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Carnot

Carnot

December 1995

PISCES Field Chemical Emissions Monitoring Project: Site 120 Emissions Report

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October 27, 1994

Mr. William H. Maxwell, P.E. (MD13)
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Dear Mr. Maxwell:

In response to the Clean Air Act Amendments of 1990, the Electric Power Research Institute (EPRI) initiated the PISCES (Power Plant Integrated Systems: Chemical Emissions Studies) program to better characterize the source, distribution, and fate of trace elements from utility fossil-fuel-fired power plants. As part of the PISCES program, the Field Chemical Emissions Monitoring (FCEM) program has sampled extensively at a number of utility sites, encompassing a range of fuels, boiler configurations, and particulate, SO_2, and NO_x control technologies. EPRI is actively pursuing additional FCEM sampling programs, with 29 sites either completed or planned.

This site report presents a preliminary summary of data gathered during a sampling program conducted at one of the FCEM sampling programs - Site 120. Site 120 consists of an 700 MW boiler burning natural gas. The NOx controls are the only air pollution control devices at Site 120 and include flue gas recirculation (FGR), overfire air (OFA) ports, and off-stoichiometric firing utilitizing burners-out-of-service (BOOS).

The Site 120 sampling and analytical plan included some differences from the standard sampling and analytical plans at other FCEM sites. Specifically, the California Air Regulatory Board (CARB) methods were used to sample for the volatile organic compounds (VOCs) and the polycyclic aromatic hydrocarbons (PAHs). In the multi-metals trains, the filter and associated rinses were combined with the impinger fractions in order to obtain lower detection limits - thus only total metal concentrations are available, instead of differentiating between particulate and vapor phase concentrations. Most of the metals reported had significant background levels in the filters, making these values questionable.

The primary objective of this report is to transmit the preliminary results from Site 120 to the EPA for use in evaluating select trace chemical emissions from fossil-fuel-fired steam generating plants. **It should be noted that the results presented in this report are considered PRELIMINARY.** As additional data tests at this site. If this is done, the new data will be made available to the Environmental Protection Agency (EPA).

In addition to the raw data in the Appendix, the report provides an assessment of the material balances, discusses the data quality, identifies suspect data, and offers possible explanations for the questionable data. This report does not compare the results from Site 120 with the results from previous utility sites. Nor does this site report attempt to address the environmental and health risk impacts associated with the trace chemical emissions.

EPRI hopes that this site report is of assistance to the EPA in evaluating utility trace chemical emissions as well as the associated health risk impacts.

Sincerely,

Paul Chu
Manager, Toxic Substances Control
Environmental Control Business Unit

ABSTRACT

This report is one of a series sponsored by the Electric Power Research Institute in the area of trace substance emissions from fossil-fuel power plants. This report presents the results of a sampling and analytical study to characterize trace substances emissions at Site 120. Site 120 is a natural gas-fired boiler. The NO_X controls are the only air pollution control devices at Site 120 and include flue gas recirculation, overfire air, and off-stoichiometric firing utilizing burners-out-of-service.

The objective of this report is to transmit the detailed data to the U.S. Environmental Protection Agency (EPA) to assist the Agency in evaluating utility trace chemical emissions as well as the associated health risk impacts—as mandated in Title III of the 1990 Clean Air Act Amendments. This report does not attempt to compare the results with other sites. An assessment of data from all plants that have been tested is presented in the Electric Utility Trace Substances Synthesis Report (EPRI TR-104614).

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SECTION 1.0

INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

This report summarizes data gathered by Carnot at a power plant designated Site 120 for a program sponsored by the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI) and the host utility. The objective of the Field Chemical Emissions Monitoring Project (FCEM) sponsored by EPRI is to measure the concentrations of selected inorganic and organic substances in the process and discharge streams of power plants. These data are being used to determine the fate and control of these substances.

The primary objectives of this report are to provide information on fuel composition and stack emissions and to evaluate these data according to the criteria outlined below. The information is presented in a format suitable for the U.S. Environmental Protection Agency (EPA) to use to study emissions from fossil fuel fired power plants, as mandated by the Clean Air Act Amendments (CAAA) of 1990. This report summarizes fuel and stack gas concentration data measured during the operation of a tangentially-fired boiler firing natural gas. Sampling was conducted during April 1993.

Table 1-1 lists the substances of interest to the FCEM project which were measured at Site 120. Carnot conducted the testing and has prepared this report using the following procedures to evaluate the data:

- The type and quantity of quality assurance samples were reviewed to determine the confidence that can be placed in the results; and

- The QA/QC results were compared with data quality objectives to evaluate precision and accuracy.

Results are presented for each substance by individual run and as an averaged total. To demonstrate data variability, the 95% confidence interval about the mean is also presented. The confidence interval incorporates the combined process, sampling, and analytical variabilities.

1.2 SAMPLING AND ANALYSIS PROTOCOL

The sampling and analysis protocol for Site 120 is described in Appendix A. The FCEM program has attempted to employ standard sampling and analytical procedures when possible.

TABLE 1-1
FCEM SUBSTANCES OF INTEREST
SITE 120

Elements	Organic Compounds
Arsenic	Benzene
Barium	Toluene
Beryllium	Formaldehyde
Cadmium	Naphthalene
Chromium	Acenaphthylene
Cobalt	Acenaphthene
Copper	Fluorene
Lead	Phenanthrene
Manganese	Anthracene
Mercury	Fluoranthene
Molybdenum	Pyrene
Nickel	Benzo(a)anthracene
Selenium	Chrysene
Phosphorus	Benzo(b)fluoranthene
Vanadium	Benzo(k)fluoranthene
	Benzo(a)pyrene
	Indeno(1,2,3-cd)pyrene
	Dibenzo(a,h)anthracene
	Benzo(g,h,i)perylene
	2-Methylnaphthalene
	7,12-Dimethylbenz(a)anthracene
	3-Methylcholanthrene

Additional Evaluations:

VOC (benzene, toluene, formaldehyde, and methane/TGNMO) at 20% of full load condition and at air preheater outlet O_2 levels of 10.33, 8.66 and 10.16%, dry.

VOC (benzene, toluene, formaldehyde, and methane/TGNMO) at 103% of full load condition and at air preheater outlet O_2 levels of 2.89, 3.15 and 3.46%, dry.

TGNMO = Total Gaseous Non-Methane Organics. Excludes inorganic carbon compounds such as CO and CO_2.

The methods used are comparable to those used at other FCEM sites with the following exceptions:

- Benzene and toluene samples were collected in Tedlar bags according to California Air Resources Board (CARB) methodology rather than using VOST sampling. At the time of sampling, there were some concerns with the VOST method. Previous experience indicates that Tedlar bag sampling gives adequate results.
- Exhaust gas metals were determined as the total per sample train rather than differentiating between particulate and vapor phase metals.
- PAH were collected and analyzed according to CARB methodology. These samples were analyzed using isotope dilution methodology by high resolution gas chromatography/low resolution mass spectrometry with selected ion monitoring (HRGC/LRMS-SIM).
- Triplicate on-line measurements of natural gas composition (major hydrocarbons plus O_2, H_2O, He, H_2, N_2, CO_2, CO, H_2S, COS) and heating value were performed for EPA Method 19 F-factor calculations. Additional single samples were taken for analysis of trace elements and species.

1.3 QUALITY ASSURANCE/QUALITY CONTROL

The completeness of the quality assurance data was reviewed to judge whether the quality of the measurement data could be evaluated with the available information. In general, the results of the QC checks available for Site 120 indicate that the sample results are well characterized. An evaluation of the accuracy, precision, and bias of the data, even if only qualitative, is considered to be an important part of the data evaluation. A full discussion of each of these components of quality can be found in Section 5.0.

Standard QA/QC checks for this type of sampling program involve the use of: (1) duplicate field samples and lab analyses, matrix spike and lab control duplicates and replicate tests to determine precision; (2) matrix spikes, surrogate spikes, and laboratory control samples to determine accuracy; and (3) field blanks, trip blanks, method blanks, and reagent blanks to determine if any of the samples were contaminated during collection or analysis. Most of these standard QA/QC checks were used on samples from Site 120. Some QA/QC checks do not apply to some types of analyses; for example, surrogate spikes do not apply to metals analysis. The absence of any of these "standard" quality control checks from the Site 120 report does not necessarily reflect poorly on the quality of the data but does limit the ability to measure the various components of measurement error.

1.4 DATA QUALITY

The available QA/QC results were compared to the data quality objectives shown in Section 5.0. QA/QC results outside the data quality objectives are noted and discussed, other quality assurance values are evaluated, and the potential effect on data quality is noted. The detailed information presented in Section 5.0 supports the conclusion that the data quality objectives were met with the following exceptions:

- Because of low metals emissions expected from a gas-fired source, the interpretation of field blank levels becomes more difficult. Although field blank levels for all metals except barium were low (less than 1.07 $\mu g/Nm^3$), the field blank level was greater than 50% of the uncorrected sample values for arsenic, barium, copper, lead, manganese and molybdenum.

- Field spikes (surrogate spikes) were not added to the XAD-2 resin modules before sampling. Although pre-extraction spikes were acceptable for all PAH species, the lack of field spikes prevents the evaluation of gains or losses of PAH species from field handling.

- Field blank levels for formaldehyde were similar to sample levels. The trip spike (spiked reagent brought to the field) indicates a low positive bias. Trip spike recovery was 111%. Because of the low sample levels, any formaldehyde contribution from field conditions can be significant compared to the sample values.

- The toluene result from Run 8C was not used because it was anomalously high. It was seven times higher than any other toluene result from the program.

1.5 REPORT ORGANIZATION

Section 2.0 of this report briefly describes the plant and the sample locations. Section 3.0 discusses the results of the chemical analysis of the natural gas and flue gas streams. Section 4.0 discusses the results from additional tests conducted to determine the effect of unit operation on VOC emissions. Section 5.0 presents QA/QC and engineering evaluations of the data. Section 6.0 presents example calculations, and a glossary of terms is provided in Section 7.0. The appendices contain information on sampling and analytical methods, stream concentrations, sampling data, process operation, error propagation equations, and detailed QA/QC data.

SECTION 2.0

SITE DESCRIPTION

This section presents a description of the test site, designated Site 120, and the sampling locations at this site.

2.1 FACILITY INFORMATION

The boiler at Site 120 is a Combustion Engineering (CE) tangentially-fired boiler rated at 750 MW gross. The boiler currently has a maximum load of 700 MW gross, limited by the maximum cooling water temperature allowed to leave the unit. This forced-draft boiler is capable of firing either natural gas or low-sulfur residual fuel oil. Tests were performed only on natural gas. Fuel oil had not been fired for at least one year prior to this test program. Table 2-1 summarizes the configuration of the unit at Site 120. Figure 2-1 presents a process flow diagram of Site 120.

NO_x controls are the only air pollution control devices installed at this facility. NO_x controls installed at Site 120 include flue gas recirculation (FGR) to the windbox, overfire air (OFA) ports above the top burner rows on two furnace walls, and off-stoichiometric firing utilizing burners-out-of-service (BOOS). During BOOS operation, the gas flow to the selected burners is shut off, but the air registers remain wide open. The local NO_x limit at Site 120 at the time of the test program was 175 ppmc (ppm at 3% O_2).

2.2 SAMPLING LOCATIONS

Samples were taken from two process streams: the natural gas fuel and the exhaust gas. Figure 2-1 identifies the three sampling locations used for the test program.

A brief description of each sampling location follows:

- Natural gas was the only fuel stream sampled. Samples were collected at the main boiler gas header, which supplies natural gas to Site 120.
- NO_x, CO, O_2 and CO_2 were continuously monitored through a 32-point probe array installed in the two air preheater inlet ducts. This array contained 16 points per inlet duct. The emissions monitors at this location measure these exhaust gas components on a dry basis.

TABLE 2-1
SITE 120 CONFIGURATION

BOILER:	
Maximum Gross Electrical Output, MW	700
Boiler Type	Tangentially Fired
NO_x Emission Limit, ppm at 3% O_2	175
NO_x Controls	Windbox FGR Overfire Air Ports Off-Stoichiometric Firing (BOOS)
Fuel Type	Natural Gas
Fuel Methane Content, mole%(1)	96.2
Fuel Higher Heating Value, Btu/scf at 68°F(1)	1,002

(1) Average values measured during sampling.

- There were no sample ports installed on the stack of Site 120. Therefore, flue gas samples were taken through eight test ports installed in the two outlet ducts from the air preheater. 20 points per duct, or a total of 40 points were sampled for isokinetic tests according to EPA Method 1. A portable O_2 meter was used to collect O_2 data on a dry basis in conjunction with the test runs.

The procedures used for collecting, pretreating, and analyzing the samples from Site 120 are discussed in Appendix A. Table 2-2 presents an overview of the types of analyses performed on these streams.

2.3 PROCESS OPERATION DURING TESTING

Table 2-3 summarizes the operating conditions at Site 120. It should be noted that the "normal" O_2 levels referred to below vary with the load at which the boiler was operated and the NO_x control device operating levels.

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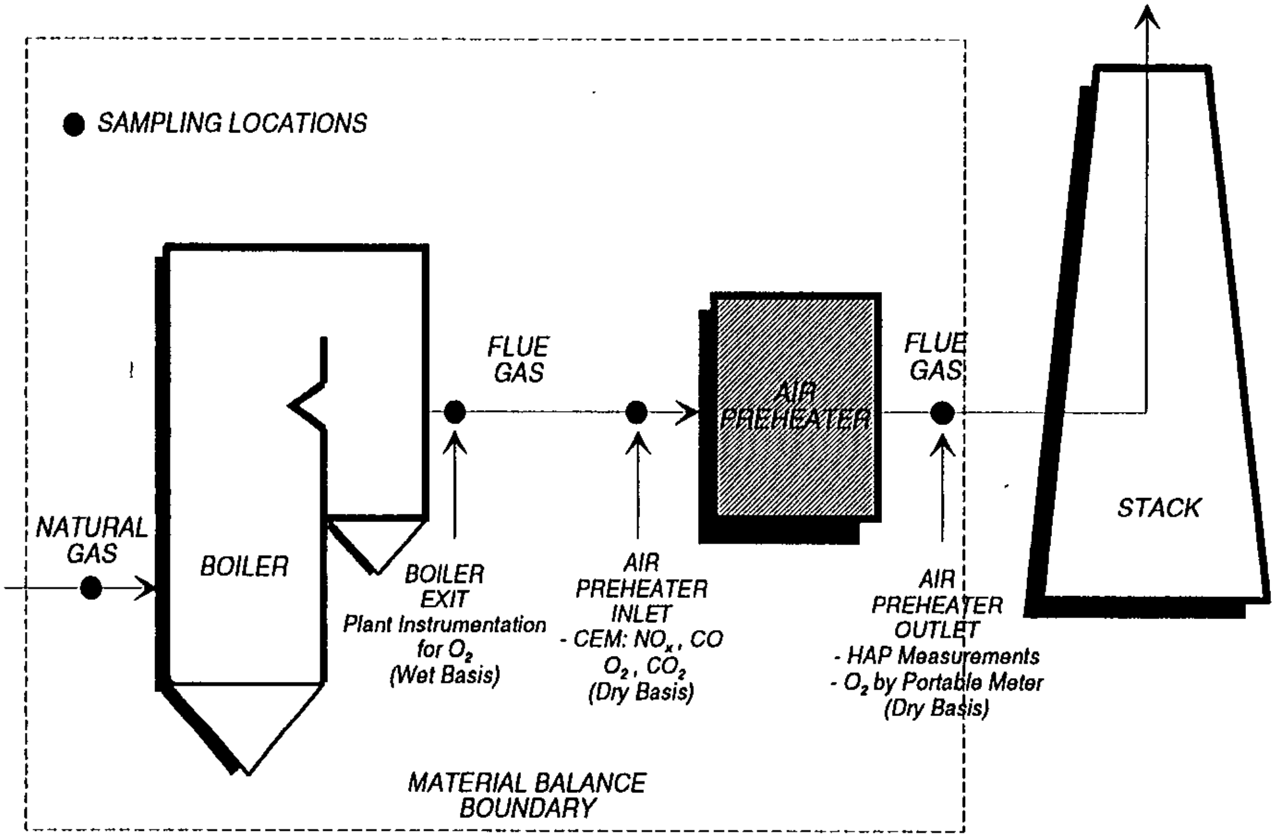


Figure 2-1. Process Flow Diagram of Site 120

TABLE 2-2
PROCESS STREAM ANALYSES PERFORMED

Stream	Metals(1)	Semi-Volatile Organics(2)	Volatile Organics(3)	Composition(4)
Natural Gas	✓	✓	✓	✓
Flue Gas	✓	✓	✓	

(1) Flue gas metals include the target species arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, phosphorus, selenium and vanadium. Metals analysis in natural gas include the target species arsenic and mercury.

(2) Semi-Volatile Organics include nineteen PAH species.

(3) Volatile Organics include benzene, toluene, and formaldehyde.

(4) Composition for natural gas analysis includes hydrocarbons, non-hydrocarbons (O_2, H_2O, He, H_2, N_2, CO_2, CO, NO, NO_x), sulfur compounds, oxygenated compounds, nitrogen compounds, halocarbons, radon and higher heating value.

The base PISCES test program (Runs 7, 8 and 9) was conducted at nominal full load. Average load during this base testing was 679 gross MW with normal boiler exit O_2 levels of 1.5 to 1.8 %, wet. Oxygen levels measured at the air preheater outlet averaged 3.08% for the three runs. All controls were operated in automatic control, with the exception of the excess air to fuel ratio control.

All NO_x controls were in operation for the base tests, and the average NO_x emissions were 98 ppmc (ppm corrected to 3% O_2), or 1.13 lb/MW-hr. FGR was at normal conditions, the overfire air ports were fully open, and there was 1 BOOS.

Six additional tests (Runs 1 through 6) were conducted to determine the effect of unit operation on VOC emissions. Three tests (Runs 1, 2 and 3) were conducted at minimum load, averaging 134 gross MW. The remaining three tests (Runs 4, 5 and 6) were conducted at maximum load, averaging 697 gross MW. Boiler exit oxygen levels, FGR levels and BOOS were the three variables for the minimum load tests, while only FGR levels and BOOS were varied for the maximum load tests. It was not possible to vary boiler exit oxygen levels at maximum load due to the NO_x emission limit for the boiler. For all six tests, the overfire air ports were wide open.

Test 1 (normal O_2 level, normal FGR level, 8 BOOS) produced NO_x emissions of 35 ppmc (0.52 lb/MW-hr) at a boiler exit O_2 level of 8.30%. Test 2 (minimum O_2 level, high FGR level, 8 BOOS) produced NO_x emissions of 25 ppmc (0.37 lb/MW-hr) at a boiler exit O_2 level

TABLE 2-3
SITE 120 OPERATING CONDITIONS

Test No.	1	2	3	4	5	6	7	8	9
Test Condition	Min. Load	Min. Load	Min. Load	Max. Load	Max. Load	Max. Load	Baseline	Baseline	Baseline
Load, gross MW	133	134	134	708	689	693	681	678	678
FGR Level	Normal	High	High	High	Low	Normal	Normal	Normal	Normal
Overfire Air Ports	Open	Open	Open	Open	Open	Open	Open	Open	Open
BOOS	8	8	12	0	0	2	1	1	1
Boiler Exit O_2, % wet	8.30	6.56	7.75	1.49	NA	1.68	1.73	1.78	1.53
Air Preheater Inlet O_2, % dry	9.73	7.92	9.46	1.82	2.22	2.53	2.01	2.14	2.24
Air Preheater Outlet O_2, % dry	10.33	8.66	10.16	2.89	3.15	3.46	3.08	2.87	3.30
NO_x, ppmc(1)	35	25	23	65	181	103	96	100	98

(1) ppmc = ppm corrected to 3% O_2

Notes:
Boiler exit O_2 from plant instrumentation
Air Preheater Inlet O_2 measured by continuous emission monitor
Air Preheater Outlet O_2 calculated from inlet O_2 and leakage across the air preheater for tests 1-6 and measured by portable O_2 meter for tests 7-9.
During test 5 the NO_x level exceeded the NO_x emission limit of 175 ppmc. Because this was not a normal operating condition, an emission variance was obtained as part of conducting the PISCES FCEM test program.

NA: Not Available

of 6.56%. Test 3 (normal O_2 level, high FGR level, 12 BOOS) produced NO_x emissions of 23 ppmc (0.36 lb/MW-hr) at a boiler exit O_2 level of 7.75%.

Test 4 (minimum O_2 level, high FGR level, 0 BOOS) produced NO_x emissions of 65 ppmc (0.72 lb/MW-hr) at a boiler exit O_2 level of 1.49%. Test 5 (minimum O_2 level, low FGR level, 0 BOOS) produced NO_x emissions of 181 ppmc (2.08 lb/MW-hr) at an air preheater inlet O_2 level of 2.22%. Boiler exit O_2 was not available for this test. Test 6 (minimum O_2 level, normal FGR level, 2 BOOS) produced NO_x emissions of 103 ppmc (1.19 lb/MW-hr) at a boiler exit O_2 level of 1.68%.

During test 5 the NO_x level exceeded the NO_x emission limit of 175 ppmc. Because this was not a normal operating condition, an emission variance was obtained as part of conducting the PISCES FCEM test program.

Further discussion of the process operation is provided in Section 5.1. Appendix E contains the process operation data.

SECTION 3.0

RESULTS

This section summarizes the data collected at Site 120 during the base test program with the unit operating at full load with normal boiler exit O_2 levels. Because the focus of this report is on exhaust gas emissions, only natural gas characterization data and flue gas stream data are presented here in detail. VOC data collected during the unit operation tests is summarized in Section 4.0. Sampling, preparation and analytical methods are summarized in Appendix A. Detailed analytical data can be found in Appendices B and C.

3.1 SAMPLING SCHEDULE

Sampling at Site 120 was performed in April 1993. Figure 3-1 presents the sampling schedule for the test program at Site 120. Test numbers have been assigned sequentially and all tests conducted simultaneously have the same number. Additional designators indicate the sample train type and sampling location.

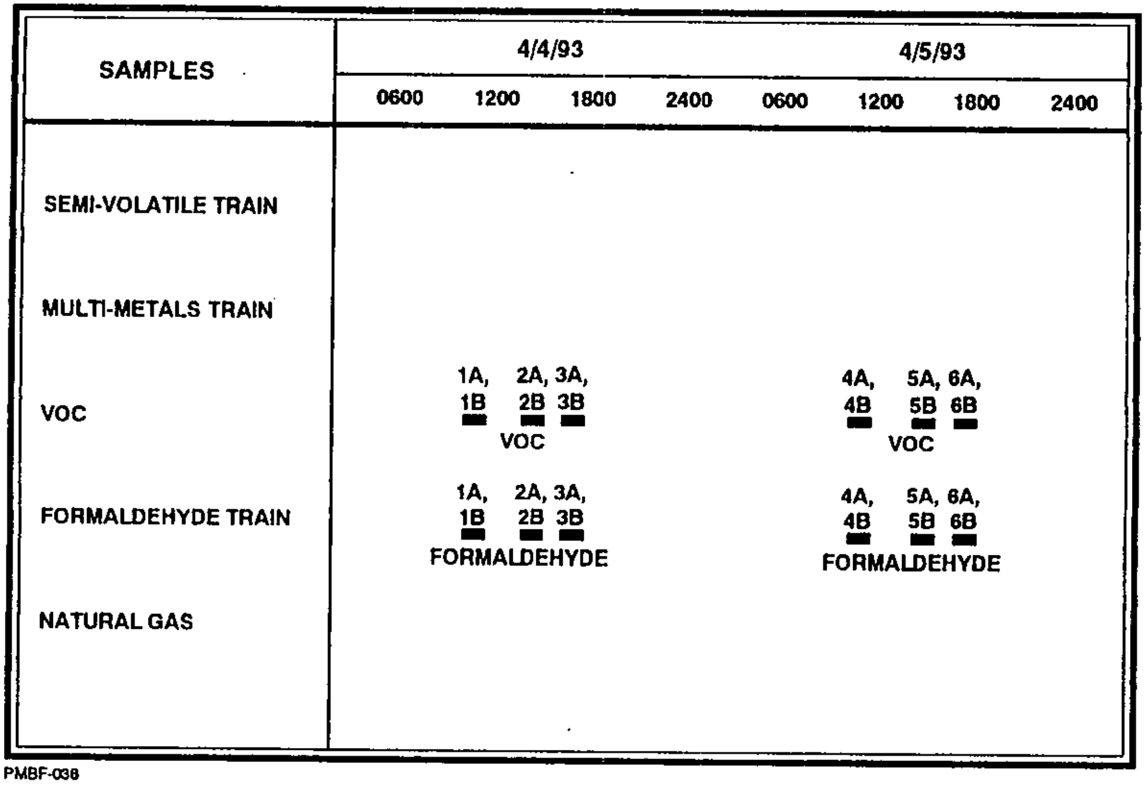
Four types of sampling trains were used to collect flue gas samples from the stack for the FCEM species of interest. These trains were: multimetals trains, semi-volatile organics trains, Tedlar bag samples for benzene and toluene, and formaldehyde trains. Each multimetals and semi-volatile test required a full isokinetic traverse of the air preheater outlet ducts. Tedlar bag samples for benzene and toluene and formaldehyde samples were collected nonisokinetically at a single point in the air preheater outlet ducts.

3.2 DATA TREATMENT

Several conventions were developed for treating the test data and developing average concentrations of substances in the natural gas and flue gas streams. The conventions used in this report are consistent with the PISCES FCEM data treatment procedures.

3.2.1 Blank Corrections

The individual run measurements were corrected for the reagent blank analysis when it was available and when it is allowed by the reference method. A reagent blank consists of the chemicals and filters used in the field and in the laboratory during analysis. It is often the best indicator of the initial background level of the species of interest. Laboratory blanks were also performed but were not used to correct the sample data from this program. The laboratory



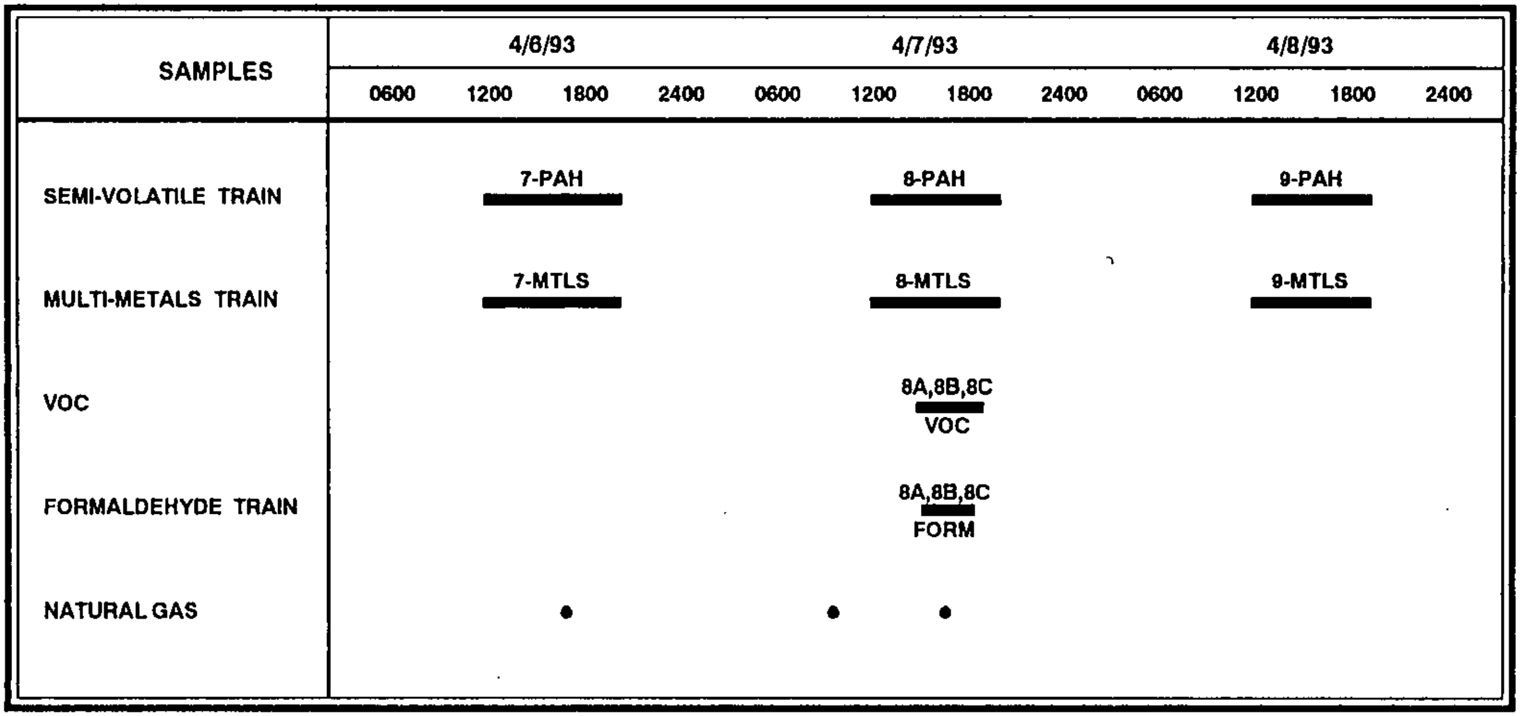
KEY:

▬ CONTINUOUS SAMPLING
1 INDICATES RUN NUMBER

NOTES:

RUNS 1 THROUGH 6 WERE UNIT OPERATION TESTS:
RUN 1: MINIMUM LOAD, NORMAL O_2, NORMAL FGR, 8 BOOS
RUN 2: MINIMUM LOAD, MINIMUM O_2, HIGH FGR, 8 BOOS
RUN 3: MINIMUM LOAD, NORMAL O_2, HIGH FGR, 12 BOOS
RUN 4: MAXIMUM LOAD, MINIMUM O_2, HIGH FGR, 0 BOOS
RUN 5: MAXIMUM LOAD, MINIMUM O_2, LOW FGR, 0 BOOS
RUN 6: MAXIMUM LOAD, MINIMUM O_2, NORMAL FGR, 2 BOOS

Figure 3-1. Sampling Schedule for Site 120



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KEY:

● DENOTES SAMPLE TIMES FOR ON-LINE FUEL F-FACTOR ANALYSIS
▬ CONTINUOUS SAMPLING
1 INDICATES RUN NUMBER

NOTE:

NATURAL GAS SAMPLE TIMES INDICATE ON-LINE FUEL F-FACTOR ANALYSIS
(SAMPLING TIMES FOR OTHER FRACTIONS ANALYZED FOR TRACE SPECIES NOT SUPPLIED BY IGT;
HOWEVER SAMPLES WERE TAKEN ON 4/7/93.)

