Worldwide Pollution Control Association

WPCA/LG&E and KU

Coal-fired APC Environmental Seminar

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Advanced Emissions Solutions, Inc.
Advancing Cleaner Energy

Hg Control Challenges

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WPCA Seminar – May 23, 2017

Disclaimer

This presentation includes general information on coal and coal-fired boilers intended for education and illustration purposes only. All information is provided "AS-IS" and without warranty or liability of any kind.

Compliance with Air Rules Means Choices for Air Pollution Control

Mercury Control

- Three main strategies for Hg air emissions control
  - Activated carbon injection (ACI)
  - Coal halogen injection (CHI)
  - Wet or dry FGDs
- These may be combined (e.g., ACI+CHI, CHI+FGD, ACI+FGD, etc.)

Factors Affecting Hg Control in Baghouses

- Temperature
- Capacity of PAC/Fly ash
- Cleaning frequency
- SO_3 (and SO_2)

Effect of Temperature on Hg Removal across FF

- Presque Isle Power Plant (PIPP): PRB-fired boiler, HESP followed by FF
- Brominated PAC injected at FF inlet
- Effect of FF temperature on brominated PAC performance

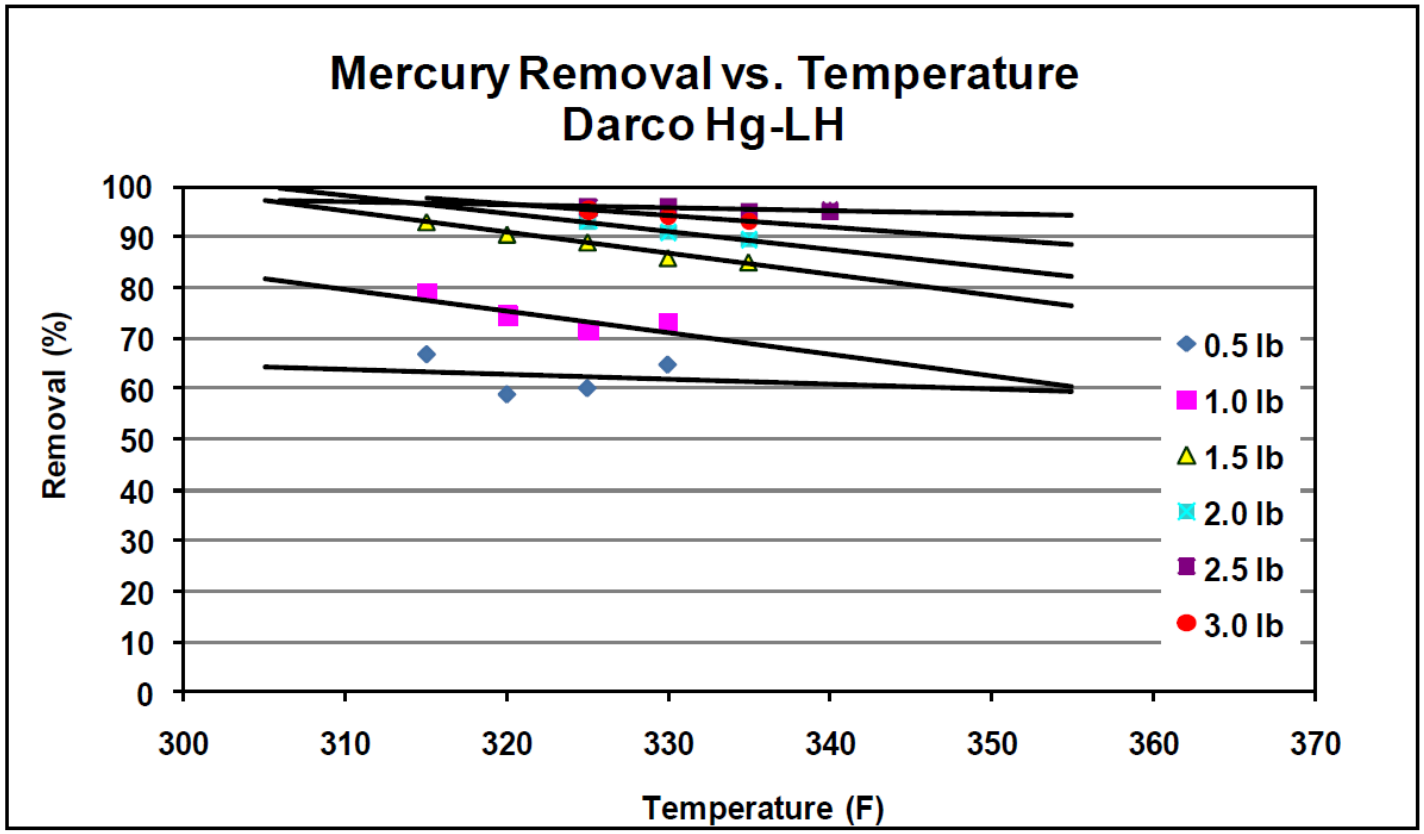
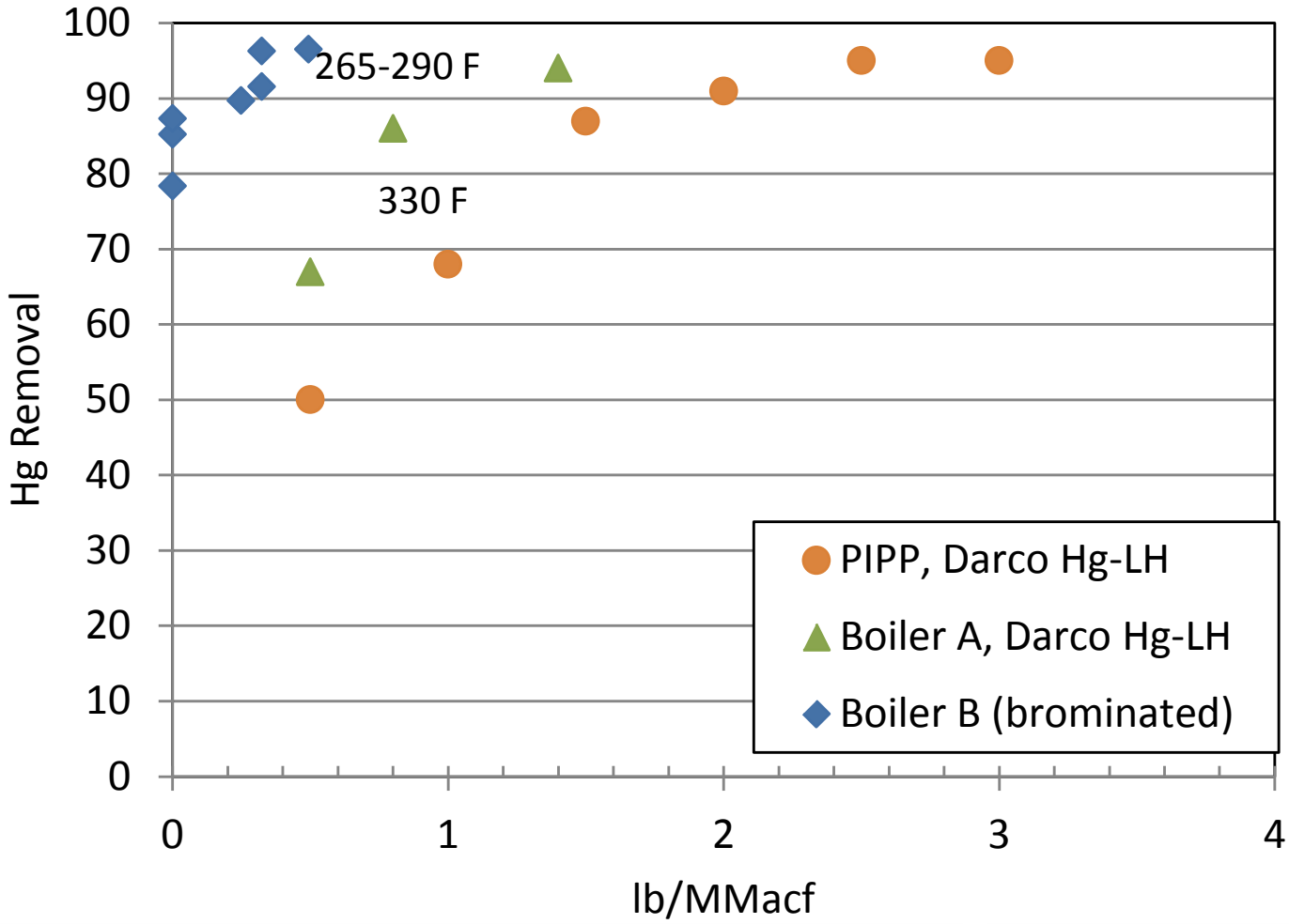


Figure 4-97. Effect of Temperature on Mercury Removal using DARCO® Hg LH.

Effect of Temperature on Hg Removal across FF

- Comparison of PIPP (330°F) with two other PRB-fired boilers at different temperatures

