BASIN ELECTRIC
POWER COOPERATIVE

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April 10, 2000

Mr. William Grimley
Emission Measurement Center (MD-19)
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Attn: Electric Utility Steam Generating Unit Mercury Unit Test Program

Dear Mr. Grimley:

Enclosed are two (2) copies of the Stack Test Report for the Speciated Mercury Emissions Testing at the Basin Electric Power Cooperative Laramie River Station Units 1 and 3.

If you have any questions or comments as to the contents of this test report please contact me.

Sincerely,

Jerry Menge
Air Quality Program Coordinator

jm:mev
Enclosure
cc: Dan Olson,
WY Department of Environmental Quality w/encl.

SPECIATED MERCURY EMISSIONS TESTING

Performed For
BASIN ELECTRIC POWER COOPERATIVE

At The
Laramie River Station
Unit 3
Scrubber Inlet and Stack
Wheatland, Wyoming

September 22 and 23, 1999

Mostardi Platt

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

945 Oaklawn Avenue
Elmhurst, Illinois 60126-1012
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MOSTARDI PLATT PROJECT 93859
DATE SUBMITTED: MARCH 23, 2000

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 has been gathered in accordance with the procedures outlined in the Quality Assurance Project Plan.

MOSTARDI-PLATT ASSOCIATES, INC.

Bruce Randall

Bruce Randall mgq
Regional Manager

Reviewed by:

Scott W. Banach

Scott W. Banach
Director, Project Engineering

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1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

The U.S. Environmental Protection Agency (EPA), 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 EPA to calculate the annual mercury emissions from each unit. This information will assist the EPA 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. Braun Intertec Corporation (Braun Intertec) conducted the emission measurements. MOSTARDI-PLATT ASSOCIATES, INC. (Mostardi Platt) was retained by Braun Intertec to complete the report.

EPA selected Unit 3 at the Basin Electric Power Cooperative (BEPC) Laramie River Station (LRS) in Wheatland, Wyoming to be one of seventy eight coal-fired utility steam generating units to conduct emissions measurements. The test was performed at LRS Unit 3 on September 22 and 23, 1999. Simultaneous measurements were conducted at the inlet of the Dry Scrubber and Main Stack. 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:

- Braun Intertec Project Manager - Bruce Randall (651) 686-0700
- Braun Intertec Test Director - James Tryba (651) 686-0700
- BEPC Air Quality Program Coordinator - Jerry Menge (701) 223-0441
- BEPC AVS Plant Contact/Process Monitor - Terry Archbold (307) 222-9601

2.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

2.1 PROCESS DESCRIPTION

Figure 2-1 illustrates the basic operational steps for this coal-fired steam generator. The steps are:

1. Sub-bituminous coal is delivered to the plant by unit train.
2. The coal is conveyed to the plant where it is pulverized.
3. The coal is combusted in the furnace using primary and secondary air.
4. The flue gas enters the scrubber and is sprayed with a mixture of lime and fly ash slurry.
5. The gas enters the precipitator where the particulates are removed.
6. The gas exits the precipitator and then the stack.

The LRS Unit 3 consists of a Babcock and Wilcox pulverized coal-fired boiler. The unit has a gross electric generation capacity of 600 MW. During the test, the average gross electric generation was 581 MW.

Sub-bituminous coal is supplied to the Laramie River Station by unit trains from the Buckskin, Rawhide, and Cordero mines. The coal is conveyed to the plant coalbunkers, where it is fed to the pulverizers. From the pulverizers, coal is blown into the furnace using primary air as the conveyor and secondary air as fuel combustion air. During the test, the average coal feed rate was 335 tons per hour (tph).

Flue gas from the unit's boiler flows into the scrubbers where it is sprayed with a mixture of lime and fly ash slurry to remove sulfur dioxide. The flue gas exits the scrubber and enters the Electrostatic Precipitator (ESP), where suspended particulates are removed. The cleaned flue gas is emitted from a 600 foot stack with a fiberglass liner. The flue gas enters perpendicular to the stack. Continuous Emissions Monitoring Systems (CEMS) equipment is located on the 300 foot level of the stack.

