

Behavior of Mercury in Air Pollution Control Devices on Coal-Fired Utility Boilers¹

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ABSTRACT

Coal-fired power plants are major point sources of mercury discharges into the atmosphere. After considerable study of mercury emissions and their impact on the environment, US EPA, in December, 2000, made a determination to regulate mercury emissions from coal-fired electric utility boilers. EPA is to propose air pollution emission regulations by December 15, 2003, and promulgate them by December 15, 2004.

Regulation of mercury emissions may necessitate additional air pollution control devices being installed at utility power plants. Before regulations are imposed, it is important to understand the behavior of mercury in existing devices. Extensive measurement of mercury emissions at power plants have demonstrated that high levels of removal can occur in existing devices. However, the complexity of mercury chemistry, the variability of coal feedstocks and of boiler designs make it imperative that a clear understanding of the behavior of mercury in air pollution control equipment be developed. In this paper, the database for mercury speciation and stack emissions in coal-fired power plants is reviewed; this largely consists of the Mercury Information Collection Request (ICR) initiated by the US EPA in 1999, designed to provide new information to help in making future regulatory determinations on controlling mercury emissions from coal-fired power plants. Phase III of this effort involved a plant testing program for mercury emissions including mercury speciation from coal-fired power plants. Over 80 plants were statistically selected for this testing based on several factors, which included boiler type, configuration of air pollution control equipment, and fuel type. For each plant, measurements of mercury in the coal (along with other coal composition data) and the flue gas were made. Flue gas measurements were made at the stack and at the inlet to the last air pollution control device (APCD) using the Ontario Hydro method, which provides mercury speciation data (elemental, oxidized, and particulate-bound).

In this paper, ICR data on mercury speciation in flue gas, coal composition, boiler design and operation, are examined to look for trends in the behavior of mercury in coal-fired power plants. The speciation of mercury at the inlet to particulate control devices was found to depend on the chlorine content of the coal and on the temperature at the inlet to the device. Wet FGD's, dry scrubbers, and fabric filters can all remove a significant amount (50-90%) of the mercury in the flue gas under certain conditions. Critical information is missing from the ICR data, particularly the composition of the fly ash, and the lack of this information reduces the quality of the model predictions.

¹ Prepared for Power Production in the 21st Century: Impacts of Fuel Quality and Operations, Engineering Foundation Conference, Snowbird, UT, October 28-November 2, 2001

INTRODUCTION

The United States Environmental Protection Agency (EPA) has estimated that during the period 1994-1995 annual emissions of mercury from human activities in the United States were 159 tons (Keating et al, 1997). Approximately 87% of these emissions were from combustion sources. Coal-fired utilities in the U.S. were estimated to emit 51 tons of mercury per year into the air during this period.

The form of mercury emitted from point sources is a critical variable in modeling the patterns and amount of mercury deposition from the atmosphere (Pai et al, 1997). Both elemental and oxidized mercury are emitted to the air from combustion point sources. Elemental mercury has a lifetime in the atmosphere of up to a year, while oxidized forms of mercury have lifetimes of a few days or less as a result of the higher solubility of Hg^{+2} in atmospheric moisture. Elemental mercury can thus be transported over long distances, whereas oxidized and particulate mercury deposit near the point of emission. Once mercury has deposited on land or water, it can transform into methylmercury, an organic form, and thereby enter the food chain. Humans are most likely to be exposed to methylmercury through consumption of fish.

In December of 2000, the US EPA made a decision to regulate the emission of mercury from coal-fired power plants. A proposed regulation will be due no later than December 2003 and promulgated no later than December 2004. Utility industry compliance would have to be in place by December 2007. Compliance with the proposed regulation may in some cases necessitate additional controls for mercury. Since some mercury is removed by existing air pollution control devices (APCDs), it is vital to understand the behavior in existing equipment in order to cost-effectively control emissions. The speciation of mercury in the flue gas of a coal-fired power plant affects the amount of mercury retained in the air pollution control devices (and not emitted out the stack) because the chemistry of elemental mercury in flue gas is different from that of oxidized mercury.

In order to understand the technical and economic feasibility of mercury controls on coal-fired power plants, it is therefore necessary to understand the chemistry of mercury in flue gas and the potential physical and chemical interactions at various points in the system. In this paper, data from full-scale power plants are reviewed with the intent of testing specific hypotheses about the behavior of mercury in coal-fired boilers.

BEHAVIOR OF MERCURY IN COMBUSTION SYSTEMS

Mercury is present in coal in low concentrations, on the order of 0.1 ppmw. In the combustion zone of a coal-fired power plant, all the mercury in coal is vaporized as elemental mercury, yielding vapor concentrations of mercury in the range of 1 to 20 $\mu\text{g}/\text{m}^3$ (1 to 20 ppbw). At furnace exit temperatures (1700 K), all of the mercury is expected to remain as the thermodynamically favored elemental form in the gas. As the gas cools after combustion, oxidation reactions can occur, significantly reducing the concentration of elemental mercury by the time the post-combustion gases reach the stack. Equilibrium thermochemical calculations predict that HgCl_2 will be formed at low temperatures in coal combustion flue gas (Senior et al, 2000). However, the complete oxidation of elemental mercury that is

predicted from equilibrium is rarely observed in practice. This has led to the conclusion that there are kinetic limitations to the oxidation of mercury in flue gas from coal-fired power plants (Senior et al, 2000).