Figure 3-1. Sampling Schedule for Site 120 (continued) blank is not exposed to field conditions and contains only the chemicals needed for analysis so it is expected to be lower than the reagent blank. Field blanks are performed in the field in the same manner as the samples. They provide information on sample collection conditions, background levels associated with sampling equipment as well as the sampling and analytical reagents, but are not used to correct the results.

For this program reagent blank levels were subtracted from the exhaust gas sample results for arsenic, barium, chromium, copper and lead. When the blank correction was equal to or greater than 50% of the uncorrected measurement the concentration is flagged with a "B". For this program only the blank correction for copper exceeds this level.

When the field blank was equal to or greater than 50% of the uncorrected measurement, the concentration is flagged with an "F." Exhaust gas concentrations are low on a gas-fired source so several species were detected at levels similar to the field blanks and are flagged. These include arsenic, barium, copper, lead, manganese, molybdenum, maphthalene and formaldehyde. Appendix H presents blank correction data and an example of how the blank correction contribution is calculated.

3.2.2 Average Concentrations

The following criteria were used to average data from the individual runs.

- When all values are above the reporting limit, the mean arithmetic concentration is calculated using the reported quantities.

- For results that include values both above and below the reporting limit, one-half of the reporting limit is used for values below the reporting limit to calculate the mean. For example:

Analytical Values	Calculation	Mean Value
10,12,ND(8)	(10+12+[8/2])/3	8.7

By our convention, the calculated mean cannot be smaller that the largest reporting limit value. In the following example, the calculated mean is 2.8. This is less than the largest reporting limit, so the reported mean becomes ND(4).

Analytical Values	Mean Value
5,ND(4), ND(3)	ND(4)

- When all analytical results are less then the reporting limit, the presented value is the largest reporting limit value expressed as "ND (the largest reporting limit value)."

3.2.3 Summation of Multiple Train Fractions

Some sample trains, such as mercury in the metals train, are analyzed in multiple fractions. If all fractions were detected, the total emissions were reported as the sum of the measurements. If all fractions were not detected, total emissions were reported as not detect, less than the sum of the reporting limits of the fractions. If one or more, but not all fractions were not detected, the total is reported as the sum of the detected values and one-half of the reporting limit for the non-detected values.

3.2.4 Method Detection Limit and Reporting Limit

The method detection limit (MDL) is defined by 40 CFR 136, Appendix B - Definition and Procedure for the Determination of the Method Detection Limit - Revision 1. It states, "The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyzed concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte." The MDL is determined by seven replicate analyses of an analyte in a given matrix at one to five times the estimated MDL. It is calculated as:

$$\text{MDL} = 3.143\ S$$

where:

S is the standard deviation of the replicate analyses, and

3.143 is the student "t" value corresponding to seven replicates with n-1 degrees of freedom at the 99% confidence level.

Additional criteria are imposed by the procedure for calculating subsequent method detection limits. In practice, the method detection limit can be impacted by variability in performing the analytical procedure, the sample matrix and the analyte concentration of the sample. Because the method detection limit may not completely specify the confidence an analytical laboratory has in reporting a result, a laboratory typically presents a reporting limit or quantitation limit. The numerical difference between the method detection limit as defined by the CFR and a laboratory's reporting limit varies for different types of analyses and sample matrices but generally varies from the MDL value to approximately three times greater than the MDL. The values presented in this report are all based on individual laboratories' stated reporting limits. Both the detection and the reporting limit are indicated by "ND" in this report.

3.2.5 Assignment of Bias and Uncertainty Estimates

In calculating the uncertainties that are presented in this report, procedures were followed that have been previously established for FCEM data treatment. This procedure involved calculating an overall uncertainty for each result using standard statistical techniques and known measurement biases. An error propagation analysis was performed on calculated results to determine the contribution of process, sampling and analytical variability, and measurement bias, to the overall uncertainty in the result.

Example calculations and bias and uncertainty estimates are presented in Appendix F.

3.3 NATURAL GAS

This section presents the analytical results for natural gas samples. Natural gas sampling and analysis was performed by IGT Analytical. Natural gas sampling was performed on April 6-7, 1993, during Runs 7 and 8.

IGT conducted triplicate on-line measurements of natural gas composition (major and minor components) and higher heating value (HHV) for EPA Method 19 F-factor calculations. In addition to the triplicate composition and HHV analyses, IGT also collected several sample types for trace species analysis. These sample types included a whole gas sample, cryogenic sample trap condensate, a lean gas sample (collected after the cryogenic trap), particulate, pipeline condensate, sorbent tubes and pipeline deposits. These various samples were analyzed for trace species, including metals, oxygenated compounds, nitrogen compounds, halocarbons, sulfur compounds and radon. Analysis for trace species was only conducted once on these various sample types.

Laboratory methods of analysis for many trace species have not been established for natural gas, so IGT has developed a number of internal analysis methods. Samples were screened initially by GC/MS to determine which species were present, and then analyzed for those species using the procedures listed in Appendix A.

Table 3-1 presents the natural gas analysis results for Site 120. Complete results are presented in Appendix B. As noted above, composition and higher heating value determinations were performed in triplicate, while trace species values reflect a single analysis. For those components determined using triplicate on-line analysis, an uncertainty at the 95% confidence interval is also shown in Table 3-1. The confidence interval is the range about the mean in which the true mean lies within a given probability. For instance, it is 95% certain that the true mean ethane value in the natural gas is between 1.69 and 2.01 mole percent.

3.4 FLUE GAS

Table 3-2 summarizes the concentration of the species in the flue gas emitted from the boiler. Additional data are presented in Appendix B. Flue gas flow rates are calculated form the fuel flow and F-factor. For the metals results, the probe and nozzle rinse, filter and nitric acid/hydrogen peroxide impinger catch were all combined before analysis; therefore, the data represent the total (particulate plus vapor phase) metal concentration in the flue gas. The separate fractions were combined to lower the reporting limits. Mercury results were obtained by analyzing the permanganate impinger solution and an aliquot from the front half and nitric acid/hydrogen peroxide impinger solution. These results were added together to provide the total mercury concentration.

The toluene result from Run 8C was not included in the average because it was anomalously high compared to the other toluene measurements made during this test program.

The total concentrations from the three runs were averaged according to the convention outlined previously to obtain an overall mean concentration and the uncertainty at the 95% confidence interval. Appendix F contains detailed descriptions of bias estimates and uncertainty calculations.

3.5 EMISSION FACTORS

Table 3-3 presents mean emission factors, expressed as lb/10^{12} Btu, for Site 120.

The metals with the highest emission factors were barium, chromium, nickel and vanadium at 2.4, 1.1, 3.6 and 3.2 lb/10^{12} Btu, respectively. Emission factors for the other metals ranged from 0.01-0.58 lb/10^{12} Btu.

Of the PAH target species, only naphthalene, phenanthrene, fluoranthene, pyrene and 2-methylnaphthalene were detected. Their emission levels ranged from 0.003-0.24 lb/10^{12} Btu. Other PAH species were not detected in the range of 0.001-0.016 lb/10^{12} Btu.

Formaldehyde had the highest emission value of the volatile organic species at 11.9 lb/10^{12} Btu. Toluene emission levels were 2.2 lb/10^{12} Btu, and benzene was not detected.

TABLE 3-1
NATURAL GAS ANALYSIS FOR SITE 120

Parameter	Mean	95% C.I.
Fuel Flow Rate (Baseline), kscfhr at 68°F	6,537	9.0
Moisture, ppm	200	NC
Oxygen, ppm	2.9	NC
Helium, mole%	0.033	0.001
Hydrogen, mole%	0.002@	0.0
Nitrogen, mole%	1.00	0.32
Carbon Dioxide, mole%	0.58	0.67
HHV, Btu/scf at 68°F	1,002	2.8
Hydrocarbons, mole% (1)		
Methane	96.2	0.9
Ethane	1.85	0.16
Propane	0.195	0.186
i-Butane	0.025	0.010
n-Butane	0.031	0.023
neo-Pentane	0.0006@	NC
i-Pentane	0.01	0.0
n-Pentane	0.01	0.0
C6 & Heavier	0.021	0.005
Aliphatics, ppm		
Cyclopentane	7	NC
Hexanes	76	NC
Methyl cyclopentane	20	NC
Cyclohexane	20	NC
Heptanes	40	NC
Methyl cyclohexane	19	NC
Octanes	13	NC
Nonanes	2.6	NC
Decanes	1.8	NC
Undecanes	1.3	NC
Dodecanes	0.6	NC
Tridecanes	0.1@	NC
Tetradecanes	ND(0.1)	NC

ND( ) - species not detected at the reporting limit. (continued)

@ - species detected at less than five times the reporting limit.

NC - Not calculated; only one analysis performed for this species.

Notes:

(1) Results (with the exception of neopentane) from triplicate on-line fuel composition analyses performed on-site.

(2) Only a qualitative or semi-quantitative analysis can be performed on these elements.

(3) Other metals include: antimony, germanium, iron, silicon, and tin.

TABLE 3-1 (continued)
NATURAL GAS ANALYSIS FOR SITE 120

Parameter	Mean	95% C.I.
Aromatics, ppm		
Benzene	6	NC
Toluene	6	NC
Ethylbenzene	0.3@	NC
Xylenes	1.0	NC
C3-benzenes	0.1@	NC
Naphthalenes	ND(0.1)	NC
PAH	ND(0.02)	NC
Sulfur Compounds, ppm		
Hydrogen sulfide	0.02@	NC
Carbonyl sulfide	0.17	NC
Carbon disulfide	ND(0.02)	NC
Methyl mercaptan	0.03@	NC
Ethyl mercaptan	ND(0.02)	NC
i-Propyl mercaptan	ND(0.02)	NC
n-Propyl mercaptan	ND(0.02)	NC
t-Butyl mercaptan	0.93	NC
Dimethyl sulfide	0.02@	NC
Methyl ethyl sulfide	ND(0.02)	NC
Diethyl sulfide	ND(0.02)	NC
Methyl ethyl disulfide	ND(0.02)	NC
Diethyl disulfide	ND(0.02)	NC
Methyl i-propyl disulfide	ND(0.02)	NC
Ethyl i-propyl disulfide	ND(0.02)	NC
Ethyl n-propyl disulfide	ND(0.02)	NC
i-Propyl n-propyl disulfide	ND(0.02)	NC
Di-i-propyl disulfide	ND(0.02)	NC
i-Propyl t-butyl disulfide	ND(0.02)	NC
Ethyl t-butyl disulfide	ND(0.02)	NC
Di-t-butyl disulfide	ND(0.02)	NC
Thiophane	0.21	NC
Other target compounds	ND(0.02)	NC
Halocarbons, ppm		
35 target compounds	ND(0.1)	NC
PCB	ND(0.01)	NC

ND( ) - species not detected at the reporting limit.

(continued)

@ - species detected at less than five times the reporting limit.

NC - Not calculated; only one analysis performed for this species.

Notes:

(1) Results (with the exception of neopentane) from triplicate on-line fuel composition analyses performed on-site.

(2) Only a qualitative or semi-quantitative analysis can be performed on these elements.

(3) Other metals include: antimony, germanium, iron, silicon, and tin.

TABLE 3-1 (continued)
NATURAL GAS ANALYSIS FOR SITE 120

Parameter	Mean	95% C.I.
Nitrogen Compounds, ppm		
Ammonia	ND(4)	NC
17 target compounds	ND(0.5)	NC
Oxygenated Compounds, ppm		
Methanol	28	NC
Acetaldehyde	ND(1)	NC
Acetone	ND(1)	NC
Other 14 target compounds	ND(1)	NC
Elements/Compounds		
Total Arsenic, μg/m3	ND(2)	NC
Total Mercury, μg/m3	ND(0.01)	NC
NO, ppm	0.1@	NC
NOx, ppm	ND(0.3)	NC
Radon, pCi/L	2@	NC
Metals and Anion Precursors, ppm		
Cobalt (2)	ND(0.1)	NC
Copper (2)	ND(0.05)	NC
Lead (2)	ND(0.1)	NC
Nickel	ND(0.05)	NC
Selenium	ND(0.002)	NC
Phosphorus	ND(0.01)	NC
Chlorine	ND(0.2)	NC
Fluorine	ND(1)	NC
Bromine	ND(0.1)	NC
Other metals (3)	ND	NC

ND( ) - species not detected at the reporting limit.
@ - species detected at less than five times the reporting limit.
NC - Not calculated; only one analysis performed for this species.
pCi/L - picocuries per liter or 3.7 disintegrations per minute per liter.
Notes: (1) Results (with the exception of neopentane) from triplicate on-line fuel composition analyses performed on-site.
(2) Only a qualitative or semi-quantitative analysis can be performed on these elements.
(3) Other metals include: antimony, germanium, iron, silicon, and tin.

TABLE 3-2
STACK GAS COMPOSITION DATA AT SITE 120

Substance/Stream	Run 7	Run 8	Run 9	Average	Field Blank[1]	95% C.I.
Exhaust Gas Stream Flow Rates,[2]						
dscfm	1,101,834	1,089,522	1,114,648	1,102,001		31,213
Nm^3/hr	1,744,398	1,724,906	1,764,685	1,744,663		49,416
Metals, ug/Nm^3						
Arsenic	0.73	0.21F	0.23F	0.39F	0.23	0.72
Barium	4.9F	3.4F	4.2F	4.2F	4.8	1.8
Beryllium	ND(0.01)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	NC
Cadmium	ND(0.04)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	NC
Chromium	1.8	1.3	2.3	1.8	0.34	1.2
Cobalt	0.30@	0.15@	0.16@	0.20@	ND(0.15)	0.20
Copper	0.39BF	0.27BF	0.59BF	0.42BF	0.37	0.41
Lead	0.48F	0.47F	0.44F	0.46F	0.34	0.06
Manganese	0.66F	0.52@F	0.77F	0.65F	1.0	0.31
Mercury	ND(0.57)	ND(0.59)	ND(0.56)	ND(0.59)	ND(0.23)	NC
Molybdenum	0.94F	0.96F	1.1F	0.99F	0.85	0.19
Nickel	6.7	4.6	7.0	6.1	0.76	3.3
Selenium	ND(0.04)	ND(0.04)	ND(0.04)	ND(0.04)	ND(0.04)	NC
Phosphorous	ND(0.89)	ND(0.91)	ND(0.94)	ND(0.94)	ND(0.91)	NC
Vanadium	6.3	4.4	5.6	5.4	0.41	2.3

(continued)

ND( ) - Not detected at less than the reporting limit.
NC - Not calculated.
@ - Concentration is less than five times the reporting limit.
B - Blank correction exceeded 50% of uncorrected result.
F - Field blank exceeded 50% of uncorrected result.
(1) Field blank levels shown for metals results only.
(2) Exhaust gas stream flow rates for each run are the average flow rates per test run calculated from the fuel flow and F-factor

TABLE 3-2 (continued)
STACK GAS COMPOSITION DATA AT SITE 120

Substance/Stream	Run 7	Run 8	Run 9	Average	95% C.I.
PAH, ug/Nm³					
Naphthalene	0.56F	0.32F	0.34F	0.40F	0.33
Phenanthrene	0.017	0.013@	0.018	0.016	0.007
Fluoranthene	0.010@	ND(0.004)	ND(0.005)	0.005@	0.011
Pyrene	0.016@	0.005@	0.004@	0.008@	0.016
2-Methylnaphthalene	0.016	0.008	0.022	0.015	0.017
VOC, ug/Nm³	Run 8A	Run 8B	Run 8C		
Benzene	ND(0.70)	ND(0.70)	ND(0.70)	ND(0.70)	NC
Toluene	6.1	1.4@	$30.2^{(3)}$	3.8	30.8
Formaldehyde	7.0F	9.1F	7.8F	8.0F	6.9

ND( ) - Not detected at less than the reporting limit.
NC - Not calculated.
@ - Concentration is less than five times the reporting limit.
B - Blank correction exceeded 50% of uncorrected result.
F - Field blank exceeded 50% of uncorrected result.
Note:
VOC Runs 8A, 8B, and 8C performed during Run 8.
(3) Toluene value for Run 8C not included in average. The confidence interval is calculated based on two measurements.

TABLE 3-3
STACK GAS EMISSION FACTORS AT SITE 120

Exhaust Gas Flow Rate, dscfm(1)	1,102,000	
Fuel Flow Rate, kscfhr at 68°F	6,537	
HHV, Btu/scf at 68°F	1,002	
Substance	lb/10^{12} Btu	95% C.I.
Metals		
Arsenic	0.23F	0.43
Barium	2.4F	1.0
Beryllium	ND(0.01)	NC
Cadmium	ND(0.03)	NC
Chromium	1.1	0.8
Cobalt	0.12	0.12
Copper	0.25F	0.24
Lead	0.27F	0.03
Manganese	0.38F	0.18
Mercury	ND(0.34)	NC
Molybdenum	0.58F	0.11
Nickel	3.6	2.0
Selenium	ND(0.03)	NC
Phosphorus	ND(0.56)	NC
Vanadium	3.2	1.4
PAH		
Naphthalene	0.24F	0.20
Phenanthrene	0.010	0.004
Fluoranthene	0.003	0.007
Pyrene	0.005	0.010
2-Methylnaphthalene	0.009	0.010
VOC		
Benzene	ND(0.40)	NC
Toluene(2)	2.2	17.8
Formaldehyde	11.9F	10.2

(1) Exhaust gas flow rate calculated from the fuel flow and F-factor.
(2) Toluene result excludes Run 8C. The confidence interval is calculated based on two measurements.
ND( ) - Not detected at less than the reporting limit.
NC - Not calculated.
F - Field blank exceeded 50% of average uncorrected result.

SECTION 4.0

UNIT OPERATION AND VOC EMISSIONS

This section summarizes the data collected at Site 120 during tests conducted to determine the effect of unit operation (load and excess air) on benzene, toluene, formaldehyde and methane/TGNMO (Total Gaseous Non-Methane Organics) emissions. Unit operation during these additional tests (Runs 1 through 6) was discussed in Section 2.3, and the sampling schedule was included in Section 3.1. As with the results from the base test program, sampling, preparation and analytical methods are summarized in Appendix A. Detailed analytical data can be found in Appendices B and C, sampling data are located in Appendix D and quality assurance measurements are summarized in Appendices G and H.

4.1 TEST OVERVIEW

In order to determine if emissions of volatile organic compounds are impacted by operating changes that impact the combustion process, three tests (Runs 1, 2, and 3) were performed at minimum load, and three tests (Runs 4, 5 and 6) were performed at maximum load.

Minimum load was selected as the first alternate test condition since it is a common operating condition for utility boilers, and because it produces the lowest flame and furnace temperatures that would normally be observed in the boiler. Excess air level, FGR level and BOOS were the three variables chosen to be changed for the minimum load tests. These variables are commonly controlled to minimize NO_x emissions from utility boilers. The minimum load tests were conducted at an average load of 134 MW gross (20% of full load). Boiler exit O_2 levels were 8.30, 6.56 and 7.75% for Runs 1, 2 and 3, respectively.

Maximum load was selected as the second alternate test condition since it produces the highest flame and furnace temperatures that would normally be observed in the boiler. FGR level and BOOS were the two variables chosen to be changed for the maximum load tests. It was not possible to vary the excess air level at maximum load due to the possibility of exceeding the NO_x emission limit for the boiler. The maximum load tests were conducted at an average load of 697 gross MW (103% of full load). Boiler exit O_2 levels were 1.49 and 1.68% for Runs 4 and 6, respectively. Boiler exit O_2 was not available for Run 5.

Unit operating data were collected once for each test condition. Detailed unit operating data are presented in Appendix E.

4.2 FLUE GAS

Table 4-1 presents the stack gas concentrations of benzene, toluene, formaldehyde and methane/TGNMO for the three minimum load and three maximum load tests. For reference, the concentrations of benzene, toluene and formaldehyde from the base test program at full load are also included. Methane/TGNMO were not determined for the base test program.

The total concentrations from each run were averaged according to the convention outlined previously to obtain an overall mean concentration and the uncertainty at the 95% confidence interval. Appendix F contains detailed descriptions of bias estimates and uncertainty calculations.

TABLE 4-1
STACK GAS VOC DATA AT SITE 120

Substance/Stream				Average	95% C.I.
VOC, ug/Nm^3					
Full Load, Normal O_2 (679 MW, 1.78% O_2)(1)	Run 8A	Run 8B	Run 8C		
Benzene	ND(0.70)	ND(0.70)	ND(0.70)	ND(0.70)	NC
Toluene	6.1	1.4@	30.2	3.8	30.8
Formaldehyde	7.0F	9.1F	7.8F	8.0F	6.9
Minimum Load, Normal O_2, Normal FGR, 8 BOOS (133 MW, 8.30% O_2)(1)	Run 1A	Run 1B			
Benzene	0.73@	ND(0.70)		ND(0.70)	NC
Toluene	4.3	4.1		4.2	1.0
Formaldehyde	2.8@F	2.3@F		2.5@F	3.3
Methane	ND(0.71)	ND(0.71)		ND(0.71)	NC
TGNMO	15.8	15.0		15.4	5.4
Minimum Load, Minimum O_2, High FGR, 8 BOOS (134 MW, 6.56% O_2)(1)	Run 2A	Run 2B			
Benzene	3.3@	1.2@		2.3@	13.6
Toluene	1.5@	1.7@		1.6@	1.3
Formaldehyde	2.8@F	2.7@F		2.8@F	0.9
Methane	ND(0.71)	ND(0.71)		ND(0.71)	NC
TGNMO	8.6	10.5		9.6	11.8
Minimum Load, Normal O_2, High FGR, 12 BOOS (134 MW, 7.75% O_2)(1)	Run 3A	Run 3B			
Benzene	0.73@	1.4@		1.1@	4.5
Toluene	1.6@	2.3@		2.0@	4.8
Formaldehyde	2.5@F	3.0@F		2.7@F	2.5
Methane	ND(0.71)	ND(0.71)		ND(0.71)	NC
TGNMO	10.2	11.8		11.0	10.0

(continued)

Notes:

@ Concentration is less than five times the reporting limit.

F - Field blank exceeded 50% of uncorrected result.

NC - Not calculated.

TGNMO - Total gaseous non-methane organics. Excludes inorganic carbon compounds such as CO and CO_2.

Runs 8A, 8B and 8C performed during Run 8. Run 8C not included in average.

Runs 1A and 1B performed during Run 1.

Runs 2A and 2B performed during Run 2.

Runs 3A and 3B performed during Run 3.

(1) O_2 level at boiler exit, % wet from plant instrumentation.

TABLE 4-1 (continued)
STACK GAS VOC DATA AT SITE 120

Substance/Stream				Average	95% C.I.
VOC, ug/Nm^3					
Full Load, Normal O_2 (679 MW, 1.78% O_2)(1)	Run 8A	Run 8B	Run 8C		
Benzene	ND(0.70)	ND(0.70)	ND(0.70)	ND(0.70)	NC
Toluene	6.1	1.4@	30.2	3.8	30.8
Formaldehyde	7.0F	9.1F	7.8F	8.0F	6.9
Maximum Load, Minimum O_2, High FGR, 0 BOOS (708 MW, 1.49% O_2)(1)	Run 4A	Run 4B			
Benzene	0.80@	2.2@		1.5@	9.0
Toluene	4.0@	1.3@		2.7@	17.4
Formaldehyde	4.5@F	4.7@F		4.6@F	0.8
Methane	ND(0.71)	ND(0.71)		ND(0.71)	NC
TGNMO	69.6	15.8		42.7	341.3
Maximum Load, Minimum O_2, Low FGR, 0 BOOS (689 MW, 2.22% O_2)(2)	Run 5A	Run 5B			
Benzene	1.4@	1.1@		1.3@	2.3
Toluene	2.1@	2.1@		2.1@	0.3
Formaldehyde	7.8F	6.8F		7.3F	6.0
Methane	ND(0.71)	ND(0.71)		ND(0.71)	NC
TGNMO	18.7	19.8		19.3	7.3
Maximum Load, Minimum O_2, Normal FGR, 2 BOOS (693 MW, 1.68% O_2)(1)	Run 6A	Run 6B			
Benzene	1.0@	0.77@		0.89@	1.6
Toluene	1.4@	1.3@		1.3@	0.8
Formaldehyde	7.3F	7.3F		7.3F	0.9
Methane	ND(0.71)	ND(0.71)		ND(0.71)	NC
TGNMO	13.4	18.9		16.2	35.0

Notes:

@ Concentration is less than five times the reporting limit.

F - Field blank exceeded 50% of uncorrected result.

NC - Not calculated.

TGNMO - Total gaseous non-methane organics. Excludes inorganic carbon compounds such as CO and CO_2.

Runs 8A, 8B and 8C performed during Run 8. Toluene result for Run 8C not included in average.

Runs 4A and 4B performed during Run 4.

Runs 5A and 5B performed during Run 5.

Runs 6A and 6B performed during Run 6.

(1) O_2 level at boiler exit, % wet from plant instrumentation.

(2) O_2 level at air preheater inlet, % dry from CEM.

SECTION 5.0

DATA EVALUATION

Several procedures can be used to evaluate the information developed during a field sampling program. In the case of Site 120, three methods were used to evaluate data quality. First, the process operation data were examined to determine if the unit operated at normal, steady-state conditions during the sampling periods. Second, the QA/QC protocol for sampling and analytical procedures used at Site 120 (i.e., equipment calibration and leak checks, duplicates, blanks, spikes, standards, etc.) was evaluated. Site 120 QA/QC data were compared with FCEM project objectives. Data quality was evaluated using QA/QC measurements that assess bias, accuracy and precision, such as blank measurement, matrix spike recoveries, surrogate recoveries, replicate runs and laboratory control duplicates. Third, trace metal material balances were calculated around the boiler. Material balances involve the summation and comparison of mass flow rates in several streams often sampled and analyzed by different methods. Closure of material balance within an acceptable range can be used as an indicator of accurate results for the fuel and the boiler outlet stream.

5.1 PROCESS OPERATION

Process operating data were examined to ensure that operation was stable during sampling periods. Measurements were taken from control room instrumentation. Boiler operating data were collected several times during each test. Table 5-1 shows the key unit operating parameters and conditions for the base test program. The coefficient of variation (CV), defined as the standard deviation of the measurements divided by the mean of the measurements, was calculated for each parameter to evaluate process variability over the three days of testing.

Steady boiler operation was maintained during the base test program, as indicated by the low CVs for load, air flow, fuel flow, feedwater flow and oxygen levels.