Figure 2-1: Laramie River Station Process Flow Diagram

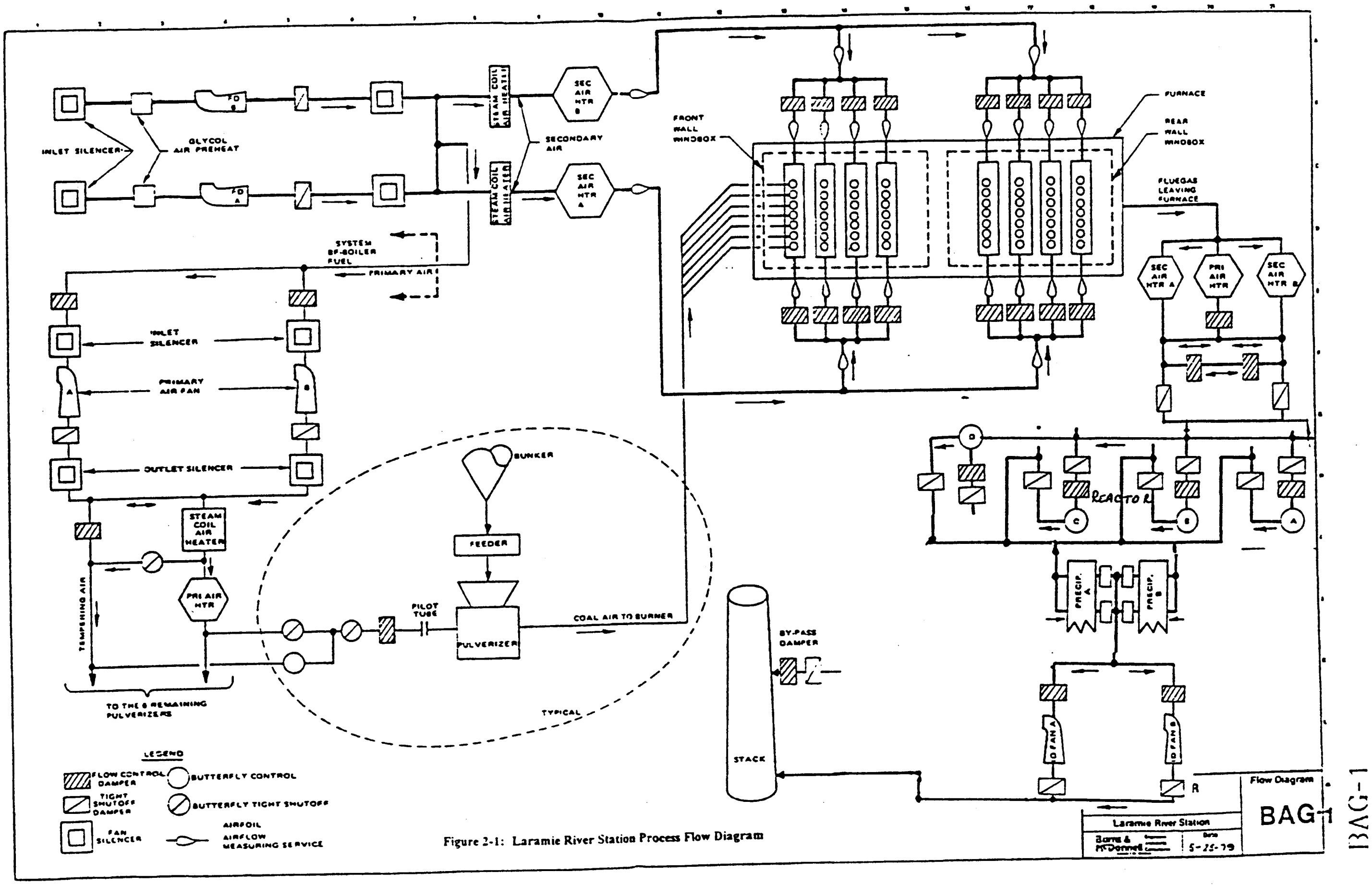


Figure 2-1: Laramie River Station Process Flow Diagram

2.2 CONTROL EQUIPMENT DESCRIPTION

The scrubber is a Babcock and Wilcox scrubber consisting of four spray drier modules. The flue gas is passed through one or more of the four modules in the scrubber. A slurry with 20% to 30% solids containing slake lime and fly ash is introduced to the chamber by individual atomizers. The heat of the flue gas dries the liquid in the slurry. The suspended particulates are removed by an ESP manufactured by Babcock and Wilcox.

Table 2-1 presents a summary of the normal ranges of operating parameters the scrubber/ESP during the test.

Table 2-1: Scrubber/ESP Operating Parameters

Parameter	Normal Range
Volumetric Flow Rate	1.0-1.4mmscfm
Inlet SO_2 Concentration	200-500 ppm
Outlet SO_2 Concentration	40-80 ppm
Outlet SO_2 Mass Flow Rate	650-1150 lb/hr
Modules in service	4 SDA Chambers
% Slurry Solids	20-30%
Slurry Feed Rate	90-135 gpm
Scrubber Inlet Temp	275-350°F
Scrubber Outlet Temp	160-185°F
Lime to Sulfur Ratio	1.1-1.5

2.3 FLUE GAS SAMPLING LOCATIONS

Emissions sampling was conducted at (1) the inlet to the dry scrubber, and (2) the main stack. Figures 2-2 and 2-3 are schematics of these sampling locations.