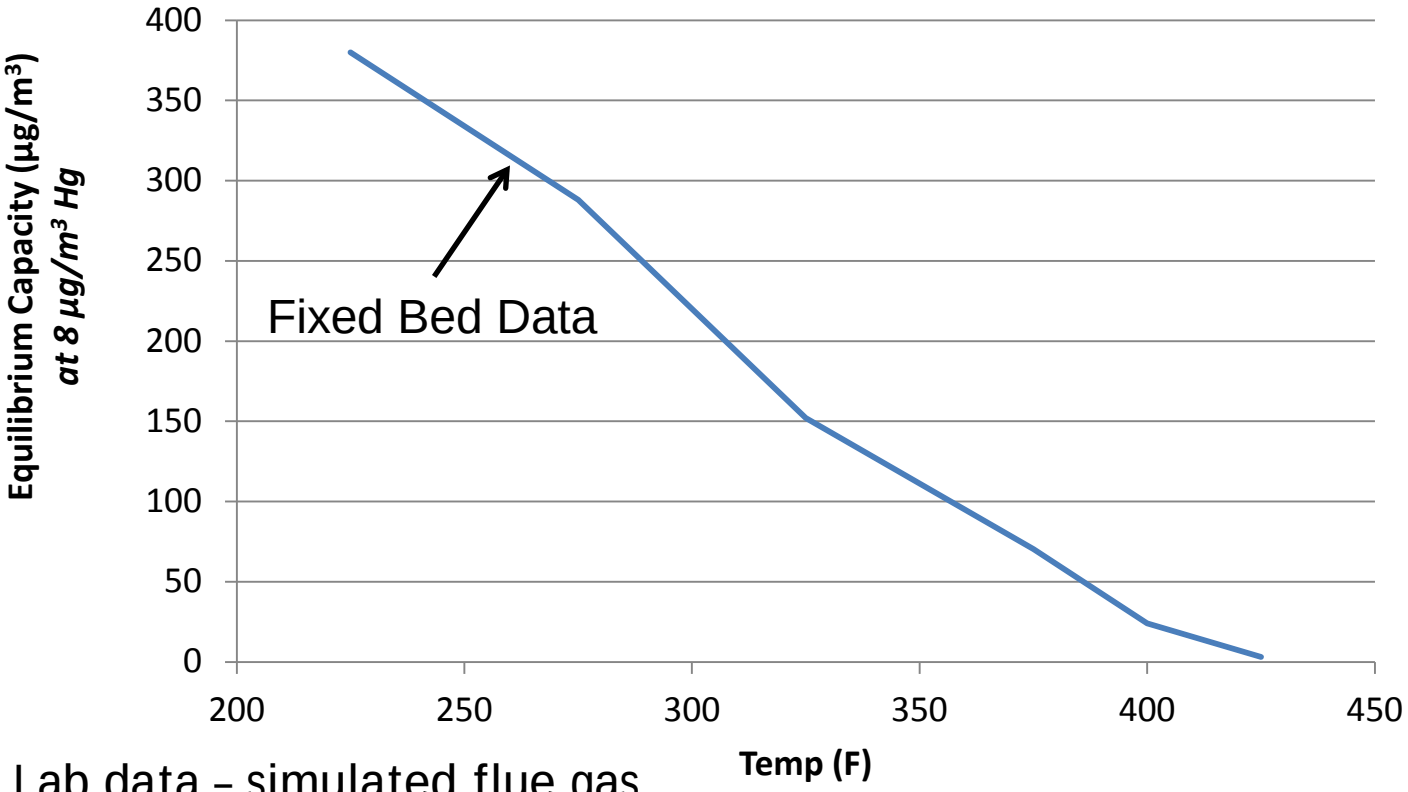


Mercury “Breakthrough” Testing

- Many tests have been conducted in the laboratory where gas laden with Hg is passed through a heated bed of carbon
- In a fixed-bed system, when PAC reaches “capacity” for mercury, it typically releases mercury in the oxidized form (i.e. oxidized mercury is measured at the outlet of the bed)
- Temperature is a critical parameter that affects the capacity of PAC for mercury
  - If temperature of PAC saturated with mercury is increased and capacity is exceeded, it can take several hours before release stops, even if inlet Hg is set to zero

PAC Adsorption Capacity vs. Temperature

- The higher the temperature, the less Hg can be held on PAC
- This "equilibrium capacity" is also a function of the Hg concentration in the gas: Higher inlet Hg concentration => higher equilibrium capacity on PAC



