Mercury Measurements and Control

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McIlvaine Hot Topic Hour

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

Source	Limit	Units	Measurement	When?
Utility Boiler – not low rank	1.2	Lb/TBtu	Continuous	Apr, 2015
Utility Boiler – low rank	4	Lb/TBtu	Continuous	Apr, 2015
New Utility Boiler	0.003*	Lb/GWh	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, 2015
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

Continuous Mercury Measurements

- Electronic CEMS
  - Real–time measurement of Hg
  - Risk of lost data may be less
  - EPA/NIST protocol
  - No need to send personnel up to collect/replace traps every few days
  - Potential for process control
- Sorbent Traps
  - Lower capital cost
  - Simpler, but need people trained in handling samples and selecting correct trap size and sample rate
  - In principle, accurate to lower concentrations
  - More consistent with RATA method of choice

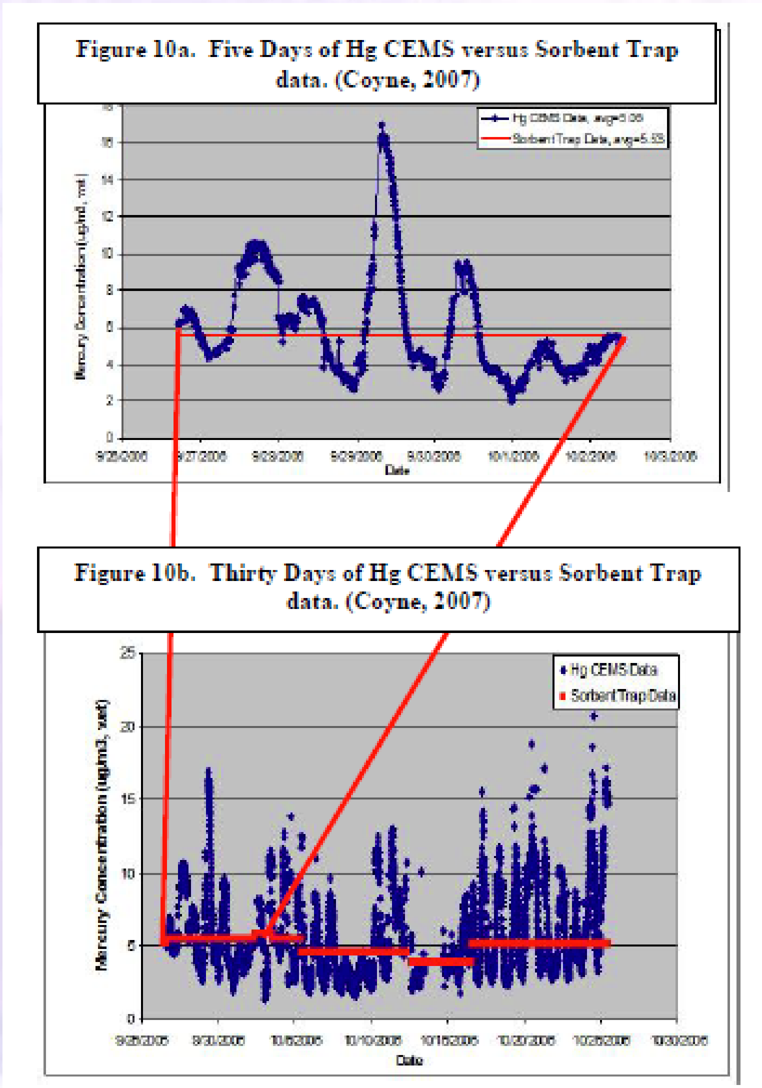
Factors determining Sorbent Trap Sensitivity and Concern for Sample Integrity

- Size of Sample (time duration or frequency of trap replacement and sample rate)
  - Size of Trap
  - Impacted by analytical method
- Skill of analyst
- Analysis method
  - Atomic absorption is less sensitive than atomic fluorescence, so use larger sample for atomic absorption
  - Analysis method also impacts whether or not sample is destroyed

Experience with Electronic CEMS

- Both of the major suppliers *initially* had some problems with failure of heated sample line
  - Around 10% of installations had significant failures
  - Significant dollar item and troublesome to correct
  - *Good news* - sample line problem has been addressed
- Other "teething" pains, but also generally addressed
- Questions about accuracy at low Hg concentrations
  - UND EERC study
- NIST traceability
  - EPA protocol using gas generators that are regularly compared to NIST prime gas generator

