DOE/PC/93253--T2

A Study of Toxic Emissions From A Coal-Fired Gasification Plant

DE-AC22-93PC93253

DCN 95-643-004-07

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Final Report, December 1995

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EXECUTIVE SUMMARY

Under the Fine Particulate Control/Air Toxics Program, the U.S. Department of Energy (DOE) has been performing comprehensive assessments of toxic substance emissions from coal-fired electric utility units. An objective of this program is to provide information to the U.S. Environmental Protection Agency (EPA) for use in evaluating hazardous air pollutant emissions as required by the Clean Air Act Amendments (CAAA) of 1990. The Electric Power Research Institute (EPRI) has also performed comprehensive assessments of emissions from many power plants and provided the information to the EPA. The DOE program was implemented in two phases. Phase 1 involved the characterization of eight utility units, with options to sample additional units in Phase 2. Radian was one of five contractors selected to perform these toxic emission assessments.

Radian's Phase 1 test site was at Southern Company Service's Plant Yates, Unit 1, which, as part of the DOE's Clean Coal Technology Program, was demonstrating the CT-121 flue gas desulfurization technology. A commercial-scale prototype integrated gasification-combined cycle (IGCC) power plant was selected by DOE for Phase 2 testing. Funding for the Phase 2 effort was provided by DOE, with assistance from EPRI and the host site, the Louisiana Gasification Technology, Inc. (LGTI) project. This document presents the results of that effort.

The Louisiana Gasification Technology Inc. (LGTI) project was selected by the U.S. Synthetic Fuels Corporation to demonstrate the Dow Syngas process. The project commenced operation in 1987. It was partially funded by a Price Guarantee Commitment between Dow and the Synfuels Corporation. The guarantee has since been assumed by the Office of Synthetic Fuels, U.S. Treasury Department. Dow has formed a subsidiary, Destec Energy, which operates and markets their gasification technology.

Radian's assessment of emissions involved the collection and analysis of samples from the major input, process, and output streams of the IGCC plant for selected substances including those identified in Title III of the CAAA. These measurements provide information on the performance of processing systems within the plant and data on the fate of trace substances.

Site Description

The LGTI plant is located within Dow Chemical's Louisiana Division complex in Plaquemine, Louisiana. The petrochemical complex located there produces chlorine and caustic. The gasifier provides both process steam and synthesis gas, which is burned in turbines to produce electricity for the complex. Subbituminous coal from the Rochelle mine in the Powder River basin is used to produce a medium-Btu synthesis gas. At design feed rates of 2,200 tons of coal per day, 30,000 MM Btu of syngas is produced. Additional steam generated in the process produces a net output equivalent to 161 MW of electric power.

Process Description

Dow's gasifier design is proprietary but can be classified as a high-temperature, entrained-flow, slagging type. Coal is fed to the gasifier as a coal-water slurry which eliminates the need for coal lock hoppers. Oxygen and steam are added in a controlled manner to maintain the reactor within the design temperature range. Slag is removed as a water slurry, while hot synthesis gas is cooled in a heat recovery train that raises process steam. A particulate scrubber removes char from the gas, which is recycled to the gasifier. Further cooling of the syngas occurs followed by processing in a Selectamine™ unit to remove H_2S. The sweet syngas that results is blended with natural gas and fired in two gas turbines to produce electricity. The acid gas from the Selectamine™ unit is processed in a Selectox™ unit, producing elemental sulfur. Sour condensate is steam stripped, and the sour off-gas and Selectox™ tail gases are incinerated. Figure ES-1 shows a simplified block diagram of the plant. It also identifies the sampling locations used during this project.

Sampling Locations/Analytes

Due to the number and type of sampling locations as well as the groups of analytes measured, it was necessary to employ a phased approach during the test program. The majority of the plant was characterized during three consecutive test periods in November 1994. In a fourth test period, conducted in May 1995, a hot-gas probe was used to gather high-temperature/pressure samples from the raw syngas. Table ES-1 lists the sampling locations (the number refers to the location on Figure ES-1), the test period, and the types of analytes measured.

Quality Assurance and Quality Control

A rigorous QA/QC program was employed to ensure that the quality of the data produced during this effort would be well defined. Three major questions were addressed during this assessment: First, was the plant operating in a normal condition? Second, was the sampling of process streams representative, and last, were the analytical results obtained correct? Each of these concerns is discussed briefly below.

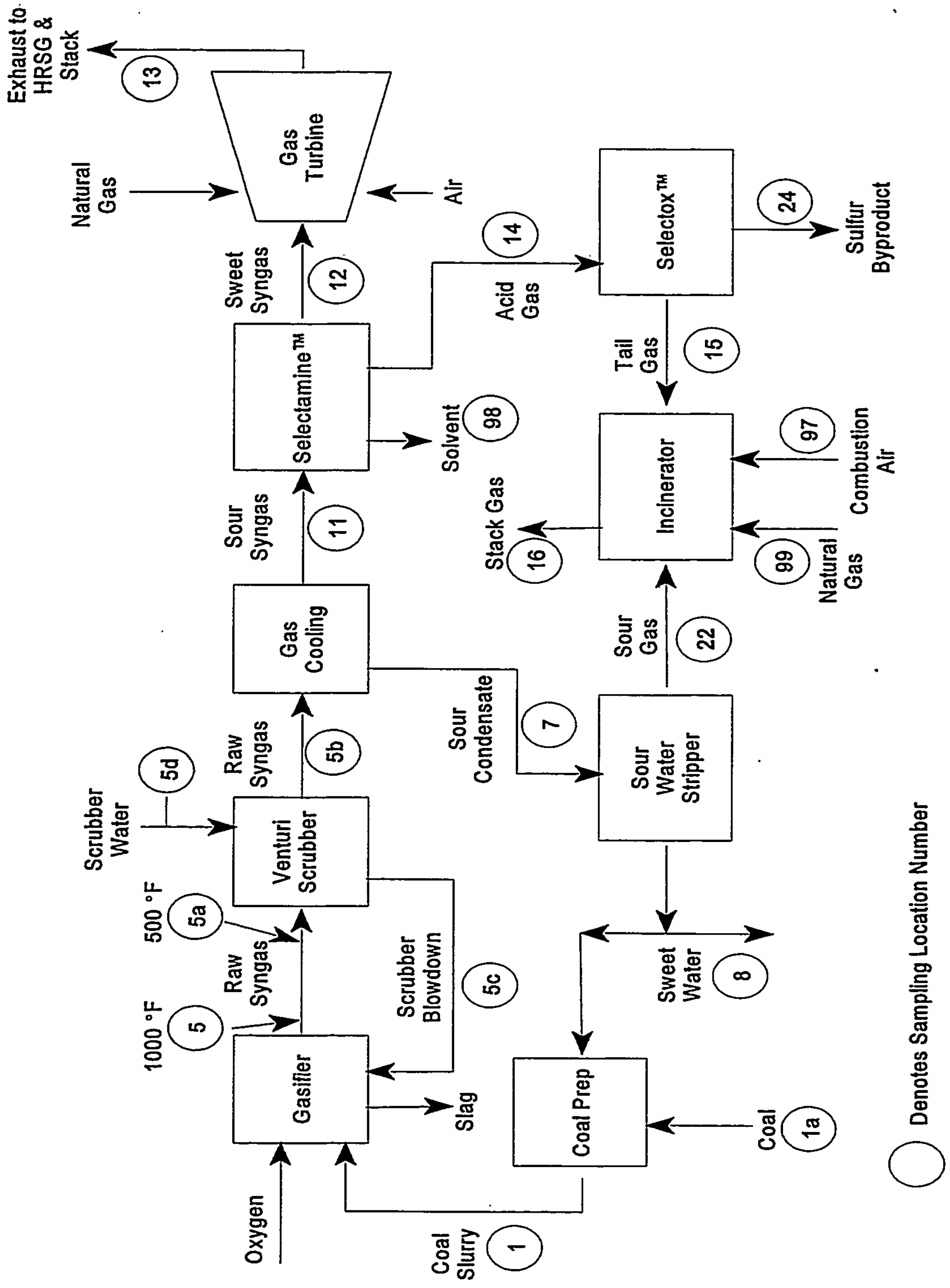

Figure ES-1
LGTI Block Flow Diagram

"

Table ES-1
Sampling Locations and Analytes

Location	Stream	Test Period	Analytes
1	Coal slurry	1, 2, 3	Metals, ultimate, proximate, anions
1a	Coal pile	1, 2, 3	Metals, ultimate, proximate, anions
		3	Radionuclides
4	Slag	1, 2, 3	Metals, ultimate, proximate, anions
		3	Radionuclides
5	Raw gas, 1,000°F	4	Vapor: metals, Cl, F, NH_3, HCN Particulate: metals
5a	Raw gas, 500°F	3	Metals, C_1-C_{10}, Cl, F, NH_3, HCN
5a	Raw gas, 500°F	probe shakedown test	Particulate: metals
5b	Raw gas, scrubbed	3	Metals, C_1-C_{10}, Cl, F, NH_3, HCN
5c	Scrubber blowdown (char)	3	Metals, ultimate, proximate, anions
	(filtrate)	3	Metals, ultimate, proximate, anions, ammonia, cyanide, suspended solids
5d	Scrubber water	3	Metals, ultimate, proximate, anions, ammonia, cyanide
7	Sour condensate	2	Metals, cyanide, volatile/semivolatile organics, aldehydes, anions, ammonia, phenol, sulfide, water quality
8	Sweet water	2	Metals, cyanide, volatile/semivolatile organics, aldehydes, anions, ammonia, phenol, sulfide, water quality
11	Sour syngas	1	Particulates, metals, C_1-C_{10}, volatile organics, major gases, sulfur species, semivolatile organics, aldehydes, Cl, F, NH_3, HCN
12	Sweet syngas	1	Particulates, metals, C_1-C_{10}, volatile organics, major gases, sulfur species, semivolatile organics, aldehydes, Cl, F, NH_3, HCN
13	Turbine exhaust	1	Particulates, PM-10, metals, VOST, semivolatile organics, aldehydes, Cl, F, NH_3, HCN, H_2SO_4, CEM gases
14	Acid gas	1	Metals, C_1-C_{10}, major gases, sulfur species, semivolatile organics, Cl, F, NH_3, HCN
15	Tail gas	1	Metals, C_1-C_{10}, major gases, sulfur species, semivolatile organics, NH_3, HCN
		2	C_1-C_{10}, sulfur species, semivolatile organics, NH_3, HCN, CEM gases
16	Incinerator stack	2	Particulates, PM-10, metals, VOST, sulfur species, semivolatile organics, aldehydes, Cl, F, NH_3, HCN, H_2SO_4, CEM gases

Table ES-1 (Continued)

Location	Stream	Test Period	Analytes
22	Sour gas	2	C_1-C_{10}, major gases, NH_3, HCN
24	Sulfur	1	Metals, ultimate, proximate
97	Combustion air	2	C_1-C_{10}, major gases, sulfur species, NH_3, HCN
98	Selectamine™ solvent	1	Metals, ash, volatile organics, heat stable salts
		3	Metals, ash, heat stable salts
99	Natural gas	2	Metals, C_1-C_{10}, sulfur species

Plant Operating Conditions

In general, the plant operation was very consistent, and the major monitored processes varied by less than ±10% during the test periods. On the third day of testing, November 5, the coal feed system plugged briefly, resulting in the unit going off-line for about 24 hours. Testing was resumed after another 24 hours on November 7. All other plant operational periods were normal with minimal variability.

Sample Collection

With the exceptions of the sampling locations discussed below, all other locations were sampled with minimal problems. While the collected samples are considered to be representative of normal process operation, some of the sampling methodologies used on the internal steams for trace elements are in their developmental stages and have not been validated or fully demonstrated. Therefore, the vapor phase metals results for some of the *internal* process streams are considered to be semi-quantitative.

Several of the internal gas streams contain high levels of water vapor. When the pressure and temperature is reduced during sample collection, moisture condensation occurs. Three sampling locations were heat traced to minimize condensation but another was physically impractical to heat trace. Therefore, at this one sample location, the mass of condensate collected was not equivalent to the gas volume collected, and some results for water-soluble components (i.e. ammonia) from this location have been invalidated due to their being non-representative.

One stream (the sour water stripper overhead), contained particularly high levels of NH_3 and CO_2. Upon cooling, ammonium carbonate deposits formed and plugged the sample line, preventing the collection of many of the planned samples for this stream.

In spite of the severe conditions encountered at many of the internal sampling locations, over 97% of the samples identified in the test plan were successfully obtained.

Analytical Results

At LGTI, both oxidized (containing excess oxygen) and reduced (containing hydrogen or sub-stoichiometric amounts of oxygen) streams exist in the process. Analytical QC results for the influent and effluent streams (coal, slag, sweet water, incinerator stack gas, and turbine stack gas) indicate that the analytical data are, with very few exceptions, of good quality and acceptable for use. This statement implies that the bias and precision of the results met the project data quality objectives and that minimal contamination was identified as a result of reagent, sampling, or analytical procedures. The material balances that were performed around the entire plant also support the "reasonableness" of the data obtained for the input and output streams of the plant.

A similar statement can be made for measurements of many of the internal streams. However, confidence in some of the results is not as high for the following reasons:

- No standard or validated methods are available or exist for sampling some of the substances measured.
- Some of the streams were sampled and analyzed by more than one method. When compared, the results from the different methods, in some instances, were conflicting.
- It was not possible to accurately determine particulate loading in most internal streams. This makes elemental material balances particularly difficult since trace element concentrations are typically highest in the particulate phase.
- Comparisons between different streams (e.g., by mass balance) sometimes produced illogical results.

Because of these reasons, the internal stream results, particularly for vapor-phase trace metal concentrations, should be considered only as approximations of the true concentrations.

Results

Testing at the LGTI facility has shown the following results:

- **LGTI's emissions of hazardous air pollutants were quite low.** For many substances the combined emission factors (turbine and incinerator stack) were lower than well-controlled pulverized coal steam-electric plants. QA/QC results for the emissions streams show, among other things, that ***76% of the trace element balances met the material balance objectives of 70 - 130% closure.*** Emission factors for selected HAPs are presented in Table ES-2.
- **The particulate emissions from the turbine exhaust stack were very low, measuring approximately 4 mg/Nm^3.**
- **The majority of trace and major elements present in the coal were found in the slag.**

Table ES-2
Emission Factors for Selected HAPs

	Combined Incinerator and Turbine Stack Emissions		
	Emission Rate	Emission Factor	
	lb/hr	lb/10^{12} Btu	95% CI
Particulate Loading	25	9,100	6,000
Ionic Species			
Chloride	1.7	740	180
Fluoride	0.090	38	22
Ammonia as N	1.2	440	430
Metals			
Antimony	0.011	4	4.7
Arsenic	0.0056	2.1	1.9
Barium	0.0096	3.5	1.3
Beryllium	2.5e-04	0.09	0.03
Cadmium	0.0078	2.9	3.8
Chromium	0.0073	2.7	0.63
Cobalt	0.0015	0.57	0.58
Lead	0.0077	2.9	1.5
Manganese	0.0083	3.1	6.5
Mercury	0.0046	1.7	0.43
Molybdenum	0.019	6.9	5.6
Nickel	0.011	3.9	3.6
Selenium	0.008	2.9	1.3
Aldehydes			
Acetaldehyde	0.0048	1.8	1.5
Benzaldehyde	0.0079	2.9	2.6
Formaldehyde	0.045	17	7.5
Volatile Organic Compounds			
Benzene	0.012	4.4	1.7
Carbon Disulfide	0.12	46	14
Toluene	5.3e-05	0.033	0.02
PAHs/SVOCs			
2-Methylnaphthalene	9.8e-04	0.36	0.55
Acenaphthylene	7.1e-05	0.026	0.0075
Benzo(a)anthracene	6.2e-06	0.0023	0.0002
Benzo(e)pyrene	1.5e-05	0.0056	0.0007
Benzo(g,h,i)perylene	2.6e-05	0.0096	0.0005
Naphthalene	1.1e-03	0.4	0.12
Benzoic acid	0.39	140	65

- **Some reduction in the concentration of trace substances in the syngas was measured across the Selectamine™ unit for both vapor-phase elements and organics.** Unfortunately, an operational procedure prevented an accurate assessment of the change in Selectamine™ liquid composition during the test period and trace element accumulation in the Selectamine™ solvent could not be determined.

- **The performance of the Selectox™ unit in converting H_2S to sulfur was relatively low, presumably due to the overall low sulfur level of the feed coal.** The SO_2 emissions from the gas turbine were about 0.02 lbs/MM Btu, and 0.13 lbs/MM Btu for the turbine and incinerator combined. These values were, however, well within the permitted limits for the LGTI facility.

- **Trace element mass balances around internal systems were uncertain due to the problems associated with the chemistry of sample collection and analysis of a reduced gas matrix.**

- **Although this test program was not focused on methods development, critical information was obtained regarding the characterization of trace elements in a reduced gas matrix.** The EPA Reference Method 29 (proposed), i.e., the multi-metals train, ***was ineffective in syngas (reduced gas) matrices (with the exception of mercury, discussed below)***. Although not validated, two other sampling techniques (charcoal tubes and VPAAS) for selected trace elements were implemented in parallel and these provided valuable insights into the deficiencies of EPA Method 29 for reduced gas matrices. The information obtained in this program, will provide a basis for method modifications needed for future work in characterizing IGCC systems.

- **This program resulted in a major breakthrough in the characterization of mercury in a syngas matrix.** The use of a semi-continuous mercury analyzer indicates that at least two forms of mercury are present in the synthesis gas. One of the forms is believed to be elemental mercury, the other is probably ionic. Additionally, valuable information was obtained for several absorbing/speciating solutions for the collection of mercury. The information obtained during the first three sampling periods provided the basis for modifications to the EPA Method 29 sampling train **specifically for the collection of mercury** during test Period 4. These modifications proved to be effective in the collection of mercury and will pave the way for future quantitative mercury measurements (perhaps even speciation) in syngas matrices.

- **A sampling probe was designed, fabricated, and successfully used to extract samples from a high temperature (1,000°F) and high pressure (350 psi) location.** Demonstrating the ability to collect representative samples under these conditions will allow the DOE to conduct further research in the characterization of hot gas removal systems.

Recommendations

During the four test periods at the LGTI plant and the subsequent examination and treatment of the collected data, the need for improvements, particularly in the area of syngas sampling, became apparent. These needs are expressed below as recommendations for further activities in these areas .

- **Improved and/or new methods for quantitatively collecting vapor-phase metals from syngas matrices are needed.**
  - It appears that the charcoal adsorbent used at LGTI behaved differently in the sour syngas compared to the sweet syngas. Charcoals impregnated with substances such as iodine or sulfide should be investigated for potential application in sampling syngas streams. Other adsorbents could also be investigated.
  - The existing Method 29 train was shown to be ineffective for quantitatively collecting samples of most vapor-phase metals from syngas streams (with modifications, mercury was an exception). By using other absorbing solutions, it might be possible to improve the effectiveness of this method, at least for some selected vapor-phase metals in syngas streams.
  - An on-line, vapor phase atomic absorption spectrophotometer (VPAAS) system (one of the alternate methods used for measuring trace metals in syngas) proved to be an effective method for determining the level of vapor-phase metals in the syngas streams. This method should be investigated further to add more elements to the list of analytes and to improve use of the instrumentation in the field environment. In particular, the studies for mercury speciation should be expanded to include identification of the different ionic mercury forms and potentially the development of "wet" test methods for mercury characterization in syngas matrices.
- **The hot gas probe insertion system designed and built for the LGTI testing was a complete success.** Further, the probe itself was also successfully used to collect and recover particulate samples from the hot gas stream. However, some improvements to the probe and enhancements of its capabilities should be considered.
  - The syngas stream at the LGTI plant (as well as streams at certain other syngas plants) contains a large amount of water vapor. The hot gas probe was designed for a gas stream temperature of 1,200°F. At LGTI, somewhat lower gas temperatures(< 1,000°) were encountered. As a result, during the collection of vapor-phase samples, the gas temperature dropped below the dew point and some of the water vapor in the syngas stream condensed in the probe. The probe should be modified to allow for internal heating so that condensation can be prevented.

— With minimal modifications, the probe could be used to determine particulate loadings and particle size distribution in low dust loading environments like those found at the outlet (and perhaps inlet) of a hot gas removal system.

— The probe insertion system will be effective regardless of the severity of the conditions in the gas stream being sampled. However, if the probe is to be used to sample gas streams at temperatures above 1250°F, the current materials of construction may be inappropriate. The material requirements and design changes necessary to accommodate very high temperature gas streams should be determined.

