REINHOLD ENVIRONMENTAL Ltd.

2016 APC-Wastewater Round Table & Expo Presentation

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MATS Compliance Achieved

Now It's Time to Optimize Your System

"OPTIMIZATION OF ALL APC SYSTEMS AS PART OF AN OVERALL COMPLIANCE STRATEGY. "

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This presentation will cover the compliance needs and options required in the optimization of both fabric filters (primarily "TOXECON™" polishing type FF Systems), Dry Sorbent Injection systems (DSI and ACI) and ESP systems with the ultimate goal of achieving MATS compliance with the lowest O&M costs. Cost savings may include; Sorbent costs (activated carbon and hydrated lime), Baghouse Pressure Drops, ESP operation and ultimately filter bag life.

An overview of industry experiences well as recent experience by Southern Company on their newly commissions fleet of TOXECON™ pulse jet fabric filters and sorbent injection systems will be discussed.

Baghouse System Optimization

- Conventional (Stand alone) and TOXECON type baghouse systems, regardless of cleaning technology type, can benefit from being optimized to maximized system performance, especially when combined with ACI or DSI systems

- Areas of Fabric Filter optimization may include:
  - Cleaning frequencies (Pressure Drop Initiation vs. timer set point)
  - Pulse pressures (How much cleaning force is required?)
  - For Reverse Gas Collector Designs
    - Fan sizing
    - Bag Tension
    - Acoustic horn usage and design
  - **Proper Flow Distribution** to both compartments and filter bags
  - PM Emissions and Pressure Drops
  - Bag life
  - ACI injection rates/carbon types

- Hg Emissions and ACI injection rates Optimization

Sonic Horn Placement

What can you adjust to improve operation?

- **Cleaning frequencies** – Are you over cleaning or under cleaning the bags.
- **Pulse pressures** (How much cleaning force is required?) *The initial cleaning pressure likely lower than the ultimate pulse pressure in order to protect the precoat material and develop a proper filter cake*
- For Reverse Gas Collector Designs, Acoustic horn usage, number of horns and frequency, RG Fan Operation
- **System Pressure Drops –** Do you want to keep DP at a reduced level or increase the filter cake losses to maintain higher levels of PAC in the ash cake? Not a standard answer.
- **Proper Flow Distribution** to both compartments and filter bags
- **PM Emissions** (bag conditions, cleaning frequencies, ash loadings and cleaning intensity can impact PM emissions)
- **Mercury Emissions vs ACI rates and carbons** (Potential use of Hg CEMS to provide feed forward/feed back control loop to provide only PAC levels needed vs. Hg emissions.
- **Bag life** – This ultimately is the result of many factors, including system operation, flue gas temperatures, coal types, pre-coat of bags, etc. Over temperature operation and/or sub-dew point operation can impact both bag life and pressure drops

APC System Optimization

- Hg Emissions and ACI Injection Rate Optimization
  - Use of mercury CEMS downstream of both fabric filters and ESP's as well
  - Improves control of injection rates vs actual Hg emissions leaving PM Control device.
  - More accurate than utilizing wet stack Hg emission measurements which could be caused by WFGD Hg re-emission issues
  - Helpful when fuel and Flue gas temperature variations are common occurrence at the plant and/or load swings
  - Improvement over just a feed forward control such as boiler load or flow rates by adding the more accurate feed back loop. (Feed forward/Feed Back control)

Sonic Horn Placement

Fabric Filter Optimization for HG control and Improvements

EXAMPLES OF TWO CASE STUDIES SHOWING HG CAPTURE IMPROVEMENT DUE TO HIGH OPERATING TEMPERATURES OR LONG TIME PERIODS BETWEEN CLEANING CYCLES.

