PG&E Generating ™

Northeast Regional Office

January 14, 2000
BOS-99-58

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 Test Program

Dear Mr. Grimley:

RE: **Final Report – Mercury Emissions Test Program of Unit 1 Circulating Fluidized Bed (CFB) Coal Fired Boiler at the Scrubgrass Generating Station, Kennerdell, Pennsylvania**

On behalf of PG&E Generating Company (PG&E Gen) and Scrubgrass Generating Station, I am pleased to submit three (3) copies of the referenced Final Report. The Final Report contains the results of speciated mercury emissions testing at Scrubgrass Generating Station Unit 1, in Kennerdell, Pennsylvania. PG&E Gen conducted this testing to fulfill the requirements of Phase III of the US EPA's mercury Information Collection Request (ICR), which selected Scrubgrass Generating Station for performance of speciated mercury emissions testing.

In conducting this testing, PG&E Gen followed all of the requirements, methods, and protocols of the ICR, including submitting a Quality Assurance Program Plan (QAPP) and a Site-Specific Test Plan (SSTP) for Unit 1.

Please call me if you need further information regarding this submittal.

Very truly yours,

A. Rayner Kenison
Environmental Manager,.
PG&E Gen Mercury ICR Program Coordinator
Phone: (617) 788-3369
Fax: (617) 788-3150
Email: ray.kenison@gen.pge.com

TRC

Customer-Focused Solutions

Final Report

Mercury Emissions Test Program of the Circulating Fluidized Bed Boiler, Unit 1 at the Scrubgrass Generating Station Kennerdell, Pennsylvania

Prepared for:

PG&E Generating Company
Scrubgrass Generating Station
RR1, Lisbon Road, P.O. Box 39
Kennerdell, Pennsylvania 16374

Prepared by:

TRC Environmental Corporation
Boott Mills South
Foot of John Street
Lowell, Massachusetts 01852
(978) 970-5600

January 2000

TRC

Customer-Focused Solutions

TRC Project No. 26046-0010

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FINAL REPORT

**Mercury Emissions Test Program of the
Circulating Fluidized Bed Boiler, Unit 1
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DISCLAIMER

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INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

1.1.1 Problem Definition and Background

The United States Environmental Protection Agency (USEPA), in its "Study of Hazardous Air pollutant emissions from Electric Utility Steam Generating Units – Final Report to Congress", stated that mercury is the Hazardous Air Pollutant (HAP) of greatest potential concern from coal-fired utility steam generators and that additional research and monitoring are merited. The USEPA also listed a number of research needs related to mercury emissions (e.g., how much is emitted from various types of units; how much is divalent vs. elemental mercury; and how do factors such as control device, fuel type, and plant configuration affect emissions and speciation). After reviewing the report, the Administrator concluded that obtaining additional information was appropriate and necessary for subsequent regulatory decisions. Specifically, the data will provide the USEPA with updated information on the total amount of mercury emitted from electric utility steam generating units and on the speciation and controllability of such mercury.

The USEPA, under its authority of Section 114 of the Clean Air Act (CAA), is requiring all coal-fired electric utility steam generating units to provide certain information under an Information Collection Request (ICR) that will allow the Agency to calculate the annual mercury emissions from each such unit and subsequently determine whether it is appropriate and necessary to regulate the mercury emissions from electric utility steam generating units. Section 112(n)(1)(A) of the CAA allows the Administrator to regulate the electric utility steam generating units if it is found that such regulation is appropriate and necessary after the results of the ICR are reviewed.

The ICR was approved on November 13, 1998 by the Office of Management and Budget and consists of three parts. In Part I, all units were required to submit background information on the coal fired, and unit descriptions, including operations and control devices. In Part II, all units

were required to sample the coal fired over each month at least three times, for the 1999 calendar year and analyze the samples for mercury, chlorine, gross heating value and proximate analysis. For participation in Part III, speciated mercury emission testing, the agency statistically selected units based on coal type, control device, and operations. Emissions testing was conducted utilizing the most current revision of the DRAFT Ontario Hydro Mercury Sampling Method. This method is a modification of USEPA Method 29 in 40 CFR 60 Appendix A.

The units selected for Part III were notified in writing by the USEPA. PG&E Generating Company (PG&E Gen) received written notice that the Scrubgrass Generating Station had been selected to participate in Part III.

TRC Environmental Corporation (TRC) of Lowell, Massachusetts was retained by PG&E Gen to conduct the mercury emissions test program on Unit 1 at the Scrubgrass Generating Station.

1.1.2 Facility Information

The facility is located in Kennerdell, Pennsylvania and is designated by ORIS/Facility ID 050974, with Unit ID No. 1. Unit 1 is a circulating fluidized bed limestone injection combustion unit. Particulate matter (PM) emissions from the unit are controlled by a baghouse. Sulfur dioxide (SO_2) emissions are reduced by the limestone injected into the circulating fluidized bed. Mercury emissions testing was conducted at the inlet to the baghouse of Unit 1 and at the combined outlet stack of Unit 1 and Unit 2 to determine speciated mercury emissions prior to and following emission control.

1.2 PROJECT ORGANIZATION

1.2.1 Purpose/Background

The purpose of the project organization was to provide a clear understanding of the role that each party would play in the study and to provide lines of authority and reporting.

1.2.2 Roles and Responsibilities

Figure 1-1 presents PG&E Gen's organization chart for this program showing the individuals responsible for each element of the overall program and the primary lines of communication.

1.2.2.1   PG&E Generating Company

Mr. A. Rayner Kenison was the PG&E Gen Program Coordinator. He provided the overall program coordination amongst the Plant Program Coordinator, the USEPA Emissions Measurement Center, and TRC Environmental Corporation. The PG&E Gen Program Coordinator reviewed the Quality Assurance Program Plan (QAPP), the Site Specific Test Plan (SSTP), each test report, and submitted the final versions to the USEPA Emissions Measurement Center.

Mr. Paul Mikolaycik, Environmental Manager for the Scrubgrass Generating Station, served as the Plant Program Coordinator and directed the test program for the facility. Mr. Mikolaycik acted as the primary contact with TRC and designated the appropriate PG&E Gen personnel to coordinate plant operations with the emission test program. Mr. Mikolaycik coordinated the unit operations, the coal sampling, and emissions tests during each test run.

Additional Scrubgrass personnel provided support in obtaining process data, coal samples, and limestone samples. PG&E Gen and TRC would like to recognize the contributions of the Scrubgrass Unit 1 and Unit 2 operations and support personnel in the successful completion of this program.

1.2.2.2   TRC Environmental Corporation

TRC Environmental Corporation conducted the mercury emissions testing program for PG&E Gen.

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┌─────────────────────────┐        ┌──────────────────────────────┐
│  US EPA EMISSIONS       │        │  MERCURY EMISSIONS           │
│  MEASUREMENT CENTER     │        │  SAMPLING TEST PROGRAM       │
│                         │        │  PG&E GENERATING CO.         │
│  William Grimley        │────────│  PROGRAM COORDINATOR         │
│  919-541-1065           │        │  A. Rayner Kenison           │
│  Lara Autry             │        │  617-788-3369                │
│  919-541-5544           │        └──────────────────────────────┘
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┌─────────────────┐   ┌──────────────────────────────┐
│ COAL SAMPLING │────│ SCRUB GRASS STATION PLANT   │
└─────────────────┘   │ PROGRAM   │
┌─────────────────┐   │ COORDINATOR   │
│ OPERATIONS   │────│ Paul Mikolaycik   │
└─────────────────┘   │ 814-385-6661 ext. 28   │
                       └──────────────────────────────┘

┌──┐
│ MERCURY EMISSIONS SAMPLING   │
│ TRC ENVIRONMENTAL CORPORATION   │
│ PROGRAM MANAGER   │
│ Michael Martin   │
│ 978-656-3550   │
└──┘

┌──────────────────────────┐
│ QA/QC OFFICER   │
│ Howard Schiff   │
│ 978-656-3542   │
└──────────────────────────┘

| ONTARIO HYDRO METHOD MERCURY ANALYSIS PHILPS ANALYTICAL SERVICES CANADA Ron McLeod 905-332-8788 | FIELD TEAM LEADER Michael Martin 978-656-3550 | COAL ANALYSIS TESTING AND ENGINEERING Jerry Wheeler 606-248-4205 | CALIBRATIONS SAMPLING EQUIPMENT TRC | LABORATORY COORDINATION AND DATA VALIDATION Edward MacKinnon 978-656-3553 | DATA REDUCTION Caren O'Brien 978-656-3548 | REPORT PREPARATION Michael Martin 978-656-3550 |

QA
Jerry Wheeler
606-248-4205

QA
Gerry Bengert

Figure 1-1 Program Organization - Mercury Emissions Sampling Program

1.2.2.2.1   TRC's Program Manager

Mr. Michael Martin, of TRC's Air Measurements Department, served as TRC's program manager and the primary point of contact with PG&E Gen for this project. TRC's field crew operated under the direct supervision of Mr. Martin. Mr. Martin coordinated the field crew's activities with the designated PG&E Gen personnel to complete the program on schedule and in accordance with the EPA approved Site Specific Test Plan (SSTP).

The Program Manager had the full responsibility and authority from both a technical and administrative standpoint for the successful conduct of this work. He was the principal point of contact with the PG&E Gen Program Coordinator for all matters relating to contract performance and technical progress.

Working with TRC's Laboratory Coordinator, TRC's Program Manger managed the assignment of analytical work to the analytical laboratories. Ultimately, TRC's Program Manager was responsible for assuring that all tasks were completed on schedule and within budget, while maintaining the quality objectives of the program. To do so, TRC's Program Manager carried out the following functions:

- Administered program activities within the TRC team (s).
- Coordinated activities within the TRC team(s).
- Attended program meetings.
- Conducted pretest site specific surveys.
- Effected corrective actions which included quality, budget and schedule maintenance measures.
- Interacted with the sampling teams to ensure proper performance of the test procedures.
- Communicated directly with the PG&E Gen Program Manager.
- Prepared or reviewed Site Specific Test Plans
- Reviewed the QAPP.
- Prepared or reviewed the site specific test reports.

- Reviewed the data validation and reduction.

In summary, TRC's Program Manager ensured that the program was effectively staffed, managed, coordinated and satisfactorily completed.

1.2.2.2.2   TRC's QA Officer

Program Quality Assurance / Quality Control was under the direction of Mr. Howard F. Schiff, Program QA Officer. He was responsible for ensuring that all program deliverables adhered to the highest quality principles. He reported programmatically to the Program Manager, but he derived his authority from the TRC Air Measurements Manager.

TRC's QA Officer initiated or followed up on corrective actions and aided in the preparation of the section of the site specific final report summarizing QA/QC activities, problems identified and corrective actions taken.

TRC's QA Officer carried out the following functions:

- Implemented all QA procedures.
- Prepared or reviewed the QAPP.
- Reviewed and approved each Site Specific Test Plan (SSTP) prior to submittal.
- Ensured that all required equipment calibrations were conducted prior and subsequent to each field test.
- Provided written summaries of Program QC activities for submission to the Program Manager.
- Advised technical staff of appropriate QC measures and corrective actions, prepared QC procedure write-up, as needed.
- Assisted in data analysis.
- Reviewed Site Specific Final Test Reports.

1.2.2.2.3   TRC's Laboratory Coordinator

Laboratory coordination and data validation were under the direction of Mr. Edward MacKinnon, who carried out the following functions:

- Acted as the laboratory coordinator between the sampling team(s) and the analytical laboratories.
- Communicated the specific analytical QC requirements to the laboratories.
- Supervised the schedule and budget for the laboratories.
- Received, validated, and distributed the laboratory data.
- Assisted in data analysis.
- Assisted in report preparation.

1.2.2.2.4   Field Team Leader's Responsibilities

The Field Team Leader coordinated the activities of the sampling team. The Field Team Leader was responsible for the following functions:

- Supervised the source sampling train operators.
- Coordinated the sampling program with the Plant Program Coordinators.
- Assisted the train operators in trouble-shooting and maintaining the sampling trains.
- Collected all sampling train data sheets, determined isokinetic ratios, determined acceptability of train leak checks and ensured that each train was operated in accordance with the EPA sampling protocol.
- Oversaw the recovery, packing and shipping of the samples to the respective analytical laboratory.
- Informed the TRC and PG&E Gen Program and Plant Program Coordinators on which sampling runs met all validating criteria and if not, determined if additional sampling runs were to be conducted.

1.2.2.3   *Analytical Laboratory*

The contracted analytical laboratories (Phillips Analytical Services (Phillips) and Commercial Testing and Engineering) were responsible for sample analysis and assisting with data reporting. The contracted laboratories were responsible for conducting the analyses in accordance with the methods and procedures specified in the SSTP and the QAPP. Specifically, Phillips analyzed the Ontario Hydro Mercury train samples and Commercial Testing and Engineering analyzed the as-fired coal samples and the flue gas desulfurization media samples.

The Laboratory Managers were responsible to ensure that the QAPP was followed. In summary, the Laboratory Managers performed the following duties:

*   Ensured that laboratory services were available to support the sample analysis.
*   Ensured that the Program Quality Assurance Program Plan was followed.
*   Ensured that the laboratory QA/QC procedures were implemented.

SECTION 2.0

FACILITY AND SAMPLING LOCATION DESCRIPTIONS

2.1   PROCESS DESCRIPTION AND OPERATION

This section briefly describes the facility. There are two separate units at the facility, Units 1 and 2. The test program was conducted on Unit 1.

The Scrubgrass Generating Station is comprised of two identical circulating fluidized bed boilers (CFB, Units 1 & 2) firing waste coal. Sulfur dioxide emissions reduction is accomplished by injecting limestone directly into the coal bed. Particulate matter emissions from each unit are controlled by a dedicated fabric filter (baghouse). The exhaust from each baghouse passes through an ID fan and into a common 362 foot exhaust stack. A plan view of the plant is presented in Figure 2-1.

2.1.1   Circulating Fluidized Bed Boiler

The circulating fluidized bed boilers are manufactured by Tampella. For each unit, waste bituminous coal is fed to the bed of the unit from four coal silos to four belt feeders to four injection nozzles at a rate of 75 K lb/hour, with a maximum capacity rating (MCR) of 360 K lb/hour (KPH) steam. The combined steam flow from both units is directed to one turbine generator set. Limestone is fed from silos to two belt feeders. Each feeder feeds the unit from two injection nozzles for a total of four injection nozzles. The lime injection nozzles are at the same location as the coal feed nozzles. Limestone is fed at a rate between 5 to 10 K lb/hour depending upon the sulfur content of the coal. The feedback from the SO_2 continuous emission monitoring system (CEMS) controls the limestone feed rate.

2.1.2   Fabric Filter Unit (Baghouse)

The fabric filter units were manufactured by Brandt. There are 10 compartments, each containing

Figure 2-1. PG&E Scrubgrass Generating Station - Plan View

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256 Righton bags. The design collection efficiency is 99.96% for PM_{10}. The operating pressure drop (ΔP) is 2 to 5.5 inches H_2O. Bag cleaning is by pulse jet and is actuated whenever the ΔP exceeds 5.5 inches H_2O.