The major kinetic pathway to formation of HgCl_2 in flue gas is believed to be through the reaction of atomic chlorine Cl with elemental mercury (Helble, et al., 2000; Sliger, et al., 2000, Widmer, et al., 2000, Niksa and Helble, 2001). Although the oxidation of elemental mercury in the convective pass is assumed to proceed primarily via gas-phase reaction, experimental evidence suggests that some fly ash can catalyze oxidation of elemental mercury. Iron oxide has been shown to promote this oxidation (Ghorishi, 1998). Other constituents in the fly ash (carbon, calcium compounds) may also contribute. The presence of acid gases (HCl, SO_2 , NO, NO_2) in the flue gas has also been shown to cause oxidation in the presence of fly ash (Carey, et al., 1998; Miller, et al., 1998). Furthermore, selective catalytic reduction (SCR) technology for NO_x control has been observed to oxidize a portion of elemental mercury (Gutberlet et al, 1992, Fahlke and Bursik, 1995, Laudal et al, 2001).

Thus, the coal composition (in terms of chlorine content and ash composition), the operation of the combustion system (in terms of unburned carbon in the ash), and temperature and residence time in the particulate control device will all affect mercury speciation in the gas and the amount of mercury adsorbed on the particulate matter. Other components of the air pollution control system such as FGD and selective catalytic reduction (SCR) systems may also affect both the speciation of mercury in the stack and the amount of mercury removed in the air pollution control equipment as a whole.

FULL-SCALE MEASUREMENTS OF MERCURY SPECIATION

The Information Collection Request (ICR) initiated by the United States EPA in 1999 was designed to provide more information which could be useful for making a regulatory determination about mercury emissions from coal-fired power plants. Data from Part 3 of the ICR comprise a set of measurements of mercury speciation from coal-fired power plants. Plants were selected based on the configurations of air pollution control equipment and fuel type. For each plant, the input value of mercury in the coal was measured (along with other coal composition data). Mercury measurements were made at the stack and at the inlet to the last air pollution control device (APCD) using the Ontario Hydro method that gives elemental, oxidized, and particulate-bound mercury. Table 1 summarizes the configurations for the ICR data sets, comparing the distribution of units tested with the distribution of the boiler population in the United States.

Coal-fired power plants already have air pollution control devices (APCDs) such as fabric filters and electrostatic precipitators (ESPs) for particulate control, scrubbers for SO_2 control and low- NO_x burners (LNBS), selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for NO_x control. Most of these have some impact on mercury speciation and emissions (Senior, 2000). Removal of mercury in the APCD depends on chlorine content, temperature and type of particulate control device. In some cases, the composition of the gas and of the ash may also have an effect on mercury speciation and removal.

If there is mercury in the particulate phase at the inlet to an ESP or fabric filter, these devices will remove it efficiently. Unburned carbon has been suspected of adsorbing mercury for both eastern and western bituminous and sub-bituminous coals. Often a consequence of low- NO_x burners or a low- NO_x combustion systems, pulverized coal boilers

can produce high levels of unburned carbon when burning bituminous coals (DeVito and Rosenhoover, 1998), or less commonly, sub-bituminous coal (Butz, et al., 1999). Mercury has been found to concentrate in the carbon-rich fraction of fly ash (Li, et al., 1997, Huggins, et al., 2000). However, it is not possible to generalize and conclude that high carbon in ash will always give high levels of particulate-bound mercury. Unfortunately, data collected as part of the ICR do not include any information on the carbon content of the ash. As discussed below, this will limit the utility of the ICR data for use in developing prediction methods for speciation and emissions.

Table 1. Summary of APCD and Coal Type Information for ICR Data Sets

APCD Equipment	Coal Type	% units tested in ICR	% existing units
Cold-side ESP	Bituminous	7.2	48.3
Cold-side ESP	Low Rank	7.1	11.7
Hot-side ESP	Bituminous	7.2	6.6
Hot-side ESP	Low Rank	3.6	2.4
Cold-side ESP + FGD	Bituminous	6	8.8
Cold-side ESP + FGD	Low Rank	9.2	2.5
Hot-side ESP + FGD	Bituminous	4.8	0.7
Hot-side ESP + FGD	Low Rank	3.6	1
FF	Bituminous	3.6	2.9
FF	Low Rank	7.2	2.7
FF + Wet FGD	Bituminous	7.2	1.6
FF + Wet FGD	Low Rank	3.6	1.6
SDA + FF	Bituminous	3.6	2.9
SDA + FF	Low Rank	7.2	1.3
SDA + ESP	Bituminous	2.4	0.2
SDA + ESP	Low Rank	3.6	0.3
FF + FBC	Bituminous	3.6	2.9
Other	Other	9.3	1.6

Sorption of mercury by fly ash has been observed to be dependent on temperature for both eastern bituminous coals and western sub-bituminous coals (Amrhein, et al., 1999). Some fly ash has been observed to oxidize elemental mercury in both laboratory scale apparatus (Norton, et al., 2000, Ghorishi, et al., 2000, Dunham et al., 2001) and pilot scale baghouses. Laboratory experiments using well-controlled gas compositions indicate that the composition of the gas, particularly the amounts of HCl, NO_x, and SO₂, influences mercury oxidation. The composition of the ash is also important. Experiments with model fly ash compounds (Ghorishi, 1998; Ghorishi, et al., 2000) exposed to mercury in a laboratory fixed bed reaction have shown that iron oxide is particularly effective at oxidizing elemental

mercury in simulated flue gas. Many eastern bituminous coals and lignites contain substantial amounts of iron oxide in the ash.