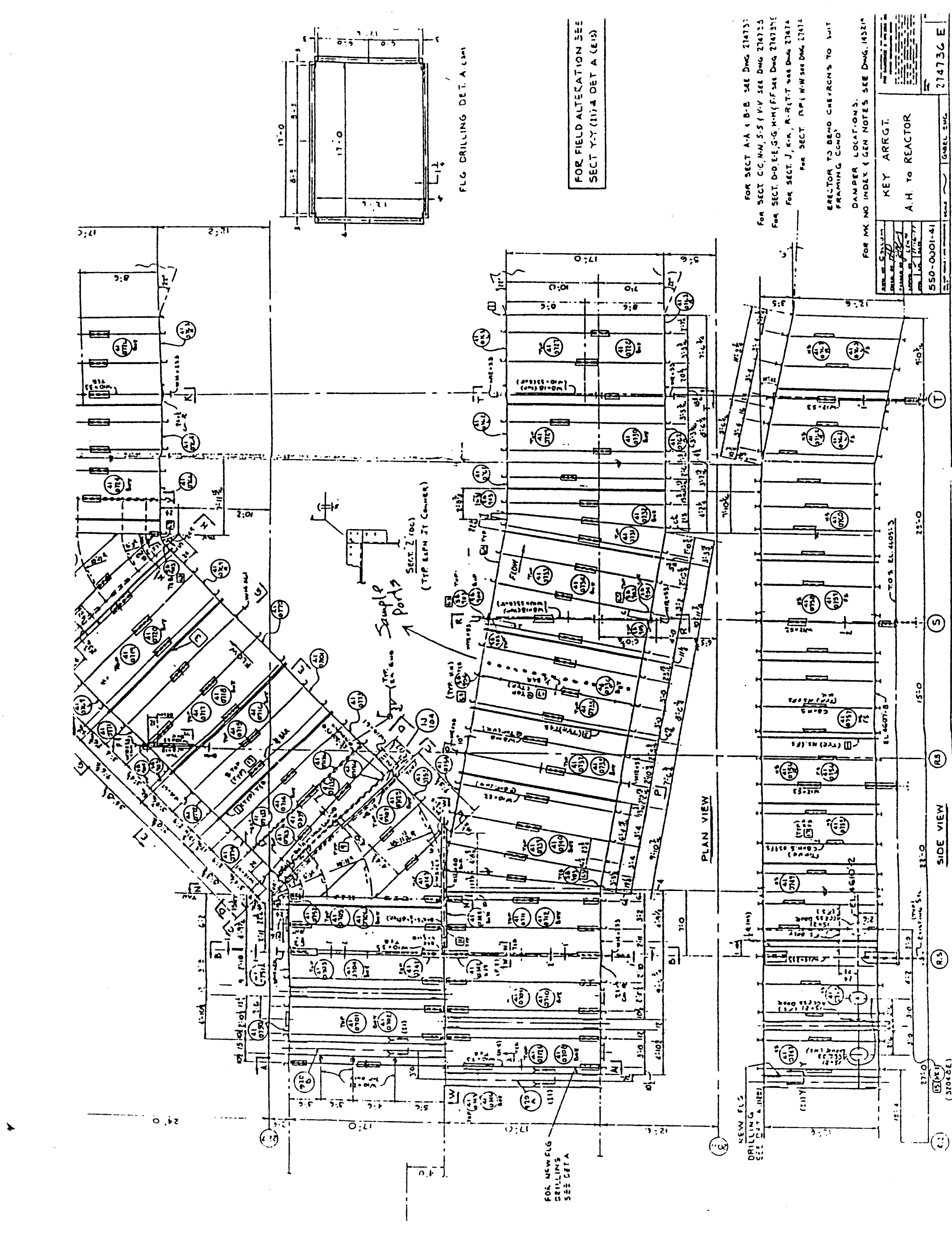
2.3.1 Dry Scrubber Inlet. See Figure 4-1. After leaving the furnace and air heaters, the flue gas flows into a four-way manifold. Each leg of the manifold is connected to a scrubber. Sampling was conducted at one of the four scrubbers, as conditions in each leg were expected to be identical. The horizontal inlet duct to the scrubber is 17 feet wide and 12.5 feet deep, and is equipped with 16 sample ports, consisting of six inch threaded pipe nipples (with caps), approximately one foot long.

Due to its proximity to the manifold, the inlet location does not meet the port placement criteria of EPA Method 1. The Ontario-Hydro Method (Section 10.1.5) requires that sample be collected for not less than two hours, and not more than three hours. The method further requires that sample be collected for at least five minutes at each traverse point. Per the "Electric Utility Steam Generating Unit Mercury Emissions" web page; the furthest traverse point into the duct was sixteen feet from the side of the duct.

Sampling was conducted at three traverse points in eight of the sixteen ports (twenty four total points). In each of the eight test ports, sample was collected for five minutes per point at the following points:

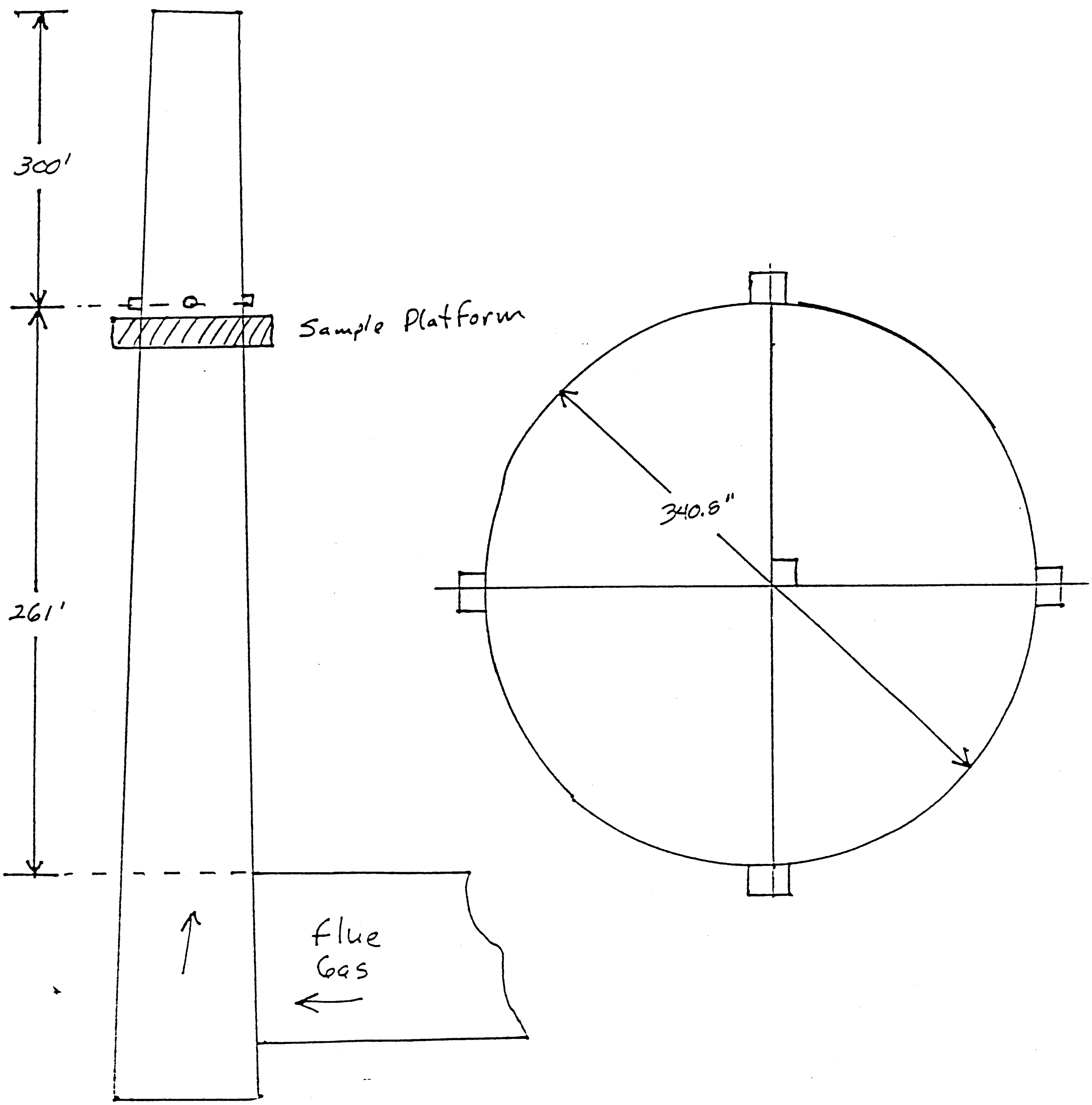
Traverse Point Number	Distance From Inside Top Wall (inches)
1	24.1
2	72.3
3	120.4

