A Better Alternative to SO$_3$ for conditioning Electrostatic Precipitators (ESP)

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Cold-side ESP Performance

- High ash resistivity at typical cold-side ESP operating temperatures (250 – 350 °F), especially with low-sulfur coal, causes poor ESP performance.
- PRB coal has high calcium content. Calcium and magnesium lower ESP performance through increased resistivity effects.
Effects of Sulfur and Temperature on Ash Resistivity

Cold-side ESP on low-sulfur coal
Hot-side ESP Performance

- Significant decrease in fly ash resistivity at flue gas temperatures above 600 °F – good!
- However, back corona causes poor hot-side ESP performance in units treating both eastern and western low-sulfur coal ashes.
- Back corona is caused by “sodium depletion” that occurs in the layer of ash permanently residing on the collection plate. This depletion leads to an increase in the electrical resistivity of the ash to an unacceptable level (from $1 \times 10^9 \sim 5 \times 10^{10}$ to $1 \times 10^{11}$ to $5 \times 10^{12}$ ohm-cm) because sodium ions are the principal carriers of electrical charge in the ash at elevated temperatures, thus inhibiting normal ESP operation.

Increase sodium in fly ash is the solution!
Traditional Solution: Injecting SO₃

- Inject SO₃ to lower the ash resistivity for cold-side ESP.
- SO₃ concentration in flue gas @ 6 ~ 10 ppm is normally enough.
- Injecting SO₃ does NOT solve the problem of sodium depletion of hot-side ESP.
Negative Effect of $SO_3$ on Mercury Removal

- 350 MW boiler burning low-sulfur coal
- $SO_3$ measured at SCR Outlet
Problem: Mercury

- EPA will set standards for mercury and a number of other toxics by late 2011.
- 23 states require coal-fired utilities to reduce their mercury emissions by 80 ~ 90% (Michigan, New Jersey, Massachusetts, Illinois, ...).

Solution: Sodium

- Use Sodium compounds to condition ESP and remove $\text{SO}_3$
  - One stone to hit two birds!
Sodium Reduces Ash Resistivity

Effect of increasing sodium content in ash is same as sulfur in coal!
Traditional Sodium Addition

• The most common conditioning agents are sodium sulfate (Na$_2$SO$_4$) and sodium carbonate (Na$_2$CO$_3$).
• The material is spread on coal as the coal is being transported to the bunkers.
• Typical application rates:
  – Na$_2$SO$_4$: 5 lbs/ton of coal
  – Na$_2$CO$_3$: 3.75 lbs/ton of coal
  – These chemical addition rates will typically increase the magnitude of the ash sodium content by about 0.5%. 

Issues with Na$_2$CO$_3$ and Na$_2$SO$_4$

- **Cost:**
  - Na$_2$CO$_3$: ~ $200/t$
  - Na$_2$SO$_4$: ~ $300/t$

- **Too much sodium in coal poses the risk of causing slagging in boilers.**
  - Melting point of Na$_2$CO$_3$: 1564 °F (851 °C)
  - Melting point of Na$_2$SO$_4$: 1623 °F (884 °C)
Solutions

- Introduce a low-cost sodium compound downstream of combustion zone (< 1500 °F).
- Use trona instead of Na₂CO₃ and Na₂SO₄ as the source of sodium.
- Spray trona onto coal only IF a small amount of additional sodium is needed.

Low capital and O&M costs!
What is Trona?

• Trona is an ore mined underground
• Trona is naturally formed sodium sesquicarbonate ($\text{Na}_2\text{CO}_3\cdot\text{NaHCO}_3\cdot\text{2H}_2\text{O}$)
• Green River, Wyoming, has billions of tons of Trona

$$2(\text{Na}_2\text{CO}_3\cdot\text{NaHCO}_3\cdot\text{2H}_2\text{O})(s) + \text{heat} \rightarrow 3\text{Na}_2\text{CO}_3(s) + 5\text{H}_2\text{O}(g) + \text{CO}_2(g)$$
Trona Injection Test Results

- Trona was injected upstream of a hot-side ESP (100 MW boiler).
- 32 tests were conducted at various unit loads and on both Central Appalachian and Colombian coals (representing two different low-sulfur coals).
- Opacity was continuously monitored during the entire test period. It remained consistently below 4% with no spikes.
- Up to 80% SO₂ was removed.

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<th>Baseline</th>
<th>Trona Injection</th>
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<td>PM10 (lb/MBtu)</td>
<td>0.035</td>
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