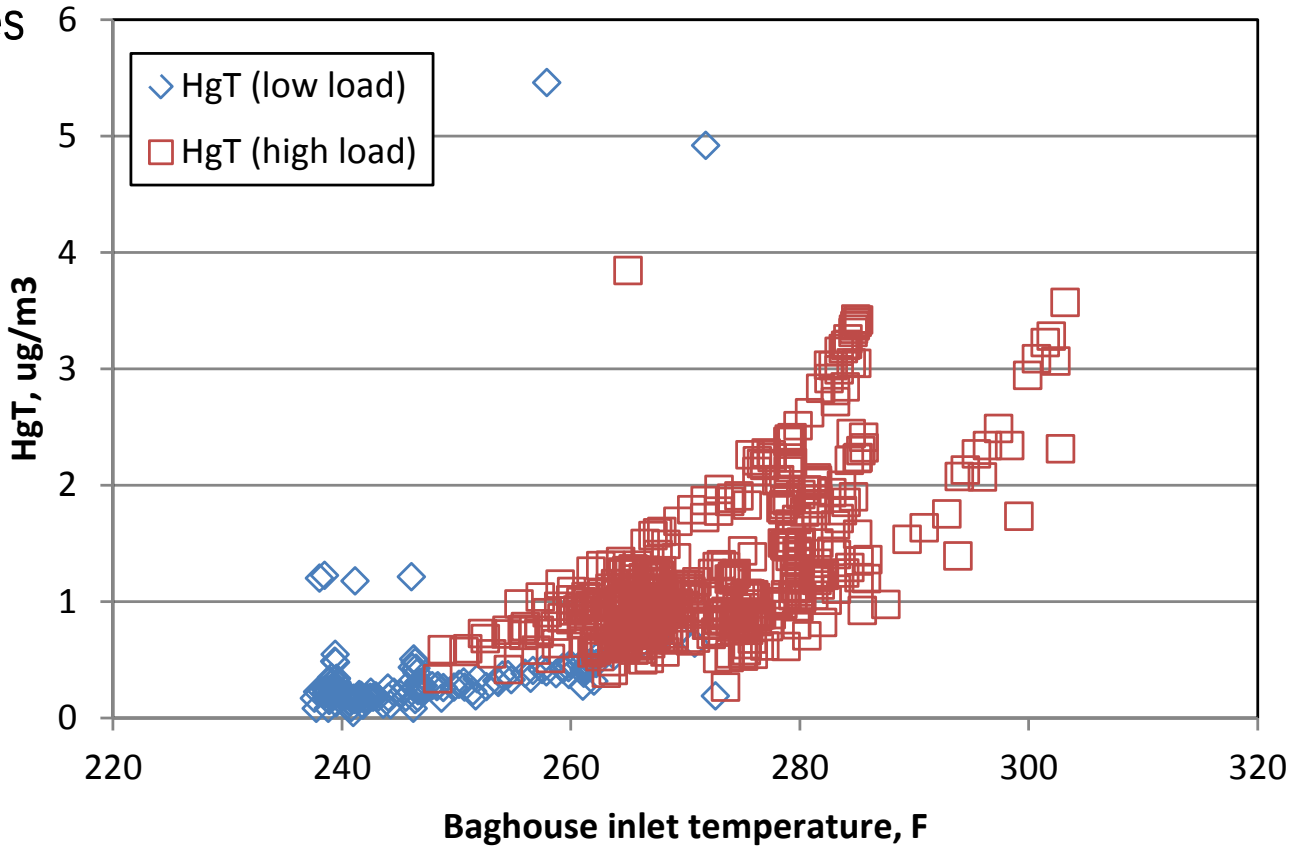
- Lab data – simulated flue gas

Mercury "Breakthrough" and Baghouses

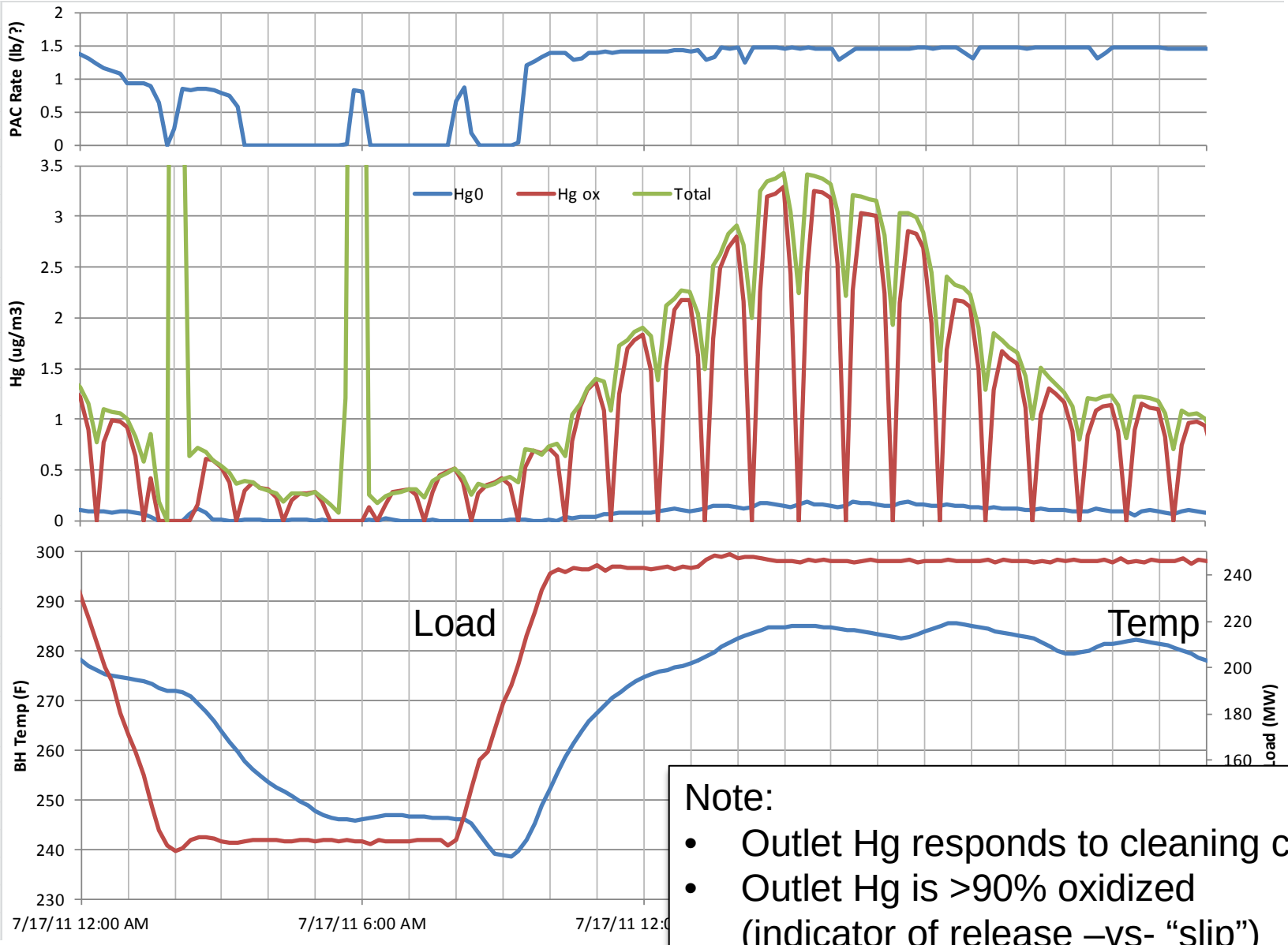
- In a baghouse, gas passes across a "fixed bed" of PAC on the filter cake
- If PAC is allowed to remain on the filter after becoming saturated with Hg, it will release mercury, especially if the temperature increases
- High oxidized Hg at the stack on a unit firing low halogen coal (e.g. PRB) suggests that the PAC is adsorbing and releasing Hg
- *This looks a lot like re-emission*

