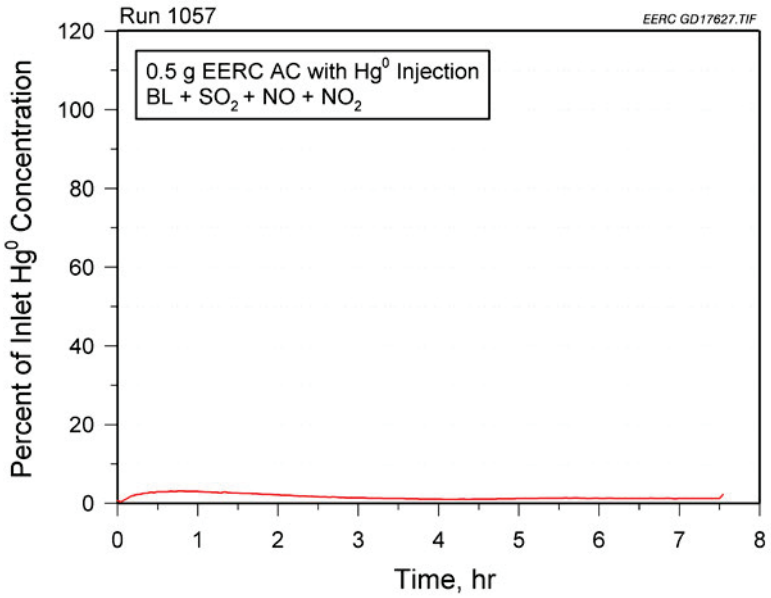
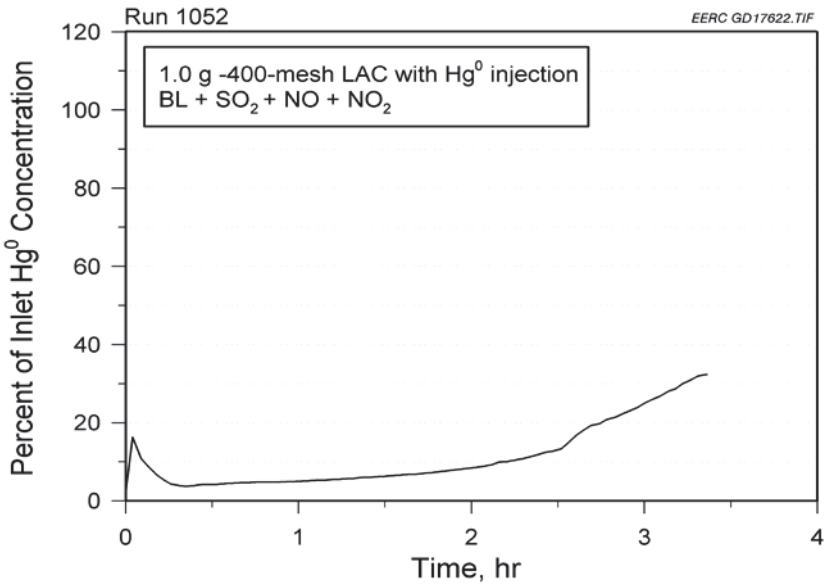
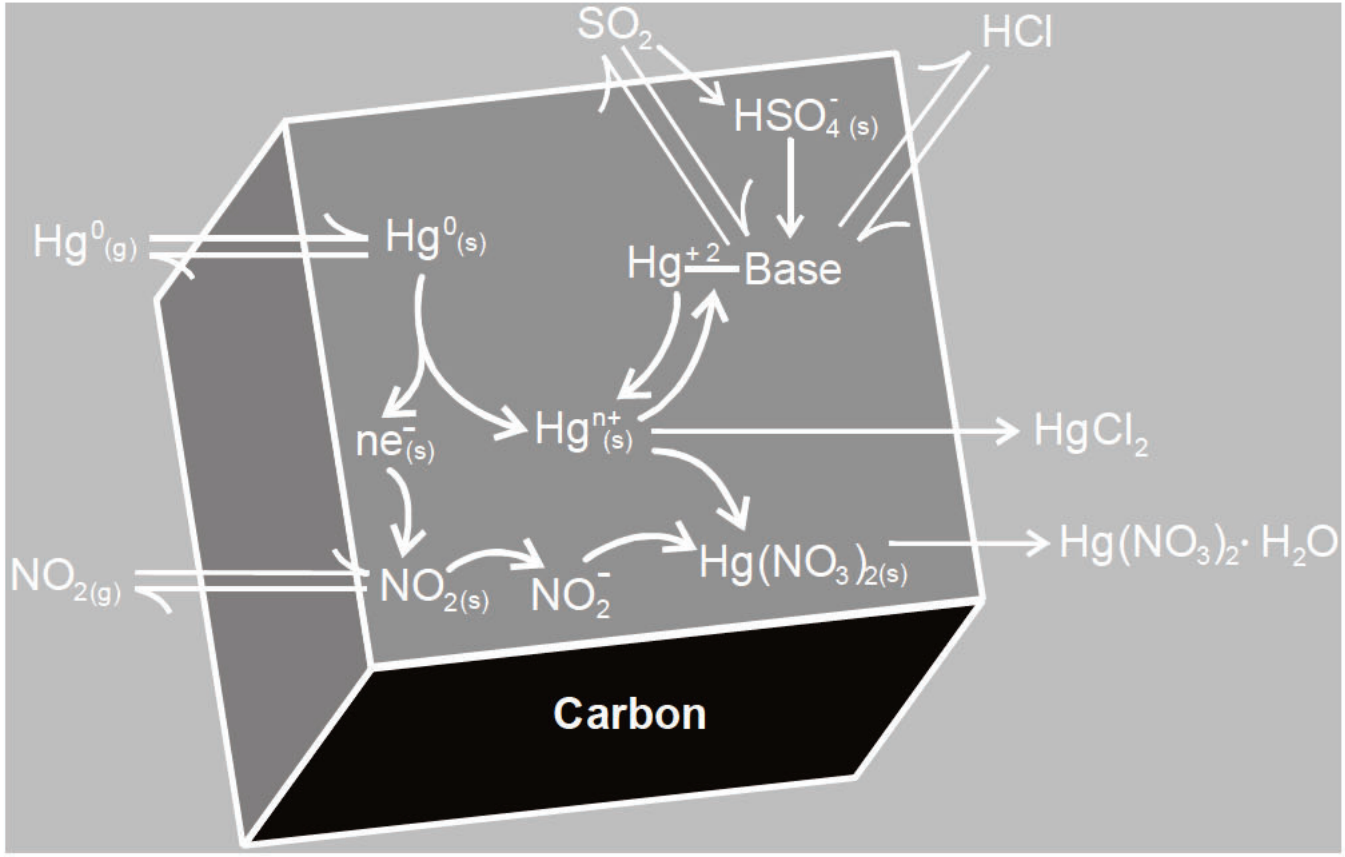
Breakthrough Curves for Norit FGD and High-Sodium North Dakota Lignite AC





