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## Research and Development

EMISSION TEST REPORT

FIELD TEST OF CARBON INJECTION  
FOR MERCURY CONTROL

CAMDEN COUNTY MUNICIPAL  
WASTE COMBUSTOR

### Prepared for

Office of Air Quality Planning and Standards

### Prepared by

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## **ABSTRACT**

In 1992, the U.S. Environmental Protection Agency conducted a parametric testing project to evaluate the use of powdered activated carbon for removing volatile pollutants from municipal waste combustor (MWC) flue gas. This testing was conducted at the spray dryer absorber/electrostatic precipitator (SD/ESP)-equipped MWC in Camden County, New Jersey. The primary test objectives were to evaluate the effect of carbon type, carbon feed rate, carbon feed method, and ESP operating temperature on emissions of mercury (Hg) and chlorinated dioxins and furans (CDD/CDF), and to assess the impact of carbon injection on the particulate matter control performance of the ESP. Secondary objectives were to examine the impact of carbon injection on emissions of other metals and volatile organic compounds (VOC). The testing included operation of three different carbon injection systems and examined 16 different SD/ESP and carbon injection system operating conditions. The test was conducted as a follow-on to an EPA-funded testing program at a SD/fabric filter-equipped MWC that focused on the performance of carbon injection for controlling Hg emissions.

The test results indicate that carbon injection upstream of an SD/ESP could achieve high levels (greater than 90%) of Hg and CDD/CDF reduction. Key system operating parameters are carbon feed rate, carbon feed method, and ESP temperature. No detrimental impacts on ESP performance were identified. The study also found that carbon injection does not have a significant impact on emissions of the other metals examined or of VOC.

## EMISSION TEST REPORT

### FIELD TEST OF CARBON INJECTION FOR MERCURY CONTROL CAMDEN COUNTY MUNICIPAL WASTE COMBUSTOR

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## CONVERSION FACTORS

	To Convert From	To	Multiply By
Area	ft <sup>2</sup>	m <sup>2</sup>	9.2903E-2
Density	lbm/ft <sup>3</sup>	kg/m <sup>3</sup>	1.6019E+1
Energy	Btu	J	1.0551E+3
Force	lbf	N	4.4482
Length	ft	m	3.048E-1
	in.	m	2.5400E-2
	in.	mm	2.540E+1
Mass	lbm	kg	4.535E-1
	lbm	g	4.535E+2
	gr	g	6.486E-2
Mass Concentration	gr/ft <sup>3</sup>	g/m <sup>3</sup>	2.29
Power	ft - lbf/s	W	1.3558
Pressure	lbf/in. <sup>2</sup>	Pa	6.895E+3
Temperature	°F	°C	5/9(T <sup>F</sup> - 32°)
Volume	ft <sup>3</sup>	m <sup>3</sup>	2.8317E-2
Volumetric Flow	ft <sup>3</sup> /s	m <sup>3</sup> /s	2.8317E-2
Weight	ton	Mg	1.10

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systems already in existence, as well as the potential for some existing MWCs currently equipped with an ESP only to retrofit a SD or other control technology upstream of the existing ESP to reduce acid gas and organic emissions.

In addition, very little data are available from either SD/FF or SD/ESP-equipped MWCs on the effectiveness of carbon injection for reducing emissions of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (CDD/CDF) and various volatile organic compounds (VOC).

## **1.2    Test Objectives**

To help develop a better understanding of the effectiveness of carbon injection in reducing emissions of Hg, CDD/CDF, and VOC from MWCs, the EPA's Air and Energy Engineering Research Laboratory (AEERL) conducted a series of tests at the Camden County MWC in Camden, New Jersey. The objectives of these tests were to evaluate:

- The level of Hg reduction achievable by carbon injection at SD/ESP-equipped MWCs;
- The extent to which emissions of other metals, CDD/CDF, and VOC can also be reduced by carbon injection;
- Whether carbon characteristics (particle size, pore size) or injection method (dry powder, lime slurry) are important in SD/ESP systems;
- Whether carbon residence time in lime slurry affects carbon performance;
- Whether PM collection efficiency and operating temperature of the ESP have a significant impact on Hg collection; and
- Whether carbon injection has any detrimental impacts on the particulate matter (PM) collection performance of an ESP.

## 1.0 SUMMARY

### 1.1 Introduction

The 1990 Clean Air Act Amendments require the U.S. Environmental Protection Agency (EPA) to promulgate mercury (Hg) emission limits for municipal waste combustor (MWC) facilities.<sup>1</sup> To comply with this requirement, the EPA has gathered data from MWCs to provide background information on various Hg control devices and technologies.<sup>2</sup> Most of the data on Hg control methods, including testing funded by EPA in 1991 at the Ogden Martin Systems of Stanislaus, Inc. (OMSS) MWC, are from units equipped with spray dryer absorber/fabric filter (SD/FF) systems.<sup>2-7</sup>

Data from SD/FF-equipped systems indicate that over 90 percent reduction in Hg concentrations is achievable by adsorption of Hg onto carbon particles in the flue gas.<sup>2,4,6,7</sup> Based on available data, it appears the source of carbon can be residual carbon present in fly ash emitted from the combustion system or commercially manufactured activated carbon injected into the flue gas.<sup>2,4,6-8</sup> The testing of activated carbon injection at the OMSS MWC found that for SD/FF-equipped MWCs the carbon feed rate was the primary factor affecting Hg control.<sup>4,6,7</sup> The OMSS testing also indicated there are no significant differences in Hg control performance as a function of the physical characteristics of the carbon (original material, particle size, pore size, and density), the method of injection (as a dry powder or mixed with SD slurry), or the location of injection (economizer exit, SD inlet, and into the SD).<sup>4,6,7</sup> It is not possible to determine from these tests, however, how much of the Hg removal from the flue gas is achieved in the SD versus the FF.

There are very little data available on Hg control at MWCs equipped with spray dryer absorber/electrostatic precipitator (SD/ESP) systems.<sup>2,6</sup> Because of uncertainties regarding the mechanisms of Hg capture by carbon, it is not possible to directly translate the data collected at SD/FF-equipped MWCs to units equipped with SD/ESP systems. Data on the collection of Hg by SD/ESPs are of interest because of the number of such



- Hg reductions exceeding 90% are achievable by injection of dry carbon at both of the ESP operating temperatures examined (270°F and 350°F).\*
- The most important process variables affecting Hg emissions are carbon feed rate, injection method, and ESP operating temperature.
- The amount of unburned carbon present in fly ash plays a significant role in determining baseline Hg emissions.
- Carbon characteristics are not significant in determining Hg control efficiency when carbon is injected as a dry powder. Carbon characteristics may be important, however, if carbon is injected as a slurry.
- Slurry injection of carbon is less effective in reducing Hg emissions than dry injection. This conclusion is in contract with the results of the OMSS testing and may be due to the performance characteristics of an ESP versus a FF, to differences in carbon properties, or some other unknown phenomena.
- Assuming a baseline Hg removal efficiency of 30% by a SD/ESP without carbon injection, the average reduction can be increased to 90% by injecting approximately 200 mg of carbon per dry standard cubic meter (mg/dscm). This injection rate is approximately triple the rate needed to achieve 90% Hg reduction by a SD/FF-equipped MWC with similar baseline Hg levels.
- Injection of carbon can reduce stack emissions of CDD/CDF by over 75%. However, there is no apparent effect of carbon injection on emissions of VOC.
- Emissions of other metals other than Hg are primarily associated with PM and their control is determined primarily by the efficiency of the PM control device. Possible exceptions to this relationship are molybdenum and selenium. There is no apparent in reduction emissions of these metals from carbon injection.
- There is no apparent impact of carbon injection on the ESP's PM control efficiency.

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\*English Engineering units were used in measurements during testing and are customarily used at MWC facilities in the U.S. Conversion factors from English Engineering to SI units are given at the end of the front matter.

### 1.3 Test Design

To achieve the objectives stated above, the test program was divided into three distinct testing efforts that were conducted during two testing phases. Phase I was designed to provide baseline information on Hg control levels as a function of carbon type and feed rates. To accomplish this objective, five days of testing were conducted at baseline conditions and with two different carbon types and feed rates. This information was used to select the carbon type and feed rates for Phase II.

Phase II was separated into two sections, parametric testing and ESP performance testing. The parametric tests evaluated the impact of key carbon injection system operating variables on emissions of Hg, other metals, and organic compounds. Specific parameters of interest to the test design were:

- Carbon feed rate;
- Carbon injection method (as a dry powder and mixed with lime slurry);
- ESP operating temperature; and
- Number of ESP fields.

To accomplish this test program, eight test conditions were conducted.

The ESP performance testing was designed to evaluate whether there are any detrimental impacts on ESP performance due to carbon injection over an extended time period and to assess the relationship between PM collection efficiency and Hg control. To satisfy these objectives, 5 days of sampling were conducted over a 13-day period.

### 1.4 Conclusions

Based on the data collected during the Camden County tests, the following conclusions were reached:

### **1.5.2 Evaluation of Carbon Injection on Other Combustion Sources**

Previous testing of activated carbon injection has focused on combustion of municipal waste and, to a lesser extent, medical waste. Based on the magnitude of potential air toxic emissions from other combustion sources, testing of activated carbon injection on other major stationary sources of Hg or VOC may be desirable. For example, it may be beneficial to examine injection of activated carbon into the flue gas from a coal-fired boiler or sewage sludge incinerator during future testing.

### **1.5.3 Development of an Activated Carbon Injection Process Model**

There are sufficient data available to define key process parameters affecting the performance on activated carbon injection. Development of a computerized process model could be useful in better defining the relationship between and importance of key parameters. For example, the data from the Camden County and OMSS tests provide contradictory information on the performance of activated carbon when injected into MWC flue gas as a slurry. Key uncertainties in defining the cause of these differences relate to understanding wetted carbon behavior (e.g., surface wetting and pore pluggage); the impact of SD design on slurry particle agglomeration, mixing, and reactor vessel residence time; and the amount of Hg collection possible in a SD reactor and ESP versus that occurring within the bag cake of a FF. Availability of a computerized process model addressing these issues may enhance knowledge of how to most effectively apply carbon injection technology.

## **1.6 Report Organization**

The remainder of the report is divided into six section. Section 2 describes the Camden County facility, the test matrix, carbon feed system, characteristics of the tested carbons, and the sampling locations. Section 3 summarizes the collected process and flue gas data, and interprets the test data in light of the project objectives. Sections 4 and 5 provide details on the collected process and flue gas data for Units B and A,

## 1.5 Apparent Data Gaps

The data collected during carbon injection testing at the Camden County MWC and during the earlier testing at the OMSS MWC indicate that carbon injection upstream of a SD/ESP or SD/FF is an effective control technique for reducing Hg concentrations in MWC flue gas. There remain, however, a number of unanswered questions regarding the potential performance of carbon injection when applied to other types of combustors and air pollution control systems. For example, the Camden County data indicate that carbon injection may be a viable technique for reducing emissions of Hg, and potentially CDD/CDF, from some MWC's equipped with an ESP only. It is unclear, however, whether carbon injection can be used to control emissions of volatile metals and organics from other combustion sources, such as coal-fired boilers, that have significantly different flue gas characteristics. These questions suggest apparent data gaps in three primary areas.

### 1.5.1 Fundamental Studies on Carbon Adsorption of Speciated Mercury Compounds

Most of the Hg in MWC flue gas is present as a mercuric (+2) ion. Ionic Hg may be more readily adsorbed onto untreated carbon particles, such as those used in the Camden County and OMSS tests, than is elemental Hg. In combustion sources having lower chlorine and/or higher sulfur contents, a greater portion of the total Hg in flue gas is expected to be in the elemental form. In these situations, use of carbons that have been impregnated with iodine, sulfur, or chlorine compounds to improve adsorption of elemental Hg may be of value. The effects of Hg speciation and carbon properties on Hg capture have not been defined by laboratory and field testing.

respectively. Section 6 describes the sampling and analytical procedures used during the study, and Section 7 provides summary statistics and discussion regarding measures taken to control and assess data quality. Backup material from the field testing, laboratory analysis, and statistical analyses of the data used in preparing this report are in separate appendices. Backup materials from the field testing program and from subsequent analytical and statistical analyses used to prepare this report are not included here because of the large amount of material involved. This material has been placed in the EPA's public docket on MWC standards development (A-90-45) by EPA's Office of Air Quality Planning and Standards.

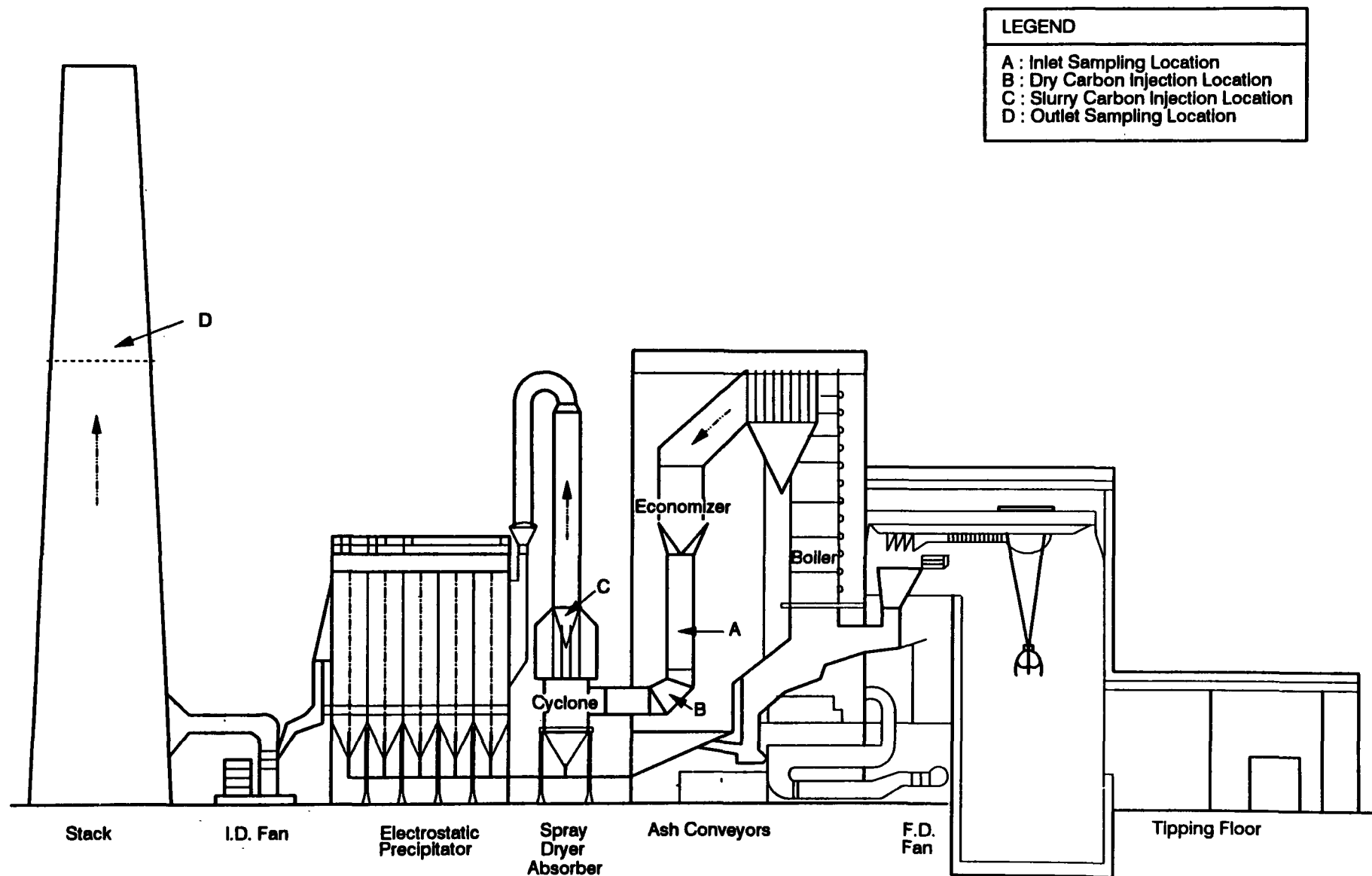


Figure 2-1. Schematic of the Camden County  
Municipal Waste Combustor

## 2.0 TEST DESIGN

### 2.1 Description of the Camden County Municipal Waste Combustor

The Camden County MWC is owned and operated by Camden County Energy Recovery Associates, a subsidiary of Foster Wheeler Power Systems, Inc. It is located in Camden, New Jersey, and began operating in 1991. The facility contains three identical mass-burn waterwall combustion units, designated as Units A, B, and C. Each unit is capable of burning 350 tons per day of municipal solid waste (MSW). The grate firing system used in each of the three units was supplied by Detroit Stoker Company. The MSW burned at the facility is supplied by the city of Camden and surrounding towns. Steam produced by the facility powers two 17-MW turbogenerators and electricity (or steam) can also be sold directly to area industries. The facility is designed to process 1,050 tons of MSW per day, 365 days per year. A general schematic of each unit is shown in Figure 2-1.

The air pollution control system on each combustor consists of a Belco SD (licensee of Deutsche Babcock) and a Belco five-field ESP. Flue gas from the combustor leaves the economizer and enters a vertical 76-inch inner diameter (ID) circular duct. The flue gas travels down the duct, through a 90-degree elbow, and into a cyclone located at the base of the SD. The cyclone separates coarse PM from the flue gas and distributes flue gas to six vertical flow tubes that connect to the base of the SD vessel. A two-fluid nozzle located at the top of each flow tube is used to inject lime slurry upward into concurrently flowing flue gas for removal of acid gases. The lime slurry flow rate is controlled by the stack  $\text{SO}_2$  concentration. Dilution water flow rate is controlled by the reaction chamber exit temperature. The flue gas then proceeds upward through the vertical SD reaction chamber and exits through a 64-inch outer diameter (OD) circular duct. This duct makes a 180-degree turn and the flue gases are directed downward into the five-field ESP. During normal operation, only four of the ESP fields are in operation, with the fifth field providing spare capacity in case of operating problems or maintenance on one of the other fields.

information on Hg control performance as a function of carbon type and carbon feed rate. This information was used to define operating conditions during the Phase II tests. The Phase II tests included two distinct efforts. One of these efforts focused on parametric testing designed to provide data on the impact of key carbon injection system operating variables on Hg control efficiency. The other Phase II testing effort examined the impact of extended carbon injection on ESP performance and of PM collection efficiency on Hg control.

The design of these three testing efforts is discussed below. With one exception (Condition 4A), triplicate sampling runs were conducted at each test condition. One test condition was completed per day. During all of the tests, the plant's process and continuous emissions monitoring equipment was used to monitor combustor and SD/ESP operating conditions.

#### **2.2.1 Phase I -- Characterization Testing**

Phase I included the five test conditions listed in the upper portion of Table 2-1. All testing in this phase was conducted on Unit B. During these tests, carbon was injected as a dry powder into the flue gas duct just prior to the cyclone located at the base of the SD. This location was selected because it was expected to provide sufficient time and turbulence for good mixing of the carbon into the flue gas. Based on the fine particle size of the injected carbon and preliminary experiments conducted prior to Phase B1 tests, it is expected that the cyclone removed little if any of the injected carbon.

The objective of these tests was to assess Hg control levels for two different carbon types and feed rates. Both of the carbons, Darco FGD and Darco PC-100, were produced by American Norit Company and were used during the OMSS MWC testing.<sup>4</sup> A description of each carbon is provided in Section 2.4. The lower target carbon feed rate was 4.5 kilograms per hour (kg/hr) (10 pounds per hour [lb/hr]), which equates to a flue gas concentration of 60 mg of carbon per dry standard cubic meter of flue gas



Typical operating conditions for the air pollution control system are:

- Economizer exit temperature, 450 to 480°F;
- SD exit temperature, 280°F;
- Lime slurry flow, 6 to 7 gpm;
- Lime slurry specific gravity, 1.08;
- Dilution (cooling) water flow, 6 to 11 gpm;
- Economizer exit SO<sub>2</sub> concentration, 125 to 200 ppmv; and
- ESP exit SO<sub>2</sub> concentration, 20 to 40 ppmv.

The lime slurry feed rate can be automatically controlled to obtain a specified SO<sub>2</sub> outlet concentration or the lime slurry feed rate controller can be manually set to provide a constant feed rate.

The gases from each ESP are ducted into a separate flue in the stack. The stack contains four 72-inch ID, circular flues: one for each of the three operating units and one reserved for a future unit. The stack exit is approximately 366 feet above ground level.

The process control systems include a Bailey Net 90 (INFI90) for the boiler, a separate control and data display system for the SD/ESP, and two separate data system for the plant's continuous emissions monitoring system (CEMS). The CEMS equipment includes extractive monitors for SO<sub>2</sub> and O<sub>2</sub> at the economizer exit and for O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O, CO, THC, CH<sub>4</sub>, SO<sub>2</sub>, HCl, and NO<sub>x</sub> in the stack, and a stack opacity monitor.

## 2.2 Test Matrix

The Camden County MWC test program encompassed three distinct testing efforts and was conducted in two phases. Phase I was designed to provide baseline

(mg/dscm) corrected to 7% O<sub>2</sub>.<sup>\*</sup> This is approximately equal to the high carbon feed rate tests conducted at OMSS. The higher target carbon feed rate of 27 kg/hr (60 lb/hr) equates to approximately 360 mg/dscm of flue gas and was believed to be sufficiently high to ensure Hg removal efficiencies in excess of 90% and emission levels less than 100 µg/dscm.

During each run, simultaneous sampling was conducted at the economizer exit and in the stack for total PM and Hg using the multiple metals sampling train. Each sampling run was one hour in duration (excluding port changes and any equipment problems). In addition, a Method 5 type sampling train was operated at the economizer exit to collect a daily composite sample of PM. The composite sample was then used for determination of percent carbon in the fly ash resulting from incomplete combustion.

Both carbon types indicated similar levels of Hg control during the Phase I testing. Based upon these results, the less expensive Darco FGD was selected as the carbon for the Phase II testing.

## 2.2.2 Phase II -- Parametric Testing

The Phase II parametric testing included eight test conditions and was designed to evaluate the impact of carbon feed rate, carbon feed method, and flue gas temperature on Hg control. The test conditions are described in the lower portion of Table 2-1. All of these tests were conducted on Unit B.

During each run, simultaneous sampling was conducted at the economizer exit and in the stack for total PM and Hg using the multiple metals sampling train. During six of the test conditions (five from Phase II and one from Phase I), the sampling fractions collected by the multiple metals train were analyzed for 16 other metals. These

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<sup>\*</sup> Based on a flue gas flow rate of 75,000 dscm per hour. Unless otherwise noted, all flue gas flow rates used in this document are based on correction to standard conditions [20°C (68°F) and 101.3 kPa (14.7 psia)] and 7% O<sub>2</sub>.

**TABLE 2-1 UNIT B TEST MATRIX  
CAMDEN COUNTY MWC (1992)**

Condition	Phase	ESP Temperature (°F)	Number of ESP Fields	Carbon Type	Carbon Feed Method	Carbon Feed Rate (lb/hr)	Sample Analytes
B1	I	270	4	None	--	--	Hg, PM, %C
B2	I	270	4	FGD	Dry	10	Metals, PM, %C
B3	I	270	4	PC-100	Dry	10	Hg, PM, %C
B4	I	270	4	PC-100	Dry	60	Hg, PM, %C
B5	I	270	4	FGD	Dry	60	Hg, PM, %C
B6	II-PT	350	4	None	--	--	Hg, PM, %C
B7	II-PT	350	4	FGD	Dry	50	Metals, PM, %C
B8	II-PT	270	4	FGD	Dry	25	Hg, PM, %C
B9	II-PT	270	4	FGD	Dry	5	Hg, PM, %C
B10	II-PT	270	4	None	--	--	Metals, PM, %C, CDD/CDF, VOC
B11	II-PT	270	4	FGD	Dry	50	Metals, PM, %C, CDD/CDF, VOC
B12	II-PT	270	4	FGD	Slurry	50	Metals, PM, %C, CDD/CDF
B13	II-PT	270	4	FGD	Slurry	25	Metals, PM, %C

**TABLE 2-2 UNIT A TEST MATRIX  
CAMDEN COUNTY MWC**

<b>Condition</b>	<b>Phase</b>	<b>ESP Temperature (°F)</b>	<b>Number of ESP Fields</b>	<b>Carbon Type</b>	<b>Carbon Feed Method</b>	<b>Carbon Feed Rate (lb/hr)</b>	<b>Sample Analytes</b>
A1	II-ESP	270	4	None	--	--	Hg, Cd, Pb, PM, %C, PSD
A2	II-ESP	270	4	FGD	Slurry	50	Hg, Cd, Pb, PM, %C, PSD
A3	II-ESP	270	4	FGD	Slurry	50	Hg, Cd, Pb, PM, %C, PSD
A4	II-ESP	270	4	FGD	Slurry	50	Hg, Cd, Pb, PM, %C, PSD
A5	II-ESP	270	3	FGD	Slurry	50	Hg, Cd, Pb, PM, %C, PSD

metals included cadmium (Cd), lead (Pb), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), chromium (Cr), cobalt (Co), copper (Cu) manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl) and vanadium (V). In addition, a Method 5 type sampling train was operated at the economizer exit to collect a daily composite sample of PM for determination of percent carbon in the fly ash. Except for the three test conditions discussed below, the planned sampling durations for each sampling run was one hour long.

The testing also included sampling for CDD/CDF during Conditions B10, B11, and B12, and for VOC during Conditions B10 and B11. Each sampling run during these three test conditions was two hours in duration.

### 2.2.3 Phase II -- Electrostatic Precipitator Performance Testing

The other objectives of the Phase II testing were to evaluate whether there are any detrimental impacts on ESP performance due to carbon injection over an extended time period, and to assess the relationship between PM collection efficiency and Hg control. To satisfy these objectives, five days of sampling were conducted over a 12-day period on Unit A. Following an initial day of testing without carbon injection that was used to establish baseline performance, FGD carbon was added to the lime slaking tank and continuously fed as a slurry into the spray dryer.

As shown in Table 2-2, the first four days of sampling were conducted with four ESP fields in service. These tests were run on the day prior to the start of carbon injection and on the first, third, and eighth days after the start of carbon injection. After completion of testing on the eighth day, the last ESP field was turned off, thus resulting in operation with only three fields. On the fourth day after the unit had been operating with three fields, the fifth day of sampling was conducted. The delay in sampling until the fourth day after reducing the ESP to three-field operation was designed to allow the

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\* Unless otherwise noted, all run durations mentioned in the report are actual sampling times and exclude port changes and equipment problems.

transport system. Carbon feed rates were controlled by adjusting the screw feeder speed. A schematic of this system is shown in Figure 2-2. The metered carbon passed out the end of the screw feeder tube and dropped into a funnel connected to the pneumatic transport system. The transport system consisted of a Fox™ Air Eductor to provide air/carbon mixing and a flexible transport hose connecting the eductor to the injection probe. Transport air was supplied by the plant compressed air system.

The carbon injection probe consisted of a 1-inch pipe inserted into the side of the 90° elbow located just prior to the cyclone. The end of the probe was cut at a 45° angle, which faced downstream. The end of the probe was located five inches below the duct centerline. The off-center location was chosen to avoid a downstream obstruction and to take advantage of the turbulence created by the 90° turn in the flue gas flow. The cyclone also provided additional turbulence for mixing and equalized the distribution of flue gas flow to the SD. The cyclone was sized to remove only large particles in the flue gas, and was expected to have negligible removal of the injected carbon.

Prior to the start of testing, the feeder was calibrated by recording the voltage applied to the screw feeder DC motor over a range of voltages and the corresponding mass feed rate of carbon. Based on these data, a calibration curve was developed. During each test condition, the desired motor voltage was set. In addition, the carbon level in the feeder hopper was regularly monitored. When the carbon level fell to a preset point, the hopper was refilled. By recording the amount of carbon added and the time between refilling, the carbon feed rate was confirmed.

At the end of each testing day, the carbon feed rate was adjusted to the target level for the next day of testing. The feeder then operated overnight at this rate to condition the SD/ESP prior to the start of the next day of testing.

ESP to reach equilibrium with regard to PM collection efficiency. The three-field tests were conducted to evaluate probable carbon injection effects on MWCs with smaller ESPs than at Camden.

During each run, simultaneous sampling was conducted at the economizer exit and in the stack for total PM, Hg, Cd, and Pb using the multiple metals sampling train. At the stack sampling location during each run, two eight-stage Andersen impactors were operated to evaluate the particle size distribution (PSD) of emitted PM. In addition, a Method 5 type sampling train was operated at the economizer exit to collect a daily composite sample of PM for determination of percent carbon in the fly ash. The PM and PSD data provided a direct indication of whether degradation in ESP performance is associated with carbon injection. Because of enrichment of Cd and Pb onto fine particulate, these two elements are expected to be sensitive indicators of degraded performance. Each metals train sampling run was one hour long. The two PSD trains were run throughout each test day to collect sufficient particulate for quantitative measurement of the weight gain by each impactor stage.

## 2.3 Carbon Feed Systems

Carbon was fed to Units A and B by two different methods using three different injection systems. The testing on Unit B included injection of dry carbon and addition of carbon into a slurry mix tank installed just prior to the SD. Carbon was injected into Unit A by addition of carbon to lime slurry in the plant's existing lime slurry feed tank.

### 2.3.1 Dry Carbon Feed System

The primary carbon feed method used during the Unit B testing was injection of dry carbon into the flue gas duct just upstream of the SD inlet cyclone. The dry injection system consisted of a K-tron™ Model S-200 screw feeder and a pneumatic

### 2.3.2 Short Retention Time Carbon Slurry Feed System

The second carbon feed system used during testing on Unit B involved addition of carbon to the lime slurry in a mixing tank installed just prior to the spray dryer. This mixing system was designed to provide a relatively short contact time between the carbon and lime slurry prior to injection of slurry into the SD through the existing slurry atomization nozzles. Estimated carbon retention time in the slurry with this system was about 10 minutes.

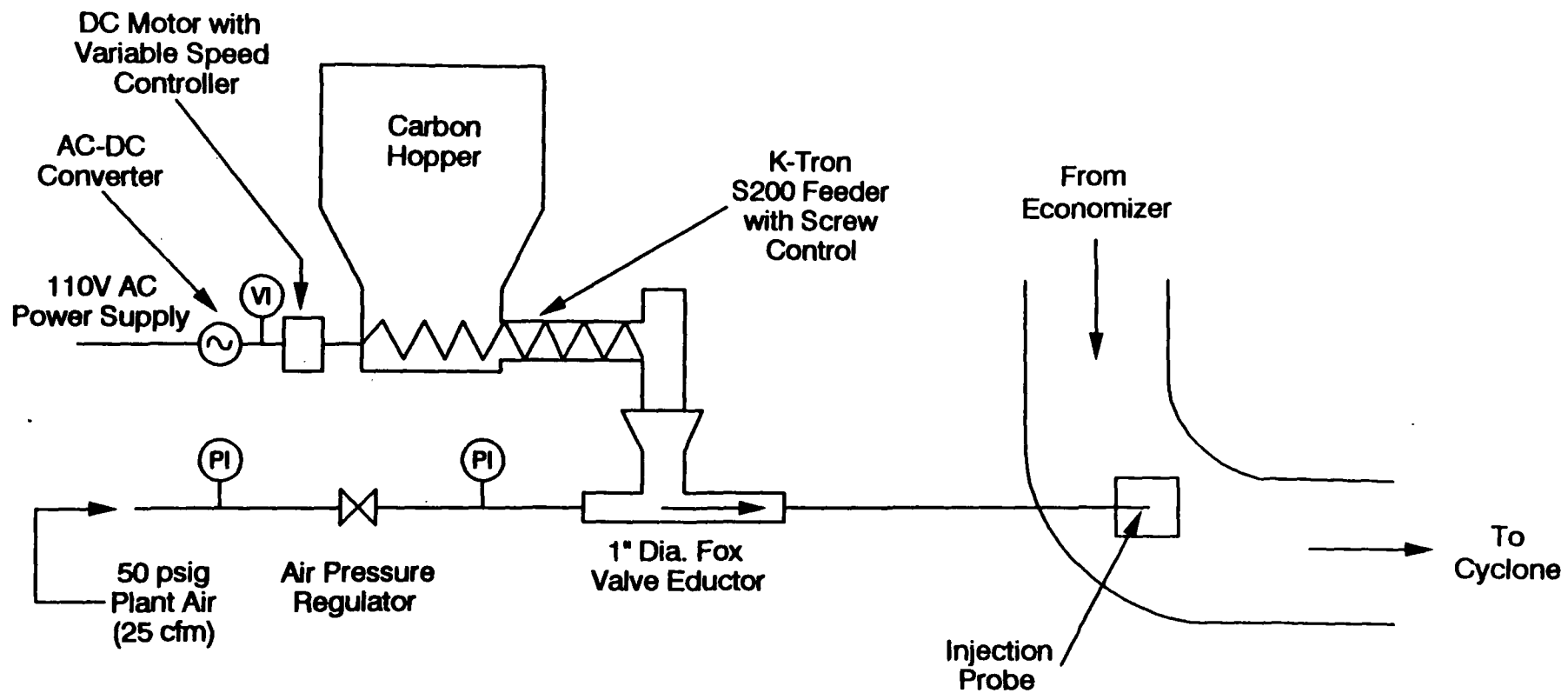
The system consisted of a 200 gallon polyethylene holding tank equipped with a mixer and pump, and a K-tron™ Model S-200 volumetric screw feeder. A schematic of this system is shown in Figure 2-3. Lime slurry was supplied to the small tank from the existing slurry system. Flow to the tank was controlled using manually operated parallel valves. Carbon was added to the tank using the volumetric screw feeder. An electrically operated tank mixer was used to maintain a homogenous mixture of carbon and slurry. A diaphragm pump was used to pump the carbon and slurry mixture from the tank to the reactor via the existing slurry control valve and slurry flow meter. The pump was set to deliver a constant flow rate.

Carbon feed rates were determined in the same manner as described previously in Section 2.3.2.

### 2.3.3 Slaking Tank Carbon Slurry Feed System

Carbon was fed to Unit A as a carbon/lime slurry by mixing carbon with lime and water in the lime slurry feed tank during each slaking cycle. The amount of carbon added during each slaking cycle was designed to maintain a constant carbon content in the slurry. The target slurry feed rate during all testing was 9 gallons per minute. During two of the runs, flows were adjusted to correct for "abnormal" stack SO<sub>2</sub> levels; however, all runs averaged between 8.2 and 9.6 gpm, and the condition averages were





**Figure 2-2. Dry Carbon Injection System**

between 8.8 and 9.2 gpm. The amount of carbon added during each slaking cycle was recorded so that the average carbon injection rate could be confirmed.

The carbon slurry mixture was injected into the reactor through the existing slurry feed and atomization system. Existing slurry storage, slurry mixing, and slurry transport equipment was used; therefore, no additional equipment was required. The carbon retention time in the slurry for any single test condition is estimated to range from 3 to 8 hours, with an average of approximately 5 hours. Three hours represents the minimum slurry volume maintained in the slurry feed tank prior to addition of fresh lime and carbon at the start of a slaking cycle. Eight hours represents the maximum residence time before adding fresh lime and carbon.

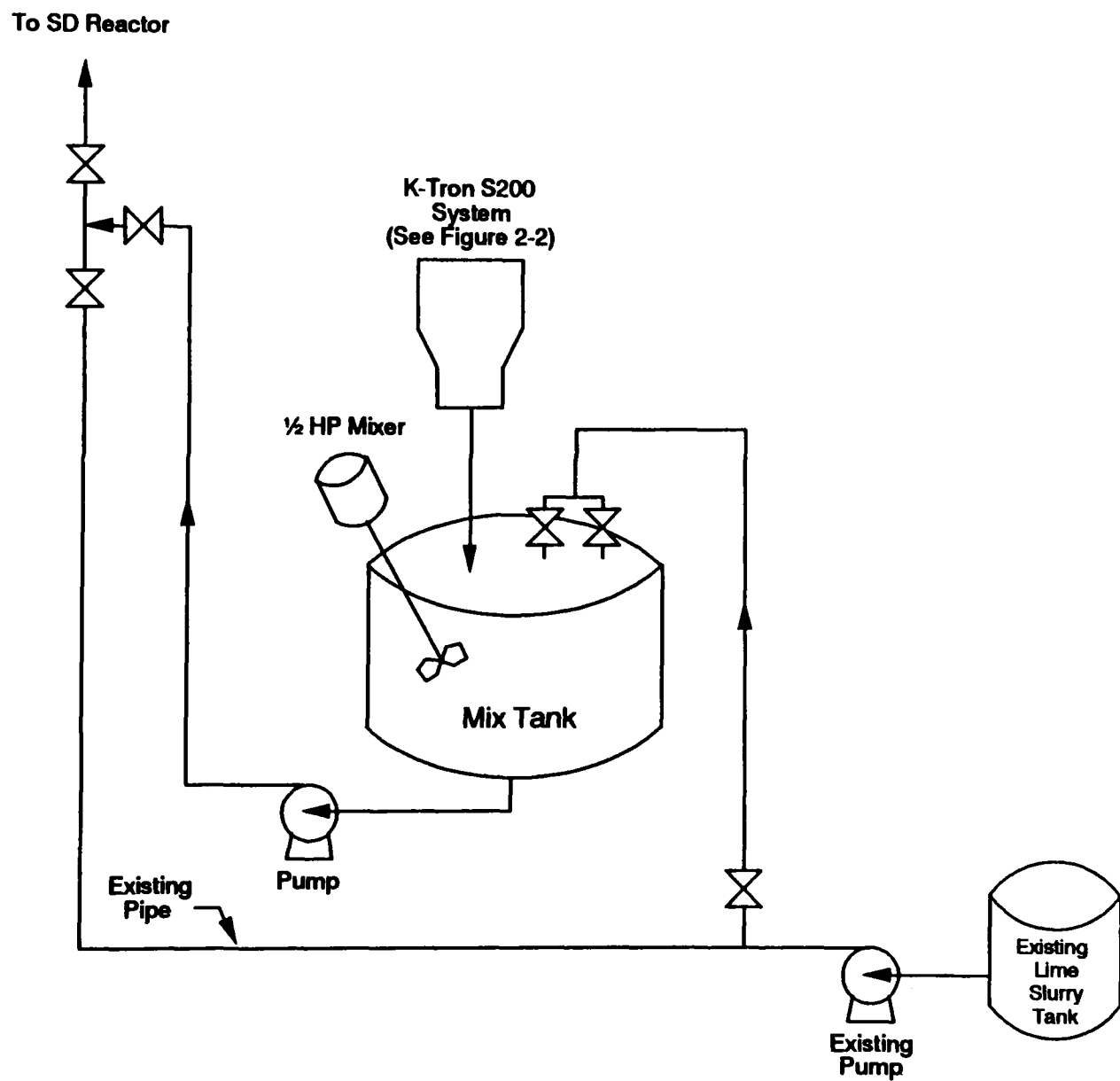
## **2.4 Description of Tested Carbons**

Two different carbons were used to investigate whether carbon type was critical to Hg removal by an SD/ESP-equipped MWC. Information on activation method, surface area, pore radius, grind, and tamped density is summarized for both carbons in Table 2-3. The first carbon used in the testing (Darco PC-100) was a thermally activated, bituminous coal-based carbon with medium surface area and high tamped density. The second carbon (Darco FGD) was thermally activated from lignite and had a lower surface area, smaller average particle size, and lower tamped density than the coal-based carbon.

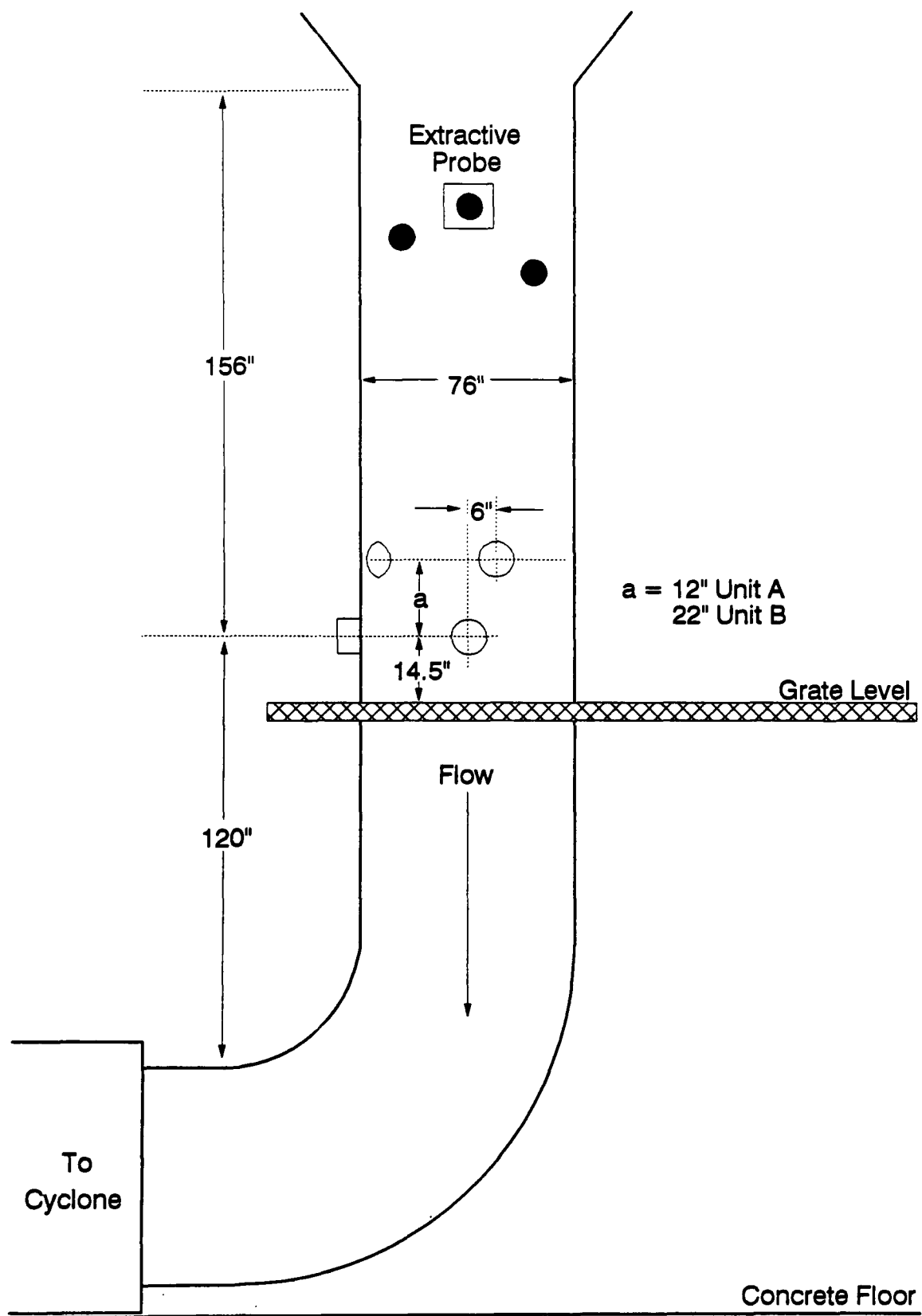
## **2.5 Sampling Locations**

### **2.5.1 Economizer Outlet Flue Gas Sample Location**

A general schematic of the economizer outlet flue gas sampling location is shown in Figure 2-4. The flue gas exits the economizer through a circular duct with an ID of 76 inches. Two pairs of flue gas sample ports are located on this duct. One pair is located approximately 156 inches (2.05 equivalent diameters) from the nearest upstream



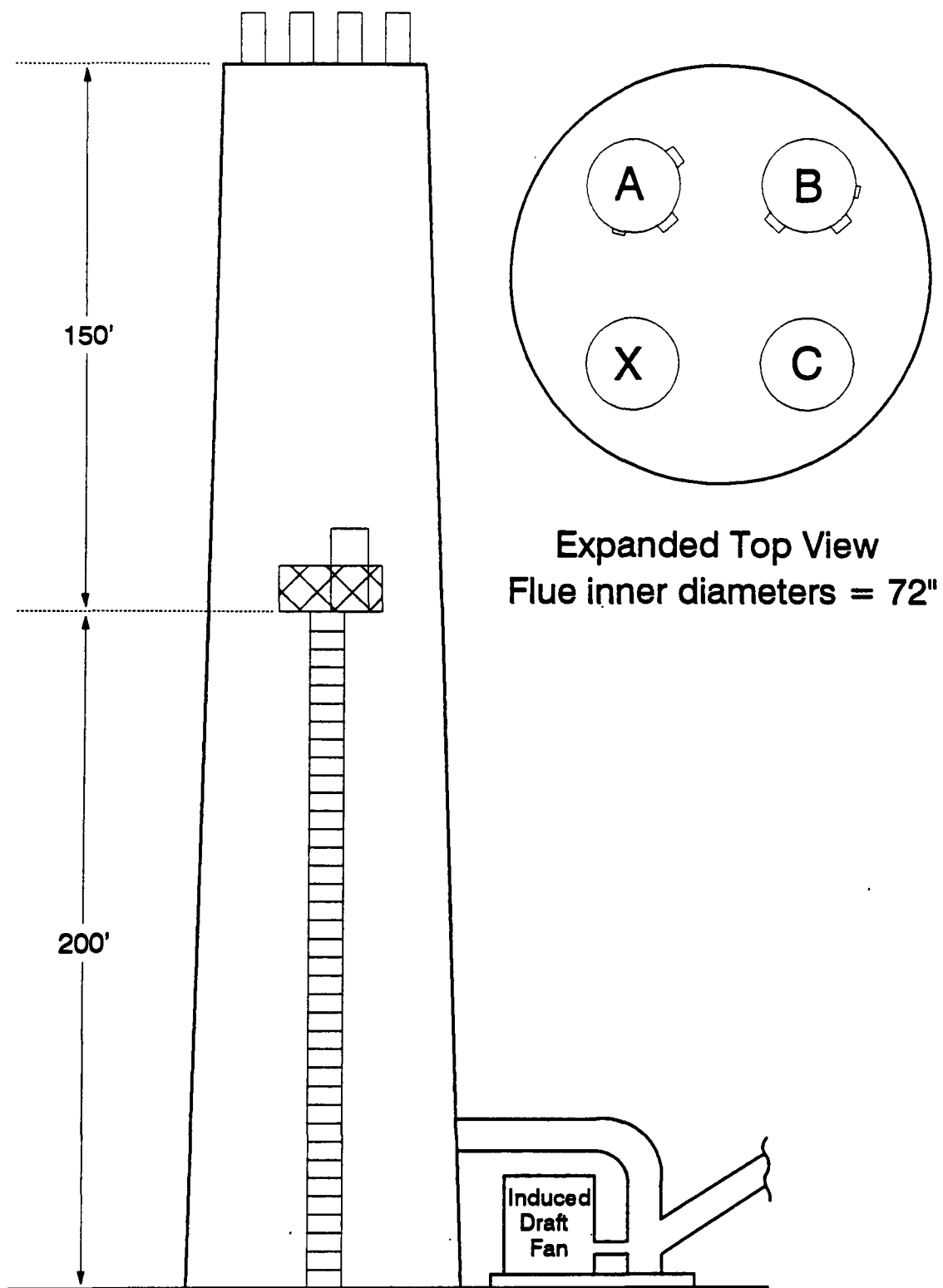
**Figure 2-3. Short-Duration Slurried Carbon Injection System**



**Figure 2-4. Economizer Outlet Flue Gas Sample Location**

**TABLE 2-3 DESCRIPTION OF ACTIVATED CARBONS TESTED  
CAMDEN COUNTY MWC**

Source Material	Brand Name	Activation Method	Surface Area (m <sup>2</sup> /g)	Average Pore Radius (10 <sup>-9</sup> m)	Grind		Tamped Density (kg/m <sup>3</sup> )
					% Thru 200 Mesh	% Thru 325 Mesh	
Coal	Darco PC-100	Thermal	950	1.5	97.1	72.8	690
Lignite	Darco FGD	Thermal	600	3.0	99.9	98.2	470



**Figure 2-5. Stack Flue Gas Sample Location**

disturbance and approximately 120 inches (1.6 equivalent duct diameters) from the nearest downstream disturbance. The other pair of ports (which were added for this program) are located 6 inches to the right and 12 inches above the other pair of ports for Unit A, and 6 inches to the right and 22 inches above the other pair for Unit B. All of the ports at this location were 4 inches in diameter. A 24-point sampling matrix was used for this location for both units. Sufficient work space was available at this location, therefore, no additional preparations were required to traverse two trains simultaneously with each pair of ports.

