

REINHOLD ENVIRONMENTAL Ltd.



**2015 APC Round Table  
& Expo Presentation**

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# Startup under MATS - Implementation Lessons Learned

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Sheila Glesmann, Joe Wong, Robert Huston  
ADA Carbon Solutions

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Reinhold APC Conference – Atlanta, GA  
July 13, 2015

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# MATS Start-up & Shutdown Rule

# Rule Finalized November 2014

- Finalizes the startup and shutdown requirements in February 2012 rule (Option 1 in the final rule).
- Provides alternative work practice standard as an option for startup (Option 2 in the final rule).
- For a given EGU, emissions data that is identified as being within a startup period or a shutdown period will not be included in the compliance average. Some considerations:
  - Each pollutant is subject to a 30-day or 90-day averaging period for emissions,
  - EPA's analysis of the best-performing 12% of the units from existing data, and
  - EPA's belief that sources can over-control to make up for periods when the hourly rate exceeds the compliance-level rolling average. Theoretically, when unit stability is not achieved within the defined startup period, emissions could be averaged out over the full 30 or 90 *boiler operating days*.
  - "Boiler operating day for units constructed, reconstructed, or modified before February 29, 2005, means a 24-hour period during which fossil fuel is combusted in a steam-generating unit for the entire 24 hours." (other conditions apply for newer units)

- Requires MATS compliance except when in periods of startup / shutdown
  - EPA questions the ability to measure HAPs at the start of electrical generation, but wants to gather data during startup and shutdown to assist with determining any changes for the eight-year residual risk review of the standards.
  - Monitoring, recordkeeping and reporting still required.
- Mercury measurement alternatives during s/s
  1. Use CEMS at all times.
  2. Use two separate sorbent trap systems and switch at startup/shutdown.
  3. Use a single sorbent trap system and include startup and shutdown periods in compliance averaging period (30-day or 90-day).
- Diluent Cap calculations apply during s/s
- There are extensive reporting requirements for each startup and shutdown detailing startup fuels, time, and equipment performance.

- EPA allows the operator to select one of two methods of determining compliance during startup periods, Option 1 or Option 2. Both options include the following:
  - CMS must be active for any period of fuel firing. Data collection and calculations such as the pollutant emission rate for each hour of startup are required. Recordkeeping and reporting requirements are fairly extensive, as provided in §63.10032 and §63.10021(h).
    - For common stacks: When electrical load of a contributing unit is zero, use 5% of maximum electrical load as the default value in calculations of emission rates. As soon as the load is non-zero, the indicated value must be used.
  - The startup period begins with the first firing of fuel in the boiler for any purpose. The exception is if the boiler has not operated previously, in which case startup begins with first-ever firing of fuel for the purpose of generating electricity or *useful thermal energy*\*.

\*EPA's language is: "useful thermal energy (such as heat or steam) for industrial, commercial, heating, or cooling purposes".

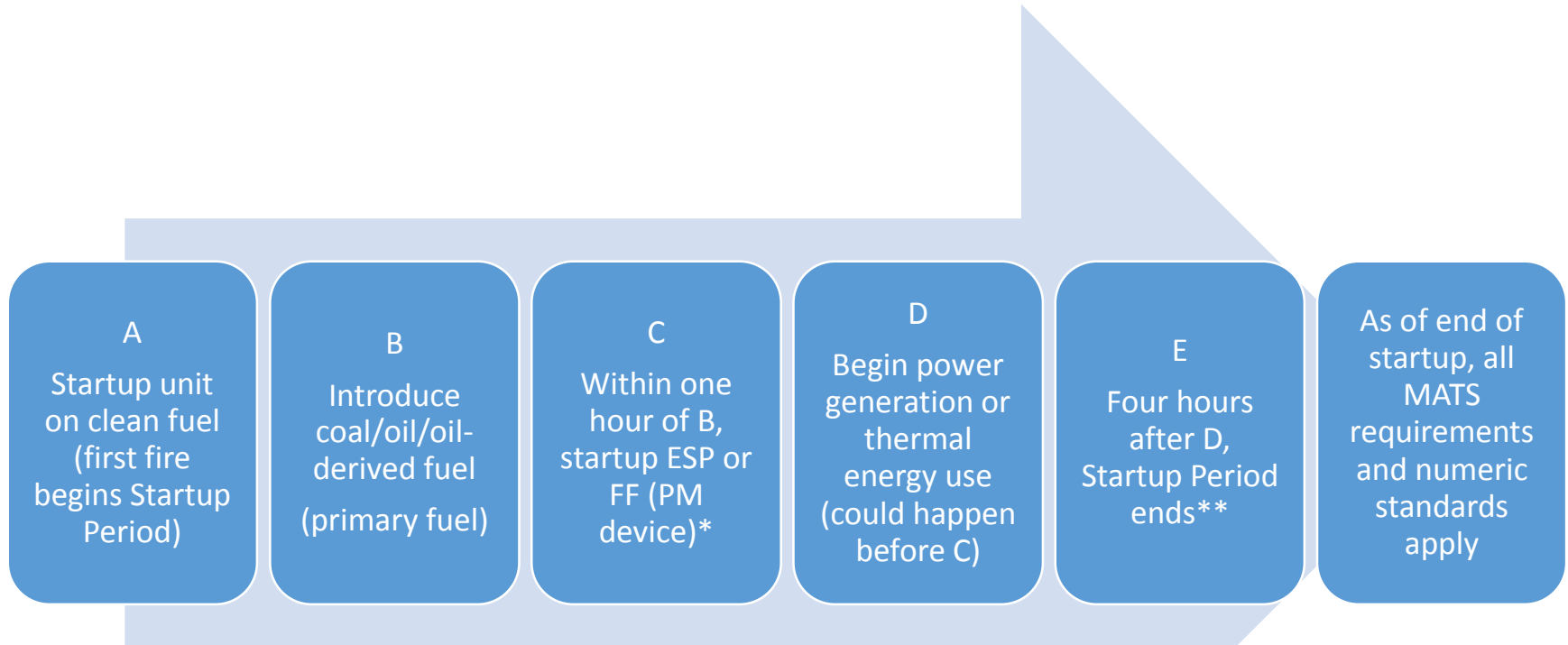
- Two types of fuels are identified: the startup or auxiliary fuel (e.g., natural gas, distillate oil) or “clean fuel” and the primary fuel (coal, residual oil or solid oil-derived fuel).
  - In many cases the unit will require introduction of the “primary fuel” before flue gas conditions are sufficient for starting the APC equipment. The gas and oil ignition systems that are available for startup are typically sized to achieve 10% of the fuel heat input, with some variances in Class 1, 2, or 3 ignition systems as per National Fire Protection Association (NFPA) 85 standard requirements\*.
  - Defined in § 63.10042

\*“Guidance Document on Startup and Shutdown Under MATS,” ICAC White Paper, July 2015.

- “Clean fuels” must be fired for ignition.
- *Startup ends when first power is generated or useful thermal energy is produced.*
  - Any fraction of an hour counts as a full hour. This hour is the first post-shutdown MATS compliance hour. This hour and subsequent hours must be included in the 30- or 90- rolling day emissions averages.

- “Clean auxiliary fuels” must be utilized to the maximum extent possible throughout the entire startup period. The EGU must have sufficient clean, auxiliary fuel capacity to engage and operate the PM control device within one hour of adding primary fuel to the unit.
- *Must comply with all MATS and NSPS standards within four hours of the time of electricity generation.*
- Engage all other APCDs as expeditiously as possible, and in any case to support all other emission standards.
- Must meet the startup period work practice requirements as identified in §§63.10020(e). (data recording)

# Timeline: Startup Option 2



\*if unit does not have sufficient clean fuel capacity to operate ESP or FF within one hour of firing primary fuel, it must increase its clean fuel capacity.

\*\*Clean fuel use must be maximized until end of Startup Period

- To utilize Option 2 there are additional reports and information that need to be provided to EPA by an independent Professional Engineer. The report must be submitted with the EGU's Notification of Compliance Status and must show:
  - How the current condition of the PM device, including any modifications, can meet the rule requirements.
  - Time needed to engage PM device after initial fire.
  - PM device effectiveness at initial operation and under normal operation.
  - PM emission rate.
  - Uncontrolled PM emission rate.
  - The capacity of auxiliary fuels for each unit.