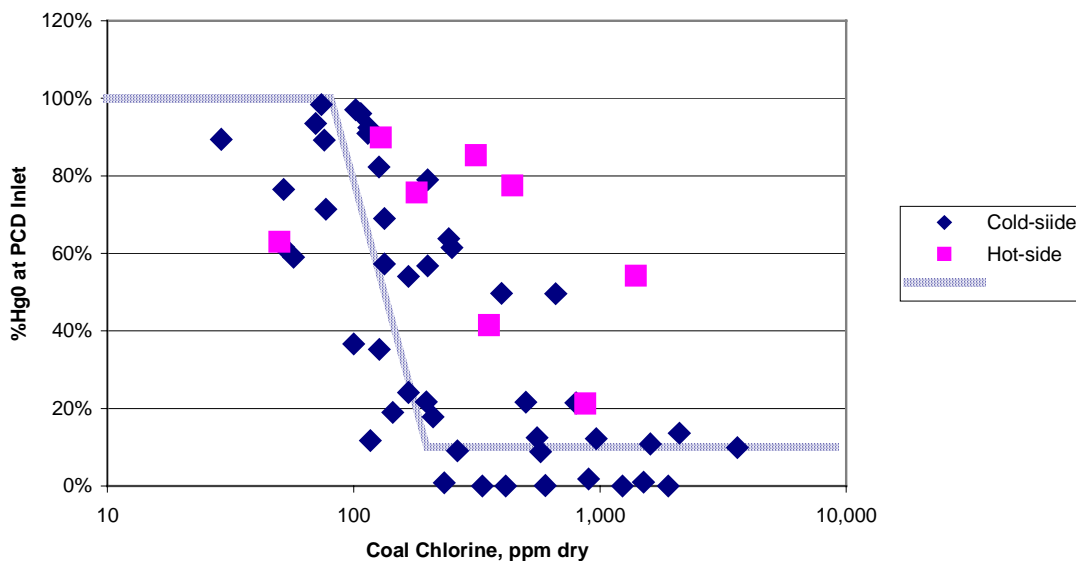
Based on a detailed study of the behavior of mercury in a pilot scale wet scrubber, the adsorption of oxidized mercury appears to be strongly correlated with the mass transfer in the scrubber, usually expressed as liquid-to-gas (L/G) ratio and weakly dependent on pH of the scrubber solution (Amrhein, et al., 1999). The type of FGD system (forced vs. natural oxidation, for example, or limestone vs. magnesium-lime) also affects the amount of oxidized mercury removed in the scrubber (DeVito and Rosenhoover, 1998).

Mercury Speciation

The speciation of mercury at the inlet to the particulate control device (PCD) determines how effectively the device, as well as any downstream scrubber, will remove mercury. Therefore, it is important to understand how the split between elemental, oxidized, and particulate mercury is affected by coal composition and operating conditions.

Previous work has shown that the oxidation of mercury in post-combustion flue gas is kinetically limited because equilibrium would suggest that at the inlet to the PCD all mercury would be in an oxidized form. In addition to gaseous oxidation, heterogeneous oxidation can also take place, as discussed above.

Conversion of mercury should therefore be a function of coal composition (particularly chlorine content), ash loading, and carbon content of ash. This is illustrated in Figure 1, which shows the percentage of mercury as elemental at the inlet to the PCD as a function of coal chlorine content. There is a large uncertainty in the measurement of coal chlorine, as discussed by (Chu, 2000) which may account for some of the scatter in the figure. The ICR data do not contain information on the composition of the ash, which may also have some bearing on the speciation of mercury in the flue gas.



Despite the scatter in the speciation data in Figure 1, general trends are evident. Coals with less than about 100 ppm Cl have predominantly elemental mercury at the inlet to the PCD, while coals with greater than about 500 ppm Cl have less than 20% elemental mercury. Hot-side ESPs do not follow that trend as well. These devices have inlet temperatures in the range of 500-800 F (260-425 C). Figure 2 shows the percentage of mercury at the inlet to particulate control devices as a function of inlet temperature. For temperatures above approximately 500 F (260 C), the mercury speciation appears to be determined by the temperature. At lower temperatures, other factors, such as coal chlorine and ash composition become dominant.