In addition to the two pairs of sampling ports described above, an additional port located approximately 4 feet above the grate with a 4-inch pipe nipple was available for non-traversing tests. This port was used for fly ash sampling using an EPA Method 5 type train.

## 2.5.2 Stack Flue Gas Sample Location

After the flue gas exits the ESP, it passes through an induced draft fan located at the base of the stack. The gas enters the flue and is emitted into the atmosphere approximately 366 feet from ground level. The test platform is located approximately 200 ft from ground level as shown in Figure 2-5.

The flues for Units A and B, along with Unit C and an additional flue for possible plant expansion, are located in the same stack shell. A stack sampling grate is located within the stack shell to provide access to the flues. Each of the flues has a 72-inch ID. The flues for Units A and B have one pair of ports with 6-inch diameter flanged nipples, located approximately 75 inches from the grate level. These ports were used for metals sampling on Unit A and for metals and CDD/CDF sampling on Unit B. One additional port, with a 4-inch diameter flanged nipple, is located approximately 52 inches above the grate level. This port was used for PSD sampling on Unit A and for VOC sampling on Unit B.

**TABLE 2-4 SAMPLING MATRIX  
CAMDEN COUNTY MWC (1992)**

<b>Parameters</b>	<b>Method</b>
Mercury and Other Metals	EPA Multi-Metals Method
Particulate Matter	
CDD/CDF	EPA Method 23
VOC	SW 846 Method 0030 (VOST)
Particle Size Distribution	Instack Cascade Impactor
Fly Ash Carbon	EPA Method 5
Carbon in Fly Ash	ASTM D 3178-84
SO <sub>2</sub> , O <sub>2</sub> (Inlet)	Plant CEMs QA (40 CFR, Part 60, Appendix F)
SO <sub>2</sub> , O <sub>2</sub> , CO <sub>2</sub> , HCl, NO <sub>x</sub> , CO, THC, H <sub>2</sub> O, Opacity (Stack)	
Steam Flow and Furnace Temperature	Plant Process Monitors
Economizer Outlet Temperature	
Lime Slurry and Dilution Water Flow	
SD Outlet Temperature	
ESP Voltage, Amperage, Spark Rate	



## 2.6 Sampling and Analytical Methods

Sampling methods used during the emission tests are listed in Table 2-4. Summary descriptions of the sampling methods and corresponding analytical methods are provided in Section 6. These sampling and analytical methods are also contained in EPA or American Society of Testing and Materials (ASTM) reference documents. The method used for Hg, other metals, and PM (EPA multi-metals method) is documented in the Environmental Protection portion of the Code of Federal Regulations (40 CFR), Part 266, Appendix IX.<sup>9</sup> The methods used for PM carbon samples (EPA Method 5) and CDD/CDF measurements (EPA Method 23) are contained in 40 CFR, Part 60, Appendix A.<sup>10,11</sup> The method used for VOST sampling and analysis (SW 846 Method 0030) is documented in EPA's Test Methods for Evaluating Solid Waste.<sup>12</sup> The method used for determining the amount of carbon in fly ash is contained in the 1984 Annual Book of ASTM Standards, Part 26.<sup>13</sup> The plant Continuous Emission Monitors (CEMs) were operated in accordance with the quality assurance requirements of 40 CFR, Part 60, Appendix F.<sup>14</sup>

Table 2-5 shows the sampling times, minimum sample volumes, and detection limits of the methods. Detailed descriptions of the sampling methods and the corresponding analyses are provided in Section 6.

**TABLE 2-5 SAMPLING TIMES, MINIMUM SAMPLING VOLUMES,  
AND DETECTION LIMITS  
CAMDEN COUNTY MWC (1992)**

Sampling Train	Sampling Time (hours) <sup>a</sup>	Minimum Sample Volume (dscf)	Analyte	Detection Limit	
				Flue Gas <sup>b</sup>	Analytical
PM/Metals	1 <sup>c</sup>	30	PM	0.003 gr/dscf	10-50 mg
			Hg	0.05 µg/dscm	0.0002 µg/ml
			Cd	0.4 µg/dscm	0.001 µg/ml <sup>d</sup>
			Pb	1.2 µg/dscm	0.003 µg/ml <sup>d</sup>
CDD/CDF <sup>e</sup>	2	90	CDD/CDF	0.03 ng/dscm	0.05 ng
VOST	1	20 liters per pair of tubes	Volatile Organics	0.025-0.5 µg/dscm	1-20 ng per pair of tubes

- <sup>a</sup> An average sampling rate of 0.5 ft<sup>3</sup>/min was used to calculate sampling time.
- <sup>b</sup> Flue gas detection limit is calculated conservatively by summing the front-half and back-half detection limits. Solution volume for front-half and back-half fractions are typically 300 ml and 150 ml, respectively.
- <sup>c</sup> During times when CDD/CDF sampling was also conducted, run time was two hours.
- <sup>d</sup> Based on graphite furnace atomic absorption spectroscopy (GFAA).
- <sup>e</sup> Detection limits for penta, hexa, and hepta isomers are approximately 5 times the above value and the detection limits for the octa isomers are approximately 10 times the above value.

**TABLE 3-1. SUMMARY OF TEST CONDITIONS AND MERCURY TEST RESULTS  
CAMDEN COUNTY MWC (1992)**

Phase-Condition	Run Number	Carbon Type	Injection Method	Carbon Injection Rate (mg/dscm @ 7% O <sub>2</sub> )	ESP Inlet Temp (°F)	Total Carbon at Cyclone Inlet (mg/dscm @ 7% O <sub>2</sub> )	Mercury Conc at Inlet (µg/dscm @ 7% O <sub>2</sub> )	Mercury Conc at Outlet (µg/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)
I-B1	1	None	--	0	269	79 <sup>a</sup>	356	175	50.8
	2			0	267	79 <sup>a</sup>	1363	210	84.6
	3			0	262	79 <sup>a</sup>	711	54	92.4
	Avg			0	266	79 <sup>a</sup>	810	146	75.9
I-B2	4	FGD	Dry	73	274	154 <sup>a</sup>	972	296	69.5
	5			79	266	160 <sup>a</sup>	593	63	89.4
	6			78	275	159 <sup>a</sup>	835	149	82.2
	Avg			77	272	158 <sup>a</sup>	800	169	80.4
I-B3	7	PC-100	Dry	89	264	154 <sup>a</sup>	593	134	77.4
	8			73	272	138 <sup>a</sup>	639	29	95.5
	9			88	273	153 <sup>a</sup>	586	102	82.6
	Avg			83	270	148 <sup>a</sup>	606	88	85.2
I-B4	10	PC-100	Dry	477	265	579 <sup>a</sup>	491	21	95.7
	11			456	290	558 <sup>a</sup>	440	14	96.8
	12			418	291	520 <sup>a</sup>	512	17	96.6
	Avg			450	282	552 <sup>a</sup>	481	17	96.4
I-B5	13	FGD	Dry	430	275	534 <sup>a</sup>	680	9	98.6
	14			444	277	548 <sup>a</sup>	820	13	98.4
	15			450	262	554 <sup>a</sup>	644	12	98.2
	Avg			441	271	546 <sup>a</sup>	715	12	98.4
II-B6	10	None	--	0	348	74	365	301	17.5
	11			0	350	101	249	177	28.9
	12			0	349	55	349	261	25.2
	Avg			0	349	77	321	246	23.9

### 3.0 INTERPRETATION OF RESULTS

This section summarizes the flue gas and process data collected during the Camden County MWC testing (Section 3.1) and discusses the relationship between carbon injection and emissions of Hg (Section 3.2), other metals (Section 3.3), CDD/CDF (Section 3.4), VOC (Section 3.5), and acid gases (Section 3.6), and the impact of carbon injection on ESP performance (Section 3.7). Where appropriate, the test results from Camden County are compared to the results from SD/FF testing at OMSS.

#### 3.1 Data Summary

A summary of key operating data is presented in Table 3-1. The table includes carbon type, injection rate and method, ESP temperature, total carbon concentration at the cyclone inlet, Hg inlet and outlet concentrations, and Hg removal efficiency. Additional process and emissions data are presented in Sections 4 and 5.

#### 3.2 Mercury

As described in Section 2.2, activated carbons produced from lignite and bituminous coals were injected at different rates into the flue gas as a dry powder and with the lime slurry feed to the SD. To evaluate the effectiveness of carbon injection and SD/ESP operating conditions on emissions, the following operating parameters were studied: carbon type, injection rate and method, inherent carbon content of the combustor fly ash, carbon retention time in the SD slurry, ESP temperature, and PM emission rate.

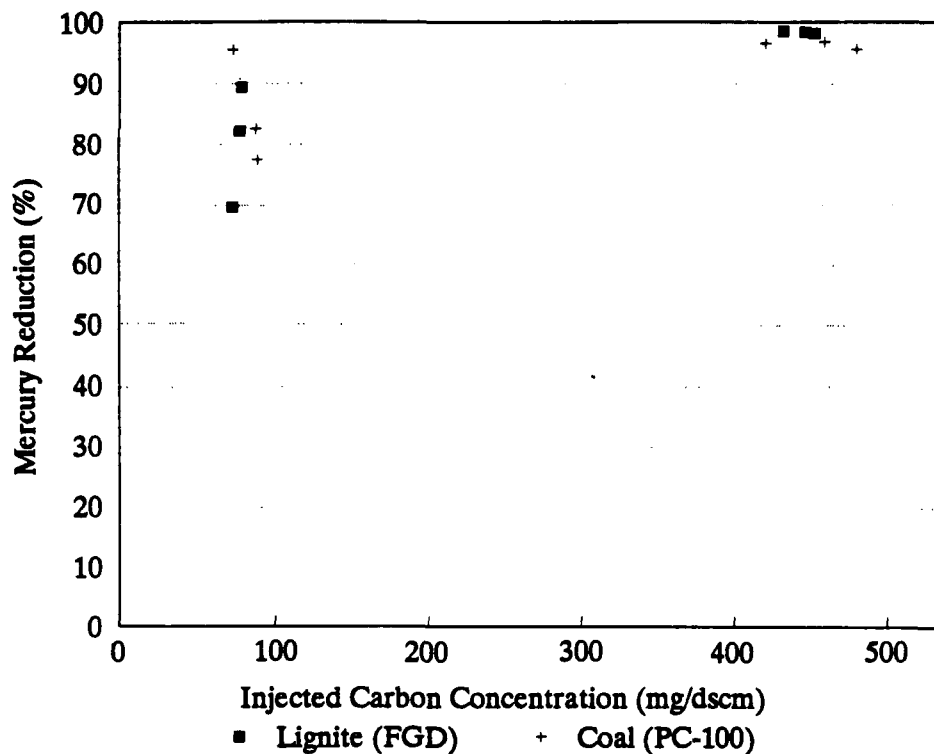
TABLE 3-1, CONTINUED

Phase-Condition	Run Number	Carbon Type	Injection Method	Carbon Injection Rate (mg/dscm @ 7% O <sub>2</sub> )	ESP Inlet Temp (°F)	Total Carbon at Cyclone Inlet (mg/dscm @ 7% O <sub>2</sub> )	Mercury Conc at Inlet (µg/dscm @ 7% O <sub>2</sub> )	Mercury Conc at Outlet (µg/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)
II-B13	37	FGD	Slurry	183	266	233	382	78	79.7
	38			194	263	265	377	81	78.5
	39			200	264	248	974	158	83.8
	Avg			192	264	249	578	106	80.7
II-A1	1	None	—	0	277	100	268	121	54.9
	2			0	270	86	430	290	32.6
	3			0	273	198	610	322	47.2
	Avg			0	273	128	436	244	44.9
II-A2	4	FGD	Slurry	344	265	427	302	55	81.9
	5			346	265	468	403	78	80.7
	6			343	266	450	1412	261	81.5
	Avg			344	265	448	706	131	81.4
II-A3	7	FGD	Slurry	402	278	579	530	43	91.9
	8			356	269	412	458	108	76.4
	9			386	288	629	690	156	77.4
	Avg			381	278	540	559	102	81.9
II-A4	22	FGD	Slurry	442	285	640	643	49	92.3
	23			391	283	567	816	90	89.0
	Avg			417	284	604	730	70	90.7
II-A5	31	FGD	Slurry	269	283	381	335	40	88.0
	32			280	283	404	294	51	82.6
	33			249	284	356	364	52	85.6
	Avg			266	283	380	331	48	85.4

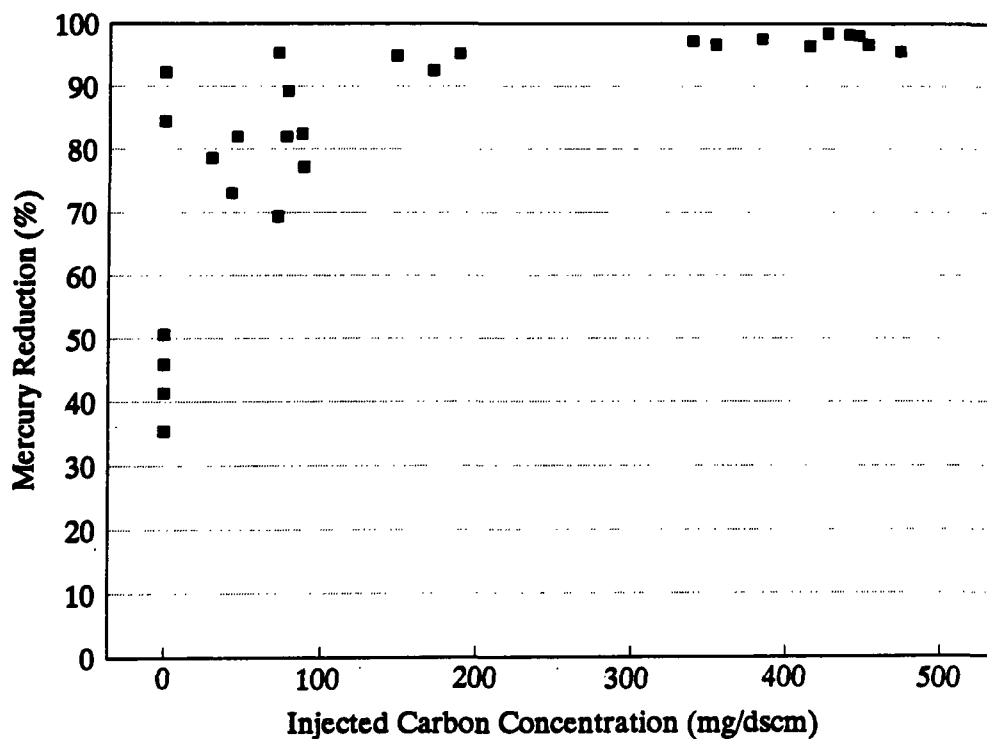
<sup>a</sup>Inlet PM concentration was not measured during Phase I; inherent carbon concentrations for Phase I estimated based on the average inlet PM measured during Phase II and the measured fly ash percent carbon for the test condition.

TABLE 3-1, CONTINUED

Phase-Condition	Run Number	Carbon Type	Injection Method	Carbon Injection Rate (mg/dscm @7% O <sub>2</sub> )	ESP Inlet Temp (°F)	Total Carbon at Cyclone Inlet (mg/dscm @ 7% O <sub>2</sub> )	Mercury Conc at Inlet (μg/dscm @ 7% O <sub>2</sub> )	Mercury Conc at Outlet (μg/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)
II-B7	13	FGD	Dry	313	352	387	964	107	88.9
	14			329	352	429	506	22	95.6
	15			324	344	418	778	59	92.4
	Avg			322	349	411	749	63	92.3
II-B8	16	FGD	Dry	173	267	305	545	40	92.7
	17			149	263	276	455	23	95.0
	18			190	262	306	525	24	95.4
	Avg			171	264	295	508	29	94.4
II-B9	19	FGD	Dry	30	266	111	485	103	78.8
	20			46	266	141	957	170	82.2
	21			43	265	129	463	124	73.2
	Avg			40	266	127	635	132	78.1
II-B10	25	None	--	0	269	83	663	388	41.5
	26			0	266	98	433	279	35.6
	27			0	258	91	384	207	46.1
	Avg			0	264	91	493	291	41.0
II-B11	28	FGD	Dry	357	271	506	626	20	96.8
	29			342	273	504	635	16	97.4
	30			387	269	505	664	16	97.7
	Avg			362	271	505	642	17	97.3
II-B12	34	FGD	Slurry	324	269	385	299	50	83.2
	35			325	269	368	521	77	85.3
	36			336	275	403	300	69	77.0
	Avg			328	271	385	373	65	81.8



**Figure 3-1. Effect of Carbon Type on Mercury Reduction**  
(Dry Injection and 270° F ESP Inlet Temperature)



**Figure 3-2. Effect of Injected Carbon Concentration on Mercury Reduction**  
(FGD Carbon, Dry Injection and 270° F ESP Inlet Temperature)

### 3.2.1 Impact of Carbon Type

The influence of carbon type was examined during testing with lignite-based carbon (Conditions B2 and B5) and coal-based carbon (Conditions B3 and B4). Conditions B2 and B3 were conducted at a low carbon feed rate of approximately 80 mg/dscm. Conditions B4 and B5 were conducted at a high carbon feed rate of approximately 450 mg/dscm. The carbon was injected as a dry powder during each condition.

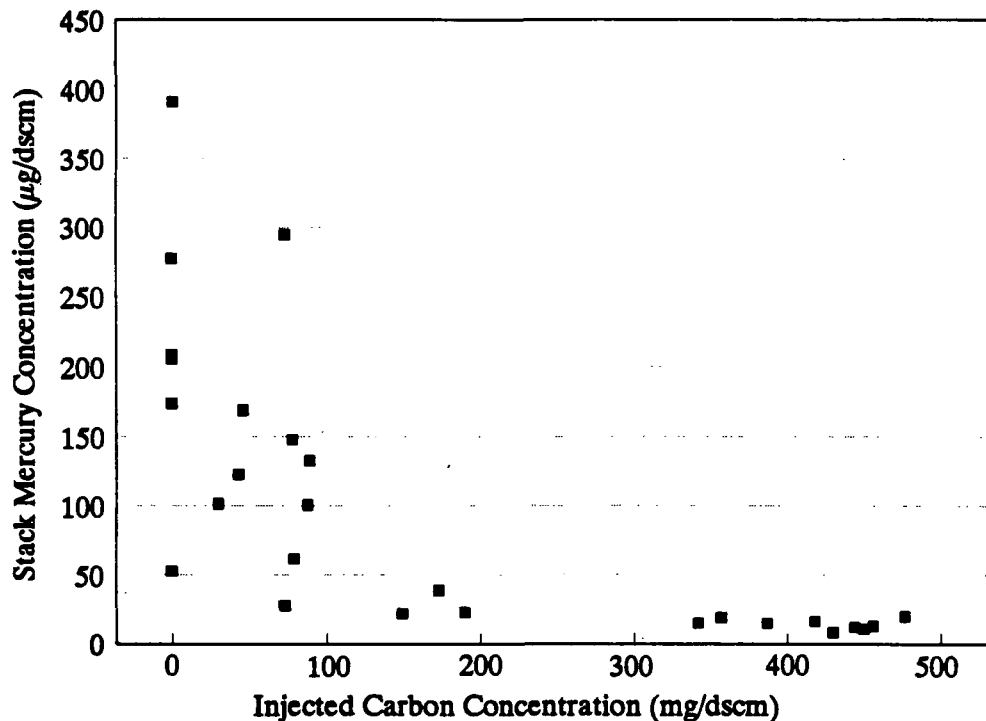
Figure 3-1 shows the calculated Hg removal efficiency during each test run. At the low carbon feed rate, the calculated removal efficiency was 70 to 89% with the lignite-based carbon and 78 to 96% with the coal-based carbon. At high carbon feed rates, the removal efficiency was 98 to 99% with the lignite-based carbon and 95 to 97% with the coal-based carbon. Because there was no clear distinction in the removal efficiency of these two carbons, the remaining tests were conducted using the more economical lignite-based carbon. The similarity in performance of these two carbons when injected as a dry powder is consistent with the results of the OMSS testing.<sup>4</sup>

### 3.2.2 Impact of Carbon Injection Rate

Figure 3-2 graphs Hg removal efficiency as a function of carbon injection rate. The data points show the removal efficiencies measured during individual runs conducted at an ESP temperature of approximately 270°F and while injecting either dry, lignite-based carbon, or no carbon. The specific test conditions are B1, B2, B5, B8, B9, B10, and B11. The carbon injection rates range from 40 to 450 mg/dscm.

As evident from the figure, increasing carbon injection increases the Hg reduction and decreases the variability of Hg reduction between individual runs of the same condition. These tendencies were also observed during the OMSS test program. However, the carbon feed rates at Camden County were significantly higher than at OMSS, where the highest feed rate with dry carbon was approximately 70 mg/dscm.<sup>4</sup>





**Figure 3-3. Effect of Injected Carbon Concentration on Mercury Emissions**  
(FGD Carbon, Dry Injection and 270° F ESP Inlet Temperature)

composite PM sample was collected at the economizer exit during each test condition and analyzed for carbon content. The carbon levels measured during each day were between 1.1 and 2.2% of the dried sample weight. The percent carbon found in each daily sample was then multiplied by the measured PM loading at the economizer exit for each run on that day. The resulting estimate of inherent carbon in mg/dscm was then added to the rate at which activated carbon was injected to estimate the total carbon level in the flue gas. One shortcoming of this approach is that only a single estimate of the PM carbon content is obtained for each day and any run-to-run variations in combustion conditions that could result in increased carbon levels during an individual run are not measured. Also, some large fly ash carbon is removed by the spray dryer inlet cyclone and this carbon loss is unaccounted for.

As shown in Figure 3-4, the 40 to 70% reduction in emitted Hg in the absence of carbon injection could be explained by the presence of approximately 100 mg/dscm of unburned carbon associated with the emitted PM. At OMSS, the carbon content of the

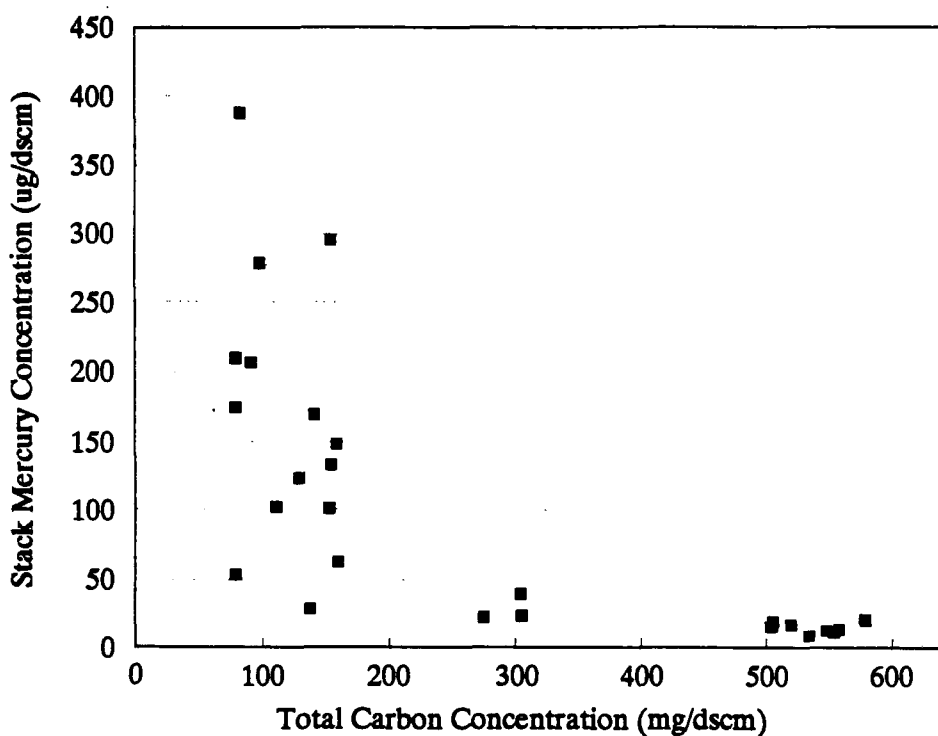
For dry carbon injection rates above 150 mg/dscm, Hg removals were 93% or greater, and exhibited relatively small increases in Hg reduction. At these feed rates, the variability between runs of a given test condition was 3% or less. At carbon feed rates of less than 150 mg/dscm, the Hg removal efficiencies were noticeably lower and the run-to-run variability between individual runs was as much as 20% during a single test condition.

The greatest variability in Hg reduction was observed during Conditions B1 and B10, with no carbon injection. In particular, during Runs 2 and 3 of Condition B1, removal efficiencies were 85 and 93%, which are nearly double the value of other runs with no carbon injection. It was initially believed that these high values may reflect poor combustion conditions caused by high moisture content in the waste stream. However, similar "wet waste" were experienced during the Phase II tests, and no abnormally high Hg captures were observed. Review of the three previous quarterly Hg emission tests of Unit B shows reductions during three-run tests of 41 to 43%, 41 to 55%, and 30 to 73% (all based on EPA Method 101A). These data suggest that Hg removals without carbon injection for the tested unit is typically between 40 and 50%, but can be both higher or lower.

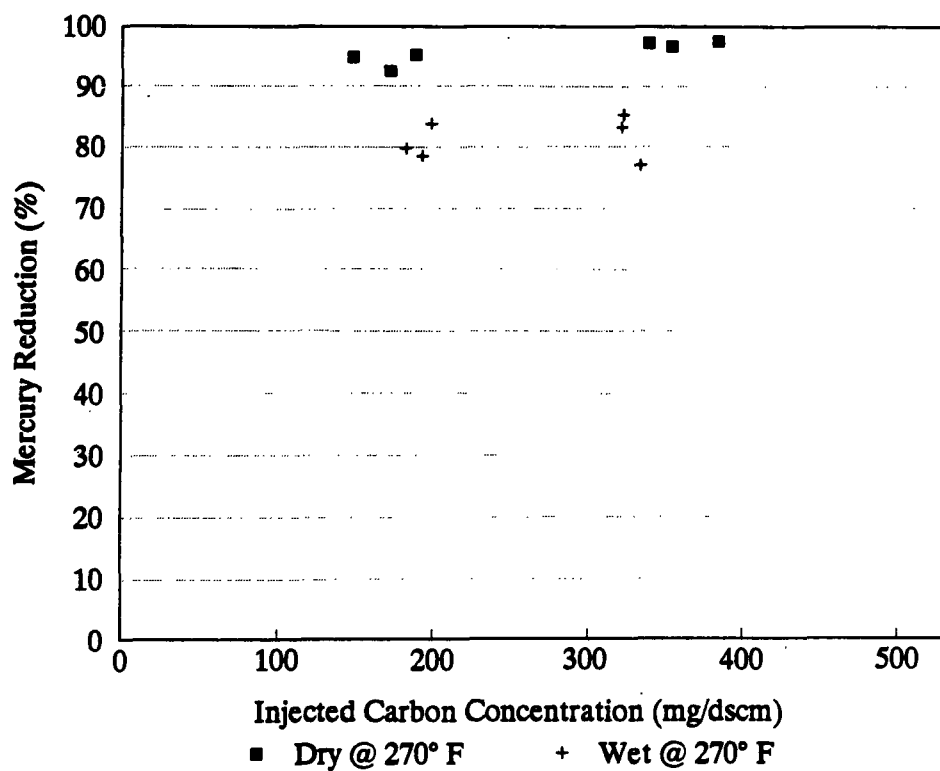
The effect of carbon injection rate on stack Hg concentrations is shown in Figure 3-3. The trends in these data are similar to the Hg reduction data. Specifically, at carbon injection rates above 150 mg/dscm, stack concentrations show relatively little run-to-run variation, while at lower carbon injection rates, there is significant variability in the run-to-run data.

### 3.2.3 Impact of Inherent Carbon

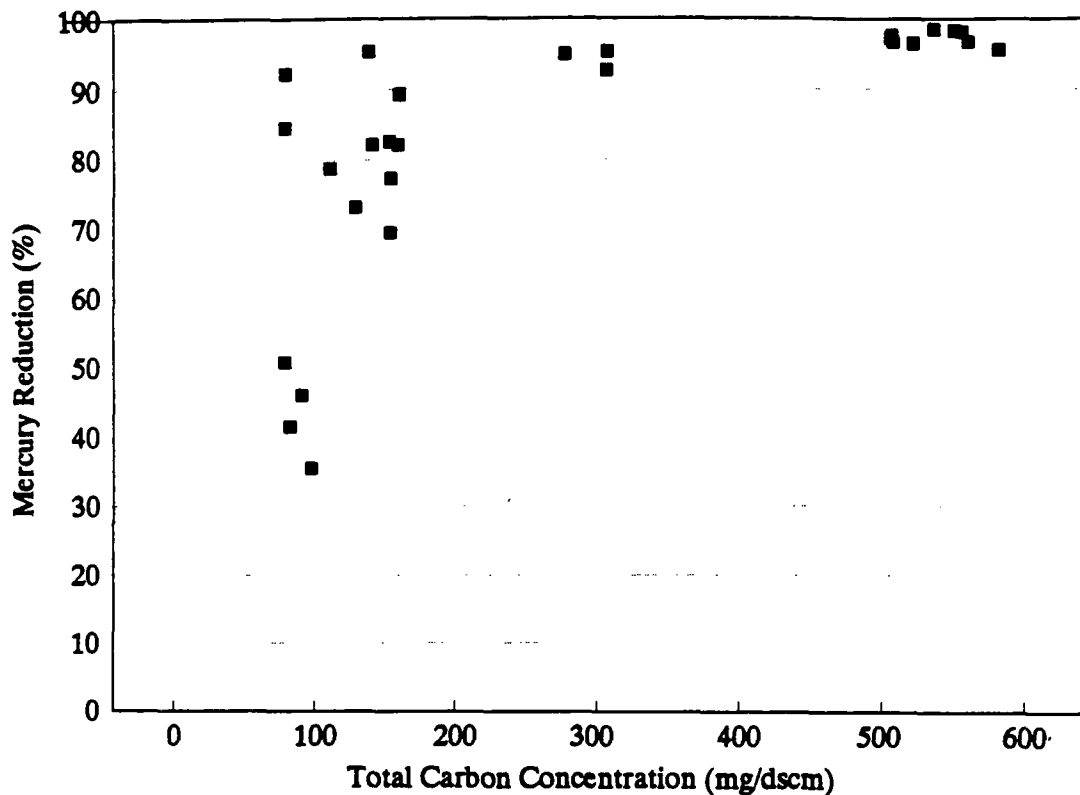
Part of the variability in Hg reductions during the EPA-funded and previous tests may result from differences in the amount of unburned carbon in the PM emitted from the combustor. To estimate the amount of unburned carbon present in the flue gas, a



**Figure 3-5. Effect of Total Carbon Concentration on Mercury Emission**  
(FGD Carbon and 270° F ESP Inlet Temperature)



**Figure 3-6. Effect of Carbon Feed Method on Mercury Reduction**  
(FGD Carbon and 270° F ESP Inlet Temperature)



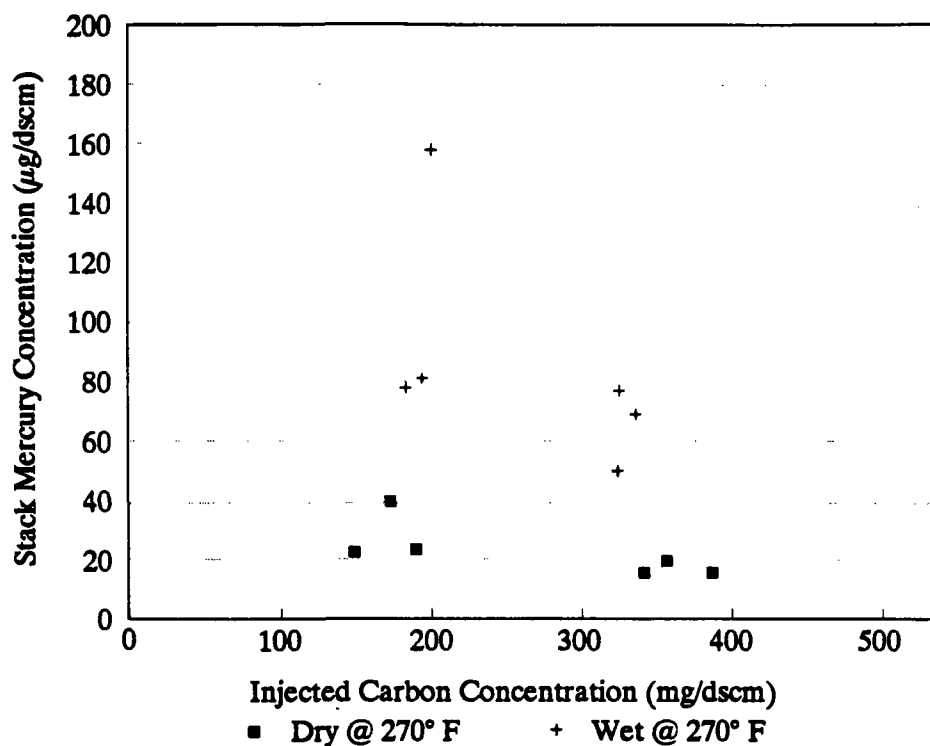
**Figure 3-4. Effect of Total Carbon Concentration on Mercury Reduction**  
(FGD Carbon, Dry Injection and 270° F ESP Inlet Temperature)

PM emitted from the combustor (0.5 to 1.0%) was approximately one-half the level at Camden County and the Hg reduction without carbon injection was also approximately one-half the level (25%).<sup>4</sup>

Figure 3-5 is a plot of the stack Hg concentration versus total carbon concentration.

### 3.2.4 Impact of Carbon Injection Method

Figure 3-6 shows the relationship between carbon injection method and Hg removal. At medium carbon injection rates (150 to 200 mg/dscm), removal efficiencies were 92 to 95% with dry injection (Condition B8) and 79 to 84% when the carbon was injected as a slurry (Condition B13). At high carbon injection rates (320 to 390 mg/dscm), removal efficiencies were 97 to 98% with dry injection (Condition B11)



**Figure 3-7. Effect of Carbon Feed Method on Mercury Emissions**  
(FGD Carbon and 270° F ESP Inlet Temperature)

Conditions A2, A3, and B12 were used to assess the impact of carbon retention time in the slurry. The average carbon feed concentration for these conditions was 320 to 400 mg/dscm. As shown in Figure 3-8, the Hg removal efficiency for the testing on Units A and B were very similar with both units averaging 82%. As a result, it appears the decreased Hg adsorbance of the Darco FGD carbon when mixed with slurry occurs rapidly and does not change with slurry retention time in excess of the minimum times tested at Camden.

### 3.2.6 Impact of ESP Temperature

Figure 3-9 shows the relationship between ESP temperature and Hg removal efficiency when operating without carbon injection and at high carbon injection concentrations. As discussed in Section 3.2.2, when operating without carbon injection and an ESP temperature near 270°F (Conditions B1 and B10), Hg removals averaged roughly 50%. At the higher ESP temperature of 350°F (Condition B6), the Hg removal

and 77 to 85% with slurried carbon (Condition B12). Figure 3-7 shows the relationship between carbon feed method and Hg stack concentrations. These data suggest that the feed method does affect Hg removal efficiency and emissions.

This observation is in contrast to the OMSS results, which found that feed method did not have a significant impact on Hg emissions and Hg removal. The cause of this difference is uncertain, but may be due to the different carbon type used or the type of PM control device. The carbon used for the OMSS SD/FF slurry testing was a coal-based carbon, rather than the lignite-based carbon used during slurry testing at Camden County.<sup>4</sup>

As discussed in Section 2.4, the lignite-based carbon is characterized as having larger average pore diameters than the coal-based carbon. Lignites are also generally more hygroscopic than bituminous coals. Both of these factors may contribute to greater wetting or plugging of the carbon surface, and thus reduced reactivity.

The difference in PM control device may also be significant. For an ESP, as used at Camden County, most of the Hg adsorption occurs while carbon is suspended in the flue gas (a residence time of 10 to 20 seconds). For a FF, as used at OMSS, the carbon has additional time to dry and adsorb Hg while it is held in the filter cake.

### 3.2.5 Impact of Carbon Retention Time in Lime Slurry

The carbon retention time in the lime slurry was different for Unit A and Unit B. On Unit A, carbon was added to the lime slaking tank approximately once every five hours. Carbon retention time in the slurry is estimated to be three to eight hours. On Unit B, carbon was added to the slurry in a mixing tank installed just prior to the SD. Retention time of the carbon in this system is estimated at 8 to 10 minutes.

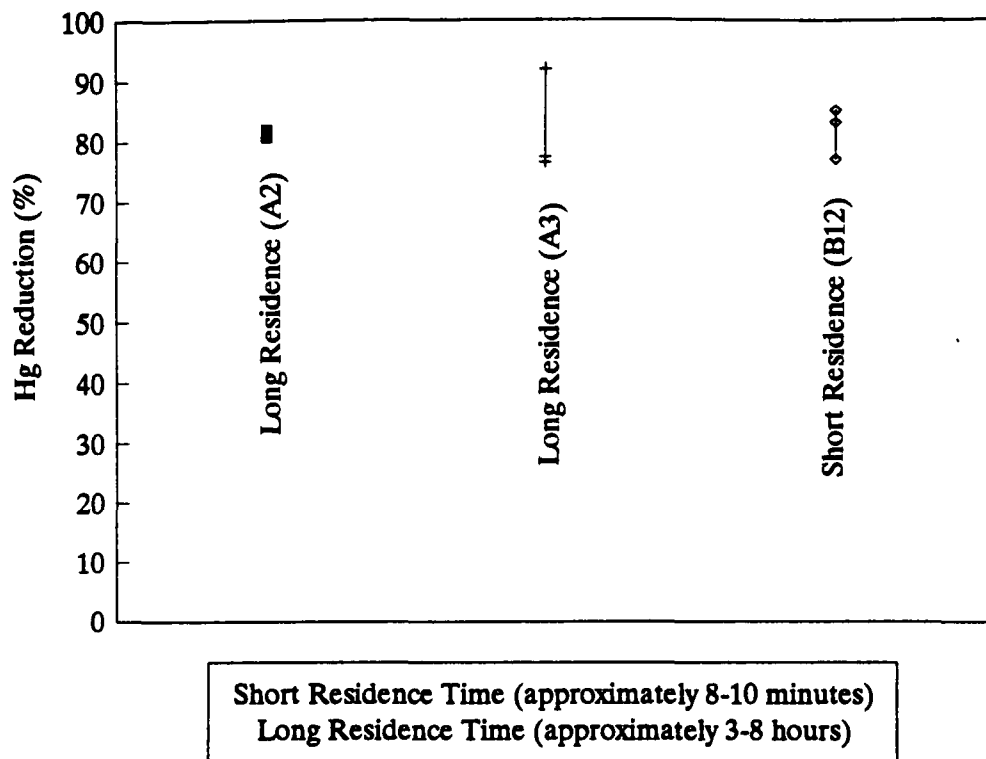
was 18 to 29%. At high carbon feed rates and an ESP inlet temperature of 270°F (Condition B11), Hg removals were 97 to 98%. At similar carbon feed rates, but an ESP temperature of 350°F (Condition B7), Hg removals were 89 to 96%. These data suggest that the ability of carbon to absorb Hg is directly related to flue gas temperature, but that even at relatively high temperatures of 350°F, activated carbon injection can achieve significant Hg reductions.

### 3.2.7 Impact of PM Control Efficiency

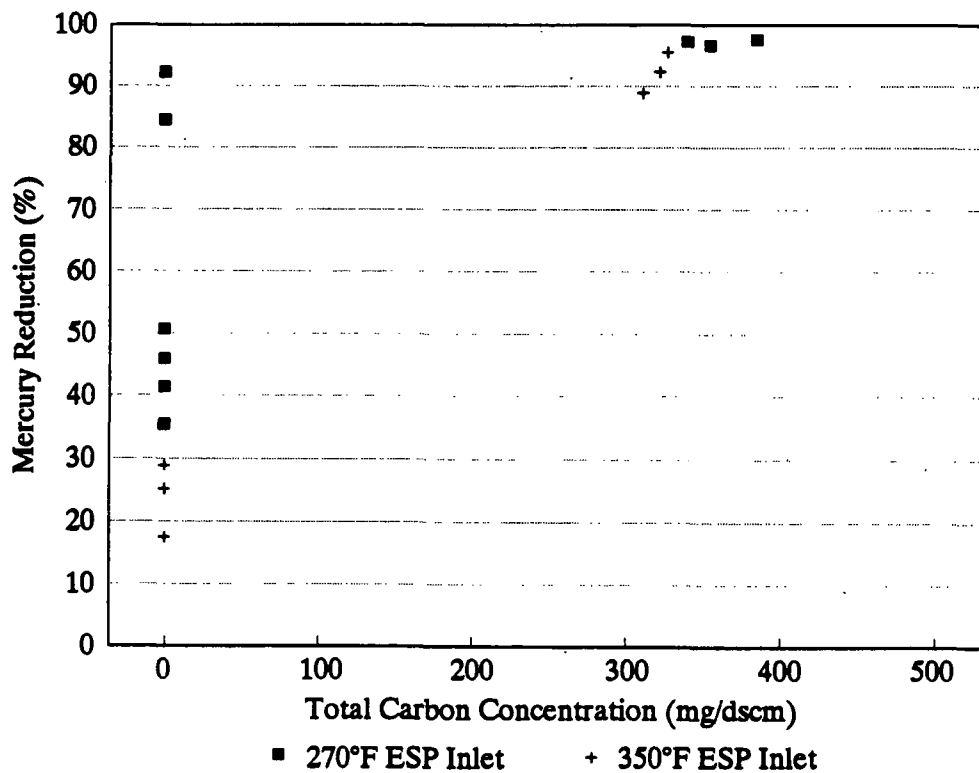
Particulate matter removal efficiencies during the Camden County testing were greater than 99.9% for all but five runs. These five runs occurred during Conditions B10, B13, A3 and A5. Condition B10 was conducted without carbon injection. Conditions B13, A3 and A5 were conducted while injecting carbon as a slurry. As can be seen on Figure 3-10, there is no apparent relationship between PM and Hg removal efficiency during these four test conditions.

### 3.2.8 Multivariate Regression Analysis

A stepwise multivariate regression analysis was used to assess the statistical significance of individual process variables and to develop predictive equations of Hg removal efficiency and outlet concentration. The process variables examined in this analysis included injected carbon concentration, total carbon concentration (i.e., injected carbon plus unburned carbon in the fly ash), carbon injection method (dry or slurry), SD outlet temperature, inlet Hg concentration, and PM control efficiency. In a stepwise multivariate regression analysis, the model first identifies the single independent (i.e., process) variable that is the strongest predictor of the dependent variable (outlet Hg concentration or removal efficiency). If the independent variable is statistically significant (the 95% confidence level based on the t-statistic was used in the analysis), the model then identifies the next most significant variable, which when combined with the first variable best predicts the dependent variable. A t-statistic based confidence level is used for statistical analysis of small populations (less than 30 test data points).



**Figure 3-8. Effect of Carbon Retention Time in Lime Slurry on Mercury Reduction**  
(FGD Carbon, Dry Injection and 270° F ESP Inlet Temperature)



**Figure 3-9. Effect of ESP Temperature on Mercury Reduction**



the removal of Hg when carbon was not injected due to the presence of inherent carbon in the fly ash and the difference in carbon utilization rates observed for dry versus slurry injection. Based on review of the residual error estimates from the initial regression analysis, Run 3 of Condition I-B1 was determined to be a statistical outlier and was excluded from use in the final regression analyses.