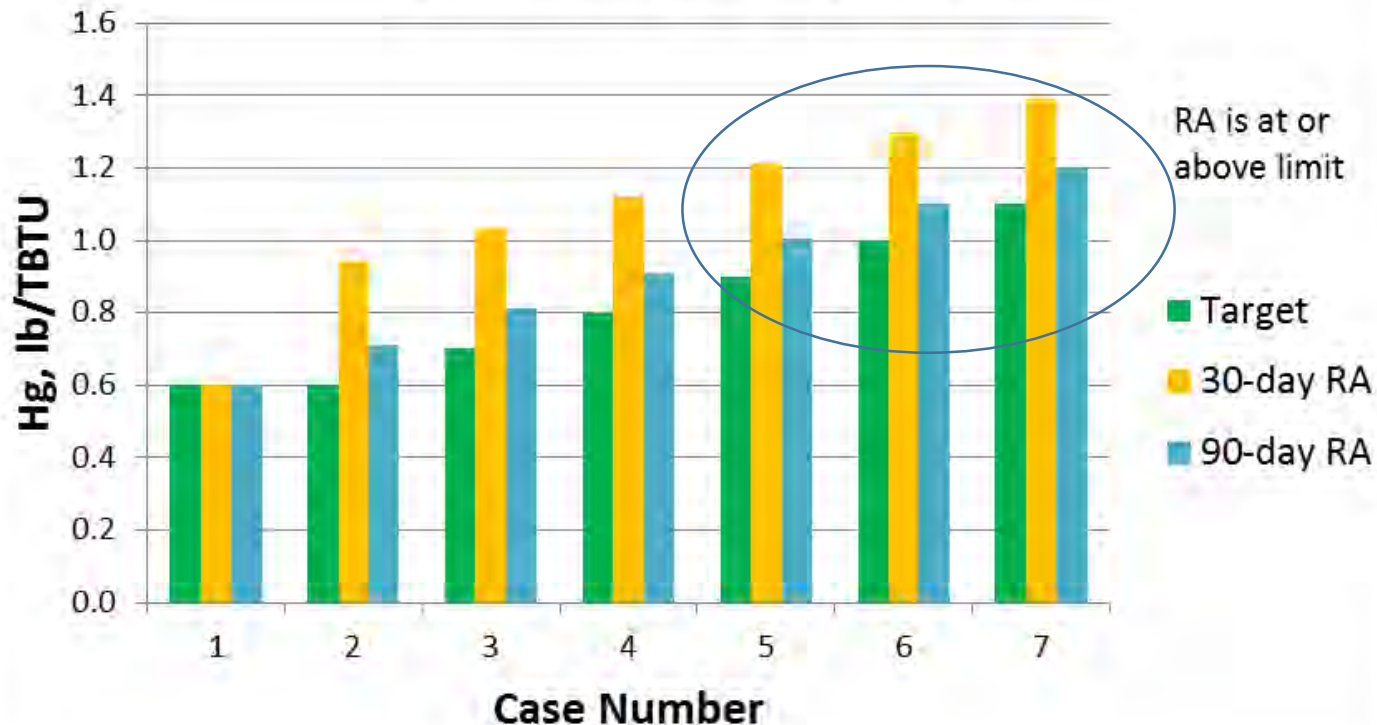
- Shutdown begins when:
  - The EGU no longer generates electricity or makes useful thermal energy when primary fuel is being fired in the EGU, *or*
  - Upon cessation of primary fuel, *whichever is earlier*.
- Shutdown ends when the EGU no longer generates electricity **and** fuel is not fired. Any fraction of an hour in which shutdown occurs constitutes a full hour of shutdown.
- The plant must operate all CMS during shutdown as well as collect appropriate data, and calculate the pollutant emission rate for each hour of shutdown. In addition, the plant must operate all applicable control devices and continue to operate those control devices after the cessation of primary fuel being fed into the EGU and for as long as possible thereafter considering operational and safety concerns.
- The plant must operate APCDs when necessary to comply with other standards made applicable to the EGU by a permit limit or a rule other than the MATS and that requires operation of the control devices.

# Startup /Shutdown Rule Implications

- Very unit-specific
- Extensive analysis needed to determine best approach
- Option 2 quite complex and requires significant PE involvement
  - May require operational adjustments to equipment or clean fuel capacity addition to get longer startup period
- Definitions and timing dictated probably do not match unit
- 12% rule was applied separately
- Data reporting and calculations alone need attention
- APC systems startup need review for each unit to assess applicability
- There are exceptions/exemptions that can be requested (safety)

## Illustration of Emission Spike Impact on Rolling Average

Spike = 3 Days\*4 lb/TBTU



- When the startup period includes firing the primary fuel, APC equipment must be engaged as described in the permit
  - Recommend to inject sorbents only when duct velocity exceeds the saltation velocity
  - Particulate control equipment should be operating normally prior to starting ACI
  - Follow manufacturer's and sorbent supplier's recommendations
  - Keep air flowing through lances to prevent backflow of flue gases between lances when idle – or isolate lances. The backflow of flue gas will carry ash and can plug lances.
- One factor that can be controlled and kept stable is PAC quality...

# Application of a Consistent PAC

## Three Critical Mechanisms

### **Contact**

of mercury, which is in very dilute concentrations in the flue gas, with the capture media

### **Conversion**

of elemental mercury ( $\text{Hg}^0$ ) to an oxidized state ( $\text{Hg}^+$  or  $\text{Hg}^{++}$ ) to enhance mercury's receptivity to the capture media

### **Capture**

of the mercury in the capture media's structure for removal from the system

All three mechanisms must occur in seconds or less to achieve compliance.

## Surfaces

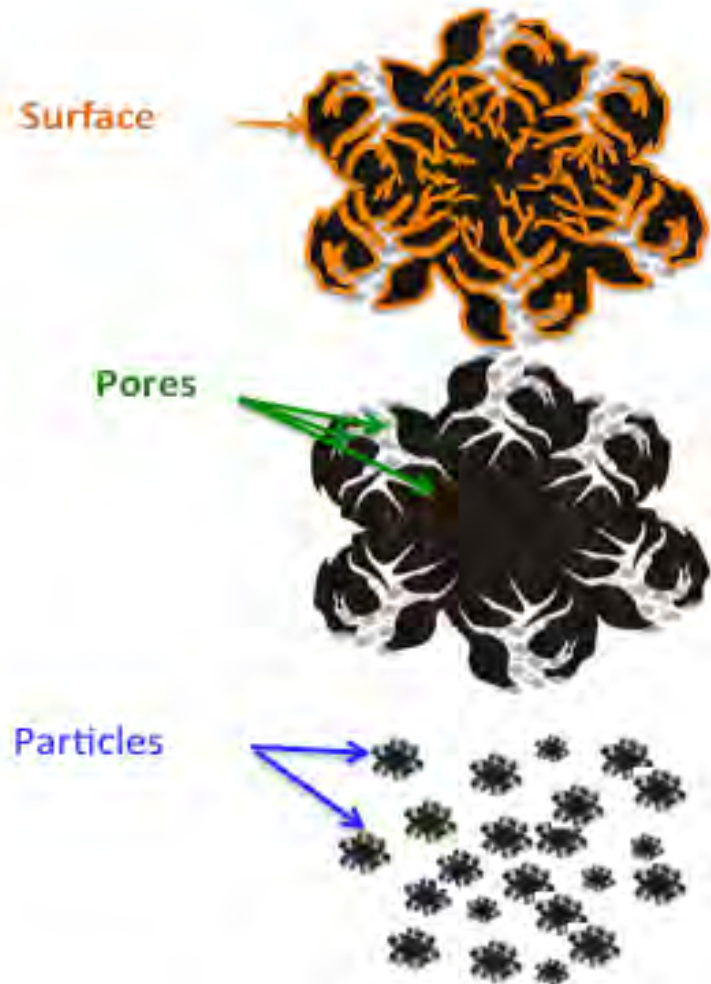
- Host for chemical reactants, catalysts and chemical functionalities

## Pores

- “Holes” of varying sizes to “transport” and “capture” target molecules to be removed

## Particles

- Transportation medium to deliver desired properties to the right location at the right time



Tuning carbon surfaces, pores and particles improves Hg control properties

# Advancing the View on PAC Mercury Capture Performance

Activated Carbon Properties	Applications Performance “Surrogate Tests”	Applications Performance “Direct Tests”
<ul style="list-style-type: none"> <li>• Surface Area</li> <li>• Pore Volume</li> <li>• Moisture</li> <li>• Bulk Density</li> <li>• Particle Size</li> <li>• Abrasion Number</li> <li>• Extractables pH</li> </ul>	<ul style="list-style-type: none"> <li>• Ignition Temperature</li> <li>• Total Sulfur</li> <li>• Halide Content</li> <li>• Iodine Number</li> <li>• Molasses Number</li> <li>• Decolorizing Index</li> <li>• Bromophenol Blue Capacity</li> <li>• Butane Activity</li> </ul>	<ul style="list-style-type: none"> <li>• Packed Bed Hg Breakthrough</li> </ul>

