



Model Mercury Test Program

Bituminous Coal-Fired Power Plant

OVERVIEW

This document contains data obtained from an actual mercury test program conducted by Air Quality Services, LLC, with the technical and analytical support of Frontier Geosciences, Inc. (co-author of *US EPA Method 324*, *US EPA Method 1631* and author of the *FAMS™ Method*). This data is presented in graphical summary form, and is intended to provide the reader with a representative example of the type of low detection level, quality-assured mercury test results that have become our standard.

The field collection portion of the mercury test program was conducted over a two-day span on a coal-fired utility boiler system rated at 281 MW and combusting Illinois Basin coal. Air pollution control devices (APCD) include a selective catalytic reduction (SCR) unit for NO_x control, an electrostatic precipitator (ESP) for particulate control, and a flue gas desulphurization (FGD) wet scrubber for SO₂ control. The tested flue gas stream merges with a separate flue gas stream from a 100 MW coal-fired boiler prior to the FGD unit. The *Boiler System Sampling Scheme* on the following page illustrates the boiler system configuration.

A flue gas sampling plan was developed and implemented at strategic locations along the flue gas stream. Flue gas samples were obtained by US EPA Method 324 [for particle-bound and total mercury] and the Fluegas Absorbent Mercury Speciation™ (FAMS™) Method [for particle-bound, total and speciated mercury]. These methods represent a significant advancement for mercury-in-flue-gas sampling and analysis, and were periodically conducted in duplicate to insure reproducible, quality-assured results. Table 1 summarizes the location, type and number of flue gas samples collected during each test run.

Table 1: Flue Gas Samples Collected

Run #	INLET SCR		OUTLET SCR		OUTLET ESP		INLET FGD		STACK		Totals
	M 324	FAMS	M 324	FAMS	M 324	FAMS	M 324	FAMS	M 324	FAMS	
1		1				1	1	1	1	2	7
2		1				1	1	2	1	2	8
3		1				1	1	2	1	2	8
4		1				1		2	1	2	7
5		1		1		1	1	1		1	6
6		1		1		1	1	1		1	6
Totals	0	6	0	2	0	6	5	9	4	10	42

During the test period, selected material samples were also taken at two-hour intervals (whenever practical) and analyzed for total mercury concentration as shown in Table 2:

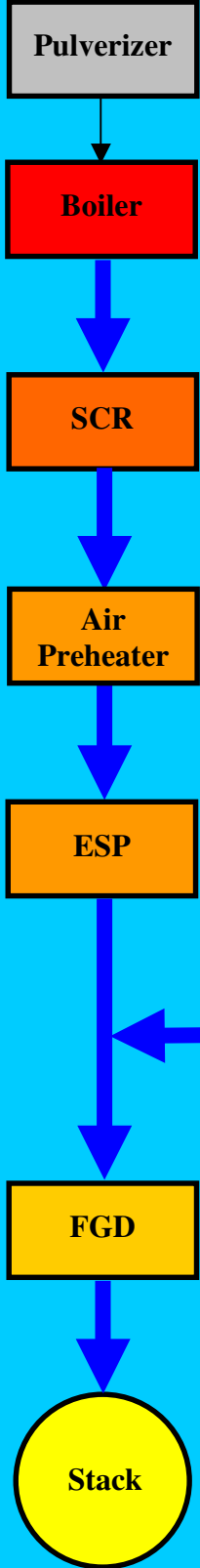




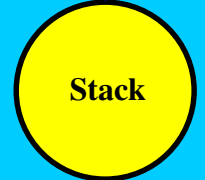
Table 2: Selected Material Samples Collected

Material	No.	Comments
Pulverized Coal	5	Illinois Basin coal
Fly Ash	5	obtained from ESP
Bottom Ash	5	obtained from the ash pond
Sodium Bisulfide Solution	5	used for SO ₃ reduction in the SCR
Scrubber Slurry	5	FGD media
Source Water	5	makeup for scrubber slurry
Lime	5	makeup for scrubber slurry
Gypsum	5	FGD byproduct
Totals	40	

The 42 flue gas samples taken during the six (6) test runs produced 150 flue gas data points¹, and the selected material samples produced 40 additional data points, yielding an impressive total of 190 data points. All samples were properly digested and analyzed by cold vapor atomic fluorescence spectrometry in accordance with US EPA Method 1631. The quantity and quality of the information obtained during this test program gives exceptional insight into the fate of mercury throughout the boiler system. For additional information regarding US EPA Method 324, FAMS™ and US EPA Method 1631, refer to the AQS publication entitled “Mercury Emissions Studies and Test Services”, or contact Steve Endress at (812) 452-4785..