5.2 SAMPLE COLLECTION

Several factors indicate the acceptable collection of gas samples. Key components of the sampling equipment—pitot tubes, thermocouples, dry gas meters, and sampling nozzles—were calibrated before use in the field. Dry gas meter calibrations were checked at the end of sampling. These and additional periodic equipment calibrations are on file at Carnot. The methods used to collect metals, PAH, and volatile organic compounds were comparable to those used at other FCEM sites. All sampling runs were well-documented, and isokinetic flue gas

TABLE 5-1
SUMMARY OF UNIT OPERATION
SITE 120

Date	4/6/93	4/7/93	4/8/93	Mean	CV(1)
Unit Load, MW gross	681	678	678	679	0.25%
Air Flow into boiler, MMscfh	58	59	58	58	1.0%
Fuel Gas Flow, kscfh at 60°F	6,440	6,441	6,434	6,438	0.06%
Feedwater Flow, MMlb/hr	5.24	5.25	5.24	5.24	0.1%
O_2, % dry, APH inlet	2.01	2.14	2.24	2.13	5%

(1) The coefficient of variation (CV) is the standard deviation divided by the mean. For this test program unit operating parameters exhibiting a CV of 5% or less were considered indicative of stable operation.

samples for the base test program were collected at rates between 95 and 105% isokinetic. Typical flue gas conditions at full load during the base test program were 3.08% oxygen, 17.7% moisture, 284°F and calculated flow rates of approximately 1,102,000 dscfm. The values are typical of a natural gas-fired utility boiler of this size and design.

Sufficient data were collected using standard sampling and analysis methods to ensure acceptable data completeness and the comparability of measurements. Major differences from other FCEM programs were that benzene and toluene samples were collected according to CARB Method 410A in Tedlar bags and formaldehyde samples were collected non-isokinetically according to CARB Method 430 in midget impingers containing 2,4-dinitrophenylhydrazine.

Flue gas was sampled at the eight available test ports on the two air preheater outlet ducts. Four vertical ports were available per duct. This sampling location did not meet EPA Method 1 requirements for minimum distances from flow disturbances. Three-dimensional velocity testing indicated that the location did meet EPA Method 1, Section 2.5 criteria of ≤20 degrees resultant angle and ≤10 degrees standard deviation. For the air preheater outlet location, the resultant angle was 9.8 degrees, with a standard deviation of 10 degrees.

Natural gas samples are considered to be representative of the gas fired during the flue gas sampling. Each natural gas sample analyzed for F-factor calculations was a grab sample, with one sample collected at the end of the first baseline testing day, and the remaining two samples collected at the beginning and end of the second baseline testing day.

Calculated exhaust gas flow rates were used for this site. The flow rates are calculated using natural gas usage and fuel F-factor as follows:

Flow rate (dscfm) = fuel usage (scf/hr @ 68°F) x HHV (Btu/scf @ 68°F) x F-factor (dscf/MMBtu @ 0% O_2) x MMBtu/10^6 Btu x 1 hr/60 min x (20.9/(20.9 - %O_2))

where: HHV = 998 Btu/scf @ 68°F, and
F-factor = 8,618 dscf/MMBtu @ 0% O_2.

This calculation was used to determine exhaust gas flow rates because it was subject to less uncertainty than the flow rates determined by S-type pitot traverse measurements. The natural gas fuel usage was determined from control room instrumentation. On average, the air preheater outlet pitot traverse flow rate results were 0.8% higher than the F-factor flow rates.

Details on sample collection are contained in Appendix A (sampling and analytical summary). Process stream flow rates and conditions during testing are presented in Appendix D.

5.3 EVALUATION OF MEASUREMENT DATA QUALITY

An evaluation of the quality of the measurement data is based on quality control data obtained experimentally during sampling and analysis. Generally, the type of quality control information obtained that pertains to measurement precision, accuracy, and blank effects, is determined using various types of replicate, spiked, and blank samples. The specific characteristics evaluated depend on the type of quality control checks performed. For example, blanks may be prepared at different stages in the sampling and analysis process to isolate the source of a blank effect. Similarly, replicate samples may be generated at different stages to isolate and measure sources of variability. The QA/QC measures commonly used as part of the FCEM data assessment protocol, and the characteristic information obtained, are summarized in Table 5-2. The absence of any of these types of quality control checks from the data reports does not necessarily reflect poorly on the quality of the data, but does limit the ability to measure the various components of measurement error.

As shown in the table, different QC checks provide different types of information pertaining to the sources of inaccuracy, imprecision, or blank effects. As part of the FCEM project, measurement precision and accuracy are typically estimated from QC indicators that cover as much of the total sampling and analytical process as feasible. Precision and accuracy measurements are based primarily on the actual sample matrix. The precision and accuracy estimates obtained experimentally during the test programs are compared with data quality objectives (DQOs) established for the FCEM project.

These DQOs are not intended to be used as validation criteria, but they can be used as empirical estimates of the precision and accuracy that are expected from existing reference

TABLE 5-2
TYPES OF QUALITY CONTROL SAMPLES

QC Activity	Characteristic Measured
Precision	
Replicate samples collected over time under the same conditions	Total variability, including process or temporal, sampling and analytical.
Duplicate field samples collected simultaneously	Sampling plus analytical variability at the actual sample concentrations.
Duplicate analyses of a single sample	Analytical variability at the actual sample concentrations.
Matrix- or media-spiked duplicates	Sampling plus analytical variability at an established concentration.
Laboratory control sample duplicates	Analytical variability in the absence of sample matrix effects
Surrogate-spiked sample sets	Analytical variability in the sample matrix but at an established concentration.
Accuracy	
Matrix-spiked samples	Analyte recovery in the sample matrix, indicating possible matrix interferences and other effects. In a single sample, includes both random error (imprecision) and systematic error (bias)
Media-spiked samples	Same as matrix-spiked samples. Used where a matrix-spiked sample is not feasible, such as certain stack sampling methods.
Surrogate-spiked samples	Analyte recovery in the sample matrix, to the extent that the surrogate compounds are chemically similar to the compounds of interest. Primarily used as an indicator of analytical efficacy.
Laboratory control standards (LCS)	Analyte recovery in the absence of actual sample matrix effects. Used as an indicator of analytical control.
Standard Reference Material	Analyte recovery in a matrix similar to the actual samples
Blank Effects	
Field Blank	Total sampling plus analytical blank effect, including sampling equipment and reagents, sample transport and storage, and analytical reagents and equipment.
Trip Blank	Blank effects arising from sample transport and storage. Typically used only for volatile organic compound analyses.
Method Blank	Blank effects inherent in analytical method, including laboratory reagents and equipment.
Reagent Blank or Field Reagent Blank	Blank effects from reagents used during sampling and analysis.

measurement methods. Although analytical precision and accuracy are relatively easy to quantify and control, sampling precision and accuracy are unique to each site and each sample matrix. Data that do not meet these objectives are not necessarily unacceptable. Rather, the intent is to document the precision and accuracy actually obtained; the objectives serve as benchmarks for comparison. The effects of not meeting the objectives should be considered in light of the intended use of the data.

5.4 ANALYTICAL QUALITY CONTROL RESULTS

Table 5-3 summarizes the types of quality control data reported for Site 120. The results of these analyses are summarized in Appendices G and H. Table 5-4 presents a summary of precision and accuracy measurements. Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of the sampling procedure.

Based on quality control data evaluated, the majority of the results met the project objectives.

The following potential problems were highlighted by the quality control data:

- Because of low metals emissions expected from a gas-fired source, the interpretation of field blank levels becomes more difficult. Although field blank levels for all metals except barium were low (less than 1.07 μg/Nm^3), the field blank level was greater than 50% of the uncorrected sample values for arsenic, barium, copper, lead, manganese and molybdenum.

- The reagent blank for copper was 61% of the uncorrected sample values.

- Field spikes (surrogate spikes) were not added to the XAD-2 resin modules before sampling. Although pre-extraction spikes were acceptable for all PAH species, the lack of field spikes prevents the evaluation of gains or losses of PAH species from field handling.

- Field blank values for naphthalene were 97% of the uncorrected sample values. Naphthalene is a suspected degradation product of a common contaminant in the XAD-2 resin used in the PAH sampling train.

- Field blank levels for formaldehyde were similar to sample levels. The trip spike (spiked reagent brought to the field) indicate a low positive bias. Trip spike recovery was 111%. Because of the low sample levels, any formaldehyde contribution from field conditions can be significant compared to the sample values.

- The toluene blank level was 7.2 μg/Nm^3 compared to sample levels that ranged from 1.4 to 6.1 μg/Nm^3 . The high blank level appears to be an isolated case,

TABLE 5-3
TYPES OF QUALITY CONTROL DATA REPORTED
SITE 120

	Precision					Accuracy				Blank			
Analysis	Replicate Runs	Duplicate Field Samples	Duplicate Laboratory Analysis	Matrix or Media Spiked Duplicate	Laboratory Control Sample Duplicate	Matrix or Media Spike	Surrogate Spike	Laboratory Control Sample	Standard Reference Material	Field Blank	Trip Blank	Laboratory Method Blank	Reagent Blank (Field)
<u>Exhaust Gas</u>													
Metals	✓		✓		✓	✓		✓		✓		✓	✓
Polycyclic Aromatic Hydrocarbons	✓		✓	✓		✓	✓			✓		✓	
Volatile Organic Compounds	✓		✓										✓
Formaldehyde	✓		✓	✓		✓				✓	✓	✓	
<u>Natural Gas</u>													
Major and Minor Components	✓		✓						✓				

TABLE 5-4
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
Site 120

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Metals in Exhaust Gas	Precision - Duplicate Analysis Accuracy - Spiked Samples				
Arsenic		10% RPD	75-125%	61% RPD	92%
Barium		10% RPD	75-125%	1.0% RPD	89%
Beryllium		10% RPD	75-125%	NC	84%
Cadmium		10% RPD	75-125%	NC	80%
Chromium		10% RPD	75-125%	0.6% RPD	83%
Cobalt		10% RPD	75-125%	26% RPD	82%
Copper		10% RPD	75-125%	1.2% RPD	86%
Lead		10% RPD	75-125%	2.9% RPD	78%
Manganese		10% RPD	75-125%	1.5% RPD	82%
Mercury		10% RPD	75-125%	NC	93%
Molybdenum		10% RPD	75-125%	0.8% RPD	82%
Nickel		10% RPD	75-125%	2.7% RPD	74%
Selenium		10% RPD	75-125%	NC	91%
Phosphorus		10% RPD	75-125%	NC	87%
Vanadium		10% RPD	75-125%	0.2% RPD	82%
PAH in Exhaust Gas (detected species)	Precision - Matrix Spike Duplicate Accuracy - Pre-extraction Surrogate Spikes				
Naphthalene		50% RPD	50-150%	NP	71%
Phenanthrene		50% RPD	50-150%	9.9% RPD	89%
Fluoranthene		50% RPD	50-150%	0.0% RPD	89%
Pyrene		50% RPD	50-150%	1.7% RPD	95%
2-Methylnaphthalene		50% RPD	50-150%	NP	NA

Precision for metals was measured as duplicate analyses and replicate runs. Replicate runs results are contained in Appendix G.
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of the sampling procedure.
Accuracy for metals was assessed by post-digestion laboratory spikes.
Precision for PAH analyses also determined by replicate runs (Appendix G).
Accuracy for PAH analyses determined by pre-sampling surrogate spikes (field spikes) and blank matrix spikes.

RPD = Relative Percent Difference.
NA = Not available.
NC = Not calculated; analyte reported as not detected in two or more runs.
NP = Not performed.

(continued)

TABLE 5-4 (continued)
SUMMARY OF PRECISION AND ACCURACY ESTIMATES
SITE 120

Measured Parameter	How Measured	Objectives		Measured	
		Precision	Accuracy	Precision	Accuracy
Formaldehyde in Exhaust Gas	Precision - Replicate Runs Accuracy - Spiked Samples	10% RPD	60-140%	5% RPD	105%
Benzene and Toluene in Exhaust Gas	Precision - Replicate Runs Accuracy - Spiked Samples				
Benzene		20% RPD	70-130%	11% RPD	NP
Toluene		20% RPD	70-130%	18% RPD	NP
Major and Minor Components in Natural Gas	Precision-Replicate Runs Accuracy-Standard Reference Material	10% RPD	10%	0.8% RPD	1.0%

Precision for Formaldehyde also assessed by replicate runs and multiple pre-test reagent blanks (Appendices G and H).
Accuracy as used in this table reflects laboratory recovery and does not reflect the accuracy of procedure sampling.
Accuracy for Formaldehyde determined from laboratory matrix spikes. A trip spike indicated 111% recovery.
Precision for Benzene and Toluene also determined by replicate runs (Appendix F).
RPD = Relative Percent Difference.
NP = Not Performed.

and probably does not represent contamination of the sample.

5.4.1 Metals

Precision

The precision of metals analyses of flue gas samples can be estimated from the results of duplicate laboratory analyses. The precision data on duplicate analyses were compared to the precision objective of <10% RPD.

All metals met this criteria with the exception of arsenic (61%) and cobalt (26%). Beryllium, cadmium, mercury, selenium, and phosphorus were not detected in the fraction analyzed and thus precision could not be calculated.

Precision for metals was also calculated based on replicate runs. This type of precision estimate should be more variable than that obtained from duplicate analyses due to variability in the process and sampling. Precision is calculated in terms of a coefficient of variation CV. The precision data on replicate runs were compared to an objective of <20% CV. Of all the detected elements, only lead (4%), manganese (19%), molybdenum (9%), and vanadium (18%) met this objective.

Accuracy

The accuracy of metals analyses in flue gas was determined from spiked samples. A spike recovery objective of 75-125% is specified by the multi-metals analysis. Typically if the recovery is not within ±25% of nominal and matrix interferences are suspected, the laboratory attempts to analyze the sample using either an alternate instrumental technique or by the method of standard additions (MSA). Arsenic and selenium were analyzed by ICP-AES with hydride generation.

Spike recoveries for all metals except nickel (74%) met the objective.

Blank Effects

Low levels of five metals were found in the reagent blank. Seven metals were found in the laboratory method blank. Blank correction contributions were low or zero, with only arsenic (20%) and copper (61%) exceeding 20%. Field blanks were higher than 50% of the uncorrected measurement for the following detected metals: arsenic (81%), barium (114%), copper (96%), lead (77%), manganese (162%) and molybdenum (86%).

Conclusions

Analysis for nickel had a spike recovery of 74%, which was lower than the objective. Duplicate analysis for arsenic and cobalt resulted in an RPD of 61% and 26%, respectively.

Field blank levels were higher than 50% of the exhaust gas values for arsenic, barium, copper, lead, manganese, and molybdenum.

5.4.2 Polycyclic Aromatic Hydrocarbons

Precision

Five PAH species were detected: naphthalene, phenanthrene, fluoranthene, pyrene, and 2-methylnaphthalene. Precision was determined by duplicate blank matrix spikes. A data quality objective of <50% RPD was set for PAH samples. Phenanthrene, fluoranthene and pyrene met this objective; however, the method blank was not spiked for naphthalene at a level high enough to be distinguished from the concentration in the blank XAD-2 resin. Duplicate matrix spikes were not performed for 2-methylnaphthalene.

Accuracy

The accuracy of the PAH analyses was estimated by the internal recovery of deuterated standards added to each sample before extraction. Acceptable recovery is 50-150%. The recoveries of all PAH species were acceptable, ranging from 60-110%. Field spikes (surrogate spikes) were not added to the XAD-2 resin modules before sampling. Although pre-extraction spikes were acceptable for all PAH species, the lack of field spikes prevents the evaluation of gains or losses of PAH species from field handling.

Blank Effects

All PAH species, except for naphthalene, were not detected in the laboratory method blank at 0.006-0.052 ug per sample. Naphthalene was detected in the method blank at 1.3 μg per sample, which was 70% of the average sample value. Of the detected PAH species, only naphthalene had a field blank level which was higher than 50% of the average uncorrected sample measurements with a value of 97%. Naphthalene is a suspected degradation product of a common contaminant to the XAD-2 resin used in the sampling train (Thomson, R.D., Foster, M.G., "Degradation of XAD-2 Resin In Dry Storage and Its Impact on PAH Analysis," AWMA, 1991). Typically, all samples using this resin are biased high for naphthalene, though it is difficult to evaluate the extent of the high bias.

Conclusion

PAH results are acceptable, however naphthalene field blank levels are greater than 50% of the sample levels which may indicate a high bias in sample results. Field spikes were not added to the resin modules so gains or losses of PAH from field handling cannot be assessed.

5.4.3 Volatile Organic Compounds

Precision

Precision for VOC was calculated based on duplicate analyses of exhaust gas samples, with a DQO of <20% RPD. One benzene duplicate, out of the eight duplicates performed, exceeded the DQO with a value of 26% RPD. Three toluene duplicates, out of the eight duplicates performed, exceeded the DQO with values of 33, 22 and 35%. The high RPD's are typical when analyzing concentration levels at or near the reporting limit.

Accuracy

Matrix spikes were not performed.

Blank Effects

Benzene was not detected in the Tedlar bag blank, while toluene was detected at a concentration of 7.2 $\mu g/Nm^3$. This exceeded the objective of <2.1 $\mu g/Nm^3$; however, this appears to be an isolated case, and does not appear to represent field contamination because most of the toluene measurements were below this level. Blank levels were not subtracted to obtain final sample results.

Conclusion

Precision for VOC analysis did not meet the objective for one of the eight benzene and three of the eight of the toluene samples performed. The accuracy of the analysis is uncertain due to a lack of sample spikes. Blanks levels were acceptable for benzene, but not toluene. However, most samples contained levels of toluene at much lower levels than the blank, and the high blank value appears to be an isolated case and is not an indication of laboratory contamination.

5.4.4 Methane and Total Gaseous Non-Methane Organics

Precision

Precision for methane/TGNMO samples is determined by duplicate analysis, with a data quality objective of <20% RPD. Methane was not detected in any of the samples at limit of 1 ppm, and therefore precision could not be calculated. The two TGNMO duplicates performed met the DQO of <20% with an average RPD of 0.65%.

Accuracy

Matrix spikes were not performed.

Blank Effects

Blanks were not performed.

Conclusion

Precision for Methane/TGNMO analysis met the objective for all samples. The accuracy of the analysis could not be assessed for this test series due to a lack of sample spikes. Blanks levels were not determined.

5.4.5 Formaldehyde

Precision

Precision was determined by duplicate analysis of formaldehyde samples. All five duplicate analyses performed met the DQO of <10% RPD with a range of 0% to 8.7%.

Accuracy

The accuracy of the analysis was estimated from matrix spike recoveries. Matrix spike recoveries averaged 105%. Field and trip spikes were also collected. A field spike is a vial of DNPH solution spiked with formaldehyde that is connected to the sampling equipment, leak checked, and recovered. Field spike recovery was 121%. A trip spike is a spiked vial of DNPH solution that is never opened. Trip spike recovery was 111%. All spike recoveries met the DQO of 60-140%.

Blank Effects

Sample values are not corrected for reagent blank values of DNPH or for field blank levels. Field blank levels were consistently at or above sample levels. Reagent blank levels were 12% of the average sample value.

Conclusion

Sample precision and accuracy met the data objective. Field blank levels are at or above many of the samples. Other quality assurance indicators for formaldehyde, such as the trip and field spikes, indicate a low positive bias. Because of the low sample levels any formaldehyde contribution from field conditions can be significant compared to the sample values.

5.4.6 Fuel Composition Analysis

Precision

Precision is determined by duplicate analysis of the natural gas fuel samples. The data quality objective for this analysis is 10% RPD. The average RPD for detected species was

0.82%, with all species meeting the objective. Additional evidence of sample precision can be provided by replicate sample analysis, with a DQO of <20% CV. The average CV for the on-site analysis of the three fuel replicates was 13.2% CV. All species met the objective with the exception of propane (39%), n-butane (30%), and CO_2 (46%).

Accuracy

Accuracy is estimated by analysis of a laboratory check standard. The average RPD for analysis of this standard was 1.2%, and all species met the data quality objective of 10% RPD. No matrix spikes were performed.

Blank Effects

No blank analysis was performed.

Conclusion

Precision for fuel analysis was acceptable. A laboratory check standard met the recovery objective. No blank analysis was performed.

5.5 STACK SAMPLING QUALITY CONTROL RESULTS

Sampling quality control was well documented in this program. It included calibration sheets for most of the equipment used, including the gas meters, portable O_2 meters, and CEM calibration. Also on file are calibrations for temperature indicators and pitot assemblies. Gas meters are calibrated before and after sampling and can differ no more than 3% from the original meter calibration. The sampling data were evaluated and comments were made on the sampling data sheets about the sampling locations, techniques used, and specific tests comments. In general, a methodical and conservative approach was employed to collect the samples according to the specifications.

The precision of the sampling can be estimated by comparing results for various parameters of the replicate samples, notably velocity, moisture content, and gas composition. A comparison of the measured flow rate to calculated flow rates from F-factor determination was made. Average measured flow rates were 0.8% higher than the calculated flow rates.

The accuracy of the sampling is usually assumed from the calibration and proper operation of the equipment and from historical validation of the methods. Field blanks were used to assess any biases that may be caused by contamination of the equipment, location, or operator errors. Field blank values were not subtracted from tests results. Field blanks were performed for all tests except the VOC trains. Reagent blanks were collected for all tests except the PAH tests, where laboratory reagent blanks were used.

5.6 MATERIAL BALANCE RESULTS

At Site 120, only two streams were used to define material balance: natural gas fuel and exhaust gas stack samples. Closure is defined as the ratio of output to input mass. A 100% closure indicates perfect agreement of the measured input and output mass flow rates. No species was detected in both the natural gas fuel and the exhaust gas, therefore a mass balance could not be computed for trace elements.

SECTION 6.0

EXAMPLE CALCULATIONS

This section presents the methodology and sample calculations used to develop the results presented in Sections 3.0 and 4.0. Specifically, the calculation of stream flow rates, confidence intervals and unit-energy-based results are discussed. Appendix D contains detailed calculation procedures for calculating emissions concentrations from sample train, analytical and CEM data.

6.1 STREAM FLOW RATES

Appendix D presents information about the stream flow rates measured or calculated at Site 120 during the sampling period.

Stack gas flow rates were calculated from natural gas flow, higher heating value and fuel F-factor, as described in Section 5.2. Although flue gas flow rates were measured directly during isokinetic sampling, the calculated flow rate is considered to be more accurate for this location.

Natural gas flow rates were determined using control room instrumentation.

6.2 MEANS AND CONFIDENCE INTERVALS FOR STREAM CONCENTRATIONS

The mean concentrations and 95% confidence intervals (CIs) about the mean were calculated for each target substance in the streams sampled. The means were calculated according to the conventions listed in Section 3.0. The equations used to calculate the 95% confidence intervals are presented in Appendix F.

Example calculations for naphthalene in the flue gas follow here; these results were shown in Table 3-3.

The concentration data (in $\mu g/Nm^3$) given for naphthalene in Table 3-3 are:

Run 7	Run 8	Run 9
0.56	0.32	0.34

The mean is calculated from the individual run totals:

Mean = (0.56 + 0.32 + 0.34)/3 = 0.40

The sample standard deviation of the individual run totals is calculated:

$$S_p = \sqrt{[(0.56-0.40)^2 + (0.32-0.40)^2 + (0.34-0.40)^2]\ /2} = 0.133$$

The standard deviation of the average is calculated according to the equation in Appendix F for N = 3:

$$S_{\overline{pi}} = 0.133/\sqrt{3}$$

$$= 0.077$$

The bias error is found by root-sum-squaring the product of the bias error and the sensitivity from each run (see Appendix F). According to the conventions listed in Section 3.0, no bias error is assigned to values above reporting limits, whereas a bias error of one-half the reporting limit is assigned to values below reporting limits. Since all values are above the detection limit, no bias errors are assigned to each of the three values. The sensitivity of the mean to each run in this case is 1/3. An additional bias of 5% of the average sample value or 0.02 is introduced because of the difference in particle collection from ideal conditions during isokinetic tests.

$$\beta_r = \sqrt{((1/3\ x\ 0)^2 + (1/3\ x\ 0)^2 + (1/3\ x\ 0)^2)^2 + (0.02)^2}$$

$$= \sqrt{(0)^2 + (0.02)^2}$$

$$= 0.02$$

The total uncertainty in the result is found from:

$$U_r = \sqrt{\beta_r^2 + (t \; x \; S_p)^2}$$

$$= \sqrt{(0.02)^2 + (4.3 \; x \; 0.077)^2}$$

$$= 0.33$$

Thus, the naphthalene result is reported as 0.40 ± 0.33 μg/Nm^3.

6.3 UNIT ENERGY EMISSION FACTORS

In addition to the gas-phase concentrations, unit-energy-based emission factors expressed as lb/10^{12} Btu have been developed for each target substance. These values were determined by calculating the concentration of a substance in the flue gas (lb/ft^3) and multiplying by the fuel F-factor and O_2 correction, according to EPA Method 19.

The equation used for trace species emissions is:

$$lb/10^{12} \; Btu = \mu g/m^3 \times m^3/35.31 \; ft^3 \times 10^6 \mu g/g \times lb/454g$$

$$\times \; F\text{-}factor \; @ \; 0\% \; O_2 \times 10^{-6} \times 20.9/(20.9 - \% \; O_2)$$

The 95% confidence intervals for emission factors were calculated according to the equations presented in Appendix F. For each parameter (concentration, unit heat rate, and unit load) the mean, standard deviation, number of points, and bias estimates were used to calculate the combined uncertainty in the mean emission factors.

SECTION 7.0

GLOSSARY

ASTM	American Society for Testing and Materials
BOOS	Burners-Out-of-Service
Btu	British Thermal Unit
CAAA	Clean Air Act Amendments of 1990
CARB	California Air Resources Board
CEMS	Continuous Emissions Monitoring System
CI	Confidence Interval
CV	Coefficient of Variation
CVAAS	Cold Vapor Atomic Absorption Spectrophotometry
DL	Detection Limit
DQO	Data Quality Objective
dscfm	Dry Standard Cubic Feet per Minute (1atm, 68°F)
EPA	U.S. Environmental Protection Agency
FCEM	Field Chemical Emissions Monitoring
FGR	Flue Gas Recirculation
FID/TCA	Flame Ionization Detection with Total Combustion Analysis
GC/AED	Gas Chromatography with Atomic Emission Detection
GC/ELCD	Gas Chromatography with Electroconductivity Detection
GC/FID	Gas Chromatography with Flame Ionization Detection
GC/FPD	Gas Chromatography with Flame Photometric Detection
GC/MS	Gas Chromatography with Mass Spectrometer
GC/SCD	Gas Chromatography with Sulfur Chemiluminescence Detection
GC/TCD	Gas Chromatography with Thermal Conductivity Detection
GFAAS	Graphite Furnace Atomic Absorption Spectrophotometry
GPA	Gas Producers Association
HHV	Higher Heating Value
HPLC	High Pressure Liquid Chromatography
HRGC/FID	High Resolution Gas Chromatography with Flame Ionization Detection
HRGC/LRMS-SIM	High Resolution Gas Chromatography/Low Resolution Mass Spectrometry with Selected Ion Monitoring
IC	Ion Chromatography
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
ICP-Hydride	Inductively Coupled Plasma with Hydride Generation
ID	Induced Draft
LCS	Laboratory Check Standards
MMBtu	Million British Thermal Units

MW	Megawatt
NC	Not Calculated
ND	Not Detected
NIST	National Institute of Standards and Technology
Nm^3	Dry Normal Cubic Meter (0°C, 1atm)
NM	Not Measurable
NP	Not Performed
NR	Not Reported
OFA	Overfire Air
PAH	Polycyclic Aromatic Hydrocarbons
PISCES	Power Plant Integrated Systems Chemical Emission Study
ppmc	Parts per million corrected to 3% O_2
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
RPDM	Relative Percent Difference from the Mean
TGNMO	Total Gaseous Non-Methane Organics
UOM	Unit of Measure

APPENDIX A

SAMPLING AND ANALYTICAL SUMMARY

This appendix presents the methods used to collect, preserve and analyze each type of sample collected at Site 120. Summary tables presented include the following:

A-1	Reference Table for Sampling Methods
A-2	Air Preheater Outlet Test Schedule
A-3	3-D Velocity Summary for Air Preheater Outlet
A-4	Sampling Train Configurations for Air Preheater Outlet Samples
A-5	Sampling and Analytical Methods for Air Preheater Outlet Samples
A-6	Sampling Schedule for Natural Gas Samples
A-7	Analytical Methods for Natural Gas Samples
A-8	Sample Handling and Preparation Procedures

Descriptions of the flue gas sampling trains and fuel sample collection methods follow the summary tables.

