SPECIATED MERCURY EMISSIONS TESTING

Performed For
NORTHERN STATES POWER COMPANY

At The
Bay Front Plant
Unit No. 5
Bahco Mechanical Collector Inlet and Outlet
Ashland, Wisconsin

October 26 and 27, 1999

Northern States Power Company

100 North Barstow Street
P.O. Box 8
Eau Claire, WI 54702-0008
Telephone (800) 895-4999

May 12, 2000

Mr. William Grimley
U.S. Environmental Protection Agency
Emissions, Measurement Center (MD-19)
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

Dear Mr. Grimley:

Enclosed, please find three (3) copies of the test report for the Speciated Mercury Emissions Testing performed on the Bahco Mechanical Collector Inlet and Outlet of boiler #5 at Northern States Power Company's (NSP's) Bay Front Generating plant in Ashland, Wisconsin on October 26 and 27, 1999.

If you have any questions regarding this report, please contact me at 715/839-1346.

Sincerely,

Tina M. Ball
Sr. Environmental Analyst

cc: Bob Gowdy, NSP- Bay Front plant

Mostardi-Platt Associates, Inc.
A Full-Service
Environmental Consulting
Company

945 Oaklawn Avenue
Elmhurst, Illinois 60126-1012
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Facsimile 630-993-9017

Mostardi Platt

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October 26 and 27, 1999

MOSTARDI PLATT PROJECT 94303
DATE SUBMITTED: APRIL 24, 2000

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CERTIFICATION SHEET

Having supervised and worked on the test program described in this report, and having written this report, I hereby certify the data, information, and results in this report to be accurate and true according to the methods and procedures used.

Data collected under the supervision of others is included in this report and is presumed to have been gathered in accordance with recognized standards.

MOSTARDI-PLATT ASSOCIATES, INC.

Jeffery C. Daniels
Project Supervisor

Reviewed by:

Frank H. Jarke
Manager, Analytical and Quality Assurance

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1.0 INTRODUCTION

1.1 Summary of Test Program

The United States Environmental Protection Agency (USEPA), is using its authority under section 114 of the Clean Air Act, as amended, to require that selected coal-fired utility steam generating units provide certain information that will allow the USEPA to calculate the annual mercury emissions from each unit. This information will assist the USEPA Administrator in determining whether it is appropriate and necessary to regulate emissions of Hazardous Air Pollutants (HAPs) from electric utility steam generating units. The Emission Measurement Branch (EMB) of the Office of Air Quality Planning and Standards (OAQPS) oversees the emission measurement activities. MOSTARDI-PLATT ASSOCIATES, INC. (Mostardi Platt) conducted the mercury emission measurements.

The USEPA selected Unit No. 5 at the Bay Front Plant of Northern States Power Company in Ashland, Wisconsin to be one of seventy-eight coal-fired utility steam generating units to conduct mercury emissions measurements. Testing was performed at Unit No. 5 on October 26 and 27, 1999, and was the only tested unit at this facility. Simultaneous measurements were conducted at the Bahco Mechanical Collector Inlet and Outlet. Mercury emissions were speciated into elemental, oxidized, and particle-bound mercury using the Ontario-Hydro test method. Fuel samples were also collected concurrently with Ontario-Hydro samples in order to determine fuel mercury content.

1.2 Key Personnel

The key personnel who coordinated the test program and their telephone numbers are:

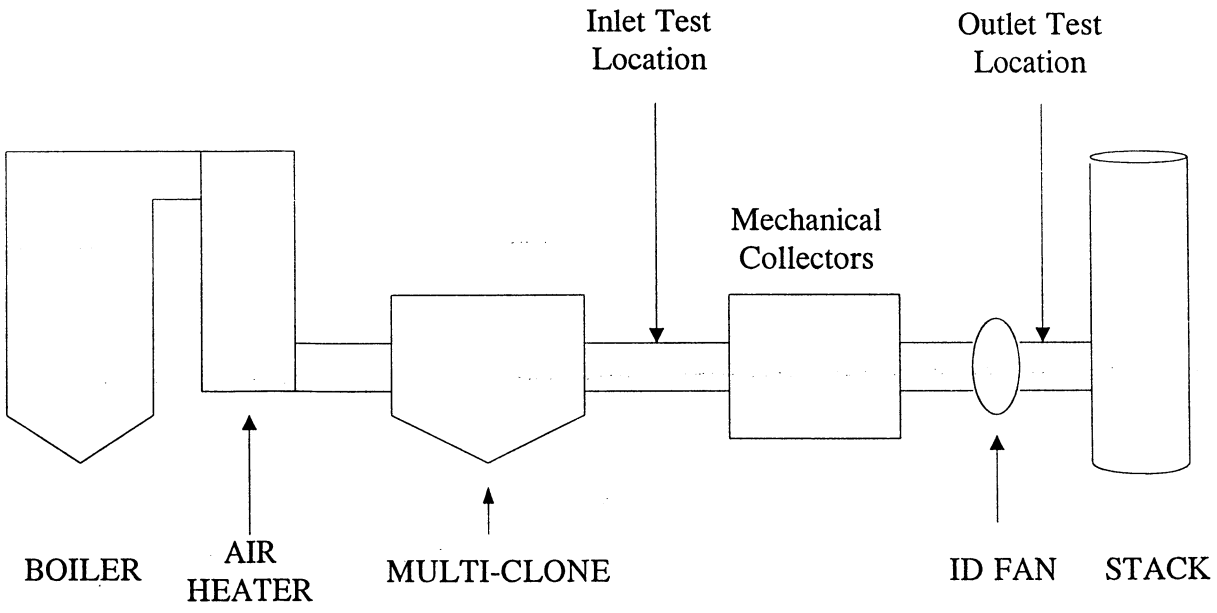
- Mostardi Platt Vice President, James Platt 630-993-9000
- Plant Coordinator, Jeffrey Wright 715-682-7216

2.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

2.1 Process Description

Bay Front Unit No. 5 is a cyclone-fired, forced draft boiler rated at 27 MW (gross). Figure 2-1 shows a schematic of the boiler and pollution control equipment, including sample points.