Comparison of Electronic Hg CEMS v. Sorbent Traps

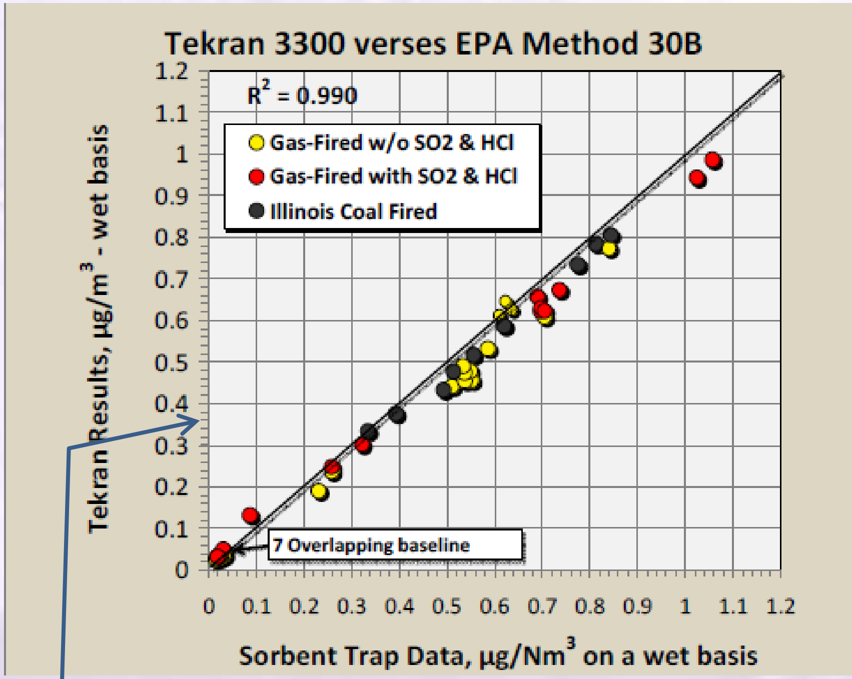


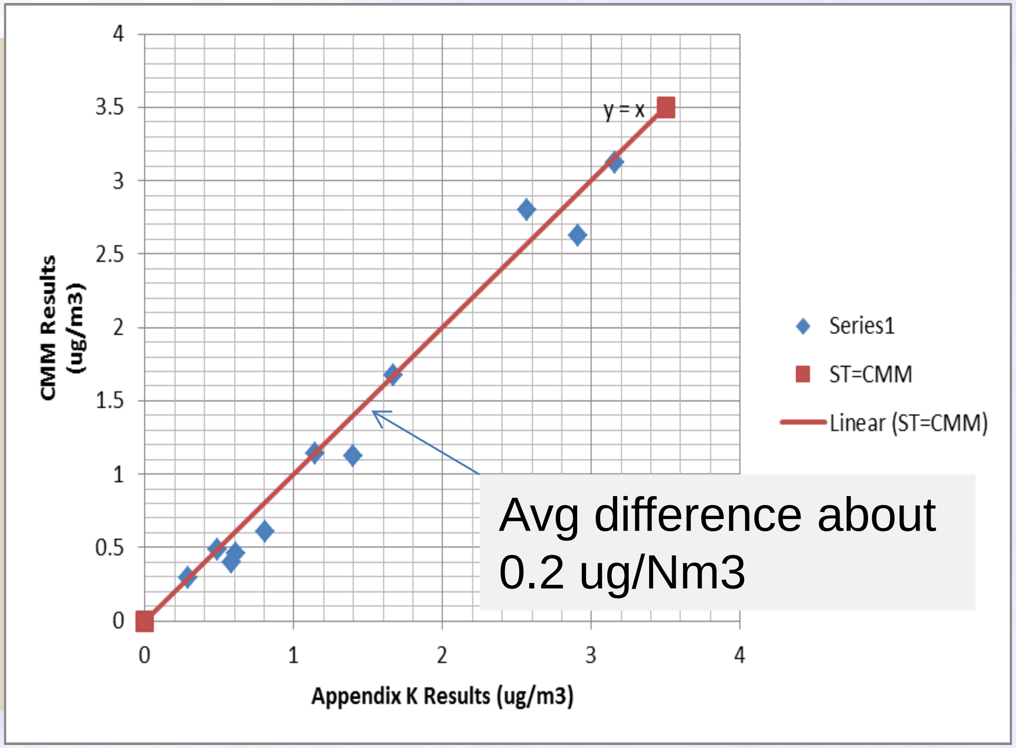
Sorbent traps

- cannot capture variability of Hg emissions
- may be important depending upon the coal or how the plant is operated

Coyne, L., Winter, S., Schmid, V., Wright, J., “Challenges and Prospects for Sorbent-Based Mercury Emissions Monitoring and Testing”, AWMA Conference, June 28, 2007

Comparison of Hg CEMS v Sorbent Traps





Sorbent traps *typically* yield a slightly higher measurement than electronic Hg CEMS – in fact larger differences than shown here have been observed!

