Presentation Overview

- EGU MATS Compliance – *enough time*?
- Use of electronic HgCEM Systems for tuning Hg Abatement “Process”, on-line monitoring and optimization, and compliance monitoring
- NIST Traceability – current state of affairs
- Proposed EPA limits for RATA – and more reasonable RATA tolerances.
- Example data.
- Conclusions
2011 Federal Register Notices – Mercury and Air Toxics and New Source Performance Standards

- Electric utility (MATS) and boilers and incinerators NSPS
- Pollutants
  - NSPS - SO2, NOx, PM filter
  - MATS – HCl, HF, and Hg
  - Alternative limits – PM, non-Hg HAP metals, SO2
- Testing and monitoring appendices
  - Hg CEMS and sorbent trap CMS
  - HCl and HF CEMS
- 211 pages
  - FR notice - 3 column Table of Contents
  - MATS rule – 2 column Table of Contents
U.S. EPA EGU MATS and Cement MACT
Summary – [Hg] must be really low ~ 1.5 ug/m$^3$ for EGUs

- EPA Electric Generating Unit Mercury and Air Toxic Standards (MATS) promulgated January 2012
- Targeted MATS Pollutants and limits

- The EPA Portland Cement MACT
- Targeted MACT Pollutants and limits

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Existing Source Std.</th>
<th>New Source Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>1.2 lbs/T BTU</td>
<td>0.35 lbs/T BTU</td>
</tr>
<tr>
<td>PM</td>
<td>0.03 lbs/M-BTU</td>
<td></td>
</tr>
<tr>
<td>HCl</td>
<td>0.002 lbs/M BTU</td>
<td></td>
</tr>
<tr>
<td>THC</td>
<td>24 ppmvd</td>
<td>24 ppmvd</td>
</tr>
<tr>
<td>PM</td>
<td>0.07 lbs/ton clinker</td>
<td>0.02 lbs/ton clinker</td>
</tr>
<tr>
<td>HCl</td>
<td>3 ppmvd</td>
<td>3 ppmvd</td>
</tr>
<tr>
<td>Organic HAP (Alternative to THC)</td>
<td>12 ppmvd</td>
<td>12 ppmvd</td>
</tr>
</tbody>
</table>

Deadline for Compliance – April, 2015

Deadline for Compliance – September, 2015
Impact of Regulations

1. New Air Pollution Control Strategies
2. New or Improved Monitoring Technologies
3. Proof of Performance of 1 & 2
4. Compliance Monitoring and Reporting
5. Control Systems Performance Monitoring and Optimization
6. Plant Retirements

We are still in the learning process – and compliance deadlines on upon us!
All your measurements will be down here!
Economics of Hg Removal - 500 MWe Plant

Accurate Measurement and Traceability are Critical

Reduction in Hg emissions from 80 – 90% using ACI costs an additional $500K! (reduction from 1.0 to 0.6 µg/m³)
Accurately Measuring pptv - Levels of Mercury in Flue Gas

- 1 µg/m³ Hg = 112 parts per trillion (v/v)
- Many potential interferences and losses.
- Tekran R&D spent 1998 to 2003 understanding flue gas mercury reactions in the laboratory – and we’re still learning
- Mercury appears in different species
  - Elemental - Hg⁰
  - Ionic - Hg²⁺
  - Particulate-bound - Hgₚ
- Detectors can only measure Hg⁰
Oxidized mercury conversion and interference prevention: The Tekran approach (pat’d)

- Task: quantitatively convert all Hg$^{2+}$ to Hg$^{0}$ with no back reactions in the presence of high concentration redox compounds and reactive surfaces
- Proprietary thermal converter material set at 700C
- DI water mist injected into tail of thermal converter to “fix” Hg$^{0}$ from potential back reactions and eliminate interferences
- Gas is rapidly chilled, water condenses carrying away reactive compounds, and Hg$^{0}$ in a clean gas matrix goes to the analyzer

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New 3300xi HgCEMS
Same trusted components with improved physical design

3300 HgCEM

3300Xi HgCEM

2537Xi+ Analyzer
System controller

3310Xi
Hg\textsuperscript{0} Calibrator

3321
- Conditioner
- Controller
- Oxidizer Option

* wall mounted *
Tekran New Generation HgCEM System
3321 Sample Conditioner and Control Unit

Converter
Conditioner
Components

- HgCl₂ Generator
  - Oxidizer Type
  - Optional

- Modular Power Panel
- Modular Umbilical Heaters
- Probe Control Hardware
- Modular Electronics

Wall-mounted - cabinet closed
Tekran 3300Xi Dual Port Sampling

Applications:

- Mercury control technology
  - Research and development
  - Acceptance testing at new installations
  - Optimization and performance monitoring

- Regulatory monitoring of multiple, close-proximity emissions stacks.

www.tekran.com
EERC Study Low-Level Measurements (funded by EPRI, ICCI, CATM)
NIST Traceability Protocol

- Elemental Hg generators used vs. Hg cylinder gas.
- NIST Traceability involves unbroken chain of calibrators – and ongoing adherence to U.S. EPA traceability protocol.
- EGU’s typically 0 - 10 µg/m³
- Portland Cement - two levels
  - Mill On – e.g. (0-30 µg/m³)
  - Mill Off – e.g. (0 – 300 µg/m³)
- Corrections Required in Emissions if Calibration Fails
NIST Traceability Protocol for Hg Generators
Unbroken Chain of Comparisons

Slide courtesy of Jeff Ryan, U.S. EPA Clean Air Markets
## NIST Hg Generator Calibration Levels
(as received from NIST Dec. 2013)