Figure 2-1 Schematic of the Boiler and Pollution Control Equipment



The following is a list of operating components for this unit:

- Babcock & Wilcox, cyclone fired, forced draft boiler
- 27 MW gross capacity
- Fuel:
  - Arch Mine Bituminous coal, 0.60% sulfur

- No SO_2 control
- No NO_X control
- Western Research multi-clones and Bahco mechanical collectors

2.2 Control Equipment Description

Particulate emissions from the boiler are controlled by a Western Research Multi-Clone and Bahco Mechanical Collector with estimated collection efficiencies of 98% and 59.6%, respectively.

The flue gas at the inlet was approximately 274°F. At the outlet, the gas temperature was approximately 272°F and contained approximately 7.5 percent (7.5%) moisture.

2.3 Flue Gas Sampling Locations

2.3.1 Inlet Location

Inlet samples were collected at the Mechanical Collector Inlet. A schematic and cross section of the inlet location are shown in Figure 2-2. This location does not meet the requirements of USEPA Method 1.

Four (4) six-inch sample ports were installed at the Mechanical Collector Inlet at 90° intervals, approximately five (5) feet off the roof level in the base of the stack. Eye hooks (1" ID) were also installed 4-5 feet above each test port in order to support a monorail system.

2.3.2 Outlet Location

Outlet samples were collected at the mechanical collector outlet sample ports. A schematic and cross section of the outlet location are shown in Figure 2-3. This location meets the requirements of USEPA Method 1.

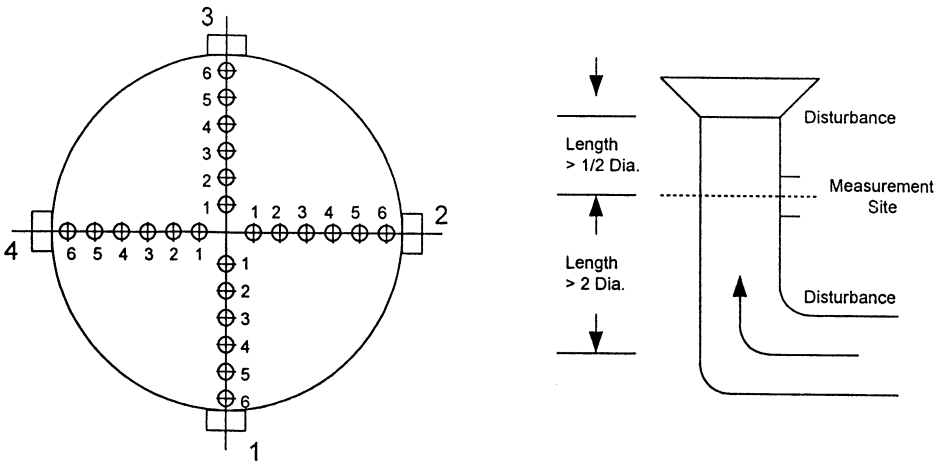
The flue gas at the outlet was above the method specification of a minimum filtration temperature of 120°C. Therefore, the in-stack filtration per Method 17 was used.

2.4 Fuel Sampling Location

Coal samples were collected at the coal feeders to each individual cyclone. One sample was collected from each feeder during each test run, and the feeder samples collected during a test run were composited prior to analysis.

