

February 29, 2000

Detroit Edison



Mr. William Grimley/Ms. Lara Autry
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/Ms. Autry:

Enclosed please find one copy of the final report "Source Emissions Survey" for the Mercury Speciation Sampling on Unit 4 located at Detroit Edison Company's, St Clair Power Plant, East China, Michigan.

Should you have any questions on the information contained in the enclosed submittal, please direct your comments to Mr. Mark Mullen, Air Quality Engineer, Detroit Edison, 6100 West Warren, H-136, Detroit, Michigan 48210. Mr. Mullen may be reached at (313) 897-0298 or via email at mullenm@dteenergy.com.

Sincerely,

A handwritten signature in black ink, appearing to read "Mark Mullen".

Mark Mullen
Environmental Management & Resources

Attachment

FILE: epa-report.doc

Cc: Tom Batts – St Clair Power Plant
Dennis Leonard - EMR



P.O. Box 598
Addison, TX 75001
(972) 931-7127

**SOURCE EMISSIONS SURVEY
OF
THE DETROIT EDISON COMPANY
ST. CLAIR POWER PLANT
UNIT NUMBER 4 PRECIPITATOR NORTH INLET DUCT
AND UNIT NUMBER 4 STACK
EAST CHINA, MICHIGAN**

NOVEMBER 1999

FILE NUMBER 99-158

TABLE OF CONTENTS

1	INTRODUCTION	1-1
1.1	<u>Summary of Test Program</u>	1-1
1.2	<u>Key personnel</u>	1-1
2	SOURCE AND SAMPLING LOCATION DESCRIPTIONS	2-1
2.1	<u>Process Description</u>	2-1
2.1.1	<u>Coal Handling</u>	2-1
2.1.2	<u>Boiler Operation</u>	2-1
2.2	<u>Control Equipment Description</u>	2-4
2.2.1	<u>Precipitator</u>	2-4
2.2.2	<u>Flyash and Bottom Ash</u>	2-7
2.3	<u>Flue Gas and Process Sampling Locations</u>	2-7
2.3.1	<u>Inlet Sampling Location</u>	2-7
2.3.2	<u>Stack Sampling Location</u>	2-8
2.3.3	<u>Coal Sampling Location</u>	2-8
3	SUMMARY AND DISCUSSION OF RESULTS	3-1
3.1	<u>Objectives and Test Matrix</u>	3-1
3.1.1	<u>Objective</u>	3-1
3.1.2	<u>Test Matrix</u>	3-1
3.2	<u>Field Test Changes and Problems</u>	3-3
3.3	<u>Handling of Non-Detects</u>	3-3
3.3.1	<u>A single analytical fraction representing a subset of a mercury species is not detected</u>	3-3
3.3.2	<u>All fractions representing a mercury species are not detected.</u>	3-3
3.3.3	<u>No mercury is detected for a species on all three test runs.</u>	3-4
3.3.4	<u>Mercury is detected on one or two of three runs.</u>	3-4
3.4	<u>Summary of Results</u>	3-5
4	SAMPLING AND ANALYTICAL PROCEDURES.....	4-1
4.1	<u>Emission Test Methods</u>	4-1
4.1.1	<u>Mercury</u>	4-2
4.2	<u>Process Test Methods</u>	4-4
4.3	<u>Sample Tracking and Custody</u>	4-4
5	QA/QC ACTIVITIES.....	5-1
6	DESCRIPTION OF TESTS.....	6-1

7 APPENDICES.....	7-1
A. Source Emissions Calculations.....	A-1
B. Field Data	B-1
C. Calibration Data	C-1
D. Analytical Data	D-1
E. Unit Operational Data.....	E-1
F. Chain of Custody Records	F-1
G. Resumes.....	G-1

Figures

Figure 2-1 Description of sampling locations at the St. Clair Unit Number 4 North
 Precipitator Inlet Duct2-9

Figure 2-2 Description of sampling points at the St. Clair Unit Number 4 North
 Precipitator Inlet Duct2-10

Figure 2-3 Description of sampling locations at the St. Clair Unit Number 4 Stack2-11

Figure 2-4 Description of sampling points at the St. Clair Unit Number 4 Stack2-12

Figure 2-5 Description of coal sampling locations at the St. Clair Unit Number 42-13

Tables

Table 1-1 Test Program Organization1-2

Table 3-1 Test Matrix for Mercury ICR Tests at St. Clair Unit Number 43-2

Table 3-2 St. Clair Unit Number 4 Source Emissions Results3-6

Table 3-3 St. Clair Unit Number 4 Mercury Removal Efficiency3-7

Table 3-4 St. Clair Unit Number 4 Mercury Speciation Results3-8

Table 3-5 St. Clair Unit Number 4 Process Data3-9

Table 5-1 Major Project Quality Control Checks.....5-1

Table 5-2 Unit Number 4 Matrix Spike Summary.....5-2

Table 5-3 Unit Number 4 Duplicate and Triplicate Analyses Summary5-3

Table 5-4 QC Checklist and Limits for Methods 1 and 25-4

Table 5-5 QC Checklist and Limits for Method 5/17 Sampling5-5

Table 5-6 QC Checklist and Limits for Ontario Hydro Mercury Speciation5-6

1 INTRODUCTION

1.1 Summary of Test Program

METCO Environmental, Dallas, Texas, conducted a source emissions survey of The Detroit Edison Company, St. Clair Power Plant, located in East China, Michigan, on November 2, 3, and 4, 1999. The purpose of these tests was to meet the requirements of the EPA Mercury Information Request. Speciated mercury concentrations at the Unit Number 4 Precipitator North Inlet Duct, speciated mercury emissions at the Unit Number 4 Stack, and mercury and chlorine content of the fuel were determined. The sulfur, ash, and Btu content of the fuel were also determined.

The sampling followed the procedures set forth in the Code of Federal Regulations, Title 40, Chapter I, Part 60, Appendix A, Methods 1, 2, 3B, 4, 5, 17, and 19; in the Ontario Hydro Method, Revised July 7, 1999; ASTM Methods D2234, D6414-99, E776/300.0, D-4239, D-3174, and D-3286.

1.2 Key personnel

Mr. Bill Hefley of METCO Environmental was the onsite project manager. Mr. Shane Lee, Mr. Mike Bass, Mr. Jason Conway, Mr. Scott Hart, and Mr. Jason Brown of METCO Environmental performed the testing.

Mr. Mark Mullen of The Detroit Edison Company acted as the utility representative and performed process monitoring and sampling.

