MAINTENANCE OF CONTINUOUS EMISSIONS MERCURY MONITORING SYSTEMS (HgCEMS) UNDER THE U.S. EPA PC MACT AND EGU MATS RULES

CEMTEK Environmental User's Group Meeting

by

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Hg CEMS Maintenance Overview

1. *These systems are more complicated than conventional CEMS*
2. Operator Training and Proficiency Realization may take months
3. Measurement levels are Parts per Trillion!
4. Mercury Speciation (Hg^0 and Hg^{2+}) (Hg^P ?) – Also multiple calibration gases and NIST Traceability Protocol
5. Heated Umbilicals and Mercury Transport Challenges?

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Some "Headwinds" in Meeting Lowered Emissions Limts – with Focus on Mercury

1. What is the Economic Impact? (e.g. implementation, Plant Closings, Jobs)?
2. Can One Measure New Low Limits of Parts per Trillion *(Says Who)*?
3. Calibration Gases and Traceability Protocols (Work in Progress)
4. Mercury Speciation (Hg^0 and Hg^{2+}) (Hg^P ?)
5. Heated Umbilicals and Mercury Transport Issues
6. Service, Maintenance and Percent Monitor Availability (PMA)
7. Relative Accuracy Test Audits (RATAs) (Methods and Training)
8. CEMS Data Acquisition and Handling Systems (DAHS) and Reporting
9. Use of HgCEM Systems for Compliance and Control

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SUMMARY OF ADVANCES IN CEM-BASED MERCURY FLUE-GAS MEASUREMENTS, STIMULATED BY :

US EPA EMISSION REGULATIONS & QA/QC

- CHALLENGES OF MEASURING Hg IN FLUE GAS

- PERFORMANCE EVALUATIONS AT LOW Hg LEVELS (PARTS PER TRILLION!)

- TECHNICAL ADVANCES

- INTERNATIONAL FOCUS (MINAMATA CONVENTION)

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U.S. EPA EGU MATS and Cement MACT

U.S. EPA Mercury Regulation	Existing Source Standard	New Source Standard	Deadline for Compliance (B)
Electric Generator Unit (EGU)MATS	1.2 lbs./T-BTU (A)	0.35 lbs./T-BTU	April 2015 +1
Portland Cement MACT	55 lbs./MM tons clinker	21 lbs./MM tons clinker	Sept. 2015 +1

- (A) Summary – for EGUs, mercury concentration must be really low at ~ 110 parts per trillion (v/v) = 1.5 µg/m^3 for EGUs *(Controlled Levels may be 50-75% of that)*

- (B) One-Year Compliance Extensions Granted by U.S. EPA

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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

Pollutant	Existing Source Std.	New Source Std.
Mercury	1.2 lbs/T-BTU	0.35 lbs/T-BTU
PM	0.03 lbs/M-BTU	
HCl	0.002 lbs/M-BTU	

Deadline for Compliance – April, 2016

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

Pollutant	Existing Source Std.	New Source Std
Mercury	55 lbs/MM tons clinker	21 lbs/MM tons clinker
THC	24 ppmvd	24 ppmvd
PM	0.07 lbs/ton clinker	0.02 lbs/ton clinker
HCl	3 ppmvd	3 ppmvd
Organic HAP (Alternative to THC)	12 ppmvd	12 ppmvd

Deadline for Compliance – September, 2015

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MACT Rules Finalized (finally)
Hg Emission Limits and Measurement Methods

(Courtesy of Andover Technology Partners)

Source	Limit	Units	Measurement	When?
Utility Boiler – not low rank	1.2	Lb/Tbtu (~1.5 ug/m^3)	Continuous	Apr, 2016
Utility Boiler – low rank	4	Lb/TBtu	Continuous	Apr, 2016
New Utility Boiler	0.003*	Lb/GWh (~0.35 ug/m^3)	Continuous	NA
Industrial Boiler	5.7	Lb/TBtu	Periodic (fuel or stack)	Jan, 2016
New Industrial Boiler	0.80	Lb/TBtu	Periodic (fuel or stack)	NA
Cement Kiln	55	Lb/million ton clinker	Continuous	Sep, 2016
New Cement Kiln	21	Lb/million ton clinker	Continuous	NA

* About 23% of the existing unit limit

- Continuous Measurements
  - Electronic CEMS (Continuous data)
  - Sorbent traps (Appendix K) (Continuous sample but not continuous data)
- Periodic measurements
  - Sorbent traps

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New RATA Limits from U.S. EPA

- New and tighter alternative performance specification for Hg RATAs for effluent concentrations $\leq$ 2.5ug/m^3.