Figure 2-2 Schematic of the Bahco Mechanical Collector Inlet Sampling Location

Inlet Sampling Location



Plant: Northern States Power
Bay Front Plant

Date: October 26 and 27, 1999

Unit No: Unit 5

Duct No: Bahco Mechanical Collector Inlet

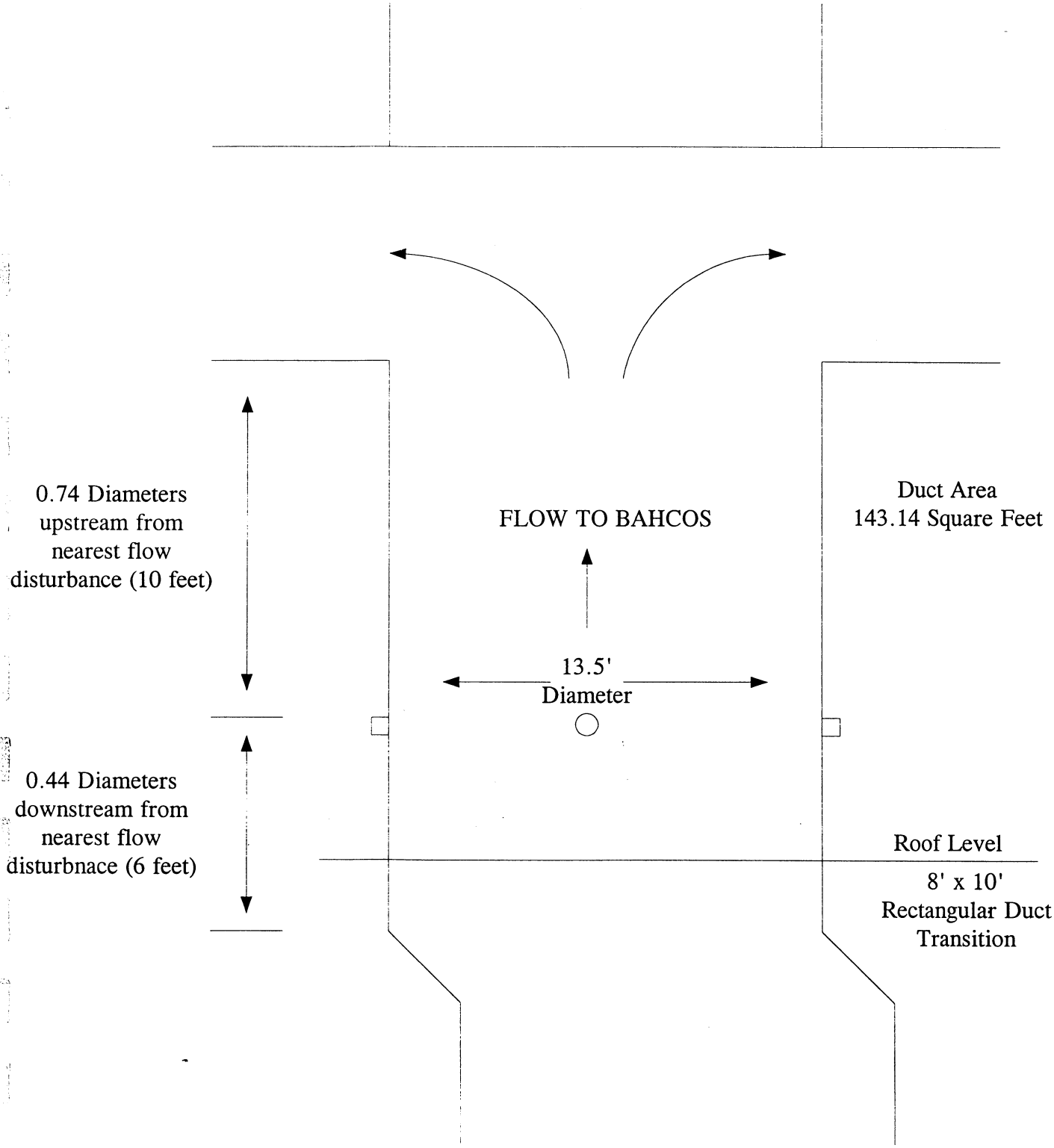
Duct Diameter: 13.5 Feet

Duct Area: 143.14 Square Feet

No. of Test Points: 24

No. of Test Ports: 4

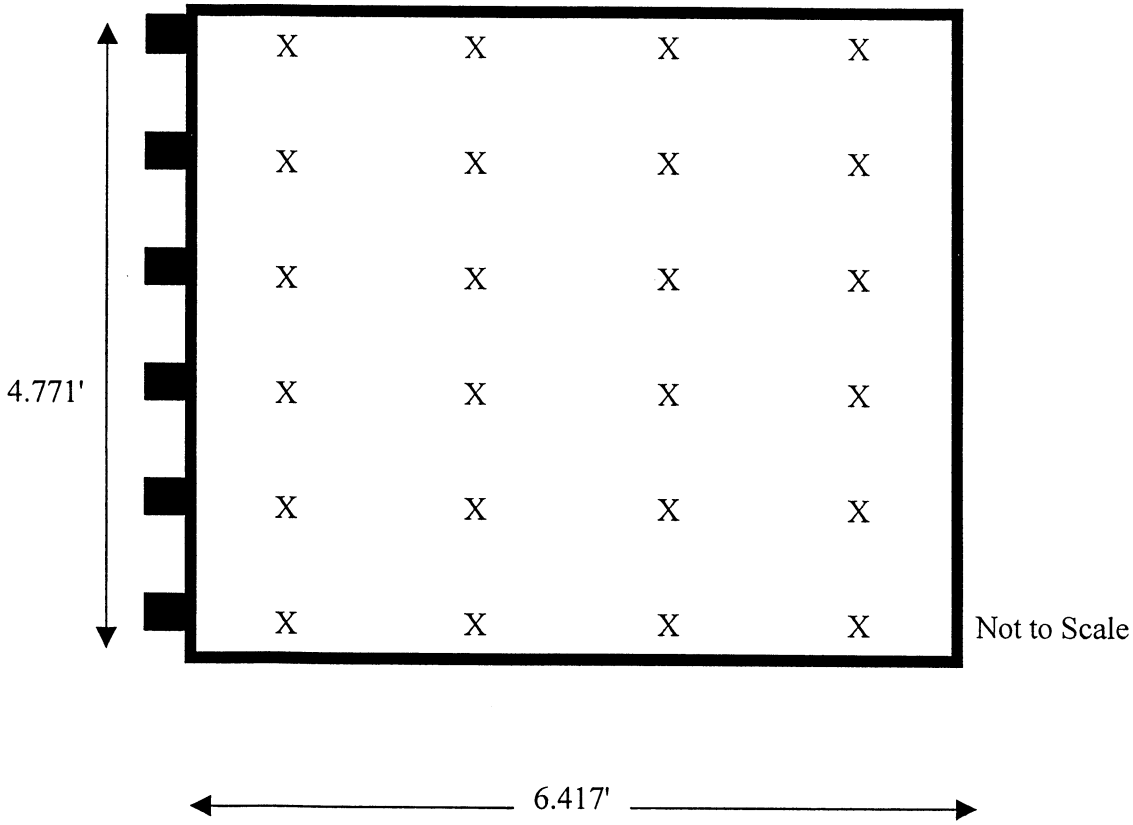
Northern States Power Company - Bay Front Plant
Bahco Mechanical Collector
Inlet Sampling Location