Figure 2-2: Schematic of the LRS Unit 3 Inlet Sampling Location



Schematic of LRS Unit 3 Dry Scrubber Inlet Sampling Location.

Figure 2-3: Schematic of the LRS Unit 3 Main Stack Sampling Location



The inlet sampling location did not meet the criteria of Method 1. Per the "Electric Utility Steam Generating Unit Mercury Emissions" web page, no modifications to the sampling procedure will be made, since ". . .(a) mercury is primarily in the gaseous phase and is not impacted by uncertainties in the gas flow and isokinetic sampling rate, and (b) stratification of mercury species is not expected."

2.3.2 Main Stack. See Figure 2-3. The diameter of the main stack at the sample location is 340.8 inches. The main stack is equipped with four 4" sample ports. The sample ports are located 261 feet (9.2 duct diameters) downstream of the flue gas entry to the stack, and 300 feet (10.6 duct diameters) upstream of the stack exit. Sampling was conducted at a total of twelve traverse points, three in each of the four ports. In each port, sample was collected for ten minutes per point, at the following points:

Traverse Point Number	Distance From Inside Wall (inches)
1	15.0
2	49.8
3	100.9

2.4 FUEL SAMPLING LOCATION

Fuel samples were collected at the inlet to the Gravimetric Coal feeders by diverting the sub-bituminous coal to a sampling container. The sample at this point was expected to be homogeneous.

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 EPA 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 dry scrubber/ESP).

- During the test period, obtain process operating data: Gross MW, heat input (MMBtu/hr) and coal feed rate (tons per hour) and control equipment operating data: exhaust gas volumetric flow rate (SCFH), outlet SO2, NOx and CO2 concentrations (ppm), SO2 and NOx emission rate (lb/hr), scrubber inlet SO2 concentration (ppm), number of scrubber modules in service, % solids in the slurry feed, slurry feed rate (gal/min), scrubber inlet and outlet temperature, stack temperature, opacity.

Table 3-1 presents the sampling and analytical matrix and sampling log.

Table 3-1: Sampling Matrix

Run No.	Sample	Test	Location/Clock Time/Sampling Time	
Date	Type	Method	Inlet	Outlet
1 9/22/99	Speciated Mercury	Ontario Hydro	1240-1512 120	1240-1506 120
2 9/22/99	Speciated Mercury	Ontario Hydro	1613-1822 120	1613-1829 120
3 9/23/99	Speciated Mercury	Ontario Hydro	0803-1010 120	0803-1028 120

3.2 FIELD TEST CHANGES AND PROBLEMS

Hydroxylamine Sulfate Solution. On July 9, 1999, Bruce Randall received a telephone call from the Energy and Environmental Research Center. The caller informed Mr. Randall that the recipe for this solution was to be revised such that equal amounts of Hydroxylamine Sulfate and Sodium Chloride were utilized. Mr. Randall verbally confirmed this change with Mr. Bill Grimley of EPA. This change was incorporated and utilized.

3.3 PRESENTATION OF RESULTS

3.3.1 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.

Table 3-2: Comparison of Volumetric Flow Rate Data

	Scrubber Inlet x 4 KACFM/KSCFM/KDSCFM	Stack KACFM/KSCFM/KDSCFM	CEMS KSCFM
Run 1	2,606/1,532/1,372	2,597/1,841/1,559	1,816
Run 2	2,619/1,528/1,366	2,711/1,917/1,634	1,909
Run 3	2,586/1,526/1,364	2,586/1,830/1,558	1,865
Average	2,604/1,529/1,367	2,631/1,863/1,584	1,863

The measured volumetric flow rate (KSCFM) at the inlet when multiplied by a factor of 4 was approximately 18% lower than that measured at the stack. The measured volumetric flow rate at the stack (KSCFM) was the same as that determined by the CEMS. The Adjusted Scrubber Inlet mercury mass flow rates presented Table 3-3 have been corrected to the Main Stack flue gas flow rates.

