MONTANA-DAKOTA
UTILITIES CO.
A Division of MDU Resources Group, Inc.

400 North Fourth Street
Bismarck, ND 58501
(701) 222-7900

February 3, 2000

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

RE: Heskett Station Unit 2 Speciated Mercury Test Report

Dear Mr. Grimley/Ms. Autry:

Enclosed is the Speciated Mercury Emissions Testing Report for the Heskett Station Unit 2 conducted on July 19 & 20, 1999. I have included six copies, one being unbound as requested.

During 1999, Mostardi Platt acquired Braun Intertec testing services. Personnel responsible for sampling and reporting remained unchanged from the start of the project to completion.

If you have any questions pertaining to the report, please contact me at 701-222-7689.

Sincerely,

Rick Patzman

Rick Patzman
Senior Environmental Scientist

cc: Gary Gress, Andrea Stomberg\File, Office
Alan Welte, Heskett Station

File: Air/Hazardous Air Pollutants/Mercury

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SPECIATED MERCURY EMISSIONS TESTING

Performed For
MONTANA-DAKOTA UTILITIES

At The
Heskett Station
Unit B2
Mandan, North Dakota

Test Date
July 19 and 20, 1999

Mostardi Platt

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

945 Oaklawn Avenue
Elmhurst, Illinois 60126-1012
Phone 630-993-9000
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MOSTARDI PLATT PROJECT 92930
DATE SUBMITTED: JANUARY 27, 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 mga

Bruce Randall
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 was retained to compile the test report.

EPA selected Unit B2 at the Montana-Dakota Utilities Co. (M-DU) Heskett Station in Mandan, North Dakota to be one of seventy-eight coal-fired utility steam generating units to conduct emissions measurements. The test performed at M-DU Heskett Station Unit B2, was the only test at this facility, and it was conducted on July 19 and 20, 1999. Simultaneous measurements were conducted at the inlet and outlet of the Electrostatic Precipitator (ESP). 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 (651) 686-0700
- M-DU Plant Manager - Alan Welte (701) 222-7890
- M-DU Plant Contact/Process Monitor - Art Carlson (701) 222-7890

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. Coal is delivered to the plant via railroad cars and stockpiled on site.
2. The coal is conveyed to the plant where it is pulverized.
3. The coal is combusted in the furnace.
4. The flue gas enters a multicyclone collector and then exits to an air heater.
5. The flue gas enters the ESP from the air heater.
6. The gas exits the ESP and exits the stack.

The Heskett Station Unit B2 consists of a Babcock and Wilcox fluidized bed combustor rated at 989 million British Thermal units per hour (MMBtu/hr). The boiler is capable of burning up to approximately 75 tons of coal per hour. Normal full load is between 68 and 85 megawatts (MW). During the test, the average gross electric generation was 78.2 MW.

During start-up of the boiler, natural gas is combusted in a duct burner, then the hot gases are injected into the boiler. As temperatures in the bed increase, coal is added to the fluidized bed. Once coal fire is established, the natural gas firing is discontinued. As the flue gas exits the boiler, it passes through a multicyclone collector prior to an ESP. From the ESP, flue gas exits through a 300 foot stack. During the test, the average coal feed rate was 61.2 tons per hour (tph).

2.2 CONTROL EQUIPMENT DESCRIPTION

Particulate matter emissions from the boiler are controlled by a Western Precipitation multicyclone and a Research Cottrell ESP. The multicyclone is capable of achieving 78% control efficiency, and is in service when the boiler is in operation. There are no isolation gates present to remove the multicyclone from operation.

The ESP has a total of 10 TR sets. These sets are located in two rows containing five sets each. Both rows and all TR sets are in service when the boiler is in operation. There are no dampers or isolation gates to control flue gas flow through the ESP. Effected by the quality of the coal, voltage to the TR sets is determined by adjusting the power to a level just below sparking.

Table 2-1 presents a summary of the average operating parameters for the ESP during the test.

Table 2-1: ESP Operating Parameters

Parameter	Normal Range
TR Sets in Service	10 sets
TR Set Voltage	34.35kV

2.3 FLUE GAS SAMPLING LOCATIONS

Emissions sampling was conducted at: (1) the inlet to the ESP, 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 ESP inlet location consists of two ducts. Each duct is ten feet deep and ten feet wide. Both ducts are equipped with seven sample ports, consisting of four inch threaded pipe nipples (with caps), approximately two feet long. Sampling was conducted on the western-most of the two ducts.

Neither ESP inlet duct sample location meets 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. Sampling was conducted at four traverse points in each of the seven ports (twenty-eight total points). Sample duration was five minutes per traverse point, for a total sample time of one hundred and forty (140) minutes.