TABLE A-1
REFERENCE TABLE FOR SAMPLING METHODS
SITE 120

Stream	Target Substances	Collection Method
Air Preheater Outlet	Metals: As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Hg, Mo, Ni, P, Se, V	EPA Multi-Metals
	Polycyclic Aromatic Hydrocarbons	CARB 429
	Benzene, Toluene, Methane/TGNMO	CARB 410A (bags)
	Formaldehyde	CARB 430
Air Preheater Inlet	NO_x, CO, O_2, CO_2	EPA 7E, 10, 3A
Natural Gas	Metals, higher heating value, hydrocarbons, non-hydrocarbons, sulfur compounds, oxygenated compounds, nitrogen compounds, halocarbons, radon	Grab samples

TABLE A-2
AIR PREHEATER OUTLET TEST SCHEDULE
SITE 120

Test No.	Date	Time	Description
1A-FORM	4/4/93	1005/1105	Formaldehyde
1B-FORM	4/4/93	1005/1105	Formaldehyde
1A-VOC	4/4/93	1010/1030	Benzene and Toluene
1B-VOC	4/4/93	1040/1100	Benzene and Toluene
2A-FORM	4/4/93	1355/1455	Formaldehyde
2B-FORM	4/4/93	1355/1455	Formaldehyde
2A-VOC	4/4/93	1400/1420	Benzene and Toluene
2B-VOC	4/4/93	1430/1450	Benzene and Toluene
3A-FORM	4/4/93	1635/1735	Formaldehyde
3B-FORM	4/4/93	1635/1735	Formaldehyde
3A-VOC	4/4/93	1635/1655	Benzene and Toluene
3B-VOC	4/4/93	1710/1730	Benzene and Toluene
4A-FORM	4/5/93	0950/1050	Formaldehyde
4B-FORM	4/5/93	0950/1050	Formaldehyde
4A-VOC	4/5/93	955/1015	Benzene and Toluene
4B-VOC	4/5/93	1025/1045	Benzene and Toluene
5A-FORM	4/5/93	1345/1445	Formaldehyde
5B-FORM	4/5/93	1345/1445	Formaldehyde
5A-VOC	4/5/93	1350/1410	Benzene and Toluene
5B-VOC	4/5/93	1420/1440	Benzene and Toluene
6A-FORM	4/5/93	1645/1745	Formaldehyde
6B-FORM	4/5/93	1645/1745	Formaldehyde
6A-VOC	4/5/93	1650/1710	Benzene and Toluene
6B-VOC	4/5/93	1720/1740	Benzene and Toluene
7-PAH	4/6/93	1145/2030	Polycyclic Aromatic Hydrocarbons
7-MTLS	4/6/93	1145/2030	Metals
8-PAH	4/7/93	1155/1930	Polycyclic Aromatic Hydrocarbons
8-MTLS	4/7/93	1155/1930	Metals
8A-FORM	4/7/93	1415/1515	Formaldehyde
8B-FORM	4/7/93	1550/1650	Formaldehyde
8C-FORM	4/7/93	1725/1825	Formaldehyde
8A-VOC	4/7/93	1435/1455	Benzene and Toluene
8B-VOC	4/7/93	1610/1630	Benzene and Toluene
8C-VOC	4/7/93	1745/1805	Benzene and Toluene
9-PAH	4/8/93	1155/1905	Polycyclic Aromatic Hydrocarbons
9-MTLS	4/8/93	1155/1905	Metals

TABLE A-3
3D VELOCITY SUMMARY
AIR PREHEATER OUTLET
SITE 120

Site:	120	Data By:	DW
Sample Location:	APH Outlet	Barometric Pressure, in. Hg:	30.03
Test No.:	1-3D	Static Pressure, in. Hg:	-0.29
Probe Id No.:	B-2131	Absolute Pressure, in. Hg:	30.01
Unit Load:	Baseline	Average O_2, % dry:	3.00
Test Date:	4/6/93	Average CO_2, % dry:	10.00
Time (Start/Stop):	1820/2045	Moisture Content, %:	17.50
		Molecular Weight, wet:	27.67

Sample Port	Sample Point	Resultant Angle, degrees	Sample Port	Sample Point	Resultant Angle, degrees
1	1	4.9	6	1	25.7
1	2	11.4	6	2	13.9
1	3	0.8	6	3	4.9
1	4	0.8	6	4	3.4
1	5	1.4	6	5	6.2
3	1	34.5	7	1	19.2
3	2	20.9	7	2	17.9
3	3	10.5	7	3	11.8
3	4	8.7	7	4	4.7
3	5	8.7	7	5	11.0
4	1	45.1	8	1	4.8
4	2	0.8	8	2	5.9
4	3	1.7	8	3	5.8
4	4	10.0	8	4	2.3
4	5	13.1	8	5	1.3
5	1	13.0			
5	2	7.0			
5	3	0.8			
5	4	4.1			
5	5	5.1			

<u>Results:</u>

Yaw Angle:	2.7 degrees	Stack Temperature	284°F
Pitch Angle:	0.0 degrees	Velocity*:	44.21 ft/sec
Resultant Angle:	9.8 degrees	Axial Velocity:	43.41 ft/sec
Standard Deviation:	10.0 degrees	*Velocity in direction of flow	

Note: All results are averages for the test.

TABLE A-4
SAMPLE TRAIN CONFIGURATIONS FOR AIR PREHEATER OUTLET SAMPLES
SITE 120

						Impinger Contents				
Sample Train	Nozzle	Filter	Filter Holder	Probe	Sample Line	#1	#2	#3	#4	#5
EPA Multi-Metals Draft Method 29	Glass	Method 5 ultrapure 110 mm filter	Method 5 glass	Glass	Teflon	100 ml 5% HNO_3/ 10% H_2O_2	100 ml 5% HNO_3/ 10% H_2O_2	Empty	100 ml 4% $KMnO_4$/ 10% H_2SO_4	300-400 g silica gel
Semi-VOST CARB 429	Glass	Method 5 toluene-rinsed 110 mm filter	Method 5 glass	Glass	Teflon to XAD-2 resin column	Empty stub-stem	100 ml organic-free D.I. H_2O	Empty	300-400 g silica gel	N/A
Benzene, Toluene, Methane/TGNMO CARB 410A	N/A	N/A	N/A	Glass	Teflon, 1/4"	Sample collected over 30 minutes in Tedlar bag				
						Midget Impingers				
Formaldehyde CARB 430	N/A	47 mm in-stack fiberglass filter to prevent particulate interference	Method 5 Teflon-coated stainless steel	Glass	Teflon, 1/8"	10 ml DNPH	10 ml DNPH	Empty	10-20 ml silica gel	N/A

N/A = Not Applicable
TGNMO = Total Gaseous Non-Methane Organics

TABLE A-5
SAMPLING AND ANALYTICAL METHODS FOR AIR PREHEATER OUTLET SAMPLES
SITE 120

Parameter	No. of Replicates	Duration of Test (Minutes)	Sample Rate	Collection and Preparation Reference Method	Measurement Principle	Analytical Reference Method	Method Detection Limit	Comments
Metals:	3	360	1 m^3/hour	EPA Multi-Metals				
Arsenic					ICP-Hydride	EPA SW486 7061	0.04 $\mu g/m^3$	
Barium					ICP-AES	EPA SW846 6010	0.08 $\mu g/m^3$	
Beryllium					ICP-AES	EPA SW846 6010	0.02 $\mu g/m^3$	
Cadmium					ICP-AES	EPA SW846 6010	0.05 $\mu g/m^3$	
Chromium					ICP-AES	EPA SW846 6010	0.08 $\mu g/m^3$	
Cobalt					ICP-AES	EPA SW846 6010	0.14 $\mu g/m^3$	
Copper					ICP-AES	EPA SW846 6010	0.08 $\mu g/m^3$	
Lead					GFAAS	EPA SW846 7421	0.05 $\mu g/m^3$	
Manganese					ICP-AES	EPA SW846 6010	0.11 $\mu g/m^3$	
Mercury					CVAAS	EPA SW846 7470	0.54 $\mu g/m^3$	
Molybdenum					ICP-AES	EPA SW846 6010	0.11 $\mu g/m^3$	
Nickel					ICP-AES	EPA SW846 6010	0.28 $\mu g/m^3$	
Phosphorus					ICP-AES	EPA SW846 6010	0.04 $\mu g/m^3$	
Selenium					ICP-Hydride	EPA SW486 7741	0.85 $\mu g/m^3$	
Vanadium					ICP-AES	EPA SW846 6010	0.08 $\mu g/m^3$	
Volatile Organic Compounds:	3	30	0.2 ℓ/min	CARB 410A	GC/MS	CARB 410A, EPA TO-14		Collected in Tedlar bags.
Benzene							0.65 $\mu g/m^3$	
Toluene							0.77 $\mu g/m^3$	
Methane/TGNMO							667 $\mu g/m^3$	
Formaldehyde:	3	60	0.07 ft^3/min	CARB 430	HPLC	CARB 430	1.0 $\mu g/m^3$	Collected in midget impingers.

(continued)

TABLE A-5 (continued)
SAMPLING AND ANALYTICAL METHODS FOR AIR PREHEATER OUTLET SAMPLES
SITE 120

Parameter	No. of Replicates	Duration of Test (Minutes)	Sample Rate	Collection and Preparation Reference Method	Measurement Principle	Analytical Reference Method	Method Detection Limit	Comments
Polycyclic Aromatic Hydrocarbons:	3	360	1 m^3/hour	CARB 429	HRGC/LRMS-SIM	CARB 429		
Naphthalene							0.020 μg/m^3	CARB 429 with isotope dilution used where isotopically labeled standards were available.
Acenaphthylene							0.003 μg/m^3	
Acenaphthene							0.001 μg/m^3	
Fluorene							0.002 μg/m^3	
Phenanthrene							0.003 μg/m^3	
Anthracene							0.003 μg/m^3	
Fluoranthene							0.004 μg/m^3	
Pyrene							0.004 μg/m^3	
Benzo(a)anthracene							0.002 μg/m^3	
Chrysene							0.003 μg/m^3	
Benzo(b)fluoranthene							0.002 μg/m^3	
Benzo(k)fluoranthene							0.002 μg/m^3	
Benzo(a)pyrene							0.003 μg/m^3	
Indeno(1,2,3-cd)pyrene							0.005 μg/m^3	
Dibenzo(a,h)anthracene							0.004 μg/m^3	
Benzo(g,h,i)perylene							0.003 μg/m^3	
2-Methylnaphthalene							0.001 μg/m^3	Method of internal standardization used for 2-methylnaphthalene, 3-methylcholanthrene and 7,12 dimethylbenzo(a)anthracene
7,12-Dimethylbenz(a)anthracene							0.011 μg/m^3	
3-Methylcholanthrene							0.004 μg/m^3	

Notes: The metals detection limits are calculated using an average sample volume of 7.04 m^3.
The PAH detection limits are calculated using an average sample volume of 4.95 m^3.
The formaldehyde detection limit is calculated using an average sample volume of 0.10 m^3.
NO_x, CO, O_2 and CO_2 determined in conjunction will all tests by EPA Methods 7E and 3A.
Velocity and moisture measured in conjunction with all isokinetic tests by EPA Methods 2 and 4.

TABLE A-6
SAMPLING SCHEDULE FOR NATURAL GAS SAMPLES
SITE 120

Date	Sample Name	Number of Samples	Time
4/6/93	IGAS 0842	1	1645
4/7/93	IGAS 0843	1	0930
4/7/93	IGAS 0844	1	1620

Note: Samples listed were collected for on-line composition and higher heating value analysis. Additional sample types were collected on 4/7/93 for trace species analysis; however, specific collection times were not provided by IGT.

TABLE A-7
ANALYTICAL METHODS FOR NATURAL GAS SAMPLES
SITE 120

Parameter	Measurement Principle	Reference Method	Method Detection Limit	Comments
Major hydrocarbons	GC/FID, GC/TCD	ASTM D-1945, D-1946	0.001-0.03 mole%	
Non-hydrocarbons (O_2, H_2O, He, H_2, N_2, CO_2 CO)	GC/FID, GC/TCD	ASTM D-1945, D-1946	0.002-0.03 mole% 10 ppm (H_2O)	
C5 + hydrocarbons	HRGC/FID	Modified GPA	0.02-1 ppm	
Sulfur compounds	GC/FPD, GC/SCD		0.02-1 ppm	
Oxygenated compounds	GC/AED, HPLC		0.01-1 ppm	
Nitrogen compounds	GC/AED		0.5-4 ppm	
Halocarbons	GC/ELCD		0.01-1 ppm	
Trace elements	GC/AED		0.002-1 ppm	
NO	Chemiluminescence		0.1 ppm	
NO_x	IC		0.3 ppm	
Radon	Gamma spectroscopy		1 pCi/l	

TABLE A-8
SAMPLING HANDLING AND PREPARATION PROCEDURES
SITE 120

Sample Type	Parameter	Sample Fraction Description	Sample Containers	Sample Handling and Preservation	Laboratory Preparation Procedure
Flue Gas Samples	Metals	Filter	Petri dish	Seal	Parr Bomb HF/HNO_3 digestion
		Front-half nitric peroxide rinse	500 ml acid-washed amber HDPE Nalgene	Seal and mark liquid level	Combine with filter, Parr Bomb digestion
		5% HNO_3/ 10% H_2O_2 impinger rinse	1000 ml acid-washed amber HDPE Nalgene	Seal and mark liquid level	Remove Hg fraction, evaporate remainder at 70°C with excess HNO_3 (pH 1)
		4% $KMnO_4$/10% H_2SO_4 impinger rinse	500 ml acid-washed amber HDPE Nalgene	Seal and mark liquid level	Digest with H_2SO_4
				All fractions: ship at conclusion of metals tests	

(continued)

TABLE A-8 (continued)
SAMPLING HANDLING AND PREPARATION PROCEDURES
SITE 120

Sample Type	Parameter	Sample Fraction Description	Sample Containers	Sample Handling and Preservation	Laboratory Preparation Procedure
Flue Gas Samples	PAH	Filter	Hexane-rinse, foil-lined petri dish	Seal, store at ≤ 4°C	Soxhlett extraction
		XAD-2 column	Not applicable	Wrap with foil to keep XAD-2 from exposure to light. Store at ≤ 4°C	Soxhlett extraction
		Front-half organic rinse	500 ml organic-free amber glass bottle with Teflon-lined lid	Seal and mark liquid level Store at ≤ 4°C	Soxhlett extraction
		Back-half organic rinse	500 ml organic-free amber glass bottle with Teflon-lined lid	Seal and mark liquid level Store at ≤ 4°C	Soxhlett extraction
		Back-half water impinger rinse	500 ml organic-free amber glass bottle with Teflon-lined lid	Seal and mark liquid level Store at ≤ 4°C	Soxhlett extraction
				All fractions: Sample to be extracted within 7 days of sampling; analysis to be performed within 40 days. Ship at conclusion of PAH tests.	
	Benzene, Toluene	Tedlar bag	Not applicable	Seal valve with tape to prevent accidental release of sample. Store bag in light-free container.	Cryogenic pre-concentration
	Formaldehyde	DNPH filtration and line rinse	Organic free DI H_2O washed 40 ml glass sample vials with teflon lined lid	Seal and mark liquid level. Store at ≤ 4°C. Analyze within 7 days. Ship at conclusion of formaldehyde tests.	Extraction

Natural Gas Collection Procedures

Natural Gas

Natural gas sampling and analysis was performed by IGT Analytical. IGT conducted triplicate on-line measurements of natural gas composition (major and minor components) and heating value for EPA Method 19 F-factor calculations. Additional samples were collected and analyzed for the target compounds listed below:

- Non-hydrocarbons: He, H_2, O_2, CO, CO_2, H_2O, As, Hg
- Hydrocarbons: C_1-C_{14} paraffins, C_2-C_3 olefins, BTEX, PAH
- Oxygenated compounds: Acetone, methanol, glycols, aldehydes, phenols, cresols
- Nitrogen compounds: NH_3, NO/NO_x, amines, N-heterocycles
- Halocarbons: Freons and landfill gas components (C_1-C_3, cyclic, aromatic), PCBs
- Sulfur compounds: H_2S, SO_2, COS, CS_2, sulfur odorants and derivatives
- Metals: Volatile compounds of As, Co, Cu, Fe, Ge, Hg, Ni, P, Pb, Sb, Se, Si, Sn
- Others: NORM (naturally occurring radioactive materials including radon)

The characterization and quantification of trace species was not limited to these components. An initial screening of the natural gas determined which components were present and any component found in the initial screening was quantified.

An MCM hygrometer from Stephens Analytical was used for moisture determination in a range of 10 to 6000 ppmv. An on-line Delta F trace oxygen analyzer with an Ascarite scrubber to remove CO_2 was used to measure oxygen in a range of 1 to 1000 ppmv. A Scintrex Model OVD-229 sulfur analyzer was used to monitor odorants and H_2S in natural gas at a concentration level of 0.1 to 10 ppmv.

Samples collected by IGT for laboratory analysis include the following:

- Whole gas samples
- Liquefied fractions (cryogenic sampling train at -70°C)
- Lean gas (after the cryogenic sampler)
- Particulate samples (collected upstream of sampler)
- Pipeline condensate
- Pipeline deposits (from brush-piggings, if available)

Samples were collected on-site using different sampling techniques to preserve and/or preconcentrate the compounds of interest for later analysis in IGT's Chicago laboratory. A 3/8" automatic insertion probe with a 3/4" pipe thread connector from Welker Engineering was used to place the tip of the probe at the center third of the pipeline to assure representative sampling. A proportional sampler from Welker Engineering was also used to sample pipeline gas with a sampling rate of 3 ml/min.

over a long span of time to collect a representative whole gas sample. Gas cylinders internally coated with phenolic resin were used to collect gas samples.

For trace organic constituents a cryogenic system (Figure 2-3), which operates at -70°C (-94°F) and at line pressures up to 12.4 x 10^6 Pa (1800 psig) was employed. The system is designed to condense, preconcentrate and recover hydrocarbons heavier than butanes for later analysis of hydrocarbons up to C_{14}. This cryogenic sampler uses a heat exchange coil made of approximately 10 feet of 1/4 inch O.D. 316 S.S. tubing wound in a helical form, which is attached to a single ended 150-ml 316 S.S. sample cylinder through a Tee connector. The gas flows downward through the coil and cylinder and exists through a straight S.S. tubing. Two valves are installed on the other end of each tubing above the level of chilling fluid.

An immersion cooler (FTS Model FC-100) is used for constant temperature control of the cryogenic bath containing one part of methanol and 3 parts of isopropanol. Dry ice is used to accelerate the cooling rate to bring the initial temperature quickly down to -70°C.

Natural gas samples for inorganic trace element analysis were collected on a variety of solid sorbent tubes. Mercury was collected at a flow rate of 1 L/min using two 6 mm ID sorbent tubes packed with 1% gilded silica beads. Arsenic was collected at a rate of 1 L/min with a 6 mm tube packed with 25% $FeCl_3$. Radon was collected at a rate of 1.2 L/min with two 2 x 3" carbon cartridges.

Stack Sample Collection and Analysis Procedures

Multi-Metals Train

Flue gas samples were withdrawn isokinetically with particulate emissions collected on a heated filter and gaseous emissions collected in a series of iced impingers. The first two impingers contained 5% HNO_3/10% H_2O_2, the fourth impinger contained 4% $KMNO_4$/10% H_2SO_4 and the fifth impinger contained silica gel. The third impinger was empty to prevent the permanganate solution in the fourth impinger from contaminating the first two impingers.

Decomposition of each sample fraction was per the EPA method. Whenever possible, decomposed sample portions were concentrated and combined with regard to preventing loss of volatile metals, to achieve the lowest detection limits possible for these samples. Materials collected in the sampling train were digested with acid solutions to solubilize inorganic target species and to remove organic constituents that may create analytical interferences. Acid digestion of the front-half and filter was performed using conventional Parr Bomb digestion techniques.

Reagent and filter blanks were analyzed for all trace metals. A spiked reagent blank for Hg and spiked reagent blank for all metals was analyzed to assess analytical recovery methods and to ensure that the decomposition procedure was accurate. Following the analysis of the samples and field blanks, a mandatory check for matrix effects and interferences was performed for each metal by spiking one outlet and one inlet sample. The inlet sample spikes were considered representative of the analytical technique because they were spiked at a level comparable to the sample concentrations. If the recovery was less than ±25% of nominal, the sample was run using the method of standard additions or an alternate technique if possible. One duplicate analysis was performed for each metal. A field blank was collected and analyzed from the inlet and the outlet locations. Analyses for the trace metals was performed by ICP-AES, ICP-Hydride, GFAAS, or CVAAS absorption, depending upon the metal of interest.

Semi-Volatile Species

Triplicate samples for PAH were collected according to CARB Method 429 - September 12, 1989 version. In this procedure, a sample was collected isokinetically and passed through a heated filter followed by an XAD-2 sorbent module in a water-cooled condenser. The sorbent module was followed by an impinger train to collect moisture and any species that might pass through the resin.

At the sample location a full field blank train was assembled, recovered and analyzed. During the recovery procedure all glassware was rinsed three times each with organic free methanol, toluene and methylene chloride. The solvent rinses were combined with the filter and sorbent module for extraction and final analysis for each train.

Prior to release to the field, each XAD-2 resin trap was spiked with deuterated standards to assess field losses or gains of PAH species. In addition, sixteen surrogate standards were added to each sample prior to the extraction step to provide recovery corrected results. Deuterated standards were not available for 2-Methylnapthalene, 3-Methylcholanthrene, or 7,12-Dimethylbenzo(a)anthracene; the method of internal standardization was used for these species. Following extraction and cleanup, a portion of the processed extract from each sample was analyzed for PAH by HRGC/LRMS-SIM.

Benzene and Toluene

Tedlar bag samples were drawn simultaneously at a single point in the air preheater outlet ducts. The samples were collected according to CARB 410A using GC/MS as the method of analysis. Duplicate analyses were performed on seven samples. Analysis for methane/TGNMO was performed on the samples taken during the unit evaluation tests by FID/TCA.

Formaldehyde

Triplicate samples for formaldehyde were collected at a single point in the air preheater outlet ducts per CARB Method 430. The flue gas was drawn non-isokinetically through a heated filter and into acidic 2,4 dinitrophenylhydrazine (DNPH) solution contained in midget impingers. The analysis for formaldehyde was performed by reverse-phase HPLC with a UV Detector. The collection solution was analyzed before release to the field to verify that there was no significant level of detectable formaldehyde. All samples were kept cold and sealed. Three field blanks were taken and analyzed by attaching blank vials of DNPH to the sampling equipment and recovering it the same way as a sample. In this way, blank DNPH solution is exposed to the ambient air and the sampling equipment for the same period of time as the sample vials. A field spike that contained 5.0 μg of formaldehyde was prepared, exposed to sampling conditions using the same procedure as the field blanks and analyzed, along with a trip blank and a trip spike (neither of which were opened).

NO_x, CO, O_2 and CO_2

Gaseous species were measured continuously using a multiprobe array in the air preheater inlet duct using a continuous emissions monitoring system. Additionally, portable O_2 meters were used with each sample train to provide sample-specific O_2 data.

Velocity and Moisture

Flue gas velocity and moisture content were measured by EPA Methods 2 and 4 in conjunction with every isokinetic test.

APPENDIX B

FCEM SITE 120 INDIVIDUAL STREAM CONCENTRATIONS

This appendix presents the Site 120 sampling results that were used to calculate the emissions and mass balances presented in this report. Results for the flue gas and for the natural gas are presented.

The following data flags are used in this table:

ND<	Not detected at less than the reporting limit
NA	Not analyzed
@	Concentration is less than five times the reporting limit
B	Blank correction exceeded 50% of uncorrected result
F	Field blank exceeded 50% of uncorrected result

APPENDIX B
SITE 120 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM		Run 7		Run 8		Run 9		Average Used
Stack Gas, Metals	Arsenic	ICP-Hydride	ug/Nm3		0.73		0.21F		0.23F		0.39F
Stack Gas, Metals	Barium	ICP-AES	ug/Nm3		4.9F		3.4F		4.2F		4.2F
Stack Gas, Metals	Beryllium	ICP-AES	ug/Nm3	ND<	0.01	ND<	0.02	ND<	0.02	ND<	0.02
Stack Gas, Metals	Cadmium	ICP-AES	ug/Nm3	ND<	0.04	ND<	0.05	ND<	0.05	ND<	0.05
Stack Gas, Metals	Chromium	ICP-AES	ug/Nm3		1.8		1.3		2.3		1.8
Stack Gas, Metals	Cobalt	ICP-AES	ug/Nm3		0.30@		0.15@		0.16@		0.20@
Stack Gas, Metals	Copper	ICP-AES	ug/Nm3		0.39BF		0.27BF		0.59BF		0.42BF
Stack Gas, Metals	Lead	GFAAS	ug/Nm3		0.48F		0.47F		0.44F		0.46F
Stack Gas, Metals	Manganese	ICP-AES	ug/Nm3		0.66F		0.52@F		0.77F		0.65F
Stack Gas, Metals	Mercury	CVAAS	ug/Nm3	ND<	0.57	ND<	0.59	ND<	0.56	ND<	0.59
Stack Gas, Metals	Molybdenum	ICP-AES	ug/Nm3		0.94F		0.96F		1.1F		0.99F
Stack Gas, Metals	Nickel	ICP-AES	ug/Nm3		6.7		4.6		7.0		6.1
Stack Gas, Metals	Selenium	ICP-Hydride	ug/Nm3	ND<	0.04	ND<	0.04	ND<	0.04	ND<	0.04
Stack Gas, Metals	Phosphorus	ICP-AES	ug/Nm3	ND<	0.89	ND<	0.91	ND<	0.94	ND<	0.94
Stack Gas, Metals	Vanadium	ICP-AES	ug/Nm3		6.3		4.4		5.6		5.4

Stream	Substance	Method	UOM		Run 7		Run 8		Run 9		Average Used
Stack Gas, PAH	Naphthalene	HRGC/LRMS-SIM	ug/Nm3		0.56F		0.32F		0.34F		0.40F
Stack Gas, PAH	Acenaphthylene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.002	ND<	0.002	ND<	0.003	ND<	0.003
Stack Gas, PAH	Acenaphthene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.002	ND<	0.001	ND<	0.003	ND<	0.003
Stack Gas, PAH	Fluorene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.005		0.004@		0.007@	ND<	0.005
Stack Gas, PAH	Phenanthrene	HRGC/LRMS-SIM	ug/Nm3		0.017		0.013@		0.018		0.016
Stack Gas, PAH	Anthracene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.004	ND<	0.002	ND<	0.003	ND<	0.004
Stack Gas, PAH	Fluoranthene	HRGC/LRMS-SIM	ug/Nm3		0.010@	ND<	0.004	ND<	0.005		0.005@
Stack Gas, PAH	Pyrene	HRGC/LRMS-SIM	ug/Nm3		0.016@		0.005@		0.004@		0.008@
Stack Gas, PAH	Benz(a)anthracene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.003	ND<	0.001	ND<	0.002	ND<	0.003
Stack Gas, PAH	Chrysene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.003	ND<	0.003	ND<	0.002	ND<	0.003
Stack Gas, PAH	Benzo(b)fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.003	ND<	0.002	ND<	0.002	ND<	0.003
Stack Gas, PAH	Benzo(k)fluoranthene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.002	ND<	0.001	ND<	0.003	ND<	0.003
Stack Gas, PAH	Benzo(a)pyrene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.002	ND<	0.002	ND<	0.002	ND<	0.002
Stack Gas, PAH	Indeno(1,2,3-cd)pyrene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.003	ND<	0.003	ND<	0.003	ND<	0.003
Stack Gas, PAH	Dibenzo(a,h)anthracene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.002	ND<	0.002	ND<	0.002	ND<	0.002
Stack Gas, PAH	Benzo(g,h,i)perylene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.002	ND<	0.002	ND<	0.002	ND<	0.002
Stack Gas, PAH	2-Methylnaphthalene	HRGC/LRMS-SIM	ug/Nm3		0.016		0.008		0.022		0.015
Stack Gas, PAH	7,12-Dimethylbenz(a)anthracene	HRGC/LRMS-SIM	ug/Nm3	ND<	0.024	ND<	0.023	ND<	0.027	ND<	0.027
Stack Gas, PAH	3-Methylcholanthrene	HRGC/LRMS-SIM	ug/Nm4	ND<	0.003	ND<	0.003	ND<	0.002	ND<	0.003

APPENDIX B
SITE 120 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM	Run 8A	Run 8B	Run 8C	Average Used
Stack Gas, VOC	Benzene, Base Load	GC/MS	ug/Nm3	ND< 0.70	ND< 0.70	ND< 0.70	ND< 0.70
Stack Gas, VOC	Toluene, Base Load	GC/MS	ug/Nm3	6.1	1.4@		3.8

Stream	Substance	Method	UOM	Run 8A	Run 8B	Run 8C	Average Used
Stack Gas, Aldehyde	Formaldehyde, Base Load	HPLC	ug/Nm3	7.0F	9.1F	7.8F	8.0F

APPENDIX B
SITE 120 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM	Run #1 (IGAS 0842)	Run #2 (IGAS 0843)	Run #3 (IGAS 0844)	Average Used
N.G. Fuel, Non-hydrocarbons	Moisture	Hygrometer	ppm				200
N.G. Fuel, Non-hydrocarbons	Oxygen	GC/TCD	ppm				2.9
N.G. Fuel, Non-hydrocarbons	Helium	GC/TCD	mole %	0.034	0.033	0.033	0.033
N.G. Fuel, Non-hydrocarbons	Hydrogen	GC/TCD	mole %	0.002	0.002	0.002	0.002@
N.G. Fuel, Non-hydrocarbons	Nitrogen	GC/TCD	mole %	0.94	1.15	0.92	1.00
N.G. Fuel, Non-hydrocarbons	Carbon Dioxide	GC/TCD	mole %	0.43	0.42	0.89	0.58