3.3.2 Mercury Mass Flow Rates. The mass flow rate of Mercury determined at each sample location is presented in Table 3-3.

Table 3-3: Summary of Results

Sample Location	Elemental Mercury (gram/hr)	Oxidized Mercury (gram/hr)	Particle-Bound Mercury (gram/hr)	Total Mercury (gram/hr)
Fuel				
Run 1				24.6
Run 2				30.1
Run 3				23.7
Average				**26.1**
Measured Scrubber Inlet				
Run 1	0.23	0.080	0.010	0.32
Run 2	3.05	0.188	0.605	3.85
Run 3	3.26	0.153	1.595	5.01
Average All Runs	**2.18**	**0.140**	**0.740**	**3.06**
Average Runs 2 & 3	**3.16**	**0.171**	**1.10**	**4.43**
Adjusted Scrubber Inlet*				
Run 1	1.09	0.385	0.05	1.52
Run 2	15.33	0.943	3.04	19.30
Run 3	15.63	0.734	7.65	24.01
Average All Runs	**10.68**	**0.687**	**3.58**	**14.95**
Average Runs 2 & 3	**15.48**	**0.839**	**5.35**	**21.66**
Main Stack				
Run 1	6.27	0.157	0.042	6.47
Run 2	7.67	0.07	0.048	7.79
Run 3	8.69	0.07	0.054	8.81
Average	**7.54**	**0.10**	**0.048**	**7.69**

* Adjusted to Main Stack flue gas flow rates.

The mass flow rate of speciated mercury measured during the first sample run at the main stack is significantly less than the subsequent two runs. The cause of this difference is not known. All field QA/QC checks were acceptable for the first run. The Fo factor and duct gas moisture content determined during this run were consistent with the subsequent two runs. If the results of the first sample run are not utilized in calculating average mass flow rates, the average results are as presented in Table 3-2.

3.3.3 Individual Run Results. A detailed summary of results for each sample run at the inlet and main stack are presented in Tables 3-4 and 3-5, respectively.

Table 3-4: Inlet Individual Run Results

Parameter	Run 1	Run 2	Run 3	Average
Sample Date	09/22/99	09/22/99	09/23/99	
Clock Time	1240-1512	1613-1822	0803-1010	
Sample Time	120	120	120	120
Average Duct Temperature (oF)	280	285	277	281
Average Duct Velocity (ft/s)	51.1	51.4	50.7	51.1
Moisture Content (%vol)	10.4	10.6	10.6	10.5
CO_2 Content (%vol dry)	10.6	10.4	10.0	10.3
O_2 Content (%vol dry)	9.9	9.9	10.1	10.0
Fo	1.038	1.058	1.080	1.059
Wet Molecular Weight (g/g-mole)	28.83	28.78	28.73	28.78
Volume Flow Rate (ACFM)	651570	654800	646520	650963
Volume Flow Rate (SCFM)	383010	382030	381420	382153
Volume Flow Rate (DSCFM)	342990	341560	340900	341817
Coal Feed Rate (ton/hr)	331	339	335	335
Coal Hg Content (mg/kg, dry basis)	0.082	0.098	0.078	0.086
Sample Volume (dscf)	64.536	64.418	62.827	
Net Elemental Hg (µg)	0.71	9.60	10.00	6.77
Net Oxidized Hg (µg)	0.25	0.59	0.47	0.44
Net Particle-Bound Hg (µg)	0.03	1.90	4.90	2.28
Total Hg (µg)	0.99	12.09	15.37	9.48
Elemental Hg ER (gram/hr)	0.23	3.05	3.26	2.18
Oxidized Hg ER (gram/hr)	0.08	0.19	0.15	0.14
Particle-Bound Hg (gram/hr)	0.01	0.61	1.60	0.74
Total Hg (gram/hr)	0.32	3.85	5.00	3.06
Sample Percentage of Isokinetic (%)	97.0	97.2	95.0	

Table 3-5: Main Stack Individual Run Results

Parameter	Run 1	Run 2	Run 3	Average
Sample Date	09/22/99	09/22/99	09/23/99	
Clock Time	1240-1506	1613-1829	0803-1028	
Sample Time	120	120	120	120
Average Duct Temperature (oF)	172	174	174	173
Average Duct Velocity (ft/s)	68.3	71.3	68.0	69.2
Moisture Content (%vol)	15.3	14.8	14.9	15.0
CO_2 Content (%vol dry)	10.5	10.3	10.6	10.5
O_2 Content (%vol dry)	10.0	10.0	9.8	9.9
Fo	1.038	1.058	1.047	1.048
Wet Molecular Weight (g/g-mole)	28.23	28.27	28.29	28.26
Volume Flow Rate (ACFM)	2596850	2711440	2586320	2631537
Volume Flow Rate (SCFM)	1841070	1917010	1830440	1862840
Volume Flow Rate (DSCFM)	1559030	1634210	1558250	1583830
Coal Feed Rate (ton/hr)	331	339	335	335
Coal Hg Content (mg/kg, dry basis)	0.118	0.142	0.114	0.125
Sample Volume (dscf)	71.570	75.473	72.098	
Net Elemental Hg (μg)	4.80	5.90	6.70	5.80
Net Oxidized Hg (μg)	0.120	0.05	0.05	0.07
Net Particle-Bound Hg (μg)	0.032	0.037	0.042	0.037
Total Hg (μg)	4.95	5.99	6.79	5.91
Elemental Hg ER (gram/hr)	6.27	7.67	8.69	7.54
Oxidized Hg ER (gram/hr)	0.16	0.07	0.07	0.10
Particle-Bound Hg (gram/hr)	0.042	0.048	0.054	0.048
Total Hg (gram/hr)	6.47	7.78	8.81	7.69
Sample Percentage of Isokinetic (%)	98.9	102.3	102.5	

