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On the Doorstep of MATS Compliance: Status and Options

McIlvaine Hot Topic Hour
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Mercury Measurement and Control

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MATS Mercury Compliance Planning

- A recent Institute of Clean Air Companies survey confirmed 181 GW of Hg control installations
  - This includes only ICAC members and not all members responded
  - Represents about 60% of coal-fired plants; potentially about 70% of those that will be operating post-MATS (assume 50-70 GW retirements)
- Technologies reported are
  - Activated Carbon Injection (ACI) 310 units; 137 GW
  - Wet Flue Gas Desulfurization additives 67 units; 32 GW
  - Upstream oxidation additives 61 units; 30 GW (combined w/ACI 12 units; w/WFGD 31 units)
  - Non-carbon sorbents 3 units; 1.6 GW

Genesis of Activated Carbon Injection (ACI) in Flue Gases

1990s

- Technology transfer of ACI from Municipal Solid Waste over to Coal Firing, but capture conditions different and mercury concentrations much lower from coal
- Major issues with measurement of Hg at these low levels in actual flue gas matrix

Early 2000s

- Significant field studies at coal plants of same PACs used for water treatment and MSW plants
- Introduction of halogen-treated activated carbons
- Measurement improvements and options expanded
- Issues such as ash disposal identified & studied

Today

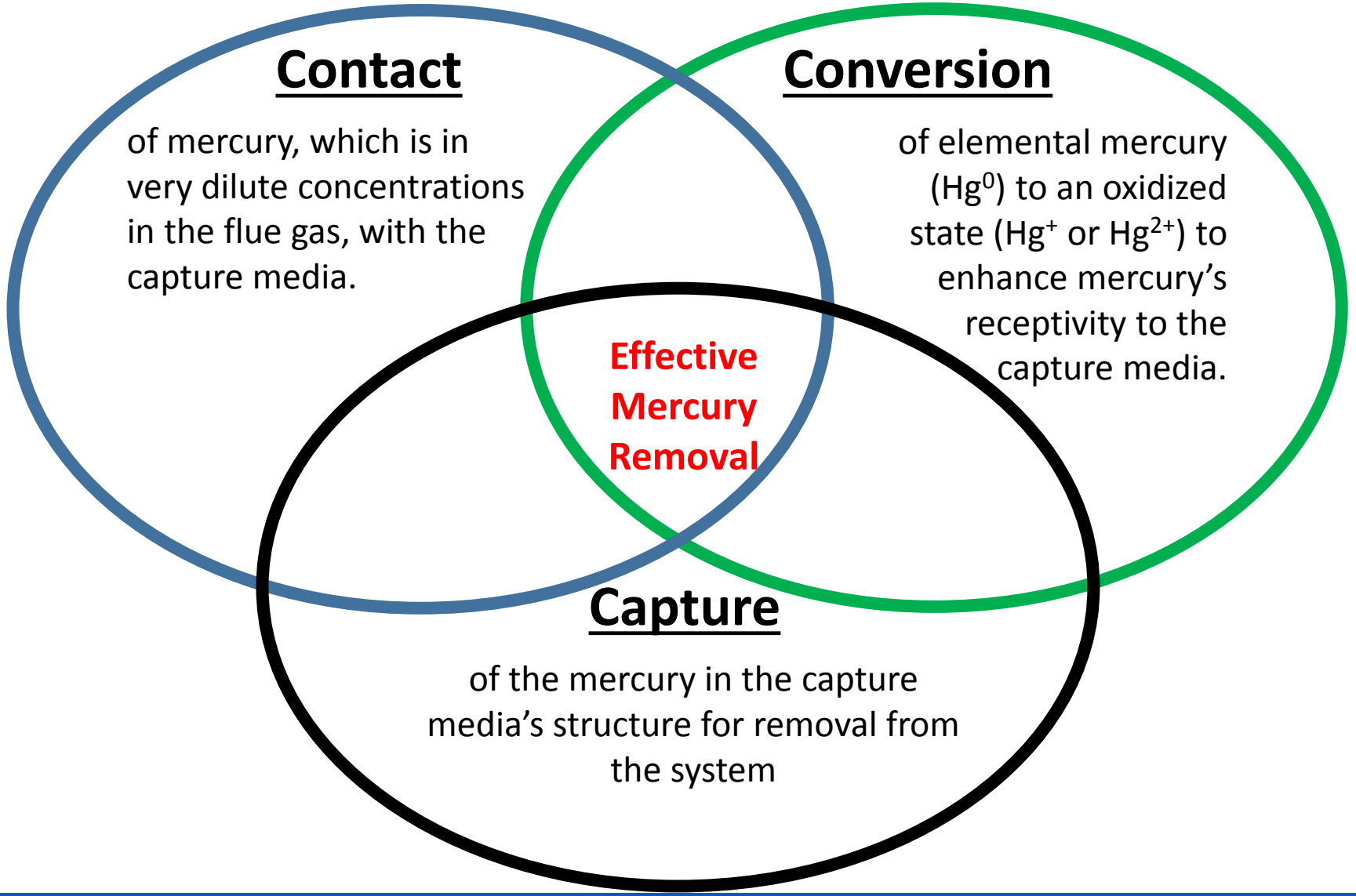
- PAC manufacturers focused attention on serving the coal-fired EGU market
- Identification of critical drivers for mercury capture
- Focused product development for niche applications
- Measurements still challenging and expensive