Conclusions

The data quality objectives were met and the results supported by the mass balance calculations, indicating that the characterization of the emission streams was very successful and the measured emissions from the LGTI process are very low. In comparison to the best controlled fossil steam-electric plants, the emissions are lower or equivalent for most substances. In Figure ES-2 the emission factors for those metals classified as HAPs from this project are compared to those obtained during the Phase I testing at Plant Yates (coal-fired boiler with ESP and scrubber).

[The reader should keep in mind that in spite of the information shown in Figure ES-2, the emission factors presented in this report are ***not*** *directly comparable to those of a conventional coal-fired power plant. At the LGTI facility, the syngas is co-fired with natural gas in two gas turbines, so there are two sources of Btu input, the coal and the natural gas. It is known that a fully natural gas-fired turbine can produce significant, measurable levels of HAPs. Unfortunately, at LGTI it is impossible to know how much of the emissions are attributable to the co-firing of the natural gas. As a result, the emission factors have been prepared as total mass out (turbine and incinerator) divided by total Btu content in (coal+incinerator natural gas+turbine natural gas).]*

Accurate quantification of internal process streams for vapor phase metals was hindered by the absence of suitable or fully developed sampling procedures. However, semi-quantitative measurements of vapor phase metals concentration were made, and valuable information was obtained to direct the development of new and/or modified methods for future tests.

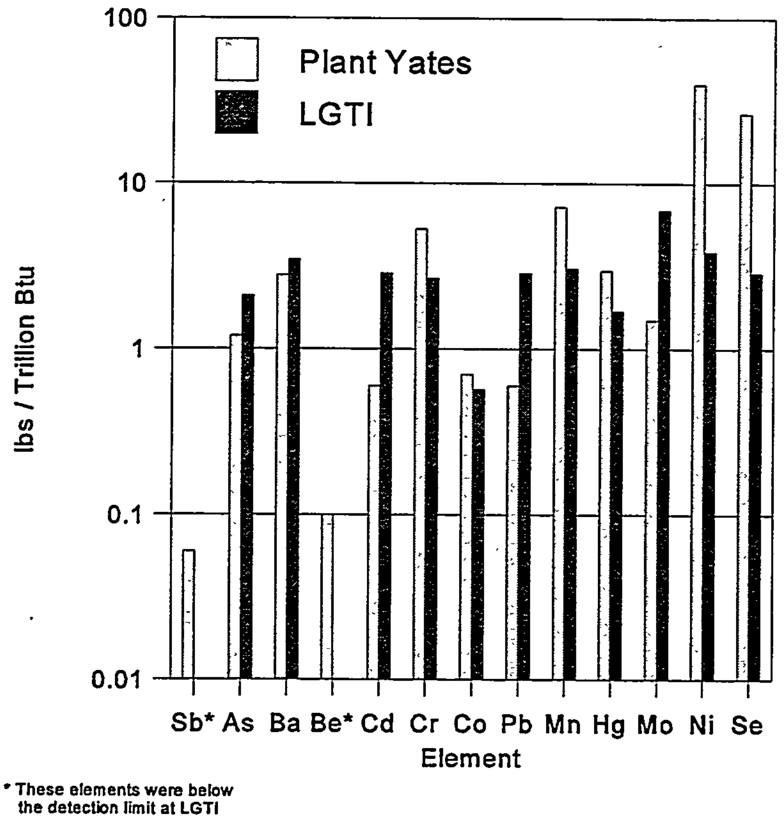

Figure ES-2
Metals Emission Factor Comparison to Plant Yates

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INTRODUCTION

Background

The Louisiana Gasification Technology, Inc. (LGTI) project was selected by the U.S. Synfuels Corporation to demonstrate the Dow gasification process. During the LGTI demonstration program, the environmental characteristics of some streams, particularly the discharge streams, have been regularly monitored as part of the Environmental Monitoring Program. However, with the passage of the Clean Air Act Amendments (CAAA) in 1990, it became very important to understand and to define the fate of currently unregulated hazardous air pollutants (HAPs) within and from various power plant configurations. The majority of HAPs have not yet been measured at the LGTI facility. For that reason, the U.S. Department of Energy (DOE) and the Electric Power Research Institute (EPRI) retained Radian Corporation to measure selected HAPs in the discharge streams and in most of the major internal process streams of the LGTI demonstration plant.

The HAPs test program was carried out in three consecutive test periods from October 30 through November 14, 1994, along with the collection of samples in support of the LGTI Environmental Monitoring Plan (EMP). This effort was jointly funded by the Pittsburgh Energy Technology Center (PETC), the Electric Power Research Institute (EPRI), and Destec Energy, Inc. Approximately 20 Radian personnel as well as representatives of PETC and Destec were on site during the two-week test effort. During this time, over 600 process samples were collected from approximately 20 locations throughout the gasification process.

In May 1995, during a fourth test period, samples of the hot, raw syngas under high pressure were obtained with the use of a specially designed probe.

Objectives

Specific objectives of this project were:

- To collect and subsequently analyze representative solid, liquid and gaseous samples of specified input and output streams of the Dow gasifier for selected hazardous air pollutants that are contained in Title III of the 1990 Clean Air Act Amendments, and to assess the potential level (concentration) of release (emission factors) of these pollutants to the atmosphere;

- To determine the removal efficiencies of specified pollution control subsystems for selected pollutants of the gasification plant; and
- To determine material balances for selected pollutants in specified input and output streams of the gasification plant, and mass flows for specific subsystems.

Table 1-1 lists the chemical substances analyzed during this project.

Emission factors, removal efficiencies, and other results rely on measurement data that vary and/or may be near or below the limit of detection for many of the substances of interest. This report includes uncertainty analyses and confidence intervals in order to assess the quality of the data.

Auditing

During the field sampling program conducted at the LGTI gasifier, a quality assurance (QA) audit was conducted by Radian Corporation's internal QA auditor. Radian's audit was conducted with the purpose of providing an objective, independent assessment of the sampling effort, thus ensuring that the sampling procedures, data generating, data gathering, and measurement activities produced reliable and useful results. As part of the audit, calibration documentation, quality control (QC) data documentation, data forms and notebooks, data review/validation procedures, and sample logging procedures were reviewed.

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 indicate that the samples were well characterized. An assessment of the accuracy, precision, and bias of the data, if only on a qualitative level, was considered to be an important part of the data evaluation. A full discussion of each of these components can be found in Section 5 and in Appendix A.

Project Organization.

Figure 1-1 shows the organization of this project.

Report Organization

This report presents a comprehensive assessment of the results of this test effort. Section 2 presents a summary of the sampling activities. Section 3 contains process operation information including trend plots of key operating parameters. Analytical results are presented in Section 4, and Section 5 contains an evaluation of data and quality. The results are discussed in Section 6. Sections 7 and 8 address special topics. Section 7 presents a comparison of the results from three different methods used to analyze for selected trace elements in a syngas matrix. Section 8 contains a discussion of mercury measurement methods, including speciation in a syngas matrix.

Table 1-1
Target Analytes

Trace Elements			
Antimony Arsenic Barium Beryllium	Boron Cadmium Chromium, total Cobalt	Copper Lead Manganese Mercury	Molybdenum Nickel Selenium Vanadium
Radionuclides			
Anions			
Chloride (HCl) Fluoride (HF) Sulfate			
Reduced Species			
Ammonia Cyanide Hydrogen Sulfide Carbonyl Sulfide Carbon Disulfide			
Major Gases			
Carbon Dioxide Carbon Monoxide Hydrogen Oxygen Nitrogen			
Minor Gases			
Sulfur Dioxide Nitrogen Oxides C_1-C_{10} Hydrocarbons			
Aldehydes			
Acetaldehyde Acrolein Benzaldehyde Formaldehyde			

Table 1-1 (Continued)

Volatile Organics	
Benzene	Methyl Chloroform (1,1,1-Trichloroethane)
Bromoform	Methyl Ethyl Ketone (2-Butanone)
Carbon Disulfide	Methylene Chloride (Dichloromethane)
Carbon Tetrachloride	Propylene Dichloride (1,2-Dichloropropane)
Chlorobenzene	Styrene
Chloroform	1,1,2,2-Tetrachloroethane
1,4-Dichlorobenzene	Tetrachloroethene
cis-1,3-Dichloropropene	Toluene
trans-1,3-Dichloropropene	1,1,2-Trichloroethane
Ethyl Benzene	Trichloroethene
Ethyl Chloride (Chloroethane)	Vinyl Acetate
Ethylene Dichloride (1,2-Dichloroethane)	Vinyl Chloride
Ethylidene Dichloride (1,1-Dichloroethane)	Vinylidene Chloride (1,1-Dichloroethene)
Methyl Bromide (Bromomethane)	m,p-Xylene
Methyl Chloride (Chloromethane)	o-Xylene

Semivolatile Organics		
Acenaphthene	Indeno(1,2,3-cd)pyrene	7,12-Dimethylbenz(a)anthracene
Acenaphthylene	Isophorone	Dimethylphenethylamine
Acetophenone	Methyl Methanesulfonate	2,4-Dimethylphenol
4-Aminobiphenyl	3-Methylchlolanthrene	Dimethylphthalate
Aniline	2-Methylnaphthalene	4,6-Dinitro-2-methylphenol
Anthracene	2-Methylphenol (o-cresol)	2,4-Dinitrophenol
Benzidine	4-Methylphenol (p-cresol)	2,4-Dinitrotoluene
Benzo(a)anthracene	N-Nitroso-di-n-butylamine	2,6-Dinitrotoluene
Benzo(a)pyrene	N-Nitrosodimethylamine	Diphenylamine
Benzo(b)fluoranthene	N-Nitrosodiphenylamine	1,2-Diphenylhydrazine
Benzo(g,h,i)perylene	N-Nitrosopropylamine	Ethyl Methanesulfonate
Benzo(k)fluoranthene	N-Nitrosopiperidine	2-Nitrophenol
Benzoic Acid	Naphthalene	4-Nitrophenol
Benzyl Alcohol	1-Naphthylamine	Pentachlorobenzene
4-Bromophenyl Phenyl Ether	2-Naphthylamine	Pentachloronitrobenzene
Butylbenzylphthalate	2-Nitroaniline	Pentachlorophenol
4-Chloro-3-Methylphenol	3-Nitroaniline	Phenacetin
p-Chloraniline	4-Nitroaniline	Phenanthrene
bis(2-Chloroethoxy)methane	Nitrobenzene	Phenol
bis(2-Chloroethyl)ether	Di-n-octylphthalate	2-Picoline
bis(2-Chloroisopropyl)ether	Dibenz(a,h)anthracene	Pronamide

Table 1-1 (Continued)

Semivolatile Organics (Continued)

1-Chloronaphthalene
2-Chloronaphthalene
2-Chlorophenol
4-Chlorophenyl Phenyl Ether
Chrysene
bis(2-Ethylhexyl)phthalate
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane

Dibenz(a,j)acridine
Dibenzofuran
Dibutylphthalate
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3'-Dichlorobenzidine
2,4-Dichlorophenol
2,6-Dichlorophenol
2,6-Dichlorophenol
Diethylphthalate
p-Dimethylaminoazobenzene

Pyrene
Pyridine
1,2,4,5-Tetrachlorobenzene
2,3,4,6-Tetrachlorophenol
1,2,24-Trichlorobenzene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2-Fluorobiphenyl
2-Fluorophenol
Nitrobenzene-d5
Phenol-d5
Terphenyl-d14
2,4,6-Tribromophenol

Additional Elements

Aluminum
Calcium
Iron

Magnesium
Phosphorus
Potassium

Silicon
Sodium
Titanium

Zinc

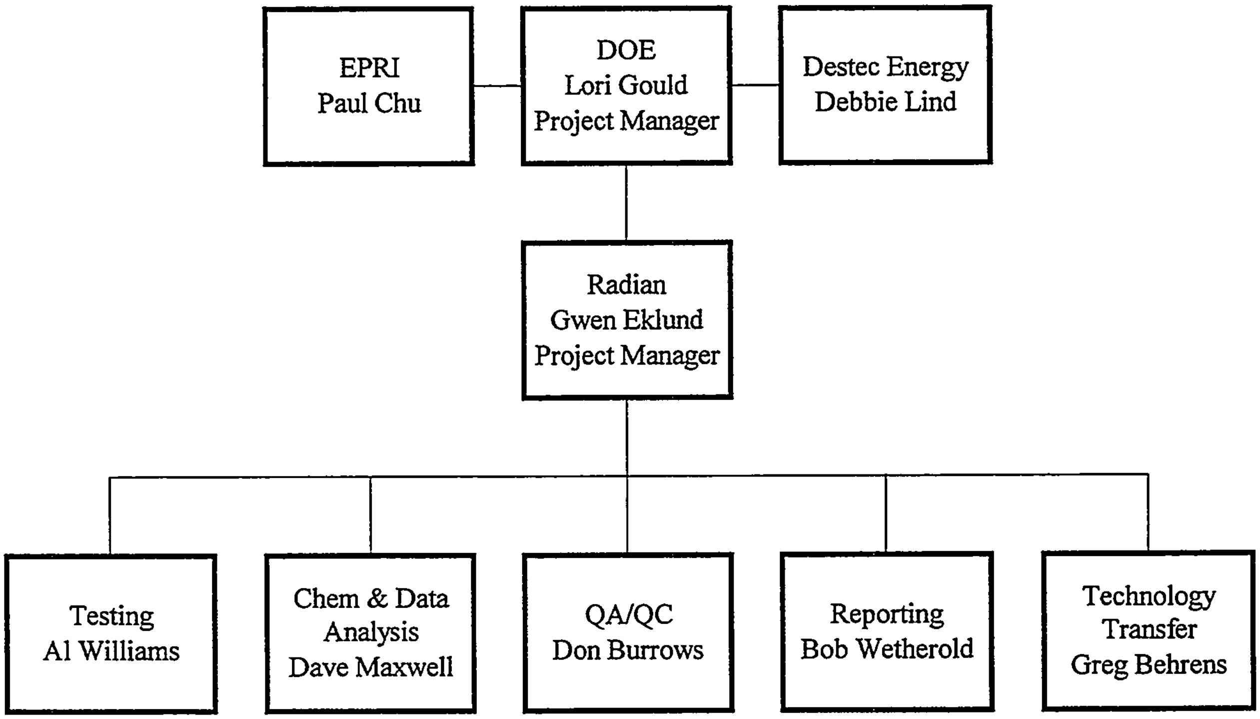

Figure 1-1
Project Team Organization

Nine appendices are also included with this report. Appendix A contains detailed information on quality control sample results and the Radian independent auditor's report. Appendix B contains a description of the sampling procedures that were used. Sample preparation and analytical techniques are presented in Appendix C. Appendix D contains example calculations for bias and precision. Appendix E contains example calculations for material balances, removal efficiency and emission factors. Appendix F contains field sampling data summary reports and the detailed analytical results are contained in Appendix G. Appendix H is a description of the hot-gas sampling probe design, and Appendix I is a glossary of terms.

2

SUMMARY OF SAMPLING ACTIVITIES

LGTI (Louisiana Gasification Technology Inc.), a subsidiary of Destec Energy Inc., operates the coal gasification plant at the Dow Louisiana Division chemical complex in Plaquemine, Louisiana. The gasification unit produces medium Btu synthesis gas (syngas) for consumption by two gas turbine power generating units at the Louisiana site.

At full capacity, the LGTI Plant produces 30,000 MM Btu of equivalent syngas per day from approximately 2,200 tons per day of western subbituminous coal from the Rochelle mine in the Powder River Basin in Wyoming. This is the equivalent of 160 MW of net power, considering both electricity and steam production.

Process Descriptions/Sample Locations

Figure 2-1 is a block flow diagram of the LGTI gasification facility at Plaquemine with the sampling points identified. The block diagram includes coal handling, gas production, particulate removal, moisture removal, acid gas cleanup, power production, wastewater stripping, acid gas treatment, sulfur production, and tail gas incineration. The following paragraphs provide a description of the process and include information on the sample collection points.

Coal Slurry

The plant receives the feedstock, Rochelle coal, by rail car. Coal is transported by conveyor (partly covered) to a coal pile. Reclaiming and transfer from the coal pile is accomplished by bulldozers that fill reclaim pit hoppers for feed to conveyors that transport coal to the precrusher. Coal samples (1a) were collected at this preparation plant. Precrushed coal is held in a feed-hopper and then transferred by weigh belt feeders to an enclosed coal slurry grinder, where recycled process water is added. Coal slurry is transported from the grinder product tank by slurry pumps to slurry storage tanks located at the gasifier area. Coal slurry (1) samples were collected from the plant's 33 and 33a feed pumps.

Gasification

The gasifier is a high-temperature, oxygen-blown, entrained-flow, slagging design. Pumps designed for handling liquid-solid suspensions at high pressure control the slurry feed rate to the gasifier. The coal slurry, which is fed to the reactor, is mixed with oxygen in the burner nozzles. The oxygen feed rate is carefully controlled to maintain the reactor temperature within a narrow range. Sulfur in the coal is converted almost totally to H_2S, and small amounts of COS, while

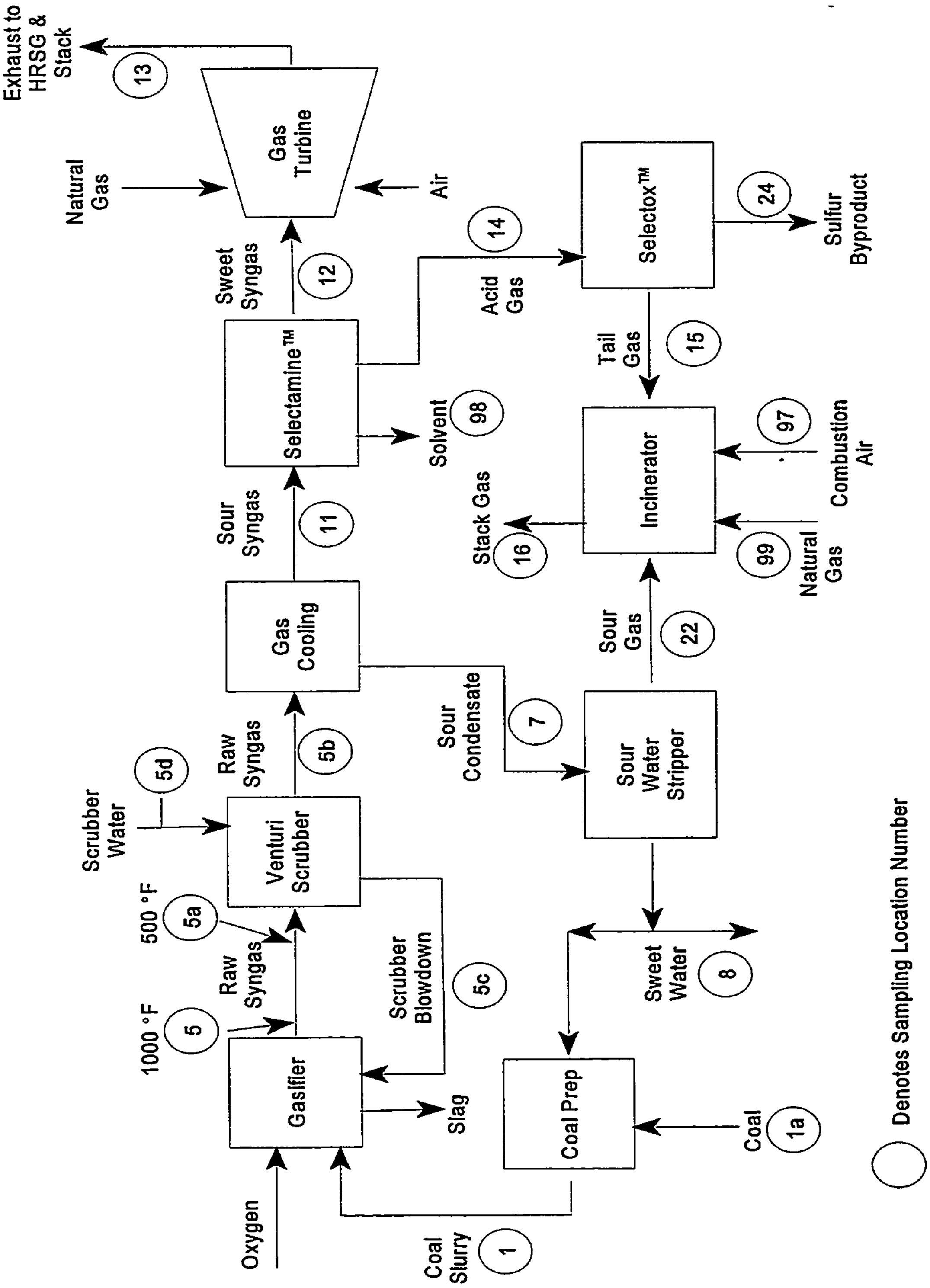

Figure 2-1
LGTI Block Flow Diagram

nitrogen is efficiently converted to NH_3, and trace amounts of cyanide and thiocyanate. Ash from the coal is fused in the combustion area of the reactor, and the molten slag is drained from the reactor bottom through an enclosed system. The molten slag is quenched and cooled by water. Slag (4) was collected from a slipstream near the slag hopper discharge.