Not to Scale Mostardi Platt Project 94303

Figure 2-3 Schematic of the Bahco Mechanical Collector Outlet Sampling Location

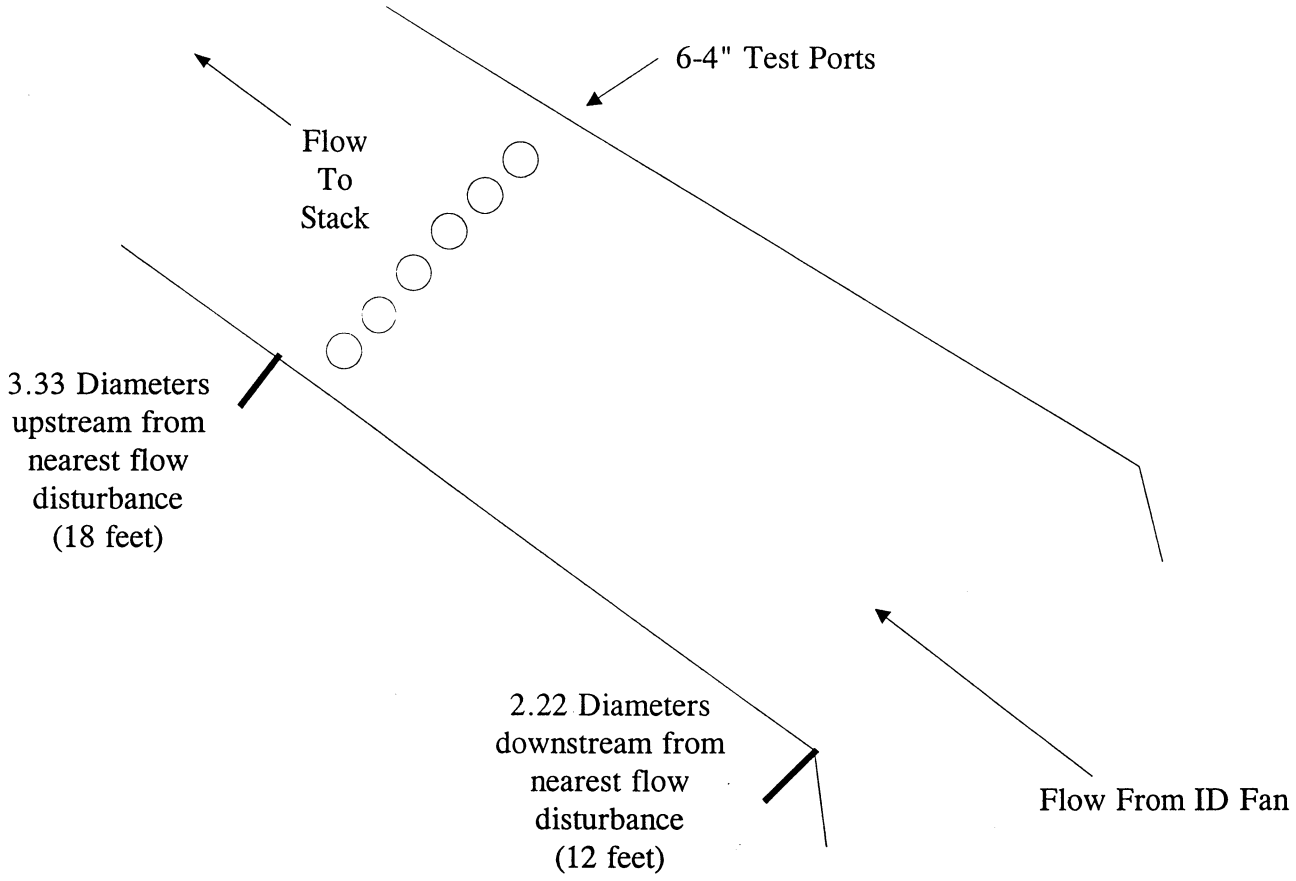
Outlet Sampling Location



Job:	Northern States Power Company Bay Front Plant		
Date:	October 26 and 27, 1999	Area:	30.616 ft^2
Unit No:	5	No. Test Ports:	6
Length:	6.417 Feet	Tests Points per Port:	4
Width:	4.771 Feet		
Duct No:	Outlet		

NSP BAY FRONT PLANT

MECHANICAL COLLECTOR
OUTLET SAMPLING DUCT



$$D = \frac{2 \times L \times W}{L + W}$$

$$D = \frac{2 \times 6.417 \times 4.771}{6.417 + 4.771}$$

5.4 - Equivalent Diameter

3.0 SUMMARY AND DISCUSSION OF TEST RESULTS

3.1 Objectives and Test Matrix

The purpose of the test program was to quantify mercury emissions from this unit. This information will assist the USEPA Administrator in determining whether it is appropriate and necessary to regulate emissions of Hazardous Air Pollutants (HAPs) from electric utility steam generating units. The specific objectives, in order of priority were:

- Compare mass flow rates of mercury at the three sampling locations (fuel, inlet to and outlet of the mechanical collectors).
- Measure speciated mercury emissions at the outlet.
- Measure speciated mercury concentrations at the inlet of the last air pollution control device.
- Measure mercury and chlorine content from the fuel being used during the testing.
- Measure the oxygen and carbon dioxide concentrations at the inlet and the outlet.
- Measure the volumetric gas flow at the inlet and the outlet.
- Measure the moisture content of the flue gas at the inlet and the outlet.
- Provide the above information to the USEPA for use in establishing mercury emission factors for this type of unit.

The test matrix is presented in Table 3-1. The table shows the testing performed at each location, methodologies employed and responsible organization.

