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Mercury Speciation Measurements on a 10 MW_e Coal-Fired Boiler Simulator

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ABSTRACT

MERCURY SPECIATION MEASUREMENTS ON A 10 MW_e COAL-FIRED BOILER SIMULATOR

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The current trends towards deregulation of electric utilities, air toxic regulations and stringent fine particulate emissions reflect an increased need for coal-based research. In response, Babcock and Wilcox invested in the state-of-the-art 100 million Btu/hr (10 MW_e equivalent) Clean Environment Development Facility (CEDF) located in Alliance, Ohio. The representative combustion conditions, flow patterns and residence times permit direct scale-up of CEDF test results to commercial boilers and pollution control devices. In cooperation with the U.S. Department of Energy and the Ohio Coal Development Office within the Ohio Office of Development, B&W is employing the CEDF to conduct a five-year project aimed at the development of practical, cost-effective strategies for reducing the emissions of hazardous air pollutants from coal-fired boilers. The project specifically targets the control of mercury, the trace element under close scrutiny by the EPA. Due to the various forms of mercury emissions from coal-fired boilers, accurate mercury speciation measurements are required to develop mercury control strategies. Current uncertainty in the accuracy and mercury speciation capability of mercury sampling methods led B&W to use both EPA Method 29 and the Ontario Hydro procedures to measure mercury emissions from CEDF pollution control devices. A comparison of the speciated mercury emissions is presented.

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INTRODUCTION

Babcock & Wilcox is conducting the Advanced Emissions Control Development Project (AECDP) which is aimed at the development of practical, cost-effective strategies for reducing the emissions of hazardous air pollutants (commonly called air toxics) from coal-fired electric utility plants. The need for such controls may arise as the U. S. Environmental Protection Agency (EPA) proceeds with implementation of requirements set forth in the Clean Air Act Amendments (CAAA's) of 1990. Promulgation of air toxics emissions regulations for electric utility plants could dramatically impact utilities burning coal, their industrial and residential customers, and the coal industry. Work during the project will supply the information needed by utilities to respond to potential air toxics regulations in a timely, cost-effective, environmentally-sound manner which supports the continued use of the Nation's abundant reserves of coal, such as those in the State of Ohio. The development work is being carried out using B&W's new 10 MW_e Clean Environment Development Facility (CEDF) wherein air toxics emissions control strategies can be developed under controlled conditions. The specific objectives of the project are to 1) measure and understand production and partitioning of air toxics species for a variety of coals, 2) optimize the air toxics removal performance of conventional flue gas cleanup systems, 3) develop advanced air toxics emissions control concepts, 4) develop and validate air toxics emissions measurement and monitoring techniques, and 5) establish a comprehensive, self-consistent air toxics data library. Development work is currently targeting the capture of mercury, fine particulate, and a variety of inorganic species such as the acid gases hydrogen chloride and hydrogen fluoride. This work is supported by the Department of Energy, the Ohio Coal Development Office within the Ohio Department of Development and Babcock & Wilcox.

APPROACH

These objectives will be achieved through development testing in B&W's state-of-the art Clean Environment Development Facility (CEDF). The project has extended the capabilities of the 100 million Btu/hr CEDF to facilitate air toxics emissions control development work on "backend" flue gas cleanup equipment. Specifically, an electrostatic precipitator (ESP), a fabric filter (baghouse), and a wet scrubber for SO₂ control were added -- all designed to yield air toxics emissions data under controlled conditions, and with proven predictability to commercial systems. A schematic of B&W's CEDF and the project test equipment added is shown in Figure 1.

The CEDF design is based on extensive numerical modelling to replicate the thermal environment and flow characteristics of a "hot" utility boiler. Convection pass metal temperatures are maintained by way of a novel double-walled tube design and cooling with boiling water. Sufficient heat-transfer surface is available to cool the flue gas from the furnace exit temperature of around 2300 °F to the convection bank exit temperature of approximately 700 °F while burning high volatile, bituminous coal at full load. After the convection bank, the flue gas enters an air heater. Careful control of the flue gas cooling rate provides a gas time-temperature profile that is similar to commercial units to generate similar levels and forms of trace substances. The backend equipment including an ESP, baghouse, wet scrubber, and combined dry scrubber/baghouse configuration can be operated simultaneously for air toxics evaluation.