Mechanism of Mercury Capture with Carbon Sorbents



Bench Scale Testing

Bench-scale screening

- Evaluate a number of different sorbents, sorbent enhancements/modifications, gas species interactions, oxidation potential, sorbent size, temperature, etc
- Fixed bed and entrained flow using simulated gas similar to that produced from burning lignite coal
- Initial screening of sorbents to evaluate capture effectiveness, oxidation potential, and capacity
- Provide relative ranking to determine most promising sorbent for pilot and full scale testing based on capacity and cost

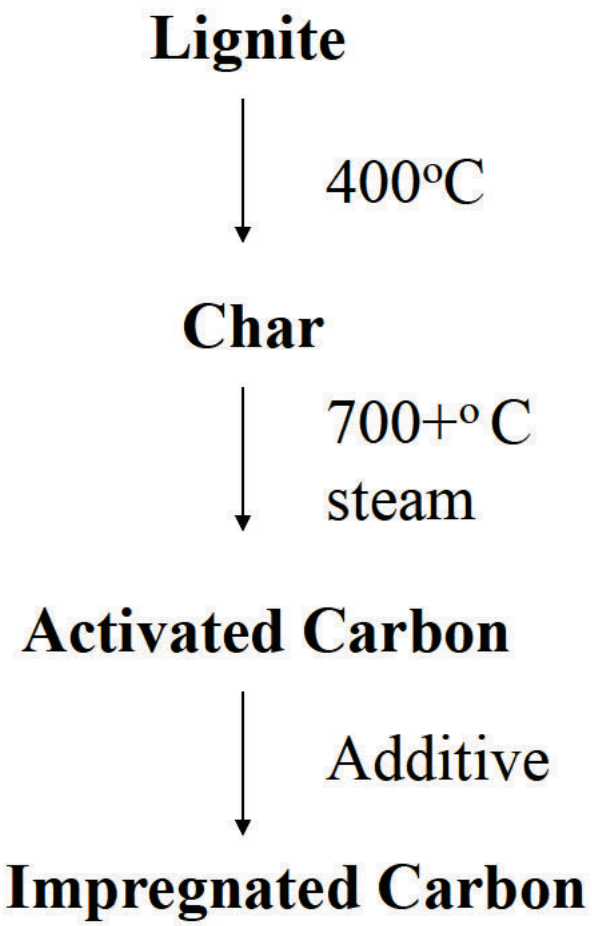
Screening Criteria

- Reactivity – Comparison to baseline Norit FGD
- Capacity – Bench-scale break through curves
- Physical properties – particle size, surface area, functionality
- Residence time – Entrained flow reactor studies
- Cost – relative to FGD carbon (50 cents/lb)