2.1.3 CEMS

The facility is equipped with a continuous emission monitoring system (CEMS). The CEMS measures and reports the combined stack opacity and O_2, SO_2, NO_x, and CO in the exhaust gas for each unit. The CEMS SO_2 data is used to control the injection rate of limestone.

2.1.4 Operating Schedule

During the test program, the Unit 1 was operating at a "steady-state" load condition throughout each test run. The steady-state load represented the maximum capacity (+/- 5%) of the source being tested.

2.2 FLUE GAS SAMPLING LOCATIONS

2.2.1 Baghouse Inlet Locations

The baghouse inlet sampling locations are presented in Figure 2-2. Figure 2-3 presents a photograph of the Unit 1 location. The Unit 2 location is a mirror image of the Unit 1 location. The rectangular ducts are 72 inches × 120 inches. The equivalent diameter for each of the baghouse inlet ducts is 90 inches. There are two sets of test ports in the side of each duct. Set A is located 24 feet and Set B is 28 feet downstream from the outlet of the air heater hopper for each unit. Port set B is located eight feet and Port set A is 12 feet upstream from the nearest disturbance (i.e., the duct changes to a horizontal position). The two sets of ports are separated by four feet. Set A is 3.2 duct diameters downstream and 1.6 duct diameters upstream. Set B is 3.7 duct diameters downstream and 1.1 duct diameters upstream. Therefore the minimum EPA Method 1 criteria were met and the maximum number of points (25) were sampled for each unit.
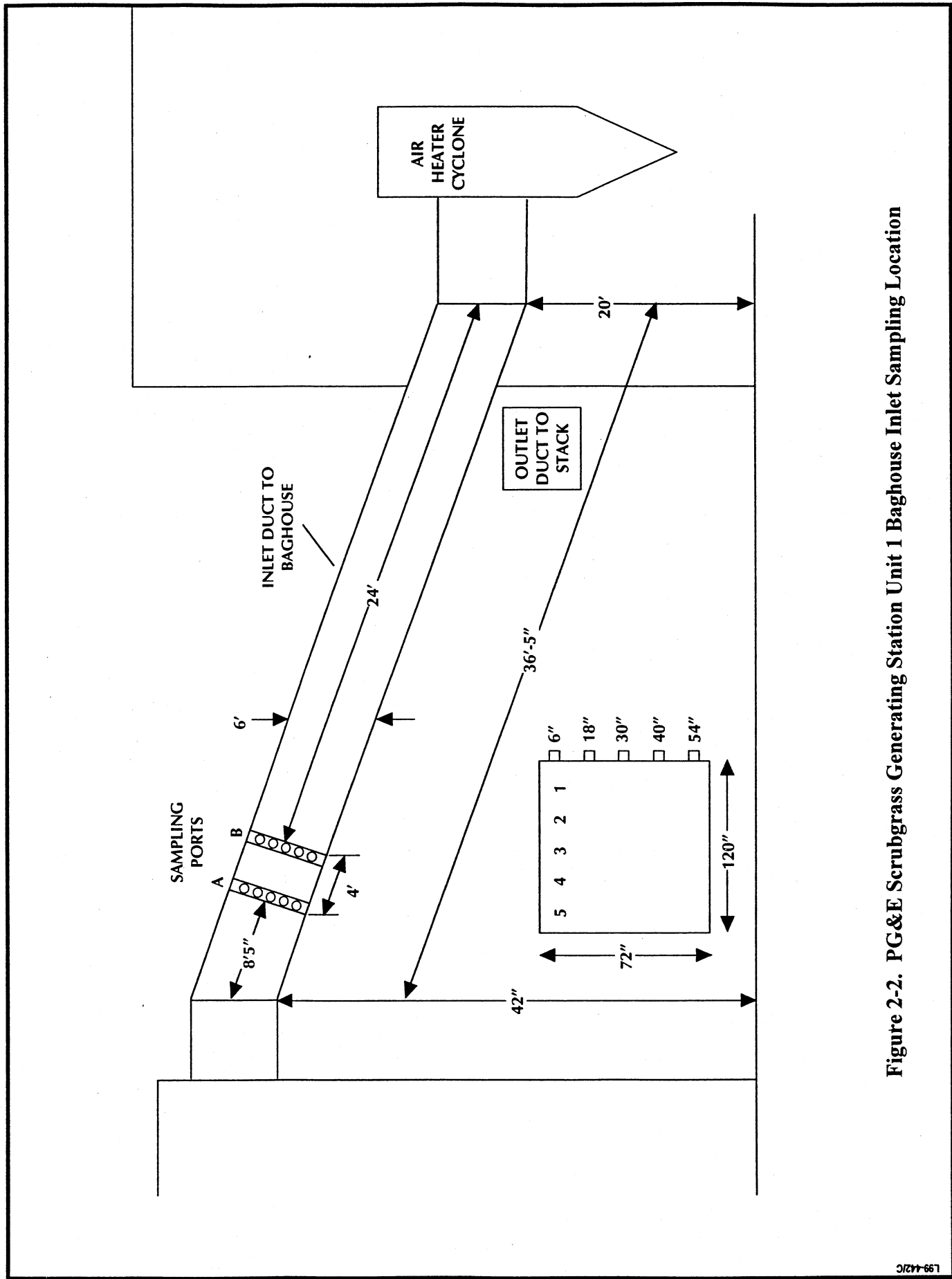
Figure 2-2. PG&E Scrubgrass Generating Station Unit 1 Baghouse Inlet Sampling Location

Figure 2-3. Unit 1 Baghouse Inlet Duct

Five sampling points were traversed in each port. For Unit 1, the Ontario Hydro train was operated in each set of ports. For Unit 2, velocity and moisture were determined using one set of ports. Table 2-1 presents the inlet traverse points. These two lines of sampling ports at the inlet duct sampling location are fitted with five 4-inch ID ports that were used for testing.

TABLE 2-1. BAGHOUSE INLET TRAVERSE SAMPLING POINTS

Point	Distance from Wall (in.)
1	12
2	36
3	60
4	84
5	108

2.2.2 Combined Outlet Stack Sampling Location

The combined outlet stack sampling location is shown in Figure 2-4. The circular stack is 129 inches in diameter. The test ports are located 73.5 feet (6.8 stack diameters) downstream of the silencer and 218.5 feet (20.3 stack diameters) upstream of the stack exhaust to the atmosphere. There are four 6-inch sampling ports installed at 90° intervals at the sample location.

TRC conducted a 24-point traverse, 6 points per port, during each test run. Table 2-2 presents these traverse points.

EL. 1758'

10'-9" ID Stack

EL. 1,539'-6"   O   **4-6" Dia. Ports With Caps**

**Large Grating Accessible
From Building Roof**

~15'   **EL. 1,466'**

Silencer

~21'   **EL. 1430'-6"**

Guillotine

ID FAN

EL. 1,396'
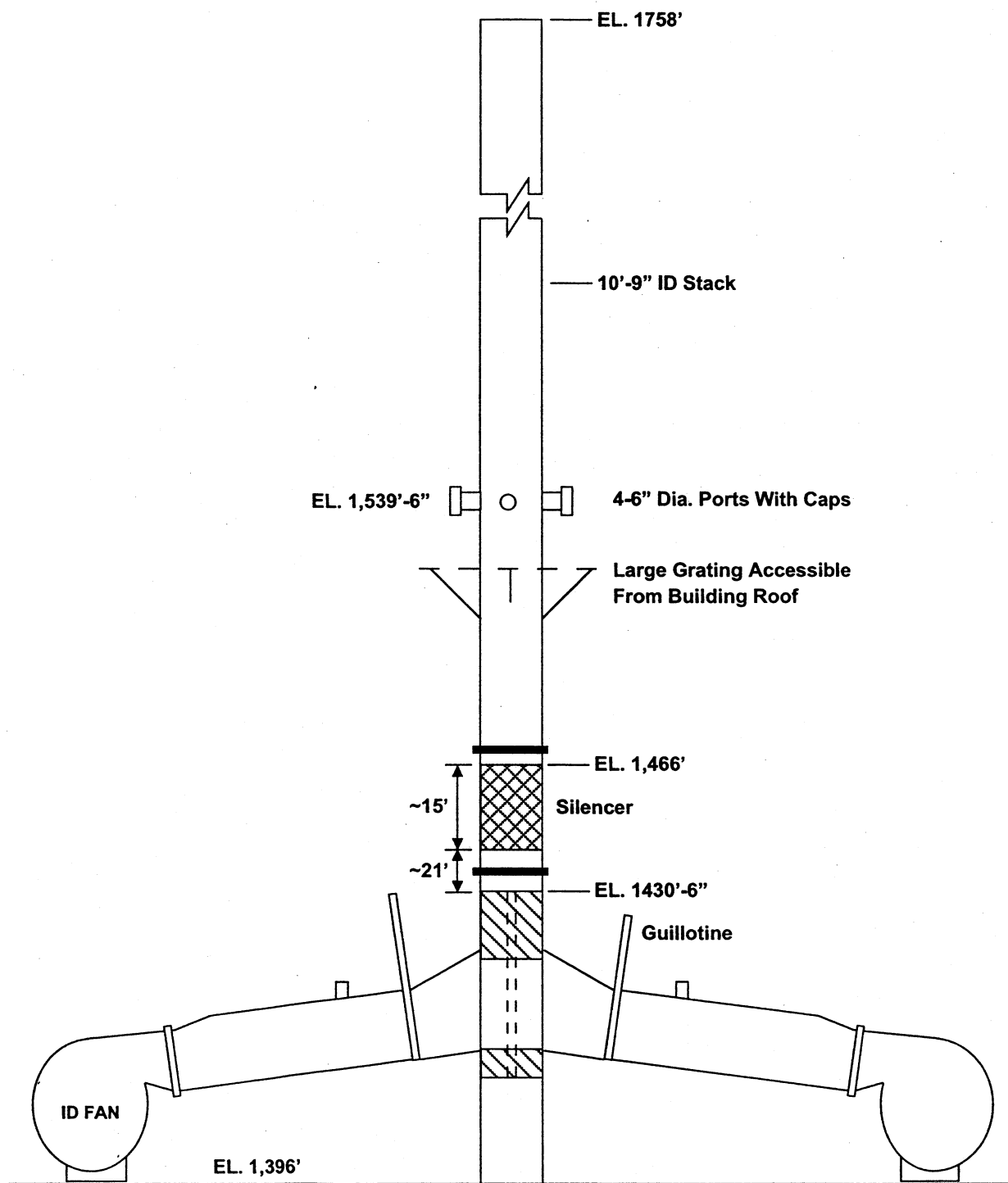
Figure 2-4. PG&E Scrubgrass Generating Station Combined Outlet Stack Sampling Location

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TABLE 2-2. COMBINED OUTLET STACK TRAVERSE SAMPLING POINTS

Point	Percent of Stack Diameter	Distance From Wall (in.)
1	2.1	2.7
2	6.7	8.6
3	11.8	15.2
4	17.7	22.8
5	25.0	32.25
6	35.6	45.9

2.3   PROCESS SAMPLING LOCATIONS

During each sample run, "as-fired" coal and "as-injected" limestone samples were obtained at the following locations.

2.3.1   Coal Samples

The coal samples were obtained from each of the four coal belt feeders on each unit. The sample extraction point is a 2-inch port with a ball valve located in the chute just above the belt as shown in Figure 2-5.

2.3.2   Limestone Samples

"As- injected" limestone samples were obtained from each of the two belt feeders on each unit. The sample was taken from the downward facing port in the section between the silo chute and the feeder (see Figure 2-6).

2.3.3   Ammonia Samples

Composite samples were obtained during Runs 1, 2, and 3. Samples were taken at the ammonia disbursement racks for each unit.

Figure 2-5. Coal Sampling Location
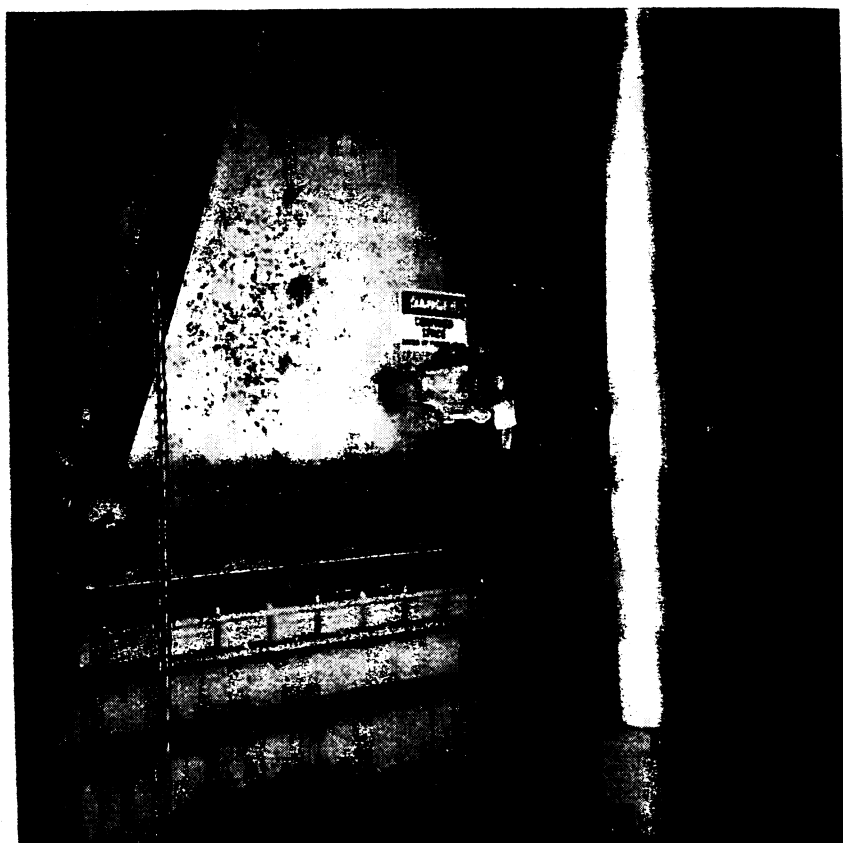
Figure 2-6.   Limestone Sampling Location

SECTION 3.0

SUMMARY AND DISCUSSION OF RESULTS

3.1   OBJECTIVES AND TEST MATRIX

The objectives of the test program for Unit 1 were as follows:

1.   measure the total inflow of mercury to the process;

2.   measure the concentration and emission rate of mercury on a speciated basis at the inlet and outlet of the facility pollution control equipment;

3.   determine the removal efficiency (RE) of the control equipment on a speciated and total basis; and

4.   calculate an overall RE based upon the total inflow of mercury to the system

5.   utilize paired sampling trains at each location to evaluate sampling method precision.

