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UPGRADING YOUR FABRIC FILTER TO MEET THE NEW MATS REGULATION PM LIMITS

**A JOURNEY DOWN THE RABBIT HOLE.
FROM THE SUBTLE TO THE INCREDIBLY OBVIOUS.**

Bruce Salisbury

June 23, 2024

Particulars

- Particulate comes in several flavors at the chimney.
- While it is important to find and fix leakage of particulate past the particulate control device, it is equally important to understand all of the sources of particulate at the CEMS system.

The new numbers

- The EPA recently announced their intention to decrease the amount of allowable particulate escaping from fossil units.
- EPA is setting the level of the primary annual $PM_{2.5}$ standard at 9.0 micrograms per cubic meter.
- EPA is not changing the current:
 - primary and secondary 24-hour $PM_{2.5}$ standards,
 - secondary annual $PM_{2.5}$ standard, and
 - primary and secondary PM_{10} standards

Sometimes regulations don't make sense.
Sometimes regulations are just regulations.



So let's talk about how you make the new number

So why should I care?

- It is an impending regulation.

But the most important reason:

Because you live here. This is the air you and your family breath.

Why wouldn't you put effort into reducing particulate emissions, particularly if it didn't cost you anything except your own effort?

Particulars, cont'd

- We will speak to three pieces of this process;
 - Finding sources of particulate leakage at the particulate control device.
 - Understand the character of any particulate getting through downstream devices, such as the scrubber.
 - Understand the value of reducing the amount of mist going out the stack.

Baghouses, Reverse gas and pulsejet

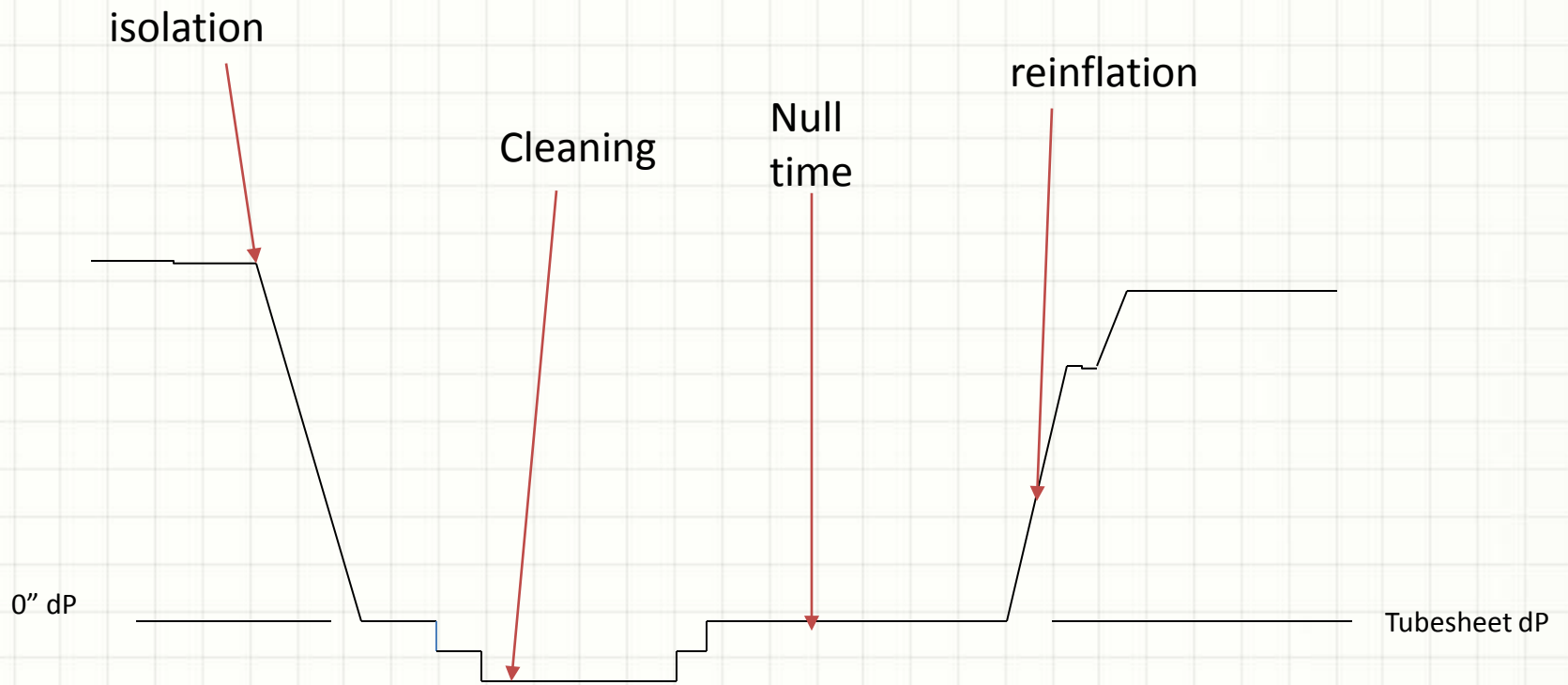
- Reverse gas baghouses isolate compartments to clean. This isolation is critical for filter failure and other compartment troubleshooting.
- While pulsejets are compartmentalized for maintenance, their troubleshooting is a bit more problematic