## EGU Applications Specific Simulation

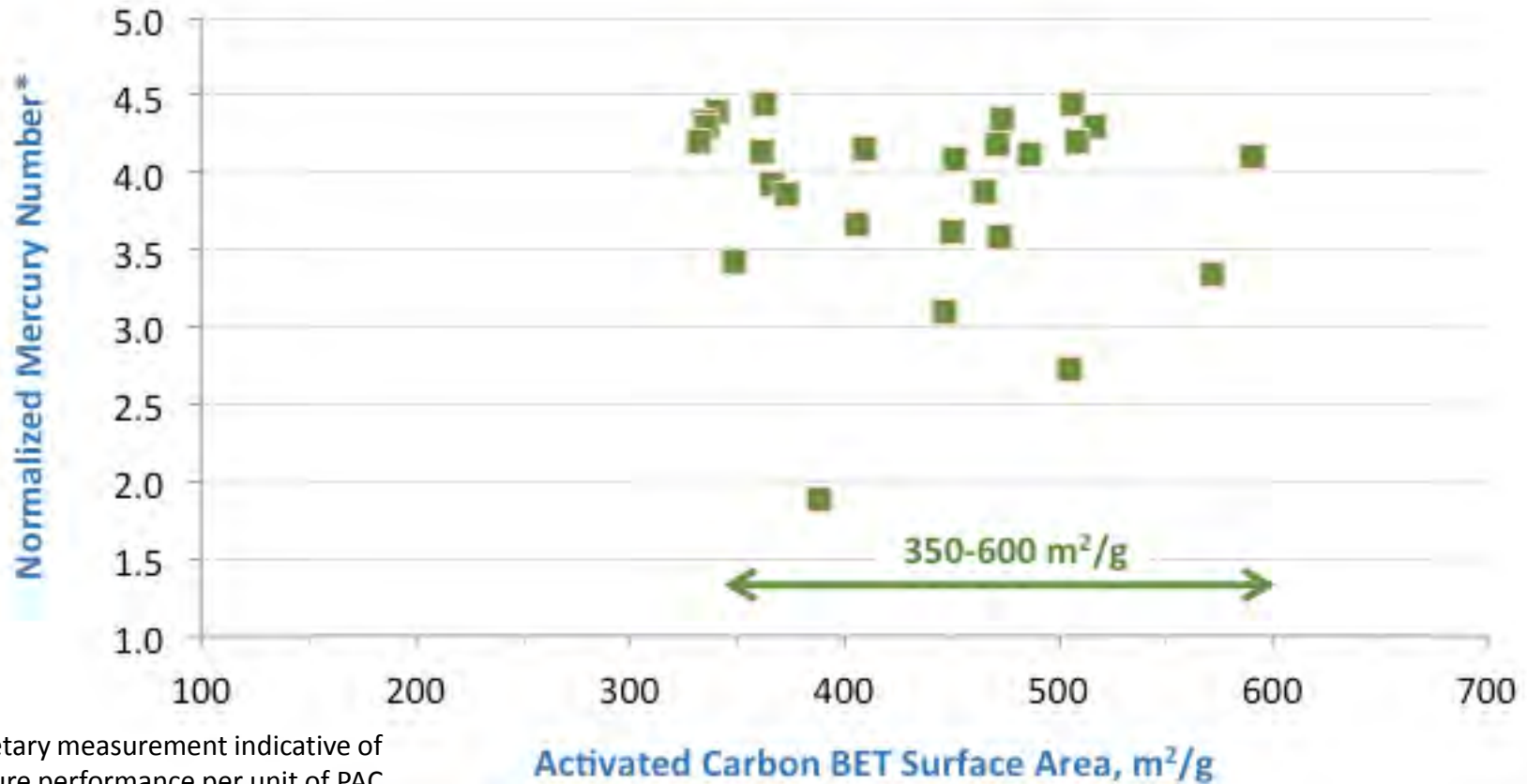
### Applications Performance “Simulation Tests”

- Dynamic Mercury Test

The Dynamic Mercury Test more closely simulates Hg capture in utility emission equipment.



Normalized Mercury Number vs. Activated Carbon Surface Area  
(Red River Carbon Plant Sorbent Screening Tests)



\*Proprietary measurement indicative of Hg capture performance per unit of PAC

Activated carbon Surface Area is important for mercury capture performance, but is not the only carbon property to consider.

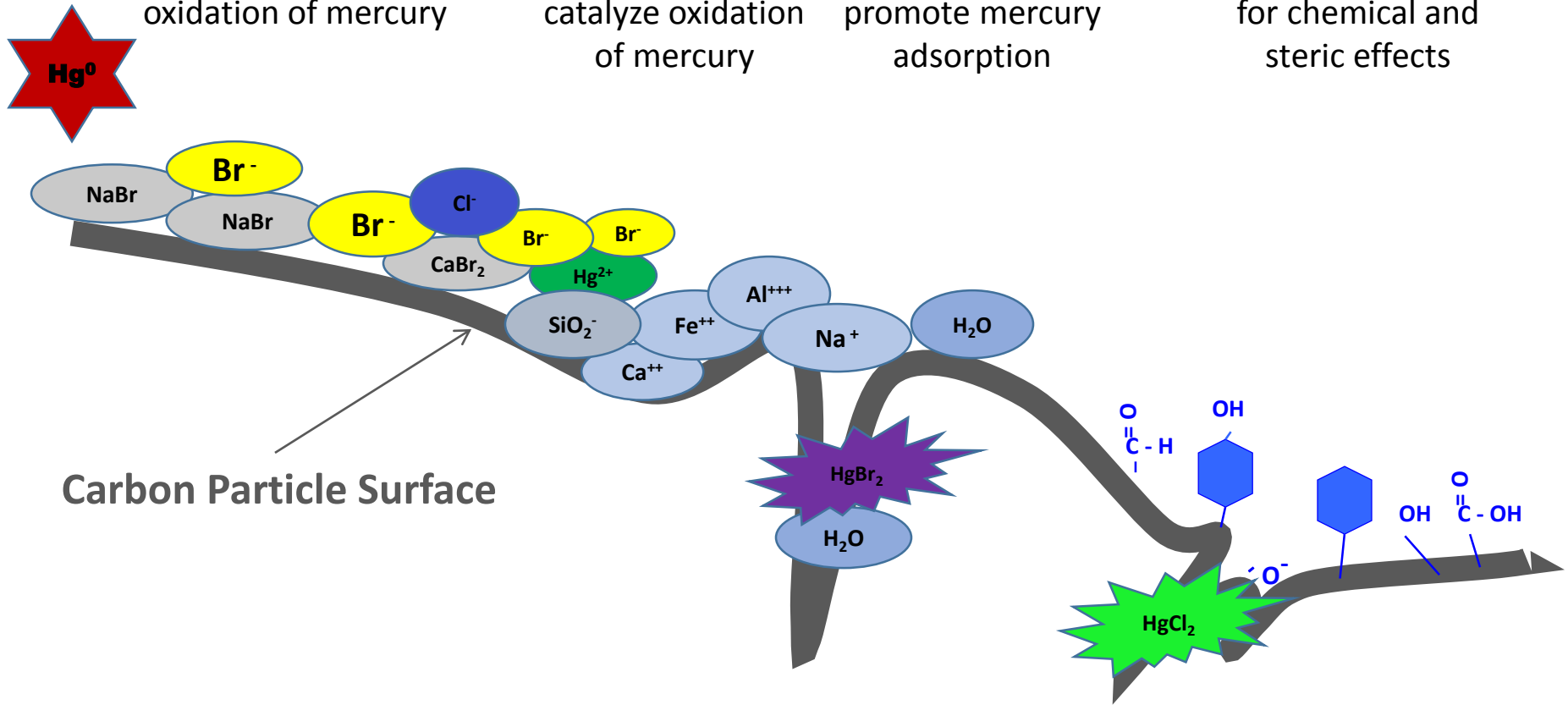
# Tuning the Activated Carbon Surface is One Key Approach

Bromine to facilitate oxidation of mercury

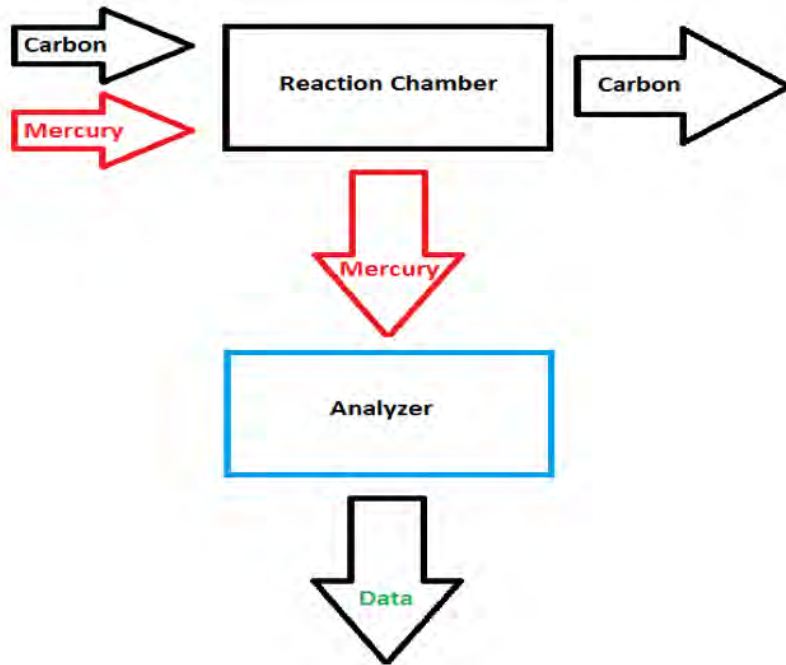
Minerals to catalyze oxidation of mercury