Stream	Substance	Method	UOM				Average Used
N.G. Fuel, Hydrocarbons	Methane	GC/FID	mole %	96.5	96.4	95.8	96.2
N.G. Fuel, Hydrocarbons	Ethane	GC/FID	mole %	1.84	1.79	1.92	1.85
N.G. Fuel, Hydrocarbons	Propane	GC/FID	mole %	0.157	0.146	0.281	0.195
N.G. Fuel, Hydrocarbons	i-Butane	GC/FID	mole %	0.024	0.022	0.030	0.025
N.G. Fuel, Hydrocarbons	n-Butane	GC/FID	mole %	0.027	0.025	0.042	0.031
N.G. Fuel, Hydrocarbons	neo-Pentane	GC/FID	mole %				0.0006@
N.G. Fuel, Hydrocarbons	i-Pentane	GC/FID	mole %	ND< 0.01	ND< 0.01	0.01	0.01
N.G. Fuel, Hydrocarbons	n-Pentane	GC/FID	mole %	ND< 0.01	ND< 0.01	0.01	0.01
N.G. Fuel, Hydrocarbons	C6 & Heavier	HRGC/FID	mole %	0.023	0.019	0.021	0.021

Stream	Substance	Method	UOM				Average Used
N.G. Fuel, Aliphatics	Cyclopentane	HRGC/FID	ppm				7
N.G. Fuel, Aliphatics	Hexanes	HRGC/FID	ppm				76
N.G. Fuel, Aliphatics	Methyl cyclopentane	HRGC/FID	ppm				20
N.G. Fuel, Aliphatics	Cyclohexane	HRGC/FID	ppm				20
N.G. Fuel, Aliphatics	Heptanes	HRGC/FID	ppm				40
N.G. Fuel, Aliphatics	Methyl cyclohexane	HRGC/FID	ppm				19
N.G. Fuel, Aliphatics	Octanes	HRGC/FID	ppm				13
N.G. Fuel, Aliphatics	Nonanes	HRGC/FID	ppm				2.6
N.G. Fuel, Aliphatics	Decanes	HRGC/FID	ppm				1.8
N.G. Fuel, Aliphatics	Undecanes	HRGC/FID	ppm				1.3
N.G. Fuel, Aliphatics	Dodecanes	HRGC/FID	ppm				0.6
N.G. Fuel, Aliphatics	Tridecanes	HRGC/FID	ppm				0.1@
N.G. Fuel, Aliphatics	Tetradecanes	HRGC/FID	ppm				ND< 0.1

APPENDIX B
SITE 120 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM		Average Used
N.G. Fuel, Aromatics	Benzene	HRGC/FID	ppm		6
N.G. Fuel, Aromatics	Toluene	HRGC/FID	ppm		6
N.G. Fuel, Aromatics	Ethylbenzene	HRGC/FID	ppm		0.3@
N.G. Fuel, Aromatics	Xylenes	HRGC/FID	ppm		1.0
N.G. Fuel, Aromatics	C3-benzenes	HRGC/FID	ppm		0.1@
N.G. Fuel, Aromatics	Naphthalenes	HRGC/FID	ppm	ND<	0.1
N.G. Fuel, Aromatics	PAH	HPLC	ppm	ND<	0.02

Stream	Substance	Method	UOM		Average Used
N.G. Fuel, Sulfur compounds	Hydrogen sulfide	GC/FPD/SCD	ppm		0.02@
N.G. Fuel, Sulfur compounds	Carbonyl sulfide	GC/FPD/SCD	ppm		0.17
N.G. Fuel, Sulfur compounds	Carbon disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Methyl mercaptan	GC/FPD/SCD	ppm		0.03@
N.G. Fuel, Sulfur compounds	Ethyl mercaptan	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	i-Propyl mercaptan	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	n-Propyl mercaptan	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	t-Butyl mercaptan	GC/FPD/SCD	ppm		0.93
N.G. Fuel, Sulfur compounds	Dimethyl sulfide	GC/FPD/SCD	ppm		0.02@
N.G. Fuel, Sulfur compounds	Methyl ethyl sulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Diethyl sulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Methyl ethyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Diethyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Methyl i-propyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Ethyl i-propyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Ethyl n-propyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	i-Propyl n-propyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Di-i-propyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	i-Propyl t-butyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Ethyl t-butyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Di-t-butyl disulfide	GC/FPD/SCD	ppm	ND<	0.02
N.G. Fuel, Sulfur compounds	Thiophane	GC/FPD/SCD	ppm		0.21
N.G. Fuel, Sulfur compounds	Other target compounds	GC/FPD/SCD	ppm	ND<	0.02

Stream	Substance	Method	UOM		Average Used
N.G. Fuel, Halocarbons	35 target compounds	GC/ELCD	ppm	ND<	0.1
N.G. Fuel, Halocarbons	PCB	GC/ECD/ELCD	ppm	ND<	0.01

APPENDIX B
SITE 120 DATA USED IN CALCULATIONS

Stream	Substance	Method	UOM		Average Used
N.G. Fuel, Nitrogen compounds	Ammonia	GC/AED	ppm	ND<	4
N.G. Fuel, Nitrogen compounds	17 target compounds	GC/AED	ppm	ND<	0.5

Stream	Substance	Method	UOM		Average Used
N.G. Fuel, Oxygenated compounds	Methanol	GC/AED	ppm		28
N.G. Fuel, Oxygenated compounds	Acetaldehyde	GC/AED	ppm	ND<	1
N.G. Fuel, Oxygenated compounds	Acetone	GC/AED	ppm	ND<	1
N.G. Fuel, Oxygenated compounds	Other 14 target compounds	GC/AED	ppm	ND<	1

Stream	Substance	Method	UOM		Average Used
N.G. Fuel, Elements/Compounds	Total Arsenic	GC/AED	ug/m^3	ND<	2
N.G. Fuel, Elements/Compounds	Total Mercury	GC/AED	ug/m^3	ND<	0.01
N.G. Fuel, Elements/Compounds	NO	Chemiluminescence	ppm		0.1@
N.G. Fuel, Elements/Compounds	NOx	IC	ppm	ND<	0.3
N.G. Fuel, Elements/Compounds	Radon	Gamma-Spectroscopy	pCi/L		2@

Stream	Substance	Method	UOM		Average Used
N.G. Gas, Metals/Anion Precursors	Cobalt	GC-AED	ppm	ND<	0.1
N.G. Gas, Metals/Anion Precursors	Copper	GC-AED	ppm	ND<	0.05
N.G. Gas, Metals/Anion Precursors	Lead	GC-AED	ppm	ND<	0.1
N.G. Gas, Metals/Anion Precursors	Nickel	GC-AED	ppm	ND<	0.05
N.G. Gas, Metals/Anion Precursors	Selenium	GC-AED	ppm	ND<	0.002
N.G. Gas, Metals/Anion Precursors	Phosphorus	GC-AED	ppm	ND<	0.01
N.G. Gas, Metals/Anion Precursors	Chlorine	GC-AED	ppm	ND<	0.2
N.G. Gas, Metals/Anion Precursors	Fluorine	GC-AED	ppm	ND<	1
N.G. Gas, Metals/Anion Precursors	Bromine	GC-AED	ppm	ND<	0.1
N.G. Gas, Metals/Anion Precursors	Other metals	GC-AED	ppm		ND

APPENDIX C

DATA NOT USED IN CALCULATIONS

C-3

This appendix contains data that was not used in emissions or mass balance calculations. This appendix also contains the results of VOC tests conducted at other than full load conditions.

APPENDIX C
SITE 120 DATA NOT USED IN CALCULATIONS

Stream	Substance	Method	UOM						Average Used
					<u>Run 8C</u>				
Stack Gas, VOC	Toluene, Base Load	GC/MS	ug/Nm3		30.2				
					<u>Run 1A</u>		<u>Run 1B</u>		
Stack Gas, VOC	Benzene, Min. Load, Norm. O2, Norm. FGR	GC/MS	ug/Nm3		0.73@	ND<	0.70	ND<	0.70
Stack Gas, VOC	Toluene, Min. Load, Norm. O2, Norm. FGR	GC/MS	ug/Nm3		4.3		4.1		4.2
Stack Gas, VOC	Methane, Min. Load, Norm. O2, Norm. FGR	FID/TCA	ug/Nm4	ND<	0.71	ND<	0.71	ND<	0.71
Stack Gas, VOC	TGNMO, Min. Load, Norm. O2, Norm. FGR	FID/TCA	ug/Nm5		15.8		15.0		15.4
					<u>Run 2A</u>		<u>Run 2B</u>		
Stack Gas, VOC	Benzene, Min. Load, Min. O2, Min. FGR	GC/MS	ug/Nm3		3.3@		1.2@		2.3@
Stack Gas, VOC	Toluene, Min. Load, Min. O2, Min. FGR	GC/MS	ug/Nm3		1.5@		1.7@		1.6@
Stack Gas, VOC	Methane, Min. Load, Min. O2, Min. FGR	FID/TCA	ug/Nm4	ND<	0.71	ND<	0.71	ND<	0.71
Stack Gas, VOC	TGNMO, Min. Load, Min. O2, Min. FGR	FID/TCA	ug/Nm5		8.6		10.5		9.6
					<u>Run 3A</u>		<u>Run 3B</u>		
Stack Gas, VOC	Benzene, Min. Load, Min. O2, Norm. FGR	GC/MS	ug/Nm3		0.73@		1.4@		1.1@
Stack Gas, VOC	Toluene, Min. Load, Min. O2, Norm. FGR	GC/MS	ug/Nm3		1.6@		2.3@		2.0@
Stack Gas, VOC	Methane, Min. Load, Min. O2, Norm. FGR	FID/TCA	ug/Nm4	ND<	0.71	ND<	0.71	ND<	0.71
Stack Gas, VOC	TGNMO, Min. Load, Min. O2, Norm. FGR	FID/TCA	ug/Nm5		10.2		11.8		11.0
					<u>Run 4A</u>		<u>Run 4B</u>		
Stack Gas, VOC	Benzene, Max. Load, Min. O2, High FGR	GC/MS	ug/Nm3		0.80@		2.2@		1.5@
Stack Gas, VOC	Toluene, Max. Load, Min. O2, High FGR	GC/MS	ug/Nm3		4.0@		1.3@		2.7@
Stack Gas, VOC	Methane, Max. Load, Min. O2, High FGR	FID/TCA	ug/Nm4	ND<	0.71	ND<	0.71	ND<	0.71
Stack Gas, VOC	TGNMO, Max. Load, Min. O2, High FGR	FID/TCA	ug/Nm5		69.6		15.8		42.7
					<u>Run 5A</u>		<u>Run 5B</u>		
Stack Gas, VOC	Benzene, Max. Load, Min. O2, Low FGR	GC/MS	ug/Nm3		1.4@		1.1@		1.3@
Stack Gas, VOC	Toluene, Max. Load, Min. O2, Low FGR	GC/MS	ug/Nm3		2.1@		2.1@		2.1@
Stack Gas, VOC	Methane, Max. Load, Min. O2, Low FGR	FID/TCA	ug/Nm4	ND<	0.71	ND<	0.71	ND<	0.71
Stack Gas, VOC	TGNMO, Max. Load, Min. O2, Low FGR	FID/TCA	ug/Nm5		18.7		19.8		19.3
					<u>Run 6A</u>		<u>Run 6B</u>		
Stack Gas, VOC	Benzene, Max. Load, Min. O2, Norm. FGR	GC/MS	ug/Nm3		1.0@		0.77@		0.89@
Stack Gas, VOC	Toluene, Max. Load, Min. O2, Norm. FGR	GC/MS	ug/Nm3		1.4@		1.3@		1.3@
Stack Gas, VOC	Methane, Max. Load, Min. O2, Norm. FGR	FID/TCA	ug/Nm4	ND<	0.71	ND<	0.71	ND<	0.71
Stack Gas, VOC	TGNMO, Max. Load, Min. O2, Norm. FGR	FID/TCA	ug/Nm5		13.4		18.9		16.2

Stream	Substance	Method	UOM			Average Used
				<u>Run 1A</u>	<u>Run 1B</u>	
Stack Gas, Aldehyde	Formaldehyde, Min. Load, Norm. O2, Norm. FGR	HPLC	ug/Nm3	2.8@F	2.3@F	2.5@F
				<u>Run 2A</u>	<u>Run 2B</u>	
Stack Gas, Aldehyde	Formaldehyde, Min. Load, Min. O2, Min. FGR	HPLC	ug/Nm3	2.8@F	2.7@F	2.8@F
				<u>Run 3A</u>	<u>Run 3B</u>	
Stack Gas, Aldehyde	Formaldehyde, Min. Load, Min. O2, Norm. FGR	HPLC	ug/Nm3	2.5@F	3.0@F	2.7@F
				<u>Run 4A</u>	<u>Run 4B</u>	
Stack Gas, Aldehyde	Formaldehyde, Max. Load, Min. O2, High FGR	HPLC	ug/Nm3	4.5@F	4.7@F	4.6@F
				<u>Run 5A</u>	<u>Run 5B</u>	
Stack Gas, Aldehyde	Formaldehyde, Max. Load, Min. O2, Low FGR	HPLC	ug/Nm3	7.8F	6.8F	7.3F
				<u>Run 6A</u>	<u>Run 6B</u>	
Stack Gas, Aldehyde	Formaldehyde, Max. Load, Min. O2, Norm. FGR	HPLC	ug/Nm3	7.3F	7.3F	7.3F

APPENDIX D

PROCESS STREAM FLOW RATES AND CALCULATION PROCEDURES

The tables in Appendix D summarize the following information for Site 120:

D-1	Mean Process Stream Flows
D-2	Flue Gas Conditions and Flow Rates for Isokinetic Tests
D-3	Sample Train Test Summaries
D-4	Air Preheater Inlet CEM Data Summary
D-5	Emission Calculations
D-6	Test 1-6 O_2 Calculations for VOC samples

TABLE D-1
MEAN PROCESS STREAM FLOWS
SITE 120

Stream	Mean Flow Rate	Standard Deviation	Source
Natural Gas, kscfh at 68°F			
Base Load	6,537	3.8	Measured(1)
Minimum Load	1,662	34.0	Measured(1)
Maximum Load	6,610	49.7	Measured(1)
Flue Gas, dscfm			
Base Load	1,100,217	11,463	Calculated(2)
Minimum Load	448,175	35,707	Calculated(3)
Maximum Load	1,119,964	26,450	Calculated(4)

(1) Measured from plant fuel flow instrumentation.
(2) Calculated from fuel F-factor and fuel flows for Runs 7, 8 and 9.
(3) Calculated from fuel F-factor and fuel flows for Runs 1, 2 and 3.
(4) Calculated from fuel F-factor and fuel flows for Runs 4, 5 and 6.

TABLE D-2
SUMMARY OF EXHAUST GAS CONDITIONS AND FLOW RATES FOR ISOKINETIC TESTS
SITE 120

Test No.	Date	Time	O_2, %[1]	CO_2, %[2]	H_2O, %	Stack Temp., °F	V_{mstd}, dscf	Gross Load, MW	Flow Rate[3] (Pitot) dscfm	Flow Rate[4] (F-factor) dscfm	Isokinetic Ratio, %
7-PAH	4/6/93	1145/2030	3.08	10.03	18.0	284	176.387	681	1,104,107	1,102,143	103.7
7-MTLS	4/6/93	1145/2030	3.07	10.03	17.7	278	254.265	681	1,111,412	1,101,525	103.2
8-PAH	4/7/93	1155/1930	2.82	10.17	17.5	287	179.386	678	1,117,528	1,086,501	104.2
8-MTLS	4/7/93	1155/1930	2.92	10.11	17.4	287	249.316	678	1,118,796	1,092,544	100.6
9-PAH	4/8/93	1155/1905	3.32	9.94	17.9	285	168.832	678	1,104,399	1,116,230	99.2
9-MTLS	4/8/93	1155/1905	3.27	9.97	17.5	286	242.391	678	1,107,992	1,113,065	98.7
Average Outlet			3.08	10.04	17.7	284			1,110,706	1,102,001	
Standard Deviation Outlet			0.19	0.09	0.2	3.4			6,375	11,444	

NA = Not applicable

Notes:

[1] Test O_2 for metals and PAH tests taken from portable O_2 meter.

[2] CO_2 calculated from APH inlet CEM values corrected to test O_2.

[3] Pitot measured flow rates are from isokinetic tests for Runs 7-9.

[4] F-factor flow rate calculated using:
dscfm=Fuel flow, kscfh*HHV, Btu/scf*F-factor @ 0% O_2, dscf/MMBtu*10^6*20.9/(20.9-O_2(test))*hr/60 min*1000

TABLE D-3
SAMPLE TRAIN TEST SUMMARY
SITE 120

PARAMETER	MULTI-METALS
Date	4/6/93
Test Number	7-MTLS
Std. Sample Volume, dscf	254.265
Std. Sample Volume, Nm^3	6.709
Test O_2, % dry	3.07
Moisture Fraction	0.177
Stack Gas Molecular Weight	27.65
Stack Gas Velocity, ft/sec	44.18
Stack Flow Rate, wacfm	1,881,803
Stack Flow Rate, dscfm	1,111,412
Isokinetic Ratio, %	103.24
Date	4/7/93
Test Number	8-MTLS
Std. Sample Volume, dscf	249.316
Std. Sample Volume, Nm^3	6.578
Test O_2, % dry	2.92
Moisture Fraction	0.174
Stack Gas Molecular Weight	27.69
Stack Gas Velocity, ft/sec	44.78
Stack Flow Rate, wacfm	1,907,359
Stack Flow Rate, dscfm	1,118,796
Isokinetic Ratio, %	100.56
Date	4/8/93
Test Number	9-MTLS
Std. Sample Volume, dscf	242.391
Std. Sample Volume, Nm^3	6.396
Test O_2, % dry	3.27
Moisture Fraction	0.175
Stack Gas Molecular Weight	27.67
Stack Gas Velocity, ft/sec	44.39
Stack Flow Rate, wacfm	1,890,748
Stack Flow Rate, dscfm	1,107,992
Isokinetic Ratio, %	98.72

Notes: Exhaust gas flow rates are measured flow rates
O_2 measurements conducted by portable O_2 meter at the air preheater outlet in conjunction with each test

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 120

PARAMETER	PAH
Date	4/6/93
Test Number	7-PAH
Std. Sample Volume, dscf	176.387
Std. Sample Volume, Nm^3	4.654
Test O_2, %dry	3.08
Moisture Fraction	0.180
Stack Gas Molecular Weight	27.62
Stack Gas Velocity, ft/sec	44.37
Stack Flow Rate, wacfm	1,889,896
Stack Flow Rate, dscfm	1,104,107
Isokinetic Ratio, %	103.67
Date	4/7/93
Test Number	8-PAH
Std. Sample Volume, dscf	179.386
Std. Sample Volume, Nm^3	4.733
Test O_2, % dry	2.82
Moisture Fraction	0.175
Stack Gas Molecular Weight	27.68
Stack Gas Velocity, ft/sec	44.79
Stack Flow Rate, wacfm	1,907,785
Stack Flow Rate, dscfm	1,117,528
Isokinetic Ratio, %	104.16
Date	4/8/93
Test Number	9-PAH
Std. Sample Volume, dscf	168.832
Std. Sample Volume, Nm^3	4.455
Test O_2, % dry	3.32
Moisture Fraction	0.179
Stack Gas Molecular Weight	27.63
Gas Velocity, ft/sec	44.41
Stack Flow Rate, wacfm	1,891,600
Stack Flow Rate, dscfm	1,104,399
Isokinetic Ratio, %	99.20

Notes: Exhaust gas flow rates are measured flow rates

O_2 measurements conducted by portable O_2 meter at the air preheater outlet in conjunction with each test

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 120

PARAMETER	BENZENE AND TOLUENE BASE LOAD
Date	4/14/93
Test Number	8A-VOC
O_2, %, dry	2.87(1)
Date	4/14/93
Test Number	8B-VOC
O_2, %, dry	2.87(1)
Date	4/14/93
Test Number	8C-VOC
O_2, %, dry	2.87(1)

(1) O_2 from concurrent isokinetic tests 8-PAH and 8-MTLS.

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 120

	BENZENE, TOLUENE AND METHANE/TGNMO	
PARAMETER	MINIMUM LOAD	MAXIMUM LOAD
Date	4/4/93	4/5/93
Test Number	1A-VOC	4A-VOC
O_2, % dry	10.33(1)	2.89(1)
Date	4/4/93	4/5/93
Test Number	1B-VOC	4B-VOC
O_2, % dry	10.33(1)	2.89(1)
Date	4/4/93	4/5/93
Test Number	2A-VOC	5A-VOC
O_2, % dry	8.66(1)	3.15(1)
Date	4/4/93	4/5/93
Test Number	2B-VOC	5B-VOC
O_2, % dry	8.66(1)	3.15(1)
Date	4/4/93	4/5/93
Test Number	3A-VOC	6A-VOC
O_2, % dry	10.16(1)	3.46(1)
Date	4/4/93	4/5/93
Test Number	3B-VOC	6B-VOC
O_2, % dry	10.16(1)	3.46(1)

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(1) Tedlar bag samples were collected on cold side of air preheater; O_2 from CEMS O_2 measured on hot side of air preheater, corrected for air preheater leakage. The calculation is presented in Table D-6.

(continued)

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 120

PARAMETER	FORMALDEHYDE BASE LOAD
Date	4/7/93
Test Number	8A-FORM
Std. Sample Volume, dscf	3.39
Std. Sample Volume, Nm^3	0.089
O_2, % dry	2.87(1)
Date	4/7/93
Test Number	8B-FORM
Std. Sample Volume, dscf	3.58
Std. Sample Volume, Nm^3	0.094
O_2, % dry	2.87(1)
Date	4/7/93
Test Number	8C-FORM
Std. Sample Volume, dscf	3.42
Std. Sample Volume, Nm^3	0.090
O_2, % dry	2.87(1)

(1) O_2 from concurrent isokinetic tests 8-PAH and 8-MTLS.

TABLE D-3 (continued)
SAMPLE TRAIN TEST SUMMARY
SITE 120

PARAMETER	FORMALDEHYDE MINIMUM LOAD	MAXIMUM LOAD
Date	4/4/93	4/5/93
Test Number	1A-FORM	4A-FORM
Std. Sample Volume, dscf	2.98	3.09
Std. Sample Volume, Nm^3	0.079	0.082
O_2, % dry	10.33(1)	2.89(1)
Date	4/4/93	4/5/93
Test Number	1B-FORM	4B-FORM
Std. Sample Volume, dscf	3.64	3.77
Std. Sample Volume, Nm^3	0.096	0.099
O_2, % dry	10.33(1)	2.89(1)
Date	4/4/93	4/5/93
Test Number	2A-FORM	5A-FORM
Std. Sample Volume, dscf	3.47	2.88
Std. Sample Volume, Nm^3	0.092	0.076
O_2, % dry	8.66(1)	3.15(1)
Date	4/4/93	4/5/93
Test Number	2B-FORM	5B-FORM
Std. Sample Volume, dscf	4.19	4.15
Std. Sample Volume, Nm^3	0.111	0.110
O_2, % dry	8.66(1)	3.15(1)
Date	4/4/93	4/5/93
Test Number	3A-FORM	6A-FORM
Std. Sample Volume, dscf	3.43	3.18
Std. Sample Volume, Nm^3	0.091	0.084
O_2, % dry	10.16(1)	3.46(1)
Date	4/4/93	4/5/93
Test Number	3B-FORM	6B-FORM
Std. Sample Volume, dscf	4.11	3.77
Std. Sample Volume, Nm^3	0.108	0.099
O_2, % dry	10.16(1)	3.46(1)

(1) Formaldehyde trains were run on cold side of air preheater; O_2 from CEMS O_2 measured on hot side of air preheater, corrected for air preheater leakage. The calculation is presented in Table D-6.

TABLE D-4
AIR PREHEATER INLET CEM DATA
SITE 120
O_2, CO_2, CO, NO_x

Test No.	APH "HOT SIDE" AVERAGES					
	O_2, %	CO_2, %	CO, ppm	CO @ 3% O_2	NO, ppm	NO_x ppm @ 3% O_2
1	9.73	6.26	ND<1.0	ND<1.6	22	35
2	7.92	7.33	ND<1.0	ND<1.4	18	25
3	9.46	6.40	ND<1.0	ND<1.6	15	23
4	1.82	10.76	103	97	69	65
5	2.22	10.52	403	386	189	181
6	2.53	10.38	146	142	106	103
7	2.01	10.63	147	139	101	96
8	2.14	10.55	95	91	104	99
9	2.24	10.55	90	86	102	98

TABLE D-5
SAMPLE TRAIN CALCULATION PROCEDURES
SITE 120

1. To Calculate Sample Volume, Actual Exhaust Flow Rate and Isokinetics for Each Sample Train

   a. Sample gas volume, dscf

   $$V_{m\,std} = 0.03342\ V_m \left(P_{bar} + \frac{H}{13.6}\right)\left(\frac{T_{ref}}{T_m}\right)(Y)$$

   b. Water vapor volume, scf

   $$V_{w\,std} = 0.0472\ V_{lc} \left(\frac{T_{ref}}{528\ {}^\circ R}\right)$$

   c. Moisture content, nondimensional

   $$B_{wo} = \frac{V_{w\,std}}{V_{m\,std} + V_{w\,std}}$$

   d. Stack gas molecular weight, lb/lb mole

   $$MW_{dry} = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2)$$

   $$MW_{wet} = MW_{dry}\ (1 - B_{wo}) + 18\ (B_{wo})$$

   e. Absolute stack pressure, in Hg

   $$P_s = P_{bar} + \frac{P_{sg}}{13.6}$$

   f. Stack velocity, ft/sec

   $$V_s = 2.90\ C_p \sqrt{\Delta P T_s}\ \sqrt{\left(\frac{29.92}{P_s}\right)\left(\frac{28.95}{MW_{wet}}\right)}$$

   g. Actual stack flow rate, wacfm

   $$Q = (V_s)(A_s)(60)$$

   h. Standard stack gas flow rate, dscfm

   $$Q_{sd} = Q\ (1 - B_{wo})\left(\frac{T_{ref}}{T_s}\right)\left(\frac{P_s}{29.92}\right)$$

   i. Percent isokinetic

   $$I = \left(\frac{17.32\,(T_s)(V_{m\,std})}{(1 - B_{wo})(\Theta)(V_s)(P_s)(D_n^{\,2})}\right)\left(\frac{528\ {}^\circ R}{T_{ref}}\right)$$

2. To Calculate Particulate Emissions

   a. Grain loading, gr/dscf

   $$C = 0.01543 \left(\frac{M_n}{V_{m\,std}}\right)$$

3. To Estimate Emissions Rates in lb/10^6 Btu Using EPA Method 19 and Given Fuel Analysis

   a. Fuel factor at 68 °F, dscf/10^6 Btu at 0% O_2

$$F_{68} = \frac{10^6[3.64(\%H) + 1.53(\%C) \bullet 0.14\ (\%N) + 0.57(\%S) - 0.46(\%O_2 fuel)]}{HHV,\ Btu/lb}$$

   b. Fuel factor at 60 °F

$$F_{60} = F_{68}\left(\frac{520\ °R}{528\ °R}\right)$$

   c. Gaseous Emissions factor, lb/10^6 Btu

$$\left(\frac{lb}{10^6\ Btu}\right)_i = (ppm)_i\ (10^{-6})\left(\frac{MW_i\ lb}{lb\ mole}\right)\left(\frac{1}{SV}\right)(F)\left(\frac{20.9}{20.9 - \%O_2}\right)$$

   d. Gaseous Emissions factor, lb/10^{12} Btu

$$\left(\frac{lb}{10^{12}\ Btu}\right)_i = \left(\frac{lb}{10^6\ Btu}\right)_i \times 10^6$$

   e. Particulate emission factor, lb/10^6 Btu

$$\left(\frac{lb}{10^6\ Btu}\right) = C\left(\frac{1\ lb}{7000\ gr}\right)(F)\left(\frac{20.9}{20.9 - \%O_2}\right)$$

   f. Particulate emission factor, lb/10^{12} Btu

$$\left(\frac{lb}{10^{12}\ Btu}\right) = \left(\frac{lb}{10^6\ Btu}\right) \times 10^6$$

4. To Calculate Trace Species Emissions Given Laboratory Results

   a. µg/sample train = (µg detected) - (µg in field or reagent blank)

   b. µg/dscm = µg sample train x (35.31/$V_{m\ std}$)

   c. µg/Nm^3 = µg/dscm x 492 °F/T_{ref}

   d. For Benzene and Toluene Results
   µg/Nm^3 = ppb x (MW_i/SV) x (35.31/2.2) x (T_{ref}/492 °F) x 10^9

   e. lb/10^{12}Btu = µg/dscm x 1m³/35.31 ft³ x F-factor, dscf/MMBtu @ O % O_2 and 68°F x 10^6 x 20.9/(20.9-O_2, %) x 1lb/454 x 10^6µg

Notes: Laboratory results could be in µg, mg or ppb. PAH, metals, formaldehyde and nitrosamine results will be in µg, particulate and anion results will be in mg, and benzene and toluene results will be in ppb.