**Table 1-1
Test Program Organization**

Organization	Individual	Responsibility	Phone Number
<i>Project Management and Oversight</i> METCO	Bill Mullins	Project Director	(972) 931-7127
<i>Project Team</i> METCO	Bill Hefley	Project Manager	(972) 931-7127
<i>Utility</i> The Detroit Edison Company	Mark Mullen	Utility Representative	(313) 897-0298
QA/QC METCO	Jim Monfries	Quality Assurance Manager	(972) 931-7127

2 SOURCE AND SAMPLING LOCATION DESCRIPTIONS

2.1 Process Description

2.1.1 Coal Handling

The St. Clair/Belle River Power Plant complex receives approximately 9,000,000 tons of coal annually through a coal handling system that serves both facilities. The St. Clair Power Plant blends a combination of eastern and western coals to minimize costs, maintain boiler capacity, and meet a 1.67 lb/mmBtu SO₂ limitation. Presently, the plant burns 85% western coal. The amount of western coal burned is limited by the greater potential of western coal to form slag on the boiler tubes, limited coal mill capacity, and the need to augment the fuel blend with higher Btu eastern coal in order to avoid boiler derates. Coal is received by both vessel and rail car. Eastern and western coals are stockpiled in separate areas. Low sulfur western and higher sulfur eastern are blended either on the coal belt conveyor or in the crusher house by variable speed feeders regulated by belt scales to achieve the appropriate blend requirements. The blended coal is crushed to appropriate size in the crusher house and then forwarded via elevating conveyor to the distribution belts in the plant bunker room. A series of dust collectors are used for dust control from the point where coal is received all the way through to the bunker room.

2.1.2 Boiler Operation

The boiler has an overhead coal storage bunker of 2,190 tons design capacity. Coal is fed to each mill from the coal bunker, through a variable speed rotating table feeder located at the top of each coal mill, each having a rated capacity of about 15 tons per hour. This feeder is driven by a 480 volt motor through a reduction gear, fed from the 480 volt auxiliary bus, 3rd floor, east of the control room.

Mill feeder breakers are located in the north 480 volt auxiliary bus 3rd floor. The feeder controls are located in the control room. There is coal shut-off valve on the 1st floor (chain operated) located directly above the feeder and another on the 3rd floor just below the bunker.

Five EL 70 Babcock & Wilcox coal mills fire Unit Number 4. These pulverizers are pressurized with primary air and use rotating balls to grind coal between grinding rings. A primary air fan is used to admit preheated air just below the lower grinding ring, drying the raw coal as it is transported in the coal bed of the grinding chamber. The primary air blows the pulverized coal from the coal bed, through the mill classifier, and into the burner lines to the furnace.

Natural gas is used as ignition fuel for the boiler. There are 14 gas ignitors located on three burner decks. A Forney International Burner Management System provides burner control and boiler protection. This consists of flame scanners for both the ignitors and main flame, an indicating panel for main flame intensity, an Operator Interface Panel for control of the gas ignitors, and a Square D PLC which provides control for the entire system. Two fans on the 4th floor provide filtered cooling air to the ignitors and scanners.

There are two forced draft fans, north and south, for the unit. The purpose of the forced draft fans is to provide (1) hot air to the pulverizers, and (2) provide combustion air through the windbox and secondary air to the secondary air registers on the coal burners. Each fan is driven by a constant speed 700 HP, 2400 VAC induction motor, coupled to a hydraulic coupling driven by a Bailey air driven controller (used for fan speed control). Each fan can be started or stopped from either the Unit control Room or a control pedestal located in the Condenser Room adjacent to each fan.

Each forced draft fan has a separate air intake duct with a damper arrangement that allows air to be taken from either inside or outside of the building. The air discharged from each forced draft fan is passed through a rotating or regenerative type air heater where the temperature is raised to about 570 °F.

Ducts and dampers are provided so that hot air can be circulated around the heaters to keep the cold-end heater plates at a high enough temperature to prevent condensation and plugging. The air discharged from both heaters enters a common duct that is connected to the burner windbox by means of two ducts, one on each side of the boilers. Some of the air for combustion is taken from the burner windbox into the furnace through the burner air registers that can be manually adjusted. For air supply to the five primary air fans, a separate duct has been provided, each end of which is connected to the ducts supplying air to the burner windbox. From this duct, individual duct connections have been made to each primary air fan suction with a mill hot air damper in each connection. For tempering the hot air going to each primary air fan, room air is taken from the tempering air duct through tempering air dampers, into the fan intake duct between the mill hot air damper and the fan. Positioning of the mill hot air damper automatically controls the temperature of the coal-air mixture leaving each mill. The quantity of primary air going to each mill is automatically controlled by positioning of the coal primary air damper located in the duct connection between the primary air fan and the mill. A minimum stop has been provided on this damper to prevent reducing the quantity of primary air to a point where coal can settle out in the burner lines.

There are two induced draft fans, north and south, for the unit. The induced draft fans provide a balanced draft for the furnace, overcome flow losses within the flue gas system, and remove the products of combustion.

Gas leaving the precipitator is drawn through the breeching and into the induced draft fans. The fans are centrifugal type, and operate at a constant nominal speed of 1185 rpm. Inlet vanes in each inlet box control gas flow through the induced fans. Each fan is driven by 2250 HP, 4160 volt induction motor. An alarm and main drive trip are provided for high vibration.

A combination of sootblowers, wallblowers, and airheater blowers are used to control furnace temperatures and pluggage. These blowers are controlled and operated from a Copes Vulcan Micro-Selectronic Controller Panel located in the control room. The controller is designed to operate the blowers in groups. These groups can be set to run in continuous mode, automatic cascade mode, or in a single group. The blowers can also be run individually by manual operation as needed. A display panel in the control room includes a boiler diagram, blower status, and LED indicators. A keypad provides access for control of the sootblowing system. A printer is located on the east wall of the control room that records the time and date a blower is placed in or removed from service and any alarm conditions.

2.2 Control Equipment Description

2.2.1 Precipitator

A Wheelabrator Lurgi Model 2X44/40/6X8/10" electrostatic precipitator with a design efficiency of 99.6% is used for flue gas particulate control. The system is designed to operate under the following conditions:

- Gas Volume: 751,000 acfm
- Temperature: 330 °F
- Pressure: -22" W.G. operating, design + 8 to -32" W.G.
- Dust Content: 0.7 – 1.40 grains/ACF
- Dust Residual: 0.007 grains/ACF or 99.5% with last field out of service or 98.5% with last two fields out of service.

Precipitator description is as follows:

- Gas Passages: 88
- Fielded Height: 40.83 feet
- No. of Fields: Six (6) at 12.48 feet
- Cross Section: 2994 Sq. Ft.
- Velocity: 4.18 FPS
- Treatment Time: 17.9 Sec.
- Collecting Area: 538,100 Sq. Ft.
- Collecting Surface: CSH – carbon steel – 18 ga.
- Discharge Electrodes: Isodyn B-5 – fields 1 – 2
Star – 0.223" Fields 3 – 6
- Discharge Frames: 1: O.D. Schedule 40 Pipe, ASTM A-36, shop pre-wired
- Support Insulators: 48 quartz
- Casing: Single wall construction – 3/16" ASTM – A36 Stiffened Plate
- Hoppers: 24 Pyramid type - 3/16" ASTM – A36 Stiffened Plate
- Dividing Wall: Single wall construction A-36 3/16" Stiffened Plate
- Gastight Roof: 1/8" mild steel
- Weather Roof: 18 ga. Corrugated weather roof covering 4" mineral wool
8 PCF Density
- Access Doors: 52 total (14 sides, 14 roof girder, 24 hopper)
- Nozzles (4 total): 2 conventional horizontal inlet and 2 horizontal outlet
3/16: mild steel stiffened ASTM – A36
- Perforated Gas Distribution Plates: 3 –10 ga. perforated plates in each inlet nozzle
- Rappers: 12 drivers, 540 hammers for CS
24 drivers, 1056 hammers for DS
2 drivers, 16 hammers for DP

The electrostatic precipitator consists of three major components:

- 1) Discharge System
- 2) Collection System
- 3) Gas Distribution System

The function of the discharge system is to cause ionization to occur within the gas passing through the precipitator. The ionization creates a negative charge on the particulate within the gas stream. Since in normal operation a certain amount of particulate can be expected to collect on the discharge frames and wires, each frame is individually rapped by impacting an anvil with a blow caused by a swinging hammer.

