TAMPA ELECTRIC

February 28, 2000

Attn: Electric Utility Steam Generating Unit
Mercury Test Program
Mr. William Grimley
U.S. Environmental Protection Agency
Emissions Measurement Center
4930 Old Page Road, Room No. E-108
Durham, North Carolina 27709

Via FedEx
Airbill No. 7908 1536 5637

Re: Tampa Electric Company (TEC) – Big Bend Station Unit 3
Mercury Information Collection Request (ICR) Part III Submittal of the Emissions Test Report

Dear Mr. Grimley:

Please find enclosed two (2) bound and one (1) unbound copies of the test report for the ICR mercury speciation test program performed at TEC's Big Bend Station Unit No. 3 on December 1 and 2, 2000.

Should you have any questions or concerns regarding the enclosed Emissions Test Report, please contact me at (813) 641-5034.

Sincerely,

for

Linda M. Kong
Associate Engineer
Environmental Planning

EP\gm\LMK119

Enclosure (3)

c: Mr. Howard Rhodes, FDEP
Mr. Winston A. Smith, EPA/RO IV
Mr. William Maxwell, EPA/ESD

WESTON PROJECT NO. 12281.001.001
EMISSIONS TEST REPORT
TAMPA ELECTRIC COMPANY
BIG BEND STATION
HILLSBOROUGH COUNTY, FLORIDA

FEBRUARY 2000

INFORMATION COLLECTION REQUEST
ASSESSMENT OF SPECIATED MERCURY
EMISSIONS FROM A COAL-FIRED BOILER

Prepared for:

TAMPA ELECTRIC COMPANY
5010 Causeway Blvd.
Tampa, Florida 33619

Prepared by:

ROY F. WESTON, INC.
1400 Weston Way
P.O. Box 2653
West Chester, Pennsylvania 19380
(610) 701-3000

TABLE OF CONTENTS

TABLE OF CONTENTS

Section **Page**

LIST OF FIGURES

Title **Page**

LIST OF TABLES

Title **Page**

1. INTRODUCTION

1.1 SUMMARY OF THE TEST PROGRAM

The U.S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS) has undertaken a program to acquire information related to mercury emissions from electric utility steam generating units. As part of this Information Collection Request (ICR), EPA has selected certain utilities for emissions testing to characterize speciated mercury emissions and the effectiveness of available control measures on such emissions.

The Tampa Electric Company (TEC), Big Bend Station Unit No. 3 located in Hillsborough County, Florida was selected as one of the ICR study sites. Mercury speciation sampling was performed on Unit No. 3 at Big Bend Station using the Ontario Hydro method. During the ICR test program, mercury speciation testing was performed on the inlet and outlet of the dry flue gas desulfurization (FGD) system serving Unit No. 3. Representative coal samples were collected in conjunction with each Ontario Hydro test.

The mercury speciation sampling activities were performed by Roy F. Weston Inc. (WESTON®), coal samples were collected by TEC, the analysis of the coal and Ontario Hydro method samples were performed by Philip Analytical Services. The test program was performed during the period of November 30 through December 2, 1999.

This test report presents the test data and test results of the mercury speciation sampling program performed on Unit No. 3 at Big Bend Station and contains all test results and discussions. Appendices of the detailed test data and test results, raw test data, process data, laboratory reports, equipment calibration records and sample calculations are also provided. This report format follows EPA's Emissions Measurement Center (EMC) guideline document (GD-043) titled, Preparation and Review of Emission Test Reports which is required for ICR report submittals.

1.2 TEST PROGRAM OBJECTIVES

During the test program mercury emissions testing using the Ontario Hydro method were performed on the inlet and outlet of the FGD serving Unit No. 3. Representative samples of the coal were sampled in conjunction with the emissions testing.

The specific objectives of this test program were as follows:

- Characterize the emissions of particulate-bound, elemental and oxidized mercury from the coal fired boiler.
- Simultaneously measure concentrations and mass emission rates of speciated mercury at the inlet and outlet of the FGD serving Unit No. 3.
- Obtain and analyze representative samples of the coal for the purpose of determining mercury, heating value, ash content, sulfur and chlorine levels.
- Document corresponding boiler, electrostatic precipitator (ESP) and FGD operations along with facility continuous emission monitoring system (CEMS) data.

A Site-Specific Sampling/Testing, Analytical and QA/QC Plan and Quality Assurance Project Plan (QAPP) dated June 1999 were developed for the ICR test program performed on Unit No. 3.

1.3 SAMPLE LOCATIONS

Representative samples from the following solid stream were collected and analyzed during the test program:

- Coal Feed.

Flue gas stream emission samples were collected at the following locations:

- Unit No. 3 & 4 FGD Inlet.
- Unit No. 3 & 4 Outlet (stack).

1.4 POLLUTANTS MEASURED

Table 1-1 presents a summary of process solid and flue gas streams and the associated pollutants and parameters measured during the test program.

1.5 TEST PROGRAM KEY PERSONNEL

The key personnel who coordinated and performed the test program, their project responsibilities and their phone numbers are:

Contact Name	Project Responsibility	Telephone No.	Facsimile No.
TEC			
Mr. David Smith	Corporate Environmental Services Contact	(813) 630-7382	(813) 630-7350
Mr. Greg Benton	Station Environmental Coordinator	(813) 228-4111 x48392	(813) 630-6920
EPA			
Mr. William Grimley	ICR Program Manager	(919) 541-1065	(919) 541-1039
WESTON			
Mr. Jeff O'Neill	Project Manager	(610) 701-7201	(610) 701-7401
Mr. Jack Mills	Test Team Leader	(610) 701-7245	(610) 701-7401
PHILIP			
Ms. Pam Peters	Technical Representative	610-921-8833	610-921-9667

Table 1-1

TEC Big Bend Station
Unit No. 3
Process Solid and Flue Gas Streams with Pollutants/Parameters

Location/Stream Type	Pollutants or Parameters	Frequency
Unit No. 3 Coal Feed	Heating value Ash content Moisture Mercury (Hg) content Chlorine (Cl) content Sulfur content	One composite sample per run (total of 3) in conjunction with flue gas sampling on Unit No. 3.
Unit No. 3 & 4 FGD Inlet and Outlet	Particulate bound and vapor phase mercury (including oxidized and elemental mercury speciation of vapor phase).	Inlet and outlet sampling by Ontario Hydro method on Unit No. 3.