Ongoing Development

- Meaningful quality criteria that correlate with mercury capture performance
- Rapid innovation targeting specific application challenges
- Solutions tailored for specific circumstances to achieve optimal compliance solutions

- Coal-fired mercury control studied by EPRI, EPA, DOE and others since 1990
- Activated Carbon Injection commercial in coal-fired power plants since 2007
- As of end of 2014, there were at least 135 GW (>300 units) of ACI on coal (ICAC)

Fundamental Requirements for Measuring PAC Hg Removal Performance



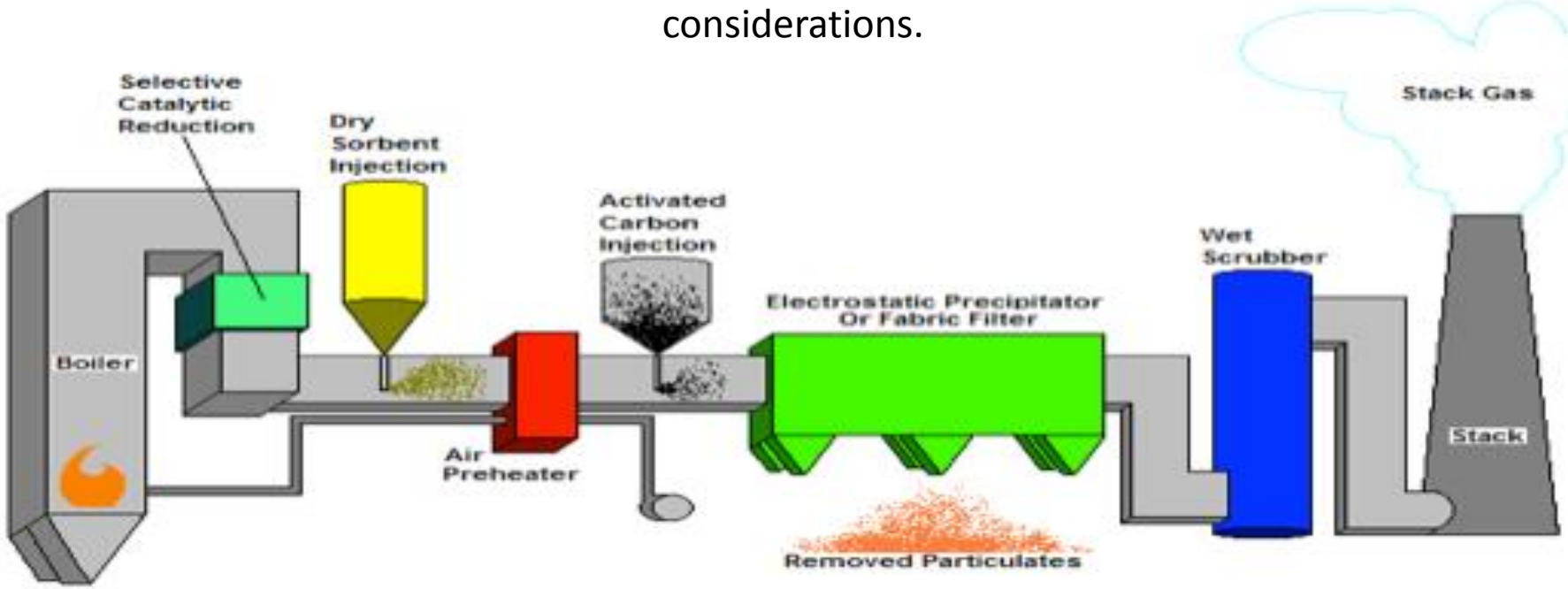
Achieving All Mercury Capture Mechanisms for Hg Control