In each port, sample was collected at the following points:

Traverse Point Number	Distance From Inside Top Wall (inches)
1	15
2	45
3	75
4	105

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 160.4 inches. The main stack is equipped with four 4" inch sample ports. The sample ports are located 150 feet (11.2 duct diameters) downstream of the flue gas entry to the stack, and 73 feet (5.5 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	7.1
2	23.4
3	47.5

2.4 FUEL SAMPLING LOCATION

Fuel samples were collected from the base of each of the three silo's conical during the test. The sample location is located just before the coal enters the feeder, which injects the coal into the boiler. The sample at this point was expected to be homogeneous.

Figure 2-1: R.M. Heskett Process Flow Diagram

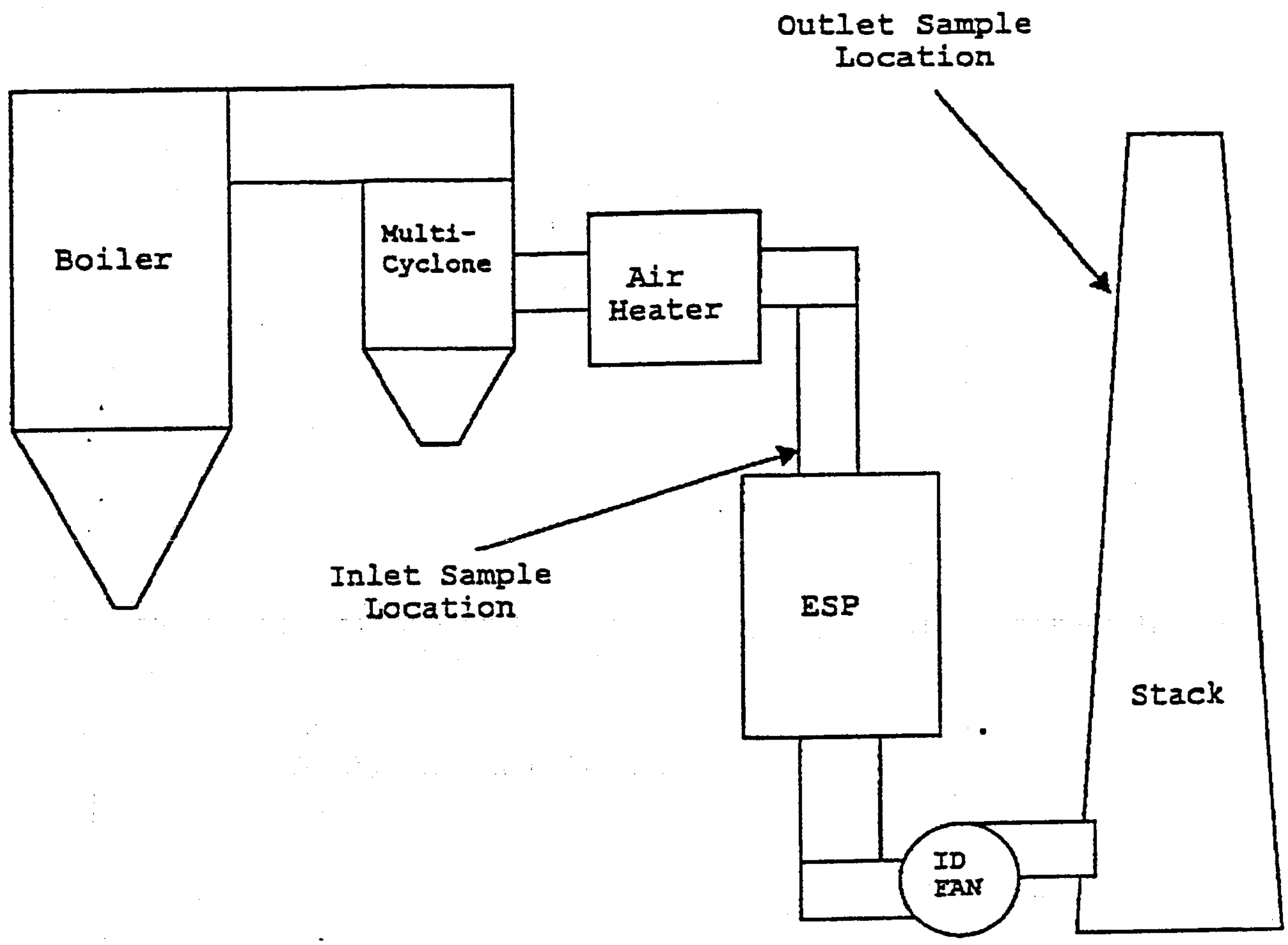


Figure 2-2: Schematic of R.M. Heskett Unit B2 ESP Inlet Sampling Location

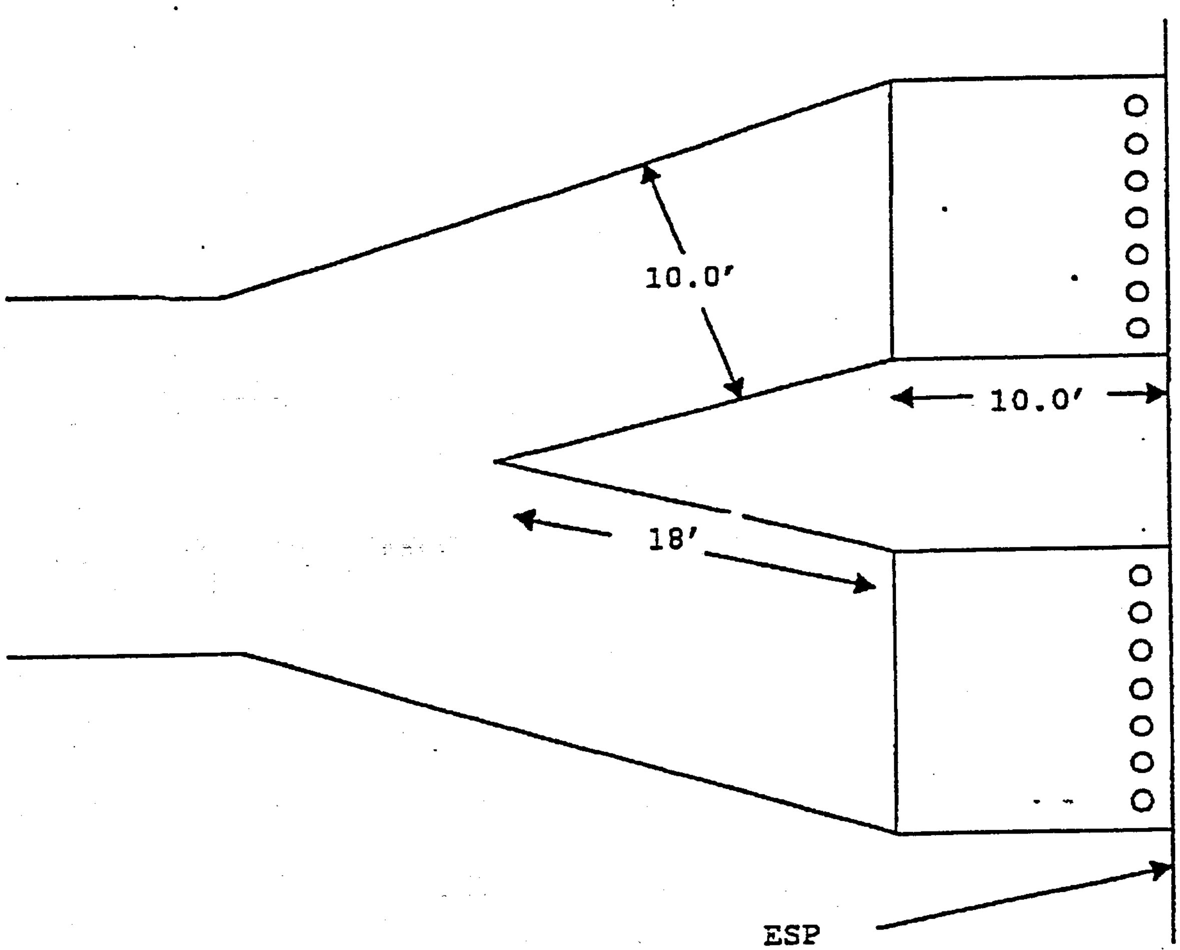
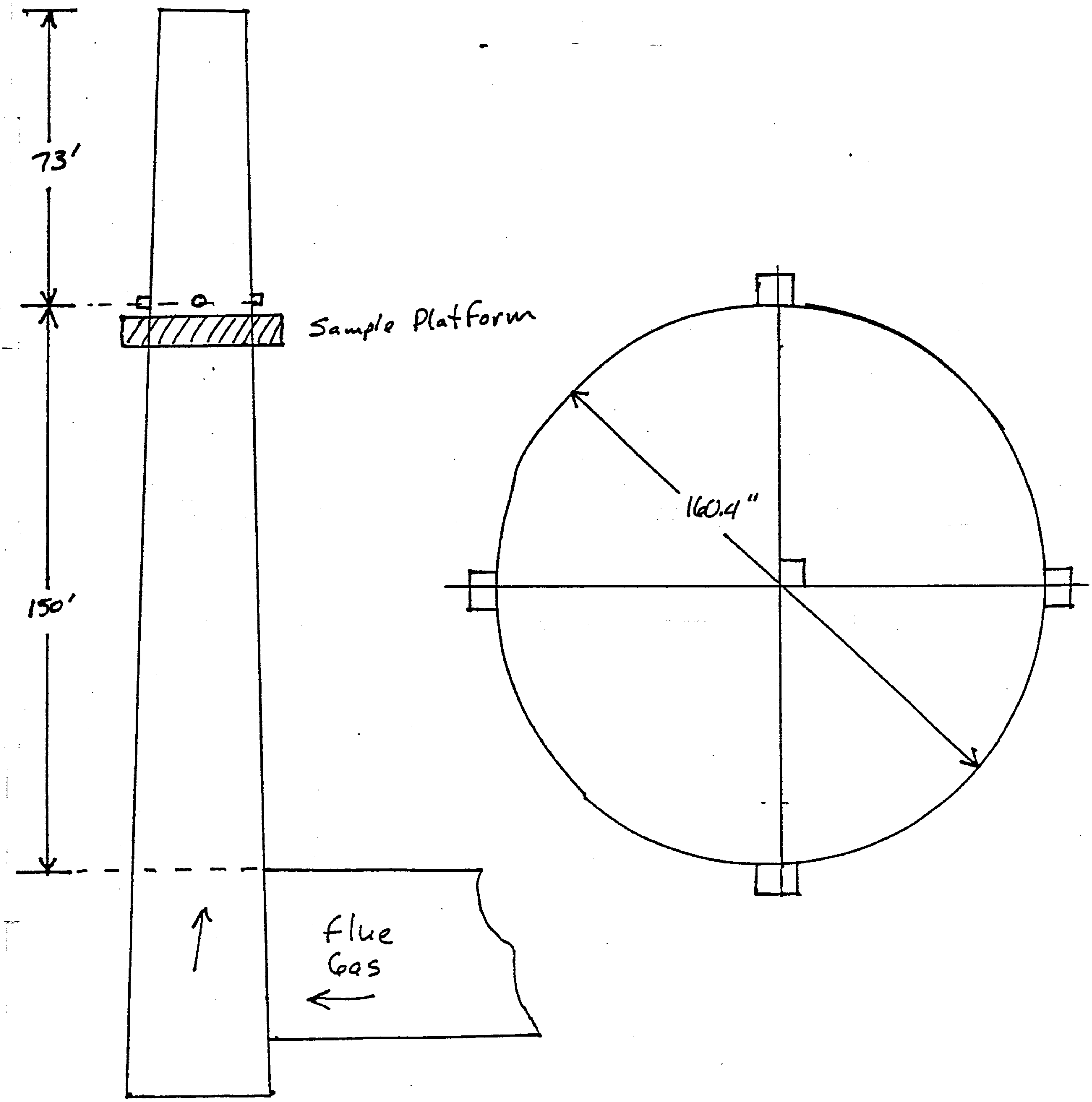