Field and reagent blank values must be evaluated before subtracting them. For example, very low blanks may merely indicate "noise" and might be disregarded. On the other hand, very high blank values may indicate sampling or analysis problems which should be investigated. It may be acceptable to use a blank correction on some projects or with some reference methods. Typically a reagent blank is a more appropriate indicator of blank levels than a field blank.

5. To Calculate CO_2, % for Each Sample Train

   a. Given CEM results for O_2, % and CO_2, % at the outlet and the portable O_2 meter results at each sample train.

   b. $$Test\ CO_2 = CEM\ CO_2 \times \frac{20.9\ -\ test\ O_2}{20.9\ -\ CEM\ O_2}$$

6. To Calculate Emissions of Gaseous Species (NO_x, CO)

   a. $$ppm\ at\ 3\%\ 0_2 = ppm\ x\ \frac{20.9\%-3\%}{20.9\%-test\ 0_2,\%}$$

   b. $$lb/hr = (ppm\ x\ 10^{-6})\left(\frac{Molecular\ weight,\ lb/lb\ mole}{specific\ molar\ volume,\ ft^3/lb\text{-}mole}\right)$$
   $$x\ Flow\ Rate,\ dscfm\ x\ 60\ min/hr$$

   Where molecular weight of NO_x = 46 and CO = 28 and the Specific molar volume of an ideal gas is 385.3 ft^3/lb-mole at 528°R (68°F)

   c. lb/MW-hr = lb/hr x 1/Unit load, MW, gross

7. To Construct a Mass Balance Around the Boiler for a Given Parameter, *i*

   a. Given fuel and flue gas results.

   b. Mass $balance_i$ = M_i (flue gas)/M_i (fuel), expressed as %

8. Nomenclature:

A_s = stack area, ft^2
B_{wo} = flue gas moisture content
C = particulate grain loading, gr/dscf
C_p = pitot calibration factor, dimensionless
D_n = nozzle diameter, in.
F = fuel F factor, dscf/10^6 Btu at 0% O_2
H = orifice pressure differential, iwg
I = % isokinetics
M_n = mass of collected particulate, mg
MW = molecular weight of flue gas

MW_i = molecular weight of species i:

NO_x : 46

CO : 28

SO_x : 64

HC : 16

θ = sample time, min.

ΔP = average velocity head, iwg = $(\overline{\sqrt{\Delta P}})^2$

P_{bar} = barometric pressure, in.Hg

P_s = stack absolute pressure, in.Hg

P_{sg} = stack static pressure, iwg

Q = wet stack gas flow rate at actual conditions, wacfm

Q_{sd} = dry stack gas flow rate at standard conditions, dscfm

SV = specific molar volume of an ideal gas at standard conditions, ft^3/lb mole

T_m = meter temperature, °R

T_{ref} = reference temperature, °R

T_s = stack temperature, °R

V_s = stack velocity, ft/sec

V_{lc} = volume of liquid collected in impingers, ml

V_m = dry meter volume uncorrected, dcf

$V_{m\ std}$ = dry meter volume at standard conditions, dscf

$V_{w\ std}$ = volume of water vapor at standard conditions, scf

Y = meter calibration coefficient

TABLE D-6
CALCULATION OF TEST 1-6 COLD-SIDE O_2 FOR VOC SAMPLES

Percent Leakage Across APH:

$$\% \text{ Leakage} = \frac{\% \ O_2 \text{ (cold)} - \% \text{ (hot)}}{20.9\% - \% \ O_2 \text{ (cold)}} \text{ X } 100\%$$

Using average CEM O_2, Average O_2 From isokinetic tests (PAH and metals) and average "Hot Side" flows for isokinetic tests:

Test	% O_2 (cold)	% O_2 (hot)	% Leakage	"Hot" Flue Gas Flow, dscfm	Leakage Flow, dscfm
7	3.08	2.01	6.00	1,039,714	62,383
8	2.87	2.14	4.00	1,047,118	41,885
9	3.30	2.24	6.02	1,051,625	63,308

Flow of leakage air across APH given by $k\sqrt{\Delta P}$, where:

ΔP = (FD discharge pressure - stack pressure, and

k = to be determined

Test	FD Dis charge Pressure, iwg	Stack Pressure, iwg	ΔP, iwg	$\sqrt{\Delta P}$	$k = \frac{\text{Leakage Flow}}{\Delta P}$
7	39.2	-0.15	39.35	6.27	9,951
8	37.4	-0.36	37.76	6.14	6,822
9	35.3	-0.37	35.67	5.97	10,604
				k_{avg} =	9,126

TABLE D-6 (continued)
CALCULATION OF TEST 1-6 COLD-SIDE O_2 FOR VOC SAMPLES

Using k_{avg} calculated above, and approximating ΔP by FD discharge pressure (neglecting stack pressure since it is low):

Test	($\approx\Delta P$) FD Dis Pressure, iwg	$\sqrt{\Delta P}$	Leakage Flow, dscfm	"Hot" Flue Gas Flow, dscfm	% Leakage
1	7.5	2.74	25,005	437,513	5.71
2	6.5	2.55	23,271	384,269	6.06
3	10.0	3.16	28,838	445,333	6.48
4	45.0	6.71	61,235	1,033,976	5.92
5	37.0	6.08	55,486	1,060,931	5.23
6	41.0	6.40	58,406	1,089,851	5.36
			↓	↓	
			$=k_{avg}\sqrt{\Delta P}$	from fuel flow and F-factor	

$$\text{Rearranging: } \%\ O_2\ (\text{Cold}) = \frac{20.9\% \left[\dfrac{\%\ \text{leakage}}{100\%}\right] + \%\ O_2\ (\text{Hot})}{\left[1 + \dfrac{\%\ \text{leakage}}{100\%}\right]}$$

Test	% O_2 (Hot)	% O_2 (Cold)
1	9.73	10.33
2	7.92	8.66
3	9.46	10.16
4	1.82	2.89
5	2.22	3.15
6	2.53	3.46

APPENDIX E

PROCESS OPERATION

SUMMARY OF BOILER OPERATING CONDITIONS
SITE 120

Test No.	1	2	3	4	5	6	7	8	9
Date	4/4/93	4/4/93	4/4/93	4/5/93	4/5/93	4/5/93	4/6/93	4/7/93	4/8/93
Test Condition	Min. Load Nom. O_2 Nom. FGR	Min. Load Nom. O_2 High FGR	Min. Load Level 3 OOS	Max. Load Low NO_x @ MCR	Max. Load Red. GR @ MCR	Max. Load Norm. GR 2 BOOS	Full Load Baseline	Full Load Baseline	Full Load Baseline
Gross MW	133	134	134	708	689	693	681	678	678
Net MW	111.7	119	118.2	683.1	680.3	682.8	665.6	661.4	661.3
BOOS	8(L4,L5)	8(L4,L5)	12(L3,L4,L5)	0	0	2(L4C2,L5C3)	1(L4C2)	1(L4C2)	1(L4C2)
FGR Level	Normal	High	High	High	Low	Normal	Normal	Normal	Normal
Overfire Air Ports	Open	Open	Open	Open	Open	Open	Open	Open	Open
Windbox/Furnace Differential, "H_2O	2.1	1	2.7	6.3	6.6	6.5	6.57	6.46	6.42
Windbox Press., "H_2O	6.5	4.5	8.5	38.5	32	34	33.9	34.4	34.4
Windbox O_2, %	19	18.5	16.75	18.2	19.3	NA	18.8	18.9	19.1
Boiler exit O_2, % dry	8.30	6.56	7.75	1.49	NA	1.68	1.73	1.78	1.53
Feedwater Flow, MMlb/hr	1.22	1.15	1.15	5.36	5.36	5.36	5.24	5.25	5.24
SH Temperature, °F	975	1013	1009	1001	986	1000	999	997	999
RH Temperature, °F	931	948	966	1003	973	999	986	987	988
FD Fan 7-1, amps	410	395	410	700	640	640	650	670	650
FD Fan 7-2, amps	395	395	400	710	660	705	680	670	690
GR Fan 7-1, amps	365	360	535	565	335	410	400	400	400
GR Fan 7-2, amps	325	325	320	600	340	455	445	445	445
CO, ppm chart (1)	82	83	82	122	NA	222	127	150	124
O_2, % (2)	10.33	8.66	10.16	2.89	3.15	3.46	3.08	2.87	3.30
NO_xPPM @ 3% O_2 (3)	35	25	23	65	181	103	96	99	98
CO, ppm @ 3% O_2 (3)	ND<1.6	ND<1.4	ND<1.6	97	386	142	139	91	86
Fuel Flow, Kscfh	1,628	1,661	1,696	6,568	6,598	6,665	6,539	6,540	6,533
Heat Rate, Btu/KW-hr	14,604	13,981	14,378	9,633	9,717	9,781	9,843	9,908	9,897
NO_x, lb/MW-hr (3)	0.52	0.37	0.36	0.72	2.08	1.19	1.1	1.15	1.13
NO_x, lb/10^6 Btu (3)	0.045	0.030	0.030	0.083	0.23	0.13	0.122	0.129	0.125
CO, lb/MW-hr (3)	NC	NC	NC	0.18	0.64	0.26	0.55	0.36	0.35

Notes:

(1) CO taken from control room strip chart.

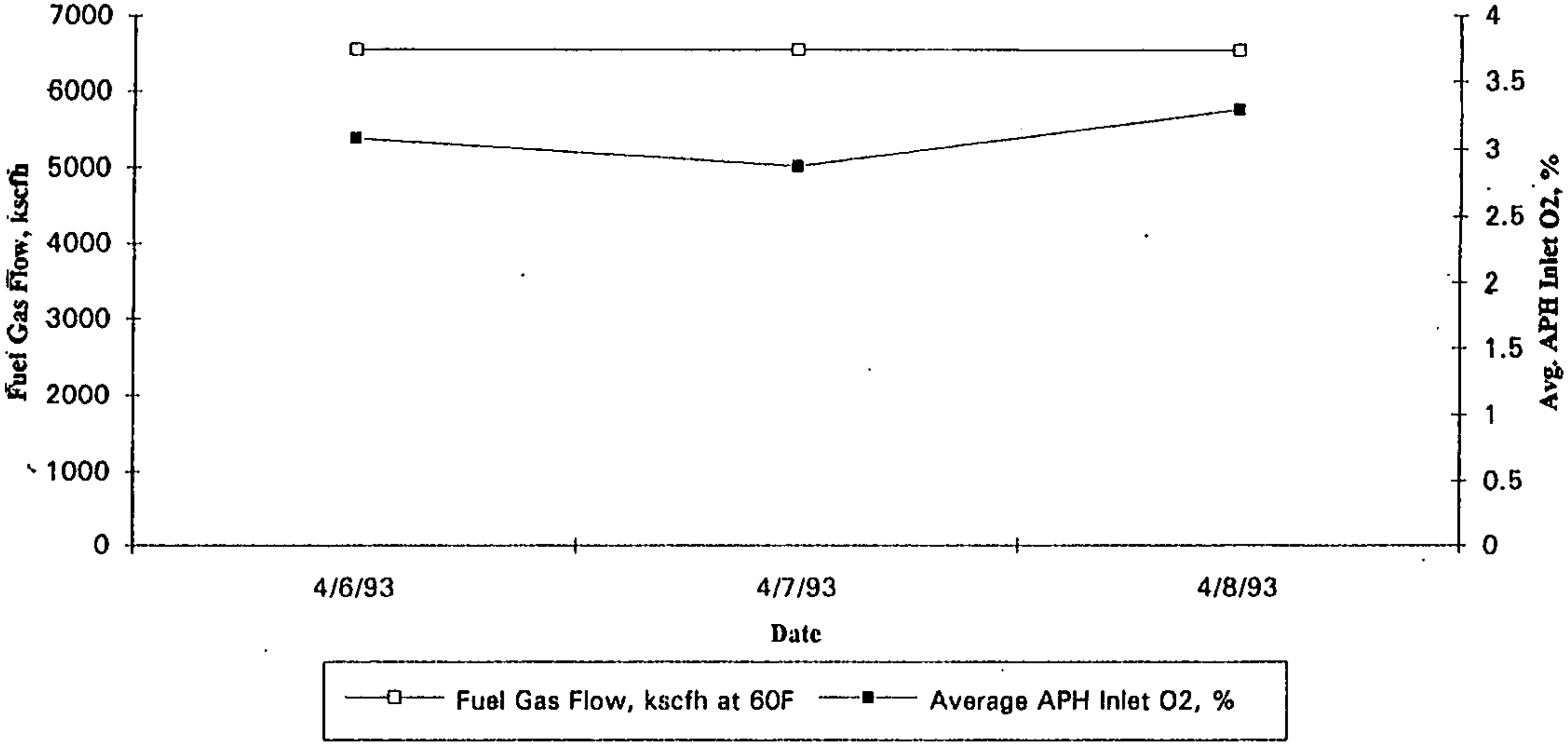
(2) Average tst run O_2 measured or calculated at air preheater outlet. Test O_2 values are presented in Appendix D.

(3) NO_x and CO were measured using a multi-point sampling grid at the APH inlet duct O_2 outlet levels are used for exhaust gas mass emissions calculations.

NC: not calculated for not detected values.

NA: not available

Figure E-1. Unit Operating Conditions, Site 120



APPENDIX F

UNCERTAINTY ANALYSIS

Because the data generated in this program may be used in conducting risk assessments and in making policy and regulatory decisions, consideration of the uncertainties in the results generated in the program are important. Assessment of the uncertainty level of a measurement is especially important when the measured results are near the detection level of the methods.

In calculating uncertainties that are presented in this report, procedures were followed that have been previously established for PISCES data treatment. This procedure involved calculating an overall uncertainty for each result using standard statistical techniques and known measurement biases. An error propagation analysis was performed on calculated results to determine the contribution of process, sampling and analytical variability, and measurement bias, to the overall uncertainty in the result. This uncertainty was determined by propagating the bias and precision error of individual parameters in the calculation of the results.

This uncertainty does not represent the total uncertainty in the result since many important bias errors are unknown and have been assigned a value of zero for this analysis. This uncertainty is only the uncertainty in the result for the period of time that the measurements were taken and does not represent long-term process variations. In addition, the following calculations assume that the population distribution of each measurement is normally distributed and that the samples collected reflect the true population.

The method described below is based on ANSI/ASME PTC 19.1-1985, "Measurement Uncertainty."

Nomenclature

r = Calculated result;
S_{pi} = Sample standard deviation of parameter i;
$S_{\overline{pi}}$ = Standard deviation of the average of parameter i;
Θ_i = Sensitivity of the result to parameter i;
B_{pi} = Bias error estimate for parameter i;
v_i = Degrees of freedom in parameter i;
v_r = Degrees of freedom in result;
S_r = Precision component of result uncertainty;
B_r = Bias component of result uncertainty;
t = Student "t" factor (two-tailed distribution at 95%);
U_r = Uncertainty in r;
P_i = Parameter i;
ΔP_i = Perturbation in parameter i;
N_i = Number of measurements of parameter i; and
E = Emission rate

For a result, r, the uncertainty in r is calculated as:

$$U_r = \sqrt{B_r^2 + (S_r * t)^2}$$

The components are calculated by combining the errors in the parameters used in the result calculation.

$$B_r = \sqrt{\sum_{i=1}^{j} (\theta_i * B_{pi})^2}$$

$$S_r = \sqrt{\sum_{i=1}^{j} (\theta_i * S_{\overline{pi}})^2}$$

The sensitivity of the result to each parameter is found from a Taylor series estimation method:

$$\theta_1 = \frac{\partial r}{\partial pi}$$

Or using a perturbation method (useful in computer applications):

$$\theta_i = \frac{r(P_i + \Delta P_i) - r(P_i)}{\Delta P_i}$$

The standard deviation of the average for each parameter is calculated as:

$$S_{\overline{pi}} = \frac{S_{pi}}{\sqrt{N_i}}$$

The degrees of freedom for each parameter is found from

$$v_i = N_i - 1$$

and the degrees of freedom for the result is found be weighing the sensitivity and precision error in each parameter.

$$v_r = \frac{S_r^4}{\sum_{i=1}^{j} \left[\frac{(S_{\overline{pi}} * \theta_i)^4}{v_i} \right]}$$

The Student "t" in the first equation is associated with the degrees of freedom in the result.

The precision error terms are generated using collected data, and assigning degrees of freedom to each parameter. Bias errors are more qualitative in nature. Bias values are assigned based on observation of the process and engineering judgment.

For this report the following sources of bias were considered:

- No bias was assigned to analytical results unless the result is less than the detection limit. Then one-half the detection limit is used for both the parameter value and its bias in calculations.

  This bias component for results below the reporting limit is calculated as:

  $$B_{pi} = \sqrt{\sum_{i=1}^{N_i} \left(B_i * \frac{1}{N_i}\right)^2}$$

- The nonaxial nature of the gas flow at the stack resulted in measured velocities by the S-type pitot probes that were up to 2.9% higher than flow rates calculated from fuel flow rate and stoichiometric calculations. During all isokinetic tests, sample flow rate was set based on the faster velocity measured by the pitot probe, as specified in EPA Methods 1, 2 and 5. This means that "true" isokinetic sampling rates may have been up to 2.9% low. Estimating errors introduced by nonisokinetic sampling, this would correspond to an uncertainty of up to 2.9% in the concentrations of particulate species. As a conservative estimate, an uncertainty of 5% was applied to all particulate species measured from isokinetic tests.

- No uncertainty was assumed due to long term process variations.

In interpreting and understanding the uncertainty values, it should be pointed out that when two levels of uncertainty are combined using a root-sum-squared process, the larger uncertainty predominates. A few examples are presented below:

- Combining two uncertainties of 10% results in a total uncertainty of 14%.
- Combining uncertainties of 50% and 8% results in a total uncertainty of 51%.
- Combining uncertainties of 90% and 10% results in an uncertainty of 90.5%.

Confidence Interval Calculations

In this report the confidence interval as a percent uncertainty is reported with the sample results. The uncertainty values calculated for this report are based on the 95% confidence interval calculated for emission factors of the target species. This confidence interval equation propagates the error associated with the parameters required to determine concentration, mass emissions, and emission factors. The uncertainty is then expressed as a percentage so that it may be applied to an average result expressed in the required units.

Emission factors are calculated in units of lb/10^{12} Btu. However, the equations used for uncertainty calculations are in mass emission units of lb/hr since these equations allow for an estimate of overall uncertainty incorporating all relevant parameters.

The following are sample calculations for the 95% confidence interval around the mean for air and fuel samples. This procedure utilized the same method outlined earlier in this section and used in the computer program.

FLUE GAS

$$E,\ lb/hr = Concentration,\ \frac{\mu g}{Nm^3} \times Heat\ Rate,\ \frac{Btu}{MW-hr} \times F-Factor,\ \frac{dscf}{MMBtu} \times$$

$$\frac{20.9}{20.9 - 0_2(test),\%} \times Load,\ MW \times 5.8127 \times 10^{-17},$$

where

$$Heat\ Rate, \frac{Btu}{MW-hr} = HHV\ of\ fuel,\ Btu/lb \times Fuel\ Flow,\ lb/hr \div Load,\ MW$$

FUEL

$$E,\ lb/hr = Concentration,\ \frac{mg}{kg} \times Heat\ Rate,\ \frac{Btu}{MW-hr} \times 10^{-6} \times Load,\ MW \times \frac{1}{HHV,\ Btu/lb}$$

The following example calculation shows how the overall uncertainty of the naphthalene value from this program was determined.

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	$\mu g/Nm^3$	0.56	0.32	0.34	0.40
Heat Rate	Btu/MW-hr	9.85×10^6	9.90×10^6	9.91×10^6	9.89×10^6
F-Factor	dscf/MMBtu	8609	8606	8604	8606
O_2 (test)	%	3.08	2.82	3.32	3.07
Load (net)	MW	666	661	661	663

The sensitivity of each variable is calculated with a perturbation for each parameter that is equal to the larger value of the standard deviation of the average, $S_{\overline{pi}}$, or the bias error, B_{pi}. For the concentration variable:

$$S_{\overline{pc}} = \frac{S_{pi}}{\sqrt{N_i}} = \frac{0.133}{\sqrt{3}} = 0.077$$

$$E_{(c\,=\,0.40)} = 0.40 \times 9.89 \times 10^6 \times 8606 \times \frac{20.9}{20.9-3.07} \times 663 \times 5.8127 \times 10^{-17} = 1.54 \times 10^{-3}$$

$$E_{(c\,=\,0.48)} = 0.48 \times 9.89 \times 10^6 \times 8606 \times \frac{20.9}{20.9-3.07} \times 663 \times 5.8127 \times 10^{-17} = 1.85 \times 10^{3}$$

$$\theta_c = \frac{E_{(Pi+\Delta Pi)} - E_{Pi}}{\Delta P_i} = \frac{E_{(c=1.91)} - E_{(c=1.59)}}{0.077}$$

$$\theta_c = \frac{1.85 \times 10^{-3} - 1.54 \times 10^{-3}}{0.077} = 3.97 \times 10^{-3}$$

Similar calculations for each parameter produce the following results:

		PARAMETER	
	Concentration, μg/Nm^3	Heat Rate, Btu/MW-hr	F-Factor, dscf/MMBtu
Mean	0.40	9.89×10^6	8606
S_{pi}	0.133	2.92×10^4	2.5
$S_{\overline{pi}}$	0.077	1.69×10^4	1.4
N_i	3	3	3
B_{pi}*	0.02	0	0
Θ_i	4.0×10^{-3}	1.6×10^{-10}	1.8×10^{-7}
ν_i	2	2	2
ΔP_i	0.077	1.69×10^4	1.4

Notes: The bias estimate for concentration includes no bias for analytical results and a 5% collection bias.

The precision and bias components are then calculated by root-sum-squaring the product of the parameter $S_{\overline{pi}}$ or B_{pi} and the sensitivity:

$$S_r = \sqrt{(\theta_c * S_{\overline{pc}})^2 + (\theta_{hr} * S_{\overline{phr}})^2 + (\theta_{ff} * S_{\overline{pff}})^2}$$

$$S_r = 3.0 \times 10^{-4}$$

$$B_r = \sqrt{(\theta_c * B_{pc})^2 + (\theta_{hr} * B_{phr})^2 + (\theta_{ff} * B_{pff})^2}$$

$$B_r = 7.8 \times 10^{-5}$$

The Student "t" factor for two degrees of freedom and a 95% confidence interval is 4.3.

The uncertainty in the result is then

$$U_r = \sqrt{B_r^2 = (S_r * t)^2} = \sqrt{(7.8 \times 10^{-5})^2 + (3.0 \times 10^{-4} \times 4.3)^2} = 1.29 \times 10^{-3}$$

The overall emission rate is reported as

$1.6 \times 10^{-3} \pm 1.29 \times 10^{-3}$ lb/hr or 83% uncertainty.

METALS
UNCERTAINTY ANALYSIS
SITE 120
PAGE 1 OF 3

SPECIES	LOC		RUN #7		RUN #8 in ug/Nm3		RUN #9		AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)		ABSOL. VALUE In lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
ARSENIC	OUT		0.73		0.21		0.23		3.93E-01	2.93E-01	185.3%	5.0%	185.3%		1.5E-03	2.8E-03	57.36%	0.0%
BARIUM			4.9		3.4		4.2		4.15E+00	7.12E-01	42.6%	5.0%	42.9%		1.6E-02	6.8E-03	11.49%	0.0%
BERYLLIUM		ND<	0.01	ND<	0.02	ND<	0.02	ND<	1.52E-02	3.67E-04	6.0%	29.3%	29.9%	ND<	5.9E-05	1.8E-05	1.70%	100.0%
CADMIUM		ND<	0.04	ND<	0.05	ND<	0.05	ND<	4.57E-02	1.10E-03	6.0%	29.3%	29.9%	ND<	1.8E-04	5.3E-05	1.70%	100.0%
CHROMIUM			1.8		1.3		2.3		1.82E+00	5.05E-01	68.8%	5.0%	68.9%		7.0E-03	4.8E-03	19.06%	0.0%
COBALT			0.30		0.15		0.16		2.02E-01	8.31E-02	102.2%	5.0%	102.3%		7.8E-04	8.0E-04	31.64%	0.0%
COPPER			0.39		0.27		0.59		4.18E-01	1.62E-01	96.5%	5.0%	96.6%		1.6E-03	1.6E-03	28.00%	0.0%
LEAD			0.48		0.47		0.44		4.62E-01	2.12E-02	11.4%	5.0%	12.4%		1.8E-03	2.2E-04	3.49%	0.0%
MANGANESE			0.66		0.52		0.77		6.46E-01	1.25E-01	48.0%	5.0%	48.3%		2.5E-03	1.2E-03	13.35%	0.0%
MERCURY		ND<	0.57	ND<	0.59	ND<	0.56	ND<	5.74E-01	1.64E-02	7.1%	29.3%	30.2%	ND<	2.2E-03	6.7E-04	2.18%	100.0%
MOLYBDENUM			0.94		0.96		1.1		9.92E-01	7.59E-02	19.0%	5.0%	19.7%		3.8E-03	7.5E-04	5.85%	0.0%
NICKEL			6.7		4.6		7.0		6.10E+00	1.34E+00	54.8%	5.0%	55.0%		2.3E-02	1.3E-02	16.84%	0.0%
SELENIUM		ND<	0.04	ND<	0.04	ND<	0.04	ND<	4.27E-02	1.03E-03	6.0%	29.3%	29.9%	ND<	1.6E-04	4.9E-05	1.70%	100.0%
PHOSPHORUS		ND<	0.89	ND<	0.91	ND<	0.94	ND<	9.15E-01	2.20E-02	6.0%	29.3%	29.9%	ND<	3.5E-03	1.1E-03	1.70%	100.0%
VANADIUM			6.3		4.4		5.6		5.43E+00	9.41E-01	43.1%	5.0%	43.3%		2.1E-02	9.1E-03	12.57%	0.0%
										AVERAGES:	46.9%	13.1%	55.0%		5.70E-03	2.9E-03	43.91%	

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PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
METALS STK:									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	6,539	6,540	6,533	6,537	3.8	0.06%	2	0.00%	NA
UNIT LOAD, net MW	666	661	661	663	2.45	0.37%	1.42	0.00%	0.00
HEAT RATE, Btu/MWhr	9.85E+06	9.90E+06	9.91E+06	9.89E+06	2.92E+04	0.29%	1.68E+04	0.00%	0.00E+00
%O2	3.07	2.92	3.27	3.09	0.18	5.69%	0.10	0.00%	0.00
O2 Correction Factor	1.172	1.162	1.185	1.173	0.01	0.99%	0.01	0.00%	0.00
Particle Collection Bias								5%	
				FREEDOM	T-VALUE				
				1	12.71				
				2	4.30				
				3	3.18				
				4	2.78				
				5	2.57				
				6	2.45				
				7	2.37				
				8	2.31				

