Advancements in Activated Carbons

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SVP Environmental and External Affairs
McIlvaine Hot Topic Hour
New Developments in Power Plant Air Pollution Control
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## Genesis of Activated Carbon Injection for Mercury Capture

### 1990s
- Multiple-pollutant control laboratory and pilot-scale studies to start evaluating co-benefits and sorbent injection
- Technology transfer of Activated Carbon Injection (ACI) from Municipal Sewer Waste over to Coal Firing, but 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 and demonstrations of same PACs used for water treatment and MSW plants
- Introduction of halogen-treated activated carbons
- Measurement improvements and options expand
- Issues such as ash disposal identified, studied

### Today
- ADA Carbon Solutions as first, fully focused PAC manufacturer for mercury removal introduces new products tailored to this application
- Identification of critical aspects of carbon that drive performance in mercury capture
- Focused product development in specific application challenges
- Measurements still challenging and high-maintenance

### Ongoing Development
- Meaningful quality criteria that correlate with mercury capture performance
- Rapid innovation targeting specific application challenges
  - High Acid Gases
  - Concrete Compatibility
  - Faster Kinetics
- Solutions tailored for specific circumstances to achieve the optimal compliance solutions

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*Coal-fired mercury control has been studied by EPRI, EPA, DOE and others since 1990*

*Activated Carbon Injection (ACI) has been commercial in coal fired power plants since 2007*

*As of mid-2012, there were 63 GW of ACI bookings (ICAC)*
Advances in High Hg Capture Efficiency
- Gen 2 - FastPAC™ Premium EGU Test

Steep, Rapid Capture
Low Hg Residual & Secure Capture

Gen 1 PowerPAC Premium™

Emission Standard 1.2 lb/TBtu

GEN 2 FastPAC™ Premium

Our patent-pending FastPAC™ Premium Reduced PAC usage by 50% and Improved Hg Removal to >95%
Innovation Focused on Mercury Capture

Water Products Re-Purposed for Mercury Capture

First Generation of Design-for-Purpose Mercury Capture PAC Products

- Power PAC™
- Power PAC Premium™

Generation 2
- Power PAC Premium Plus™
- FastPAC™ Platform

Generation 3
- SO₃ Tolerant
- Concrete Compatible
- Others

2000 - 2010

2011

2012 - Future

A Scientific Approach to PAC Design Guided by Focused Applications Expertise
Three Critical Mechanisms for Efficient Mercury Capture

Conversion of elemental mercury (Hg\(^0\)) to an oxidized state (Hg\(^+\) or Hg\(^{++}\)) to enhance mercury’s receptivity to activated carbon

Contact of mercury, which is in very dilute concentrations in the flue gas, with the activated carbon

Capture of the mercury in the activated carbon structure

All Three Mechanisms Must Occur in Seconds or Less to Achieve Compliance
Fate of Mercury – What does it take to capture mercury?

<table>
<thead>
<tr>
<th>Predominant Mercury Capture Mechanisms</th>
<th>Oxidize Mercury</th>
<th>Contact with Capture Media</th>
<th>Secure Mercury Capture &amp; Removal</th>
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</thead>
<tbody>
<tr>
<td><strong>Emission Treatment</strong></td>
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<tr>
<td>Coal Pretreatment</td>
<td>Effective</td>
<td>Effective</td>
<td>Effective?</td>
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<tr>
<td>Pre- &amp; Post Combustion Oxidation</td>
<td>Effective</td>
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<tr>
<td>Fly Ash / LOI</td>
<td>Effective</td>
<td>Effective</td>
<td>Effective?</td>
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<tr>
<td>Selective Catalytic Reduction</td>
<td>Effective</td>
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<tr>
<td>Activated Carbon Injection</td>
<td>Effective</td>
<td>Effective</td>
<td>Effective</td>
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<tr>
<td>Non-carbon Sorbents</td>
<td>Effective</td>
<td>Effective</td>
<td>Effective?</td>
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<tr>
<td>Wet Scrubber</td>
<td>Effective</td>
<td>Effective</td>
<td>Effective?</td>
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</table>

Technologies that do not fulfill all three mechanisms require supplemental process steps that could add capital and/or operating costs.
Technology Philosophy

- Engineered controls are required.
- Complementary systems are beneficial.

- Reduce Hg emissions into the downstream wet scrubber to reduce potential of Hg re-emissions.