Moisture to promote mercury adsorption

Functional groups for chemical and steric effects



The activated carbon surface can be modified in different ways to maximize Hg capture



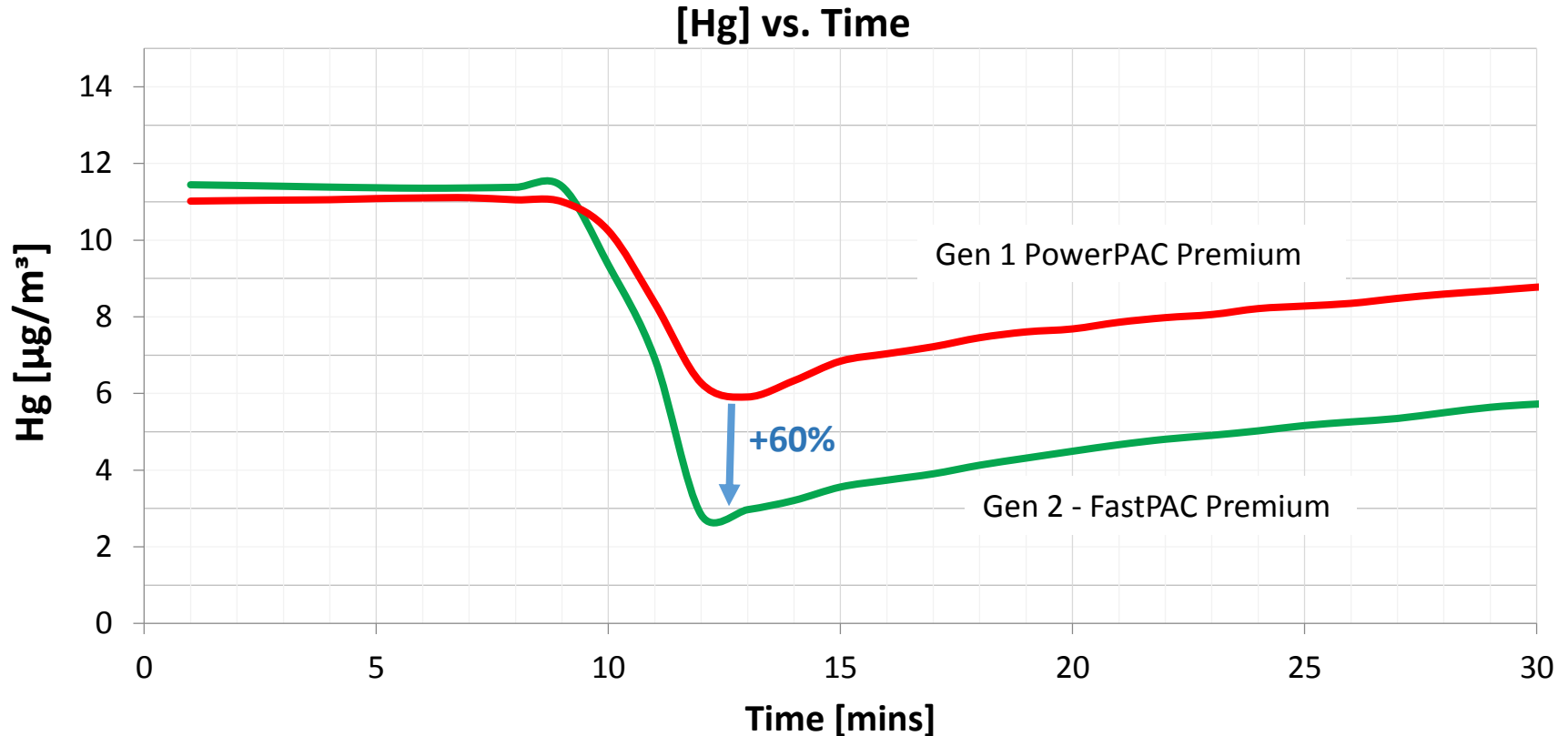
## Inputs

- Temperature: 325°F
- Gas: Air
- Target simulated injection rate: 1 to 5+ lb/MMacf
- Residence time: ~1 second
- Mercury concentration: 10  $\mu\text{g}/\text{m}^3$

## Outputs

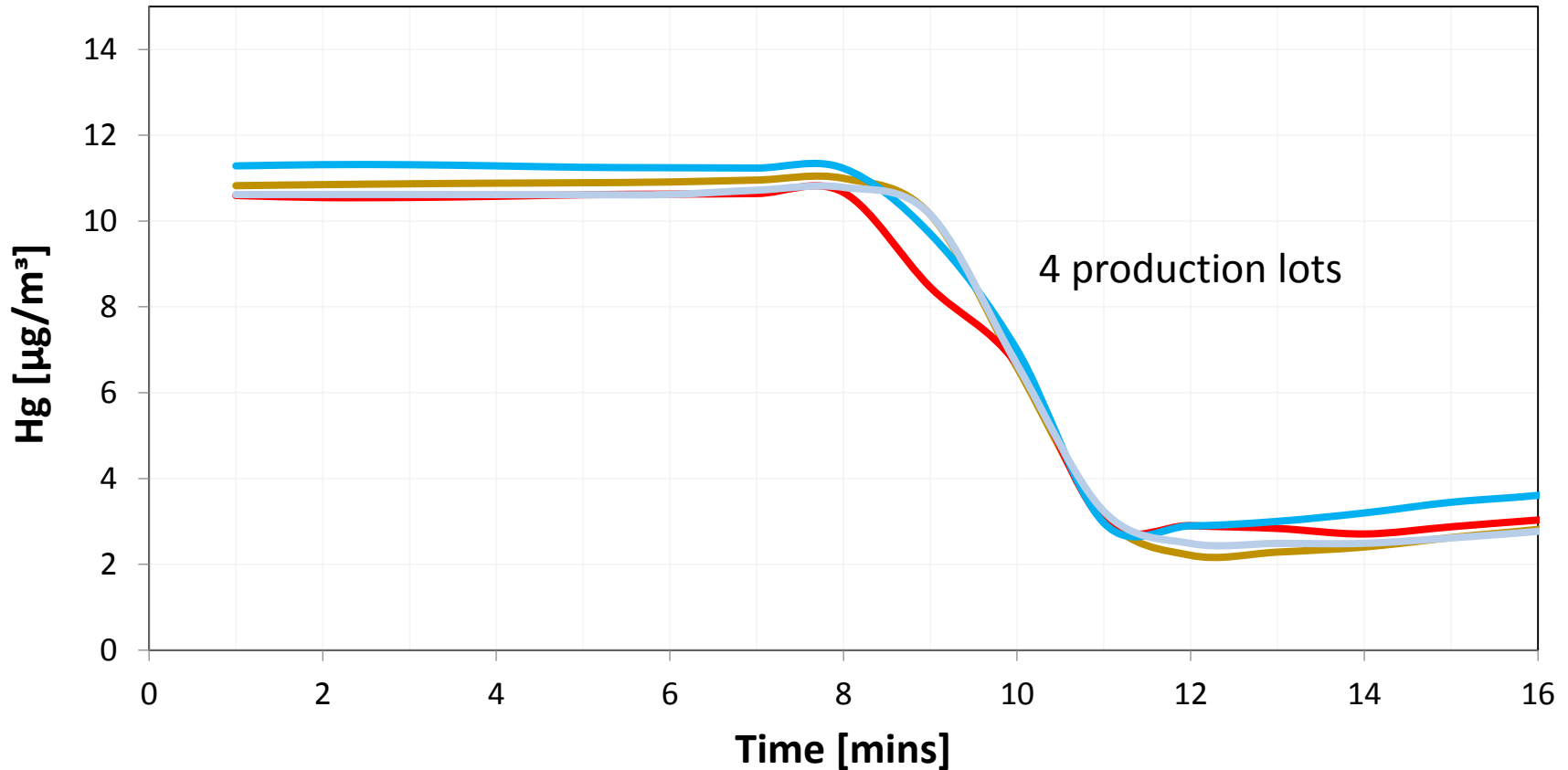
- Hg Concentration:  $\mu\text{g Hg}$  captured/g PAC

Inputs are standardized to simulate plant operating conditions, but simplified to provide easy lab-scale comparisons.



60% increase in Hg capture performance comparing a Gen 2 PAC and a Gen 1 PAC, which is an observation supported by full-scale utility injection tests.

# Dynamic Mercury Index Test: PAC Quality & Consistency



Our production Batch-to-Batch Hg removal performance is very consistent as evidenced by measurements with our lab DMI Test.

