Mercury Control from Coal to Stack

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Disclaimer

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Two Ways to Remove Mercury

- Adsorb Hg on particles
  - Unburned carbon in fly ash
  - Sorbent injection
  - Fixed adsorption structures

- Absorb oxidized Hg (Hg$^{2+}$)
  - Wet flue gas desulfurization (FGD) scrubbers
  - Dry FGD scrubbers

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Factors Affecting Mercury Emissions

Boiler Type
Combustion efficiency (LOI)
Coal

Mercury
Halogens (native or added)
Sulfur
Ash, calcium, etc.

SO₂ to SO₃ conversion
Hg Oxidation
Temperature

PM Control
Type
Temperature

SO₃ for FGC

SO₂ Control
Type
Hg re-emissions
Water management

APH

Type
Temperature

Halogen Oxidized Hg

FGD

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**Native Mercury Removal (Average %)**

<table>
<thead>
<tr>
<th>type</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>91</td>
<td>45</td>
</tr>
<tr>
<td>HS ESP</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ WFGD</td>
<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FF</td>
<td>87</td>
<td></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>

SCRs can increase Hg removal, especially for scrubbed units.
Mercury Control: Case Studies

PRB Base Case

Average: 17%*

Low Cl, Low S

Boiler
APH
ESP
Stack

*Analysis of 1999 EPA ICR data
Mercury Control: Case Studies

Low Cl, Low S

≥ 90% Achievable
Activated Carbon Injection (ACI) PRB Coal Results

Hg Removal (%)

Injection Concentration (lb/MMacf)

PRB ESP

SDA + FF

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Impact of Temperature on PAC

- The capacity of carbon for mercury decreases significantly within the range of typical APH outlet temperatures.
- The impact of changes in capacity are more pronounced on fabric filters than on ESPs.

**Equilibrium Capacity (µg/m³) at 8 µg/m³ Hg**

- Lab Fixed Bed Data

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Activated Carbon Injection (ACI) PRB Coal Results

- Hg Removal (%)
- Injection Concentration (lb/MMacf)

- SDA + FF
- PRB ESP
- ESP with SO$_3$ Conditioning

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SO$_3$ and ACI Performance

MRC Results: 10 lb/MMacf, injection upstream of APH
APH Inlet: 627 F; APH outlet: 300 F (assume 1 ppm baseline SO$_3$)

SO$_3$ and temperature have compounding negative impact on PAC
PAC Performance with FGC

Eliminating SO$_3$ FGC can provide significant PAC savings.
Addition of Halide Salts to PRB Boilers

- Increases oxidized Hg (SCRs often enhance effect)
- Can improve effectiveness of LOI and activated carbon
- Can increase capture of Hg in scrubber

Potential balance-of-plant impacts:
- Increased corrosion risk
- Halogens build up in wet scrubber liquor

Average Cl removals for wet FGDs (2010 ICR): 81% for subbit, 97% for bituminous
Removal of Br at Plant Miller wet FGD: 94-96% (Dombrowski et al., 2008)

Source: Dombrowski et al., 2006
Mercury Control: Case Studies

Poor removal expected without added ACI or halogen

Low Cl, Low S

<table>
<thead>
<tr>
<th></th>
<th>Boiler</th>
<th>SCR</th>
<th>APH</th>
<th>ESP</th>
<th>FGD</th>
<th>Stack</th>
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</thead>
<tbody>
<tr>
<td>HgP</td>
<td></td>
<td></td>
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<tr>
<td>Hg2+</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Hg0</td>
<td></td>
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</tr>
</tbody>
</table>
Mercury Control: Case Studies

**Halogen**

Little additional Hg removal without carbon

- **Low Cl, Low S**

- **Boiler**
  - APH
  - ESP
  - Stack

- **HgP**
- **Hg2+**
- **Hg0**
Mercury Control: Case Studies

Halogen

WFGD can remove soluble mercury

Low Cl, Low S

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Mercury Control: Case Studies

Some oxidized mercury may be converted to elemental in the WFGD.