Having and interpreting the right data

You don't have to have tubesheet dP, as long as you have the ability to sense when the compartment isolates, such as poppet indication. Tubesheet dP is useful for other compartment troubleshoots such as poppet shear pin failures, and externals leaks.

Opacity or triboelectric data is only useful if it is upstream of any wet system such as a wet scrubber.

Reverse gas baghouses: cleaning cycle versus tubesheet dP



The Reverse air cleaning cycle

Isolation: Closing the outlet poppets prior to cleaning.

Cleaning: Pushing reverse air through the filters to remove ash.

Null: A short period of time to allow filters to relax back into their proper position.

Reinflation: Opening of the first (reinflation poppet followed by the second to reestablish normal flow to the compartment.

So put opacity together with the tubesheet dP



We see a distinct opacity drop with isolation, indicative of a filter failure

The Opacity drop

- If you have a baghouse in good shape, this opacity drop could be as little as 1/4%.
- You will need to adjust scale on opacity if this troubleshooting is being done by a human so they can see the data. With a very clean system, it is common for the entire scale of the opacity data to be less than 5 %.
- This needs to be a solid drop during the isolation phase, otherwise it may just be noise on the opacity circuit.
- You could also use a triboelectric effect sensor if there is concern over the use of Opacity data becoming compliance data.

Opacity false leads

- You should monitor baghouse outlet temperature. External leaks, such as leaking ventilation poppets and doors will produce a vapor plume until the compartment is isolated. This causes a drop in opacity when the compartment. Baghouse temperature will tell you it's an external leak. Although this is as important to fix as a failed filter.

So put opacity together with the tubesheet dP



We see a distinct opacity drop with isolation, indicative of a filter failure. The rise and then fall in baghouse outlet temperature indicate an external leak

The Opacity drop

- To be effective, this data either needs to be on trends that can be viewed by the operator constantly or done by a computer.
- Unlike people, Computers don't have bad days or get distracted.
- So this becomes a logic test of what the opacity signal does after a compartment isolates.

The Opacity drop

- Automated systems are generally designed with a register for each compartment which counts up when the test is passed (opacity drop with isolation) and resets to zero with a failed logic test.
- These systems generally alarm when the individual compartment count gets to five.

The Opacity drop

- The five count to alarm was based on the fact that when these systems were first run and referreed, it was found that when the system was alarmed at numbers lower than five, maintenance personnel could not find the failure, more than half the time.
- Since individual results will vary, the specific site is encouraged to develop this alarm threshold for themselves.

The Opacity drop

- To put things in perspective, the automated system was run side by side with operators for a year, and the system alarmed failures at a count of 5. Operators consistently recognized and isolated the compartment at a count of 80 to 99, when left to their own troubleshooting.
- This is mostly due to the large amount of data that Operators must deal with when operating these systems.
- If it's an option, automate this function.

Triboelectric sensors

- Triboelectric sensors do not tell you the amount of solid material is coming through the control device. It is telling you the triboelectric steady state of the material leaving the machine.
- Ash materials like to exist in a hot dry state, with electrons rubbed off their surface as a positive charge.
- Carbon particles like to exist with an excess of electrons rubbed onto their surface. As a negative charge.

Triboelectric sensors

- As the temperature drops or the relative humidity of the flue gas increases, such as with the addition of SO₃, this steady state changes. However, moment to moment, it can be used for relative particulate carry through in a system.
- Tribology is more important as setting dP across the baghouse. Yes, all you former ESP folks, fly ash resistivity still matters. Even in baghouses. It a major driver of baghouse dP, but another subject, for another day.