3.3.4 Process Operating Data. The process operating data collected during the tests is presented in Table 3-6.

Table 3-6: Process Operating Data

Parameter	Run 1	Run 2	Run 3	Average
Date	09/22/99	09/22/99	09/23/99	
Start-End Time	1240-1513	1613-1829	0803-1016	
Volume Flow Rate (KSCFM)	1,816	1,909	1,865	1,863
Inlet SO_2 (ppm wet)	305	303	321	310
Stack SO_2 (ppm wet)	56.5	57.9	62.6	59.0
Stack SO_2 (lb/hr)	1033.5	1111.1	1171.2	1105.3
Scrubber Modules in Service	4	4	4	4
Ash Slurry Solids (%)	30.1	30.1	30.1	30.1
Lime Slurry Solids (%)	16.7	16.7	16.7	16.7
Ash Slurry Feed Rate (gpm)	109.1	115.1	111.5	111.9
Lime Slurry Feed Rate (gpm)	16.5	17.1	15.3	16.3
Inlet Temperature(°F)	293	297	290	293
Stack Temperature (°F)	169	175	177	174
Gross Megawatts	573	585	585	581
Stack NOx (ppm wet)	119.8	125.8	127.5	124.4
Stack NOx (lb/MMBtu)	0.24	0.25	0.25	0.25
Stack CO_2 (% vol wet)	10.4	10.6	10.7	10.6
Stack % Opacity (1 min avg.)	13	14	15	14
Coal Feed Rate (ton/hr)	331	339	335	335
Heat Input (MMBtu)	6377	6850	6713	6647

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 TEST METHODS

4.1.1 Speciated mercury emissions were determined via the draft "Standard Test Method for Elemental, 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 change in formula for the Hydroxylamine Sulfate recovery solution described in Section 3.2.2 of this report was the only change from the procedures proposed in the Site Specific Test Plan for this project.

The in-stack filtration (Method 17) configuration was utilized at the inlet location. The out-of-stack filtration (Method 5) configuration was utilized at the main stack. Figures 4-1 and 4-2 are schematics of the Ontario-Hydro sampling trains.

Figure 4-3 illustrates the sample recovery procedure. The analytical scheme was per Section 13.3 of the Ontario-Hydro Method.

Figure 4-1: Ontario-Hydro Sampling Train (Method 17 Configuration)

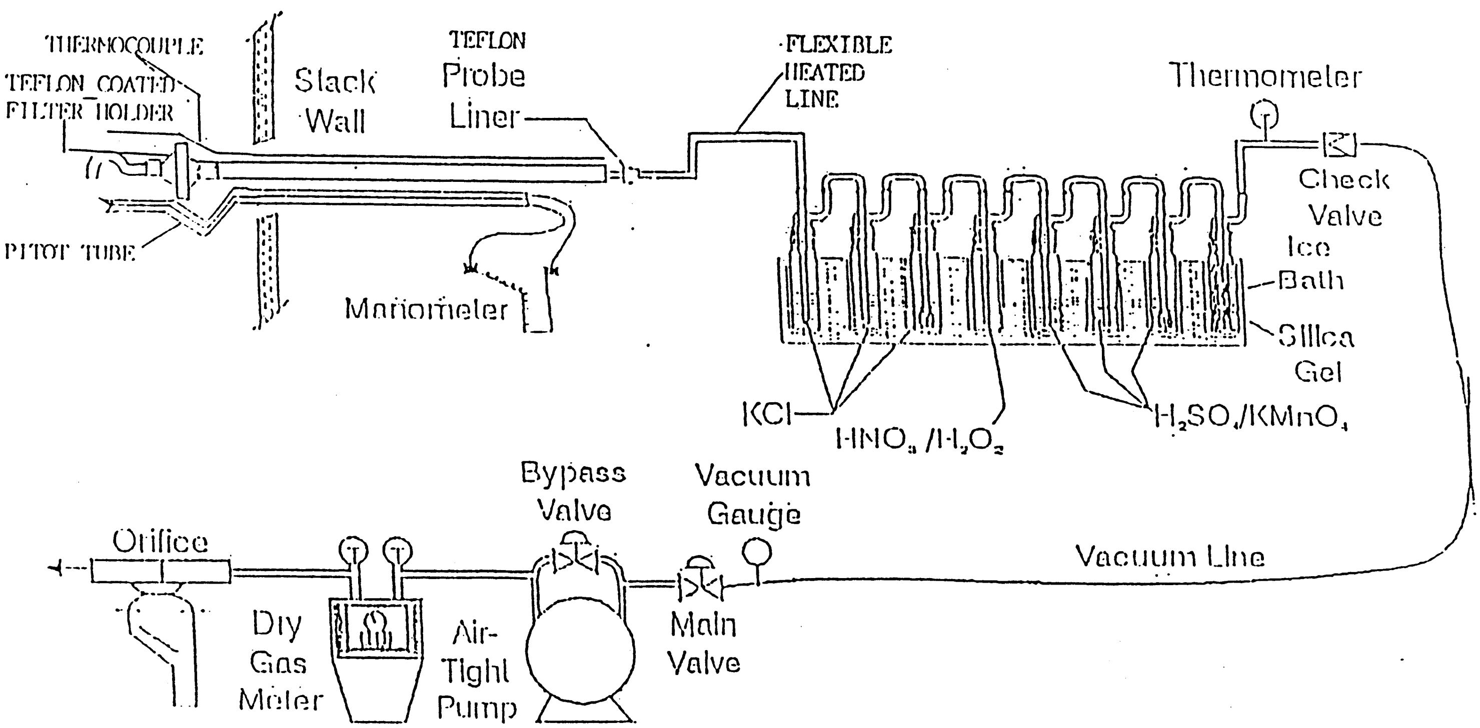


Figure 4-2: Ontario-Hydro Sampling Train (Method 5 Configuration)