### Removal Efficiency

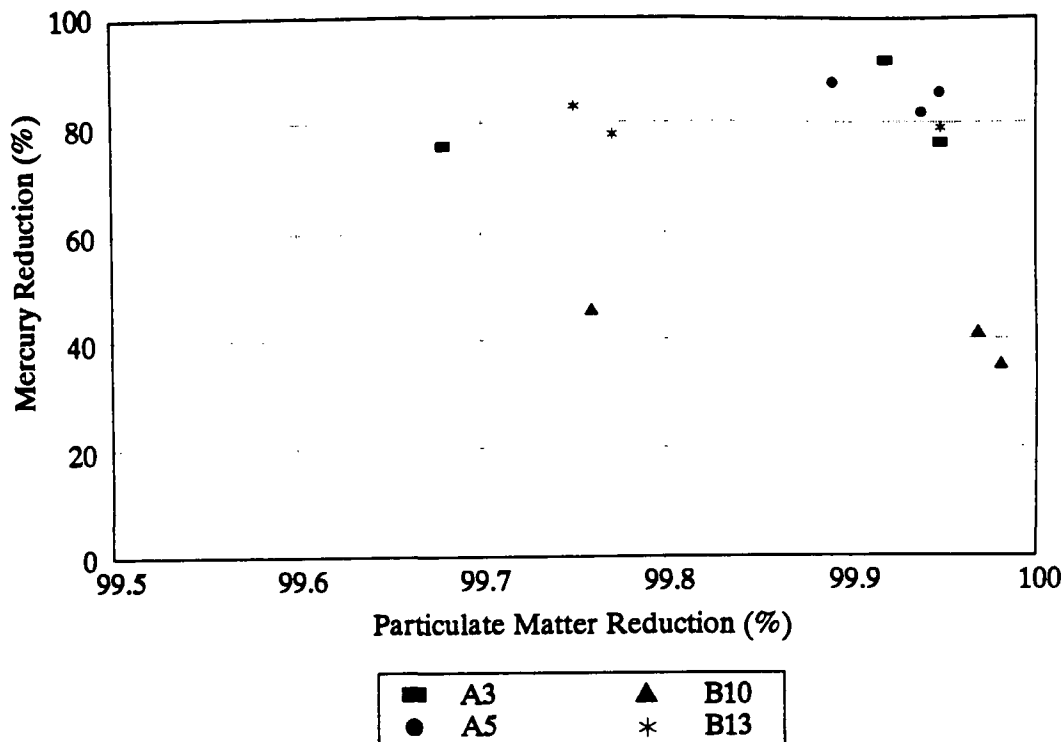
The final regression analysis identified three statistically significant process variables influencing Hg control efficiency: carbon feed rate, SD outlet temperature, and carbon injection method. The best predictive model for Hg percent reduction based on the dry carbon injection data was:

$$\ln(100 - \%RED) = 9.76 - 0.145 (CFC)^{0.5} - 2390\left(\frac{1}{T}\right) \quad (\text{Equation 3-1})$$

where %RED is % reduction in Hg, CFC is Carbon Feed Concentration in mg/dscm, and T is temperature in Kelvin. The "goodness of fit" ( $R^2$ ) of this model is 0.83. The predictive equation for slurry injection of carbon was based on the two Unit B test conditions using slurry injection and the removal efficiency of 52% derived from Equation 3-1 at zero carbon injection and a temperature of 270°F. This equation is:

$$\ln(100 - \%RED) = 9.76 - 0.0578 (CFC)^{0.5} - 2390\left(\frac{1}{T}\right) \quad (\text{Equation 3-2})$$

The calculated Hg removal efficiencies derived from Equation 3-1 at 270°F and 350°F and from Equation 3-2 at 270°F are shown in Figure 3-11, along with the actual data. The carbon injection concentration required to achieve an average reduction in Hg concentration of 90% during the Camden testing, based on injection of dry carbon at 270°F, is approximately 115 mg/dscm. Due to variations in process operation, however, the Hg reduction achieved during an individual test at a given carbon feed concentration varies. As shown in Figure 3-12, for dry injection at 270°F, 90% (i.e., the span between the 5% and 95% confidence interval lines) of the Hg reduction data at a carbon feed



**Figure 3-10. Effect of Particulate Matter Control on Mercury Reduction**  
(FGD Carbon, Wet Injection and 270° F ESP Inlet Temperature)

This variable is then tested for statistical significance and this "stepwise" process continues until no other independent variables are found to statistically improve the model.

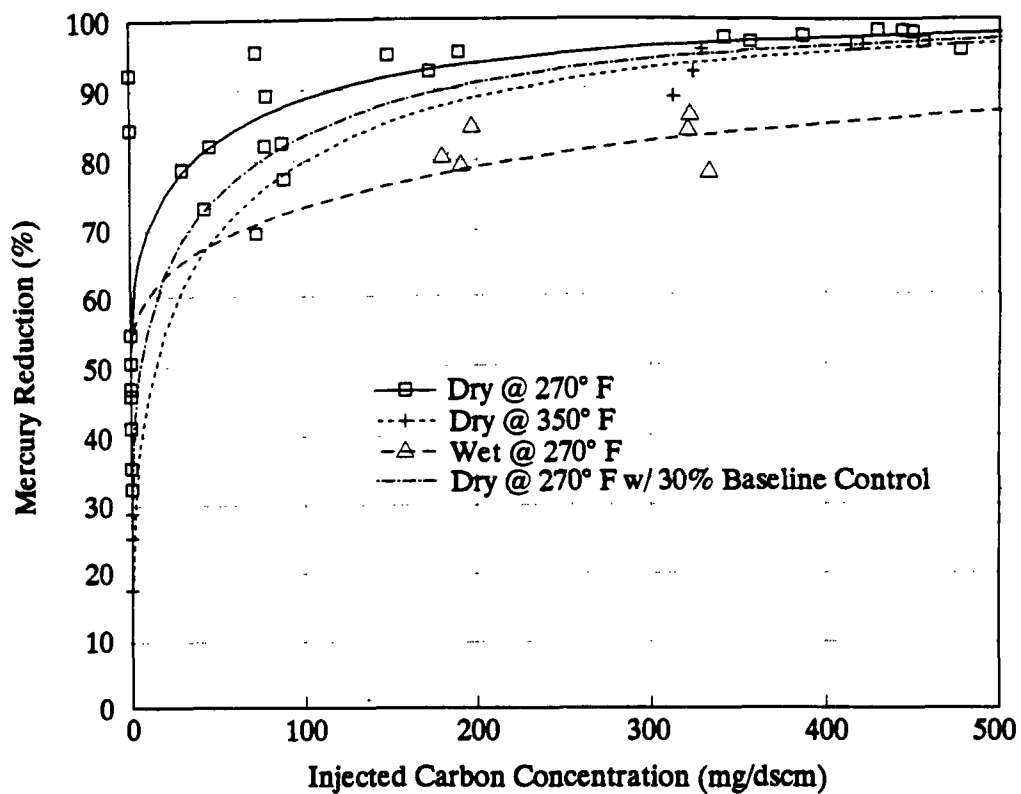
In this analysis, the percent Hg reduction values were converted to emissivity values (100 minus percent reduction). Because emissivity and emissions data are generally lognormally distributed, the natural log of the emissivity and outlet Hg levels were used as the dependant variables. To account for decreasing carbon utilization as the carbon feed rate increases, the square root of the carbon feed rate was used to linearize these data.

To estimate a mathematical model for predicting Hg control efficiency and outlet concentrations, the data set was divided into two subsets -- one consisting of the data from testing with no carbon and dry carbon injection, and the second consisting of the data with no carbon and slurry carbon injection. These data subsets were used to reflect

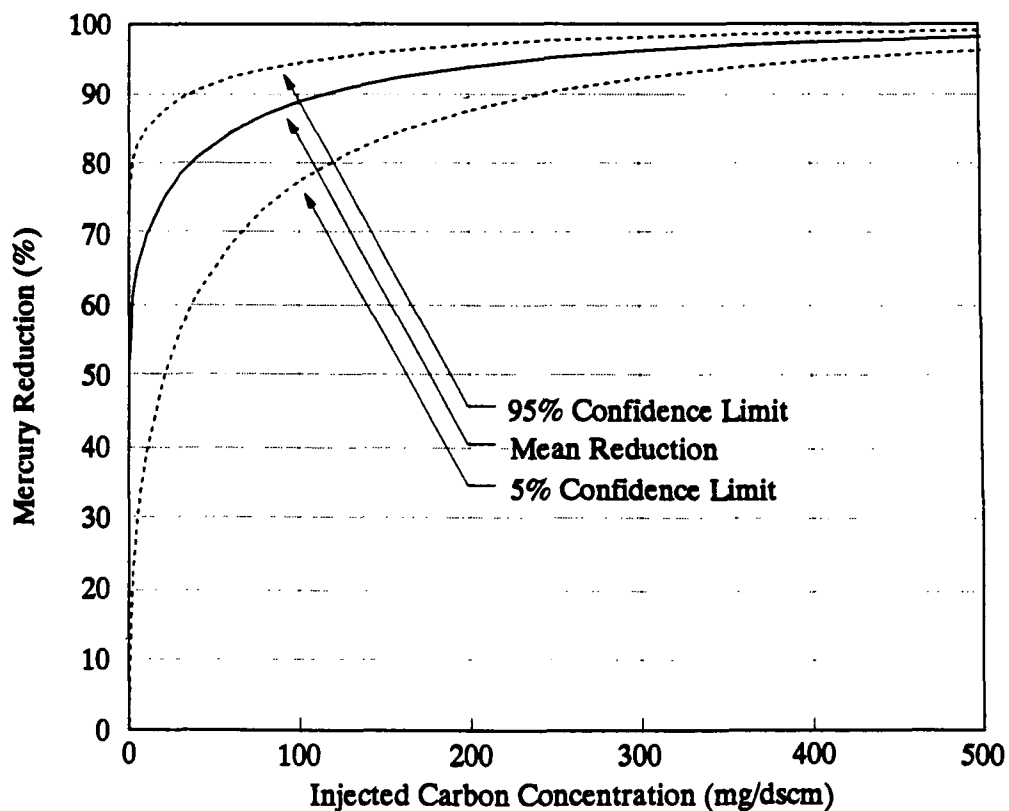
concentration of 115 mg/dscm are projected to be between approximately 80% and 95%. Alternatively, at a carbon feed concentration of 250 mg/dscm, there is still a 5% probability that the Hg reduction during an individual test will be less than 90%.

To account for the variability in the Hg reductions without carbon injection (as well as differences in the unburned carbon content of individual MWCs), the intercept constant in Equation 3-1 was adjusted to reflect a baseline (i.e., no carbon injection) Hg reduction of 30%. This reduction reflects the lower end of the test data at Camden County, and is consistent with the average Hg reduction at OMSS and several other mass burn MWCs equipped with SD/FF and SD/ESP systems that do not inject carbon. As shown by Figure 3-11, the predicted carbon feed rate needed to achieve an average reduction of 90% with dry injection at 270°F is approximately 180 mg/dscm. This injection rate is roughly three times the predicted rate needed to achieve 90% Hg reduction using the SD/FF data from the OMSS testing.<sup>4</sup> Note also that 90% removal of Hg is predicted for dry carbon at 350°F at a carbon feed concentration of approximately 230 mg/dscm, and that injection of slurried carbon is noticeably less effective, resulting in predicted average reductions of approximately 80% at injected carbon concentrations of 230 mg/dscm.

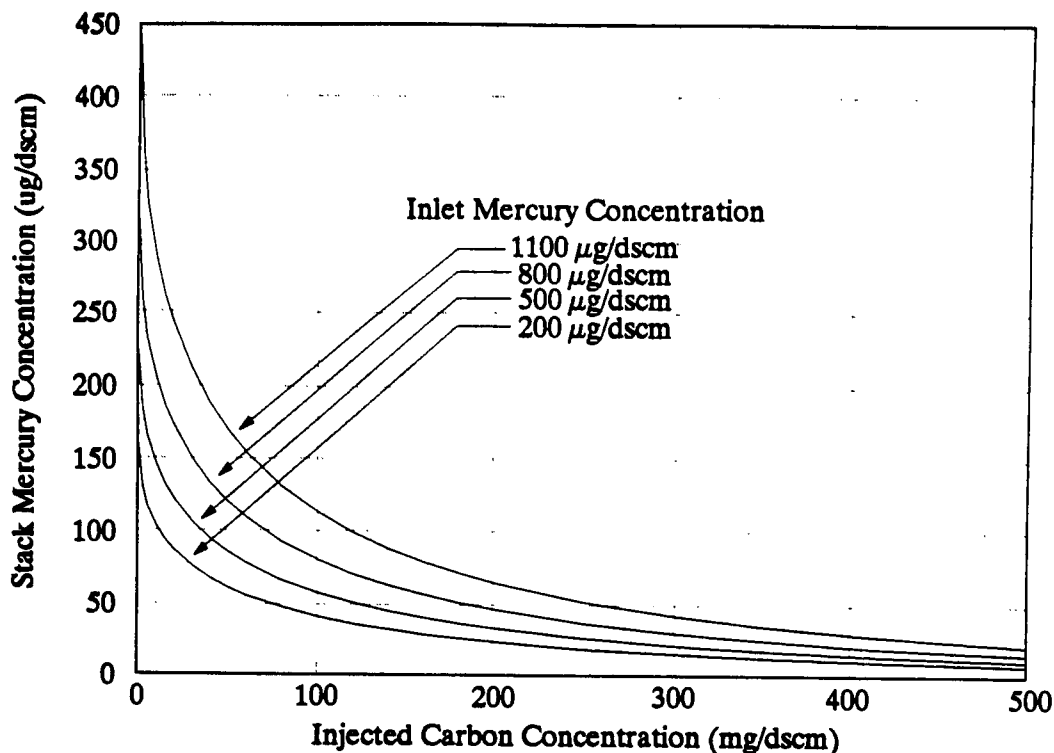
The absence of inlet Hg concentration as a statistically significant variable for predicting Hg removal efficiency is in contrast to the OMSS data and is believed to reflect the difference in control capability of systems equipped with a FF versus an ESP. With a FF, carbon will adsorb Hg both while entrained in the flue gas and after it is collected in the filter cake. When inlet Hg levels vary (e.g., due to a short-duration spike in Hg concentration), the carbon on the filter cake is able to limit the impact of the spike at the outlet. In this situation, the efficiency of the control system (i.e., entrained carbon and filter cake carbon) increases when the inlet Hg level increases. The ability of the filter cake to buffer spikes in inlet Hg levels is similar to the ability of the filter cake to moderate fluctuations in inlet acid gas levels. With an ESP, most of the Hg reduction occurs while the carbon is entrained in the flue gas and is controlled by the likelihood of contact between carbon particles and Hg prior to the collection of carbon



**Figure 3-11. Regression Analysis Results for Mercury Reduction**



**Figure 3-12. Predicted Mercury Reduction Variability with Dry Injection at 270° F**



**Figure 3-13. Regression Analysis Results for Mercury Emissions**  
(FGD Carbon, Dry Injection and 270° F ESP Inlet Temperature)

A summary of the metals removal efficiencies for each test condition is shown in Table 3-2. For Cd, Pb, As, Ba, and Cu, metals removal efficiencies exceeded 99% during all test conditions. For Cr and Mn, removal efficiencies exceeded 99% except during the high temperature run (B7) and for Mn during the medium feed rate carbon slurry test condition (B13). For Mo and Ni, removal efficiencies showed significant variability, ranging from a low of 72% for Mo during the high temperature test condition up to 98%. Removal efficiencies for Sb, Be, Co, and V could not be precisely determined due to concentrations at the ESP outlet that were below the analytical detection limit. The values shown for these four metals in Table 3-2 were estimated based on the analytical detection limit for each metal and a typical flue gas flow rate. Removal efficiencies for Ag and Tl could not be estimated because concentrations of these metals were below the analytical detection limit at both the inlet and outlet sampling location. Poor matrix spike recoveries were experienced for Se; therefore, Se data are not presented in Table 3-2.

on the ESP plates. Once the carbon particle is collected on an ESP plate, the potential for contact with Hg is greatly reduced. As a result, the control efficiency of this system (i.e., entrained carbon only) is independent of the inlet Hg level.

### Outlet Concentration

The stepwise regression analysis identified four statistically significant process variables influencing outlet Hg concentration: carbon feed rate, SD outlet temperature, carbon injection method, and inlet Hg concentration. The best predictive model for this model based on the dry injection data was:

$$\ln(\text{HgOut}) = 9.67 - 0.136(\text{CFC})^{0.5} + 0.00114(\text{HgIn}) - 1960\left(\frac{1}{T}\right) \quad (\text{Equation 3-3})$$

where HgOut and HgIn are the Hg Outlet and Inlet concentrations in mg/dscm and CFC and T are as defined in Equation 3-1. The  $R^2$  of this model is 0.81.

Figure 3-13 shows the predicted outlet concentrations from this model based on an ESP operating temperature of 270°F and inlet Hg concentrations of 200, 500, 800, and 1,100  $\mu\text{g}/\text{dscm}$ . Note that most of the reduction in outlet concentration occurs at carbon injection rates of up to approximately 100 mg/dscm. At carbon injection rates above this level, the reduction in outlet concentrations is much more gradual.

### 3.3 Other Metals

Flue gas concentrations of the 16 other metals listed in Section 2.2.2 were evaluated during six test conditions. Five of these test conditions were conducted at 270°F: no carbon injection (B10), dry carbon injection at a low and a high feed rate (B2 and B11, respectively), and slurry injection of carbon at a medium and a high feed rate (B13 and B12, respectively). The sixth test condition was conducted at 350°F with dry carbon injection (B7).

These data indicate that the 13 detected metals, with the possible exception of Mo, are emitted primarily as particulate and that control of emissions of these metals is achieved predominantly by the PM control device. There also appears to be an affect of ESP temperature on the control of Cr, Mn, and Ni, but given the small size of the data set, this partial relationship may be due to random chance. Injection of activated carbon did not have a quantifiable impact on emissions of any of the metals.

### 3.4 CDD/CDF

Economizer outlet and stack concentrations of CDD/CDF were measured during Conditions B10 (no carbon injection), B11 (dry carbon at 270°F), and B12 (slurry carbon at 270°F). Figure 3-14 shows the calculated CDD/CDF reduction for each of the three runs at these conditions. During Condition B10 without carbon injection, the total CDD/CDF removal efficiency across the SD/ESP was 78 to 80%. During Condition B11 with a high injection rate (approximately 360 mg/dscm) of dry carbon, the removal efficiency was 95 to 98%. During Condition B12 with a high injection rate of slurried carbon, the removal efficiency was 96 to 97%. These data suggest that, unlike Hg, the CDD/CDF collection efficiency of dry and slurried carbon injection is similar.

As shown in Figure 3-15, total CDD/CDF emission levels drop from 40 to 60 ng/dscm without carbon injection to less than 10 ng/dscm for dry carbon injection and less than 15 ng/dscm for slurry injection. The higher CDD/CDF outlet levels during slurry injection of carbon appears to reflect the higher concentration of CDD/CDF measured at the economizer outlet during two of the Condition B12 runs of approximately 375 ng/dscm compared with 130 to 220 ng/dscm for the other seven runs.

**TABLE 3-2. AVERAGE SD/ESP REMOVAL EFFICIENCY (%)  
FOR SELECTED TEST CONDITIONS AT  
CAMDEN COUNTY MWC (1992)<sup>a</sup>**

Condition No. Carbon Feed Rate Carbon Feed Method ESP Temperature (°F)	B2 Low Dry 270	B7 High Dry 350	B10 None None 270	B11 High Dry 270	B12 High Slurry 270	B13 Med Slurry 270
<b>Removal Efficiency (%)</b>						
Total PM	99.95 <sup>b</sup>	99.98	99.90	99.96	99.96	99.82
Cadmium	99.5	99.8	99.6	99.8	99.9	99.9
Lead	99.7	99.9	99.6	99.8	99.9	99.9
Antimony	> 99.5 <sup>c</sup>	> 99.5 <sup>c</sup>	> 99.5 <sup>c</sup>	> 99.5 <sup>c</sup>	> 99.5 <sup>c</sup>	> 99.5 <sup>c</sup>
Arsenic	99.9	99.9	99.8	99.9	99.9	99.8
Barium	99.8	99.8	99.8	99.8	99.6	99.7
Beryllium	> 85 <sup>c</sup>	> 85 <sup>c</sup>	> 85 <sup>c</sup>	> 85 <sup>c</sup>	> 85 <sup>c</sup>	> 85 <sup>c</sup>
Chromium	99.0	98.4	99.5	99.7	99.6	99.3
Cobalt	> 98 <sup>c</sup>	> 98 <sup>c</sup>	> 98 <sup>c</sup>	> 98 <sup>c</sup>	> 98 <sup>c</sup>	98 <sup>c</sup>
Copper	99.2	99.8	99.7	99.8	99.9	99.4
Manganese	99.1	97.8	99.2	99.6	99.3	98.2
Molybdenum	82.7	72.1	87.6	91.0	84.5	80.2
Nickel	93.7	96.1	98.5	97.4	98.3	96.0
Vanadium	> 98.5 <sup>c</sup>	> 98.5 <sup>c</sup>	> 98.5 <sup>c</sup>	> 98.5 <sup>c</sup>	> 98.5 <sup>c</sup>	> 98.5 <sup>c</sup>

<sup>a</sup> Selenium results not presented due to poor matrix spike recoveries.

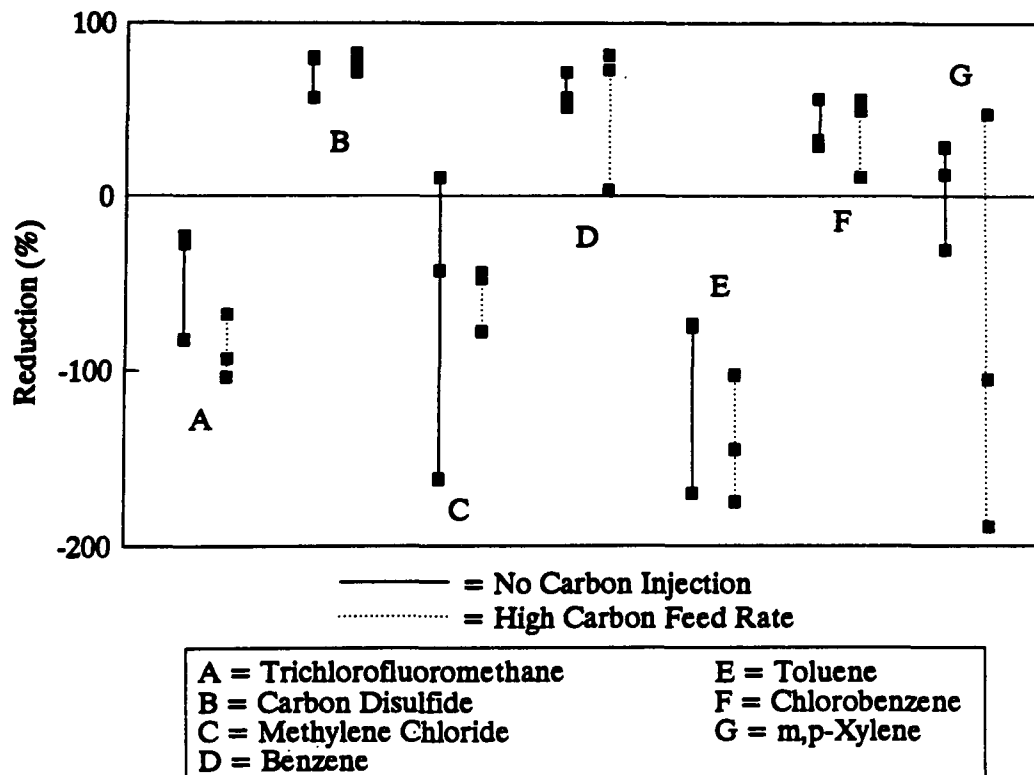
<sup>b</sup> Estimated. Inlet PM level not measured. Control efficiency based on assumed inlet value equal to average of all measured runs.

<sup>c</sup> Outlet emission rate less than detection limit. Percent reduction based on detection limit.

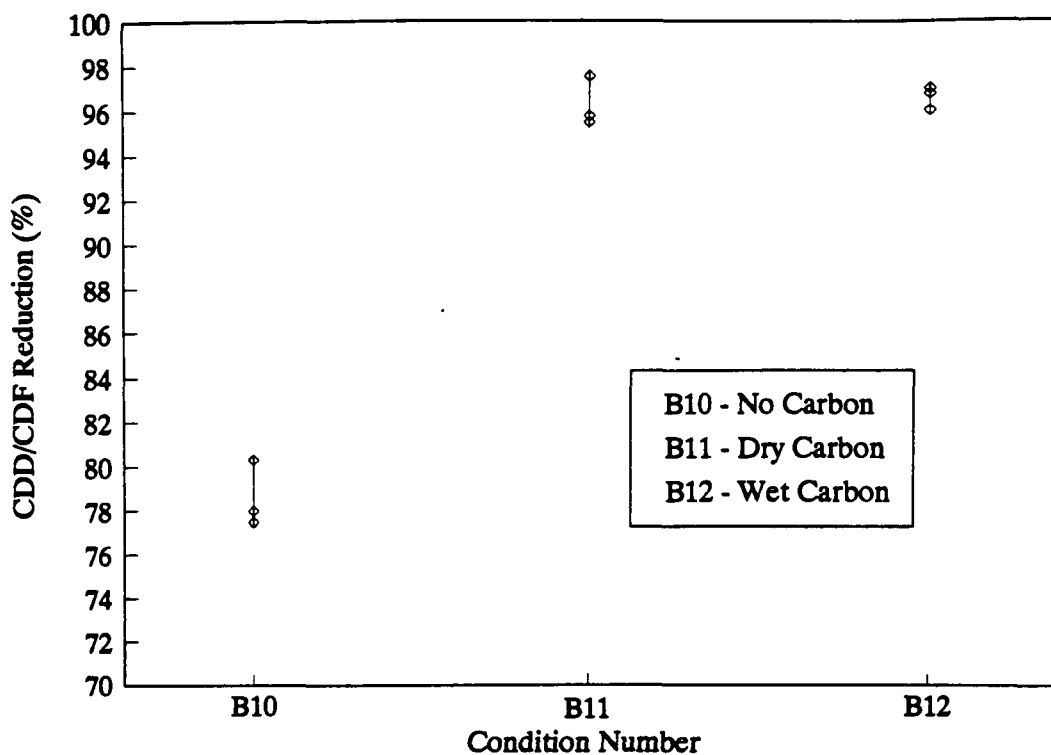


### 3.5 Volatile Organic Compounds

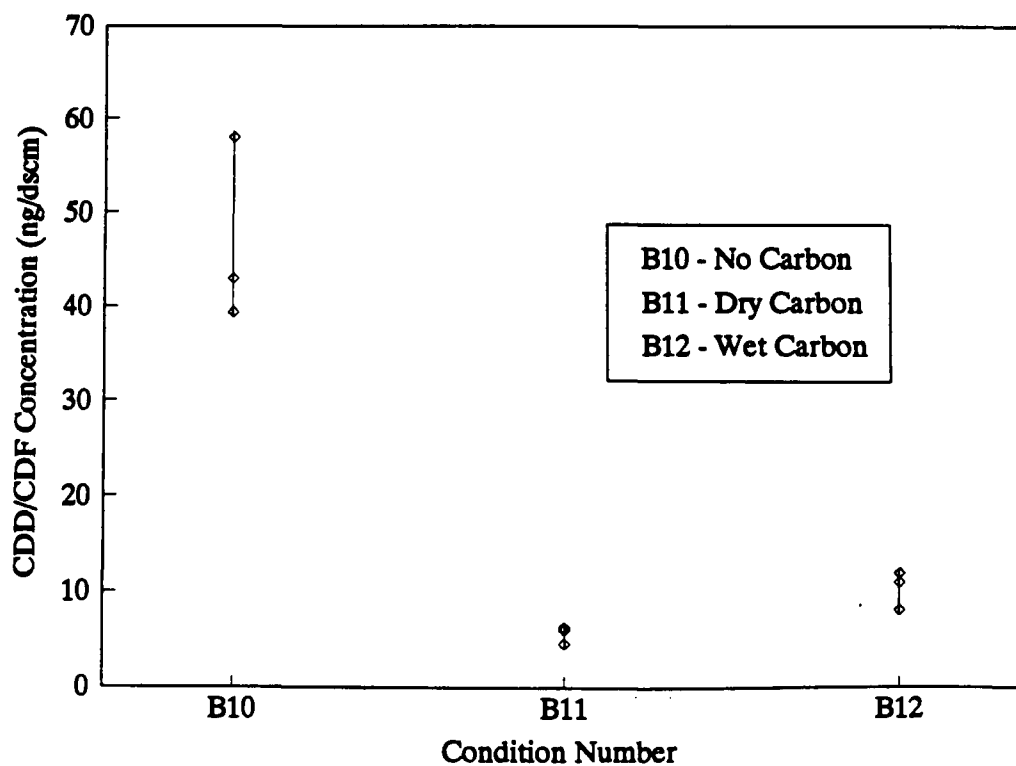
Sampling for VOC was conducted during Conditions B10 (no carbon injection) and B11 (dry carbon injection). Figure 3-16 shows the percent reduction across the SD/ESP for the seven compounds found in most of the samples. Measured concentrations of these compounds are contained in Section 4.9. As shown in Figure 3-16, there appears to be a reduction in the level of carbon disulfide, benzene, and chlorobenzene across the SD/ESP, and an increase (i.e., negative reduction) in trichlorofluoromethane, methylene chloride, and toluene. Because of the low concentrations of several of the detected compounds, the quantitative removal or formation across the SD/ESP is uncertain. Of significance to this study, however, there is no apparent impact of carbon injection on the behavior of any of these compounds.



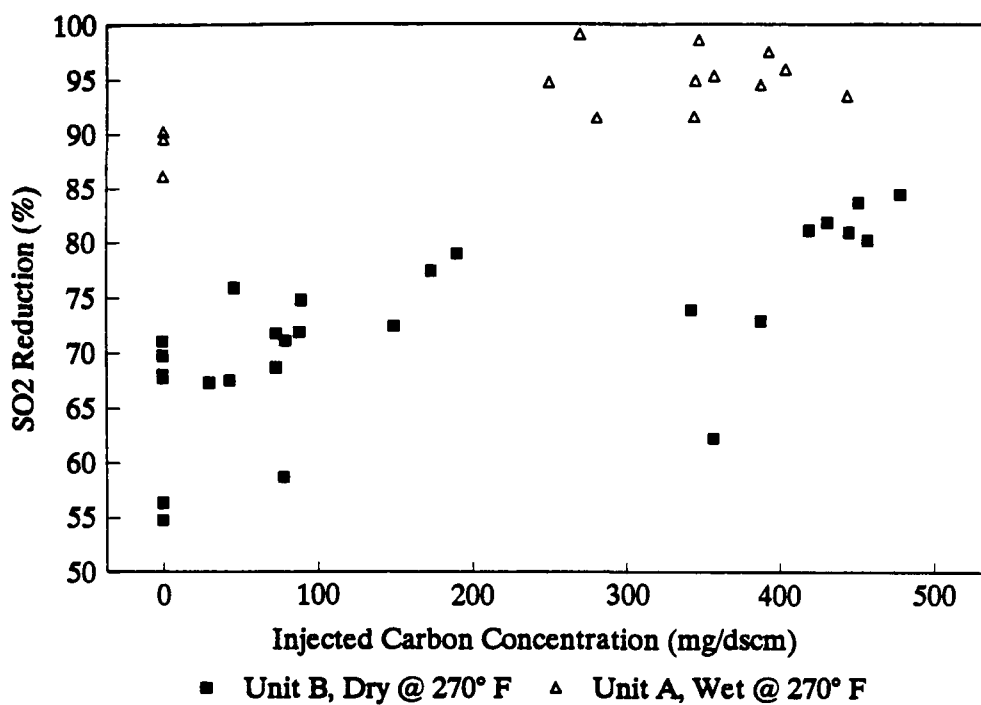
**Figure 3-16. Effect of Carbon on VOC Reduction**



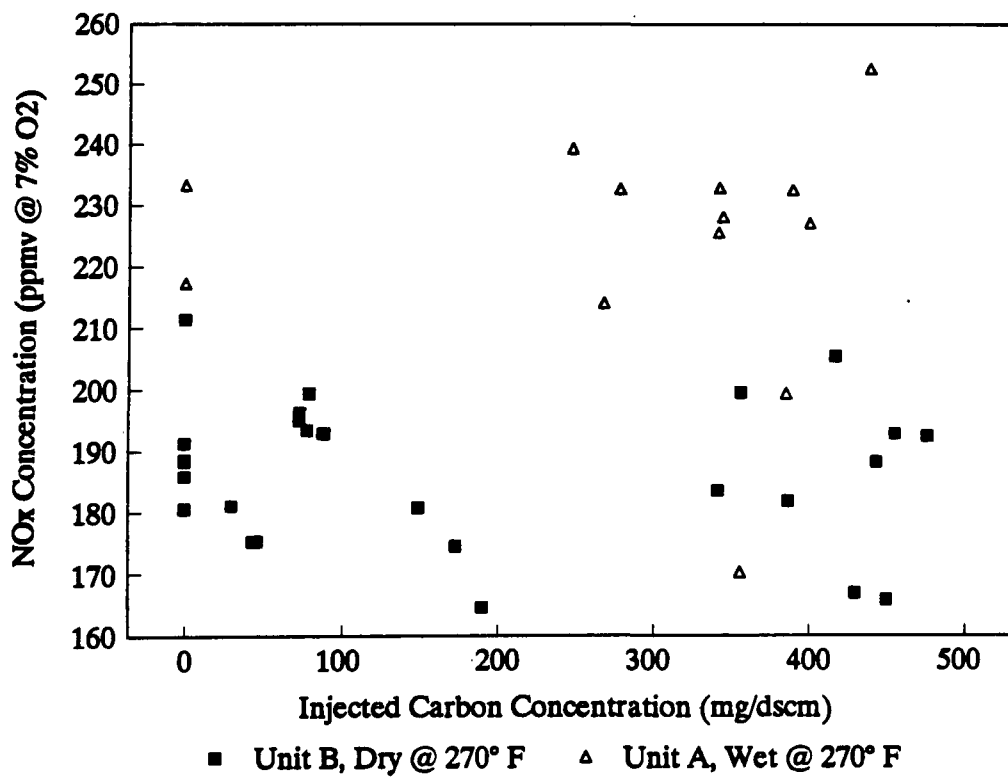
**Figure 3-14. Effect of Carbon Injection on CDD/CDF Reduction**  
(FGD Carbon and 270° F ESP Inlet Temperature)



**Figure 3-15. Effect of Carbon Injection on CDD/CDF Concentration**  
(FGD Carbon and 270° F ESP Inlet Temperature)



**Figure 3-17. Effect of Carbon Injection on SO<sub>2</sub> Reduction**



**Figure 3-18. Effect of Carbon Injection on NO<sub>x</sub> Concentration**

### 3.6 Acid Gases

During each test condition, emissions of SO<sub>2</sub>, HCl, and NO<sub>x</sub> were monitored using the plant's continuous emission monitoring systems. Figures 3-17 and 3-18 are plots of SO<sub>2</sub> removal efficiency across the SD/ESP and of stack NO<sub>x</sub> concentrations, respectively. The Unit B data are from test conditions using dry carbon injection and a target ESP operating temperature of 270°F (Conditions B1, B2, B5, B8, B10, and B11). The Unit A data are based on slurry carbon injection and include the first two test conditions (A1 without carbon and A2 with carbon injection).

Based on the general increase in SO<sub>2</sub> removal versus carbon injection rates shown in Figure 3-17, it appears that carbon injection increases SO<sub>2</sub> removal. However, the size of the data set, the effects of SO<sub>2</sub> inlet concentrations and the scatter in the data are such that this apparent relationship may be due to random chance.

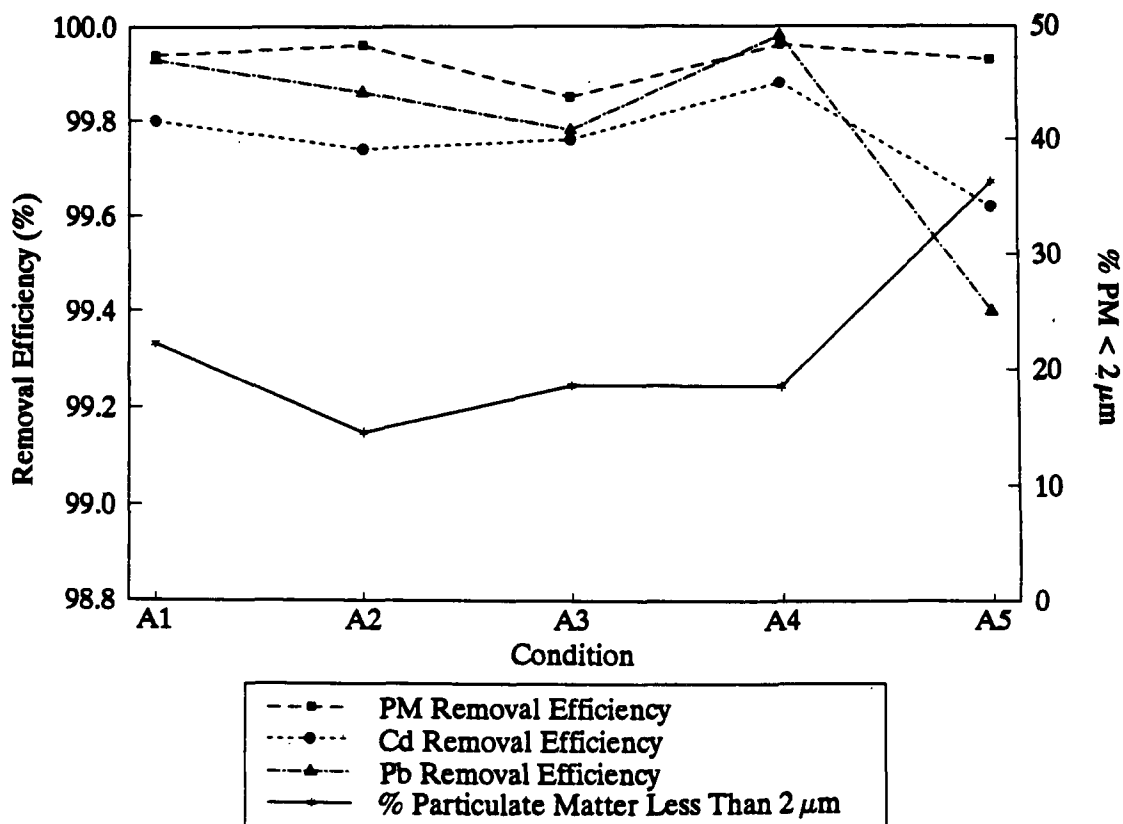
Based on the data shown in Figure 3-18, there is no apparent relationship between carbon feed rate and NO<sub>x</sub> emissions. A review of HCl data, although not shown, also did not indicate any relationship with carbon feed rate.

### 3.7 Impact of Carbon Injection on ESP Performance

To evaluate whether carbon injection might detrimentally affect the emissions control performance of the ESP, carbon was feed into Unit A continuously for 12 days. Prior to and during carbon feeding, testing was conducted to assess emissions of Hg, Cd, Pb, and PM, and to assess any changes in stack opacity levels, ESP operating characteristics, and the size distribution of emitted particulate. Test Condition A1 was conducted without carbon injection, A2 through A4 were conducted on the first, third, and eighth days after the start of carbon injection. During each of these four test conditions, the ESP was operated with four ESP fields in service. Following completion

of testing for Condition A4, the fourth ESP field was taken out of service. Condition A5 was conducted after the ESP had operated for approximately 80 hours with three fields in service.

Figure 3-19 is a plot of ESP performance as indicated by average PM, Cd, and Pb removal efficiencies and the percent of total PM less than  $2\ \mu\text{m}$  during each test condition. As shown in the figure, there was no consistent change in any of these parameters during the first four test conditions, indicating that carbon injection did not alter ESP performance. During Condition A5, with the fourth ESP field out of service, there was not a noticeable change in PM removal efficiency. However, the removal efficiency for Cd and Pb decreased, and the percent of emitted PM less than  $2\ \mu\text{m}$  increased. These changes are consistent with the expected enrichment of volatile metals onto fine particulate and the reduced ability of the ESP to collect fine particulate when the fourth ESP field was taken out of service. Stack opacity, ESP voltage, and ESP current did not vary significantly during the entire test period.



**Figure 3-19. Changes in ESP Performance Over Time**

**TABLE 4-1 CARBON FEED SYSTEM DATA FOR UNIT B  
CAMDEN COUNTY MWC (1992)**

Phase-Condition	Date	Carbon Type	Carbon Feed Method	Run	Carbon Feed Rate (lb/hr) <sup>a</sup>
I-B1	5/11/92	None	--	1	0
				2	0
				3	0
				Average	0
I-B2	5/12/92	FGD	Dry	4	12.1
				5	12.1
				6	12.1
				Average	12.1
I-B3	5/13/92	PC-100	Dry	7	12.5
				8	12.5
				9	12.5
				Average	12.5
I-B4	5/14/92	PC-100	Dry	10	61.4
				11	61.4
				12	61.4
				Average	61.4
I-B5	5/15/92	FGD	Dry	13	60.0
				14	60.0
				15	60.0
				Average	60.0
II-B6	6/2/92	None	--	10	0
				11	0
				12	0
				Average	0
II-B7	6/3/92	FGD	Dry	13	47.6
				14	51.0
				15R	51.3
				Average	50.0
II-B8	6/4/92	FGD	Dry	16	25.6
				17	25.9
				18	25.8
				Average	25.8
II-B9	6/5/92	FGD	Dry	19	4.9
				20	6.6
				21	6.7
				Average	6.1

## 4.0 CARBON INJECTION PARAMETRIC TESTING

Testing was conducted on Unit B to evaluate the impact of carbon injection system and SD/ESP operating parameters on emission control performance. Variables included carbon type, feed rate, and feed method, and ESP operating temperature. A total of 13 test conditions were conducted, with each test condition consisting of three runs conducted on the same day.

### 4.1 Carbon Feed System Data

Table 4-1 presents the data for the carbon feed systems used to feed carbon during selected tests on Unit B. These data include type of carbon fed, the carbon feed method (i.e., slurry or dry), and carbon feed rates. Carbon was injected for 10 of the 13 tests on Unit B. Of the 10 test conditions when carbon was injected, 8 injected dry carbon into the flue gas ductwork upstream of the cyclone. The two remaining tests were conducted with carbon injected into the spray dryer with the lime slurry. For these two conditions, the carbon was added to the lime slurry in a feed tank located just prior to the spray dryer.

During Run 15 on June 3, 1992, it was discovered that the dry carbon feeder had run out of carbon sometime during the last 10 minutes of the test. For this reason, the run was repeated as Run 15R.

### 4.2 Combustor Operating Data

Key combustor operating data for each test run are presented in Table 4-2. Included are run and condition averages for boiler steam flow, furnace temperature, and flue gas temperature at the economizer outlet. All of these data were collected from plant instruments.

**TABLE 4-2. UNIT B COMBUSTOR OPERATING DATA  
CAMDEN COUNTY MWC (1992)**

<b>Condition</b>	<b>Run</b>	<b>Boiler Steam Flow (lb x 10<sup>3</sup>/hr)</b>	<b>Furnace Temperature (°F)</b>	<b>Economizer Outlet Temperature (°F)</b>
<b>B1</b>	1	100.0	1121	486
	2	92.3	1079	484
	3	94.4	1141	473
	Average	95.5	1114	481
<b>B2</b>	4	87.3	1151	501
	5	98.2	1149	491
	6	97.8	1143	488
	Average	94.5	1148	493
<b>B3</b>	7	99.4	1133	472
	8	93.5	1121	481
	9	99.4	1129	484
	Average	97.5	1128	479
<b>B4</b>	10	97.6	1100	478
	11	94.5	1108	488
	12	99.3	1122	484
	Average	97.1	1110	483
<b>B5</b>	13	98.1	1168	474
	14	96.9	1147	470
	15	93.8	1203	467
	Average	96.3	1172	470
<b>B6</b>	10	98.1	1144	476
	11	100.7	1146	482
	12	99.8	1136	472
	Average	99.6	1142	477
<b>B7</b>	13	99.7	1136	476
	14	93.9	1135	475
	15	96.7	1181	468
	Average	96.2	1151	473
<b>B8</b>	16	93.9	1164	482
	17	102.4	1201	481
	18	97.5	1152	468
	Average	97.9	1173	477



TABLE 4-1, CONTINUED

Phase-Condition	Date	Carbon Type	Carbon Feed Method	Run	Carbon Feed Rate (lb/hr) <sup>a</sup>
II-B10	6/8/92	None	--	25	0
				26	0
				27	0
				Average	0
II-B11	6/9/92	FGD	Dry	28	56.1
				29	53.6
				30	62.0
				Average	57.2
II-B12	6/11/92	FGD	Slurry (small tank)	34	53.6
				35	53.7
				36	54.5
				Average	53.9
II-B13	6/12/92	FGD	Slurry (small tank)	37	28.4
				38	27.6
				39	28.8
				Average	28.3

<sup>a</sup>During Phase I, carbon feed rate calculated based on total carbon fed during test condition. During Phase II, carbon feed rate calculated for each run.

As shown in Table 4-2, the average boiler steam flow during each test condition ranged from 93,600 to 99,600 lb/hr, except during Condition B10 when two runs were less than 90,000 lb/hr. The furnace temperature condition average ranged from 1110 to 1187°F. The average of the flue gas temperature at the economizer outlet ranged from 470 to 493°F.

#### 4.3 Spray Dryer Absorber/Electrostatic Precipitator Operating Data

Operating data for the SD and ESP are presented in Table 4-3. These data include lime slurry flow rate, SD and ESP outlet temperatures, ESP secondary voltage, secondary current to each ESP field, and the stack flue gas opacity, and the measured percent carbon in the fly ash. Dilution water flow rate and spark rate across each ESP field were also measured, but are not summarized here since there were no unusual variations during any of the test runs. For each condition, run averages and condition averages are shown. Plant instruments were used to collect all data, with the exception of the ESP outlet temperature which was measured by Radian.

The higher SD outlet temperatures of Conditions B6 and B7 reflect the elevated ESP operating temperature selected for these two conditions. The lime slurry flow rates for Conditions B6 and B7 were run at higher values to compensate for the higher ESP inlet temperature (i.e., SO<sub>2</sub> capture decreases with increasing temperature and increases with increasing lime slurry flow rates). No unusual variations were noted in the ESP voltage or currents during any of the test runs. There is no apparent correlation between opacity and the amount of carbon in fly ash. The cause of the elevated opacity readings during Run 19 is unknown.