<table>
<thead>
<tr>
<th>Low-Level (µg/m³)</th>
<th>High-Level (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Levels of Interest for EGU MATS and many Mill-On PC MACT Conditions</td>
<td></td>
</tr>
<tr>
<td>0.200</td>
<td>41.00</td>
</tr>
<tr>
<td>0.501</td>
<td>85.00</td>
</tr>
<tr>
<td>1.100</td>
<td>140.10</td>
</tr>
<tr>
<td>1.313</td>
<td>148.12</td>
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<tr>
<td>1.925</td>
<td>186.77</td>
</tr>
<tr>
<td>2.740</td>
<td>233.99</td>
</tr>
<tr>
<td>4.774</td>
<td>291.78</td>
</tr>
<tr>
<td>5.701</td>
<td></td>
</tr>
<tr>
<td>8.098</td>
<td></td>
</tr>
<tr>
<td>9.499</td>
<td></td>
</tr>
<tr>
<td>11.033</td>
<td></td>
</tr>
<tr>
<td>17.102</td>
<td></td>
</tr>
<tr>
<td>19.000</td>
<td></td>
</tr>
<tr>
<td>23.003</td>
<td></td>
</tr>
<tr>
<td>28.006</td>
<td></td>
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<tr>
<td>38.890</td>
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</tr>
</tbody>
</table>

Likely levels for Portland Cement Mill-Down Conditions
Method 30B

- This method is only intended for use only under relatively low particulate conditions (e.g., sampling after all pollution control devices).

- This method is designed to measure the mass concentration of total vapor phase Hg in flue gas, including elemental Hg (Hg\(^0\)) and oxidized forms of Hg (Hg\(^{2+}\)), in micrograms per dry standard cubic meters (µg/dscm).

- Sorbent Traps have:
  - mineral wool section (intended for PM),
  - primary capture section,
  - secondary (breakthrough) capture section
  - final mineral wool section

- Hg\(^{P}\) that is captured in the trap is included in the analysis.
Why do plants use Activated Carbon Injection, Bromine, etc.?

ACI captures Hg$^0$, Bromine helps oxidize Hg making it easier to capture on PM or in a scrubber. - Which increases the Hg content of the particulate!
The Electronic HgCEMS vs. Sorbent Trap

<table>
<thead>
<tr>
<th>Feature</th>
<th>Electronic HgCEMS</th>
<th>Sorbent Trap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost (including installation)</td>
<td>2+ times higher than Sorbent Trap</td>
<td>$75-$100K</td>
</tr>
<tr>
<td>Operations and Maintenance Costs (see next slide)</td>
<td>Lower than Sorbent Trap</td>
<td>- Requires routine retrieval and analyses of traps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Traps are consumables</td>
</tr>
<tr>
<td>Training and Complexity</td>
<td>Higher Level Training – more complex</td>
<td>- Comparatively simple to operate</td>
</tr>
<tr>
<td>Real-time feedback for Process and APCD</td>
<td>Valuable for “real-time” assessments and process feedback and control</td>
<td>- No capability for real-time feedback - data only available after days of exposure and analytical processing delays</td>
</tr>
</tbody>
</table>
The Electronic HgCEMS vs. Sorbent Trap Total Cost of Ownership

HgCEMS v. Appendix K Ownership Costs

Cumulative Cost of Ownership

- $800,000
- $600,000
- $400,000
- $200,000
- $0

Year of Operation of HgCEMS

0 1 2 3 4 5 6

HgCEMS
Vavg

www.tekran.com
- The 30B mercury coming from field blank, trap blank and particulate are always positive and must always be included in the 30B Total Hg.

- For the HgCEM, mercury scrubbing by the flyash on the filter may cause a negative bias.

- Dual 30B trap difference and analytical for both can cause positive or negative bias.

- Worst case is 0.38 ug/m³ difference between methods that pass all QA criteria.
EPA Allegheny Armstrong Plant
Comparison of Sorbent Trap Results

Figure E-5: Sorbent Trap Bias Error With Respect To OHM
Comparative 30B and Electronic HgCEM System Measurements

30B vs. 3300 HgCEMS RATA Results

Test Number  | Total Hg (µg/m³)  | Percentage Difference 30B-HgCEM
1-15          | 0.00-2.00         | 0%-100%

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- The 30B mercury coming from field blank, trap blank and particulate are always positive and must always be included in the 30B Total Hg.

- For the HgCEM, mercury scrubbing by the fly ash on the filter may cause a negative bias.

- Dual 30B trap difference and analytical for both can cause positive or negative bias.

- Worst case is 0.38 ug/m³ difference between methods that pass all QA criteria.
If Hg Concentrations > 50% of Emission Limit (i.e. > ~0.75 µg/m³) HgCEMS within **20%** of Method 30B

If Hg Concentrations < 50% of Emission Limit (i.e. <~0.75 µg/m³) HgCEMS within **10%** of Emissions Limit (i.e. 0.15 µg/m³)

**Opinions** –
- above tolerances -not practical or based on current empirical information.
- Run off of “Top Ten” RATA testers on same stack would be insightful
RATA “Do-Over” Dollars

RATA Rerun Expenses

- "Post Mortem" Communications: $7,500.00
- Planning of Re-Test: $10,000.00
- HgCEMS Tune Up: $10,000.00
- Plant Dispatch Impact: $20,000.00
- RATA Rerun: $15,000.00
- RATA Report Review: $7,500.00

Total Estimated Expense = $70,000
Where Are We Now in the U.S.?

- New parameters to be measured including PM, Hg, HCl, THC
- Low-level measurements and Reference-Methods challenges and potential disconnects
- EPA Published Updates of EGU MATS 17-Feb-2015 – Federal Register – out for review.
- We’re all still learning.
- Compliance deadlines in April 2015!