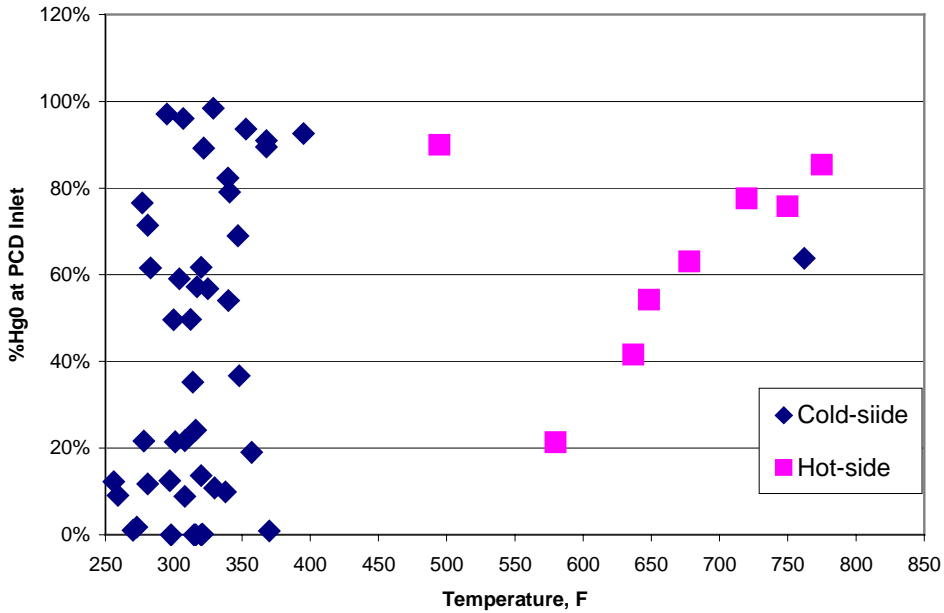


Figure 2. Fraction of Gaseous Elemental Mercury at Inlet to Particulate Control Device as a function of inlet temperature.

The speciation at the inlet to the PCD thus depends on coal composition and on the device. The coal composition effects are also reflected in the rank of the coal, since low rank coals tend to have very low chlorine contents (less than 50 ppm Cl), while bituminous coals usually have chlorine contents in the range of 300-3000 ppm. Table 2 shows the average speciation at the inlet, in terms of the percentage of mercury as elemental and particulate-bound. The striking differences between bituminous coals and low rank coals are obvious, as is the difference between hot-side and cold-side devices.

Table 2. Average Inlet Mercury Speciation as a function of coal rank and APCD.

APCD	Bituminous Hg _p	Hg ⁰	Low Rank Hg _p	Hg ⁰
ESP	44.8%	55.2%	7.3%	92.7%
HESP	1.3%	56.5%	5.2%	52.6%
FF	58.8%	21.4%	27.7%	52.6%
SDA-ESP			14.9%	61.0%
SDA-FF	69.1%	19.2%	13.1%	73.9%

Particulate Controls

Mercury removals are plotted against coal chlorine content. While the trends are clearly correct, the wide scatter of the data precludes statistically valid correlations. Interpretation of the data is confounded by issues with the accuracy of the Ontario Hydro Method to identify mercury species correctly under the conditions at the inlet to particulate control devices (PCDs). At the inlet to a PCD, the ash loading is high. In the Ontario Hydro measurement train, the ash is collected on a heated filter upstream of the liquid impingers, which collect gaseous mercury compounds. All the sampled flue gas passes through the filter for the two to three hours required to make the measurement. Both adsorption of mercury and oxidation of mercury can occur across the filter. Coal ash has been shown under laboratory conditions to be a catalyst for oxidation as well as a sorbent under some circumstances (Ghorishi et al., 2000, Norton et al., 2000, Dunham et al., 2001).

In practical terms, this can mean the Ontario Hydro measurement taken at the PCD inlet can under-report the amount of elemental mercury in the gas (and the amount of oxidized gaseous mercury, in some cases) while over-reporting the amount of particulate mercury. When the amount of mercury removal across the device is calculated, elemental mercury actually appears to be produced across the device because of oxidation at the inlet and/or, in the case of adsorption of mercury on fly ash, the amount of gaseous mercury appears to increase across the device. Evidence for this can be seen in Figure 3, which plots the apparent removal of elemental mercury across PCDs against the apparent removal of gaseous mercury. (Note that a negative value on the graph means an apparent increase in the quantity of interest.) The large negative values for both elemental mercury and gaseous mercury removals suggest errors in the measurement.

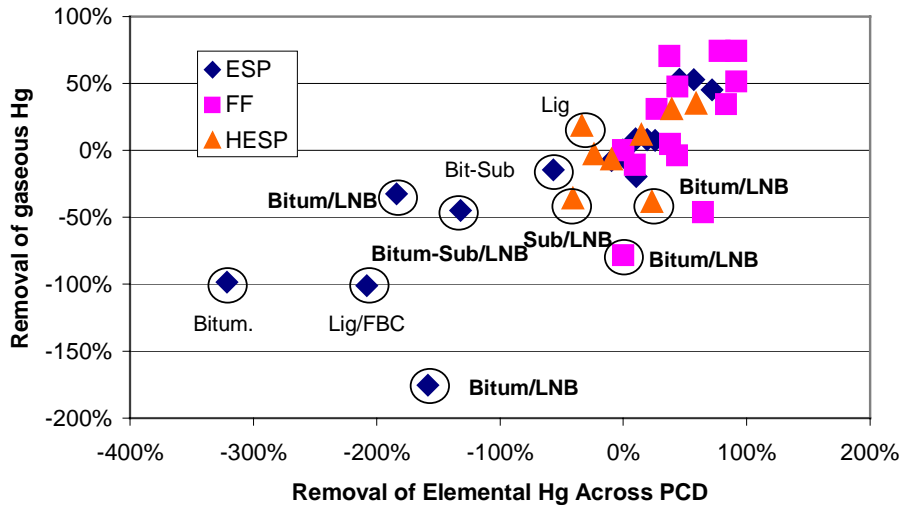


Figure 3. Removal of gaseous mercury across particulate control devices (based on inlet and outlet Ontario Hydro measurements) compared to removal of gaseous elemental mercury.