But what about pulsejets?

- Pulsejets don't have this regular cycle of isolating compartments. They have pulse rails or a rotating arm that periodically pulses.
- You are not looking for an opacity drop with systems like this, you are looking for an opacity spike associated with the pulse.
- To make this work automatically with a pulsejet, you need to have opacity (or triboelectric probes) and registers of all the pulse positions

But what about pulsejets? Cont'd

- Like the logic test for reverse gas baghouses, you track opacity spikes with rail pulses, and count.
- If you have compartmentalized filters, the final check would be to isolate the compartment and affirm that the opacity did drop when isolated.

Fiber choices for particulate reduction.

- Membrane filters seem to have a higher performance level for particulate removal than woven fabrics.
- Membrane has the advantage of generally having lower flange to flange pressure drop.
- Membrane is still more expensive than woven fabrics.
- Acid resistant woven fabrics like the Burlington I625 fiber are excellent at oxidizing mercury, so if the baghouse is a cornerstone of mercury compliance, fabric changes may not be possible.

Chronic Opacity

Sometimes there is a persistent Opacity that does not seem to tie back to a filter failure.

These can be caused by:

- Leaking bypass poppets
- Structural leaks between the clean and dirty side of the baghouse.

Chronic Opacity

Leaking bypass poppets are generally leaking for two reasons.

- The seal air system is not working correctly.
- The pneumatic controls do not have the poppet sealed against the poppet skirt.

Chronic Opacity

The easiest way to confirm that the bypass poppet is indeed leaking, it to put a small port in a line of sight to the downstream side of the poppet so personnel can look during walkdowns. This is under negative pressure and clean flue gas, so it is easy to observe.

Internal leakage must be found by internal inspection and require an outage to perform.

What if I don't have a baghouse?

- Very low particulate performance is possible with mediocre particulate control equipment.
- Units were tested that had venturi scrubbers for particulate and SO₂ control. A cheap, but traditionally mediocre combination of pollution control equipment.
- I won't speak to ESP's due to the fact that I am not a SME for ESP's.

Other particulate control equipment.

- Testing revealed that from the scrubber on, there were four additional particulate control devices the plant was unaware of:
 - The mist eliminators
 - The ID fan (as opposed to a booster fan)
 - The outlet ductwork
 - The chimney
- All of these systems were saturated.

The character of the particulate going out the stack.

- Prior to any testing on these equipment, stack samples were taken of material going out the chimney. X-ray diffraction analysis indicated that this material was rare for ash and scrubber materials. The three materials identified were:
 - The bassinite form of calcium sulfate hemihydrate
 - The Crystobalite form of silicon dioxide
 - Carbon soot.

The character of the particulate going out the stack.

- These materials were recognized for two properties. The first, carbon soot, for being hydrophobic. The bassinite and cristobalite, have a zeta potential backwards to the zeta potential of normal flyash particles.
- Zeta potential is the Ph dependent surface charge on a particle when it is immersed in a fluid.
- Having an opposing charge to a wet mist eliminators provides a more efficient process for particulate collection at the mist eliminators.

Zeta Potential

- Mist eliminator materials seem to be adequate for ash and most scrubber materials. They are less than optimum for materials with an inverted zeta potential. This is an opportunity for the mist eliminator manufacturers to carve out a new niche for their product.

Mist eliminator operation

- Mist eliminators are chevron shaped panels downstream of a scrubber that provide a torturous path to provide entrapment of droplets and particulate.
 - Keep them clean
 - Keep them wet
 - Keep them repaired

Mist eliminator operation



Mist eliminator operation

- Mist eliminators should have minimal scale. No scale is better.
- Note the small holes in Mist eliminators. These create paths for droplets to sneak through. Use common sense when it is time to replace Mist Eliminators.
- If you had a sufficient amount of scaling in the Mist Eliminators, they can plug. The secret to keeping them scale free is the chemistry of your mist eliminator water source.

Keep them clean.



What happens when you clean mist eliminators with scrubber slurry.

Keep them clean.

- Pluggage of Mist Eliminators create localized high velocities efficiently carrying solids out of the scrubber vessels. Keeping them clean will keep the velocity distribution even minimizing this kind of carry through.

What happens when you clean mist eliminators with scrubber slurry.

