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February 9, 2000

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

ATTM: 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 Leland Olds Station Unit 2.

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: Dana Mount, ND State Health Department w/encl.

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Mostardi Platt

SPECIATED MERCURY EMISSIONS TESTING
Performed For
BASIN ELECTRIC POWER COMPANY
At The
Lelands Olds Station
Inlet and Outlet Ducts
Stanton, North Dakota
Test Date
July 15 and 16, 1999

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MOSTARDI PLATT PROJECT 92828
DATE SUBMITTED: FEBRUARY 2, 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 is presumed to have been gathered in accordance with recognized standards.

MOSTARDI-PLATT ASSOCIATES, INC.

Bruce Randall
Regional Manager

Reviewed by:

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 mercury emission measurements. MOSTARDI-PLATT ASSOCIATES, INC. (Mostardi Platt) was retained to complete the report.

EPA selected the Basin Electric Power Cooperative (BEPC), Leland Olds Station (LOS) in Stanton, North Dakota to be one of seventy eight coal-fired utility steam generating units to conduct emissions measurements. The test performed at LOS Unit 2 was the only test at this facility, and it was conducted on July 15 and 16, 1999. Simultaneous measurements were conducted at the inlet and outlet of the electrostatic precipitator. Mercury emissions were speciated into elemental, oxidized and particle-bound 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 (615) 686-0700
- BEPC Air Quality Program Coordinator - Jerry Menge (701) 223-0441
- BEPC LOS Plant Contact/Process Monitor - Kal Boyd (701) 745-3371

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. Lignite coal is delivered from Coteau mine 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 precipitator where the particulates are removed.
5. The gas exits the precipitator and is blown up the stack.

The Leland Olds Station Unit 2 consists of a Babcock and Wilcox lignite-burning, cyclone-fired boiler. The unit has an electric net generation capacity of 440 MW. Lignite is provided to the plant from the Coteau Freedom Mine by unit train. The coal is conveyed into the plant coal bunkers where it is fed to the coal conditioners. From the conditioners, coal is blown into the furnace using primary air as the conveyor and secondary air as fuel combustion air. Flue gas from the unit's boiler flows through an air heater to an electrostatic precipitator (ESP). From the ESP, an induced draft fan pushes the flue gas into the stack.

Unit 2 emits flue gas from a 500 foot stack. The flue gas enters perpendicular to the stack. The Continuous Emissions Monitoring System (CEMS) equipment is located at the 375 foot level.

2.2 CONTROL EQUIPMENT DESCRIPTION

The ESP, manufactured by Joy-Western Technology, is a saturable core reactor type control set, also referred to as a transistomatic precipitator control. It senses the precipitator transformer primary voltage and regulates the control current in the saturable reactor to maintain the correct power-input for peak efficiency. It also detects excessive sparking and adjusts the power input to provide the maximum average value of voltage to the electrodes.

Table 2-1 presents a summary of the normal ranges of operating parameters for the ESP.

Table 2-1: ESP Operating Parameters

Parameter	Normal Range
Volumetric Flow Rate	1.0 - 1.4mmscfm
Main Stack SO_2 Concentration	600-850 ppm
Main Stack SO_2 Mass Flow Rate	7000-10500 lb/hr
ESP Inlet Temp	350-500°F
Primary TR Set Range	260-280V (AC), 50-230 amps
Secondary TR Set Range	32-40KVA (DC), 150-1300 milliamps
Main Stack Temp	300-470°F
Stack Opacity of Emissions	<20 %
Main Stack NOx Emissions	0.55-0.90 lb/MMBtu

2.3 FLUE GAS SAMPLING LOCATIONS

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

2.3.1 ESP Inlet. See Figure 2-2. The inlet duct is 40 feet wide and 8 feet deep, and is equipped with ten sample ports, consisting of six inch threaded pipe nipples (with caps), approximately two feet long. Gas temperature at this location was approximately 400°F. Duct static pressure was approximately –12.5 " H_2O. This location is one of two ESP inlets for this source.

Due to its proximity to the manifold, the inlet location did 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. Thus, sampling was originally proposed at 3 traverse points in each of the ten ports (thirty total points). However, after discussions with EPA, it was agreed that sample would be collected from five points in each of the five center-most sample ports. Sample duration was five minutes per traverse point, for a total sample time of one hundred and twenty-five (125) minutes. The traverse point locations are presented below:

Traverse Point Number	Distance From Inside Wall (inches)
1	9.6
2	28.8
3	48.0
4	67.2
5	86.4

Per the "Electric Utility Steam Generating Unit Mercury Emissions" web page, no modifications to the sampling procedure due to potential cyclonic flow were 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 270.6 inches. The main stack is equipped with four 6" inch sample ports. Gas temperature at this location was approximately 360°F, with a static pressure of approximately –0.10"H_2O.