Table 3-1 presents the sampling and analytical matrix. Table 3-2 shows the measurements made at each test location. Precision evaluations made utilizing the paired sampling trains are presented in section 5.4.1.4 of this report.

3.2   FIELD TEST CHANGES AND PROBLEMS

3.2.1   Field Test Changes

3.2.1.1   *Correction of Inlet Duct Dimensions*

It was determined during the field test that the inlet duct dimensions reported in the SSTP were incorrect. The inlet duct dimensions had been reported as 60 inches × 120 inches in Figure 4-1 of the SSTP. The correct dimensions are 72 inches × 120 inches. During preparation of the SSTP the dimensions of the inlet duct to the baghouse for Unit 1 were incorrectly interpreted as "60 inches" rather than the correct dimension of 6.0 feet.

3.2.1.2   *Relocation of Outlet Sample Trains*

Several problems were encountered during the site setup and preliminary measurements at the baghouse exhaust duct for Unit 1. The problems involved difficulty with site logistics and test crew safety. The problems encountered were as follows:

- High positive static pressure (> 10 inches H_2O).

- Positive pressure combined with high gas temp (330° F), high SO_2, and low oxygen content (< 7%).

- Exposure of test crews at outlet, and inlet sampling locations due to proximity, to unsafe levels of SO_2 when ports were opened.

- High positive pressure and temperature which precluded the probe operator from looking down the sampling port when inserting the probe to prevent scraping or breaking the nozzle.

- Inability to maintain Teflon sample lines at the duct temperature ± 27°F. The outlet duct sampling configuration was changed from the probe/close coupled hot box to a probe/flexible heated sampling line/hot box configuration. This was necessary as the installation of a support for the probe/close coupled hot box system proved to be impractical.

Despite the best efforts of the test crew and the facility staff, all of these problems could not be overcome. PG&E Gen, TRC, and the EPA onsite observation team conferred and determined that the best course of action for crew safety and data quality was to relocate the outlet sampling location to the combined exhaust stack for Units 1 and 2. The use of the combined exhaust stack had been considered by TRC and PG&E Gen in preparation of the SSTP but had been rejected in favor of the Unit 1 outlet duct. The primary reason in attempting to sample the Unit 1 outlet duct was to reduce the sampling burden for the facility.

EPA had issued guidance on the use of the combined outlet stack location in an e-mail from Mr. Bill Maxwell dated April 21, 1999. In accordance with the e-mail, Unit 2 was operated at approximately the same load and baghouse operating conditions as Unit 1; gas flow measurements

were obtained at the Unit 2 baghouse inlet duct concurrent with the Ontario Hydro Method (OHM) testing in Unit 1 inlet duct; and all process and control information data obtained for Unit 1 was obtained for Unit 2. Coal, limestone and ammonia samples were obtained for Unit 2 in the same manner as Unit 1. A copy of the e-mail from Mr. Maxwell is provided in Appendix G.

3.2.1.3   *Inlet Sample Train Operation*

Due to the high negative static pressure encountered at the Baghouse inlet, the sample trains were started prior to insertion into the stack for each sample port traverse and were not shut down upon completion of a port traverse until after the nozzle had exited the sample port. This was necessary to avoid a back flush of the sample train and also to prevent the loss of any particulate matter during port changes. At the start of a sample port, the initial dry gas meter reading was taken as the nozzle of the sample train cleared the sample port sleeve and entered the gas stream. The final reading for a port was taken as the nozzle exited the gas stream and entered the sample port sleeve. Taking the volume readings in this manner discounted the volume of air which passed through the train prior to entering or after exiting the stack.

A significantly higher concentration of particulate matter existed at the inlet to the baghouse than had been encountered at any of the other inlet sample locations tested as part of the overall PG&E Gen test program. The higher concentration of particulate required that the cyclone and the front half of the filter housing of each inlet OHM sampling train be recovered several times during a test run in order to prevent a flow restriction within the inlet sample trains and allow the collection of an isokinetic sample for the duration of each test run. Recovering the cyclone and filters in this fashion was considered to be a minor modification to sample train operation at the Baghouse inlet location. This modification did not involve any changes to the recovery procedure, only multiple iterations of the cyclone and filter housing recovery. The cyclone and front half of the filter housing were emptied into the same sample jar and then sealed. Two sets of cyclones and filter housings for each train were alternately recovered and installed for this purpose.

3.2.1.4   Collection of Additional Process Samples

Additional process samples were obtained that were not indicated in the SSTP. As discussed in Section 3.2.1.2, process samples for coal and lime were collected for Unit 2. In addition to these two other process streams were sampled:

- Ammonia
- Bottom Ash

Selective non-catalytic reduction (SNCR) systems for NO_x control were installed in both units during July/August 1999. A 19% aqueous solution of Ammonium Hydroxide is sprayed into the gas stream after the last recycle cyclone. Composite samples were obtained during Runs 1, 2, and 3. Samples were taken at the ammonia disbursement racks for each unit. The sample lines were purged into a waste container prior to taking a sample. The composite sample for each run consisted of 250 mL from Unit 1 and 250 mL from Unit 2. The samples were analyzed in accordance with SW-846, Method 7470A.

Bottom ash samples were obtained for each unit at the start, middle, and end of each run. These samples were not intended to be utilized as part of the ICR test program, but were collected for PG&E Gen internal use. Bottom Ash was obtained from the discharge for each unit. A one gallon sample was obtained at the beginning, middle, and end of each run. These three samples were combined and reduced to a 250 ml composite sample by riffling. All sample results were below analytical detection limits. Copies of the analytical results for the bottom ash samples have been included in Appendix D.

3.2.1.5   Change in Collection Frequency of Process Samples

The SSTP called for collection of process samples at fifteen minute intervals throughout each test run. In practice, the time required to collect coal samples from the four belt feeders was taking a minimum of 16-18 minutes per unit, with no breaks for the sampling personnel. These personnel

were also responsible for the collection of limestone samples at each unit.

To remedy this situation, the interval between samples was increased to 30 minutes. The limestone sample interval was also increased to one sample every 30 minutes. These modifications are not considered to have had a significant or negative impact upon the results reported.

3.2.2 Problems

This section documents problems that were encountered in the completion of the sampling program and the actions taken to overcome and/or correct the problems. None of the problems or actions taken are considered to have had a significant or negative impact upon the results reported.

3.2.2.1   *Exhaust Stack Sampling Trains*

The following problems were experienced by the test team operating the sampling trains at the combined exhaust stack:

- Run 1 - For the first 48 minutes of Run 1 the filter box temperature of sample train B was not able to be maintained at the stack temperature of 302 to 315 ± 27°F . This was attributed to the high winds and low ambient temperatures which existed at the time of the test. Sample train A did not experience the same temperature problem as it was shielded from the wind during this time period. Both of the sample trains were stopped 48 minutes into the 144 minute test to attempt to correct the problem. The corrective action was to externally insulate the hot boxes and the back end of the sample probes. Sample train B continued to exhibit a hot box temperature more than 27° below the stack temperature for the next 24 minutes. The test team was able to remedy for the second half of the test by further insulating the hot box. For Runs 2 and 3, no temperature problems were experienced for either sample train.

- Post test Y_{qa} values greater than 5% were calculated for Run 2 and 3 of sample train A. It was determined after the completion of the third test that the manometer was not indicating the true differential pressure for the orifice meter. Further investigation discovered a leak in the manometer utilized for measuring the pressure differential (ΔH)

for the orifice meter. The leak caused operation of the sampling train at sampling rates higher than indicated by the orifice meter. TRC has determined that the manometer developed the leak near the end of the second test run. This determination is based upon the fact that the total volume measured by the dry gas meter increased from Run 1 to Run 2 and in turn to Run 3. Since the trains were operated at nearly the same indicated sampling rate, the volume recorded should have been similar. In addition, the volume recorded by the meter for Runs 2 and 3 was greater than the volume which would be expected for the average sampling rate at which the train was operated as indicated by the Y_{qa} values.

- The calculated isokenetic ratio for Run 3 of sample train A was 110.5%. This was a direct result of the manometer leak described above.

The problems experienced are not considered to have had a significant or negative impact upon the results reported. The data obtained for sample train A are considered to be valid for the following reasons:

- Analytical results for Runs 2 and 3 of sample train A were consistent with those obtained for the paired sample train B.

- Proper isokinetic ratios were maintained for Run 2 and the majority of Run 3.

- The manometer leak had no significant impact on the sample volume recorded by the dry gas meter.

3.2.2.2   *Inlet Sampling Trains*

Logistics at the Baghouse inlet were the cause of several minor problems with regard to sample train operation and port changes. The highly negative static pressure which exists at the location and its impact has been discussed previously in Section 3.1. The high particulate loading also contributed to the problems encountered. The problems encountered at the Baghouse inlet were as follows:

- Run 2 - Inlet sample train A impinger solutions were back-flushed following completion of the 3rd port. While waiting for the nozzle to cool prior to conducting a leak check of the sample train, the test crew noticed impinger solutions moving forward through u-tubes

after the sample pump had been turned off. A visual inspection of the train revealed reagent solution had carried forward from impinger 5 through to impinger 2. The back-flush of the train was attributed to the high particulate loading on the filter. The high loading prevented a release of the vacuum which occurs between the first impinger and the filter. When the pump was turned off, this vacuum pulled ("back-flushed") the impinger solutions forward from one impinger into the preceding one. The sample train was considered to be compromised and was not recovered. In order to obtain statistically significant data from the operation of the paired trains, a 4th inlet run was conducted with the dual trains. No stack train runs were conducted nor were process samples obtained during the 4th test. Process operating data was obtained. Inlet data from sample train B was utilized to report emissions for Run 2.

- The indicated inlet sample probe temperatures were not always maintained at $\pm 27°F$ in relation to the flue gas temperature. This occurred at a low percentage of the sample traverse points and in these cases the indicated temperatures were generally within 30 to 35°F of the flue gas temperature. Filter box and filter exhaust temperatures were maintained within specifications at all times. Probe heaters were operated at maximum power input for the duration of each test. Based upon the filter exhaust temperatures and the frequency of the occurrences, the data obtained for the inlet sample trains are not considered to have been compromised in any fashion.

3.3   PRESENTATION OF RESULTS

The objectives of the program, presented in section 3.1, center upon the determination of Hg emissions at the inlet and outlet of the Unit 1 emission control device. Relocation of the outlet sampling trains to the combined exhaust stack made it necessary to calculate the Hg emissions at the Unit 1 Baghouse exhaust. Two assumptions were made in performing the calculations. The assumptions required to complete the objectives identified for Unit 1 were as follows:

- The distribution (%) of speciated Hg components was the same for Unit 1 and Unit 2
- The speciated Hg RE for the Unit 1 baghouse was the same as the Unit 2 baghouse

Process operation data collected for each unit during the test program support the assumptions made. These data indicate that the units and control devices were operated under similar conditions. Given that the two units are identical in design and construction, a significant difference in performance would not be anticipated. Process data is included in Appendix G.

Presented in Tables 3-3 and 3-4 are the results required to fulfill the objectives identified for this test program. Table 3-5 presents the distribution of speciated mercury components measured at the Unit 1 baghouse inlet and the combined exhaust stack. Table 3-6 presents additional results which treat Unit 1 & 2 as if they were combined as a single unit. The following sections discuss the results pertinent to each of the objectives in greater detail. As discussed earlier, precision evaluations made utilizing the paired sampling trains are presented in section 5.4.1.4 of this report.

3.3.1   Total Mercury Inflow to the Process

The total mercury inflow to the process was determined through sampling and analysis of the fuel and other materials utilized in the normal operation of each unit at the facility. These included the limestone and the ammonia utilized for the SNCR. Results for Unit 1 and 2 are presented for each run and are based upon the concentration of mercury measured and the feed rate of each material into the process.

Tables 3-3 and 3-6 present the concentration of mercury measured in the process materials and the calculated feed rate (mg/hr) of mercury into the process. The sulfur and chlorine content of the fuel as well as the as fired HHV are also presented.

3.3.2   Speciated and Total Mercury Emissions (Inlet and Outlet of Control Device)

Paired trains were operated at each location for each of the three test runs. One sample train was invalidated as discussed previously in Section 3.2.2.1. This resulted in a total of six samples collected at the outlet location and five at the inlet location. With the exception of inlet Run 2, values presented in the summary tables represent the average of the paired trains for a given sample location and run. Results for individual test runs are presented in Appendix A.

Paired trains were operated in order to obtain a measure of precision for the speciated mercury method utilized for the test program. To obtain a statistically significant data set an additional set of paired trains were operated during a fourth test run at the baghouse inlet to Unit 1.

In the case where sample concentrations were below the Method Detection Limit (MDL) for a particular sample fraction, concentrations and emission rates were reported as "less than" (<) values. Although measurable quantities were reported by the laboratory for impingers 5 thru 7, the level of elemental mercury in the 4th impinger (HNO_3/H_2O_2) was below the MDL for all sample trains. Therefore the overall results for elemental mercury were reported as less than values. Similarly at the combined exhaust stack, the concentration of particulate bound mercury was below the MDL for all sample trains. Therefore the outlet results for particle bound mercury were reported as less than values.

3.3.2.1   Unit 1

Concentrations and emission rates for mercury are presented in Table 3-3. Results are presented on a speciated and total basis in terms of ug/dscm and mg/hr. Emission rates expressed in terms of Lb/hr and lb/MMBtu are presented in Table 3-4.

The ratio of the total process feed rate of mercury into Unit1 to the combined unit total was used in calculating the mercury emissions at the outlet of the Unit 1 control device. The mercury emissions measured at the combined outlet stack were multiplied by this ratio to determine the Unit 1 emissions.

3.3.2.2   Unit 1 and 2 Combined

Concentrations and emission rates for mercury are presented in Table 3-6. Results are presented on a speciated and total basis in terms of ug/dscm and mg/hr. Emission rates expressed in terms of Lb/hr and lb/MMBtu for the combined exhaust stack are presented in Table 3-4.

3.3.3 Emission Control Device Removal Efficiency

The removal efficiency (RE) of the emission control equipment for speciated and total mercury was evaluated as part of the test program. RE calculations are based upon the emission rate measured for each of the speciated components at the combined exhaust stack and the Unit 1 Baghouse inlet sample locations. The Total feed rate of Hg into each Unit, as determined from the process sampling, was also required to calculate the final results. Data from the fourth test run at the inlet was not utilized in the calculation of control device efficiency.

3.3.3.1   Unit 1

The control device demonstrated a high removal efficiency for the particulate bound fraction, averaging 99.99% for the test program. RE for oxidized mercury (Hg^{2+}) was determined to be 85.88% and that of elemental (Hg^0) averaged 19.00%. The overall RE for mercury averaged 99.80%. Results are presented in Table 3-3.

3.3.3.2   Unit 1 and 2 Combined

In determining the combined control device (I/O) RE it was necessary to establish the contribution of mercury on a speciated basis from Unit 2. As speciated tests were not performed on the Unit 2 baghouse inlet this was accomplished by multiplying the process mercury inflow to Unit 2 by the percentage of each component as measured at the baghouse inlet for Unit 1. The total mercury inflow for Unit 2 was determined from the analysis of process samples and respective feed rates.