Potential Sorbents– for testing

- Carbon-based Sorbent selection – 6 sorbents
  - Baseline – Norit FGD
  - Luscar – coal, char, fines
  - Minnkota – high sodium Center lignite
  - Basin/ Otter Tail – high sodium Beulah-Zap lignite
  - Others – Falkirk – high calcium
  - Calcium silicate – derived from slag
  - Lime/Carbon mixture
  - Impregnated carbons – I, S, Cl
- Char preparation - pyrolysis/steam activation
  - Tube reactor -- Bench scale
  - 4lb/hr unit – Pilot scale studies (0.03 to 0.04 lb/hr injection rates)

Activated Carbon Production

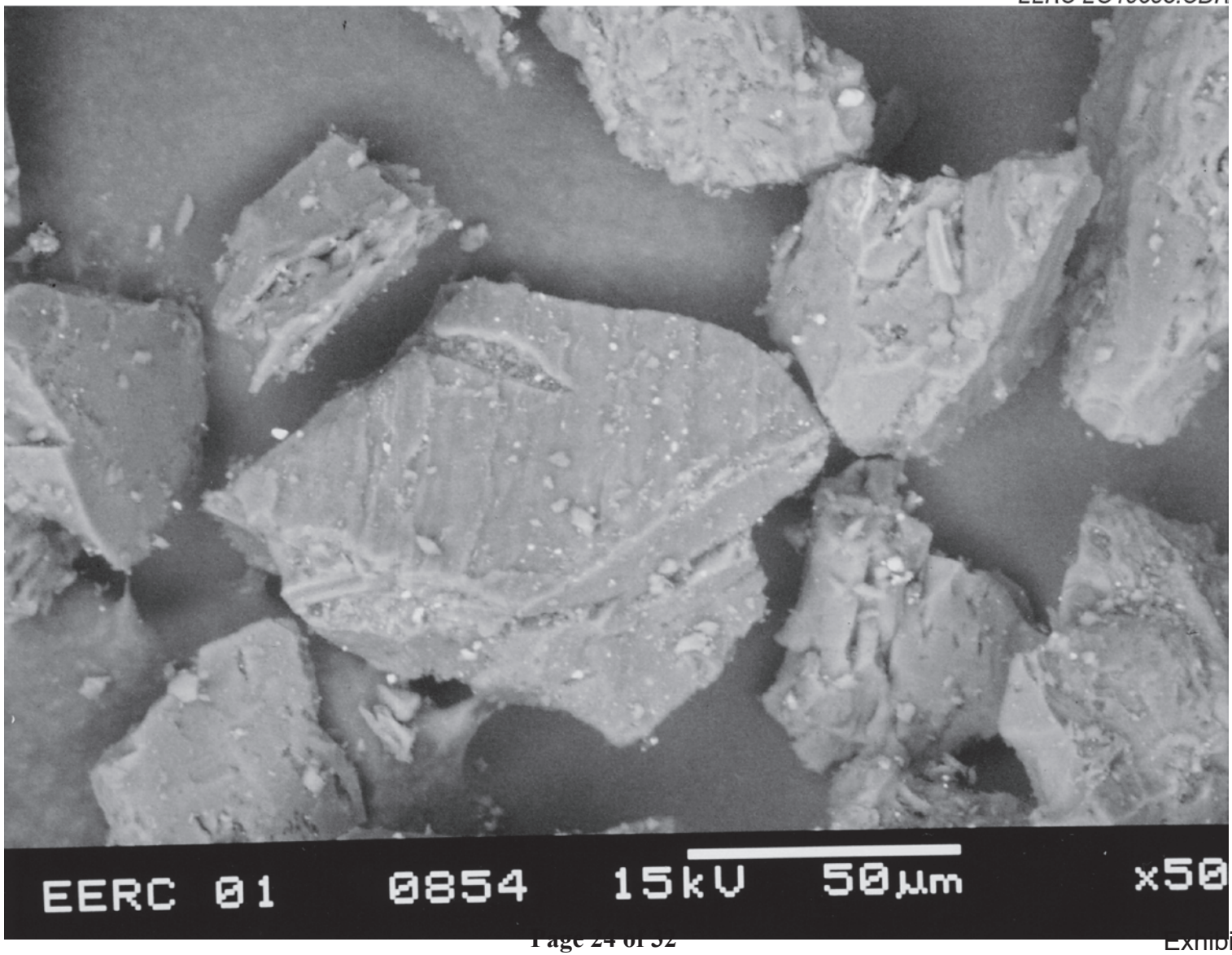


Activated Carbon Properties

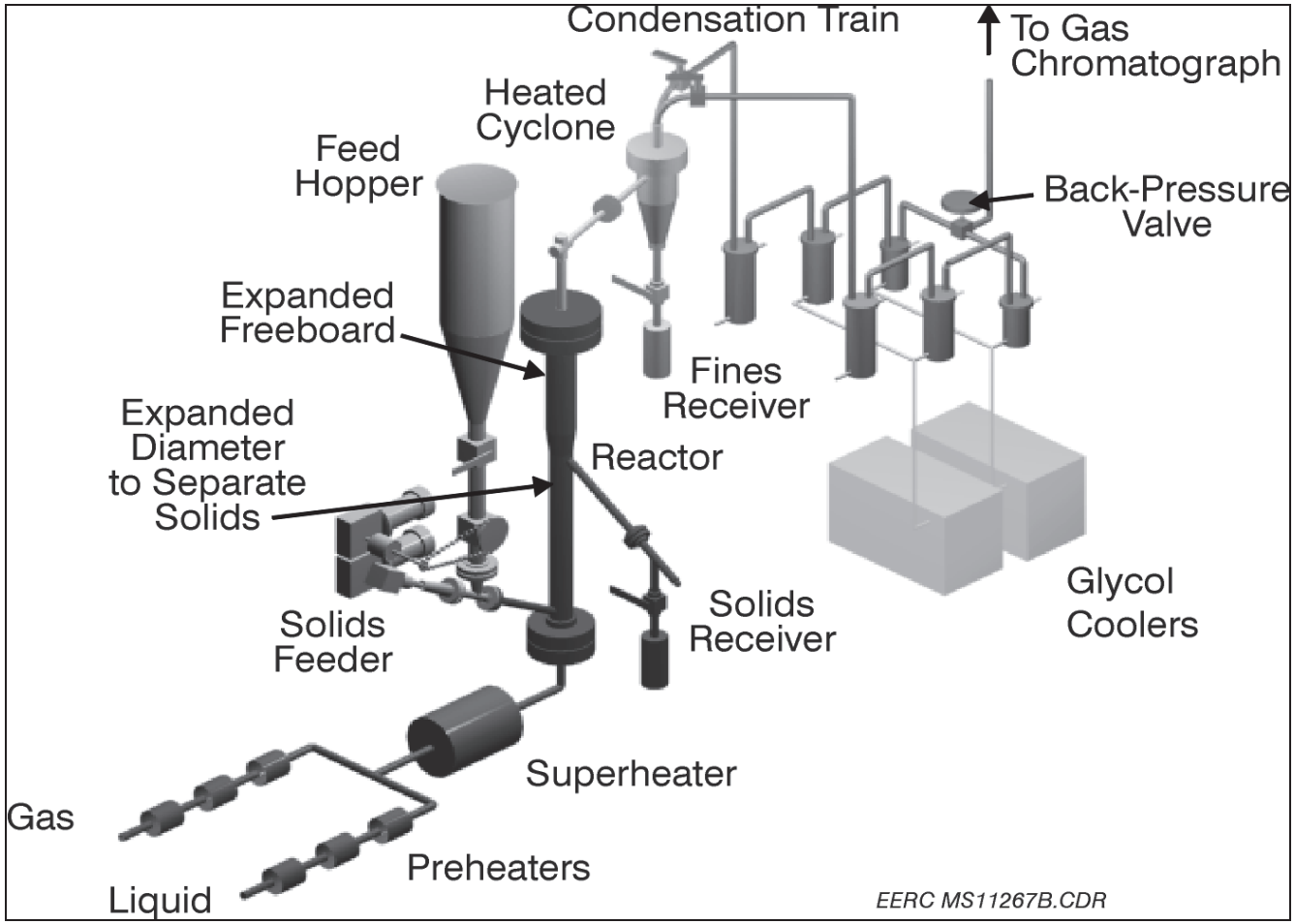
Metal Content	BET Surface Area (m^2/g)	Pore Volume (cc/g)	Avg. Pore Width (nm)
High Na	245	0.14	1.2
High Na (washed)	250	0.15	1.2
High Ca	370	0.20	1.1
Low Na, Low Ca	349	0.17	1.0