Example: BH Temperature and Hg Emissions

- PRB boiler with oversized BH using brominated PAC (fixed injection rate at high load; no injection at low load)
- Long times between cleaning mean that PAC approaches equilibrium capacity for Hg
- Hg typically increases at higher BH temperatures as maximum "capacity" decreases



Example: BH Temperature and Hg Emissions

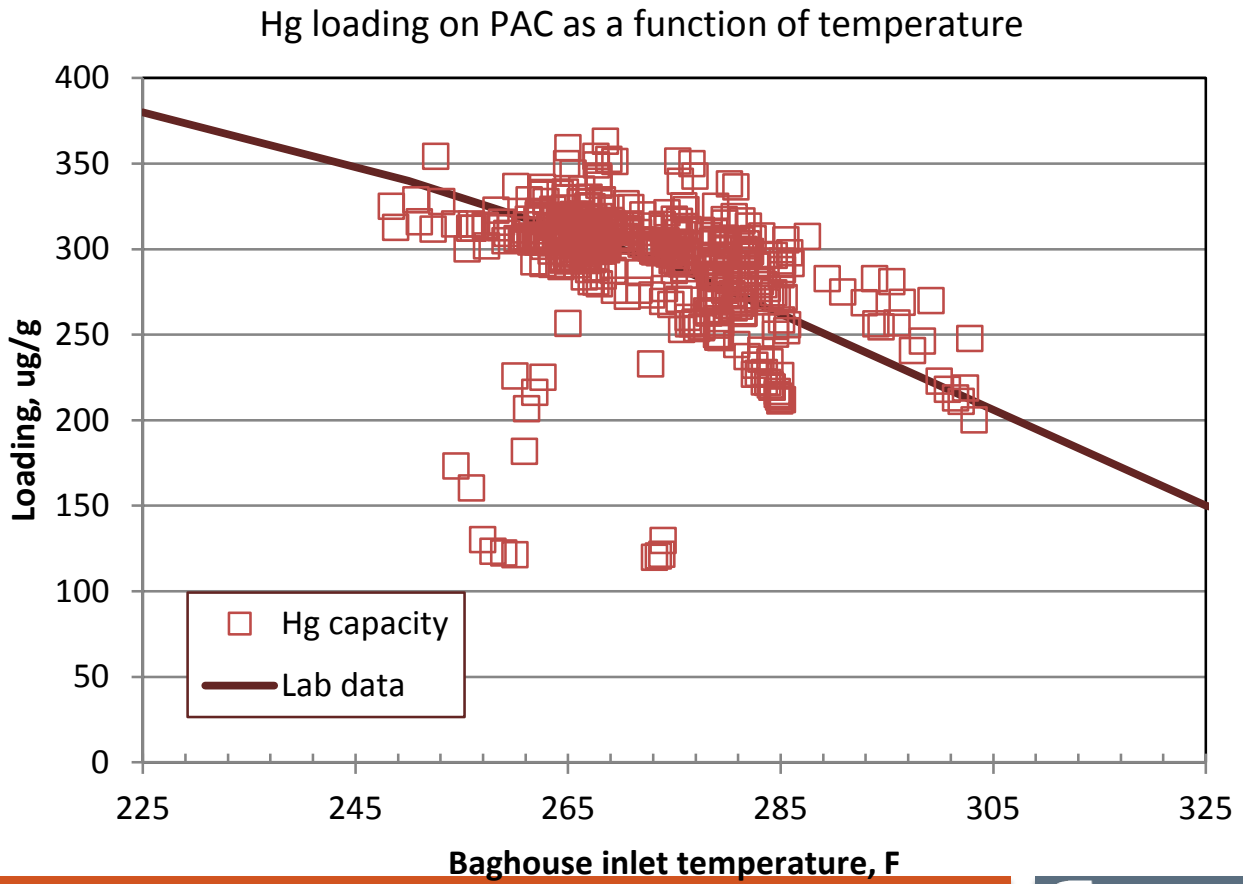


Note:

- Outlet Hg responds to cleaning cycles
- Outlet Hg is >90% oxidized (indicator of release –vs- “slip”)

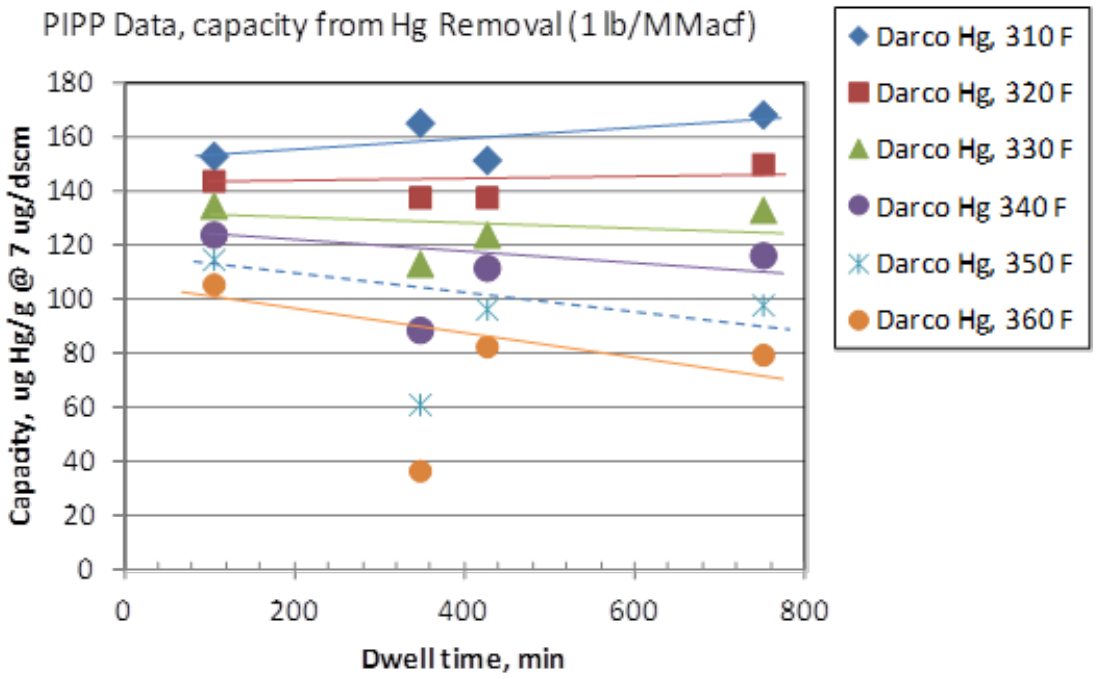
Example: BH Temperature and Hg Emissions Estimated Hg loading on the PAC

- Long times between cleaning in this baghouse mean that PAC approaches "equilibrium capacity" for Hg => consistent with lab fixed bed data
- As temperature increases, the PAC holds less Hg on average
- Which means more PAC must be injected at higher temperatures to remove Hg



Effect of Cleaning Frequency: Presque Isle

- Presque Isle (full-scale) non-brominated PAC
- Effect of cleaning frequency at temperatures > 340°F and >200 minutes dwell time