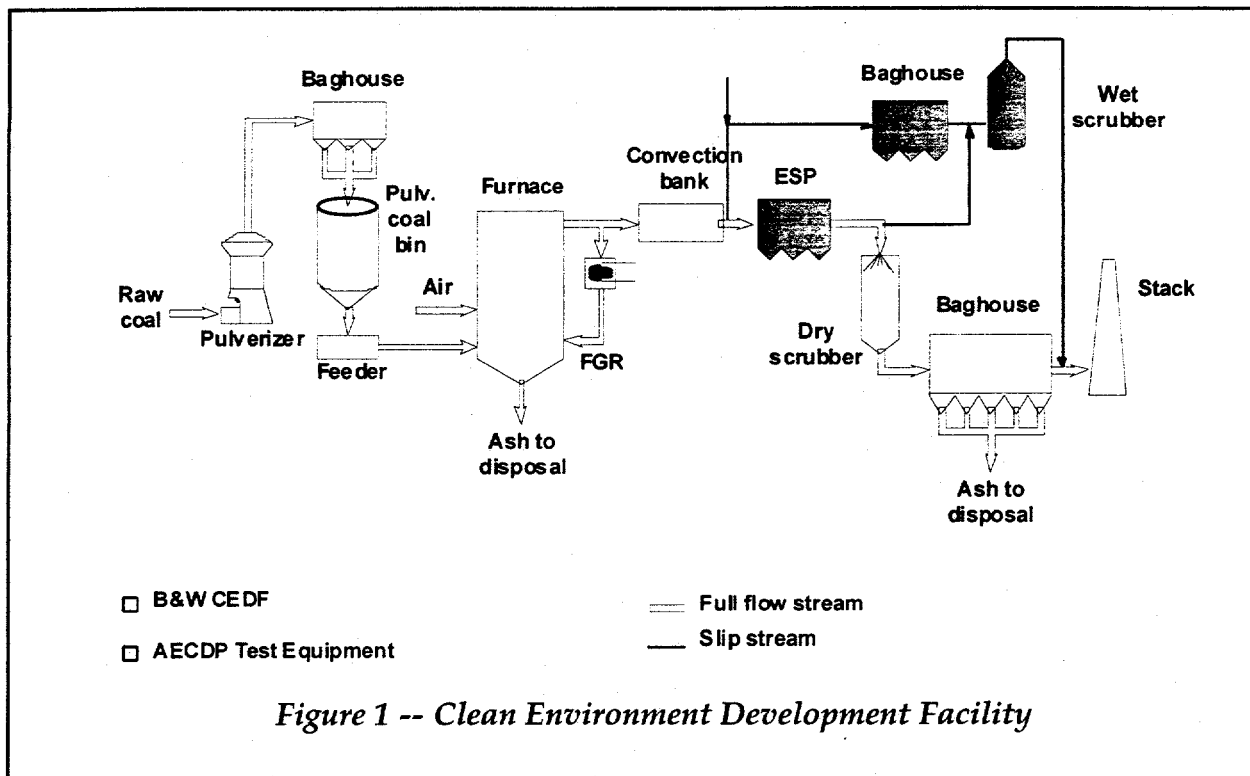


Figure 1 -- Clean Environment Development Facility

PROJECT PHASES

The project is divided into three phases. Phase I (Facility Modification and Benchmarking) consisted of installation, shakedown, validation, and benchmarking of the test equipment added (ESP, slipstream baghouse, and wet SO₂ scrubber) to B&W's CEDF. Baseline air toxics emissions and capture efficiency were established for each of the major flue gas cleanup devices: ESP, baghouse, and wet SO₂ scrubber. All tests were conducted with a high sulfur Ohio steam coal. The work in this phase culminated in the development of a data library for use by project participants.

Phase II (Optimization of Conventional Systems) testing will involve the development of air toxics control strategies based on conventional particulate and SO₂ control equipment. Development testing, engineering and evaluation will be done to optimize the performance of these devices for the capture of air toxic species. Phase II testing will also provide data on the impacts of coal properties on air toxics emissions for several steam coals. The development of new air toxics measurement techniques and monitoring instrumentation will also be investigated in this phase. Phase II work started in early 1996.

Phase III (Advanced Concepts and Comparison Coals) testing will be directed at the development of new air toxics emissions control strategies and devices, to further reduce the emissions of selected toxics. Testing will also be conducted to extend the air toxics data library to include a broader range of coal types. Finally, the development work on advanced air toxics emissions measurement and monitoring techniques begun in Phase II will continue in Phase III.

FACILITY OPERATION

The first test series of Phase II was completed in June, 1996. The test focus was the characterization of trace metal and particulate emissions from the particulate control devices as a function of ESP and slipstream baghouse operating conditions. The resulting information will be used to guide future evaluation of commercial control concepts for utilities that are equipped with wet scrubbers. Testing emphasis was placed on mercury speciation and control.

The CEDF was operated at constant, full load conditions (100 million Btu/hr, 10 MW_e equivalent). Key CEDF operating parameters (coal feed rate, load) had standard deviations of approximately 1.5%. A blend of Ohio 5 and 6 (Lower and Middle Kittanning) was fired with a low NO_x burner at a rate of approximately 4 tons per hour. The average CEDF boiler flue gas composition as measured at the air heater outlet is provided on a dry basis in Table 1. Low carbon carryover in the ESP hopper ash between 2.0 - 2.5% was measured by loss on ignition (LOI). Sootblowing, scheduled between sampling incidents, was done with full commercial size utility sootblowers.