The sample ports were located 269 feet (11.9 duct diameters) downstream of the flue gas entry to the stack, and 129 feet (5.7 duct diameters) upstream of the stack exit. Sampling was conducted at a total of twelve traverse points, three in each of the four ports. Sample duration was ten minutes per traverse point, for a total sample duration of one hundred and twenty (120) minutes. The traverse point locations are presented below:

Traverse Point Number	Distance From Inside Wall (inches)
1	11.9
2	39.5
3	80.1

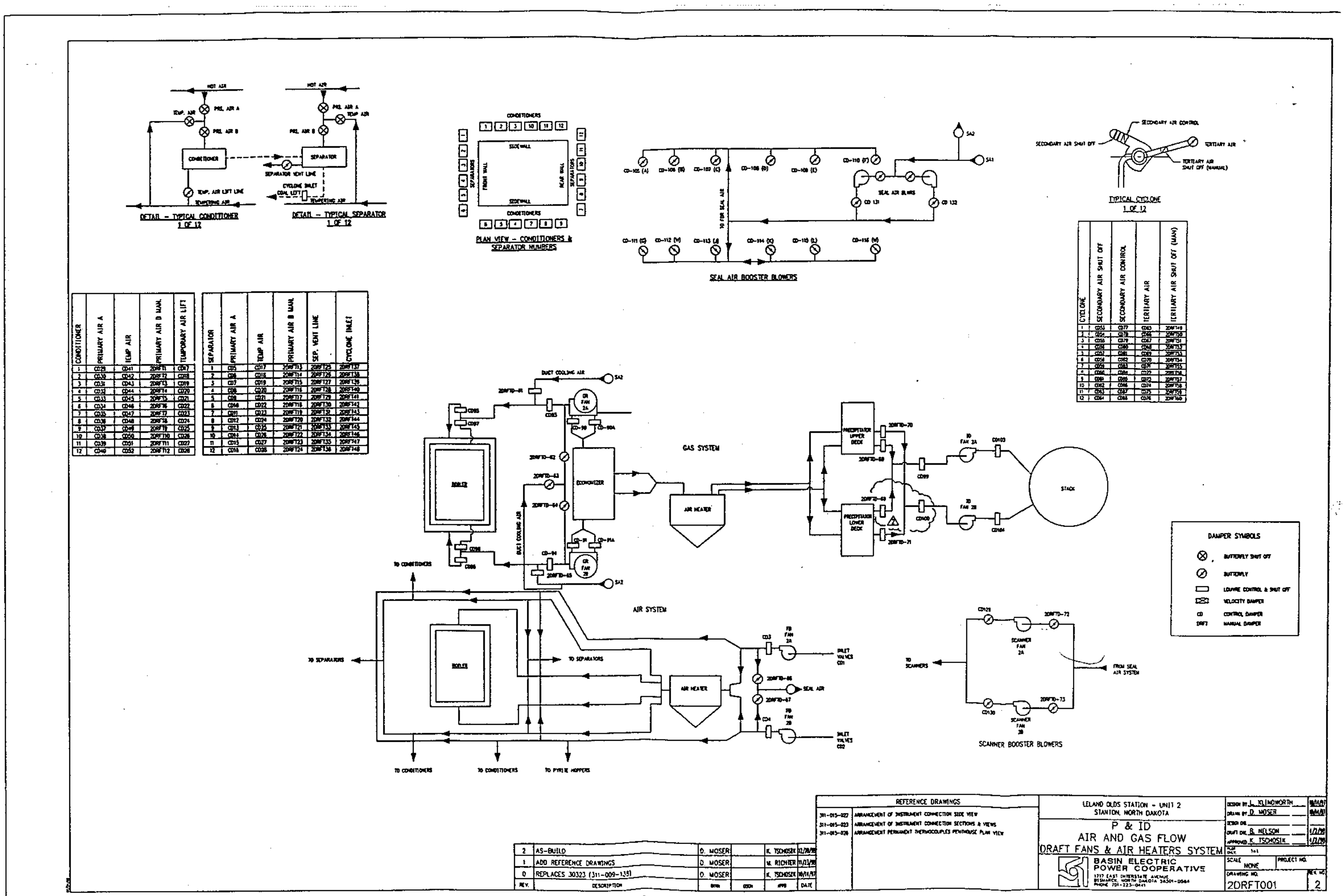


Figure 2-1 **Leland Olds Station process flow diagram**

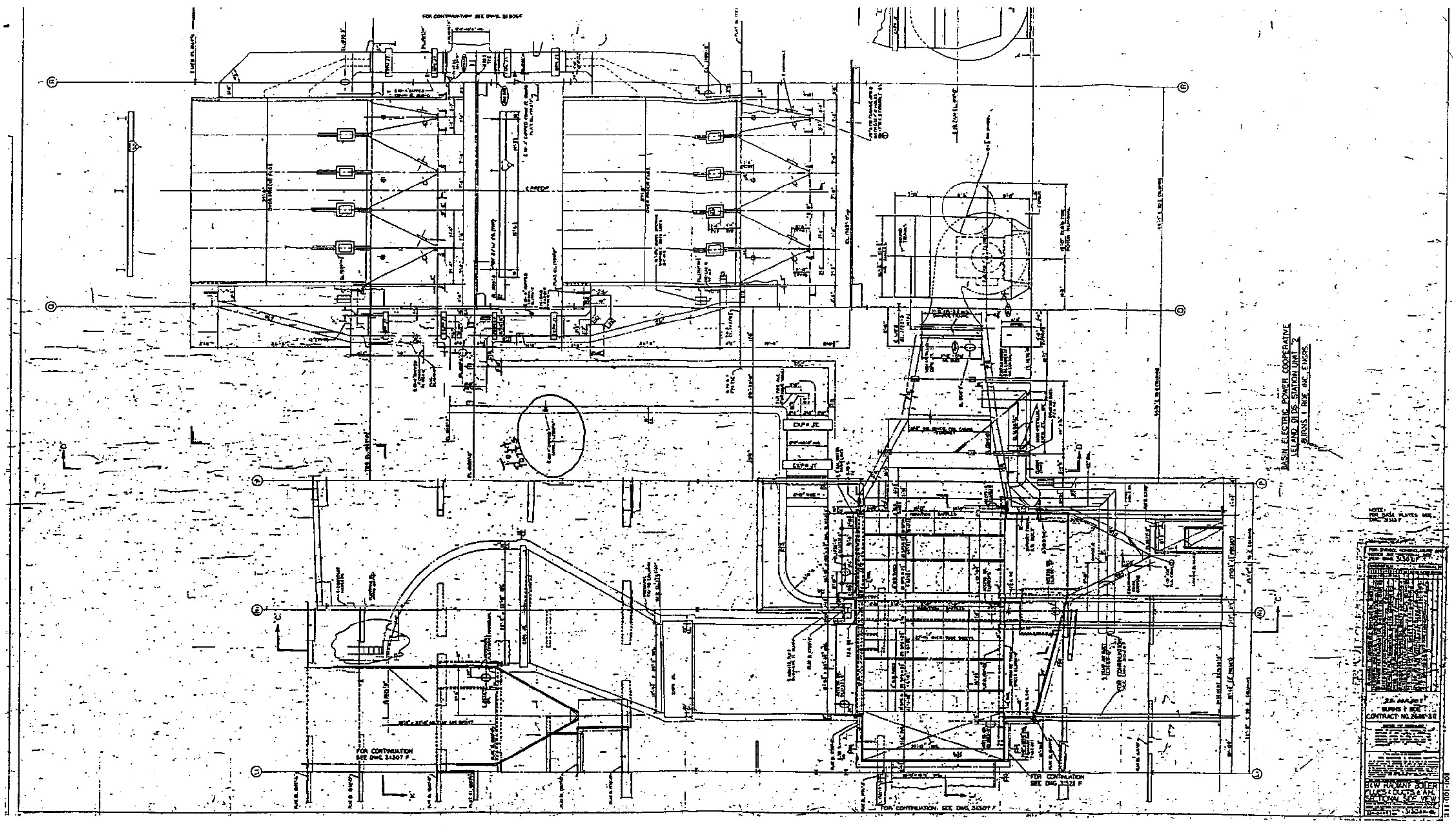
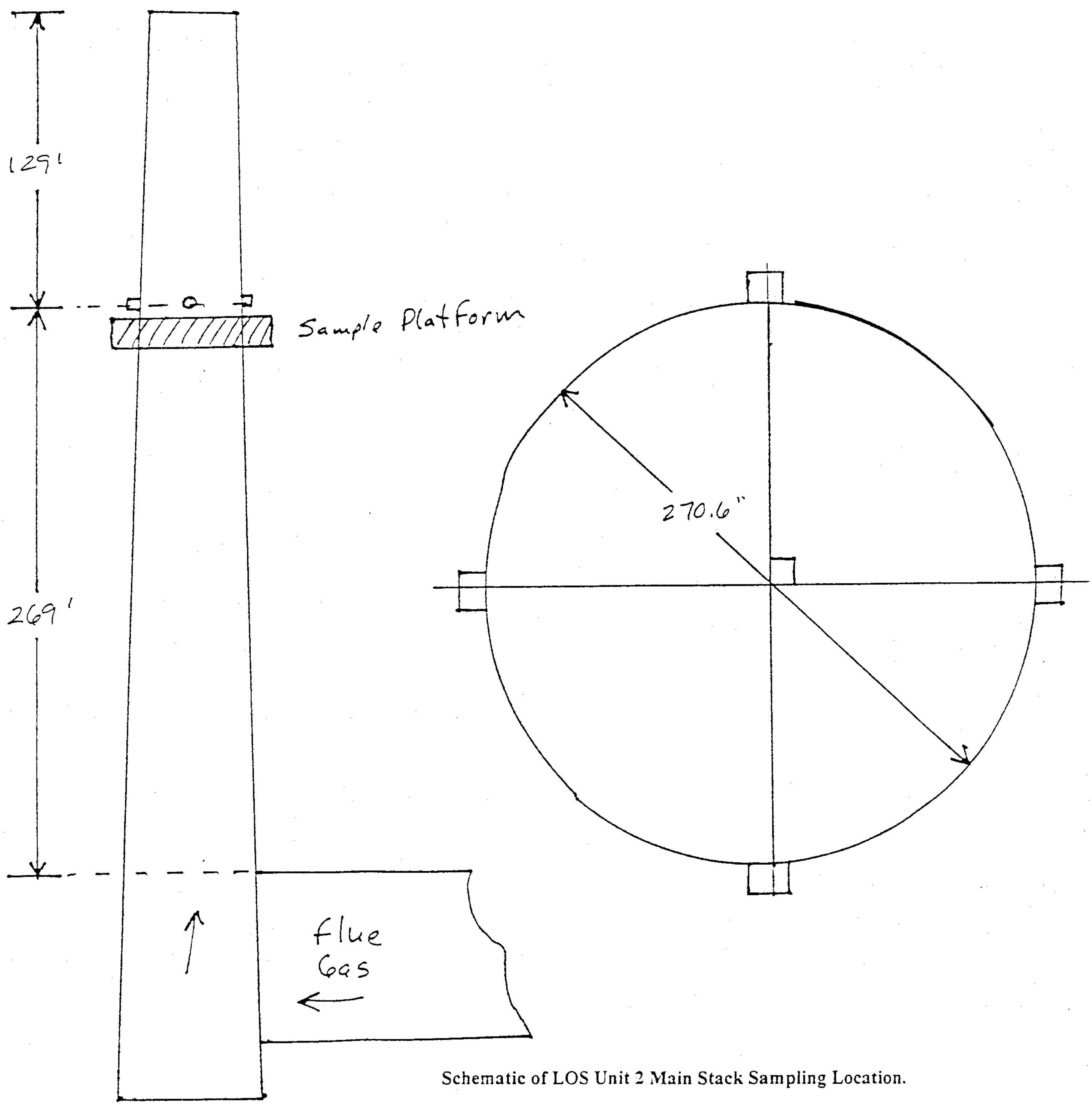


