Low CapEX Solutions for Compliance with Industrial Boiler MACT

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ADA Environmental Solutions

McIlvaine Hot Topic Hour
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ADA Environmental Solutions creates and delivers cutting edge technical and chemical solutions to reduce emissions from coal-fired power plants, Portland cement kilns and industrial boilers, helping customers meet environmental goals while balancing their business needs.
Key Points of This Presentation

• ICI Boiler MACT is a *multi-pollutant regulation* with limits for mercury, HCl, particulate matter, and carbon monoxide

• ICI Boiler MACT solutions for solid fuels:
  – Finding a low-cost solution for multiple pollutants is highly desirable: Hg, HCl, PM
  – Integration of sorbent injection with particulate control can provide control of both mercury and HCl
  – Sorbent selection and system design are critical
ICI Boiler Emission Limits

• Hg and HCl emissions are fuel-specific, therefore all solid fuels (Coal and Biomass) have the same limits
  – Gas and liquid fuels have separate limits
• PM and CO are equipment-specific, so limit depends on the type of combustion system and the fuel
• Dioxin/furan emissions regulated under at work practice standard
ICI Boiler Limits: How Do They Compare with Electric Utility Limits?

- Example: Coal-Fired Stoker, Bituminous Coal

<table>
<thead>
<tr>
<th>Boiler MACT Limits:</th>
<th>Utility MATS Limits:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PM, lb/MMBtu</strong></td>
<td><strong>PM, lb/MMBtu</strong></td>
</tr>
<tr>
<td><strong>HCl, lb/MMBtu</strong></td>
<td><strong>HCl, lb/MMBtu</strong></td>
</tr>
<tr>
<td><strong>Hg, lb/Tbtu</strong></td>
<td><strong>Hg, lb/Tbtu</strong></td>
</tr>
<tr>
<td>0.028</td>
<td>0.03</td>
</tr>
<tr>
<td>0.022</td>
<td>0.002</td>
</tr>
<tr>
<td>3.1</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Estimated emission at Boiler MACT Limit:

- Filterable PM\(^1\), gr/dscf
- \(HCl^1\), ppmvd
- Mercury\(^1\), µg/dscm

- Filterable PM\(^1\), gr/dscf
- 0.017
- 20.0
- 4.3

Estimated control efficiency, based on fuel:

- HCl
- 19%
- 98%

- Mercury
- 65%
- 86%

\(^1\)Concentrations at 3% \(O_2\)

**INPUT COAL PROPERTIES**

<table>
<thead>
<tr>
<th>Coal Rank</th>
<th>As-received coal composition</th>
<th>Dry coal composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal S, wt%</td>
<td>Coal Cl, µg/g</td>
</tr>
<tr>
<td>Bituminous</td>
<td>3.60%</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>Coal Ash, wt%</td>
<td>Coal Hg, µg/g</td>
</tr>
<tr>
<td></td>
<td>10.30%</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Coal HHV, Btu/lb</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11,011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coal H(_2)O, wt%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.30%</td>
<td></td>
</tr>
</tbody>
</table>
The Compliance Challenge

• **Integrated Decisions**
  – Multiple regulations. Decisions on one pollutant may affect options for others

• **Tight Timeframes**
  – Many capital decisions must be made 2 to 3 years before implementation

• **Limited Resources**
  – Testing Services, Engineering and Construction Services, APC Equipment, Chemicals
Low CapEX Choices for ICI Boilers

• Units with hot-side ESP or Cyclones
  – No clear low capital options (mercury driver). A downstream fabric filter (TOXECON™) may be required.
  – Possible Hot-to-Cold Side ESP conversion

• Units with cold-side ESPs and Fabric Filters
  – Fuel (low mercury, low sulfur, low chlorine)
  – DSI as required to meet acid gas limits
  – Maximize ACI effectiveness
    • Minimize SO₃
      (DSI to mitigate or use alternative FGC)
Factors Affecting Mercury Control

- **Coal Type**
  - Halogen content (Cl, Br, other)
  - Sulfur content
  - Mercury content

- **Flue Gas**
  - Acid Gases (HCl, SO$_2$, SO$_3$)
  - Gas Temperature **

- **Boiler type**

- **Emission Control Equipment** (e.g. SCR, ESP, FF, etc.)