2. PLANT AND SAMPLING LOCATION DESCRIPTIONS

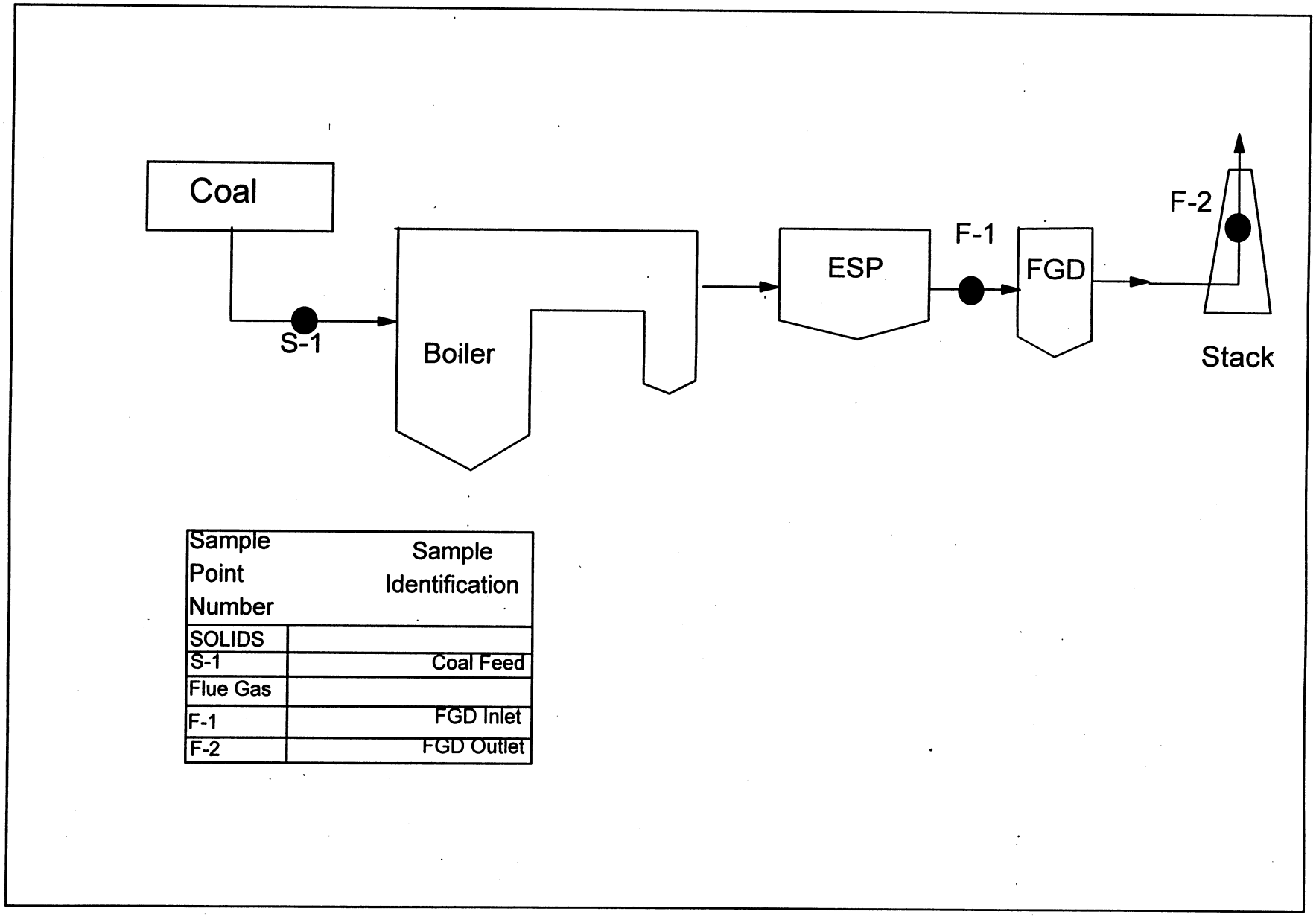
2.1 TEC BIG BEND UNIT NO. 3 OVERVIEW

Tampa Electric Company operates Big Bend Unit No. 3, which is a 4,115 MMBtu/hr pulverized coal fired boiler at Big Bend Station located in Hillsborough County, Florida. The primary fuel is bituminous coal supplied to the boiler via three mills, through two feeders per mill. The steam generated by the boiler is used to produce electricity in a steam turbine generator. Unit No. 3 is designed to operate at a full load of 445 megawatts (MW).

Acid gas and particulate emissions are controlled using a FGD limestone scrubber and an ESP. The FGD system serves both Units No. 3 and No. 4; however, during the test program Unit No. 4 was off-line.

The continuous emissions monitoring system (CEMS) measures the effluent concentration of sulfur dioxide (SO_2), carbon dioxide (CO_2), volumetric flow rate and opacity in the gas stream at the FGD outlet stack location. In addition, the inlet duct to the FGD is configured to monitor gaseous concentrations of SO_2, CO_2, and oxides of nitrogen (NO_x).

Figure 2-1 presents a schematic of the Unit No. 3 boiler and pollution control equipment.



Sample Point Number	Sample Identification
SOLIDS	
S-1	Coal Feed
Flue Gas	
F-1	FGD Inlet
F-2	FGD Outlet

FIGURE 2-1
PROCESS SCHEMATIC AND SAMPLING/TESTING LOCATIONS
TEC-BIG BEND STATION UNIT NO. 3

c:\freelance drawings\TECOfig2-1

2.2 PROCESS SOLID SAMPLING LOCATIONS AND SAMPLING PROCEDURES

2.2.1 Unit No. 3 Coal Sampling

Samples of the coal feed stream were collected and composited during each test run. The coal is introduced to the boiler by three mills through two feeders per mill (total of 6 feeders). During each test, TEC representatives collected a coal sample every 15-minutes from one of the six feeders (alternating from feeder to feeder).

The individual grab samples were composited into a single sample per test run.

2.3 FLUE GAS SAMPLING LOCATIONS

2.3.1 Unit No. 3 & 4 FGD Inlet

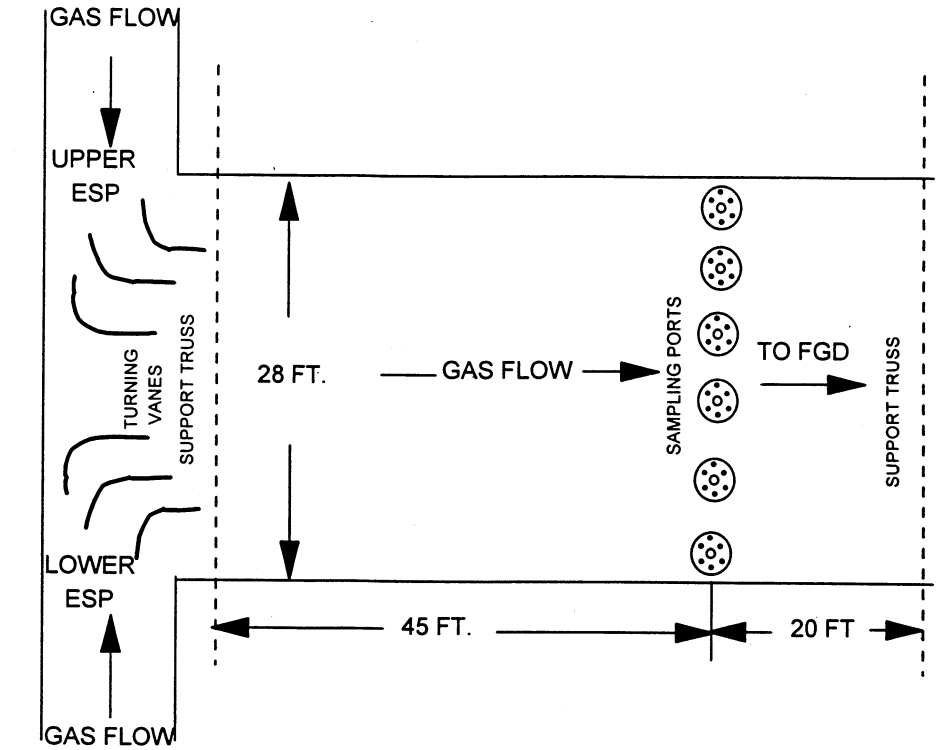
The test site at the FGD inlet is located on the horizontal 15′ deep by 28′ high rectangular duct. A total of six (6) 6″ ID test ports are located vertically along the long side of the duct. The ports are located 45′ (2.3 diameters) downstream from the ESP outlet and 20′ (1.0 diameters) upstream of the transition duct leading to the FGD inlet.

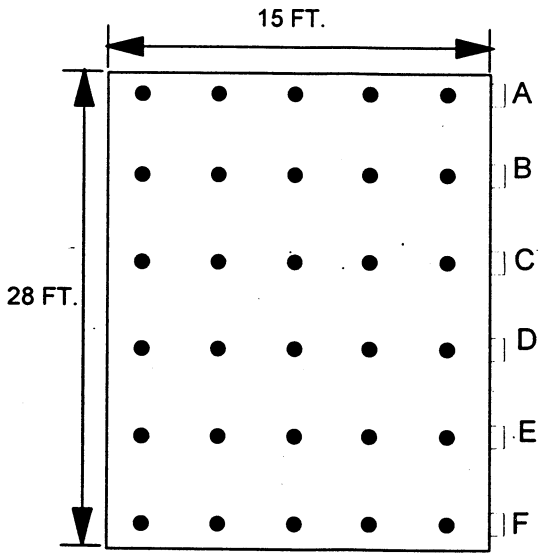
During each test run a total of five traverse points in each port (total of 30 points) were sampled. See Figure 2-2 for a schematic of the FGD inlet test site.

2.3.2 Unit No. 3 & 4 FGD Outlet (Stack)

A total of four (4) test ports are in place on the 28′ 10″ ID flue. The test ports are located 86′ (3 diameters) downstream from the nearest disturbance and 245′ (8.5 diameters) from the nearest upstream distance (stack exit).

A total of 6 points per port (24 total) were sampled. See Figure 2-3 for a schematic of the Unit No. 3 stack test location.





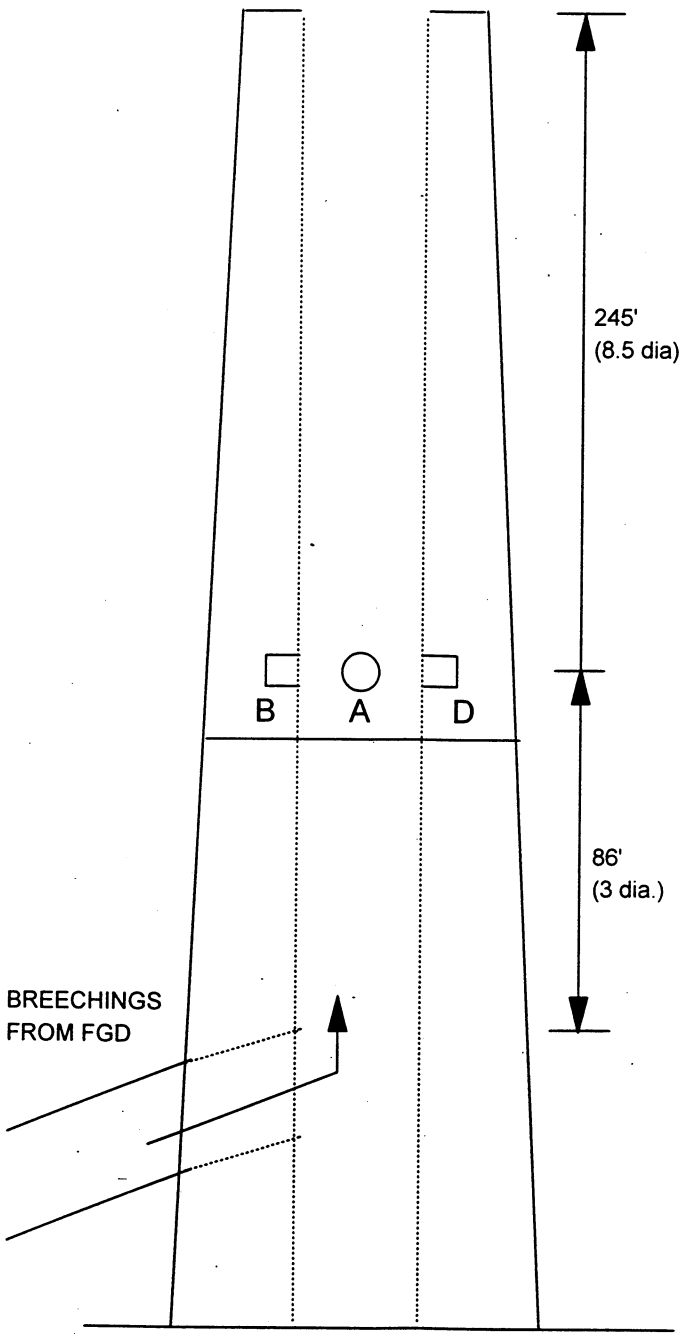
TEST PORT TRAVERSE POINT		DISTANCE FROM INSIDE NEAR WALL (INCHES)
A,B,C,D,E,F	1	18
	2	54
	3	90
	4	126
	5	162