The function of the collecting system is to collect negatively charged particles within the gas stream on a grounded surface. The collection system consists of steel plates that are suspended at the top and are held together at the bottom with a rapping bar. Particulate is loosened from the plates by rapping and fall directly into the hoppers without being reentrained into the gas stream.

The purpose of the gas distribution system is to distribute gas uniformly throughout the cross-section of the precipitator. This is to ensure that the discharge and collecting systems are uniformly loaded in removing the particulate matter from the gas stream. The gas distribution system consists of perforated gas distribution plates and an air straightening grid located in the inlet nozzle and vertical baffles located in the outlet nozzle. The perforated plates are rapped to dislodge any particulate that would cling to the distribution plate and cause disruption in the normal flow of gas through the precipitator.

Gas leaving the precipitator is drawn through the induced draft fans and is exhausted to a 599 foot stack. SO₂, NO_x, CO₂, volumetric flow, and opacity are measured in the stack with data collected and archived in a data acquisition and handling system.

2.2.2 Flyash and Bottom Ash

Flyash is collected in hoppers beneath the individual precipitator modules. There are 24 precipitator hoppers. The ash is transported by vacuum from the hoppers to a primary and secondary collector. A pressurized line transports the flyash from the collectors to the South Silo. At the South Silo the ash is loaded into trucks for disposal.

There are three ash hoppers on the economizer. The ash from the economizer hoppers is sluiced into the bottom ash system. Bottom ash falls into hoppers at the bottom of the boiler. High pressure water jets move the bottom ash to clinker grinders and deposit it in the bottom ash pit. From the ash pit, the ground up ash is transported to the primary bottom ash settling basin by means of a Hydro-Jet pump and associated piping. Bottom ash and settled solids are loaded into trucks for disposal. Process water is discharged via and a NPDES outfall.

2.3 Flue Gas and Process Sampling Locations

2.3.1 Inlet Sampling Location

The sampling location on the Unit Number 4 Precipitator North Inlet Duct is 50 feet above the ground. The sampling locations are located 11 feet 9 inches (1.23 equivalent duct diameters) downstream from the bend in the duct and 6 feet 6 inches (0.68 equivalent duct diameters) upstream from another bend in the duct.

2.3.2 Stack Sampling Location

The sampling location on the Unit Number 4 Stack is 195 feet above the ground. The sampling locations are located 145 feet (10.80 stack diameters) downstream from the inlet to the stack and 404 feet (30.10 stack diameters) upstream from the outlet of the stack.

2.3.3 Coal Sampling Location

The coal sampling locations are located at the coal feeders to each of the individual mills.

Figure 2-1
Description of sampling locations at the St. Clair Unit Number 4 North Precipitator Inlet Duct

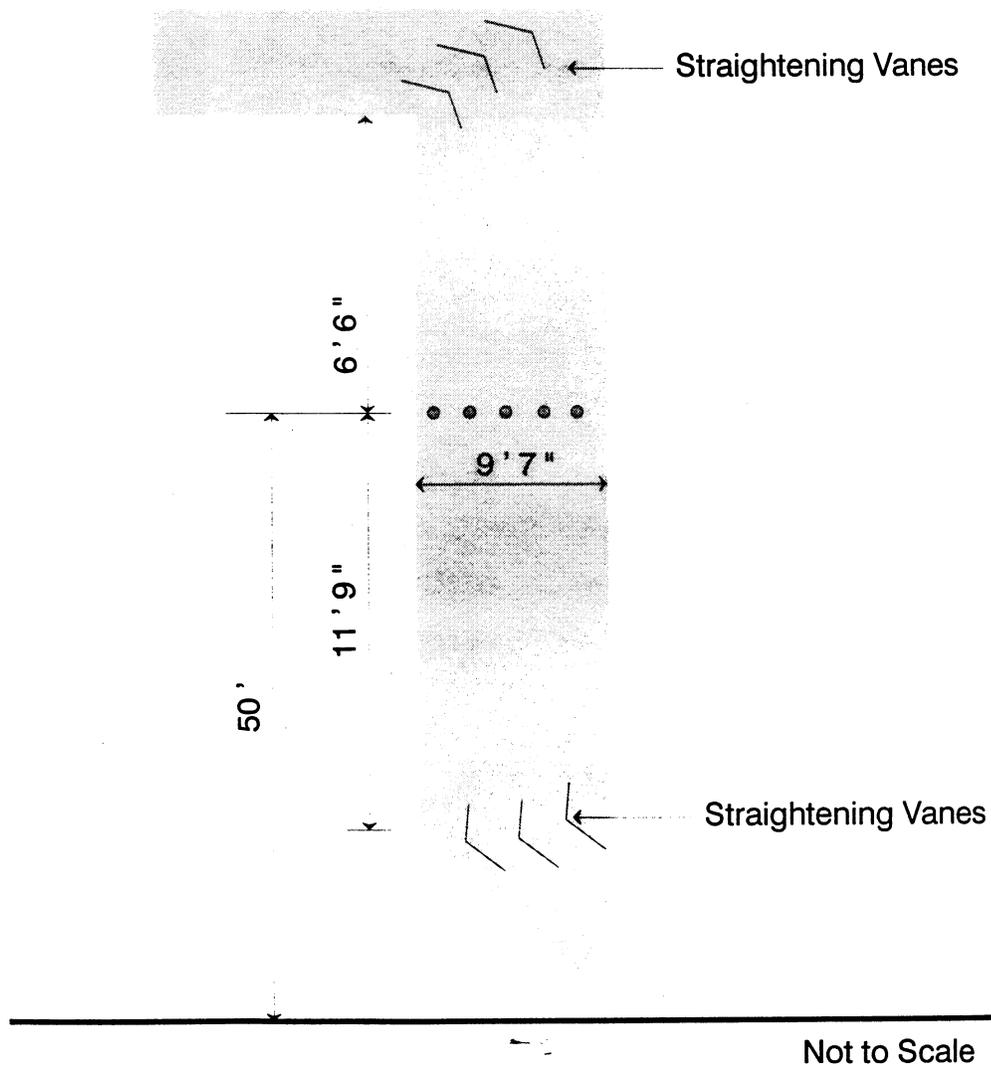


Figure 2-2
Description of sampling points at the St. Clair Unit Number 4 North Precipitator Inlet Duct

