Advances in Mercury Control Technology for Industrial Sources

July 9, 2008
Presentation Outline

- MACT History – Activated Carbon
- Factors Controlling Mercury Emissions
- Case Study
- Activated Carbon Supply
What is Activated Carbon?
## MACT Overview

<table>
<thead>
<tr>
<th>NESHAP</th>
<th>MWC MACT</th>
<th>HWC MACT</th>
<th>Foundry MACT</th>
<th>2° Al Smelter MACT</th>
<th>Portland Cement MACT</th>
<th>Boiler MACT</th>
<th>Coal-Fired Electric Utilities (no MACT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hg</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dioxins / Furans</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Original Boiler MACT

- **BACT for Existing Sources**
  - Large Units: heat input > 10 mmbtu/hour
  - Non-mercury metallic HAP: Fabric Filter
  - Mercury: Fabric Filter
  - Inorganic HAP: Scrubbers
  - Organic HAP: none identified
Estimated Hg Emissions by Source

<table>
<thead>
<tr>
<th>Source</th>
<th>1990</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWCs</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>MWIs</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Utilities</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Chlor-alkali</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Ind. boilers</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Sec. Steel</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>HWCs</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Gold Mining</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Total Emissions - 1990 = 221 tons
Total Emissions - 2002 = 119 tons
Plant Dynamics Affecting Hg Capture

- Coal Type
- Configuration of APCD
- Boiler efficiency – unburned carbon (UBC) in fly ash
Key Factors Affecting Hg Capture

Coal Burned in Industrial Boilers

<table>
<thead>
<tr>
<th>Coal Type</th>
<th>Hg ppm</th>
<th>Cl ppm</th>
<th>S Wt. %</th>
<th>Ash Wt. %</th>
<th>HHV BTU/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitum.</td>
<td>0.11 (0.04 - 0.28)</td>
<td>1033 (48 – 2730)</td>
<td>1.69 (0.55 – 4.1)</td>
<td>11.1 (5.4 – 27.3)</td>
<td>13,203 (8646 – 14014)</td>
</tr>
<tr>
<td>Sub-Bit.</td>
<td>0.07 (0.02 – 0.14)</td>
<td>158 (51 – 1143)</td>
<td>0.5 (0.22 – 1.16)</td>
<td>8.0 (4.7 – 26.7)</td>
<td>12,005 (8606 – 13168)</td>
</tr>
<tr>
<td>Lignite</td>
<td>&gt;0.11 (133 – 233)</td>
<td>188 (133 – 233)</td>
<td>1.30 (0.8 – 1.42)</td>
<td>19.4 12.2 – 24.6</td>
<td>10,028 (9487 – 10702)</td>
</tr>
</tbody>
</table>

Coal data reported on dry basis. About 15% of units use coal blends.

Possible APCD in a Coal Fired Utility Plant

Industrial Boilers are Similar

- Flue Gas
- Hot Air & Coal
- SCR
- Hg^0
- Air Preheater
- Residue
- SDA
- ESP or Bag House
- Fly Ash
- Residue
- Wet FGD
- Fan
APCD Affect on Hg Capture

- **CS-ESP**
  - poor Hg capture (<5%) with PRB or lignite
  - about 30% removal with bituminous coals

- **Fabric Filter**
  - up to 90% mercury capture with bituminous coals
  - low Hg capture with lignite or PRB coals
Case Study: MACT – Iron Foundry

– MACT Regulations, passed in 2003, require reduction in Hg emissions through mandatory elimination of Hg switches in scrap feed.
– NJDEP Enacted their own emission-based Hg reduction stds. Allowing no more than 35 mg/metric ton of scrap or 75% reduction. Passed in 4/07, compliance by 1/10.
– Other states expected to follow.
– Expected PAC usage ~120,000 lbs/yr per facility
MACT – Iron Foundry

<table>
<thead>
<tr>
<th>Monitor</th>
<th>Stack</th>
<th>Avg</th>
<th>Test</th>
<th>Date</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234OFF</td>
<td>5.7</td>
<td>28</td>
<td>45</td>
<td>12-12</td>
<td>56-69</td>
</tr>
<tr>
<td>131 ON</td>
<td>3.56</td>
<td>8</td>
<td></td>
<td>13-14</td>
<td></td>
</tr>
</tbody>
</table>