# Rapid Innovation Will Continue to Enhance Activated Carbon Performance

## Gen 1 “Adaptation”

**Traditional PAC Products  
Adapted  
for Mercury Removal**

## Gen 2 “Innovation”

**Step-change Improvement  
in Hg Capture Efficiency**

## Gen 3+ “Collaborative Specialization”

**Resolving Specialized  
Emission Requirements**

- Concrete Compatible
- Acid/SO<sub>3</sub> Tolerant
- DSI Compatible
- High Temperature
- Others

GEN 1 PACs developed in the mid-2000s are no longer the industry performance standard ... it's new Gen 2 and Gen 3+ carbons

# Powdered Activated Carbon (PAC) Handling & Management

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

- SDS – Safety data sheet
- Provides workers/employees and emergency personnel with information and procedures for safe handling and work practices for a specific substance.
  - Includes:
    - Physical and Chemical Properties
    - Toxicity
    - First Aid Measures
    - Handling and Storage
    - Disposal Considerations
    - Transport Information
    - Regulatory Information
    - Others...



SAFETY DATA SHEET


Page 1 of 7

Halogenated Emission Control Series

Section 1. Identification of Product and Company

<p><u>Supplier</u>                  ADA Carbon Solutions (Red River), LLC                  1460 W. Canal Court                  Littleton, CO 80120-5632                  Telephone Number: 888-843-8416                  FAX Number: 303-962-1970</p>	<p><u>Manufacturer</u>                  ADA Carbon Solutions (Red River), LLC                  1460 W. Canal Court                  Littleton, CO 80120-5632                  Telephone Number: 888-843-8416                  FAX Number: 303-962-1970</p>
<p><u>Supplier Emergency Contacts &amp; Phone Number</u>                  CHEMTREC: 800-424-9300</p>	<p><u>Manufacturer Emergency Contacts &amp; Phone Number</u>                  CHEMTREC: 800-424-9300</p>
<p>Product Name: PowerPAC Premium®, PowerPAC Premium Plus™, FastPAC Premium™, FastPAC Premium -80™                  CAS Number: N/A  <u>Product/Material Uses</u>                  Powdered carbon sorbent of vapor-phase mercury in flue gas, primarily in coal-fired power plants.</p>	

Section 2. Hazard(s) Identification

GHS Classification		
Health	Environmental	Physical
Skin Irritation 3 Eye Irritation 2B		
 <p><b>WARNING:</b> Activated carbon (especially when wet) removes oxygen from air and can lower the concentration of oxygen inside vessels and other confined spaces.</p>		

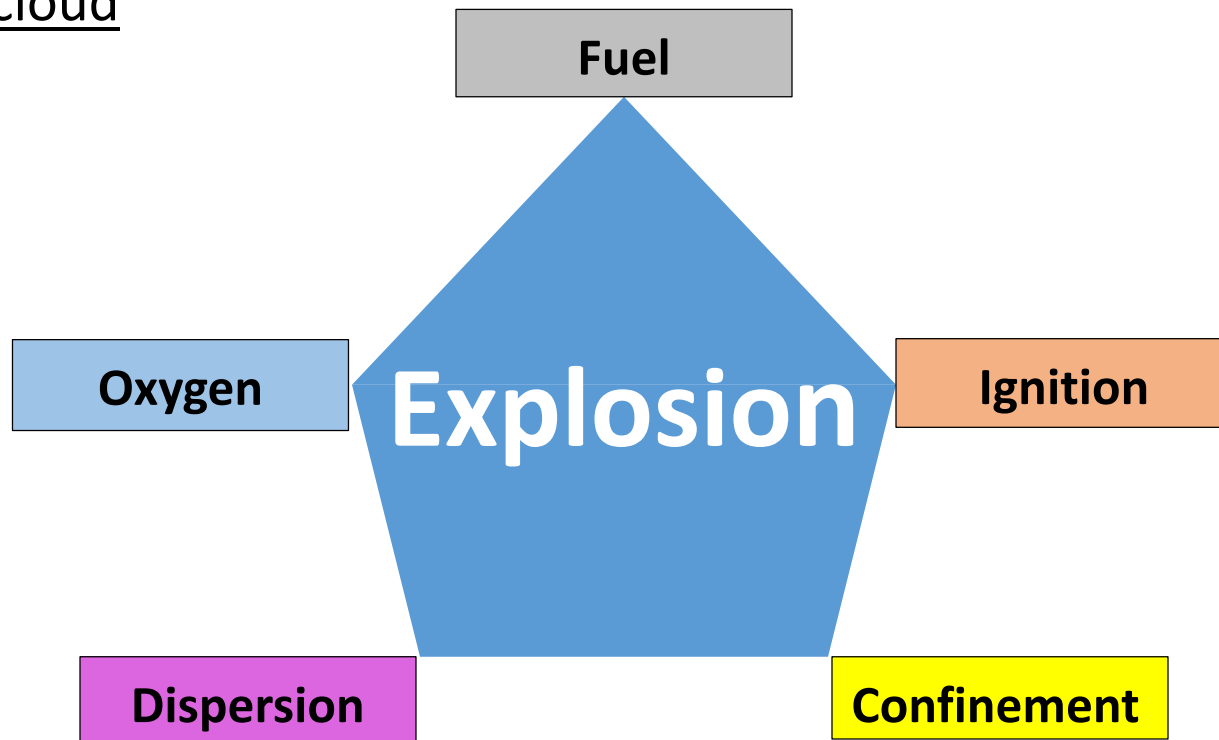
	Moisture wt%	Volatiles wt%	Ash wt%	Fixed Carbon wt%
Typical Coal	37	26	9	28
ADA FastPAC Premium PAC	6	6	27	61

Coal and PAC share some common aspects, but are vastly different in many respects.

- Class II, Div. 2 Group F is a National Electrical Code (NEC) designation.
- Less than 6% volatiles
  - Primarily CO<sub>2</sub>, CO and O<sub>2</sub>
  - VOC content typically < 100 ppm
- NFPA 654
- NFPA 68
- OSHA  
<http://www.osha.gov/Publications/3371combustible-dust.pdf>

- Combustible dusts are a small portion of the particulate solids. Combustible dusts are further defined by Occupational Safety and Health Administration (OSHA) by the following properties:
  - A particle size less than 420 microns (in comparison, table salt has an average particle size of 100 microns and Human hair is 40-300 microns); and
  - Present a fire or explosion hazard when dispersed and ignited in air.

- For a dust explosion to occur; the three required components for a fire must be present: (1) Fuel, (2) Oxygen, (3) Ignition (Heat)
- Along with two additional required components: (4) Dispersion of dust particles in sufficient quantity and concentration; and (5) Confinement of the dust cloud



# Overview of Dust Explosion Safety

- The minimum ignition energy (MIE) is greater than 10 joules for ADA Carbon Solution
- Auto ignition occurs at temperatures **greater than 400°C**

Dust Explosion Class	$K_{st}$ (bar.m/s)	Characteristic	Typical Material
St 0	0	No Explosion	Silica
St 1	> 0 and $\leq 200$	Weak Explosion	Powdered Milk, Charcoal, Sugar, Coal
St 2	> 200 and $\leq 300$	Strong Explosion	Cellulose, Wood Flour
St 3	> 300	Very Strong Explosion	Aluminum, Magnesium

Sources: OSHA (CPL 03-00-008, Combustible Dust National Emphasis Program); NFPA 68 (Standard on Explosion Prevention by Deflagration Venting).

Wet or dry activated carbon depletes oxygen from the air, creating oxygen-deficient atmospheres in confined spaces.

- If powdered activated carbon is in a confined or closed space, it may deplete the oxygen levels from the air. The oxygen content of the air in the confined space should be determined before workers are allowed to enter such a space. All applicable low-oxygen work rules and procedure should be followed.

- All activated carbons have a tendency to chemisorb oxygen when exposed to air to achieve an equilibrium oxygen level on its surfaces and pores.
- This chemisorption process is exothermic and can produce carbon monoxide as a byproduct.
- Activated carbon is a highly insulative material.
- If the exothermic heat of the chemisorption is not dissipated effectively, then heat can be trapped potentially raising the temperature of the carbon to the point of self-combustion, particularly in the surface layer exposed to oxygen.
  - This issue relates primarily to TOXECON configuration

- Avoid excessive inhalation of activated carbon dust. Appropriate protective equipment should be worn when working with activated carbon, including eyewear and respiratory protection.