- Data on left from EERC study, data on right courtesy of Tekran

Roughly equal to new power plant limit

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Typical Hg concentration on PM

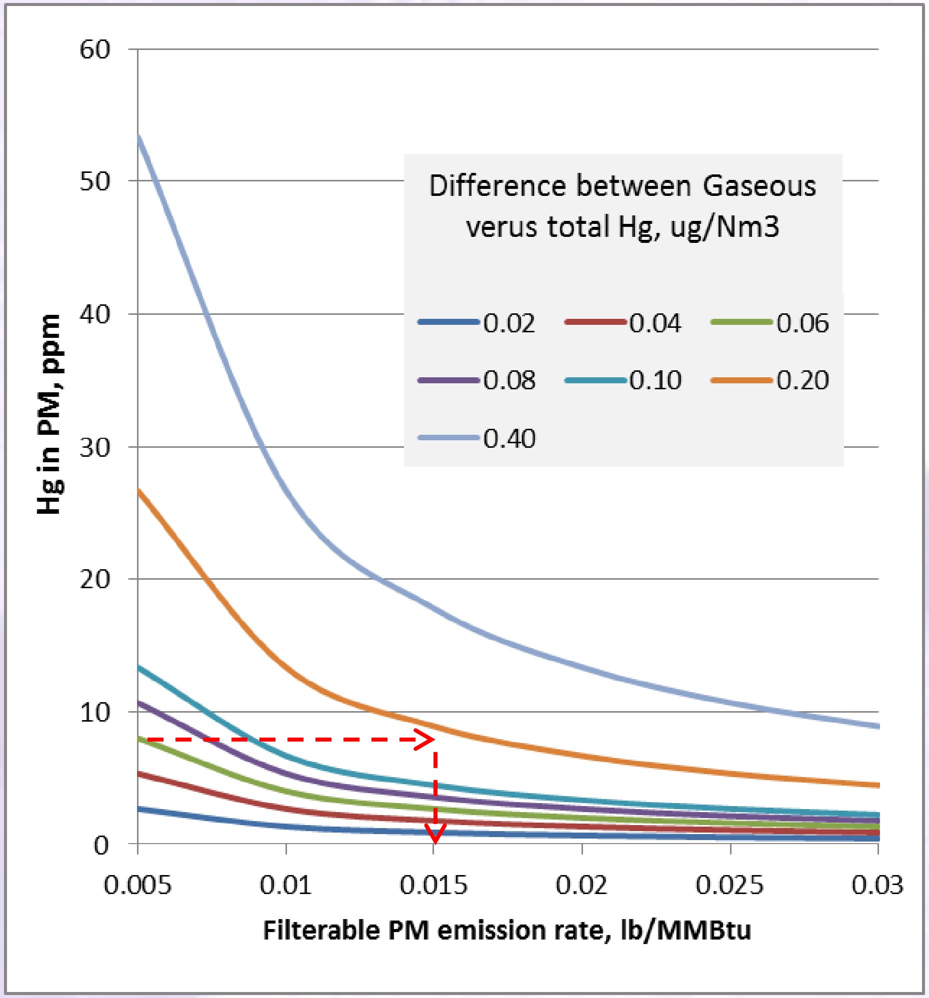
Mercury concentration (mg/kg or ppm) in Fly Ash particles

- Higher concentration on smaller particles
- Would expect concentration of Hg in activated carbon collected in PM control device to be significantly higher

Fly ash sample	Dust diameter (µm)			
	0-3	3-10	10-24	24-45
(G)	9.0827	6.2917	3.6420	1.0657

Jedrusik, M., and Swierczok, A., "The influence of unburned carbon particle on electrostatic precipitator collection efficiency", 13th International Conference on Electrostatics, Journal of Physics: Conference Series 301 (2011) 012009

Hg in PM, PM emission rate and difference in gaseous and total Hg – how they relate



- Sorbent trap measurements will include the mercury on particulate matter (they should only be used after PM control device)
- Difference in measured Hg concentration between sorbent traps and Hg CEMS can be explained by mercury on particulate