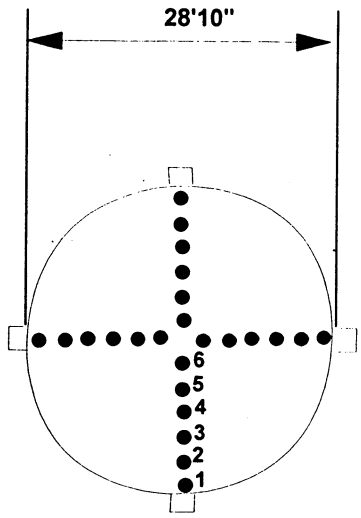
Port Length=17"

DRAWING NOT TO SCALE

FIGURE 2-2
UNIT 3 & 4 FGD INLET DUCT TEST SITE
PORT AND TRAVERSE POINT LOCATIONS

c:\freelance drawings\bigbendfig4-1





PLAN AT SAMPLING PORT LOCATION

Traverse Point Number	Distance From Inside Near wall
A,B,C,D - 1	7 1/4
2	23 1/8
3	40 7/8
4	61 1/4
5	86 1/2
6	123 1/8

PORT LENGTH = 14"

Drawing Not to Scale

Figure 2-3
UNIT 3 STACK TEST SITE
PORT AND TRAVERSE POINT LOCATIONS

c:\freelance drawings\bigbendfig4-2

3. SUMMARY AND DISCUSSION OF TEST RESULTS

3.1 SAMPLING/TESTING, ANALYTICAL AND QC MATRICES

The detailed sampling/testing, analytical and QC matrices for this survey are presented on Tables 3-1 and 3-2 for the coal, and flue gas sampling locations, respectively. Each table specifies the following components:

- Sampling point identification and description.
- Test objective, number and length of test runs performed, and samples/data collected.
- Parameters measured.
- Sampling or monitoring methods employed, including sample preservation technique.
- Maximum sample holding time.
- Sample preparation/extraction and analysis methods applied.
- Sampling and analytical program design (i.e., number of samples collected/analyzed by type and method). This includes the number, or frequency and type, of QC samples analyzed for each parameter.
- Laboratory that analyzed each type of sample.

3.2 PRESENTATION OF RESULTS

3.2.1 Mercury Speciation Test Results

A summary of the Ontario Hydro method mercury speciation test results are presented on Tables 3-3, 3-4, and 3-5 for Unit No. 3.

Table 3-3 presents the measured mercury concentrations in micrograms per cubic meter (ug/m^3) for each test run and provides the percent of particulate, oxidized and elemental mercury in comparison to the total mercury.

Tables 3-4 and 3-5 presents the mercury concentrations and mass emission rate values for particulate, oxidized, elemental and total mercury for each individual test run along with the

Table 3-1

Sampling/Testing, Analytical, and QC Plan
Unit No. 3 — Clean Coal Feed

No. of Test Runs: 3

Test Objective: Determine total mercury and chlorine content of as-fired coal.

Sampling Objective: Collect a representative sample.

Parameters to be Determined:	**Mercury**	**Chlorine**	**Heating Value**	**Ash Content**	**Sulfur Content**	**Mass Flow Rate**
Sampling or Monitoring Method:	Representative sample increments were obtained from the six (6) individual boiler coal feeders once every 15-minutes (alternating from feeder to feeder) during each test period. Samples stored in air-tight, plastic-lined bucket					Gravimetric readings from batch scale
Sample Preparation/Extraction and Analysis Method(s):	ASTM D2013 and EPA Method 7471	ASTM E776 and EPA Method 300	ASTM D3286	ASTM D3174	ASTM D4239	
Maximum Holding Time (days):	28	28	28	28	28	NA
Sampling or Monitoring Design:						
Total No. of Samples	3	3	3	3	3	NA
Site Blanks	0	0	0	0	0	NA
Trip Blanks	0	0	0	0	0	NA
Lab Blanks	1	1	1	1	1	NA
Blank Spikes[2]	0	0	0	0	0	NA
Replicates[3]	1 batch	1/batch	1/batch	1/batch	1/batch	NA
QC Spikes[4]	1/batch[1]	1/batch	1/batch	1/batch	1/batch	NA
Total No. of Samples Analyzed	6	6	6	6	6	NA
Analytical Laboratory:	Philip Analytical Services					NA

Notes: [1]A batch consists of a maximum of 20 samples.

[2]A blank spike (or method spike) is a sample of reagent-grade water spiked with the analyte(s) of interest that is prepared and analyzed with the associated sample batch.

[3]This indicates that a duplicate analysis is made on one or more samples as a QC mechanism to measure analytical precision.

[4]A sample of similar matrix is spiked with a known amount of the analyte(s) of interest to determine percent recovery.

Table 3-2

Sampling/Testing, Analytical, and QC Plan
Unit No. 3 FGD Inlet and Outlet

No. of Test Runs: 3 per unit
Test Objective: Perform mercury speciation sampling at inlet and outlet of FGD.
Sampling Objective: Collect a representative sample.

Parameters to be Determined:	**Speciated Mercury**
Sampling or Monitoring and Preservation Method(s)	Ontario Hydro Method
Sample Preparation/Extraction and Analysis Method(s):	Ontario Hydro Method
Maximum Holding Time (days):	45
Sampling or Monitoring Design:	
Length of Test:	$\geq$ 120 min
Sample Size	1 to 2.5 m^3
Total No. of Samples	3 at inlet and outlet
Site/Reagent Blanks	Minimum of 1 per sample type
Train Blanks	1 per test location (total of 2)
Lab Blanks	1 per batch[1]
Blank Spikes[2]	1 per batch
Replicates[3]	All samples
Total No. of Samples Analyzed[4]	~90
Analytical Laboratory:	Philip Analytical Services

[1]A batch consists of a maximum of 10 samples.
[2]A blank spike (or method spike) is a sample of reagent-grade water spiked with the analyte(s) of interest that is prepared and analyzed with the associated sample batch.
[3]This indicates that a duplicate analysis is made on one or more samples as a QC mechanism to measure analytical precision.
[4]Approximate number of total samples and individual fractions, duplicates and other QC samples.

Note: The facility CEMS measured sulfur dioxide (SO_2), carbon dioxide (CO_2), flow and opacity on the FGD outlet and SO_2, CO_2 and oxides of nitrogen (NO_x) at the FGD inlet.

TABLE 3-3
COMPARISON OF MERCURY SPECIATION TO TOTAL MERCURY RESULTS
UNIT NO. 3

Mercury Species	Unit No. 3 Inlet						
	Run 1		Run 2		Run 3		Average
	(ug/m^3)	% of Total	(ug/m^3)	% of Total	(ug/m^3)	% of Total	% of Total
Particulate Bound Mercury Emissions	0.078	1.13	0.050	0.74	0.02	0.37	0.75
Oxidized Mercury Emissions	4.56	66.18	4.54	67.52	4.14	66.42	66.71
Elemental Mercury Emissions	2.25	32.69	2.13	31.74	2.07	33.21	32.55
Total Mercury Emissions	6.90	100.00	6.72	100.00	6.24	100.00	100.00

Mercury Species	Unit No. 3 Outlet						
	Run 1		Run 2		Run 3		Average
	(ug/m^3)	% of Total	(ug/m^3)	% of Total	(ug/m^3)	% of Total	% of Total
Particulate Bound Mercury Emissions	0.04	2.13	< 0.004	0.30	0.02	1.20	1.21
Oxidized Mercury Emissions	0.16	8.48	0.09	6.04	0.18	10.29	8.27
Elemental Mercury Emissions	1.66	89.39	1.34	93.66	1.58	88.52	90.52
Total Mercury Emissions	1.86	100.00	1.43	100.00	1.79	100.00	100.00

TABLE 3-4
TAMPA ELECTRIC COMPANY, BIG BEND STATION
SUMMARY OF MERCURY SPECIATION TEST DATA AND TEST RESULTS
UNIT NO. 3 INLET