The combined control devices demonstrated a high removal efficiency for the particulate bound fraction, averaging 99.99% for the test program. RE for oxidized mercury (Hg^{2+}) was determined to be 85.43% and that of elemental (Hg^0) averaged 17.18%. The overall RE for mercury averaged 99.80%. Results are presented in Table 3-6.

3.3.4 Overall Process Removal Efficiency

The RE of the process for total mercury was evaluated as part of the test program. RE calculations are based upon the inflow of mercury to the system, based upon process monitoring, and the total mercury emission rate measured at the control device exhaust. The overall process RE for mercury averaged 99.77% for Unit 1 and Unit 1 & 2 combined as a single unit. Data from the fourth test run at the inlet was not utilized in the calculation of process removal efficiency.

TABLE 3-1. PG&E GEN SCRUBGRASS GENERATING STATION TEST MATRIX

Sampling Location	Sample/Type Pollutant	Sampling Method	Sampling Organization	No. of Trains at Location	No. of Runs Per Train	Sample Run Time (min)	Analytical Method	Analytical Laboratory
Inlet to Unit 1 Baghouse	Mercury speciated	Ontario Hydro (includes EPA M1, 2 & 4), M3B (Bag)	TRC	2	3	120	Ontario/Hydro & SW846, 7047A, CVAA	Philips Analytical Services
	O_2/CO_2		TRC		3	120	3B Orsat	TRC
Inlet to Unit 2 Baghouse	Volumetric Flow Rate	EPA M1, 2 & 4	TRC	1	3	120	N/A	N/A
	O_2/CO_2	M3B (Bag)	TRC	1	3	120	3B Orsat	TRC
Combined Outlet Stack	Mercury Speciated	Ontario Hydro (includes EPA M1, 2 & 4) M3B (Bag)	TRC	2	3	120	Ontario/Hydro & SW846, 7470A, CVAA	Philips Analytical Services
	O_2/CO_2		TRC	1	3	120	3B Orsat	TRC
Coal Sampling Units 1&2	Sample Mercury Sulfur Chlorine GCV proximate moisture	ASTM D2234-97a	PG&E Gen	–	3	120	ASTM 2013-86 D3684-94 D4234-92 D4208-88 D5865-98 D5142-90 D3302-97	Commercial Testing & Engineering
Limestone Units 1&2	Mercury	ASTM D2334-97A	PG&E Gen	–	3	120	SW846, 7471A	Commercial Testing & Engineering
Ammonia Units 1&2	Mercury	ASTM D2334-97A	PG&E Gen	–	1	–	SW846, 7470A	Commercial Testing & Engineering

**TABLE 3-2. MEASUREMENTS CONDUCTED AT EACH TEST LOCATION
RUNS 1, 2, AND 3**

Units 1 & 2 Baghouse Inlet[1]	Combined Outlet Stack	Process
EPA-EMC - Pre-003 Speciated Mercury - Ontario Hydro	EPA-EMC - Pre-003 Speciated Mercury - Ontario Hydro	Coal Feed Sample
O_2/CO_2 (M3B)	O_2/CO_2 (M3B)	Limestone Sample
Sampling Location & Traverse Points (M-1)	Sampling Location & Traverse Points (M-1)	Ammonia Sample
Velocity (M-2)	Velocity (M-2)	
Moisture (M-4)	Moisture (M-4)	

1- Unit 2 Baghouse Inlet only sampled for Velocity, Moisture, and O_2/CO_2

TABLE 3-3. SUMMARY TABLE OF EMISSIONS DATA AND REMOVAL EFFICIENCIES - UNIT 1

Method/Component	Units	Unit 1 Baghouse Inlet[1]				Unit 1 Baghouse Outlet[2]				Inlet/Outlet Removal Efficiency			
		1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
Ontario Hydro / Hg													
Particle Bound	μg/dscm	141.10	98.60	62.62	100.77	<0.0043	<0.0043	<0.0041	<0.0042				
	mg/hr	31,163	21,894	13,735	22,264	<1.09	<1.14	<0.98	<1.07	99.997%	99.995%	99.994%	99.99%
Oxidized, Hg^{2+}	μg/dscm	0.52	0.33	0.18	0.34	0.0495	00361	0.0298	0.0385				
	mg/hr	115	73	39	76	12.53	9.58	7.19	9.77	89.08%	86.81%	81.76%	85.88%
Elemental, Hg^{0}	μg/dscm	<0.29	<0.15	<0.12	<0.19	<0.1205	<0.1196	<0.1141	<0.1181				
	mg/hr	<64	<34	<27	<42	<30.40	<31.90	<27.54	<29.95	52.57%	6.03%	-1.59%	-19.00%
Total, Hg	μg/dscm	<141.91	<99.08	<62.92	<101.30	<0.17	<0.16	<0.15	<0.16				
	mg/hr	<31,341	<22,000	<13,801	<22,381	<44	<43	<36	<41	99.86%	99.81%	99.74%	99.80%

Method/Component	Units	Unit 1 Process Samples				Unit 2 Process Samples				Unit 1 Process Removal Efficiency[3]			
		1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
Coal Samples													
Hg	μg/g	5.50E-01	5.20E-01	5.10E-01	5.27E-01	5.00E-01	4.20E-01	5.20E-01	4.80E-01	99.75%	99.77%	99.80%	99.77%
Hg Rate	mg/hr	16,711	17,877	17,504	17,364	14,978	13,677	17,504	15,386				
Sulfur	Wt %	1.49	1.52	1.40	1.47	1.57	1.28	1.47	1.44				
Chlorine	%	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06				
HHV	Btu/lb	8,509	8,520	7,996	8,342	8,554	8,520	7,996	8,357				
Lime Slurry Samples	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1				
	mg/hr	<668	<834	<665	<722	<827	<1,112	<818	<919				
Ammonia Samples	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				
	mg/hr	<1	<1	<1	<1	<1	<1	<1	<1				
Total Hg Feed Rate	mg/hr	<17,380	<18,712	<18,170	<18,088	<15,806	<14,790	<18,324	<16,307				

[1] - With the exception of Run 2, all reported values represent average of the paired trains.

[2] - Unit 1 Baghouse Outlet = $Hg^{Comb.\ Stack}$ x ((Total $Hg^{Unit\ 1}$) ÷ (Total $Hg^{Unit\ 1}$ + Total $Hg^{Unit\ 2}$))

[3] - Process Removal Efficiency % = (Total $Hg^{Unit\ 1}$ - $Hg^{outlet\ Unit\ 1}$) ÷ (Total $Hg^{Unit\ 1}$)

TABLE 3-4. SUMMARY TABLE OF EMISSION RATES - UNIT 1 and COMBINED OUTLET STACK

Method/Component	Units	Unit 1 Baghouse Inlet[1]				Unit 1 Baghouse Outlet[2,3]				Combined Outlet Stack			
		1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
Ontario Hydro / Hg													
Particle Bound	lb/hr	6.78E-02	4.76E-02	2.99E-02	4.84E-02	<2.36E-06	<2.48E-06	<2.14E-06	<2.33E-06	<4.51E-06	<4.44E-06	<4.30E-06	<4.42E-06
	lb/MMBtu	1.31E-04	8.86E-05	5.69E-05	9.23E-05	<4.15E-09	<3.84E-09	<3.54E-09	<3.84E-09	<4.02E-09	<3.92E-09	<3.73E-09	<3.89E-09
Oxidized, Hg^{2+}	lb/hr	2.50E-04	1.58E-04	6.75E-05	1.58E-04	2.73E-05	2.08E-05	1.56E-05	2.12E-05	5.21E-05	3.73E-05	3.14E-05	4.03E-05
	lb/MMBtu	4.80E-07	2.94E-07	1.64E-07	3.13E-07	4.78E-08	3.23E-08	2.59E-08	3.53E-08	4.62E-08	3.31E-08	2.73E-08	3.55E-08
Elemental, Hg^0	lb/hr	<1.39E-04	<7.39E-05	<5.90E-05	<9.08E-05	<6.62E-05	<6.94E-05	<5.99E-05	<6.52E-05	<1.26E-04	<1.24E-04	<1.20E-04	<1.24E-04
	lb/MMBtu	<2.68E-07	<1.37E-07	<1.12E-07	<1.73E-07	<1.16E-07	<1.07E-07	<9.90E-08	<1.08E-07	<1.13E-07	<1.10E-07	<1.04E-07	<1.09E-07
Total, Hg	lb/hr	<6.82E-02	<4.79E-02	<3.00E-02	<4.87E-02	<9.58E-05	<9.27E-05	<7.77E-05	<8.87E-04	<1.83E-04	<1.66E-04	<1.56E-04	<1.68E-04
	lb/MMBtu	<1.32E-04	<8.90E-05	<5.71E-05	<9.28E-05	<1.68E-07	<1.44E-07	<1.28E-07	<1.47E-07	<1.63E-07	<1.47E-07	<1.35E-07	<1.48E-07

[1] - With the exception of Run 2, all reported values represent average of the paired trains.
[2] - Unit 1 Baghouse Outlet lb/hr = lb/hr$^{Comb.\ Stack}$ x ((Total Hg$^{Unit\ 1}$) ÷ (Total Hg$^{Unit\ 1}$ + Total Hg$^{Unit\ 2}$))
[3] - Unit 1 Baghouse Outlet lb/MMBtu= lb/hr$^{Unit\ 1\ out}$ ÷ MMBtu/hr$^{Unit\ 1}$

TABLE 3-5. DISTRIBUTION OF SPECIATED MERCURY EMISSIONS

Method/Component	Units	Unit 1 Baghouse Inlet[1]				Combined Outlet Stack			
		1	2	3	Avg	1	2	3	Avg
Ontario Hydro / Hg									
Particle Bound	mg/hr	31,163	21,894	13,735	22,264	<2.1	<2.0	<2.0	<2.0
	% of Total	99.4%	99.5%	99.5%	99.5%	2.5%	2.6%	2.8%	2.6%
Oxidized, Hg^{2+}	mg/hr	115	73	39	76	23.9	17.15	14.4	18.5
	% of Total	0.4%	0.3%	0.3%	0.3%	28.5%	22.0%	20.1%	22.7%
Elemental, Hg^0	mg/hr	<64	<34	<27	<42	<58.0	<57.1	<55.3	<56.8
	% of Total	0.2%	0.2%	0.2%	0.2%	69.1%	73.2%	77.1%	73.1%
Total , Hg	mg/hr	<31,341	<22,000	<13,801	<22,381	<84	<76	<72	<77

[1] - With the exception of Run 2, all reported values represent average of the paired trains.

TABLE 3-6. SUMMARY TABLE OF EMISSIONS DATA AND REMOVAL EFFICIENCIES - COMBINED UNIT

Method/Component	Units	Unit 1 Baghouse Inlet[1]				Combined Outlet Stack				Inlet/Outlet Removal Efficiency[2]			
		1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
Ontario Hydro / Hg													
Particle Bound	µg/dscm	141.10	98.60	62.62	100.77	<0.0043	<0.0043	<0.0041	<0.0042				
	mg/hr	31,163	21,894	13,735	22,264	<2.07	<2.04	<1.98	<2.03	99.996%	99.994%	99.994%	99.99%
Oxidized, Hg^{2+}	µg/dscm	0.52	0.33	0.18	0.34	0.0495	0.0361	0.0298	0.0385				
	mg/hr	115	73	39	76	23.93	17.15	14.44	18.51	86.14%	85.88%	84.26%	85.43%
Elemental, Hg^0	µg/dscm	<0.29	<0.15	<0.12	<0.19	<0.1205	<0.1196	<0.1141	<0.1181				
	mg/hr	<64	<34	<27	<42	<58.05	<57.11	<55.30	<56.82	39.80%	-0.61%	12.34%	17.18%
Total, Hg	µg/dscm	<141.91	<99.08	<62.92	<101.30	<0.17	<0.16	<0.15	<0.16				
	mg/hr	<31,341	<22,000	<13,801	<22,381	<84	<76	<72	<77	99.86%	99.81%	99.74%	99.80%

Method/Component	Units	Unit 1 Process Samples				Unit 2 Process Samples				Overall Process Removal Efficiency			
		1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
Coal Samples													
Hg	µg/g	5.50E-01	5.20E-01	5.10E-01	5.27E-01	5.00E-01	4.20E-01	5.20E-01	4.80E-01	99.75%	99.77%	99.80%	99.77%
Hg Rate	mg/hr	16,711	17,877	17,504	17,364	14,978	13,677	17,504	15,386				
Sulfur	Wt %	1.49	1.52	1.40	1.47	1.57	1.28	1.47	1.44				
Chlorine	%	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06				
HHV	Btu/lb	8,509	8,520	7,996	8,342	8,554	8,520	7,996	8,357				
Lime Slurry Samples	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1				
	mg/hr	<668	<834	<665	<722	<827	<1,112	<818	<919				
Ammonia Samples	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002				
	mg/hr	<1	<1	<1	<1	<1	<1	<1	<1				
Total Hg Feed Rate	mg/hr	<17,380	<18,712	<18,170	<18,088	<15,806	<14,790	<18,324	<16,307				

[1] - With the exception of Run 2, all reported values represent average of the paired trains.

[2] - Inlet/Outlet Removal Efficiency % = $[(((Hg^{in\ Unit1} \times \%\ Hg^{in\ Unit1}) + (Total\ Hg^{Unit2} \times \%\ Hg^{in\ Unit1})) - Hg^{outlet}) \div (Hg^{in\ Unit1} + (Total\ Hg^{Unit2} \times \%\ Hg^{in\ Unit1}))]$

SECTION 4.0

SAMPLING AND ANALYTICAL PROCEDURES

4.1 OVERVIEW

This section describes the procedures that TRC followed during the field sampling program. Throughout the program TRC followed 40 CFR, Part 60, Appendix A Methods and USEPA Preliminary Approved Sampling Protocols.

The remainder of this section is divided into several subsections: Field Program Description; Presampling Activities, Onsite Sampling Activities, Process Monitoring, Analytical Procedures, and Calculations.

The following test methods were utilized:

•	EPA EMC Pre-003	Draft Standard Test Method for Elemental, Oxidized, Particle Bound Mercury Emissions in Flue Gas Generated From Coal-Fired Stationary Sources (Ontario Hydro Method) 7/7/99 revision.
•	EPA Method 1	Sample Velocity Traverse for Stationary Sources
•	EPA Method 2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S pitot tube)
•	EPA Method 3B	Gas Analysis for the Determination of Emission Rate Correction Factor or Excess Air
•	EPA Method 4	Determination of Moisture Content in Stack Gases
•	ASTM D2234-97a	Standard Practice For the Collection of Representative Samples of Coal

4.2   PRESAMPLING ACTIVITIES

Presampling activities included equipment calibration, precleaning of the sample train glassware, and other miscellaneous tasks. Each of these activities are described or referenced in the following subsections. Other presampling activities included team meetings, equipment packing, and finalization of all details leading up to the coordinated initiation of the sampling program.