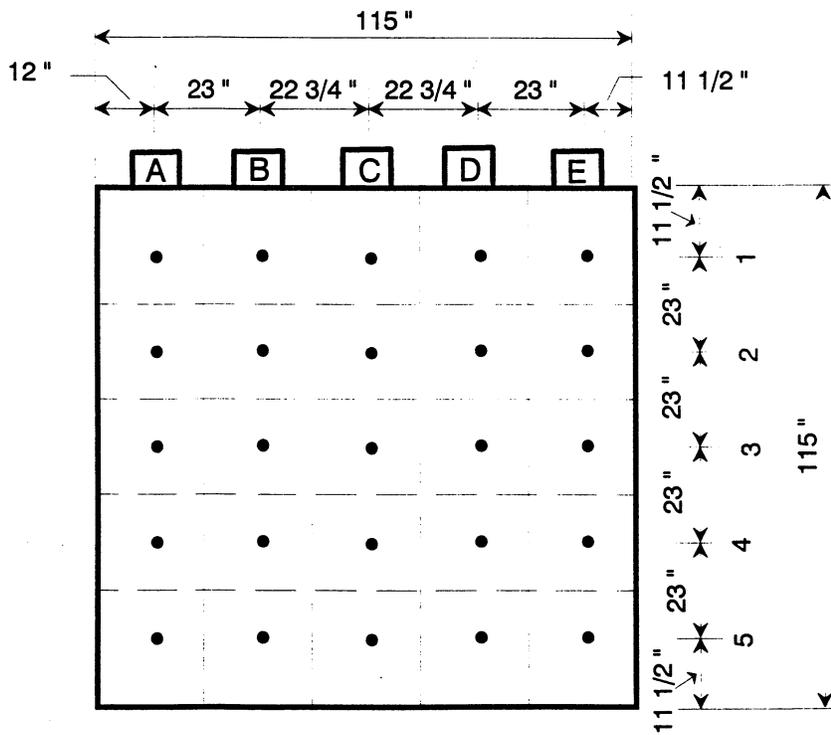
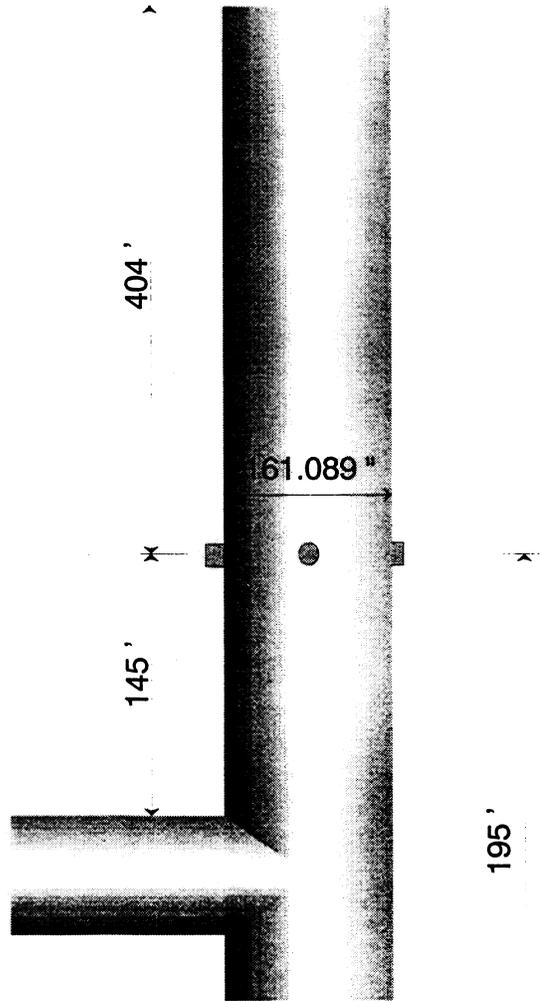


Figure 2-3
Description of sampling locations at the St. Clair Unit Number 4 Stack