Particulate Removal

The hot raw syngas produced in the gasifier passes through several gas cooling and cleaning systems. Before particulate removal, the gas is first cooled in a convection cooler by heat exchange with water for steam production. Hot raw syngas (Stream 5) was sampled from this location using a high-temperature, high-pressure retractable sampling probe (fourth test period). The syngas temperature at this sample point was 1,000°F, and the stream's characteristics are considered typical of the syngas likely to be encountered by hot gas cleanup systems currently being developed and evaluated.

Entrained particulate matter (char) is removed from the gas by a wet venturi scrubber system. The raw syngas was sampled at the inlet to the scrubber (Stream 5a), and the scrubbed raw syngas was collected from the scrubber outlet duct (Stream 5b). The syngas temperature at the scrubber inlet was approximately 450°F.

The scrubber water containing the removed char is recycled by injection into the gasifier with the secondary slurry feed. Samples of the clean scrubber water feeding the venturi were collected from the storage tank at the suction of the venturi scrubber pumps (Stream 5d). The char solids were recovered by filtering the recycled char water (Stream 5c) collected from a tap in the transfer line.

Gas Cooling/Moisture Removal

The particulate-free gas is cooled further to condense moisture from the gas. The cooled syngas entering the acid gas removal system (sour syngas-11) was sampled downstream of a large condensate knock-out vessel immediately upstream of the acid gas removal system. The condensate removed from the cooled gas (sour condensate-7) contains substantial amounts of soluble sulfide, ammonia, and carbon dioxide and was collected from a tap in the line transferring the sour condensate to the sour water stripper.

Acid Gas Removal

Dow's Selectamine™ acid gas removal process removes over 97% of the sulfur species from the sour syngas. The principal ingredient in the Selectamine™ solvent is methyl diethanolamine (MDEA). The acid gas is absorbed in the MDEA solution. A portion of the MDEA is removed periodically and is regenerated or replenished with fresh solution to control the buildup of contaminants in the solution. The sweetened product gas (12) is sent by pipeline to the power plant for use as gas turbine fuel. It was sampled near the LGTI control room on the main transfer pipe to Power II. The concentrated acid gas (14), which consists primarily of H_2S, CO_2 and water, is recovered by stripping the rich MDEA solvent. The concentrated acid gas stream is sent to the sulfur recovery unit. It was sampled from a transfer line in the sulfur unit. The MDEA solvent (98) was sampled by Dow personnel from the spent solvent line before a partial regeneration step which was performed during the test period.

Sulfur Recovery/Incineration

The Selectox™ process is used to recover sulfur from the acid gas produced in the Selectamine™ unit. This process uses a fixed bed of Selectox™ catalyst to oxidize a portion of the H_2S to SO_2 prior to sulfur production, as opposed to the combustion furnace in the Claus process. A Claus reactor then catalyzes a redox reaction between the H_2S and SO_2 to produce elemental sulfur. Sulfur byproduct (24) was collected from the reservoir with metal sampling cups. The tail gas from the Selectox™ unit is fed to an incinerator to oxidize the small amount of remaining H_2S to SO_2. The tail gas (15) was sampled beneath the Selectox™ reactor. The incinerator stack gas (16) is exhausted to the atmosphere. Ports in the stack were used for this sample. Combustion air (97) from tank vents and natural gas (99) for the incinerator were sampled from available ports and taps.

Power Production

Clean syngas from the acid gas removal unit is co-fired with natural gas in two gas turbines at Dow's Power II facility. The two Westinghouse WD501-D5 gas turbines, can burn either natural gas or a blend of syngas and natural gas, and each can produce up to 105 MW of electrical power. In addition, a waste heat boiler recovers much of the energy in the turbine exhaust and produces steam for the Dow Chemical facility. Each turbine exhaust is routed through a heat recovery boiler and emitted to the atmosphere from the turbine exhaust stacks. During the testing, the Btu content of the fuel was approximately 63% syngas and 37% natural gas for the turbine that was tested.

Process Wastewater

The sour water condensed from the product gas as it cools is directed to the wastewater treatment system which includes filtration and stripping. Stripped sour water (sweet water) from the treatment system is recycled to the coal preparation area. Excess sweet water (8) is discharged through a permitted outfall. The sour gas (22) stripped from the condensate is routed to the tail gas incinerator. It was sampled at the fan deck.

Samples Collected

Tables 2-1 through 2-7 define the samples targeted for collection. The samples that *were not* collected, primarily from the sour gas location, have been shaded. The problems associated with sampling (or collecting samples) at this and other locations are discussed below. Overall sample

Table 2-1
Gas Stream Sampling Matrix—Period 1[a]

Parameter	Sour Syngas, 11	Sweet Syngas, 12	Acid Gas, 14	Tail Gas, 15	Turbine Stack, 13	Media Blank	PE Audit
Particulate Loading	▨ 3	3			3		
PM-10					3		
Metals, M-29	3	3+FB	3	3	3+FB	1	
Metals, Direct AAS	1	2					
Metals, Charcoal Tubes	3	3+FB	3				
C_1 - C_{10} by GC-FID	3	3	3	3			
Volatile Organics by VOST					3x(3+FB)	1	
Volatile Organics by TO-14	3	3			3	1	
Major Gases by GC-TCD	3	3	3	3			
H_2S, COS, CS_2, DMS, DMDS, methyl mercaptan by GC-FPD	3	3	3	3			
H_2S by M-11		3					
Semivolatile Organics	3	3	3	3	3+FB	1	
Aldehydes	3	3			3+FB	1	
Chloride, Fluoride	3	3	3		3+FB	1	
Ammonia	3	3	3	3	3+FB	1	1
Cyanide	3	3	3	3	3+FB	1	1
SO_2/H_2SO_4 by M-8					3	1	1
SO_2, NO_x, CO,O_2, CO_2 by CEM					3		

[a] Shaded areas indicate samples not collected.

PE = Performance evaluation audit sample.

FB = Field blank.

Table 2-2
Solid and Liquid Stream Sampling Matrix—Period 1[a]

Parameter	Raw Coal, 1a	Coal Slurry, 1	Slag, 4	MDEA, 98	Sulfur Byproduct, 24
	Field Samples	Field Samples	Field Samples	Field Samples	Field Samples
Metals	3	3 x 2	3	1	3 (2)
Ultimate, Proximate	3	3 x 2	3		3 (2)
Chloride, Fluoride	3	3 x 2	3		
Ash				1	
Volatile Organics				1	
Heat stable salts				1	

[a] Shaded areas indicate samples not collected; actual number in parentheses.

Table 2-3
Gas Stream Sampling Matrix—Period 2[a]

Parameter	Tail Gas, 15	Natural Gas, 99	Sour Gas, 22	Combustion Air, 97	Incinerator Stack, 16	Media Blank	PE Audit
Particulate Loading					3	1	
PM-10					3	1	
Metals, M29[b]		3	3		3+FB	1	1
C_1 - C_{10}	3	3	3	3	3		
Volatile Organics by VOST					3x(3+FB)	1	
Volatile Organics by TO-14					3	1	
Total Chromatographical Organics					3		
Major Gases by GC-TCD			3	3			
H_2S, COS, CS_2, DMS, DMDS, methyl mercaptan by GC-FPD	3	3		3	3		
H_2S by M-11					3		
Semivolatiles	3		3		3+FB	1	
Aldehydes					3+FB	1	
Chloride, Fluoride					3	1	
Ammonia	3		3+FB	3	3		
Cyanide	3		3+FB	3	3		
SO_2/H_2SO_4, M-8					3+FB		
NO_x, M-7D					3		1
SO_2,NO_x,CO, O_2, CO_2 by CEM	3 (1)				3 (2)		

[a] Shaded areas indicate samples not collected; actual number in parentheses.

[b] Sb, As, Ba, Be, B, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Se, Pb, V, and Zn. Alkali metals: Ca, Mg, Na and K. Major metals: Al, Fe, and Ti.

FB = Field blank.

Table 2-4
Solid and Liquid Stream Sampling Matrix—Period 2

Parameter	Raw Coal, 1a	Coal Slurry, 1	Slag, 4		Sour Condensate, 7		Sweet Water, 8		
	Field Samples	Field Samples	Field Samples	Duplicate Sample	Field Samples	Duplicate Sample	Field Samples	Duplicate Sample	PE Audit[a]
Metals[b]	3	3 x 2[c]	3	1	3	1	3	1	1
Ultimate, Proximate[d]	3	3 x 2	3	1					
Chloride, Fluoride	3	3 x 2	3	1					
Cyanide[e]					3	1	3	1	1
Volatile Organics					3	1	3	1	
Semivolatile Organics					3	1	3	1	
Aldehydes					3	1	3	1	
Anions[f]					3	1	3	1	1
Ammonia, Phenol, COD					3	1	3	1	1
Sulfide					3	1	3	1	
Water Quality[g]					3	1	3	1	

[a] Performance evaluation (PE) audit sample.

[b] Coal slurry collected from two locations, 33 and 33a: 3 (samples) x 2 (streams).

[c] Target trace metals: Sb, As, Ba, Be, B, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Se, Pb, V, and Zn. Alkali metals: Ca, Mg, Na and K. Major metals: Al, Fe, Si, and Ti.

[d] Moisture, ash, higher heating value (HHV), C, H, O, N, S, volatile and fixed carbon. Slag samples not analyzed for HHV or volatile and fixed carbon.

[e] Water streams analyzed for total and free cyanide and thiocyanate.

[f] Anions: Cl^-, F^-, $SO_4^=$, PO_4^{-3}, and formate.

[g] Water Quality: pH, conductivity, and total suspended solids (TSS).

Table 2-5
Gas Stream Sampling Matrix—Period 3

Parameter	Raw Gas (500°F), 5a	Scrubbed Raw Gas, 5b	Media Blank	PE Audit
Particulate Loading		3		
Metals, Method 29[b]	3[c]+FB[d]	3	1	1
Metals, Direct AAS[e]				
Metals, Charcoal Tubes[f]	3	3	3	
C_1 - C_{10}[g]	3	3		
Ammonia	3	3+FB		
Cyanide	3	3+FB		
Chloride, Fluoride	3	[c] 3+FB	1	1

[a] Performance evaluation (PE) audit sample.

[b] Target trace metals: Sb, As, Ba, Be, B, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Se, Pb, V, and Zn. Alkali metals: Ca, Mg, Na and K. Major metals: Al, Fe, and Ti. Silicon determined in the raw gas (5a) particulate phase only.

[c] Includes particulate- and vapor-phase analysis.

[d] FB = Field blank.

[e] Direct atomic absorption spectrophotometry (AAS) for As, Cd, Cu, Fe, Pb, Hg, Ni, Se, Zn.

[f] Sb, As, Cd, Fe, Pb, Hg, Ni, Zn.

[g] C_1 - C_6 hydrocarbons, benzene, toluene, and xylene.

Table 2-6
Solid and Liquid Stream Sampling Matrix—Period 3

Parameter	Raw Coal, 1a	Coal Slurry, 1			Slag, 4		Rcy. Char Solids, 5c		Rcy. Char Filtrate		Scrubber Inlet Water	MDEA, 98
	Field Samples	Field Samples	Dup	PE Audit	Field Samples	PE Audit	Field Samples	Dup	Field Samples	Dup	Field Samples	Field Samples
Metals	3	3 x 2	1	1	3	1	3	1	3	1	3	1
Ultimate/Proximate	3	3 x 2	1	1	3	1	3	1	3	1	3	
Radionuclides	3				3							
Chloride/Fluoride	3	3 x 2	1	1	3	1	3	1	3	1	3	
Ammonia									3	1	3	
Cyanide									3	1	3	
Ash												1
Heat Stable Salts												1
Total Suspended Solids									3	1		

Dup = Duplicate sample.

PE = Performance evaluation audit sample.

Table 2-7
Gas Stream Sampling Matrix, Period 4

Parameter	(Shakedown) Raw Gas Particulate, 5a	Raw Gas, 1,000°F, 5
Metals, Method 29[a]	2[b]	3
Charcoal Tubes[c]		3
Ammonia		3
Cyanide		3
Chloride, fluoride		3

[a] Target trace metals: Sb, As, Ba, Be, B, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Se, Pb, V, and Zn. Alkali metals: Ca, Mg, Na, and K. Major metals: Al, Fe, Si, and Ti.

[b] Particulate only.

[c] Sb, As, Cd, Fe, Pb, Hg, Ni, Zn.

capture for the testing effort exceeded 97 percent. Because of the number of sampling locations, the effort was conducted in four periods. Period 1 targeted the sulfur removal and turbines, Period 2 focused on the sour water and incinerator, and Period 3 addressed gasifier streams. Period 4, conducted separately in May 1995, sampled the hot raw syngas (Location 5). Prior to that, *shakedown* testing to assess the operability and functionality of the hot gas probe was completed in April, 1995. Shakedown testing was done at low (500°F) temperature conditions. The sampling matrix is presented in Table 2-7. All targeted samples were collected and no problems were encountered during the hot gas sampling phase of the program. The temperature at the hot gas location was over 900°F. The sampling system that was used was designed for a maximum temperature of 1,250°F.

Problems Encountered

Particulate-Free Gas (5b)

The sample port at the outlet of the venturi scrubber required the use of a long run (>20 feet) of stainless steel tubing to reach the sampling station. The hot gas extracted from the process line cooled rapidly in the tubing. Consequently, the condensed moisture in the gas line could not be sampled or collected representatively. To minimize the effects from the condensed moisture, the first sample tap was run continually and the condensed moisture was collected in a knockout. All samples were collected from taps downstream of the first tap in an attempt to collect only vapor-phase concentrations. (Multiple taps were used on sample lines to provide samples for the various measurement methods.)

Because some of the vapor-phase species are soluble in water, these gas samples may be biased low. Fractions of the "condensed" water in the knockout were collected and analyzed for specific volatile species (such as ammonia, cyanide and metals for example). "Vapor-phase" data for ammonia and cyanide were adjusted to account for the water fractions.

Sour Syngas (11)

Similar difficulties were encountered at the sour syngas location. Even though the sample port was downstream of a knock-out vessel, an excessive amount of water was collected from the first sample tap relative to the others. The high moisture content precluded the measurement of particulate loading as the filter substrates became wet, and the filtration capacity was compromised. Samples collected at this location, prior to the discovery of the moisture problem, were not analyzed and sample collection was repeated with a condensate knock-out system upstream of the sample header.

Sour Gas (22)

High concentrations of ammonia and carbon dioxide in the sour gas resulted in the crystallization of ammonium carbonate in the sample lines. The ammonium carbonate formed plugged each of the sampling systems used preventing most samples from being obtained. The only samples collected were for cyanide and ammonia. This was possible only because the sample volume required for these species is small (one cubic foot).

Plant Operational Problems

On the third day of testing (Period 1), Saturday, November 5, plant operations were suspended due to equipment plugging in the coal feed system. The plant was off-line for approximately 24 hours and was given another 24 hours to restabilize. Testing resumed on Monday, November 7.

Sampling Equipment Problems

On the same day the plant was taken off line, the compressor in a refrigerator, used to keep samples for semivolatile organic analyses cool, malfunctioned and heated the interior and freezer compartments. This refrigerator contained samples from the first two days of testing as well as blank or empty XAD resin cartridges for future test periods. The possibility of either loss of sample or contamination of the blank media for those yet to be used was considered. Many of the internal process steams were known to contain measurable quantities of semivolatile organics and the emission gas steams (turbine and incinerator stacks) were thought to contain extremely low concentrations of semivolatile organics (these steams were being analyzed by HRGC/MS). Following discussions with PETC, EPRI, and Destec, a decision was reached to rerun all semivolatile tests and to replace all the blank XAD resin that was subjected to the temperature excursion in the refrigerator. New resins were obtained and all affected tests were repeated.

3

PROCESS OPERATION

The plant operation was stable and within the specified or target process operating limits during the monitoring period, except for one brief shutdown that occurred on November 5. Following the shutdown, the plant was restarted on November 6 and reached stable and normal operating conditions within a few hours.

To ensure that samples were taken under typical and representative operating conditions, key process data and information were manually acquired and logged on a regular basis. These data were selected to allow monitoring of all the major systems within the gasification unit during testing. At the completion of testing, detailed (five-minute averages) process data were obtained from the LGTI data acquisition system in the form of computer printouts.

The values of several key operating parameters obtained from the data acquisition system are summarized in Table 3-1. Average values of the selected parameters are presented for the overall testing period as well as the three primary test periods. The data represent the daily periods (0700 through 1800 hours) during which most of the testing was conducted. Also shown in the table are the maximum, minimum, and standard deviation for each set of data. Several subsets of these data are shown graphically in Figures 3-1 through 3-7. Each of the figures shows key parameters associated with a specific process unit. In a few cases, parameter data are shown in more than one figure to illustrate the stability of the particular process unit during the testing periods. The data in each figure represent hourly values during the hours of 0700 through 1800 for November 3-4 and November 6-13. The consistent and stable operation of the plant can be seen from the graphs, as well as from the relatively low standard deviations of the data sets presented in Table 3-1.

Process operation was not directly monitored during Period 4, however, an LGTI operator was stationed at the sampling location and was in direct contact with the control room at all times. No upsets which would affect the gasification system were noted during the Period 4 testing.

Table 3-1
Summary of Key Process Parameters

	Test Period Average	Period 1 11/4-11/7	Period 2 11/8-11/11	Period 3 11/11-11/13
Slag Production, dry ton/day (LGTI)				
Coal Feed Rate, dry ton/day (LGTI)				
Coal Feed Rate (Radian calc), ton/day (dry)				
Average Calculated Rate				
Maximum Calculated Rate				
Minimum Calculated Rate				
Sample Standard Deviation				
Primary Slurry, % solids				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Primary Slurry Rate 1, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Primary Slurry Rate 2, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Second Stage Slurry, % solids				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Second Stage Slurry Rate, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Average				

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Table 3-1 (Continued)

	Test Period Average	Period 1 11/4-11/7	Period 2 11/8-11/11	Period 3 11/11-11/13
HR120B Average Temperature, °F				
Maximum				
Minimum				
Sample Standard Deviation				
Sour Syngas Flow From E-163, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Scrubber Gas Inlet Temperature, °F				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Scrubber Gas Inlet Pressure, psig				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Water Flow to Venturi Scrubber, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Water Flow to Tangential Nozzles, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Demineralized Water Flow to Scrubber				
Average				
Maximum				
Minimum				
Sample Standard Deviation				

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Table 3-1 (Continued)

	Test Period Average	Period 1 11/4-11/7	Period 2 11/8-11/11	Period 3 11/11-11/13
Water Flow to MX-125, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
C-165 Blowdown to C-160, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Scrubber Outlet Gas Temperature, °F				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Scrubber Outlet Gas Pressure, psig				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Sweet Syngas Flow Rate. lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Acid Gas Flow Rate, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				

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Table 3-1 (Continued)

	Test Period Average	Period 1 11/4-11/7	Period 2 11/8-11/11	Period 3 11/11-11/13
Combustion Air Rate to F-251, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
F-251 (Incinerator) Exit Temperature, °F				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Incinerator Stack Gas Flow Rate, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Total SO_2 Flow Rate to Incinerator Stack, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Stripper Overhead Temperature, °F				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Sweet Water to Ditch, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				

Table 3-1 (Continued)

	Test Period Average	Period 1 11/4-11/7	Period 2 11/8-11/11	Period 3 11/11-11/13
C-170 (Absorber) Overhead Temperature. °F				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
C-180 (Stripper) Temperature above Tray 17, °F				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Lean MDEA Rate to C-170, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Tail Gas Flow Rate, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
K-250 Vent Gas Flow Rate, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Methane Flow Rate to F-251 (Incinerator), lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				

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Table 3-1 (Continued)

	Test Period Average	Period 1 11/4-11/7	Period 2 11/8-11/11	Period 3 11/11-11/13
Steam Drum Blowdown to C-270, pph				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
D-251 Blowdown to C-270, pph				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
C-180 Water Purge to C-270, gpm				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Steam Flow to Stripper Reboiler, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Syngas Flow to GT-400, M lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Fuel Gas (Natural Gas) to GT-400, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				

Table 3-1 (Continued)

	Test Period Average	Period 1 11/4-11/7	Period 2 11/8-11/11	Period 3 11/11-11/13
Syngas to GT-400, % of total fuel				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
Power Produced by GT-400, MW				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
GT-400 Stack C Temperature, °F				
Average				
Maximum				
Minimum				
Sample Standard Deviation				
SO_2 Emitted from GT-400, lb/hr				
Average				
Maximum				
Minimum				
Sample Standard Deviation				

Figure 3-1
Process Parameters for Gasification System

Figure 3-2
Process Parameters for Power II

Figure 3-3
Selectamine™ Process Parameters

Figure 3-4
Selectox™ Process Parameters

Figure 3-5
Incinerator Process Parameters

Figure 3-6
Incinerator Process Parameters

Figure 3-7
Sour Water Stripper Process Parameters

4

ANALYTICAL RESULTS

The analytical results for all four test periods of the test program are presented in this section. The results have been organized by stream matrix (gaseous, solid, or liquid) and are reported as averages with a 95% confidence interval. *[Since EPA Method 29 was determined to be ineffective in the collection of trace elements in reduced gas matrices, results from Method 29 are not reported in this section, when data from alternative trace element techniques are available.]* The results reported for the organic compounds have been limited to only those compounds which were detected. Complete details of all results including individual test runs may be found in Appendix G.