Figure 2-2

Schematic of LOS Unit 2 ESP Inlet Sampling Location.



Schematic of LOS Unit 2 Main Stack Sampling Location.

Fi

Figure 2-3

2.4 FUEL SAMPLING LOCATION

Fuel samples were collected at the feeders to the fuel conditioners. 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 is 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 are:

- Compare mass flow rates of mercury at the three sampling locations (fuel, inlet to and outlet of the ESP).

- During the test period, obtain process operating data and control equipment operating data as follows: Main stack volumetric flow rate; Main Stack SO_2 concentration and emission rate (ppm and lb/hr, respectively); Main Stack Opacity (%); Main Stack NOx concentration and emission rate (ppm and lb/MMBtu, respectively); Main Stack CO_2 concentration (%); Main stack temperature; Heat Input; Megawatt generation; ESP inlet temperature; Coal flow rate.

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

Table 3-1: Sampling Matrix

Run No. Date	Sample Type	Test Method	Location/Clock Time/Sampling Time	
			Inlet	Outlet
1 7/15/99	Speciated Mercury	Ontario Hydro	1140-1641 125	1140-1634 120
2 7/16/99	Speciated Mercury	Ontario Hydro	0803-1018 125	0803-1016 120
3 7/16/99	Speciated Mercury	Ontario Hydro	1100-1313 120	1100-1311 120

3.2 FIELD TEST CHANGES AND PROBLEMS

3.2.1 Inlet Sample Location. Prior to the first test run at the inlet location, a Method 5 configuration probe was inserted into the duct to ensure that the filter would remain in place during sampling. It became immediately apparent that the high vacuum at this location caused the filter paper to be sucked from the supporting frit. For this reason, the Method 17 configuration was used for all sampling at the inlet location.

As described in 2.3.1, sample was not collected at the inlet sample location as was initially planned. For the reasons described in Section 2.3.1, it is not anticipated that this change led to any bias in the determination of mercury concentrations.

3.2.2 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 Mercury Mass Flow Rates. The mass flow rate of Mercury determined at each sample location is presented in Table 3-2.

Table 3-2: 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				<11.51
Run 2				10.52
Run 3				<15.78
Average				<12.60
ESP Inlet*				
Run 1	<5.27	0.36	0.90	<6.53
Run 2	<14.27	0.73	0.41	<15.41
Run 3	<7.44	1.26	4.46	<13.16
Average	**<8.99**	**0.78**	**1.92**	**<11.69**
Main Stack				
Run 1	<6.21	1.26	<0.008	<7.47
Run 2	<8.35	1.72	<0.008	<10.08
Run 3	<0.87**	2.46	<0.008	<3.33
Average All Runs	**<5.14**	**1.81**	**<0.008**	**<6.96**
Average Runs 1 & 2	**<7.28**	**1.49**	**<0.008**	**<8.78**

* The mass flow rates of mercury at the inlet have been doubled in this table. This takes into account the fact that only one of two control device inlets was sampled. (See Section 3.3.2)

** The acidified potassium permanganate fraction of Main Stack Run 3 was broken prior to shipping.

3.3.2 Comparison of Volumetric Flow Rate. Volumetric flow rate is a critical factor in calculating mass flow rates. Since this one of two control device inlets was sampled at this source, it would be expected that approximately half of the flue gas from the unit would flow through each control device. As can be seen in Table 3-3 on the following page, this was the case. On a standard cubic foot per minute (SCFM) basis, the inlet flow rate was 50.6% of the main stack flow rate. On a dry SCFM basis, the inlet flow rate was 50.4% of the main stack flow rate.