The average trace element concentrations in the Phase I and Phase II composite coals are compared in Table 2. As in Phase I testing, each pulverized, as-fired coal sample that made up the composite samples was individually analyzed for mercury to better evaluate the coal mercury variability. The as-fired average coal mercury content based on the twenty (20) individual samples was 0.22 ± 0.04 ppm (18%). The as-fired average coal mercury content based on the eight (8) composite coal samples was 0.25 ± 0.025 ppm (10%). Coal mercury recovery ranged between 102 - 103% for European coal standards.

Flue Gas Component	Average
NO _x , ppm	< 200
SO ₂ , ppm	2,370
CO ₂ , %	15.4
O ₂ , %	3.28
HCl, lb/10 ⁹ Btu	84,500
Particulate, lb/10 ⁶ Btu	3.82

Table 2 Coal Trace Element Analysis, ppm		
Analyte	Phase I	Phase II
Antimony	0.95 ± 0.86	0.19 ± 0.04
Arsenic	1.25 ± 0.42	7.76 ± 0.87
Barium	18.25 ± 0.91	17.01 ± 5.77
Beryllium	2.92 ± 0.43	3.11 ± 0.43
Cadmium	0.21 ± 0.11	0.19 ± 0.28
Chromium	13.97 ± 0.56	18.13 ± 2.17
Cobalt	0.94 ± 0.14	4.91 ± 0.19
Lead	3.75 ± 0.53	6.10 ± 1.27
Mercury	0.24 ± 0.05	0.25 ± 0.02
Nickel	9.59 ± 2.38	15.31 ± 5.3
Selenium	1.84 ± 0.24	2.51 ± 0.24
Chloride	1,154 ± 30	1,018 ± 288

SAMPLING AND ANALYTICAL PROCEDURES

Mercury and particulate emissions were the primary targets of the test series. In addition, other trace metals (antimony, arsenic, barium, cadmium, chromium, cobalt, lead, manganese, nickel and selenium) were selectively analyzed to provide ESP and baghouse performance data. Sampling time was generally 4 hours to ensure quantification (at levels at least 10 times the detection limit) of trace metals that are well controlled across particulate devices. The 4-hour sample time was twice as long as necessary to quantify the mercury emissions.

Sampling was conducted according to EPA Method 29 and Ontario Hydro procedures. EPA Method 29 was selected as the current EPA-approved grab sampling method for *total* mercury and other metals. The Ontario Hydro method, which has been evaluated by several organizations to provide an improved measure of the elemental and oxidized mercury species relative to EPA Method 29, was most frequently employed. The Ontario Hydro method was selected based on initial reports that Ontario Hydro total mercury emissions were comparable to Method 29 and the ease of sample recovery relative to Method 29. To leverage operating time, an independent sampling contractor (ATS, Inc.) performed nearly simultaneous measurements. ATS, Inc. was specifically selected on the basis on their experience in Ontario Hydro sampling and mercury analysis. Each sampling organization was also responsible for the analysis of samples collected by its personnel. Ninety-eight percent (98%) of the planned flue gas samples were obtained within one hour of the original schedule.

In Method 29, oxidized mercury is collected in the initial impingers (nitric acid/peroxide) and the remaining elemental mercury is collected in the final impingers (potassium permanganate solution). It is suspected that the nitric acid/peroxide may oxidize the elemental mercury resulting in an over-reporting of the oxidized mercury fraction.

In the Ontario Hydro (OH) method, the initial impinger solutions of Method 29 are modified. Potassium chloride (KCl) is substituted for the nitric acid/peroxide solutions to capture the oxidized component. This modification is believed to minimize the potential for oxidation of elemental mercury in the peroxide impinger solutions and provide a better measure of the mercury species distribution in the flue gas.

The evaluation of alternative sampling methods to quantify mercury species in coal-fired flue gas is the subject of several on-going research projects primarily funded by the DOE and EPRI. Inherent limitations of Method 29 for quantifying mercury species have been recognized and are driving the development of alternative sampling techniques. EPA Method 29, however, is still a benchmark for comparison of total mercury emissions for alternative methods.

Observations on the mercury sampling methods include: ^[1]

During OH sampling, a substantial portion of the mercury can be lost. To minimize mercury loss primarily from the KCl impingers, the use of a preservative (permanganate, dichromate, or peroxide) is recommended.

The amount of mercury captured on the sampling filter, and therefore the amount reported as particulate-phase mercury, is influenced by filter temperature.

Oxidation of elemental mercury across high sulfur, bituminous coal flyash is suspected.