Results for the analyses performed by on-line VPAAS are contained in Section 7, mercury is discussed further in Section 8.

Continuous emission monitors were run at both the turbine exhaust stack and the incinerator stack. The results for the CEMs are presented graphically in Figures 4-1 and 4-2.

The incinerator was monitored during test Period 2 for three days, November 9-11, 1994. On November 11, a leak was discovered in the sample delivery system. Efforts to detect the source of the leak were unsuccessful and, since the system was off and on all during the day, no useful data was obtained for November 11. Upon reduction of all the CEM data, it was obvious, based upon oxygen content, that the data from November 10 was also obtained with a leak in the sampling system. The bias produced by the leak appeared to be consistent throughout the day, therefore, the data from November 10 could be adjusted to account for the dilution due to ambient air. The adjusted data is presented in all appropriate tables and figures.

The analytical data have been summarized and a consistent "cell labeling" convention has been used in the tables as follows:

- ND or "<" = Not detected;
- NA = Not analyzed;
- NC = Not calculated (such as the 95% CI for ND values);
- NS = Not able to obtain a sample; and
- IS = Invalid sample (due to sampling or analytical bias).

All analyses performed on solids are reported on a dry basis.

The analytical data for all streams are presented in Tables 4-1 through 4-13 and are organized as follows:

Table	Title	Process Streams
4-1	CEM Data Summary	Turbine and Incinerator Stacks
4-2	Turbine Stack Emissions	Turbine Stack
4-3	Incinerator Stack Emissions	Incinerator Stack
4-4	Synthesis Gas Streams	Raw, Sweet, and Sour Syngas
4-5	Internal Process Streams	Sour, Acid, and Tail Gas
4-6	Incinerator Fuel Gases	Natural Gas and Combustion Air
4-7	Hot Raw Syngas Streams	Syngas at 1000°F, Syngas at 500°F
4-8	Solid Feed Streams	Raw Coal, Primary and Secondary Slurry Feed
4-9	Recycled Char Streams	Recycled Char, Dry Char (1000°F), Dry Char (500°F)
4-10	Solid Effluent Streams	Slag, Sulfur
4-11	Sour Water Stripper, Aqueous Streams	Sour Condensate, Sweet Water
4-12	Recycled Char Water	Scrubber Inlet Water, Recycle Char Filtrate
4-13	Selectamine™ Solvent	Selectamine™ Solvent

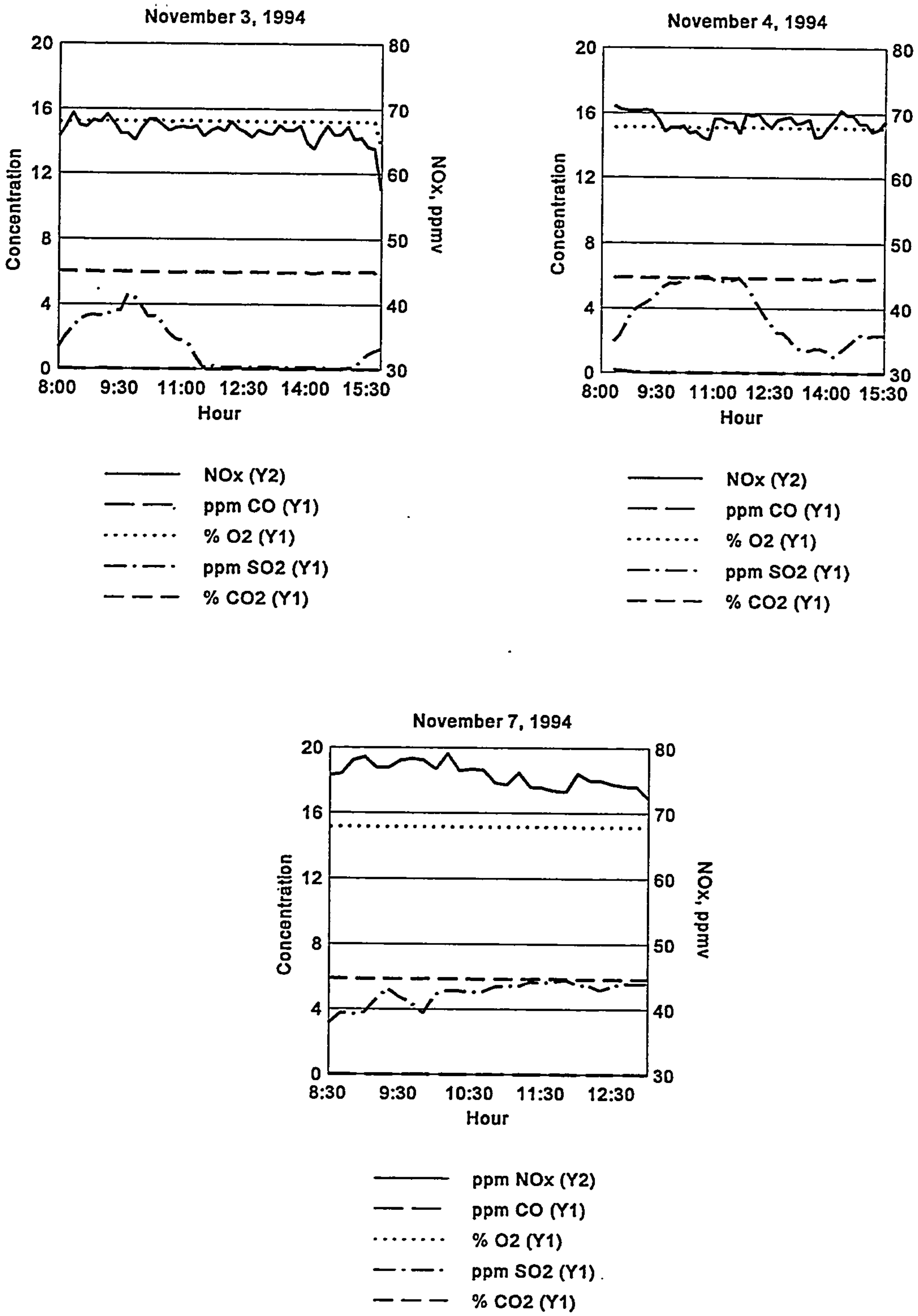

Figure 4-1
CEM Results, Turbine Exhaust Stack

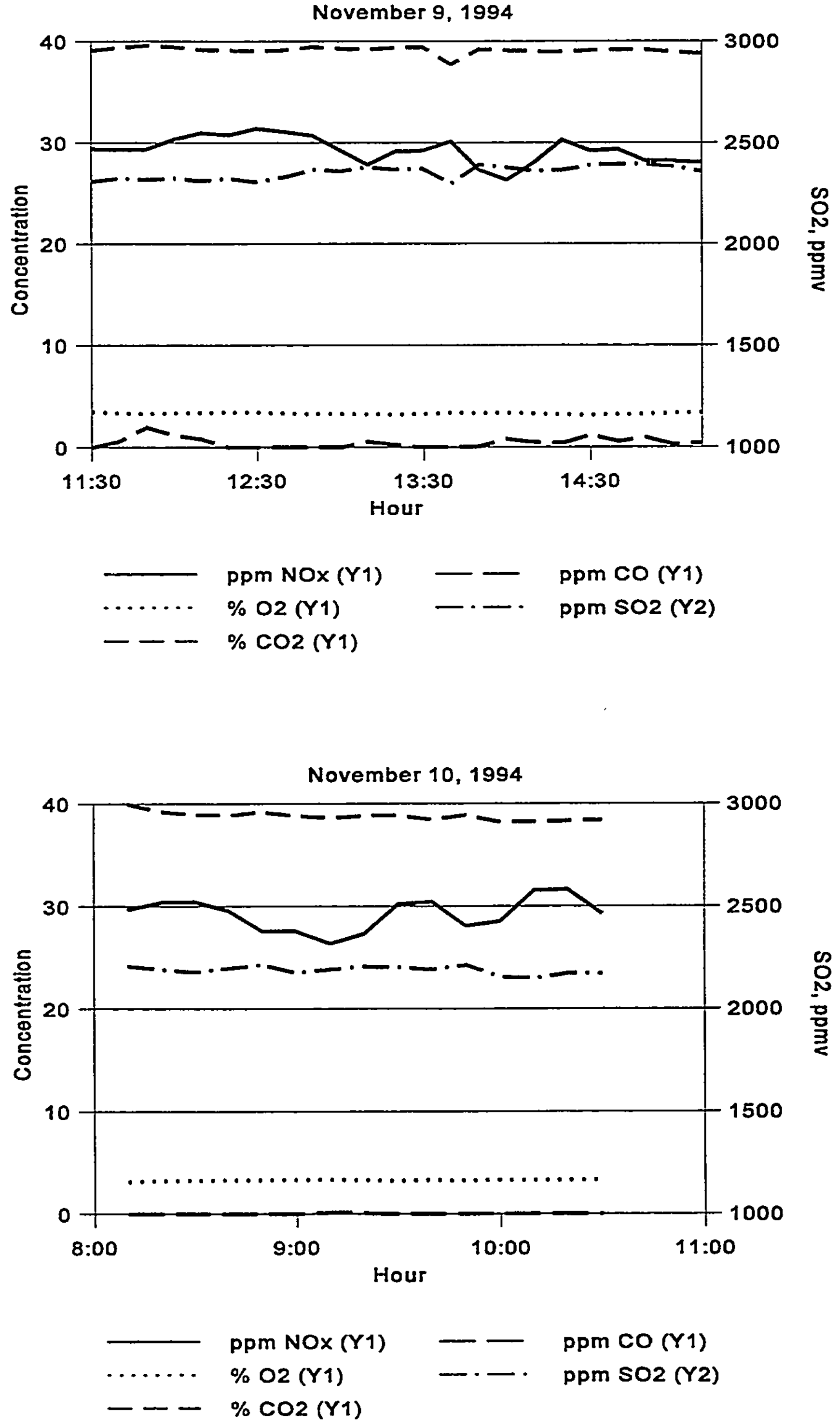

Figure 4-2
CEM Results, Incinerator Stack

Table 4-1
CEM Data Summary

	Oxygen, %	Carbon Dioxide, %	Carbon Monoxide, ppmv	Sulfur Dioxide, ppmv	Nitrogen Oxides, ppmv
Turbine Stack (13) - Reporting Periods 11/3, 11/4, 11/7					
Average	15.2	5.9	<1	3.1	70.5
Maximum	16.3	6.1	NC	6.2	80.6
Minimum	14.5	4.8	NC	<1	54.6
Standard Deviation	0.07	0.08	NC	1.9	4.9
Incinerator Stack (16) - Reporting Period 11/9					
Average	3.5	38.5	0.9	2340	28
Maximum	4.3	40.2	2.9	2480	33.4
Minimum	3.1	34.1	0	2240	20.1
Standard Deviation	0.3	0.9	0.7	50	1.8

Table 4-2
Turbine Stack Emissions

Analyte	Particulate Phase		Vapor Phase		Total[a]	
	Average	95% CI	Average	95% CI	Average	95% CI
Particulate Loading, mg/Nm^3	3.86	3.5	NC	NC	NC	NC
Ionic Species, µg/Nm^3						
Chloride	68	200	350	270	420	110
Fluoride	2.4	3.7	19	18	22	13
Sulfate	1,100	680	23,000	7,500	24,000	7,500
Ammonia as N	NA	NC	190	250	NC	NC
Cyanide	NA	NC	< 3.2	NC	NC	NC
Metals, µg/Nm^3						
Aluminum	34	18	< 15	NC	34	18
Antimony	< 2.2	NC	< 0.022	NC	< 2.2	NC
Arsenic	1.1	1.6	0.084	0.089	1.2	1.1
Barium	1.6	1.3	0.36	0.62	2	0.75
Beryllium	< 0.012	NC	< 0.04	NC	< 0.012	NC
Boron	NA	NC	< 4.9	NC	NC	NC
Cadmium	0.62	0.035	0.99	3.1	1.6	2.2
Calcium	82	200	34	27	120	150
Chromium	1	0.61	0.47	0.57	1.5	0.38
Cobalt	0.29	0.48	0.028	0.026	0.32	0.34
Copper	7.5	15	0.77	3.2	8.3	11
Iron	74	230	8	5.6	82	160
Lead	0.99	1.5	0.6	0.92	1.6	0.90
Magnesium	10	12	< 13	NC	10	12
Manganese	0.45	1.3	1.2	5.2	1.7	3.8
Mercury, total	0.01	0.01	0.7	0.19	0.71	0.26
Molybdenum	3.8	3.3	< 0.037	NC	3.8	3.3
Nickel	0.98	0.53	1.2	2.9	2.2	2.1
Phosphorus	130	5.2	< 31	NC	130	5.2
Potassium	81	250	< 230	NC	81	250

Table 4-2 (Continued)

Analyte	Particulate Phase		Vapor Phase		Total[a]	
	Average	95% CI	Average	95% CI	Average	95% CI
Selenium	0.44	1.2	1.2	1.1	1.7	0.76
Silicon	NA	NC	40	20	NC	NC
Sodium	140	82	64	64	210	48
Titanium	2.9	6.3	0.48	0.73	3.3	4.5
Vanadium	0.37	0.19	0.1	0.21	0.47	0.13
Zinc	13	13	14	26	28	15
Aldehydes, µg/Nm³						
Acetaldehyde	NA	NC	0.99	0.86	NC	NC
Benzaldehyde	NA	NC	1.7	1.5	NC	NC
Formaldehyde	NA	NC	9.4	4.4	NC	NC
Volatile Organic Compounds, µg/Nm³						
Benzene	NA	NC	2.5	1.0	NC	NC
Carbon Disulfide	NA	NC	2.8	8.4	NC	NC
Methylene Chloride	NA	NC	55	81	NC	NC
Trichlorofluoromethane	NA	NC	26	45	NC	NC
PAHs/SVOCs, ng/Nm³						
Benzoic acid[b]	< 1,300	NC	80,000	38,000	80,000	38,000
bis(2-Ethylhexyl)phthalate[c]	4,200	18,000	< 800	NC	4,200	18,000
Di-n-butylphthalate[c]	< 400	NC	100,000	350,000	100,000	350,000

[a] Total concentration calculated only when results for both particulate and vapor phases were analyzed.

[b] Probable artifact of XAD resin.

[c] Most likely sample contamination.

Table 4-3
Incinerator Stack Emissions

Analyte	Particulate Phase		Vapor Phase		Total[a]	
	Average	95% CI	Average	95% CI	Average	95% CI
Particulate Loading, mg/Nm^3	141	26	NC	NC	NC	NC
Ionic Species, µg/Nm^3						
Chloride	< 150	NC	< 2,100	NC	< 2,100	NC
Fluoride	< 1.7	NC	26	22	26	22
Sulfate	140,000	19,000	11,000,000	1,700,000	12,000,000	1,700,000
Ammonia as N	NA	NC	750	1,400	NC	NC
Cyanide	NA	NC	5	7.9	NC	NC
Metals, µg/Nm^3						
Aluminum	52	0.9	< 18	NC	52	0.9
Antimony	< 2.1	NC	< 0.028	NC	< 2.1	NC
Arsenic	0.18	0.41	0.51	1.2	0.69	0.90
Barium	1.7	0.98	0.11	0.21	1.8	0.71
Beryllium	< 0.012	NC	< 0.051	NC	< 0.012	NC
Boron	NA	NC	14	17	NC	NC
Cadmium	0.44	0.18	1.5	4.1	2	2.9
Calcium	42	4.1	42	48	85	34
Chromium	2.8	1.2	0.84	1.1	3.6	0.75
Cobalt	0.33	0.31	0.048	0.08	0.38	0.22
Copper	1.9	1	0.65	2.6	2.6	1.5
Iron	190	130	16	9.8	200	89
Lead	0.27	0.47	1.9	2.9	2.2	2.1
Magnesium	7.3	1.1	< 17	NC	7.3	1.1
Manganese	1.4	0.65	8.2	30	9.6	22
Mercury, total	0.015	0.018	28	2.4	28	3.7
Molybdenum	5.1	0.5	0.048	0.064	5.2	0.36
Nickel	3.1	3.1	2.1	1.4	5.2	1.8
Phosphorus	180	12	< 760	NC	180	12
Potassium	< 16	NC	< 290	NC	< 16	NC

Table 4-3 (Continued)

Analyte	Particulate Phase		Vapor Phase		Total[a]	
	Average	95% CI	Average	95% CI	Average	95% CI
Selenium	< 0.029	NC	< 0.21	NC	< 0.21	NC
Silicon	NA	NC	57	17	NC	NC
Sodium	130	150	86	120	210	87
Titanium	0.9	0.46	< 0.55	NC	0.9	0.46
Vanadium	0.55	0.12	0.74	1.9	1.3	1.3
Zinc	9.5	7.4	16	28	26	20
Aldehydes, µg/Nm³						
Acetaldehyde	NA	NC	0.65	0.95	NC	NC
Acrolein	NA	NC	< 0.59	NC	NC	NC
Benzaldehyde	NA	NC	< 0.59	NC	NC	NC
Formaldehyde	NA	NC	0.78	0.29	NC	NC
Volatile Organic Compounds, µg/Nm³						
Benzene	NA	NC	2.5	3	NC	NC
Bromomethane	NA	NC	3.8	2.3	NC	NC
Carbon Disulfide	NA	NC	5.2	1.6	NC	NC
Toluene	NA	NC	0.91	1	NC	NC
Trichlorofluoromethane	NA	NC	0.5	0.45	NC	NC
PAHs/SVOCs, ng/Nm³						
Di-n-butylphthalate[b]	4,100	18,000	31,000	29,000	35,000	18,000
Benzoic acid[c]	< 2,000	NC	81,000	20,000	81,000	20,000
bis(2-Ethylhexyl)phthalate[b]	< 600	NC	5,300	23,000	5,300	23,000

[a] Total concentration calculated only when results for both particulate and vapor phases were analyzed.

[b] Likely due to sample contamination.

[c] Probable artifact of XAD resin.