Not to Scale

Figure 2-4
Description of sampling points at the St. Clair Unit Number 4 Stack

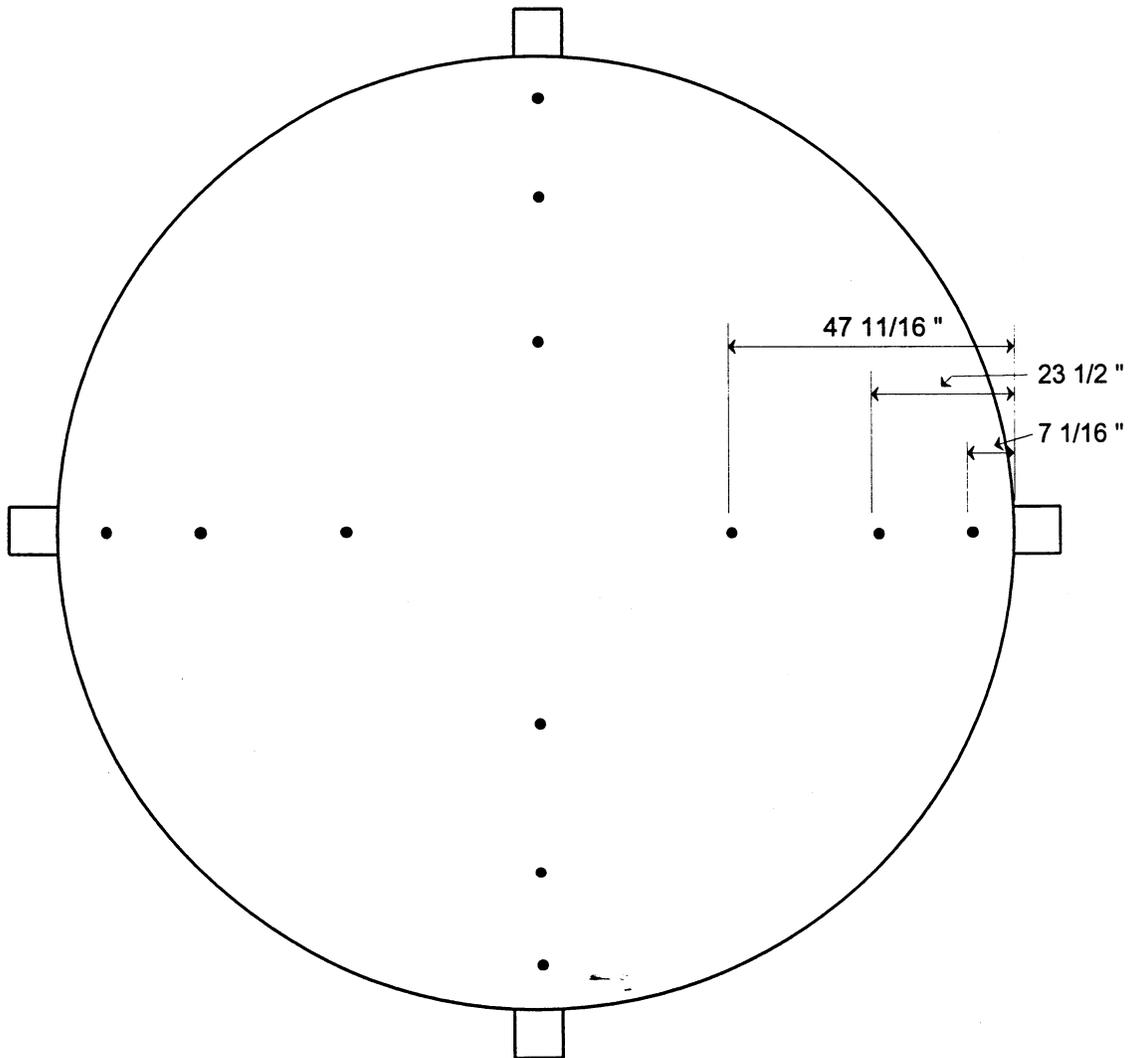


Figure 2-5
Description of coal sampling locations at the St. Clair Unit Number 4

Mill Sampling Location

Boiler

ESP

Stack

3 SUMMARY AND DISCUSSION OF RESULTS

3.1 Objectives and Test Matrix

3.1.1 Objective

The objective of the tests was to collect the information and measurements required by the EPA Mercury ICR. Specific objectives listed in order of priority are:

1. Quantify speciated mercury emissions at the stack.
2. Quantify speciated mercury concentrations in the flue gas at the inlet.
3. Quantify fuel mercury and chlorine content during the stack and inlet tests.
4. Provide the above information for use in developing boiler, fuel, and specific control device mercury emission factors.

3.1.2 Test Matrix

The test matrix is presented in Table 1. The table includes a list of test methods to be used. In addition to speciated mercury, the flue gas measurements include moisture, flue gas flow rates, carbon dioxide, and oxygen.

**Table 3-1
Test Matrix for Mercury ICR Tests at St. Clair Unit Number 4**

Sampling Location	No. of Runs	Species Measured	Sampling Method	Sample Run Time	Analytical Method	Analytical Laboratory
Stack	3	Speciated Hg	Ontario Hydro	120 min	Ontario Hydro	TestAmerica
Stack	3	Moisture	EPA 4	Concurrent	Gravimetric	METCO
Stack	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
Stack	3	O ₂ & CO ₂	EPA 3B	Concurrent	Orsat	METCO
Inlet	3	Speciated Hg	Ontario Hydro	125 min	Ontario Hydro	TestAmerica
Inlet	3	Moisture	EPA 4	Concurrent	Gravimetric	METCO
Inlet	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
Inlet	3	O ₂ & CO ₂	EPA 3B	Concurrent	Orsat	METCO
Coal Feeders	3	Hg, Cl, Sulfur, Ash, and Btu/lb in coal	ASTM D2234	1 grab sample every 30-minutes per mill per run	ASTM D6414-99 (Hg), ASTM E776/300.0 (Cl), ASTM D-4239 (S), ASTM D-3174 (Ash), and ASTM D-3286 (Btu/lb)	TestAmerica and Philip Services

3.2 Field Test Changes and Problems

No deviations were made from the approved Sampling and Analytical Test Plan.

3.3 Handling of Non-Detects

This section addresses how data will be handled in cases where no mercury is detected in an analytical fraction. It should be noted that the analytical method specified in the Ontario Hydro Method has a very low detection limit, which is expected to be well below flue gas levels for most cases if the laboratory uses normal care and state of the art analytical equipment. However, there may be cases where certain fractions of a test do not show detectable mercury levels. This section addresses how non-detects will be handled in calculating and reporting mercury levels.

3.3.1 A single analytical fraction representing a subset of a mercury species is not detected.

When more than one sample component is analyzed to determine a mercury species (such as analyzing the probe rinse and filter catch separately to determine total particulate mercury) and one fraction is not detected, it will be counted as zero. Total mercury for that species will be the sum of the detected values of the remaining fraction(s). For example, if the probe rinse had $ND < 0.05 \mu\text{g}$ and the filter had $1.5 \mu\text{g}$, total particulate mercury would be reported as 1.5 micrograms.

3.3.2 All fractions representing a mercury species are not detected.

If all fractions used to determine a mercury species are not detected, the total mercury for that species will be reported as not detected, at the sum of the detection limits of the individual species.

For example, if the probe rinse were not detected at 0.003 μg and the filter catch were not detected at 0.004 μg , the reported particulate mercury would be reported as ND < 0.007 μg . This is expected to represent a small fraction (<1%) of the total mercury, even under worse case scenario of 1 $\mu\text{g}/\text{Nm}^3$.

3.3.3 No mercury is detected for a species on all three test runs.

When all three test runs show no detectable levels of mercury for a mercury species, that mercury species will be reported as not detected at less than the highest detection limit. For example, if three results for elemental mercury are ND < 0.10, ND < 0.13, and ND < 0.10, the results would be reported as ND < 0.13 (the highest of the three detection levels).

In calculating total mercury, a value of zero will be used for that species. For example, if particulate mercury were ND < 0.11 μg , oxidized mercury were 2.0 μg , and elemental mercury were 3.0 μg , total mercury would be reported as 5.0 μg .

In calculating the percentage of mercury in the other two species, a value of zero will be used. For the example listed in the preceding paragraph, the results would be reported as 0% particulate mercury, 40% oxidized mercury, and 60% elemental mercury.

3.3.4 Mercury is detected on one or two of three runs.

If mercury is detected on one or two of three runs, average mercury will be calculated as the average of the detected value(s) and half of the detection limits for the non-detect(s).

Example 1: The results for three runs are 0.20, 0.20, and ND < 0.10. The reported value would be calculated as the average of 0.20, 0.20, and 0.05, which is 0.15 μg .

Example 2: The results for three runs are 0.14, ND < 0.1, and ND < 0.1. The average of 0.14, 0.05, and 0.05 is calculated to be 0.08. Since this is below the detection limit of 0.1, the reported value is ND < 0.1.

3.4 Summary of Results

The results of the tests performed at The Detroit Edison Company, St. Clair Unit Number 4 are listed in the following tables.

**Table 3-2
St. Clair Unit Number 4 Source Emissions Results**

Run Number	1	2	3
Test Date	11/03/99	11/03/99	11/04/99
Test Time	0915-1158	1320-1544	0840-1100
North Inlet Gas Properties			
Flow Rate - ACFM	338,889	345,832	366,623
Flow Rate - DSCFM*	208,204	211,094	229,141
% Water Vapor - % Vol.	8.23	8.57	7.70
CO ₂ - %	12.2	12.2	11.8
O ₂ - %	7.4	7.2	8.0
% Excess Air @ Sampling Point	53	51	60
Temperature - °F	280	284	286
Pressure - "Hg	27.97	28.04	28.52
Percent Isokinetic	98.3	97.0	96.6
Volume Dry Gas Sampled - DSCF*	60.549	60.548	65.501
Stack Gas Properties			
Flow Rate - ACFM	590,392	646,311	616,482
Flow Rate - DSCFM*	375,774	403,794	394,821
% Water Vapor - % Vol.	7.43	8.25	7.47
CO ₂ - %	12.0	11.2	11.4
O ₂ - %	7.8	8.4	8.8
% Excess Air @ Sampling Point	58	65	71
Temperature - °F	279	288	286
Pressure - "Hg	28.69	28.76	29.15
Percent Isokinetic	94.7	94.3	97.9
Volume Dry Gas Sampled - DSCF*	65.586	70.165	71.260