#### 4.4 Mercury

Table 4-4 presents the Hg results for the testing on Unit B. The table shows Hg concentrations for each sample fraction, for the total train, and the percent reduction across the SD/ESP. The HCl rinses of the KMnO<sub>4</sub>/H<sub>2</sub>SO<sub>4</sub> impingers were also

**TABLE 4-2, CONTINUED**

<b>Condition</b>	<b>Run</b>	<b>Boiler Steam Flow (lb x 10<sup>3</sup>/hr)</b>	<b>Furnace Temperature (°F)</b>	<b>Economizer Outlet Temperature (°F)</b>
<b>B9</b>	19	96.8	1139	472
	20	98.6	1153	469
	21	85.4	1115	471
	Average	93.6	1136	471
<b>B10</b>	25	84.1	1109	470
	26	87.9	1127	469
	27	99.4	1171	481
	Average	90.4	1136	473
<b>B11</b>	28	97.6	1173	487
	29	98.1	1192	487
	30	98.2	1197	479
	Average	98.0	1187	484
<b>B12</b>	34	99.2	1159	478
	35	99.8	1175	472
	36	99.5	1192	483
	Average	99.5	1176	478
<b>B13</b>	37	95.7	1143	470
	38	92.3	1161	466
	39	96.8	1187	473
	Average	94.9	1164	470

TABLE 4-3, CONTINUED

Run	Lime Slurry Flow Rate (gpm)	SD Outlet Temp (°F)	ESP Outlet Temp (°F)	ESP Voltage (KV)	ESP TR1-1 Current (mA)	ESP TR1-2 Current (mA)	ESP TR1-3 Current (mA)	ESP TR1-4 Current (mA)	Opacity (%)	Carbon In Fly Ash (%)
Phase I, Condition B5										
13	8.1	275	281	47	192	434	426	448	0.0	1.86
14	8.2	277	278	46	230	437	431	448	0.0	
15	8.1	262	273	46	285	439	411	448	0.0	
Average	8.1	271	277	46	236	437	423	448	0.0	
Phase II, Condition B6										
10	9.6	348	353	46	126	424	440	448	1.0	1.56
11	10.6	350	348	46	135	405	440	448	1.0	
12	9.1	349	348	46	115	395	440	448	1.0	
Average	9.8	349	350	46	125	408	440	448	1.0	
Phase II, Condition B7										
13	8.8	352	347	45	122	418	447	448	1.0	1.53
14	9.0	352	346	45	150	435	448	448	1.0	
15	8.8	344	342	45	151	426	448	448	1.0	
Average	8.9	349	345	45	141	426	448	448	1.0	
Phase II, Condition B8										
16	9.2	267	274	48	229	440	389	448	1.0	1.89
17	9.1	263	272	48	247	440	379	448	1.0	
18	9.3	262	270	48	274	440	374	448	1.0	
Average	9.2	264	272	48	250	440	380	448	1.0	
Phase II, Condition B9										
19	9.2	266	268	48	289	440	376	448	3.2	1.69
20	9.1	266	265	48	284	440	372	448	1.5	
21	9.2	265	269	48	273	440	372	448	1.0	
Average	9.2	266	268	48	282	440	373	448	1.9	

**TABLE 4-3. UNIT B SPRAY DRYER ABSORBER/  
ESP OPERATING DATA  
CAMDEN COUNTY MWC (1992)**

Run	Lime Slurry Flow Rate (gpm)	SD Outlet Temp (°F)	ESP Outlet Temp (°F)	ESP Voltage (KV)	ESP TR1-1 Current (mA)	ESP TR1-2 Current (mA)	ESP TR1-3 Current (mA)	ESP TR1-4 Current (mA)	Opacity (%)	Carbon In Fly Ash (%)
Phase I, Condition B1										
1	8.2	269	274	47	293	440	419	448	0.0	1.41
2	8.2	267	277	48	292	439	408	448	0.0	
3	8.2	262	263	46	292	443	403	448	0.0	
Average	8.2	266	271	47	292	441	410	448	0.0	
Phase I, Condition B2										
4	8.1	274	254	47	211	433	416	448	0.1	1.45
5	8.2	266	269	48	268	443	417	448	0.3	
6	8.1	275	272	48	282	441	413	448	0.5	
Average	8.1	272	265	48	254	439	415	448	0.3	
Phase I, Condition B3										
7	8.3	264	271	46	278	440	412	448	1.0	1.16
8	8.2	272	270	47	269	440	422	448	1.3	
9	8.2	273	277	47	277	440	418	448	1.8	
Average	8.2	270	273	47	275	440	417	448	1.4	
Phase I, Condition B4										
10	8.2	265	273	46	241	440	419	448	0.0	1.82
11	8.2	290	287	46	167	431	436	448	0.0	
12	8.2	291	292	46	217	439	435	448	0.1	
Average	8.2	282	284	46	208	437	430	448	0.0	

**TABLE 4-4. UNIT B MERCURY RESULTS**

Condition	Run	Mercury Concentration (ug/dscm at 7% O2)								Removal Efficiency (%)
		Inlet				Outlet				
		Filter & Probe Rinse	HNO3/ H2O2 Impingers	KMnO4/ H2SO4 Impingers	Total	Filter & Probe Rinse	HNO3/ H2O2 Impingers	KMnO4/ H2SO4 Impingers	Total	
B1	1	231	121	4.9	356	0.13	151	23.7	175	50.8
	2	498	820	45.0	1363	5.01	132	73.4	210	84.6
	3	412	294	4.9	711	0.78	46	7.5	54	92.4
	AVG	380	412	18.2	810	1.97	110	34.9	147	75.9
B2	4	537	434	0.5	972	2.69	256	37.1	296	69.5
	5	330	262	0.8	593	0.11	62	0.7	63	89.4
	6	560	274	0.5	835	0.41	128	20.5	149	82.2
	AVG	476	323	0.6	800	1.07	149	19.4	169	80.4
B3	7	229	362	0.7	593	ND	116	17.5	134	77.5
	8	396	238	5.9	639	0.22	18	10.4	29	95.5
	9	322	241	23.0	586	ND	80	21.8	102	82.6
	AVG	316	280	9.9	606	0.07	71	16.6	88	85.2
B4	10	339	145	6.8	491	0.05	14.1	6.9	21.0	95.7
	11	287	143	9.5	440	ND	10.5	3.4	13.9	96.8
	12	331	177	3.5	512	ND	14.5	2.9	17.4	96.6
	AVG	313	144	8.2	465	0.03	12.3	5.2	17.5	96.3
B5	13	397	273	9.1	680	0.18	4.32	4.9	9.4	98.6
	14	606	206	8.3	820	0.38	7.08	5.9	13.3	98.4
	15	219	410	15.0	644	0.17	3.10	8.5	11.8	98.2
	AVG	407	297	10.8	715	0.24	4.84	6.4	11.5	98.4
B6	10	120	240	4.6	365	0.11	283	17.9	301	17.6
	11	137	98	13.7	249	ND	165	12.8	177	28.7
	12	120	221	7.4	349	0.04	252	8.6	261	25.2
	AVG	126	187	8.6	321	0.05	233	13.1	246	23.8
B7	13	395	557	11.3	964	1.23	91.7	14.1	107	88.9
	14	248	248	8.9	506	0.32	18.6	3.3	22.3	95.6
	15R*	345	431	2.2	778	1.27	49.2	8.9	59.4	92.4
	AVG	329	412	7.5	749	0.94	53.2	8.8	62.9	92.3

ND = Not Detected

\* Run 15R was conducted due to possible problems caused by an interruption in carbon feed toward the end of Run 15.

**TABLE 4-3, CONTINUED**

Run	Lime Slurry Flow Rate (gpm)	SD Outlet Temp (°F)	ESP Outlet Temp (°F)	ESP Voltage (KV)	ESP TR1-1 Current (mA)	ESP TR1-2 Current (mA)	ESP TR1-3 Current (mA)	ESP TR1-4 Current (mA)	Opacity (%)	Carbon In Fly Ash (%)
Phase II, Condition B10										
25	9.2	269	276	47	287	445	372	448	1.0	1.59
26	9.1	266	274	49	333	444	370	448	1.0	
27	9.2	258	274	47	295	438	356	448	1.1	
Average	9.2	264	275	48	305	442	366	448	1.0	
Phase II, Condition B11										
28	9.2	271	279	48	269	441	385	448	1.0	2.20
29	9.2	273	280	48	282	443	382	448	1.0	
30	9.1	269	277	47	286	438	374	448	1.7	
Average	9.1	271	279	48	279	441	380	448	1.2	
Phase II, Condition B12										
34	7.9	269	277	48	260	438	387	448	1.0	1.20
35	7.9	269	279	48	280	440	382	448	1.0	
36	7.9	275	282	47	249	441	385	448	1.0	
Average	7.9	271	279	48	263	439	385	448	1.0	
Phase II, Condition B13										
37	8.0	266	273	47	273	441	382	448	1.0	1.16
38	7.9	263	273	48	283	442	388	448	1.0	
39	8.0	264	272	48	280	445	389	448	1.0	
Average	7.9	265	272	48	278	443	386	448	1.0	

analyzed, but the levels of Hg were generally less than the detection limit. Because of the consistently low Hg level in these samples, the Hg found in this fraction has not been included in the table and is not discussed further.

The inlet Hg concentrations during each test condition averaged from 321 to 810  $\mu\text{g}/\text{dscm}$ . The maximum inlet concentration for an individual run was 1363  $\mu\text{g}/\text{dscm}$  during Condition B1, Run 2. The minimum run concentration was 249  $\mu\text{g}/\text{dscm}$  during Condition B6, Run 11. The average filter concentration levels during each condition ranged from 39 to 67% of the total Hg collected. The average  $\text{HNO}_3/\text{H}_2\text{O}_2$  impinger concentration level ranged from 31 to 58%, with the  $\text{KMnO}_4/\text{H}_2\text{SO}_4$  impinger containing roughly 4% of the total Hg collected.

The condition average outlet Hg levels ranged from 11.5 to 292  $\mu\text{g}/\text{dscm}$ . The maximum outlet concentration for an individual run was 389  $\mu\text{g}/\text{dscm}$  during Condition B10, Run 25. The minimum concentration for an individual run was 9.4  $\mu\text{g}/\text{dscm}$  during Condition B5, Run 13. The filters contained less than 8% of the total Hg collected at the outlet. The average  $\text{HNO}_3/\text{H}_2\text{O}_2$  impinger concentration levels ranged from 42 to 93% of the total Hg content, while  $\text{KMnO}_4/\text{H}_2\text{SO}_4$  impinger levels ranged from 4 to 56%.

Percent reduction averages ranged from 24%, with no carbon injection during Condition B6, to 98% with the high carbon injection rate during Condition B5.

#### 4.5 Cadmium and Lead

Flue gas concentrations of Cd and Pb were determined during six test conditions. Five of these six test conditions were conducted at 270°F: no carbon injection (B10), dry carbon injection at a low and high feed rate (B2 and B11, respectively), and slurry carbon injection at a medium and high feed rate (B13 and B12, respectively). The sixth test condition was at 350°F and dry carbon injection at a high rate (B7). The results for each metal are shown in Table 4-5 and include front-half and back-half results for both



TABLE 4-4. (continued)

Condition	Run	Mercury Concentration (ug/dscm at 7% O2)								Removal Efficiency (%)
		Inlet				Outlet				
		Filter & Probe Rinse	HNO3/ H2O2 Impingers	KMnO4/ H2SO4 Impingers	Total	Filter & Probe Rinse	HNO3/ H2O2 Impingers	KMnO4/ H2SO4 Impingers	Total	
B8	16	262	262	20.6	545	2.58	29.9	5.3	37.8	93.1
	17	206	238	10.3	455	0.49	17.9	4.3	22.7	95.0
	18	184	339	2.2	525	0.46	20.3	3.3	24.1	95.4
	AVG	217	280	11.0	508	1.18	22.7	4.3	28.2	94.5
B9	19	224	258	2.6	485	4.85	92.9	5.4	103	78.7
	20	414	527	16.9	957	0.42	166	3.1	170	82.2
	21	192	262	8.9	463	1.55	116	6.4	124	73.2
	AVG	277	349	9.5	635	2.27	125	4.9	132	78.1
B10	25	351	300	11.4	663	0.17	358	30.8	389	41.3
	26	165	253	14.3	433	1.68	265	12.3	279	35.7
	27	205	171	7.4	384	1.99	199	6.4	207	46.0
	AVG	241	241	11.0	493	1.28	274	16.5	292	41.0
B11	28	295	327	3.7	626	1.10	11.0	8.0	20.1	96.8
	29	465	161	9.8	635	1.24	6.8	8.3	16.4	97.4
	30	193	427	44.7	664	0.75	10.0	4.8	15.6	97.7
	AVG	318	305	19.4	642	1.03	9.3	7.1	17.4	97.3
B12	34	139	157	3.0	299	1.09	39.6	9.6	50.3	83.2
	35	193	324	4.5	521	1.74	69.0	5.8	76.5	85.3
	36	195	98	7.0	300	2.21	56.8	10.1	69.1	77.0
	AVG	176	193	4.8	373	1.68	55.1	8.5	65.3	81.8
B13	37	117	234	30.6	382	7.51	57.0	13.2	77.7	79.7
	38	290	79	7.7	377	19.88	44.3	16.8	81.0	78.5
	39	485	485	5.2	974	9.73	141	7.0	158	83.8
	AVG	297	266	14.5	578	12.37	80.7	12.4	105	80.7

the SD inlet and ESP outlet sampling locations. Due to inadvertent archiving of samples, the SD inlet back-fractions from Runs 26 and 30, and the ESP outlet back-half fraction from Run 27 were not analyzed.

For Cd, average reduction efficiencies across the SD/ESP were 99.6% during Condition B10 without carbon injection and 99.5 to 99.9% with carbon injection. For Pb, average reduction efficiencies were 99.6% without carbon injection and 99.7 to 99.9% with carbon injection. Removal efficiencies without carbon injection were in excess of 99.9% during two of the runs and 98.8% during the third run. The average metals concentrations at the ESP outlet were 4 to 8  $\mu\text{g}/\text{dscm}$  for Cd and 14 to 68  $\mu\text{g}/\text{dscm}$  for Pb for each test condition.

Of the total Cd and Pb concentrations measured at the SD inlet, over 99.8% was in the front-half except during Run 36. During this run, the back-half accounted for 10% of the total Cd and 13% of the Pb. These higher values may have been caused by penetration of particulate through or around the sampling train filter. At the ESP outlet sampling location, the front-half generally accounted for over 70% of the total Cd and 90% of the total Pb, but was lower on several runs.

#### 4.6 Other Metals

Flue gas concentrations of antimony, arsenic, barium, beryllium, chromium, cobalt, copper, manganese, molybdenum, nickel, silver, thallium, and vanadium were also determined during the same six test conditions discussed in Section 4.5. The results for each metal are shown in Table 4-6 and include front-half and back-half results for both the SD inlet and ESP outlet sampling locations. As with Cd and Pb, the SD inlet back-fractions from Runs 26 and 30, and the ESP outlet back-half fraction from Run 27 were not analyzed. The results of selenium QC spike recoveries were not satisfactory and data for selenium are not reported.

**TABLE 4-5. UNIT B CADMIUM AND LEAD RESULTS<sup>a</sup>  
CAMDEN COUNTY MWC (1992)**

Condition	Run	Cadmium (ug/dscm at 7% O2)							Lead (ug/dscm at 7% O2)						
		Inlet			Outlet			Removal Efficiency (%)	Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total		Front Half	Back Half	Total	Front Half	Back Half	Total	
B2	4	1485	0.32	1486	8.96	0.63	9.59	99.35	27421	2.40	27424	99.9	3.59	103	99.62
B2	5	1481	0.30	1482	4.58	2.29	6.87	99.54	12535	4.33	12540	54.7	1.40	56.1	99.55
B2	6	1550	0.24	1550	3.97	2.31	6.28	99.59	27416	0.97	27417	23.1	20.5	43.6	99.84
B2	AVG	1505	0.28	1506	5.84	1.74	7.58	99.50	22458	2.57	22460	59.2	8.49	67.7	99.67
B7	13	3055	ND	3055	4.09	0.17	4.26	99.86	23362	0.72	23363	22.6	0.45	23.0	99.90
B7	14	1348	ND	1348	2.00	0.60	2.60	99.81	24837	1.77	24838	18.6	0.56	19.2	99.92
B7	15R	1327	ND	1327	1.19	0.50	1.69	99.87	24130	0.88	24131	15.5	0.50	16.0	99.93
B7	AVG	1910	ND	1910	2.43	0.42	2.85	99.85	24110	1.12	24111	18.9	0.51	19.4	99.92
B10	25	1137	0.74	1138	0.64	0.42	1.06	99.91	14472	4.55	14476	5.57	0.30	5.87	99.96
B10	26	1102	NA	1102	1.15	0.28	1.43	99.87	20939	NA	20939	6.79	ND	6.79	99.97
B10	27	1027	0.39	1027	9.63	NA	9.63	99.06	15403	3.34	15407	186	NA	186	98.79
B10	AVG	1089	0.57	1089	3.81	0.35	4.04	99.63	16938	3.94	16941	66.2	0.15	66.3	99.57
B11	28	1159	ND	1159	1.17	ND	1.17	99.90	23188	0.38	23188	21.9	0.56	22.5	99.90
B11	29	1251	ND	1251	1.38	1.52	2.90	99.77	18759	1.70	18761	20.1	0.90	21.0	99.89
B11	30	1321	NA	1321	3.88	0.18	4.06	99.69	17269	NA	17269	57.6	0.59	58.2	99.66
B11	AVG	1244	ND	1244	2.14	0.57	2.71	99.78	19739	1.04	19739	33.2	0.68	33.9	99.82
B12	34	1217	ND	1217	1.78	0.38	2.16	99.82	20871	ND	20871	21.9	ND	21.9	99.90
B12	35	3446	ND	3446	0.98	0.25	1.23	99.96	25341	0.49	25342	6.97	0.44	7.41	99.97
B12	36	1330	142	1472	0.82	0.45	1.27	99.91	15960	2483	18442	11.4	0.49	11.8	99.94
B12	AVG	1998	47.3	2045	1.19	0.36	1.55	99.92	20724	828	21552	13.4	0.31	13.7	99.94
B13	37	1478	0.32	1479	1.15	ND	1.15	99.92	30647	1.98	30649	11.7	ND	11.7	99.96
B13	38	1275	0.31	1275	1.99	0.41	2.40	99.81	17573	3.48	17576	53.5	ND	53.5	99.70
B13	39	1783	2.13	1785	1.28	1.54	2.82	99.84	19384	12.4	19396	10.8	1.66	12.4	99.94
B13	AVG	1512	0.92	1513	1.47	0.65	2.12	99.86	22535	5.95	22541	25.3	0.55	25.9	99.87
Estimated Detection Limit		5.91	0.12	6.02	0.40	0.10	0.49	NA	59.1	0.35	59.4	1.48	0.30	1.78	NA

<sup>a</sup>ND = Not Detected  
NA = Not Analyzed  
NC = Not Calculated

**TABLE 4-6, CONTINUED**

Condition	Run	Barium (ug/dscm at 7% O2)							Beryllium (ug/dscm at 7% O2)						
		Inlet			Outlet			Removal Efficiency (%)	Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total		Front Half	Back Half	Total	Front Half	Back Half	Total	
B2	4	2742	ND	2742	5.76	ND	5.76	99.79	3.31	ND	3.31	ND	ND	ND	>99.99
B2	5	3077	ND	3077	5.85	ND	5.85	99.81	3.53	ND	3.53	ND	ND	ND	>99.99
B2	6	3338	ND	3338	5.51	ND	5.51	99.83	26.2	ND	26.2	ND	ND	ND	>99.99
B2	AVG	3052	ND	3052	5.71	ND	5.71	99.81	11.0	ND	11.0	ND	ND	ND	>99.99
B7	13	3235	ND	3235	5.93	ND	5.93	99.82	ND	ND	ND	ND	ND	ND	NC
B7	14	3903	ND	3903	5.32	ND	5.32	99.86	4.08	ND	4.08	ND	ND	ND	>99.99
B7	15R	3102	ND	3102	4.66	ND	4.66	99.85	4.14	ND	4.14	ND	ND	ND	>99.99
B7	AVG	3413	ND	3413	5.30	ND	5.30	99.84	2.74	ND	2.74	ND	ND	ND	>99.99
B10	25	2274	3.20	2277	2.93	ND	2.93	99.87	2.69	ND	2.69	ND	ND	ND	>99.99
B10	26	2865	NA	2865	3.62	2.20	5.82	99.80	2.98	NA	2.98	ND	ND	ND	>99.99
B10	27	2054	1.54	2055	6.35	NA	6.35	99.69	3.00	ND	3.00	ND	ND	ND	>99.99
B10	AVG	2398	2.37	2399	4.30	1.10	5.03	99.79	2.89	ND	2.89	ND	ND	ND	>99.99
B11	28	2213	1.26	2215	2.34	0.88	3.22	99.85	2.11	ND	2.11	ND	ND	ND	>99.99
B11	29	1965	1.34	1967	2.63	0.97	3.60	99.82	2.86	ND	2.86	ND	ND	ND	>99.99
B11	30	1117	NA	1117	3.26	0.88	4.14	99.63	2.64	NA	2.64	ND	ND	ND	>99.99
B11	AVG	1765	1.30	1766	2.74	0.91	3.65	99.79	2.54	ND	2.54	ND	ND	ND	>99.99
B12	34	1044	ND	1044	2.66	ND	2.66	99.74	2.52	ND	2.52	ND	ND	ND	>99.99
B12	35	2027	ND	2027	2.30	ND	2.30	99.89	ND	ND	ND	ND	ND	ND	NC
B12	36	168	40.8	209	2.02	ND	2.02	99.04	2.84	ND	2.84	ND	ND	ND	>99.99
B12	AVG	1080	13.6	1093	2.33	ND	2.33	99.79	1.79	ND	1.79	ND	ND	ND	>99.99
B13	37	1983	ND	1983	4.59	ND	4.59	99.77	ND	ND	ND	ND	ND	ND	NC
B13	38	1835	ND	1835	8.72	ND	8.72	99.52	ND	ND	ND	ND	ND	ND	NC
B13	39	2908	4.65	2912	4.48	ND	4.48	99.85	ND	ND	ND	ND	ND	ND	NC
B13	AVG	2242	1.55	2243	5.93	ND	5.93	99.74	NA	ND	ND	ND	ND	ND	NC
Estimated Detection Limit		11.80	1.18	13.0	0.99	0.99	1.98	NA	1.98	0.20	2.17	0.20	0.20	0.40	NA

\*ND = Not Detected  
 NA = Not Analyzed  
 NC = Not Calculated

**TABLE 4-6. UNIT B OTHER METAL RESULTS<sup>a</sup>  
CAMDEN COUNTY MWC (1992)**

Condition	Run	Antimony (ug/dscm at 7% O <sub>2</sub> )							Arsenic (ug/dscm at 7% O <sub>2</sub> )						
		Inlet			Outlet			Removal Efficiency (%)	Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total		Front Half	Back Half	Total	Front Half	Back Half	Total	
B2	4	4227	ND	4227	ND	ND	ND	>99.99	1257	ND	1257	1.41	ND	1.41	99.89
B2	5	4786	ND	4786	ND	ND	ND	>99.99	1367	ND	1367	1.03	ND	1.03	99.92
B2	6	3457	ND	3457	ND	ND	ND	>99.99	1073	ND	1073	0.59	ND	0.59	99.95
B2	AVG	4157	ND	4157	ND	ND	ND	>99.99	1232	ND	1232	1.01	ND	1.01	99.92
B7	13	3414	ND	3414	ND	ND	ND	>99.99	1132	ND	1132	1.23	ND	1.23	99.89
B7	14	3371	ND	3371	ND	ND	ND	>99.99	852	ND	852	0.68	ND	0.68	99.92
B7	15R	6205	ND	6205	ND	ND	ND	>99.99	603	ND	603	0.74	ND	0.74	99.88
B7	AVG	4330	ND	4330	ND	ND	ND	>99.99	862	ND	862	0.88	ND	0.88	99.90
B10	25	3204	ND	3204	ND	ND	ND	>99.99	579	ND	579	ND	ND	ND	>99.99
B10	26	3527	NA	3527	ND	ND	ND	>99.99	838	NA	838	ND	ND	ND	>99.99
B10	27	2396	27.4	2423	ND	ND	ND	>99.99	676	0.52	677	4.69	ND	4.69	99.31
B10	AVG	3042	13.7	3052	ND	ND	ND	>99.99	697	0.26	698	1.56	ND	1.56	99.78
B11	28	2424	ND	2424	ND	ND	ND	>99.99	738	ND	738	ND	ND	ND	>99.99
B11	29	4288	31.3	4319	ND	ND	ND	>99.99	670	ND	670	ND	ND	ND	>99.99
B11	30	3251	NA	3251	ND	ND	ND	>99.99	1219	NA	1219	1.38	ND	1.38	99.89
B11	AVG	3321	15.6	3331	ND	ND	ND	>99.99	876	ND	876	0.46	ND	0.46	99.95
B12	34	2435	12.2	2447	ND	ND	ND	>99.99	1217	1.48	1219	0.66	ND	0.66	99.95
B12	35	4257	15.2	4273	ND	ND	ND	>99.99	588	ND	588	0.38	ND	0.38	99.93
B12	36	3813	213	4025	ND	ND	ND	>99.99	1685	78.0	1763	0.43	ND	0.43	99.98
B12	AVG	3502	80.1	3582	ND	ND	ND	>99.99	1163	26.5	1190	0.49	ND	0.49	99.96
B13	37	3786	45.1	3831	ND	ND	ND	>99.99	559	ND	559	0.75	ND	0.75	99.87
B13	38	4828	34.8	4862	ND	ND	ND	>99.99	637	ND	637	1.48	ND	1.48	99.77
B13	39	3877	31.0	3908	ND	ND	ND	>99.99	523	3.10	526	0.54	ND	0.54	99.90
B13	AVG	4163	36.9	4200	ND	ND	ND	>99.99	573	1.03	574	0.92	ND	0.92	99.84
Estimated Detection Limit		177	11.8	189	9.88	9.88	19.8	NA	1.18	0.12	1.30	0.40	0.10	0.49	NA

<sup>a</sup>ND = Not Detected  
NA = Not Analyzed  
NC = Not Calculated

**TABLE 4-6, CONTINUED**

Condition	Run	Cobalt (ug/dscm at 7% O2)							Copper (ug/dscm at 7% O2)						
		Inlet			Outlet			Removal Efficiency (%)	Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total		Front Half	Back Half	Total	Front Half	Back Half	Total	
B2	4	81.1	ND	81.1	ND	ND	ND	>99.99	4456	1.71	4458	29.4	2.05	31.5	99.29
B2	5	69.5	ND	69.5	ND	ND	ND	>99.99	4216	ND	4216	44.5	3.31	47.8	98.87
B2	6	72.7	ND	72.7	ND	ND	ND	>99.99	7748	ND	7748	10.2	41.0	51.2	99.34
B2	AVG	74.4	ND	74.4	ND	ND	ND	>99.99	5473	0.57	5474	28.1	15.5	43.5	99.20
B7	13	88.1	ND	88.1	ND	ND	ND	>99.99	4313	ND	4313	8.61	ND	8.61	99.80
B7	14	101	ND	101	ND	ND	ND	>99.99	4435	ND	4435	9.18	ND	9.18	99.79
B7	15R	276	ND	276	ND	ND	ND	>99.99	3964	ND	3964	6.34	ND	6.34	99.84
B7	AVG	155	ND	155	ND	ND	ND	>99.99	4237	ND	4237	8.04	ND	8.04	99.81
B10	25	71.3	ND	71.3	ND	ND	ND	>99.99	2894	ND	2894	3.43	ND	3.43	99.88
B10	26	132	NA	132	ND	ND	ND	>99.99	3857	NA	3857	8.02	4.23	12.3	99.68
B10	27	83.9	ND	83.9	ND	NA	NA	>99.99	4279	ND	4279	18.6	NA	18.6	99.56
B10	AVG	95.8	ND	95.8	ND	ND	ND	>99.99	3677	ND	3677	10.0	2.12	11.4	99.69
B11	28	86.4	ND	86.4	ND	ND	ND	>99.99	3478	ND	3478	4.46	5.71	10.2	99.71
B11	29	116	ND	116	ND	ND	ND	>99.99	3662	1.97	3664	4.36	2.97	7.33	99.80
B11	30	82.3	NA	82.3	ND	ND	ND	>99.99	3149	NA	3149	6.89	ND	6.89	99.78
B11	AVG	94.9	ND	94.9	ND	ND	ND	>99.99	3430	0.98	3431	5.23	2.89	8.13	99.76
B12	34	60.9	ND	60.9	ND	ND	ND	>99.99	23480	ND	23480	8.19	ND	8.19	99.97
B12	35	50.7	ND	50.7	ND	ND	ND	>99.99	5676	ND	5676	2.44	4.81	7.25	99.87
B12	36	97.5	1.60	99.1	ND	ND	ND	>99.99	4788	301	5089	2.84	1.45	4.29	99.92
B12	AVG	69.7	0.53	70.2	ND	ND	ND	>99.99	11315	100	11415	4.49	2.09	6.58	99.94
B13	37	57.7	ND	57.7	ND	ND	ND	>99.99	3606	ND	3606	4.31	4.03	8.34	99.77
B13	38	126	ND	126	ND	ND	ND	>99.99	3862	ND	3862	8.87	ND	8.87	99.77
B13	39	98.9	ND	98.9	ND	ND	ND	>99.99	3489	6.20	3495	6.02	39.7	45.7	98.69
B13	AVG	94.0	ND	94.0	ND	ND	ND	>99.99	3652	2.07	3654	6.40	14.6	21.0	99.43
Estimated Detection Limit		11.8	1.18	13.0	0.99	0.99	1.98	NA	23.6	2.36	26.0	1.98	1.98	3.95	NA

\*ND = Not Detected  
 NA = Not Analyzed  
 NC = Not Calculated

**TABLE 4-6, CONTINUED**

Condition	Run	Chromium (ug/dscm at 7% O2)							Vanadium (ug/dscm at 7% O2)						
		Inlet			Outlet			Removal Efficiency (%)	Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total		Front Half	Back Half	Total	Front Half	Back Half	Total	
B2	4	1485	3.54	1489	3.46	2.43	5.89	99.60	297	ND	297	ND	ND	ND	>99.99
B2	5	1367	1.82	1369	8.39	2.03	10.4	99.24	353	ND	353	ND	ND	ND	>99.99
B2	6	1550	1.67	1551	2.95	26.9	29.9	98.08	381	ND	381	ND	ND	ND	>99.99
B2	AVG	1467	2.34	1470	4.93	10.5	15.4	98.95	344	ND	344	ND	ND	ND	>99.99
B7	13	1222	4.31	1226	3.67	32.5	36.1	97.05	270	ND	270	ND	ND	ND	>99.99
B7	14	1419	8.87	1428	3.73	6.65	10.4	99.27	337	ND	337	ND	ND	ND	>99.99
B7	15R	1431	4.65	1435	3.88	14.2	18.1	98.74	310	ND	310	ND	ND	ND	>99.99
B7	AVG	1357	5.95	1363	3.76	17.8	21.5	98.42	306	ND	306	ND	ND	ND	>99.99
B10	25	827	2.58	830	2.36	3.79	6.15	99.26	207	ND	207	ND	ND	ND	>99.99
B10	26	1058	NA	1058	2.65	4.14	6.79	99.36	276	NA	276	ND	ND	ND	>99.99
B10	27	10269	2.05	10271	7.06	NA	7.06	99.93	248	ND	248	ND	ND	ND	>99.99
B10	AVG	4051	2.32	4053	4.02	3.97	6.67	99.84	243	ND	243	ND	ND	ND	>99.99
B11	28	1476	ND	1476	2.49	0.88	3.36	99.77	232	ND	232	ND	ND	ND	>99.99
B11	29	1340	1.34	1341	2.35	2.21	4.56	99.66	286	ND	286	ND	ND	ND	>99.99
B11	30	1117	NA	1117	3.38	1.31	4.70	99.58	244	NA	244	ND	ND	ND	>99.99
B11	AVG	1311	0.67	1311	2.74	1.47	4.21	99.68	254	ND	254	ND	ND	ND	>99.99
B12	34	1044	2.96	1047	1.98	1.37	3.35	99.68	217	ND	217	ND	ND	ND	>99.99
B12	35	568	ND	568	1.95	1.46	3.42	99.40	162	ND	162	ND	ND	ND	>99.99
B12	36	1330	18.6	1349	2.27	1.01	3.28	99.76	301	3.19	305	ND	ND	ND	>99.99
B12	AVG	980	7.19	988	2.07	1.28	3.35	99.66	227	1.06	228	ND	ND	ND	>99.99
B13	37	667	2.52	670	4.45	ND	4.45	99.34	216	ND	216	ND	ND	ND	>99.99
B13	38	1931	3.48	1935	6.27	ND	6.27	99.68	328	ND	328	ND	ND	ND	>99.99
B13	39	1008	4.26	1012	5.25	4.86	10.1	99.00	213	ND	213	ND	ND	ND	>99.99
B13	AVG	1202	3.42	1205	5.32	1.62	6.94	99.42	253	ND	253	ND	ND	ND	>99.99
Estimated Detection Limit		11.8	1.18	13.0	0.99	0.99	1.98	NA	23.6	2.36	26.0	1.98	1.98	1.95	NA

\*ND = Not Detected  
 NA = Not Analyzed  
 NC = Not Calculated

**TABLE 4-6, CONTINUED**

Condition	Run	Nickel (ug/dscm at 7% O2)						
		Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total	
B2	4	446	2.40	448	17.9	1.79	19.7	95.60
B2	5	433	3.19	436	5.60	6.87	12.5	97.14
B2	6	381	ND	381	8.07	35.9	43.9	88.48
B2	AVG	420	1.86	422	10.5	14.8	25.4	93.98
B7	13	395	ND	395	ND	16.9	16.9	95.72
B7	14	390	5.68	396	ND	18.6	18.6	95.29
B7	15R	362	7.58	370	ND	9.83	9.83	97.34
B7	AVG	382	4.42	387	ND	15.1	15.1	96.09
B10	25	248	6.20	254	2.07	4.72	6.79	97.33
B10	26	485	NA	485	2.29	4.59	6.88	98.58
B10	27	359	2.65	362	1.41	NA	1.41	99.61
B10	AVG	364	4.43	367	1.93	4.65	6.58	98.21
B11	28	295	ND	295	1.90	ND	1.90	99.36
B11	29	322	2.05	324	4.29	5.46	9.75	96.99
B11	30	437	NA	437	1.44	16.9	18.3	95.80
B11	AVG	351	1.03	352	2.54	7.46	10.0	97.16
B12	34	243	ND	243	5.05	ND	5.05	97.92
B12	35	253	ND	253	ND	1.74	1.74	99.31
B12	36	328	5.14	333	1.83	5.99	7.82	97.65
B12	AVG	275	1.71	277	2.29	2.58	4.87	98.24
B13	37	216	ND	216	ND	ND	ND	>99.99
B13	38	348	5.02	353	ND	ND	ND	>99.99
B13	39	291	ND	291	8.07	26.9	35.0	87.98
B13	AVG	285	1.67	287	2.69	8.96	11.7	95.93
Estimated Detection Limit		23.6	2.36	26.0	1.98	1.98	3.95	NA

\*ND = Not Detected  
 NA = Not Applicable  
 NC = Not Calculated



**TABLE 4-6, CONTINUED**

Condition	Run	Manganese (ug/dscm at 7% O <sub>2</sub> )							Molybdenum (ug/dscm at 7% O <sub>2</sub> )						
		Inlet			Outlet			Removal Efficiency (%)	Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total		Front Half	Back Half	Total	Front Half	Back Half	Total	
B2	4	3542	19.4	3561	3.97	25.6	29.6	99.17	274	ND	274	24.3	ND	24.3	91.13
B2	5	3647	8.89	3656	11.2	21.6	32.8	99.10	125	ND	125	25.4	ND	25.4	79.71
B2	6	3338	3.70	3341	3.59	320303	320307	-9486.24	113	ND	113	25.6	ND	25.6	77.37
B2	AVG	3509	10.7	3519	6.25	23.6	31.2	99.11	171	ND	171	25.1	ND	25.1	85.30
B7	13	3594	82.7	3677	2.54	116	119	96.78	ND	ND	NA	25.4	ND	25.4	NC
B7	14	4258	213	4471	45.2	18.6	63.9	98.57	90.5	ND	90.5	25.3	ND	25.3	72.05
B7	15R	3102	77.6	3180	2.33	63.4	65.7	97.93	ND	ND	NA	23.3	ND	23.3	NC
B7	AVG	3651	124	3776	16.7	65.9	82.6	97.81	30.2	ND	30.2	24.7	ND	24.7	18.24
B10	25	2377	21.7	2399	1.57	17.2	18.7	99.22	83.7	ND	83.7	15.0	ND	15.0	82.07
B10	26	3857	NA	3857	1.68	47.6	49.3	98.72	101	NA	101	17.6	ND	17.6	82.61
B10	27	3252	18.0	3270	8.34	NA	8.34	99.74	608	ND	608	10.9	NA	10.9	98.20
B10	AVG	3162	19.8	3175	3.86	32.4	25.5	99.20	264	ND	264	14.5	ND	14.5	94.51
B11	28	3057	2.95	3060	1.54	2.78	4.32	99.86	179	ND	179	12.4	ND	12.4	93.06
B11	29	3930	5.00	3935	4.70	23.5	28.2	99.28	134	ND	134	11.8	ND	11.8	91.23
B11	30	4673	NA	4673	3.13	5.95	9.08	99.81	95.5	NA	95.5	10.6	NA	10.6	88.86
B11	AVG	3887	3.98	3889	3.12	10.7	13.9	99.64	136	ND	136	11.6	ND	11.6	91.48
B12	34	2522	4.70	2527	4.23	20.5	24.7	99.02	84.4	ND	84.4	10.9	ND	10.9	87.05
B12	35	1825	5.27	1830	1.19	17.4	18.6	98.98	58.8	ND	58.8	13.2	ND	13.2	77.47
B12	36	3635	168	3804	1.32	6.94	8.26	99.78	97.5	ND	97.5	10.7	ND	10.7	89.01
B12	AVG	2661	59.5	2720	2.25	15	17.2	99.37	80.2	ND	80.2	11.6	ND	11.6	85.50
B13	37	2524	16.8	2541	36.1	9.59	45.7	98.20	119	ND	119	25.0	ND	25.0	78.97
B13	38	4248	16.4	4265	68.8	19.9	88.7	97.92	145	ND	145	27.5	ND	27.5	81.00
B13	39	2520	523	3043	6.53	43.5	50.1	98.36	118	ND	118	23.0	ND	23.0	80.51
B13	AVG	3097	186	3283	37.2	24.3	61.5	98.13	127	ND	127	25.2	ND	25.2	80.22
Estimated Detection Limit		11.8	1.18	13.0	0.99	0.99	1.98	NA	59.1	5.91	65.0	4.94	4.94	9.88	NA

<sup>a</sup>ND = Not Detected  
 NA = Not Analyzed  
 NC = Not Calculated

<sup>b</sup>There was Mn contamination of the back half outlet fraction for Run 6 due to blowback of Mn from the KMnO<sub>4</sub> impingers into the HNO<sub>3</sub> impingers following the post-run leak check. This value is not used in the averages.

**TABLE 4-7. UNIT B PARTICULATE  
MATTER RESULTS  
CAMDEN COUNTY MWC (1992)**

<b>Phase- Condition</b>	<b>Run Number</b>	<b>Inlet PM (g/dscm @ 7% O<sub>2</sub>)</b>	<b>Outlet PM (g/dscm @ 7% O<sub>2</sub>)</b>	<b>Removal Efficiency (%)</b>
<b>I-B1</b>	1	NA*	0.0040	NA
	2	NA	0.0036	NA
	3	NA	0.0042	NA
	Avg	NA	0.0039	NA
<b>I-B2</b>	4	NA	0.0036	NA
	5	NA	0.0022	NA
	6	NA	0.0022	NA
	Avg	NA	0.0027	NA
<b>I-B3</b>	7	NA	0.0012	NA
	8	NA	0.0024	NA
	9	NA	0.0041	NA
	Avg	NA	0.0026	NA
<b>I-B4</b>	10	NA	0.0014	NA
	11	NA	0.0021	NA
	12	NA	0.0024	NA
	Avg	NA	0.0020	NA
<b>I-B5</b>	13	NA	0.0075	NA
	14	NA	0.0026	NA
	15	NA	0.0019	NA
	Avg	NA	0.0040	NA
<b>II-B6</b>	10	4.77	0.0012	99.98
	11	6.48	0.0010	99.99
	12	3.53	0.0011	99.97
	Avg	4.93	0.0011	99.98
<b>II-B7</b>	13	4.80	0.0013	99.97
	14	6.52	0.0013	99.98
	15	6.16	0.0015	99.97
	Avg	5.83	0.0014	99.98
<b>II-B8</b>	16	6.97	0.0019	99.97
	17	6.69	0.0014	99.98
	18	6.14	0.0013	99.98
	Avg	6.60	0.0015	99.98

#### 4.7 Particulate Matter

Table 4-7 presents the PM concentrations for each run, as well as condition averages. Because of the need for expedited Hg analysis of the EPA SW-846 Method 0012 front-half fraction collected at the SD inlet during Phase I, gravimetric analyses of the probe rinse and filter catch were not performed. As a result, inlet PM data are not available for these runs.

The average inlet concentrations for the Phase II-B test conditions ranged from 4.76 to 6.60 g/dscm, and the corresponding outlet averages ranged from 0.0011 to 0.0088 g/dscm. All of the individual runs achieved greater than 99.7% reduction of particulate matter.

#### 4.8 CDD/CDF

Table 4-8 presents the CDD/CDF results for Conditions B10, B11, and B12. The table presents economizer outlet and stack concentrations of each congener; the total CDD, total CDF, and combined CDD/CDF concentrations; and the removal efficiencies for CDD, CDF, and combined CDD/CDF.

Inlet CDD concentrations during individual runs ranged from 18 to 103 ng/dscm. Inlet CDF concentrations ranged from 114 to 302 ng/dscm. Total CDD/CDF concentrations averaged 46.8 ng/dscm during Condition B10, 5.6 ng/dscm during Condition B11, and 10.5 ng/dscm during Condition B12. Total CDD/CDF removal efficiencies were greater than 95% for runs with carbon injection. Removal efficiencies were between 77 and 80% without carbon injection.

**TABLE 4-8. CDD/CDF RESULTS  
CAMDEN COUNTY MWC (1992)**

CONGENER	Condition B10 (no carbon injection, 270 F ESP Inlet temperature)								
	Run 25			Run 26			Run 27		
	Inlet (ng/dscm @ 7% O <sub>2</sub> )	Outlet (ng/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)	Inlet (ng/dscm @ 7% O <sub>2</sub> )	Outlet (ng/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)	Inlet (ng/dscm @ 7% O <sub>2</sub> )	Outlet (ng/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)
<b>DIOXINS</b>									
2378 TCDD	0.558	0.147	73.7	0.589	0.112	81.0	0.469	0.0929	80.2
Other TCDD	11.8	2.13	82.0	5.60	1.17	79.1	4.75	0.894	81.2
12378 PCDD	1.01	0.162	84.0	1.11	0.136	87.8	0.796	0.139	82.5
Other PCDD	5.40	1.38	74.4	5.78	0.665	88.5	3.18	0.790	75.2
123478 HxCDD	0.589	0.0735	87.5	0.445	0.0568	87.2	0.354	0.0557	84.2
123678 HxCDD	0.693	0.0808	88.3	0.622	0.0608	90.2	0.371	0.0639	82.8
123789 HxCDD	0.589	0.0661	88.8	0.511	0.0520	89.8	0.354	0.0552	84.4
Other HxCDD	5.47	0.588	89.2	4.42	0.471	89.4	2.90	0.522	82.0
1234678 HpCDD	4.96	0.353	92.9	3.56	0.240	93.2	2.21	0.314	85.8
Other HpCDD	4.24	0.331	92.2	3.11	0.224	92.8	2.12	0.499	76.5
Octa CDD	8.37	0.676	91.9	7.22	0.424	94.1	4.07	0.575	85.9
<b>Total CDD</b>	<b>43.7</b>	<b>5.99</b>	<b>86.3</b>	<b>33.0</b>	<b>3.61</b>	<b>89.0</b>	<b>21.6</b>	<b>4.00</b>	<b>81.5</b>
<b>FURANS</b>									
2378 TCDF	4.13	1.10	73.3	4.22	0.801	81.0	4.07	0.813	80.0
Other TCDF	110	31.2	71.5	86.9	23.2	73.3	79.0	20.1	74.6
12378 PCDF	4.75	1.03	78.4	5.22	0.881	83.1	3.80	0.755	80.1
23478 PCDF	4.44	1.10	75.2	4.67	0.801	82.8	3.62	0.697	80.8
Other PCDF	50.8	11.1	78.1	53.5	8.73	83.7	40.3	8.42	79.1
123478 HxCDF	3.41	0.514	84.9	ND	0.464	0.0	2.56	0.436	83.0
123678 HxCDF	ND	0.581	0.0	ND	0.408	0.0	2.65	0.436	83.6
123789 HxCDF	ND	0.360	0.0	ND	0.112	0.0	1.77	0.232	86.9
234678 HxCDF	1.00	0.110	89.0	0.945	0.104	89.0	0.486	0.0987	79.7
Other HxCDF	18.3	2.92	84.1	17.9	2.59	85.5	11.98	2.22	81.4
1234678 HpCDF	5.89	0.882	85.0	5.33	0.648	87.8	4.77	0.697	85.4
1234789 HpCDF	1.76	0.140	92.1	1.33	0.0881	93.4	0.751	0.174	76.8
Other HpCDF	4.75	0.522	89.0	1.89	0.304	83.9	0.0442	0.116	-163
Octa CDF	4.55	0.375	91.8	3.00	0.176	94.1	1.50	0.232	84.5
<b>Total CDF</b>	<b>213</b>	<b>52.0</b>	<b>75.6</b>	<b>185</b>	<b>39.3</b>	<b>78.7</b>	<b>157</b>	<b>35.4</b>	<b>77.5</b>
<b>Total CDD + CDF</b>	<b>257</b>	<b>58.0</b>	<b>77.5</b>	<b>218</b>	<b>42.9</b>	<b>80.3</b>	<b>179</b>	<b>39.4</b>	<b>78.0</b>

**TABLE 4-7, CONTINUED**

<b>Phase- Condition</b>	<b>Run Number</b>	<b>Inlet PM (g/dscm @ 7% O<sub>2</sub>)</b>	<b>Outlet PM (g/dscm @ 7% O<sub>2</sub>)</b>	<b>Removal Efficiency (%)</b>
II-B9	19	4.80	0.0012	99.97
	20	5.66	0.0018	99.97
	21	5.10	0.0039	99.92
	Avg	5.19	0.0023	99.96
II-B10	25	5.36	0.0016	99.97
	26	6.27	0.0015	99.98
	27	5.84	0.0138	99.76
	Avg	5.82	0.0056	99.90
II-B11	28	6.78	0.0016	99.98
	29	7.38	0.0011	99.99
	30	5.39	0.0039	99.93
	Avg	6.52	0.0022	99.96
II-B12	34	5.09	0.0025	99.95
	35	3.62	0.0011	99.97
	36	5.58	0.0018	99.97
	Avg	4.76	0.0018	99.96
II-B13	37	4.24	0.0021	99.95
	38	6.12	0.142	99.77
	39	4.12	0.0102	99.75
	Avg	4.83	0.0089	99.82

NA - Not available. Inlet PM levels were not determined during Phase I due to the need for expedited mercury analysis of the front half fraction.