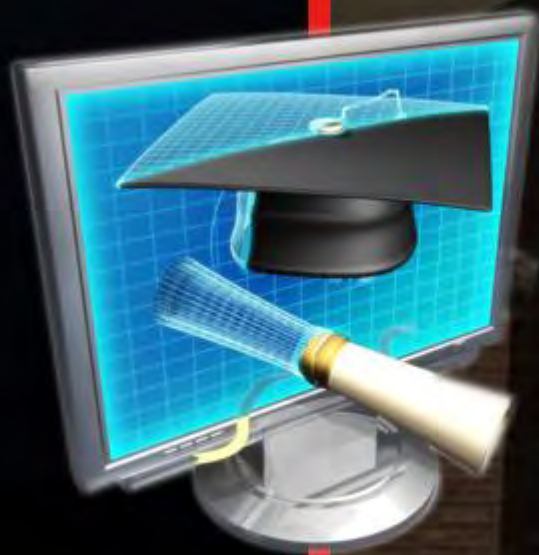


## **Always follow good handling and housekeeping practices**

- Avoid spills and accumulations of dust, or generation of airborne dust. If a spill does happen use a broom or HEPA filter vacuum for cleanup (if area of spill is classified as explosion area than vacuum should be explosion proof).
- Operators should be aware of the ignition sensitivity and explosion severity of all the material in their plant – available on SDS sheets.
- Do not enter places where bulk material is used or stored until adequately ventilated to prevent asphyxiation.
- Avoid inhalation and eye contact.
- Ground all transfer, blending, and dust collecting equipment to prevent static discharge. Remove all ignition sources from material handling, transfer, and processing areas where dust may be present.
- If activated carbon is contained, hoppers should be emptied frequently and particular care should be exercised when hopper heaters are in use.
- Cutting or welding operations should not be used near this material.



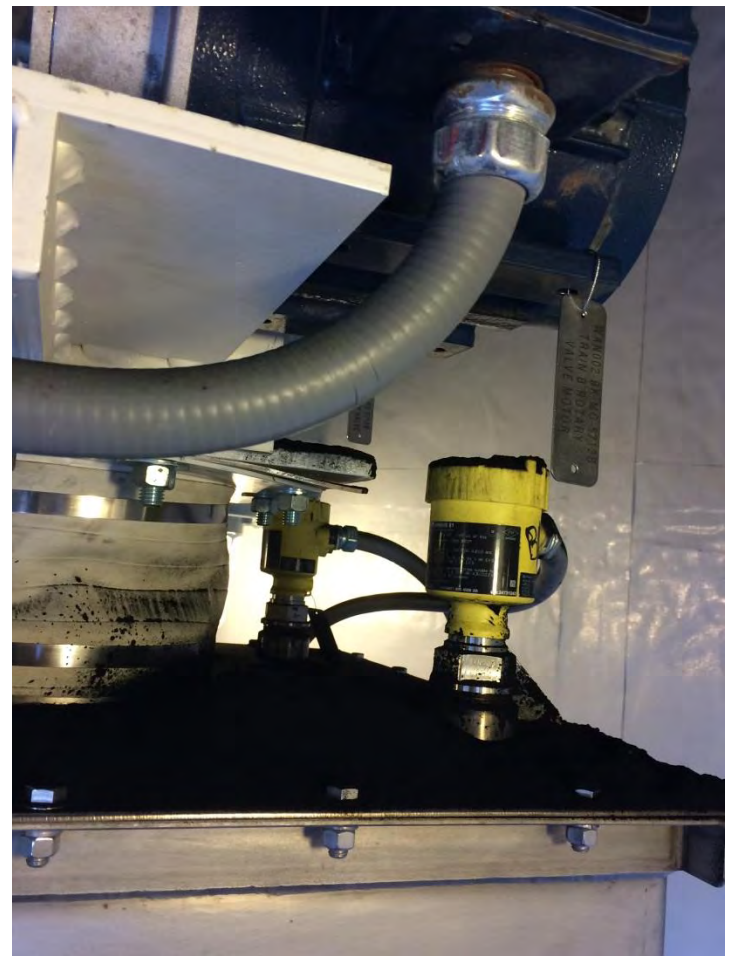
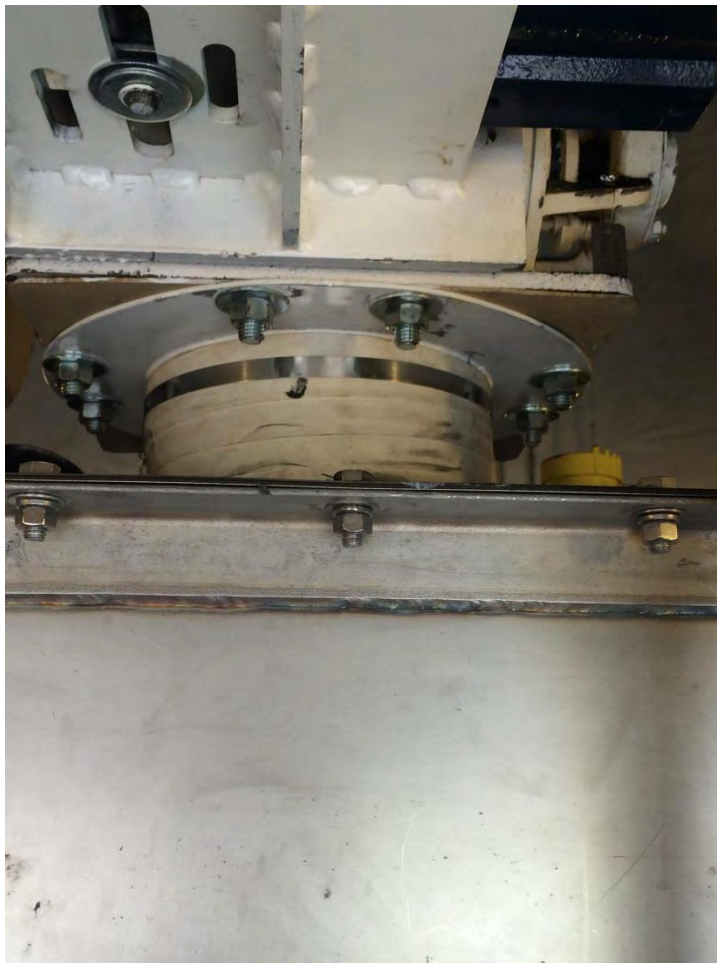
# ACI Start-Up Experiences



Reinhold 2015  
David Bonner



# Improper Gaskets





# Pressurizing the Hoppers





# Pressurizing the Hoppers

- Rotary Valve would fill
- Due to blinding the fabric, the displaced air couldn't escape through the filter sock quickly enough
- The Gravimetric weigh scale would see an enormous spike
- Would eventually settle down as the rotary valve filled again and started it all over



# Vent Hoses

We replaced the filter sock with a 4" vent hose that connected from the roof of the hopper, in place of the filter, to the top of the drop tube assembly





# Vent Hoses

- We immediately saw good results
- Rotary Valve could fill without a deviation in feedrate
- However, over time we noticed slightly more erratic control
  - We believed the duct suction was pulling too much on the inside of the hopper and not enough from ambient

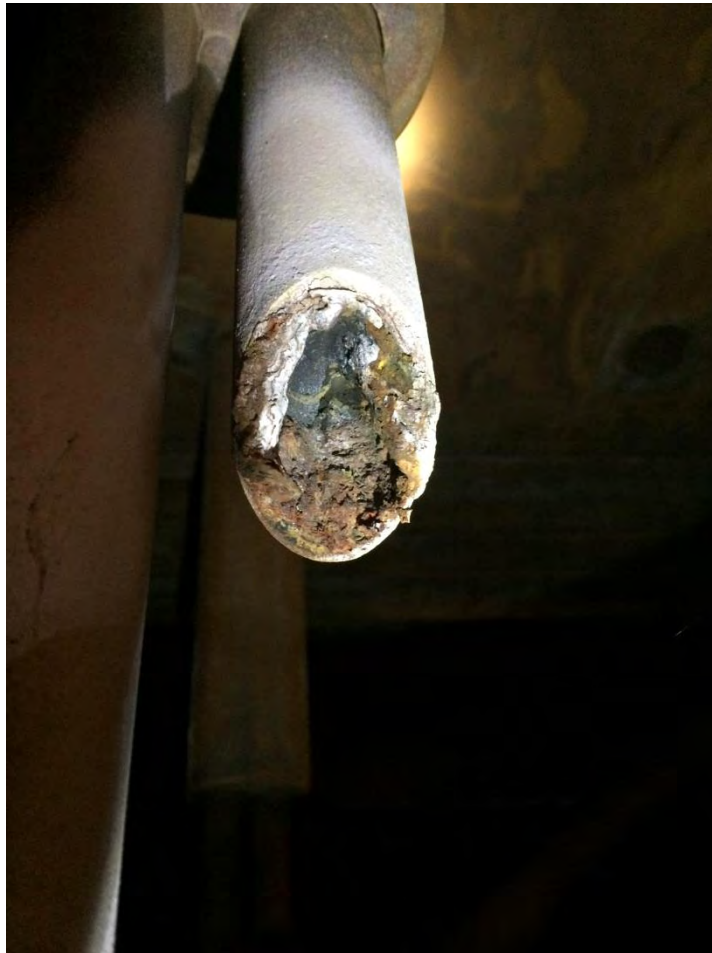
# 3" Eductor Opening

- Noticed the system was able to follow feedrate demand much more smoothly





# Lance Build Up





# Ratholing

- Simultaneously with the pressuring hopper issue, we suspected rat-holing inside the hoppers, especially at high feed rates
- Plant personnel have inspected the hopper through the vent opening and confirmed bridging of PAC
- Consistent with all OIS data we've been monitoring