Characterization of wet scrubber mercury behavior with Method 29 often results in higher elemental mercury emissions measured at the scrubber outlet relative to the inlet. This has been attributed to the higher SO₂ levels at the scrubber inlet that result in an over-reporting of oxidized mercury.

Many of these phenomena were observed at a scale between 0.1 - 4 MW_e and frequently with simulated flue gas combined with mercury spiking. As discussed, B&W has independently observed similar phenomena at the 10 MW_e scale with unaltered coal-fired flue gas.

METHODS DISCUSSION

Total mercury emissions from the boiler and at the baghouse outlet as measured by EPA Method 29 and the OH method are compared in Table 3. Mercury emissions are reported in $\mu\text{g}/\text{dscm}$ normalized to 3% O_2 . Total uncontrolled mercury measured by both methods was lower than predicted mercury emissions based on the mercury coal content ($28.9 \pm 3.0 \mu\text{g}/\text{dscm}$) under the assumption that no partitioning onto the boiler bottom ash occurs. The lower mercury levels measured by the OH method compared to Method 29 coincide with observations made by other researchers.

Table 3 Comparison Between Ontario Hydro and Method 29		
Total Mercury Emissions [$\mu\text{g}/\text{dscm}$]		
Method	Boiler Outlet	Baghouse Outlet
Method 29	19.6 ± 4.3	21.3 ± 5.6
Ontario Hydro	14.1 ± 2.4	11.7 ± 5.1

Ontario Hydro Preservative

The lower total mercury emissions measured by the OH method were primarily due to the consistently lower oxidized mercury concentrations (compared to Method 29) suggesting a loss of mercury from the OH KCl impingers. In the absence of an oxidizing species such as peroxide, oxidized mercury could be reduced to more volatile elemental mercury. A number of preservatives (permanganate, dichromate, or peroxide) have been recommended for use in the OH KCl solutions to retard mercury loss during recovery.^[1] To date, B&W experience has been limited to the use of dichromate. The results of several B&W test programs suggest a correlation of the time between the completion of sampling and the addition of preservative to the amount of mercury loss from the OH impinger solutions. Immediate preservation after leak checking and rapid analytical recovery may reduce mercury loss. In future tests, B&W plans to add KMnO_4 preservative (for the visual color change) in known quantities after post leak checking.

Influence of SO_2

The uncontrolled boiler mercury emissions measured by Method 29 and the OH method are further broken down into the speciated fractions in Figure 2. The percentage of the total emissions attributed to elemental mercury measured with Method 29 by both sampling teams was consistently lower than

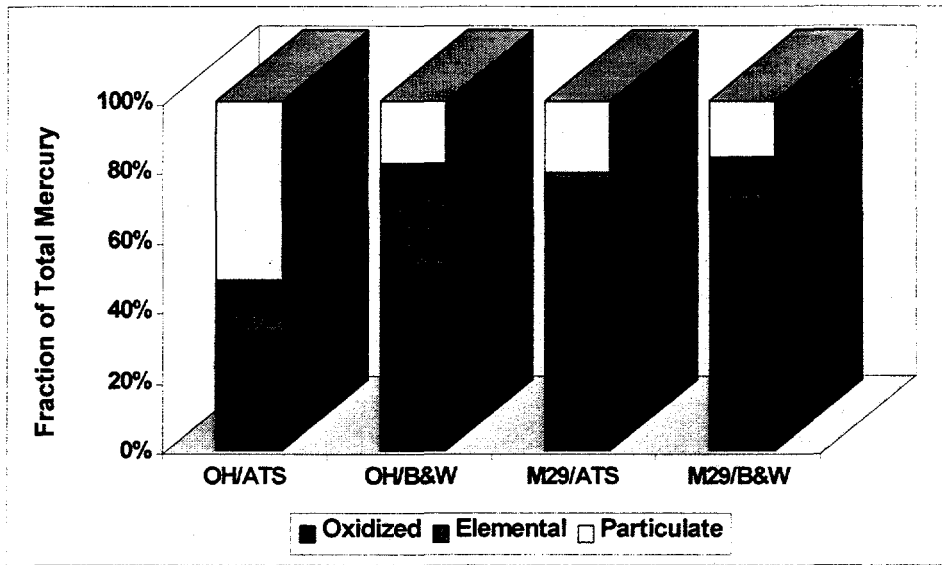


Figure 2 -- Uncontrolled Mercury Speciation Data Based on Ontario Hydro and Method 29

measured with OH train. Extensive bench-scale experiments have been conducted by the Energy & Environmental Research Center (EERC) to examine whether flue gas constituents influence the ability of Method 29 to provide accurate speciated mercury results, namely the oxidation of elemental mercury by SO_2 . EERC found that the addition of 1,500 ppm SO_2 to simulated flue gas resulted in the collection of about 10 - 12 % of the injected elemental mercury in the acidified peroxide impingers, therefore reported as oxidized mercury. ^[1] The elemental mercury CEDF boiler emissions averaged 1.21 $\mu\text{g}/\text{dscm}$ according to Method 29 and averaged 3.15 $\mu\text{g}/\text{dscm}$ on the basis of four OH measurements. On the basis of these averages, approximately 62% of the elemental mercury was not collected in the Method 29 KMnO_4 impingers. This suggests that there is an increase in the under reporting of elemental mercury (or over reporting of oxidized mercury) by Method 29 at SO_2 concentrations of 2,400 ppm relative to 1,500 ppm SO_2 .