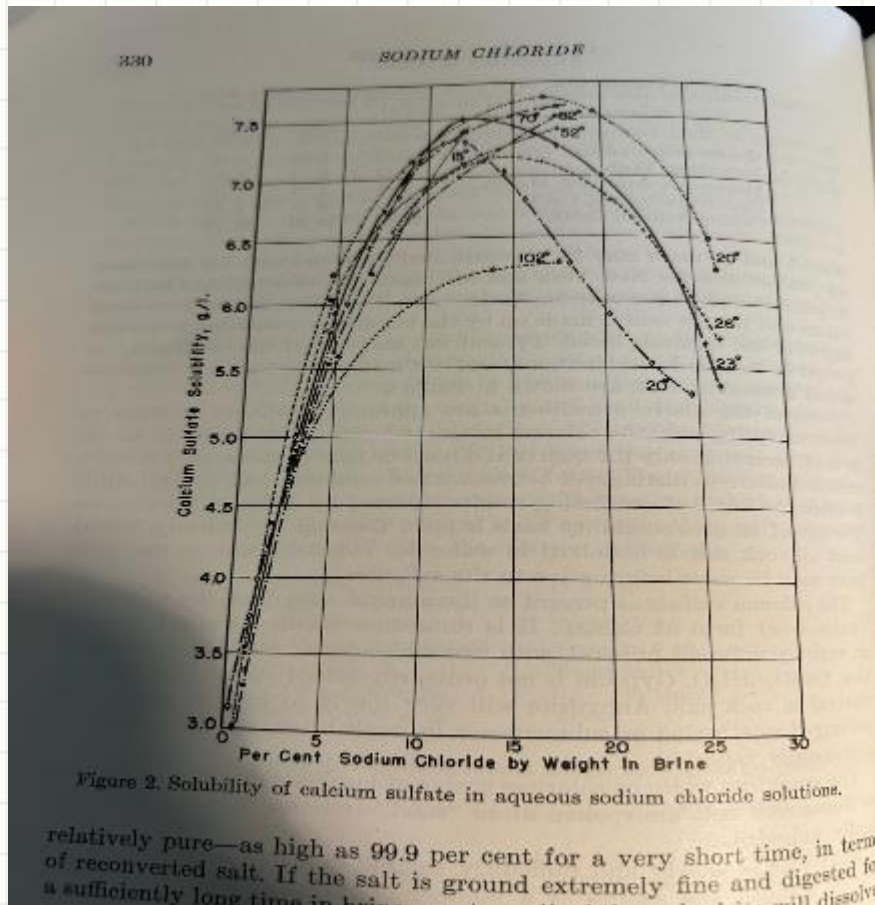
Mist eliminator operation

- Mist eliminators have sprays. Use them to keep the ME's clean rather than just running them when dP is high. Don't spray all the time, as this will wear them out.
- The spray source must have enough, and the right kind of TDS to keep things in solution from the ME's. Chloride is very helpful in this instance. Calcium sulfate is 7 times more soluble in water with high chlorides as opposed to pure water.
- Clean water, in this case, is not your friend. (and is never your friend in a scrubber)

Mist eliminator operation

- Chemicals such as thiosulfates help chloride keep calcium sulfate.
- In addition, higher dissolved solids buffers this system to keep the pH in mist eliminators from being as low as it would be without buffering.
- Since there is no usable alkalinity introduced into the Mist eliminators, (at least deliberately) clean, low TDS water is not your friend and will not keep your Mist eliminators clean.

Mist eliminator operation



From the book "Sodium Chloride", Kaufmann, Reinhold publishing, copyright 1960.