Table 3-1
TEST MATRIX FOR THE NSP - BAY FRONT PLANT, UNIT NO. 5

Sampling Location	No. of Runs	Parameters	Sampling Method	Sample Run Time (min)	Analytical Method	Analytical Laboratory
Outlet	3	Speciated Hg	Ontario Hydro	120	EPA SW846 7470	TEI
Outlet	3	Moisture	EPA 4	120	Gravimetric	Mostardi Platt
Outlet	3	Flow	EPA 1 & 2	120	Pitot Traverse	Mostardi Platt
Outlet	3	O_2/CO_2	EPA 3	120	Orsat	Mostardi Platt
Inlet	3	Speciated Hg	Ontario Hydro	120	EPA SW846 7470	TEI
Inlet	3	Moisture	EPA 4	120	Gravimetric	Mostardi Platt
Inlet	3	Flow	EPA 1 & 2	120	Pitot Traverse	Mostardi Platt
Inlet	3	O_2/CO_2	EPA 3	120	Orsat	Mostardi Platt
Fuel Feeders	3	Hg, Cl in Fuel	Grab	1 Sample Per Feeder Per Run	ASTM D3684 (Hg) ASTM D4208 (Cl)	CTE

3.2 Field Test Changes and Problems

There were no field changes or problems encountered during this test program.

3.3 Presentation of Results

3.3.1 Mercury Mass Flow Rates

The mass flow rates of mercury determined at each sample location are presented in Table 3-2.

Table 3-2
SUMMARY OF RESULTS

Sample Location	Elemental Mercury (lb/hr)	Oxidized Mercury (lb/hr)	Particle-Bound Mercury (lb/hr)	Total Mercury (lb/hr)
Fuel				
Run 1				0.00052
Run 2				0.00052
Run 3				0.00052
Average				**0.00052**
Inlet				
Run 1	0.00031	0.00011*	0.00011	0.00053
Run 2	0.00033	0.00011*	0.00019	0.00064
Run 3	0.00027	0.00012*	0.00001	0.00040
Average	**0.00031**	**0.00011**	**0.00010**	**0.00052**
Outlet				
Run 1	0.00027	0.00009	0.00017	0.00052
Run 2	0.00029*	0.00045	0.00014	0.00088
Run 3	0.00027*	0.00055	0.00007	0.00090
Average	**0.00028**	**0.00036**	**0.00013**	**0.00076**

* Data Suspect

3.3.2 Comparison of Volumetric Flow Rate

Volumetric flow rate is a critical factor in calculating mass flow rates. Ideally, the volumetric flow rate (corrected to standard pressure and temperature) measured at the inlet to the control device should be the same as that measured at the stack, which should be the same as that measured by the CEMS. The volumetric flow rates of the three locations on a thousand standard cubic foot per minute basis (KSCFM) are given in Table 3-3.

Table 3-3 COMPARISON OF VOLUMETRIC FLOW RATE DATA							
	Inlet			Outlet			CEMS
Run No.	KACFM	KSCFM	KDSCFM	KACFM	KSCFM	KDSCFM	KSCFM
Run 1	213.0	151.6	136.7	86.8	61.4	56.4	69.8
Run 2	173.5	124.6	115.6	98.0	70.0	65.0	67.7
Run 3	169.5	121.1	112.5	94.2	66.8	62.0	68.2
Average	185.3	132.4	121.6	93.0	66.1	61.1	68.6

The measured volumetric flow rate (KSCFM) at the outlet was approximately 4% lower than that measured by the CEMS at the stack. Because the inlet location did not meet the requirements of USEPA Method 1, the outlet volumetric flow rates were used to determine the emission rates at the inlet.

3.3.3 Individual Run Results

A detailed summary of results for each sample run at the inlet and outlet test locations are presented in Tables 3-4 and 3-5, respectively.

3.3.4 Process Operating Data

The process operating data collected during the tests is included in Appendix A. A summary of the coal usage and mass emission rate of mercury available from coal are presented in Table 3-6.

Table 3-4
BAHCO MECHANICAL COLLECTOR INLET INDIVIDUAL RUN RESULTS

Test Run Number:	**1**	**2**	**3**	**Average**
Source Condition		Normal		
Fuel Factor, dscf/10^6 Btu	9678	9708	9767	
Date	10/26/99	10/27/99	10/27/99	
Start Time	14:15	8:45	12:50	
End Time	16:56	11:25	15:43	
Elemental Mercury:				
HNO_3-H_2O_2, ug detected	0.305	0.462	0.228	0.332
H_2SO_4-$KMnO_4$, ug detected	2.798	1.988	1.768	2.185
Reported, ug	3.103	2.450	1.996	2.516
ug/dscm	1.48	1.37	1.16	1.34
lb/hr	0.00076	0.00059	0.00049	0.00061
lb/hr (based on outlet dscfm)	0.00031	0.00033	0.00027	0.00031
lb/10^{12} Btu	1.52	1.38	1.24	1.38
Oxidized Mercury:				
KCl, ug detected	1.118	0.840	0.869	0.942
Reported, ug	1.118	0.840	0.869	0.942
ug/dscm	0.53	0.47	0.51	0.50
lb/hr	0.00027	0.00020	0.00021	0.00023
lb/hr (based on outlet dscfm)	0.00011	0.00011	0.00012	0.00011
lb/10^{12} Btu	0.55	0.47	0.54	0.52
Particle-bound Mercury:				
Filter, ug detected	1.096	1.358	0.095	0.850
HNO_3, ug detected	0.003	0.002	<0.004	<0.003
Reported, ug	1.099	1.360	0.097	0.852
ug/dscm	0.52	0.76	0.06	0.45
lb/hr	0.00027	0.00033	0.00002	0.00021
lb/hr (based on outlet dscfm)	0.00011	0.00019	0.00001	0.00010
lb/10^{12} Btu	0.54	0.77	0.06	0.46
Total Inlet Speciated Mercury:				
ug/dscm	2.53	2.61	1.72	2.29
lb/hr	0.00130	0.00112	0.00073	0.00105
lb/hr (based on outlet dscfm)	0.00053	0.00064	0.00040	0.00052
lb/10^{12} Btu	2.61	2.62	1.84	2.36
Average Gas Volumetric Flow Rate:				
@ Flue Conditions, acfm	212,977	172,302	169,478	184,919
@ Standard Conditions, dscfm	136,722	114,859	112,467	121,349
Average Gas Temperature, °F	277.0	270.2	273.9	273.7
Average Gas Velocity, ft/sec	24.80	20.06	19.73	21.53
Flue Gas Moisture, percent by volume	9.82	7.18	7.12	8.04
Average Flue Pressure, in. Hg	29.73	29.71	29.71	
Barometric Pressure, in. Hg	29.45	29.45	29.45	
Average %CO_2 by volume, dry basis	10.7	11.8	10.5	11.0
Average %O_2 by volume, dry basis	8.7	8.3	9.0	8.7
% Excess Air	68.72	64.88	73.46	69.02
Dry Molecular Wt. of Gas, lb/lb-mole	30.064	30.220	30.040	
Gas Sample Volume, dscf	74.233	62.927	60.751	
Isokinetic Variance	103.0	104.0	102.5	