However, SO_2 can also behave as a reducing agent. During sampling in high SO_2 flue gas streams, a pink precipitate has been observed in the connecting glassware and neck of the first OH KCl impinger. Sulfur dioxide has been reported to reduce selenious acid to elemental selenium which is a reddish-pink solid. ^[2] Selenium in the elemental form has also been observed to precipitate from wet scrubber limestone absorber filtrates. Identification of the selenium was confirmed by X-ray Fluorescence. If SO_2 can reduce oxidized forms of selenium, it is feasible that SO_2 may reduce oxidized mercury in wet scrubbers.

Filter Temperature Impacts

Figure 2 also illustrates the high fraction of particulate mercury during the OH measurements conducted by ATS which was attributed to the temperature of the sampling filter. The impact of the filter

temperature on the mercury particulate results where the flue gas temperature was maintained at approximately 300 °F under constant full load conditions is shown in Figure 3. Due to the lower filter temperature maintained by ATS personnel, the fraction of mercury measured in the particulate was higher than measured by B&W. To overcome impacts of filter temperature on mercury speciation results, the filter should be maintained at the flue gas temperature. In the case of measurements downstream of a wet scrubber, the filter temperature should probably be maintained at 250 °F as prescribed by EPA Method 29.

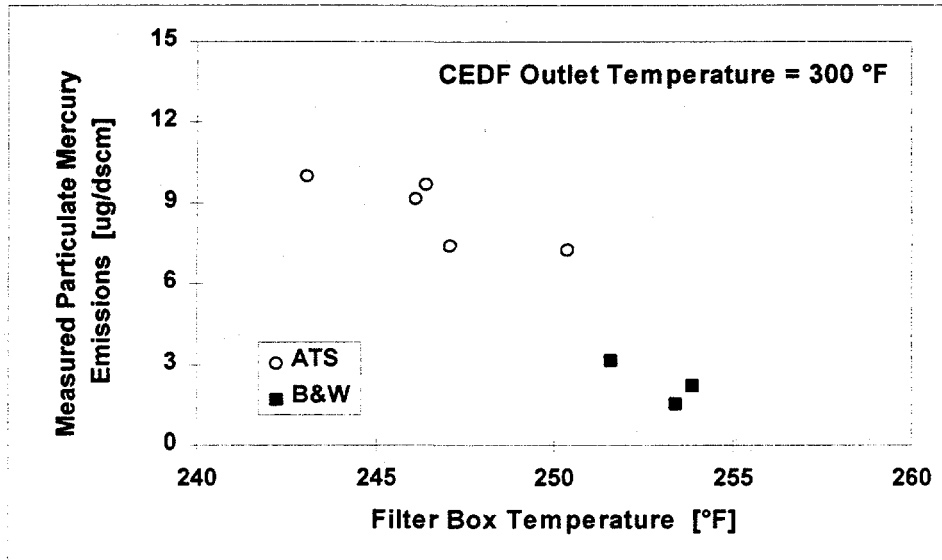


Figure 3 -- Impact of Ontario Hydro Filter Temperature on Mercury Particulate Emissions

Digestion of Ontario Hydro Solutions

Digestion of Method 29 nitric acid/peroxide impingers solutions is required to destroy the peroxide present before reduction of oxidized mercury and subsequent measurement as elemental mercury by cold vapor atomic absorption spectroscopy (CVAAS). The OH method does not specify the digestion of the KCl impinger solutions. Organic compounds are a positive interference at the 253.7 nm line for elemental mercury absorption measurements. At ppb levels of mercury in the impinger solutions, absorption of organic compounds could be significant. Therefore, samples were analyzed directly (after dichromate preservation) and again after the standard method of Method 29 digestion was performed. Figure 4 compares the KCl mercury content before and after digestion. The average 12% reduction in mercury suggests a high bias of oxidized mercury emissions by the OH method due to the presence of organics in the flue gas.

