate emissions and ESP electrical conditions during all tests
Data review	Weeks 4-5	No injection testing, but can continue to monitor operating parameters (precipitator, particulates, etc.)
Long-term tests	Weeks 6-10	Operate at consistent injection rate 24 hours a day, 4 weeks while load following. ASTM M6784-02 M26A, M5 or 17 tests. Sorbent and rate TBD based on testing results.

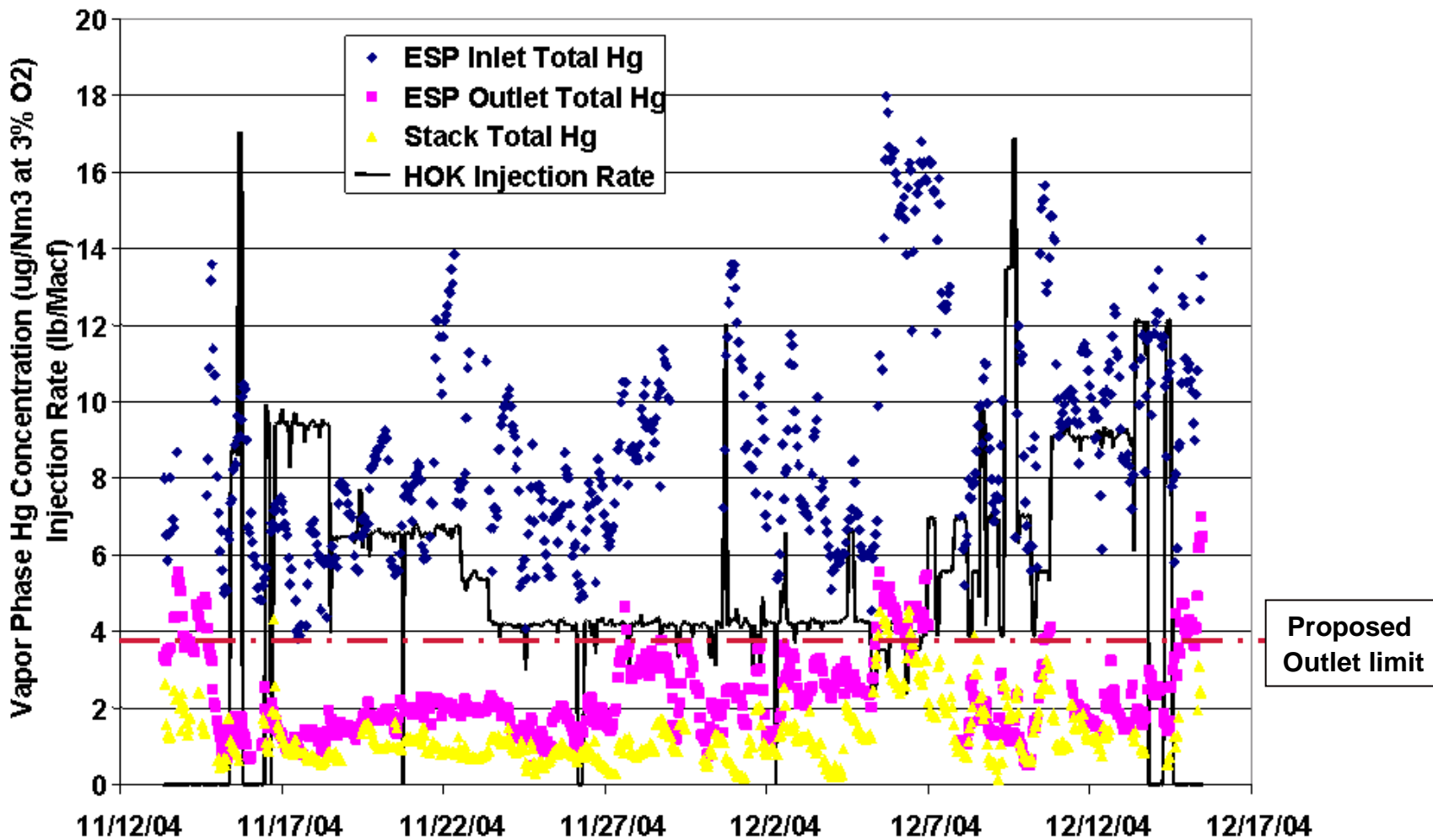
Field ACI Data Issues

- **Sampling problems present for sites with reactive ash, high SO₃, selenium, NO₂**
- **Total mercury OK, proper inlet speciation difficult**