$$\left|RM_{avg} - C_{avg}\right| + |CC| \leq 0.5 \text{ ug/m}^3$$

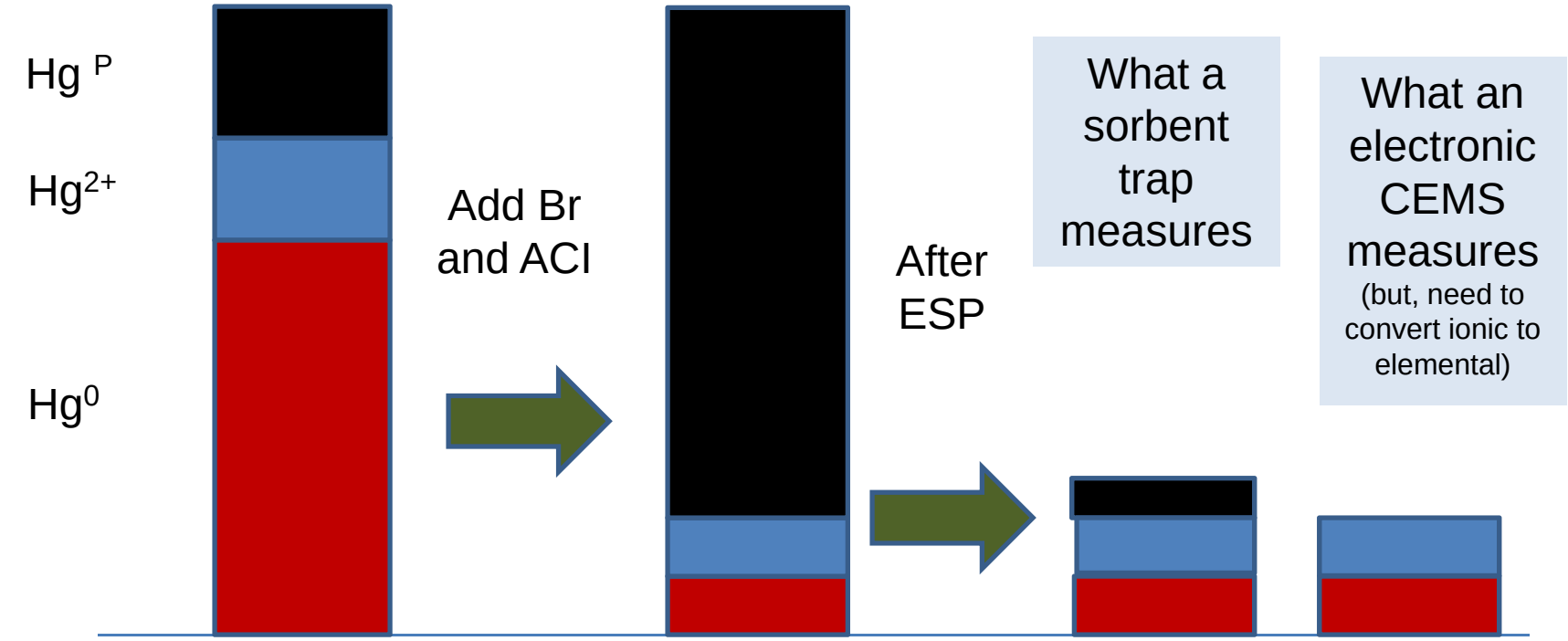
- Renewed interest in low level Hg measurements and calibrations standards used to calibrate Hg CEMS

Why do power plants add ACI and/or Br?

(Courtesy of Andover Technology Partners)

Br helps oxidize Hg^0 making it easier to capture on PM or in a scrubber, ACI captures Hg as Hg^P

- Which increases the Hg content of the fly ash!



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Situation Overview – New Resources

- HgCEMS Operations and Maintenance will require new plant resources, e.g.
  - *Development of a Monitoring Program*
  - *Training programs for HgCEMS personnel*
  - *HgCEMS Maintenance activities*
  - *Data Review and Reporting*
  - *RATA preparation and support*
  - *Possible training on use of electronic HgCEMS for APCD control*
- Portland Cement Plant I&C Staff already have “a full platter”

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Hg CEMS System Design, Performance and Support Criteria

- **Reliability** – system needs to provide high availability of data to support regulatory reporting and Hg abatement systems feedback
- **Service** – must be supported by trained Service personnel, available spare parts, etc.
- **Training Support Programs** – comprehensive training required for plant personnel and contractors to service and maintain CMMS.
- **NIST Traceability** – Hg generators need to be traceable to the National Institute of Standards and Technology (NIST)
- **Low- and High-Level Measurement Accuracy** – Accurate measurements will lead to accurate reporting and optimization of Air Pollution Control Devices

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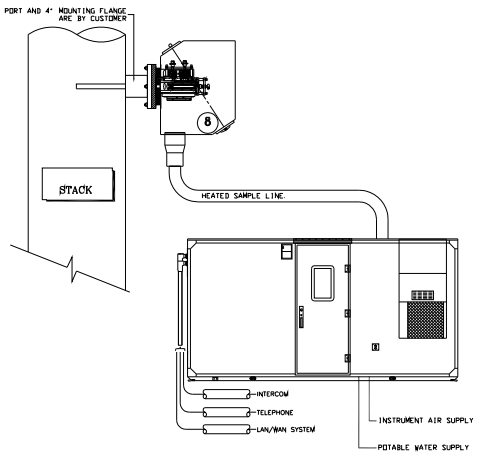
Typical CEMS Schematic with Shelter



Example Electronic HgCEMS

Consists of:

1. *Custom Dilution Probe (not shown)*
2. *Heated Transport Line (AKA "Umbilical" – not shown)*
3. *Elemental (Hg^0) Calibrator*
4. *Ionic (Hg^{2+}) Calibrator*
5. *Flue-Gas Conditioner*
6. *Trace-level Hg Analyzer*
7. *System Controller and Software (multiple options)*

HgCEMS Calibration Protocol

- Daily Elemental Mercury (i.e.Hg^0) "zero/spans" at levels which book-end normal plant emissions (e.g. 0-20 µg/m^3)
- Weekly/Regular high-level calibrations concurrent with Mill-Off Operations (e.g. 0-300 µg/m^3)
- Weekly "Integrity" tests – Ionic Mercury (i.e. Hg^{2+}) challenge
- Ongoing compliance with NIST Traceability Protocol

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What is NIST Traceability for Mercury About?