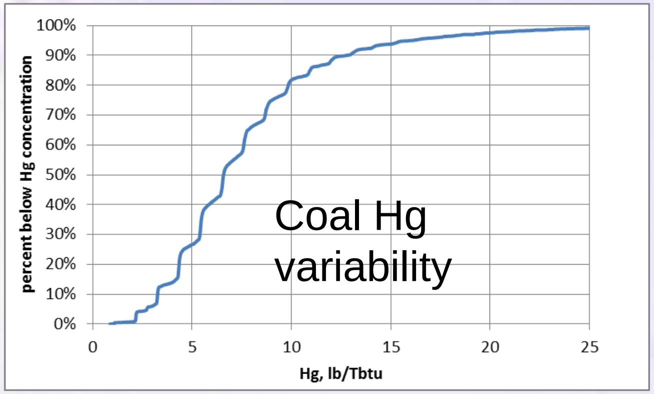
Controls

- Utility units
  - Widely studied and issues generally known
  - Will focus on one idea for reducing cost
- Industrial boilers
  - Unless have high Hg coal and just an ESP, should have no problem with compliance with limit using ACI
- Cement kilns
  - Some special issues that I'll discuss

Hg Control

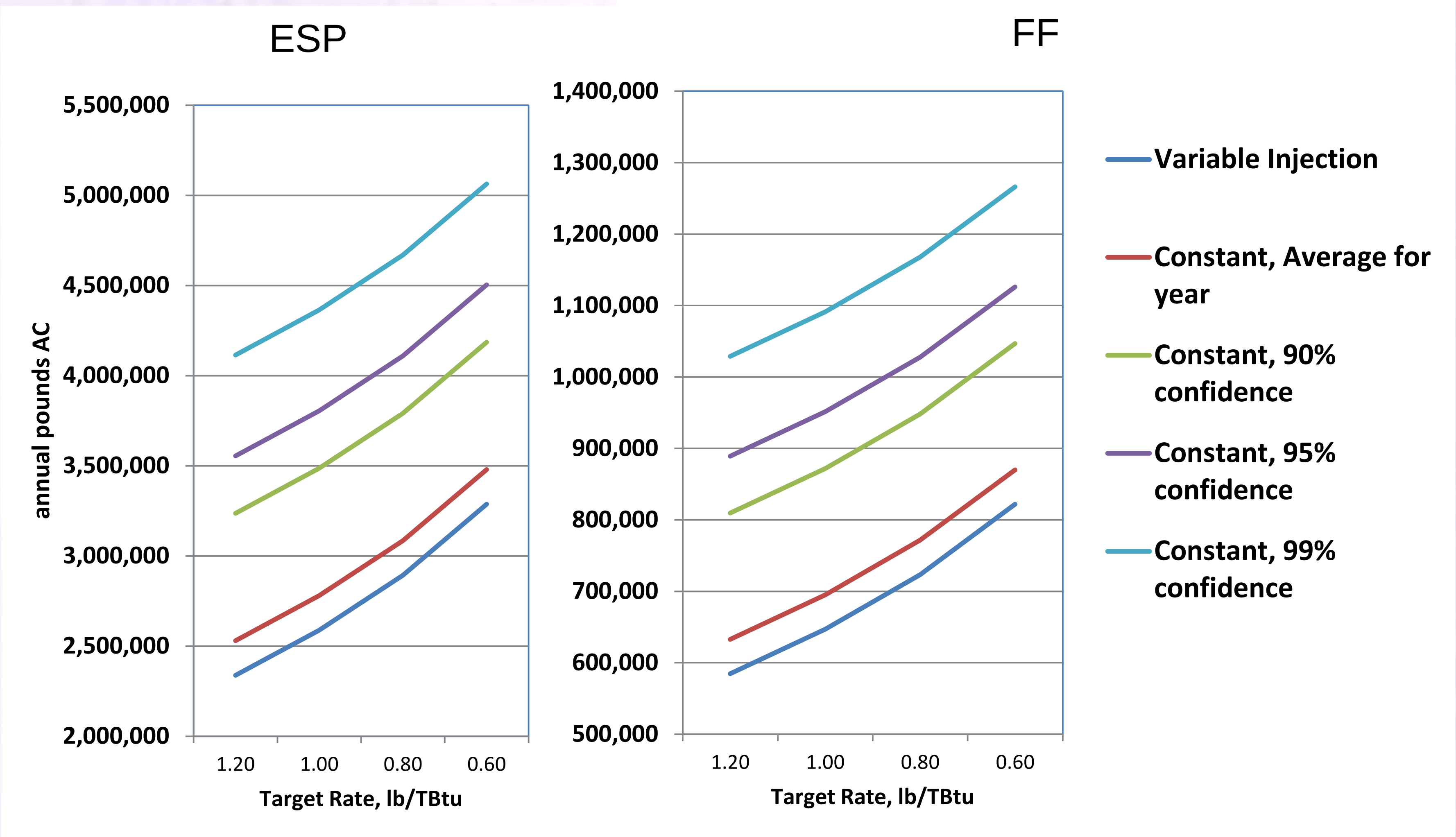
- Cobenefit, or “Passive” Controls
  - PM, SO_2 and NOx controls
  - Often not enough to consistently achieve below limit.
- “Active” Controls
  - ACI or other sorbents, halogen additives, scrubber additives
  - What is the benefit of feedback control of these active controls using a Hg CEMS?