Table 4-4
Synthesis Gas Streams

Analyte	Raw Syngas (5b)		Sour Syngas (11)		Sweet Syngas (12)	
	Average	95% CI	Average	95% CI	Average	95% CI
Particulate Loading, mg/Nm^3					0.0038	0.0098
Ionic Species, µg/Nm^3						
Ammonia as N			3,400	2,700	310	270
Chloride			<2,100	NC	<2,400	NC
Cyanide			5,600	12,000	110	130
Fluoride			15	6.5	21	3.6
Metals-Vapor Phase (Charcoal), µg/Nm^3						
Antimony			< 1.1	NC	< 0.039	NC
Arsenic			270	270	6	2.1
Barium			6.3	2.3	0.23	0.14
Beryllium			< 0.36	NC	< 0.013	NC
Boron			100	15	3.2	0.23
Cadmium			< 0.85	NC	< 0.031	NC
Chromium			93	14	3.6	1.7
Cobalt			< 5.9	NC	< 0.22	NC
Copper			46	10	1.8	0.18
Iron			2,300	190	85	12
Lead			< 0.85	NC	< 0.031	NC
Manganese			10	4.2	0.4	0.57
Mercury			11	13	0.099	0.024
Molybdenum			45	20	1.6	0.74
Nickel			17	24	0.94	1.5
Selenium			2.8	5.9	0.18	0.15
Vanadium			8.3	2.8	0.28	0.31
Zinc			< 3.8	NC	0.37	0.32

Table 4-4 (Continued)

Analyte	Raw Syngas (5b)		Sour Syngas (11)		Sweet Syngas (12)	
	Average	95% CI	Average	95% CI	Average	95% CI
Aldehydes, µg/Nm³						
Acetaldehyde			9.2	0.99	140	41
Acrolein			< 0.6	NC	< 1.3	NC
Benzaldehyde			0.72	1.1	< 1.3	NC
Formaldehyde			1.6	1.6	2.3	2.3
PAHs/SVOCs-Vapor Phase, µg/Nm³						
2-Methylnaphthalene			60	21	8.9	3
Acenaphthene			110	19	<2.8	NC
Acenaphthylene			260	19	8.4	2.6
Anthracene			8.5	0.06	<3.5	NC
Dibenzofuran			22	7	<2.5	NC
Fluoranthene			8	NC	< 1.2	NC
Fluorene			28	97	<2	NC
Naphthalene			6,900	1,300	960	88
Pentachlorophenol			17	58	< 1.3	NC
Phenanthrene			55	87	<2.6	NC
Phenol			7.6	35	<3.7	NC
Pyrene			10	9.6	< 1.7	NC

Table 4-4 (Continued)

Analyte	Raw Syngas (5b) Average	Raw Syngas (5b) 95% CI	Sour Syngas (11) Average	Sour Syngas (11) 95% CI	Sweet Syngas (12) Average	Sweet Syngas (12) 95% CI
Gas Composition						
Hydrogen (mol%)			32	4	32	8
Nitrogen (mol%)			2	2	2	0.5
Oxygen/Argon (mol%)			< 1	NC	< 1	NC
Carbon Dioxide (mol%)			31	2	30	5
Carbon Monoxide (mol%)			33	2	33	3
Methane (mol%)			2	0.1	2	0.1
C2 (ppmv)			7.8	0.1	9.2	1.2
C3 (ppmv)			0.2	0.3	0.2	0.2
C4 (ppmv)			< 0.1	NC	< 0 .1	NC
C5 (ppmv)			0.1	0.1	0.1	0.1
C6 (ppmv)			250	16	240	23
C7 (ppmv)			1	0.5	2.9	3.1
C8 (ppmv)			< 0.1	NC	< 0.1	NC
H_2S (ppmv)			920	70	27	10
COS (ppmv)			29	4	26	2
CS_2 (ppmv)			< 1	NC	< 1	NC

Table 4-5
Internal Process Streams

Analyte	Sour Gas (22)		Acid Gas (14)		Tail Gas (15)	
	Average	95% CI	Average	95% CI	Average	95% CI
Ionic Species, µg/Nm^3						
Ammonia as N	34%	11%	19,000	12,000	100,000	130,000
Chloride	NS	NC	< 5,600	NC	NA	NC
Cyanide	190,000	110,000	1,400	150	89,000	22,000
Fluoride	NS	NC	42	18	NA	NC
Metals-Vapor Phase (Charcoal), µg/Nm^3						
Antimony	NS	NC	< 2.1	NC	NA	NC
Arsenic	NS	NC	4.9	7.3	NA	NC
Barium	NS	NC	12	5.4	NA	NC
Beryllium	NS	NC	< 0.69	NC	NA	NC
Boron	NS	NC	180	56	NA	NC
Cadmium	NS	NC	< 1.6	NC	NA	NC
Chromium	NS	NC	210	78	NA	NC
Cobalt	NS	NC	< 11	NC	NA	NC
Copper	NS	NC	58	20	NA	NC
Iron	NS	NC	4,000	1,600	NA	NC
Lead	NS	NC	9.6	30	NA	NC
Manganese	NS	NC	11	27	NA	NC
Mercury	NS	NC	4	1.1	NA	NC
Molybdenum	NS	NC	72	13	NA	NC
Nickel	NS	NC	25	29	NA	NC
Selenium	NS	NC	< 1.7	NC	NA	NC
Vanadium	NS	NC	9.9	8.2	NA	NC
Zinc	NS	NC	< 7.3	NC	NA	NC
Metals-Vapor Phase (M-29), µg/Nm^3						
Aluminum	NS	NC	< 13	NC	< 120	NC
Antimony	NS	NC	0.062	0.043	0.072	0.23
Arsenic	NS	NC	2.7	4.9	0.4	1.2

Table 4-5 (Continued)

Analyte	Sour Gas (22)		Acid Gas (14)		Tail Gas (15)	
	Average	95% CI	Average	95% CI	Average	95% CI
Metals-Vapor Phase (M-29), µg/Nm^3 (Continued)						
Barium	NS	NC	0.47	0.5	0.69	1.9
Beryllium	NS	NC	< 0.034	NC	< 0.32	NC
Boron	NS	NC	5.8	9	< 40	NC
Cadmium	NS	NC	0.41	0.26	1.7	5.6
Calcium	NS	NC	95	110	220	580
Chromium	NS	NC	65	110	27	110
Cobalt	NS	NC	1.2	1.8	6.5	25
Copper	NS	NC	15	21	3.8	9
Iron	NS	NC	140	190	34	91
Lead	NS	NC	0.66	0.71	7.8	25
Magnesium	NS	NC	21	30	< 110	NC
Manganese	NS	NC	19	45	0.76	1.9
Mercury	NS	NC	0.99	1.2	11	31
Molybdenum	NS	NC	4.6	7.2	0.61	1.7
Nickel	NS	NC	230	340	33	60
Phosphorus	NS	NC	88	120	< 5,000	NC
Potassium	NS	NC	< 200	NC	< 1,900	NC
Selenium	NS	NC	3.7	9.7	< 1.3	NC
Silicon	NS	NC	74	36	170	480
Sodium	NS	NC	78	110	270	740
Titanium	NS	NC	0.82	0.91	< 3.6	NC
Vanadium	NS	NC	0.94	2.5	0.42	1.2
Zinc	NS	NC	14	34	50	120
PAHs/SVOCs-Vapor Phase, µg/Nm^3						
Acenaphthene	NS	NC	1,700	440	44	140
Acenaphthylene	NS	NC	3,100	800	< 27	NC
Anthracene	NS	NC	31	18	< 18	NC

Table 4-5 (Continued)

Analyte	Sour Gas (22)		Acid Gas (14)		Tail Gas (15)	
	Average	95% CI	Average	95% CI	Average	95% CI
PAHs/SVOCs-Vapor Phase, µg/Nm^3 (Continued)						
Dibenzofuran	NS	NC	270	82	160	440
Fluorene	NS	NC	660	12	11	81
Naphthalene	NS	NC	110,000	28,000	89,000	38,000
Phenanthrene	NS	NC	240	290	< 150	NC
Gas Composition						
Hydrogen (mol%)	NA	NC	< 1	NC	NA	NC
Nitrogen (mol%)	NA	NC	< 1	NC	3	0.3
Oxygen/Argon (mol%)	NA	NC	< 1	NC	< 1	NC
Carbon Dioxide (mol%)	NA	NC	98	NC	97	0.3
Carbon Monoxide (mol%)	NA	NC	< 1	NC	< 0 .1	NC
Methane (ppmv)	700	50	420	44	390	40
C2 (ppmv)	5.4	0.5	2.3	0.6	1.3	0.5
C3 (ppmv)	170	40	8.8	2.4	6.5	4.7
C4 (ppmv)	7	4	< 0.1	NC	< 0.1	NC
C5 (ppmv)	< 0.1	NC	< 0.1	NC	< 0.1	NC
C6 (ppmv)	440	20	350	24	330	30
C7 (ppmv)	2	3	2.1	1.5	2.7	2
C8 (ppmv)	6	7	< 0.1	NC	2	4
H_2S (ppmv)	1.3%	NC	1.5%	0.2	3,000	300
COS (ppmv)	< 1	NC	170	NC	85	55
CS_2 (ppmv)	< 1	NC	< 1	NC	42	28

Table 4-6
Incinerator Fuel Gases

Analyte	Natural Gas (99)		Combustion Air (97)	
	Average	95% CI	Average	95% CI
Ionic Species, µg/Nm³				
Ammonia as N	NA	NC	460,000	55,000
Cyanide	NA	NC	10,000	2,400
Metals-Vapor Phase (M-29), µg/Nm³				
Aluminum	< 12	NC	NA	NC
Antimony	< 0.018	NC	NA	NC
Arsenic	0.068	0.031	NA	NC
Barium	0.04	0.043	NA	NC
Beryllium	< 0.029	NC	NA	NC
Boron	< 4.1	NC	NA	NC
Cadmium	0.37	0.26	NA	NC
Calcium	43	19	NA	NC
Chromium	1.5	0.22	NA	NC
Cobalt	0.54	2.2	NA	NC
Copper	< 0.047	NC	NA	NC
Iron	6	3.5	NA	NC
Lead	3.6	12	NA	NC
Magnesium	< 11	NC	NA	NC
Manganese	0.049	0.17	NA	NC
Mercury	0.35	0.16	NA	NC
Molybdenum	0.14	0.055	NA	NC
Nickel	0.74	1.6	NA	NC
Phosphorus	< 26	NC	NA	NC
Potassium	< 190	NC	NA	NC
Selenium	< 0.14	NC	NA	NC
Silicon	24	10	NA	NC
Sodium	28	12	NA	NC

Table 4-6 (Continued)

Analyte	Natural Gas (99)		Combustion Air (97)	
	Average	95% CI	Average	95% CI
Metals-Vapor Phase (M-29), µg/Nm^3 (Continued)				
Titanium	< 0.33	NC	NA	NC
Vanadium	0.032	0.037	NA	NC
Zinc	8.3	2.3	NA	NC
Gas Composition				
Hydrogen (mol%)	<1	NC	NA	NC
Nitrogen (mol%)	< 1	NC	NA	NC
Oxygen/Argon (mol%)	< 1	NC	NA	NC
Carbon Dioxide (mol%)	< 1	NC	NA	NC
Carbon Monoxide (mol%)	< 1	NC	NA	NC
Methane (ppmv)	99%	NC	650	120
C2 (ppmv)	4,500	90	5	3
C3 (ppmv)	1,400	140	0.9	0.3
C4 (ppmv)	390	50	0.2	0.2
C5 (ppmv)	140	20	< 0.1	NC
C6 (ppmv)	53	12	7.2	0.3
C7 (ppmv)	110	20	1	1
C8 (ppmv)	10	1	0.6	0.05
H_2S (ppmv)	< 1	NC	< 1	NC
COS (ppmv)	< 1	NC	< 1	NC
CS_2 (ppmv)	< 1	NC	< 1	NC

Table 4-7
Hot Raw Syngas Streams

	Raw Syngas @ 1000°F (5)[a]		Raw Syngas @ 500°F (5a)	
Analyte	Average	95% CI	Average	95% CI
Ionic Species, µg/Nm ^{3}				
Ammonia as N				
Chloride				
Cyanide				
Fluoride				
Metals-Vapor Phase (Charcoal), µg/Nm ^{3}				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Manganese				
Mercury				
Molybdenum				
Nickel				
Selenium				
Vanadium				
Zinc				

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Table 4-7 (Continued)

Analyte	Raw Syngas @ 1000°F (5)[a]		Raw Syngas @ 500°F (5a)	
	Average	95% CI	Average	95% CI
Gas Composition				
Hydrogen (mol%)				
Nitrogen (mol%)				
Oxygen/Argon (mol%)				
Carbon Dioxide (mol%)				
Carbon Monoxide (mol%)				
Methane (mol%)				
C2 (ppmv)				
C3 (ppmv)				
C4 (ppmv)				
C5 (ppmv)				
C6 (ppmv)				
C7 (ppmv)				
C8 (ppmv)				
H_2S (ppmv)				
COS (ppmv)				
CS_2 (ppmv)				

[a] Samples collected with high temperature/pressure sampling probe.

Table 4-8
Solid Feed Streams

Analyte	Raw Coal (1a) Average	Raw Coal (1a) 95% CI	Primary Slurry Feed (32) Average	Primary Slurry Feed (32) 95% CI	Secondary Slurry Feed (33) Average	Secondary Slurry Feed (33) 95% CI
Ultimate/Proximate Parameters						
Moisture, total (Wt.%)	29	0.24	45	0.30	48	0.44
% Solids in Slurry (Wt.%)	NA	NC	55	0.30	52	0.44
Ash (Wt. %)	6.7	0.30	6.4	0.08	7.7	0.15
Carbon (Wt. %)	70	0.37	69	0.43	69	0.31
Hydrogen (Wt. %)	4.6	0.08	4.8	0.09	4.7	0.07
Nitrogen (Wt. %)	0.99	0.02	1	0.02	1.1	0.06
Sulfur (Wt. %)	0.28	0.01	0.28	0.01	0.28	0.01
Oxygen (by difference) (Wt. %)	17	0.39	19	0.34	17	0.31
Volatile Matter (Wt. %)	46	0.34	46	0.29	45	0.48
Fixed Carbon (Wt. %)	47	0.43	48	0.32	47	0.52
Higher Heating Value (Btu/lb)	12,000	68	12,000	39	12,000	46
Chloride (µg/g)	39	5.7	43	7.0	56	9.2
Fluoride (µg/g)	76	27	45	5.0	260	45
Metals, µg/g						
Aluminum	6,300	400	5,800	140	7,200	220
Antimony	0.12	0.023	0.01	0.031	0.43	0.047
Arsenic	0.98	0.066	0.74	0.13	2.2	0.32
Barium	370	97	390	8.6	500	27
Beryllium	0.27	0.029	0.21	0.04	0.31	0.039
Boron	32	0.95	26	2.4	35	0.77
Cadmium	0.1	0.035	0.074	0.016	1.8	0.87
Calcium	11,000	440	10,000	170	13,000	280
Chromium	4.7	2.1	3.3	1.4	5.2	1.9
Cobalt	1.9	0.11	1.5	0.27	2.2	0.15
Copper	11	0.79	9.6	1.5	15	1.6
Iron	2,400	98	2,300	77	2,900	84
Lead	1.3	0.20	0.85	0.16	8.3	2.2

Table 4-8 (Continued)

Analyte	Raw Coal (1a)		Primary Slurry Feed (32)		Secondary Slurry Feed (33)	
	Average	95% CI	Average	95% CI	Average	95% CI
Metals, µg/g (Continued)						
Magnesium	2,200	93	2,100	41	2,700	78
Manganese	9.9	0.62	8	1.3	11.0	0.80
Mercury	0.11	0.013	0.11	0.028	0.087	0.0086
Molybdenum	0.55	0.054	0.49	0.091	0.73	0.073
Nickel	1.6	0.56	1.8	0.51	1.1	0.37
Phosphorus	300	50	290	26	310	26
Potassium	210	26	200	50	210	26
Selenium	3.4	2.6	1.4	0.54	5	1.3
Silicon	11,000	790	9,900	230	12,000	340
Sodium	1,000	34	1,000	500	1,300	50
Strontium	200	50	200	50	200	50
Titanium	580	75	540	56	690	26
Vanadium	13	0.87	10	1.4	14	0.91
Zinc	7.9	0.81	8.6	2.5	57	25
Radionuclides, pCi/g						
Actinium-228 @ 338 KeV	0.047	0.29	NA	NC	NA	NC
Actinium-228 @ 911 KeV	0.12	0.45	NA	NC	NA	NC
Actinium-228 @ 968 KeV	0.14	0.85	NA	NC	NA	NC
Bismuth-212 @ 727 KeV	-0.27	1.5	NA	NC	NA	NC
Bismuth-214 @ 1120 KeV	0.31	0.11	NA	NC	NA	NC
Bismuth-214 @ 1764 KeV	0.32	0.61	NA	NC	NA	NC
Bismuth-214 @ 609 KeV	0.16	0.19	NA	NC	NA	NC
Lead-210 @ 46 KeV	0.4	1.7	NA	NC	NA	NC
Lead-212 @ 238 KeV	0.13	0.029	NA	NC	NA	NC
Lead-214 @ 295 KeV	0.21	0.11	NA	NC	NA	NC
Lead-214 @ 351 KeV	0.15	0.066	NA	NC	NA	NC
Potassium-40 @ 1460 KeV	-0.038	0.12	NA	NC	NA	NC

Table 4-8 (Continued)

Analyte	Raw Coal (1a)		Primary Slurry Feed (32)		Secondary Slurry Feed (33)	
	Average	95% CI	Average	95% CI	Average	95% CI
Radium-226 @ 226 KeV	0.057	0.038	NA	NC	NA	NC
Thallium-208 @ 583 KeV	0.037	0.076	NA	NC	NA	NC
Thallium-208 @ 860 KeV	-0.23	0.95	NA	NC	NA	NC
Thorium-234 @ 63 KeV	0.13	0.29	NA	NC	NA	NC
Thorium-234 @ 92 KeV	0.047	0.38	NA	NC	NA	NC
Uranium-235 @ 143 KeV	-0.023	0.17	NA	NC	NA	NC

Table 4-9
Recycled Char Streams

Analyte	Recycled Char (5c)		Dry Char (1000°F)[a]		Dry Char (500°F)[a]	
	Average	95% CI	Average	95% CI	Average	95% CI
Ultimate/Proximate Parameters						
Ash (Wt. %)						
Carbon (Wt. %)						
Hydrogen (Wt. %)						
Nitrogen (Wt. %)						
Sulfur (Wt. %)						
Oxygen (by difference) (Wt. %)						
Volatile Matter (Wt. %)						
Fixed Carbon (Wt. %)						
Higher Heating Value (Btu/lb)						
Chloride (µg/g)						
Fluoride (µg/g)						
Metals, µg/g						
Aluminum						
Antimony						
Arsenic						
Barium						
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						

Table 4-9 (Continued)

Analyte	Recycled Char (5c)		Dry Char (1000°F)[a]		Dry Char (500°F)[a]	
	Average	95% CI	Average	95% CI	Average	95% CI
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Mercury						
Molybdenum						
Nickel						
Phosphorus						
Potassium						
Selenium						
Silicon						
Sodium						
Strontium						
Titanium						
Vanadium						
Zinc						

[a] Dry char samples filtered from raw syngas with hot gas sampling probe, only two samples collected at 500 degree location.