- EPA has released interim [1] traceability protocols for Hg calibrators (July 2, 2009)
  (http://www.epa.gov/airmarket/emissions/mercury/hgmonitoring.html)
- NIST & EPA preparing for EGU MATS and PC MACT by:
  - *Coordinating needs with anticipated EPA Guidelines*
  - *Generating lower certified concentrations of Hg (e.g. 0.2 µg/m3)*
  - *Providing higher ranges of calibration (30- 300+ µg/m3)*
  - *Certifying "Vendor Primes" for HgCEMS suppliers and customers.*

[1] – Even though termed "Interim", *they appear here to stay!*

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Mercury Generator Traceability

- There are no economical and accurate “gas bottle” standards for gaseous mercury calibration- Hg Generators are used for this purpose
- Hg Generators must be traceable to the National Institute of Standards and Technology (NIST)
- An ongoing Traceability program is required for HgCEMS operations.
- Figure on right shows “Vendor Prime” referenced against Field standards as part of “Hot Swap Program”

Hg Calibrators – HOT – Standby System for NIST Traceability

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NIST Traceability Protocol for Hg Generators

- Requirements extracted from EPA Interim Elemental and Ionic Protocol documents
  - Released: July 2, 2009
  - Establishes unbroken chain from NIST to “Vendor Prime” to Field calibrators and generators
  - Mercury “generators” are employed vs. gas bottle standards

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NIST Traceability - Continued

- Separate protocol documents for Elemental calibrators and Ionic calibrators
  - Uses “bracketing” to transfer certified concentrations from one generation to another
- Ionic Calibrators divided into:
  - Evaporative $HgCl_2$ generators
  - Converting $HgCl_2$ calibrators

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Importance of Hg CEMS Maintenance

- Helps maintain and insure accuracy of emissions data
- Routine maintenance may reduce long-term cost of HgCEMS ownership
- May assist in meeting thresholds for Percent Monitor Availability
- Provides important feedback on the performance of Air Pollution Control Devices (APCD)
- Can provide insights into related process variables such as Hg in limestone or shale

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Calibration Challenges with HgCEMS

- Calibrations Required at two levels
  - Mill On – e.g. (0-30 µg/m^3)
  - Mill Off – e.g. (0 – 300 µg/m^3)

- If High Level Off by >20%, Reported Hg Output must be corrected!

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Some Options for Hg CEMS Maintenance

Approach	Perspectives
1. Hire and Train In-house staff	- Promotes cross-utilization of talent in house - Likely 3-6 months learning curve - Subject to staff turnover impacts
2. Contract Outside	- Potentially higher costs? - Reduced cross-utilization of personnel?
3. Hybrid Approach	- Contract Regular (e.g. quarterly) service calls from CEMS supplier - Rely on Supplier – Dial Up (i.e. remote access) support and diagnostics

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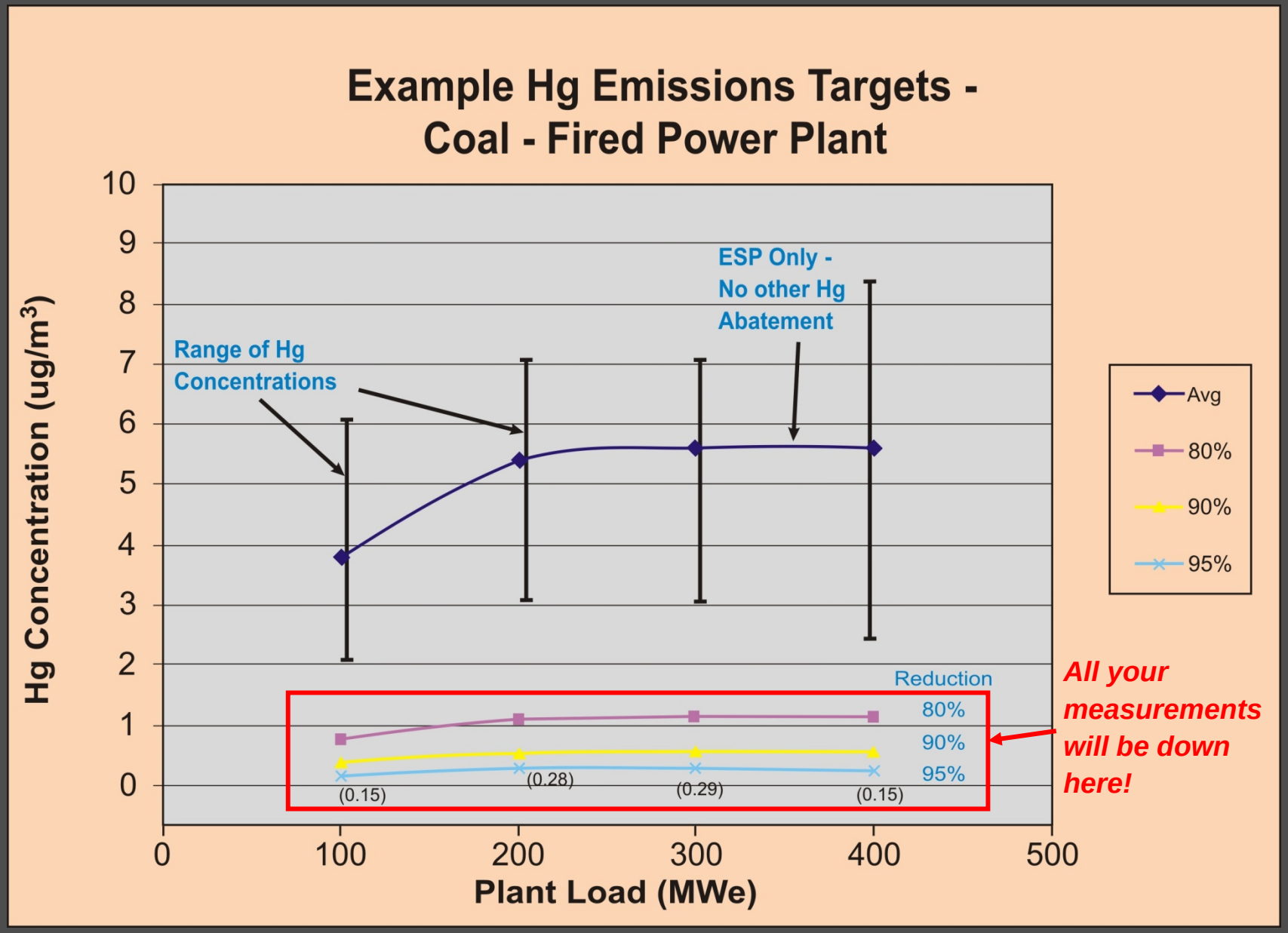
Passing a RATA Requires Preparation and Insight!