Laboratory Analysis can be found in Appendix F.

Table 3-5
BAHCO MECHANICAL COLLECTOR OUTLET INDIVIDUAL RUN RESULTS

Test Run Number:	**1**	**2**	**3**	**Average**
Source Condition		Normal		
Fuel Factor, dscf/10^6 Btu	9678	9708	9767	
Date	10/26/99	10/27/99	10/27/99	
Start Time	14:15	8:45	12:50	
End Time	17:10	11:35	15:39	
Elemental Mercury:				
HNO_3-H_2O_2, ug detected	0.258	0.182	0.198	0.213
H_2SO_4-$KMnO_4$, ug detected	2.898	1.768	1.638	2.101
Reported, ug	3.156	1.950	1.836	2.314
ug/dscm	1.27	1.20	1.18	1.22
lb/hr	0.00027	0.00029	0.00027	0.00028
lb/10^{12} Btu	1.35	1.27	1.27	1.30
Oxidized Mercury:				
KCl, ug detected	0.998	2.978	3.688	2.555
Reported, ug	0.998	2.978	3.688	2.555
ug/dscm	0.40	1.83	2.36	1.53
lb/hr	0.00009	0.00045	0.00055	0.00036
lb/10^{12} Btu	0.43	1.95	2.56	1.64
Particle-bound Mercury:				
Filter, ug detected	1.953	0.928	0.497	1.126
HNO_3, ug detected	ND <0.002	ND <0.003	ND <0.004	ND <0.003
Reported, ug	1.953	0.928	0.497	1.126
ug/dscm	0.79	0.57	0.32	0.56
lb/hr	0.00017	0.00014	0.00007	0.00013
lb/10^{12} Btu	0.84	0.61	0.34	0.60
Total Outlet Speciated Mercury:				
ug/dscm	2.47	3.60	3.86	3.31
lb/hr	0.00052	0.00088	0.00090	0.00076
lb/10^{12} Btu	2.62	3.83	4.18	3.54
Average Gas Volumetric Flow Rate:				
@ Flue Conditions, acfm	86,846	98,046	94,162	93,018
@ Standard Conditions, dscfm	56,393	65,000	62,030	61,141
Average Gas Temperature, °F	274.1	268.8	273.2	272.0
Average Gas Velocity, ft/sec	47.28	53.37	51.26	50.64
Flue Gas Moisture, percent by volume	8.10	7.15	7.17	7.48
Average Flue Pressure, in. Hg	29.39	29.49	29.49	
Barometric Pressure, in. Hg	29.43	29.45	29.45	
Average %CO_2 by volume, dry basis	10.3	10.5	9.6	10.1
Average %O_2 by volume, dry basis	9.0	9.0	9.1	9.0
% Excess Air	73.09	73.51	74.18	73.59
Dry Molecular Wt. of Gas, lb/lb-mole	30.003	30.045	29.907	
Gas Sample Volume, dscf	87.417	57.481	55.092	
Isokinetic Variance	100.8	102.2	102.6	

Laboratory Analysis can be found in Appendix F.

Table 3-6
COAL USAGE RESULTS

Test Run Number:	1	2	3	Average
Date	10/26/99	10/27/99	10/27/99	
Start Time	14:15	8:45	12:50	
End Time	17:10	11:35	15:39	
Coal Properties:				
Carbon, % dry	72.32	71.98	72.25	72.18
Hydrogen, % dry	5.08	4.97	4.92	4.99
Nitrogen, % dry	1.48	1.53	1.54	1.52
Sulfur, % dry	0.65	0.65	0.66	0.65
Ash, % dry	7.57	7.51	7.56	7.55
Oxygen, % dry (by difference)	12.90	13.36	13.07	13.11
Volatile, % dry	41.71	41.45	41.51	41.56
Moisture, %	13.77	13.73	13.26	13.59
Heat Content, Btu/lb dry basis	12790	12635	12597	12674
F_d Factor O_2 basis, dscf/10^6 Btu	9678	9708	9767	9718
F_c Factor CO_2 basis, scf/10^6 Btu	1815	1829	1841	1828
Chloride, ug/g dry	110	119	152	127.0
Mercury, ug/g dry	0.06	0.06	0.06	0.06
Coal Consumption*:				
Feeder A, Klbs/hr	5.00	5.00	5.00	
Feeder B, Klbs/hr	5.00	5.00	5.00	
Total Raw Coal Input, Klbs/hr	10.00	10.00	10.00	10.00
Total Coal Input, lbs/hr dry	8623	8627	8674	8641
Total Mercury Available in Coal:				
Mercury, lbs/hr	0.00052	0.00052	0.00052	0.00052
Mercury, lbs/10^{12} Btu	4.69	4.75	4.76	4.73

* Coal Firing rates were provided by plant personnel.
Laboratory Analysis can be found in Appendix F.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Test Methods