In order to give meaning to the mercury mass balance, the mass flow rate of mercury measured at the inlet location (one of two inlets) was doubled. This approach was assumed to be valid, based on the discussion above.

The CEMS measured an average flow rate (KSCFM) approximately 4.4% higher than that measured via the Ontario-Hydro traverses.

Table 3-3: Comparison of Volumetric Flow Rate Data

	Inlet KACFM/KSCFM/KDSCFM	Stack KACFM/KSCFM/KDSCFM	CEMS KSCFM
Run 1	1,057/613/539	1,977/1,228/1,070	1,290
Run 2	1,115/651/558	2,035/1,273/1,106	1,309
Run 3	1,088/631/538	2,006/1,245/1,070	1,314
Average	1,087/632/545	2,006/1,249/1,082	1,304

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	7/15/99	7/16/99	7/15/99	
Clock Time	1140-1641	0803-1018	1100-1313	
Sample Time	125	125	125	125
Average Duct Temperature (°F)	390	394	401	395
Average Duct Velocity (ft/s)	55.1	58.1	56.7	56.6
Moisture Content (%vol)	12.1	14.4	14.8	13.8
CO_2 Content (%vol dry)	14.7	14.2	14.1	14.3
O_2 Content (%vol dry)	5.3	5.6	5.6	5.5
Fo	1.061	1.077	1.085	1.074
Wet Molecular Weight (g/g-mole)	29.05	28.70	28.64	28.80
Volume Flow Rate (ACFM)	1057200	1114800	1087900	1086600
Volume Flow Rate (SCFM)	612600	651500	630700	631600
Volume Flow Rate (DSCFM)	538600	557800	537600	544700
Coal Feed Rate (ton/hr)	396	325	547	423
Coal Hg Content (mg/kg, dry basis)	<0.05	0.056	<0.05	<0.052
Sample Volume (dscf)	63.109	65.661	63.695	64.155
Net Elemental Hg (µg)	<5.15	<14.00	<7.35	<8.83
Net Oxidized Hg (µg)	0.35	0.72	1.24	0.77
Net Particle-Bound Hg (µg)	0.88	0.40	4.40	1.89
Total Hg (µg)	<6.38	<15.12	<12.99	<11.49
Elemental Hg ER (gram/hr)	<2.64	<7.13	<3.72	<4.49
Oxidized Hg ER (gram/hr)	0.18	0.37	0.63	0.39
Particle-Bound Hg (gram/hr)	0.45	0.20	2.23	0.96
Total Hg (gram/hr)	<3.27	<7.70	<6.58	<5.84
Sample Percentage of Isokinetic (%)	97.1	97.5	98.2	97.6

Table 3-5: Main Stack Individual Run Results

Parameter	Run 1	Run 2	Run 3	Average
Sample Date	7/15/99	7/16/99	7/16/99	
Clock Time	1140-1634	0803-1016	1100-1311	
Sample Time	120	120	120	120
Average Duct Temperature (°F)	359	359	365	361
Average Duct Velocity (ft/s)	82.5	84.9	83.7	83.7
Moisture Content (%vol)	12.9	13.1	14.0	13.3
CO_2 Content (%vol dry)	14.6	13.9	13.9	14.1
O_2 Content (%vol dry)	5.8	5.8	5.8	5.8
Fo	1.034	1.086	1.086	1.069
Wet Molecular Weight (g/g-mole)	28.95	28.83	28.71	28.83
Volume Flow Rate (ACFM)	1977000	2034500	2005600	2012400
Volume Flow Rate (SCFM)	1228100	1272500	1245000	1248500
Volume Flow Rate (DSCFM)	1070200	1106200	1070300	1082200
Coal Feed Rate (ton/hr)	396	325	547	423
Coal Hg Content (mg/kg, dry basis)	<0.05	0.056	<0.05	<0.052
Sample Volume (dscf)	77.178	82.834	81.285	80.432
Net Elemental Hg (µg)	<7.46	<10.42	<1.100*	<6.25
Net Oxidized Hg (µg)	1.51	2.15	3.11	2.26
Net Particle-Bound Hg (µg)	<0.01	<0.01	<0.01	<0.01
Total Hg (µg)	<8.98	<12.58	<4.22	<8.59
Elemental Hg ER (gram/hr)	<6.21	<8.35	<0.87	<5.14
Oxidized Hg ER (gram/hr)	1.26	1.72	2.46	1.81
Particle-Bound Hg (gram/hr)	<0.008	<0.008	<0.008	<0.008
Total Hg (gram/hr)	<7.48	<10.1	<3.33	<6.97
Sample Percentage of Isokinetic (%)	95.2	94.4	95.7	95.1

* The acidified potassium permanganate fraction of Run 3 was broke prior to shipping. Only H_2O_2 fraction analyzed.