Case Study 1– Mid-West Utility (PRB Coal)

- Baghouse was downstream of ESP (TOXECON) & originally sized for future CDS Scrubber
- Very low air-to-cloth ratios (~ 2 FPM) and long times between cleaning of the bags due to low FF pressure drops
- Carbon sat on the bags for extended time periods and was highly saturated with Hg
- When flue gas temperatures increased above 370F, Hg was released from carbon, requiring higher feed rates to maintain required HG levels

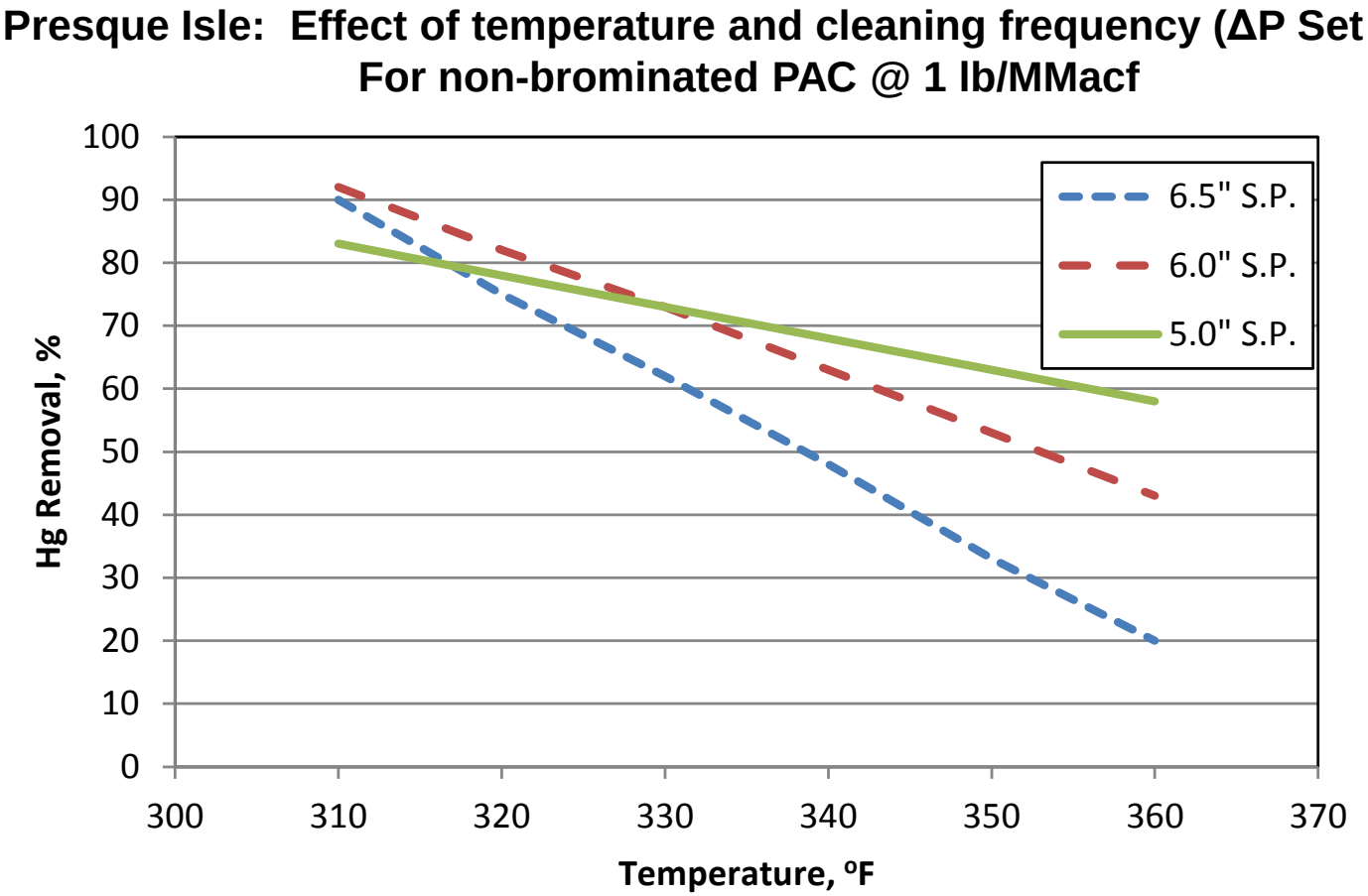
Solution

Isolated FF compartments to force A/C ratio higher and cleaning cycles to increase, resulting in a thinner filter cake with fresh PAC present.