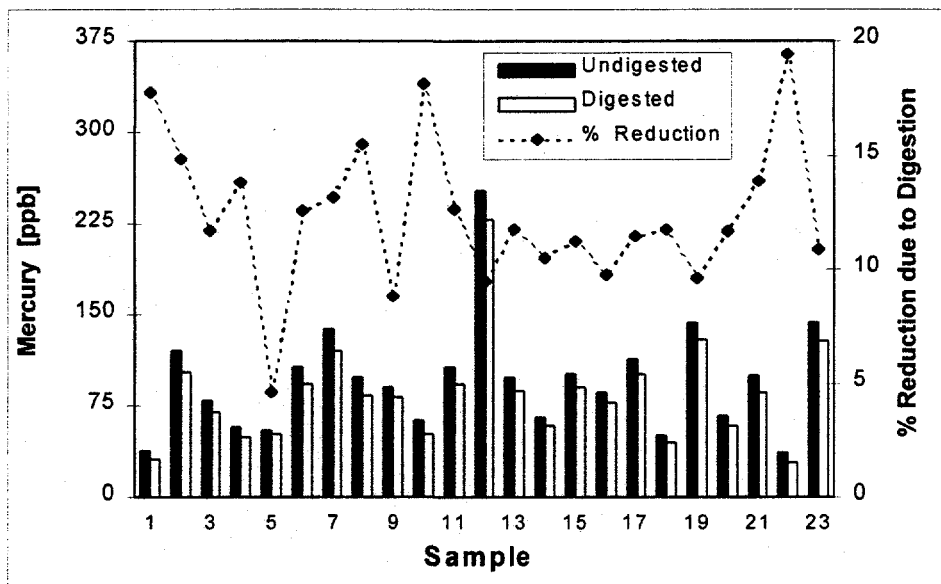


Figure 4 -- Impact of Digestion on Ontario Hydro KCl Impinger Solutions

MERCURY EMISSIONS CONTROL

Pulse-Jet Baghouse

Two fabrics, Ryton and GORE-TEX®, were evaluated for particulate and mercury emissions control. Particulate emissions lower than the current New Source Performance Standard of 0.03 lb/million Btu were readily achieved with both the Ryton and GORE-TEX® fabrics. The Ryton fabric reduced particulate emissions to less than 0.01 lb/million Btu over a range of air-to-cloth ratios (3 - 4.3 ft/min) and baghouse operating temperatures (240 - 300 °F). The GORE-TEX® fabric provided significant improvement in particulate control. Particulate penetration through the GORE-TEX® fabric was less than 0.005 lb/million Btu over a similar range of air-to-cloth ratio and baghouse operating temperature.

Total slipstream baghouse mercury emissions as measured by EPA Method 29 and the OH method were previously compared in Table 3. The majority of the mercury emissions exiting the baghouse and entering the wet scrubber was measured as the oxidized form. However, due to the possible loss of oxidized mercury in the OH KCl impinger solutions and presumed inability of Method 29 to adequately speciate at high SO₂ concentrations, the discussions of mercury behavior across the control devices will be generally limited to elemental mercury as measured by the OH method and total mercury as measured by Method 29.

The elemental mercury emissions entering the slipstream baghouse averaged $2.8 \pm 1.0 \mu\text{g}/\text{dscm}$ as measured by both sampling teams in the flue gas temperature range of 300 - 350 °F. Table 4 compares the average elemental mercury emissions exiting the baghouse based on the OH method for both fabric types. The number within the parentheses signifies the number of replicate measurements. The results from both sampling teams do not suggest a consistent impact of fabric type on elemental mercury

a transformation or removal of elemental mercury. Since the elemental mercury emissions were comparable between fabrics (for each sampling team) the transformation or removal is likely due to the high-sulfur bituminous coal flyash. Although suspect due to loss of oxidized mercury from the OH KCl solutions, B&W generally measured higher oxidized mercury at the baghouse exit than at the inlet, supporting the possible oxidation of elemental mercury across the slipstream baghouse coal flyash filter cake. Similar results based on Method 29 were observed in Phase I testing which suggested a transformation of elemental to oxidized mercury across the slipstream baghouse. Total baghouse mercury removal as measured by both sampling teams with Method 29 was negligible at a baghouse temperature of 300 °F. The majority of the baghouse mercury emissions were in the oxidized form.

Fabric	ATS Measurements [$\mu\text{g}/\text{dscm}$]	B&W Measurements [$\mu\text{g}/\text{dscm}$]
Ryton	0.27 \pm 0.19 (6)	1.61 \pm 0.51 (5)
GORE-TEX®	0.36 \pm 0.18 (4)	1.26 \pm 0.57 (3)

Electrostatic Precipitator

Elemental mercury emissions entering the ESP (and baghouse) were measured at 2.8 \pm 1.0 $\mu\text{g}/\text{dscm}$ throughout the test period as previously discussed. The average elemental mercury emissions (based on OH sampling) from the ESP as a function of ESP outlet temperature are presented in Table 5. As measured by both sampling teams, elemental mercury passed unaffected through the ESP over operating temperatures of 250 - 300 °F. The ESP temperature was controlled with a flue gas cooler or by flue gas humidification. The variation in total mercury emissions from the ESP (similarly to the slipstream baghouse) was primarily due to variation in the oxidized fraction supporting the loss of mercury from the OH impinger solutions. Even with the presumed loss of oxidized mercury, the majority of the mercury emissions exiting the ESP were measured as the oxidized form. Total ESP mercury removal as measured by both sampling teams with Method 29 was negligible at an ESP temperature of 330 °F.

