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2012 APC Round Table & Expo Presentation

July 16-17, 2012, in Baltimore, MD / Hosted by Duke Energy, Entergy,
FirstEnergy, Southern Company & TVA

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Triboelectric oxidation of mercury and mechanisms that impact it

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Rules, rules, rules.

- MACT rule will drive almost all coal plants to 1.2 lbs/ trillion btu's
- Utilities are developing strategies for conforming to the several components of this rule.
- This discussion will specifically speak to the mechanism of mercury removal.
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There are at least four mechanisms for mercury removal

- *Forcing oxidation chemically*
- Chlorine, fluorine or bromine in flue
- Incipient levels of free chlorine in some coals make this a non-issue.
- Calcium bromide addition on coal, Has the added benefit of reducing NO_x emissions.
Chlorine, fluorine, or bromine injection in flue gas.
- Peroxide injection in flue gas.

Forcing oxidation triboelectrically

- In hot dry environments, such as flue gas, minerals, exhibit a propensity for electron depleted, in the case of fly ash, to electron rich surfaces, in the case of activated carbon. These electron depleted surfaces are electronically no different than any other ionic process in chemistry, and will be the focus of this discussion.

- Chlorine or fluorine adhere to electron-depleted sites on fabric filters, or ash cake, increasing oxidation potential for elemental mercury

Adsorption

- carbon is injected upstream of a particulate control device, usually a baghouse,
- Materials like activated carbon have active adsorption sites that can absorb elemental mercury

Scrubbing of mercury

- Oxidized mercury is like scrubbing any other particulate.
- Elemental mercury scrubbing is harder, requiring a mechanism to tie mercury up as mercury as mercury sulfide. Materials such as calcium sulfide, or sodium hydrosulfide are the chemicals of choice for elemental mercury removal.
- Both mechanism require some care in scrubber chemistry to assure no reemission of mercury.

Synergy and destruction

- There is a synergy, and self destructive process to these mechanisms. A careful process of thought must go into the decision making process. If performance mechanisms are not considered as part of the total pollution control strategy

- A typical coal plant could use several of the following methods of pollution control mechanism in its journey to comply with emission regulations.

Pollution control types

- Low NO_x burners.
- Over-fired air systems
- Calcium bromide injection
- SCR's, with ammonia injection
- Hot-side or cold side ESP's
- With flue gas conditioning. Usually SO₃.

Part deux

- Reverse gas or pulse jet baghouses.
- With multiple choices of filters
- With a large range of fly ash resistivity.
- Dry or wet scrubbers, operating in either a forced oxidation, or inhibited oxidation mode.
- Wet precipitators

- All of these mechanisms can impact each other's ability to perform their pollution control tasks.

Hg removal specifically?

- The two most popular methods of mercury removal are adsorption through active carbon injection, and forced oxidation of mercury on a filter, or filter cake.

Triboelectric oxidation

- The higher the triboelectric steady state, the higher the accumulation of acid gas components, and the higher the oxidation potential to elemental mercury.

Things that positively impact this process are:

- Flue gas temperature, as it relates to the resistivity of the fly ash. Generally higher is better.
- Excess O₂. As excess O₂ goes up, flue gas relative humidity decreases, increasing the triboelectric steady state.
- Fabric choices. Materials having high triboelectric potentials in flue gas environments exhibit better mercury oxidation and removal behavior. Materials that have poor triboelectric potentials will exhibit poorer mercury oxidation potentials.

Positive impacts

- Flue gas conditioning. Conditioning agents that lower the acid dew point, such as Polyethylene oxide, or analine, should increase the triboelectric potential.
- A lack of materials having electron enhanced tribologies. Very low un-burnt carbon levels, or low presences of activated carbon enhance the baghouses ability to oxidize mercury.

Things negatively impacting this triboelectric potential are:

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- *Low to very low excess O₂:*
- Raises the relative humidity of the flue gas, lowering the triboelectric potential, and mercury oxidation potential. Systems that might contribute to this issue are Low NO_x burners and overfired air systems.
- *Presence of unburned carbon in ash, or activated carbon:*
- Carbon particles take up charge sites on fly ash and filter media, taking away sites for chlorine and fluorine to provide oxidizing environment at the filters. Systems providing these mechanisms of interference would be Low NO_x burners, and activated carbon injection systems.

Negative impacts

- *Low fly ash resistivity:*
 - This can be incipient in the ash, or the result of mechanism such as flue gas conditioning.
- *Low fabric filter tribology:*
 - This is the result of fiber choices for these filters
 - Flue gas conditioning using SO₃.
 - SO₃ lowers fly ash resistivity by raising the apparent relative humidity of flue gas. This increase in the acid dew point, lowers the triboelectric potential

Positive synergies for carbon adsorption

- Lower flue gas temperatures, or higher acid dew point.
- Lower excess O₂ conditions expected from well run Low NO_x burner systems.

Negative synergies with carbon adsorption

- Higher flue gas temperatures, or lower acid dewpoints
- Higher excess O₂ conditions.
- High fly ash resistivity

- Both of these mechanisms, activated carbon injection, and triboelectric oxidation, are very good at mercury removal, but they both suffer from the fact that :
- Neither of these mechanisms works everywhere.
- They can work in opposition to each other.

So how do you make this work?

Sort out the ambivalent

- First, understand that some components are innocuous:
- Calcium bromide injection on coal is a no impact, add-on for plants contemplating either Activated carbon injection, or baghouses use for mercury capture.
- Wet precipitators will have no negative impact on mercury control.

Looking at all of the pollution control impacts, develop rules.

Rule 1.

- If you are using a polishing baghouse for a precipitator, and it is intended to be your mercury control element, consider stopping the use of flue gas conditioning agents like SO₃.

Rule 2.

- If you are using a polishing baghouse for a precipitator, and it is your intention to be using the baghouse as a mercury control element, consider not adding activated carbon injection.

Rule 3.

- If you are using a polishing baghouse for a precipitator, and it is your intention to be using the baghouse as a mercury control element, consider use of a flu gas conditioning agent to increase fly ash resistivity, or additional excess air, bypassed around the air heaters.

Rule 4

- If you are using activated carbon for mercury control, and this material is being captured in a fabric filter, consider fabric choices with low tribology, and addition of technologies, such as flue gas conditioning.

Rule 5.

- If you have mechanisms that are adding an SO₃ burden to the flue gas, such as an SCR, consider chemically tying up the SO₃ prior to the fabric filter, or using activated carbon injection, instead.

With well thought out rules, this isn't a tug-of-war

- With all the possible pollution control strategies, and different fuels, your final strategy might have more than one hundred rules.

Questions?