* 29.92 "Hg, 68 °F (760 mm Hg, 20 °C)

**Table 3-3
St. Clair Unit Number 4 Mercury Removal Efficiency**

Run Number	1	2	3	Average
Test Date	11/03/99	11/03/99	11/04/99	
Test Time	0915-1158	1320-1544	0840-1100	
Total mercury				
North Inlet - lb/10 ¹² Btu*	4.85	4.57	5.15	4.86
Stack - lb/10 ¹² Btu	3.12	3.66	4.69	3.82
Removal efficiency - %	35.7	19.9	8.9	21.5
Particulate mercury				
North Inlet - lb/10 ¹² Btu*	1.80	2.05	0.70	1.52
Stack - lb/10 ¹² Btu	<5.25E-3	<5.14E-3	<5.23E-3	<5.25E-3
Removal efficiency - %	>99.7	>99.7	>99.3	>99.6
Oxidized mercury				
North Inlet - lb/10 ¹² Btu*	1.64	1.52	1.39	1.52
Stack - lb/10 ¹² Btu	0.97	0.99	0.95	0.97
Removal efficiency - %	40.9	34.9	31.7	35.8
Elemental mercury				
North Inlet - lb/10 ¹² Btu*	1.41	1.00	3.06	1.82
Stack - lb/10 ¹² Btu	2.15	2.67	3.74	2.85
Removal efficiency - %	-----	-----	-----	-----

* The concentrations of mercury measured at the North Precipitator Inlet were assumed to be equal to the South Precipitator Inlet.

**Table 3-4
St. Clair Unit Number 4 Mercury Speciation Results**

Run Number	1	2	3	Average
Test Date	11/03/99	11/03/99	11/04/99	
Test Time	0915-1158	1320-1544	0840-1100	
North Inlet Mercury Speciation				
Particulate mercury – µg	3.27	3.78	1.32	—
µg /dscm	1.91	2.20	0.71	1.61
lbs/10 ¹² Btu	1.80	2.05	0.70	1.52
% of total Hg	37.1	44.9	13.6	31.9
Oxidized mercury – µg	2.97	2.80	2.60	—
µg /dscm	1.73	1.63	1.40	1.59
lbs/10 ¹² Btu	1.64	1.52	1.39	1.52
% of total Hg	33.8	33.3	27.0	31.4
Elemental mercury - µg	2.55	1.84	5.74	—
µg /dscm	1.49	1.07	3.09	1.88
lbs/10 ¹² Btu	1.41	1.00	3.06	1.82
% of total Hg	29.1	21.9	59.4	36.8
Total mercury – µg	8.79	8.42	9.66	—
µg /dscm	5.13	4.91	5.21	5.08
lbs/10 ¹² Btu	4.85	4.57	5.15	4.86
Stack Mercury Speciation				
Particulate mercury – µg	<0.010	<0.010	<0.010	—
µg /dscm	<5.38E-3	<5.03E-3	<4.96E-3	<5.38E-3
lbs/10 ¹² Btu	<5.25E-3	<5.14E-3	<5.23E-3	<5.25E-3
% of total Hg	0.0	0.0	0.0	0.0
Oxidized mercury – µg	1.84	1.93	1.82	—
µg /dscm	0.99	0.97	0.90	0.95
lbs/10 ¹² Btu	0.97	0.99	0.95	0.97
% of total Hg	31.1	27.0	20.3	26.1
Elemental mercury – µg	4.10	5.20	7.16	—
µg /dscm	2.21	2.62	3.55	2.79
lbs/10 ¹² Btu	2.15	2.67	3.74	2.85
% of total Hg	68.9	73.0	79.7	73.9
Total mercury – µg	5.94	7.13	8.98	—
µg /dscm	3.20	3.59	4.45	3.75
lbs/10 ¹² Btu	3.12	3.66	4.69	3.82
Coal Analysis				
Mercury - ppm dry	0.060	0.055	0.069	0.061
Mercury - lbs/10 ¹² Btu	6.10	5.50	7.16	6.25
Chlorine - ppm dry	400	300	300	333
Moisture - %	22.6	23.3	22.9	22.9
Sulfur - % dry	0.94	0.96	0.96	0.95
Ash - % dry	7.40	6.36	6.24	6.67
HHV - Btu/lb as fired	9,630	9,720	9,700	9,683
Coal flow - lbs/hr as fired	187,200	187,200	187,200	187,200
Total Heat Input – 10 ⁶ Btu/hr	1,802.7	1,819.6	1,815.8	1,812.7
Total Mercury Mass Rates				
lbs/hr input in coal	0.011	0.010	0.013	0.011
lbs/hr at Precipitator Inlet*	8.74E-3	8.32E-3	9.35E-3	8.80E-3
lbs/hr emitted*	5.62E-3	6.66E-3	8.52E-3	6.93E-3

* Calculated based on Total Heat Input.

**Table 3-5
St. Clair Unit Number 4 Process Data**

Run Number	1	2	3
Test Date	11/03/99	11/03/99	11/04/99
Test Time	0915-1158	1320-1544	0840-1100
Unit Operation			
Unit Load - MW net	157.3	157.4	158.5
Coal Mills in Service	All	All	All
Coal Flow - tons/hr	93.6	93.6	93.6
Steam Flow – klbs/hr	1,150.3	1,151.4	1,152.6
CEMS Data			
NO _x – ppm	310.4	310.6	342.5
SO ₂ – ppm	494.6	488.5	472.7
CO ₂ - %	11.39	11.55	10.36
Stack Gas flow – kscfh	27,939.8	27,888.6	30,200.1
Stack Gas Temperature - °F	273.7	281.3	280.8
Opacity - %	2.5	2.5	2.8

4 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Emission Test Methods

The sampling followed the procedures set forth in the Code of Federal Regulations, Title 40, Chapter I, Part 60, Appendix A, Methods 1, 2, 3B, 4, 5, 17, and 19; in the Ontario Hydro Method, Revised July 7, 1999; and ASTM Methods D2234, D6414-99, E776/300.0, D-4239, D-3174, and D-3286.

A preliminary velocity traverse was made at each of the five ports at the inlet sampling location, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 1.2 degrees. Alternate procedures would be required if the angle of cyclonic flow were greater than 20 degrees. Five traverse points were sampled from each of the five ports, for a total of twenty-five traverse points.

A preliminary velocity traverse was made at each of the four ports at the stack sampling locations, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 2.3 degrees. Alternate procedures would be required if the angle of cyclonic flow were greater than 20 degrees. Three traverse points were sampled from each of the four ports for a total of twelve traverse points.

The sampling trains were leak-checked at the end of the nozzle at 15 inches of mercury vacuum before each test, and again after each test at the highest vacuum reading recorded during each test. This was done to predetermine the possibility of a diluted sample.

The pitot tube lines were checked for leaks before and after each test under both a vacuum and a pressure. The lines were also checked for clearance and the manometer was zeroed before each test.