Figure 2-3: Schematic of R.M. Heskett Unit B2 Main Stack Sampling Location



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 ESP).
- During the test period, obtain process operating data: TR set voltage, the number of TR sets in service for the ESP, the amount of fuel combusted during the test based on the heat input calculation from the unit's Continuous Emissions Monitoring System (CEMS).

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 7/19/99	Speciated Mercury	Ontario Hydro	1330-1713 140	1320-1713 120
2 7/20/99	Speciated Mercury	Ontario Hydro	0800-1112 140	0800-1110 120
3 7/20/99	Speciated Mercury	Ontario Hydro	1157-1444 140	1157-1441 120

3.2 FIELD TEST CHANGES AND PROBLEMS

3.2.1 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 [illegible]	Oxidized Mercury [illegible]	Particle-Bound Mercury [illegible]	Total Mercury [illegible]
<u>Fuel</u>				
Run 1				3.560
Run 2				3.133
Run 3				2.686
Average				**3.126**
<u>ESP Inlet</u>				
Run 1*	<0.938	1.414	1.242	<3.594
Run 2*	<0.648	0.238	0.728	<1.614
Run 3*	<0.740	0.106	1.790	<2.636
Average*	**<0.776**	**0.586**	**1.253**	**<2.615**
<u>Main Stack</u>				
Run 1	<1.188	0.374	0.027	<1.589
Run 2	1.306	0.100	0.017	1.423
Run 3	<1.123	0.044	0.013	<1.180
Average	**<1.206**	**0.173**	**0.019**	**<1.397**

* - Results are doubled to account for both ducts.