		Predominant Mercury Capture Mechanisms		
		Conversion to Oxidized Mercury	Contact with Capture Media	Capture & Removal
Emission Treatment	Pre- & Post Combustion Oxidation	Effective		
	Fly Ash / LOI		Effective	Effective or unstable?
	Selective Catalytic Reduction	Effective		
	Activated Carbon Injection	Effective	Effective	Effective
	Wet Scrubber		Effective	Effective or Re-emissions?

- Technology treatments that do not fulfill all three mechanisms require supplemental process steps.
- Avoiding unintended consequences or negative Balance of Plant (BOP) impacts for each option are also keys to success.

Integrating the APC System to Maximize Native and Co-benefit Hg Capture

Technology solutions need to be cost effective for Hg control and favorable to balance-of-plant considerations.



Coal Pretreatment | Combustion Oxidation | Dry Sorbent Injection | **Sorbent Injection** | Wet Scrubber Additives | Post Scrubber Treatments

- Integrate technology options and actively manage mercury control.
- Maximize native capture of mercury.

Advanced View of PAC Properties

Activated Carbon Properties

- Surface area
- Pore Volume
- Moisture
- Bulk Density
- Particle Size
- Extractable pH
- Ignition Temperature
- Total Sulphur
- Halogen Content

Applications Performance "Surrogate Tests"

- Iodine Number
- Molasses Number
- Decolorizing Index
- Bromophenol Blue Capacity
- Butane Activity

Applications Performance "Static Tests"