Integrated orsat samples were collected and analyzed according to EPA Method 3B during each test.

4.1.1 Mercury

Triplicate samples for mercury were collected. The samples were taken according to EPA Methods 1, 2, 3B, 4, 5, and 17; and the Ontario Hydro Method, Revised July 7, 1999. For each run at the inlet sampling location, samples of five-minute duration were taken isokinetically at each of the twenty-five traverse points for a total sampling time of 125 minutes. For each run at the stack sampling location, samples of ten-minute duration were taken isokinetically at each of the twelve traverse points for a total sampling time of 120 minutes. Data was recorded at five-minute intervals. Reagent blanks and field blanks were submitted.

The “front-half” of the sampling train at the inlet sampling location contained the following components:

Teflon Coated Nozzle
In-stack Quartz Fiber Thimble and Backup Filter and Teflon Coated Support
Heated Glass Probe @ > 248°F

The “front-half” of the sampling train at the outlet sampling location contained the following components:

Teflon Coated Nozzle
In-stack Quartz Fiber Filter and Teflon Coated Support
Heated Glass Probe @ > 248°F

The "back-half" of the sampling train at both sampling locations contained the following components:

<u>Impinger Number</u>	<u>Impinger Type</u>	<u>Impinger Contents</u>	<u>Amount</u>	<u>Parameter Collected</u>
1	Modified Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
2	Modified Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
3	Greenburg-Smith Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
4	Modified Design	5% HNO ₃ and 10% H ₂ O ₂	100 ml	Elemental Mercury and Moisture
5	Modified Design	4% KMnO ₄ and 10% H ₂ SO ₄	100 ml	Elemental Mercury and Moisture
6	Modified Design	4% KMnO ₄ and 10% H ₂ SO ₄	100 ml	Elemental Mercury and Moisture
7	Greenburg-Smith Design	4% KMnO ₄ and 10% H ₂ SO ₄	100 ml	Elemental Mercury and Moisture
8	Modified Design	Silica	200 g	Moisture

All glassware was cleaned prior to use according to the guidelines outlined in EPA Method 29, Section 5.1.1 and the Ontario Hydro Method, Revised July 7, 1999, Section 13.2.15. All glassware connections were sealed with Teflon tape.

At the conclusion of each test, the filter and impinger contents were recovered according to procedures outlined in the Ontario Hydro Method, Revised July 7, 1999, Section 13.2.

Mercury samples were analyzed by Cold Vapor Atomic Absorption and Fluorescence Spectroscopy.

4.2 Process Test Methods

A modified ASTM D2234 method of coal sampling was followed. For each test run, a grab sample of coal was collected from each coal feeder to each of the individual mills at thirty-minute intervals. One composite sample was prepared for analysis from the individual feeder samples. Each sample was analyzed for mercury, chlorine, sulfur, ash, and Btu content by ASTM Methods D6414-99, E766/300.0, D-4239, D-3174, and D-3286, respectively.

4.3 Sample Tracking and Custody

Samples and reagents were maintained in limited access, locked storage at all times prior to the test dates. While on site, they were at an attended location or in an area with limited access. Off site, METCO and TestAmerica provided limited access, locked storage areas for maintaining custody.

Chain of custody forms are located in Appendix F. The chain of custody forms provide a detailed record of custody during sampling, with the initials noted of the individuals who loaded and recovered impinger contents and filters, and performed probe rinses.

All samples were packed and shipped in accordance with regulations for hazardous substances.

5 QA/QC ACTIVITIES

The major project quality control checks are listed in Table 5-1. Matrix Spike Summaries are listed in Table 5-2. Duplicate and Triplicate Analyses Summaries are listed in Table 5-3. Additional method-specific QC checks are presented in Table 5-4 (Methods 1 and 2), Table 5-5 (Method 5/17 sampling), and Table 5-6 (Ontario Hydro sample recovery and analysis). These tables also include calibration frequency and specifications.

**Table 5-1
Major Project Quality Control Checks**

<i>QC Check</i>	<i>Information Provided</i>	<i>Results</i>
<i>Blanks</i>		
Reagent blank	Bias from contaminated reagent	No Mercury was detected
Field blank	Bias from handling and glassware	No Mercury was detected
<i>Spikes</i>		
Matrix spike	Analytical bias	Sample results were between 75% - 125% recovery
<i>Replicates</i>		
Duplicate analyses	Analytical precision	Results were < 10% RPD
Triplicate analyses	Analytical precision	Results were < 10% RPD

**Table 5-2
Unit Number 4 Matrix Spike Summary**

<i>Sampling Location</i>	<i>Run Number</i>	<i>Container</i>	<i>Results (ug)</i>	<i>True Value (ug)</i>	<i>Recovery (%)</i>
Inlet Duct	2	5	4.38	4.90	89
Inlet Duct	3	1B	0.048	0.050	96
Stack	1	3	1.643	1.650	100
Stack	2	1A	0.058	0.050	116
Stack	2	2	0.582	0.560	104
Stack	2	3	8.08	7.70	105

**Table 5-3
Unit Number 4 Duplicate and Triplicate Analyses Summary**

Sampling Location	Run Number	Container	Results (ug)	Duplicate Results		Triplicate Results	
				(ug)	RPD	(ug)	RPD
Inlet Duct	1	1A	3.27	3.22	1.4	-----	----
		1B	<0.010	<0.010	0	-----	----
		2	<0.124	<0.124	0	<0.124	0
		3	2.97	3.06	3	3.08	3.4
		4	<0.700	<0.700	0	-----	----
	5	2.55	2.55	0	-----	----	
	2	1A	3.78	3.81	0.8	-----	----
		1B	<0.010	<0.010	0	-----	----
		2	<0.114	<0.114	0	-----	----
		3	2.80	2.76	1.4	-----	----
		4	<0.680	<0.680	0	-----	----
	5	1.84	1.89	2.7	-----	----	
	3	1A	1.32	1.32	0	1.30	1.5
		1B	<0.010	<0.010	0	-----	----
		2	<0.180	<0.180	0	-----	----
3		2.60	2.59	0.4	-----	----	
4		<0.720	<0.720	0	-----	----	
5	5.74	5.74	0	-----	----		
Stack	1	1A	<0.010	<0.010	0	<0.010	0
		2	<0.320	<0.320	0	-----	----
		3	1.84	1.84	0	-----	----
		4	<0.660	<0.660	0	-----	----
		5	4.10	4.11	0.2	-----	----
	2	1A	<0.010	<0.010	0	-----	----
		2	<0.112	<0.112	0	-----	----
		3	1.93	1.96	1.2	-----	----
		4	<0.720	<0.720	0	-----	----
		5	5.20	5.10	1.9	5.00	3.9
	3	1A	<0.010	<0.010	0	-----	----
		2	<0.220	<0.220	0	-----	----
		3	1.82	1.84	1.1	-----	----
		4	<0.580	<0.580	0	-----	----
		5	7.16	7.11	0.7	-----	----