1. EPA has tightened RATA tolerances
2. The HgCEMS must be properly maintained
3. NIST Traceability is important (30B and HgCEMS!)
4. Understanding potential differences in Method 30B and Electronic HgCEMS is important
5. The cost and impacts of re-RATAs are large



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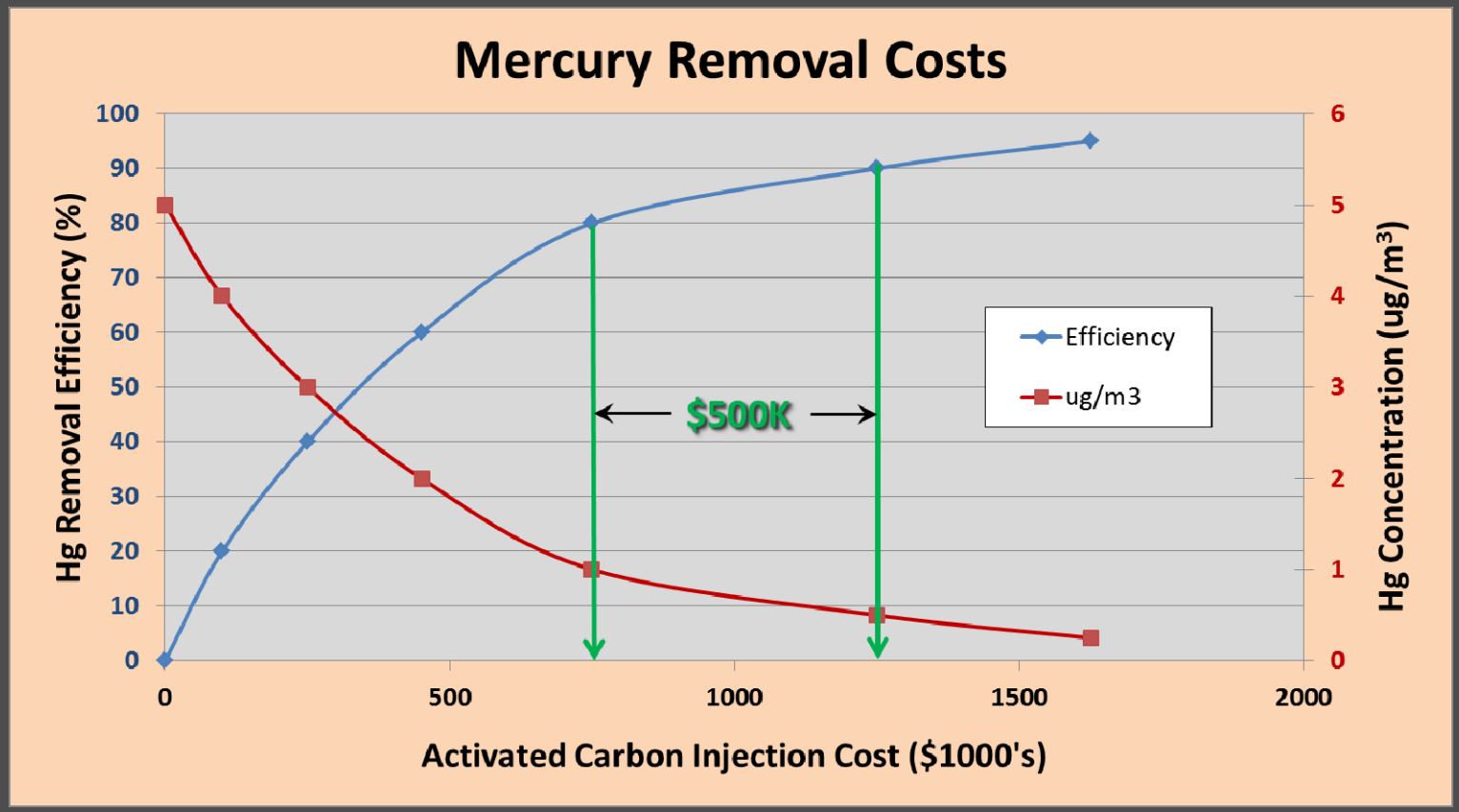
Economics of Hg Removal - 500 MWe Plant