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RPDM	RPDM	CONC. DELTA P DETERMINATION			Particle										
FOR	ALL	NORM.	ND	> OF NSTD	Coll. Eff.	THETA CALCULATIONS FOR:			RESULTS:						
MIXED	ND	STD DEV	BIAS	OR BIAS	Bias	CONC.	HEAT RT	F-factor	Sr	Br	vr	vr	t:	Ur	% Ur
		(Spc')	(Bpc1)		(Bpc2)	(THETAc)	(THETAhr)	(THETAff)							
57.36%	57.36%	1.69E-01	0.00E+00	NSTDV	1.96E-02	3.8E-03	1.5E-10	1.8E-07	6.5E-04	7.5E-05	2.00	2	4.3	2.8E-03	185.3%
11.49%	11.49%	4.11E-01	0.00E+00	NSTDV	2.08E-01	3.8E-03	1.6E-09	1.9E-06	1.6E-03	8.0E-04	2.00	2	4.3	6.8E-03	42.9%
50.00%	1.70%	2.12E-04	4.40E-03	**BIAS**	7.62E-04	3.8E-03	5.9E-12	6.8E-09	8.2E-07	1.7E-05	2.06	2	4.3	1.8E-05	29.9%
50.00%	1.70%	6.36E-04	1.32E-02	**BIAS**	2.29E-03	3.8E-03	1.8E-11	2.0E-08	2.5E-06	5.2E-05	2.06	2	4.3	5.3E-05	29.9%
19.06%	19.06%	2.91E-01	0.00E+00	NSTDV	9.12E-02	3.8E-03	7.1E-10	8.1E-07	1.1E-03	3.5E-04	2.00	2	4.3	4.8E-03	68.9%
31.64%	31.64%	4.80E-02	0.00E+00	NSTDV	1.01E-02	3.8E-03	7.9E-11	9.0E-08	1.8E-04	3.9E-05	2.00	2	4.3	8.0E-04	102.3%
28.00%	28.00%	9.38E-02	0.00E+00	NSTDV	2.09E-02	3.8E-03	1.6E-10	1.9E-07	3.6E-04	8.0E-05	2.00	2	4.3	1.6E-03	96.6%
3.49%	3.49%	1.22E-02	0.00E+00	**BIAS**	2.31E-02	3.8E-03	1.8E-10	2.1E-07	4.7E-05	8.9E-05	2.02	2	4.3	2.2E-04	12.4%
13.35%	13.35%	7.21E-02	0.00E+00	NSTDV	3.23E-02	3.8E-03	2.5E-10	2.9E-07	2.8E-04	1.2E-04	2.00	2	4.3	1.2E-03	48.3%
50.00%	2.18%	9.46E-03	1.66E-01	**BIAS**	2.87E-02	3.8E-03	2.2E-10	2.6E-07	3.7E-05	6.5E-04	2.04	2	4.3	6.7E-04	30.2%
5.85%	5.85%	4.38E-02	0.00E+00	**BIAS**	4.96E-02	3.8E-03	3.9E-10	4.4E-07	1.7E-04	1.9E-04	2.01	2	4.3	7.5E-04	19.7%
16.84%	16.84%	7.76E-01	0.00E+00	NSTDV	3.05E-01	3.8E-03	2.4E-09	2.7E-06	3.0E-03	1.2E-03	2.00	2	4.3	1.3E-02	55.0%
50.00%	1.70%	5.94E-04	1.23E-02	**BIAS**	2.13E-03	3.8E-03	1.7E-11	1.9E-08	2.3E-06	4.8E-05	2.06	2	4.3	4.9E-05	29.9%
50.00%	1.70%	1.27E-02	2.64E-01	**BIAS**	4.57E-02	3.8E-03	3.6E-10	4.1E-07	4.9E-05	1.0E-03	2.06	2	4.3	1.1E-03	29.9%
12.57%	12.57%	5.43E-01	0.00E+00	NSTDV	2.72E-01	3.8E-03	2.1E-09	2.4E-06	2.1E-03	1.0E-03	2.00	2	4.3	9.1E-03	43.3%

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SPECIES	LOC		RUN #7		RUN #8 in ug/Nm3		RUN #9		AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)		ABSOL. VALUE in lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
Naphthalene	OUT		0.56		0.32		0.34		4.04E-01	1.34E-01	82.5%	5.0%	82.7%		1.6E-03	1.3E-03	25.50%	0.0%
Acenaphthylene		ND<	0.002	ND<	0.002	ND<	0.003	ND<	2.53E-03	3.32E-04	32.6%	29.5%	43.9%	ND<	9.7E-06	4.3E-06	10.07%	100.0%
Acenaphthene		ND<	0.002	ND<	0.001	ND<	0.003	ND<	2.04E-03	7.20E-04	87.8%	30.5%	92.9%	ND<	7.8E-06	7.3E-06	25.17%	100.0%
Fluorene		ND<	0.005		0.004		0.007 @	ND<	4.4E-03	1.12E-03	62.9%	18.4%	65.5%	ND<	1.7E-05	1.1E-05	17.76%	100.0%
Phenanthrene			0.017		0.013		0.018		1.63E-02	2.66E-03	40.6%	5.0%	40.9%		6.3E-05	2.6E-05	12.24%	0.0%
Anthracene		ND<	0.004	ND<	0.002	ND<	0.003	ND<	3.04E-03	9.90E-04	81.0%	30.3%	86.5%	ND<	1.2E-05	1.0E-05	22.93%	100.0%
Fluoranthene			0.010	ND<	0.004	ND<	0.005		4.75E-03	4.26E-03	223.0%	23.3%	224.2%		1.8E-05	4.1E-05	69.09%	32.1%
Pyrene			0.016		0.005		0.004		8.20E-03	6.48E-03	196.5%	5.0%	196.6%		3.2E-05	6.2E-05	60.86%	0.0%
Benz(a)anthracene		ND<	0.003	ND<	0.001	ND<	0.002	ND<	1.88E-03	6.10E-04	80.8%	30.3%	86.2%	ND<	7.2E-06	6.2E-06	24.95%	100.0%
Chrysene		ND<	0.003	ND<	0.003	ND<	0.002	ND<	2.67E-03	2.94E-04	27.3%	29.4%	40.2%	ND<	1.0E-05	4.1E-06	8.42%	100.0%
Benzo(b)fluoranthene		ND<	0.003	ND<	0.002	ND<	0.002	ND<	2.31E-03	4.50E-04	48.3%	29.7%	56.7%	ND<	8.9E-06	5.0E-06	13.84%	100.0%
Benzo(k)fluoranthene		ND<	0.002	ND<	0.001	ND<	0.003	ND<	2.12E-03	1.08E-03	127.1%	31.7%	131.0%	ND<	8.1E-06	1.1E-05	39.38%	100.0%
Benzo(a)pyrene		ND<	0.002	ND<	0.002	ND<	0.002	ND<	1.95E-03	6.14E-05	7.9%	29.3%	30.3%	ND<	7.5E-06	2.3E-06	2.34%	100.0%
Indeno(1,2,3-cd)pyrene		ND<	0.003	ND<	0.003	ND<	0.003	ND<	2.60E-03	8.19E-05	7.9%	29.3%	30.3%	ND<	1.0E-05	3.0E-06	2.34%	100.0%
Dibenzo(a,h)anthracene		ND<	0.002	ND<	0.002	ND<	0.002	ND<	1.87E-03	2.76E-04	36.6%	29.5%	47.0%	ND<	7.2E-06	3.4E-06	10.73%	100.0%
Benzo(g,h,i)perylene		ND<	0.002	ND<	0.002	ND<	0.002	ND<	1.73E-03	5.46E-05	7.9%	29.3%	30.3%	ND<	6.7E-06	2.0E-06	2.34%	100.0%
2-Methylnaphthalene			0.016		0.008		0.022		1.55E-02	7.00E-03	112.6%	5.0%	112.7%		5.9E-05	6.7E-05	31.12%	0.0%
7,12-Dimethbenz(a)anth		ND<	0.024	ND<	0.023	ND<	0.027	ND<	2.46E-02	2.03E-03	20.5%	29.4%	35.8%	ND<	9.5E-05	3.4E-05	6.32%	100.0%
3-Methylcholanthrene		ND<	0.003	ND<	0.003	ND<	0.002	ND<	2.67E-03	1.75E-04	16.3%	29.3%	33.6%	ND<	1.0E-05	3.4E-06	5.00%	100.0%
										AVERAGES:	68.4%	23.6%	77.2%		1.02E-04	8.35E-05	20.5%	

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PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
PAH STACK:									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	6,539	6,540	6,533	6,537	4	0.06%	2	0.00%	NA
UNIT LOAD, net MW	666	661	661	663	2.45	0.37%	1.42	0.00%	0.00
HEAT RATE, Btu/MWhr	9.85E+06	9.90E+06	9.91E+06	9.89E+06	2.92E+04	0.29%	1.68E+04	0.00%	0.00E+00
%O2	3.08	2.82	3.32	3.07	0.25	8.14%	0.14	0.00%	0.00
O2 Correction Factor	1.173	1.156	1.189	1.173	0.02	1.40%	0.01	0.00%	0.00
Particle Collection Bias								5%	

DEGREES FREEDOM	T-VALUE
1	12.71
2	4.30
3	3.18
4	2.78
5	2.57
6	2.45
7	2.37
8	2.31

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		CONC. DELTA P DETERMINATION			Particle	THETA CALCULATIONS FOR:			RESULTS:						
RPDM FOR MIXED	RPDM ALL ND	NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Coll. Eff. Bias (Bpc2)	CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAff)	Sr	Br	vr	vr	t	Ur	% Ur
25.50%	25.50%	7.75E-02	0.00E+00	NSTDV	2.02E-02	3.8E-03	1.6E-10	1.8E-07	3.0E-04	7.8E-05	2.00	2	4.3	1.3E-03	82.7%
50.00%	10.07%	1.92E-04	7.36E-04	**BIAS**	1.27E-04	3.8E-03	9.9E-13	1.1E-09	7.4E-07	2.9E-06	2.00	2	4.3	4.3E-06	43.9%
50.00%	25.17%	4.15E-04	6.12E-04	**BIAS**	1.02E-04	3.8E-03	7.9E-13	9.1E-10	1.6E-06	2.4E-06	2.00	2	4.3	7.3E-06	92.9%
31.15%	17.76%	6.48E-04	7.88E-04	**BIAS**	2.22E-04	3.8E-03	1.7E-12	2.0E-09	2.5E-06	3.1E-06	2.00	2	4.3	1.1E-05	65.5%
12.24%	12.24%	1.54E-03	0.00E+00	NSTDV	8.15E-04	3.8E-03	6.3E-12	7.3E-09	5.9E-06	3.1E-06	2.00	2	4.3	2.6E-05	40.9%
50.00%	22.93%	5.72E-04	9.07E-04	**BIAS**	1.52E-04	3.8E-03	1.2E-12	1.4E-09	2.2E-06	3.5E-06	2.00	2	4.3	1.0E-05	86.5%
69.09%	36.97%	2.46E-03	1.08E-03	NSTDV	2.37E-04	3.8E-03	1.8E-12	2.1E-09	9.5E-06	4.2E-06	2.00	2	4.3	4.1E-05	224.2%
60.86%	60.86%	3.74E-03	0.00E+00	NSTDV	4.10E-04	3.8E-03	3.2E-12	3.7E-09	1.4E-05	1.6E-06	2.00	2	4.3	6.2E-05	196.6%
50.00%	24.95%	3.52E-04	5.60E-04	**BIAS**	9.38E-05	3.8E-03	7.3E-13	8.4E-10	1.4E-06	2.2E-06	2.00	2	4.3	6.2E-06	86.2%
50.00%	8.42%	1.70E-04	7.74E-04	**BIAS**	1.34E-04	3.8E-03	1.0E-12	1.2E-09	6.5E-07	3.0E-06	2.00	2	4.3	4.1E-06	40.2%
50.00%	13.84%	2.60E-04	6.76E-04	**BIAS**	1.16E-04	3.8E-03	9.0E-13	1.0E-09	1.0E-06	2.6E-06	2.00	2	4.3	5.0E-06	56.7%
50.00%	39.38%	6.25E-04	6.62E-04	**BIAS**	1.06E-04	3.8E-03	8.2E-13	9.5E-10	2.4E-06	2.6E-06	2.00	2	4.3	1.1E-05	131.0%
50.00%	2.34%	3.55E-05	5.64E-04	**BIAS**	9.76E-05	3.8E-03	7.6E-13	8.7E-10	1.4E-07	2.2E-06	2.04	2	4.3	2.3E-06	30.3%
50.00%	2.34%	4.73E-05	7.51E-04	**BIAS**	1.30E-04	3.8E-03	1.0E-12	1.2E-09	1.8E-07	2.9E-06	2.04	2	4.3	3.0E-06	30.3%
50.00%	10.73%	1.59E-04	5.44E-04	**BIAS**	9.36E-05	3.8E-03	7.3E-13	8.4E-10	6.1E-07	2.1E-06	2.00	2	4.3	3.4E-06	47.0%
50.00%	2.34%	3.15E-05	5.01E-04	**BIAS**	8.67E-05	3.8E-03	6.7E-13	7.7E-10	1.2E-07	2.0E-06	2.04	2	4.3	2.0E-06	30.3%
31.12%	31.12%	4.04E-03	0.00E+00	NSTDV	7.73E-04	3.8E-03	6.0E-12	6.9E-09	1.6E-05	3.0E-06	2.00	2	4.3	6.7E-05	112.7%
50.00%	6.32%	1.17E-03	7.12E-03	**BIAS**	1.23E-03	3.8E-03	9.6E-12	1.1E-08	4.5E-06	2.8E-05	2.01	2	4.3	3.4E-05	35.8%
50.00%	5.00%	1.01E-04	7.72E-04	**BIAS**	1.33E-04	3.8E-03	1.0E-12	1.2E-09	3.9E-07	3.0E-06	2.01	2	4.3	3.4E-06	33.6%

VOC/FORMALDEHYDE
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SPECIES	LOC	CONCENTRATION in ppb			AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)		ABSOL. VALUE in lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND, TO AVG
MIN LOAD, NORM O2, NORM FGR														
		RUN #1A	RUN #1B											
BENZENE	OUT	0.21	ND< 0.20 @	ND<	2.00E-01	7.07E-03	31.8%	16.7%	35.9%	ND<	1.1E-03	4.0E-04	5.00%	100.0%
TOLUENE		1.04	1.00		1.02E+00	2.83E-02	24.9%	0.0%	24.9%		6.8E-03	1.7E-03	3.92%	0.0%
FORMALDEHYDE	OUT	2.1	1.7		1.90E+00	2.83E-01	133.7%	0.0%	133.7%		4.1E-03	5.5E-03	21.05%	0.0%
METHANE	OUT	ND< 1000	ND< 1000	ND<	1.00E+03	0.00E+00	1.1%	23.6%	23.6%	ND<	1.2E+00	2.7E-01	0.00%	100.0%
TGNMO		22200	21000		2.16E+04	8.49E+02	35.3%	0.0%	35.3%		2.5E+01	8.8E+00	5.56%	0.0%
MIN LOAD, MIN O2, HIGH FGR														
		RUN #2A	RUN #2B											
BENZENE	OUT	0.96	0.35		6.55E-01	4.31E-01	591.4%	0.0%	591.4%		3.2E-03	1.9E-02	93.13%	0.0%
TOLUENE		0.37	0.42		3.95E-01	3.54E-02	80.4%	0.0%	80.4%		2.3E-03	1.9E-03	12.66%	0.0%
FORMALDEHYDE	OUT	2.1	2.0		2.05E+00	7.07E-02	31.0%	0.0%	31.0%		3.9E-03	1.2E-03	4.88%	0.0%
METHANE	OUT	ND< 1000	ND< 1000	ND<	1.00E+03	0.00E+00	1.1%	23.6%	23.6%	ND<	1.0E+00	2.4E-01	0.00%	100.0%
TGNMO		12100	14700		1.34E+04	1.84E+03	123.2%	0.0%	123.2%		1.4E+01	1.7E+01	19.40%	0.0%
MIN LOAD, NORM O2, HIGH FGR														
		RUN #3A	RUN #3B											
BENZENE	OUT	0.21	0.41		3.10E-01	1.41E-01	409.7%	0.0%	409.7%		1.8E-03	7.3E-03	64.52%	0.0%
TOLUENE		0.39	0.57		4.80E-01	1.27E-01	238.1%	0.0%	238.1%		3.3E-03	7.8E-03	37.50%	0.0%
FORMALDEHYDE	OUT	1.9	2.2		2.05E+00	2.12E-01	92.9%	0.0%	92.9%		4.5E-03	4.2E-03	14.63%	0.0%
METHANE	OUT	ND< 1000	ND< 1000	ND<	1.00E+03	0.00E+00	1.1%	23.6%	23.6%	ND<	1.2E+00	2.8E-01	0.00%	100.0%
TGNMO		14300	16500		1.54E+04	1.56E+03	90.7%	0.0%	90.7%		1.8E+01	1.7E+01	14.29%	0.0%

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PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
MIN LOAD, NORM O2, NORM FGR									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	1,628	1,628		1,628	0	0.00%	0	0.00%	NA
UNIT LOAD, net MW	112	112		112	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	1.46E+07	1.46E+07		1.46E+07	2.06E+04	0.14%	1.19E+04	0.00%	0.00E+00
%O2	10.33	10.33		10.33	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor	1.977	1.977		1.977	0.00	0.00%	0.00	0.00%	0.00
Particle Collection Bias								0%	
MIN LOAD, MIN O2, HIGH FGR									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	1,661	1,661		1,661	0	0.00%	0	0.00%	NA
UNIT LOAD, net MW	119	119		119	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	1.40E+07	1.40E+07		1.40E+07	1.97E+04	0.14%	1.14E+04	0.00%	0.00E+00
%O2	8.66	8.66		8.66	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor	1.708	1.708		1.708	0.00	0.00%	0.00	0.00%	0.00
Particle Collection Bias								0%	
MIN LOAD, NORM O2, HIGH FGR									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	1,696	1,696		1,696	0	0.00%	0	0.00%	NA
UNIT LOAD, net MW	118	118		118	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	1.44E+07	1.44E+07		1.44E+07	2.03E+04	0.14%	1.17E+04	0.00%	0.00E+00
%O2	10.16	10.16		10.16	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor	1.946	1.946		1.946	0.00	0.00%	0.00	0.00%	0.00
Particle Collection Bias								0%	

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RPDM FOR MIXED	RPDM ALL ND	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAff)	RESULTS: Sr	Br	vr	vr	t:	Ur	% Ur
5.00%	5.00%	5.00E-03	3.33E-02	**BIAS**	0.00E+00	5.6E-03	7.7E-11	1.3E-07	2.8E-05	1.9E-04	1.00	1	12.7	4.0E-04	35.9%
3.92%	3.92%	2.00E-02	0.00E+00	NSTDV	0.00E+00	6.6E-03	4.6E-10	7.9E-07	1.3E-04	0.0E+00	1.00	1	12.7	1.7E-03	24.9%
21.05%	21.05%	2.00E-01	0.00E+00	NSTDV	0.00E+00	2.2E-03	2.8E-10	4.8E-07	4.3E-04	0.0E+00	1.00	1	12.7	5.5E-03	133.7%
0.00%	0.00%	0.00E+00	2.36E+02	**BIAS**	0.00E+00	1.2E-03	7.9E-08	1.3E-04	9.6E-04	2.7E-01	1.09	1	12.7	2.7E-01	23.6%
5.56%	5.56%	6.00E+02	0.00E+00	NSTDV	0.00E+00	1.2E-03	1.7E-06	2.9E-03	6.9E-01	0.0E+00	1.00	1	12.7	8.8E+00	35.3%
93.13%	93.13%	3.05E-01	0.00E+00	NSTDV	0.00E+00	5.0E-03	2.3E-10	3.8E-07	1.5E-03	0.0E+00	1.00	1	12.7	1.9E-02	591.4%
12.66%	12.66%	2.50E-02	0.00E+00	NSTDV	0.00E+00	5.8E-03	1.7E-10	2.7E-07	1.5E-04	0.0E+00	1.00	1	12.7	1.9E-03	80.4%
4.88%	4.88%	5.00E-02	0.00E+00	NSTDV	0.00E+00	1.9E-03	2.8E-10	4.5E-07	9.5E-05	0.0E+00	1.00	1	12.7	1.2E-03	31.0%
0.00%	0.00%	0.00E+00	2.36E+02	**BIAS**	0.00E+00	1.0E-03	7.3E-08	1.2E-04	8.5E-04	2.4E-01	1.09	1	12.7	2.4E-01	23.6%
19.40%	19.40%	1.30E+03	0.00E+00	NSTDV	0.00E+00	1.0E-03	9.7E-07	1.6E-03	1.3E+00	0.0E+00	1.00	1	12.7	1.7E+01	123.2%
64.52%	64.52%	1.00E-01	0.00E+00	NSTDV	0.00E+00	5.8E-03	1.2E-10	2.1E-07	5.8E-04	0.0E+00	1.00	1	12.7	7.3E-03	409.7%
37.50%	37.50%	9.00E-02	0.00E+00	NSTDV	0.00E+00	6.8E-03	2.3E-10	3.8E-07	6.1E-04	0.0E+00	1.00	1	12.7	7.8E-03	238.1%
14.63%	14.63%	1.50E-01	0.00E+00	NSTDV	0.00E+00	2.2E-03	3.2E-10	5.3E-07	3.3E-04	0.0E+00	1.00	1	12.7	4.2E-03	92.9%
0.00%	0.00%	0.00E+00	2.36E+02	**BIAS**	0.00E+00	1.2E-03	8.2E-08	1.4E-04	9.8E-04	2.8E-01	1.09	1	12.7	2.8E-01	23.6%
14.29%	14.29%	1.10E+03	0.00E+00	NSTDV	0.00E+00	1.2E-03	1.3E-06	2.1E-03	1.3E+00	0.0E+00	1.00	1	12.7	1.7E+01	90.7%

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SPECIES	LOC	CONCENTRATION In ppb			AVERAGE (r)	SAMPLE STD. DEV. (Spl)	% SAMPLE RND ERR (Sr,%)	SAMPLE % BIAS (Br,%)	% UNCERT. (Ur,%)	ABSOL. VALUE In lb/hr	ABSOL. UNCERT. (Ur)	% RPDM	% CONTRIB OF ND. TO AVG
MAX LOAD, MIN O2, HIGH FGR													
		RUN #4A	**RUN #4B**										
BENZENE	OUT	0.23	0.64		4.35E-01	2.90E-01	598.5%	0.0%	598.5%	5.8E-03	3.5E-02	94.25%	0.0%
TOLUENE		0.98	0.32		6.50E-01	4.67E-01	644.8%	0.0%	644.8%	1.0E-02	6.6E-02	101.54%	0.0%
FORMALDEHYDE	OUT	3.4	3.5		3.45E+00	7.07E-02	18.4%	0.0%	18.4%	1.8E-02	3.3E-03	2.90%	0.0%
METHANE	OUT	ND< 1000	ND< 1000		ND< 1.00E+03	0.00E+00	1.1%	23.6%	23.6%	ND< 2.7E+00	6.4E-01	0.00%	100.0%
TGNMO		97600	22200		5.99E+04	5.33E+04	799.3%	0.0%	799.3%	1.6E+02	1.3E+03	125.88%	0.0%
MAX LOAD, MIN O2, LOW FGR													
		RUN #5A	**RUN #5B**										
BENZENE	OUT	0.41	0.31		3.60E-01	7.07E-02	176.4%	0.0%	176.4%	4.9E-03	8.6E-03	27.78%	0.0%
TOLUENE		0.52	0.51		5.15E-01	7.07E-03	12.4%	0.0%	12.4%	8.3E-03	1.0E-03	1.94%	0.0%
FORMALDEHYDE	OUT	5.8	5.1		5.45E+00	4.95E-01	81.6%	0.0%	81.6%	2.8E-02	2.3E-02	12.84%	0.0%
METHANE	OUT	ND< 1000	ND< 1000		ND< 1.00E+03	0.00E+00	1.1%	23.6%	23.6%	ND< 2.8E+00	6.6E-01	0.00%	100.0%
TGNMO		26200	27800		2.70E+04	1.13E+03	37.6%	0.0%	37.6%	7.5E+01	2.8E+01	5.93%	0.0%
MAX LOAD, MIN O2, NORM FGR													
		RUN #6A	**RUN #6B**										
BENZENE	OUT	0.29	0.22		2.55E-01	4.95E-02	174.3%	0.0%	174.3%	3.6E-03	6.2E-03	27.45%	0.0%
TOLUENE		0.34	0.31		3.25E-01	2.12E-02	58.6%	0.0%	58.6%	5.4E-03	3.1E-03	9.23%	0.0%
FORMALDEHYDE	OUT	5.4	5.5		5.45E+00	7.07E-02	11.7%	0.0%	11.7%	2.9E-02	3.4E-03	1.83%	0.0%
METHANE	OUT	ND< 1000	ND< 1000		ND< 1.00E+03	0.00E+00	1.1%	23.6%	23.6%	ND< 2.9E+00	6.7E-01	0.00%	100.0%
TGNMO		18800	26500		2.27E+04	5.44E+03	215.9%	0.0%	215.9%	6.5E+01	1.4E+02	34.00%	0.0%
BASELINE													
		RUN #8A	**RUN #8B**	**RUN #8C**									
BENZENE	OUT	ND< 0.20	ND< 0.20	ND< 0.2	ND< 2.00E-01	0.00E+00	0.4%	28.9%	28.9%	ND< 2.8E-03	8.1E-04	0.00%	100.0%
TOLUENE		1.49	0.33		9.10E-01	8.20E-01	809.5%	0.0%	809.5%	1.5E-02	1.2E-01	127.47%	0.0%
FORMALDEHYDE	OUT	12.3	21.5	12.3	1.54E+01	5.31E+00	85.9%	0.0%	85.9%	8.2E-02	7.1E-02	26.61%	0.0%

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PARAMETER	RUN #1	RUN #2	RUN #3	AVERAGE	STD DEV (Spl)	%STDEV (Spl,%)	N STDEV (Spl')	% BIAS (Bpl,%)	BIAS (Bpl)
MAX LOAD, MIN O2, HIGH FGR									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	6,568	6,568		6,568	0	0.00%	0	0.00%	NA
UNIT LOAD, net MW	683	683		683	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	9.64E+06	9.62E+06		9.63E+06	1.36E+04	0.14%	7.85E+03	0.00%	0.00E+00
%O2	2.89	2.89		2.89	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor	1.160	1.160		1.160	0.00	0.00%	0.00	0.00%	0.00
Particle Collection Bias								0%	
MAX LOAD, MIN O2, LOW FGR									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	6,598	6,598		6,598	0	0.00%	0	0.00%	NA
UNIT LOAD, net MW	680	680		680	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	9.73E+06	9.71E+06		9.72E+06	1.37E+04	0.14%	7.92E+03	0.00%	0.00E+00
%O2	3.15	3.15		3.15	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor	1.177	1.177		1.177	0.00	0.00%	0.00	0.00%	0.00
Particle Collection Bias								0%	
MAX LOAD, MIN O2, NORM FGR									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	6,665	6,665		6,665	0	0.00%	0	0.00%	NA
UNIT LOAD, net MW	683	683		683	0.00	0.00%	0.00	0.00%	0.00
HEAT RATE, Btu/MWhr	9.79E+06	9.77E+06		9.78E+06	1.38E+04	0.14%	7.97E+03	0.00%	0.00E+00
%O2	3.46	3.46		3.46	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor	1.198	1.198		1.198	0.00	0.00%	0.00	0.00%	0.00
Particle Collection Bias								0%	
BASELINE									
F-factor, dscf/mmBtu	8,609	8,606	8,604	8,606	2.52	0.03%	1.45	0.00%	0.00
HHV, Btu/scf @68F	1,003	1,001	1,003	1,002	1.15	0.12%	0.67	0.00%	0.00
FUEL FLOW, kscfhr@68F	6,540	6,540	6,540	6,540	0	0.00%	0	0.00%	NA
UNIT LOAD, net MW	666	661	661	663	2.45	0.37%	1.42	0.00%	0.00
HEAT RATE, Btu/MWhr	9.86E+06	9.90E+06	9.92E+06	9.89E+06	3.26E+04	0.33%	1.88E+04	0.00%	0.00E+00
%O2	2.87	2.87	2.87	2.87	0.00	0.00%	0.00	0.00%	0.00
O2 Correction Factor	1.159	1.159	1.159	1.159	0.00	0.00%	0.00	0.00%	0.00
Particle Collection Bias								0%	

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RPDM FOR MIXED	RPDM ALL ND	CONC. DELTA P DETERMINATION NORM. STD DEV (Spc')	ND BIAS (Bpc1)	> OF NSTD OR BIAS	Particle Coll. Eff. Bias (Bpc2)	THETA CALCULATIONS FOR: CONC. (THETAc)	HEAT RT (THETAhr)	F-factor (THETAff)	RESULTS: Sr	Br	vr	vr	t	Ur	% Ur
94.25%	94.25%	2.05E-01	0.00E+00	NSTDV	0.00E+00	1.3E-02	6.0E-10	6.7E-07	2.7E-03	0.0E+00	1.00	1	12.7	3.5E-02	598.5%
101.54%	101.54%	3.30E-01	0.00E+00	NSTDV	0.00E+00	1.6E-02	1.1E-09	1.2E-06	5.2E-03	0.0E+00	1.00	1	12.7	6.6E-02	644.8%
2.90%	2.90%	5.00E-02	0.00E+00	NSTDV	0.00E+00	5.1E-03	1.8E-09	2.1E-06	2.6E-04	0.0E+00	1.01	1	12.7	3.3E-03	18.4%
0.00%	0.00%	0.00E+00	2.36E+02	**BIAS**	0.00E+00	2.7E-03	2.8E-07	3.2E-04	2.3E-03	6.4E-01	1.09	1	12.7	6.4E-01	23.6%
125.88%	125.88%	3.77E+04	0.00E+00	NSTDV	0.00E+00	2.7E-03	1.7E-05	1.9E-02	1.0E+02	0.0E+00	1.00	1	12.7	1.3E+03	799.3%
27.78%	27.78%	5.00E-02	0.00E+00	NSTDV	0.00E+00	1.4E-02	5.0E-10	5.7E-07	6.8E-04	0.0E+00	1.00	1	12.7	8.6E-03	176.4%
1.94%	1.94%	5.00E-03	0.00E+00	NSTDV	0.00E+00	1.6E-02	8.5E-10	9.6E-07	8.0E-05	0.0E+00	1.01	1	12.7	1.0E-03	12.4%
12.84%	12.84%	3.50E-01	0.00E+00	NSTDV	0.00E+00	5.2E-03	2.9E-09	3.3E-06	1.8E-03	0.0E+00	1.00	1	12.7	2.3E-02	81.6%
0.00%	0.00%	0.00E+00	2.36E+02	**BIAS**	0.00E+00	2.8E-03	2.9E-07	3.2E-04	2.3E-03	6.6E-01	1.09	1	12.7	6.6E-01	23.6%
5.93%	5.93%	8.00E+02	0.00E+00	NSTDV	0.00E+00	2.8E-03	7.7E-06	8.7E-03	2.2E+00	0.0E+00	1.00	1	12.7	2.8E+01	37.6%
27.45%	27.45%	3.50E-02	0.00E+00	NSTDV	0.00E+00	1.4E-02	3.6E-10	4.1E-07	4.9E-04	0.0E+00	1.00	1	12.7	6.2E-03	174.3%
9.23%	9.23%	1.50E-02	0.00E+00	NSTDV	0.00E+00	1.6E-02	5.5E-10	6.2E-07	2.5E-04	0.0E+00	1.00	1	12.7	3.1E-03	58.6%
1.83%	1.83%	5.00E-02	0.00E+00	NSTDV	0.00E+00	5.4E-03	3.0E-09	3.4E-06	2.7E-04	0.0E+00	1.02	1	12.7	3.4E-03	11.7%
0.00%	0.00%	0.00E+00	2.36E+02	**BIAS**	0.00E+00	2.9E-03	2.9E-07	3.3E-04	2.4E-03	6.7E-01	1.09	1	12.7	6.7E-01	23.6%
34.00%	34.00%	3.85E+03	0.00E+00	NSTDV	0.00E+00	2.9E-03	6.6E-06	7.5E-03	1.1E+01	0.0E+00	1.00	1	12.7	1.4E+02	215.9%
50.00%	0.00%	0.00E+00	5.77E-02	**BIAS**	0.00E+00	1.4E-02	2.9E-10	3.2E-07	2.3E-06	8.1E-04	2.17	2	4.3	8.1E-04	28.9%
127.47%	127.47%	5.80E-01	0.00E+00	NSTDV	0.00E+00	1.6E-02	1.5E-09	1.7E-06	9.6E-03	0.0E+00	1.00	1	12.7	1.2E-01	809.5%
26.61%	26.61%	3.07E+00	0.00E+00	NSTDV	0.00E+00	5.4E-03	8.4E-09	9.6E-06	1.6E-02	0.0E+00	2.00	2	4.3	7.1E-02	85.9%

APPENDIX G

QUALITY ASSURANCE AND QUALITY CONTROL DATA

This appendix presents detailed quality assurance and quality control (QA/QC) data for the flue gas and natural gas samples for Site 120. The QA/QC data includes results of duplicate samples, spiked samples and laboratory check standards (LCS). Additional QA/QC data such as instrument calibration data required by the sampling and analytical methodology is maintained by Carnot and the laboratory. QA/QC data is grouped by sample type and analysis. All data pertaining to an analysis is presented together. Analytical data and blank analyses are presented in Appendix H. QA/QC results are presented in the following tables.