Increasing Hg concentration challenge & increasing complexity of chemistry and consistent process control.

The combination of SCR and wet FGD does not guarantee compliance with MATS.
Southern Plant Gorgas: Gen-3 FastPAC Premium® 80 SO₃ Tolerant Carbon

- Load: ~100 MW
- Alabama Bituminous Coal
- Fuel Sulfur: 1.5–2.5 wt%
- SCR: No
- Flue Gas Temperature: 310°F
- DSI-ACI-Cold Side ESP

Graph showing Hg removal across PM device (%) vs. PAC injection rate (lb/MMacf) for different carbon types:

- Gen 2 FastPAC Premium® + Hydrated Lime
- Gen 3 FastPAC Premium® 80 SO₃ Tolerant Carbon Only
- Gen 1 Carbons in High Sulfur Eastern Bituminous Coal

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Full-Scale Utility Test: FastPAC™ Premium 80 & Developmental SO₃ Tolerant Carbons

- >700 Megawatt Unit
- Lignite Coal
  - High Hg, 25-35 lb/Tbtu
  - High SO₃, 15+ppm
- Cold Side ESP
- CEMS

SO₃ Tolerant Carbons Highly Effective for High Mercury, High Sulfur Lignite Coal
Advances in SO$_3$ Tolerant Carbons – FastPAC Premium™ 80

• Over 18 full-scale utility tests of our FastPAC™ Premium 80 SO$_3$ tolerant PAC
• MATS compliance options for efficient Hg capture for high-sulfur coal demonstrated
  o Combination of DSI and ACI enhances mercury removal on high sulfur fuels and complements the performance of FGD co-benefit.
  o Combination of DSI and ACI provide sufficient mercury removal for MATS compliance on sub bituminous and select bituminous coal.
• New Generation-3 ADA Carbon Solutions SO$_3$ Tolerant carbons allow effective operational options with reduced PAC and DSI requirements
Advances in Concrete Compatibility From Our FastPAC™ Premium

Concrete Foam Stability vs. Time at ~ 3 lb/MMacf ACI

Our patent-pending FastPAC™ Premium PAC conserves Air Entrainment Agent Usage and provides Rapid Foam Stability

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Advances in Hg Capture Efficiency & Concrete Compatibility with Our Gen-2 FastPAC Premium™ Product Platform

• 53 Full plant utility tests completed in 2012 through the end of May 2013
• 30-60% lower activated carbon consumption
  - Lower particulate load on ESP
  - Reduced maintenance requirements & less equipment wear
  - Potential for baghouse capital avoidance
• Steeper Hg capture efficiency
  - Greater than 95+% Hg capture capability
  - Active control capabilities
  - Broader operational flexibility to meet compliance
  - Extend useful life of plant operations as opposed to shutdown
• Concrete Capability
  - Acceptance by fly ash marketer
  - Lower ash carbon content
  - Rapid Foam Stability
We Take Pride in Leading the Activated Carbon Performance Landscape

<table>
<thead>
<tr>
<th>PAC Platform</th>
<th>Introduction</th>
<th>Attributes</th>
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<tbody>
<tr>
<td>FastPAC™ Premium</td>
<td>Spring 2011</td>
<td>• Fast Reaction &amp; Adsorption Kinetics</td>
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<tr>
<td></td>
<td></td>
<td>• High Hg capture efficiency - low PAC dosage</td>
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<td></td>
<td></td>
<td>• Low Hg residual in flue gas</td>
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<td>Concrete Compatible</td>
<td>Summer 2011</td>
<td>• Low Foam Index – low AEA requirement</td>
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<tr>
<td></td>
<td></td>
<td>• Rapid Foam Stability – constant AEA over time</td>
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<tr>
<td>FastPAC™ Premium 80</td>
<td>Spring 2012</td>
<td>• SO₃ Tolerant</td>
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<tr>
<td></td>
<td></td>
<td>• Low or no DSI requirements</td>
</tr>
<tr>
<td>Other Developmental</td>
<td>Fall 2012 – Spring</td>
<td>• Address niche concerns identified by customers such as optimization for</td>
</tr>
<tr>
<td>Products</td>
<td>2014</td>
<td>specific unit configurations, higher flue gas temperatures</td>
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</tbody>
</table>

We continue to focus R&D resources on developing new carbons that lead the industry in providing cost-effective, reliable options for MATS compliance.

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*Expertise. Reliability. Compliance.*
Thank you!

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