TABLE 4-8. CONTINUED

Congener	Condition B12 (slurry carbon injection, 270 F, ESP inlet temperature)								
	Run 34			Run 35			Run 36		
	Inlet (ng/dscm @ 7% O2)	Outlet (ng/dscm @ 7% O2)	Removal Efficiency (%)	Inlet (ng/dscm @ 7% O2)	Outlet (ng/dscm @ 7% O2)	Removal Efficiency (%)	Inlet (ng/dscm @ 7% O2)	Outlet (ng/dscm @ 7% O2)	Removal Efficiency (%)
<b>DIOXINS</b>									
2378 TCDD	0.621	0.0308	95.0	0.562	0.0349	93.8	0.439	0.0528	88.0
Other TCDD	6.45	0.164	97.5	6.32	0.153	97.6	4.81	0.159	96.7
12378 PCDD	1.24	0.0578	95.4	1.49	0.0401	97.3	0.879	0.0390	95.6
Other PCDD	6.69	0.200	97.0	8.03	0.193	97.6	5.04	0.120	97.6
123478 HxCDD	1.15	0.0452	96.1	1.15	0.0388	96.6	0.563	0.0244	95.7
123678 HxCDD	1.15	0.0251	97.8	1.38	0.0278	98.0	0.697	0.0198	97.2
123789 HxCDD	0.956	0.0213	97.8	1.07	0.0168	98.4	0.611	0.0139	97.7
Other HxCDD	10.1	0.197	98.1	11.3	0.201	98.2	5.77	0.140	97.6
1234678 HpCDD	13.4	0.170	98.7	10.7	0.226	97.9	5.83	0.112	98.1
Other HpCDD	12.4	0.157	98.7	9.98	0.0776	99.2	5.63	0.106	98.1
Octa CDD	48.7	0.484	99.0	20.7	0.621	97.0	17.2	0.317	98.2
<b>Total CDD</b>	<b>103</b>	<b>1.55</b>	<b>98.5</b>	<b>72.6</b>	<b>1.63</b>	<b>97.8</b>	<b>47.5</b>	<b>1.10</b>	<b>97.7</b>
<b>FURANS</b>									
2378 TCDF	3.44	0.163	95.3	4.25	0.175	95.9	2.77	0.152	94.5
Other TCDF	85.4	4.48	94.8	93.3	4.290	95.4	66.0	3.35	94.9
12378 PCDF	5.54	0.213	96.1	5.97	0.220	96.3	3.63	0.192	94.7
23478 PCDF	5.35	0.182	96.6	5.39	0.201	96.3	3.34	0.145	95.7
Other PCDF	61.7	2.74	95.6	69.0	2.36	96.6	40.8	1.78	95.6
123478 HxCDF	6.69	0.0364	99.5	7.11	0.0343	99.5	ND	0.126	0.0
123678 HxCDF	ND	0.182	0.0	7.11	0.162	97.7	ND	0.126	0.0
123789 HxCDF	ND	0.213	0.0	6.08	0.194	96.8	ND	0.0727	0.0
234678 HxCDF	1.91	0.151	92.1	2.18	0.142	93.5	0.898	0.0225	97.5
Other HxCDF	36.3	0.987	97.3	37.2	0.956	97.4	16.3	0.645	96.0
1234678 HpCDF	24.8	0.490	98.0	20.7	0.388	98.1	9.55	0.264	97.2
1234789 HpCDF	5.26	0.0816	98.4	4.13	0.0647	98.4	1.72	0.0370	97.8
Other HpCDF	8.12	0.308	96.2	11.9	0.110	99.1	4.97	0.0621	98.7
Octa CDF	29.6	0.370	98.7	27.5	0.214	99.2	5.83	0.126	97.8
<b>Total CDF</b>	<b>274</b>	<b>10.6</b>	<b>96.1</b>	<b>302</b>	<b>9.51</b>	<b>96.8</b>	<b>156</b>	<b>7.09</b>	<b>95.4</b>
<b>Total CDD + CDF</b>	<b>377</b>	<b>12.2</b>	<b>96.8</b>	<b>374</b>	<b>11.1</b>	<b>97.0</b>	<b>203</b>	<b>8.20</b>	<b>96.0</b>

TABLE 4-8. CONTINUED

Congener	Condition B11 (dry carbon injection, 270 F ESP inlet temperature)								
	Run 28			Run 29			Run 30		
	Inlet (ng/dscm @ 7% O <sub>2</sub> )	Outlet (ng/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)	Inlet (ng/dscm @ 7% O <sub>2</sub> )	Outlet (ng/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)	Inlet (ng/dscm @ 7% O <sub>2</sub> )	Outlet (ng/dscm @ 7% O <sub>2</sub> )	Removal Efficiency (%)
<b>DIOXINS</b>									
2378 TCDD	0.422	ND	100.0	0.286	0.0169	94.1	0.317	ND	100.0
Other TCDD	4.14	ND	100.0	2.94	0.102	96.5	3.98	0.090	97.7
12378 PCDD	0.718	0.0250	96.5	0.55	0.0207	96.3	0.667	0.0264	96.0
Other PCDD	3.84	0.106	97.2	2.95	0.124	95.8	3.97	0.166	95.8
123478 HxCDD	0.490	0.0225	95.4	0.25	0.0157	93.7	0.328	0.0162	95.1
123678 HxCDD	0.581	0.0200	96.6	0.29	0.0245	91.4	0.339	0.0198	94.2
123789 HxCDD	0.524	0.0140	97.3	0.24	0.0163	93.2	0.305	0.0126	95.9
Other HxCDD	4.10	0.130	96.8	2.2	0.182	91.6	3.21	0.149	95.4
1234678 HpCDD	3.88	0.100	97.4	1.8	0.144	92.2	2.04	0.138	93.2
Other HpCDD	3.18	0.0873	97.3	1.75	0.125	92.8	1.92	0.126	93.4
Octa CDD	8.21	0.206	97.5	4.6	0.307	93.3	4.07	0.336	91.8
<b>Total CDD</b>	<b>30.1</b>	<b>0.711</b>	<b>97.6</b>	<b>17.9</b>	<b>1.08</b>	<b>94.0</b>	<b>21.1</b>	<b>1.08</b>	<b>94.9</b>
<b>FURANS</b>									
2378 TCDF	2.74	0.231	91.6	2.49	0.0880	96.5	3.05	0.108	96.5
Other TCDF	66.8	1.39	97.9	55.6	2.17	96.1	65.9	2.17	96.7
12378 PCDF	3.42	0.119	96.5	2.67	0.125	95.3	3.05	0.138	95.5
23478 PCDF	2.85	0.0873	96.9	2.86	0.100	96.5	2.94	0.120	95.9
Other PCDF	38.2	0.917	97.6	28.6	1.22	95.7	31.3	1.30	95.8
123478 HxCDF	2.74	0.0936	96.6	1.84	0.100	94.6	ND	0.038	0.0
123678 HxCDF	ND	0.0873	0.0	1.94	0.107	94.5	ND	0.084	0.0
123789 HxCDF	ND	0.0561	0.0	1.38	0.0690	95.0	1.470	0.1020	93.1
234678 HxCDF	0.752	0.0200	97.3	0.42	0.0295	92.9	0.475	0.0780	83.6
Other HxCDF	13.6	0.429	96.8	8.3	0.510	93.8	9.4	0.537	94.3
1234678 HpCDF	66.1	0.168	97.5	3.6	0.219	93.9	3.96	0.228	94.2
1234789 HpCDF	1.37	0.0293	97.9	0.66	0.0476	92.8	0.72	0.0456	93.7
Other HpCDF	3.42	0.0830	97.6	1.9	0.122	93.7	1.99	0.1160	94.2
Octa CDF	3.31	0.0624	98.1	1.7	0.119	92.8	1.58	0.120	92.4
<b>Total CDF</b>	<b>146</b>	<b>3.77</b>	<b>97.4</b>	<b>114</b>	<b>5.03</b>	<b>95.6</b>	<b>126</b>	<b>5.19</b>	<b>95.9</b>
<b>Total CDD + CDF</b>	<b>176</b>	<b>4.48</b>	<b>97.5</b>	<b>132</b>	<b>6.10</b>	<b>95.4</b>	<b>147</b>	<b>6.27</b>	<b>95.7</b>

**TABLE 4-9. FREQUENCY OF VOC DETECTED  
IN TUBE PAIRS  
CAMDEN COUNTY MWC (1992)**

<b>Number of Traps With Detectable Levels (Out of 24 Traps)</b>		
<b>Compound</b>	<b>Inlet</b>	<b>Outlet</b>
Bromomethane	5	1
Trichlorofluoromethane	8	14
1,1-Dichloroethene	0	1
Carbon Disulfide	24	21
Acetone	1	0
Methylene Chloride	16	23
Chloroform	2	2
1,1,1-Trichloroethane	0	4
Carbon Tetrachloride	1	1
Benzene	24	23
4-Methyl-2-Pentanone	0	1
Toluene	2	22
Tetrachloroethene	0	4
2-Hexanone	2	1
Chlorobenzene	17	1
m,p-Xylene	18	22
o-Xylene	4	3
Styrene	1	0
1,1,2,2-Tetrachloroethane	0	1



#### 4.9 Volatile Organic Compounds

Sampling for VOC was conducted for 19 target compounds during the 6 runs of Conditions B10 and B11. During both conditions, VOC were measured at the economizer outlet and in the stack. During an individual run, 4 pairs of traps were collected. Thus, for the 6 runs, there were a total of 24 inlet and 24 outlet pairs of traps.

As shown in Table 4-9, of the 19 target compounds, only 7 were detected in greater than 40% of the sampling trap pairs. The remaining 12 compounds were detected in less than 20% of the sampling trap pairs.

Table 4-10 presents the VOC inlet and outlet concentrations and removal efficiency results for the 7 compounds that were detected in over 40% of the trap pairs. Concentrations were calculated by summing the compound mass found in all 4 trap pairs, dividing by the total metered volume, and correcting to 7% O<sub>2</sub>. If a compound was not detected in a trap pair, the compound was assumed to be present at the detection limit.

It appears that three of the compounds (trichlorofluoromethane, methylene chloride, and toluene) increased between the inlet and outlet, while three others (carbon disulfide, benzene, and chlorobenzene) appear to be reduced. For the seventh compound (m,p-xylene), the reported levels are higher at the outlet in three runs and lower in the others. Except for benzene and carbon disulfide, however, the average detected levels in the inlet samples were less than five times the practical quantitation limit of the analytical method. As a result, the analytical data are subject to a relatively high degree of uncertainty. Relative to the impact of carbon injection, the removal efficiency for each of the compounds appears to be similar whether carbon is injected or not.

#### 4.10 Fly Ash Carbon Content

Table 4-11 presents the carbon analysis of the Unit B fly ash samples. A single composite sample was collected during each condition at the economizer outlet using an EPA Method 5 sampling train. The condition results were between 1.20 and 2.36% carbon on a dry basis.

#### 4.11 Volumetric Flow and Moisture by EPA Methods 1 and 4

Unit B inlet and outlet gas flow rates and moisture contents were determined using the procedures in EPA Methods 1 and 4, respectively. The results are presented in Table 4-12. These values are based on measurements from the EPA multi-metals sampling train. The plant CEMS were used to measure O<sub>2</sub>. Volumetric flow rates are expressed in dry standard cubic meters per minute (dscmm) at measured O<sub>2</sub> concentrations, and the moisture content is expressed in volume percent. Average inlet results were 8 to 10% O<sub>2</sub>, 14 to 21% moisture, and flow rates of 2200 to 2700 dscmm. Average outlet results were 10 to 13% O<sub>2</sub>, 16 to 21% moisture, and flow rates of 2800 to 3400 dscmm. During the test conditions conducted at a target SD outlet temperature of 270°F, (all but Conditions B6 and B7), the moisture gain across the SD averaged 2%. During the two test conditions conducted at a target SD outlet temperature of 350°F, the average moisture gain was negligible.

The inlet flue gas moisture content measured during Run 6 based on Method 4 calculations was 13.9%, which appears to be anomalously low compared to the inlet moisture levels during other runs and to the measured outlet moisture level during the same run. The value shown in Table 4-12 of 16.6% was estimated by subtracting 2.0% from the outlet flue gas moisture content for the run (i.e., the average difference between the inlet and outlet moisture contents during the other runs conducted at a target SD exit temperature of 270°F). A similar adjustment of 2.0% was used to estimate the flue gas moisture content at the stack during Runs 1 and 3. During Run 1, the outlet impingers were not weighed prior to recovery. During Run 3, the original

**TABLE 4-10. VOLATILE ORGANIC COMPOUND RESULTS<sup>a</sup>  
CAMDEN COUNTY MWC (1992)**

Inlet Concentration (ug/dscm at 7% O <sub>2</sub> )						
Compound	Condition B10			Condition B11		
	Run 25	Run 26	Run 27	Run 28	Run 29	Run 30
Trichlorofluoromethane	4.2	1.5	0.6	0.9	0.6	0.6
Carbon Disulfide	3.6	5.7	5.0	6.1	6.2	6.3
Methylene Chloride	0.8	1.0	1.6	0.9	0.8	0.6
Benzene	10.3	7.0	4.8	2.8	9.5	6.2
Toluene	0.7	0.6	0.6	0.6	0.6	0.6
Chlorobenzene	1.4	0.9	0.8	0.7	1.3	1.3
m,p-Xylene	1.2	1.8	1.9	1.1	3.3	0.6
Outlet Concentration (ug/dscm at 7% O <sub>2</sub> )						
Compound	Condition B10			Condition B11		
	Run 25	Run 26	Run 27	Run 28	Run 29	Run 30
Trichlorofluoromethane	7.7	1.9	0.7	1.8	1.2	1.0
Carbon Disulfide	1.6	1.1	1.0	1.4	1.8	1.1
Methylene Chloride	2.0	1.4	1.5	1.2	1.2	1.0
Benzene	5.0	2.0	2.1	2.7	1.7	1.7
Toluene	1.2	1.1	1.6	1.7	1.2	1.4
Chlorobenzene	0.6	0.6	0.6	0.6	0.7	0.6
m,p-Xylene	1.6	1.3	1.6	3.3	1.7	1.2
Removal Efficiency (%)						
Compound	Condition B10			Condition B11		
	Run 25	Run 26	Run 27	Run 28	Run 29	Run 30
Trichlorofluoromethane	-82.1	-27.1	-22.5	-103.4	-92.9	-67.5
Carbon Disulfide	56.7	80.7	79.3	77.7	71.6	82.8
Methylene Chloride	-162.0	-42.6	10.6	-43.9	-47.2	-77.5
Benzene	51.0	71.5	56.8	3.2	81.6	73.0
Toluene	-73.3	-75.0	-170.0	-175.0	-102.5	-145.0
Chlorobenzene	56.0	32.2	28.6	11.1	49.4	55.6
m,p-Xylene	-30.5	28.3	12.5	-189.5	47.2	-105.0

<sup>a</sup>Method detection limit (MDL) for each of the detected compounds is 10 ng per tube pair, which equates to an approximate flue gas concentration of 0.6 µg/dscm at 7% O<sub>2</sub>. If the compound was not detected during analysis of a trap pair, the compound was assumed to be present at the detection limit.

**TABLE 4-12. UNIT B VOLUMETRIC FLOW AND  
MOISTURE RESULTS  
CAMDEN COUNTY MWC (1992)**

Phase- Condition	Run Number	Inlet			Outlet		
		O <sub>2</sub> (%)	Flow Rate (dscmm)	Stack Moisture (%)	O <sub>2</sub> (%)	Flow Rate (dscmm)	Stack Moisture (%)
I-B1	1	9.3	1467	16.8	11.7	1747	18.8 <sup>a</sup>
	2	10.2	1388	17.4	12.6	1687	18.6
	3	8.6	1346	18.4	11.5	1692	19.3 <sup>a</sup>
	Avg	9.4	1400	17.5	11.9	1709	18.9
I-B2	4	9.1	1447	16.8	11.7	1793	18.8
	5	9.0	1435	16.9	11.7	1754	19.1
	6	9.4	1485	16.6 <sup>a</sup>	12.0	1797	18.6
	Avg	9.2	1456	16.8	11.8	1781	18.8
I-B3	7	8.9	1364	16.6	11.4	1698	18.4
	8	9.8	1380	14.2	12.2	1707	17.7
	9	9.2	1468	16.2	11.7	1767	19.1
	Avg	9.3	1404	15.7	11.8	1724	18.4
I-B4	10	9.2	1410	15.7	12.1	1840	17.1
	11	9.4	1312	16.4	12.0	1780	17.6
	12	9.1	1432	15.7	12.0	1805	17.7
	Avg	9.2	1384	15.9	12.0	1808	17.4
I-B5	13	8.8	1322	15.3	11.8	1671	16.5
	14	9.5	1280	14.2	12.7	1652	15.8
	15	8.6	1178	15.3	11.8	1457	16.6
	Avg	9.0	1260	14.9	12.1	1594	16.3
II-B6	10	9.2	1215	16.2	11.5	1781	16.5
	11	9.0	1297	16.9	11.3	1914	17.0
	12	9.0	1410	15.8	11.1	1954	14.8
	Avg	9.1	1307	16.3	11.3	1883	16.1
II-B7	13	8.7	1309	16.5	11.0	1857	16.3
	14	9.1	1382	16.7	11.3	1787	16.7
	15R	8.2	1313	17.0	10.6	1721	16.1
	Avg	8.7	1335	16.7	11.0	1789	16.3
II-B8	16	9.3	1340	15.6	11.5	1715	18.6
	17	8.1	1425	17.5	10.5	1562	19.6
	18	8.4	1144	16.5	10.7	1435	18.2
	Avg	8.6	1303	16.5	10.9	1571	18.8

**TABLE 4-11. UNIT B FLY ASH CARBON RESULTS  
CAMDEN COUNTY MWC**

<b>Phase-Condition</b>	<b>Carbon Content (% by weight, dry basis)</b>
I-B1	1.41
I-B2	1.45
I-B3	1.16
I-B4	1.82
I-B5	1.86
II-B6	1.56
II-B7	1.53
II-B8	1.89
II-B9	1.69
II-B10	1.56
II-B11	2.20
II-B12	1.20
II-B13	1.16

outlet moisture result of 11.8% was substantially below the level measured during the other runs. During Run 25, the silica gel impinger used at the inlet sampling location broke following successful final leak check of the train and absorbed water in the impinger bucket. To estimate the actual moisture level, a silica gel weight gain of 8.3 g was used, based on the average weight gain during other runs.

#### 4.12 Continuous Emissions Monitoring Data

The CEM data are presented in Table 4-13. The CEM data includes spray dryer inlet O<sub>2</sub> and SO<sub>2</sub>, and stack NO<sub>x</sub>, HCl, CO<sub>2</sub>, H<sub>2</sub>O, O<sub>2</sub>, CO, and SO<sub>2</sub>. All concentrations shown in the table are presented at actual O<sub>2</sub> levels. However, the SO<sub>2</sub> removal efficiency was calculated after adjustment of the inlet and outlet concentrations to 7% O<sub>2</sub>. Stack methane and THC were also recorded by the CEM system; however, neither were found above a 0.1 ppm concentration level and are not reported.

Average uncorrected inlet SO<sub>2</sub> levels during each condition ranged between 45 and 93 ppm and average uncorrected outlet concentrations were between 9 and 17 ppm. The average corrected SO<sub>2</sub> removal were 64 to 83%. During the two test conditions with no carbon injection, SO<sub>2</sub> reductions were 64 to 65%. With carbon injection, the SO<sub>2</sub> reductions were 67 to 82%. The higher SO<sub>2</sub> removal efficiencies with carbon injection may be the result of higher inlet SO<sub>2</sub> levels rather than increased SO<sub>2</sub> removals associated with carbon injection. Outlet NO<sub>x</sub> levels during each test condition were between 110 and 136 ppm, and average HCl levels were less than 5 ppm during all test conditions except B12. The cause of the higher measured HCl level (18 ppm) during Condition B12 is unknown.

Average CO concentrations for each test condition ranged from 9 to 22 ppm. Comparison of average CO concentrations with the fly ash carbon content data in Table 4-11 does not indicate any significant relationship between these two parameters.

**TABLE 4-12, CONTINUED**

Phase-Condition	Run Number	Inlet			Outlet		
		O <sub>2</sub> (%)	Flow Rate (dscmm)	Stack Moisture (%)	O <sub>2</sub> (%)	Flow Rate (dscmm)	Stack Moisture (%)
II-B9	19	8.6	1382	17.8	10.9	1531	19.6
	20	8.2	1199	18.3	10.6	1476	19.7
	21	8.7	1353	18.5	11.1	1417	20.0
	Avg	8.5	1311	18.2	10.9	1475	19.7
II-B10	25	9.6	1275	18.1 <sup>b</sup>	11.7	1478	20.5
	26	9.2	1205	17.6	11.5	1412	20.8
	27	8.2	1350	18.9	10.8	1534	21.3
	Avg	9.0	1277	18.2	11.3	1475	20.9
II-B11	28	8.9	1376	17.2	11.2	1643	20.4
	29	8.8	1361	17.8	10.9	1596	20.4
	30	8.1	1318	17.6	10.5	1511	21.6
	Avg	8.6	1352	17.5	10.9	1583	20.8
II-B12	34	8.9	1449	15.9	11.0	1641	18.3
	35	8.7	1426	15.2	11.0	1619	17.6
	36	8.7	1399	16.1	10.7	1525	18.1
	Avg	8.8	1425	15.7	10.9	1595	18.0
II-B13	37	8.7	1334	16.7	10.9	1558	18.5
	38	8.7	1224	16.0	10.9	1431	17.1
	39	8.6	1230	16.1	10.8	1518	17.6
	Avg	8.7	1263	16.2	10.9	1502	17.1

\*Value calculated based on reported moisture gains appeared erroneous. Value shown is calculated by adding 2.0% to the inlet or subtracting 2.0% from the outlet.

<sup>b</sup>The silica gel impinger broke after run was completed. The weight gain by this impinger is estimated at 8.3 g based on the average of the other runs.

**TABLE 4-13, CONTINUED**

Phase- Condition	Run	Inlet <sup>a</sup>		Outlet <sup>a</sup>							SO <sub>2</sub> Reduction <sup>b</sup> (%)
		O <sub>2</sub> (%)	SO <sub>2</sub> (ppm)	NO <sub>x</sub> (ppm)	HCl (ppm)	CO <sub>2</sub> (%)	H <sub>2</sub> O (%)	O <sub>2</sub> (%)	CO (ppm)	SO <sub>2</sub> (ppm)	
II-B10	25	9.6	45.0	127.1	4.6	10.3	17.4	11.7	17.3	15.9	56.4
	26	9.3	57.1	126.2	10.5	10.5	17.5	11.5	12.3	14.7	68.1
	27	8.2	66.1	137.5	8.9	11.2	18.8	10.8	8.6	17.0	67.8
	Avg	9.0	56.1	130.2	8.0	10.6	17.9	11.3	12.7	15.9	64.1
II-B11	28	9.0	52.8	139.7	6.5	10.8	17.2	11.2	7.9	16.2	62.4
	29	8.8	94.6	132.4	10.1	11.0	17.3	10.9	12.7	20.3	74.1
	30	8.1	76.3	136.4	4.4	11.5	17.8	10.5	7.1	16.7	73.1
	Avg	8.6	74.6	136.2	7.0	11.1	17.4	10.8	9.2	17.7	69.9
II-B12	34	8.9	84.9	133.4	26.2	11.0	16.2	11.0	13.2	18.1	74.0
	35	8.7	59.3	125.1	13.5	11.0	15.8	11.0	11.4	15.3	68.2
	36	8.7	83.7	137.3	14.4	11.3	16.3	10.7	6.0	7.3	75.3
	Avg	8.7	76.0	131.9	18.0	11.1	16.1	10.9	10.2	16.9	72.5
II-B13	37	8.7	82.6	131.6	4.6	11.1	16.5	10.9	9.0	16.9	75.0
	38	8.7	60.1	121.5	2.2	11.1	16.1	10.9	18.0	15.1	69.3
	39	8.6	54.9	121.1	2.0	11.1	15.8	10.8	13.7	14.5	67.9
	Avg	8.7	65.9	124.8	2.9	11.1	16.1	10.9	13.6	15.5	70.7

<sup>a</sup>Concntrations are reported at actual O<sub>2</sub> levels, dry basis.

<sup>b</sup>Based on concentration corrected to 7% O<sub>2</sub>, dry basis.



**TABLE 4-13. UNIT B CEM RESULTS  
CAMDEN COUNTY MWC (1992)**

Phase- Condition	Run	Inlet <sup>a</sup>		Outlet <sup>a</sup>							SO <sub>2</sub> Reduction <sup>b</sup> (%)
		O <sub>2</sub> (%)	SO <sub>2</sub> (ppm)	NO <sub>x</sub> (ppm)	HCl (ppm)	CO <sub>2</sub> (%)	H <sub>2</sub> O (%)	O <sub>2</sub> (%)	CO (ppm)	SO <sub>2</sub> (ppm)	
I-B1	1	9.3	50.1	125.1	1.4	10.3	17.2	11.7	8.1	12.0	69.8
	2	10.2	49.5	126.9	1.2	9.4	16.0	12.6	43.5	11.1	71.1
	3	8.5	36.0	122.6	0.6	10.5	17.7	11.5	11.5	12.4	54.8
	Avg	9.3	45.2	124.9	1.0	10.1	17.0	11.9	21.0	11.8	65.2
I-B2	4	9.1	50.7	129.6	1.6	10.3	16.7	11.7	12.8	11.1	71.9
	5	9.0	55.1	132.5	1.7	10.3	16.5	11.7	10.5	12.3	71.2
	6	9.4	31.9	124.4	0.8	10.0	16.1	12.0	12.7	10.2	58.8
	Avg	9.2	45.9	128.9	1.4	10.2	16.4	11.8	12.0	11.2	67.3
I-B3	7	8.9	58.2	132.3	1.1	10.6	16.2	11.4	9.0	11.5	74.9
	8	9.8	46.4	123.4	2.0	9.7	15.3	12.2	15.7	11.2	68.8
	9	9.2	60.9	128.2	2.8	10.3	15.9	11.7	12.0	13.4	72.0
	Avg	9.3	55.2	128.0	1.9	10.2	15.8	11.8	12.2	12.0	71.9
I-B4	10	9.2	110.2	122.4	2.5	9.9	14.7	12.1	12.4	12.7	84.7
	11	9.4	70.3	124.0	5.1	10.0	15.0	12.0	19.6	10.6	80.5
	12	9.1	42.6	132.1	2.5	10.0	14.9	12.0	11.2	6.0	81.4
	Avg	9.2	74.4	126.2	3.4	10.0	14.9	12.0	14.4	9.8	82.2
I-B5	13	8.8	64.1	109.7	1.0	10.1	14.4	11.8	26.4	8.6	82.1
	14	9.5	89.8	111.6	3.3	9.3	13.9	12.7	19.5	12.2	81.2
	15	8.6	41.7	109.0	0.7	10.2	14.9	11.8	16.3	5.0	83.9
	Avg	9.0	65.2	110.1	1.7	9.9	14.4	12.1	20.7	8.6	82.4
II-B6	10	9.2	51.8	131.8	3.0	10.4	14.4	11.5	9.7	9.4	77.3
	11	9.0	75.4	126.6	4.7	10.7	14.9	11.3	11.4	11.8	80.7
	12	9.0	151.6	129.6	15.5	10.8	13.9	11.1	7.2	30.8	75.2
	Avg	9.1	92.9	129.3	7.7	10.6	14.4	11.3	9.4	17.3	77.7
II-B7	13	8.7	53.1	122.8	9.0	10.9	14.5	11.0	12.1	11.1	74.2
	14	9.1	53.4	126.3	4.8	10.7	14.7	11.3	15.6	9.1	79.0
	15	8.2	46.8	124.0	4.1	11.4	15.0	10.6	13.5	10.4	72.7
	Avg	8.7	51.1	124.4	5.9	11.0	14.7	11.0	13.7	10.2	75.3
II-B8	16	9.3	60.3	118.4	2.5	10.5	15.9	11.5	20.8	11.0	77.6
	17	8.1	62.0	135.6	2.0	11.4	17.6	10.5	8.5	13.8	72.6
	18	8.4	68.9	121.1	1.3	11.2	16.2	10.7	9.7	11.6	79.2
	Avg	8.6	63.7	125.1	1.9	11.0	16.6	10.9	13.0	12.1	76.5
II-B9	19	8.6	47.2	130.7	0.3	11.1	17.3	10.9	12.8	12.5	67.4
	20	8.2	61.6	130.3	0.4	11.4	17.3	10.6	11.9	12.1	76.0
	21	8.7	48.9	124.0	0.0	10.9	18.0	11.1	42.0	12.8	67.6
	Avg	8.5	52.5	128.4	0.2	11.1	17.5	10.9	22.2	12.4	70.3

**TABLE 5-1 UNIT A CARBON FEED SYSTEM DATA  
CAMDEN COUNTY MWC (1992)**

Condition	Date	Carbon Type	Carbon Feed Method	Run	Carbon Feed Rate (lb/hr)
A1	5/29/92	None	None	1	0
				2	0
				3	0
				Average	0
A2	5/30/92	FGD	Slurry <sup>a</sup>	4	49.0
				5	51.1
				6	51.1
				Average	50.4
A3	6/1/92	FGD	Slurry <sup>a</sup>	7	62.3
				8	56.4
				9	56.4
				Average	58.4
A4	6/6/92	FGD	Slurry <sup>a</sup>	22	51.0
				23	51.0
				Average	51.0
A5	6/10/92	FGD	Slurry <sup>a</sup>	31	42.7
				32	42.7
				33	42.7
				Average	42.7

<sup>a</sup>Fed manually from 50 lb bags into the lime slurry feed tank during lime slaking periods.

## 5.0 ELECTROSTATIC PRECIPITATOR PERFORMANCE TESTING

Testing to evaluate the long-term impact of carbon injection on ESP performance was conducted over a 13-day period on Unit A. These tests included one day of baseline testing without carbon injection (Condition A1), three days of testing with four ESP fields in service (Conditions A2, A3, and A4), and one day of testing with three ESP fields in service (Condition A5). Carbon was continuously added to the SD lime slurry feed tank during slaking from Day 2 through Day 13. Three test runs were conducted during Conditions A1, A2, A3, and A5. During Condition A4, only two runs were completed due to operating problems that precluded a third run.

### 5.1 Carbon Feed System Data

Table 5-1 summarizes key data for the carbon feed system used during testing on Unit A. These data include type of carbon fed, the carbon feed method (i.e., slurry or dry), and carbon feed rates.

All carbon injected into Unit A was mixed with the lime slurry. Carbon was fed manually from 50 lb bags into the lime slurry feed tank that was dedicated to the Unit A SD throughout the testing. The carbon was fed only during normal slaking periods, which usually lasted less than an hour and occurred once every four to five hours. Slaking (and thus carbon addition to the slurry) was not done during a sampling run so as not to interfere with or bias a run. The objective was to operate with a constant carbon injection rate between Day 2 (Condition A2) and Day 14 (Condition A5). As indicated in Table 5-1, however, average injection rates during each condition ranged from 42.7 to 58.4 lb/hr.

Records were kept of the amounts and times at which carbon was added so that carbon injection rates could be monitored. Table 5-2 gives the complete record of carbon added to the lime slurry feed tank during the 13 days of carbon addition. Carbon feed rates were calculated for the time between each slaking period by dividing the sum

TABLE 5-2, CONTINUED

Slake Number	Date	Slake Start Time	Slake Stop Time	Carbon Added (lb)	Time Between Starts (min)	Average Carbon Feed Rate (lb/hr)
29	6/4/92	1230	1320	261	284	55.1
30	6/4/92	1715	1805	256	285	53.9
31	6/4/92	2223	2323	248	308	48.3
32	6/5/92	0331	0431	250	308	48.7
33	6/5/92	0840	0943	251	309	48.7
34	6/5/92	1333	1430	247	293	50.6
35	6/5/92	1824	1925	248	291	51.1
36	6/5/92	2322	0022	248	298	49.9
37	6/6/92	0415	0515	251	293	51.4
38	6/6/92	0929	1024	250	314	47.8
39	6/6/92	1421	1518	248	292	51.0
40	6/6/92	2015	2135	300	354	50.8
41	6/7/92	0128	0229	255	313	48.9
42	6/7/92	0654	0756	262	326	48.2
43	6/7/92	1152	1251	257	298	51.7
44	6/7/92	1644	1745	265	292	54.5
45	6/7/92	2139	2228	258	295	52.5
46	6/8/92	0228	0318	265	289	55.0
47	6/8/92	0711	0803	257	283	54.5
48	6/8/92	1152	1250	256	281	54.7
49	6/8/92	1646	1742	258	294	52.7
50	6/8/92	2145	2235	258	299	51.8
51	6/9/92	0237	0326	256	292	52.6
52	6/9/92	0723	0811	255	286	53.5
53	6/9/92	1206	1258	254	283	53.9
54	6/9/92	1655	1749	256	289	53.1
55	6/9/92	2157	2248	251	302	49.9
56	6/10/92	0244	0344	256	287	53.5
57	6/10/92	0733	0840	250	289	51.9
58	6/10/92	1334	1409	257	361	42.7

**TABLE 5-2 UNIT A LONG-TERM CARBON FEED DATA  
CAMDEN COUNTY MWC**

<b>Slake Number</b>	<b>Date</b>	<b>Slake Start Time</b>	<b>Slake Stop Time</b>	<b>Carbon Added (lb)</b>	<b>Time Between Starts (min)</b>	<b>Average Carbon Feed Rate (lb/hr)</b>
1	5/29/92	2235	2323	200	--	--
2	5/30/92	0307	0355	203	272	44.8
3	5/30/92	0730	0810	197	263	44.9
4	5/30/92	1236	1326	250	306	49.0
5	5/30/92	1832	1926	303	365	51.1
6	5/30/92	2320	2359	203	288	42.3
7	5/31/92	0400	0455	258	280	55.3
8	5/31/92	0855	0940	259	295	52.7
9	5/31/92	1353	1439	255	298	51.3
10	5/31/92	1731	1807	202	218	55.6
11	5/31/92	2130	2220	255	239	64.0
12	6/1/92	0205	0305	306	275	66.8
13	6/1/92	0656	0755	302	291	62.3
14	6/1/92	1200	1300	308	304	60.8
15	6/1/92	1718	1820	299	318	56.4
16	6/1/92	2205	2305	253	287	52.9
17	6/2/92	0255	0355	298	290	61.7
18	6/2/92	0754	0856	301	299	60.4
19	6/2/92	1247	1343	248	293	50.8
20	6/2/92	1739	1839	250	292	51.4
21	6/2/92	2236	2336	248	297	50.1
22	6/3/92	0316	0416	253	280	54.2
23	6/3/92	0740	0840	250	264	56.8
24	6/3/92	1220	1320	259	280	55.5
25	6/3/92	1710	1810	259	290	53.6
26	6/3/92	2209	2309	259	299	52.0
27	6/4/92	0300	0400	257	291	53.0
28	6/4/92	0746	0846	256	286	53.7

**TABLE 5-3. UNIT A COMBUSTOR  
OPERATING DATA  
CAMDEN COUNTY MWC (1992)**

Condition	Run	Boiler Steam Flow (lb x 10 <sup>3</sup> /hr)	Furnace Temperature (°F)	Economizer Outlet Temperature (°F)
A1	1	100.0	1157	482
	2	101.3	1165	465
	3	95.9	1155	479
	Average	99.0	1159	475
A2	4	98.1	1145	479
	5	91.3	1128	480
	6	94.6	1110	494
	Average	94.7	1128	484
A3	7	89.6	1130	441
	8	102.7	1167	469
	9	102.9	1190	501
	Average	98.4	1162	470
A4	22	72.1	1052	470
	23	84.1	1113	474
	Average	79.6	1082	472
A5	31	93.3	1126	485
	32	94.4	1138	494
	33	99.3	1157	495
	Average	95.7	1140	492

of the carbon added during each slaking cycle by the time elapsed between slaking cycles.

## 5.2 Combustor Operating Data

Key combustor operating data for each test run are presented in Table 5-3. Included are boiler steam flow, furnace temperature, and flue gas temperature at the economizer outlet. For each condition, run averages and the condition averages are shown. All of these data were collected from plant instruments.

As shown in Table 5-3, the boiler steam flow averages for Conditions A1, A2, A3, and A5 ranged from 95,600 to 99,000 lb/hr. Because of problems maintaining the desired combustor operating conditions due to wet refuse, the steam production rate during Condition A4 averaged 80,000 lb/hr. The furnace temperature condition averages ranged from 1128 to 1162°F during Conditions A1, A2, A3, and A5, but decreased to an average of 1085°F during Condition A4, again due to wet refuse fed during this test. The average of the flue gas temperature at the economizer outlet ranged from 470 to 492°F and did not vary significantly between test conditions.

## 5.3 Spray Dryer Absorber/Electrostatic Precipitator Operating Data

Operating data for the SD and ESP are presented in Table 5-4. These data include lime slurry flow rate, SD and ESP outlet temperatures, ESP secondary voltage, secondary current to each ESP field, and the stack flue gas opacity. Dilution water flow and ESP field spark rate data were also collected, but are not summarized here. For each condition, run and condition averages are shown. Plant instruments collected all the data, with the exception of the ESP outlet temperature which was measured by Radian. The fourth ESP field was not in operation during Condition A5.

## 5.4 Mercury

Table 5-5 presents the Hg test results. The average inlet Hg concentrations during each condition ranged from 331 to 729  $\mu\text{g}/\text{dscm}$ . The distribution of Hg in the three sampling train fractions for each condition varied from 28 to 71% in the filter, 27 to 67% in the  $\text{HNO}_3/\text{H}_2\text{O}_2$  impingers, and less than 5% in the  $\text{KMnO}_4/\text{H}_2\text{SO}_4$ .

The outlet Hg levels during each condition averaged 48 to 131  $\mu\text{g}/\text{dscm}$  when carbon was injected and 245  $\mu\text{g}/\text{dscm}$  when carbon was not injected. Variations in outlet Hg concentrations are consistent with changes in inlet Hg concentrations, carbon injection rates, and fly ash carbon content (see Table 3-1). With the exception of Run 31, the filter fraction contained less than 9% of the total Hg collected by the sampling train. The average Hg percentages in the  $\text{HNO}_3/\text{H}_2\text{SO}_4$  impingers ranged from 47 to 69% with carbon injection and was 87% when carbon was not injected. The Hg percentages in the  $\text{KMnO}_4/\text{H}_2\text{SO}_4$  impingers ranged from 24 to 52% with carbon injection and was 10% when carbon was not injected.

The average Hg reduction was 45% with no carbon injection during Condition A1 and ranged from 81 to 91% during Conditions A2 through A5 when carbon was injected.

## 5.5 Cadmium and Lead

Concentrations of Cd and Pb during these tests are shown in Table 5-6. For Cd, average removal efficiencies across the SD/ESP were 99.80% during Condition A1, 99.74 to 99.88% during Conditions A2 through A4, and 99.62% during Condition A5. For Pb, average removal efficiencies were 99.93% for Condition A1, 99.78 to 99.98% for Conditions A2 through A4, and 99.40% for Condition A5.

Of the total Cd and Pb concentrations measured at the inlet sampling location, over 99.8% were associated with the front-half fraction, except during Runs 2, 4, and 8. During these three runs, the back-half accounted for 3 to 7% of the total catch for both



**TABLE 5-4. UNIT A SPRAY DRYER ABSORBER/ESP OPERATING DATA  
CAMDEN COUNTY MWC (1992)**

Run	Lime Slurry Flow Rate (gpm)	SD Outlet Temp (°F)	ESP Outlet Temp (°F)	ESP Voltage (KV)	ESP TR1-1 Current (mA)	ESP TR1-2 Current (mA)	ESP TR1-3 Current (mA)	ESP TR1-4 Current (mA)	Opacity (%)
<b>Phase II, Condition A1</b>									
1	9.1	277	284	46	288	441	456	450	0.0
2	9.6	270	277	47	280	446	454	455	0.0
3	9.0	273	277	47	260	443	451	451	0.1
Average	9.2	274	280	47	276	443	454	452	0.0
<b>Phase II, Condition A2</b>									
4	9.2	265	273	47	270	448	456	456	0.0
5	9.0	265	269	46	270	448	456	456	0.0
6	8.2	266	272	47	288	448	454	456	0.0
Average	8.8	265	272	47	276	448	455	456	0.0
<b>Phase II, Condition A3</b>									
7	9.1	274	278	47	281	448	452	453	0.0
8	9.1	262	269	46	282	448	451	450	0.0
9	9.0	281	288	46	220	448	449	448	0.0
Average	9.1	272	278	46	261	448	451	450	0.0
<b>Phase II, Condition A4</b>									
22	9.1	280	285	46	275	441	451	454	0.0
23	9.1	278	283	46	288	444	452	456	0.0
Average	9.1	279	284	46	282	442	452	455	0.0
<b>Phase II, Condition A5</b>									
31	9.1	276	283	47	284	448	454	OOS <sup>a</sup>	0.0
32	9.1	276	283	47	272	448	451	OOS	0.0
33	9.1	275	284	47	285	448	455	OOS	0.0
Average	9.1	276	283	47	280	448	453	OOS	0.0

<sup>a</sup>OOS = Out Of Service.

**TABLE 5-6. UNIT A CADMIUM AND LEAD RESULTS<sup>a</sup>  
CAMDEN COUNTY MWC (1992)**

Condition	Run	Cadmium (ug/dscm at 7% O2)							Lead (ug/dscm at 7% O2)						
		Inlet			Outlet			Removal Efficiency (%)	Inlet			Outlet			Removal Efficiency (%)
		Front Half	Back Half	Total	Front Half	Back Half	Total		Front Half	Back Half	Total	Front Half	Back Half	Total	
A1	1	842	1.28	843	1.46	0.42	1.88	99.78	19637	6.17	19643	13.3	1.01	14.3	99.93
A1	2	1669	51.4	1720	2.23	0.39	2.62	99.85	20857	626	21482	12.1	1.20	13.3	99.94
A1	3	1350	0.46	1350	2.50	0.47	2.97	99.78	23007	2.15	23009	14.1	1.77	15.9	99.93
A1	AVG	1287	17.7	1304	2.07	0.43	2.49	99.81	21167	211	21378	13.2	1.32	14.5	99.93
A2	4	993	33.1	1026	1.47	0.25	1.72	99.83	13820	345	14165	14.5	0.97	15.5	99.89
A2	5	1114	1.11	1115	2.00	0.66	2.66	99.76	23453	14.5	23468	27.7	2.15	29.9	99.87
A2	6	1004	1.40	1005	2.41	1.20	3.61	99.64	17565	3.23	17569	28.3	1.70	30.0	99.83
A2	AVG	1037	11.9	1049	1.96	0.71	2.66	99.75	18279	121	18401	23.5	1.61	25.1	99.86
A3	7	1218	0.45	1218	3.56	0.48	4.04	99.67	21814	3.64	21818	80.5	1.35	81.8	99.62
A3	8	747	50.9	798	1.66	0.46	2.12	99.73	10523	849	11371	20.8	1.11	21.9	99.81
A3	9	2099	0.48	2100	2.33	0.35	2.68	99.87	32446	3.44	32450	27.6	0.89	28.5	99.91
A3	AVG	1355	17.3	1372	2.52	0.43	2.95	99.79	21594	285	21880	43.0	1.11	44.1	99.80
A4	22	1860	0.60	1861	2.35	0.22	2.56	99.86	32679	ND	32679	9.00	ND	9.0	99.97
A4	23	1296	0.39	1296	1.00	0.20	1.21	99.91	36711	5.18	36716	5.48	ND	5.48	99.99
A4	AVG	1578	0.50	1578	1.67	0.21	1.88	99.88	34695	2.59	34697	7.24	0.00	7.24	99.98
A5	31	1142	0.22	1142	6.55	0.43	6.98	99.39	16129	2.36	16131	103	1.46	104	99.35
A5	32	1084	ND	1084	0.59	0.40	0.99	99.91	17921	1.75	17923	84.7	ND	84.7	99.53
A5	33	2150	0.29	2151	8.87	0.60	9.46	99.56	15835	3.71	15839	109	ND	109	99.31
A5	AVG	1459	0.17	1459	5.34	0.47	5.81	99.60	16628	2.61	16631	98.8	0.49	99.2	99.40
Estimated Detection Limit		10.1	0.20	10.3	0.72	0.18	0.90	NA	101	0.61	102	2.69	0.54	3.22	NA

<sup>a</sup>ND = Not Detected.

**TABLE 5-5. UNIT A MERCURY RESULTS  
CAMDEN COUNTY MWC (1992)**

Condition	Run	Mercury Concentrations (ug/dscm at 7% O2)								Removal Efficiency (%)
		Inlet				Outlet				
		Filter & Probe Rinse	HNO3/ H2O2 Impingers	KMnO4/ H2SO4 Impingers	Total	Filter & Probe Rinse	HNO3/ H2O2 Impingers	KMnO4/ H2SO4 Impingers	Total	
A1	1	168	97	3.4	268	0.6	107	14.2	121	54.8
	2	83	320	26.4	430	10.6	251	27.9	290	32.5
	3	353	245	11.7	610	10.3	280	32.4	322	47.2
	AVG	202	221	13.8	436	7.2	213	24.8	245	44.8
A2	4	158	128	15.8	302	0.5	36.7	17.6	54.8	81.9
	5	90	235	78.2	403	0.6	36.9	40.0	77.6	80.7
	6	341	1058	14.2	1412	5.1	198	58.1	261	81.5
	AVG	196	473	36.1	706	2.1	90.6	38.6	131	81.4
A3	7	236	291	2.7	530	ND	27.9	14.9	42.7	91.9
	8	139	289	30.5	458	1.2	37.4	69.3	108	76.4
	9	401	286	2.5	690	ND	80.0	75.6	156	77.4
	AVG	259	289	11.9	559	0.4	48.4	53.3	102	81.9
A4	22	189	452	1.8	643	0.3	25.4	23.5	49.2	92.3
	23	302	497	16.6	816	2.2	47.0	40.7	89.9	89.0
	AVG	245	475	9.2	729	1.3	36.2	32.1	69.5	90.7
A5	31	217	116	1.3	335	8.3	26.8	5.06	40.2	88.0
	32	206	69	19.9	294	4.5	32.5	14.1	51.1	82.6
	33	279	82	2.5	364	3.0	34.2	15.2	52.4	85.6
	AVG	234	89	7.9	331	5.3	31.1	11.5	47.9	85.4

<sup>a</sup>ND = Not Detected.

<sup>b</sup>Run 24 was terminated due to plant operating problems.

**TABLE 5-7. UNIT A PARTICULATE MATTER RESULTS  
CAMDEN COUNTY MWC (1992)**

<b>Condition</b>	<b>Run</b>	<b>INLET PM (g/dscm @ 7% O<sub>2</sub>)</b>	<b>OUTLET PM (g/dscm @ 7% O<sub>2</sub>)</b>	<b>Removal Efficiency (%)</b>
<b>A1</b>	<b>1</b>	<b>5.11</b>	<b>0.0034</b>	<b>99.93</b>
	<b>2</b>	<b>4.42</b>	<b>0.0035</b>	<b>99.92</b>
	<b>3</b>	<b>10.2</b>	<b>0.0043</b>	<b>99.96</b>
	<b>AVG</b>	<b>6.57</b>	<b>0.0037</b>	<b>99.94</b>
<b>A2</b>	<b>4</b>	<b>5.78</b>	<b>0.0019</b>	<b>99.97</b>
	<b>5</b>	<b>8.62</b>	<b>0.0038</b>	<b>99.96</b>
	<b>6</b>	<b>7.57</b>	<b>0.0035</b>	<b>99.95</b>
	<b>AVG</b>	<b>7.32</b>	<b>0.0031</b>	<b>99.96</b>
<b>A3</b>	<b>7</b>	<b>7.49</b>	<b>0.0059</b>	<b>99.92</b>
	<b>8</b>	<b>2.36</b>	<b>0.0075</b>	<b>99.68</b>
	<b>9</b>	<b>10.3</b>	<b>0.0048</b>	<b>99.95</b>
	<b>AVG</b>	<b>6.73</b>	<b>0.0061</b>	<b>99.85</b>
<b>A4</b>	<b>22</b>	<b>8.81</b>	<b>0.0057</b>	<b>99.94</b>
	<b>23</b>	<b>7.86</b>	<b>0.0016</b>	<b>99.98</b>
	<b>AVG</b>	<b>8.33</b>	<b>0.0036</b>	<b>99.96</b>
<b>A5</b>	<b>31</b>	<b>7.36</b>	<b>0.0078</b>	<b>99.89</b>
	<b>32</b>	<b>8.19</b>	<b>0.0051</b>	<b>99.94</b>
	<b>33</b>	<b>7.04</b>	<b>0.0034</b>	<b>99.95</b>
	<b>AVG</b>	<b>7.53</b>	<b>0.0054</b>	<b>99.93</b>

metals and may have been caused by penetration of particulate through or around the filter. The total metal concentrations for each test condition at the inlet were relatively consistent, ranging from 1,049  $\mu\text{g}/\text{dscm}$  to 1,578  $\mu\text{g}/\text{dscm}$  for Cd, and 16,628 to 34,695  $\mu\text{g}/\text{dscm}$  for Pb.

