Activated Carbon in Challenging Flue Gas Environments

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Agenda

• Introduction

• Calgon Carbon R&D Efforts

• Fluepac Advances/Advantages
  • Sulfur Tolerance
  • Concrete Friendliness
  • DSI Compatible

• Summary, Q/A
Who Is Calgon Carbon Corporation?

- We are the world’s largest producer of granular activated carbon
- We solve customer purification and separation problems with an array of technologies
- Activated carbon is our core competency with a diverse product portfolio
- Globally deliver over 400 MM pounds per year

240 PATENTS

23 OFFICES
SALES AND SERVICE

1100+ EMPLOYEES

15 FACILITIES
MANUFACTURING, REACTIVATION, EQUIPMENT

70+ YEARS EXPERIENCE

$548 million
2013 Net Sales
Market Leader in Research and Development

• Investment to date > $12MM
  ▪ Fluepac Product Development
  ▪ Full scale product demonstrations and trials

• All test data generated by independent testing services
  ▪ Independent Contractors – Injection skid, traps, and CEMS (TL and Super sack capabilities)
    o Element 1 Engineering, Apogee Scientific, and others
    o Transparent testing and “real time” data
  ▪ MRC – 100s of product formulations tested for countless system variations
Non-Brominated Product Offerings

**Standard**
- FLUEPAC® MC

**Advanced**
- FLUEPAC® MC MAXX
- FLUEPAC® SPR MAXX
- FLUEPAC® SL

Paired with Boiler Additive/Refined Coal

Brominated Product Offerings

- FLUEPAC® MC+
- FLUEPAC® ST
- FLUEPAC® STF
- FLUEPAC® S3
- FLUEPAC® SF3
Challenge 1: High-Sulfur Flue Gas Streams
Calgon Carbon is #1 in SO$_3$ tolerance

All carbons fed at same feed rate.

September, 2013
5 ppm SO$_3$
Full-Scale Utility Test with $\text{SO}_3$, 3 ppm

Fluepac ST achieved compliance at 75% reduced injection rate when compared to competitive Br-PAC without CaBr$_2$. 

![Graph showing ACI Comparison at 3 ppm SO$_3$.](image)
Full-Scale Utility Test with SO$_3$, 6 ppm

At 6 ppm SO$_3$ Fluepac ST only required ~1 more lb/MMacf injection rate to reach compliance, while the competitive brominated product will not reach compliance at a reasonable rate with this configuration.
Full-Scale Utility Test with $\text{SO}_3$, 9 ppm

At 9 ppm $\text{SO}_3$, Fluepac ST was still able to achieve compliance at a reasonable injection rate. However, Fluepac SF3 achieved compliance easily. The competitive PAC was not tested at 9 ppm $\text{SO}_3$. 
Challenge 2: Fly Ash Quality – Concrete Friendliness
Foam Index – It’s All About Porosity

Typical surfactant

2,000x magnification
Larger pores (meso & macro) readily adsorb large surfactant molecules

400,000x magnification
Micropores (<2 nm) cannot adsorb large surfactant molecules

A balance of micro and macro pores desired to maximize access to micropores (for mercury capture) and minimize adsorption of AEA’s
Fly Ash Sales Possible with Calgon Carbon Products

Utility Foam Index Results

- Lignite based carbons readily adsorb air entrainment additives
- Calgon bituminous based carbons are inherently concrete friendly
- Target levels for ash sales

- Competitor "concrete friendly" brominated PAC
- Mix of competitor PAC and MC Maxx
- MC Maxx
- Mix of MC Maxx and ST
- ST

Target levels for ash sales

R² = 0.9489

Percent carbon in ash
Superior Ash Compatibility of FLUEPAC® Products

Independent Fly Ash Broker Foam Index Testing of Class F Fly Ash Mixed with 2 wt. % PAC

- Baseline Class F fly ash
- Bituminous PAC 1
- Bituminous PAC 2
- Bituminous Br-PAC
- Lignite PAC 1
- Concrete friendly lignite PAC
- Lignite PAC 2

Calgon Carbon FLUEPAC® Products
DSI Compatibility
FLUEPAC® DSI Compatibility

Fluepac ST with trona rates of 500 – 6,000 lbs/hr shows nearly no impact of trona on Hg removal performance.
Summary of PAC Advances

**Sulfur Tolerance**
- Highly resistant to the negative impact of high levels of SO3 in flue gas streams

**Low Impact Carbons for Fly Ash Preservation**
- Raw material selection leads to an inherently concrete-friendly carbon
- Less carbon in fly ash → More concrete friendly → *Preservation of fly ash sales*

**DSI Compatibility**
- Resistant to the impact that dry sorbents will have on carbon injection rates
Questions?
Thank you for your time.