- More frequent cleaning by inserting shorter timer override of reducing DP trigger point are also potential adjustments

FF was able to maintain required mercury emissions with significantly lower PAC injection rates

Case Study 2: Impact of Higher Operating Temperatures (PRB-fired Boiler with PAC Injection)



Source: Final Report, DOE Cooperative Agreement No. DE-FC26-04NT41766

Proper Baghouse Flow Distribution is critical for enhanced baghouse performance

Flow Distribution Continued:

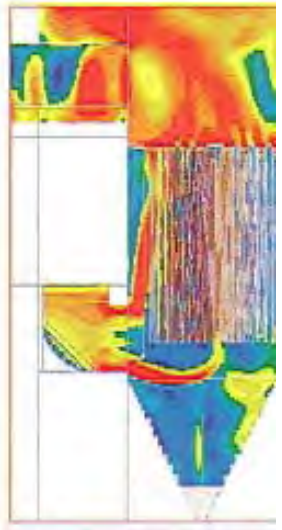
Proper FF designs require good flow and inlet particulate distribution for optimum performance along both the length of baghouse (comp.-to-comp.)as well as within each compartment

Improper flow distribution can impact many areas including:

- Pressure Drops
- Particulate Emission Levels
- Bag Life
- Effective and Optimized Mercury Capture

Model Studies Are Critical

- Whether you utilize a physical flow or CFD model, it is important that good flow characteristics are designed into the system
- This is especially critical with existing mercury MATS rules which require ~90% mercury capture (1.2 lb/Tbtu)
- Uniform flows are required between baghouse casings (When multiple casings/boiler are used), individual compartments and filter bags
- High velocity zones can result in failed bags within the compartments. Many times the same bags will repeatedly fail



Uniform Injection of Activated Carbon

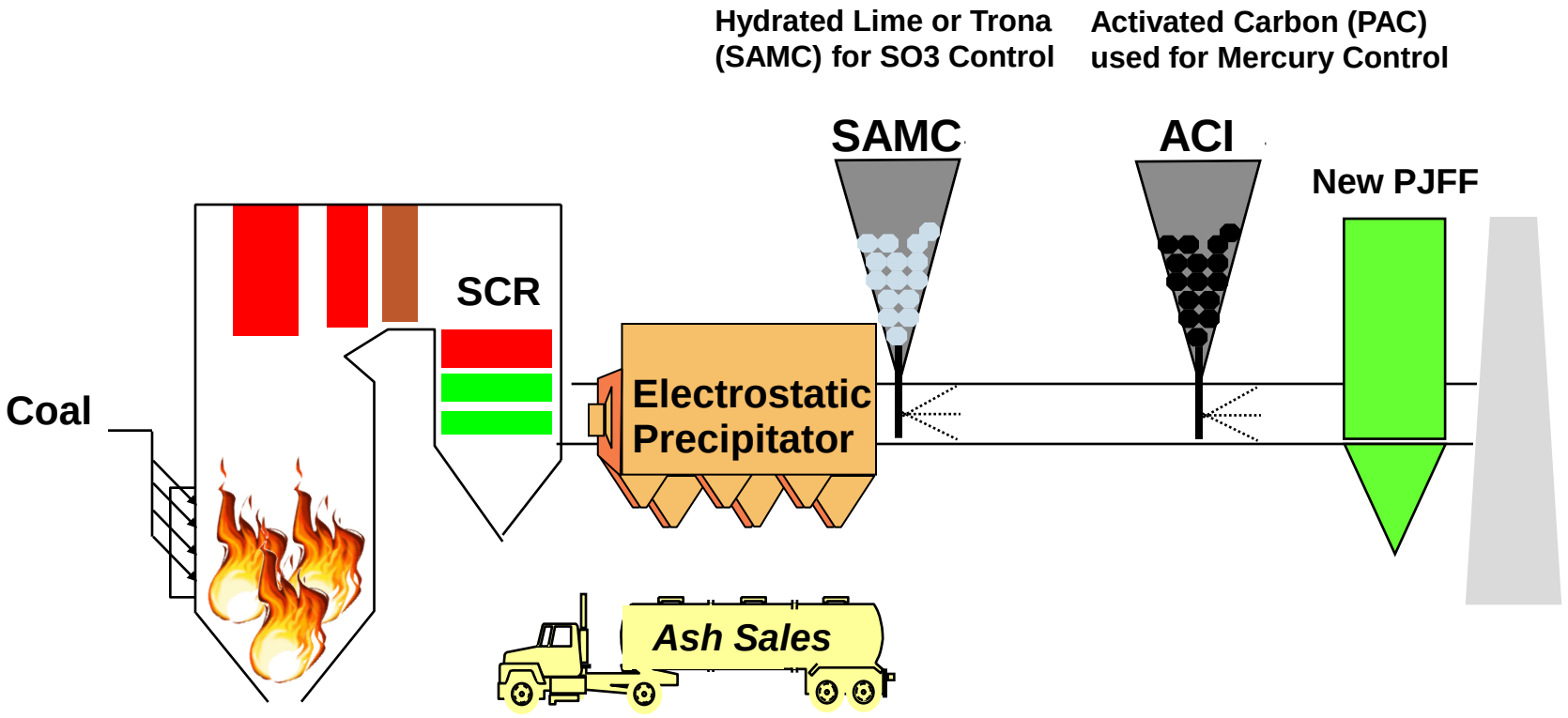
- Activated carbon needs to reach all the bags in every compartment in the baghouse and not just a few compartments to optimize performance
- Performance can be enhanced when all the compartments received similar quantities of PAC (Greater Surface Area For Hg Capture)
- Best to model particle tracking as well as flows from both lances and in ductwork to ensure carbon reaches all the compartments