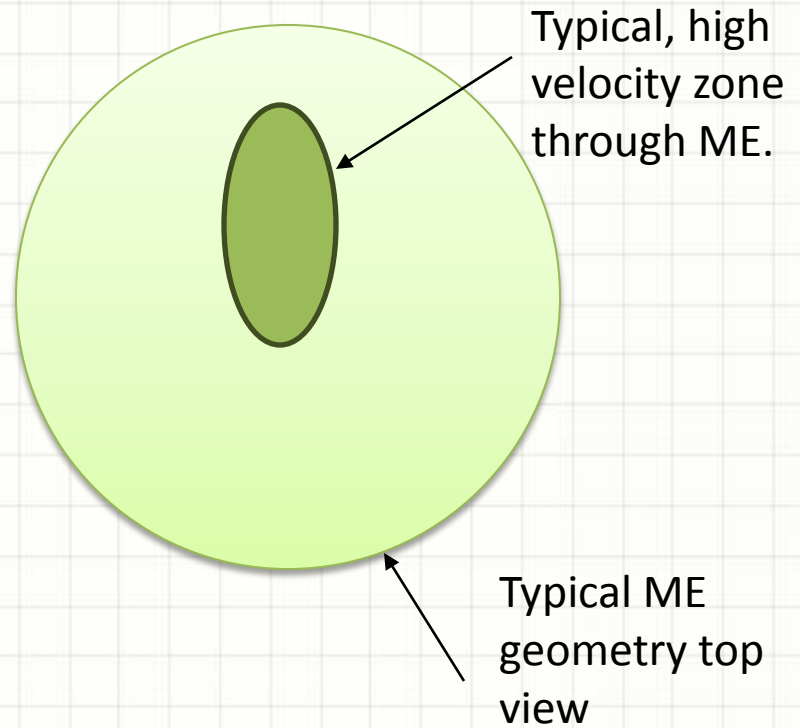
Keeping chloride in your mist eliminator spray wash will keep your ME's cleaner.

Mist eliminator operation

- Traverse testing of mist eliminators indicated that the streamline for flow through the mist eliminator has a high enough gas flow that the mist eliminators were usually dry. It was believed that if this could be cured, they would perform better.
- Since constant spraying on these mist eliminators would cause early and excessive wear on them, sprays were installed to provide a sheet of process liquor immediately underneath the mist eliminator. It then relied on the vertical velocity to sweep the droplets up and into the mist eliminators to keep them wet.
- Fan sprays with a 30-degree angle were used.