4.2.1   Equipment Calibration

See Section 5.0, Quality Assurance and Quality Control, of this Final Report.

4.2.2   Glassware Preparation

The sample train glassware and sample containers required specialized precleaning to avoid contamination of the sample from the collection container or devices.

The Ontario Hydro sampling train glassware was precleaned with an alconox soap and water wash. The glassware was rinsed with tap water, followed by three additional rinses with deionized water. The glassware was then soaked in a 10 percent nitric acid solution for 4 hours, rinsed three times with deionized water, and a final rinse with acetone. The glassware was then air dried and sealed with parafilm.

4.3   ONSITE SAMPLING ACTIVITIES

Onsite sampling activities included equipment set up and conducting simultaneous testing of the Unit 1 baghouse inlet and the outlet exhaust stack for Units 1 and 2.

4.3.1   EPA Methods 1 and 2 for Velocity Measurements and Cyclonic Flow

Velocity traverses were conducted at all sampling locations with an S-type pitot assembly in

accordance with 40 CFR Part 60, Appendix A, Method 1 *"Sample and Velocity Traverses for Stationary Sources"* and Method 2 *"Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)"*. An S-type pitot tube with an attached inclined manometer was used to measure the gas velocities. An attached Type-K thermocouple with a remote digital display was used to determine the flue gas temperature. During the test program, velocity measurements were conducted during each test run at each sampling location. The required number of velocity measurement points for each sampling location was determined following EPA Method 1.

Cyclonic flow checks were conducted at each sampling location prior to sampling in accordance with Section 2.4 of EPA Method 1. This procedure is referred to as the nulling technique. An S-type pitot tube connected to an inclined manometer was used in this method. The pitot tube was positioned at each traverse point so that the face openings of the pitot tube were perpendicular to the stack cross-sectional plane. This position is called the "0° reference". The velocity pressure (ΔP) measurement was noted. If the ΔP reading was zero, the cyclonic angle was recorded as 0°. If the ΔP reading was not zero, the pitot tube was rotated clockwise or counter clockwise until the ΔP reading became zero. This angle was then measured with a leveled protractor and reported to the nearest degree. After this null technique was applied at each traverse point, the average of the cyclonic angles was calculated. If this average was less than 20°, the flow condition in the source was acceptable to test. Flow conditions were acceptable at all locations.

4.3.2 EPA Method 4 for Moisture

Moisture was determined for each test run according to EPA Reference Method 4, *"Determination of Moisture Content in Stack Gases,"* as an integral part of the Ontario Hydro Method. The principle of this method is to remove the moisture from the sample stream and determine the moisture either volumetrically or gravimetrically.

Prior to the test program, a preliminary Method 4 was conducted at each sampling location to determine moisture and allow for the calculation of isokinetic sampling ratios. This sampling train used a glass lined probe with a thermocouple and S-type pitot tube attached to the probe for the

measurement of gas temperature and velocity. The sample gas passed through a series of four ice-cooled impingers kept below 68°F to enable condensation of entrained moisture. The first two impingers contained 100 mL of deionized water. The third impinger was empty and the fourth impinger contained a preweighed amount of silica gel. The impingers were followed by a dry gas meter, pump, and calibrated orifice meter. All impingers were weighed prior to the setup of the train.

Leak checks of the entire Method 4 sampling trains were performed before and after each sampling run. All leak checks and leakage rates were documented on the relevant field test data sheet. The acceptance criterion for the Method 4 train was a leak rate of ≤ 0.02 cfm at the highest vacuum obtained during the run.

Following the completion of the preliminary test run, the Method 4 train was transported to a recovery area onsite. The sample recovery sequence was as follows:

- Removed the sampling train to the recovery area;
- Noted the condition of the train (i.e., impinger contents color, silica gel color, etc.); and
- The final weight of all impingers were obtained.

4.3.3 Ontario Hydro Mercury Speciation Train (EPA EMC Pre-003)

Speciated mercury (Hg) was determined at the Unit 1 baghouse inlet duct and the combined exhaust stack via EMC Pre-003 "*Draft Standard Test Method for Elemental, Oxidized, Particle Bound, and Total Mercury Emissions in the Flue Gas Generated From Coal Fired Stationary Sources (Ontario Hydro Method)*". The description of the sampling and analytical methodology in this section is based on the draft method released July 7, 1999.

The OHM sampling train consisted of a heated stainless steel, glass-lined probe with a glass button-hook nozzle. A thermocouple and S-type pitot tube were attached to the probe for

the measurement of gas temperature and velocity. The probe and sampling train were oriented in a horizontal position as shown in Figure 4-1.

The sample gas passed through the probe assembly to a heated tared glass fiber filter, on a Teflon filter support, contained in a borosilicate filter holder. The probe and the gases exiting the filter holder were maintained at either the stack temperature ± 27°F or at 248°F ± 25°F whichever was greater. Downstream of the heated filter, the sample gas passed through a series of eight ice bath cooled impingers, kept below 68°F to enable condensation of entrained moisture and the gaseous mercury species. The first, second and third impingers each contained 100 mL of a 1N KCl solution. The fourth impinger contained 100 mL of a 5% HNO_3/10% H_2O_2 solution. The fifth, sixth, and seventh impingers each contained 100 mL of a 4% $KMnO_4$/10% H_2SO_4 solution. The eighth impinger contained 200 - 400 gms of silica gel. All filled impingers were weighed prior to placing the impingers in the train. The impingers were followed by a leak free pump, dry gas meter and calibrated orifice meter.

The first, second, fourth, sixth, and eighth impingers were of the Modified Greenburg design. The third, fifth and seventh impingers were standard Greenburg Smith impingers. No silicone grease was used in the train.

At the inlet and outlet sampling locations, two Ontario Hydro trains were run concurrently over the entire sampling period. The trains were not co-located. At the inlet sampling location one train was run in each set of sampling ports. The outlet trains were run in separate ports until all 4 ports were sampled by both trains. Sampling was isokenetic with a sample volume of between 35.31 and 88.25 dscf (1-2.5 dscm) collected. All stack and train operating parameters were recorded at each sampling point.

The sampling duration at each location was as follows:
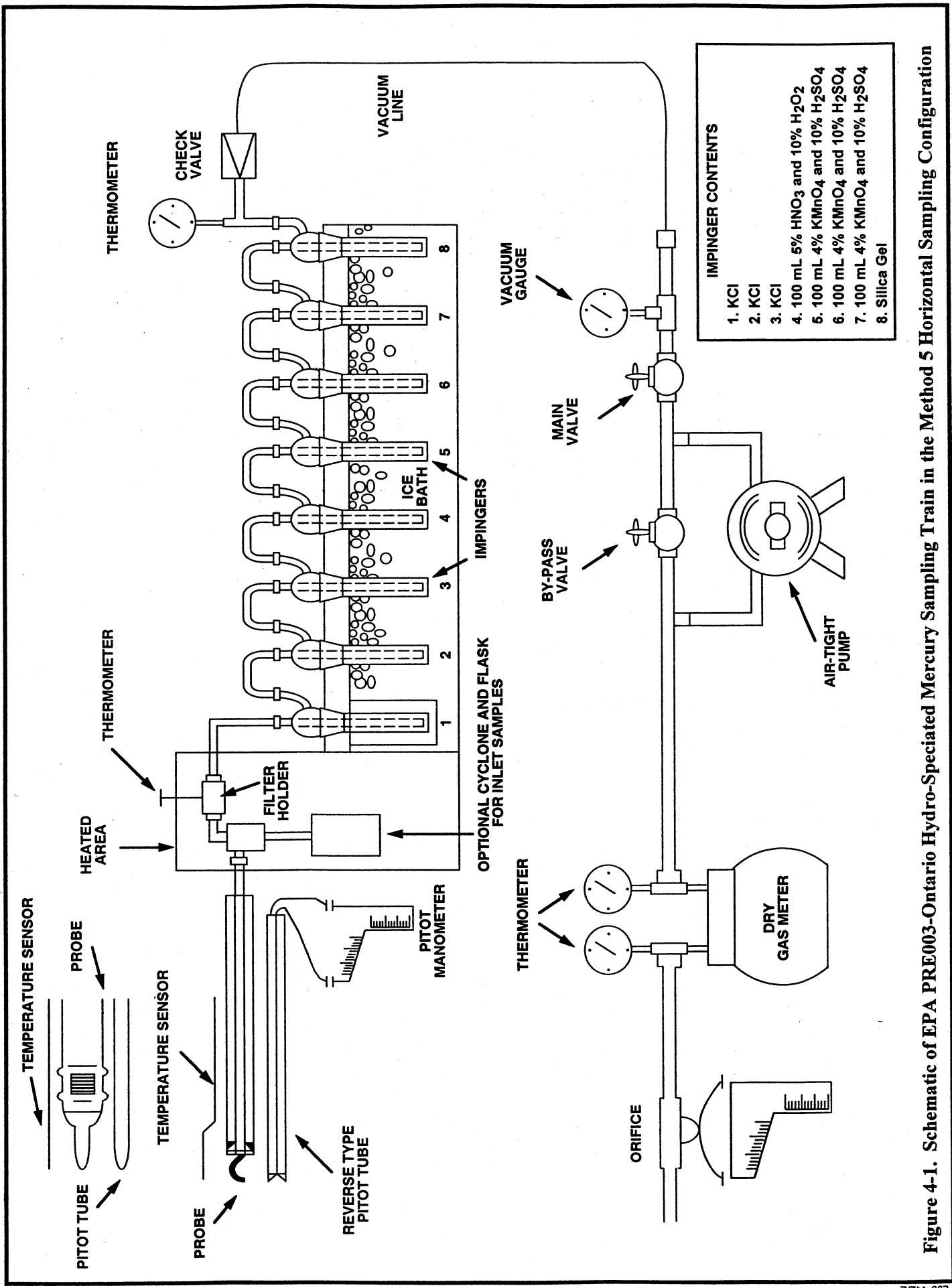
Figure 4-1. Schematic of EPA PRE003–Ontario Hydro-Speciated Mercury Sampling Train in the Method 5 Horizontal Sampling Configuration

IMPINGER CONTENTS

1. KCl
2. KCl
3. KCl
4. 100 mL 5% HNO_3 and 10% H_2O_2
5. 100 mL 4% $KMnO_4$ and 10% H_2SO_4
6. 100 mL 4% $KMnO_4$ and 10% H_2SO_4
7. 100 mL 4% $KMnO_4$ and 10% H_2SO_4
8. Silica Gel

3/99-442/E

Unit 1 Baghouse Inlet:

- The test duration was 150 minutes
- Each of the 25 traverse points were sampled for 6 minutes
- stack and train operating parameters were recorded every 3 minutes

Unit 1 & 2 Combined Exhaust Stack:

- The test duration was 144 minutes
- Each of the 24 traverse points were sampled for 6 minutes
- stack and train operating parameters were recorded every 3 minutes

Leak checks of the entire Ontario Hydro sampling trains were performed before and after each sampling run. All leak checks and leakage rates were documented on the relevant field test data sheets. The acceptance criterion was a post run leak rate of ≤ 0.02 cfm at the highest vacuum obtained during the test run. The pre run leak check criterion was ≤ 0.02 cfm at 15 in Hg.

Following the completion of each test run, the Ontario Hydro train was transported to a recovery area onsite. The sample recovery sequence was as follows:

- All openings on the probe, inlet to cyclone/or filter holder and impingers were sealed with teflon tape.

- The sampling train was removed to the recovery area.

- The condition of the train was noted (i.e., filter, impinger contents color, silica gel color, etc.).

- Container No. 1 - Disassembled the filter housing and transferred the filter to its original glass petri dish. Sealed the petri dish with Teflon^R tape and labeled it with the appropriate sample information. Any filter fibers adhering to the support gasket were transferred to the petri dish.

- Container 1B - The ash collected in the cyclone/flask from the inlet trains was transferred to a 250 mL amber wide mouth bottle. The bottle was sealed with teflon tape and labels.

- Container No. 2 - The front half of the train, nozzle, probe, and front-half filter housing, cyclone and flask were brush-rinsed with 100 mL of 0.1N nitric acid into an amber glass container with a Teflon^R-lined cap. The container was sealed and labeled.

- Container No. 3 - The contents of the first three KCl impingers were weighed. The filter support, backhalf of the filter holder and connecting glassware were rinsed with 0.1 N HNO_3 into a glass amber container with a Teflon lined cap. The 5% $KMNO_4$ solution was added to each impinger until a purple color remained. The solutions were then poured into the container. The impingers and connecting glassware were rinsed with 10% HNO_3. Although unlikely, if deposits remained on the impinger surfaces, they were removed by doing another 10% HNO_3 rinse that had a very small amount (several drops) of 10% hydroxylamine sulfate solution added to each of the KCl impingers. These rinses were added to Container 3. If the solution in Container 3 became clear, a small amount of the 5% $KMnO_4$ solution was added until a pink or slightly purple color was obtained. Checked again after 90 minutes to ensure that the purple color remained. Performed a final rinse of the impingers and connecting glassware with 0.1 N HNO_3 and added this rinse to Container 3. The container was sealed and labeled.

- Container No. 4 - The contents of the fourth impinger were weighed and transferred to a glass amber container with a Teflon^R-lined cap. The impinger and U-tubes were rinsed twice with three 25 mL portions of 0.1N nitric acid into a sample container. The container was sealed and labeled.

- Container No. 5 (Impingers 5 through 7, $H_2SO_4/KMnO_4$ Impinger Contents and Rinses) - Dried the exterior surfaces of Impingers 5, 6, and 7. Then weighed and recorded the weight of each impinger (to the nearest 0.5 g). Poured all of the liquid from the three H_2SO_4-$KMnO_4$ impingers into a glass sample, Container 5. Rinsed the impingers and connecting glassware with a 0.1 N HNO_3. If deposits remained on the impinger surfaces, after the two rinses, removed them by doing a third rinse with 0.1 N HNO_3 and several drops hydroxylamine sulfate. On a drop by drop basis added more hydroxylamine sulfate until the deposits were removed. Added these rinses to Container 5. If the solution in Container 5 became clear, added small amounts of H_2SO_4-$KMnO_4$ solution until a pink or slightly purple color was obtained. Performed a final 0.1 N HNO_3 rinse of the impingers and connecting glassware followed by a water rinse. The 0.1 N HNO_3 rinse was added to Container 5, and the water rinse was discarded. The container was sealed and labeled.

- The silica gel impinger was weighed to obtain a final weight.

- Solution Blanks (Containers 6 thru 10) - Solution blanks were taken each time new reagents were prepared.

- Container 6 - (0.1 N HNO_3 Blank) - Placed 50 mL of the 0.1 N HNO_3 solution used in the sample recovery process into a properly labeled container. Sealed the container.