At the outlet sampling location, total Cd levels were relatively uniform during Conditions A1 through A4, ranging from 1.88 to 2.95  $\mu\text{g}/\text{dscm}$ . For Condition A5, the average outlet Cd level increased to 5.81  $\mu\text{g}/\text{dscm}$ . For Pb, the average outlet levels were more variable, ranging from 7.2 to 44.1  $\mu\text{g}/\text{dscm}$  during Conditions A1 through A4, and reaching 99.2  $\mu\text{g}/\text{dscm}$  during Condition A5. Of the total Cd and Pb measured at the stack, 6 to 50% of the Cd and 1 to 11% of the Pb were found in the back-half fraction.

## 5.6 Particulate Matter

Table 5-7 presents the inlet and outlet PM concentrations for the five Unit A test conditions. Results for each run, condition averages, and percent reduction are provided. The economizer outlet averages for each condition ranged from 6.6 to 8.2  $\text{g}/\text{dscm}$ , and the average stack concentrations for each condition ranged from 0.00321 to 0.00618  $\text{g}/\text{dscm}$ . All of the individual runs achieved greater than 99.9% reduction of PM, except for Run 8. The lower PM reduction during Run 8 is due in part to the low PM concentration measured at the inlet and is consistent with the potential penetration of PM around or through the filter discussed in Section 5.5 for this run.

## 5.7 Fly Ash - Percent Carbon

Table 5-8 presents the carbon analysis of the Unit A fly ash samples. A single composite sample was collected during each condition at the economizer outlet using an EPA Method 5 sampling train. On a dry basis, the condition results were between 1.42 and 2.36% carbon.

## 5.8 Particle Size Distribution

Two sets of PSD samples were collected using an 8-stage Andersen impactor during Conditions A1, A3, A4, and A5. One set of samples was collected during Condition A2. Both of the PSD trains operated during Condition A4 experienced operating problems: a loose impinger connection was discovered on one of the trains at the end of the run, and the other had problems with operation of the sampling pump. Post-test review of the collected data from the first train indicated that the flue gas moisture content was lower than for other trains and that the isokinetic flow rate was high. As a result, the samples collected by the first train were rejected. Post-test review of data from the second train indicated that all QA/QC criteria were met. Therefore, the data from this train were accepted.

Selected data from each of the accepted PSD trains are presented in Table 5-9. The data include the start and stop times for each sampling period; the cumulative mass fraction collected following the second, fourth, sixth, and eighth impactor stages; and the total PM loading. As indicated by these data, the particle size distribution samples collected during Conditions A1 through A4 are generally consistent with each other, with the exception of Run PSD-5. The cause of this difference during Run PSD-5 is unknown. The total PM loading from all six trains run during Conditions A1 through A4 are similar. During Condition A5, with the fourth ESP field out of service, there was an increase in the fraction of PM less than  $9\ \mu\text{m}$  in diameter and in the total quantity of PM collected. Comparison of the average measurements from Conditions A1 through A4 versus Condition A5 indicates that the emissions of PM greater than  $9\ \mu\text{m}$  were approximately  $0.0007\ \text{g/dscm}$  during all of the tests. However, emissions of PM less than  $9\ \mu\text{m}$  during Condition A5 were approximately  $0.002\ \text{g/dscm}$  compared to  $0.0005\ \text{g/dscm}$  during Conditions A1 through A4.

**TABLE 5-8. UNIT A FLY ASH CARBON RESULTS  
CAMDEN COUNTY (MWC) 1992**

<b>Test Condition</b>	<b>Carbon Content (% by weight, dry basis)</b>
A1	1.95
A2	1.42
A3	2.36
A4	2.25
A5	1.52

## 5.9 Volumetric Flow and Moisture by EPA Methods 1 and 4

Unit A inlet and outlet gas flow rates and moisture contents were determined using the procedures in EPA Methods 1 and 4, respectively. The results are presented in Table 5-10. The values were measured using the EPA multi-metals sampling train. The flow rates are expressed in dscmm at actual O<sub>2</sub> levels, and the moisture content is expressed in percent by volume. Average inlet results were 8 to 11% O<sub>2</sub>, 14 to 17% moisture, and flow rates of 1236 to 1490 dscmm. Average outlet results were 11 to 13% O<sub>2</sub>, 17 to 19% moisture, and flow rates of 1550 to 1624 dscmm.

During Conditions A4 and A5, the inlet O<sub>2</sub> monitor appeared to be reporting high results (11 to 13% O<sub>2</sub>). Review of the plant calibration data for both of these days and discussions with plant personnel indicated that these readings were potentially erroneous. The values shown for inlet O<sub>2</sub> concentrations for both of the conditions were calculated by subtracting 2.4% from the outlet O<sub>2</sub> reading for the same run. This adjustment factor was based on the average difference in O<sub>2</sub> (caused by air infiltration to the SD/ESP) between the inlet and outlet sampling locations during the other test conditions.

## 5.10 Continuous Emission Monitoring Data

The CEM data are presented in Table 5-11. The CEM data include spray dryer absorber inlet O<sub>2</sub> and SO<sub>2</sub> concentrations, and stack outlet NO<sub>x</sub>, HCl, CO<sub>2</sub>, H<sub>2</sub>O, O<sub>2</sub>, and SO<sub>2</sub> concentrations. All concentrations are presented at actual O<sub>2</sub> levels. However, the SO<sub>2</sub> removal efficiency was calculated after normalizing the inlet and outlet SO<sub>2</sub> concentrations to 7% O<sub>2</sub>. Outlet methane and THC were also recorded by the CEM system; however, neither were found above a 0.1 ppm concentration level and are not reported.



**TABLE 5-9 UNIT A PARTICLE SIZE DISTRIBUTION DATA  
CAMDEN COUNTY MWC**

Condition (Date)	Run No.	Sampling Period (Start-Stop Time)	Cumulative Mass Fraction Less Than Indicated Particle Size ( $\mu\text{m}$ ) <sup>a</sup>				PM Loading (g/dscm)
			9.0	4.0	1.3	0.5	
A1 (5/29)	PSD-1	13:50-16:50	0.398	0.306	0.213	0.111	0.00120
	PSD-2	18:50-21:50	0.398	0.343	0.230	0.047	0.00193
	Average		0.398	0.325	0.222	0.079	0.00157
A2 (5/30)	PSD-3	10:40-18:40	0.364	0.236	0.145	0.036	0.00071
	Average		0.364	0.236	0.145	0.036	0.00071
A3 (6/1)	PSD-5	10:45-19:45	0.741	0.589	0.267	0.100	0.00128
	PSD-6	15:00-20:00	0.269	0.195	0.104	0.034	0.00102
	Average		0.505	0.392	0.186	0.067	0.00115
A4 (6/6)	PSD-22B	15:30-22:10	0.256	0.205	0.185	0.140	0.00122
	Average		0.256	0.205	0.185	0.140	0.00122
A5 (6/10)	PSD-30A	10:20-18:20	0.760	0.548	0.350	0.139	0.00138
	PSD-30B	10:15-18:15	0.768	0.638	0.376	0.205	0.00399
	Average		0.764	0.593	0.363	0.172	0.00269

<sup>a</sup> Theoretical particle cut sizes vary with sample collection rate for individual train, sizes shown are approximate.

**TABLE 5-11. UNIT A CEN RESULTS  
CAMDEN COUNTY MWC (1992)**

Phase- Condition	Run	Inlet <sup>a</sup>		Outlet <sup>a</sup>							SO <sub>2</sub> Reduction <sup>b</sup> (%)
		O <sub>2</sub> (%)	SO <sub>2</sub> (ppm)	NO <sub>x</sub> (ppm)	HCl (ppm)	CO <sub>2</sub> (%)	H <sub>2</sub> O (%)	O <sub>2</sub> (%)	CO (ppm)	SO <sub>2</sub> (ppm)	
II-A1	1	9.2	100.9	156.7	7.3	10.4	15.5	11.6	9.4	7.8	90.3
	2	8.1	130.6	160.0	7.7	11.2	15.2	10.7	5.1	10.8	89.6
	3	9.1	99.7	147.5	9.5	10.4	15.9	11.5	15.0	10.9	86.2
	Avg	8.8	110.4	154.8	8.2	10.7	15.5	11.3	9.8	9.8	88.7
II-A2	4	8.8	95.8	161.4	5.3	10.7	17.4	11.3	8.8	3.8	95.0
	5	9.7	68.4	143.4	1.3	9.8	15.8	12.2	15.2	0.7	98.7
	6	9.9	105.2	141.8	3.8	9.8	17.5	12.2	7.6	6.9	91.7
	Avg	9.5	89.8	148.9	3.5	10.1	16.9	11.9	10.5	3.8	95.1
II-A3	7	10.1	55.2	146.0	0.7	9.9	15.4	12.0	10.5	1.8	96.0
	8	7.9	114.6	130.1	0.9	11.6	16.6	10.3	5.2	4.3	95.4
	9	10.7	49.7	126.8	1.0	9.8	15.1	12.1	14.0	2.3	94.6
	Avg	9.6	73.2	134.3	0.9	10.5	15.7	11.5	9.9	2.8	95.4
II-A4	22	11.3	29.2	131.7	0.0	8.3	15.3	13.7	22.6	1.4	93.6
	12	10.1	42.8	141.2	0.0	9.5	17.1	12.5	11.9	0.8	97.6
	Avg	10.7	36.0	136.4	0.0	8.9	16.2	13.1	17.3	1.1	95.6
II-A5	13	9.8	32.0	134.6	0.9	9.8	16.1	12.2	12.5	0.2	99.2
	14	9.8	78.1	146.3	3.0	9.7	16.1	12.2	15.2	5.1	91.6
	15	9.0	64.4	154.1	1.9	10.6	17.9	11.4	13.3	2.7	94.8
	Avg	9.5	58.2	145.0	1.9	10.0	16.7	11.9	13.7	2.7	95.2

<sup>a</sup>Concentrations are reported at actual O<sub>2</sub> levels, dry basis.

<sup>b</sup>Based on concentration corrected to 7% O<sub>2</sub>, dry basis.

**TABLE 5-10. UNIT A VOLUMETRIC FLOW AND MOISTURE RESULTS  
CAMDEN COUNTY MWC (1992)**

Condition	RUN	Inlet			Outlet		
		O2 (%)	Flow Rate (dscmm)	Moisture (%)	O2 (%)	Flow Rate (dscmm)	Moisture (%)
A1	1	9.2	1329	14.0	11.6	1587	16.8
	2	8.1	1197	14.5	10.7	1518	17.0
	3	9.1	1183	15.0	11.5	1545	18.1
	AVG	8.8	1236	14.5	11.3	1550	17.3
A2	4	8.8	1236	15.5	11.3	1511	19.7
	5	9.7	1388	14.7	12.2	1647	16.3
	6	9.9	1424	17.1	12.2	1695	20.1
	AVG	9.5	1350	15.8	11.9	1618	18.7
A3	7	10.1	1510	16.5	12.0	1670	17.6
	8	7.9	1282	15.2	10.3	1474	19.4
	9	10.7	1507	14.6	12.1	1729	17.5
	AVG	9.6	1433	15.4	11.5	1624	18.1
A4	22	11.3 <sup>a</sup>	1263	15.2	13.7	1521	17.5
	23	10.1 <sup>a</sup>	1272	17.7	12.5	1550	18.2
	AVG	10.7	1267	16.5	13.1	1535	17.8
A5	31	9.8 <sup>a</sup>	1504	16.3	12.2	1526	19.1
	32	9.8 <sup>a</sup>	1446	15.4	12.2	1663	18.5
	33	9.0 <sup>a</sup>	1518	17.2	11.4	1614	20.2
	AVG	9.5	1490	16.3	11.9	1601	19.3

<sup>a</sup>Oxygen data from inlet CEM appeared to be erroneous for Conditions A4 and A5. Inlet O<sub>2</sub> levels were calculated by subtracting 2.4% from outlet O<sub>2</sub> levels.

Condition average inlet SO<sub>2</sub> concentrations were between 36 and 110 ppm, and average outlet concentrations were between 1 and 10 ppm. The average SO<sub>2</sub> removal was 89% with no carbon injection and 96% with carbon injection. Outlet NO<sub>x</sub> concentrations ranged between 133 and 155 ppm. Outlet HCl concentrations averaged 8 ppm without carbon injection and 2 ppm with carbon injection.

The average outlet SO<sub>2</sub> concentrations measured from Unit A (1 to 10 ppm) are lower than those measured from Unit B (8 to 17 ppm). This difference raised questions regarding a potential error in one of the CEMs. However, based on review of SD/ESP and CEM performance data for both units with plant personnel, it was concluded that the measured SO<sub>2</sub> levels from both units were correct.

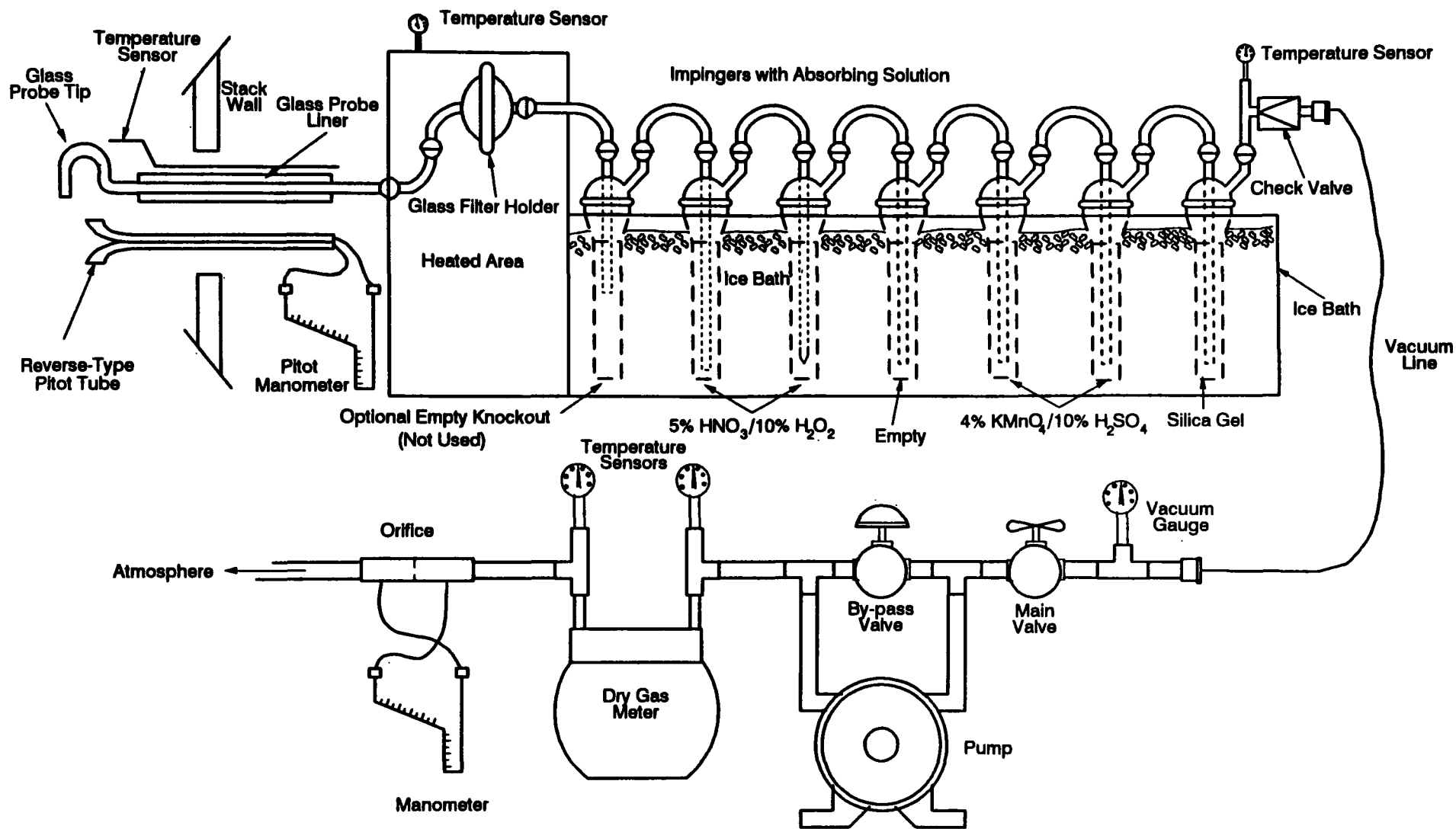


Figure 6-1. Schematic of Multiple Metals Sampling Train

## 6.0 FLUE GAS SAMPLING AND ANALYTICAL PROCEDURES

This section describes the flue gas sampling and analytical procedures used during the testing at the Camden County Resource Recovery Facility (CCRRF).

### 6.1 Particulate Matter and Multiple Metals

The EPA multi-metals method was used to determine concentrations of PM and Hg in flue gas during all tests.<sup>9</sup> The same method was also used to determine the concentration of other selected metals (cadmium, lead, antimony, arsenic, barium, beryllium, boron, chromium, cobalt, copper, manganese, molybdenum, nickel, selenium, silver, thallium, and vanadium) during several test conditions. Sampling was conducted simultaneously at the economizer outlet and in the stack. At the economizer outlet, a 24-point sampling matrix was used. For the stack location, a 12-point sampling matrix was used. During the three test conditions during which CDD/CDF were also sampled, the sampling duration was two hours. During all other test conditions, the runs were one hour in duration.

#### 6.1.1 Sampling Equipment Preparation

The multiple metals sampling train is shown in Figure 6-1. The train consists of a glass nozzle and probe, a heated filter assembly with a glass fiber filter and Teflon® filter support, a series of impingers, and the standard EPA Method 5 (40 CFR, Part 60, Appendix A) meterbox and vacuum pump. The sample is not exposed to any metals surfaces in the train. The contents of the sequential impingers include an optional knockout impinger for collecting moisture (this impinger was not used during the Camden County testing), two impingers with a 5% nitric acid ( $\text{HNO}_3$ )/10% hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) solution, an empty impinger to protect against impinger solution contamination, two impingers with a 4% potassium permanganate ( $\text{KMnO}_4$ )/10% sulfuric acid ( $\text{H}_2\text{SO}_4$ ) solution, and an impinger containing silica gel. The second impinger containing  $\text{HNO}_3/\text{H}_2\text{O}_2$  was of the Greenburg-Smith design; the other

The sampling trains were leak checked at the start and finish of sampling. Leak checks were also performed before and after every port change. The acceptable pre-test leak rate was less than 0.02 cubic feet per minute (cfm) at approximately 15 inches of Hg.

After successful completion of the pre-test leak check and when all train components were at their required temperatures, the initial dry gas meter reading was recorded and the test was initiated. Sampling train data for each sampling point were recorded on standard data forms.

Recovery procedures began as soon as the probe was removed from the stack and the post-test leak check was completed. To facilitate transfer from the sampling location to the recovery trailer, the sampling train was disassembled into three sections: the nozzle/probe liner, the filter holder, and the impingers. Each of these sections were capped with Teflon® tape before removal to the recovery trailer.

Once in the trailer, the sampling train was recovered as six separate front-half and back-half fractions. A diagram illustrating front-half and back-half sample recovery procedures is shown in Figure 6-2.

### 6.1.3 Particulate Matter Analysis

The general gravimetric procedure described in Section 4.3 of EPA Method 5 was used to determine the amount of collected PM. The key difference was the use of a metal-free probe brush to avoid potential metals contamination of the probe wash sample. All sample drying, desiccation, and weighing activities were performed in Radian's Perimeter Park Laboratory.

The filters and precleaned beakers were dried to a constant weight before use. The same balance was used for weighing the samples prior to and after testing. The acetone rinses were evaporated to dryness under a clean hood at 70°F in a tared beaker.

impingers had straight tubes. The impingers were connected together with clean glass U-tube connectors and were arranged in an impinger bucket.

Equipment preparation included calibration and leak checking of all sampling train equipment as specified in EPA Method 5. This equipment includes the probe nozzles, pitot tubes, metering system, probe heater, temperature gauges, leak check metering system, and barometer.

#### 6.1.2 Sampling Equipment Operation and Recovery

Prior to sampling, preliminary measurements were made to ensure isokinetic sampling. These included determining the traverse point locations and performing a preliminary velocity traverse, cyclonic flow check, and moisture determination. These measurements were used to calculate a "K factor," which was used to determine an isokinetic flue gas sampling rate.

Measurements were made of the duct inside diameter, port length, and the distances to the nearest upstream and downstream flow disturbances. These measurements were used to verify the sampling point locations required by EPA Method 1 guidelines. The insertion depths were then marked on the sampling probe using an indelible marker.

After assembling the train, the heaters for the probe liner and filter box were turned on. The system was then brought to the appropriate temperature, and a pre-test leak check of the sampling train was conducted. The filter skin temperature was maintained at  $120 \pm 14^{\circ}\text{C}$  ( $248 \pm 25^{\circ}\text{F}$ ). The probe temperature was maintained above  $100^{\circ}\text{C}$  ( $212^{\circ}\text{F}$ ).



The residue was desiccated for 24 hours in a desiccator containing fresh silica gel at room temperature. The filter was also desiccated under the same conditions to a constant weight. Each replicate weighing had to agree to within 0.5 mg or 1% (whichever is greater) between two consecutive weighings, conducted at least 6 hours apart. Weight gain was reported to the nearest 0.1 mg.

Following weighing, the desiccated filter and acetone rinse samples were sent to Radian's Summit Park laboratory for metals analysis. The filter and acetone rinse samples collected from the economizer exit sampling location during the Phase I Characterization Test were sent directly to Summit Park for expedited Hg analysis. As a result, PM loadings at the economizer exit are not available for these runs.

#### 6.1.4 Metals Analytical Procedures

A diagram illustrating the sample preparation and analytical procedure for the target metals is shown in Figure 6-3. As shown in this figure, metals analyses were conducted on four distinct fractions:

- Front-half (filter, acetone probe rinse, and nitric acid probe rinse);
- $\text{HNO}_3/\text{H}_2\text{O}_2$  impingers;
- $\text{KMnO}_4/\text{H}_2\text{SO}_4$  impingers; and
- HCl rinse.

The first two fractions were analyzed for Hg and for other metals. The last two fractions were analyzed for Hg only. All metals analyses were conducted in Radian's Summit Park Laboratory.

The acetone probe rinse and  $\text{HNO}_3$  probe rinse for each train were combined to yield the front-half sample fraction. The front-half fractions were then digested with concentrated  $\text{HNO}_3$  and hydrofluoric (HF) acid in a microwave-heated pressure vessel.

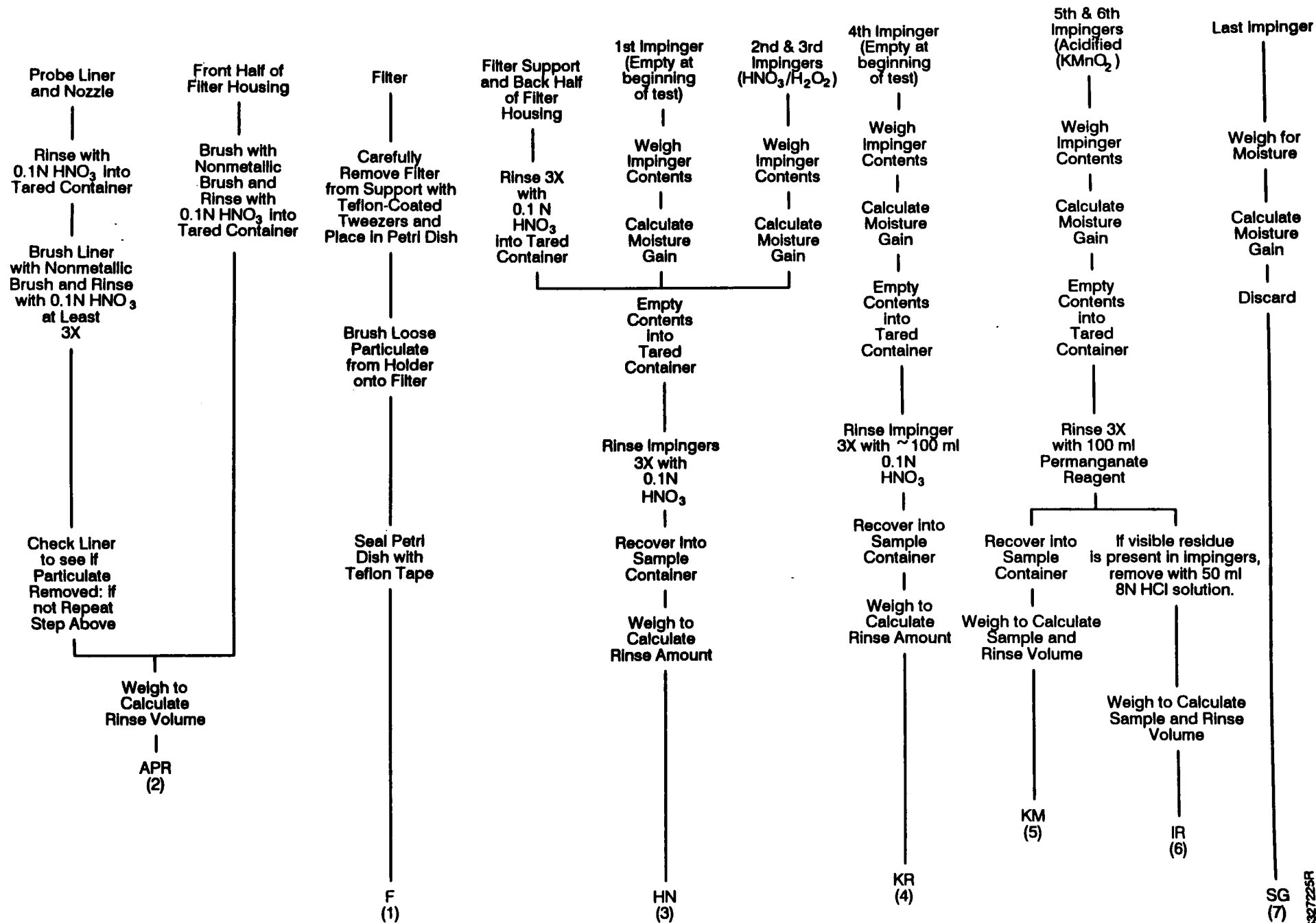


Figure 6-2. Metals Sample Recovery Scheme

The microwave digestion took place over a period of approximately 10 to 12 minutes in intervals of 1 to 2 minutes at 600 watts. The fraction was diluted to a specified volume with deionized (DI) water and divided for analysis.

Aliquots were taken from each of the remaining four fractions (front-half digest,  $\text{HNO}_3/\text{H}_2\text{O}_2$ ,  $\text{KMnO}_4/\text{H}_2\text{OSO}_4$ , and  $\text{HCl}$ ) for analysis of Hg by cold vapor atomic absorption (CVAAS) (EPA Methods 7470 and 7471). Each of these samples were prepared for analysis as indicated in Figure 6-3.

For the test runs requiring analysis for other metals, aliquots were taken from the front-half and  $\text{HNO}_3/\text{H}_2\text{O}_2$  fractions. These aliquots were prepared as indicated in Figure 6-3 and analyzed for other metals by ICAP by EPA Method 6010. Because of the detection limitations of ICAP for As, Cd, Pb, and Se, additional analyses were conducted by GFAA. Based on the levels of the metals present at both sampling locations, GFAA was used for analysis of As (Method 7060, Cd (Method 7131), and Pb (Method 7421) on the stack front-half fraction, and on the economizer outlet and stack  $\text{HNO}_3/\text{H}_2\text{O}_2$  fractions. For Se (Method 7740), the front-half and  $\text{HNO}_3/\text{H}_2\text{O}_2$  fractions from both the economizer outlet and stack were analyzed by GFAA. To improve the detection limit for metals run by GFAA, all of the sample remaining after removal of aliquots for Hg and ICAP analyses was reduced to near dryness prior to sample preparation.

## 6.2 CDD/CDF

The sampling and analytical method used for determining flue gas emissions of CDD/CDF was EPA Method 23.<sup>11</sup> Sample recovery techniques incorporated the latest EPA Office of Research and Development guidance on replacing the methylene chloride rinses with toluene rinses. Samples were simultaneously collected at the economizer outlet and in the stack. Samples times during each run were two hours.

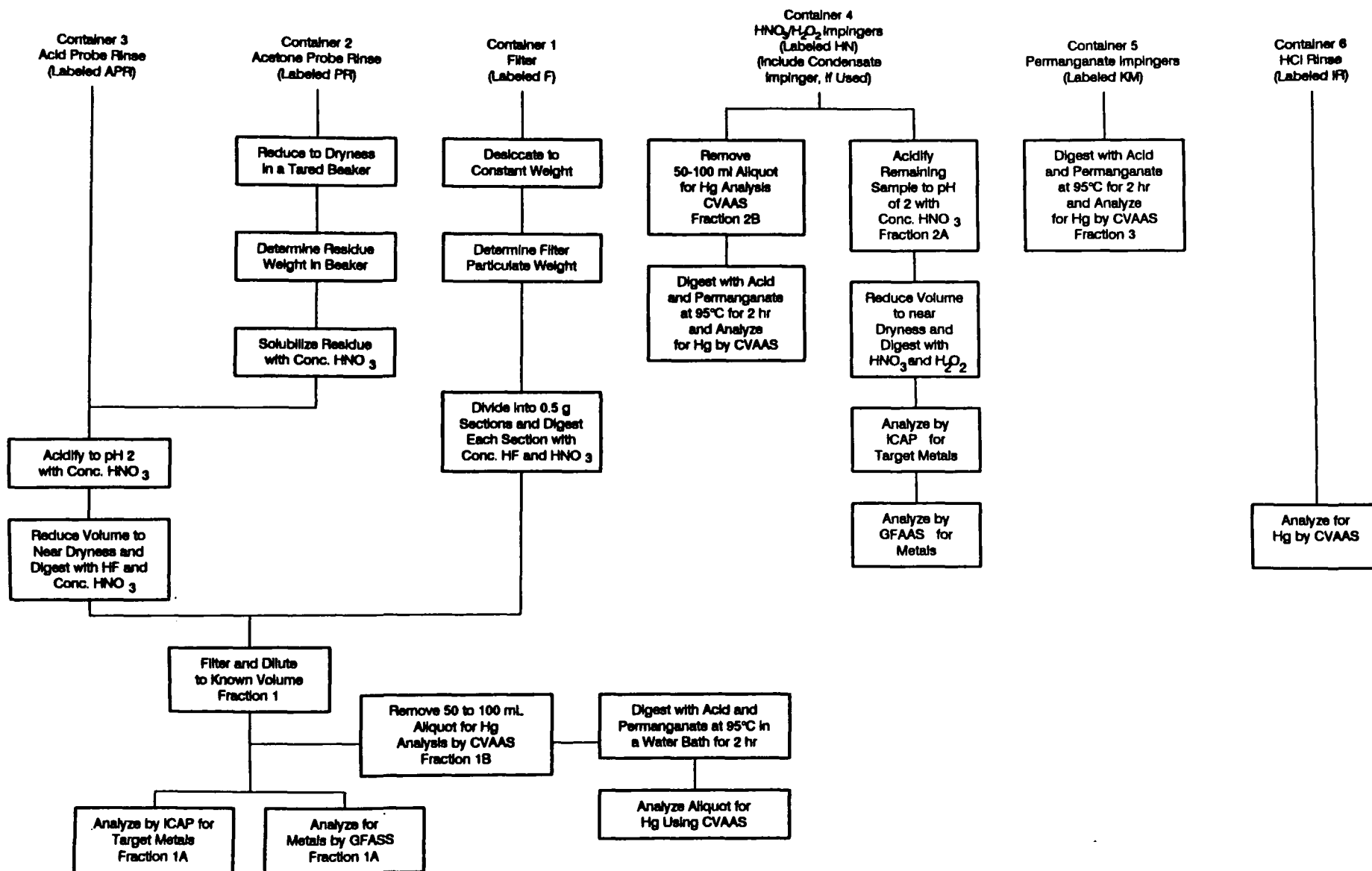


Figure 6-3. Metals Sample Preparation and Analysis Scheme

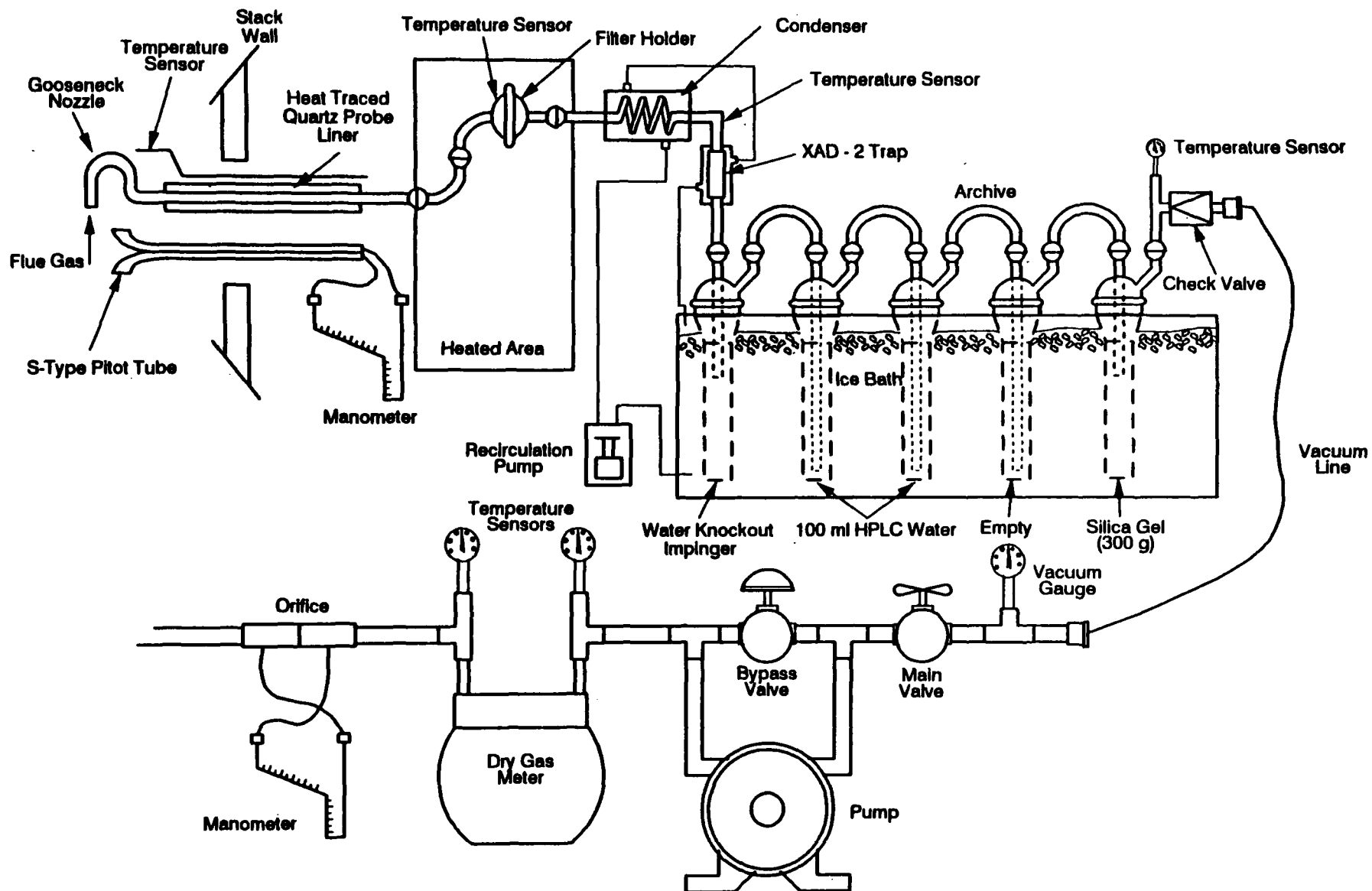


Figure 6-4. CDD/CDF Sampling Train Configuration

All of the CDD/CDF analyses, as well as preparation of the XAD-II collection modules, were performed by Twin Cities Testing in St. Paul, Minnesota. Preparation of all other sampling train equipment was conducted by Radian.

#### 6.2.1 Sampling Equipment Preparation

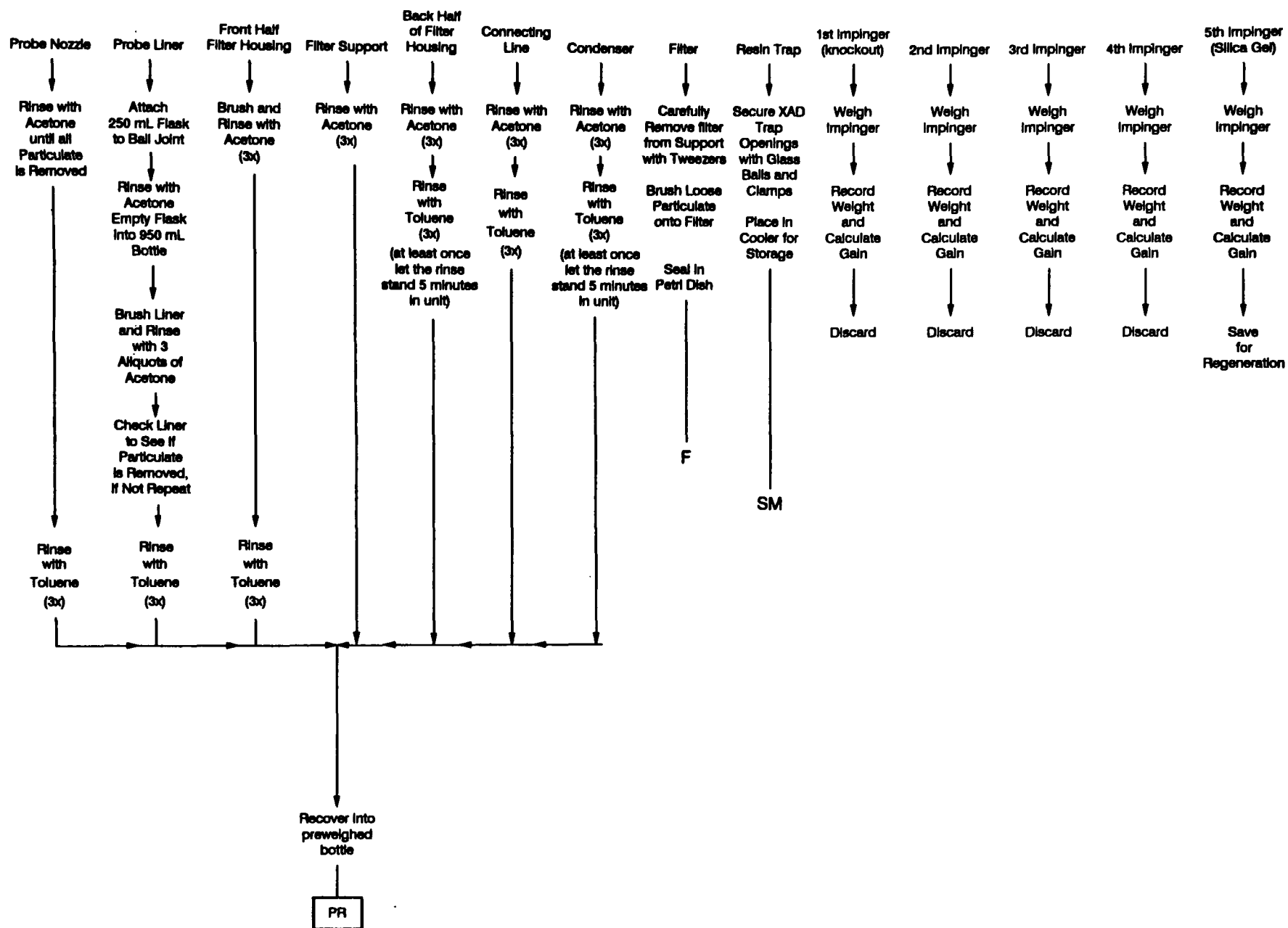
The CDD/CDF sampling method used the sampling train shown in Figure 6-4. The sampling system was similar to a Method 5 train with the exception of the following:

- All components (glass probe liner/nozzle, all other glassware, filters) were pre-cleaned using solvent rinses and extraction techniques; and
- A condensing coil and XAD-II® resin absorption module for collection of CDD/CDF were located between the filter and impinger train.

In addition to the standard EPA Method 5 requirements, the CDD/CDF sampling method includes several preparation steps for ensuring that the sampling train components are not contaminated with organics that may interfere with analysis. The glassware, glass fiber filters, and absorbing resin were cleaned, and the filters and resin were checked for residue before they were packed. The remaining preparation included calibration and leak checking of all sampling train equipment, including meter boxes, thermocouples, nozzles, pitot tubes, and umbilicals.

#### 6.2.2 Sampling Equipment Operation and Recovery

The CDD/CDF preliminary measurement procedures and sampling procedures were identical to those described in Section 6.1.2 for the multiple metals sampling. To facilitate transfer from the sampling location to the recovery trailer, the sampling train was disassembled into the following sections: probe liner, filter holder,



### Figure 6-5. CDD/CDF Field Recovery Scheme

filter-to-condenser glassware, condenser/sorbent module, and impingers. Each of these sections were capped with methylene chloride-rinsed aluminum foil or ground glass caps before removal to the recovery trailer. Once in the trailer, sample recovery followed the scheme shown in Figure 6-5. The samples were recovered and stored in cleaned amber glass bottles to prevent light degradation.

All CDD/CDF recovery rinses were completed using toluene instead of methylene chloride. All solvents used for train recovery were pesticide grade. To prevent the introduction of chemical impurities which interfere with the quantitative analytical determination, the highest grade reagents were used for train recovery.

Field recovery resulted in the sample components listed in Table 6-1. The sorbent module was stored on ice at all times. The samples were shipped to the analytical laboratory accompanied by written information designating target analyses.

### 6.2.3 Analytical Procedures

High resolution gas chromatography (HRGC) and high resolution mass spectrometry (HRMS) were used to determine CDD/CDF concentrations. The target CDD/CDF congeners are listed in Table 6-2.

Each of the field sample fractions was combined into a single sample and analyzed according to the scheme in Figure 6-6. For the CDD/CDF analysis, isotopically-labeled surrogate compounds and internal standards were added to the samples before the extraction process was initiated. The internal standards and surrogates that were used are described in detail in EPA Method 23.



**TABLE 6-2 TARGET CDD/CDF CONGENERS  
CAMDEN COUNTY MWC (1992)**

---

**DIOXINS:**

2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD)  
Total tetrachlorinated dibenzo-p-dioxins (TCDD)  
1,2,3,7,8 pentachlorodibenzo-p-dioxin (1,2,3,7,8 PeCDD)  
Total pentachlorinated dibenzo-p-dioxins (PeCDD)  
1,2,3,4,7,8 hexachlorodibenzo-p-dioxin (1,2,3,4,7,8 HxCDD)  
1,2,3,6,7,8 hexachlorodibenzo-p-dioxin (1,2,3,6,7,8 HxCDD)  
1,2,3,7,8,9 hexachlorodibenzo-p-dioxin (1,2,3,7,8,9 HxCDD)  
Total hexachlorinated dibenzo-p-dioxins (HxCDD)  
1,2,3,4,6,7,8 heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8 HpCDD)  
Total heptachlorinated dibenzo-p-dioxins (HpCDD)  
Total octachlorinated dibenzo-p-dioxins (OCDD)

**FURANS:**

2,3,7,8 tetrachlorodibenzofurans (2,3,7,8 TCDF)  
Total tetrachlorinated dibenzofurans (TCDF)  
1,2,3,7,8 pentachlorodibenzofuran (1,2,3,7,8 PeCDF)  
2,3,4,7,8 pentachlorodibenzofuran (2,3,4,7,8 PeCDF)  
Total pentachlorinated dibenzofurans (PeCDF)  
1,2,3,4,7,8 hexachlorodibenzofuran (1,2,3,4,7,8 HxCDF)  
1,2,3,6,7,8 hexachlorodibenzofuran (1,2,3,6,7,8 HxCDF)  
2,3,4,6,7,8 hexachlorodibenzofuran (2,3,4,6,7,8 HxCDF)  
1,2,3,7,8,9 hexachlorodibenzofuran (1,2,3,7,8,9 HxCDF)  
Total hexachlorinated dibenzofurans (HxCDF)  
1,2,3,4,6,7,8 heptachlorodibenzofuran (1,2,3,4,6,7,8 HpCDF)  
1,2,3,4,7,8,9 heptachlorodibenzofuran (1,2,3,4,7,8,9 HpCDF)  
Total heptachlorinated dibenzofurans (HpCDF)  
Total octachlorinated dibenzofurans (OCDF)

---

**TABLE 6-1 CDD/CDF SAMPLE FRACTIONS SHIPPED  
TO ANALYTICAL LABORATORY  
CAMDEN COUNTY MWC (1992)**

<b>Container/ Component</b>	<b>Code</b>	<b>Fraction</b>
1	F	Filter(s)
2	PR <sup>a</sup>	Acetone and toluene rinses of nozzle, probe, front-half/back-half filter holder, filter support, connecting glassware, and condenser
3	SM	XAD-II resin trap (sorbent module)

<sup>a</sup>Rinses include acetone and toluene which were recovered into the same sample bottle.

Data for the mass spectrometer were recorded and stored on a computer file, as well as printed on paper. Results such as amount detected, detection limit, retention time, and internal standard and surrogate standard recoveries were calculated by computer. The chromatograms were retained by Twin City Testing and were also included in the analytical report delivered to Radian.