Reducing utility AC usage with feedback control with Hg CEMS



- 500 MW plant burning PRB coal
- 75% capacity factor
- Different ACI control scenarios
  - ***Variable – control to outlet rate via feedback from Hg CEMS***
  - Constant – **constant AC injection rate** to meet target outlet rate on average
  - 90% confidence – **constant injection rate** based on being under target rate 90% of the time
  - 95% confidence – **constant injection rate** based on being under target rate 95% of the time
  - 99% confidence – **constant injection rate** based on being under target rate 99% of the time
  - Target rates, 0.60, 0.80, 1.0, and 1.2 lb/TBtu
  - ESP and FF
  - Didn't factor in coal bromine additives to reduce AC consumption

Estimated Annual AC usage



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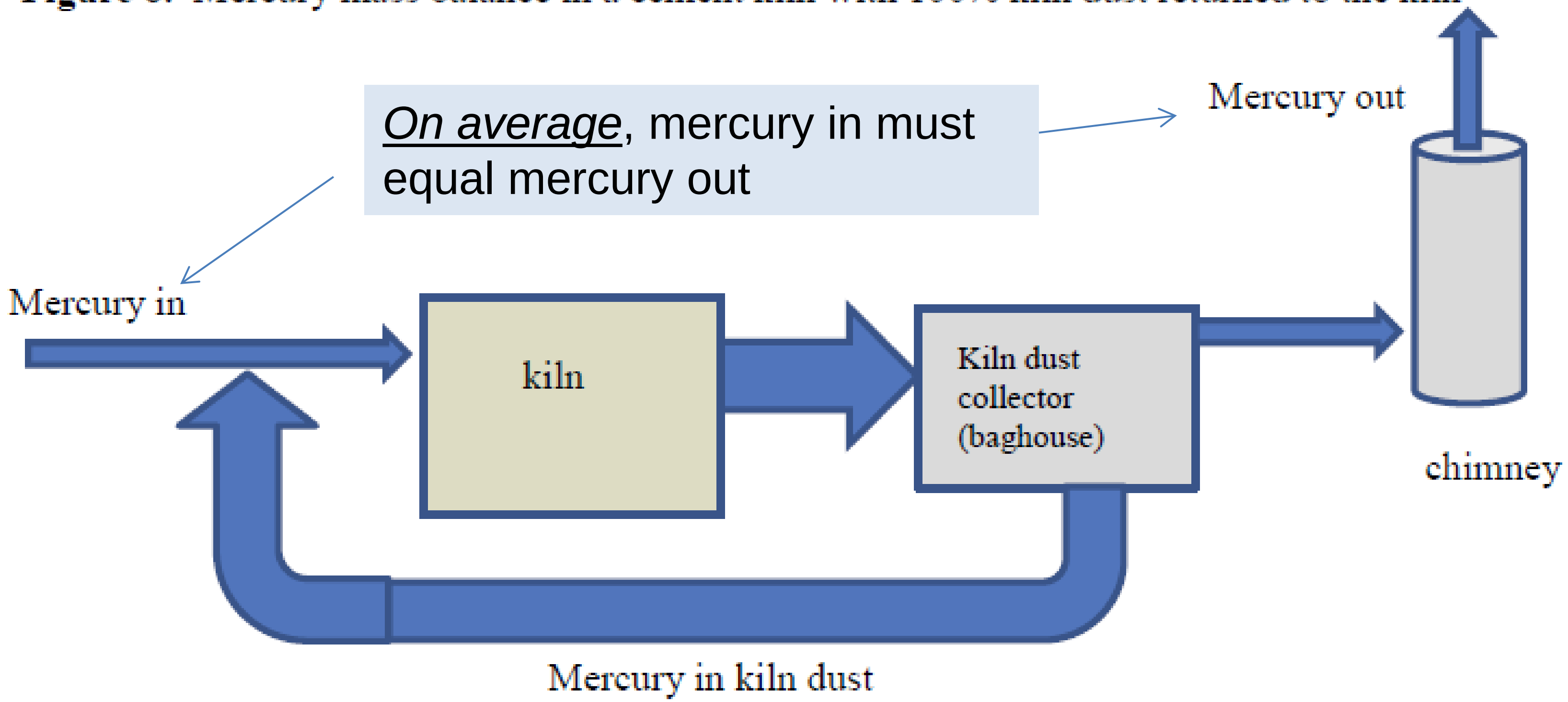
Activated Carbon usage can be reduced