3.3.2 <u>Comparison of Volumetric Flow Rate</u>. 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 each inlet to the control device should be approximately one half of that measured at the stack. As can be seen in Table 3-3, the agreement between the stack flow rates and doubled ESP inlet flow rates on a dry standard cubic foot per minute basis (KDSCFM) was quite good.

Table 3-3: Comparison of Volumetric Flow Rate Data

	ESP Inlet KACFM/KSCFM/KDSCFM	ESP Inlet Doubled KACFM/KSCFM/KDSCFM	Stack KACFM/KSCFM
Run 1	220.08/130.49/112.19	440.16/260.98/224.38	391.43/246.31/210.12
Run 2	206.10/124.34/106.00	412.20/248.68/212.00	366.38/234.79/200.54
Run 3	198.30/117.20/99.66	396.60/234.40/199.32	365.05/229.60/196.12
Average	**208.16/124.01/105.95**	**416.32/248.02/211.90**	**374.29/236.90/202.26**

The doubled measured volumetric flow rate (KDSCFM) at the inlet was approximately 5% higher than that measured at the stack. Percent differences of this magnitude should be considered to be very good, and indicate that mass flow rates of mercury calculated based on this data should be representative.

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 (one duct only)

Parameter	Run 1	Run 2	Run 3	Average
Sample Date	7/19/99	7/20/99	7/20/99	
Clock Time	1330-1713	0800-1112	1157-1444	
Sample Time	140	140	140	140
Average Duct Temperature (oF)	328	315	331	325
Average Duct Velocity (ft/s)	36.68	34.35	33.05	34.69
Moisture Content (%vol)	14.0	14.7	15.0	14.6
CO_2 Content (%vol dry)	11.8	11.8	12.3	12.0
O_2 Content (%vol dry)	8.6	8.6	8.2	8.5
Fo	1.042	1.042	1.033	1.039
Wet Molecular Weight (g/g-mole)	28.52	28.43	28.46	28.47
Volume Flow Rate (ACFM)	220,080	206,100	198,300	208,160
Volume Flow Rate (SCFM)	130,490	124,340	117,200	124,010
Volume Flow Rate (DSCFM)	112,190	106,000	99,660	105,950
Coal Feed Rate (ton/hr)	61.325	60.592	61.682	61.200
Coal Hg Content (mg/kg, wet basis)	0.064	0.057	0.048	0.056
Sample Volume (dscf)	46.636	43.656	42.795	44.362
Net Elemental Hg (μg)	<3.250	<2.225	<2.650	<2.708
Net Oxidized Hg (μg)	4.900	0.820	0.380	2.033
Net Particle-Bound Hg (μg)	4.300	2.500	6.400	4.400
Total Hg (μg)	<12.450	<5.545	<9.430	<9.142
Elemental Hg ER (gram/hr)	<0.469	<0.324	<0.370	<0.388
Oxidized Hg ER (gram/hr)	0.707	0.119	0.053	0.293
Particle-Bound Hg (gram/hr)	0.621	0.364	0.895	0.627
Total Hg (gram/hr)	<1.797	<0.807	<1.318	<1.307
Sample Percentage of Isokinetic (%)	96.1	95.2	99.3	96.9

Table 3-5: Main Stack Individual Run Results

Parameter	Run 1	Run 2	Run 3	Average
Sample Date	7/19/99	7/20/99	7/20/99	
Clock Time	1320-1713	0800-1110	1157-1441	
Sample Time	120	120	120	120
Average Duct Temperature (oF)	319	307	321	316
Average Duct Velocity (ft/s)	46.5	43.5	43.4	44.5
Moisture Content (%vol)	14.7	14.6	14.6	14.6
CO2 Content (%vol dry)	12.3	12.2	12.2	12.2
O2 Content (%vol dry)	7.9	8.0	8.2	8.0
Fo	1.057	1.057	1.041	1.052
Wet Molecular Weight (g/g-mole)	28.48	28.48	28.49	28.48
Volume Flow Rate (ACFM)	391,430	366,380	365,050	374,287
Volume Flow Rate (SCFM)	246,310	234,790	229,600	236,900
Volume Flow Rate (DSCFM)	210,120	200,540	196,120	202,260
Coal Feed Rate (ton/hr)	61.325	60.592	61.682	61.200
Coal Hg Content (mg/kg, wet basis)	0.064	0.057	0.048	0.056
Sample Volume (dscf)	87.527	83.031	83.267	84.608
Net Elemental Hg (µg)	<8.250	9.010	<7.950	<8.403
Net Oxidized Hg (µg)	2.600	0.690	0.310	1.200
Net Particle-Bound Hg (µg)	0.190	0.120	0.089	0.133
Total Hg (µg)	11.040	9.820	8.349	9.736
Elemental Hg ER (gram/hr)	<1.188	1.306	<1.123	<1.206
Oxidized Hg ER (gram/hr)	0.374	0.100	0.044	0.173
Particle-Bound Hg (gram/hr)	0.027	0.017	0.013	0.019
Total Hg (gram/hr)	<1.589	1.423	<1.180	<1.397
Sample Percentage of Isokinetic (%)	97.9	97.3	99.8	98.4