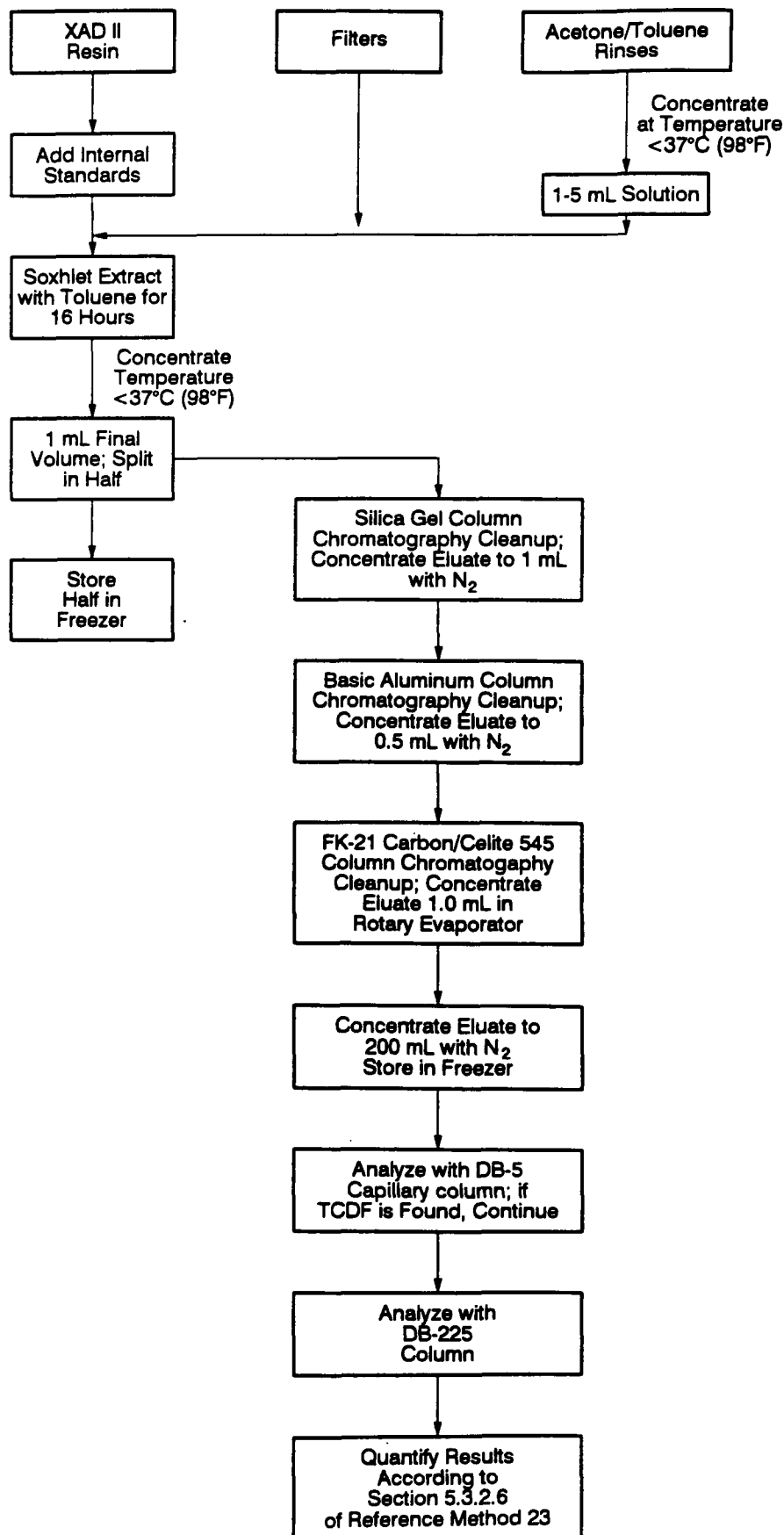
### 6.3 Volatile Organic Compounds

Sampling for VOC was conducted according to SW-846 Method 0030.<sup>12</sup> The VOST is designed to collect VOC with boiling points between 86°F and 212°F. Sampling for VOC was limited to two test conditions and included simultaneous sampling at the economizer exit and stack. During each VOST run, four pairs of collection traps were used, with each pair being used for 20 minutes at a sampling rate of 1 L/min.

The list of target analytical species is given in SW-846 Method 8240<sup>12</sup> and presented in Table 6-3. Flue gas detection limits for most of the compounds are about 1.0 µg/m<sup>3</sup>, except for polar molecule water-soluble compounds which have higher detection limits. Preparation of the resin traps used for sample collection and analysis of collected samples was conducted by Air Toxics, Ltd in Rancho Cordova, California. Preparation of the sampling trains and associated equipment was performed by Radian.

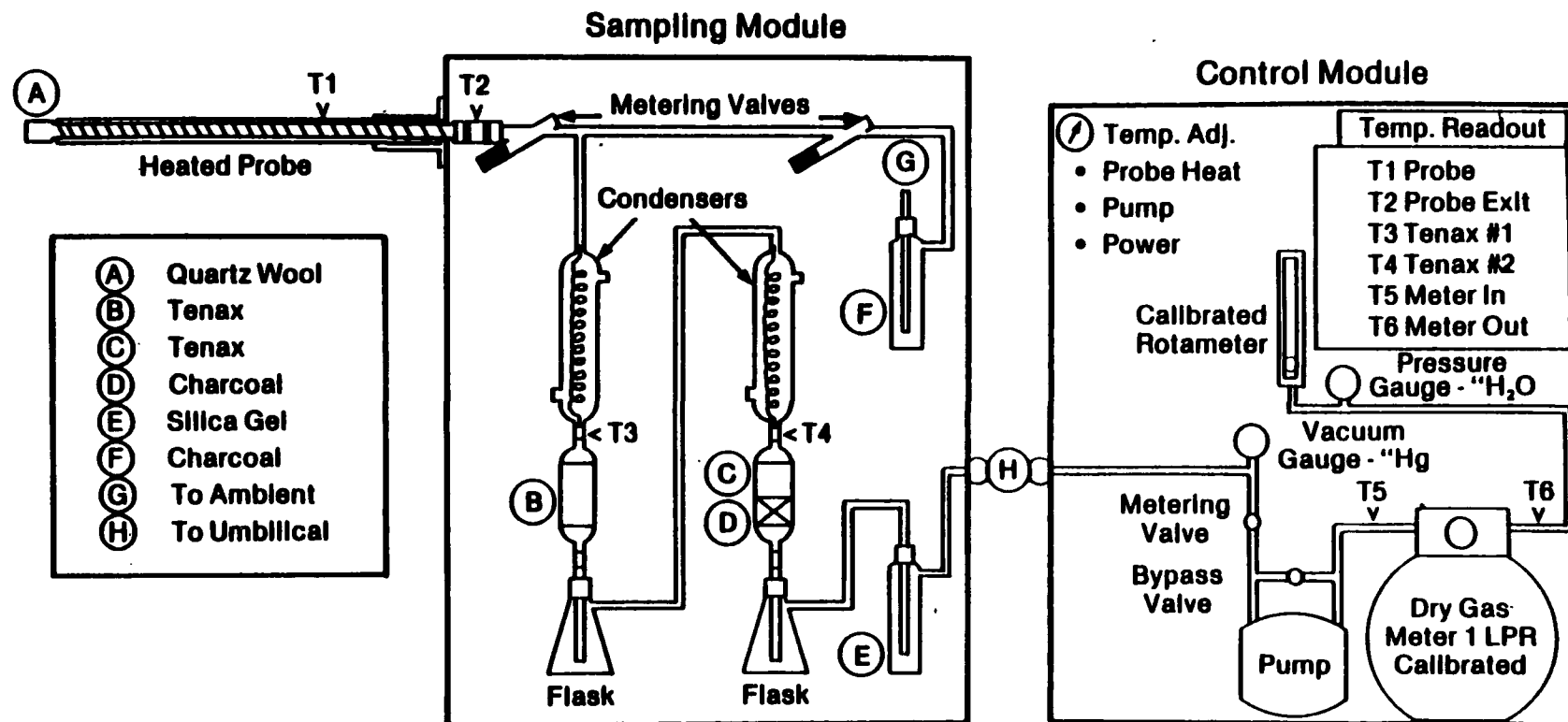
#### 6.3.1 Sampling Equipment and Preparation

A schematic of the VOST is shown in Figure 6-7. The flue gas was sampled from the stack through a glass probe containing a glass wool plug. The probe temperature was maintained above 300°F. The gas sample was cooled to 68°F by a water-cooled condenser and was passed through a pair of resin traps in series, a silica gel drying tube, a rotameter, a sampling pump, and a dry gas meter. The first resin trap contained approximately 1.6 g of Tenax and the second trap contained approximately 1 g of Tenax followed by 1 g of petroleum-based charcoal. The rotameter indicated the volumetric



5316213R

Figure 6-6. Extraction and Analysis Schematic for CDD/CDF Samples



**Figure 6-7. Schematic of VOST Sampling Train**

**TABLE 6-3. VOLATILE COMPOUNDS QUANTIFIED BY  
SW-846 METHOD 8240  
CAMDEN COUNTY MWC (1992)**

Compound	Compound
Acetone	trans-1,2-Dichloroethene
Acrolein	1,2-Dichloropropane
Acrylonitrile	cis-1,3-Dichloropropene
Benzene	trans-1,3-Dichloropropene
Bromochloromethane (I.S.)	1,4-Difluorobenzene (I.S.)
Bromodichloromethane	Ethanol
p-Bromofluorobenzene (surr.)	Ethylbenzene
Bromoform	Ethyl methacrylate
Bromomethane	2-Hexanone
2-Butanone	Iodomethane
Carbon disulfide	Methylene chloride
Carbon tetrachloride	4-Methyl-2-pentanone
Chlorobenzene	Styrene
Chlorobenzene-d <sub>5</sub> (I.S.)	1,1,2,2-Tetrachloroethane
Chlorodibromomethane	Tetrachloroethene
Chloroethane	Toluene
2-Chloroethyl vinyl ether	Toluene-d <sub>8</sub> (surr.)
Chloroform	1,1,1-Trichloroethane
Chloromethane	1,1,2-Trichloroethane
Dibromomethane	Trichloroethene
1,4-Dichloro-2-butane	Trichlorofluoromethane
Dichlorodifluoromethane	1,2,3-Trichloropropane
1,1-Dichloroethane	Vinyl acetate
1,2-Dichloroethane	Vinyl chloride
1,2-Dichloroethane-d <sub>4</sub> (surr.)	Xylene
1,1-Dichloroethene	

### 6.3.3 Analytical Procedures

The sorbent cartridges were analyzed according to SW-846 Method 5041/8240. Method 5041 defines thermal desorption techniques for processing the resin traps. Analysis was then completed by purge and trap GC/MS as shown in Figure 6-8. This procedure utilizes HRGC and low resolution mass spectroscopy (LRMS). One sample was screened by GC/FID to determine the relative concentration of the species prior to mass spectroscopy.

### 6.4 Fly Ash Carbon Content

A daily fly ash sample was collected for analysis of unburned carbon. The daily sample was withdrawn from a single point in the economizer outlet using an EPA Method 5 sampling train. The nozzle was sized to allow isokinetic sampling at approximately 0.5 dscfm. A cyclone was used in front of the filter to facilitate collection of a large volume of ash without clogging the filter. The train was run for the duration of the test period each day to ensure that a representative sample was collected. Each sample was analyzed for carbon content by Commercial Testing and Engineering in South Holland, Illinois, using ASTM Method D3178-84, Carbon and Hydrogen in the Analysis Sample of Coal and Coke.<sup>13</sup>

### 6.5 Particle Size Distribution

Flue gas samples were collected from the stack during each of the Unit A tests to determine the size distribution of emitted particles. Sampling was conducted using an Andersen Mark III pre-impactor and a Mark II 8-stage cascade impactor. During each of these tests, two trains were operated to collect duplicate composite samples over the duration of the test day. Particles were separated based on their inertial properties as they flowed through succeeding stages with smaller acceleration jets (higher velocities). Larger particles impacted on the initial collection stages and smaller particles were

gas sampling rate, and the dry gas meter recorded the total gas volume that passed through the meter during the sampling period.

Prior to field use, the glass tubes and condensers used with the VOST were cleaned with a non-ionic detergent in an ultrasound bath, rinsed three times with organic-free water, and dried at 212°F. The traps were filled and conditioned according to the above referenced protocol and analyzed by GC/FID to verify that the traps were free from background contamination. Preparation of the sampling equipment included calibration of dry gas meters and temperature measuring devices.

### 6.3.2 Sampling Equipment Operation and Recovery

The VOST probe was inserted to a single point of average gas velocity in the centroid area of the duct or stack. Since the target species were gases, isokinetic sampling was not required. The trains were leak checked before and after sampling with each pair of traps.

The handling procedures for the VOST traps emphasized the need to minimize potential sample contamination. The VOST traps were stored in a clean cooler, separate from all other types of samples collected at the site. Used traps were stored on cold packs or ice. The time that the traps were exposed to ambient air during train assembly and disassembly was minimized.

One pair of field blank traps was collected per test run by removing the end caps from a pair of traps for the length of time required to exchange two pairs of traps during sampling (approximately 5 minutes). Also, one pair of trip blanks was collected per test site. The trip blank consisted of a pair of traps that were taken to the site and were stored with the other VOST samples, but remained capped throughout the test.



collected in the downstream stages. The impactor was placed inside the stack so that the sample stream maintained all of the flue gas's physical characteristics, such as temperature and viscosity. The sample was then isokinetically extracted through the nozzle so that a representative distribution of particles was collected. All desiccation and weighing of filtrates and rinses to determine the mass of collected particulate was conducted in Radian's Perimeter Park Laboratory.

#### 6.5.1 Sampling Equipment Preparation

The PSD train is shown in Figure 6-9. The sampling train is similar to the EPA Method 5 train except that a pre-separator and a cascade impactor were used in the stack instead of a glass-lined probe and external filter. Prior to sampling, the impactor housing, nozzle, and filter holders were cleaned. All filters were desiccated, placed inside a folded sheet of cleaned aluminum foil, and tared on a five-place balance prior to use. The filter used in the impactor were Reeve Angel 934AH substrates. The foil and filters were handled with tweezers to avoid weight gain due to fingerprints. Replicate weighings at least six hours apart had to agree within 0.05 mg in order to accept the weight.

After preparing the impingers, the probe was attached to the impingers, and the system was checked for a leak rate of less than  $0.0005 \text{ m}^3/\text{min}$  (0.02 cfm). After a successful leak check, the impactor and nozzle were attached to the probe. The nozzle size was selected to allow isokinetic sampling at the flow rate required for proper particle separation. The impactor was preheated to approximately stack temperature by placing it inside the stack with the nozzle sealed and out of the flue gas flow.

#### 6.5.2 Sampling Equipment Operation and Recovery

Sampling was conducted at a single point of average flue gas velocity at a fixed sampling rate. The sampling rate was adjusted to obtain the required flow rate through the impactor based on expected gas conditions and was not adjusted during the run.

## VOST ANALYSIS PROTOCOL

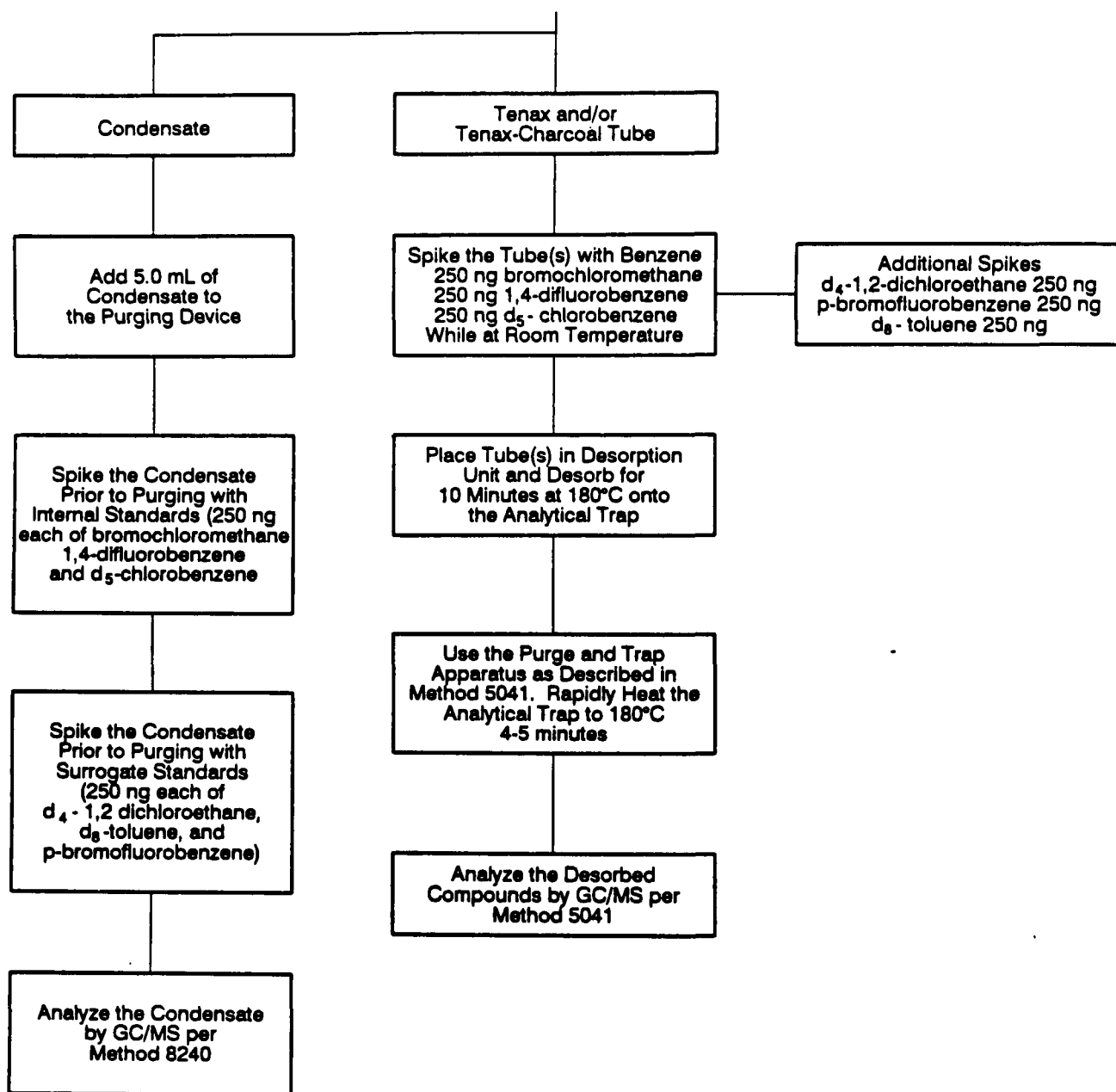


Figure 6-8. VOST Analysis Protocol

After sampling was completed, the impactor was cooled in a vertical position prior to recovery. During the recovery operation, each filter was examined for particle bounce, overloading, and reentrainment. Any particles lost to surfaces upstream of a stage substrate were recovered by dry brushing and added to that substrate. The filter substrate and collected particulate from each stage were placed inside the same piece of cleaned aluminum foil with which the filter was tared and sealed by crimping the edges of the foil. This approach minimized the loss of particulate from the sample during shipment. Particles from the nozzle and pre-separator were collected in a separate fraction using an acetone rinse. In the final calculations, the weight of collected particulate in this fraction was added to that of the first stage.

The substrates were desiccated and allowed to come to a constant weight ( $\pm 0.05$  mg). The final values were reported to the nearest 0.01 mg.

## 6.6 Volumetric Flow Rate and Moisture Content

The volumetric flow and moisture content of the flue gas during each run were based on the data collected from the multiple metals train.

### 6.6.1 Determination of Duct Gas Velocity by EPA Method 2

The volumetric flow rate (duct gas velocity) was measured according to EPA Method 2 (40 CFR Part 60, Appendix A). A Type K thermocouple and S-type pitot tube were used to measure flue gas temperature and velocity, respectively. The pitot tubes were inspected before being used and were leak checked before and after each run, following the protocols in the method.

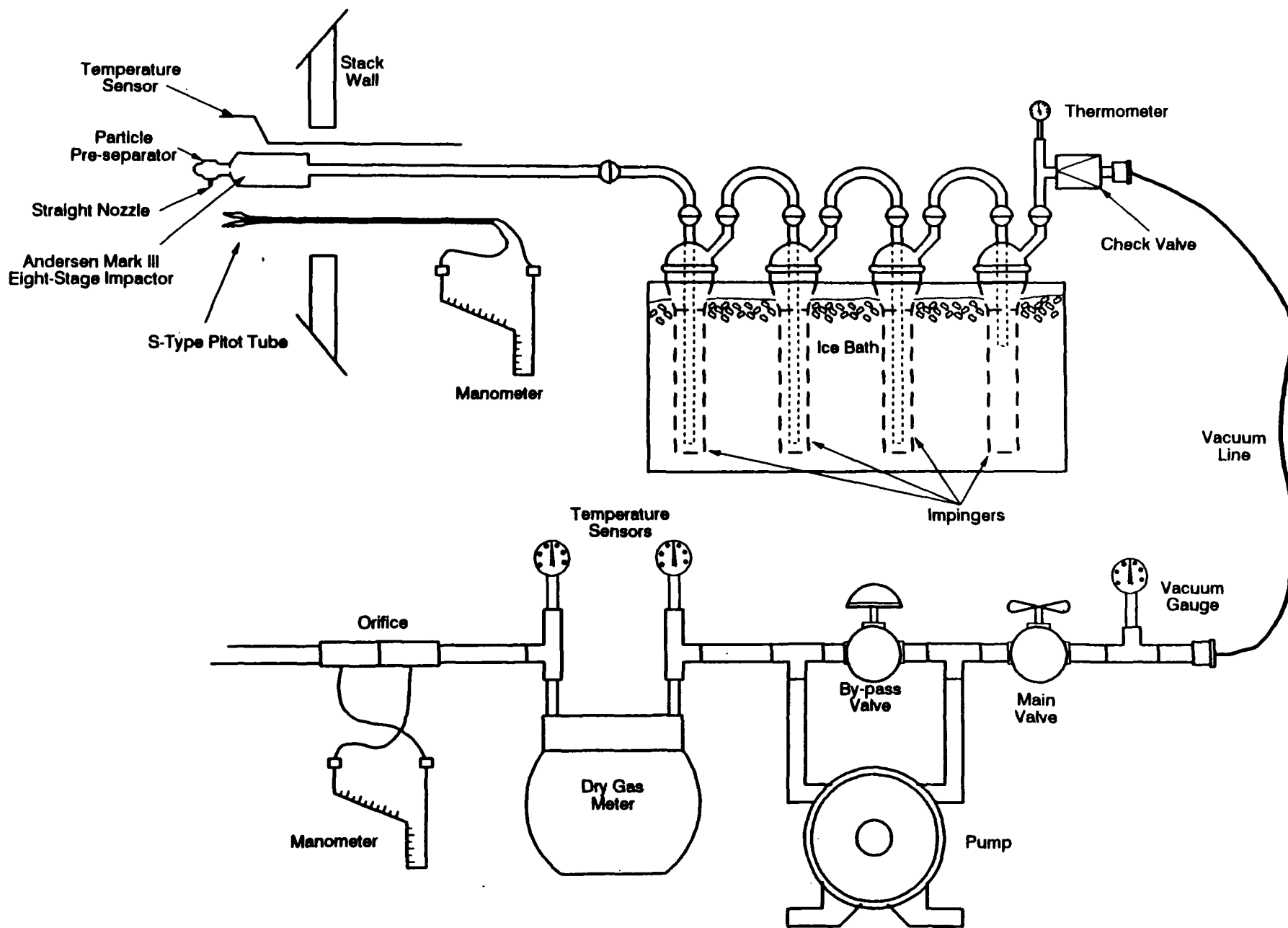


Figure 6-9. Sampling Train for Particle Size Distribution Tests

The stack CEMS was also an extractive system. The effluent gas sample was drawn from the stack via a filter and heated sampling line to a Bodenseewerk Mekos multicomponent analyzer, which analyzes the gas sample for O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O, CO, THC, CH<sub>4</sub>, SO<sub>2</sub>, HCl, and NO<sub>x</sub>. The gas sample exiting the Mekos analyzer passed through an electrical gas cooler to remove moisture and was then delivered to Westinghouse/Maihak Oxygor O<sub>2</sub> and JUM THC analyzers. A Monitrol T5C-1000 opacity monitor installed on each stack continuously monitored opacity levels.

The analog gas concentration data from the analyzers was transmitted to the respective Odessa CEM data acquisition system. The Odessa DAS calculated the pollutant emission levels in parts per million (ppm) corrected to 7% O<sub>2</sub>. These values were then archived on the DAS once every minute. At the end of each test day, the one-minute readings for all flue gas parameters were transferred to a floppy disk by plant personnel and given to Radian.

#### 6.7.2 Calibration

The CEMS had been certified using EPA QA/QC protocols for CEMS (40 CFR Part 60, Appendix F). During the testing, the CEMS were calibrated daily using a two-point calibration. A low-level calibration gas (typically a zero concentration gas) and a high-level calibration gas were used for this procedure. All calibrations were completed by passing the calibration gas through the entire sampling system. The results of these calibrations were printed in a daily report.

#### 6.8 Process Data Collection

Combustor conditions and SD/ESP operating parameters were monitored using CCRRF's existing data acquisition systems. Combustor operating parameters that were recorded included one-minute average steam production rate, furnace temperature, and

The parameters measured at each traverse point included:

- Pressure drop across the pitot;
- Stack temperature;
- Stack static; and
- Ambient pressure.

A Method 5 computer program was used to calculate the average velocity during the sampling period.

#### 6.6.2 Determination of Flue Gas Moisture Content by EPA Method 4

The flue gas moisture content was determined according to EPA Method 4 (40 CFR Part 60, Appendix A). Before sampling, the initial weight of the impingers was recorded. When sampling was completed, the final weights of the impingers were recorded, and the weight gain was calculated. The weight gain and the volume of gas sampled were used to calculate the average moisture content (percent) of the flue gas.

### 6.7 Continuous Emission Monitors

#### 6.7.1 Equipment Description

The flue gas composition at the economizer exit and stack was monitored during each test using the permanently installed CEMS operated by the CCRRF. The CEMS on both units were identical.

The CEMS at the economizer exit included extractive SO<sub>2</sub> and O<sub>2</sub> monitors. Gas samples were extracted through a sintered probe and heated sampling line and delivered to a gas conditioner for moisture removal. The gas was then supplied to Western Research SO<sub>2</sub> and Rosemount Analytical O<sub>2</sub> analyzers.

economizer exit temperature. Operating parameters of the SD/ESP that were recorded included:

- Lime slurry and dilution water flow rates;
- SD inlet and outlet temperatures;
- ESP secondary voltage, secondary amperage, and spark rate per field; and
- Stack SO<sub>2</sub> and opacity levels.

Each of the SD/ESP parameters were recorded as instantaneous values read once each minute, rather than as one-minute averages. All of these data were continuously logged onto the plant DAS systems -- a Bailey NET-90 for the combustor parameters and a Belco Merlin system for the SD/ESP parameters. At the end of each test day, the data spanning the testing period were downloaded by CCRRF and Belco personnel onto a floppy disk and given to Radian.

## **7.1 Overview of Data Quality**

The QAPP established specific QA objectives for precision and accuracy for measurement of each flue gas emission parameter, including Hg, other metals, CDD/CDF, VOST, O<sub>2</sub>, and particulates. The primary QC results used to evaluate precision and accuracy for each analytical parameter are summarized in Table 7-1. Results of matrix spike/matrix spike duplicates were used as QC indicators for Hg and the other metals. Results of surrogate spikes were used as QC indicators for analyses using GC/MS methods. Measured QC values that are not within the specified data quality objectives are discussed in detail in Sections 7.4 and 7.5. Other data quality indicators for each type of analysis are presented throughout the remainder of Section 7.

There are no cases where data quality issues prevent sound conclusions from being made regarding the effectiveness of carbon injection in reducing emissions of Hg, Cd, Pb, CDD/CDF, and volatile organics. With the exception of a limited number of samples, the quality of measurement data generated for the test parameters fully meet the data quality objectives outlined in the QAPP. Generally, there is no impact on the acceptability of the data quality, except for Se. Data quality issues related to Se are summarized in Section 7.4.

## **7.2 Sampling Quality Control**

Sampling activities conducted during the Camden County MWC testing include the following for stack gases:

- EPA multi-metals method for determination of Hg, other metals, and particulate matter;
- EPA Method 23 for determination of CDD/CDF;
- EPA SW-846 Method 0030 for determination of volatile organics; and
- In-stack Anderson cascade impactor particle size distribution.



## 7.0 QUALITY ASSURANCE/QUALITY CONTROL

As a part of the testing at the Camden County MWC, Radian designed and implemented a quality assurance/quality control (QA/QC) effort tailored to meet the specific needs of this project. The testing was conducted in accordance with QA/QC procedures described in the Quality Assurance Project Plan (QAPP). The results of the QA/QC effort demonstrate that the data are reliable, defensible, and meet project objectives for completeness, representativeness, and comparability. The data meet the QA objectives for precision and accuracy and there are no data quality issues that effect conclusions regarding the effectiveness of carbon injection.

The primary objectives of the QA/QC effort were to control, assess, and document data quality. In order to accomplish these objectives, the QA/QC approach consisted of the following key elements:

- Definition of data quality objectives that reflect the overall technical objectives of the project;
- Design of a sampling, analytical, QA/QC, and data analysis system to meet these objectives;
- Evaluation of the measurement system performance; and
- Initiation of corrective action when measurement system performance did not meet the specifications.

These elements include the use of validated or standard sampling and analytical procedures, along with specified calibration requirements, QC checks, data reduction and validation procedures, and sample tracking.

A summary of analysis results for QA/QC samples, which includes measures of precision and accuracy, and limitations in the use of this data is presented in this section.

Quality control activities associated with sampling are described in the QAPP. These activities include adherence to accepted reference method protocols, use of standardized data recording sheets, equipment calibration, and collection of field blanks. Records documenting these sampling activities are presented in the Appendices of this report.

#### 7.2.1 Multi-Metals Method Flue Gas Sampling Quality Control

Stack sampling QC data, including isokinetic sampling rates, sample volume collected, maximum recorded leak rate, and maximum allowable leak rate, are summarized in Table 7-2 for each multi-metals method run. All of the data quality indicators are within acceptable limits, with the exception of low isokinetic sampling rates for three runs and high leak rates for four runs.

The isokinetic sampling rates for Phase I Outlet Run 1 (81%), Phase II Outlet Run 26 (89%), and Phase II Inlet Run 35 (88%) were below the QC objective of 90 to 110% isokinetic. The low isokinetic sampling rate for these runs do not significantly effect the metals results because the isokinetic sampling rate was only slightly outside the QC objective. Emission rates for these test runs may have a slight high bias due to the low isokinetic sampling rate.

The acceptance criteria for sample train leak checks is a leak rate of less than 4% of the average sampling rate or 0.02 dscf, whichever is less. This criteria was met by all of the outlet sampling trains and by 49 of 53 inlet sampling trains. Two of the four high leak rates met the 0.02 dscf criteria, but were 5% of the sample rate (Phase II Inlet Runs 18 and 22). The other two high leak rates were 10% (Phase II Inlet Run 19) and 20% (Phase II Inlet Run 30). The final sample volume for these four test runs were not corrected for the high leak rates. If corrections had been made to account for leaks, flue gas flow rates would be 1 to 7% lower than shown.

**TABLE 7-1. COMPARISON TO QUALITY CONTROL OBJECTIVES  
CAMDEN COUNTY MWC (1992)**

Parameter	QC Analysis	Precision			Accuracy		
		Measured	Objective	Ratio <sup>a</sup>	Measured	Objective	Ratio
Mercury	Matrix Spike	0% - 15.4%	<20 RPD	22/22	70% - 138% <sup>b</sup>	70% - 130%	40/44
Cadmium	Matrix Spike	0% - 17.4%	<20 RPD	12/12	82% - 116%	70% - 130%	24/24
Lead	Matrix Spike	0% - 10.2%	<20 RPD	12/12	66% - 146% <sup>b</sup>	70% - 130%	21/24
Other Metals <sup>c</sup>	Matrix Spike	0% - 20.6% <sup>b</sup>	<20 RPD	154/155	0% - 146% <sup>b</sup>	70% - 130%	288/298
CDD/CDF	Surrogate Spike	6% - 42.2% <sup>b</sup>	<40% RSD	9/10	33% - 128% <sup>b</sup>	50% - 150%	95/100
	Method Spike	2.8% - 55% <sup>b</sup>	<40% RSD	16/17	68% - 260% <sup>b</sup>	50% - 150%	49/51
Volatile Organics	Surrogate Spike	1.5% - 60.3% <sup>b</sup>	<40% RSD	35/36	80% - 308% <sup>b</sup>	50% - 150%	178/180
	Method Spike	4.9% - 17.0%	<40% RSD	6/6	87% - 127%	50% - 150%	36/36
Oxygen	Daily CEM Cal Annual RATA	0% - 14.4% <sup>b</sup>	<10% CV	47/48	92% - 98%	80% - 120%	4/4

<sup>a</sup>Number of samples meeting QC objective compared to total number of samples analyzed.

<sup>b</sup>Measurements outside of the specified objectives are discussed in Section 7.4 for each analytical parameter and matrix.

<sup>c</sup>Summary statistics do not include selenium. Selenium met 41.7% of the data quality accuracy objectives.

**TABLE 7-2, CONTINUED**

Run Number	Isokinetic (%)	Standard Meter Volume (dscf)	Average Sample Rate (dscfm)	Maximum Leak Check (dscf @ in Hg)	4% Sample Rate (dscfm)	Acceptable Leak Rate? <sup>a</sup>
<b>Phase I - Metals - Outlet</b>						
10	101	43.60	0.727	0.007 @ 10	0.029	Y
11	103	38.81	0.647	0.007 @ 10	0.026	Y
12	101	41.87	0.698	0.005 @ 10	0.028	Y
13	102	36.21	0.603	0.007 @ 10	0.024	Y
14	101	38.88	0.648	0.010 @ 10	0.026	Y
15	102	34.74	0.579	0.008 @ 11	0.023	Y
<b>Phase II - Metals - Inlet</b>						
1	99.7	29.90	0.498	0.012 @ 8	0.020	Y
2	102	27.59	0.460	0.017 @ 6	0.018	Y
3	101	27.10	0.452	0.014 @ 7	0.018	Y
4	101	28.19	0.470	0.012 @ 10	0.019	Y
5	102	22.44	0.374	0.006 @ 6	0.015	Y
6	110	24.89	0.415	0.009 @ 7	0.017	Y
7	104	24.99	0.416	0.010 @ 10	0.017	Y
8	109	22.23	0.371	0.015 @ 14	0.015	Y
9	105	25.20	0.420	0.008 @ 12	0.017	Y
10	109	20.99	0.350	0.008 @ 14	0.014	Y
11	108	22.27	0.371	0.009 @ 11	0.015	Y
12	108	22.36	0.373	0.005 @ 12	0.015	Y
13	108	22.39	0.373	0.008 @ 12	0.015	Y
14	107	23.46	0.391	0.009 @ 10	0.016	Y
15R	108	22.42	0.374	0.009 @ 4	0.015	Y
16	106	22.59	0.377	0.008 @ 14	0.015	Y
17	107	24.14	0.402	0.011 @ 12	0.016	Y
18	108	19.66	0.328	0.015 @ 6	0.013	N
19	106	23.16	0.386	0.040 @ 4	0.015	N
20	108	20.56	0.343	0.008 @ 14	0.014	Y

**TABLE 7-2. METALS STACK SAMPLING QUALITY CONTROL DATA  
CAMDEN COUNTY MWC - PHASE I & II (1992)**

Run Number	Isokinetic (%)	Standard Meter Volume (dscf)	Average Sample Rate (dscfm)	Maximum Leak Check (dscf @ in Hg)	4% Sample Rate (dscfm)	Acceptable Leak Rate? <sup>a</sup>
<b>Phase I - Metals - Inlet</b>						
1	96.8	38.52	0.642	0.005 @ 4	0.026	Y
2	102	31.32	0.522	0.012 @ 10	0.021	Y
3	102	33.89	0.565	0.009 @ 9	0.023	Y
4	101	36.41	0.607	0.009 @ 10	0.024	Y
5	102	36.20	0.603	0.008 @ 14	0.024	Y
6	97.3	35.81	0.597	0.008 @ 14	0.024	Y
7	100	33.87	0.565	0.005 @ 14	0.023	Y
8	98.0	33.52	0.559	0.015 @ 15	0.022	Y
9	100	36.52	0.609	0.015 @ 5	0.024	Y
10	99.1	34.65	0.577	0.008 @ 10	0.023	Y
11	101	32.73	0.546	0.009 @ 10	0.022	Y
12	99.0	35.15	0.586	0.008 @ 15	0.023	Y
13	99.6	32.67	0.544	0.011 @ 15	0.022	Y
14	98.6	31.29	0.522	0.009 @ 8	0.021	Y
15	99.8	29.16	0.486	0.009 @ 15	0.019	Y
<b>Phase I - Metals - Outlet</b>						
1	81.0	38.78	0.646	0.006 @ 7	0.026	Y
2	107	41.30	0.688	0.010 @ 8	0.028	Y
3	104	37.46	0.624	0.016 @ 8	0.025	Y
4	108	41.68	0.695	0.008 @ 10	0.028	Y
5	102	41.96	0.699	0.012 @ 10	0.028	Y
6	99.9	35.81	0.597	0.008 @ 10	0.024	Y
7	102	41.39	0.678	0.014 @ 10	0.027	Y
8	100	40.57	0.665	0.006 @ 11	0.027	Y
9	103	39.24	0.643	0.018 @ 11	0.026	Y

**TABLE 7-2, CONTINUED**

Run Number	Isokinetic (%)	Standard Meter Volume (dscf)	Average Sample Rate (dscfm)	Maximum Leak Check (dscf @ in Hg)	4% Sample Rate (dscfm)	Acceptable Leak Rate? <sup>a</sup>
<b>Phase II - Metals - Outlet</b>						
12	99.1	37.24	0.621	0.018 @ 10	0.025	Y
13	98.4	35.14	0.586	0.010 @ 7	0.023	Y
14	103	38.41	0.640	0.014 @ 10	0.026	Y
15	103	35.33	0.589	0.018 @ 11	0.024	Y
15R	102	36.82	0.614	0.018 @ 11	0.025	Y
16	104	38.40	0.640	0.017 @ 10	0.026	Y
17	108	39.56	0.659	0.006 @ 8	0.026	Y
18	107	33.13	0.552	0.012 @ 9	0.022	Y
19	107	35.43	0.590	0.010 @ 8	0.024	Y
20	107	37.21	0.620	0.013 @ 7	0.025	Y
21	109	32.27	0.556	0.016 @ 10	0.022	Y
22	97.3	34.85	0.581	0.016 @ 8	0.023	Y
23	102	37.33	0.622	0.005 @ 8	0.025	Y
25	107	74.47	0.621	0.018 @ 8	0.025	Y
26	89.0	59.21	0.493	0.018 @ 8	0.020	Y
27	105	75.72	0.631	0.010 @ 8	0.025	Y
28	97.4	69.18	0.577	0.010 @ 9	0.023	Y
29	103	70.99	0.592	0.005 @ 8	0.024	Y
30	106	75.38	0.628	0.010 @ 9	0.025	Y
31	106	37.93	0.632	0.011 @ 10	0.025	Y
32	103	39.99	0.678	0.012 @ 9	0.027	Y
33	107	40.79	0.680	0.012 @ 9	0.027	Y
34	102	72.61	0.605	0.019 @ 7	0.024	Y
35	102	71.13	0.593	0.018 @ 7	0.024	Y
36	106	76.32	0.636	0.018 @ 9	0.025	Y
37	105	35.31	0.589	0.015 @ 6	0.024	Y
38	104	32.09	0.535	0.006 @ 5	0.021	Y
39	101	37.95	0.633	0.014 @ 10	0.025	Y

<sup>a</sup>The values shown in the table for 4% of the sample rate were compared to a value of 0.02 dscfm. The maximum allowable leak rate was established as the lesser of two values.

**TABLE 7-2, CONTINUED**

Run Number	Isokinetic (%)	Standard Meter Volume (dscf)	Average Sample Rate (dscfm)	Maximum Leak Check (dscf @ in Hg)	4% Sample Rate (dscfm)	Acceptable Leak Rate? <sup>a</sup>
<b>Phase II - Metals - Inlet</b>						
21	107	23.04	0.384	0.006 @ 14	0.015	Y
22	101	20.34	0.339	0.015 @ 4	0.013	N
23	104	21.05	0.351	0.008 @ 14	0.014	Y
25	104	42.01	0.350	0.003 @ 5	0.014	Y
26	99.6	38.08	0.317	0.011 @ 12	0.013	Y
27	105	45.15	0.376	0.006 @ 14	0.015	Y
28	106	38.81	0.323	0.006 @ 7	0.013	Y
29	105	45.41	0.378	0.009 @ 5	0.015	Y
30	108	37.76	0.315	0.065 @ 4	0.013	N
31	102	24.41	0.407	0.009 @ 14	0.016	Y
32	104	20.00	0.333	0.006 @ 4	0.013	Y
33	104	25.10	0.418	0.011 @ 13	0.017	Y
34	102	47.05	0.392	0.011 @ 7	0.016	Y
35	87.7	39.70	0.331	0.010 @ 6	0.013	Y
36	102	45.38	0.378	0.007 @ 14	0.015	Y
37	105	22.32	0.372	0.009 @ 15	0.015	Y
38	107	20.84	0.347	0.012 @ 8	0.014	Y
39	106	20.60	0.343	0.014 @ 4	0.014	Y
<b>Phase II - Metals - Outlet</b>						
1	101	36.12	0.602	0.009 @ 7	0.024	Y
2	101	34.47	0.575	0.010 @ 8	0.023	Y
3	102	35.50	0.592	0.007 @ 10	0.024	Y
4	102	34.80	0.580	0.012 @ 15	0.023	Y
5	98.6	36.65	0.611	0.005 @ 12	0.024	Y
6	104	39.85	0.664	0.010 @ 14	0.027	Y
7	98.7	35.63	0.594	0.012 @ 8	0.024	Y
8	105	33.41	0.557	0.012 @ 10	0.022	Y
9	103	38.36	0.639	0.015 @ 10	0.026	Y
10	102	35.09	0.585	0.016 @ 6	0.023	Y
11	101	37.24	0.621	0.012 @ 7	0.025	Y

**TABLE 7-3. CDD/CDF STACK SAMPLING QUALITY CONTROL DATA  
CAMDEN COUNTY MWC - PHASE II (1992)**

Run Number	Isokinetic (%)	Standard Meter Volume (dscf)	Average Sample Rate (dscfm)	Maximum Leak Check (dscf @ in Hg)	4% Sample Rate (dscfm)	Acceptable Leak Rate? <sup>a</sup>
<b>Phase II - CDD/CDF - Inlet</b>						
25	103	42.01	0.350	0.018 @ 9	0.014	N
26	99.5	37.75	0.315	0.017 @ 15	0.013	N
27	101	43.66	0.364	0.014 @ 7.5	0.015	Y
28	99.2	35.88	0.299	0.012 @ 8	0.012	Y
29	100	44.01	0.367	0.014 @ 9	0.015	Y
30	104	33.89	0.282	0.030 @ 6.5	0.011	N
34	101	42.79	0.357	0.012 @ 10	0.014	Y
35	103	35.10	0.293	0.006 @ 7	0.012	Y
36	96.3	42.12	0.351	0.014 @ 10	0.014	Y
<b>Phase II - CDD/CDF - Outlet</b>						
25	105	72.58	0.605	0.014 @ 10	0.024	Y
26	103	78.78	0.657	0.018 @ 8	0.026	Y
27	108	83.68	0.697	0.018 @ 10	0.028	Y
28	102	81.09	0.676	0.012 @ 13	0.027	Y
29	103	78.28	0.652	0.010 @ 10	0.026	Y
30	107	78.67	0.656	0.014 @ 10	0.026	Y
34	103	78.94	0.658	0.012 @ 9	0.026	Y
35	103	76.63	0.639	0.008 @ 10	0.026	Y
36	98.4	72.85	0.607	0.016 @ 8	0.024	Y

<sup>a</sup>The values shown in the table for 4% of the sample rate were compared to a value of 0.02 dscfm. The maximum allowable leak rate was established as the lesser of two values.



As mentioned in Section 4.1.1, the moisture content for the multi-metals method trains during Phase II Outlet Runs 1 and 3 and Phase I Inlet Run 6 appeared erroneous. Revised values were estimated by subtracting 2.0% from the outlet or adding 2.0% to the inlet flue gas moisture content for these runs. The 2.0% adjustment was selected based on the average difference between the inlet and outlet moisture contents during the other runs. Also, during Phase II Inlet Run 25, the silica gel impinger broke following successful final leak check of the train, and the silica absorbed water from the impinger bucket. To estimate the actual moisture level, a silica gel weight gain of 8.3 g was used based on the average weight gain during other inlet runs.

#### 7.2.2 Method 23 Flue Gas Sampling Quality Control

Stack sampling QC data, including isokinetic sampling rates, sample volume collected, maximum recorded leak rate, and maximum allowable leak rate, are summarized in Table 7-3 for each Method 23 run. All of the data quality indicators are within acceptable limits, with the exception of high leak rates for three runs.

As with the EPA multi-metals method, the acceptance criteria for sampling train leak checks is a leak rate of less than 4% of the average sampling rate or 0.02 dscf, whichever is less. All of the outlet trains and six of nine inlet trains met this criteria. Two of the trains (Inlet Runs 25 and 26) met the 0.02 dscf criteria, but had leaks of 5% of the sampling rate. The third train (Inlet Run 30) had a 10% leak rate. The final sample volume for these test runs were not corrected for the high leak rates. If corrections had been made, flue gas flow rates would be 1 to 3% lower than shown.

#### 7.2.3 Volatile Organic Flue Gas Sampling Quality Control

Stack sampling QC data, including average standard meter volume and maximum recorded leak rate, are summarized in Table 7-4 for each VOST run. All of the data quality indicators are within acceptable limits for all runs.

#### 7.2.4 Particle Size Distribution (PSD)

There were no problems observed during the PSD sampling, except for the two PSD trains operated during Condition A4. One train had a loose impinger connection which was discovered at the end of the run, and the other train had sampling pump problems. Post-test review of the collected data from the first train indicated that the flue gas moisture content was lower than for other trains and that the isokinetic flow rate was high. As a result, the samples collected by the first train were invalidated. Post-test review of data from the second train indicated that all QA/QC criteria were met. Therefore, the data from this train are acceptable.

#### 7.3 Sample Storage and Holding Time

Sample hold times specified in the QAPP were met for all samples, with the exception of the CDD/CDF samples and 33 front-half fractions (acetone and nitric probe rinses, and filter) for the analysis of Hg. The QAPP called for a maximum CDD/CDF sample hold time of 21 days. All of these samples were analyzed 28 to 30 days after completion of the tests. Although the CDD/CDF hold times exceeded the QAPP objectives, they were within the 30-day hold time limit in EPA Method 23. Therefore, the data are acceptable.

The hold time for Hg, as specified by SW-846 Method 7470, is 38 days. The hold times were missed by 1 to 10 days for Phase II Inlet Runs 13 through 15, 22, 23, and the Field Blank and Outlet Runs 13 through 39. The hold times were missed because the filters and acetone probe rinses were weighed for particulate matter at Radian's Morrisville, North Carolina laboratory, before the samples were sent to Radian's Austin, Texas laboratory for sample digestion and analysis. Any potential loss of Hg in the front-half fractions due to extended hold time would lower the reported Hg concentrations. For these runs, the Hg concentration was not noticeably lower than for other runs at similar operating conditions that met the hold time limits. As a result, the values detected are considered acceptable for calculating removal efficiencies.