- Through use of a feedback control system with an electronic Hg CEMS
- Savings depend upon facility particulars
  - Coal Hg concentration and variability
  - Boiler size
  - Air pollution control system
  - Operating characteristics
- This concept also applies for other control methods besides ACI, although the economics will differ

Mercury mass balance – Portland cement kilns

Figure 6. Mercury mass balance in a cement kiln with 100% kiln dust returned to the kiln



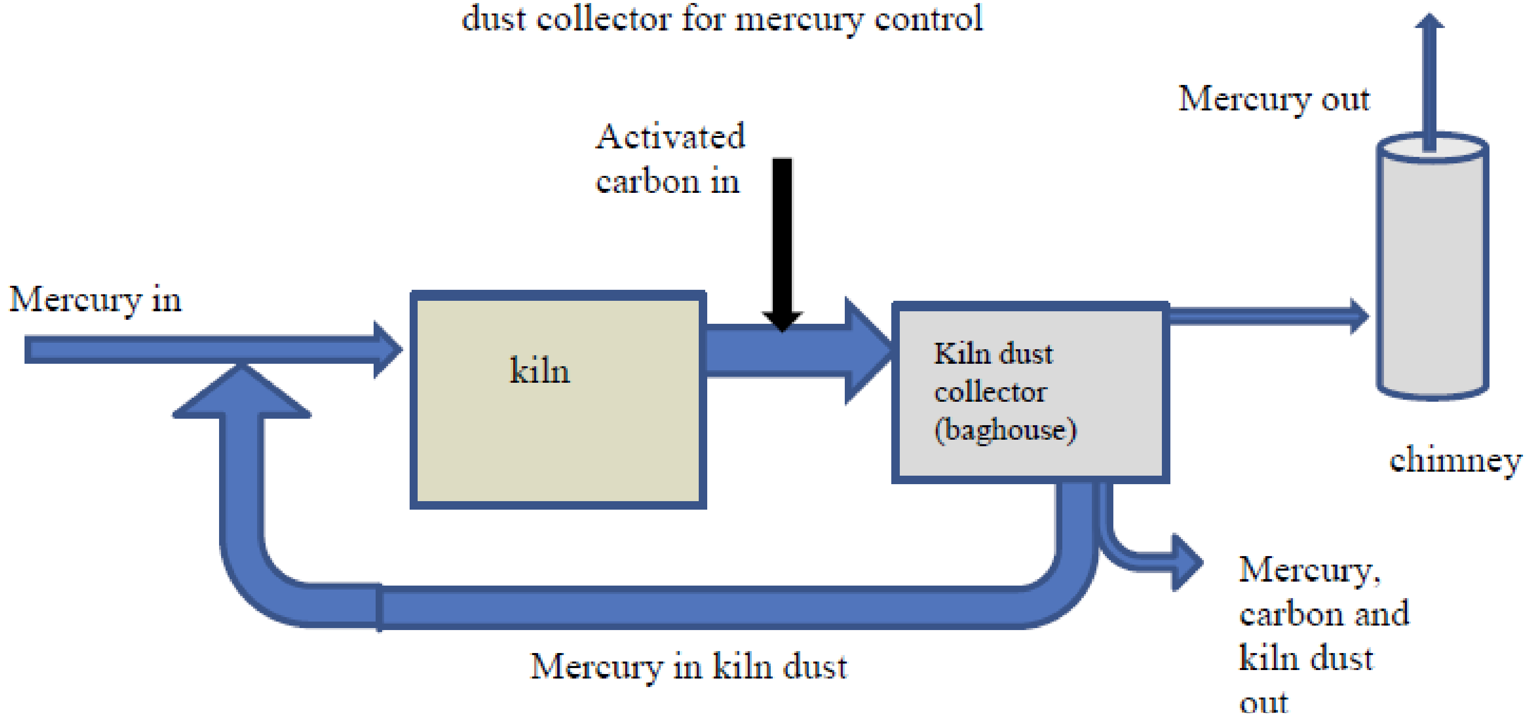
Equilibrium takes a long time to reach after start up even under ideal conditions
Equilibrium is never actually reached due to:

- Raw mill periodically out of service on precalciner kilns
- Variability of Hg in feed or coal and other operating variables