SEM Microphotograph of High-Sodium Carbon

EERC EO19658.CDR



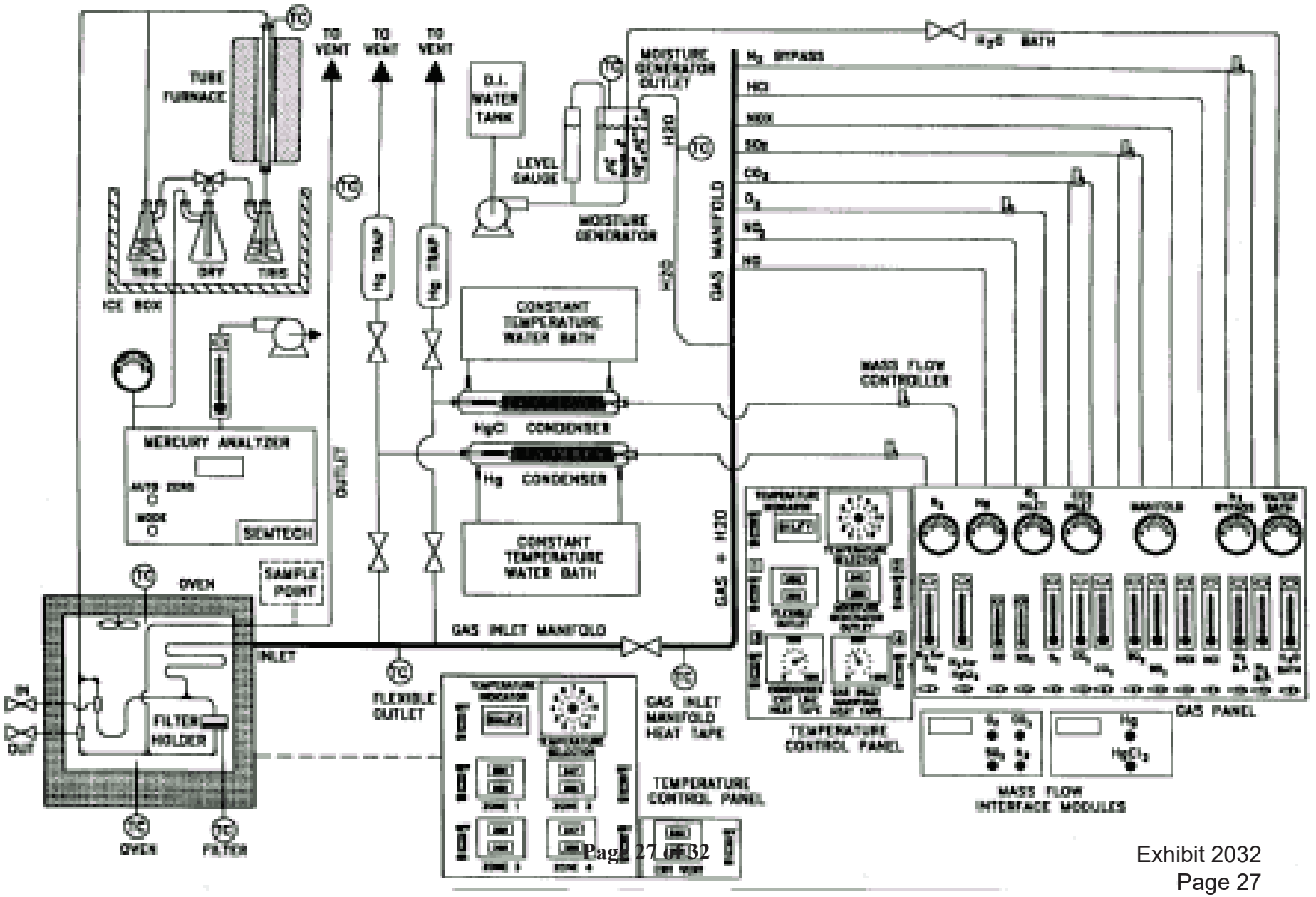
Small Reactor to Produce Char (4lb/hr)