**TABLE 7-4. VOST STACK SAMPLING QUALITY CONTROL DATA  
CAMDEN COUNTY MWC - PHASE II (1992)**

<b>Run Number</b>	<b>Average Standard Meter Volume (dscf)</b>	<b>Maximum Leak Check (dscf @ in Hg)</b>	<b>Acceptable Leak Rate?</b>
<b>Phase II - VOST - Inlet</b>			
25	0.718	0 @ 20	Y
26	0.670	0 @ 17	Y
27	0.665	0 @ 19	Y
28	0.681	0 @ 18	Y
29	0.671	0 @ 18	Y
30	0.664	0 @ 18	Y
<b>Phase II - VOST - Outlet</b>			
25	0.670	0 @ 22.5	Y
26	0.669	0 @ 21	Y
27	0.670	0 @ 22	Y
28	0.676	0 @ 21	Y
29	0.673	0 @ 21	Y
30	0.673	0 @ 21	Y

**Analytical QC criteria for the metals train analyses were:**

- **70 to 130% recovery for laboratory control samples and matrix spike samples; and**
- **<20% relative percent difference (RPD) for duplicates or <20% relative standard deviation (RSD) for replicates.**

**Recoveries and RPDs for matrix spike/matrix spike duplicates for Hg analyzed for Phase I and II are presented in Table 7-5. Recoveries and RPDs for laboratory control samples and analytical spikes for the other metals analyzed for Phase I are presented in Table 7-6. Phase II recoveries and RPDs are presented in Table 7-7.**

**Verification of system accuracy was provided by the performance evaluation audit of blind metals samples provided by RTI. Measured and audit values for the two blind samples are provided in Table 7-8. All of the sample recoveries were between 90 and 104%, well within the QC criteria of 70 to 130%.**

#### **Mercury Analytical Quality Control**

**Of these analyses, 40 out of 44 (91%) met the accuracy QC criteria. All of the samples met the precision QC criteria. The matrix spike recoveries for the Outlet Run 27 sample were 131 and 135%, and recoveries for the Outlet Run 33 sample were 135 and 138%. The high recovery for these samples indicates either a potential spiking problem or a matrix interference. Because the laboratory control samples, the calibration quality control samples, and other front-half fraction recoveries met the QC criteria, a matrix interference is not likely. As shown in Table 7-5, analysis of 3 other front-half fractions showed 90 to 114% Hg recoveries. Since a spiking problem is indicated for the four matrix spikes and other QC analyses met the data quality objectives, the Hg analytical results are judged to be acceptable.**

## **7.4 Analytical Quality Control**

Analytical methods used during the carbon injection testing included the following:

- Metals by SW-846 Method 7470 for Hg, Method 7060 for As, Method 7131 for Cd, Method 7421 for Pb, Method 7740 for Se, and Method 6010 for other metals by ICAP;
- Chlorinated CDD/CDF by EPA Method 23;
- Volatile organics by SW-846 Method 8240; and
- Gravimetric analysis for Method 5 and particle size distribution.

Results for matrix spikes, method spikes, control samples, field blanks, and audit samples are summarized in this section. These samples served the dual purpose of controlling and assessing measurement data quality, and provided the basis for precision and accuracy estimates.

No significant blank contamination problems were identified during the analysis of field and laboratory blanks and no blank corrections were performed for reported emissions data.

### **7.4.1 Multiple Metals Analytical Quality Control**

Quality control associated with the determination of metals in stack gas samples included the analysis of laboratory control samples, matrix spike/matrix spike duplicates, analytical spikes, and audit samples.

**TABLE 7-5, CONTINUED**

	Mercury Recovery (%)		Relative Difference (%)
	Matrix Spike	Matrix Spike Duplicate	
Permanganate Fraction - Matrix Spike/Matrix Spike Duplicate Results			
Phase I - Permanganate Fraction (Outlet Run 7)	98	87	11.9
Phase I - Permanganate Fraction (Outlet Run 15)	93	96	3.2
Phase II - Permanganate Fraction (Inlet Run 7)	84	84	0
Phase II - Permanganate Fraction (Outlet Run 9)	98	102	4.0
Phase II - Permanganate Fraction (Outlet Run 14)	104	104	0
Phase II - Permanganate Fraction (Outlet Run 21)	109	110	0.9
Phase II - Permanganate Fraction (Inlet Run 26)	126	122	3.2
Phase II - Permanganate Fraction (Inlet Run 32)	114	112	1.8
Phase II - Permanganate Fraction (Outlet Run 32)	126	124	1.6

**TABLE 7-5. MATRIX SPIKE RESULTS FOR MERCURY IN FLUE GAS  
CAMDEN COUNTY MWC - PHASE I AND II (1992)**

	Mercury Recovery (%)		Relative Difference (%)
	Matrix Spike	Matrix Spike Duplicate	
Front Fraction - Matrix Spike/Matrix Spike Duplicate Results			
Phase I - Front Fraction (Outlet Run 13)	114	110	3.6
Phase II - Front Fraction (Outlet Run 27)	135	131	3.0
Phase II - Front Fraction (Inlet Run 29)	90	105	15.4
Phase II - Front Fraction (Outlet Run 33)	138	135	2.2
Phase II - Front Fraction (Inlet Run 39)	101	98	3.0
Nitric/Peroxide Fraction - Matrix Spike/Matrix Spike Duplicate Results			
Phase I - Nitric Fraction (Outlet Run 10)	78	75	3.9
Phase I - Nitric Fraction (Outlet Run 15)	128	125	2.4
Phase II - Nitric Fraction (Outlet Run 10)	85	91	6.8
Phase II - Nitric Fraction (Inlet Run 12)	105	107	0.9
Phase II - Nitric Fraction (Outlet Run 15)	106	106	0
Phase II - Nitric Fraction (Inlet Run 19)	98	107	8.8
Phase II - Nitric Fraction (Outlet Run 23)	103	110	6.6
Phase II - Nitric Fraction (Outlet Run 38)	105	104	1.0

**TABLE 7-6, CONTINUED**

	Metal Recovery (%)							
	Lead	Manganese	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium
<b>Laboratory Control Sample Results</b>								
Laboratory Control Sample 1	101	96	98	97	99	95	101	97
Laboratory Control Duplicate 1	102	96	99	98	98	95	99	98
Relative Difference (%)	1.0	0	1.0	1.0	1.0	0	2.0	1.0
<b>Analytical Spike/Analytical Spike Duplicate Results</b>								
Front Half, Outlet Run 6	74	NA	NA	NA	113	NA	NA	NA
Front Half Duplicate, Outlet Run 6	82	NA	NA	NA	109	NA	NA	NA
Relative Difference (%)	10.2	--	--	--	3.6	--	--	--
Back Half, Outlet 6	79	102	88	85	128	89	0	87
Back Half Duplicate, Outlet Run 6	72	102	88	86	138	87	0	87
Relative Difference (%)	9.3	0	0	1.2	7.5	2.3	0	0

\*NA = Not analyzed, this analytical spike was only analyzed by GFAAS, not ICAP.



**TABLE 7-6. MATRIX SPIKE RESULTS FOR METALS IN FLUE GAS, PHASE I  
CAMDEN COUNTY MWC (1992)**

	Metal Recovery (%)								
	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper
<b>Laboratory Control Sample Results</b>									
Laboratory Control Sample 1	99	101	97	98	115	94	97	97	96
Laboratory Control Duplicate 1	100	96	97	99	111	95	98	96	96
Relative Difference (%)	1.0	5.1	0	1.0	3.5	1.0	1.0	1.0	0
<b>Analytical Spike/Analytical Spike Duplicate Results</b>									
Front Half, Outlet Run 6	NA <sup>a</sup>	108	NA	NA	NA	94	NA	NA	NA
Front Half Duplicate, Outlet Run 6	NA	107	NA	NA	NA	97	NA	NA	NA
Relative Difference (%)	--	0.9	--	--	--	3.1	--	--	--
Back Half, Outlet 6	13	109	91	98	112	82	86	84	87
Back Half Duplicate, Outlet Run 6	16	113	90	97	114	82	86	85	86
Relative Difference (%)	20.6	3.6	1.1	1.0	1.8	0	0	1.2	1.2

**TABLE 7-7, CONTINUED**

	Metal Recovery (%)								
	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper
<b>Analytical Spike/Analytical Spike Duplicate Results</b>									
Front Half, Outlet 33	77	126	99	94	NA	100	96	93	97
Front Half Duplicate, Outlet Run 33	83	129	100	94	NA	84	97	93	97
Relative Difference (%)	7.5	2.4	1.0	0	--	17.4	1.0	0	0
Front Half, Inlet 39	95	84	98	91	NA	96	96	96	97
Front Half Duplicate, Inlet Run 39	91	86	93	89	NA	92	94	93	91
Relative Difference (%)	4.3	2.4	5.2	2.2	--	4.3	2.1	3.2	6.4
Front Half, Outlet 39	68	91	98	92	NA	87	96	94	95
Front Half Duplicate, Outlet Run 39	67	99	97	92	NA	87	96	93	94
Relative Difference (%)	1.5	8.4	1.0	0	--	0	0.0	1.1	1.1
Back Half, Outlet Run 9	80	84	91	87	112	83	92	87	88
Back Half Duplicate, Outlet Run 9	84	83	92	88	111	84	90	88	89
Relative Difference (%)	4.9	1.2	1.1	1.1	0.9	1.2	2.2	1.1	1.1
Back Half, Outlet 23	89	92	99	96	118	102	100	101	98
Back Half Duplicate, Outlet Run 23	94	90	100	97	119	101	101	102	98
Relative Difference (%)	5.5	2.2	1.0	1.0	0.8	1.0	1.0	1.0	0
Back Half, Inlet 31	84	98	95	89	88	108	93	93	92
Back Half Duplicate, Inlet Run 31	90	98	98	91	92	105	94	93	94
Relative Difference (%)	6.9	0	3.1	2.2	4.4	2.8	1.1	0	2.2
Back Half, Outlet 38	88	88	98	90	114	96	96	94	92
Back Half Duplicate, Outlet Run 38	89	91	97	90	113	100	95	93	92
Relative Difference (%)	1.1	3.4	1.0	0	0.9	4.1	1.0	1.1	0

**TABLE 7-7. MATRIX SPIKE RESULTS FOR METALS IN FLUE GAS, PHASE II  
CAMDEN COUNTY MWC (1992)**

	Metal Recovery (%)								
	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper
<b>Laboratory Control Sample Results</b>									
Laboratory Control Sample 1	99	100	97	98	115	116	97	97	96
Laboratory Control Duplicate 1	100	101	97	99	111	116	98	96	96
Laboratory Control Sample 2	98	99	99	98	103	109	100	100	98
Laboratory Control Duplicate 2	96	101	99	98	103	103	100	100	98
Relative Standard Deviation (%)	1.7	1.0	1.2	0.5	5.6	5.7	1.5	2.1	1.2
<b>Analytical Spike/Analytical Spike Duplicate Results</b>									
Front Half, Outlet Run 14	78	108	101	95	NA <sup>a</sup>	99	101	96	97
Front Half Duplicate, Outlet Run 14	70	104	98	93	NA	96	97	95	94
Relative Difference (%)	10.8	3.8	3.0	2.1	--	3.1	4.0	1.0	3.1
Front Half, Outlet 27	97	141	96	90	NA	104	93	89	93
Front Half Duplicate, Outlet Run 27	92	118	95	90	NA	90	92	90	92
Relative Difference (%)	5.2	17.8	1.0	0.0	--	14.4	1.1	1.1	1.1
Front Half, Inlet 29	106	80	97	89	NA	97	94	92	100
Front Half Duplicate, Inlet Run 29	110	76	99	89	NA	98	96	93	103
Relative Difference (%)	3.7	5.1	2.0	0.0	--	1.0	2.1	1.1	3.0

<sup>a</sup>Not analyzed. Boric acid is added to the front fraction during sample preparation, therefore, invalidating the analysis for boron.

**TABLE 7-7, CONTINUED**

	Metal Recovery (%)							
	Lead	Manganese	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium
<b>Analytical Spike/Analytical Spike Duplicate Results</b>								
Front Half, Outlet 33	97	94	95	93	94	83	102	98
Front Half Duplicate, Outlet Run 33	93	94	94	94	93	85	93	97
Relative Difference (%)	4.2	0	1.1	1.1	1.1	2.4	9.2	1.0
Front Half, Inlet 39	111	97	96	94	5.6	87	84	95
Front Half Duplicate, Inlet Run 39	106	94	93	92	0	84	86	93
Relative Difference (%)	4.6	3.1	3.2	2.2	200	3.5	2.4	2.1
Front Half, Outlet 39	100	94	96	90	73	84	93	96
Front Half Duplicate, Outlet Run 39	100	93	94	91	84	83	95	95
Relative Difference (%)	0	1.1	2.1	1.1	14.0	1.2	2.1	1.0
Back Half, Outlet Run 9	87	88	87	89	99	87	88	91
Back Half Duplicate, Outlet Run 9	88	88	87	89	87	87	88	91
Relative Difference (%)	1.1	0	0	0	12.9	0	0	0
Back Half, Outlet 23	101	104	98	98	83	85	100	100
Back Half Duplicate, Outlet Run 23	104	108	98	96	78	95	98	100
Relative Difference (%)	2.9	3.8	0	2.1	6.2	11.1	2.0	0
Back Half, Inlet 31	98	91	92	92	0	91	92	92
Back Half Duplicate, Inlet Run 31	94	92	93	94	0	93	90	94
Relative Difference (%)	4.2	1.1	1.1	2.2	--	2.2	2.2	2.2
Back Half, Outlet 38	99	92	93	95	62	91	92	93
Back Half Duplicate, Outlet Run 38	97	91	92	95	66	90	92	92
Relative Difference (%)	2.0	1.1	1.1	0	6.3	1.1	0	1.1

**TABLE 7-7, CONTINUED**

	Metal Recovery (%)							
	Lead	Manganese	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium
<b>Laboratory Control Sample Results</b>								
Laboratory Control Sample 1	94	96	98	97	91	95	101	97
Laboratory Control Duplicate 1	96	96	99	98	91	95	99	98
Laboratory Control Sample 2	100	99	99	97	88	100	97	100
Laboratory Control Duplicate 2	102	99	98	99	89	101	98	100
Relative Standard Deviation (%)	3.7	1.8	0.6	1.0	1.7	3.3	1.7	1.5
<b>Analytical Spike/Analytical Spike Duplicate Results</b>								
Front Half, Outlet Run 14	66	97	99	97	69	87	108	99
Front Half Duplicate, Outlet Run 14	66	94	96	93	66	86	99	97
Relative Difference (%)	0	3.1	3.1	4.2	4.4	1.2	8.7	2.0
Front Half, Outlet 27	90	91	90	90	64	77	98	94
Front Half Duplicate, Outlet 27	94	90	91	90	66	77	90	94
Relative Difference (%)	4.3	1.1	1.1	0	3.1	0	8.5	0
Front Half, Outlet 29	132	98	92	89	111	91	82	95
Front Half Duplicate, Outlet Run 29	146	102	93	90	132	92	88	96
Relative Difference (%)	10.1	4.0	1.1	1.1	17.3	1.1	7.1	1.0

## **Cadmium Analytical Quality Control**

All analyses met the accuracy and precision QC criteria.

## **Lead Analytical Quality Control**

All analyses for Phase I met the accuracy and precision QC criteria. For Phase II, analytical spikes for Pb had two front-half fraction spikes that were outside control limits, with Outlet Run 14 at 66% and Outlet Run 29 at 132% and 146% recovery. Four other front fraction analytical spikes had 90 to 106% recovery. The laboratory control samples analyzed were 96 to 100% recovery, which is well within the QC objective of 80 to 120% recovery for these analyses. The poor Pb recoveries for the three analytical spikes suggest a potential spiking problem or a matrix interference. Since the laboratory control samples, the calibration quality control samples, and other front fraction recoveries are in control, the Pb analytical results are acceptable.

## **Other Metals Analytical Quality Control**

For the other metal samples analyzed, 288 out of 298 (96%) met the accuracy QC criteria for Phase I and II. All analyses, except for some analytical spikes for Sb, As, and Tl, met the accuracy and precision QC criteria. The spike recoveries for Sb in the back-half fraction, Phase I Outlet Run 6, were 13 and 16% recovery. As indicated by the spike recovery results, a low bias is likely for the Sb back fraction results. The laboratory control samples analyzed show acceptable recoveries for all of the elements. The exceedances for As and Tl are expected to have limited impact on data quality.

Selenium recoveries met the QC criteria for only 10 of the 24 (41%) samples analyzed. Because most of the samples did not meet the data quality objective, the values determined for Se were viewed as questionable and are not reported.

**TABLE 7-8. AUDIT SAMPLE RESULTS FOR METAL ANALYSIS  
CAMDEN COUNTY MWC PHASE II (1992)**

<b>Sample ID</b>	<b>Analyte</b>	<b>SW-846 Method</b>	<b>Measured Concentration (µg/l)</b>	<b>Audit Concentration (µg/l)</b>	<b>Recovery (%)</b>
3967-56H-03	Cadmium	7131	34	36	94.4
	Lead	7421	380	420	90.4
	Mercury	7470	1.47	1.6	91.9
3967-56H-04	Cadmium	7131	62	60	103.3
	Lead	7421	400	420	95.2
	Mercury	7470	4.16	4.0	104.0

**TABLE 7-9. SURROGATE RECOVERY RESULTS FOR CDD/CDF  
CAMDEN COUNTY MWC - PHASE II (1992)**

Run	% Recovery				
	TCDD	PeCDF	HxCDF 478	HxCDD 478	HpCDF 789
<b>Inlet</b>					
Run 25	74	93	90	80	100
Run 26	83	101	99	87	105
Run 27	91	107	92	81	98
Run 28	81	89	89	91	108
Run 29	77	120	94	85	108
Run 30	82	105	95	88	98
Run 34	86	91	97	98	114
Run 35	84	94	102	96	108
Run 36	76	88	83	72	96
Field Blank	78	96	87	83	97
Relative Standard Deviation	6.3	10.1	6.2	9.0	6.0
<b>Outlet</b>					
Run 25	83	128	88	103	104
Run 26	83	108	93	84	99
Run 27	94	110	99	89	104
Run 28	84	76	95	100	102
Run 29	86	86	90	101	112
Run 30	87	95	94	87	108
Run 34	87	98	88	98	107
Run 35	64	86	74	80	84
Run 36	82	108	86	80	105
Field Blank	43	41	33	29	30
Relative Standard Deviation	18.7	42.2	22.8	25.3	25.3



#### 7.4.2 CDD/CDF Analytical Quality Control

Quality control associated with the determination of CDD/CDFs in stack gas samples included method spikes and audit samples. Additionally, all samples were spiked with isotopically labeled surrogates. The CDD/CDF stack gas analytical data are of acceptable quality. Analytical QC criteria for the CDD/CDF train analyses were:

- 50 to 150% recovery for surrogates and method spikes; and
- <40% RSD for replicates.

Surrogate recoveries for the stack gas CDD/CDF analyses are summarized in Table 7-9. The accuracy QC objective was met for all samples except for the Outlet field blank. This sample was low for all compounds, ranging from 29 to 43%. Since this sample was a field blank, the low recoveries have no impact on the quality of the CDD/CDF emissions data. However, results reported for the field blank may have a slightly low bias.

Method spike recoveries for the stack gas CDD/CDF analyses are summarized in Table 7-10. The data quality objective for accuracy and precision was met for all compounds except for Spike 709A for 2,3,7,8-TCDD and 2,3,7,8-TCDF. The recovery for 2,3,7,8-TCDD was 155% and 2,3,7,8-TCDF was 260%. Because this is a method spike, there is not a possibility of the matrix interference causing high recoveries. The recovery for 2,3,7,8-TCDD and 2,3,7,8-TCDF in Spike 707 and 708B met the data quality objectives and, therefore, it appears that the high values are caused by a spiking error.

Results from the analysis of method blanks and field blanks are summarized in Table 7-11. No blank corrections were made in calculating stack emission rates. Any background contamination in the samples or analytical system would, therefore, tend to cause a high bias in the reported emission rates.

Verification of system accuracy was provided by the analysis of blind CDD/CDF audit samples provided by RTI. Measured values for the audit samples are provided in Table 7-12. All isomers were within acceptable limits except for hexa-CDF, for which measured values in both samples were slightly high.

#### **7.4.3 Stack Gas Volatile Organic Compound Quality Control**

Quality control associated with the determination of VOC in stack gas samples included analysis of method spikes and audit samples. In addition, all samples were spiked with isotopically labeled surrogates. Analytical QC criteria for the VOST analyses were:

- 50 to 150% recovery for surrogates and method spikes;
- <40% RSD for replicates.

The analysis of one VOST tube for Outlet Run 26 was lost due to an instrument failure. However, because four sets of tubes were collected during each run, three valid sample sets were still obtained, and the 100% completeness objective was met for this run.

The results of the field blank results for each test are provided in Tables 7-13 and 7-14. No blank corrections were made in calculating stack emission rates. Any background contamination in the samples would, therefore, tend to cause a high bias in the reported emission rates.

**TABLE 7-10. CDD/CDF METHOD SPIKE RESULTS  
CAMDEN COUNTY MWC PHASE II (1992)**

Isomers	Spike Recovery (%)			RSD <sup>a</sup> (%)
	Spike 707	Spike 709A	Spike 708B	
2,3,7,8-TCDD	120	155	110	18
1,2,3,7,8-PeCDD	110	100	88	11
1,2,3,4,7,8-HxCDD	94	98	93	2.8
1,2,3,6,7,8-HxCDD	88	100	86	8.3
1,2,3,7,8,9-HxCDD	77	86	74	7.9
1,2,3,4,6,7,8-HpCDD	98	100	90	5.5
Octa CDD	105	100	95	5.0
2,3,7,8- TCDF	130	260	115	55
1,2,3,7,8-PeCDF	110	110	95	8.2
2,3,4,7,8-PeCDF	120	140	77	29
1,2,3,4,7,8-HxCDF	100	110	96	7.1
1,2,3,6,7,8-HxCDF	99	97	91	4.4
1,2,3,7,8,9-HxCDF	73	94	68	18
2,3,4,6,7,8-HxCDF	88	92	83	5.1
1,2,3,4,6,7,8-HpCDF	100	100	90	6.0
1,2,3,4,7,8,9-HpCDF	120	110	110	5.1
Octa CDF	100	105	100	2.8

<sup>a</sup>RSD = (standard deviation/mean) x 100

**TABLE 7-12. CDD/CDF AUDIT RESULTS  
CAMDEN COUNTY MWC (1992)**

Isomer	Sample 3967-56H-01			Sample 3967-56H-02		
	Measured Conc. (mg/L)	Audit Conc. (mg/L)	Recovery (%)	Measured Conc. (mg/L)	Audit Conc. (mg/L)	Recovery (%)
2378 TCDD	0.390	0.375	104	0.510	0.500	102
Total TCDD	0.390	0.375	104	1.100	1.250	88
12378 PeCDD	0.460	0.375	123	0.0033	0.0	---
Total PeCDD	0.460	0.375	123	0.760	0.750	101
123478 HxCDD	0.450	0.375	120	0.970	0.750	129
123678 HxCDD	0.0062	0.0	---	ND	0.0	---
123789 HxCDD	0.0018	0.0	---	ND	0.0	---
Total HxCDD	0.460	0.375	123	0.970	0.750	129
1234678 HpCDD	0.450	0.375	120	0.0077	0.0	---
Total HpCDD	0.450	0.375	120	0.0077	0.0	---
Total OCDD	0.300	0.375	80	0.0052	0.0	---
2378 TCDF	0.580	0.500	116	0.400	0.375	107
Total TCDF	0.580	0.500	116	0.400	0.375	107
12378 PeCDF	0.560	0.500	112	0.390	0.375	104
23478 PeCDF	0.0035	0.0	---	0.0020	0.0	---

**TABLE 7-11. CDD/CDF FLUE GAS BLANK RESULTS  
CAMDEN COUNTY MWC - PHASE II (1992)**

Isomer	Method Blank Results (ng)		Field Blank Results (ng)	
	Blank 707	Blank 709	Inlet	Outlet
2,3,7,8-TCDF	[0.0210]	[0.0180]	0.040	[0.0180]
Total TCDF	ND <sup>a</sup>	ND	0.500	0.0110
2,3,7,8-TCDD	[0.0270]	[0.0260]	[0.028]	[0.0160]
Total TCDD	ND	ND	ND	ND
1,2,3,7,8-PeCDF	[0.0065]	[0.0045]	0.046	0.0067
2,3,4,7,8-PeCDF	[0.0056]	[0.0078]	0.050	[0.0130]
Total PeCDF	ND	ND	0.430	0.0067
1,2,3,7,8-PeCDD	[0.0051]	[0.0047]	0.014	[0.0067]
Total PeCDD	ND	ND	0.086	ND
1,2,3,4,7,8-HxCDF	[0.0030]	0.0058	0.050	0.0072
1,2,3,6,7,8-HxCDF	[0.0018]	[0.0023]	0.050	0.0059
1,2,3,7,8,9-HxCDF	[0.0020]	[0.0030]	0.046	0.0051
2,3,4,6,7,8-HxCDF	[0.0018]	[0.0033]	0.018	[0.0026]
Total HxCDF	ND	ND	0.390	0.0350
1,2,3,4,7,8-HxCDD	[0.0055]	[0.0042]	0.014	0.0041
1,2,3,6,7,8-HxCDD	[0.0052]	[0.0057]	0.018	[0.0075]
1,2,3,7,8,9-HxCDD	[0.0033]	[0.0074]	0.012	0.0028
Total HxCDD	ND	ND	0.150	0.0069
1,2,3,4,6,7,8-HpCDF	[0.0039]	[0.0099]	0.180	0.0280
1,2,3,4,7,8,9-HpCDF	[0.0027]	[0.0100]	0.047	0.0092
Total HpCDF	ND	ND	0.290	0.0450
1,2,3,4,6,7,8-HpCDD	0.0054	0.0110	0.160	0.0230
Total HpCDD	0.0054	0.0220	0.290	0.0230
OCDF	[0.0100]	[0.0100]	0.180	0.0510
OCDD	0.0880	0.1500	0.560	0.1700

<sup>a</sup>ND = Not Detected

[ ] = less than 5 times the method detection limit.

**TABLE 7-13. VOST FIELD BLANK RESULTS - CONDITION B10  
CAMDEN COUNTY MWC - PHASE II (1992)**

Compound	INLET (total ng)														
	Run 25					Run 26					Run 27				
	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube
Trichlorofluoromethane	120	140	ND <sup>a</sup>	ND	ND	34	ND	18	34	ND	ND	ND	ND	ND	ND
Carbon Disulfide	35	130	40	33	ND	88	78	46	150	ND	220	62	32	29	ND
Methylene Chloride	ND	12	18	10	ND	27	ND	ND	14	ND	19	10	72	12	ND
Benzene	240	290	91	59	48	35	24	24	360	12	120	81	73	59	ND
Toluene	10	15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	26	41	14	ND	ND	ND	ND	ND	25	ND	15	17	ND	14	ND
m,p-Xylene	12	22	17	31	44	23	17	15	58	ND	40	18	60	ND	26
Compound	OUTLET (total ng)														
	Run 25					Run 26					Run 27				
	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube
Trichlorofluoromethane	280	210	ND	ND	ND	ND	ND	65	37	ND	ND	ND	18	11	ND
Carbon Disulfide	48	28	16	11	ND	ND	ND	21	29	ND	12	29	ND	20	ND
Methylene Chloride	26	38	28	39	11	ND	13	24	40	ND	19	27	24	31	ND
Benzene	120	100	65	48	14	ND	32	35	50	ND	31	41	36	36	ND
Toluene	20	19	26	13	ND	ND	15	20	25	ND	27	28	26	27	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	29	18	28	32	ND	ND	15	29	27	ND	21	35	28	28	ND

<sup>a</sup>ND = Not Detected.

Note: Final values were not field blank corrected.

TABLE 7-12. CONTINUED

Isomer	Sample 3967-56H-01			Sample 3967-56H-02		
	Measured Conc. (mg/L)	Audit Conc. (mg/L)	Recovery (%)	Measured Conc. (mg/L)	Audit Conc. (mg/L)	Recovery (%)
Total PeCDF	0.560	0.500	112	0.390	0.375	104
123478 HxCDF	0.710	0.500	142 <sup>a</sup>	0.490	0.375	131 <sup>a</sup>
123678 HxCDF	ND	0.0	---	ND	0.0	---
123789 HxCDF	ND	0.0	---	ND	0.0	---
234678 HxCDF	ND	0.0	---	ND	0.0	---
Total HxCDF	0.710	0.500	142 <sup>a</sup>	0.490	0.375	131 <sup>a</sup>
1234678 HpCDF	0.420	0.500	84	0.310	0.375	83
1234789 HpCDF	0.0009	0.0	---	ND	0.0	---
Total HpCDF	0.420	0.500	84	0.310	0.375	83
Total OCDF	0.560	0.500	112	0.380	0.375	101

<sup>a</sup> Outside acceptable limits of recovery for HxCDF of 40-130%.

Surrogate recoveries for the stack gas volatile organic analyses are summarized in Tables 7-15 and 7-16. The data quality objectives for the surrogate recoveries were met for all analyses, with the exception of high surrogate recoveries for 1,2-Dichloroethane-d4 and 4-Bromofluorobenzene in the Inlet Run 27C tube. The high recoveries suggest a potential high bias in results reported for this one pair of tubes. This potential high bias for this one pair of tubes has no impact on the overall data quality for the VOST results.

Analytical method spike results for the stack gas volatile organic analyses are summarized in Table 7-17. The data quality objectives were met for all of the analyses.

Verification of the accuracy of the VOST system was provided through sampling and analysis of two EPA cylinder audits. Triplicate pairs of VOST tube samples were collected for each cylinder. The results of the audit samples are summarized in Table 7-18. Recoveries for all measured compounds were within the project data quality objectives of 50 to 150%, except for vinyl chloride. The coefficient of variance (CV) for individual runs of each audit gas by each train ranged from 0 to 24.9%, well within the acceptable CV of 40%.

Although the recovery and CV values for all of the compounds except vinyl chloride are within the data quality objectives, the reported concentrations for the inlet sampling train are consistently higher than for the outlet sampling train. This suggests the possibility of a systematic bias in operation of the two trains. Review of sampling train and analytical QC data for the audit samples suggests that the low recoveries for the outlet train samples may be attributable to differences in chromatograph performance when the samples were run. Specifically, the inlet audit samples were run as part of Data Package A, while the outlet audit samples were run as part of Data Package F. As indicated on Table 7-17, method spike recoveries for Data Package F were lower than for the other packages. Review of the flue gas samples included in each data package indicates that only the outlet samples for Run 30 may have been influenced



**TABLE 7-14. VOST FIELD BLANK RESULTS - CONDITION B11  
CAMDEN COUNTY MWC - PHASE II (1992)**

Compound	INLET (total ng)														
	Run 28					Run 29					Run 30				
	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube
Trichlorofluoromethane	28	11	ND <sup>a</sup>	ND	ND	12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	280	76	16	32	ND	140	110	98	64	ND	67	42	37	290	ND
Methylene Chloride	24	11	ND	12	ND	15	13	15	ND	ND	ND	ND	ND	10	ND
Benzene	65	60	24	36	ND	89	86	200	250	ND	150	140	65	74	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	14	11	ND	ND	ND	ND	15	26	36	ND	23	27	20	20	ND
m,p-Xylene	21	31	ND	14	44	51	49	56	60	ND	ND	ND	ND	ND	ND
Compound	OUTLET (total ng)														
	Run 28					Run 29					Run 30				
	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube	Tube A	Tube B	Tube C	Tube D	Blank Tube
Trichlorofluoromethane	54	38	17	11	ND	41	17	ND	13	ND	37	ND	ND	ND	ND
Carbon Disulfide	28	24	25	13	ND	55	27	21	14	ND	23	12	24	16	ND
Methylene Chloride	23	20	24	15	ND	23	20	18	17	ND	31	14	13	13	ND
Benzene	61	45	41	32	ND	50	21	21	23	ND	37	20	30	29	ND
Toluene	37	28	26	19	ND	45	15	11	ND	ND	30	15	15	38	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	14	ND	ND	ND	ND	ND	ND	ND	ND
m,p-Xylene	56	73	36	55	15	29	25	17	43	ND	23	35	ND	14	ND

<sup>a</sup>ND = Not Detected

Note: Final values were not field blank corrected.

**TABLE 7-15, CONTINUED**

Tube	Surrogate Recovery (%)			Sample Hold Time (days)
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	
Inlet, Run 27				
27A	125	116	102	8
27B	100	99	107	8
27C	308	107	160	8
27D	102	99	96	8
Field Blank	108	95	100	8
Relative Standard Deviation	60.3	8.1	23.5	
Inlet, Run 28				
28A	105	103	83	9
28B	108	96	92	9
28C	105	100	93	9
28D	108	99	92	9
Field Blank	108	88	94	9
Relative Standard Deviation	1.5	5.9	4.9	

**TABLE 7-15. SURROGATE RECOVERY RESULTS AND HOLD TIMES FOR  
INLET VOST  
CAMDEN COUNTY MWC - PHASE II (1992)**

Tube	Surrogate Recovery (%)			Sample Hold Time (days)
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	
Inlet, Run 25				
25A	105	100	106	8
25B	95	120	113	8
25C	108	91	104	8
25D	103	103	101	8
Field Blank	114	99	104	8
Relative Standard Deviation	6.6	10.4	4.3	
Inlet, Run 26				
26A	97	101	102	8
26B	100	94	102	8
26C	96	96	132	8
26D	99	101	106	8
Field Blank	93	99	96	8
Relative Standard Deviation	2.8	3.2	13.1	

**TABLE 7-16. SURROGATE RECOVERY RESULTS AND HOLD TIMES FOR  
OUTLET VOST  
CAMDEN COUNTY MWC - PHASE II (1992)**

Tube	Surrogate Recovery (%)			Sample Hold Time (days)
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	
Outlet, Run 25				
25A	104	101	113	8
25B	102	117	100	8
25C	111	97	109	8
25D	108	104	104	8
Field Blank	100	99	114	9
Relative Standard Deviation	4.2	7.6	5.5	
Outlet, Run 26				
26A	NA <sup>a</sup>	NA	NA	NA
26B	85	133	106	9
26C	99	110	87	9
26D	102	108	100	9
Field Blank	102	99	80	9
Relative Standard Deviation	8.4	12.9	12.7	

**TABLE 7-15, CONTINUED**

Tube	Surrogate Recovery (%)			Sample Hold Time (days)
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	
Inlet, Run 29				
29A	105	93	100	9
29B	113	85	104	9
29C	109	90	106	9
29D	111	89	108	9
Field Blank	110	93	102	9
Relative Standard Deviation	2.7	3.7	3.0	
Inlet, Run 30				
30A	110	88	100	9
30B	114	90	111	9
30C	90	103	101	11
30D	91	110	95	11
Field Blank	94	108	100	11
Relative Standard Deviation	11.3	10.2	5.8	

**TABLE 7-16, CONTINUED**

Tube	Surrogate Recovery (%)			Sample Hold Time (days)
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	
Outlet, Run 29				
29A	105	91	102	8
29B	98	102	93	9
29C	100	97	92	9
29D	105	93	106	9
Field Blank	92	107	100	11
Relative Standard Deviation	5.4	6.7	6.1	
Outlet, Run 30				
30A	98	105	103	11
30B	96	112	92	11
30C	97	114	82	11
30D	88	141	84	11
Field Blank	96	108	82	12
Relative Standard Deviation	4.2	12.4	10.2	

<sup>a</sup>NA = Not analyzed due to instrument malfunction.

**TABLE 7-16, CONTINUED**

Tube	Surrogate Recovery (%)			Sample Hold Time (days)
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	
Outlet, Run 27				
27A	98	102	84	9
27B	113	94	102	9
27C	112	101	92	9
27D	115	91	102	9
Field Blank	118	95	90	9
Relative Standard Deviation	6.9	5.1	8.4	
Outlet, Run 28				
28A	114	93	103	8
28B	113	94	104	8
28C	119	92	112	8
28D	109	119	80	8
Field Blank	113	92	100	8
Relative Standard Deviation	3.1	12.0	11.9	

**TABLE 7-18. VOLATILE ORGANIC SAMPLING TRAIN AUDIT RESULTS  
CAMDEN COUNTY MWC - PHASE II (1992)**

Compound	Audit Concentration (ppb)	Inlet Train (ppb)				Outlet Train (ppb)			
		Run 1	Run 2	Run 3	Recovery (%) <sup>a</sup>	Run 1	Run 2	Run 3	Recovery (%) <sup>a</sup>
Cylinder 514A									
Vinyl Chloride	14.6	8.3	7.9	7.5	54	3.7	5.1	5.9	34 <sup>b</sup>
Acetone	--	ND <sup>c</sup>	ND	ND	--	14	11	ND	--
Methylene Chloride	--	ND	0.41	ND	--	ND	ND	ND	--
Chloroform	16.8	16	18	21	109	11	12	10	66
Carbon Tetrachloride	11.6	10	10	15	101	7.9	9.3	8.8	75
Benzene	15.6	15	17	22	115	11	12	11	73
Toluene	--	ND	ND	0.29	--	0.84	0.43	0.27	--
Tetrachloroethene	15.2	11	14	18	94	8.7	9.3	8.9	56
Cylinder 514B									
Vinyl Chloride	19.3	12	12	12	62	7.9	7.5	7.5	40 <sup>b</sup>
Carbon Disulfide	--	0.38	0.35	ND	--	ND	ND	ND	--
Methylene Chloride	--	1.2	ND	ND	--	ND	ND	ND	--
Chloroform	34.0	43	39	39	119	23	21	21	64
Carbon Tetrachloride	9.7	11	11	11	113	7.0	6.9	6.8	71
Benzene	30.2	44	40	44	141	22	22	21	72
Toluene	--	ND	ND	ND	--	0.51	0.46	0.56	--
1,2-Dichloroethane	--	0.47	0.49	ND	--	ND	ND	ND	--
Tetrachloroethene	10.1	13	12	13	125	6.4	6.0	5.4	59

<sup>a</sup>Recovery based on difference between audit concentration and average of measured concentrations.

<sup>b</sup>Recovery exceeded acceptance limits of 50 to 150%.

<sup>c</sup>ND = Not Detected.



**TABLE 7-17. VOLATILE ORGANIC SAMPLING TRAIN  
METHOD SPIKE RECOVERY RESULTS  
PRECISION AND ACCURACY VOST ANALYSES  
CAMDEN COUNTY MWC - PHASE II (1992)**

Compound	% Recovery <sup>a</sup>						Relative Standard Deviation <sup>b</sup> (%)
	Method Spike A	Method Spike B	Method Spike C	Method Spike D	Method Spike E	Method Spike F	
Vinyl Chloride	111	117	127	127	127	77	17.0
1,1-Dichloroethene	112	119	127	117	117	88	11.8
Chloroform	122	118	117	121	121	87	11.8
1,2-Dichloropropane	112	109	102	111	111	93	7.0
Toluene	114	115	103	116	116	107	4.9
Ethyl Benzene	113	112	98	116	116	111	6.0

<sup>a</sup>Method Spike A - F correspond to Air Toxics, Ltd. data packages 9206080 A-F.

<sup>b</sup>  $RSD = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$

**TABLE 7-19. CEM DAILY CALIBRATION CHECKS - UNIT A  
CAMDEN COUNTY MWC (1992)**

Condition	Date	Economizer O <sub>2</sub>				Stack O <sub>2</sub>			
		Zero = 0%		Span = 20.9%		Zero = 0%		Span = 20.9%	
		Actual (%)	Error (%)	Actual (%)	Error (%)	Actual (%)	Error (%)	Actual (%)	Error (%)
A1	05/29/92	0.1	0.3	19.8	-5.2	-0.2	-0.7	22.0	5.2
A2	05/30/92	0.2	0.7	19.2	-8.1	-0.2	-0.7	22.1	5.4
A3	06/01/92	0.5	2.1	17.9	-14.4	NA	NA	NA	NA
-- <sup>a</sup>	06/06/92	0.0	0.0	13.7	-34.5	NA	NA	NA	NA
A4	06/06/92	0.0	0.0	21.1	1.0	-0.1	-0.4	21.6	3.3
-- <sup>b</sup>	06/07/92	0.0	0.0	21.0	0.3	-0.1	-0.4	22.0	5.2
-- <sup>b</sup>	06/08/92	0.0	0.0	20.9	0.0	-0.1	-0.4	21.9	4.8
-- <sup>b</sup>	06/09/92	0.0	0.0	20.7	-0.8	NA	NA	21.6	3.3
A5	06/10/92	NA	NA	NA	NA	-0.2	-0.7	NA	NA
RSD (%) <sup>c</sup>			0.8		5.5		0.1		1.0

<sup>a</sup>Results of economizer CEM calibration conducted at 04:30. Recalibration conducted at 14:30. Emissions testing began at 15:57.

<sup>b</sup>Calibration results for these days included in table to show CEM stability. Results not included in RSD calculation except as noted in footnote c.

<sup>c</sup>RSD (Relative Standard Deviation)=Standard Deviation/Span. Excludes CEM data from morning of 6/06/92; see footnote a. Includes data from 6/09/92 when data from 6/10/92 not available.

by the low method spike recoveries for Data Package F. Review of the flue gas data does not indicate any clear difference between the Run 30 samples and those from other runs. As a result, the VOST results reported in Sections 3 and 4 are considered valid.

## 7.5 Continuous Emission Monitors

The plant's CEMs were used to monitor flue gas composition at the economizer exit and stack. The CEMs on Units A and B were of identical design and are described in Section 6.7. The QC criteria established in the QAPP for the CEM system were limited to the measurement of O<sub>2</sub> and included an accuracy criterion of 80 to 120% of the reference method value and a precision criterion of less than 10% deviation between the measured and calibration gas values during each daily calibration check.

To confirm the accuracy of each of these systems, each of the monitors was certified in accordance with the QA/QC protocols for CEMS in 40 CFR Part 60, Appendix F. These tests were conducted on Units A and B in February 1992. The measured relative accuracy of the Unit A economizer and stack O<sub>2</sub> monitors was 91.1% and 98.2% of the reference method, respectively. For Unit B, the relative accuracy of the economizer and stack monitors was 95.4% and 96.0% of the reference method.

To confirm measurement precision during the testing period, 2-point (zero and span) calibration checks were conducted each day. The results of the daily calibration check on Units A and B are presented in Tables 7-19 and 7-20, respectively. As noted in Table 7-19, the economizer O<sub>2</sub> monitor on Unit A exhibited significant span drift between May 29 and June 6. This drift was corrected by recalibrating the monitor prior to the start of testing on June 6. With the exception of the Unit A economizer CEM calibration check on June 1, each of the daily checks met the QC criteria of less than the 10% deviation.

During Conditions A4 and A5, the economizer O<sub>2</sub> monitor on Unit A indicated O<sub>2</sub> levels that were higher than during other runs and that were similar to the levels measured by the stack monitor. This suggests higher combustor O<sub>2</sub> levels during these two conditions and less air infiltration across the SD/ESP system. Based on review of plant process data and discussion with plant personnel, it was concluded that the economizer CEM was reporting erroneously high O<sub>2</sub> levels. As a result, the economizer O<sub>2</sub> measurements for these two test conditions were calculated by subtracting 2.4% from the stack O<sub>2</sub> reading for the same run. This adjustment factor was based on the average difference in O<sub>2</sub> between the inlet and outlet sampling locations during the other test conditions on both Units A and B.

**TABLE 7-20. CEM DAILY CALIBRATION CHECKS - UNIT B  
CAMDEN COUNTY MWC (1992)**

Condition	Date	Economizer O <sub>2</sub>				Stack O <sub>2</sub>			
		Zero = 0%		Span = 20.9%		Zero = 0%		Span = 20.9%	
		Actual (%)	Error	Actual	Error	Actual	Error	Actual	Error
B1	05/11/92	NA	NA	NA	NA	0.4	1.9	21.6	3.3
B2	05/12/92	NA	NA	NA	NA	0.4	1.9	21.2	1.4
B3	05/13/92	NA	NA	NA	NA	0.4	1.9	21.5	2.9
B4	05/14/92	0.0	0.0	20.3	-2.9	0.4	1.9	20.6	-1.4
B5	05/15/92	NA	NA	NA	NA	0.4	1.9	21.3	1.9
B6	06/02/92	0.0	0.0	20.1	-3.8	-0.3	-1.1	20.9	0.0
B7	06/03/92	0.0	0.0	20.2	-3.3	-0.3	-1.1	20.9	0.0
B8	06/04/92	0.0	0.0	20.2	-3.3	-0.3	-1.1	21.1	1.0
B9	06/05/92	0.0	0.0	20.0	-4.3	-0.3	-1.1	20.5	-1.9
B10	06/08/92	0.0	0.0	20.1	-3.8	-0.3	-1.1	20.9	0.0
B11	06/09/92	NA	NA	NA	NA	-0.3	-1.1	20.7	-1.0
B12	06/11/92	0.0	0.0	20.1	-3.8	-0.3	-1.1	20.4	-2.4
B13	06/12/92	0.0	0.0	20.2	-3.3	-0.3	-1.1	20.9	0.0
RSD (%) <sup>a</sup>			0.0		0.4		0.0		1.7

<sup>a</sup>RSD (Relative Standard Deviation)=Standard Deviation/Span

## **8.0 REFERENCES**

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16. ABSTRACT The report gives results of parametric tests to evaluate the injection of powdered activated carbon to control volatile pollutants in municipal waste combustor (MWC) flue gas. The tests were conducted at a spray dryer absorber/electrostatic precipitator (SD/ESP)-equipped MWC in Camden County, New Jersey. Primary test objectives were to evaluate the effect of carbon type, feed rate, feed method, and ESP operating temperature on emissions of mercury (Hg) and chlorinated dioxins and furans (CDD/CDF), and to assess the impact of carbon injection on the particulate matter control performance of the ESP. Secondary objectives were to examine the impact of carbon injection on emissions of other metals and volatile organic compounds (VOCs). The tests included operating three different carbon injection systems and examining 16 different SD/ESP and carbon injection system operating conditions. Test results indicate that carbon injection upstream of a SD/ESP can achieve high levels (> 90%) of Hg and CDD/CDF reduction. Key system operating parameters are carbon feed rate, carbon feed method, and ESP temperature. No detrimental impacts on ESP performance were identified. The study also found that carbon injection does not have a significant impact on emissions of the other metals examined or of VOCs.		13. TYPE OF REPORT AND PERIOD COVERED Task Final; 1/92 - 4/93	
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Activated Carbon	Electrostatic Precipitators	Stationary Sources	11G
Mercury (Metal)	Particles	Municipal Waste Combustion	07B 13I
Wastes	Organic Compounds	Dioxins	14G
Combustion	Volatility	Particulate	21B 07C
Flue Gases		Volatile Organics	20M
Halohydrocarbons			07C
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