Outlet Hg emissions are therefore highly variable

Mercury mass balance with ACI

Figure 7. Mercury mass balance with activated carbon and bleed of kiln dust from existing kiln dust collector for mercury control



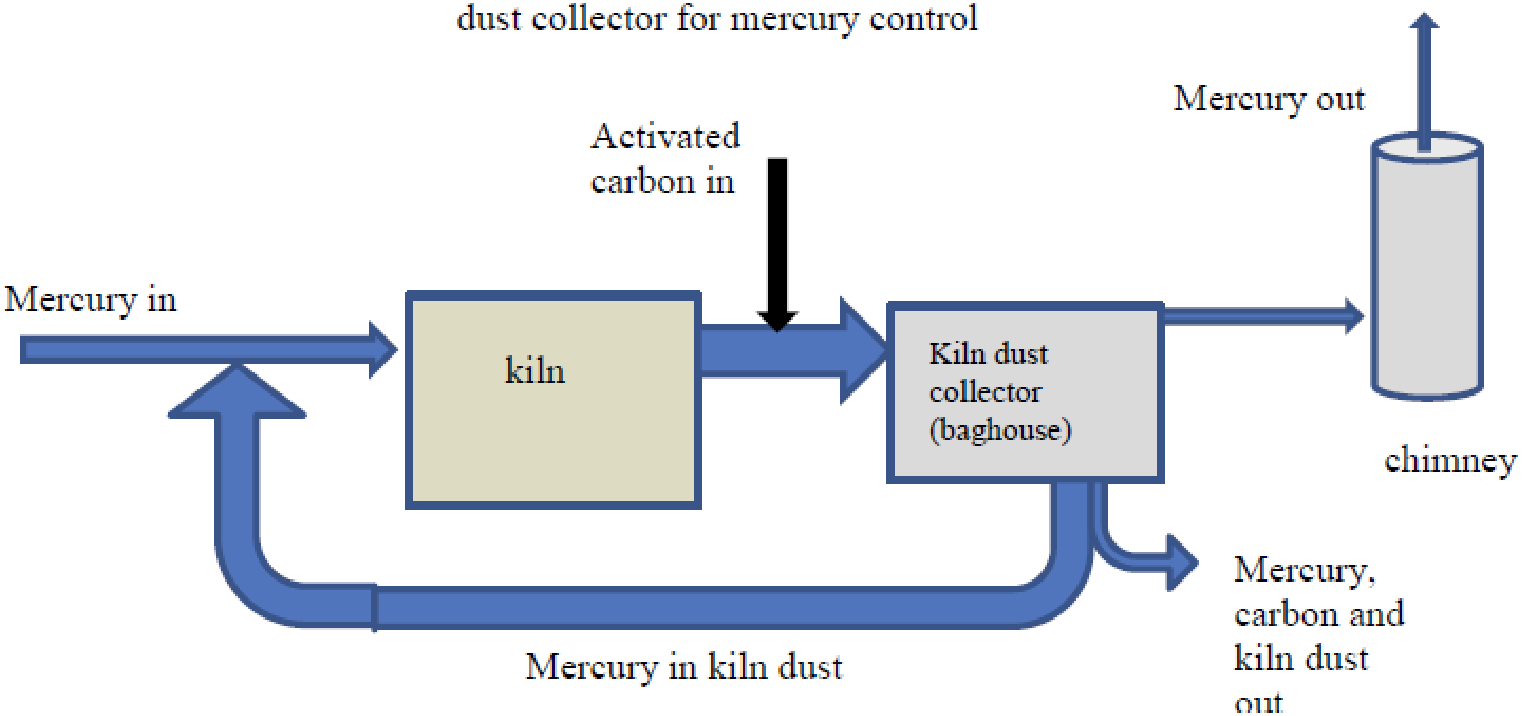
82% capture efficiency can be achieved through:

- 82% reduction* with ACI and 100% bleed of kiln dust
- 90% reduction* with ACI and 51% bleed of kiln dust
- 95% reduction* with ACI and 24% bleed of kiln dust

* "reduction" means reduction in gaseous Hg upstream of the ACI that becomes captured PM in the baghouse as a result of ACI

Mercury mass balance with ACI

Figure 7. Mercury mass balance with activated carbon and bleed of kiln dust from existing kiln dust collector for mercury control