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)

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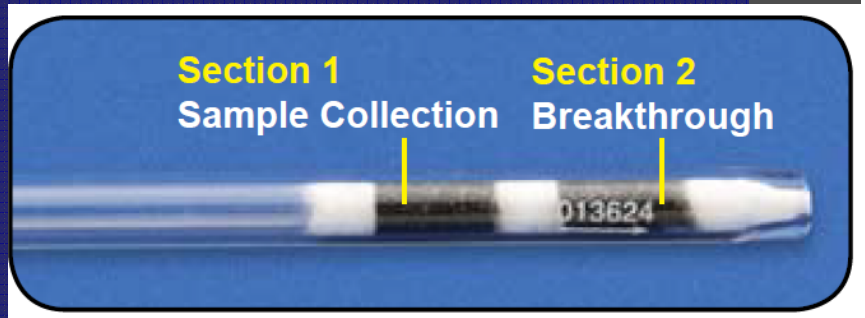
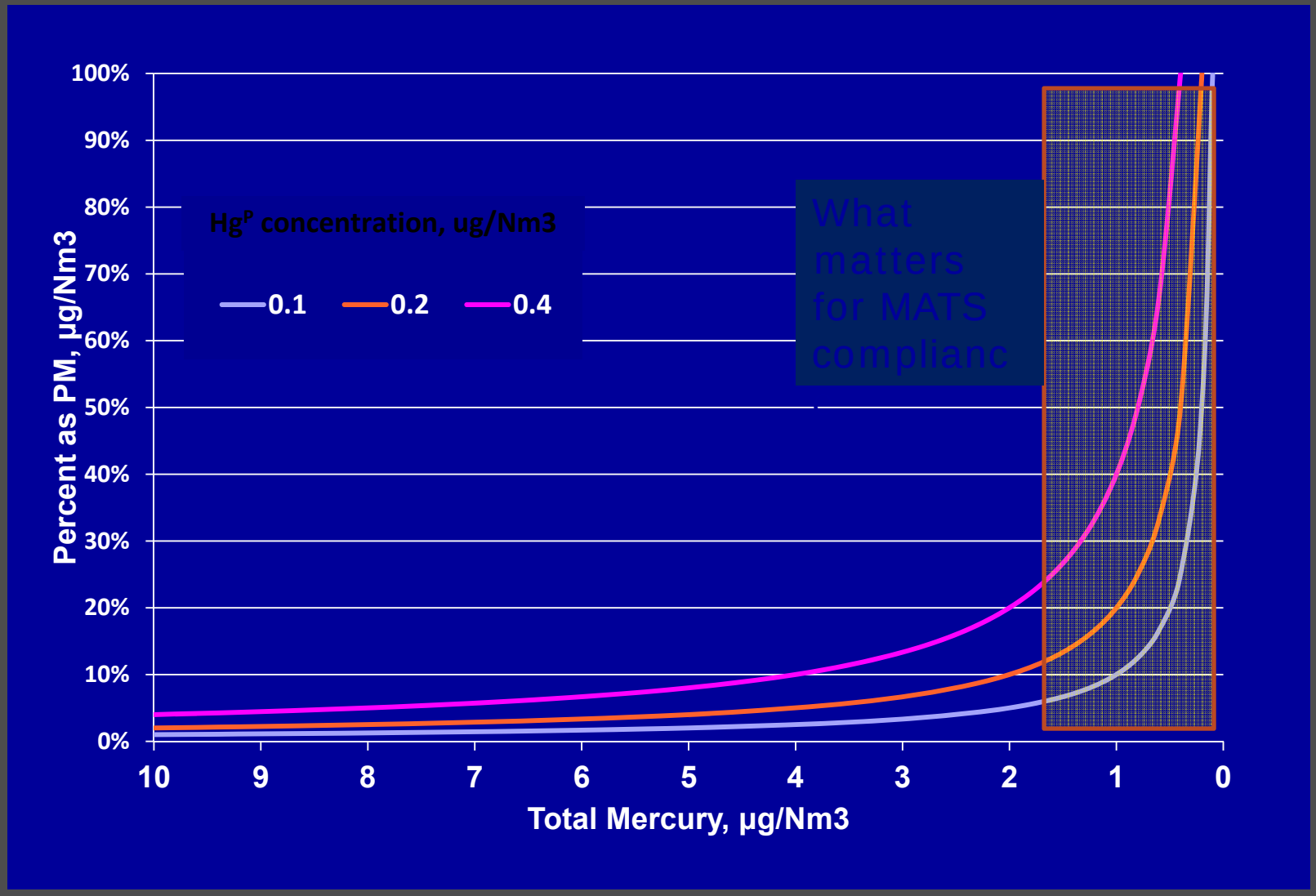
Method 30B

- 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,
  - primary capture section,
  - secondary (breakthrough) capture section
  - Final mineral wool section
- Hg^P that is captured in the trap is included in the analysis