TEST DATA:				
Test run number	1	2	3	
Location	Unit No.3 Inlet	Unit No.3 Inlet	Unit No.3 Inlet	
Test date	12/1/99	12/1/99	12/2/99	
Test time period	1125-1424	1645-1922	1130-1430	
PROCESS DATA:				
Unit Load, MW	437	431	437	
Coal feed rate, lb/hr.	326400	322400	324200	
Coal Btu content, Btu/lb.	11510	11560	11720	
Heat Input, 10^6 Btu/hr	4030	4034	4071	
GAS STREAM VELOCITY AND VOLUMETRIC FLOW DATA:				
Avg. gas stream velocity, ft./sec.	53.2	53.2	52.6	AVERAGE
Avg. gas stream volumetric flow, wacf/min.	1340600	1340700	1326400	1335900
Avg. gas stream volumetric flow, dscf/min. (1)	848000	847700	836600	844100
PARTICULATE BOUND MERCURY EMISSIONS:				
Conc., ug/m^3	0.08	0.05	0.02	0.050
Conc., ug/Nm^3 (2)	0.08	0.05	0.02	0.054
Emission rate, lbs/10^{12} Btu.	0.06	0.04	0.02	0.04
Emission rate, lbs/hr	2.46E-04	1.58E-04	7.23E-05	1.59E-04
OXIDIZED MERCURY EMISSIONS:				
Conc., ug/m^3	4.56	4.54	4.14	4.41
Conc., ug/Nm^3 (2)	4.90	4.87	4.44	4.74
Emission rate, lbs/10^{12} Btu.	3.60	3.57	3.19	3.45
Emission rate, lbs/hr	1.45E-02	1.44E-02	1.30E-02	1.40E-02
ELEMENTAL MERCURY EMISSIONS:				
Conc., ug/m^3	2.25	2.13	2.07	2.15
Conc., ug/Nm^3 (2)	2.42	2.29	2.22	2.31
Emission rate, lbs/10^{12} Btu.	1.78	1.68	1.59	1.68
Emission rate, lbs/hr	7.16E-03	6.77E-03	6.49E-03	6.81E-03
TOTAL MERCURY EMISSIONS: (3)				
Conc., ug/m^3	6.90	6.72	6.24	6.62
Conc., ug/Nm^3 (2)	7.40	7.21	6.69	7.10
Emission rate, lbs/10^{12} Btu.	5.44	5.29	4.80	5.17
Emission rate, lbs/hr	0.022	0.021	0.020	0.021

(1) Standard conditions = 68 deg. F. (20 deg. C.) and 29.92 inches Hg (760mm Hg).
(2) Nm3 = Normal cubic meter (32 deg. F. (0 deg. C.) and 29.92 inches Hg (760mm Hg)).
(3) Non-detects included in total mercury catch value.

TABLE 3-5
TAMPA ELECTRIC COMPANY, BIG BEND STATION
SUMMARY OF MERCURY SPECIATION TEST DATA AND TEST RESULTS
UNIT NO. 3 OUTLET

TEST DATA:						
Test run number	1		2	3		
Location	Unit No.3 Outlet		Unit No.3 Outlet	Unit No.3 Outlet		
Test date	12/1/99		12/1/99	12/2/99		
Test time period	1125-1359		1645-1922	1131-1430		
PROCESS DATA:						
Unit Load, MW	437		431	437		
Coal feed rate, lb/hr.	326400		322400	324200		
Coal Btu content, Btu/lb.(as received)	11510		11560	11720		
Heat Input, 10^6 Btu/hr	4030		4034	4071		
GAS STREAM VELOCITY AND VOLUMETRIC FLOW DATA:						
Avg. gas stream velocity, ft./sec.	36.0		34.8	35.5		AVERAGE
Avg. gas stream volumetric flow, wacf/min.	1410500		1362500	1391400		1388100
Avg. gas stream volumetric flow, dscf/min. (1)	1120700		1122700	1113900		1119100
PARTICULATE BOUND MERCURY EMISSIONS:						
Conc., ug/m^3	0.040	<	0.004	0.021	<=	0.022
Conc., ug/Nm^3 (2)	0.043	<	0.005	0.023	<=	0.023
Emission rate, lbs/10^{12} Btu.	4.13E-02	<	4.51E-03	2.19E-02	<=	2.26E-02
Emission rate, lbs/hr	1.66E-04	<	1.82E-05	8.93E-05	<=	9.13E-05
OXIDIZED MERCURY EMISSIONS:						
Conc., ug/m^3	0.16		0.09	0.18		0.14
Conc., ug/Nm^3 (2)	0.17		0.09	0.20		0.15
Emission rate, lbs/10^{12} Btu.	0.16		0.09	0.19		0.15
Emission rate, lbs/hr	6.62E-04		3.64E-04	7.68E-04		5.98E-04
ELEMENTAL MERCURY EMISSIONS:						
Conc., ug/m^3	1.66		1.34	1.58		1.53
Conc., ug/Nm^3 (2)	1.78		1.44	1.70		1.64
Emission rate, lbs/10^{12} Btu.	1.73		1.40	1.62		1.58
Emission rate, lbs/hr	6.98E-03		5.64E-03	6.61E-03		6.41E-03
TOTAL MERCURY EMISSIONS: (3)						
Conc., ug/m^3	1.86		1.43	1.79		1.69
Conc., ug/Nm^3 (2)	1.99		1.54	1.92		1.82
Emission rate, lbs/10^{12} Btu.	1.94		1.49	1.83		1.75
Emission rate, lbs/hr	7.80E-03		6.02E-03	7.47E-03		7.10E-03
TOTAL MERCURY REMOVAL EFFICIENCY:	64.37%		71.78%	61.77%		65.97%

(1) Standard conditions = 68 deg. F. (20 deg. C.) and 29.92 inches Hg (760mm Hg).
(2) Nm3 = Normal cubic meter (32 deg. F. (0 deg. C.) and 29.92 inches Hg (760mm Hg)).
(3) Non-detects included in total mercury catch value.

measured volumetric flow rates. Average values with the standard deviation (SDEV) and percent relative standard deviation (% RSD) have been calculated and are presented.

3.2.1.1 Unit No. 3

For the Unit No. 3 & 4 FGD Inlet an average of 0.8 percent of the total mercury measured is particulate bound mercury. On average the oxidized mercury was 67 percent of the total and the elemental mercury was approximately 33 percent of the total mercury collected. At the Unit No. 3 & 4 FGD outlet, elemental mercury comprised the highest of the total at 91 percent. The oxidized mercury was 8 percent of the total and the particulate bound mercury was one percent.

Based on the total mercury measurements the average removal efficiency for the FGD was 66 percent with an average mass emission rate of 0.0071 pounds per hour.

The average total mercury emission rates for Unit No. 3 were 1.69 ug/m^3, 1.75 lbs/10^{12} Btu and 0.0071 lb/hr.

3.2.2 Process Solid Sample Stream Results

Table 3-6 provides a summary of the analytical results obtained on the coal feed samples collected on Unit No. 3.

For each parameter measured on the Unit No. 3 coal feed stream, the concentration or percent value is presented (on an as received basis) for each individual test run along with the average values.

Detailed analytical summaries are provided in Appendix D of this report.

Based on the mercury content of the coal and the measured coal feed rate, the mass rate of mercury introduced to the boiler averaged 0.041 lb/hr.

Table 3-6

Summary of Coal Sample Results
Unit No. 3 Coal Feed Samples

Parameter[1]	Test Run No.			Average
	1	2	3	
Mercury,ppm (mg/kg)	0.160	0.102	0.113	0.125
Chlorine, %	0.16	0.16	0.15	0.16
Heating value, Btu/lb	11510.	11560.	11720.	11597.
Ash, %	9.97	9.59	9.19	9.58
Sulfur, %	2.85	2.91	2.78	2.85
Moisture, %	9.55	9.58	9.69	9.60

(1) As received basis.

3.2.3 Unit Operation and Key Operational Parameters

This section describes the Unit No. 3 operations during the test program and provides the key operating parameters that were monitored and documented during testing.

3.2.3.1 Unit Operation During Testing

Operation of Unit No. 3 during testing was representative of normal daily operation at or near full load. Steady-state testing conditions were maintained during all test periods. The normal sootblowing activities were maintained on the boiler during testing.

3.2.3.2 Process Control Data

All key power generation process operating parameters and control data were recorded during each test period. FGD operational indicators data were recorded by a data acquisition system. ESP data was recorded manually by TEC personnel. The facilities CEMS data acquisition system provided concentration values.

A summary of the key operating data is provided in Table 3-7 for Unit No. 3. All additional boiler, ESP and FGD operations data and CEM data are provided in Appendix B.

3.3 TESTING PROBLEMS OR MODIFICATIONS

No sampling or analytical problems were noted during the test program. No process problems were noted during any of the test periods.

Table 3-7
Summary of Key Process Control Data
Unit No. 3

Parameter	Units	Run No.		
		1	2	3
Gross Generation	MW	437	431	437
Net Generation	MW	426	418	425
Coal Feed Total	Tons/hr[1]	163.2	161.2	162.1
Main Steam Flow	10^3 lbs/hr	2852	2791	2825
Main Steam Temp.	°F	1005	1008	1013
FGD Inlet CEM (SO_2)	ppm/v	2229.1	2322.4	2268.3
	lb/10^6 Btu	4.73	4.79	4.67
FGD Inlet CEM (CO_2)	%	14.1	14.5	14.5
FGD Inlet CEM (NO_x)	ppm/v	424.1	410.4	418.9
	lb/10^6 Btu	0.65	0.61	0.62
FGD Injection Rate	GPM	222.2	222.2	222.2
Stack Opacity	%	12.0	11.0	17.2
Stack Flow	ACFM	1,384,000	1,373,000	1,374,900
Stack CEMs (SO_2)	ppm/v,	29.0	34.8	44.8
	lb/10^6 Btu	0.09	0.10	0.13
Stack CEM (CO_2)	%	9.7	10.6	10.5
FGD SO_2 Removal Efficiency	%	98.1	97.9	97.3

(1) Calculated based on BTU content of coal and total heat output of boiler.