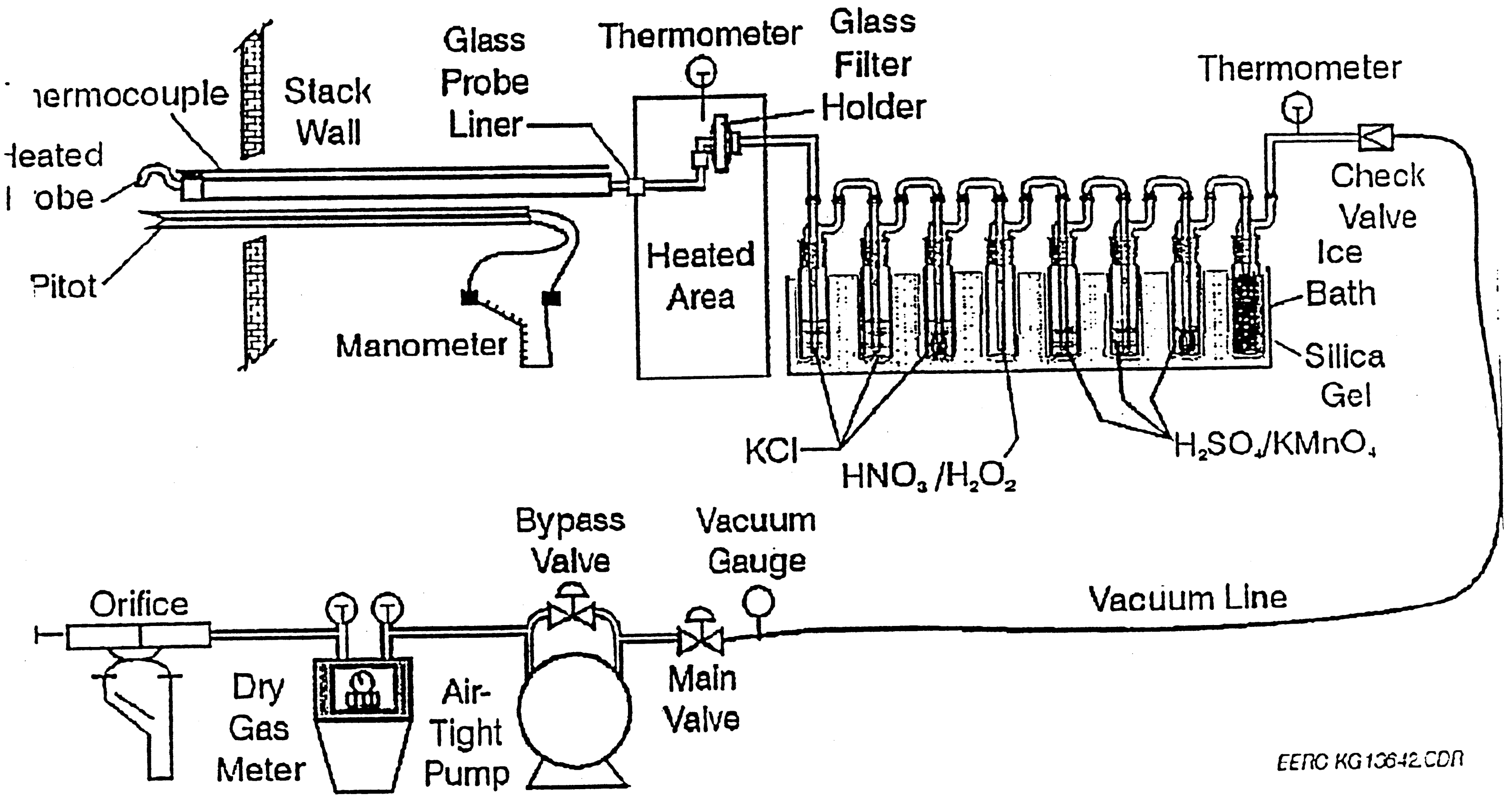
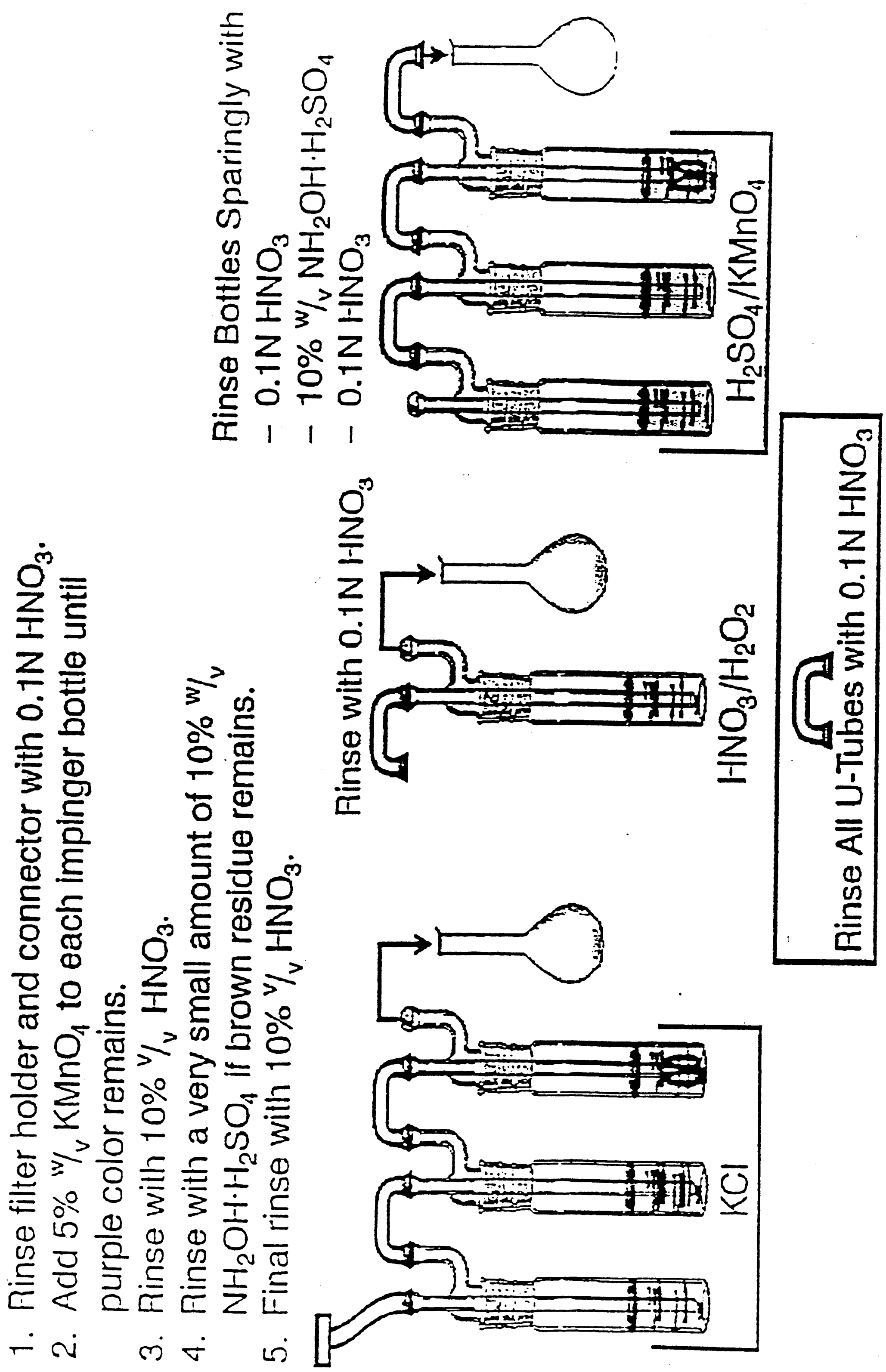