Apex Method 30B Mercury Sorbent Traps

Impact of Hg^P on total Hg



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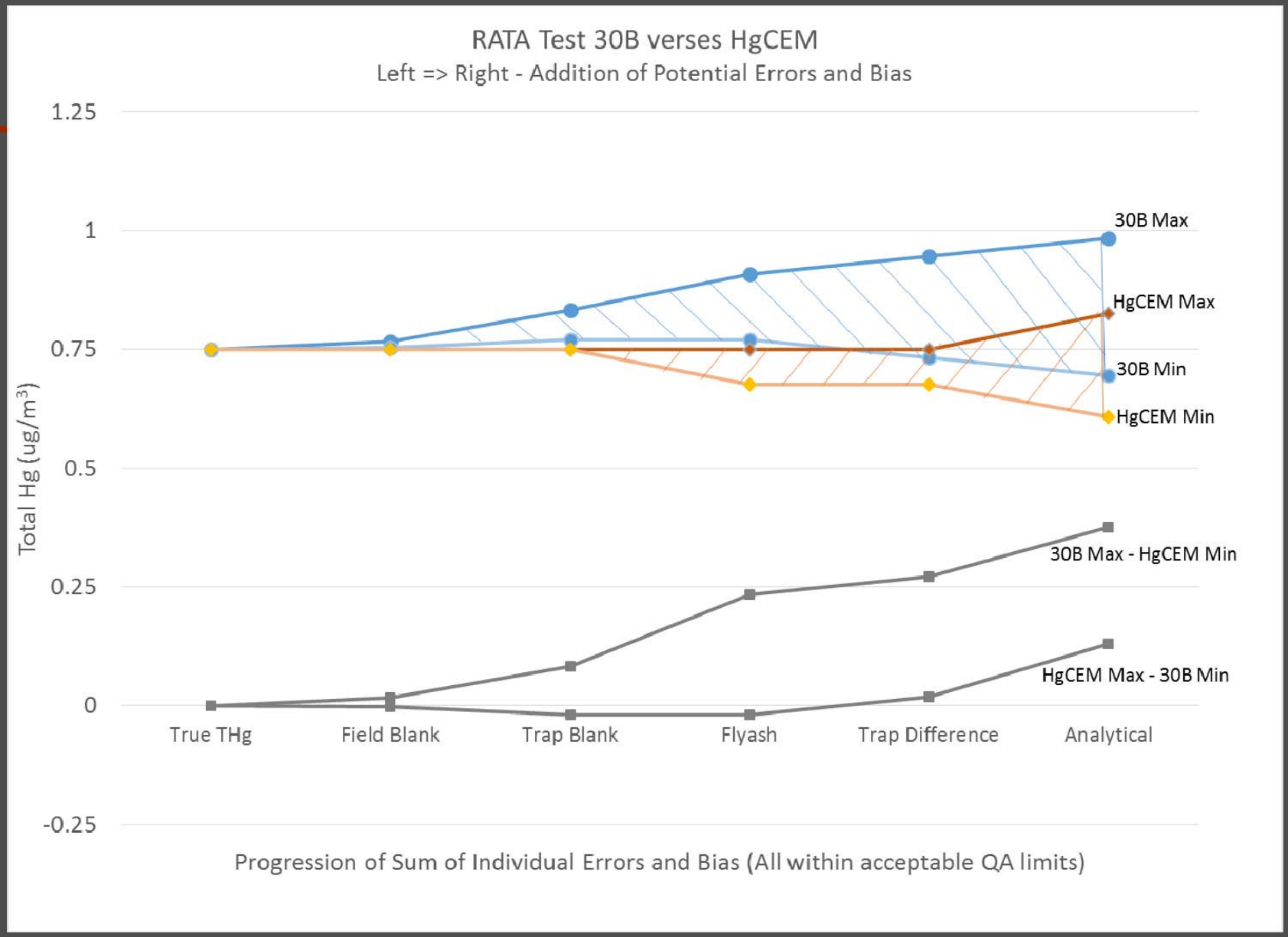

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EPA Allegheny Armstrong Plant Comparison of Sorbent Trap Results