4. SAMPLING AND ANALYTICAL PROCEDURES

4.1 DESCRIPTION OF SAMPLING EQUIPMENT

4.1.1 Ontario Hydro Mercury Speciation Method

The Ontario Hydro sampling train contained the following components:

- At the inlet location a calibrated borosolicate nozzle was attached to a heated Teflon probe. The probe was attached to a heated 90 millimeter (mm) quartz filter. The probe and filter temperature were maintained at the approximate flue gas temperature.

- At the inlet location the heated probe was equipped with a calibrated thermocouple to measure flue gas temperature and a calibrated S-type pitot tube to measure flue gas velocity pressure.

- At the outlet location a heated borosilicate probe and nozzle was attached to a heated filter holder containing a 90 (mm) quartz fiber filter. The probe was equipped with a calibrated thermocouple to measure flue gas temperature and a calibrated S-type pitot tube to measure flue gas velocity pressure.

- A flexible heated Teflon line was used to connect the outlet of the filter holder to the first impinger at both test locations.

- An impinger train consisting of eight impingers. The first, second, and third impingers each contained 100 ml of 1 Normal (N) potassium chloride (KCl). The fourth impinger contained 100 ml of 5% nitric acid (HNO_3) and 10% hydrogen peroxide (H_2O_2). The fifth, sixth and seventh impingers each contained 100 ml of 4% potassium permanganate ($KMnO_4$) and 10% sulfuric acid (H_2SO_4). The eighth impinger contained 300 grams of dry preweighed silica gel. The third and seventh impingers were a Greenburg-Smith type; all other impingers were of a modified design. All impingers were maintained in a crushed ice bath.

- A vacuum line (umbilical cord) with adapter to connect the outlet of the impinger train to a control module.

- A control module containing a 3-cfm carbon vane vacuum pump (sample gas mover), a calibrated dry gas meter (sample gas volume measurement device), a calibrated orifice (sample gas flow rate monitor) and inclined manometers (orifice and gas stream pressure indicators).

- A switchable calibrated digital pyrometer to monitor flue and sample gas temperatures.

See Figure 4-1 for a schematic of the Ontario Hydro test train used at both the inlet and outlet test locations.

4.2 CO_2 AND O_2 SAMPLING EQUIPMENT

The fixed gases sampling train (Figure 4-2) used at the Unit No. 3 inlet and outlet test sites was assembled in accordance with EPA Method 3 and consisted of the following components:

- A stainless steel or Teflon probe (fastened to the Ontario Hydro sampling probe) with a plug of glass wool to remove particulate.
- An ice-cooled condenser to remove moisture from the sampled gases.
- A diaphragm pump to draw a sample of the gases.
- A valve and rate meter to control and monitor gas stream sampling rates, respectively.
- A Tedlar® bag to contain the sample of flue gases.

For Unit No. 3, the CO_2 and O_2 concentrations of each bag were analyzed using an Orsat analyzer.

4.3 SAMPLING PROCEDURES

The following paragraphs and flow charts summarize the procedures used to sample the flue gases, recovery of the resultant samples and analyze the samples.

4.3.1 Preliminary Tests

Following equipment setup, preliminary test data was compiled at each of the emission test sites to verify pretest data/assumptions, determine nozzle sizes, and compute isokinetic sampling rates.

Test site geometric measurements were measured and sampling point distances were recalculated. A pitot traverse was performed to determine velocity profiles and to check for the presence/absence of cyclonic flow at each site. The cyclonic flow checks proved negative at both locations. As appropriate, flue gas temperatures, dry gas composition, and moisture content were also determined by EPA Reference Methods 2, 3, and 4, respectively.