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	7/19/99	7/20/99	7/20/99	
Start-End Time	1330-1705	0805-1025	1159-1431	
TR Sets in Service	10	10	10	10
Average TR Set Voltage (kV)	34.21	34.48	34.37	34.35

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 TEST METHODS

4.1.1 Speciated mercury emissions were determined using 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.

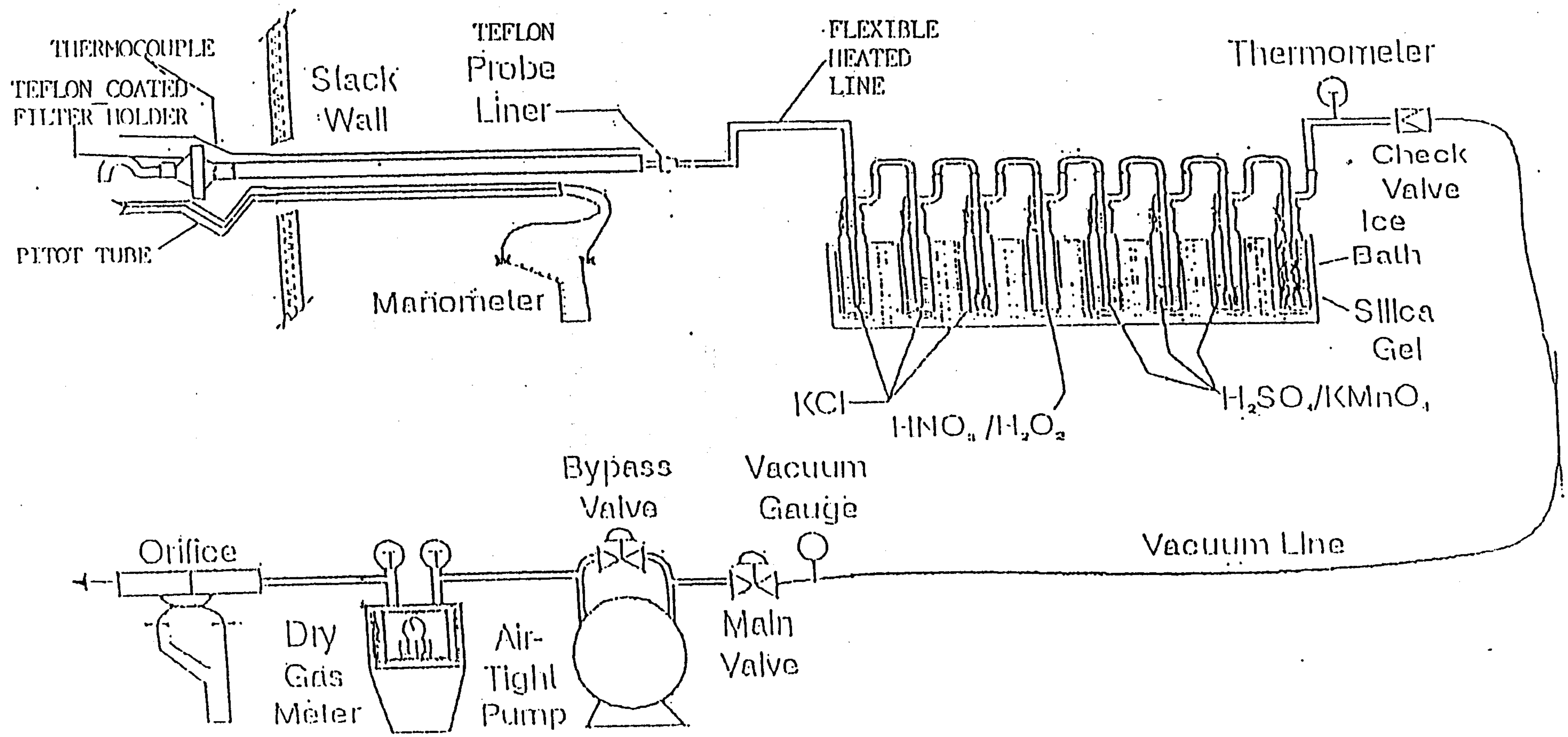


Figure 4-1: Ontario-Hydro Sampling Train (Method 17 Configuration)

