REINHOLD ENVIRONMENTAL Ltd.

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Triboelectric Oxidation of mercury in Fabric Filters

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Why would we care?

- A Clean Air Mercury Rule appeared in the fifth year of George W. Bush's presidency.
- Required 70% removal by January, 2010. Higher removal rates later.
- States followed with similar, and frequently, tougher rules.
- The Federal rule was vacated by the courts, but this did not impact most State Rules.
- In January, 2010, many utilities needed to comply with their state rules.
- Now there is MACT looming on the horizon.
- So lets discuss how this is done.

Mercury removal was first noticed in baghouses during EPRIs' PISCES project in the early 1990's

- Unit 4 was a test subject during Pisces, and Mercury oxidation was observed. Getting "great mercury oxidation".
- From 1990 to 2011, "Great" isn't that great.
- The whisper effect invoked itself in the industry, and soon this became : "Baghouses oxidize mercury".
- This is simply not always true.

Mercury oxidation comes from halogens such as chlorine or fluorine, in flue gas.

- Some eastern utilities have enough incipient chlorine to make mercury removal numbers by doing nothing beyond particulate control.
- Some experimental coals have more chlorine, or bromine than western fuels.
- work has been done with chlorine injection.
- Bromenated carbon has been tested for units using carbon injections.

Mercury control is really a “horses for courses” issue

- If you are a candidate for filter oxidation of mercury, you may not be a good candidate for carbon injection.
- If you are a good candidate for carbon injection, baghouses may contribute little if any to mercury control.
- Carbon adsorption and filter oxidation exist at opposite ends of the triboelectric chemistry spectrum and can interfere with each other.

Carbon adsorption

- Is your best option when fly ash resistivity is low and SO3 presence is high.
- Works by adsorbing mercury onto activated carbon surfaces.
- Appears to have been a good choice for utilities like Wisconsin Electric.
- Could be a good choice for utilities with low resistivity ash, particularly ones with spray dryers.

Filter Oxidation

- Baghouses come in two flavors, Reverse Gas and Pulsejet.
- In Reverse Gas Baghouses, the ash cake is the filter.
- In Pulsejet Baghouses, the filter is the filter.
- Reverse Gas is your best performer when fly ash resistivity is high. Though these are large, and expensive devices.
- Pulsejet is your best choice when fly ash resistivity is low, but flue gas conditions provide very low relative humidities.

So how does it work?

- Quite simply, The Triboelectric Effect.
- All surfaces have triboelectric states in hot, dry gas environments.
- Particles, and fibers with the presence of rubbing, want to head toward, and exist in equilibrium in an electron depleted, electron neutral, or electron positive state, under these conditions.

Mercury oxidation is indirect.

- Very resistive fly ash exists in a triboelectric environment as an electron depleted surface.
- This positive charge attracts chlorine and fluorine atoms in the flue gas, what few there are.
- This provides a hyper-accumulation of chlorine in the filter cake.
- This high oxidation potential oxidizes mercury as it passes through the filter, changing it from a gas to a particulate.
- Mercury is captured in the particulate control device or scrubbed.

Fibers can perform the same function.

- Finishes like PTFE, I-625, and other acid resistant finishes have surface tribologies similar to class-F fly ash for reverse gas baghouses
- PPS (Polyphenylene sulfate) is a good fit for pulsejets.
- P-84 is argued to be a better pulsejet fiber, but there is very little data on mercury oxidation with this fiber.

So what interferes with this process? Carbon, SO3, and relative humidity

- Carbon has the same charge state as chlorine, existing in a triboelectric steady state with an excess of electrons.
- Carbon can tie up these same triboelectric sites, reducing the oxidation potential at the filter by taking up sites that could be occupied by chlorine and fluorine.
- Attention to, and control of the amount of carbon in the ash, is the first component.
- If you are relying on oxidation of mercury with a filter or high resistivity ash, activated carbon injection can be at cross purposes.

So what interferes with this process Part II

- Anything that will raise the relative humidity of the flue gas.(flue gas conditioning)
- Lowering back-end temperature.
- Lowering excess O2.
- Increasing SO3 (sulfur trioxide) presence.
- Spray Dryer scrubbers.
- Tube leaks.

This makes multi-pollutant control more complicated

- Excess O2 is used to control NOx.
- SCR's have a tendency to generate SO3.
- Spray Dryers are a relatively inexpensive SO2 control option
- Robust mercury oxidation physics can generate pressure drop issues.
- A hard look at all future pollutant requirements is key

So how do you measure this?

- In a reverse gas baghouse, this can be measured with a triboelectric probe. (commercially available)
- It is easier to measure the voltage gradient in the baghouse
- This type of measurement has multiple other uses in both baghouses and precipitators.

If a little is good, a lot is not necessarily better.

- In a perfect world, all chlorine would stay on the filter, and filter cake.
- As the triboelectric steady state increases, chlorine can stick to ash particles in areas of a compartment that are not useful for mercury oxidation.
- The control curve can be saddle-shaped, and the optimum control point must be found through testing.

Pulsejets require a different approach

- The filter is the oxidizing media, not the ash.
- So you need to measure the voltage potential of the filter with respect to the baghouse.
- This requires electrical separation of some filters from the tube sheet to allow this measurement.
- This is measured as a voltage differential between the filter and the tube sheet.
- Anything that impacts tribology will negatively impact the filters ability to oxidize mercury, just like a reverse gas baghouse.

Jealously guard your chlorine supply

- In reverse gas baghouses, Some of the chlorine and fluorine is lost in the process when ash is cleaned off of filters.
- In pulse jet baghouses, chlorine and fluorine can be removed from the filter by cleaning. Over cleaning of filters will negatively impact your ability oxidize mercury.
- Large amounts of oxidizing chemicals can come off the filters or filter cake with any reduction in the triboelectric steady state.

So there is no “silver bullet”?

- Understanding the physics, chemistry and their interrelationships is the key to successful mercury control.
- Have a sufficient amount of devices and data to control the process instead of depending on the arbitrary operation of the machine.
- Understand that all control parameters can have other negative impacts both in the baghouse, and other parts of the process.

If you get it right?

- You may not be a hero, but at least you are not the slowest antelope in the herd.
- Getting it WRONG is not an option.

Questions?