¹ Each FAMS™ sample produces four (4) data points (Hg^P, Hg⁰, Hg⁺², and total Hg) and each US EPA Method 324 sample produces two (2) data points (Hg^P and total Hg).

BOILER SYSTEM SAMPLING SCHEME

<u>Sampling</u>	<u>System/APCD</u>	<u>Comments</u>
<p>Five (5) samples of pulverized coal were taken at two-hour intervals</p>	 <pre> graph TD Pulverizer[Pulverizer] --> Boiler[Boiler] Boiler --> SCR[SCR] SCR --> AirPreheater[Air Preheater] AirPreheater --> ESP[ESP] ESP --> FGD[FGD] FGD --> Stack((Stack)) </pre>	<p>The Hg contained in the coal is the initial source of Hg in the flue gas.</p>
<p>Five (5) samples of bottom ash were obtained from wet sluice at two-hour intervals.</p>		<p>Nearly all of the Hg contained in the coal is vaporized into elemental Hg (Hg⁰) in the combustion zone of the boiler.</p>
<p>One (1) FAMS sample was obtained during each of six (6) test runs at the SCR inlet (total of 6 samples). One (1) FAMS sample was obtained during test runs #5 and #6 at the SCR outlet (total of 2 samples). Five (5) samples of sodium bisulfite solution were obtained during the test period at two-hour intervals.</p>		<p>The SCR incorporates NH₃ and a proprietary catalyst for NO_x control along with sodium bisulfide (SBS) injection for SO₃ control. The flue gas is sorbing Hg through this system.</p>
<p>One (1) FAMS sample was obtained during each of six (6) test runs at the ESP outlet (total of 6 samples). Five (5) samples of fly ash were obtained during the test period at two-hour intervals.</p>		<p>The ESP is removing 71% of the Hg⁺², 96% of the Hg⁰, and 99% of the Hg^P (as measured at the SCR outlet). Total Hg removed through the ESP is 88.41%</p>
<p>Nine (9) FAMS samples and five (5) Method 324 samples were obtained during the six (6) test runs at the FGD inlet (total of 14 samples). Five (5) samples of scrubber slurry were obtained during the test period at two-hour intervals. Five (5) samples of lime, five (5) samples of gypsum, and five (5) samples of source water were obtained.</p>		<p>A separate flue gas stream merges with the system being tested. Hg concentrations (approx. 1.62 µg Hg/m³) in this merging stream (prior to the inlet of the FGD) were deduced from the Hg addition from the ESP outlet to the FGD inlet.</p>
<p>Ten (10) FAMS samples and four (4) Method 324 samples were obtained during the six (6) test runs at the stack (total of 14 samples).</p>		<p>The FGD is effectively removing all of the remaining Hg⁺², leaving only Hg⁰ to be emitted at the stack.</p> <p>Overall Hg removal from the inlet of the SCR to the stack, including the addition of the merging flue gas stream at the FGD inlet, is 86.32%.</p>