Location	ESP Inlet	ESP Outlet @ 250 °F	ESP Outlet @ 300 °F
[$\mu\text{g}/\text{dscm}$]	2.8 \pm 1.0 (11)	3.4 \pm 1.2 (3)	3.2 \pm 1.1 (18)

Wet Scrubber

Mercury emissions control by the flue gas desulfurization (FGD) system was not a primary focus of the Phase II test series. However, a few measurements were made to provide some characterization of the potential for mercury emissions control and to scope out parameters for evaluation in future testing. Mercury emissions from the slipstream wet scrubber were measured by ATS, Inc. using the OH method. The limestone forced oxidation scrubber was operated downstream of the slipstream baghouse at two different conditions:

- Low gas velocity - High slurry spray flux
Liquid-to-gas ratio (L/G) of 81 gpm/kacfm
- High gas velocity - Low slurry spray flux
Liquid-to-gas ratio (L/G) of 22 gpm/kacfm

The range of operating conditions was consistent with current commercial wet FGD system operations. An average pH of 5.2 was maintained at both test conditions.

A total of six emission measurements were obtained at the wet scrubber outlet. Two suspect measurements indicated a higher level of elemental mercury present at the scrubber outlet than the *total* level of mercury present at the scrubber inlet. The oxidized mercury and particulate mercury emissions measured in these two tests were consistent with the other four measurements. The wet scrubber mercury speciation measurements excluding the two suspect test results are summarized in Table 6. The scrubber inlet data in Table 6 represents the average of 18 measurements at the baghouse outlet by ATS and B&W. Oxidized mercury results are provided as they clearly show a reduction of oxidized mercury across the wet scrubber.

Table 6 Wet Scrubber Speciated Mercury Emissions - Ontario Hydro			
Location	Elemental [ug/dscm]	Oxidized [ug/dscm]	Total [ug/dscm]
Scrubber Inlet	0.8 ± 0.7	9.0 ± 3.9	10.0 ± 4.3
Scrubber Outlet L/G 81 gpm/kacfm	1.7 ± 0.1	0.3 ± 0.3	2.0 ± 0.4
Scrubber Outlet L/G 22 gpm/kacfm	5.6 ± 1.9	0.5 ± 0.2	6.1 ± 1.8

High efficiency removal of oxidized mercury was observed at both test conditions with an average of 95%. More elemental mercury was measured at the scrubber outlet than at the inlet for both test conditions with the OH method. This is consistent with wet scrubber experience reported in the literature with Method 29. [3,4,5,6] B&W intends to investigate whether the observed elemental mercury behavior is a result of a sampling artifact or wet scrubber operation.

Spray Dryer / Baghouse

Mercury emissions from the CEDF full-flow lime spray dryer/baghouse SO₂ emissions control system were measured using the OH method. Low particulate flue gas from the ESP was directed to the dry scrubber. The dry scrubber was conservatively operated at a 45 degree approach to saturation temperature (165 °F scrubber outlet temperature) to maintain SO₂ emissions below 1.0 lb SO₂/million Btu. The coal sulfur content averaged 3.1%. SO₂ removal averaged approximately 82% over the time period when the mercury emissions were measured.

Mercury measurements around the spray dryer/baghouse are summarized in Table 7. The values represent the averages of three measurements by B&W. The spray dryer inlet mercury measurements at the ESP outlet were conducted simultaneously with measurements downstream of the CEDF baghouse. In a commercial spray dryer, the particulate would not normally have been removed from the flue gas upstream of the spray dryer. Particulate phase mercury was low (typically less than 0.3 µg/dscm) at both the inlet and outlet of the FGD system. The uniform spray dryer/baghouse outlet mercury emissions, primarily in the elemental form, are illustrated in Figure 5.

Table 7 Spray Dryer/Baghouse Speciated Mercury Emissions - Ontario Hydro			
Location	Elemental [ug/dscm]	Oxidized [ug/dscm]	Total [ug/dscm]
Spray Dryer Inlet	2.5 ± 1.6	6.8 ± 1.2	9.3 ± 0.4
Stack	3.2 ± 0.5	0.2 ± 0.1	3.4 ± 0.5

Total mercury removal across the spray dryer/baghouse system was approximately 64% based on OH sampling. Based on the OH measurements, the spray dryer effectively removed approximately 97% of the oxidized and particulate phase mercury. Unlike the wet scrubber, there did not appear to be any trend toward increased levels of elemental mercury across the dry scrubber configuration.