TABLE G-1
SUMMARY OF QUALITY CONTROL RESULTS FOR EXHAUST GAS METALS ANALYSES

Duplicate Sample Results

9-MTLS

Element	Method	Sample Value ug/train	Duplicate Value, ug/train	RPD	Data Quality Objective for Duplicates	Comments
Arsenic	ICP-HYDRIDE	2.4*	4.6*	61	90-110	Exceeds Limit
Barium	ICP-AES	33.1	33.4	1.0	90-110	
Beryllium	ICP-AES	ND<0.1	ND<0.1	NC	90-110	
Cadmium	ICP-AES	ND<0.3	ND<0.3	NC	90-110	
Chromium	ICP-AES	15.6	15.7	0.6	90-110	
Cobalt	ICP-AES	1.4	1.8	26	90-110	Exceeds Limit
Copper	ICP-AES	7.9	8.0	1.2	90-110	
Lead	GFAAS	3.8	3.9	2.9	90-110	
Manganese	ICP-AES	4.9	4.9	1.5	90-110	
Mercury						
FH/BH	CVAAS	ND<3	ND<3	NC	90-110	
KMnO4	CVAAS	ND<0.7	ND<0.7	NC	90-110	
Molybdenum	ICP-AES	6.9	7.0	0.8	90-110	
Nickel	ICP-AES	44.6	43.4	2.7	90-110	
Selenium	ICP-HYDRIDE	ND<0.28*	ND<0.28*	NC	90-110	
Phosphorus	ICP-AES	ND<6	7.6	NC	90-110	
Vanadium	ICP-AES	36.4	36.3	0.2	90-110	

Notes:

RPD: Relative percent difference

NC: Not calculated – there were no detected values

*Arsenic and selenium ICP-HYDRIDE duplicate data is from a different sample program prepared and analyzed in the same batch as these samples.

Table G-1 (continued)
SUMMARY OF QUALITY CONTROL RESULTS FOR EXHAUST GAS METALS ANALYSES

Spike Results

Element	Lab blank Pre-digestion % Recovery	9-MTLS Post-digestion % Recovery	Data Quality Objective for Spikes	Comments
Arsenic	89	92	75-125	
Barium		89	75-125	
Beryllium		84	75-125	
Cadmium		80	75-125	
Chromium		83	75-125	
Cobalt		82	75-125	
Copper		86	75-125	
Lead		78	75-125	
Manganese		82	75-125	
Mercury				
FH/BH	102	90	75-125	
KMnO4	103	95	75-125	
Molybdenum		82	75-125	
Nickel		74	75-125	Post-digestion exceeds limit
Selenium	78	91	75-125	
Phosphorus		87	75-125	
Vanadium		82	75-125	

Laboratory Check Standards Results

Element	Initial Calibration % Recovery	Continuing Calibration % Recovery	Data Quality Objective for LCS	Comments
Arsenic	99.67%	93.42%	90-110	
Barium	100.70%	101.50%	90-110	
Beryllium	92.36%	93.72%	90-110	
Cadmium	103.68%	102.54%	90-110	
Chromium	106.50%	105.10%	90-110	
Cobalt	101.56%	100.20%	90-110	
Copper	102.48%	102.96%	90-110	
Lead	107.00%	100.67%	90-110	
Manganese	104.64%	104.20%	90-110	
Mercury				
FH/BH	112.75%	100.25%	80-120	
KMnO4	106.00%	101.50%	80-120	
Molybdenum	99.62%	99.09%	90-110	
Nickel	102.28%	101.28%	90-110	
Selenium	101.75%	93.00%	90-110	
Phosphorus	96.70%	102.28%	90-110	
Vanadium	98.68%	98.96%	90-110	

Correlation Coefficients for MSA Data, R2

Sample ID	Arsenic, R2	Selenium, R2	Data Quality Objective for MSA
LAB BLANK	0.9999	0.9089*	>0.995
7-MTLS	0.9967	0.9997	>0.995
8-MTLS	0.9999	0.9748*	>0.995
9-MTLS	0.9965	0.9137*	>0.995
FB-MTLS	1.0000	0.7966*	>0.995
RB-MTLS	0.9983	0.9997	>0.995

Notes:
*Less than the DQO for MSA.
MSA: Samples analyzed by the Method of Standard Additions
The MSA data for Arsenic and Selenium was not used due to variable detection limits and spread of data. ICP-AES/Hydride data was reported instead.

TABLE G-2
SUMMARY OF QUALITY CONTROL RESULTS FOR EXHAUST GAS PAH ANALYSES
SITE 120

Duplicate Matrix Spike Recoveries:	Blank Matrix Spike #1 % Recovery	Blank Matrix Spike #2 % Recovery	RPD	Data Quality Objective for Duplicates	Comments
Naphthalene	NA	NA	NC	<50	
Acenaphthylene	150	150	0.0	<50	
Acenaphthene	79	74	6.5	<50	
Fluorene	105	91	14.3	<50	
Phenanthrene	138	125	9.9	<50	
Anthracene	119	116	2.6	<50	
Fluoranthene	125	125	0.0	<50	
Pyrene	118	116	1.7	<50	
Benz(a)anthracene	113	113	0.0	<50	
Chrysene	150	150	0.0	<50	
Benzo(b)fluoranthene	109	109	0.0	<50	
Benzo(k)fluoranthene	125	125	0.0	<50	
Benzo(a)pyrene	103	101	2.0	<50	
Indeno(1,2,3-cd)pyrene	101	98	3.0	<50	
Dibenzo(a,h)anthracene	70	68	2.9	<50	
Benzo(g,h,i)perylene	100	100	0.0	<50	
2-Methylnaphthalene	NS	NS	NC	<50	
7,12-Dimethylbenz(a)anthracene	NS	NS	NC	<50	
3-Methylcholanthrene	NS	NS	NC	<50	

Duplicate Matrix Spike Internal Recoveries:	Blank Matrix Spike #1 % Recovery	Blank Matrix Spike #2 % Recovery	RPD	Data Quality Objective for Duplicates	Comments
Napthalene-2H8	49	67	31	<50	
Acethenapthylene-2H8	48	69	36	<50	
Acenapthene--2H10	48	69	36	<50	
Fluorene-2H10	52	75	36	<50	
Phenanthrene-2H10	71	84	17	<50	
Anthracene-2H10	82	100	20	<50	
Fluoranthene-2H10	92	98	6.3	<50	
Pyrene-2H10	94	98	4.2	<50	
Benz(a)anthracene-2H12	80	78	2.5	<50	
Chrysene-2H12	76	76	0.0	<50	
Benzo(b)fluoranthene-2H12	83	83	0.0	<50	
Benzo(k)fluoranthene-2H12	84	83	1.2	<50	
Benzo(a)pyrene-2H12	83	84	1.2	<50	
Indeno(1,2,3-c,d)pyrene-2H12	99	96	3.1	<50	
Dibenzo(a,h)anthracene-2H14	99	96	3.1	<50	
Benzo(g,h,i)perylene-2H12	96	90	6.5	<50	

NA: Samples were not spiked with a level high enough above background to determine its spike recovery.
NC: Not calculated -- data not meaningful, or spikes not performed.
NS: Not Spiked
RPD: Relative Percent Difference

TABLE G-2 (continued)
SUMMARY OF QUALITY CONTROL RESULTS FOR EXHAUST GAS PAH ANALYSES
SITE 120

PAH Recovery Results	Method Blank	Average Matrix Spike	Field Blank	7-PAH	8-PAH	9-PAH	Data Quality Objective for Spikes	Comments
Internal Recoveries, % (added pre-extraction)								
Napthalene-2H8	63	58	66	66	66	82	50-150	
Acethenapthylene-2H8	62	59	81	60	79	96	50-150	
Acenapthene--2H10	58	59	79	71	74	91	50-150	
Fluorene-2H10	59	64	85	74	73	93	50-150	
Phenanthrene-2H10	69	78	92	82	84	100	50-150	
Anthracene-2H10	74	91	110	64	92	93	50-150	
Fluoranthene-2H10	80	95	100	83	83	100	50-150	
Pyrene-2H10	80	96	100	86	88	110	50-150	
Benz(a)anthracene-2H12	76	79	84	84	92	94	50-150	
Chrysene-2H12	82	76	74	77	80	84	50-150	
Benzo(b)fluoranthene-2H12	80	83	87	82	88	94	50-150	
Benzo(k)fluoranthene-2H12	80	84	82	78	83	89	50-150	
Benzo(a)pyrene-2H12	68	84	92	75	85	84	50-150	
Indeno(1,2,3-c,d)pyrene-2H12	100	98	100	82	94	100	50-150	
Dibenzo(a,h)anthracene-2H14	67	98	98	75	85	94	50-150	
Benzo(g,h,i)perylene-2H12	91	93	91	74	83	90	50-150	
Surrogate Recoveries, % (field spikes)								
Benzo(e)pyrene-2H12	NS	NS	NS	NS	NS	NS	50-150	
Terphenyl-2H14	NS	NS	NS	NS	NS	NS	50-150	

NS: Not Spiked -- Laboratory inadvertantly used internal spikes instead of surrogate spikes in resin columns.

TABLE G-3
SUMMARY OF QUALITY CONTROL RESULTS FOR EXHAUST GAS FORMALDEHYDE ANALYSES

Sample Duplicate Analysis

Sample ID	Sample ug/sample	Duplicate ug/sample	RPD	Data Quality Objective for Duplicates	Comments
1-Form A #1	0.12	0.11	8.7	10	
2-B-Form #2	0.22	0.22	0.0	10	
4-A-Form #2	0.23	0.25	8.3	10	
5-A-FB-Form #1	0.33	0.36	8.7	10	
8A-FB-Form #1	0.72	0.72	0.0	10	

Spike Analysis

	Expected Value ug/sample	Measured Value ug/sample	% Recovery	Data Quality Objective for Spikes	Comments
Matrix Spikes:					
1-Form-A #1	6.72	6.33	94	60-140	
4-B-Form #1	6.72	7.29	108	60-140	
8A-Form #1	6.72	7.64	114	60-140	
Trip Spike:	5.00	5.53	111	60-140	
Field Spike:	5.00	6.03	121	60-140	

RPD: Relative Percent Difference

TABLE G-4
SUMMARY OF QUALITY CONTROL RESULTS FOR EXHAUST GAS VOC ANALYSES

Sample Duplicate Results

Component	Sample ID	Run # 1 ppb, v/v	Run #2 ppb, v/v	RPD	Data Quality Objective for Duplicates	Comments
Benzene	1-A-VOC	0.21	0.21	0.0	20	
	1-B-VOC	ND<0.20	0.24	NC	20	
	2-B-VOC	0.32	0.38	17	20	
	4-A-VOC	0.26	0.20	26	20	Exceeds Limit
	4-B-VOC	0.64	0.63	1.6	20	
	8A-VOC	ND<0.20	ND<0.20	NC	20	
	8B-VOC	ND<0.20	ND<0.20	NC	20	
	BLK-VOC	ND<0.20	ND<0.20	NC	20	
Toluene	1-A-VOC	1.21	0.87	33	20	Exceeds Limit
	1-B-VOC	1.11	0.89	22	20	Exceeds Limit
	2-B-VOC	0.44	0.40	10	20	
	4-A-VOC	1.05	0.91	14	20	
	4-B-VOC	0.26	0.37	35	20	Exceeds Limit
	8A-VOC	0.30	0.36	18	20	
	8B-VOC	7.08	7.63	7.5	20	
	BLK-VOC	1.67	1.74	4.1	20	
Methane	1-B-VOC	ND<1	ND<1	NC	20	
	4-A-VOC	ND<1	ND<1	NC	20	
TGNMO	1-B-VOC	20.9	21.0	0.5	20	
	4-A-VOC	97.2	98.0	0.8	20	

Calibration Standards Identification

Benzene and Toluene:	NIST 1811
Methane / TGNMO:	Scott Specialty Gas Cylinder # ALM-2341

Matix spikes were not performed on VOC samples.
NC: Not calculated -- there were no detected values.
RPD: Relative Percent Difference

TABLE G-5
SUMMARY OF QUALITY CONTROL RESULTS FOR ANALYSIS OF NATURAL GAS

Component	Replicate 1 volume %	Replicate 2 volume %	% Difference	Quality Objective
Methane (C1)	96.5	96.5	0.00%	10%
Ethane (C2)	1.84	1.85	0.54%	10%
Propane (C3)	0.157	0.157	0.00%	10%
i-Butane (C4)	0.024	0.023	4.26%	10%
n-Butane (C4)	0.027	0.027	0.00%	10%
i-Pentane (C5)	ND<0.001	ND<0.001	NC	10%
n-Pentane (C5)	ND<0.001	ND<0.001	NC	10%
C6 Plus	0.023	0.024	4.26%	10%
Carbon Dioxide	0.43	0.43	0.00%	10%
Nitrogen (N2)	0.94	0.94	0.00%	10%
Carbon Monoxide	0.43	0.43	0.00%	10%
Helium	0.034	0.034	0.00%	10%
Hydrogen	0.002	0.002	0.00%	10%
Oxygen/Argon	ND<0.03	ND<0.03	NC	10%
Ethene	ND<0.03	ND<0.03	NC	10%
Propene	ND<0.002	ND<0.002	NC	10%
1-Butene	ND<0.003	ND<0.003	NC	10%
Butadiene	ND<0.006	ND<0.006	NC	10%
neo-Pentane	ND<0.001	ND<0.001	NC	10%
Pentenes	ND<0.001	ND<0.001	NC	10%

NC: Not calculated -- there were no detected values.

TABLE G-6
NATURAL GAS ANALYSIS OF NIST STANDARD REFERENCE MATERIAL

Component	Replicate 1 volume %	Certified NIST Value volume %	% Difference	Data Quality Objective
Oxygen/Argon	ND<0.003	ND<0.003	NC	10%
Nitrogen	2.632	2.612	0.77%	10%
Carbon Dioxide	1.002	1.009	0.69%	10%
Methane (C1)	90.435	90.494	0.07%	10%
Ethane (C2)	4.056	4.010	1.15%	10%
Propane (C3)	1.009	1.000	0.90%	10%
i-Butane (C4)	0.308	0.311	0.96%	10%
n-Butane (C4)	0.300	0.306	1.96%	10%
i-Pentane (C5)	0.101	0.103	1.94%	10%
n-Pentane (C5)	0.103	0.101	1.98%	10%
C6 Plus	0.055	0.054	1.85%	10%

NC: Not calculated -- there were no detected values.

APPENDIX H

ANALYTICAL AND BLANK CORRECTION DATA

This Appendix contains summary tables of the laboratory analysis results for the exhaust gas. These tables indicate the analytical results obtained for field blanks, reagent blanks and laboratory preparation blanks. Field blanks are a sampling train that is set up and recovered at the test site using the same procedure as an actual sample. In general, field blanks are not used to correct the result but do indicate the level of the analyte present in the sample train introduced by the recovery procedures. Reagent blanks are collected in the field and consist of reagents and filters used for each sample train. Laboratory preparation blanks consist only of the chemicals needed to decompose and analyze the samples. All blanks are carried through the entire analytical procedure. Corrections to the data for reagent or preparation blanks are noted. For a series of tests the blank correction contribution is calculated as:

$$\frac{\sum_{n=1}^{i}\left(\frac{\textit{Amount of blank correction}}{\textit{Original sample value}} x\ 100\right)}{n}$$

For example, the flue gas arsenic result was corrected for the reagent blank of 0.5 μg. Raw data for the test series were 5.4, 1.9 and 2.0 μg per train. The blank correction contribution is calculated as:

$$\frac{\left(\frac{0.5}{5.4} x\ 100\right) + \left(\frac{0.5}{1.9} x\ 100\right) + \left(\frac{0.5}{2.0} x\ 100\right)}{3}$$

or

$$\frac{(9.3\% + 26.3\% + 25.0\%)}{3}$$

or

$$20.2\%$$

Blank corrections in no case bring the sample value below the reporting limit. If the blank correction results in a value lower than the reporting limit, the final result is presented as detected at the reporting limit.

Tables in this appendix include:

H-1	Trace Metals Analytical Results Summary
H-2	PAH Analytical Results Summary
H-3	Formaldehyde Analytical Results Summary
H-4	VOC Analytical Results Summary
H-5	Summary of Blank Corrections Made to Analytical Data

TABLE H-1
TRACE METALS ANALYTICAL RESULTS SUMMARY
SITE 120

Sample I.D.	Laboratory Blank	Reagent Blank	Field Blank	7-MTLS	8-MTLS	9-MTLS	Blank Correction Contribution, % (Average)
	ug/train						
Arsenic	1.3	0.5	2.0	5.4	1.9	2.0	20
Barium	13	6.4	38	39	29	33	19
Beryllium	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	0
Cadmium	ND<0.3	ND<0.3	ND<0.3	ND<0.3	ND<0.3	ND<0.3	0
Chromium	0.7	1.0	3.2	13	9.8	16	8
Cobalt	ND<1	ND<1	ND<1	2	1	1	0
Copper	1.9	4.1	6.5	6.7	5.9	7.9	61
Lead	0.7	0.6	2.8	3.8	3.7	3.4	17
Manganese	ND<0.8	ND<0.8	6.7	4.4	3.4	4.9	0
Mercury							
FH/BH	ND<0.9	ND<0.6	ND<1	ND<3	ND<3	ND<3	0
KMnO4	ND<0.04	ND<0.3	ND<0.5	ND<0.8	ND<0.9	ND<0.6	0
Molybdenum	1.6	ND<0.8	5.6	6.3	6.3	6.9	0
Nickel	ND<2	ND<2	5	45	30	45	0
Selenium	ND<0.25	ND<0.25	ND<0.28	ND<0.28	ND<0.28	ND<0.28	0
Phosphorus	ND<6	ND<6	ND<6	ND<6	ND<6	ND<6	0
Vanadium	ND<0.6	ND<0.6	2.7	42	29	36	0

Notes:

The reagent blank was subtracted from the laboratory results to obtain the final results for As, Ba, Cr, Cu and Pb.
Arsenic and Selenium were analyzed by ICP-AES with Hydride generation.

TABLE H-2
PAH ANALYTICAL RESULTS SUMMARY
SITE 120

Sample I.D.	Method Blank	Field Blank	7-PAH	8-PAH	9-PAH
Species					
Naphthalene	1.3	1.4	2.6	1.5	1.5
Acenaphthylene	ND <0.015	ND <0.011	ND <0.011	ND <0.011	ND <0.013
Acenaphthene	ND <0.0060	ND <0.012	ND<0.010	ND<0.0060	ND <0.012
Fluorene	ND <0.010	ND<0.0060	ND<0.022	0.021	0.029
Phenanthrene	ND <0.015	0.021	0.080	0.063	0.082
Anthracene	ND <0.016	ND <0.0060	ND<0.019	ND <0.010	ND <0.013
Fluoranthene	ND <0.020	ND<0.021	0.045	ND <0.021	ND <0.021
Pyrene	ND <0.020	ND<0.021	0.073	0.022	0.019
Benz(a)anthracene	ND <0.012	ND <0.0080	ND <0.012	ND <0.0070	ND <0.0070
Chrysene	ND <0.017	ND <0.0090	ND <0.014	ND <0.012	ND <0.011
Benzo(b)fluoranthene	ND <0.011	ND <0.0070	ND <0.013	ND <0.0090	ND<0.010
Benzo(k)fluoranthene	ND <0.012	ND <0.011	ND <0.0070	ND <0.0070	ND <0.015
Benzo(a)pyrene	ND <0.016	ND <0.0090	ND <0.0090	ND <0.0090	ND<0.0090
Indeno(1,2,3-cd)pyrene	ND <0.023	ND <0.012	ND <0.012	ND <0.012	ND <0.012
Dibenzo(a,h)anthracene	ND <0.018	ND <0.0060	ND <0.0090	ND <0.010	ND <0.0070
Benzo(g,h,i)perylene	ND <0.013	ND <0.0080	ND <0.0080	ND <0.0080	ND <0.0080
2-Methylnaphthalene	ND <0.0060	0.015	0.074	0.039	0.099
7,12-Dimethylbenz(a)anthracene	ND <0.052	ND <0.11	ND <0.11	ND <0.11	ND <0.12
3-Methylcholanthrene	ND <0.019	ND <0.0090	ND <0.013	ND <0.013	ND <0.011

The PAH results are already corrected by the lab for the laboratory method blank and internal spike recoveries.

TABLE H-3
FORMALDEHYDE ANALYTICAL RESULTS SUMMARY
SITE 120

Sample I.D.	ug/Test	Reagent Blank, ug	Blank Correction Contribution	Field Blank
1A-FORM	0.22	0.0073	0.0%	
1B-FORM	0.22	0.0073	0.0%	0.48
2A-FORM	0.26	0.0073	0.0%	
2B-FORM	0.30	0.0073	0.0%	0.81
3A-FORM	0.23	0.0073	0.0%	
3B-FORM	0.32	0.0073	0.0%	0.62
4A-FORM	0.37	0.0073	0.0%	
4B-FORM	0.47	0.0073	0.0%	0.84
5A-FORM	0.59	0.0073	0.0%	
5B-FORM	0.75	0.0073	0.0%	0.33*
6A-FORM	0.61	0.0073	0.0%	
6B-FORM	0.73	0.0073	0.0%	0.32*
8A-FORM	1.48	0.0073	0.0%	1.70
8B-FORM	2.72	0.0073	0.0%	1.55
8C-FORM	1.48	0.0073	0.0%	1.64
		Average:	0.0%	

NP: Not Performed

*Field blank consisted of only one vial, instead of two.

A trip blank was not performed.

TABLE H-4
VOC ANALYTICAL RESULTS SUMMARY
SITE 120

Component	Sample I.D.	ppb, v/v	Pre-test Tedlar Bag Blank	Blank Correction Contribution
Benzene	1A-VOC	0.21	ND<0.20	0.0%
	1B-VOC	ND<0.20	ND<0.20	0.0%
	2A-VOC	0.96	ND<0.20	0.0%
	2B-VOC	0.35	ND<0.20	0.0%
	3A-VOC	0.21	ND<0.20	0.0%
	3B-VOC	0.41	ND<0.20	0.0%
	4A-VOC	0.23	ND<0.20	0.0%
	4B-VOC	0.64	ND<0.20	0.0%
	5A-VOC	0.41	ND<0.20	0.0%
	5B-VOC	0.31	ND<0.20	0.0%
	6A-VOC	0.29	ND<0.20	0.0%
	6B-VOC	0.22	ND<0.20	0.0%
	8A-VOC	ND<0.20	ND<0.20	0.0%
	8B-VOC	ND<0.20	ND<0.20	0.0%
	8C-VOC	ND<0.20	ND<0.20	0.0%
Toluene	1A-VOC	1.04	1.71	0.0%
	1B-VOC	1.00	1.71	0.0%
	2A-VOC	0.37	1.71	0.0%
	2B-VOC	0.42	1.71	0.0%
	3A-VOC	0.39	1.71	0.0%
	3B-VOC	0.57	1.71	0.0%
	4A-VOC	0.98	1.71	0.0%
	4B-VOC	0.32	1.71	0.0%
	5A-VOC	0.52	1.71	0.0%
	5B-VOC	0.51	1.71	0.0%
	6A-VOC	0.34	1.71	0.0%
	6B-VOC	0.31	1.71	0.0%
	8A-VOC	1.49	1.71	0.0%
	8B-VOC	0.33	1.71	0.0%
	8C-VOC	7.36	1.71	0.0%
			Average:	0.0%

NP: Not Performed

TABLE H-5
SUMMARY OF BLANK CORRECTIONS MADE TO ANALYTICAL DATA
SITE 120

Sample Type	Parameter	Type of Blank Correction	Blank Correction Contribution
Exhaust Gas	Arsenic	Reagent Blank	20%
	Barium	Reagent Blank	19%
	Beryllium	None	0.0%
	Cadmium	None	0.0%
	Chromium	Reagent Blank	8.0%
	Cobalt	None	0.0%
	Copper	Reagent Blank	61%
	Lead	Reagent Blank	17%
	Manganese	None	0.0%
	Mercury	None	0.0%
	Molybdenum	None	0.0%
	Nickel	None	0.0%
	Selenium	None	0.0%
	Phosphorus	None	0.0%
	Vanadium	None	0.0%
	PAH	None	0.0%
	Formaldehyde	None	0.0%
	Volatile Organic Compounds	None	0.0%

TABLE H-4 (continued)
VOC ANALYTICAL RESULTS SUMMARY
SITE 120

Component	Sample I.D.	ppm, v/v	Pre-test Tedlar Bag Blank	Blank Correction Contribution
Methane	1A-VOC	ND<1	NP	0.0%
	1B-VOC	ND<1	NP	0.0%
	2A-VOC	ND<1	NP	0.0%
	2B-VOC	ND<1	NP	0.0%
	3A-VOC	ND<1	NP	0.0%
	3B-VOC	ND<1	NP	0.0%
	4A-VOC	ND<1	NP	0.0%
	4B-VOC	ND<1	NP	0.0%
	5A-VOC	ND<1	NP	0.0%
	5B-VOC	ND<1	NP	0.0%
	6A-VOC	ND<1	NP	0.0%
	6B-VOC	ND<1	NP	0.0%
TGNMO	1A-VOC	22.2	NP	0.0%
	1B-VOC	21.0	NP	0.0%
	2A-VOC	12.1	NP	0.0%
	2B-VOC	14.7	NP	0.0%
	3A-VOC	14.3	NP	0.0%
	3B-VOC	16.5	NP	0.0%
	4A-VOC	97.6	NP	0.0%
	4B-VOC	22.2	NP	0.0%
	5A-VOC	26.2	NP	0.0%
	5B-VOC	27.8	NP	0.0%
	6A-VOC	18.8	NP	0.0%
	6B-VOC	26.5	NP	0.0%
			Average:	0.0%

NP: Not Performed

Tests 8A-VOC, 8B-VOC, 8C-VOC, and the Blank were not analyzed for Methane/TGNMO.