**Table 5-4
QC Checklist and Limits for Methods 1 and 2**

Quality Control Activity	Acceptance Criteria and Frequency	Reference
Measurement site evaluation	>2 diameters downstream and 0.5 diameters upstream of disturbances*	Method 1, Section 2.1
Pitot tube inspection	Inspect each use for damage, once per program for design tolerances	Method 2, Figures 2-2 and 2-3
Thermocouple	+/- 1.5% (°R) of ASTM thermometer, before and after each test mobilization	Method 2, Section 4.3
Barometer	Calibrate each program vs. mercury barometer or vs. weather station with altitude correction	Method 2, Section 4.4

* Although the inlet sampling location did not meet the requirements of EPA Method 1, three-dimensional flow testing as described in EPA Method 1 was not performed. A preliminary velocity traverse was made at each of the five ports at the inlet sampling location, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 1.2 degrees

**Table 5-5
QC Checklist and Limits for Method 5/17 Sampling**

Quality Control Activity	Acceptance Criteria and Frequency	Reference
<i>Pre-mobilization checks</i>		
Gas meter/orifice check	Before test series, $Y_D \pm 5\%$ (of original Y_D)	Method 5, Section 5.3
Probe heating system	Continuity and resistance check on element	
Nozzles	Note number, size, material	
Glassware	Inspect for cleanliness, compatibility	
Thermocouples	Same as Method 2	
<i>On-site pre-test checks</i>		
Nozzle	Measure inner diameter before first run	Method 5, Section 5.1
Probe heater	Confirm ability to reach temperature	
Pitot tube leak check	No leakage	Method 2, Section 3.1
Visible inspection of train	Confirm cleanliness, proper assembly	
Sample train leak check	≤ 0.02 cf at 15" Hg vacuum	Method 5, Section 4.1.4
<i>During testing</i>		
Probe and filter temperature	Monitor and confirm proper operation	
Manometer	Check level and zero periodically	
Nozzle	Inspect for damage or contamination after each traverse	Method 5, Section 5.1
Probe/nozzle orientation	Confirm at each point	
<i>Post test checks</i>		
Sample train leak check	≤ 0.02 cf at highest vacuum achieved during test	Method 5, Section 4.1.4
Pitot tube leak check	No leakage	Method 2, Section 3.1
Isokinetic ratio	Calculate, must be 90-110%	Method 5, Section 6
Dry gas meter calibration check	After test series, $Y_D \pm 5\%$	Method 5, Section 5.3
Thermocouples	Same as Method 2	
Barometer	Compare w/ standard, ± 0.1 " Hg	

Table 5-6 QC Checklist and Limits for Ontario Hydro Mercury Speciation

Quality Control Activity	Acceptance Criteria and Frequency	Reference
<i>Pre-mobilization activities</i>		
Reagent grade	ACS reagent grade	Ontario Hydro Section 8.1
Water purity	ASTM Type II, Specification D 1193	Ontario Hydro Section 8.2
Sample filters	Quartz; analyze blank for Hg before test	Ontario Hydro Section 8.4.3
Glassware cleaning	As described in Method	Ontario Hydro Section 8.10
<i>On-site pre-test activities</i>		
Determine SO ₂ concentration	If >2500 ppm, add more HNO ₃ -H ₂ O ₂ solution	Ontario Hydro Section 13.1.13
Prepare KCl solution	Prepare batch as needed	Ontario Hydro Section 8.5
Prepare HNO ₃ -H ₂ O ₂ solution	Prepare batch as needed	Ontario Hydro Section 8.5
Prepare H ₂ SO ₄ -KMnO ₄ solution	Prepare daily	Ontario Hydro Section 8.5
Prepare HNO ₃ rinse solution	Prepare batch as needed; can be purchased premixed	Ontario Hydro Section 8.6
Prepare hydroxylamine solution	Prepare batch as needed	Ontario Hydro Section 8.6
<i>Sample recovery activities</i>		
Brushes and recovery materials	No metallic material allowed	Ontario Hydro Section 13.2.6
Check for KMnO ₄ Depletion	If purple color lost in first two impingers, repeat test with more HNO ₃ -H ₂ O ₂ solution	Ontario Hydro Section 13.1.13
Probe cleaning	Move probe to clean area before cleaning	Ontario Hydro Section 13.2.1
Impinger 1,2,3 recovery.	After rinsing, add permanganate until purple color remains to assure Hg retention	Ontario Hydro Section 13.2.8
Impinger 5,6,7 recovery.	If deposits remain after HNO ₃ rinse, rinse with hydroxylamine sulfate. If purple color disappears after hydroxylamine sulfate rinse, add more permanganate until color returns	Ontario Hydro Section 13.2.10
Impinger 8	Note color of silica gel; if spent, regenerate or dispose.	Ontario Hydro Section 13.2.11
<i>Blank samples</i>		
0.1 N HNO ₃ rinse solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
KCl solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
HNO ₃ -H ₂ O ₂ solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
H ₂ SO ₄ -KMnO ₄ solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
Hydroxylamine sulfate solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
Unused filters	Three from same lot.	Ontario Hydro Section 13.2.12
Field blanks	One per set of tests at each test location.	Ontario Hydro Section 13.4.1
<i>Laboratory activities</i>		
Assess reagent blank levels	Target <10% of sample value or $\leq 10 \times$ instrument detection limit. Subtract as allowed.	Ontario Hydro Section 13.4.1
Assess field blank levels	Compare to sample results. If greater than reagent blanks or greater than 30% of sample values, investigate. Subtraction of field blanks not allowed.	Ontario Hydro Section 13.4.1
Duplicate/triplicate samples	All CVAAS runs in duplicate; every tenth run in triplicate. All samples must be within 10% of each other; if not, recalibrate and reanalyze.	Ontario Hydro Section 13.4.1

6 DESCRIPTION OF TESTS

Personnel from METCO Environmental arrived at the plant at 7:30 a.m. on Tuesday, November 2, 1999. After meeting with plant personnel and attending a brief safety meeting, the equipment was moved onto the Unit Number 4 Precipitator Inlet Duct and Stack. The preliminary data was collected. The equipment was secured for the night. All work was completed at 5:00 p.m.

On Wednesday, November 3, work began at 7:00 a.m. The equipment was prepared for testing. The first set of tests for mercury began at 9:15 a.m. Testing continued until the completion of the second set of tests at 3:44 p.m. The samples were recovered. The equipment was secured for the night. All work was completed at 5:30 p.m.

On Thursday, November 4, work began at 7:00 a.m. The equipment was prepared for testing. The third set of tests for mercury began at 8:40 a.m. and was completed at 11:00 a.m.

The samples were recovered. The equipment was moved off of the sampling locations and loaded into the sampling van. The samples and the data were transported to METCO Environmental's laboratory in Dallas, Texas, for analysis and evaluation.

Operations at The Detroit Edison Company, St. Clair Power Plant, Unit Number 4
Precipitator Inlet Duct and Stack, located in East China, Michigan, were completed at
3:30 p.m. on Thursday, November 4, 1999.

A handwritten signature in cursive script that reads "Billy J. Mullins, Jr." with a horizontal line drawn underneath the signature.

Billy J. Mullins, Jr. P.E.
President