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	7/15/99	7/16/99	7/16/99	
Start-End Time	1140-1634	0803-1016	1100-1311	
Volume Flow Rate (KSCFM)	1,290	1,309	1,314	1,304
Stack SO_2 (ppm wet)	747	699	715	720
Stack SO_2 (lb/hr)	9,591	9,510	9,378	9,493
Inlet Temperature(°F)	370	370	378	373
Stack Temperature (°F)	361	359	366	362
Gross Megawatts	432	442	440	438
Stack NOx (lb/MMBtu)	0.548	0.546	0.569	0.554
Stack CO_2 (% vol wet)	12.4	12.2	12.5	12.4
Stack % Opacity (6-min avg.)	10.2	10.7	10.6	10.5
Coal Feed Rate (ton/hr)	396	325	547	423
Heat Input - CO_2 based MMBtu	5025	5160	5162	5116

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)

Speciated Mercury Sampling Train Equipped with In-Stack Filter

Ontario Hydro Method

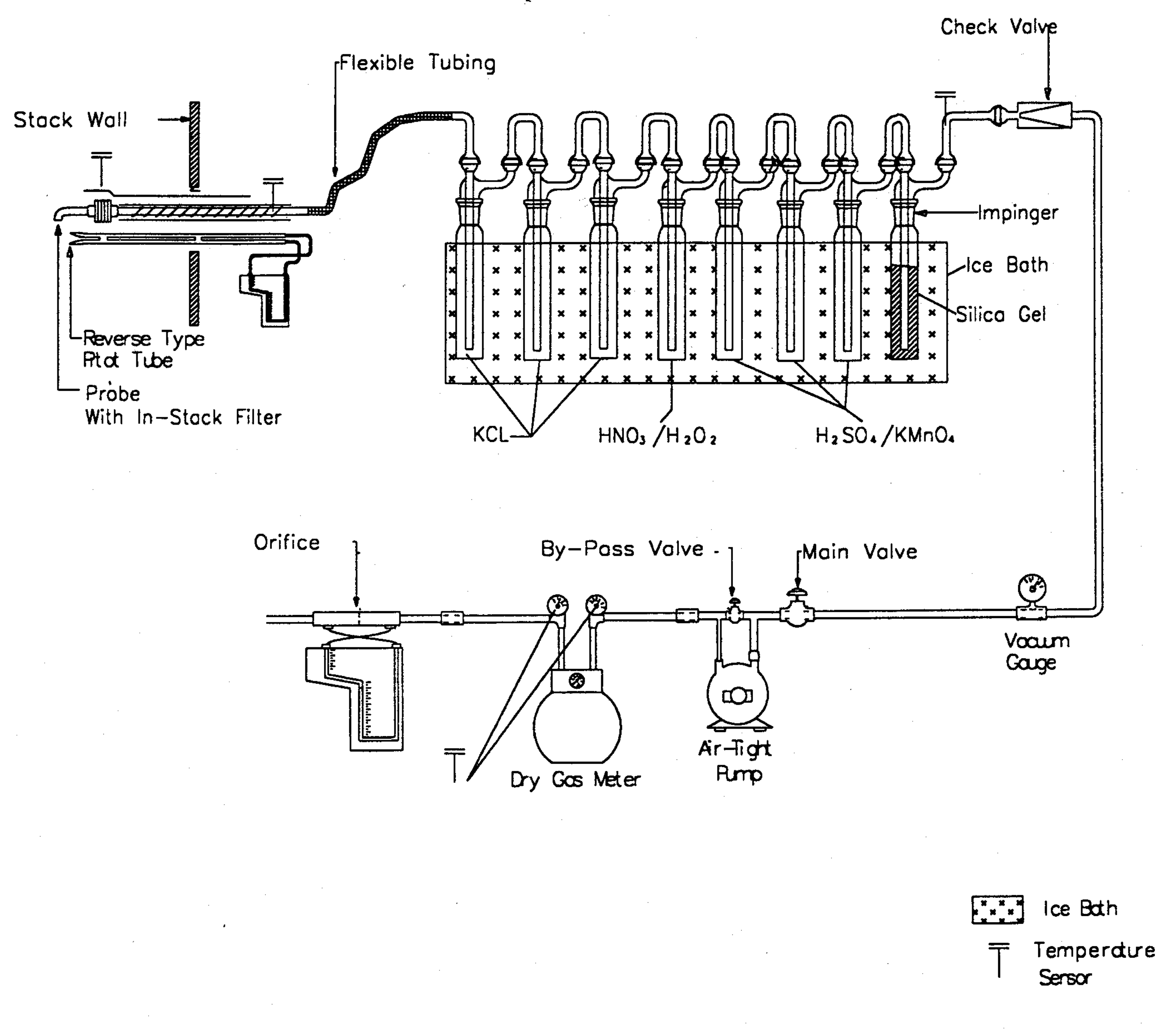


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Figure 4-2: Ontario-Hydro Sampling Train (Method 5 Configuration)