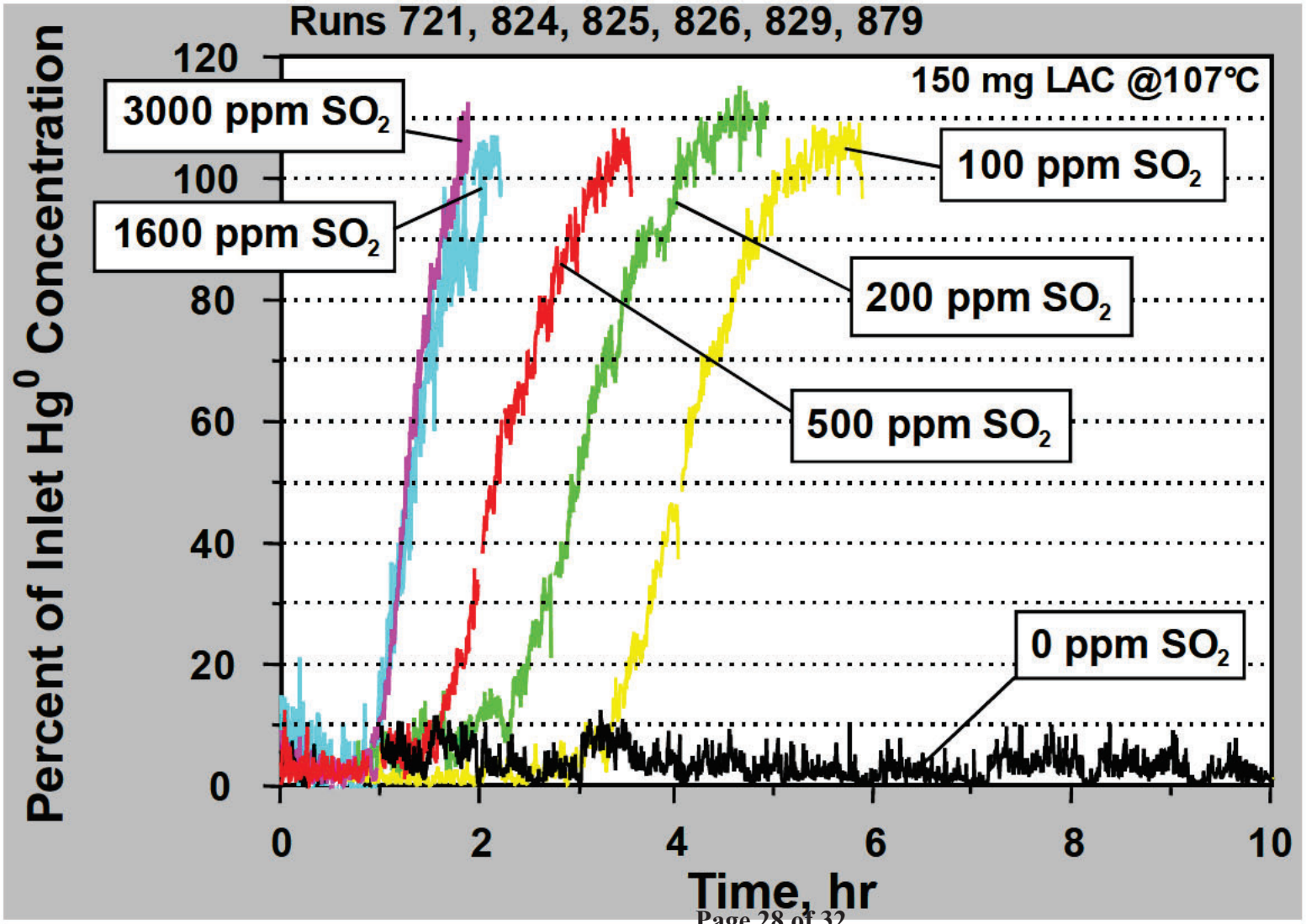
Characterization -- AC

- Carbon characterization
  - Chemical – C, H, N, S, and ash and ash composition
  - Physical – surface area (iodine #, one point nitrogen BET) – consider 10 point BET to calculate porosity ($600 to 800), particle size distribution.
  - X-ray photoelectron spectroscopy (XPS) on selected starting and spent carbons to determine functionality