- Container 7 (1 N KCl Blank) - Placed 50 mL of the 1 N KCl solution used as the impinger solution into a properly labeled container. Sealed the container.

- Container 8 (5% HNO_3 - 10% v/v H_2O_2 Blank) - Placed 50 mL of the HNO_3-H_2O_2 solution used as the nitric acid impinger reagent into a properly labeled container. Sealed the container.

- Container 9 (H_2SO_4 - $KMnO_4$ Blank) - Placed 50 mL of the H_2SO_4 - $KMnO_4$ solution used as the impinger solution in the sample recovery process into a properly labeled container. Refer to Note 4 in Section 13.2.10.5 of this method.

- Container 10 (10% Hydroxylamine Sulfate Blank) - Placed 100 mL of hydroxylamine sulfate solution into a properly labeled sample container. Sealed the container.

- Container 11 (Sample Filter Blank) - Once during each field test, placed into a properly labeled petri dish three unused blank filters from the same lot as the sampling filters. Sealed the petri dish.

- All containers were checked to ensure proper sealing, proper labeling, and that all liquid levels were marked. All samples were logged onto a chain-of-custody record.

The Ontario Hydro train produced the following samples:

- Container No. 1 - Filter
- Container No. 1B - Ash (Inlet only)
- Container No. 2 - Front-Half 0.1N HNO_3 Rinse
- Container No. 3 - Impingers 1, 2 & 3 KCl Impinger Catch & Rinse
- Container No. 4 - Impinger 4 - 0.1N HNO_3 Impinger Catch & Rinse
- Container No. 5 - Impingers 5 - 7 - $KMnO_4$ Impinger Catch & Rinse

4.3.4 EPA Method 3B for O_2 and CO_2

The O_2 and CO_2 concentrations in the integrated bag sample were analyzed onsite within four hours of the completion of the run with an Orsat analyzer as per EPA Method 3B, "*Gas Analysis for the Determination of Emission Rate Correction Factor Excess Air*". Three or more passes were made until three results were within 0.2% (absolute) of each other.

4.3.5 Process Sampling

4.3.5.1 Coal Sampling

An integrated composite sample of the "as-fired" coal was obtained for each unit during each sampling run according to ASTM D-2234-97.

The feeders for both Units 1 and 2 were sampled. The sampler utilized was a five foot long, two-inch diameter steel tube which was cut length wise leaving an open area 1.5 inches wide by 3 feet long. The ball valve was opened and the sampler inserted into the port with the open side inverted to the flowing coal. The tube opening was then turned into the flowing coal and pulled back through the coal column and out of the port. The sub sample was placed in a 5 gal precleaned plastic bucket. Every 30 minutes, three such sub samples were obtained from each of the feeders. A separate container was utilized for each feeder. A full container was obtained from each feeder for each run. At the completion of the run, the 4 containers were mixed and reduced by riffling to one composite sample contained in one 5 gal container for each of the units. The sample in the container for each run was treated according to ASTM 2013 at the laboratory to further reduce the composite to the required analytical sample size.

4.3.5.2 Limestone Sampling

A limestone sample was obtained every 15 minutes from each of the two belt feeders' sampling ports by opening the valve and filling a 500 mL sample jar by gravity. The ball valve for each sampling port was opened and purged by allowing the limestone to flow into a waste bucket. For each sampling period , two 500 ml sub-samples were obtained from each of the two feeders for each unit and placed in the 5 gallon precleaned plastic container. The composite for each unit was reduced by riffling to a 500 mL sample in a precleaned glass container.

4.3.5.3   ***Ammonia Sampling***

Composite samples were obtained during Runs 1, 2, and 3. Samples were taken at the ammonia disbursement racks for each unit. The sample lines were purged into a waste container prior to taking a sample. The composite sample for each run consisted of 250 mL from Unit 1 and 250 mL from Unit 2. The samples were analyzed in accordance with SW-846 Method 7470A.

4.4   PROCESS MONITORING

The facility operations data acquisition system (DAS) was utilized to record all operations data at one minute intervals. The data was averaged over the entire run period. Coal and limestone feed were also totalized over the run.

Operations data collected by the facility is incorporated in Appendix G. The following process data was obtained.

Coal feeders	feed rate K lb/hr and totalizer reading for each feeder
Limestone	feed rate K lb/hr and totalizer reading for each feeder
Electrical generation	KW
Main steam flow	K lb/hour
Main steam temp.	°F
Main steam pressure	PSIG
Reheater steamer flow	K lb/hr
Feed water flow	K lb/hr
Furnace draft	in H_2O
Wind box pressure	in H_2O
Air heater temperature	in °F, out °F
Gas recirculation rate	%
Mills in operation	Total #
Burners in operation	Total #
Combustion air flow	K lb/hr
Furnace O_2/CO	% and ppm
Bag House temp.	°F
Baghouse Δp	in H_2O

4.5   ANALYTICAL PROCEDURES

4.5.1   Mercury - Ontario Hydro Train Fractions

The Ontario Hydro train sample fractions samples were prepared according to Pre-003 and were analyzed for mercury by following the procedures in SW-846 Method 7470A. A schematic of the analytical process is shown in Figure 4-2.

The sampling train components were recovered and digested in the separate fractions. Materials collected in the sampling train were digested with acid solutions to dissolve inorganics and to remove organic constituents that may create analytical interferences. Acid digestion was performed using conventional or microwave digestion techniques.

All acid digested sample train fractions were analyzed for mercury by cold vapor atomic absorption spectroscopy (CVAAS) (SW 846 7470A).

4.5.2   Coal Analyses

The samples were analyzed for sulfur, mercury, chlorine, total moisture, proximate analysis, and gross calorific value (GCV) by the methods delineated below. A schematic of the analytical process is shown in Figure 4-3.

Coal Sampling and Analysis

- ASTM D2234-97a Standard Practice for the Collection of Representative Samples of Coal.
- ASTM D2013-86 (1994) Standard method for Preparing Coal samples for Analysis.
- ASTM D3684-94 Standard Test Method for Total Mercury in Coal by the Oxygen Bomb Combustion /Atomic Absorption Method.
- ASTM D4208 -88 Standard Test Method for Chlorine in Coal by the Oxygen Bomb Combustion/Ion Selective Electrode Method.
- ASTM D3302-97a Standard Test Method for Total Moisture in Coal.
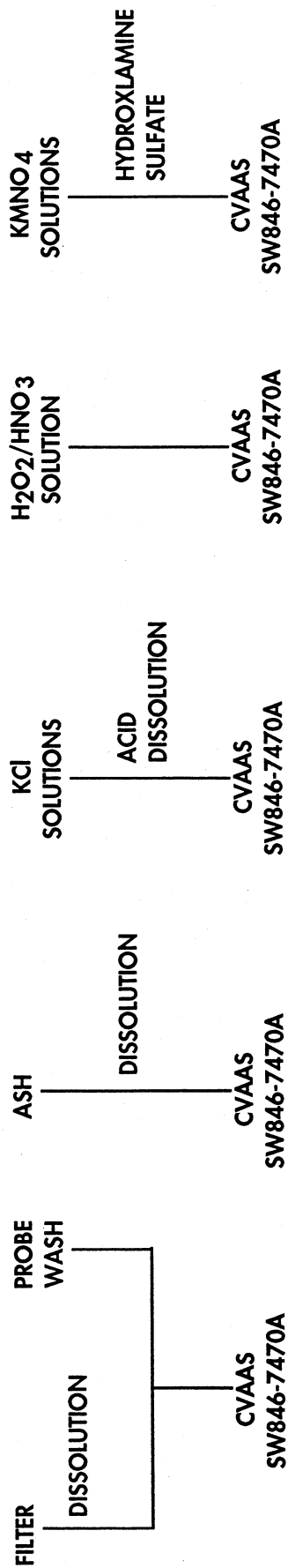
Figure 4-2. Analytical Scheme for EPA PRE003 Ontario Hydro Sampling Train Mercury Analysis

L99-442/G

COMPOSITE COAL SAMPLE
PREPARATION AND MOISTURE DETERMINATION
ASTM D2013 AND D3302

DRY COAL SUBSAMPLES

MERCURY ANALYSIS
ASTM D3684
DISSOLUTION IN
OXYGEN BOMB

ANALYSIS
SW846 7470A
CVAAS

SULFUR ANALYSIS
ASTM D4239-3.3
HIGH TEMP
COMBUSTION IR
DETECTION

CHLORINE
ANALYSIS
ASTM D2361

DILUTION IN
OXYGEN BOMB

POTENTIOMETRIC
TITRATION

GVC

ASTM D5865
BOMB
CALORIMETER

PROXIMATE
ANALYSIS

– ASH
– MOISTURE
– VOLATILE MATTER
ASTM D5142

Figure 4-3. Coal Sample Analytical Scheme

L99-442/H

4-14

- ASTM D5142-90 Standard Test Method for Proximate Analysis of the Analysis Sample of Coal and Coke by Instrumental Procedures.
- ASTM D 4239-97 Standard Test Methods for Sulfur in the Analysis Sample of Coal and Coke Using High Temperature Tube Furnace Combustion Methods.
- ASTM D 5865-98 Standard Test Method for Gross Calorific Value Of Coal and Coke
- EPA SW846 7470A Mercury in Liquid Waste (Manual Cold Vapor Technique).
- EPA SW846 7471A Mercury in Solid or Semi-Solid Waste (Manual Cold Vapor Technique).

The calculations for the concentration of pollutant in coal are given in each ASTM standard method. Pollutant concentrations were reported by the laboratory as follows:

Mercury	$\mu g/g$, (ppm)
Chlorine	$\mu g/g$, (ppm)
Sulfur	wt%, (lb/lb)
ash	wt%, (lb/lb)
moisture	wt%, (lb/lb)
gross heating value	Btu/lb

4.5.3   Limestone Analyses

The limestone samples were analyzed for mercury via SW846-7471A Mercury in Solid or Semi Solid Waste (Manual Cold Vapor Techniques).
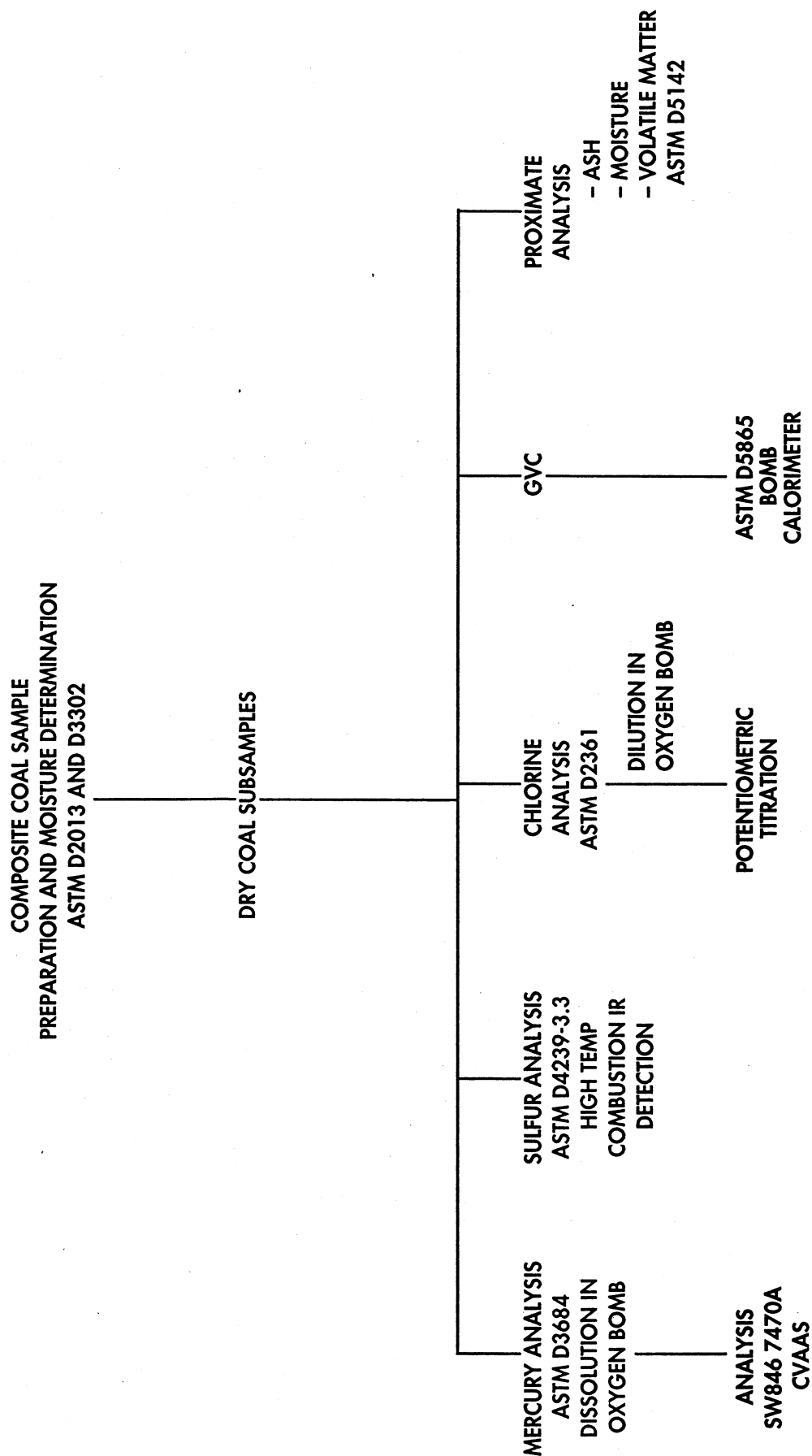
4.5.4   Ammonia Analyses

The ammonia samples were analyzed for mercury via SW846-7470A Mercury in Liquid Waste (Manual Cold Vapor Technique).

4.6   CALCULATIONS

4.6.1   Flowrates and Isokinetics

The sequential calculations for the determination of gas velocity at stack conditions (afpm), gas

volumetric flow rate at stack conditions (acfm), gas volumetric flow rate at standard conditions (dscfm), and isokinetics found in 40 CFR 60 Appendix A Methods 1-5 are presented below.