- Low Cl,
- Low S

Potential Re-Emissions

- HgP
- Hg2+
- Hg0
Halogen

SCRs can increase Hg oxidation

Low Cl, Low S

Boiler, SCR, APH, ESP, FGD, Stack

HgP, Hg2+, Hg0
Mercury Control: Case Studies

Halogen

SCRs can increase Hg oxidation

Potential Re-Emissions

Low Cl, Low S

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PAC and High Sulfur Coal

Typical Removal Required for MATS Compliance

High Sulfur (2.8 wt%) Bituminous Coal
Cold Side ESP

PAC Injection Rate (lb/MMacf)

- FastPAC™ Premium
- FastPAC™ Premium S
- FastPAC™ Premium S + Hydrated Lime

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Base Case #2
Low Cl, High S

Low Cl, High S

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Advancing Cleaner Energy
Mercury Control: Case Studies

MATS compliance may be challenging.

Low Cl, High S

Boiler
APH
ESP
FGD
Stack

HgP
Hg2+
Hg0

Advancing Cleaner Energy

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DSI can improve PAC effectiveness

... but will it be enough?

Low Cl, High S
Improving Mercury Control in Wet Scrubbers

- High Hg conversion catalysts
- Reduce SCR Temperature
- Increase halogen content if coal levels are low
- Halogens
- Carbon
- Other Additives
- Novel structures

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Mercury Control: Case Studies

Halogen

Low Cl, High S

Limit Re-emissions

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Mercury Control: Case Studies

Halogen

Low Cl, High S

Boiler  |  SCR  |  APH  |  ESP  |  FGD  |  Stack

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Removing Oxidized Mercury in WFGDs

- Southern Company Plants with SCR, ESP, WFGD
- More than 40 months of WFGD operations
- Mercury control greater than 90% was achieved 47% of the time
- Important factors include SCR temperature, age, coal halogen

Corey A. Tyree, Southern Company, 2010
Factors Affecting Hg Oxidation Across SCRs

Some plants may achieve good oxidation EXCEPT during summer months and ozone season.

- Higher temperature $\rightarrow$ Lower oxidation
- Higher ammonia $\rightarrow$ Lower oxidation

Shintaro Honjo, Mitsubishi Heavy Industries America, Mega Symposium 2012
Coal to Stack: Integrated Approaches for Multi-Pollutant Compliance

Example: Fuel (low Hg, low S, low Cl)

Activated carbon for mercury control
Coal additives to manage ACI usage and Hg removal effectiveness
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

Scrubber additives or manage scrubber operation as needed to limit re-emissions
Example: Fuel (high Hg, high S, high Cl)

WFGD to control oxidized Hg, SO\textsubscript{2} and HCl

*Scrubber additives and/or manage scrubber operation as needed to limit re-emissions*

SCR: Manage SCR operation and catalyst choice to control NO\textsubscript{x}, increase fraction of oxidized mercury (and resulting removal in WFGD)

*Choose catalyst to limit SO\textsubscript{3} conversion*

ACI trim as needed with DSI as required to control SO\textsubscript{3} to increase ACI effectiveness when required (e.g. summer operation)
Compliance Strategies for Mercury

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

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

► For units with SCR/FGD:
  - Low conversion SO$_2$ → SO$_3$ SCR catalyst and minimize NH$_3$ slip
  - Provide sufficient halogens to oxidize the Hg
  - Minimize re-emission of Hg$^0$ from wet FGD
  - Use ACI as needed for trim

► MATS limits may be challenging on units with higher sulfur coals. Year round compliance may require SO$_3$ mitigation and careful WFGD re-emissions management
Final Thoughts

► Plan early
► Build a coal-to-stack compliance plan
► Get the right people in the conversation

Don’t be fooled

Mercury has a reputation of being a trickster
Questions?