Table 4-10
Solid Effluent Streams

Analyte	Slag (4)		Sulfur (24)	
	Average	95% CI	Average	95% CI
Ultimate/Proximate Parameters				
Ash (Wt. %)	89.8	5.1	NA	NC
Carbon (Wt. %)	9.5	5.2	NA	NC
Hydrogen (Wt. %)	0.15	0.07	NA	NC
Nitrogen (Wt. %)	0.04	0.05	NA	NC
Sulfur (Wt. %)	0.03	0.02	98.7	7.0
Oxygen (by difference) (Wt. %)	0.27	0.19	NA	NC
Volatile Matter (Wt. %)	NA	NC	NA	NC
Fixed Carbon (Wt. %)	NA	NC	NA	NC
Higher Heating Value (Btu/lb)	NA	NC	NA	NC
Chloride (µg/g)	84	56	NA	NC
Fluoride (µg/g)	200	50	NA	NC
Metals, µg/g				
Aluminum	91,000	5,300	16	150
Antimony	1.07	0.25	<3	NC
Arsenic	6	0.96	<3	NC
Barium	5,900	390	<2	NC
Beryllium	3.4	0.37	<2	NC
Boron	350	30	<10	NC
Cadmium	0.20	0.11	<2	NC
Calcium	160,000	9,800	20	95
Chromium	76	8.3	4	38
Cobalt	26	2.8	<4	NC
Copper	150	11	<2	NC
Iron	37,000	2,200	9	38
Lead	3	1.1	<3	NC

Table 4-10 (Continued)

Analyte	Slag (4)		Sulfur (24)	
	Average	95% CI	Average	95% CI
Magnesium	33,000	2,200	4	25
Manganese	130	12	<2	NC
Mercury	0.020	0.006	0.095	0.19
Molybdenum	7.6	0.52	<20	NC
Nickel	38	4.1	<4	NC
Phosphorus	4,100	210	NA	NC
Potassium	2,700	250	<20	NC
Selenium	14	5.7	24	180
Silicon	160,000	9,500	<20	NC
Sodium	16,000	1,100	<20	NC
Strontium	2,300	910	NA	NC
Titanium	8,100	500	2	13
Vanadium	170	13	<2	NC
Zinc	47	5.6	15	170
Radionuclides, pCi/g				
Actinium-228 @ 338 KeV	2.3	0.9	NA	NC
Actinium-228 @ 911 KeV	2.5	1.1	NA	NC
Actinium-228 @ 968 KeV	2.5	1.1	NA	NC
Bismuth-212 @ 727 KeV	2.8	1.1	NA	NC
Bismuth-214 @ 1120 KeV	2.7	0.9	NA	NC
Bismuth-214 @ 1764 KeV	2.6	1.4	NA	NC
Bismuth-214 @ 609 KeV	2.7	1.2	NA	NC
Lead-210 @ 46 KeV	0.33	1.4	NA	NC
Lead-212 @ 238 KeV	2.3	0.87	NA	NC
Lead-214 @ 295 KeV	2.8	1.2	NA	NC
Lead-214 @ 351 KeV	2.8	1.2	NA	NC
Potassium-40 @ 1460 KeV	2	1.8	NA	NC
Radium-226 @ 226 KeV	3.5	1.3	NA	NC

Table 4-10 (Continued)

Analyte	Slag (4)		Sulfur (24)	
	Average	95% CI	Average	95% CI
Thallium-208 @ 583 KeV	0.82	0.34	NA	NC
Thallium-208 @ 860 KeV	1.1	0.52	NA	NC
Thorium-234 @ 63 KeV	1.9	2.3	NA	NC
Thorium-234 @ 92 KeV	1.4	0.76	NA	NC
Uranium-235 @ 143 KeV	0	0.56	NA	NC

Table 4-11
Sour Water Stripper Aqueous Streams

Analyte	Sour Condensate (7)		Sweet Water (8)	
	Average	**95% CI**	**Average**	**95% CI**
Water Quality Parameters				
pH			8.75	0.22
Specific conductance (μmhos)			71.8	18
Total Suspended Solids (mg/L)			1.9	3.4
Chemical Oxygen Demand (mg/L)			53	3.9
Total phenolics (mg/L)			0.55	0.1
Ionic Species, mg/L				
Ammonia as N			7.3	3.6
Chloride			0.88	0.15
Cyanide, amenable			0.035	0.1
Cyanide, total			1.5	1.2
Fluoride			1.8	0.7
Formate			3.2	0.41
Phosphate, total (as P)			0.26	0.1
Sulfate			< 0.047	NC
Thiocyanate			0.82	0.72
Metals, mg/L				
Aluminum			0.5	0.14
Antimony			< 0.076	NC
Arsenic			0.0038	0.0024
Barium			0.53	0.07
Beryllium			0.0006	0.0013
Boron			0.039	0.051
Cadmium			0.005	0.0024
Calcium			2.6	0.11
Chromium			0.0087	0.003
Cobalt			< 0 .004	NC
Copper			0.015	0.0044
Iron			1.2	0.14
Lead			0.33	0.25
Magnesium			1	0.058

Table 4-11 (Continued)

Analyte	Sour Condensate (7)		Sweet Water (8)	
	Average	95% CI	Average	95% CI
Manganese			0.0024	0.0034
Mercury			<0.000033	NC
Molybdenum			0.011	0.0051
Nickel			0.022	0.042
Phosphorus			0.24	0.07
Potassium			0.9	1.1
Selenium			0.032	0.02
Silicon			7.23	0.35
Sodium			3.79	0.038
Titanium			0.02	0.011
Vanadium			<0.0045	NC
Zinc			0.25	0.13
Aldehydes, mg/L				
Acetaldehyde			<0.01	NC
Acrolein			<0.01	NC
Benzaldehyde			<0.01	NC
Formaldehyde			<0.01	NC
Volatile Organic Compounds, µg/L				
1,4-Bromofluorobenzene			46	1.2
Acetone			5.2	3.2
Benzene			<0.46	NC
Methylene chloride			<3	NC
Semivolatile Organic Compounds, µg/L				
2,4,6-Tribromophenol			160	32
2-Fluorobiphenyl			61	15
2-Fluorophenol			160	33
4-Methylphenol/3-Methylphenol			0.49	1.1
Benzoic acid			9.2	26
Fluoranthene			2.6	1.1
Phenol			400	84
Pyrene			11	5.6

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Table 4-12
Recycled Char Water

Analyte	Scrubber Inlet Water		Recycle Char Filtrate	
	Average	95% CI	Average	95% CI
Water Quality Parameters				
Total Suspended Solids (mg/L)				
Ionic Species (mg/L)				
Ammonia as N				
Chloride				
Cyanide, amenable				
Cyanide, total				
Fluoride				
Thiocyanate				
Metals, mg/L				
Aluminum				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				

Table 4-12 (Continued)

Analyte	Scrubber Inlet Water		Recycle Char Filtrate	
	Average	95% CI	Average	95% CI
Manganese				
Mercury				
Molybdenum				
Nickel				
Phosphorus				
Potassium				
Selenium				
Silicon				
Sodium				
Titanium				
Vanadium				
Zinc				

Table 4-13
Selectamine™ Solvent

Analyte	Units	Pre-Test Sample Average	Post-Test Sample Average[a]
Ash	Wt.%		
Density	g/cc		
Heat Stable Salts	Wt.%		
Total Suspended Solids	mg/L		

[a] The solvent was regenerated during the test program.

5

DATA EVALUATION AND QUALITY CONTROL

The measurement data obtained from this project were subjected to numerous quality control (QC) checks designed to measure the completeness, representativeness, and comparability of the results. The results of these QC checks were evaluated and compared to the data quality objectives (DQOs) established at the onset of this project for precision, accuracy, and representativeness of individual sample measurements. Quality control checks that fail to meet the DQOs do not necessarily render the data unacceptable; however, they may affect the representativeness and comparability of the results reported. It is not intended that DQOs be used as acceptance criteria, but rather as empirical estimates of the precision and accuracy expected from existing reference measurement methods considered acceptable for the task of providing meaningful results. This section presents the precision and accuracy actually obtained, with the DQOs serving as benchmarks for comparison.

A comprehensive listing of all individual quality control sample results (and data quality objectives) are presented in Appendix A. Results for blank samples, matrix-spike and surrogate-spike recoveries, and performance evaluation standards are presented. In reference to these results, this section:

- Provides a performance assessment of the analytical systems for each matrix and analyte and the rationale for reporting data from specific sampling and analytical methods;
- Discusses sample representativeness and identifies any potentially affected results;
- Describes the conventions for handling analytical data; and
- Presents the results of material balances which are used to assess the overall representativeness of the data.

Quality Control Results

Insuring the quality of the analytical data is key to the design of a quality control system. Numerous quality control checks were used throughout sample preparation and analysis to indicate the accuracy and precision of the handling procedures and analytical instrumentation. Table 5-1 defines the various QC measures performed.

Quality control measurements internal to the laboratory were made to confirm the accurate operation of the analytical instrumentation and to verify the absence of any significant source of contamination. Specifically, laboratory control standards (LCS) were used to confirm that the

Table 5-1
Quality Control Checks

QC Check	Description	Purpose
Laboratory Check Standard/ Laboratory Check Standard Duplicate (LCS/LCSD)	Standard samples prepared in a "clean" matrix from sources other than the calibration solutions.	Results are used to measure the accuracy and precision of the analytical system after calibration and at regular intervals during analysis of samples. LCS/LCSD results must meet control limits before analysis of samples can proceed.
Performance Evaluation Audit Sample (PE Sample)	Standard Reference Material (SRM), well-characterized reference sample, or standard sample prepared in a similar matrix to that of the samples. Submitted to the lab double-blind (i.e. unknown to the lab in concentration and not identified as a QC sample).	Enables an independent assessment of the laboratory's ability to provide accurate results in a matrix similar to that of the samples.
Matrix-Spiked Sample/ Matrix-Spiked Duplicate (MS/MSD)	Real samples spiked with the analyte(s) of interest, usually before sample preparation.	Spike recovery between MS/MSD samples indicates accuracy and precision of the preparation and analytical method for the spiked sample matrix. Poor recovery may indicate matrix effects, loss during sample prep, or disparity between the spiked and parent sample concentration.
Analytical Spiked Sample/ Analytical Spiked Duplicate (AS/ASD)	Real samples spiked with the analyte(s) of interest after sample preparation, immediately before analysis.	Similar to MS/MSD, but spike recovery between AS/ASD samples only indicates accuracy and precision of the analytical method for the spiked sample matrix. Poor recovery may indicate matrix effects or disparity between the spiked and parent sample concentration.
Surrogate Spiked Samples	Isotopically-labeled or substituted compounds similar to the compound(s) of interest which are added to the sample matrix when matrix spiking is not feasible.	Results indicate accuracy of the analytical system for a limited number of analytes which are related to the surrogate compounds.
Method Blanks	Sample of all reagents used in sample preparation and carried through all sample preparation steps.	Method blanks are used to indicate potential contamination from sample preparation and/or reagent impurities.
Media Blanks	Samples of prepared, unused collection media (i.e. filters, impinger solutions, sorbents, etc.)	Analysis is used to indicate the background levels of analytes present in the media used for sample collection.
Field Blanks	Samples of collection media that have been prepared and recovered like actual samples, but with no sample contact.	Analysis indicates the levels of analytes present from media background and that potentially introduced from sample handling.
Duplicate Samples	Samples from the same source collected simultaneously.	Results indicate total variability (precision) between samples due to sample collection, handling, preparation, and analysis.
Analytical Duplicates	Duplicate analysis of the same sample.	Indicates analytical precision only.

analytical instrumentation was operating within specified control parameters. Method blanks were used to indicate background levels of analytes in the materials used in the preparation of samples. Failure to meet the method criteria for LCS recovery and method blank levels would result in reanalysis, repreparation of samples, or both until the system was found to be in control. During this program, there were no LCS results reported outside of method-specified control range indicating that all analytical systems were performing within method-specified limits for accuracy and precision.

Matrix-spiked and matrix-spiked duplicate (MS/MSD) samples were analyzed to determine accuracy and precision of the analytical techniques. Wherever practical, matrix-spiked samples were prepared for each matrix to provide an indication of an analytical technique's accuracy. For analyses where the entire sample was required, analytical spikes (spikes added to the final prepared sample) were substituted for matrix spikes. In addition to matrix-spiked samples, or for analytes where matrix-spiking was not practical, surrogate-spiked samples, standard reference materials, and/or performance evaluation audit samples were analyzed to provide an additional measurement of accuracy. In addition to MS/MSD samples, duplicate analyses were used to measure analytical precision.

This section continues with a discussion on the significance of blank sample results and on the accuracy and precision of each method used to measure each group of target analytes (i.e., metals, anions, volatile organics, etc.) relative to each sample matrix. The sample preparation and analytical techniques summarized in Tables 5-2, 5-3, and 5-4 were assessed for data quality of the gas, solid, and aqueous sample matrices, respectively.

Metals—Solid Streams and Gas Particulate Samples

The analytical techniques used for metals analysis of coal, slurry, slag, char, sulfur, and filtered gas particulate samples include inductively coupled plasma emission spectroscopy (ICP-AES), atomic absorption spectrophotometry [i.e. graphite furnace (GFAAS) and cold vapor (CVAAS)], and x-ray fluorescence spectrophotometry (XRF). Due to the low concentrations of many trace elements found in these matrices, the more sensitive inductively coupled plasma mass spectrometry (ICP/MS) technique was used for all samples except sulfur and gas particulate filters. All of these analytical techniques require a sample digestion or fusion step to prepare the solid sample for analysis, so similar QC samples were prepared for these matrices.

With the exception of the solid digestate analyses for nickel by ICP/MS, analysis results for method blank samples showed no evidence of significant contamination from either laboratory or field handling, respectively. Nickel contamination can be explained since the skimmer cones used to sample the plasma in an ICP/MS are nickel-plated to withstand the high temperatures of the plasma. High nickel concentrations in the blanks (and high matrix spike recoveries) suggest some corrosion of the cones by the sample matrix was taking place, therefore the nickel values measured by ICP-AES were used.

Table 5-2
Summary of Analytical Methods for Gas Samples

Sample Matrix	Sampling Train	Analyte	Sample Preparation and Analytical Method
Filter and probe rinse solids[a]	EPA Method 29 (draft)	Al, Sb, Ba, Be, Ca, Cr, Co, Cu, Fe, Mg, Mn, Mo, Ni, P, K, Si, Na, Ti, V, & Zn.	Mixed-acid microwave digestion/ ICP-AES (SW6010)
		As, Cd, Pb, & Se.	Mixed-acid microwave digestion/ GFAAS (SW7060,7131,7421,7740)
		Hg	Mixed-acid microwave digestion/ CVAAS (SW7470)
HNO_3/H_2O_2 impinger solutions	EPA Method 29 (draft)	Al, Sb, Ba, Be, B, Ca, Cr, Co, Cu, Fe, Mg, Mn, Mo, Ni, P, K, Si, Na, Ti, V, & Zn.	Digestion (SW3005)/ICP-AES (SW6010)
		As, Cd, Pb, & Se.	Digestion (SW3020)/GFAAS (SW7060,7131,7421,7740)
		Hg	Peroxide reduction/CVAAS (SW7470)
		Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, & V.	ICP/MS (SW6020)
4% $KMnO_4$/10% H_2SO_4 impinger solution[a]	EPA Method 29 (draft)	Hg	CVAAS (SW7470)
Charcoal Sorbent[b]	Radian	Al, Sb, Ba, Be, Ca, Cr, Co, Cu, Fe, Mg, Mn, Mo, Ni, P, K, Si, Na, Ti, V, & Zn.	Nitric acid microwave digestion/ ICP-AES (SW6010)
		As, Cd, Pb, & Se.	Nitric acid microwave digestion/ GFAAS (SW7060,7131,7421,7740)
		Hg	Nitric acid microwave digestion/ CVAAS (SW7470)
H_2SO_4 impinger solutions	EPA Method 26 (modified)	Ammonia	Colorimetric (EPA Method 350.2, 350.1)
		Chloride	Ion Chromatography (EPA Method 26)
		Fluoride	Specific Ion Electrode (EPA Method 340.2)
2% $Zn(C_2H_3O_2)_2$ impinger solution	Texas Air Control Board	Total Cyanide	Colorimetric (EPA Method 335.2)

Table 5-2 (Continued)

Sample Matrix	Sampling Train	Analyte	Sample Preparation and Analytical Method
Filter and FH rinse[a]	EPA Method 0010	SVOCs/PAHs	GC/MS (SW8270)[a] HRGC/MS (CARB 429)[a]
XAD, condensate, and BH rinse		SVOCs/PAHs	GC/MS (SW8270) HRGC/MS (CARB 429)[a]
2,4-DNPH impinger solution	EPA Method 0011	Aldehydes	HPLC (EPA Method 0011)
VOST[a]	EPA Method 0030	Volatile organic compounds	GC/MS (SW8240)
4% $KMnO_4$/10% NaOH impinger solution[a]	EPA Method 7D	NO_x	Ion Chromatography

[a] Turbine stack and incinerator flue gas samples only.

[b] Internal process streams only.

Table 5-3
Summary of Analytical Methods for Solid Streams

Matrix	Sample Handling	Analyte	Sample Preparation and Analytical Method
Coal/Char/Slag	Composite samples are air-dried and ground to pass a 60-mesh sieve.	Carbon, Hydrogen, Nitrogen	ASTM D5373
		Sulfur	ASTM D4239
		Ash	ASTM D3174
		Volatile Matter [a]	ASTM D3175
		Fixed Carbon [a]	ASTM D3172
		HHV [a]	ASTM D2015
		Chlorine (as Cl^-)	ASTM D4208 (adapted for IC analysis) [a] HNO_3 acid leach/potentiometry [b]
		Fluorine (as F^-)	ASTM D3761/SIE [a] NaOH fusion/SIE [b] ASTM D4208 (adapted for IC analysis) [a]
		Major ash minerals: Al, Ca, Fe, Mg, P, K, Si, Na, & Ti.	ASTM D4326 (XRF)
		Ba, Ni, & Zn.	ASTM D3683/ICP-AES
		Sb, As, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Se, & V.	ASTM D3683, mixed-acid microwave digestion (HF, HCl, HNO_3), and EPA SW3020. Analysis by ICP/MS.
		Boron	Na_2CO_3 fusion/ICP-AES
		Mercury	Double gold amalgamation/CVAAS
Sulfur	Grab samples were ground and mixed.	Sulfur	ASTM D4239
		Ash	ASTM D3174
		Sb, Ba, Be, Cr, Co, Cu, Mn, Mo, Ni, & V.	ASTM D3683/ICP-AES
		As, Cd, Pb, & Se	ASTM D3683/GFAAS
		Boron	Na_2CO_3 fusion/ICP-AES
		Mercury	Double gold amalgamation/CVAAS

[a] Coal and char samples only.

[b] Slag samples only.

Table 5-4
Summary of Analytical Methods for Liquid Process Streams

Process Stream	Sample Handling	Analyte	Sample Preparation and Analytical Method
Sour Condensate, Sweet Water, Scrubber Inlet Water, and Recycle Char Filtrate	On-site analysis.	pH	EPA 150.1
		Specific conductance	EPA 120.1
		Total Suspended Solids (TSS)	EPA 160.2
		Sulfide	Orion SIE
	Composite samples cooled to 4° C. Filtered prior to analysis.	Fluoride	EPA 340.2
		Chloride, Sulfate	EPA 300.0
		Formate	EPA 300.0 (modified)
		Phosphate	EPA 365.1
	Grab samples treated with $PbCO_3$, filtered, and pH adjusted >12 with CaO.	Total Cyanide	EPA 335.2
		Free Cyanide	EPA 335.1
		Thiocyanate	SM 412K
	Composite samples treated with H_2SO_4 to pH<2.	Ammonia	EPA 350.2, 350.1
		COD	EPA 410.1
		Phenol	EPA 420.1
	Composite samples treated with HNO_3 to pH<2.	Al, Sb, Ba, Be, B, Ca, Cr, Co, Cu, Fe, Mg, Mn, Mo, Ni, P, K, Si, Na, Ti, V, & Zn.	SW3005/SW6010
		As, Cd, Pb, & Se	SW3020/SW7060, 7131, 7421, 7740
		Mercury	SW7470
	Grab samples cooled to 4° C.	Semivolatile Organic Compounds	SW8270
		Aldehydes	SW8315 (proposed)
		Volatile Organic Compounds	SW8240
Selectamine™ Solvent	Grab samples stored in amber glass bottles at room temperature.	Heat Stable Salts	Union Carbide - Titration with NaOH
		Ash	ASTM D3174
		Total Suspended Solids (TSS)	EPA 160.2

Any metal concentrations in gas-filter media blank samples would be significant considering the small amount of particulate material collected for analysis. For these samples, multiple blanks were analyzed and the results averaged. This provided a value for correcting the sample results for background concentrations associated with the collection media. This correction was necessary to eliminate the reporting of extremely high or extremely low concentrations that could not be statistically differentiated from background concentrations in the filter media. A blank filter containing approximately 0.1 gram of a standard fly ash (NBS 1633a Ref. Filter Q-2608) was analyzed as a performance evaluation sample. The results reported in Appendix Table A-1 reflect background corrected results. Recovery of the ash standard was within 75-125% for all target metals except copper (68.6%), lead (51.0%), and molybdenum (48.3%).

Matrix spiked sample results for metals indicate digestion and analytical performance within specified recovery objectives with few consistent exceptions. In cases where two or more analytical techniques were performed (e.g., ICP-AES and ICP/MS), the technique offering the best QC sample performance and/or best detection limit was selected for the reported results. Table 5-5 identifies those metals analyzed by selected analytical techniques that did not meet the DQOs in at least 2 MS samples for the respective sample streams. These results may indicate matrix effects or uncertainty in the data for a specific process stream. The material balances presented at the end of this section can be used to assess the overall believability of the data and the effect of a potential analytical bias indicated by poor spike recovery results.

From the data presented in Tables 5-5 and Appendix A-3, the following key observations can be made:

- Lead results may be biased low in coal, slurry, char, slag, and incinerator stack gas particulate samples based on consistently low spike recovery and standard sample results;

- Copper results for coal and slag samples may be biased slightly low, although excellent spike recovery results were obtained for char, secondary slurry feed, and emitted particulate matter;

- Arsenic and cobalt results by ICP/MS in coal, slurry, and char may be biased slightly high based on spike recovery results; and

- Manganese, selenium, and vanadium results are mixed and variable, based upon the MS/MSD and PE results.