Calculations for Stack Volume and Isokinetic Ratio

Time =   TT
Dry Gas Meter, ft^3 =   VM
Pitot ΔP, in. H_2O = ΔP
Orifice ΔH, in. H_2O =   PM
Dry Gas Temp In, °F =   TMI
Dry Gas Temp Out, °F =   TMO
Stack Static Pressure, in. H_2O =   PST
Stack Temp, °F =   TS

1.   DN = Nozzle Diameter, inches

2.   PB = Barometric Pressure, inches Hg

3.   TT = Net Sampling Time, minutes

4.   VM = VM final - VM initial = Sample Gas Volume, ft^3

4A.   VML = Use only if any final or intermediate leak check rate is over 0.02 cfm
      LI =   Leak rate after any given sampling period, cfm
      TLI =   Total time of sample period in which leak occurred, minutes
      VML = VM - [(L1 - 0.02) TLI + (L2 - 0.02) TL2 + (L3 - 0.02) TL3 + (L4 - 0.02) TL4] =

5.   Average Dry Gas Temperature at meter, °F

      $$TM = \frac{\text{Average TMI} + \text{Average TMO}}{2}$$

6.   Average Orifice Pressure Drop, inches Hg

      $$PM = \frac{\text{Average } \Delta H, \text{ in. } H_2O}{13.6}$$

7.   Volume of dry gas sampled at standard conditions, dscf [a]

      $$VMSTD = \frac{528 \times (Y) \times (VM) \times (PB + PM)}{29.92 \times (TM + 460)}$$

      Y =   dry gas meter calibration factor

8.   Total Water Collected

VW =   gm H_2O silica gel + gm impinger H_2O

Note: If ml H_2O is measured - (ml × 0.9982 gm/ml = ____ gm)

9.   Volume of water vapor at standard conditions, scf[b]

VW gas =   0.04715 × VW

10. Percent moisture in stack gas

$$\% M = \frac{100 \times VW\ gas}{VMSTD + VW\ gas}$$

10a. Percent moisture in stack gas - saturation (wet bulb/dry bulb method)

$$\% M = \frac{VP}{PS} \times 100$$

PS =   Stack Pressure, absolute, inches Hg = PB ± Avg PST
PST = Stack static pressure

$$PST = \frac{PST\ in.\ H_2O}{13.6}$$

PS =   PB ± Average PST
TS_{dry} =   Stack Temperature, dry
TS_{wet} =   Stack Temperature, wet
        Note: When TS_{dry} = TS_{wet}, the gas stream is saturated
SVP = water saturation vapor pressure at TS_{wet}

$$VP = SVP - \left[0.00367 \times (PS) \times (TS_{dry} - TS_{wet}) \times \left(1 + \left(\frac{TS_{wet} - 32}{1571} \right) \right) \right]$$

11. Mole Fraction of dry gas (dimensionless)

$$MD = \frac{100 - \%M}{100}$$

Note: The proper %M must be used in this calculation. The % vapor moisture can
       never be greater than the saturation value at given stack temperature. If 10
       is greater than 10a, this is an indication of water droplets in the gas stream.
            If 10 < 10a - use 10 %M in calculation
            If 10 > 10a - use 10a %M in calculation

12. Molecular weight of dry stack gas

$$MWD = (\% CO_2 \times 0.44) + (\% O_2 \times 0.32) + [(\% CO + \% N_2) \times 0.28]$$

12a. % Excess Air

$$\%EA = \frac{[(\% O_2) - 0.5 \times (\% CO)] \times 100}{[(0.264) \times (\% N_2)] - (\% O_2) + 0.5 \times (\% CO)}$$

13. Molecular Weight of wet stack gas

$$MW = (MWD \times MD) + 18 \times (1 - MD)$$

14. AS = Stack Area, square inches

$$Circular = \left(\frac{stack\ diameter}{2}\right)^2 \pi$$

Rectangular = Length × Width

15. PS = Stack Pressure, absolute, inches Hg = PB ± Avg PST
PST = Stack static pressure

$$PST = \frac{PST\ in.\ H_2O}{13.6}$$

PS = PB ± Average PST

16. TS_{avg} = Average Stack Temperature

17. $$SDE_{avg} = \left(\sqrt{\Delta P}\right)_{avg} \times \sqrt{TS_{avg} + 460}$$

18. Stack gas velocity at stack conditions, afpm

$$VS = 5130^C \times Cp \times SDE_{avg} \times \left[\frac{1}{PS \times MW}\right]^{1/2}$$

Cp = pitot tube coefficient

19. Stack gas volumetric flow rate at stack conditions, acfm

$$Q_a = \frac{VS \times AS}{144}$$

20. Stack gas volumetric flow rate at standard conditions, dscfm[e]

$$Q_s = \frac{Q_a \times 528 \times MD \times PS}{(29.92) \times (TS_{avg} + 460)}$$

21. Percent Isokinetics

$$\%ISO = \frac{1039^f \times (TS_{avg} + 460) \times VMSTD}{VS \times TT \times PS \times MD \times (DN)^2}$$

---

[a] = Dry standard cubic feet at 68°F (528°R) and 29.92 in. Hg

[b] = Standard conditions at 68°F (528°R) and 29.92 in.Hg

[c] = $$5130 = \frac{ft}{85.5 \quad sec} \left[\frac{(lb/lb\text{-}mole) \times (in.\ Hg)}{(°R) \times (in.\ H_2O)} \right] \times 60\ sec/min$$

[d] = Actual cubic feet per minute

[e] = Dry standard cubic feet per minute at 68°F (528°R) and 29.92 in.Hg

[f] = $$1039 = \frac{29.92\ in.\ Hg}{528°R} \times \frac{144\ in.^2}{ft^2} \times \frac{4}{\pi} \times 100$$

4.6.2 Calculation for Particle Bound, Oxidized, Elemental and Total Mercury Concentrations

The calculations for mercury species (i.e., as collected by the Ontario Hydro Sampling Train) are presented below. These are excerpted from Method Pre-003.

4.6.2.1 *Particle-Bound Mercury*

4.6.2.1.1 *Case 1: Amount of Ash on the Filter is Greater Than 0.5 g*

Calculate the concentration of mercury in ug/g in the ash sample (Hg_{ash}) using Equation 8:

$$Hg_{ash}, \mu g / g = (IR)(DF) \qquad \text{[Eq. 8]}$$

where:

IR   =   instrument reading, $\mu g/L$

DF   =   dilution factor = (total digested volume, L)/(mass of ash digested, g)

Calculate the amount of mercury in the probe rinse (Hg_{pr}, Container 2) in μg using Equation 9:

$$Hg_{pr}, \mu g = (IR)(V_1) \qquad \text{[Eq. 9]}$$

where:

IR   =   instrument reading, $\mu g/L$

V_1 =   total volume of probe rinse sample from which sample aliquot was taken, L.

Calculate the amount of mercury on the sample filter blank (Hg_{fb}) in the same way using Equation 10:

$$Hg_{fb}, \mu g = (IR)(V_2) \qquad \text{[Eq. 10]}$$

where:

IR   =   instrument reading, $\mu g/L$

V_2 =   total volume of sample filter blank digest, L.

The total amount of particle-bound mercury (Hg_{tp}) then is determined using Equation 11:

$$Hg(particle), mg = (Hg_{ash})(W_{ash}) - Hg_{fb} + Hg_{pr} \qquad \text{[Eq. 11]}$$

where:

W_{ash} =   the total ash weight on filter, g

The concentration of particle-bound mercury ($\mu g/dscm$) in the gas stream is then determined using Equation 12:

$$Hg^{tp}, \mu g / dscm = Hg(particle) / V_{m(std)} \qquad \text{[Eq. 12]}$$

where:

$V_{m(std)}$ = total volume of dry gas sampled at standard (normal) conditions, dscm

4.6.2.1.2 Case 2: Amount of Ash on the Filter is Less than 0.5 g

The calculation is the same as in Case 1 except the entire sample (ash and filter) is digested; therefore, DF in Equation 8 is defined only by the total digested volume. Equations 9-11 remain the same.

4.6.2.2 Oxidized Mercury

4.6.2.2.1 KCl Solution (Impingers 1-3)

Calculate the concentration of mercury in µg/L in the KCl impinger solutions using Equation 13:

$$Hg_{KCl}, \mu g / L = (IR)(DF) \qquad \text{[Eq. 13]}$$

where:

IR = instrument reading, µg/L

DF = $\dfrac{\text{dilution factor} = V_D + V(H_2SO_4) + V(HNO_3) + V(KMnO_4) + V(K_2S_2O_8) + V(NH_2OH)}{V_D}$

V_D = total digested volume, 10 mL

$V(H_2SO_4)$ = volume of added concentrated H_2SO_4, 0.5 mL

$V(HNO_3)$ = volume of added concentrated HNO_3, 0.5 mL

$V(KMnO_4)$ = volume of added 5% w/v $KMnO_4$, 1.5 mL

$V(K_2S_2O_8)$ = volume of added 5% w/v $K_2S_2O_4$, 0.75 mL

$V(NH_2OH)$ = volume of added 10% w/v hydroxylamine sulfate, 1.0 mL

The amount of mercury in the KCl solution blank is calculated in the same way.

4.6.2.2.2   Total Oxidized Mercury (Hgo)

Total Oxidized Mercury (Hgo) is defined by method as the mercury measured in the KCl sample minus the mercury measured in the KCl solution blanks as shown in Equation 14:

$$Hg_o, \mu g = (Hg_{KCl})(V_3) - (Hg_{Ob})(V_3) \qquad \text{[Eq. 14]}$$

where:

Hg_{KCl} = Mercury concentration measured in KCl aliquot, $\mu g/L$

V_3 = Total volume of aqueous KCl from which sample aliquot was taken, L

Hg_{Ob} = Mercury concentration measured in KCl solution blank aliquot, $\mu g/L$

The concentration of Hg^{2+} ($\mu g/dscm$) in the gas stream is then determined using Equation 15:

$$Hg^{2+}, \mu g / dscm = Hg_o / V_{m(std)} \qquad \text{[Eq. 15]}$$

where:

$V_{m(std)}$ = Total volume of dry gas sampled at standard conditions, dscm

4.6.2.3   Elemental Mercury

4.6.2.3.1   HNO$_3$-H$_2$O$_2$ Solution (Impinger 4)

Calculate the concentration of mercury in $\mu g/L$ in the HNO_3-H_2O_2 impinger solution using Equation 16:

$$Hg_{H2O2}, \mu g / L = (IR)(DF) \qquad \text{[Eq. 16]}$$

where:

IR = instrument reading, $\mu g/L$

DF = dilution factor = $\dfrac{V_D + V(HCl) + V(KMnO_4) + V(K_2S_2O_8) + V(NH_2OH)}{V_D}$

V_D	=	total digested volume, 5 mL
V(HCl)	=	volume of added concentration HCl, 0.25 mL
V(KMnO$_4$)	=	volume of added saturated KMnO$_4$, mL (volume needed to turn sample to a purple color)
V(K$_2$S$_2$O$_8$)	=	volume of added 5% w/v K$_2$S$_2$O$_4$, 0.75 mL (if used)
V(NH$_2$OH)	=	volume of added 10% w/v hydroxylamine sulfate, 1.0 mL

The amount of mercury in the HNO$_3$-H$_2$O$_2$ solution blank is calculated in the same way.

4.6.2.3.2   *H$_2$SO$_4$-KMnO$_4$ Solution (Impingers 5-7)*

Calculate the concentration of mercury in µg/L in the H$_2$SO$_4$-KMnO$_4$ impinger solutions using Equation 17:

$$\text{Mercury}, \mu g / L = IR \qquad \text{[Eq. 17]}$$

where:

IR   =   instrument reading, µg/L

There is no dilution factor since no addition is made to the solution after the aliquot is taken for analysis. The concentration of mercury in the H$_2$SO$_4$-KMnO$_4$ solution blank is calculated in the same way.

4.6.2.3.3   *Total Elemental Mercury (Hg$_E$)*

Total Elemental Mercury (Hg$_E$) is defined by method as the mercury measured in the H$_2$SO$_4$-KMnO$_4$ impingers plus the mercury in the HNO$_3$-H$_2$O$_2$ impingers minus the solution blanks as shown in Equation 18:

$$Hg_E, \mu g = (Hg_{H202})(V_4) - (Hg_{Eb1})(V_4) + (Hg_{KMnO4})(V_5) - (H_{Eb2})(V_5) \qquad \text{[Eq. 18]}$$

where:

Hg_{H2O2} = Mercury concentration measured in HNO_3-H_2O_2 aliquot, μg/L

V_4 = Total volume of aqueous HNO_3-H_2O_2 from which sample aliquot was taken, L

Hg_{Eb1} = Mercury concentration measured in HNO_3-H_2O_2 solution blank aliquot, μg/L

HB_{KMNO4} = Mercury concentration measured in H_2SO_4-$KMnO_4$ aliquot μg/L

V_5 = Total volume of aqueous H_2SO_4-$KMnO_4$ from which sample aliquot was taken, L

Hg_{Eb2} = Mercury concentration measured in H_2SO_4-$KMnO_4$ solution blank aliquot, μg/L

The concentration of Hg^0 (μg/dscm) in the gas stream is then determined using Equation 19:

$$Hg^0, \text{μg/dscm} = Hg_E/V_{m(std)} \qquad \text{[Eq. 19]}$$

where:

$V_{m(std)}$ = Total volume of dry gas sampled at standard conditions, dscm

4.6.2.4 *Total Mercury*

Total mercury is defined by the method as the sum of the particulate bound mercury, oxidized mercury, and elemental mercury as shown in Equation 20:

$$Hg(total), \text{μg/dscm} = Hg^{tp} + Hg^{2+} + Hg^o \qquad \text{[Eq. 20]}$$

4.6.3 Emission Rate of Mercury Species

The following equation is used for each species.

$$\text{lb/hr} = \frac{\text{μg/dscf mercury species x Qs dscfm x 60 min/hour}}{453.59 \text{ x } 10^6 \text{ μg/lb}}$$

$$mg/hr = \frac{lb}{hour} \times \frac{453,590 \text{ mg}}{lb}$$

4.6.4 Mercury Removal Efficiency of Pollution Control System for each Species

$$RE = \frac{[(total\ inlet\ mg/hr) - (outlet\ mg/hr)]\ x100}{total\ inlet\ mg/hr} = \%$$

4.6.5 Total Mercury Introduced into the Combustion Unit

Mercury From Process Streams:

$$\frac{mg}{hr} = \left(\mu g\ /\ g\ in\ feed\right) \times \left(\frac{1000\,lbs}{Klb}\right) \times \left(\frac{453,590\,mg}{lb}\right) \times \left(\frac{1\,mg}{10^3\,\mu g}\right)$$

$$\frac{lb}{hr} = \frac{mg}{hr}\ x\ \frac{1}{453,590\,lb}$$

Total mercury to pollution control system:

mg/hr total = mg/hr coal + mg/hr limestone + mg/hr ammonia

SECTION 5.0
QUALITY ASSURANCE

5.1   OVERVIEW

Quality Assurance/Quality Control (QA/QC) protocols followed during this program were based on the procedures of the methods employed, as well as any additional measures outlined in the Quality Assurance Program Plan entitled; *"Quality Assurance Program Plan Mercury Emissions From Electric Utility Coal Fired Steam Generators Test Program US Generating Company"*, September 1999. Results of the QA/QC activities employed during this program are provided in this section.

As part of TRC's ongoing quality control for data reduction and reporting, all calculations are done using standardized EPA equations. TRC routinely reduces field data on a daily basis using a personal computer with software containing validated EPA equations. Isokinetics were determined at the end of each test day. Data such as those shown in the attached Appendices were generated each day, with the exception of pollutant concentrations and emission rates, which were obtained after sample analyses were completed.