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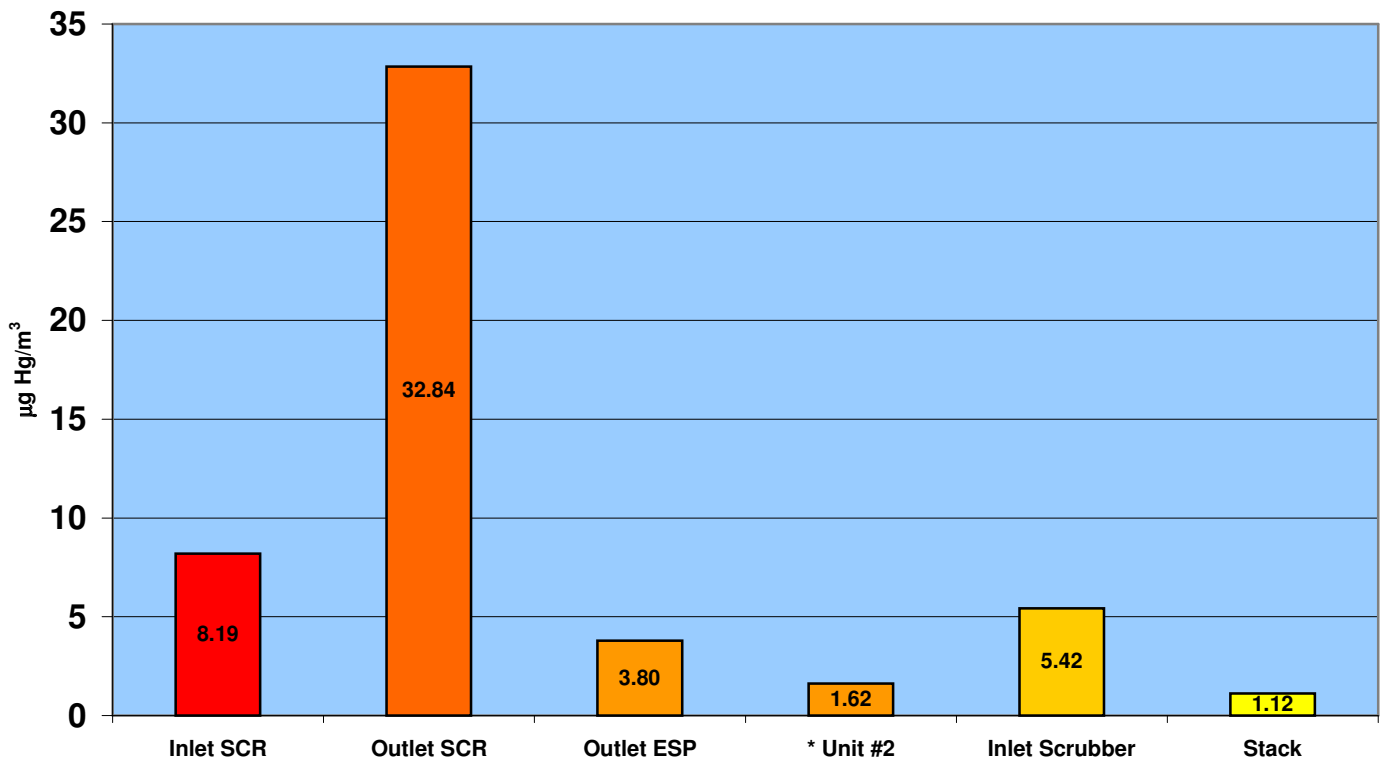
SUMMARY OF AVERAGE TOTAL MERCURY IN FLUEGAS ACROSS AIR POLLUTION CONTROL DEVICES

(data expressed in $\mu\text{g}/\text{m}^3$)

	Inlet SCR	Outlet SCR	Outlet ESP	Unit #2*	Inlet FGD	Stack
Run #1	7.53	N/A	3.98	1.19	5.16	1.04
Run #2	7.82	N/A	3.99	1.32	5.31	0.94
Run #3	8.78	N/A	3.70	2.07	5.77	1.16
Run #4	9.80	N/A	3.26	2.92	6.18	1.25
Run #5	5.79	41.26	4.00	0.92	4.92	1.19
Run #6	9.43	24.43	3.86	1.31	5.17	1.11
Average	8.19	32.84	3.80	1.62	5.42	1.12
Std. Dev.	1.47	11.90	0.29	0.74	0.47	0.11
Rel. Std. Dev.	18.0%	36.2%	7.6%	45.7%	8.6%	9.9%

* Hg contribution from separate coal combustion unit (post ESP) that merges with tested unit prior to scrubber

Avg. Total Hg in Flue Gas Across APCD's



Direction of flue gas stream and decreasing temperature →



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SUMMARY OF TOTAL SPECIATED MERCURY IN FLUEGAS ACROSS AIR POLLUTION CONTROL DEVICES