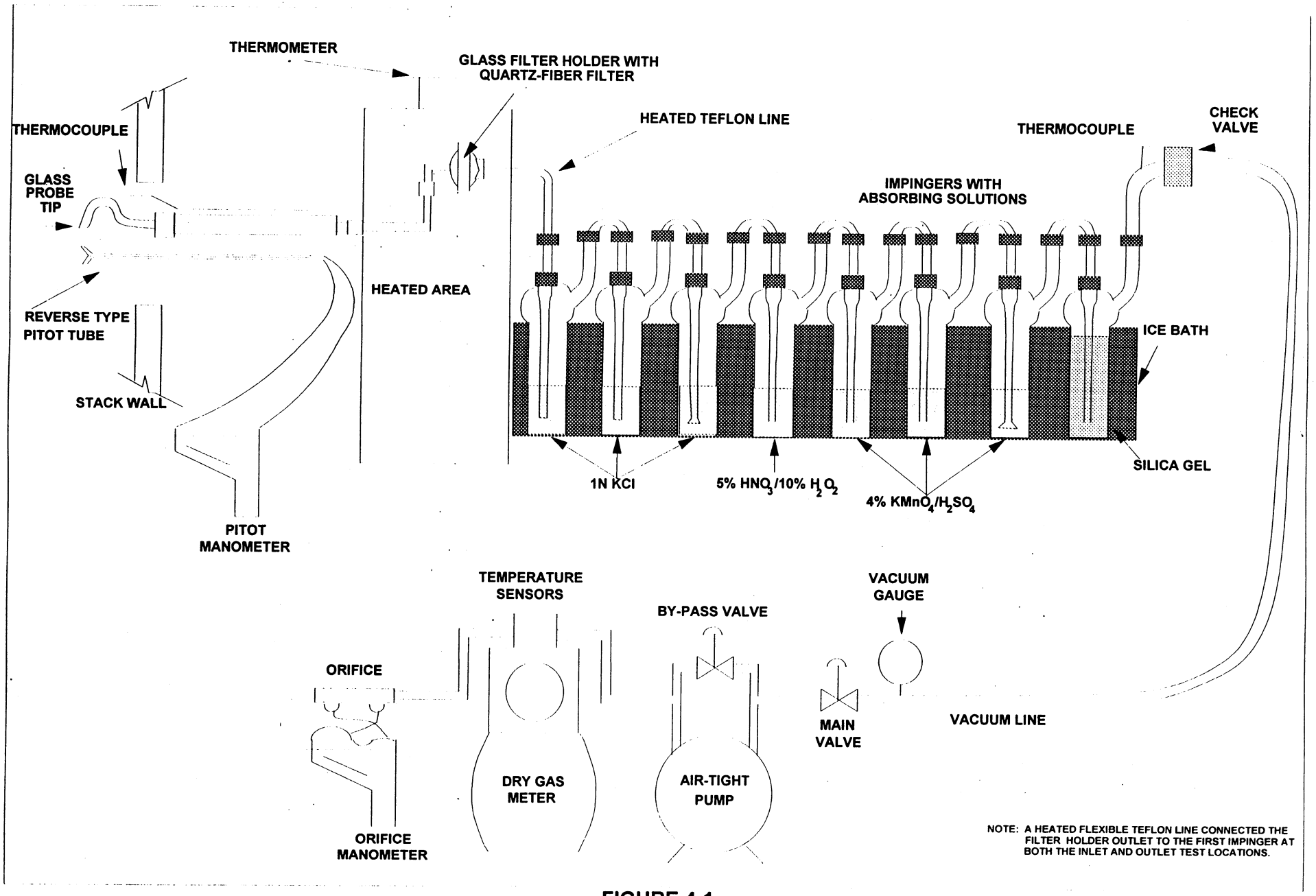


FIGURE 4-1
FGD INLET AND OUTLET TEST LOCATION
ONTARIO HYDRO SAMPLING TRAIN

c:\freelancedrawings\baghousetrain.prz

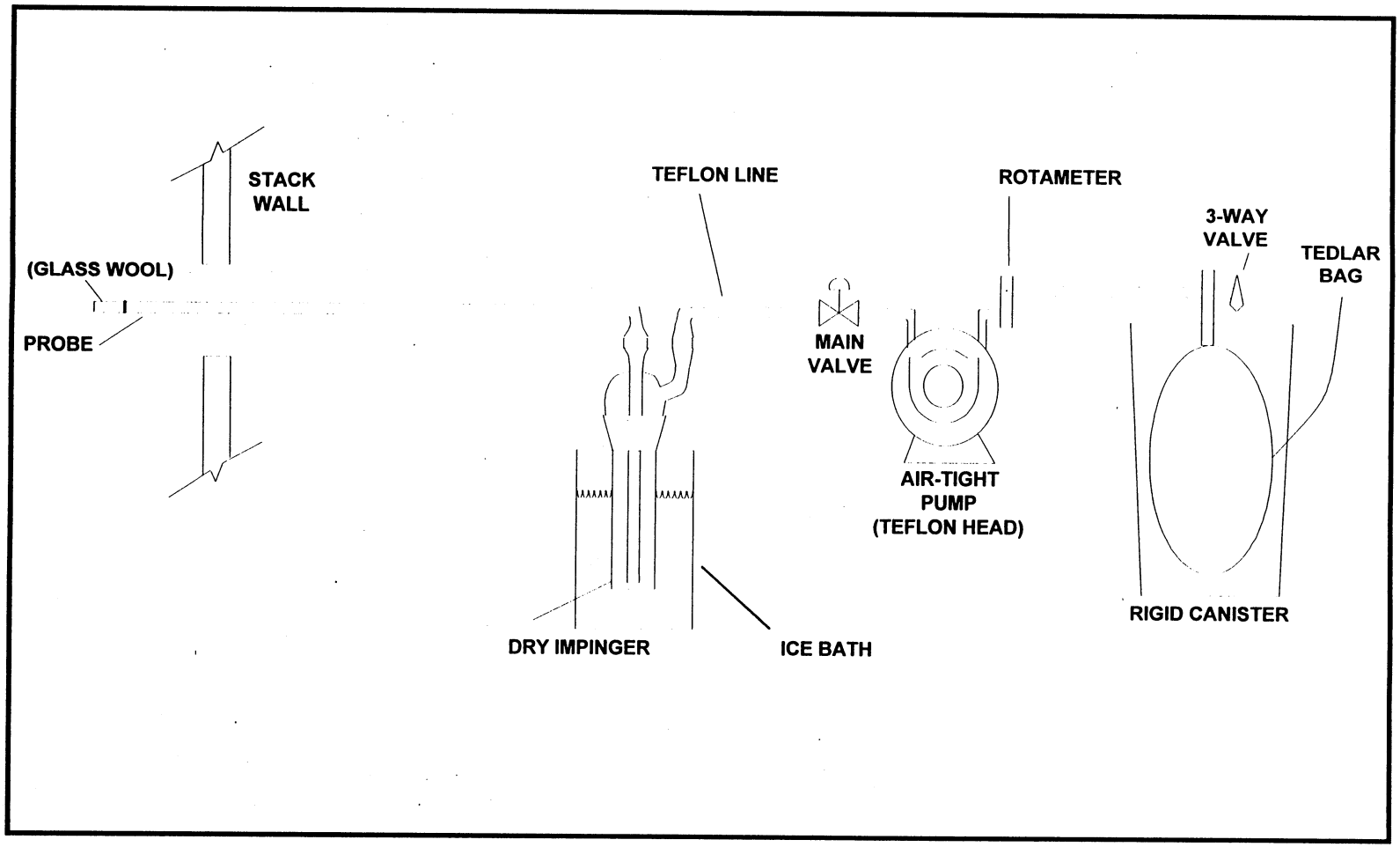


FIGURE 4-2

EPA METHOD 3 - DRY GAS STEAM COMPOSITION SAMPLING TRAIN

The preparation, sampling, and recovery procedures used to sample the emission points for speciated mercury conformed to those specified in the draft Ontario Hydro method and as described in the Site-Specific Sampling/Testing, Analytical and QA/QC plan. Each inlet test run was 120 minutes in duration with readings taken at each of the 30 traverse points once every 4 minutes. Each outlet test was 120 minutes in duration with readings taken once every 5 minutes at each of the 24 traverse points. Readings were recorded at each traverse point at all test locations. Leak checks were performed at the beginning and end of each test run and before and after test port changes at both locations. Figure 4-3 illustrates the train preparation. Figure 4-4 illustrates the sampling procedures. Figure 4-5 illustrates the sample recovery procedures.

4.4 ANALYTICAL PROCEDURES

4.4.1 Sample Analyses

4.4.1.1 Ontario Hydro Sample Analyses

Figure 4-6 presents a schematic of the analytical procedures used during analysis of the Ontario Hydro samples.

4.4.1.2 Coal Sample Analyses

4.4.1.2.1 Preparation

Preparation of the coal samples followed ASTM Method D-2013. Following air drying and riffling the coal sample was pulverized until 100% of the sample passed the 60-mesh screen.

4.4.1.2.2 Chlorine

The prepared coal sample was weighed. The weighed sample was oxidized by combustion in a bomb with a bicarbonate/carbonate solution and the amount of chlorine present determined by ion-chromatography (IC) using EPA Method 300 procedures.