These errors were corrected (by assuming that the inlet elemental mercury was the same as the outlet elemental mercury) for the cases in which large negative removals were observed. Note that these values were most often on units firing bituminous coal with ESPs and low-NO_x firing systems. There are no data on the carbon content of the ash. Figure 4 shows the corrected values. These values were used for the subsequent analysis.

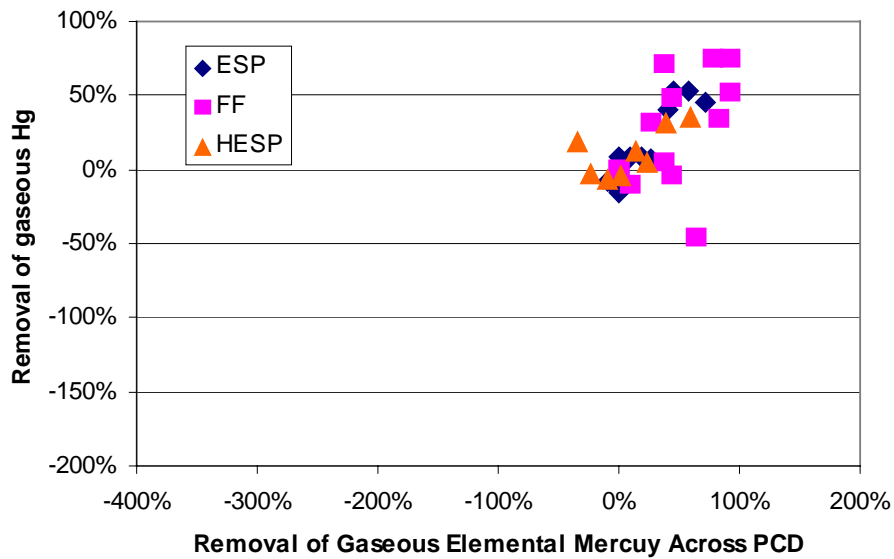


Figure 4. Corrected removal of gaseous mercury across particulate control devices (based on inlet and outlet Ontario Hydro measurements) compared to removal of gaseous elemental mercury.

Figure 5 presents mercury removals for the following types of particulate controls

- Cold-Side Electrostatic Precipitator - ESP
- Hot-side Electrostatic Precipitator - HESP
- Fabric Filter – FF
- Wet Scrubber - WS

As expected, the highest removals are for FF's followed by ESP's and lastly HESP's. This is consistent with the current understanding and expectations.

For particulate control devices, the mercury removal increases with coal chlorine content. At hot-side temperatures of 250 to 400 C (475 to 750 F), very little mercury was found in the particulate phase (Table 2); this manifests itself in the low removal of mercury by HESPs. For cold-side devices – ESPs and FFs operating in the range of 130 to 170 C (270 to 350 F) – most of the mercury at the inlet to the PCD was elemental for coals with low chlorine contents (less than about 150 ppm on a dry basis).

For bituminous coals, PCDs produce an average decrease of 20% in elemental mercury, which can be attributed to oxidation for the most part. For low rank coals, there is little change in elemental mercury across ESPs, but FFs show large decreases in elemental mercury, on the order of 50% on average. Gaseous mercury (elemental plus oxidized) is observed to decrease about 20% across PCDs for bituminous coals, suggesting that some adsorption of mercury takes place. For low rank coals, in contrast, there is virtually no change in gaseous mercury across ESPs and only about a 15% decrease on average across FFs. Thus, there is evidence for oxidation of elemental mercury as well as adsorption of gaseous mercury across particulate control devices.