4.1.1 Speciated mercury emissions

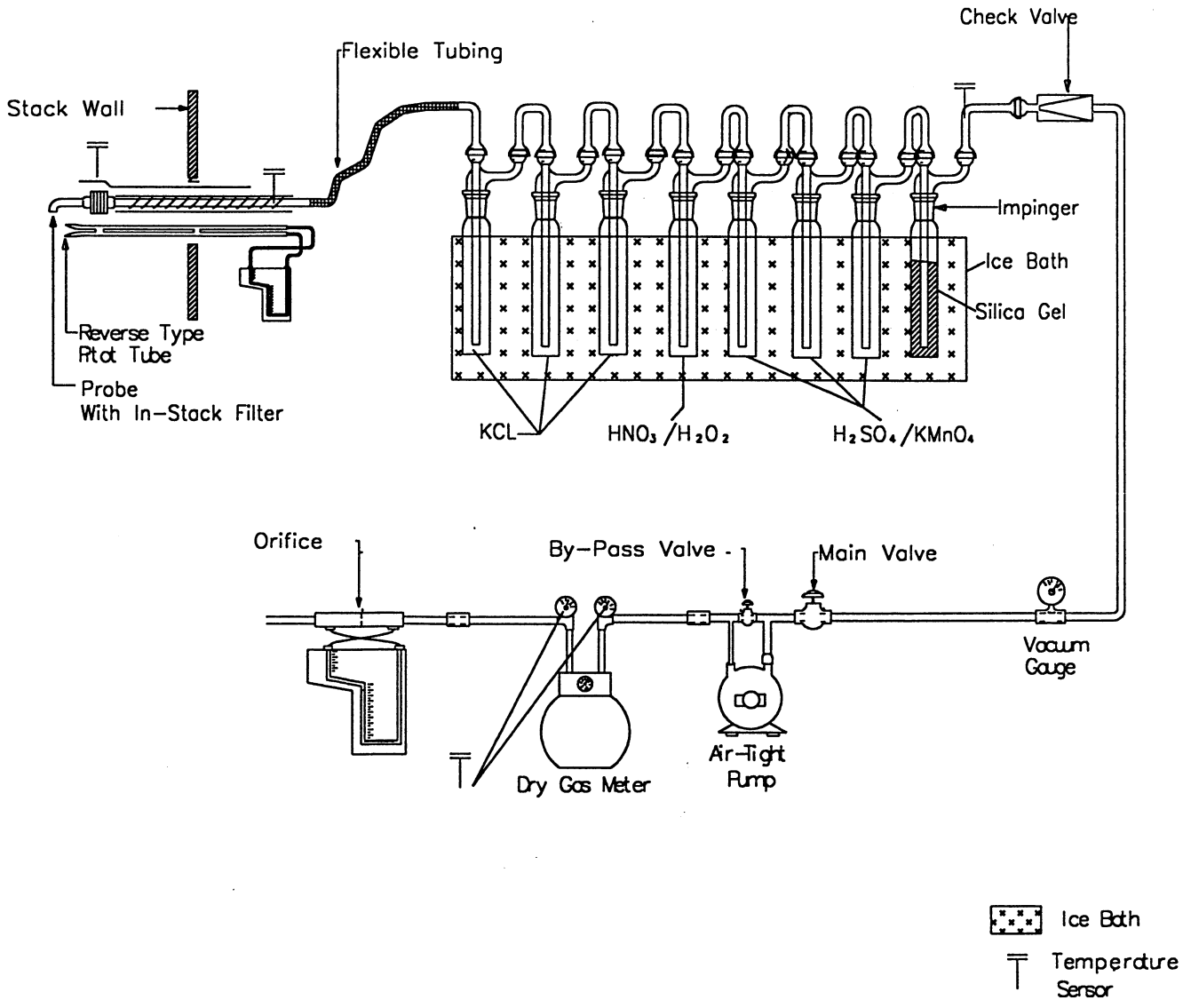
Speciated mercury emissions were determined via the draft "Standard Test Method for Elemental, Oxidized, Particle-Bound, and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources (Ontario-Hydro Method)", dated April 8, 1999. Any revisions to this test method issued after April 8, 1999, but before July 1, 1999, were incorporated.

The in-stack filtration (Method 17) configuration was utilized at the inlet and outlet test locations. Figure 4-1 is the schematic of the Ontario-Hydro sampling train.

Figure 4-2 illustrates the sample recovery procedure. The analytical scheme was per Section 13.3 of the Ontario-Hydro Method.

