Mercury Measurement and Control

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ADA Environmental Solutions

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.

NASDAQ: ADES

www.adaes.com
Topics to Cover

- Overview of MATS for existing & new plants
- Measurement of Hg
- Capabilities of available control technologies for mercury control
- Coal to Stack: Integrated approaches for multi-pollutant compliance
MATS Final Limits (Coal)

- Standards for **new** units are based on outputs

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Filterable PM</th>
<th>HCl</th>
<th>Mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td>New coal, ≥8300 Btu/lb</td>
<td>0.007 lb/MWh</td>
<td>0.0004 lb/MWh</td>
<td>0.0002 lb/GWh</td>
</tr>
<tr>
<td>New coal, &lt;8300 Btu/lb</td>
<td>0.007 lb/MWh</td>
<td>0.0004 lb/MWh</td>
<td>0.040 lb/GWh</td>
</tr>
<tr>
<td>Existing coal, ≥8300 Btu/lb</td>
<td>0.30 lb/MWh</td>
<td>0.020 lb/MWh</td>
<td>0.013 lb/GWh</td>
</tr>
<tr>
<td>Existing coal, &lt;8300 Btu/lb</td>
<td>0.30 lb/MWh</td>
<td>0.020 lb/MWh</td>
<td>0.040 lb/GWh</td>
</tr>
</tbody>
</table>

- Standards for existing units are based on inputs
- Standards for new units (bituminous, subbituminous) are ~65 times lower than for existing units!
Mercury Measurement

• Continuous measurement of Hg required
  – CEM or Sorbent Trap
• Emissions averaging
  – For existing bituminous/subbituminous units, limit of 1.2 lb/TBtu (30-day average) or 1.0 lb/TBtu (90-day average)
• Facility-wide averaging for similar units
• Challenges in measuring very low levels of Hg
The Compliance Challenge

• **Integrated Decisions**
  Multiple regulations. Decisions on one pollutant may affect options for others
  Long-range, multi-plant CapEx decisions, fuel decisions

• **Tight Timeframes**
  Implementation by 2015 for MATS and CSAPR
  Rapid, informed decisions are now required

• **Limited Resources**
  Testing Services, Engineering and Construction Services, APC Equipment, Chemicals
Fuel Choice Affects MATS Compliance

• Mercury inputs vary by region and by mine within a region
  
  MATS sets limits on Hg emissions, not percent reduction
  
  The bar is higher (for control) when Hg input is higher

• SO$_2$ and HCl emissions might also have to be controlled under MATS (or CSAPR)

• Sulfur and chlorine in coal affect ability to reduce Hg emissions

• Finding the perfect MATS coal…?
# MATS Compliance Limits: Example for Existing Bituminous Plant

**Final MACT Limits:**

<table>
<thead>
<tr>
<th></th>
<th>PM, lb/MMBtu</th>
<th>HCl, lb/MMBtu</th>
<th>SO$_2$, lb/MMBtu$^1$</th>
<th>Hg, lb/TBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.03</td>
<td>0.002</td>
<td>0.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*Estimated control efficiency, based on fuel:*

<table>
<thead>
<tr>
<th></th>
<th>HCl</th>
<th>SO$_2$,%$^1$</th>
<th>Mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>98%</td>
<td>97%</td>
<td>86%</td>
</tr>
</tbody>
</table>

$^1$Alternate acid gas limit for units with scrubbers

$^2$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 Ash, wt%</td>
</tr>
<tr>
<td>Bituminous</td>
<td>3.60%</td>
<td>10.30%</td>
</tr>
</tbody>
</table>
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*
Native Mercury Removal (Average %): The Good, the Bad, and the Ugly…

<table>
<thead>
<tr>
<th></th>
<th>Bituminous</th>
<th>Subbit.</th>
<th>Lignite</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSESP</td>
<td>41</td>
<td>17</td>
<td>-2</td>
</tr>
<tr>
<td>+ WFGD</td>
<td>73</td>
<td>21</td>
<td>45</td>
</tr>
<tr>
<td>HS ESP</td>
<td>22</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>+ WFGD</td>
<td>44</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>FF</td>
<td>87</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>+ WFGD</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDA + FF</td>
<td>95</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>SDA + ESP</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>WPS</td>
<td>14</td>
<td>-2</td>
<td>30</td>
</tr>
<tr>
<td><strong>Projected for MATS</strong></td>
<td><strong>80-90</strong></td>
<td><strong>80-90</strong></td>
<td><strong>60-90</strong></td>
</tr>
</tbody>
</table>