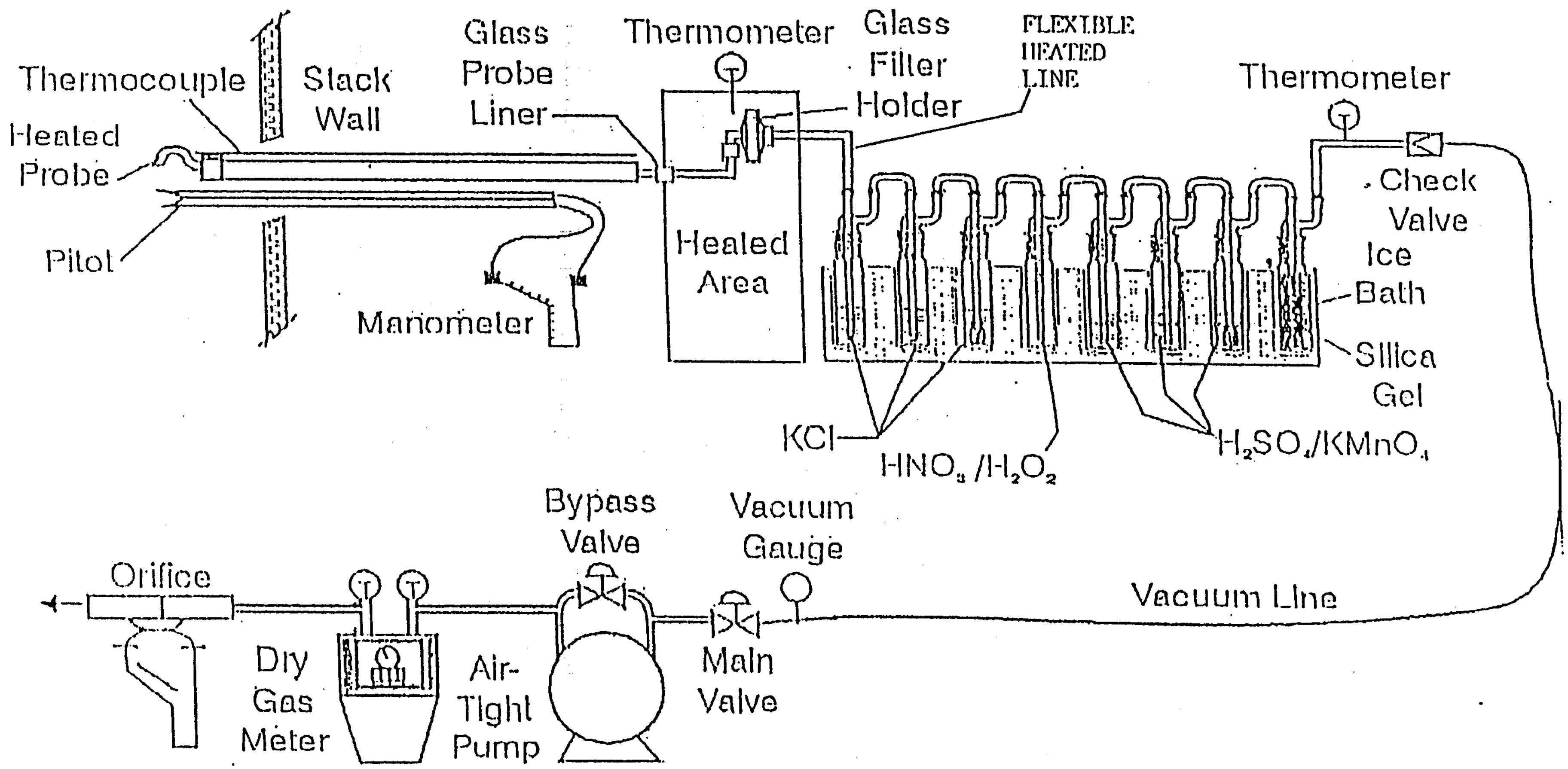


Figure 4-2: Ontario-Hydro Sampling Train (Method 5 Configuration)