Speciated Mercury Sampling Train Equipped with Out-of-Stack Filter

Ontario Hydro Method

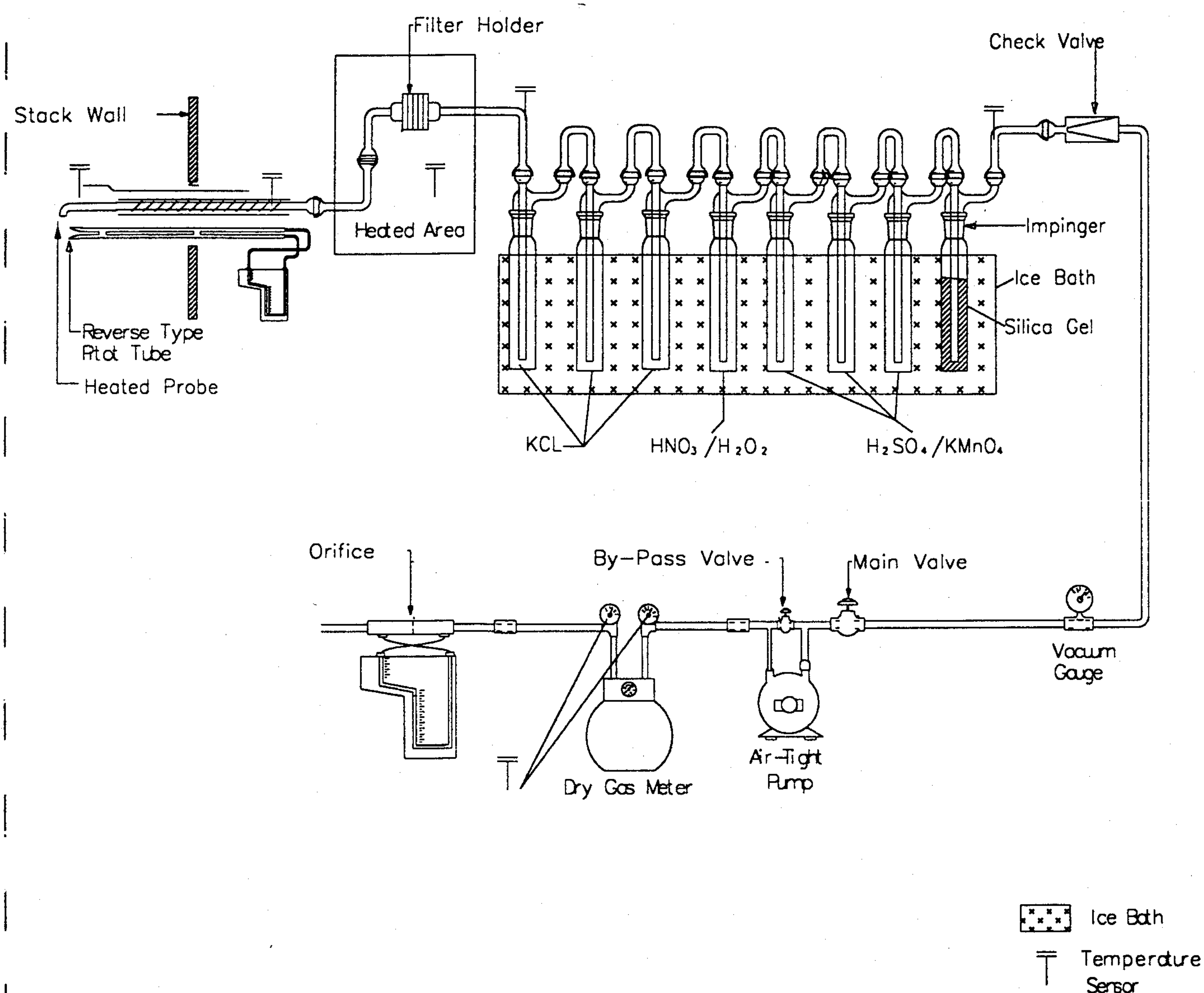

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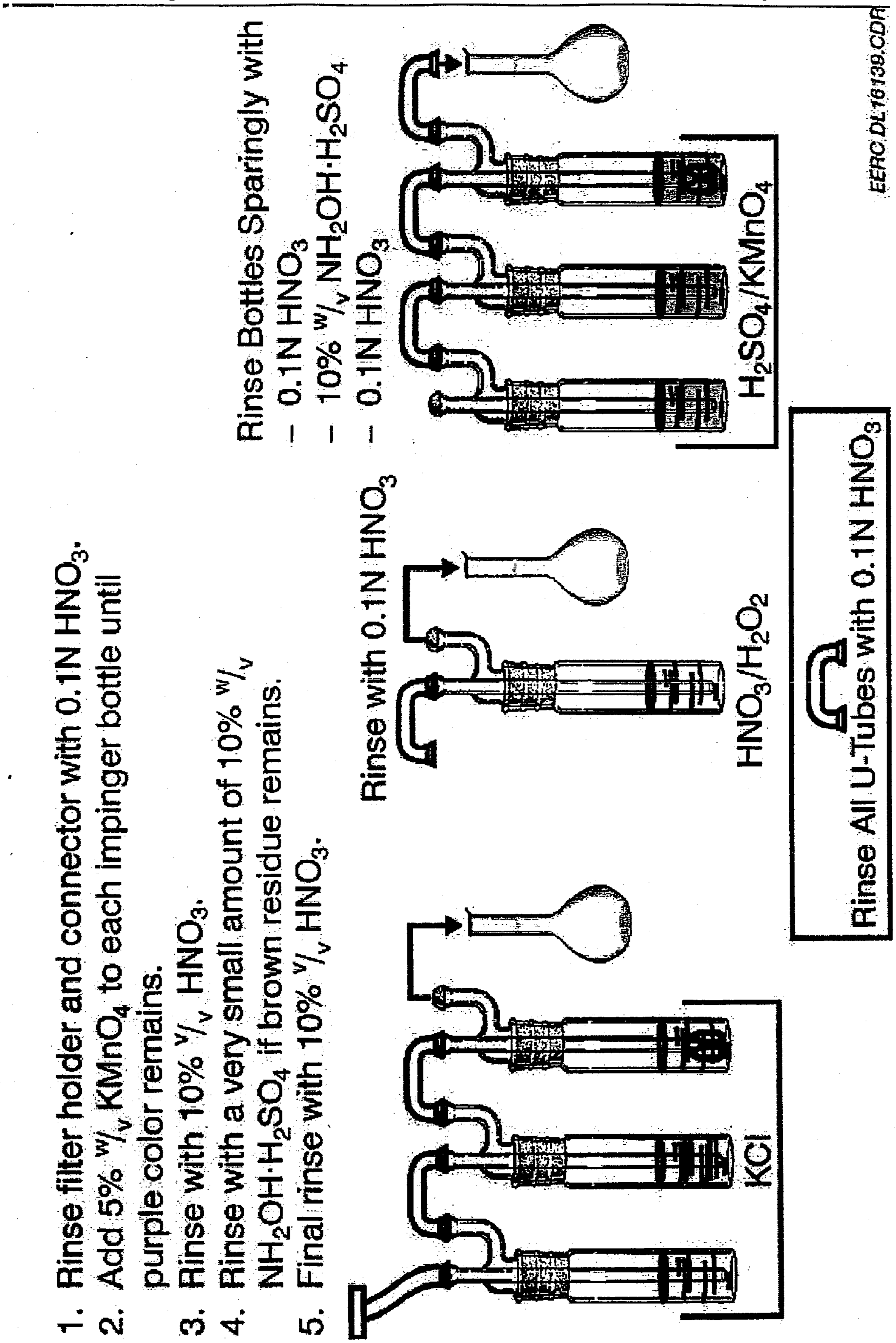
Figure 4-3: Sample Recovery Scheme for Ontario-Hydro Method Samples



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. Kal Boyd 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 2 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 LOS procedures.

Coal feed rates were determined by measuring the relative level of coal in each of 12 bunkers during each test. The total amount of coal burned during each test was estimated based on these levels. Coal feed rate was calculated by dividing the total tonnage of coal burned during each test by the duration of the test (in hours). It was the opinion of LOS staff that the average of the three coal feed rates determined via this approach was the most representative measure of coal feed rate.

5.0 INTERNAL QA/QC ACTIVITIES

5.1 QA/QC PROBLEMS

Two QA/QC problems occurred during these tests. First, a detectable amount of Mercury was found in the blank train collected at the inlet location. 0.32 micrograms of Mercury was found in the KCl impingers at the inlet location. This is 0.02 micrograms above the analytical detection limit. 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.