85%
Compliance with Activated Carbon Utility vs Typical Industrial Boiler

• **Utility**
  - Salem Harbor, MA
  - Generation nameplate ~ 90 Megawatts
  - Steam Production ~ 600,000 lb per hour
  - Air flow rate ~ 300,000 acfm
  - Burn ~ 270,000 tons/year eastern bituminous coal

• **University**
  - Located in Northeast US operating 4 Boilers
  - Boiler Size averages 125 mmBTU/hour
  - Steam Production annual average is 200,000 lb per hour
  - Air flow rate ~ 100,000 acfm
  - Burn ~ 75,000 tons/year eastern bituminous coal
## Compliance with Activated Carbon Utility vs Typical Industrial Boiler

<table>
<thead>
<tr>
<th>Location</th>
<th>Coal</th>
<th>Equipment</th>
<th>Carbon Grade</th>
<th>Carbon Rate (lb/MMacf)</th>
<th>% Removal</th>
<th>Annual Carbon Estimate (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salem Harbor</td>
<td>Est Bit</td>
<td>C-ESP</td>
<td>Darco-Hg</td>
<td>10</td>
<td>80-90</td>
<td>1,500,000</td>
</tr>
<tr>
<td>University</td>
<td>Est Bit</td>
<td>Fabric Filter</td>
<td>Darco-Hg</td>
<td>~1-3</td>
<td>80-90</td>
<td>150,000 – 500,000</td>
</tr>
</tbody>
</table>
Compliance Cost Comparison

<table>
<thead>
<tr>
<th>Air Flow</th>
<th>Capital Expense</th>
<th>Annual Carbon Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>(acfm)</td>
<td>($)</td>
<td>($)</td>
</tr>
<tr>
<td>Electric Utility</td>
<td>1,200,000</td>
<td>$1,250,000</td>
</tr>
<tr>
<td>MWC</td>
<td>175,000</td>
<td>$1,250,000</td>
</tr>
<tr>
<td>Iron Foundry</td>
<td>250,000</td>
<td>$1,250,000</td>
</tr>
<tr>
<td>Industrial Boiler</td>
<td>500,000</td>
<td>$1,250,000</td>
</tr>
</tbody>
</table>
Activated Carbon Market

• What’s important going forward?
  – Specifications
  – Performance Guarantees
  – Product Offerings
  – Demand and Supply
Activated Carbon Specifications

– EPRI Initiative
  • Molasses, Iodine Number, BET (N2) Surface Area, Methylene Blue, BWC, Tannin Number, Phenol Number & others

– Different Carbon Base = Different Test.
– Industry needs a standardized test
Performance Guarantees

• Individual AC companies may or may not offer
• Site specific – many variables including APCD and coal type consistency
• Adsorptive Tests to Characterize Activated Carbon
  – Hg Loading Capacity and Kinetics
    • Norit Americas has developed a Hg adsorption test in order to begin specifying its flue gas mercury removal products on a new CEM-based analysis.
    • Our future goal is to ensure that every lot of carbon meets expected mercury removal requirements for a standardized flue gas.
New Products - Surface Modifications

- Low Rank Fuels (DARCO Hg-LH)
- Concrete Compatible (DARCO Hg-CC)
- $\text{SO}_3$ Resistant Carbon (Darco E-26)
  - Moderate $\text{SO}_3$ Coal and $\text{SO}_3$ Conditioning Applications
- Others in development
Activated Carbon Demand

Estimated Carbon Requirements by Market

- US Market: 539 million lbs
- MWC: 19 million lbs
- CFUM States: 500 million lbs
- CFUM CAMR*: 1,000 million lbs
- Industrial Boilers: 23 million lbs
- Cement: 52 million lbs

* Assumes no new technology, better estimate is 500-800mm additional lbs with Federal MACT Rule
Activated Carbon Supply

Norit’s Supply for Future Demand
– Plant capacity is being added to meet demand
– Current powder capacity: 120 million pounds
– Permitting for 150 million additional pounds at current facilities
– Stage 2: expand to new locations
– Typical lead time for additional capacity is 12-18 months
Expansion Update