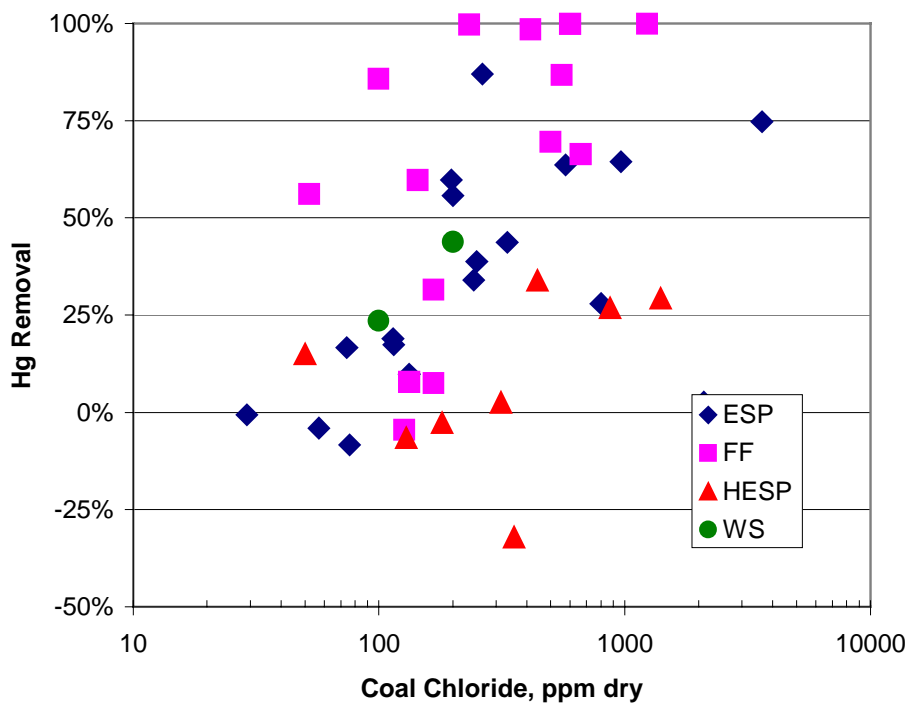


Figure 5. Mercury Removal Across Particulate Control Devices

SO₂ controls - (wet)

Figure 6 presents the data for wet FGD systems. The mercury removal results reflect the reduction across the FGD system only. However, the data points are "coded" by the type of particulate control device upstream of the FGD. This separation helps determine what (if any) effect the upstream device may have on the performance of the FGD system in removing mercury. As was the case with the particulate control technologies, mercury removals were plotted against coal chlorine.

FGDs remove oxidized mercury with an efficiency of approximately 90%. Elemental mercury is not removed to any degree across FGDs, although the average decreases in Table 2 are affected by a very few large negative values. Under some conditions, limestone scrubbers have been observed to reduce adsorbed mercury back to Hg⁰ giving rise to higher concentrations of elemental mercury at the outlet than at the inlet (Ahmrhein, et al., 1999). Assuming that no Hg⁰ is adsorbed by the scrubber, the amount of adsorbed Hg⁺² that is reduced can be calculated from the ratio of the increase in elemental mercury to the decrease in Hg⁺² across the scrubber. Based on very limited data, this also appears to be related to the L/G ratio in the scrubber. The ICR data, however, do not have complete information on scrubber operation (SO₂ removal and L/G) for every boiler and this type of detailed correlation cannot be made, limiting the accuracy of the predictions.

Bituminous coals produce flue gas with predominantly oxidized gaseous mercury. Consistent with this observation, FGDs on boilers burning bituminous coals remove about half of the gaseous mercury. In boilers burning low rank coals, the mercury is predominantly elemental in the flue gas and little gaseous mercury is removed across the FGD. Regression coefficients are insufficient to draw "universal" correlations.

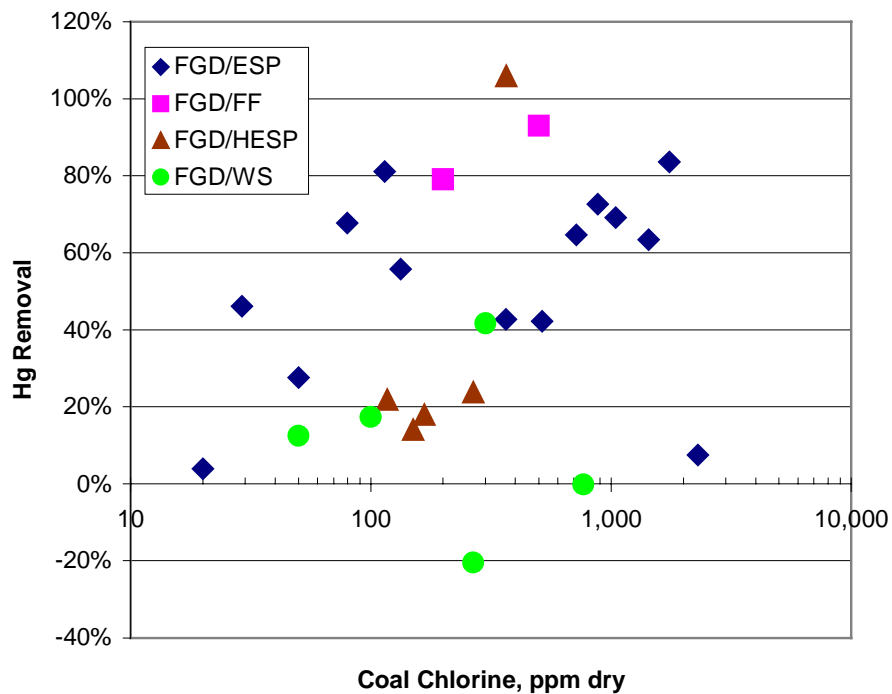


Figure 6. Mercury Removal across Wet Scrubbers

SO₂ Controls - (Dry)

Figure 7 presents the data for dry FGD systems - Spray Dryers Absorbers (SDAs). In this case the mercury removals reflect the combined reductions across the SDA and the downstream particulate control device. This is due to the physical arrangement typical of these configurations, which make it difficult to make measurements in between the two devices. The majority of the configurations tested were SDA-FF. The results suggest a strong dependence on chlorine content. This configuration yielded the only statistically significant correlation in the database. The other configuration (SDA-ESP) yielded results with a large scatter and little dependence on chlorine.