- **Hard for mass balance closure due to difficulty in getting good coal and ash samples, and actual particulate mass loading**
- **Some sites have significant variations in coal mercury and sulfur content**
 - Virtually impossible to get contemporaneous coal and outlet Hg measurements
- **Imbalance in dust loading, LOI content, and temperature within the ductwork**

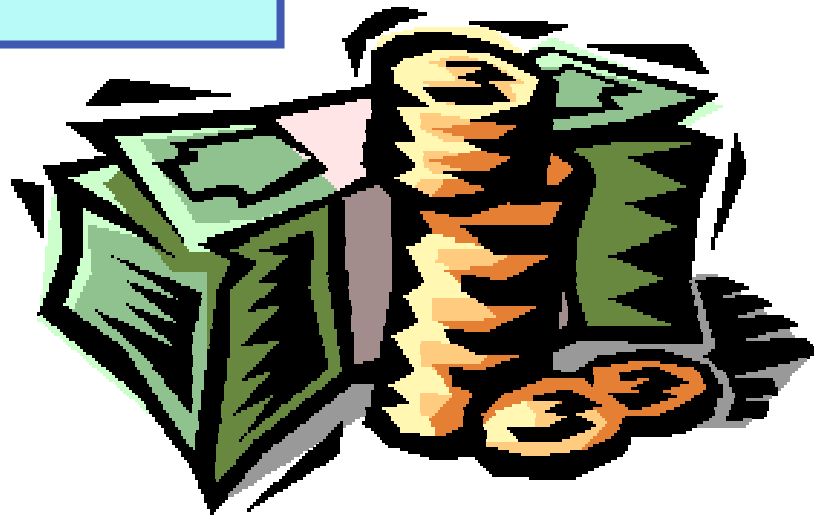
Field ACI Data Issues

- **Limited information on small ESPs**
- **Tests are all (except 1) short term (1 month or less)**
- **High baseline removals at some sites can confound incremental removal from added mercury control**
- **Definition of total mercury removal effectiveness**