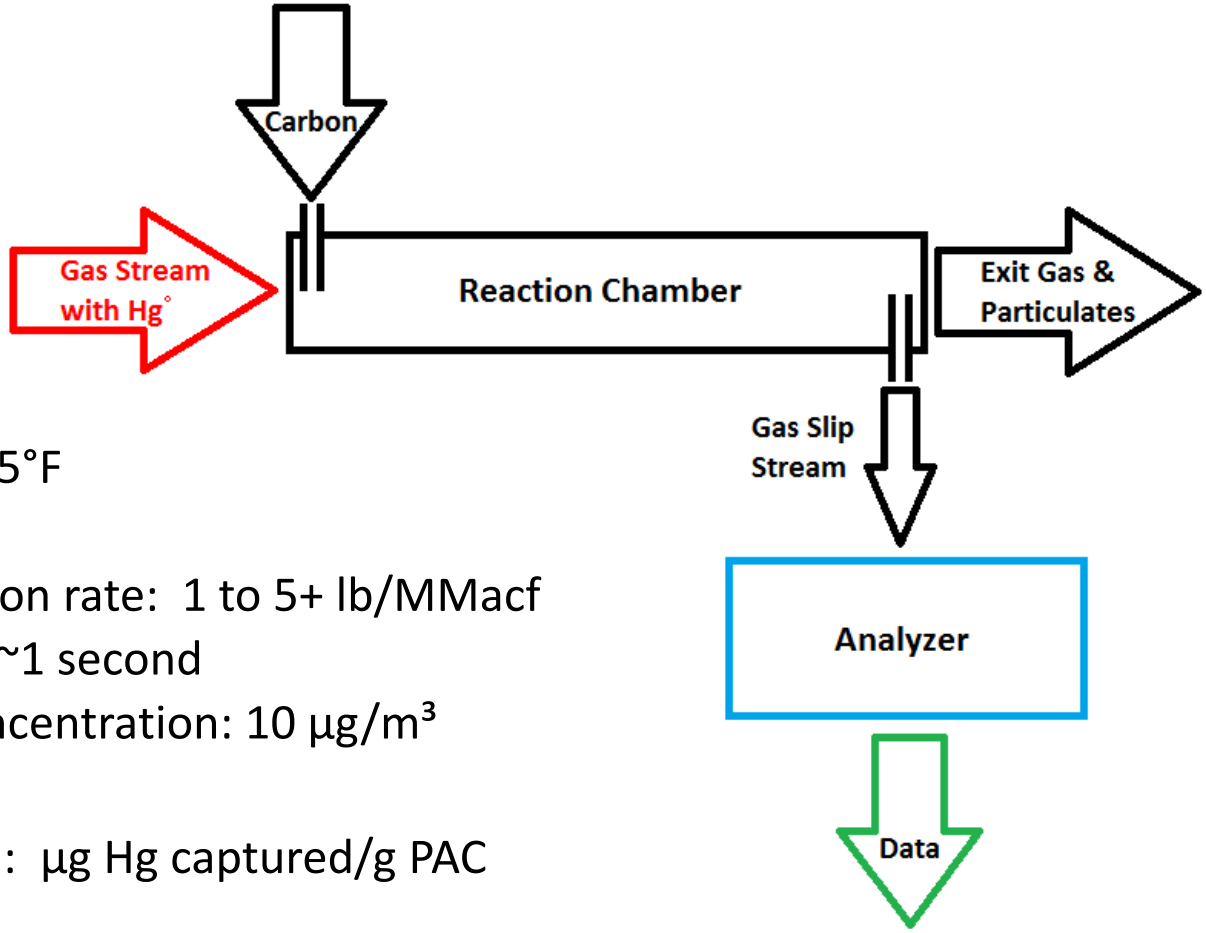
- Packed Bed Hg Breakthrough

Applications Performance "Dynamic Test"

Dynamic Mercury Index

- Allows for dynamic interaction of Hg and Carbon
- Simulates ESP capture curves
- Allows for rapid product prototyping
- Correlates with field data and verifies performance full scale

New Dynamic Mercury Test - Overview



Inputs

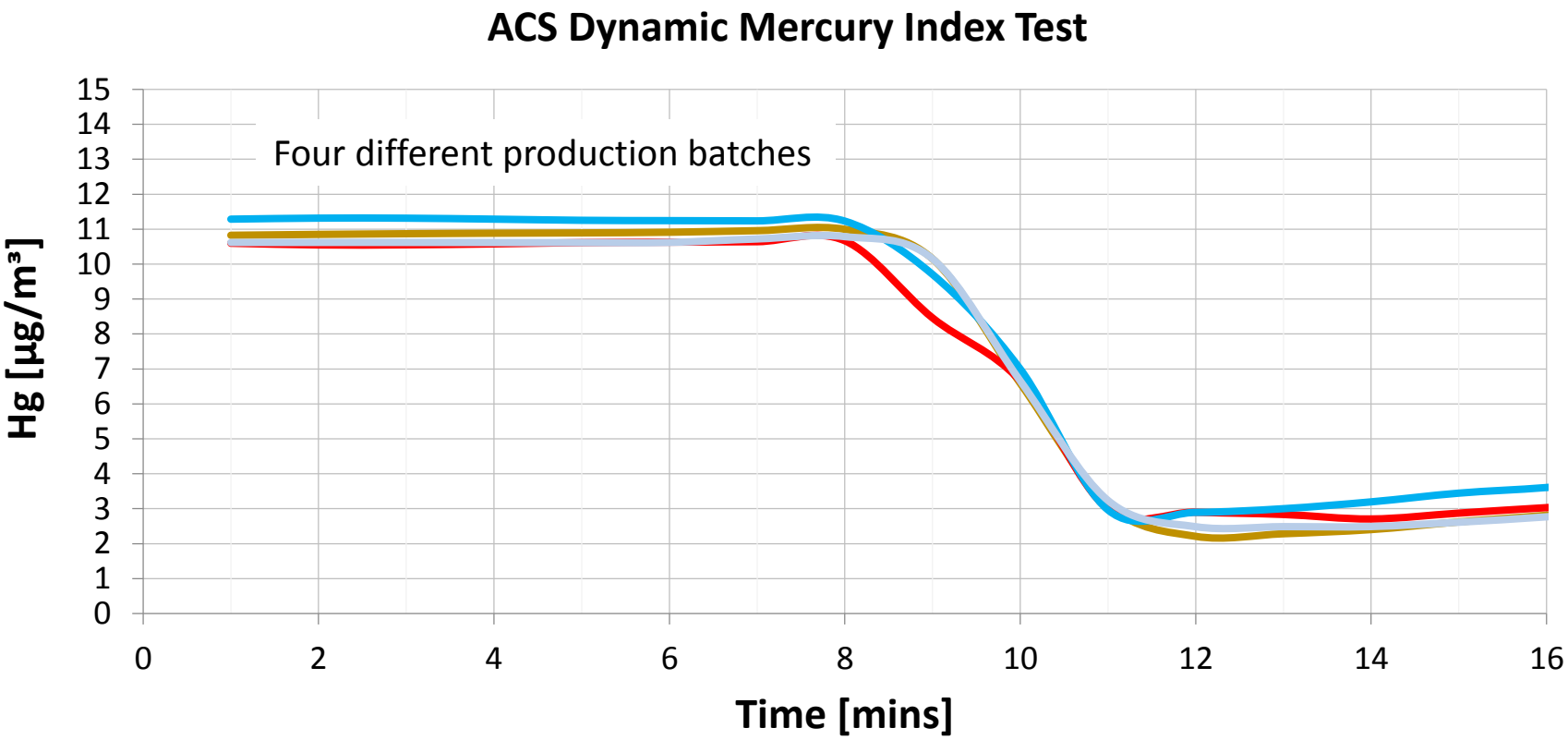
- Temperature: 325°F
- Gas: Air
- Target PAC injection rate: 1 to 5+ lb/MMacf
- Residence time: ~1 second
- Mercury inlet concentration: 10 µg/m³