TOXECON™ Type Pulse Jet FF Systems

TOXECON or polishing type pulse jet fabric filters have many similarities to conventional stand-alone fabric filters, as well as many unique design issues and challenges. These include:

- >30% Higher filtration rates (5.5-6.0:1 vs. 3.5-4.0 cfm/sq.ft of cloth)
- Greater sensitivity to ash loadings, process changes and inlet ash particle size distribution
- ESP influence on filter cake density/permeability and ash cake particle size distribution
- Greater potential for PAC/ash smoldering in casing hoppers
  - Do not store ash in hoppers if at all possible
  - Keep hopper heater usage to a minimum and maintain heater temperatures at a tight heat band to avoid high temperature excursions
  - Potentially optimize ash/carbon ratios to reduce overall ash LOI's vs. straight PAC/ash loadings.

TOXECON™ Used In a Multi-Pollutant Control MATS Configuration



ACI and DSI System Operation

- Many plants have initially placed ACI and DSI injection rates at design or guarantee levels in order to meet MATS needs
- These injection rates, while high enough to achieve desired results, likely can be reduced to lower levels and still achieve MATS.
  - Benefits can be reduced operating costs due to reduction in sorbent injection rates while still achieving required Hg emissions
  - Reduction in filter cake pressure drops and/or required cleaning frequencies, PM emissions and potentially bag life.
  - When utilizing dry sorbent such as hydrated lime for SO3 control, there can be a cost benefit to modify injection rates vs SO3 emissions at PAC injection location depending upon types of carbons being utilized. (cost considerations on types of sorbents, cost/lb, injection rates)

  Example might be as lime injection rates go up, ACI rates might be abele to reduce and visa versa.

