Particulate Control for Industrial Applications

By David G. Sloat & Paul S. Farber

Sargent & Lundy LLC

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Agenda

- **Brief of Potential Regulations**
  - Industrial MACT & compliance methods
  - Others (INSPS, NAAQS, NSR, etc…)
- **Typical PM Control Devices on Industrial Boilers**
  - Multi-clones
  - ESPs
  - Baghouses
  - Wet Absorber FGD
  - Spray Dryer FGD
- **Potential Upgrades to PM Control**
  - ESP Upgrades
  - Baghouse Retrofits with injection technology (DSI or ACI)
  - Wet and Dry FGD
  - Wet ESPs
- **Summary**

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The new Industrial MACT requirements

- 2005 Industrial MACT is currently vacated, reissue in 1-2 months
- Particulate Matter or Total Selected Metals
  - PM ≤ 0.07 lb/mmBtu or TSM ≤ 0.001 lb/mmBtu, meet either for compliance
  - PM can be used as a surrogate for TSM compliance
  - New limit could be more restrictive (*0.015 lb/mmBtu to 0.030 lb/mmBtu*)
- Hydrogen Chloride
  - HCl ≤ 0.09 lb/mmBtu
  - New limit could be more restrictive (*0.02 lb/mmBtu to 0.05 lb/mmBtu*)
- Mercury
  - Hg total ≤ 9 lb/TBtu
  - New limit could be more restrictive (*2 lb/TBtu to 3 lb/TBtu*)

Total Selected Metals include eight metals

- Typically fine particles that have condensed on the surface of a larger particle
- Order of magnitude of 1/100th mass concentration of PM
- Include non-mercury metals
  - Arsenic, Beryllium, Cadmium, Chromium, Lead, Manganese, Nickel, and Selenium
- Selenium is getting attention if it gets into wastewater
- TSM are collect with PM collection equipment

To collect PM and TSM you need very high efficiency devices

- In general, ESPs, baghouses, and wet ESP are likely needed to comply with newer more restrictive PM and TSM values

Hydrogen Chloride (HCl) is captured with wet scrubbing or dry injection

- Wet Spray Tower Absorbers FGD
  - Condenses and absorbs HCl, then it can be reacted with an alkali to form a chloride salt
  - Very effective with about 95% capture
  - Can build up in recycle slurry and be corrosive to absorber materials
  - Disposed of as a blowdown from the FGD system and some with the solid FGD waste
- Spray Dryers (or Circulating Dry Scrubber) FGD with Baghouses
  - Absorb HCl then it can be reacted with an alkali to form a chloride salt
  - Very effective with about 95% capture
  - Disposed of as part of the dry solid waste product
- Duct injection
  - Dry trona, dry hydrated lime, solution of sodium bi carbonate
  - 30% to 90% with high stoichiometry
  - More removal if humidification is used ahead of injection
  - Disposed of as part of the fly ash

Mercury is in flue gas in three species

- PM mercury is small percentage, often ≤ 10%
  - Collectable in most PM collectors
- Elemental mercury
  - Hg^{o}
  - Most difficult to collect
  - Powdered Activated Carbon (PAC) can collect at high efficiency 90% in correct conditions (T<400oF and/or SO3 ≤5 ppm)
- Oxidized mercury (also called ionic)
  - Hg^{+2}
  - Moderately difficult to collect
  - Can be collected in baghouse dust cake at 10% to 60%
  - With PAC at 90%
  - Can be collected in wet absorber at ≈90%, but only ionic

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Many existing PM control devices are not able to meet MACT, (blue cells show where a device may comply)

PM Device	Removal Efficiency		
	PM	HCl	Hg
Multi-clone	75% - 85%	none	minimal
ESP	90% - 99.5%	none	≤ 10%
Baghouse	99.50%	minimal	10% - 60%
Wet Venturi Absorber	65%-85%	moderate	minimal
Wet Spray Tower	minimal	≈ 95%	≈ 90% of ionic
Spray Dry FGD + BH	99.80%	≈ 95%	20% - 70%
Wet ESP	99.50%	minimal	≈ 90% of ionic

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Existing PM devices can be upgraded or replaced to meet MACT (green cells indicate upgrades possible)

PM Device	Removal Efficiency		
	PM	HCl	Hg
Multi-clone	75% - 85%	none	minimal
ESP	90% - 99.5%	none	≤ 10%
Baghouse	99.8%	minimal	10% - 60%
Wet Venturi Absorber	65%-85%	moderate	minimal
Wet Spray Tower	99.8% +	≈ 95%	≈ 90% of ionic
Spray Dry FGD + BH	99.8%	≈ 95%	20% to 70%
Wet ESP	99.50%	minimal	≈ 90% of ionic

Improved PM capture in an Electrostatic Precipitators

ESP Upgrades options

- Improve gas flow distribution
- Reduce air in-leakage
- Add modern TR set controls
- Add high frequency TR sets
- Gas conditioning (SO_3 or NH_3)
- Rebuild ESP internals
- Add taller ESP electrodes
- Add a field on end of ESP

ESP Replacements options

- New larger electrode area ESP
- New baghouse to collect al the PM

Helper equipment

- Slip Stream baghouse to treat partial flow and continue using the ESP
- New Polishing baghouse to collect last 5% - 10% of PM
- New polishing Wet ESP

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To capture HCl, some upgrades are possible

- Dry sorbent injection ahead of the ESP can collect 30% to 50%
- Dry sorbent injection ahead of the baghouse can collect 60% to 90%
- Usually wet or dry FGD is needed

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To capture Hg, some upgrades are possible

- PAC injection ahead of an ESP can get 30% to 60%
- PAC injection ahead of an baghouse can get ≈90% if $SO_3 \leq 5$ ppm
- PAC injection and DSI ahead of an baghouse can get ≈90% if $SO_3 \geq 5$ ppm
- Fuel additives ahead of a wet spray tower will oxidize more Hg
  - Halogens (Cl & Bromine) can help convert elemental Hg to Ionic Hg
  - Add to fuel and let elemental convert to ionic in boiler

- PAC injection ahead of an ESP/Baghouse ahead of wet spray tower gives excellent removal
- PAC injection ahead of dry FGD gives excellent removal

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- ESPs can be -
  - Upgraded for improved PM capture
  - Retrofit with trona or lime injection for improve HCl capture
  - Retrofit with PAC injection for improve Hg capture
- Baghouses can be -
  - Upgraded with better bags for improved PM capture
  - Retrofit with Trona or lime injection for improve HCl capture
  - Retrofit with spray dryer technology for improve HCl capture
  - Retrofit with PAC injection for improve Hg capture
- Multi-clones are not easily upgraded
- Wet scrubbers are not easily upgraded
- Wet ESPs are not easily upgraded

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David G. Sloat

312-269-2784

david.g.sloat@sargentlundy.com

Paul S. Farber
312-269-2261
paul.s.farber@sargentlundy.com