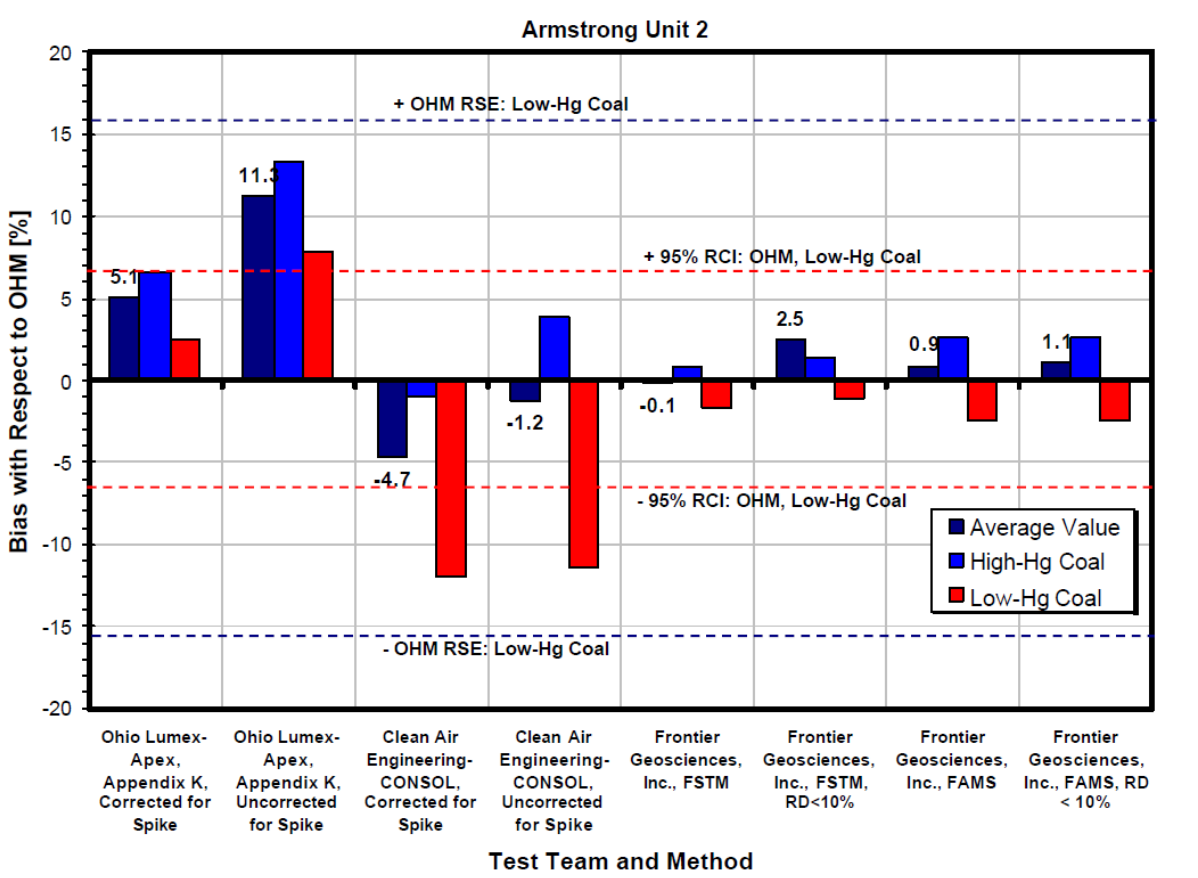
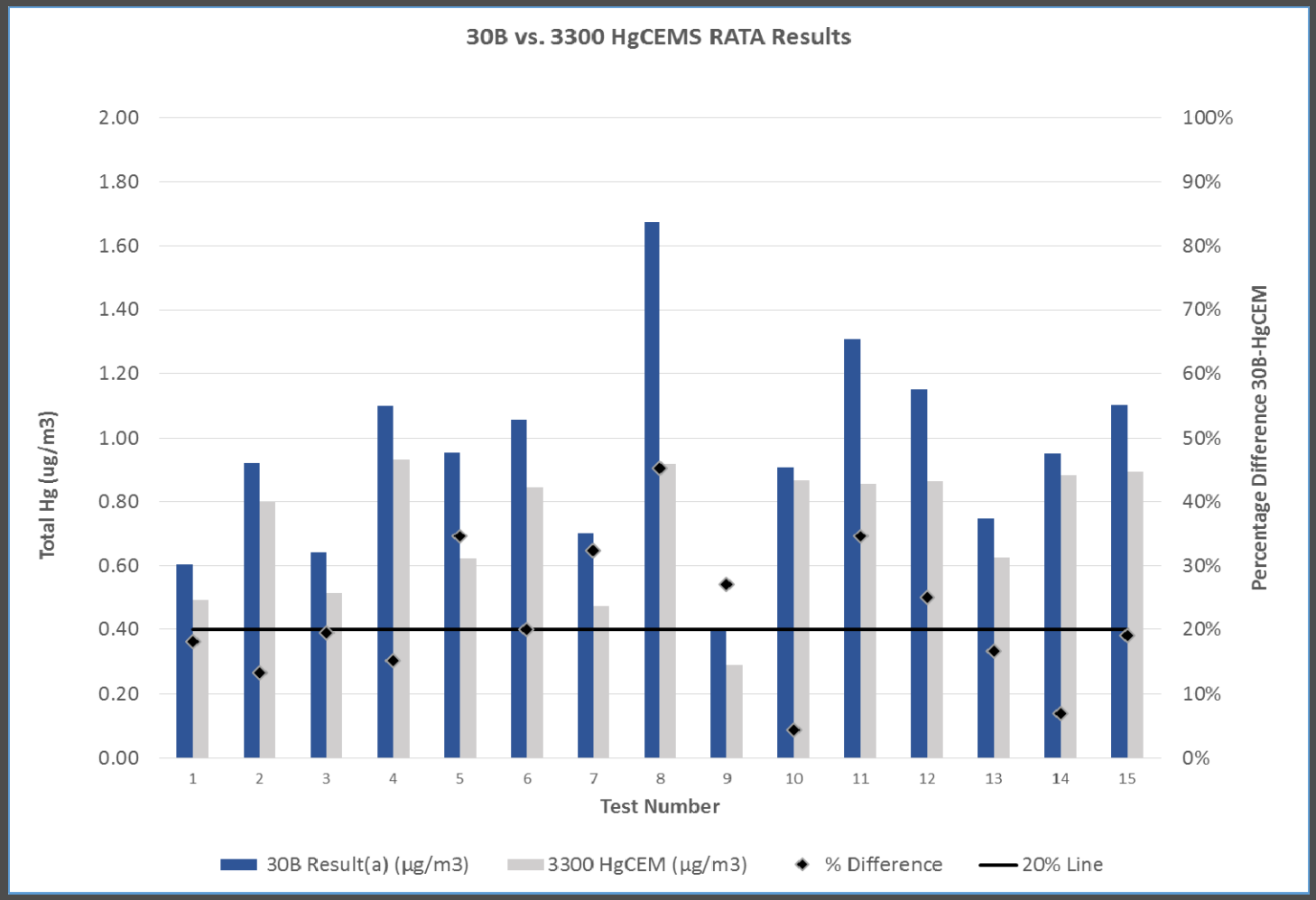


Figure E-5: Sorbent Trap Bias Error With Respect To OHM

Comparative 30B and Electronic HgCEM System Measurements



Conclusions

1. *Relative Accuracy Test Audits (RATAs) represent an important milestone in HgCEMS acceptance and EGU compliance.*

2. A number of factors can contribute to failing a RATA – ***however…*****…….**

3. proper preparation and execution for RATAs can save time and monies!