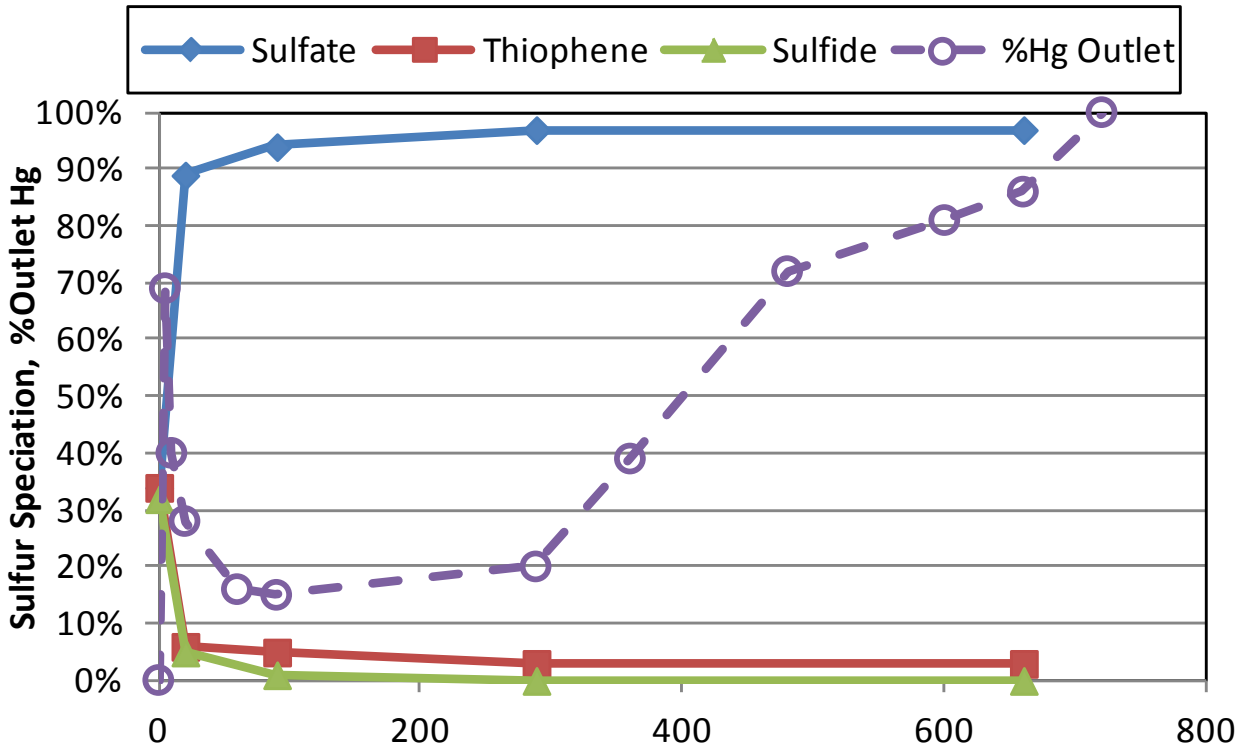
- Conclusion: At longer dwell times (less frequent cleaning) and/or higher temperatures, the equilibrium capacity of the PAC can be reached

Sulfate Accumulation on PAC

- SO_2 and SO_3 in flue gas interact with PAC sitting on the bags
- To illustrate this on a fixed bed, consider data from from Olson et al. (*J. A&WMA* **2005**, *55*, 747-754)
  - Fixed bed experiments with lignite-derived AC
  - T = 275°F (135°C)
  - Composition: 6% O_2, 12% CO_2, 15% H_2O, 580 ppm SO_2, 120 ppm NO, 6 ppm NO_2, 1 ppm HCl, 11 ug/m^3 Hg^0
  - XPS used to analyze surface composition and speciation