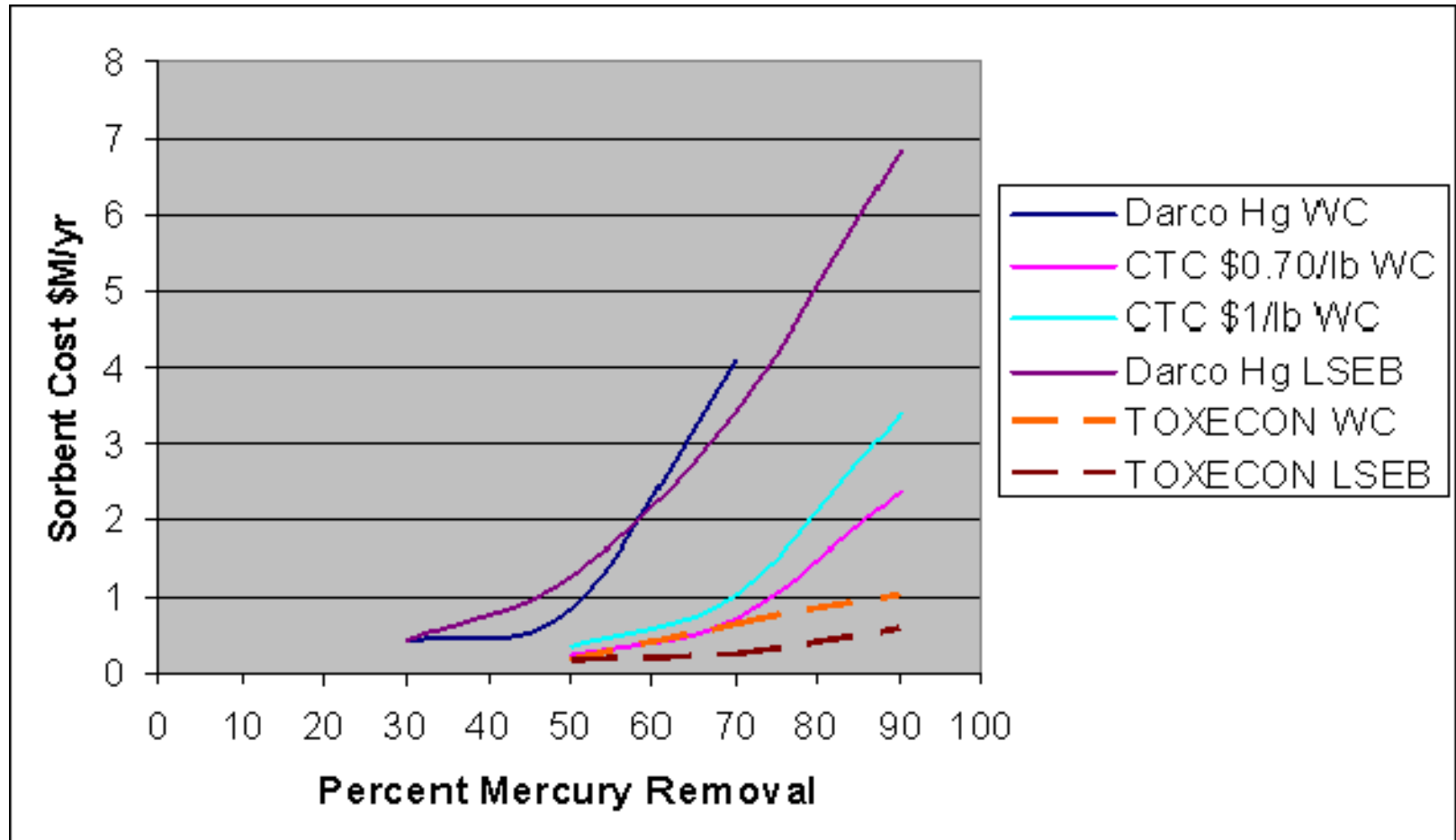
Vapor Phase Mercury Variations and Removal During ACI Testing at Yates 1