SDAs remove similar amounts of gaseous oxidized mercury as compared to FGDs, but often remove a significant amount of gaseous elemental mercury as well, particularly those on boilers burning bituminous coal that are coupled with a fabric filter.

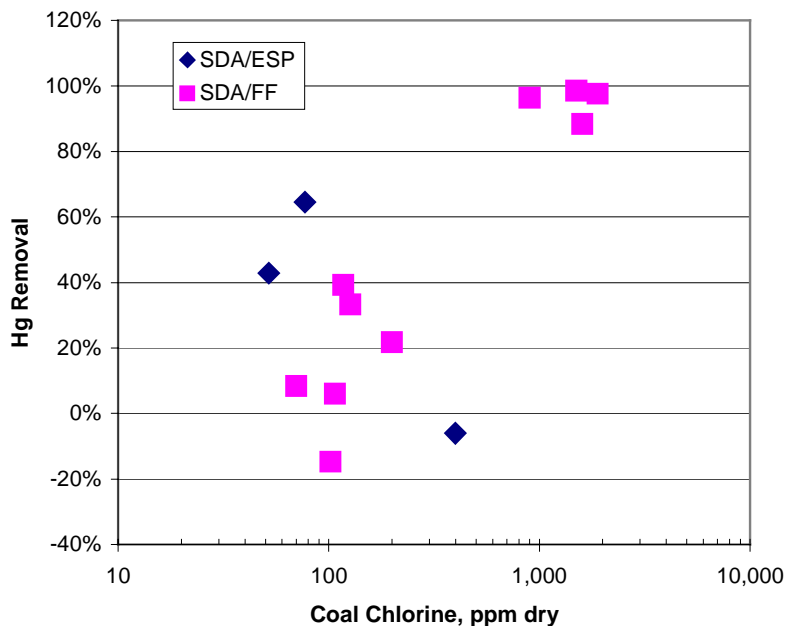
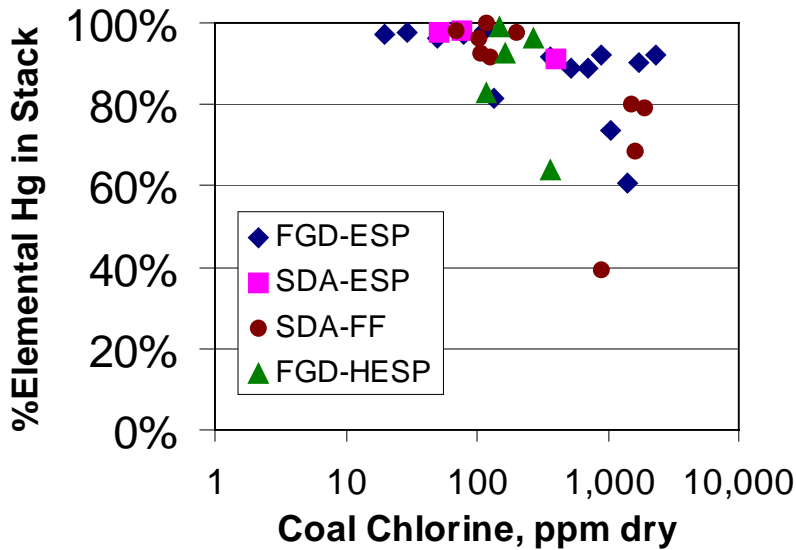


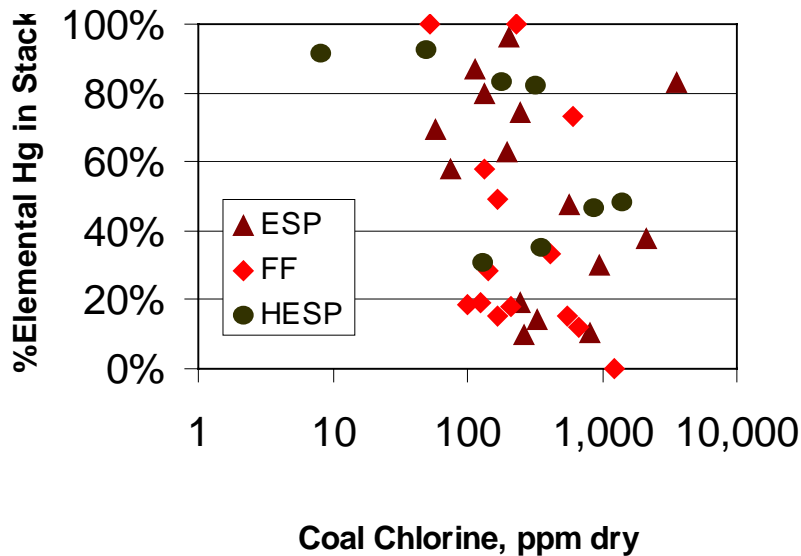
Figure 7. Mercury Removal across Spray Dry Absorbers

Speciation at stack

The stack speciation of mercury appears to depend on the chlorine content of the coal because conversion of elemental mercury to an oxidized form is probably most strongly influenced by chlorine chemistry, either heterogeneously or homogeneously. Data from EPA's Information Collection Request (Figure 8) show anywhere from almost no Hg⁰ to 95% Hg⁰ emitted from coal-fired power plants. Units with scrubbers emit very little oxidized mercury, as would be expected. Units with only particulate control devices have a much broader range of mercury speciation in the stack.