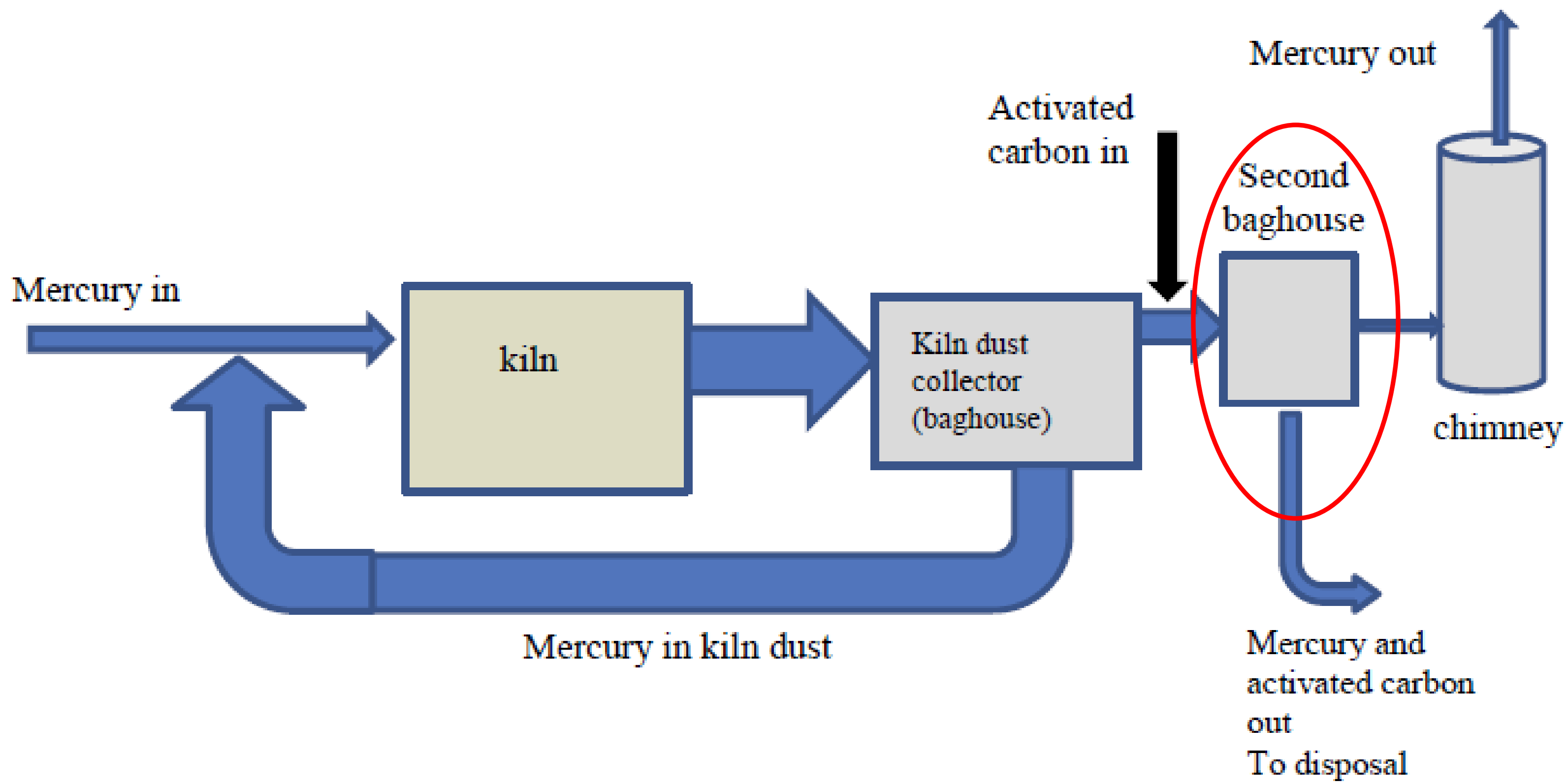
93% capture efficiency can be achieved through:

- 93% reduction* with ACI and 100% bleed of kiln dust
- 95% reduction* with ACI and 70% bleed of kiln dust
- 97% reduction* with ACI and 41% bleed of kiln dust

* "reduction" means reduction in gaseous Hg upstream of the ACI that becomes captured PM in the baghouse as a result of ACI

Mercury mass balance with ACI

Figure 8. Mercury mass balance using activated carbon and a second baghouse to control mercury emissions



- ACI with a second baghouse is likely necessary for over 90% removal of Hg on a cement kiln if changes to Hg input is not possible

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Summary

- Measurement methods have evolved
  - Electronic CEMS and sorbent traps each have their advantages
  - Sorbent traps will have slight high bias due to Hg on PM
- There are opportunities to optimize the cost of mercury control
  - Electronic CEMS permit process control
- Portland cement kilns have some special issues
  - Highly variable emissions
  - Very high removal efficiencies could require second baghouse or changes to feed

- For Questions or Comments
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