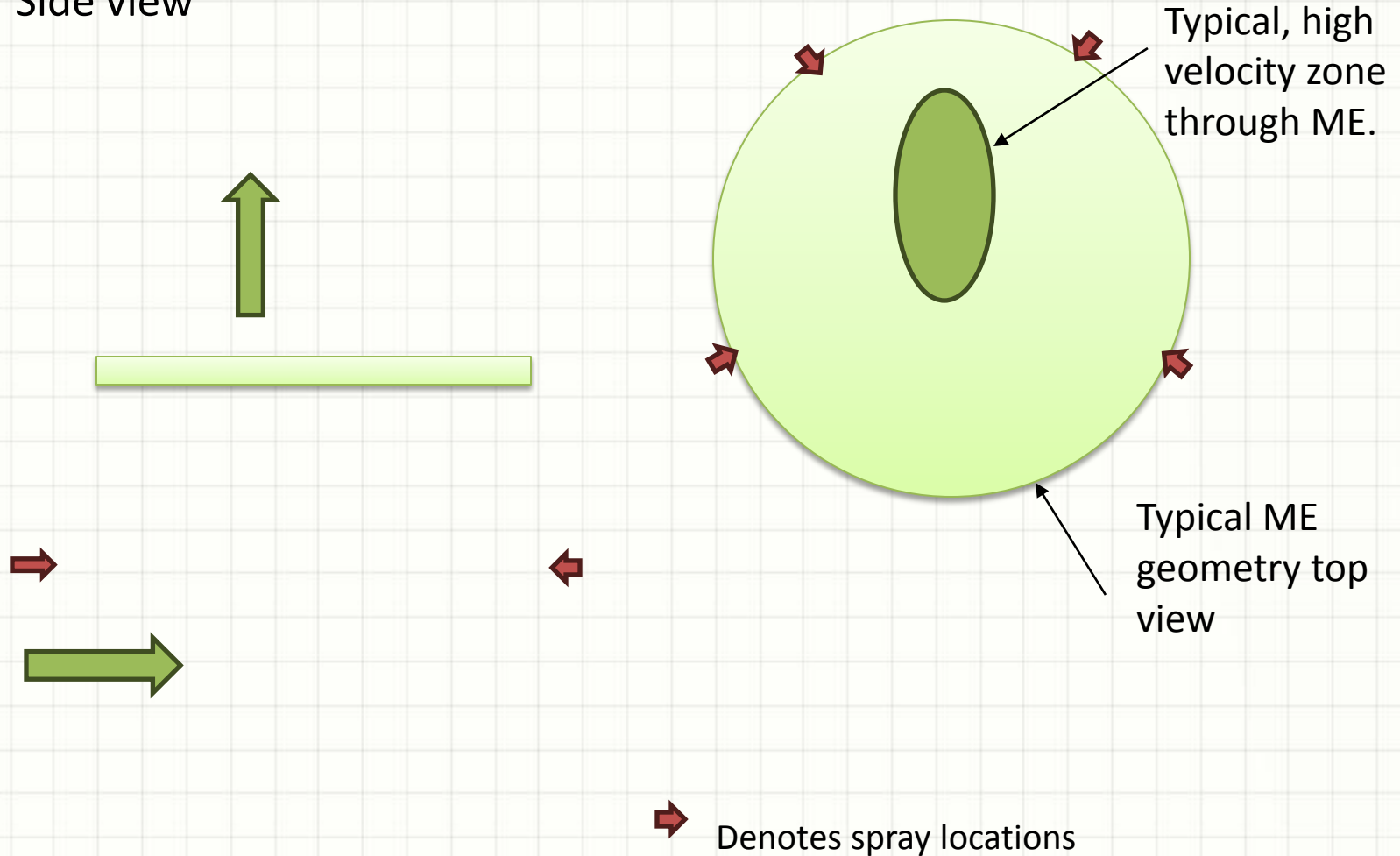
Mist eliminator operation

Side view



Wetting spray Operation

Side view



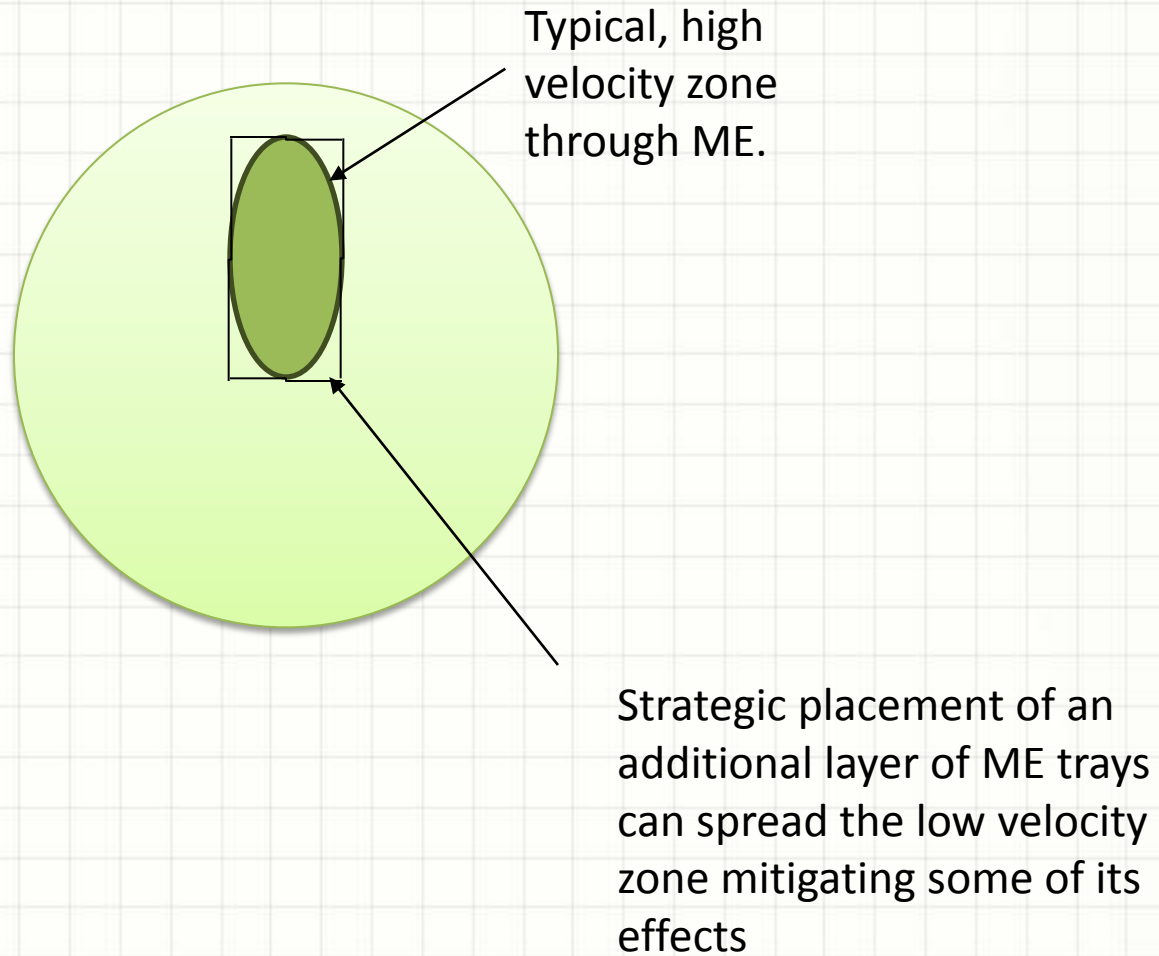
Mist eliminator spray results

- These horizontal sprays ended up being very effective at allowing the mist eliminators to capture additional particulate.
- After installation, it was discovered that the “dry mist eliminator” issue was seasonal, and the plant would only run these horizontal sprays in warm weather.

Mist eliminator spray results

- Process liquor ended up being the preferred fluid in the mist eliminators for more than one reasons.
- The chloride presence in process liquor allows materials to be in solution. This kept mist eliminators very clean.
- The buffered nature of this solution allowed for less acidic pH in the mist eliminators from solution of SO₂.

Mist eliminator operation



Mist eliminator operation

- Additional, strategic placement of mist eliminator trays to reduce the effects of high velocity zones has been tried. It is somewhat effective but:
 - This modification has caused issues with utilities and the EPA in the past.
 - This leads to more system pressure drop. Both from the additional trays and the harder to clean trays underneath.
 - Additional horizontal sprays to keep ME's wet was a more effective solution for us.

Mist eliminator materials

- There are a wide range of materials available for mist eliminators. Some of these materials advertise you should buy them because they stay clean.
- But are they staying clean because they are not collecting anything?
- I will not go into additional detail because it is worthy of its own presentation. I will just repeat:
 - Keep them wet
 - Keep them clean
 - Keep them repaired.

The ID fan as a particulate control device.

- If you have a true ID fan downstream of your scrubber, it actively works as a particulate control device if you have a saturated environment.
- If you let large amounts of fluid accumulate in these fans, they will toss materials out and downstream and be less effective as particulate control devices.

The ID fan as a particulate control device.

- The drains on these fans were modified to make them more effective at draining liquids. The net result was a small decrease in particulate.
- At this point in time, winning the particulate battle is a game of inches.

Outlet ductwork as a particulate control device.

- This assumes the system is saturated.
- There is a slight, split flow in large ductwork making the gas streams rub against the walls. This becomes your removal mechanism. That and having some moisture present.