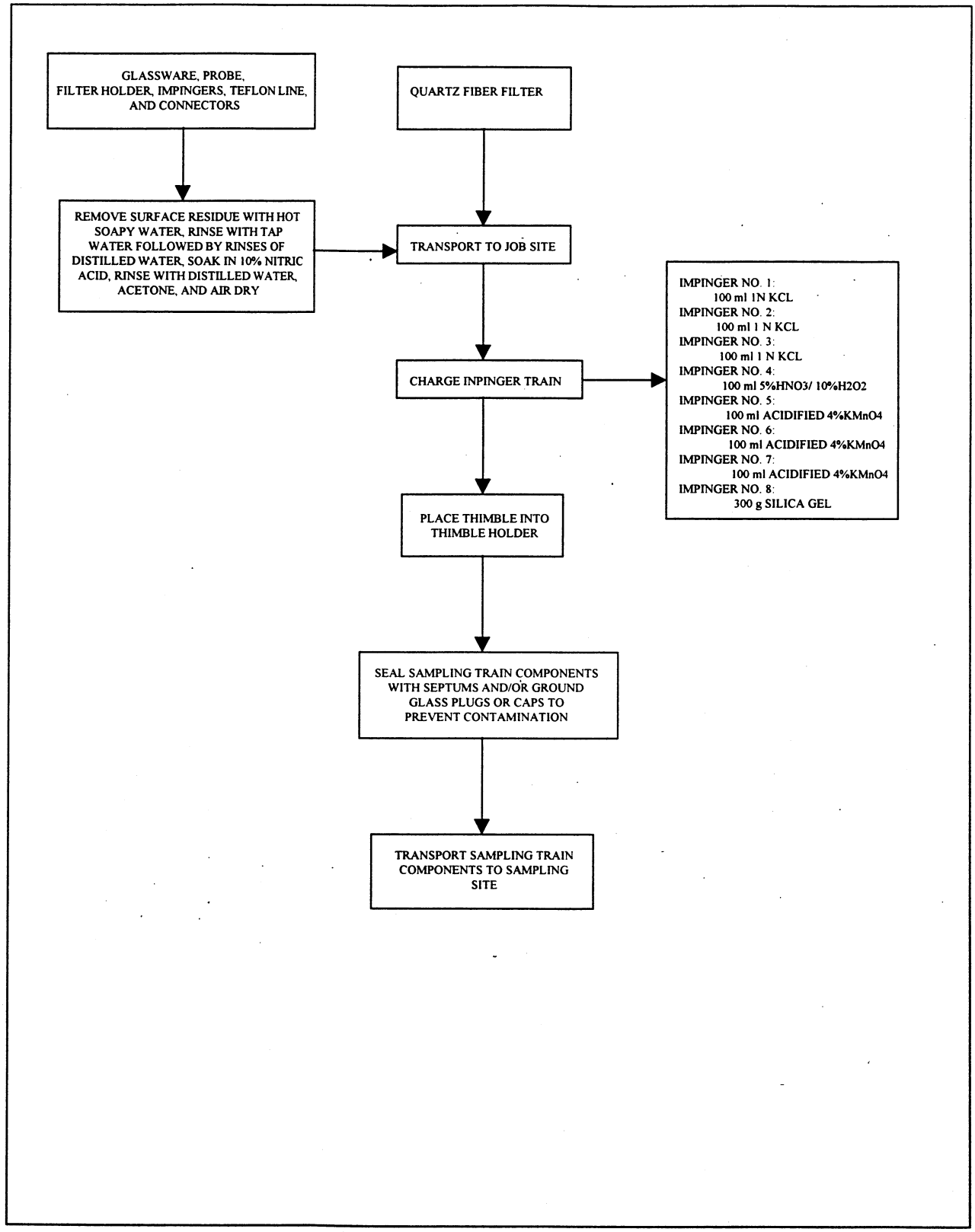


FIGURE 4-3
PREPARATION PROCEDURES FOR ONTARIO HYDRO SAMPLING TRAIN

DOE20-D20

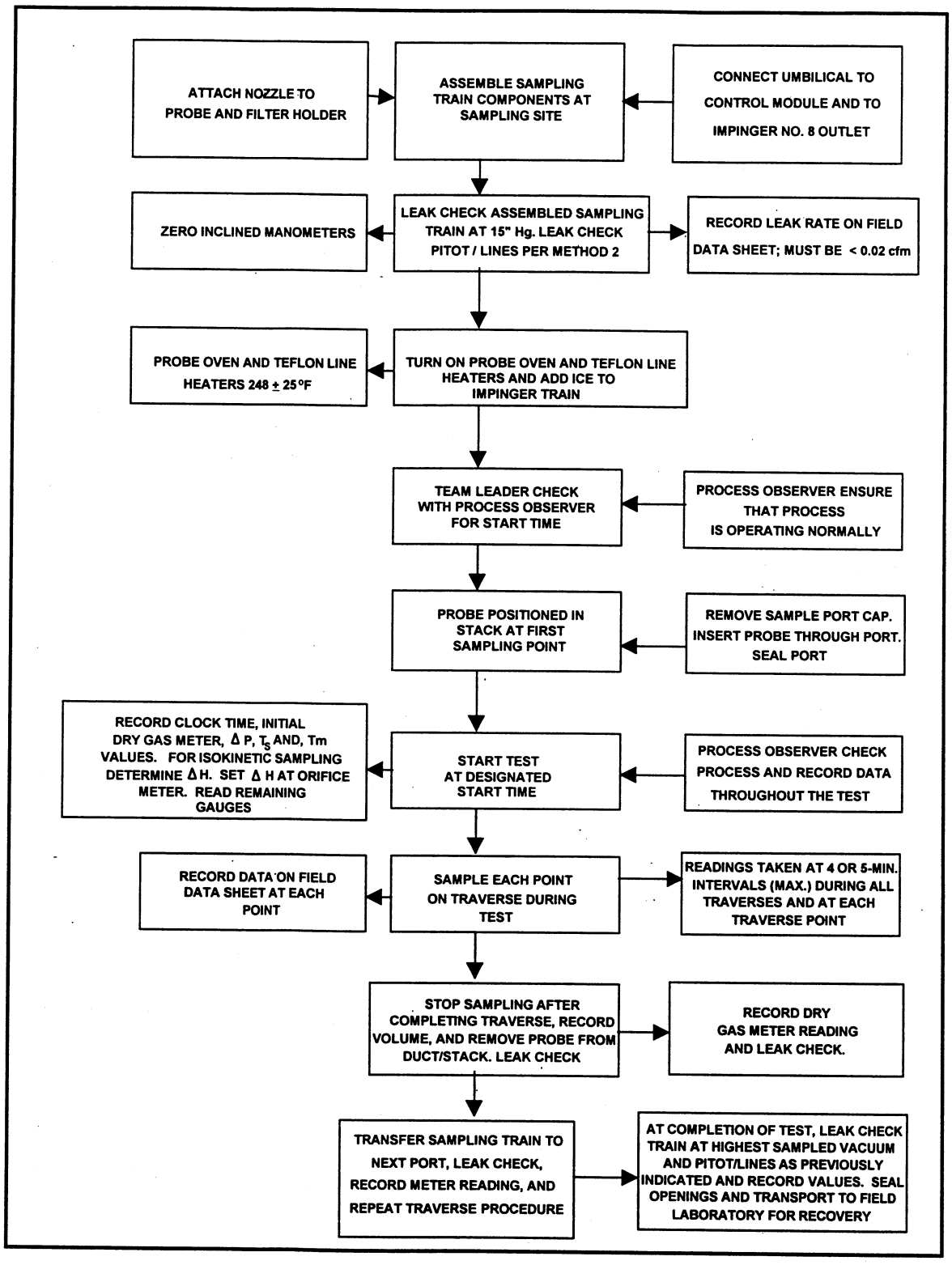


FIGURE 4 - 4
SAMPLING PROCEDURES FOR ONTARIO HYDRO TRAIN

DOE21-D20

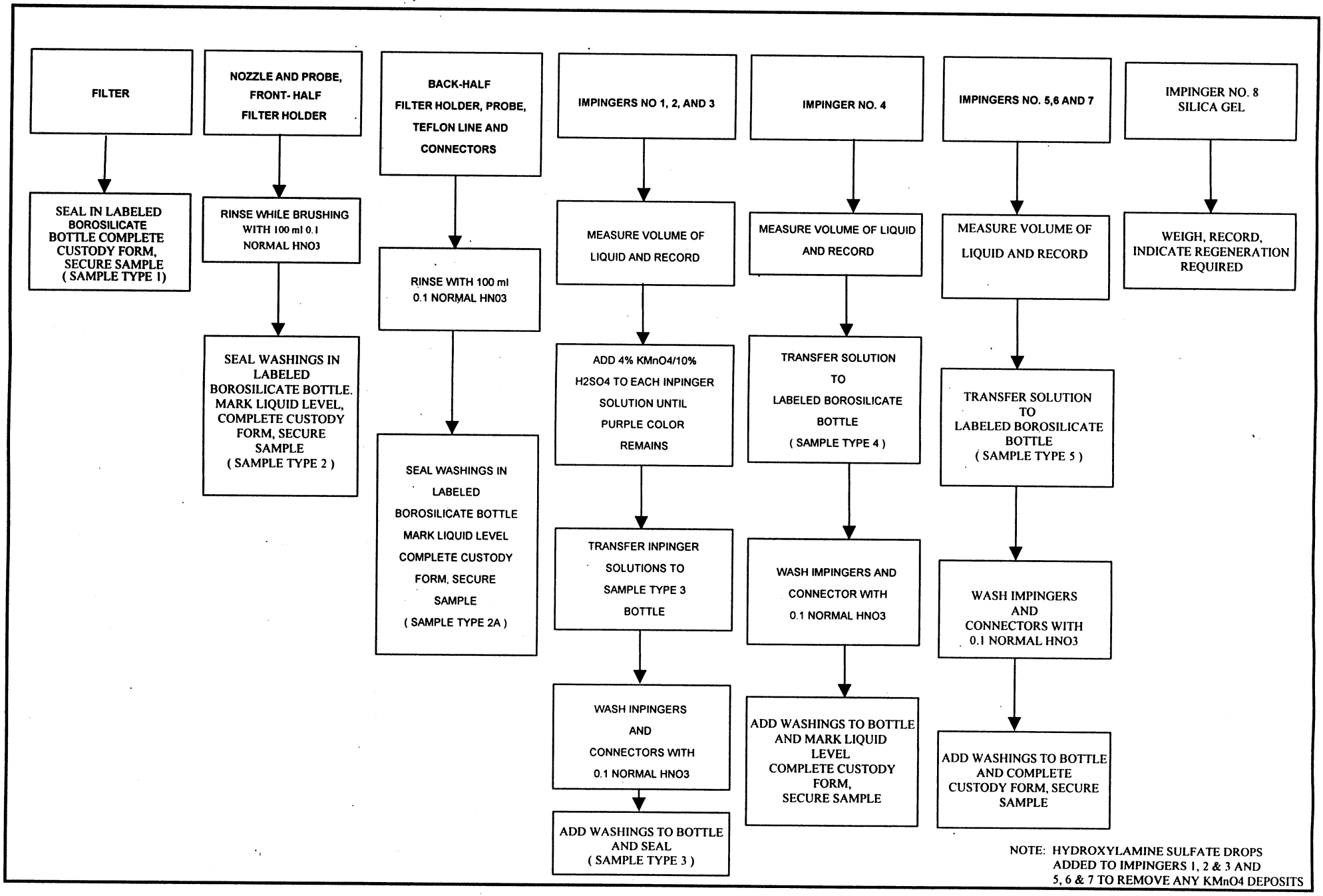


FIGURE 4 - 5
SAMPLE RECOVERY PROCEDURES FOR ONTARIO HYDRO METHOD

DOE22-D20

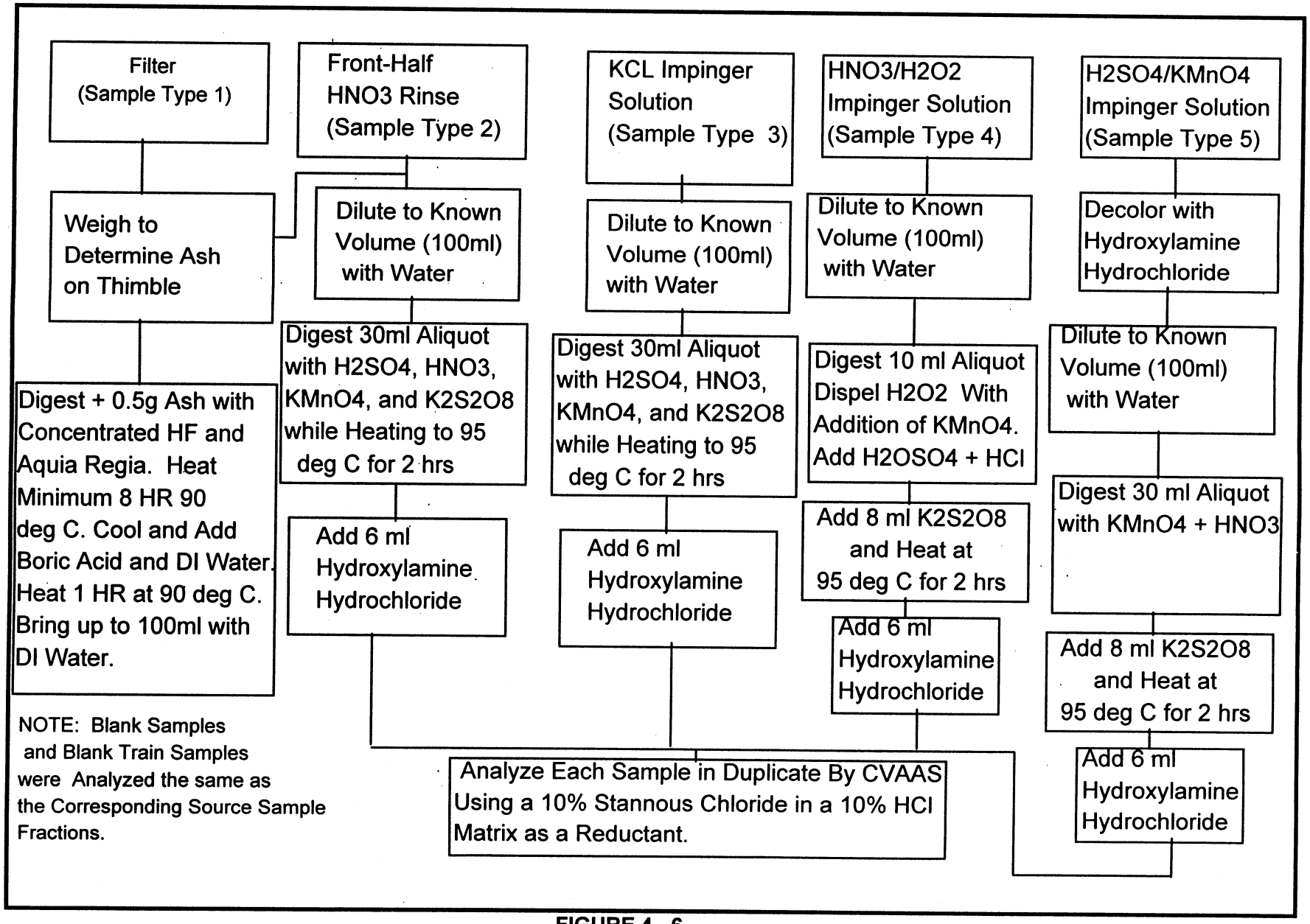


FIGURE 4 - 6
ANALYTICAL PROCEDURE FOR ONTARIO HYDRO SAMPLING TRAIN

c:\freelance drawing\Fig5-7.prz

4.4.1.2.3 Mercury

Following preparation the coal sample was weighed. The sample was digested in sulfuric acid, nitric acid and potassium permanganate.

Following digestion the liquid sample was analyzed for total mercury content using cold vapor atomic absorption (CVAA) by EPA Method 7471 procedures.

4.4.1.2.4 Ash, Sulfur and Heating Value

The prepped coal samples were analyzed for ash and sulfur content plus heating value using ASTM Methods D3174, D4239 and D3286, respectively.

5. QUALITY ASSURANCE SUMMARY

This section discusses results for QC samples collected during the test program. Discussions are provided for stack gas samples (Subsection 5.1) and coal samples (Subsection 5.2).

5.1 STACK SAMPLE QA/QC RESULTS

This section provides detailed information regarding the QA/QC activities associated with stack sample collection, analysis, and reporting.

This summary pertains to all test data collected from sampling activities performed on Unit No. 3 during the period of December 1 and 2, 1999. Analyses were performed on these samples for speciated mercury.

Project data quality objectives, as measured by precision, accuracy and completeness, were evaluated. Additionally, holding times, spike recoveries, laboratory blanks, and calibrations were evaluated to determine overall data quality based on criteria specified in the Site-Specific Sampling/Testing, Analytical and QA/QC Plan and the Quality Assurance Project Plan.

5.1.1 Stack Sample Collection and Calculations

Field QA/QC activities associated with the collection of stack Ontario Hydro method emission samples included pre- and post-test calibrations of sampling equipment, adherence to the proper sampling method procedures, documentation of field data, recovery of samples without contamination, and collection of appropriate field train and site blank samples.

Copies of the field data sheets are contained in Appendix C. Chain of custody forms are included in each laboratory report and provide a list of all samples collected and submitted for analysis during the test program. The laboratory reports are provided in Appendix D.

Proper field sampling procedures include sampling at 100% isokinetic ±10% and maintaining sample train leakage rates at ≤ 0.02 CFM. Table 5-1 contains a summary of all isokinetic

Table 5-1
Stack Emission Sampling Field QA/QC Results

Test Location	Test Run	Isokinetic Sampling Rate[1]	Initial Leak Check Rate[2]	Final Leak Check Rate[2]	Gas Meter Calibration Values[3]	
					Pre	Post[(4)]
Unit No. 3 Inlet	1	101.7	0.014	0.013	0.9961	1.0010
	2	102.3	0.010	0.006	0.9961	1.0010
	3	100.0	0.010	0.007	0.9961	1.0010
Unit No. 3 Outlet	1	101.2	0.012	0.017	1.0098	0.9970
	2	99.5	0.010	0.011	1.0098	0.9970
	3	101.1	0.016	0.008	1.0098	0.9970

1 Isokinetic rate must be 100 ± 10%. All sampling rates met isokinetic criteria.

2 Initial and final leak check value must be ≤ 0.02 CFM. All leak checks were acceptable.

3 Post-test calibration must be ± 0.05 of pre-test value. All calibration values were acceptable.

4 Based on EPA alternative post test calibration procedure.

Note: Silica gel impinger exit temperature maintained < 68°F during all test periods.

sampling rates for all tests, initial and final leak check rates, and pre- and post-test dry gas meter calibration results. This table indicates that all test runs were within the acceptable ranges for all field measurements. Appendix F contains the stack test equipment calibration data.

5.1.2 Sample Chain of Custody

Sample custody procedures were followed per Section B-2 of the QAPP. Following collection and recovery, all samples were transferred under chain of custody to representatives of Philip Analytical Services Laboratory located in Reading, Pennsylvania. The sample storage area was locked and secured during off-hours when test representatives were not on-site.

All samples arrived in good condition to the Philip laboratory.

5.1.3 Stack Emission Blank Sample Results