Speciated Mercury Sampling Train Equipped with In-Stack Filter

Ontario Hydro Method



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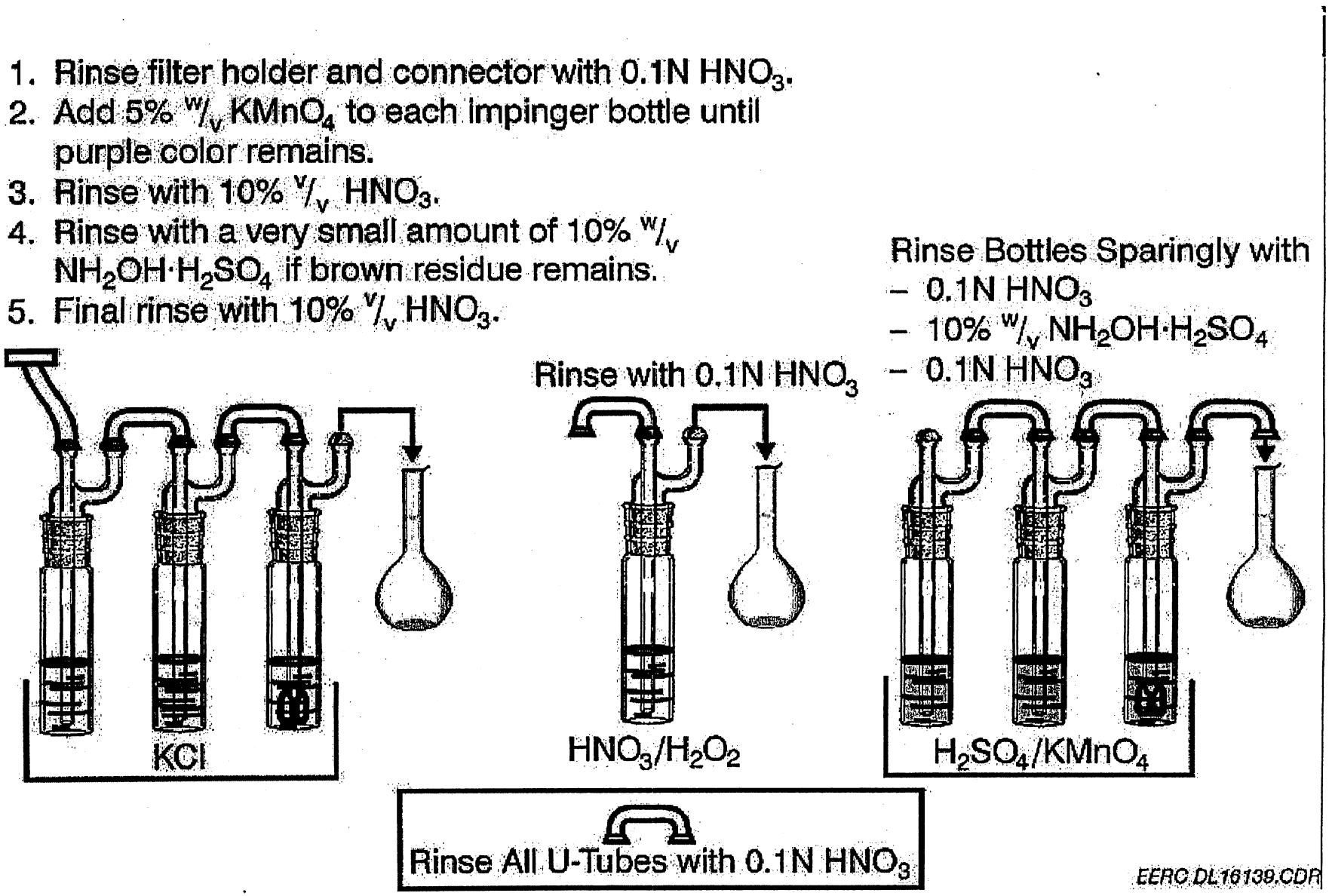

Figure 4-2 Sample Recovery Scheme for Ontario-Hydro Method Samples

4.1.2 Fuel samples

Fuel samples were collected by composite sampling. Three samples were collected at equally spaced intervals during each speciated mercury sampling run. Each set of samples was composited into a single sample for each sample run. Sample analysis was conducted according to the procedures of ASTM D3684 and ASTM D4208.

4.2 Procedures for Obtaining Process Data

Plant personnel were responsible for obtaining process-operating data. The process data presented in Table 3-6 was continuously monitored by the facility. Process data was averaged over the course of each sample run.

4.3 Sample Identification and Custody

The chain-of-custody for all samples obtained for analysis can be found in Appendix E.

5.0 INTERNAL QA/QC ACTIVITIES

All sampling, recovery and analytical procedures conform to those described in the site specific test plan. All resultant data was reviewed by the laboratory and Mostardi Platt per the requirements listed in the QAPP and were determined to be valid except where noted below.

5.1 QA/QC Problems

Reagent blanks are required to be less than ten times the detection limit or ten percent of the sample values found. All reagent blank values met this criteria.

The train blank value for the KC1 impinger at the inlet, Sample ID #025, was more than 30% of the sample values obtained at this location for the KC1 fraction. The train blank value for the H_2O_2 impinger at the outlet, Sample ID #029, was more than 30% of the sample values obtained for sample ID #020 and #021. The test results for the sampling locations have been qualified per the QAPP.

5.2 QA Audits

5.2.1 Reagent Blanks

As required by the method, blanks were collected for all reagents utilized. The results of reagent blank analysis are presented in Table 5-1.

Table 5-1 REAGENT BLANK ANALYSIS				
Sample ID#	**Sample Fraction**	**Contents**	**Mercury (μg)**	**Detection Limit (μg)**
034	Front-half	0.1N HNO_3/Filter	< 0.002	0.002
035	1 N KCl	1 N KCl	0.002	0.002
036	HNO_3/H_2O_2	HNO_3/H_2O_2	0.020	0.008
037	$KMnO_4/H_2SO_4$	$KMnO_4/H_2SO_4$	0.012	0.003

5.2.2 Blank Trains

As required by the method, blank trains were collected at both the inlet and stack sampling locations. These trains were collected on October 26, 1999. The results of blank train analysis are presented in Table 5-2.

Table 5-2 BLANK TRAIN ANALYSIS				
Sample ID #	**Sample Fraction**	**Contents**	**Mercury (μg)**	**Detection Limit (μg)**
031, 032, 033	Front-half	Filter	0.085	0.007
025	KCl impingers	Impingers/rinse	1.30	0.03
028	KCl impingers	Impingers/rinse	0.273	0.03
026	HNO_3-H_2O_2 impingers	Impingers/rinse	0.038	0.03
029	HNO_3-H_2O_2 impingers	Impingers/rinse	0.078	0.03
027	$KMnO_4/H_2SO_4$ impingers	Impingers/rinse	0.114	0.03
030	$KMnO_4/H_2SO_4$ impingers	Impingers/rinse	0.166	0.03

5.2.3 Field Dry Test Meter Audit

The field dry test meter audit described in Section 4.4.1 of Method 5 was completed prior to the test. The results of the audit are presented in Appendix C.