Benefits of Optimizing ESP Operation

There can be many benefits to the owner with an in-series (TOXECON) ESP/baghouse installation when looking at optimizing or de-tuning your ESP performance. These may include:

- Power level savings
- Increase in particle size distribution to the baghouse
- Modification to filter cake porosity
- Reduction in tube sheet pressure drops
- Reduced blinding of filter bags and resulting increase in bag life

Now lets look at how particle size changes can impact pressure drops

Fabric Filter Predictive Equation

$$\Delta P = P_R + K_2 V^2 C t$$

ΔP = total pressure drop, kPa

ΔP_R = residual pressure drop, kPa

K_2 = specific resistance coefficient of freshly deposited dust, (kPa - cm sec/g)

V = Air-to-cloth ratio (cm/sec) (Fixed Value)

C = dust loading g/cm^3

t = time between bag cleaning in sec. (Adjustable variable)

K_2 - Specific Dust Resistance Coefficient

Function of fly ash characteristics such as:

- Particle size distribution (PAC and ESP outlet ash distribution can impact size distribution)
- Density of ash cake
- Morphology (shape) of ash particles
- Cohesivity (HS coals typically product a more cohesive filter cake)

Some of these factors can be changed by selection in alkaline sorbents, activated carbons and size distributions (Some of the modern carbons can be very fine in nature) and by ESP de-tuning efforts.

ESP Modification Experience

- ESP performance modification or de-tuning has been successfully utilized on TOXECON fabric filter installations in the past
- Results have been ability to reduce filter cake pressure drops due to larger particle size distribution of ash leaving the ESP, thus resulting in more porous filter cake on bags
- Lower pressure can result in less demand for cleaning of the bags and help with:
  - Reduced emission levels
  - Potentially longer bag life

Southern Company Experience

- Scherer Lessons learned
  - Mercury re-emissions
  - ESP detuning
  - Ash Handling
- Southern Company has been conducting significant de-tuning efforts and experiments over the past few months in an effort to improve overall TOXECON pulse jet FF operation
- Test results showing impact on TOXECON inlet ash loadings, particle size distribution and on filter cake pressure drops will be presented by Gerry Klemm of Southern Company on Tuesday's sessions.

Workshop 15 (RegencyA-B)

Detuning Upstream ESPs for MATS Baghouse Operation *by Gerry Klemm, Southern Company*

We trust that you will gain significant insight into the tools you have available to you for system optimization.

Mercury Control Experience

- Wet stack mercury does not necessarily correlate to ESP or Baghouse mercury control performance
- PAC feed rate can be trimmed using ESP or Baghouse outlet CEMS
- Baghouse Mercury Re-emissions

Cleaning System Design

- Sectionalization – 2 headers per compartment
- Non adjacent pulse valve/ pipe sequencing
- All compartments cleaned simultaneously
- Air Supply capable of pulsing each bag 6 times per hour if necessary

Cleaning System Optimization

Optimize PAC gas contact time while maintaining appropriate dust cake thickness

- Lower pulse cleaning pressure
- Increase cleaning frequencies as process gas temperatures rise (especially above 325 F)

Southern Company's, GA Power Bowen Station Pilot PJFF Provides Ability to Test Various Operating Criteria and Ideas To Confirm Full-Scale Operating Issues and Explore Remedies

Conclusions

- There are many ways to optimize performance of your fabric filters and overall emission control trains. These can include:
  - Optimization of ACI and DSI injection rates needed to achieve MATS compliance levels
  - Optimizing baghouse cleaning demand and performance in coordination with sorbent injection rates
  - De-tuning of ESP power levels and resulting ash loadings and outlet ash particle size distribution
- Some or all of these modifications or changes can have a beneficial impact on overall system performance and O&M costs.
- Higher operating temperatures may require more creative FF cleaning frequencies to produce a thinner, more carbon rich filter cake to achieve higher Hg reduction levels
- Additionally, optimization of FF operation and PAC injection at shutdown and startup may help to reduce or eliminate Hg breakthrough.

Optimization Program Summary

- Optimization programs can also benefit overall baghouse and ESP operation, PM emissions and bag life
- Implementation of feed forward/feed back controls tied to Baghouse and ESP outlet Hg CEMS (when available) for trim control has been demonstrated as a means to reduce PAC consumption to achieve required Hg control levels at optimized PAC injection rates.

If you have any specific needs and/or questions, please let us know.

Thankyou

Questions?