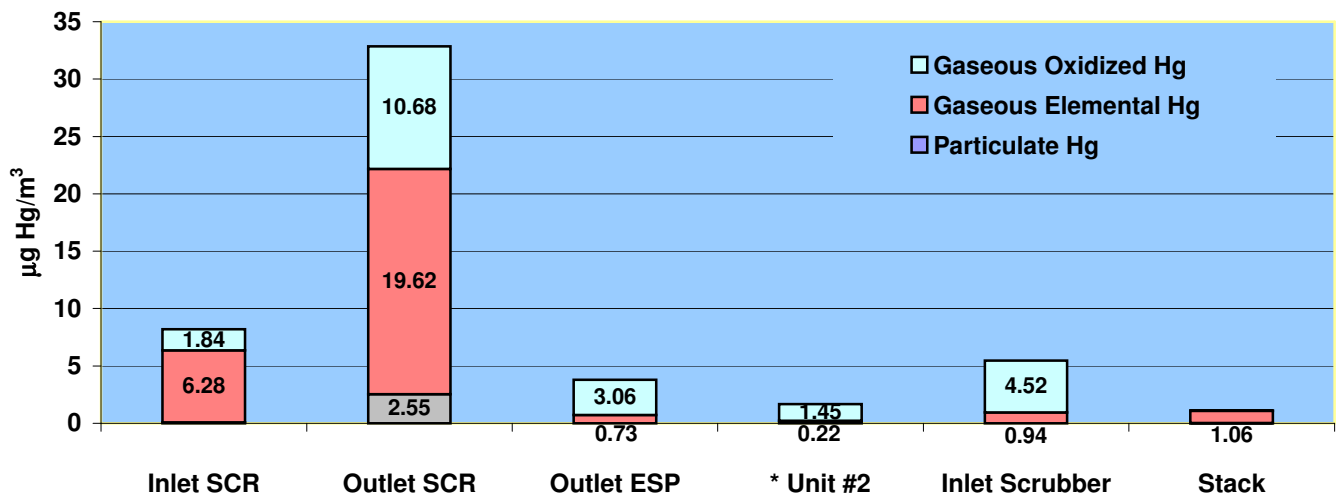
(data expressed in $\mu\text{g}/\text{m}^3$)

	Inlet SCR			Outlet SCR			Outlet ESP		
	Hg ^P	Hg ⁰	Hg ⁺²	Hg ^P	Hg ⁰	Hg ⁺²	Hg ^P	Hg ⁰	Hg ⁺²
Run #1	0.000	6.608	0.923	NA	NA	NA	NA	0.399	3.577
Run #2	0.152	7.577	0.091	NA	NA	NA	0.009	0.642	3.337
Run #3	0.087	8.658	0.041	NA	NA	NA	0.004	0.854	2.842
Run #4	NA	9.295	0.507	NA	NA	NA	0.016	0.909	2.332
Run #5	0.088	2.109	3.591	3.627	25.477	12.153	0.003	0.670	3.327
Run #6	0.110	3.440	5.877	1.464	13.762	9.202	0.000	0.891	2.967
Average	0.087	6.281	1.838	2.546	19.620	10.678	0.006	0.728	3.064
Std. Dev.	0.055	2.898	2.378	1.529	8.284	2.087	0.006	0.197	0.447
Rel. Std. Dev.	63%	46%	129%	60%	42%	20%	99%	27%	15%

	Unit #2 *			Inlet Scrubber			Stack		
	Hg ^P	Hg ⁰	Hg ⁺²	Hg ^P	Hg ⁰	Hg ⁺²	Hg ^P	Hg ⁰	Hg ⁺²
Run #1	NA	0.422	0.787	0.000	0.821	4.364	0.009	0.980	0.061
Run #2	NA	0.118	1.215	0.000	0.760	4.552	0.009	0.908	0.038
Run #3	NA	0.239	1.822	0.003	1.094	4.664	0.026	1.123	0.037
Run #4	NA	0.183	2.734	0.020	1.093	5.066	0.021	1.195	0.041
Run #5	NA	0.265	0.782	0.006	0.934	4.109	0.019	1.055	0.120
Run #6	NA	0.069	1.388	0.002	0.960	4.356	0.026	1.077	0.011
Average	NA	0.216	1.455	0.005	0.944	4.518	0.019	1.056	0.051
Std. Dev.	NA	0.125	0.739	0.007	0.137	0.329	0.008	0.102	0.037
Rel. Std. Dev.	NA	58%	51%	145%	15%	7%	43%	10%	73%