Updated Cost Projections ACI



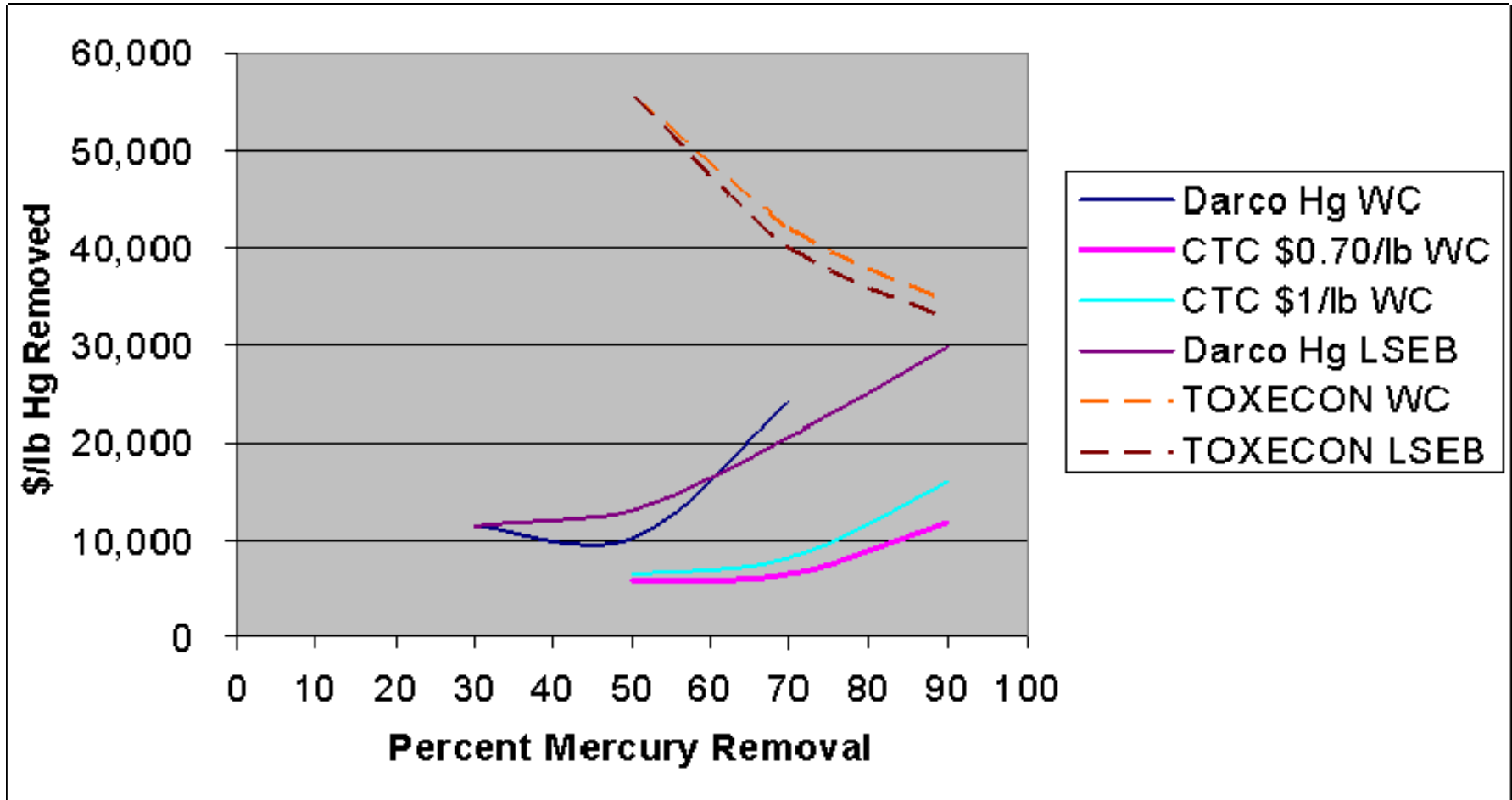
Annual ACI Mercury Control Sorbent Cost for ESP and TOXECON™ (500 MWe Plant)



Darco Hg = Norit activated carbon; CTC = chemically treated (brominated) carbon;
 WC = western coal; LSEB = low sulfur eastern bituminous

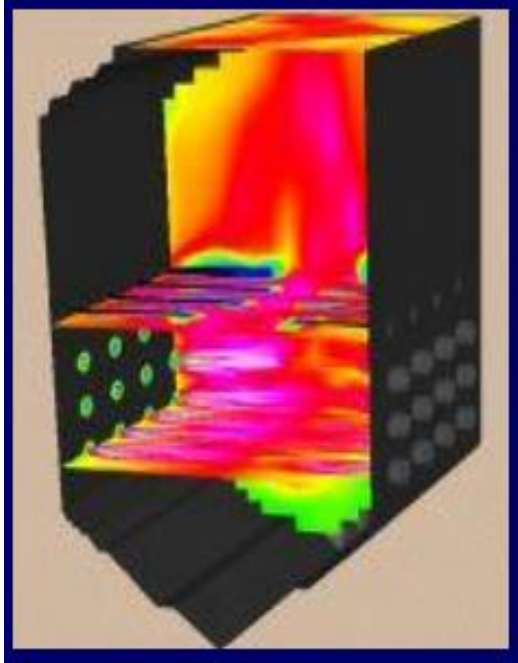
Total ACI Mercury Control Cost in \$/lb Mercury Removed