As noted in Section 3.3.1, the acidified potassium permanganate sample from Run 3 at the Main Stack was not analyzed. As the samples were being prepared for shipment in the Braun Intertec sample preparation area, this sample slipped from the grasp of the preparer and dropped to the floor.

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 is 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 HNO_3/Filter	<0.050	0.010
C8	1 N KCl	1 N KCl	<0.030	0.030
C9	HNO_3/H_2O_2	HNO_3/H_2O_2	<0.25	0.010
C10	$KMnO_4/H_2SO_4$	$KMnO_4/H_2SO_4$	<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 7/15/99. 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	<0.080	0.010
SB C01/C02	Front-half	Filter/front-half rinse	<0.010	0.010
IB C03	KCl impingers	Impingers/rinse	<0.030	0.030
SB C03	KCl impingers	Impingers/rinse	<0.030	0.030
IB C04	HNO_3-H_2O_2 impingers	Impingers/rinse	<0.25	0.010
SB C04	HNO_3-H_2O_2 impingers	Impingers/rinse	<0.25	0.010
IB C05	$KMnO_4$/H_2SO_4 impingers	Impingers/rinse	0.032	0.030
SB C05	$KMnO_4$/H_2SO_4 impingers	Impingers/rinse	<0.030	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	1.003	0.9729<Yc<1.0331	1.0074	Yes
38758	1.005	0.9749<Yc<1.0352	1.0062	Yes