Aspen Process Plant Bowen V. 2014-01-09

Home Insert Plot Layout Favorites View Tools Get Started

Trend KPI XY Event Other Plots

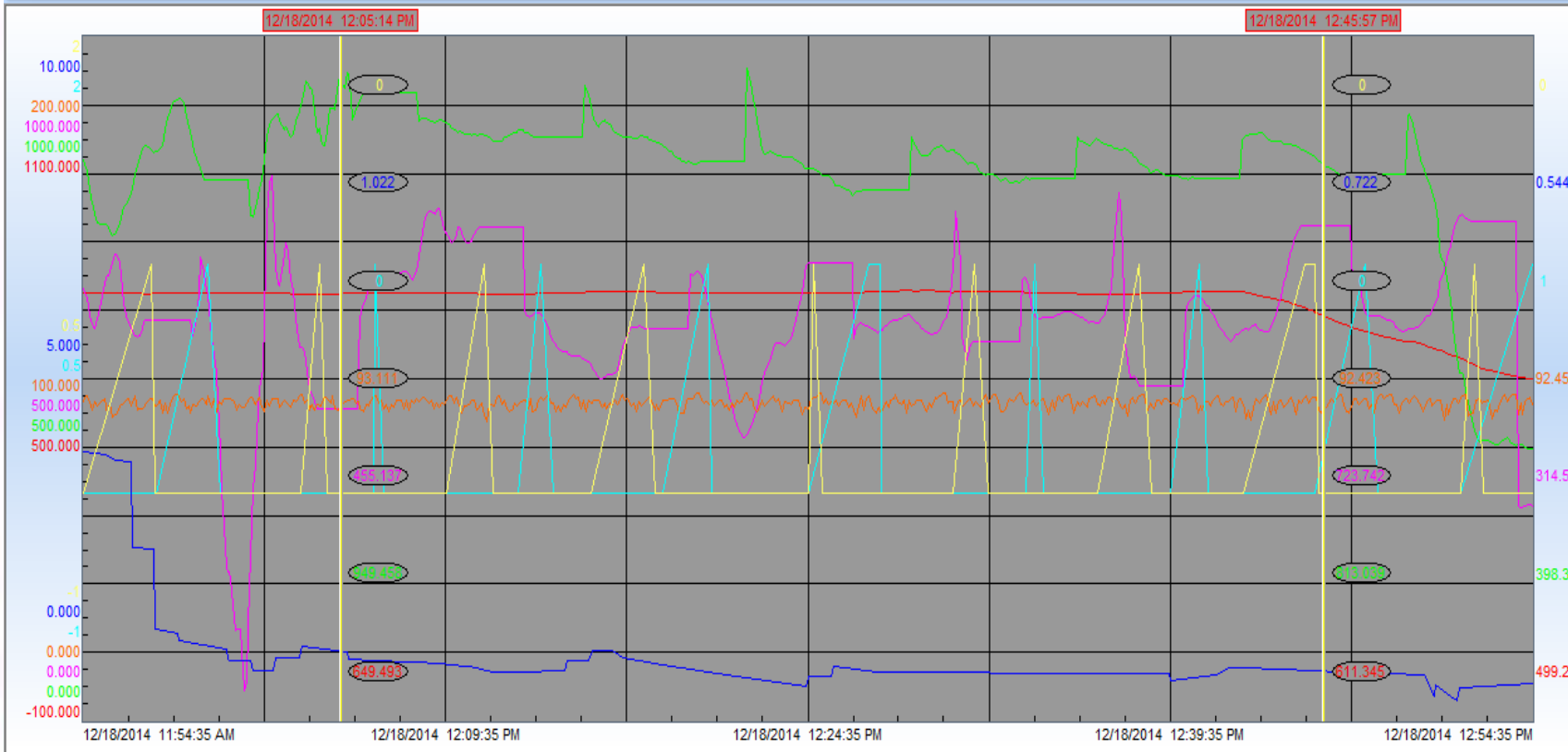
Histogram XBar Range Other SPC

Overlay Single Multiple Other APRM

Insert Delete Rename Open Favorites

Prev Next Workspace Graphic

KPI Wizard Batch Query Tool Tag Browser Other Tools



Name	Data Source	Map	Description	Value	Level	Status	Aut	Plot Min	Plot Max	Units	Shift	TZ	Type	Period	Method	Ste	Ext
2-ACI-RTRY	GPC_Bowen	SO_DISCRE	ACI TRAIN B ROT#	0	Good	Good	<input type="checkbox"/>	-1	2		0 0:00:0	Central C	Best Fit	1 Hour		<input type="checkbox"/>	<input type="checkbox"/>
2X-ACI-MFG	GPC_Bowen	SO_ANALOC	ACI MFGAS TOTAL	0.544	Good	Good	<input type="checkbox"/>	0.000	10.000	LB/TBT1	0 0:00:0	Central C	Best Fit	1 Hour		<input type="checkbox"/>	<input type="checkbox"/>
2-ACI-RTRY	GPC_Bowen	SO_DISCRE	ACI TRAIN A ROT#	1	Good	Good	<input type="checkbox"/>	-1	2		0 0:00:0	Central C	Best Fit	1 Hour		<input type="checkbox"/>	<input type="checkbox"/>
2-ACI-SUP-A	GPC_Bowen	SO_ANALOC	ACI SUPPLY AIR P	92.457	Good	Good	<input type="checkbox"/>	0.000	200.000	PSIG	0 0:00:0	Central C	Best Fit	1 Hour		<input type="checkbox"/>	<input type="checkbox"/>
2-ACI-TRN-B	GPC_Bowen	SO_ANALOC	ACI TRAIN B FEED	314.517	Good	Good	<input type="checkbox"/>	0.000	1000.001	LB/HR	0 0:00:0	Central C	Best Fit	1 Hour		<input type="checkbox"/>	<input type="checkbox"/>
2-ACI-TRN-A	GPC_Bowen	SO_ANALOC	ACI TRAIN A FEED	398.359	Good	Good	<input type="checkbox"/>	0.000	1000.001	LB/HR	0 0:00:0	Central C	Best Fit	1 Hour		<input type="checkbox"/>	<input type="checkbox"/>
2-gross-mw	GPC_Bowen	SO_ANALOC	GEN GROSS PWR	499.250	Good	Good	<input type="checkbox"/>	-100.000	1100.001	MW	0 0:00:0	Central C	Best Fit	1 Hour		<input type="checkbox"/>	<input type="checkbox"/>

