Agenda

• Who We Are
• Benefits of Using GAC for PFAS removal
• GAC Product Differentiators
• Importance of Testing in PFAS Applications
• Rapid Small Scale Column Testing (RSSCT) Results
  – PFOA/PFOS Application
  – Short Chain PFAS (PFBA, PFHxA, PFBS, PFOA, PFHxS, PFOS)
Corporate Profile

Who Is Calgon Carbon Corporation

• World’s largest producer of Granular Activated Carbon (GAC)
• Solves customer purification and separation problems with an array of technologies
• Water treatment is core competency with a diverse product portfolio

$514 million
2016 net sales

75 years
experience

1,400+ employees

25 offices
sales and service

20 facilities
Manufacturing, reactivation, equipment

240 patents
Benefits of Using GAC for PFAS Removal

- Leading technology for removal of PFCs from drinking water and groundwater
- >15 years and >20 large installations in municipal/industrial segments & > 1,000 POET GAC systems treating residential well sites
- GAC is safe & environmentally responsible - safest way to treat is to remove contaminants
- Cost effective & simultaneously removes other emerging contaminants which addresses future compliance requirements
- Reactivation of spent GAC thermally destroys adsorbed contaminants including PFC’s
Activated Carbon Differentiators

**Impact of Raw Material**
- Coal, Coconut, Lignite, Wood
- Ash impurities inherited
- Density and hardness are linked
- Transport pore structure and adsorption kinetics
- Single unique family of products from a raw material source
- Coconut ≠ Bituminous Coal

**Impact of Manufacturing Process**

Reagglomerated products exhibit:
- Even activation
- Superior Kinetics

Filtrasorb® is a re-agglomerated product that is manufactured in the United States
Importance Of Testing

- PFCs/PFASs are found in trace amounts in water
- Testing is recommended – Customer Raw Water Sample
  - Isotherm- Quick Test Method for Feasibility
  - Accelerated Column Tests(ACT)- simulate full scale performance
    - Carbon type
    - Breakthrough Data
    - Usage rates
- Water Treatment applications
  - Typically low PFOA concentrations (ppb, ppt)
  - Background TOC can be 10-100X the PFOA concentration
  - Modeling such scenarios is difficult (even with other, non-PFC compounds)
  - ACT or RSSCT is beneficial
- If client timing does not permit testing, CCC recommends as a start, 10 minutes EBCT (Empty Bed Contact Time) per adsorber, with 2 adsorbers in series for ppt/low ppb levels
RSSCT PFOA/PFOS Test Data

Reagglomerated coal significantly outperformed coconut
RSSCT Short Chain PFAS Test Data

Removal of various PFCs using Virgin Filtrasorb

<table>
<thead>
<tr>
<th>Background TOC</th>
<th>0.16 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated Empty Bed Contact Time (EBCT)</td>
<td>10 minutes</td>
</tr>
</tbody>
</table>

Reagglomerated coal is effective in removing short chain PFCs
RSSCT Short Chain PFAS Test Data

Removal of PFBS using Filtrasorb vs. Coconut

<table>
<thead>
<tr>
<th>Background TOC</th>
<th>0.16 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated Empty Bed Contact Time (EBCT)</td>
<td>10 minutes</td>
</tr>
</tbody>
</table>

Reagglomerated coal significantly outperformed coconut

Graph shows the removal of PFBS (ppt) over the number of bed volumes treated (BV). The graph compares Filtrasorb and Coconut 12x40 with a feed line indicating the background TOC level.
Key Takeaways

• Activated Carbon is the leading technology for PFAS/PFC removal from drinking water and groundwater
  – Proven for PFAS/PFCS and is the Best Available Technology (BAT) for other organic compounds
  – RSSCT data suggests GAC is effective for both PFOA/PFOS and short chain PFCs
  – Spent media can be reactivated

• Not all activated carbons are created equal
  – Impact of raw material
  – Impact of manufacturing process

• Column testing is typically recommended (ACT or RSSCT)
  – If time does not permit, series operation with 10 minutes EBCT per vessel (20 minutes total EBCT for the system) for ppt/low ppb concentrations
Questions?

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Website  
- PFC Page  
  - White Papers  
  - Fact Sheets  
- Information Line
Reference Material
Reactivation

- Reactivation is the reprocessing (recycling) of spent activated carbon at elevated temperatures

- Heat destroys the adsorbed organic material in a safe and environmentally responsible way

- Carbon is then reusable

- Frequency of reactivation is dependent on application
Column Testing (ACT or RSSCT)

- **ACT** - Accelerated Column Test
- **RSSCT** - Rapid Small Scale Column Test
## Calgon Carbon Liquid Phase Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Carbon (lbs)</th>
<th>Pressure (psig)</th>
<th>Maximum Range (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOWSORB®</td>
<td>180</td>
<td>3 recommended</td>
<td>10</td>
</tr>
<tr>
<td>Small DISPOSORB®</td>
<td>165</td>
<td>7.5 maximum</td>
<td>10</td>
</tr>
<tr>
<td>Large DISPOSORB®</td>
<td>1,000</td>
<td>7.5 maximum</td>
<td>30</td>
</tr>
<tr>
<td>Protect™ TW</td>
<td>500 – 2,000</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>Protect™ LM Series</td>
<td>500 – 2,000</td>
<td>75</td>
<td>70 per vessel, operated in series</td>
</tr>
<tr>
<td>Protect™ LM Single</td>
<td>500 – 1,500</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>CR–5000</td>
<td>5,000</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>CYCLESORB®FP1</td>
<td>1,000</td>
<td>75</td>
<td>30</td>
</tr>
<tr>
<td>CYCLESORB®FP2</td>
<td>2,000</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>CYCLESORB®HP</td>
<td>2,000</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>Model 6 (2 vessels)</td>
<td>12,000</td>
<td>75</td>
<td>200 per vessel, operated in series</td>
</tr>
<tr>
<td>Model 8 (2 vessels)</td>
<td>20,000</td>
<td>75 – 125</td>
<td>350 per vessel, operated in series</td>
</tr>
<tr>
<td>Model 10 (2 vessels)</td>
<td>40,000</td>
<td>75 – 125</td>
<td>700 per vessel, operated in series</td>
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<tr>
<td>Model 12 (2 vessels)</td>
<td>40,000</td>
<td>125</td>
<td>700 per vessel, operated in series</td>
</tr>
<tr>
<td>Model 12–40 (2 vessels)</td>
<td>80,000</td>
<td>125</td>
<td>700 per vessel, operated in series</td>
</tr>
<tr>
<td>Model 14</td>
<td>60,000</td>
<td>125</td>
<td>1,030</td>
</tr>
<tr>
<td>Mobile Adsorber</td>
<td>14,000</td>
<td>35 – 65</td>
<td>250</td>
</tr>
<tr>
<td>Dual Module (2 vessels)</td>
<td>40,000</td>
<td>75</td>
<td>300 per vessel, operated in series</td>
</tr>
<tr>
<td>Dual Express (2 vessels)</td>
<td>40,000</td>
<td>75</td>
<td>300 per vessel, operated in series</td>
</tr>
</tbody>
</table>