* Hg contribution from separate coal combustion unit (post ESP) that merges with tested unit prior to scrubber

Average Speciated Hg in Flue Gas Across APCD's

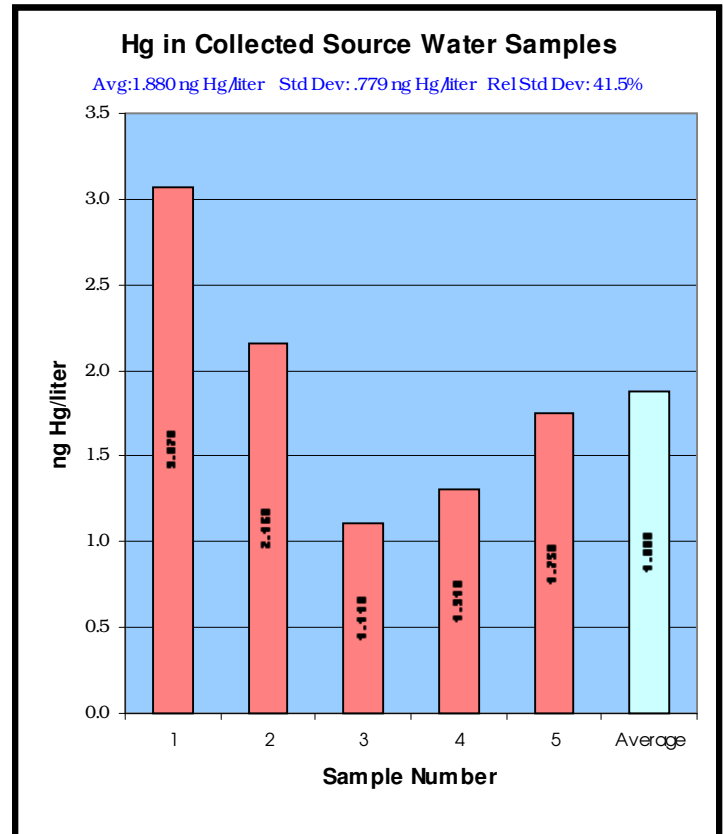