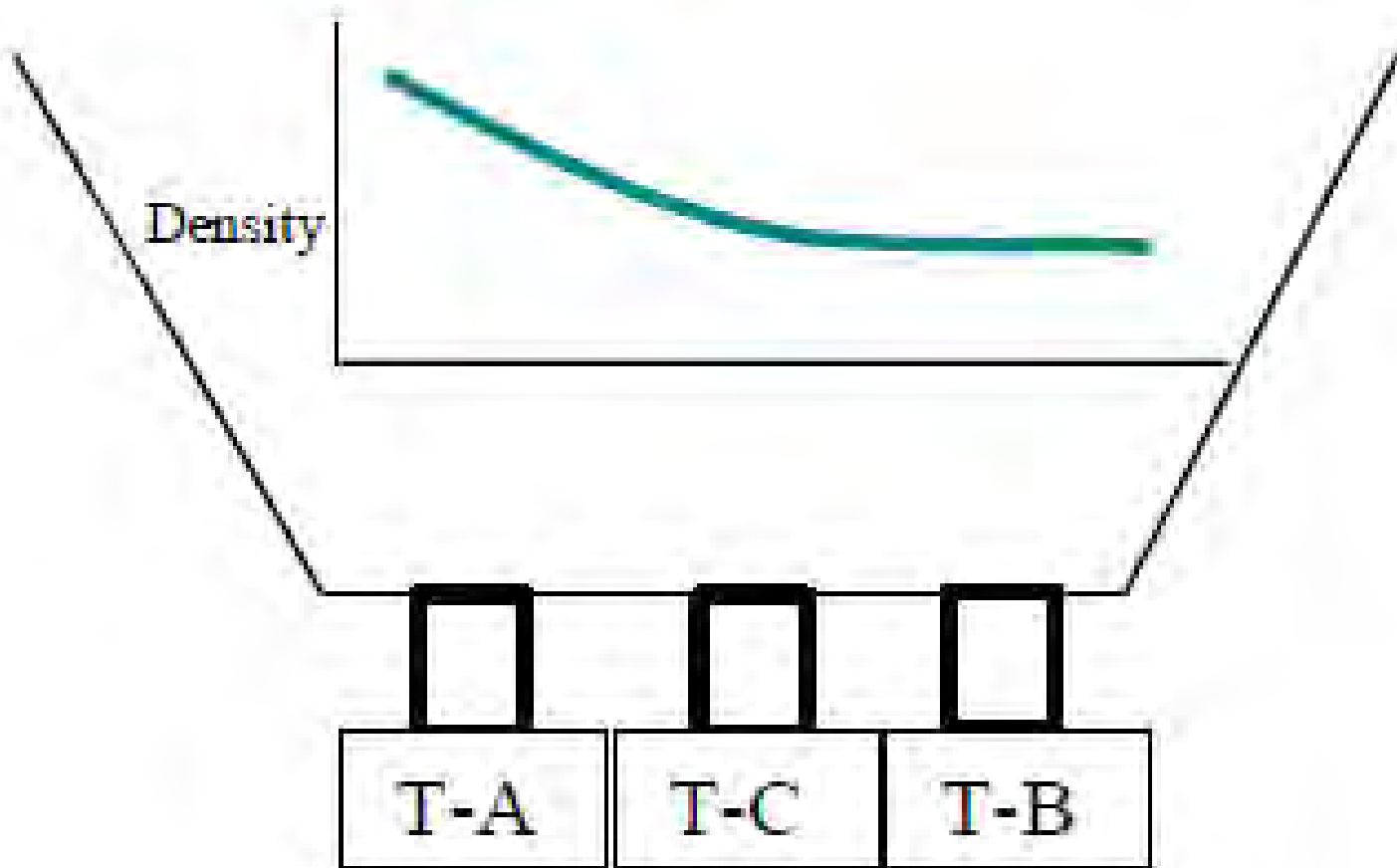


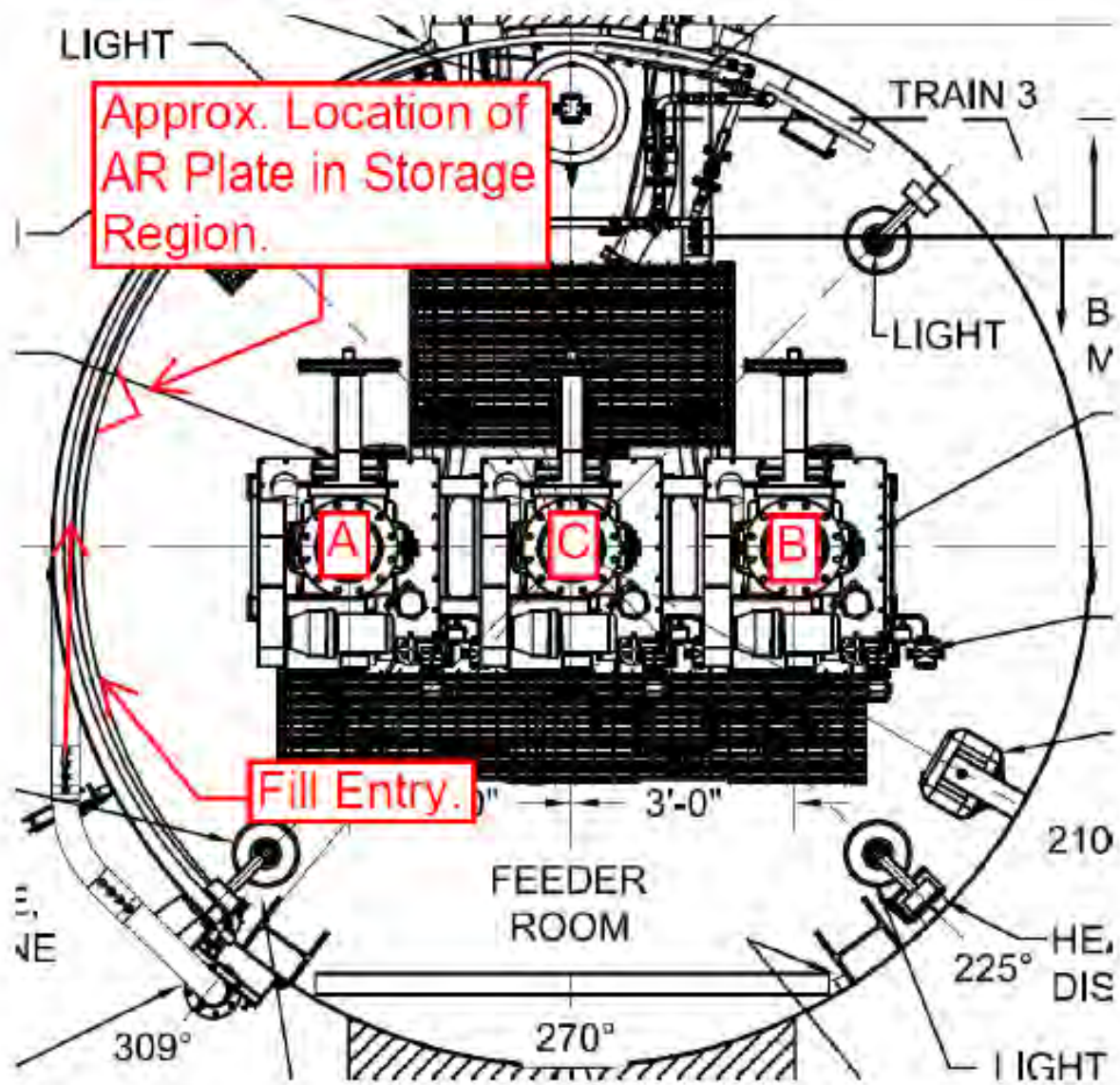
# Ratholing



- ADA ES provided hopper air fluidizers to 'de-clump' carbon and promote PAC flow







Aspen Process Explorer V7.3 Plant Bowen V. 2014-01-09

Home Insert Plot Layout Favorites View Tools Get Started

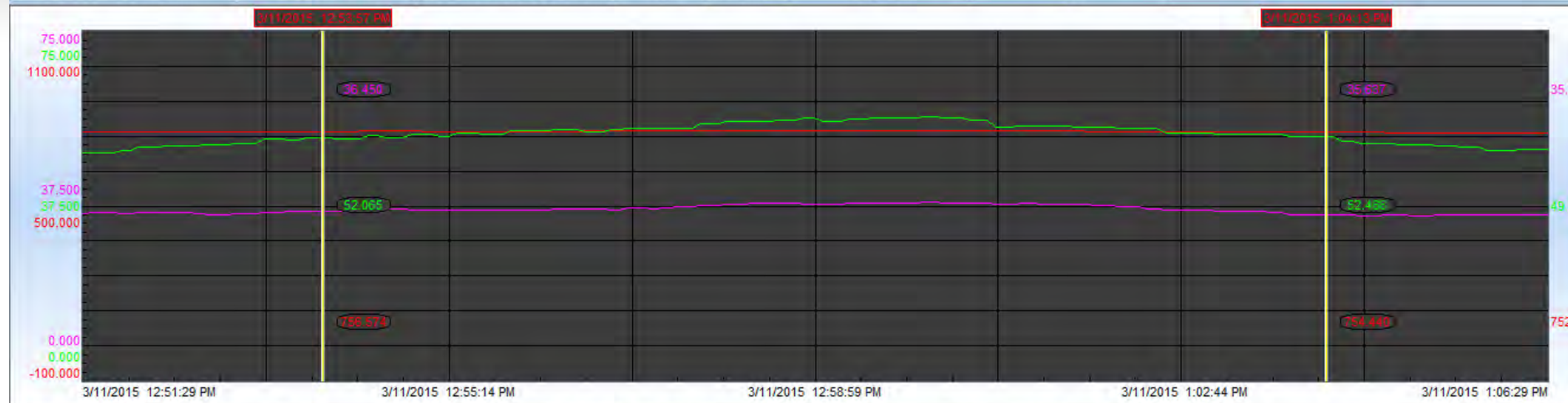
Trend KPI XY Event Other Plots Histogram XBar Range Other SPC Overlay Single Multiple Other APRM Insert Delete Rename Open Favorites Prev Next Workspace Graphic Tag Browser KPI Wizard Batch Query Tool Other Tools



Aspen Process Explorer V7.3 Plant Bowen V. 2014-01-09

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Trend KPI XY Event Other Plots Histogram XBar Range Other SPC Overlay Single Multiple Other APRM Insert Delete Rename Open Favorites Prev Next Workspace Graphic Tag Browser KPI Wizard Batch Query Tool Other Tools



Name	Data Source	Map	Description	Value	Level	Status	Aut	Plot Min	Plot Max	Units	Shift	TZ	Type	Period	Method	Ste	Ext





Plant	PAC Injection Rate	Percent Removal
Wansley 2	1300 lb/hr	74%
Wansley 1	1000 lb/hr	77%
Bowen 2	1100 lb/hr	68%
Bowen 1	1200 lb/hr	49%
Hammond 4	800 lb/hr	76%



**QUESTIONS?**

Thank You.

Contact Us:  
888.843.8416  
[www.ADA-CS.com](http://www.ADA-CS.com)  
[sales@ada-cs.com](mailto:sales@ada-cs.com)