Outputs

- Hg Concentration: µg Hg captured/g PAC
- Hg Speciation

The Dynamic Mercury Test supports the rapid development and testing of new products.

Dynamic Mercury Index Test: Ensuring PAC Quality & Consistency



We track our production Batch-to-Batch consistency with our lab Dynamic Mercury Test.

Dynamic Mercury Index Test Summary

- Provides significant advantages over traditional surrogate tests by utilizing direct application of activated carbon and Hg° in a dynamic environment
- Yields reproducible results that facilitate rapid prototyping of new products
- Supports a reliable product line through quality control and consistency based on a dynamic platform
- Facilitates a mechanistic approach to product development through contact, conversion and capture
- Supports full scale applications for compliance

Summary - Guiding Principles for Hg Control

- Insure that fundamental capture mechanisms of Conversion-Contact-Capture are completed as effectively as possible and ideally all at once
- Adopt true “engineering” or “active” control methods
- Take advantage of co-benefit capture from existing Air Pollution Control (APC) operation, but be careful not to sub-optimize their primary function
- Considering capturing & removing Hg early in your APC system to minimize the complexities of operating in multi-phase and complex chemistry regimes
- Always consider balance of plant (BOP) issues... Avoiding corrosion, excess bromine in water, scrubber re-emissions, Hg in water streams, Hg in solid wastes, impact on other contaminants, need for added chemicals, etc.
- Take advantage of new advanced Gen 2+ PACs that provide more cost-effective compliance in specialized APC system requirements
- Testing is the only way to know for sure what your plant will do when compliance levels are tight

The Good News…

PAC has been safely handled at industrial sites for decades in water treatment and in the past 20 years for flue gas injection.

To many utilities however, it is a new material. It is distinct from coal because our manufacturing process drives off volatiles and moisture, making it less susceptible to fire and explosion risk than pulverized coal. With knowledge of the proper handling it can continue to be a safe part of the industrial work environment.

Some startup guidelines are connected to material handling safety. Education on the MSDS of the material, PPE required, housekeeping/cleanup, and measurements available is recommended. For more details on safe PAC handling, refer to our handouts, product information, and technical experts.

Case Study Site – Lessons Learned

- Limit flex hose bends in the injection manifold design
- Under some circumstances bromine can lead to corrosion (interior coatings for silos can prevent or mitigate)
- Include VSDs
- Include hard piping from feeder to silo shell (instead of flex hose)
- Toxecon Baghouse related procedures

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Case Study Fleet – Lessons Learned

- Align Injection Manifold/ Lances during operation
- Initial silo fill of one truckload to identify leaks or other construction defects
  - PAC flows readily and is low in density
  - All connections, doors, and flanges must be sealed
- Add water line to the exterior top of the silo for cleaning
- Lances can plug when not in operation – clear lances
- High carbon injection rates may require additional weigh hopper venting
- Additional fluidization capability in the silo can improve flow

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Site Manifold Redesign

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Summary

- Significant implementation activities are going on currently, whether for April 2015 or April 2016
- Keep the focus on a strategy that works, good quality products, and learning from others
- Utilities are still adapting plans to the new Nov 2014 Startup/Shutdown final rule
- Resources are available to help – contact us
  - Startup
  - Quality control
  - Troubleshooting
- ICAC Mercury Control Division recently published a white paper entitled “Process Implementation Guidance for Powdered Sorbents at Electric Generating Units.” It should be available on the web shortly: www.icac.com or contact me for it.

Questions

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