- Pooling of fluid on the floor can re-entrain droplets from the floor, carrying them to the stack.
- Drains need to be clear and free flowing to prevent pooling in this duct and floors need to have a distinct drainage gradient.

The chimney as a particulate control device.

- This assumes the system is saturated.
- The same counterflow mechanism we have working in the outlet ductwork is working here.
- This assures we have droplet impact with the sides of the chimney.
- It is critical that the drains on your chimney are clean and free flowing.
- Capture efficiency here is dependent on stack velocity, and it is not linear.

The chimney as a particulate control device.

- The test subject had two units sharing a common stack. Flow out the stack drain was a constant 11 gpm with 2 units in service. When one of the two units would come offline, the stack drain flow would double to 22 gpm. A new chimney was being designed for these two units due to structural issues with the original chimney. The final chimney design incorporated a lower velocity to utilize this finding.
- Building a new chimney is not a good option for almost anyone. It does bring home the point on chimney velocity.

The chimney as a particulate control device.

- Velocity at the stack is driven by the volume of gas flowing through it. Under full load conditions, there are a few things that can have an impact on it.
 - Maintaining low excess O₂ values coming out of the boiler.
 - Maintaining air heater seals to minimize air heater leakage.
 - Minimizing external leaks into the system.

The chimney as a particulate control device.

- All “solids” going out the chimney are particulate. Even if they are dissolved solids.
- While you do get the condensation of water in the stack through adiabatic expansion, this water will not influence your final particulate number.
- Scrubber slurry droplets will influence this number. It is worth experimenting to see if there is a recovery in particulate at the Chimney, if you run the system dissolved solids level at a lower level.

How you measure particulate

- The timeline for testing can impact the final numbers.
- Have your internal environmental people look at the regulations and see where room exists to improve this number through changing the testing process.

We're here to help.

- Loss of experienced plant personnel and system knowledge combined with the sudden pushing out of shutdown timelines in coal facilities has created a knowledge gap. Like many others, West Peak is here to help. Make sure to pull in these knowledge pools, both inside and outside your company.

Questions?

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