5.2   FIELD QUALITY CONTROL SUMMARY

5.2.1   Calibration Procedures

Calibration of the field sampling equipment was performed by TRC prior to the field sampling effort. Copies of the calibration sheets were submitted to the field team leader to take onsite and for inclusion in the project file. Calibrations were performed as described in the EPA publications *"Quality Assurance Handbook for Air Pollution Measurement systems; Volume III - Stationary Source Specific Methods,"* (EPA-600/4-77-027b) and EPA 40 CFR Part 60, Appendix A. Equipment that was calibrated included the sample metering system, nozzles, barometers, thermocouples and pitot tubes. Pitot specific coefficients were determined for all pitots utilized

during the test program by wind tunnel calibration in accordance with EPA Method 2 criteria. All calibrations were available for review during the test program. Copies of the equipment calibration forms can be found in Appendix B.2.

5.2.2 Equipment Leak Checks

Prior to sampling, each sampling train was leak checked according to the procedures outlined in EPA Reference Method 5. During the course of a test run, a leak check was conducted before and after every test or if replacement of a component became necessary. Final leak checks were performed to ensure that no leaks developed in the train during the course of the test run. All leakage rates were recorded on the Isokinetic Sampling Data sheets presented in the Appendices. Leak check results for all sampling trains met method acceptance criteria.

5.2.3 Cyclonic Flow Check

The absence of cyclonic flow was verified in accordance with Section 2.4 of EPA Method 1 during preliminary traverses conducted at each sampling location.

5.2.4 Field Blanks

Field blanks for both the inlet and outlet locations were taken during the setup day prior to the first test run. The field blanks were taken to each location, leak checked, and allowed to stay at the sampling location for the same time duration as a test run. At the completion of the time period, the blank trains were leak checked and brought down to the mobile laboratory for recovery. The glassware used for the field blanks were then recycled for Test Run 2 inlet and outlet samples.

5.3   SAMPLE HANDLING

This section presents the sample handling, sample traceability, chain-of-custody (COC) procedures, sample transport and field documentation that TRC followed for the test program.

5.3.1   Sample Traceability

The purpose of sample traceability procedures was to document the identity of the sample and its handling from its first existence as a sample until analysis and data reduction were completed. Custody records traced a sample from its collection through all transfers of custody until it was transferred to the analytical laboratory. Internal laboratory records then documented the custody of the sample through its final disposition.

Sample integrity was maintained throughout all sampling and analysis programs. In accordance with SW-846, a sample was considered to be under a person's custody if the sample was:

- In that person's physical possession.
- In view of that person after acquiring possession.
- Secured by that person so that no one could tamper with the sample.
- Secured by that person in an area which was restricted to authorized personnel.

These criteria were used to define the meaning of "custody" and to ensure the integrity of the test program samples from collection to data reporting. Restricted access to the samples was an integral part of the COC procedure.

Samples were held within sight of the samplers or sample custodian, or were kept in sealed and secured containers at all times. Sealed containers were used to ship the samples to the laboratory.

5.3.2 Chain-of-Custody Documentation

5.3.2.1   *Labeling*

Sample identification labels were used by TRC to ensure that the required information was entered in the field. Sample labels were affixed to each appropriate process sample container for process samples at the time of collection. Exhaust gas sample labels were affixed to the appropriate container at the time of sample recovery. All samples collected during the test were labeled following the designated code system as stated in the Site Specific Test Plan (SSTP). Each sample label was preprinted prior to the test.

5.3.2.2   *Field Logbook*

A permanently-bound field logbook was maintained by TRC's Field Team Leader. Information pertinent to the sampling was recorded in a sampling log. All entries were made in indelible ink and all corrections followed error correction protocol of one line through the error, initial of the person performing the correction and the date of the correction. Sampling personnel also recorded all information on the appropriate sampling forms.

5.3.2.3   *Chain-of-Custody Forms*

To establish the documentation necessary to trace sample possession from the time of collection, a COC form was filled out (in four parts) and accompanied every sample or group of individually identified samples. Each person who had custody signed the COC form.

5.3.3 Sample Shipping

Samples were packaged and shipped according to U.S. Department of Transportation, International Air Transportation Authority, and EPA regulations. Samples were delivered to the laboratory so that the requested analyses were performed within the specified allowable holding

time. Samples were accompanied by the COC form. The COC form listed the variables to be analyzed by the laboratory and the total number and type of samples shipped for analysis. Authorized laboratory personnel acknowledged receipt of shipment by signing and dating the COC form.

5.4 LABORATORY QUALITY CONTROL SUMMARY

As a routine QA/QC procedure, the laboratory analyzed blank and spike samples. The blank samples included laboratory reagents (method blanks), field blanks, and reagent blanks. Method blanks are used to measure any contaminants which may be introduced to the sample during sample handling in the laboratory. Field blanks are used to measure any contaminants which may be introduced to the samples from the sampling equipment and sampling technique.

Reagent blanks help measure any sample contamination which may have occurred in the reagents used to prepare and recover the sampling trains. The spike samples consisted of matrix spikes, matrix spike duplicates (MS/MSD) and blank spikes. The matrix and blank spikes were used to check the performance and the recovery efficiency of the various analytical methods used in this work.

The precision of analyses was measured by performing spikes and spike duplicates with the analytes of interest. The difference between duplicate analyses (MS/MSD) was used to estimate the precision of the analyses and the recovery of the spike samples was used to estimate the bias (accuracy) of the analysis.

The following subsections detail the Laboratory QC measures performed on the samples which were collected during this program.

5.4.1 Mercury in Exhaust Gases

Exhaust gases were sampled for mercury utilizing the Draft Ontario-Hydro Speciated Mercury

sample train.   The analysis of the samples for mercury determination was accomplished using cold-vapor atomic absorption spectroscopy. Instrument calibration and calibration verification was performed in accordance with the above mentioned method.

5.4.1.1 *Spike and Spike Duplicates*

The results of matrix spikes and matrix spike duplicates and a laboratory blank spike and blank spike duplicate prepared and analyzed along with the samples are presented in Table 5-1. The results presented in the table indicate that the analytical system was in control for the analysis of the samples.

5.4.1.2 *Duplicate Analysis*

The results of the duplicate analysis of a prepared sample from both the inlet and outlet locations are presented in Table 5-2. The duplicate results indicate that precision of the instrument was within method criteria.

5.4.1.3 *Blank Results*

Table 5-3 presents the results of the mercury analysis of the reagent and field blanks. As can be seen in Table 5-3, no mercury contamination was detected in either the reagent blanks or the field blanks.

5.4.1.4 *Paired Sampling Trains*

During this sampling program, paired samples were collected at both the inlet and outlet locations to the control device. Paired samples were obtained by collecting exhaust gas using two sampling trains at the same location at the same time. The results (reported in ug/dscm) of the paired samples are presented in Table 5-4. Although no precision criteria was stated in the QA plan for paired samples, TRC has used the limit of 50% RPD as an indicator that a loss in precision is

occurring. In addition, the percent relative standard deviation (RSD) has been calculated for the entire data set to aid in the assessment of the precision of the entire data set.

The table shows that two components (KCl and $HNO_3/KMnO_4$) of the inlet train Run 1 pair have an RPD greater than 50%. Comparison of the Inlet A Run 1 train results with the remainder of the sample train results shows that the Run 1 inlet A train may be biased high. Comparison of the Run 1 inlet A train KCL result with the average KCl result from the remainder of the sample set shows that the Run 1 inlet A result is approximately 3.8 times higher than the average. The same comparison for the $HNO_3/KMnO_4$ fraction shows that the Run 1 inlet A train result is approximately 3 times the average result. Based on these observations, it is recommended that the KCl and $HNO_3/KMnO_4$ fractions of Run 1 inlet A should be considered estimated and possibly biased high. It must also be pointed out that on average the KCl and $HNO_3/KMnO_4$ fractions accounted for less than 0.5% of the total Hg measured at the inlet location. With this in mind, the presence of any such bias would not have had a significant impact on the reported results.

5.4.1.5   *Audit Sample Analysis*

As required by the Ontario-Hydro method, an audit sample was analyzed along with the samples. The audit sample was obtained by the National Institute for Standards and Technology (NIST). The audit sample was prepared and analyzed with percent recovery of 99%. The recovery of the audit sample analysis was well within acceptance limits of 90 - 110% recovery. The result of the audit sample analysis can be found in the analytical data package located in Appendix D.

5.4.2 Analysis of the Process Feed Samples

The process samples were analyzed for the parameters;

- Coal - mercury, sulfur, chlorine, and higher heating value,
- Lime Slurry - mercury

- Ammonia - mercury.

The quality control data submitted with the analytical results indicate that the analytical process was within method specifications and the results should be considered valid.

TABLE 5-1. SPIKE/SPIKE DUPLICATE RESULTS

Component:	Front Half								
	Spike	Sample	Measured Conc.		Percent Rec.				
	Conc.	Conc.	MS	MSD	MS	MSD	Limit	RPD	Limit
Sample ID(s):	(ug)	(ug)	(ug)	(ug)					
Blank Spike	0.1	0	0.095	0.095	95%	95%	75-125%	0.00%	20%
Inlet b Run 3	5	3.1	7.9	7.9	96%	96%	75-125%	0.00%	20%
Outlet a Run 1	0.1	0	0.10	0.10	100%	100%	75-125%	0.00%	20%
Outlet a Run 2	0.1	0	0.10	0.10	100%	100%	75-125%	0.00%	20%

Component:	KCl								
	Spike	Sample	Measured Conc.		Percent Rec.				
	Conc.	Conc.	MS	MSD	MS	MSD	Limit	RPD	Limit
Sample ID(s):	(ug)	(ug)	(ug)	(ug)					
Blank Spike	0.3	0	0.31	0.3	102%	100%	75-125%	1.65%	20%
Inlet a Run 3	0.7	0.62	1.31	1.31	103%	103%	75-125%	0.00%	20%
Outlet a Run 3	0.7	0.079	0.78	0.78	105%	105%	75-125%	0.00%	20%
Outlet a Run 2	0.67	0.1	0.77	0.78	100%	101%	75-125%	1.29%	20%

Component:	KMnO$_4$								
	Spike	Sample	Measured Conc.		Percent Rec.				
	Conc.	Conc.	MS	MSD	MS	MSD	Limit	RPD	Limit
Sample ID(s):	(ug)	(ug)	(ug)	(ug)					
Blank Spike	0.3	0	0.3	0.3	101%	101%	75-125%	0.00%	20%
Inlet b Run 2	0.7	0.11	0.64	0.69	78%	85%	75-125%	7.52%	20%

Component:	HNO$_3$/H$_2$O$_2$								
	Spike	Sample	Measured Conc.		Percent Rec.				
	Conc.	Conc.	MS	MSD	MS	MSD	Limit	RPD	Limit
Sample ID(s):	(ug)	(ug)	(ug)	(ug)					
Blank Spike	0.1	0	0.05	0.05	100%	100%	75-125%	0.00%	20%
Inlet b Run 1	2.8	0	2.8	2.8	100%	100%	75-125%	0.00%	20%

TABLE 5-2   LABORATORY DUPLICATE RESULTS

Field Sample ID.: Component	Inlet a Run 4 (mg/Kg)	Reporting Limit (mg/Kg)	Inlet a Run 4 (mg/Kg)	Reporting Limit (mg/Kg)	RPD	RPD Limit
Fly Ash	1.3	0.04	1.3	0.04	0.00%	25%
Field Sample ID.: Component	Inlet b Run 3 (ug)	Reporting Limit (ug)	Inlet b Run 3 (ug)	Reporting Limit (ug)	RPD	RPD Limit
Front Half	3.1	0.01	3.1	0.01	0.00%	25%
Field Sample ID.: Component	Inlet a Run 3 (ug)	Reporting Limit (ug)	Inlet a Run 3 (ug)	Reporting Limit (ug)	RPD	RPD Limit
KCl	0.62	0.03	0.62	0.03	0.00%	25%
Field Sample ID.: Component	Inlet b Run 2 (ug)	Reporting Limit (ug)	Inlet b Run 2 (ug)	Reporting Limit (ug)	RPD	RPD Limit
$KMnO_4$	0.11	0.03	0.13	0.03	16.7%	25%
Field Sample ID.: Component	Inlet b Run 1 (ug)	Reporting Limit (ug)	Inlet b Run 1 (ug)	Reporting Limit (ug)	RPD	RPD Limit
HNO_3/H_2O_2	<0.25	0.01	<0.25	0.01	0.0%	25%
Field Sample ID.: Component	Outlet a Run 1 (ug)	Reporting Limit (ug)	Outlet a Run 1 (ug)	Reporting Limit (ug)	RPD	RPD Limit
Front Half	<0.05	0.01	<0.05	0.01	0.0%	25%
Field Sample ID.: Component	Outlet a Run 3 (ug)	Reporting Limit (ug)	Outlet a Run 3 (ug)	Reporting Limit (ug)	RPD	RPD Limit
KCl	0.079	0.03	0.088	0.03	10.78%	25%

TABLE 5-3   BLANK RESULTS

Field Sample ID.: Component	Reagent Blank (ug)	Inlet Field Blank (ug)	Outlet Field Blank (ug)
Front Half	<0.01	<0.01	<0.01
KCl	<0.03	<0.03	<0.03
KMnO4	<0.03	<0.03	<0.03
HNO3/H2O2	<0.25	<0.25	<0.25

TABLE 5-4. PAIRED SAMPLE TRAIN RESULTS

Component	Ia Run 1 ug/dscm	Ib Run 1 ug/dscm	RPD	Ia Run 2 ug/dscm	Ib Run 2 ug/dscm	RPD	Ia Run 3 ug/dscm	Ib Run 3 ug/dscm	RPD	RSD
Front Half (part.)	134.9	147.3	9	66.4	98.6	39	73.8	58.9	23	43%
KCl	0.8	0.26	101	0.28	0.33	17	0.11	0.08	36	94%
HNO3/KMnO$_4$	0.42	0.152	94	0.125	0.153	20	0.12	0.12	1	86%
Total Hg	136.1	147.8	8	66.8	99.1	39	74.1	59.1	23	43%

Component	Oa Run 1 ug/dscm	Ob Run 1 ug/dscm	RPD	Oa Run 2 ug/dscm	Ob Run 2 ug/dscm	RPD	Oa Run 3 ug/dscm	Ob Run 3 ug/dscm	RPD	RSD
Front Half (part.)	0.004	0.004	0	0.004	0.004	7	0.004	0.004	10	4%
KCl	0.043	0.056	25	0.042	0.031	30	0.031	0.029	6	29%
HNO3/KMnO$_4$	0.121	0.120	1	0.116	0.123	6	0.11	0.119	9	4%
Total Hg	0.169	0.180	6	0.162	0.158	2	0.14	0.152	6	8%

Ia = Inlet train a   Ib = Inlet train b   Oa = Outlet train a   Ob = Outlet train b
TRC advisory limit = 50% RPD.