Mercury Control Technology – A Review

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4th i-CIPEC
September 27 – 29, 2006

Kyoto, Japan
Mercury Emissions from Power Plants Cause Human Exposure to Mercury

- **Power Plant Emissions**
- **Wet and Dry Deposition**
- **Atmospheric deposition**
  - Lake
  - Ocean
- **Fishing**
  - Commercial
  - Recreational
  - Subsistence
- **Mercury transforms into methylmercury in soils and water, then can bioaccumulate in fish**
- **Impacts**
  - Best documented impacts on the developing fetus: impaired motor and cognitive skills
  - Also: cardiovascular, immune, and reproductive system impacts
- **Humans and wildlife affected primarily by eating contaminated fish**

**Emissions Reductions**
- Reduce Atmospheric Transport and Deposition
- Reduce Ecosystem Transport and Methylation
- Reduce Human and Wildlife Exposure
- Reduce Health Impacts
Health Impacts

• Known to bioaccumulate in fish and animal tissue in its most toxic form, methylmercury.

• Human exposure to methylmercury associated with serious neurological and developmental effects.

• Adverse effects on fish, birds, and mammals include reduced reproductive success, impaired growth, behavioral abnormalities, and even death.
Regional and Global Transport of Mercury

$\text{Hg}_p$ is easily captured in PM control device in the power plant – very little is emitted

Hg$^0$ vapor is difficult to capture and tends to be transported globally

Hg$^{2+}$ may be captured in a wet SO$_2$ scrubber. The Hg$^{2+}$ vapor species that are emitted tend to deposit locally and regionally
U.S. anthropogenic mercury emissions are estimated to account for roughly three percent of the global total, and emissions from the U.S. power sector are estimated to account for about one percent of total global emissions.

U.S. Anthropogenic Mercury Emissions

Source: EPA
Two Recently Promulgated EPA Rules  
(March 2005)

- **Clean Air Interstate Rule (CAIR)** - http://www.epa.gov/cleanairinterstaterule/
  - Creates a **two-phase program** with declining emission caps
    - for NOx (for PM-2.5 and ozone control) in 2009 and 2015, and
    - for SO₂ (for PM-2.5 control) in 2010 and 2015
    - based on application of highly cost effective controls to large EGUs.

- **Clean Air Mercury Rule (CAMR)** – http://www.epa.gov/oar/mercuryrule/
  - Establishes limits on mercury emissions from new and existing coal-fired power plants and creates a market-based cap-and-trade program that will reduce nationwide utility emissions of mercury in two distinct phases
    - **Phase I (2010):** Cap is 38 tons; most mercury reductions resulting from “co-benefit” (reductions from SO₂/NOₓ/PM control technologies)
    - **Phase II (2018):** Cap is 15 tons; additional mercury-specific control technologies will likely be necessary for deeper mercury reductions.
Clean Air Mercury Rule (CAMR)

- On January 30, 2004 EPA proposed regulations for power plant Hg control
- Clean Air Mercury Rule was promulgated on March 15, 2005
- CAMR establishes limits on mercury emissions from new and existing coal-fired power plants and creates a market-based cap-and-trade program that will reduce nationwide utility emissions of mercury in two distinct phases
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Power Plant Equipment and Mercury

Hg(0), Hg(II), Hg_p - form important for capture

Hg Removal in PM Controls
Hg adsorbed in fly ash is captured; FF more effective than ESP in Hg removal.

Hg Capture in Scrubbers/Spray Dryers
FGD effective in removing Hg(II), but not Hg(0); SCR can enhance capture in wet scrubber via Hg oxidation. SDA-FF/subbituminous coal combination removes Hg very effectively;
Mercury Capture in Wet Flue Gas Desulfurization (FGD) Scrubbers

- \( \text{Hg}^{2+} \) capture depends on solubility of each compound
- \( \text{Hg}^{0} \) is insoluble and cannot be easily captured.
- Removals in 80% to 90% range achievable
- Removal can be enhanced by using oxidizers and/or oxidizing catalysts (e.g., upstream SCR catalysts)
- In some cases \( \text{Hg}^{2+} \) is reduced to \( \text{Hg}^{0} \) in the scrubber solution
  - results in re-emission and lowering of overall Hg removal
  - chemical additives can prevent such reduction
- Research underway to better understand fate of Hg in FGD waste and FGD gypsum
Sorbent Injection for Hg Control

- Injection of powdered sorbent materials is the most widely studied Hg-specific control technology.

- Most testing has used coal-based powdered activated carbon (PAC)
  - But other inorganic sorbents have been tested and are still being developed

- Standard powdered activated carbon (PAC)
  - Relies on in-duct surface halogenation (by flue gas Cl₂ or HCl)
  - Effective for bituminous coals with adequate Cl content

- Pre-halogenated powdered activated carbons (Hal-PAC)
  - Pre-loaded with halogens (e.g., Cl, Br)
  - Effective for subbituminous coals with low Cl content
Sorbent Injection

The extent of capture depends on:

- Sorbent characteristics (particle size, porosity, capacity at different gas temperatures)
- Residence time in the flue gas
- Type of PM control (FF vs. ESP)
- Concentrations of SO$_3$ and other contaminants

**Option 1**
- Sorbent injection + Compact Hybrid Particulate Collector (COHPAC™)
- Potential solution to ash reuse problems

**Option 2: Electric Power Research Institute’s TOXECON™ System**
- Sorbent injection + Compact Hybrid Particulate Collector (COHPAC™)
- Potential solution to ash reuse problems

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**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*
Activated Carbon Injection (ACI)

Activated carbon injection system

Activated carbon storage and feed system

Injection lances

Flue gas duct

Storage silo
Field Testing Results 2001 – 2005
Comparison of Standard & Halogenated PAC

Mercury Removal (%) vs. Injection Concentration (lb / MMacf)

Enhanced PAC Performance
Standard PAC Performance

Source: DOE/NETL, 2005
Example of Full Scale Testing of Br-PAC

Detroit Edison St. Clair Plant - Total Hg Removal
Thirty Day Average = 94%

B-PAC Injection Rate = 3 lb/MMacf

Source: Sid Nelson, Sorbent Technologies Corporation
For additional information

http://www.epa.gov/mercury