Packed Bed Testing

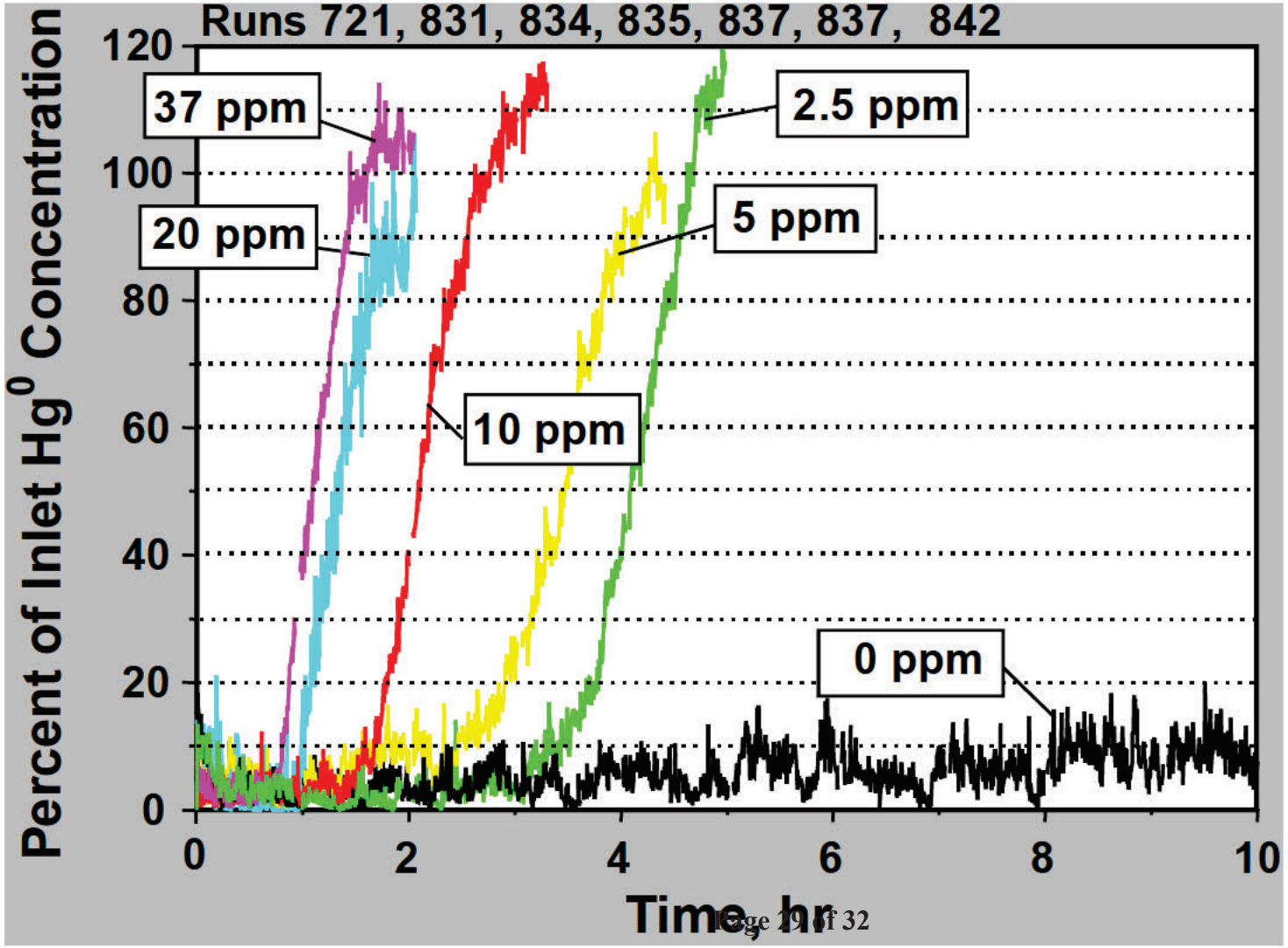


Effect of SO_2 Concentration on Hg^0 Capture with Activated Carbon



Hg^0–15 µg/m^3
O_2–6%
CO_2–12%
H_2O–8%
N_2–Balance
HCl–50 ppm
SO_2–0 to 3000 ppm
NO–400 ppm
NO_2–20 ppm

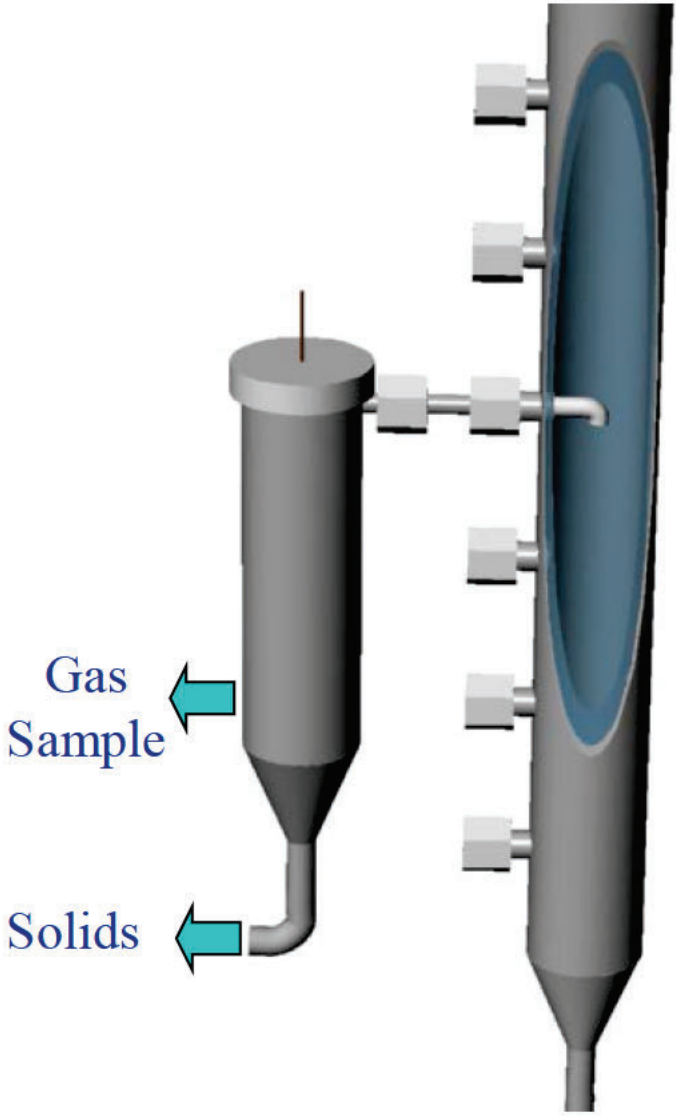
Effect of NO_2 Concentration on Hg^0 Capture with Activated Carbon