(a) Scrubbers



(b) Particulate Control Devices

Figure 8. Observed speciation of mercury in the stacks of coal-fired power plants (as percent elemental mercury) as a function of coal chlorine content.

Coal vs. flue gas measurements

A major factor contributing to the poor accuracy of the predictions for ICR data may be differences between the amount of mercury measured in the coal and the total amount in the flue gas. There were few attempts in any of the ICR data sets to carry out a mass balance of mercury around the plant, that is, to determine if the mercury coming into the plant in the

Table 3. Average mercury removals for APCD's by coal rank

APCD	Bitumin. Average Removal	Std.Dev.	N	Low Rank Average Removal	Std.Dev.	N
ESP	49.6%	25.0%	7	13.2%	20.1%	6
HESP	14.5%	31.2%	4	2.1%	9.4%	4
FF	62.6%	38.3%	5	45.4%	35.8%	5
FGD-ESP	57.6%	25.4%	7	33.7%	14.4%	2
FGD-HESP	105.9%		1	46.4%	25.9%	7
FGD-FF	86.1%	9.9%	2	19.4%	4.3%	4
FGD-WS	-0.1%		1	12.8%	25.6%	4
SDA-ESP				33.8%	36.1%	3
SDA-FF	82.9%	28.0%	5	12.1%	20.0%	5

Table 4. Average removals of gaseous mercury and mercury species for APCD's by coal rank

APCD	Bituminous			Low Rank		
	Avg Hg ⁺² decrease	Avg Hg ⁰ decrease	Avg Gaseous decrease	Avg Hg ⁺² decrease	Avg Hg ⁰ decrease	Avg Gaseous decrease
ESP	9.4%	22.6%	17.4%	-92.6%	5.6%	0.1%
HESP	-1.4%	21.9%	22.4%	14.2%	-4.5%	-0.3%
FF	5.1%	28.3%	15.6%	-61.6%	59.1%	14.7%
FGD-ESP	87.2%	-11.4%	49.3%	91.2%	-12.1%	24.4%
FGD-HESP	138.4%	-174.5%	8.4%	127.5%	-16.2%	33.9%
FGD-FF	86.8%	-1.1%	74.0%	66.5%	4.4%	27.0%
FGD-WS	78.2%	-336.2%	9.4%	81.7%	-246.3%	-47.9%
FGD-All	91.0%	-53.8%	46.5%	99.0%	-72.0%	10.3%
SDA-ESP				88.7%	-8.2%	26.6%
SDA-FF	52.1%	8.1%	51.7%	47.7%	-76.3%	2.2%

Wet FGD's, dry scrubbers, and fabric filters can all remove a significant amount of the gaseous mercury in the flue gas under certain conditions. SDAs produce decreases in oxidized mercury (50-90%). For bituminous coals, PCDs produce an average decrease of 20% in elemental mercury, which can be attributed to oxidation for the most part. For low rank coals, there is little change in elemental mercury across ESPs, but FFs show large decreases in elemental mercury, on the order of 50% on average. Gaseous mercury (elemental plus oxidized) is observed to decrease about 20% across PCDs for bituminous coals, suggesting that some adsorption of mercury takes place. For low rank coals, in contrast, there is virtually no change in gaseous mercury across ESPs and only about a 15% decrease on average across FFs. Thus, there is evidence for oxidation of elemental mercury as well as adsorption of gaseous mercury across particulate control devices.

Data from the ICR may be used to increase our knowledge of the effect of coal type, combustion system and APCD's on mercury speciation and emissions. These data must be

evaluated carefully. In many cases, critical information may be missing or measurements in error. Several sources of inaccuracy in the predictions were identified, specifically,

- Lack of ash composition data which could be used to improve the prediction of the adsorption of mercury on fly ash the oxidation of mercury in particulate control devices;
- Uncertainty in the measurement of coal chlorine, a key parameter for mercury oxidation in flue gas;
- Over-reporting of oxidized mercury by the Ontario Hydro method when applied to flue gas containing high ash loadings;
- Poor mercury mass balance closure.

APCD systems have not previously been tuned to maximize mercury capture; such a strategy may be considered in the future, if mercury regulations are imposed. Most APCDs have been associated with reductions in mercury emissions, although the speciation of mercury is very important in determining the magnitude of reduction. However, a considerable increase in our understanding of the behavior of mercury in APCDs will be required even to get consistent mercury reductions without having an impact on removal efficiency of particulate, SO₂ or NO_x.

NOMENCLATURE

ESP: Electrostatic Precipitator
FF: Fabric Filter
FGD: Flue Gas Desulfurization
SDA: Spray Dryer Absorber
FBC: Fluidized Bed Combustor
ICR: Information Collection Request

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Key words: Mercury measurements, coal-fired plants, Mercury ICR.