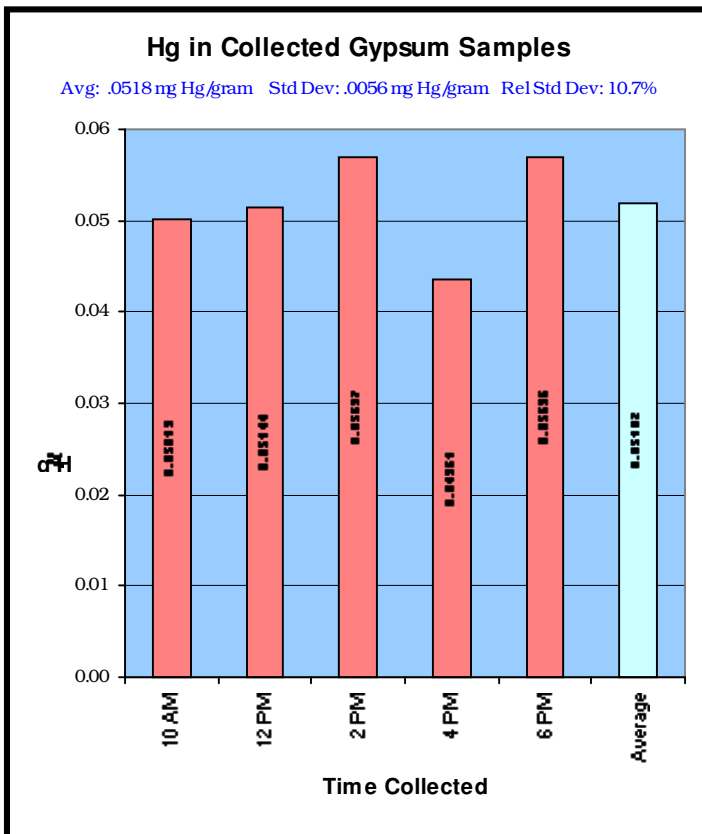
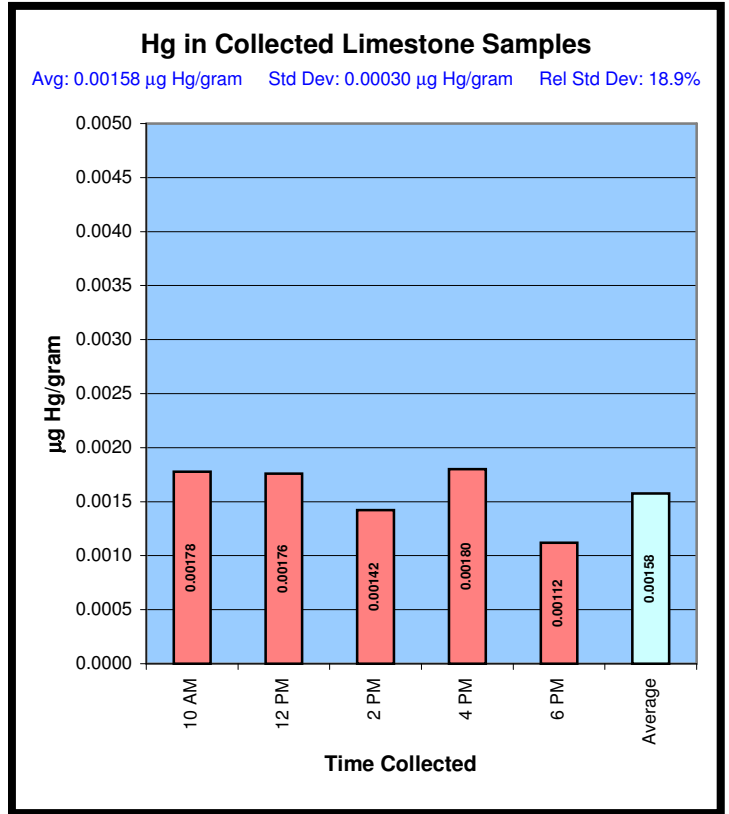
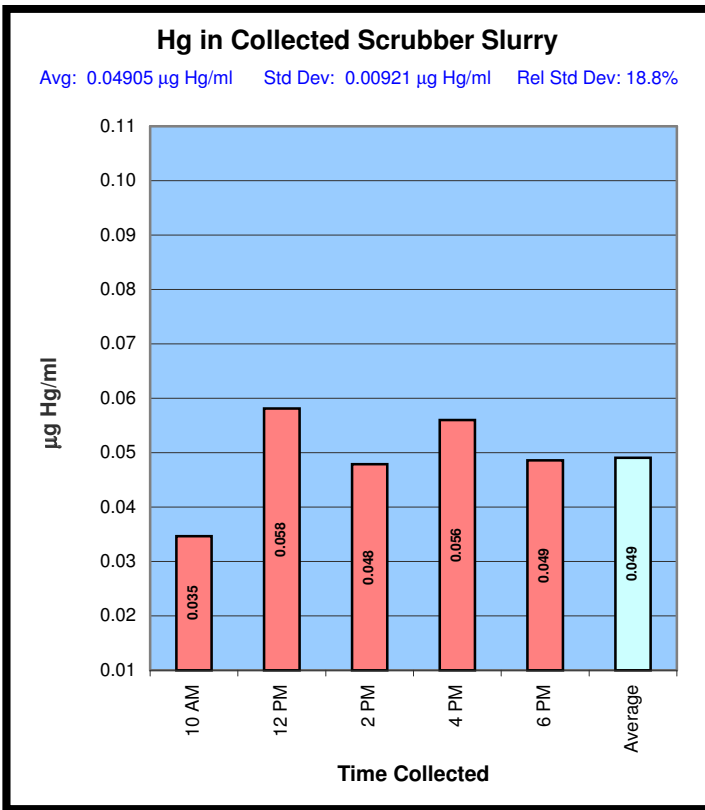




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MATERIAL SAMPLE RESULTS



MATERIAL SAMPLE RESULTS