(ESP & TOXECON™, 500 MWe Plant, does not include loss of ash sales)



Darco Hg = Norit activated carbon; CTC = chemically treated (brominated) carbon;
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Combustion Modifications



- Variations in LOI (or unburned carbon), boiler and fuel type, existing pollution control, affect mercury removal
- Modify combustion to optimize Hg capture, along with LOI, NO_x, etc.

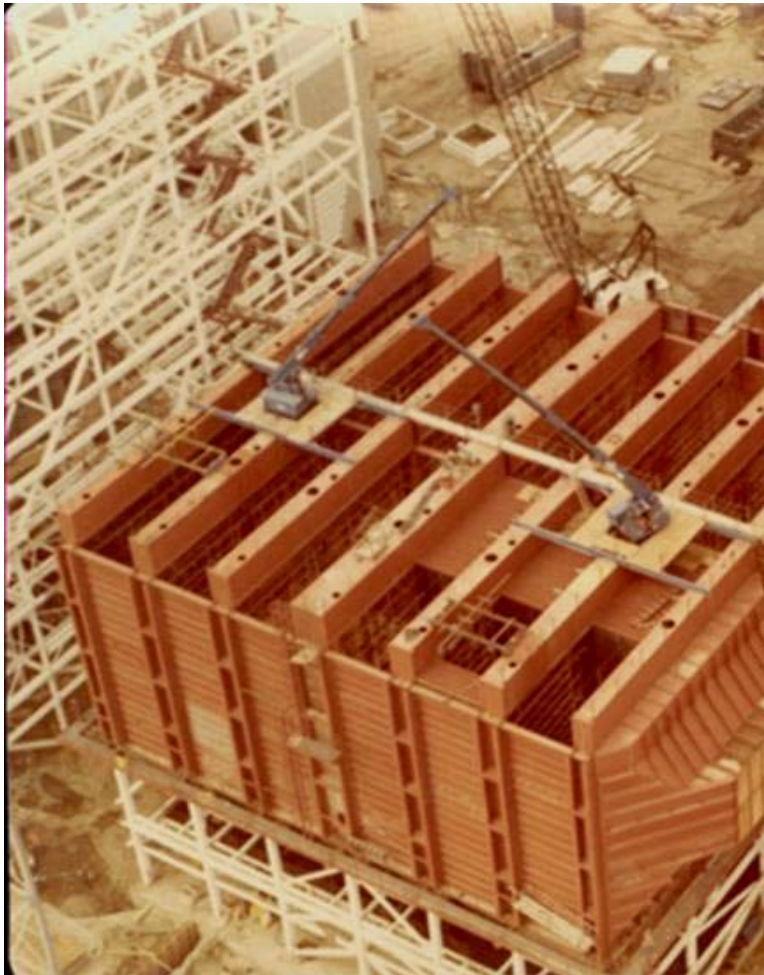
Other Development Work in Progress

- **Impact of carbon and halogens on fly ash properties (foaming agent, concrete strength, working with ash marketers)**
- **Clay based sorbents and carbon passivation agents**
- **Impact of tire and coal type and blends on baseline mercury removal**
- **Reactive membrane multipollutant (Hg, SO_x, NO_x) control**

Key Challenges

- **Sustainable mercury removals**
 - Process variability managed
 - Carbon quality consistent
 - Long-term resilience of PM collectors
- **Measurable with accuracy as a routine operation**
- **Predictable so can apply widely with confidence**
- **Known, manageable impacts**
 - Requires enough 12-18 month tests to uncover potential impacts
- **Costs that allow all plants to continue operating**
- **Waste generation minimized**