DRAFT

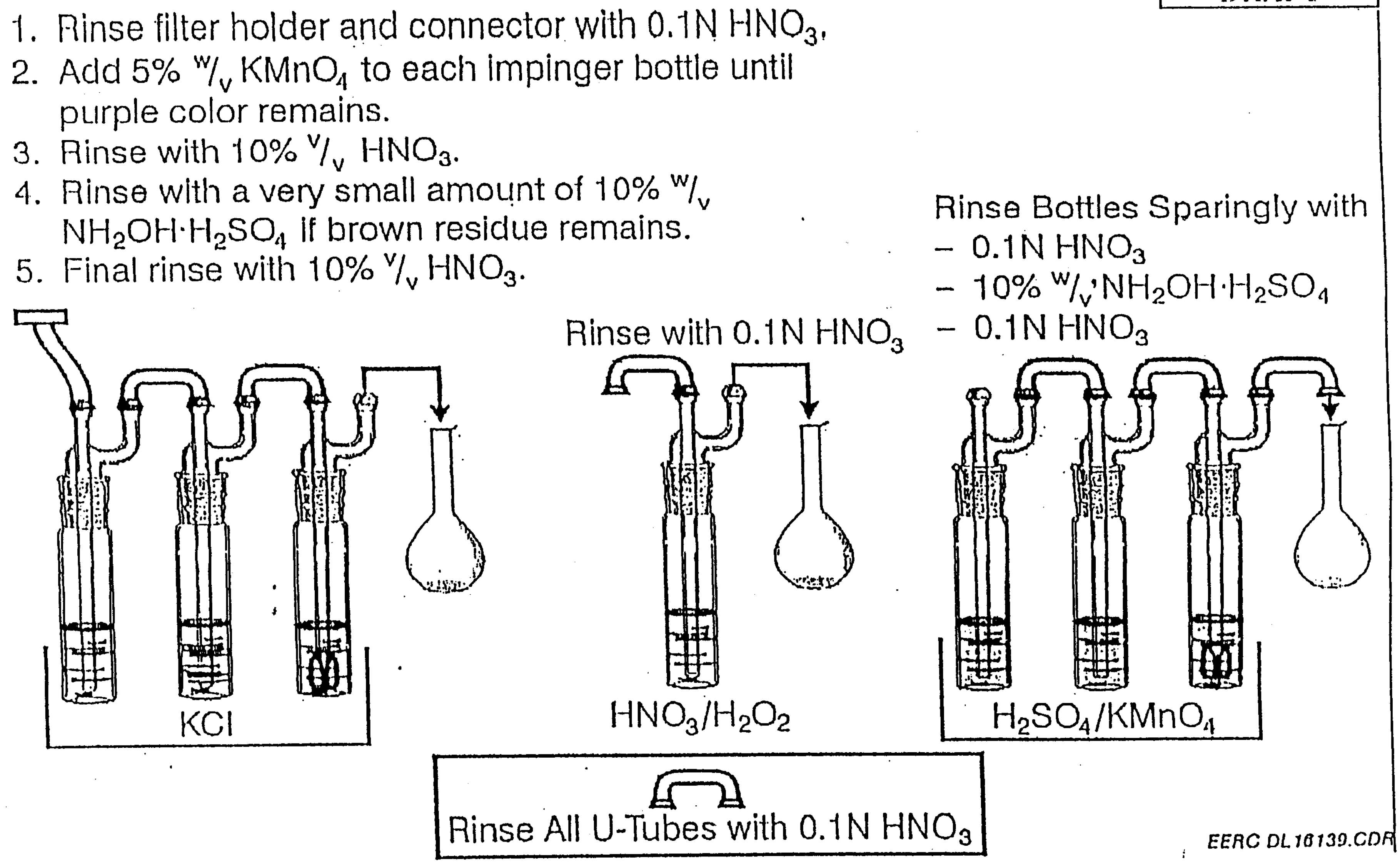


Figure 4-3: Sample Recovery Scheme for Ontario-Hydro Method Samples

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 be conducted according to Method 7471A.

4.2 PROCEDURES FOR OBTAINING PROCESS DATA

Mr. Art Carlson 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 B2 CEMS. Process data was averaged over the course of each sample run. All instruments used to collect process data are routinely calibrated according to M-DU 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 and outlet locations. In the inlet blank, 0.57 micrograms of Mercury was found in the KCl impingers and 0.30 micrograms of Mercury was found in the KMnO4 impingers. In the outlet blank, 0.66 micrograms of Mercury was found in the KCl impingers and 0.23 micrograms of Mercury was found in the KMnO4 impingers. 0.016 micrograms of Mercury were found in the outlet front-half blank. 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 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 HNO3/Filter	<0.080	0.010
C8	1 N KCl	1 N KCl	<0.030	0.030
C9	HNO3/H2O2	HNO3/H2O2	<0.25	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 7/19/99. 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	<0.10	0.010
SB C01/C02	Front-half	Filter/front-half rinse	0.016	0.010
IB C03	KCl impingers	Impingers/rinse	0.57	0.030
SB C03	KCl impingers	Impingers/rinse	0.66	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	0.30	0.030
SB C05	$KMnO_4/H_2SO_4$ impingers	Impingers/rinse	0.23	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	0.995	Yes
38758	1.005	0.9749<Yc<1.0352	1.012	Yes