Performance evaluation standards (coal SRMs) and reference samples (well characterized slag and coal samples) were also analyzed to provide an indication of analytical accuracy for major ash minerals by XRF. These results, presented in Appendix Table A-1, do not indicate any consistent analytical bias for any of the target metals. However, individual results outside the DQOs were reported for calcium, titanium, magnesium, sodium, potassium, silicon, and phosphorus.

Table 5-5
Metal Spike Recoveries Outside DQOs—Solid Streams

Matrix/Sample Stream	Metal	Analysis Method	MS/MSD Recovery	Additional Information
Raw Coal/Slurry/Char	Arsenic	ICP/MS	130%, 132%, 131%, 131%, 137%	PE Standard: 61.8%, 90.8%
	Cobalt	ICP/MS	130%, 129%, 129%, 129%	PE Standard: 98.3%, 126%
	Copper	ICP/MS	25%, 46%	PE Standard: 86.8%, 72.9%
	Lead	ICP/MS	31%, 68%, 41%, 27%, 69%, 49%, 63%	PE Standard: 31.5%, 32.8%
	Manganese	ICP/MS	24%, 54%	PE Standard: 105%, 141%
	Selenium	ICP/MS	-64%, -21%, 129%	PE Standard: 53.5%, 105%
	Vanadium	ICP/MS	17%, 43%	PE Standard: 68.0%, 87.6%
Slag	Copper	ICP/MS	62%, 74%	PE Reference Sample: 72.1%
	Lead	ICP/MS	74%, 69%	PE Reference Sample: 72.7%
Gas-Particulate Phase, Incinerator Stack Only	Lead	GFAAS	59%, 62%	PE Sample: 51.0%
	Selenium	GFAAS	18%, 18%	PE Sample: 103%

Metals-Aqueous Streams, Impinger Solutions, and Charcoal Sorbent Extracts

Metal concentrations in media blank and method blank samples were considered insignificant for all aqueous/impinger/extract samples with the exception of those collected on charcoal sorbents (vapor-phase metals) and impinger samples analyzed by ICP/MS. For these two sample sets, at least three blank samples were analyzed and the blank results were averaged to provide a representative value for correcting the sample results for background concentrations associated with the collection media. Similar to the situation with filtered gas-particulate samples, this correction was necessary to eliminate the reporting of extremely high or extremely low concentrations that could not be statistically differentiated from background concentrations in the collection media.

Matrix-spiked impinger samples (HNO_3/H_2O_2) analyzed for metals by ICP/MS were prepared at 10-20 parts per billion (ppb); concentrations much closer to the natural concentrations found in these samples and below a reasonable spiking level for ICP-AES. Spike recoveries for all of the ICP/MS elements (see Appendix Table C-1) were between 87%-124% at low ppb levels for the turbine/incinerator stack matrix and syngas matrix. Low spike recoveries were obtained for chromium (59%), cobalt (73%), and nickel (70%) in the matrix-spiked tail gas sample, one of the more complex gas matrices; however due to the low concentrations present in the gas streams, these potential biases are not considered significant. No digestion step was applied to the HNO_3/H_2O_2 samples analyzed by ICP/MS which should be advantageous in preventing losses from sample handling and volatilization from the pre-digestion step prescribed in EPA Method 29 for ICP-AES and GFAAS analyses.

Highly variable spike recovery results were obtained for mercury by ICP/MS. This is consistent with previous air-toxics assessment projects where attempts to qualify mercury by this technique have met with limited success. For this reason, CVAAS results are reported for mercury in impinger solutions. Mercury spikes were easily recovered by CVAAS from the HNO_3/H_2O_2 solutions (93%-108%). Potassium permanganate impinger solutions spiked with mercury were recovered by CVAAS with less precision (63%, 80%, 74%, and 86%).

The remaining metals not analyzed by ICP/MS were analyzed by ICP-AES. No spike recoveries outside the DQOs were obtained except for barium in the spiked tail gas (55%-64%). Gas impinger samples that contain high levels of sulfur dioxide may potentially yield a low analytical bias for barium.

Samples from each process water matrix, sweet water, sour condensate, and recycled char filtrate, were spiked prior to digestion and analyzed for metals by ICP-AES, GFAAS, and CVAAS. Spike recoveries for all metals met the DQOs in each matrix except for boron (sweet water and recycle char filtrate), lead (sweet water and recycle char filtrate), sodium (recycle char filtrate), and mercury (recycle char filtrate) which exhibited low spike recovery results. The frequency of poor spike recoveries for lead and mercury was greatest in the recycle char filtrate samples, indicating a possible matrix effect.

Analytical spikes (rather than matrix spikes) were performed on the charcoal sorbent digestates since the entire sample was digested for analysis. A blank set of charcoal tubes was spiked before digestion to check retention and recovery through the digestion process. All analytical spikes were recovered within the DQOs except for boron (74%), cobalt (72%), copper (74%), nickel (74%,70%), and zinc (68%, 71%, 73%). Matrix-spiked blank tubes demonstrated recovery for all elements except antimony (10%,14%), molybdenum (42%,46%), and mercury (52%,62%). Results for these elements by charcoal adsorption may be biased low if this is an accurate representation of digestion recovery.

Aqueous and impinger solution audit samples were also prepared for a limited set of target analytes (Al, Sb, Ba, Be, Cd, Cu, Mn, and Mo) as an additional indication of analytical accuracy. By the analytical techniques selected, audit sample recovery was within the specified DQOs for these elements spiked in the HNO_3/H_2O_2 impinger audit sample except manganese (134%). Recovery objectives for the aqueous audit sample were met for all of the selected elements except aluminum (73.2%), antimony (37.8%), and molybdenum (45.3%). Results for these elements in their respective matrices may be biased accordingly.

In summary, significant analytical bias may be indicated by poor matrix spike recovery and audit sample results for the metals in the matrices identified below:

- Chromium and barium in the tail gas appear to be biased low (this result may be present in acid gas samples as well);
- Lead, antimony, and molybdenum concentrations measured in process water streams may be biased low; and
- Incomplete recovery of antimony, molybdenum, and mercury from the charcoal sorbent samples (vapor-phase metals by charcoal) may be indicated by low recovery results for pre-digestion spikes onto blank charcoal.

Anions—Solid Streams and Gas Particulate Samples

Chloride and fluoride were measured in coal, slurry, char, and sulfur matrices prepared by combustion in an oxygen combustion bomb and analyzed by ion chromatography (IC) or specific ion electrode (SIE-sulfur only). Slag samples, since they are not combustible, were leached with a dilute nitric acid solution for chloride analysis and were fused with sodium hydroxide (NaOH) and dissolved for fluoride analysis. Gas particulate samples were leached with a carbonate/ bicarbonate solution for subsequent analysis by IC (Cl^- and $SO_4^=$) and SIE (F^-).

Method blanks prepared for chloride and fluoride by oxygen bomb/IC were free of significant detectable concentrations. However, method blank samples prepared for fluoride by NaOH fusion exhibited detectable concentrations of fluoride that were approximately equal to 10% of the actual slag sample results. No blank corrections were made to the reported slag fluoride results.

A comparison of method blank, reagent blank, and field blank samples analyzed for gas particulate-phase anions indicated varying levels of contamination either associated with the filter and/or filter leaching media or potentially introduced during field sample handling. The chloride results for the turbine stack media and field blanks account for approximately 10-25% of the average chloride concentration reported. Fluoride was detected near the detection limit in all blank samples at approximately the same concentrations found in the turbine and incinerator stack samples. No blank corrections were made, so the reported emissions for chloride and fluoride in gas particulate matter may be overestimated. Sulfate concentrations in the field blank filter samples collected at the incinerator stack and turbine stack indicate varying levels of sample media contamination. Relative to the high concentrations of sulfate detected in the incinerator stack gas particulate samples, these blank results are not significant. However, the sulfate results for the gas particulate emissions from the turbine stack were lower and may therefore be overestimated if the blank concentrations are representative of the sampling media.

Matrix spikes and audit samples were analyzed to measure the accuracy of the preparation and analysis methods. Recovery of filtered gas particulate matrix spikes were 89%-100% for chloride, fluoride, and sulfate. Coal and char samples prepared by oxygen bomb and analyzed by IC were spiked with chloride and fluoride. Recovery of chloride met the DQOs for all coal matrices and char. Fluoride spikes in char were outside the DQOs, however the spiked concentration was extremely low relative to the high sample concentration. Low fluoride spike recovery was also experienced for slag samples prepared by NaOH fusion. A sodium fluoride salt solution is spiked into the NaOH solution used to fuse the slag in a muffle furnace. Poor fluoride spike recovery may indicate incomplete retention of fluoride during the fusion step, or a matrix effect related to slag metals that interfere with the performance of the fluoride specific electrode.

The coal audit SRM (AR 2780) analyzed for chloride and fluoride reported chloride at 83.3%, and fluoride at 23.4% of the reference concentration value. Chloride and fluoride results for a coal round robin sample reported chloride and fluoride at 7.8% and 73.1%, respectively. The characterization of the round robin sample was highly variable, indicating the uncertainty associated with low level chloride and fluoride measurements in coal.

Significant quality control results affecting the analysis of anionic species in the solid sample matrices are summarized for the following sample streams:

- Chloride, fluoride, and sulfate were detected at various concentrations in blank samples of the gas particulate filters; emissions data for particulate-phase anions may be overestimated;

- Fluoride results for slag may be biased low based on poor matrix-spike recovery results; and

- Chloride and fluoride concentrations in coal and slurry are low and prone to analytical uncertainty and imprecision as indicated by spike and audit sample results.

Anions—Aqueous Streams and Impinger Solutions

Anionic species in this section include chloride, fluoride, formate (aqueous stream samples only), nitrate (Gas impinger Method 7d - NO_x), and sulfate. Only fluoride and sulfate were detected in method blanks, reagent blanks, and field blanks. Fluoride was detected between 0.0178 mg/L in the method blanks to 0.0318 mg/L in the H_2SO_4 impinger solutions used to collect HF and HCl from the gas streams. These levels are not significant with respect to the measured sample concentrations. Sulfate detected in the reagent and field blanks collected for the Method 8 sampling train indicate minor sulfate contamination in both field blanks (IPA and H_2O_2 impinger solutions). The blank concentrations were not significant relative to the H_2SO_4 and SO_2 concentrations measured in the turbine and incinerator stack gas samples.

Thiocyanate matrix spikes in one sweet water sample were recovered at 128% and 158% indicating a potentially high analytical bias.

The audit samples for ammonia (prepared in H_2SO_4 impinger solution) and cyanide (prepared in zinc acetate solution) were recovered at 94.5% and 122%, respectively. The aqueous ammonia audit sample was recovered at 87.2 percent. Cyanide audit samples were prepared with both free and complexed forms of cyanide in order to assess the laboratory's ability to differentiate both total and free cyanide as required for the process water samples. Sodium cyanide salts were used as the free cyanide source, and iron ferricyanide was used as the complexed cyanide source. Total cyanide (free + complexed) was recovered at 83.1 percent. Free cyanide alone was recovered at 104 percent. Thiocyanate, also spiked in the audit standard, was 100% recovered.

The analytical techniques for ammonia and cyanide are very sensitive, and based on the spike recovery and audit sample results, fairly accurate. The cyanide analysis methods for total and free cyanide adequately demonstrated the ability to differentiate the multiple forms of cyanide in the process water samples. No outstanding analytical problems were noted except for the possible high bias indicated for thiocyanate in process water stream samples.

Ultimate/Proximate Analysis—Solid Streams

Three reference materials were analyzed to check the methods' accuracy for the ultimate/proximate analysis parameters: carbon, hydrogen, nitrogen, sulfur, ash, volatile matter, fixed carbon, and higher heating value. A standard reference coal (Alpha Resources AR 2780) and a well-characterized "round robin" coal sample (Powder River Basin subbituminous) were submitted as blind audit coal-matrix samples. A well-characterized sample of gasifier slag was also submitted as an audit sample for the slag matrix. Only the SRM audit sample has certified reference values for measuring the accuracy of the ultimate/proximate analyses. These audit samples were selected since their matrix-analyte concentrations were similar to the samples being analyzed.

All ultimate/proximate results for the AR 2780 SRM sample met the data quality objectives (80%-120% recovery of the reference value). The results for the round robin coal sample also met the data quality objectives. Slag audit sample results for ash (99.9%), sulfur (109%), and carbon (80.6%) met the data quality objectives while hydrogen (167%) and nitrogen (not detected) did not. The slag audit sample was 98% ash—hydrogen and nitrogen concentrations were very low and close to the practical quantitation limits of the methods used.

Water Quality Parameters—Aqueous Streams

The water quality parameters determined in the process water streams were pH, conductivity, total suspended solids (TSS), chemical oxygen demand (COD), and total phenolics. Conductivity, pH, and TSS were determined on site and with the exception of pH and conductivity meter calibrations to verify proper operation, no additional quality control checks were performed.

All matrix-spiked aqueous samples indicate accurate analytical results for fluoride and sulfate in all process water streams. Fluoride and sulfate spike recoveries were between 88%-110% in all three process water matrices (sweet water, sour condensate, recycle char/scrubber water). Chloride spikes were recovered within the DQO for sweet water and recycled char water (87%-95%), but were only 20% from the sour condensate. Duplicate results indicate a matrix effect is likely, so the chloride results for the sour condensate may be biased low.

Results of the aqueous audit sample analysis demonstrated good analytical accuracy for chloride (96.2%), fluoride (106.6%), formate (100%), and sulfate (78%). Sulfate recovery from the Method 8 impinger solutions was mixed at 135% in the IPA solution and 84.3% in the H_2O_2 solution. Chloride and fluoride spiked in the H_2SO_4 impinger solution as an audit sample were recovered at 2,030% and 93.4%, respectively. The high sulfate concentration in the impinger solution presented an analytical problem with the IC system specified by the boiler and industrial furnace (BIF) regulations promulgated in 40 CFR Part 266, Appendix IX. The variability in the results is likely a result of the sample dilutions required to overcome analytical difficulties. These dilutions also increased the detection limits for chloride which produced numerous undetected results.

In summary, the analytical uncertainty associated with the anionic components in the following streams may be considered significant:

- Chloride results for the sour condensate may be biased low;
- Chloride matrix spikes and audit sample results indicate analytical imprecision for vapor-phase chloride (HCl) results in the H_2SO_4 impingers; and
- Dilutions of the H_2SO_4 impinger solutions effectively raised the limit of detection for chloride above the concentration in many of the gas stream samples.

Ammonia and Cyanide—Aqueous Streams and Impinger Solutions

Detectable concentrations of ammonia were measured in the aqueous sample method blanks and in all H_2SO_4 impinger solution blanks. Cyanide was also detected in numerous blanks, however in most cases, the detected concentration was below the reported method detection limit. Relative to the sample concentrations of ammonia and cyanide, none of the blank concentrations were significant.

Matrix spiked samples and audit samples submitted for ammonia and cyanide analysis were all recovered within the DQOs except for a single MSD sample for cyanide. Ammonia matrix spikes were recovered from gas impinger solutions between 87% and 106% and from aqueous samples between 99% and 112 percent. Cyanide spikes were recovered from zinc acetate impinger solutions between 91% and 104 percent. Aqueous sample cyanide spikes were recovered between 83% and 102% with one matrix spike of a recycle char filtrate sample reported at 207 percent. The duplicate matrix spike in this sample was recovered at 83 percent.

Matrix spikes were added to sweet water samples for phenolics, and COD. In addition, an aqueous audit sample was prepared with both phenol and potassium acid phthalate (KHP) as a COD/phenol standard.

Total phenolics were recovered from the sweet water MS/MSD pair at 104% in both samples. Total phenolics in the audit standard were recovered at 101 percent. COD measurements of KHP spikes in sweet water demonstrated 76%-85% recovery with COD in the audit sample recovered at 98.9% of the theoretical value. These results are all within the data quality objectives and indicate accurate and precise results for phenol and COD in the process water.

PAHs/SVOCs—Gas Samples

Stack gas samples and internal process gas samples were analyzed by EPA Method 8270. The stack gas samples were also analyzed by CARB Method 429 for added analytical sensitivity. Filtered gas-particulate samples collected at the turbine and incinerator stacks were also analyzed by Method 8270 and CARB 429 to provide particulate- and vapor-phase data separately. Method blanks, media blanks, and field blanks were analyzed to provide a complete characterization of the sampling media and reagents.

As many as six semivolatile organic compounds on the target analyte list were detected in the blank front-half samples (gas-particulate phase) analyzed by Method 8270 for the turbine and incinerator stacks. Only di-n-butylphthalate and bis-(2-ethylhexyl)phthalate were detected in both blanks and samples. Concentrations detected in both field and media blanks were significant with respect to the sample concentrations and may account for all or part of the sample concentration reported.

Blank samples of XAD-2 resin and rinse reagents (back-half samples) analyzed by Method 8270 contained measurable quantities of nine different semivolatile organic compounds on the target analyte list. Benzoic acid, di-n-butylphthalate, and bis-(2-ethylhexyl)phthalate were measured in all blank samples and all stack gas samples. Phthalates are present in both blank and gas sample fractions at comparable levels with the exception of a few individual sample results. The reported concentrations of these phthalate compounds in the vapor-phase samples can be attributed to the background concentrations associated with the sampling media and sample handling procedures.

Blank samples of the particulate- and vapor-phase sample collection media analyzed by high resolution gas chromatography/mass spectrometry (HRGC/MS) indicated measurable quantities of nearly all of the CARB 429 analytes. Many of the compounds were detected at levels comparable to the concentrations detected in the stack samples, so results were reported with the percentage of the value attributed to the blank.

Internal process gas streams were sampled for vapor-phase semivolatile organics only. Four method blanks and two media blanks were analyzed by Method 8270 along with all of the gas samples. Naphthalene was detected in both media blanks and one-half of the method blanks.

This was the only compound detected with any regularity in these samples although single sample results for acetophenone, benzoic acid, and bis-(2-ethylhexyl)phthalate were also measured. Naphthalene concentrations measured in the blank samples were not significant with respect to the natural sample concentrations.

Surrogate spike recoveries indicate analytical accuracy for semivolatile organic compounds. Appendix Table A-4 presents the surrogate spike recoveries for all of the particulate and vapor-phase gas samples analyzed by Method 8270 and CARB 429. The surrogate compounds and the individual recovery objectives are presented in Table 5-6.

Table 5-6
Surrogate Compounds for Method 8270 and CARB 429

Sample Sources	Analytical Method	Surrogate Compounds	Recovery Objective
Emissions Sources	EPA Method 8270	1,4-Dibromobenzene-d4	50-150%
		2-Fluorobiphenyl	30-115%
		Nitrobenzene-d5	23-120%
		Phenol-d5	24-113%
		2,4,6-Tribromophenol	19-122%
		1,3,5-Trichlorobenzene-d3	50-150%
	CARB 429	Fluorene-d10	50-150%
		Terphenyl-d14	50-150%
Internal Process Gas Streams	EPA Method 8270	2-Fluorobiphenyl	30-115%
		2-Fluorophenol	25-121%
		Nitrobenzene-d5	23-120%
		Phenol-d5	24-113%
		Terphenyl-d14	18-137%
		2,4,6-Tribromophenol	19-122%

Nearly all surrogate spikes were recovered within the method-specified recovery objectives indicating acceptable method performance. Instances where surrogate-spike recovery objectives were not met are sporadic and do not indicate any definitive analytical bias. However, some analytical difficulties were encountered with sour syngas and tail gas samples. Dilution of the sample extracts was required to minimize the matrix effects produced by high concentrations of naphthalene (and possibly other semivolatile organic compounds) which overloaded the detector.

Some samples were diluted to the point where many compounds detected in an initial sample injection went undetected in the diluted samples. These dilutions were considered when calculating the reported sample concentrations and detection limits. The handling of this data is discussed later in this section.

The following observations are summarized for SVOCs and PAHs in the gas samples:

- Phthalate-compounds detected in the SVOC stack gas samples can be attributed in part or in total to the presence of these compounds in the blank media, or introduced through sample handling and analysis;

- High resolution GC/MS provides adequate sensitivity to lower detection limits nearly 3-5 orders of magnitude (compared to GC/MS) and consequently, a complete characterization of the blank media is required to provide a statistical means of differentiating background media concentrations and actual sample results;

- Surrogate spike recoveries indicate acceptable method performance for related compounds; and

- High naphthalene concentrations in the sour syngas and tail gas matrices required that samples be diluted for analysis thereby compromising the detection limits for other compounds.