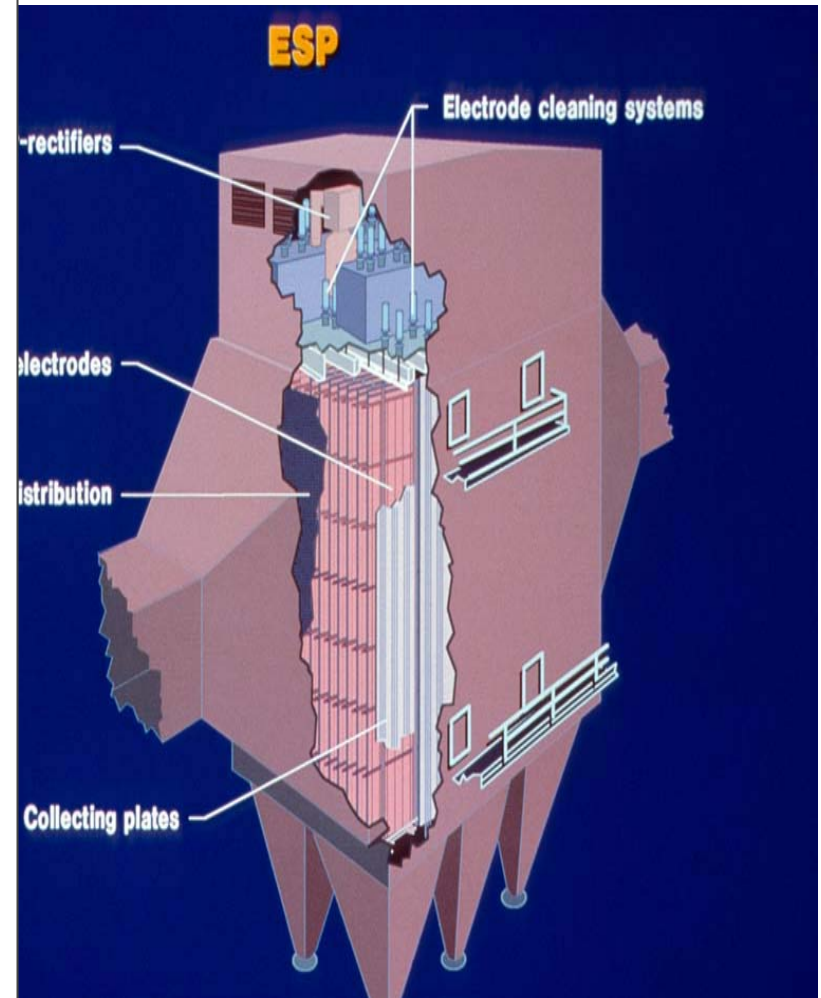
Industry/DOE/EPRI Investing Heavily in Development & Demonstration – 2005+ Tests



- **20 sites**
 - **14 ESP, 1 SD/BH, 2 WPS, 3 WFGD**
- **All coal types, some blends**
- **Most injection options**
 - **AC, CTC, Hi-T**
 - **Na₂S₄, AMS**
 - **Boiler chemical additives**
 - **TOXECON™ I and II**

Other Technologies Being Tested by Industry/DOE/EPRI in 2005

- SCR/FGD co-benefits for range of coals, catalysts, age, regeneration status, scrubber types, flue gas additives, etc.
 - Bench → full-scale SCR
- Low-T Hg oxidation catalysts
- FGD issues
 - Re-emissions
 - Sequestering Hg from gypsum
- Sorptive structures
- Combustion modifications and UBC
- Methods to protect CCP use



Progress would not have been possible without

- DOE/NETL**
- Host power plants**
- Numerous engineering firms and research organizations**
- Suppliers of carbon, sorbents, baghouses, filter fabrics,**