Blank samples were submitted with the stack emissions samples as designated in the test method and QAPP. During each set of the three test runs, a blank sample train was setup, leak checked and recovered at each of the test locations on Unit No. 3. Site blanks of the filters, impinger train solutions and recovery solutions were retained and analyzed. No mercury above the analytical detection limit was present in any of the blank train fractions at the FGD inlet location. A small amount of mercury (0.086 micrograms) was detected in the 0.1 normal nitric acid/filter site blank sample and 0.063 micrograms of mercury was found in the outlet blank train probe rinse (0.1 normal nitric acid) and filter fraction. As previously mentioned no mercury was found in the inlet blank train sample. The same nitric acid was used to recover all source and blank train samples at both locations.

The probe rinse results for outlet tests 2 and 3 were less than the measured blank values. The outlet blank train was recovered with the test run three sample. Since levels detected in the site blank and outlet blank train do not appear to correlate with the source sample results obtained at the outlet, it was decided not to apply any blank correction to the outlet source values.

5.1.4 Ontario Hydro Analysis Holding Times

Holding time is the period from sample collection to sample analysis. All holding times for all Ontario Hydro sample parameters were within the time period of 45 days per the Ontario Hydro sampling method.

5.1.5 Internal Field Audit Procedures

During the performance of the test program, the WESTON field team leader performed an audit of the field measurement activities. A field audit checklist (Technical System Audit) was used to document the internal audit. The audit included examination of field sampling records, field instrument operating records, sample collection, recovery, handling and chain-of-custody procedures. A copy of the Technical System Audit is provided in Appendix G.

5.1.6 External Performance Evaluation Audits

No performance evaluation audits were provided to WESTON by the regulatory agencies during the test program.

5.1.7 Stack Emissions QA/QC Conclusions

All mercury speciation stack emissions data and results are representative of the emissions encountered during the test periods and are acceptable following QA/QC review.

5.1.8 Ontario Hydro Sample Analysis

Each Ontario Hydro sample was analyzed in duplicate and every 1 in 10 samples were analyzed in triplicate. The relative percent difference (RPD) for duplicate analysis is ≤ 20%. With the exception of a few samples which contained very low levels of mercury near the detection limit, the RPD criteria was satisfied.

The accuracy criteria for spike samples and laboratory control samples is 80 to 120%. This criteria was satisfied in all cases.

5.1.9 Ontario Hydro Sample Analysis QA/QC Conclusions

All source sample data and results are acceptable following QA/QC review.

5.2 PROCESS SOLID SAMPLE QA/QC RESULTS

The Site-Specific Sampling/Analytical and QA/QC Plan and the QAPP for this program identified the analytical QC objectives for the process solid sample analysis.

All QA/QC analysis results are provided in Appendix D of this report. A brief summary of the results follows.

Analytical Precision

Analytical precision was determined by RPD obtained by the duplicate sample analyses. The RPD objective for the mercury and chlorine in coal was ≤ 20%. The RPD for ash, sulfur and heating value is ≤ 10%. The RPD objectives for duplicate analyses were met in all cases for all analytes.

Analytical Accuracy

The objectives for accuracy for spike samples and laboratory control samples were 70 to 130% for the mercury in coal and 80-120% for chlorine. The objectives for accuracy were satisfied in all cases.

5.2.1 Holding Times

All coal samples were analyzed within the required holding times as specified in the Site-Specific Sampling/Testing, Analytical and QA/QC Plan.

5.2.2 Process Sample QA/QC Conclusions

All solid sample process data and results are acceptable following QA/QC review.

5.3 COMPLETENESS

Laboratory completeness is a measure of the amount of valid measurements obtained from all the laboratory measurements associated with this test program. The number of valid measurements for this program satisfied the laboratory completeness goal identified in the Site-Specific Sampling/Testing, Analytical and QA/QC Plan QAPP of greater than 90 percent.

Based on a review of all QA/QC results, no data has been lost or qualified as not satisfying the QC criteria for precision and accuracy. Therefore, a 100% completeness can be assigned for both sampling and analysis.