Analysis of 1999 EPA ICR data
SCR plus FGD Increases Hg Removal

Source: Bituminous-fired plants from Consol sampling program
SCR-FGD Reduces Hg Emissions

…but >90% removal not always achieved and trim control with ACI might be needed

Source: Bituminous-fired plants from Consol sampling program
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$^{2+}$)
Halogens in Wet Scrubbers

- Adding halogens (Cl or Br) increases oxidized Hg, which increase capture of Hg in scrubber
- Wet FGD scrubbers remove halogens efficiently
  - Average Cl removals for wet FGDs (2010 ICR): 81% for subbituminous, 97% for bituminous
  - Removal of Br at Plant Miller wet FGD: 94-96%
    (Dombrowski et al., 2008)
- Halogens build up in wet scrubber liquor
Corrosion in Flue Gas

- Chlorine corrosion in furnaces can occur for very high levels of chlorine in coal (> 2000 µg/g)
  - Bromine addition at much lower concentrations
- Indirect evidence that HBr might be more corrosive than HCl at flue gas temperature
- No direct comparison, but HBr corrosion higher than baseline (no HBr) in simulated flue gas (6-month study)

Zhuang et al., 2009

![Graph showing corrosion loss vs. temperature with data points for Baseline and 51 ppmv HBr.](graph.png)
More than 1100 units in operation
~ 317 GW
~ 66% have SO$_2$ or NOx controls
Unscrubbed units
~ 50 GW bituminous
~ 60 GW subbituminous

*http://www.eia.gov
## 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
Activated Carbon Injection Performance Depends on Fuel Choice

- PRB ESP
- LS Bit ESP
- HS Bit ESP
- ESP with SO₃ Conditioning
- SDA + FF

Hg Removal (%) vs. Injection Concentration (lb/MMacf)
SO$_3$ Injection and PAC Effectiveness

- Any SO$_3$ in gas phase appears to affect Hg capture
  - SO$_3$ is used to condition fly ash for better capture in ESPs
  - SO$_3$ higher in bituminous flue gas, especially after SCR
- Typical injection targets < 10ppm in gas phase

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

Mississippi Power Plant Daniel
Low sulfur bituminous coal
Compliance Strategies for Mercury

• 80 to >90% control at the stack to meet proposed MATS emission limits required for most units

• For units with FGD/SCR:
  
  Low conversion SCR catalyst and minimize ammonia slip
  Minimize re-emission of Hg\(^0\) from wet FGD

• MATS limits achievable with ACI or ACI + coal additives on most subbituminous units if SO\(_3\) flue gas conditioning (FGC) is eliminated

• MATS limits may be challenging on units with higher sulfur coals and may require SO\(_3\) mitigation
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
- Manage SCR operation and catalyst choice to increase fraction of oxidized mercury and resulting removal in WFGD
- Utilize coal additives to manage ACI usage and Hg removal effectiveness
DSI-ACI Synergy: Example

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

Low-sulfur bituminous plant with SCR

Trona injection to reduce SO$_3$ => improve ACI performance for Hg control

![Diagram showing the effect of SO$_3$ sorbent, temperature, and milling on vapor-phase removal.](image-url)
Summary: The Multi-Pollutant View

Mercury
- 80 to >90% control required for most units
- Achievable on most subbituminous units if SO$_3$ FGC is eliminated
- Limits may be challenging on units with higher sulfur coals and may require SO$_3$ mitigation

HCl
- > 90% control required for most bituminous units. May require new scrubbers for some units.
- < 80% control required for most plants with low-rank coals. Should be achievable with fuel management, DSI or existing FGD for most plants.

Total PM
- May result in several new fabric filters
Energizing the Future with Cleaner Coal

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