Figure 4-3: Sample Recovery Scheme for Ontario-Hydro Method Samples



4.1.2 Fuel samples were collected by composite sampling. Three samples were collected at equally spaced intervals during each speciated mercury sampling run. Each set of three samples was composited into a single sample for each sample run. Sample analysis was conducted according to Method 7471A.

4.2 PROCEDURES FOR OBTAINING PROCESS DATA

Mr. Terry Archbold was responsible for obtaining process operating data. The process data presented in Table 3-6 was continuously monitored via the facility computerized control system and/or the Unit 3 CEMS. Process data was averaged over the course of each sample run. All instruments used to collect process data are routinely calibrated according to BEPC LRS procedures.

5.0 INTERNAL QA/QC ACTIVITIES

5.1 QA/QC PROBLEMS

The only QA/QC problem that occurred during these tests was that a detectable amount of Mercury was found in the blank train collected at the inlet location. 0.18 micrograms of Mercury was found in the KMnO4 impingers. The Mercury content of all other blank train sample fractions at both the inlet and the main stack was consistent with that found in reagent blanks. The cause of this issue is not known.

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

Container #	Sample Fraction	Contents	Mercury (µg)	Detection Limit (µg)
C7/C12	Front-half	0.1N HNO3/Filter	<0.010	0.010
C8	1 N KCl	1 N KCl	<0.030	0.030
C9	HNO3/H2O2	HNO3/H2O2	<0.010	0.010
C10	KMnO4/H2SO4	KMnO4/H2SO4	<0.030	0.030

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 9/23/99. The results of blank train analysis are presented in Table 5-2.

Table 5-2: Blank Train Analysis

Container #	Sample Fraction	Contents	Mercury (µg)	Detection Limit (µg)
IB C01/C02	Front-half	Filter/front-half rinse	<0.050	0.010
SB C01/C02	Front-half	Filter/front-half rinse	<0.010	0.010
IB C03	KCl impingers	Impingers/rinse	<0.10	0.030
SB C03	KCl impingers	Impingers/rinse	<0.10	0.030
IB C04	HNO3-H2O2 impingers	Impingers/rinse	<0.25	0.010
SB C04	HNO3-H2O2 impingers	Impingers/rinse	<0.25	0.010
IB C05	KMnO4/H2SO4 impingers	Impingers/rinse	0.18	0.030
SB C05	KMnO4/H2SO4 impingers	Impingers/rinse	<0.10	0.030

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 Table 5-3.

Table 5-3: Field Meter Audit

Meter Box Number	Pre-Audit Value	Allowable Error	Calculated Yc	Acceptable
81231	0.999	0.9690<Yc<1.0290	1.014	Yes
80573	0.996	0.9661<Yc<1.0259	0.995	Yes