- **ACI Design**
  - Distribution, residence time, sorbent characteristics

**Similar factors affect Hg removal from native carbon in ash and activated carbon injection**

** High flue gas temperature. may require addition of economizer/air heaters
Halogen addition at various full-scale PRB boilers

Source: Dombrowski et al., 2006
Benefits of Oxidized Mercury

Many plants’ APCDs can take advantage of native capture...if there’s enough oxidized Hg (Hg$^{2+}$)
## Activated Carbon Injection

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Range of AC for 90% Control (lb/MMacf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRB/SDA/FF</td>
<td>1 to 3</td>
</tr>
<tr>
<td>PRB/Toxecon</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Bit/Toxecon</td>
<td>2 to not achieved</td>
</tr>
<tr>
<td>PRB/ESP</td>
<td>2 to not achieved</td>
</tr>
<tr>
<td>Bit/ESP</td>
<td>2.5 to not achieved</td>
</tr>
</tbody>
</table>

EPA Estimates 141 GW new ACI for utility boilers alone. Does not even count Industrial Boiler needs.
Activated Carbon Injection Summary of PC Fired Utility Boiler Mercury Control Results

![Graph showing Hg Removal (%) vs. Injection Concentration (lb/MMacf) for different systems: PRB ESP, SDA + FF, ESP with SO₃ Conditioning, LS Bit ESP, and HS Bit ESP.]}
SO₃ Injection and PAC Effectiveness

- SO₃ is used to condition fly ash for better capture in ESPs.
- Typical injection targets < 10ppm in gas phase.
- Any SO₃ in gas phase appears to affect Hg capture.

Ameren Labadie Data: DOE DE-FC26-03NT41986 and EPRI PRB, ESP.

**Mississippi Power Plant Daniel**
Low sulfur bituminous coal
Compliance Strategies for HCl

- **Scrubbed Units** typically achieve sufficient HCl removal
- **Unscrubbed Units:**
  - Biomass: Wide range of coal chlorine, depending on biomass source; some control might be needed
  - Subbituminous-fired: Little or now control required to keep HCl below limit
  - Bituminous-fired: HCl limits may be difficult to achieve without FGD
  - *DSI may be used, depending on coal chlorine content*
Dry Sorbent Injection (DSI) Sorbents for Acid Gases (SO$_2$, HCl, SO$_3$)

- Different sorbents have been used for removal of acid gases:
  - Limestone
  - Ca(OH)$_2$
  - MgO, Mg(OH)$_2$
  - Trona (sodium sesquicarbonate), sodium bicarbonate, sodium bisulfite

- Considerations in choosing a specific sorbent
  - What needs to be removed?
  - Level of control needed?
  - Balance-of-plant impacts
DSI and HAPs Compliance

• Acid Gases (HCl):
  ✓ Alkali injection can be effective for HCl trim control

• Mercury (Hg):
  ✓ Alkali injection can effectively be used to protect AC by lowering SO$_3$

• PM:
  ◇ Must consider potential impacts
Options for Total PM

- New fabric filter or ESP upgrade might be required
- Hot to Cold-Side ESP conversions (as needed)
- DSI + ACI + FF may be a viable option for to achieve combined HCl, Hg and PM controls (where coal sulfur and chlorine is limited)
Coal to Stack: Integrated Approaches for Multi-Pollutant Compliance

Examples:

• Fuel (low mercury, low sulfur, low chlorine)
• DSI as required to meet HCl limits and/or control SO$_3$ to maximize ACI effectiveness
• Utilize coal additives to manage ACI usage and Hg removal effectiveness
DSI-ACI Synergy: Example

Medium-sulfur bituminous plant
Lime injection to reduce SO$_3$ => improve ACI performance for Hg control
DSI-ACI Synergy: Example

Low-sulfur bituminous plant with SCR
Trona injection to reduce $\text{SO}_3$ => improve ACI performance for Hg control
Summary

HCl
- 0-90%% control required for coal-fired units – less reduction (if any) for biomass-fired units
- Bituminous coals have higher chlorine and require higher reductions

Mercury
- 65-90%% control required for coal-fired units – less reduction (if any) for biomass-fired units
- Achievable on most subbituminous and biomass units
- Limits may be challenging on units with higher sulfur coals and may require SO₃ mitigation

Total PM
- May result in new fabric filters or hot- to cold-side ESP conversions
Creating a Future with Cleaner Coal

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