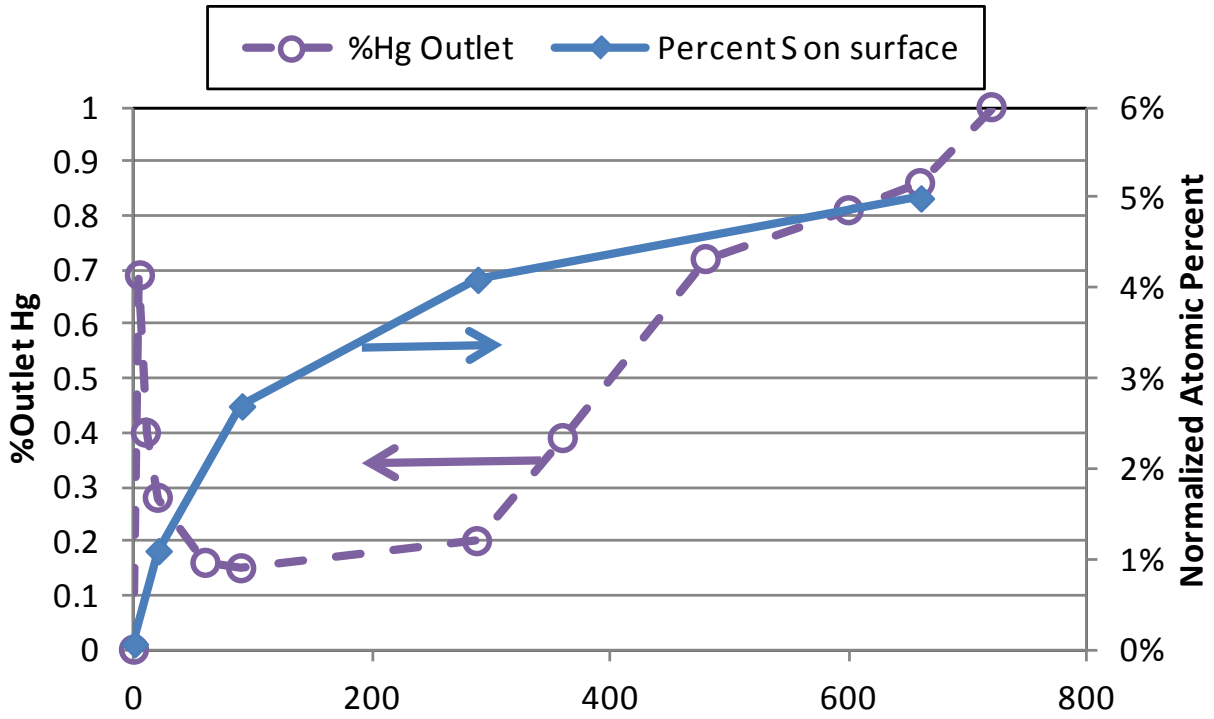
Sulfur Species on Surface

- Within 20 minutes of exposure, 90% of the sulfur on the carbon surface is sulfate
- Good Hg capture persists for about 4 hours (Hg reported as %of inlet Hg at bed outlet)



Build-Up of Sulfur on the Surface

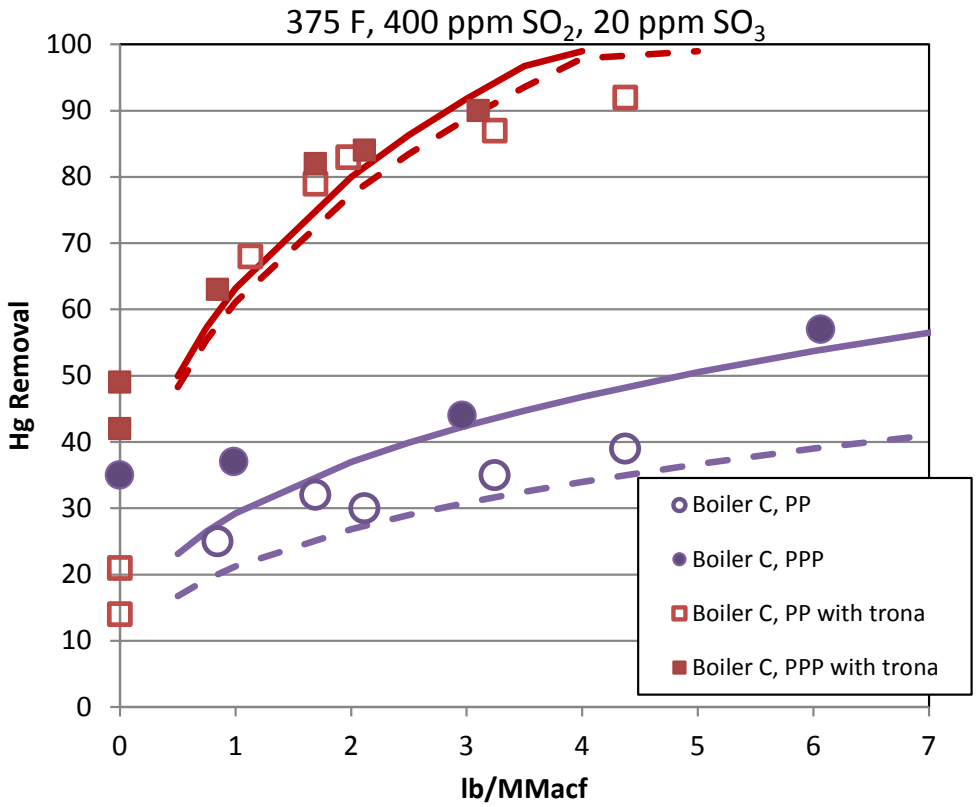
- Sulfate accumulates on the surface over time
- The atomic percentage of sulfur on the carbon surface appears to level off as the carbon approaches breakthrough for Hg



Effect of SO_3 on Hg Removal across FF

- High SO_3 in flue gas reacts with PAC in baghouses
- Reducing SO_3 improves Hg removal performance

- Bituminous-fired boiler with 20 ppmv baseline SO_3 at FF inlet: very high temperature!
- SO_3 concentration reduced by injecting trona
- PP = ADA-CS PowerPAC (non-brominated)
- PPP=ADA-CS PowerPAC Premium (brominated)



Suggestions for Managing Re-emissions from Baghouses

- Increase the PAC injection rate at higher temperatures
- Managing cleaning
  - Cleaning more frequently to remove PAC saturated with Hg (*does not overcome injection below required rates*)
  - Remove excess PAC before ramping load *(large increase in temp = potential to release previously collected Hg)*
- Improve the capacity of the PAC at higher temperatures (carbon selection)

QUESTIONS & DISCUSSION

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