Example of Service and Spare Parts Requirements HgCEMS Probe Maintenance

HgCEMS Sampling Probe Component	Labor Per Event (hrs.)	Maintenance Interval (per year)
"O" - Rings	2	1
Particulate Filter and Gaskets	4	As required – e.g. 4 in Wet FGD Application
Pressure Transducer Recertification	2	1
Service Dilution and Bypass Blocks	4	4
Replace Controller Battery Back up	0.25	1
Comprehensive Probe Cleaning	4	4

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The Electronic HgCEMS vs. Sorbent Trap

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

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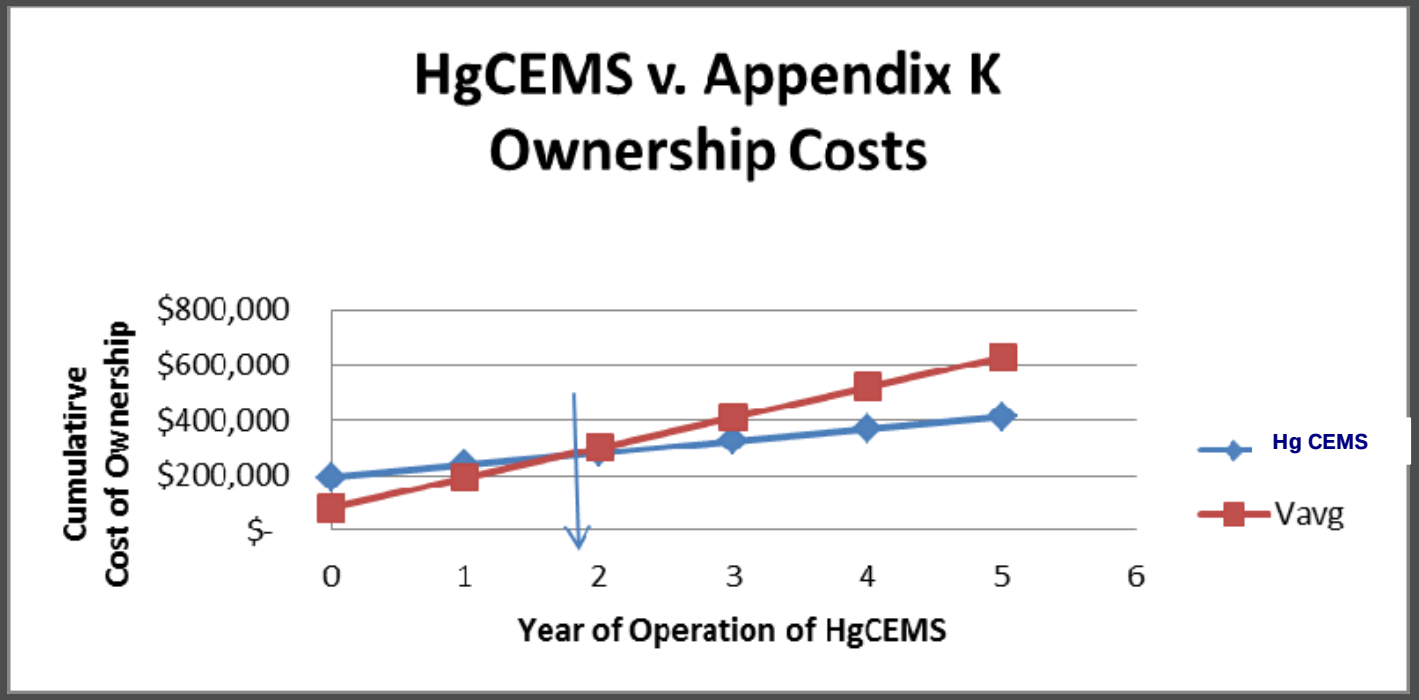
The Electronic HgCEMS vs. Sorbent Trap Total Cost of Ownership



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A Look Into the Near-Future, Why HgCEMS Maintenance May Be Even More Important!

- *New RATA Limits are in place!*
  - Instead of ±1.0 µg/m^3 when measuring < 5 µg/m^3 – tighter tolerances, particularly at <1.0 µg/m^3 are expected (e.g. +/- 0.25 µg/m^3) *Maintenance!*
- *States may enforce high PMA's (e.g. >95%) Maintenance! $ (fines?)*
- *Accuracy of Measurements is critical as limits on Hg Emissions are strict Maintenance! $*
- *NIST Traceability is an Important Part of CEMS Operations and Maintenance!*
- *Plant Economics (e.g. Process and APCD control) are impacted by HgCEMS accuracy and reliability (Maintenance!) $*

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Conclusions

- EPA's EGU MATS and PC MACT regulations will require new pollution control and emissions monitoring technologies and supporting resources for Portland Cement plants,
- Process Plants will need a strategic approach to economically satisfy EPA regulations,
- Mercury Emissions Control and Monitoring, via HgCEMS, will play a key role in Compliance,
- Key elements and considerations of HgCEMS operations and maintenance are included herein,

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