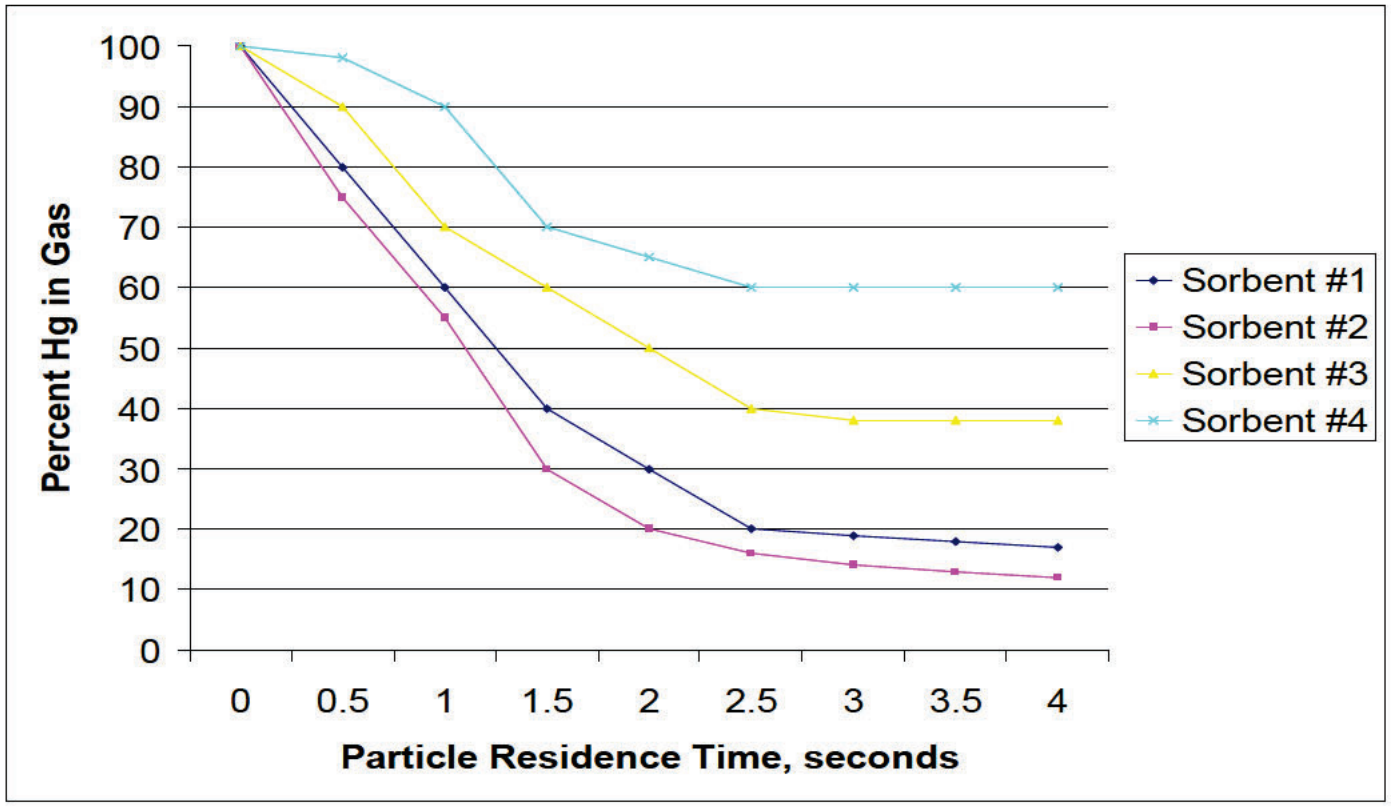
Hg^0–15 µg/m³
O_2–6%
CO_2–12%
H_2O–8%
N_2–Balance
HCl–50 ppm
SO_2–1600 ppm
NO–400 ppm
NO_2–0 to 37 ppm

Entrained Flow Reactor

- Dimensions
  - Diameter ~ 2.5 to 3 inch
  - Height ~ 6 ft
  - Port size ~ ½ inch (qty 20)
- Flows
  - Lab 30 scfh
  - Res. Time testing 50 lpm
  - Field tbd
  - Residence time = 0 to 10 secs
- Sorbent injection rate
  - 0 to 20 g/hr (lab)



Entrained Flow Reactor Results



EERC
Energy & Environmental Research Center

Results of Bench Scale Testing – Identify the best sorbent for Larger scale testing

- Initial screening of sorbents to evaluate capture effectiveness, oxidation potential, and capacity
- Provide relative ranking to determine most promising sorbent for pilot and full scale testing
  - Criteria – reactivity, capacity, physical properties (size/surface area), residence time, and cost
- Prepare sorbents for pilot scale testing