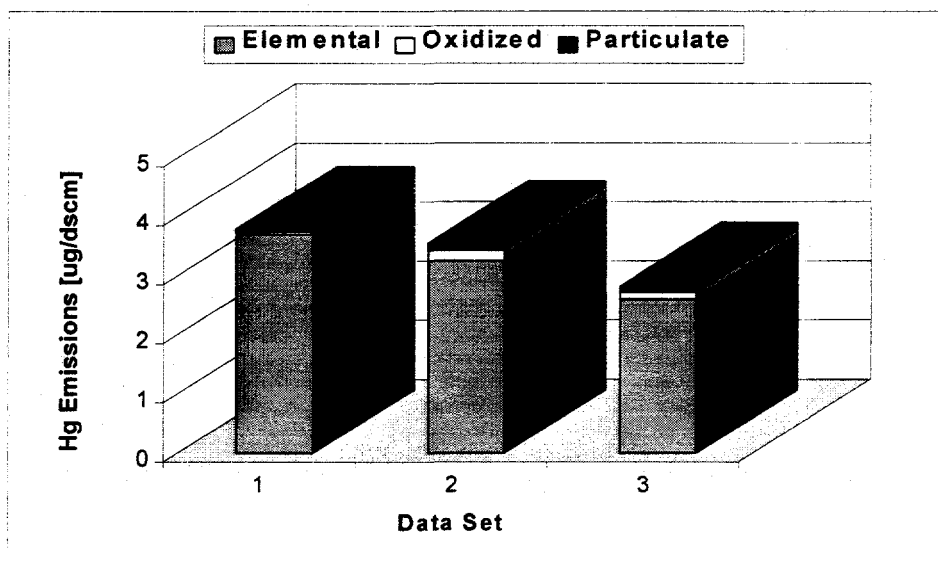


Figure 5 -- Mercury Emissions from the Spray Dryer/Baghouse

Total Mercury Control Summary

In summary, the total mercury emissions measured from the various particulate and SO₂ control devices are illustrated in Figure 6. Negligible total mercury removal was observed across the particulate control devices as measured by Method 29. Mercury emissions from the particulate devices were primarily in the oxidized form. On the basis of Ontario Hydro sampling, total mercury removals greater than 60% were obtained across the wet and dry scrubber systems during conservative operation. Mercury emissions from the flue gas desulfurization systems were mainly in the elemental form due to the consistently high levels of oxidized mercury removal (greater than 94%).

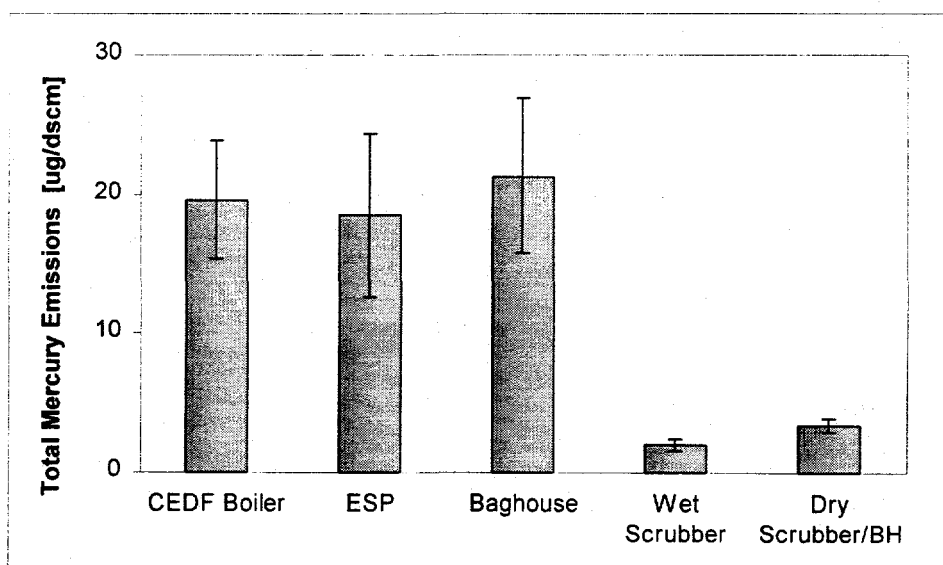


Figure 6 -- Pollution Control Device Mercury Emissions Summary

FUTURE TEST PLANS

The next test series will evaluate wet scrubber operation, modifications, or processes that will enhance mercury control in a commercially viable, cost-effective manner. Plans include more intensive wet scrubber measurements and the evaluation of a continuous mercury monitor.

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