Gas-Phase Brominated PAC for ESP Performance Improvement
Opacity vs Load - Illinois Crawford 7 - late July 2006

opacity tends to increase ~4% with time at full load [DOE preliminary]
Opacity vs Load, MWGen Crawford Plant, Illinois, Parametrics

August 06, 2006

% Opacity, 6-min. avg.

Load, MW

- Feeding problem - sometimes off

- 11:02 begin C-PAC3
- 1 lb/MMacf
- 13:33 increase C-PAC to 3 lb/MMacf
- 15:47 increase C-PAC to 5 lb/MMacf
- 18:20 turn C-PAC3 off

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Regression Lines of Opacity vs Load with C-PAC Injection,
Midwest Generation Crawford Station Unit 7, PRB Coal & 120 SCA ESP
(Treated Side Combines with Untreated Side - Preliminary Data) Aug 14th - Sep 14th

- Linear (The 3.5 days prior to injection)
- Linear (The first 5 days with C-PAC 8/17-8/22)
- Linear (From 8/22 to 8/27 with C-PAC)
- Linear (From 8/27 to 8/30 with C-PAC)
- Linear (From 9/6 to 9/14 with C-PAC w/o 9/9)

~4% (x 2) absolute high-load opacity decrease with time

The 3.5 days before injection
First 5 days
Following 5 days
Next 4 days
Last 9 days

8% Abs. Opacity Improvement
Spark Rates – First Two Fields

Prior to Parametric C-PAC Injection - Preliminary Data

Four Days of Parametric C-PAC Injection - Preliminary Data

Baseline

Parametrics

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1\textsuperscript{st}-Field Sparking During the LT Run

![Graph showing spark rate over time with dates from 8/13/06 to 9/17/06. The graph compares spark rate between Front Left and Front Right injection.]
Spark Rates – All Fields

Average Spark Rate - C-PAC Side

Front - Left
Front - Right
2nd - Left
2nd - Right
Third Field
Rear - Left
Rear - Right
Linear (2nd - Left)
Linear (Third Field)
Linear (Rear - Left)
How Does Sparking Lead to Emissions?

- **How do we believe it works?**
  - Gas-phase bromination alters the PAC surface charge characteristics
  - Lowers the net restivity of the plate ash-cake
    - 1) Raised power levels possible for collection of all ash
    - 2) No more “puffing off” of ash without sparking

- **A whole new product category (Patent Pending):**
  - Anti-sparking agents / ash-cake conditioners
Lower Fly Ash Resistivity

![Graph showing resistivity vs. 1000/Temperature (F) for Crawford LT and Crawford Baseline.](image)

- **Crawford LT**
- **Crawford Baseline**

**Resistivity, ohm-cm** vs. **1000/Temperature (F)**
Higher Power Levels Possible

Will County - Hot-Side ESP First Field - Side D1 - C-PAC & H-PAC

- Secondary (i.e. Plate) Voltage
- Secondary (i.e. Plate) Current
- Injection Rate

Does the impact on opacity translate to a reduction in particulate matter emissions?
ESP Particulate Emissions

B-PAC into a PRB Slipstream ESP

ESP Outlet Dust Particulate Monitor (mg/m$^3$) vs. ESP Inlet Dust Particulate Monitor (mg/m$^3$) vs. ESP Particulate Emissions

Feb 13

ESP Outlet Dust Particulate Monitor (mg/m$^3$)

ESP Inlet Dust Particulate Monitor (mg/m$^3$)

X20 Carbon Feed Rate (lb/MMacf)

ESP Particulate Emissions

ESP outlet dust part monitor (mg/m3) PAC Feed Rate lb/MMact ESP inlet dust part monitor (mg/m3)

0.5

5.3

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ESP Particulate Emissions

ESP Outlet Dust Particulate Monitor (mg/m$^3$)
X3 Particulate Removal (%)
X100 Carbon Feed Rate (lb/MMacf)

ESP Inlet Dust Particulate Monitor (mg/m$^3$)
Percent Particulate Removal
PAC Feed Rate lb/MMacf
ESP inlet dust part monitor (mg/m$^3$)

May 3

0.5 lb/MMacf

ESP outlet dust part monitor (mg/m$^3$)
Do Other PACS Have the Same Effect?

- **Plain PACs**
  - We have never observed the same effect

- **Bromine-Salt PACs**
  - Fundamentally different from Bromine-Gas PACs (e.g. Norit Darco Hg-LH vs. B-PAC™)
  - Never seen mention of significantly-improved ESPs
  - Possibly slightly positive, but a matter of degree