PAHs/SVOCs—Aqueous Streams

Semivolatile organic compounds were measured in sweet water and sour condensate by EPA Method 8270. Two method blanks were prepared to assess the contamination potential of the sample extraction and handling procedures. Naphthalene was the only target compound detected in the method blanks.

Surrogate spikes were added to each water sample to assess analytical accuracy. All surrogates in all samples were recovered within the method-specified recovery objectives with the exception of one phenol-d5 sample spike. No other analytical problems were noted. These results indicate acceptable method performance for the analysis of semivolatile organics in the process water samples.

Aldehydes—Impinger Solutions and Aqueous Streams

The 2,4-dinitrophenylhydrazine (DNPH) impinger solution used to collect aldehydes and ketones is very susceptible to outside sources of contamination. Consequently, numerous laboratory method blanks, media trip blanks, and impinger field blanks were collected for each batch of impinger solutions and samples shipped to the laboratory to assess the potential for sample contamination from various stages of sample handling.

None of the four target aldehyde compounds were found in any of the laboratory blanks for analytical batches of gas impinger solutions or aqueous samples. No field blanks were collected representing aqueous sample collection and handling, however a total of six DNPH media blanks were submitted; at least one for each shipment of impinger samples and each reagent batch. In three of the six DNPH media blank samples, formaldehyde was detected. In one of the six, acetaldehyde was detected, although only slightly above the detection limit. Formaldehyde and acetaldehyde were also detected at comparable levels in the field blank samples. Trip blank samples sent from the laboratory and returned to the laboratory unopened showed no signs of contamination during shipment. Since the trip blank samples were unopened in the field, these results indicate that some formaldehyde and acetaldehyde contamination of the samples may have occurred during sample handling in the field environment. Since the LGTI gasifier is located at a large chemical manufacturing complex, this possibility seems likely.

Sample results for formaldehyde in the following process streams may be affected (biased high): sour syngas (11), sweet syngas (12), incinerator stack gas (16), and to a lesser extent, turbine stack gas (13). Acetaldehyde was also detected in samples from each of these gas streams. This was not a factor in the sour and sweet syngas samples where acetaldehyde concentrations were high; however, it was significant with respect to the incinerator and turbine stack gas samples where blank levels accounted for approximately 50% to over 100% of the amount measured.

Analytical accuracy for DNPH impinger samples was measured by spike recovery from laboratory prepared spikes, trip spikes (to measure effectiveness of the preservative between the laboratory and field location), and field spikes. Formaldehyde and acetaldehyde spikes were recovered from all samples (where spiking was performed) within the method-specified recovery objectives. Acrolein was spiked in one sample and was recovered at 64%, below the 70% recovery objective. For process water samples, the lab spike and aqueous sample matrix spike were recovered within the method-specified recovery objectives for formaldehyde, acetaldehyde, and acrolein. Benzaldehyde was not spiked.

The following can be summarized from the data quality measurements for aldehydes:

- Formaldehyde and acetaldehyde were detected in the blank DNPH impinger solutions collected in the field indicating possible sample contamination from ambient sources which may bias results high (samples were not blank corrected); and

- Spike recoveries for formaldehyde and acetaldehyde indicate acceptable and accurate method performance for both aqueous samples and DNPH impinger samples.

Volatile Organics—Gas Samples (VOST) and Aqueous Streams

Volatile organic compounds were collected from the incinerator and turbine stacks using the volatile organic sampling train (VOST), while aqueous samples were collected in vials with no headspace. Due to the presence of volatile organic compounds in the field and laboratory environment, each VOST sample run included a field blank sample collected at the gas sampling location. Laboratory method blanks, and trip blanks (media blanks) were also analyzed to assess potential contamination sources. Aqueous field blank samples were not collected.

Chloromethane and bromomethane were the only compounds detected in the VOST laboratory method blanks. Analysis of field blank samples indicated the occasional presence of trichlorofluoromethane and carbon disulfide, but a more frequent and significant presence of dichloromethane (methylene chloride) which is commonly used at the stack locations for recovery of the semivolatile organics sampling train. Although efforts were made to complete SVOC sampling before running the VOST, the reported concentrations of methylene chloride in the incinerator and turbine stack samples is likely due to the presence of methylene chloride contamination from field handling.

Similarly, low concentrations of two common field and lab reagents (acetone and methylene chloride) were detected in both laboratory method blanks for aqueous samples. Both of these compounds were measured in the sour condensate and sweet water samples. Again steps were taken to isolate these samples from any direct exposure by maintaining a separate handling area apart from the sampling train recovery and chemical storage areas of the field laboratory. Based on the sample concentrations however, the consistent presence of these two compounds in the sour condensate stream cannot be ruled out as a matter of sample contamination.

To assess desorption efficiency and analytical accuracy VOST sorbents (Tenax resin and charcoal) were spiked with surrogate compounds and thermally desorbed as a single unit. Aqueous samples collected in vials with no headspace were purged entirely making surrogate spiking the best way to assess analytical recovery and accuracy. The volatile organic surrogates for both VOST and aqueous sample analysis were 1,2-dichloroethane-d4, toluene-d8, and 4-bromofluorobenzene. These surrogate spikes were recovered in all VOST and aqueous samples with the exception of some selected VOST samples collected from the incinerator stack. The high levels of SO_2 present in the incinerator stack gas may be responsible for providing a matrix effect, nonetheless, most of the results appear within the method-specified surrogate recovery objectives. Acceptable analytical performance for volatile organic compounds is indicated.

Sample Collection

Although the analytical quality control measures discussed indicate that the methods used for sample analysis were good, they say nothing about the quality of the samples collected. Numerous factors may affect representative sample collection for HAPs, especially with unconventional process systems. In fact, the sampling location itself or the nature of the process stream can present problems too difficult to overcome without costly modifications. This section discusses noteworthy observations made during process sampling that might affect a sample's representativeness.

Table 5-7 summarizes the process streams and test parameters that presented special circumstances potentially affecting representative sample collection. Of these, the moisture content of the syngas upstream of the Selectamine™ sulfur removal system was the most problematic.

Table 5-7
Sampling Issues

Sample Point	Sampling Concern	Potentially Affected Analytes	Action Taken and Possible Affect on Data Quality
Sour Syngas (11)	Excessive condensate present in main sample line, believed to be wall creep from process duct.		Sample lines arranged vertically to avoid collection of condensate in individual sample lines. Assuming gas-liquid equilibrium exists, there should be no significant bias to the samples.
Scrubbed Raw Syngas (5b)	Sample moisture condensing in long sample line before distribution from the sample header.	NH_3, HCN	Condensate knock-out impingers were used to collect the gas condensate for analysis. Impinger train results were corrected based on an aliquot of condensate representative of the theoretical gas moisture content.
Raw Syngas (5a)	Sample moisture building up in the sample line produced sporadic "burps" of condensate into the impinger trains.	NH_3 and others—high variability between sample runs indicates high degree of uncertainty associated with these results.	Condensate flow was inconsistent and not controlled or collected separately. Samples may be biased low since uncollected condensate was not accounted for.
Hot Raw Syngas (5) (High-temp Sampling Probe)	Sample moisture condensing within the sheathed part of the probe.		The sample line downstream of the probe sheath was heated and the gas flow through the main sample line was increased in an effort to maintain the gas temperature above the dew point. This appeared successful since the condensate collected in the impinger trains reflected the theoretical moisture content of the gas.
Slag	Slag fines not effectively retained by sample collection system.	Trace elements, carbon	Slag fines are usually higher in carbon and enriched with trace metals. Slag results may be biased low with respect to these components if the percentage of fines lost through the sample screen is significant.
Selectamine™ Solvent	Samples were collected before and after a regeneration period.	Metals, heat stable salts	Accumulation of salts, metals, and solids throughout the test period could not be determined.

Table 5-7 (Continued)

Sample Point	Sampling Concern	Potentially Affected Analytes	Action Taken and Possible Affect on Data Quality
Sour Gas (22)	Gas composition (primarily NH_3 and CO_2)	Metals, semivolatile organics	The chemistry of the sampling trains and sour gas components results in the precipitation of $(NH_4)_2CO_3$ or NH_4HCO_3 salts which effectively, and rapidly plug up the sampling train. Samples for metals and semivolatile organics could not be collected.
Internal process gas streams	Apparent low collection efficiency of the multi-metals sampling train (Method 29) .	Vapor-phase metals	All results reported for vapor-phase metals were much lower than results obtained by charcoal or direct AAS analysis. The use of Method 29 for quantifying vapor-phase metals in reducing gas matrices is not recommended.
Sweet and Sour Syngas	Selected results for vapor-phase metals collected by charcoal appear biased low when compared to direct AAS analysis.	Vapor-phase metals (arsenic).	Charcoal may be species-selective in its collection of vapor-phase metals from syngas.

Assuming saturation, the water vapor concentration in the hot raw syngas is about 35% by volume. As the syngas sample is extracted from the process duct it rapidly cools and water vapor is condensed in the sample line. Condensed or entrained moisture may also creep along the inside of the duct and find its way into the sample line from surface-mounted taps. The collection of a non-representative volume of water vapor in an impinger train will skew the results high for any water-soluble species of interest, particularly ammonia, hydrogen cyanide, acid gases, and possibly some metals.

Condensation and/or water entrainment upstream of the individual impinger train sampling lines was observed at the sour syngas (11), scrubbed raw syngas (5b), raw syngas (5a), and hot raw syngas (5) sampling points. Although excess condensate was present in the main sample line and could absorb any of the water soluble species of interest, it was assumed that a gas-liquid equilibrium had been established and that any gas collected in the absence of entrained water was representative of the gas stream, plus whatever representative portion of collected condensate could be attributed to each individual gas sample.

Special condensate knock-out and collection impingers were placed upstream of the sampling impingers at the scrubbed raw syngas sampling point at the outlet of the venturi scrubber. The condensate collected here is believed to represent gas moisture condensing in the line since the sample tap was taken directly from the top of the process duct where water could not easily be entrained. The collected condensate was analyzed for ammonia, cyanide, and metals. Ammonia and cyanide concentrations in the condensate were significant so the mass of analyte collected in the sample train impingers was supplemented by the mass of analyte contained in a representative aliquot of condensate. A representative aliquot of condensate was determined as follows:

1) The theoretical, saturated moisture content of the syngas at process conditions as calculated;
2) The gas moisture content, as determined from the sampling train, was calculated;
3) The difference in these two numbers represented the amount of condensate that *would have been collected* in the sampling train under ideal conditions; and
4) Assuming that any species that were found in the condensate were in equilibrium with the gas phase, the quantity of analyte represented by the condensate volume determined in Step 3 was added to the sample.

For instance, assume the theoretical moisture in Step 1 was 35 percent, and the measured moisture in Step 2 was 10 percent. What volume of moisture is represented by the 15% difference in these two numbers? Let's assume the volume is 15 mL of condensate. Then assume the analysis of the condensate was 45 µg/mL NH_3 (45 µg/mL * 15 mL = 675 µg NH_3). This 675 µg NH_3 would then be added to the total number of µg of NH_3 determined in the sample and the gas-phase concentration of ammonia was reported as the *[total measured + condensate amount]/ sample gas volume.*

Ideally, short heated sample lines would prevent condensation of water vapor, but this was not physically possible at all sampling locations. In future sampling efforts, extra attention should be given to hot gas locations. If physical limitations will bias representative sample collection, then the sampling scope should be adjusted accordingly or the resulting data evaluated with respect to the potential sample collection induced bias.

Concerns over the collection of slag samples, Selectamine™ solvent samples, and sour gas samples is explained in Table 5-7. Additional gas sampling issues include an assessment of collection efficiency for vapor-phase metals by charcoal and Method 29 in comparison to the total characterization provided by direct AAS analysis of the gas. This is discussed in more detail in Sections 7 and 8.

Data Handling Conventions

Over 25,000 individual pieces of sampling and analytical data were processed to determine the process stream sample concentrations. The concentration results for each sample are presented in Appendix Tables G-1 and G-2. The individual sample results in Table G-1 were averaged to provide the stream concentration results summarized in Section 4. This section describes the protocols used for handling data, including "not detected" results, to determine average (mean) concentration results and confidence intervals. Example calculations for determining standard deviations and confidence intervals can be found in Appendix D.

Several conventions have been developed for treating the test data and developing average concentrations of substances in the various streams. In general, there are three cases that affect the calculation of average concentrations:

- When all values for a given variable were above the detection limit, the mean concentration was calculated as the true arithmetic mean.

- For results that included values both above and below the detection limit, one-half the detection limit was used to calculate the mean. For example:

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

  By convention, the calculated mean is not allowed to be smaller than the largest detection limit value. In the following example, using one-half the detection limit would yield a calculated mean of 2.8. This is less than the highest detection limit obtained; therefore, the reported mean is <4.

Analytical Values	Calculation	Mean Value
5, <4, <3	[5+(4/2)+(3/2)]/3 = 2.8	<4

- When all analytical results for a given variable are below the detection limit, the mean is reported as "< X," where the X is the largest detection limit. The bias estimate (used where calculating confidence intervals for other parameters) is one-half of the detection level, and no confidence interval is reported.

The same convention using one-half the detection limit was also used to determine the standard deviation and 95% confidence intervals, where appropriate. All calculations were performed with unrounded numbers and the results were rounded to two or three significant figures for presentation in the tables; therefore, slight differences in calculated means and confidence intervals are attributable to round-off errors.

In a few isolated cases, samples were diluted prior to analysis in order to avoid overloading the analytical detection system. The increase in the detection limit resulting from these dilutions was taken into consideration when reporting the average results where the DL is higher than the concentrations detected at lower levels in other samples from the same test period. The analytical results for semivolatile organic compounds in sour syngas and tail gas, and chloride in turbine stack gas fit this category. The high detection limits reported for one of the three runs were not used in the calculation of the average unless the analyte was detected in the diluted sample. The omitted results are identified in Appendix Table G-1.

In addition to reporting average concentrations, total gas emissions were measured independently in two phases, vapor and particulate. To determine the total concentration for gas streams within a run, both the solid- and vapor-phase contributions were considered; however, the absence of some detectable concentrations in either (or both) phase(s) required that conventions be developed for dealing with these data. These conventions are summarized below for the following three cases:

Case 1: The concentrations in both the solid and vapor phases are above detection limits.

Case 2: The concentrations in both the solid and vapor phases are below detection limits.

Case 3: The concentration in one phase is above the detection limit, and the concentration in the other phase is below the detection limit.

For inorganic constituents of interest other than HF, HCl, NH_3, HCN, and mercury, the flue gas stream data from previous studies of coal-fired power plants have shown that most of the material is present in the solid phase, and that only a small fraction is generally found in the vapor phase. The opposite is generally true for organic species. Thus, the following conventions were selected for defining the total gas stream concentrations:

- For Case 1, the total concentration is the sum of the concentrations in the vapor and solid phases.

For example, the average total chromium concentration in the turbine stack gas is calculated as follows:

Chromium in the particulate phase = 1.02 $\mu g/Nm^3$

Chromium in the vapor phase = 0.474 $\mu g/Nm^3$

Total chromium in the turbine stack gas = 1.49 $\mu g/Nm^3$

- For Case 2, the average total concentration is considered to be the detection limit in the solid phase.

For example, the total beryllium concentration in the incinerator stack gas is calculated as follows:

Beryllium in the solid phase = < 0.012 $\mu g/Nm^3$

Beryllium in the vapor phase = < 0.051 $\mu g/Nm^3$

Total beryllium in the ESP inlet gas = $< 0.012\ \mu g/Nm^3$

An example for HCl in incinerator stack gas illustrates the exception that is applied to species predominantly associated with the vapor phase:

Chloride in the solid phase = $< 150\ \mu g/Nm^3$

Chloride in the vapor phase = $< 2{,}100\ \mu g/Nm^3$

Total chloride in the incinerator stack gas = $< 2{,}100\ \mu g/Nm^3$

- For Case 3, multiple conventions have been established, depending on the group of substances being considered.

For metals train results, if the substance is not detected in the solid phase and detected in the vapor phase at levels below the detection limit of the solid phase, the total concentration is reported as the detection limit of the solid phase and the total is flagged to note that the substance was detected at lower levels in the vapor phase. For the turbine and incinerator stack multi-metals trains, this scenario did not occur.

For metals train results, if the substance is not detected in the vapor phase and detected in the solid phase, the vapor-phase component is considered to be equal to zero.

For example, the total magnesium concentration in the turbine stack gas is calculated as follows:

Magnesium in the solid phase = $9.97\ \mu g/Nm^3$

Magnesium in the vapor phase = $< 13\ \mu g/Nm^3$

Total magnesium in the turbine stack gas = $9.97\ \mu g/Nm^3$

For semivolatile organic compounds and PAHs, the opposite is assumed. If the substance is not detected in the solid phase and detected in the vapor phase, the reported total is the concentration in the vapor phase.

For example, the average total 2-chloronaphthalene concentration in the incinerator stack gas is calculated as follows:

2-chloronaphthalene in the solid phase = $< 0.077\ ng/Nm^3$

2-chloronaphthalene in the vapor phase = $0.0976\ ng/Nm^3$

Total 2-chloronaphthalene in the incinerator stack gas = $0.0976\ ng/Nm^3$

Material Balances

The results of material balance closures are presented in the following sections. Example calculations are presented in Appendix E.

Process flow rates used to develop mass balances are summarized in Table 5-8. Mass balances were performed around the Selectamine™ and Selectox™ systems, the sour water stripper, incinerator, gas turbine, and the total plant. In addition, balances were performed around the combined Selectamine™ and gas turbine systems. Figure 5-1 depicts the mass balance boundaries for each of the individual systems. Steady-state process operation was assumed for all process systems, except the Selectamine™ unit. Due to the solvent holdup volume, significant accumulations of a substance could occur in the Selectamine™ process unit. Over a long period of steady operation, the accumulation in the Selectamine™ system could be measurable. However, the Selectamine™ was regenerated during the test period which made it impossible to quantify accumulation.

A general mass balance equation which applies to any system is:

$$\begin{bmatrix}\text{Accumulation of}\\ \text{Mass in System}\end{bmatrix} = \begin{bmatrix}\text{Mass into}\\ \text{System}\end{bmatrix} - \begin{bmatrix}\text{Mass out}\\ \text{of System}\end{bmatrix} + \begin{bmatrix}\text{Mass Generated}\\ \text{in System}\end{bmatrix} \qquad \text{(eq. 5-1)}$$

The following general equation was used to calculate mass balance closures.

$$\text{Mass Balance Closure (\%)} = 100 * \left[\frac{\text{Total Mass Out}}{(\text{Mass In} - \text{Mass Accumulated})}\right] \qquad \text{(eq. 5-2)}$$

For all systems other than the Selectamine™ unit, the accumulation term should be negligible and was assumed to be zero. Development of specific mass balance equations is presented in Appendix E.

The mass balance closure for each element met the project objective if it was between 70 and 130 percent. Poor closures and high uncertainties have their root cause in sampling, analytical, or process problems. Since an analysis of the process showed that operations were steady and representative of normal operation, problems with mass balance closures for some substances may reflect problems with analytical or sampling techniques. For all the internal process streams, sampling methodologies for trace metals are most likely the reasons for poor closure. As stated before, validated methods for trace element characterization of a syngas matrix have not been developed.

Table 5-8
Process Flow Rates During LGTI Testing

	Period 1 (11/4-11/7)	Period 2 (11/8-11/11)	Period 3 (11/11-11/13)	Total (11/4-11/13)	Std. Dev.
Coal Feed Rate (t/d, dry)					
Slag Production (t/d, dry)					
Primary Slurry Rate (gpm)					
Primary Slurry (% solids)					
Second Stage Slurry Rate (gpm)					
Second Stage Slurry (% solids)					
Sour Syngas Flow (lb/hr, wet)					
Sour Syngas Flow (lb/hr, dry)					
Demineralized Water to Venturi Scrubber (gpm)					
Sweet Syngas Flow (lb/hr, dry)					
Acid Gas Flow (lb/hr, dry)					
Tail Gas Flow Rate (lb/hr, dry)					
Vent Gas Flow to Incinerator (lb/hr)					
Methane Fuel Rate to Incinerator (lb/hr)					
Sweet Water to Ditch (gpm)					
Steam Drum blowdown to SWS (lb/hr)					
D-251 Blowdown to SWS (lb/hr)					
C-180 Blowdown to SWS (gpm)					
Sour Water to Stripper (gpm)					
C-180 Blowdown to SWS (lb/hr)					
Incinerator					
Incinerator Stack Gas Flow Rate (Nm^3/hr)	NA	19,400	NA	19,400	620
Particulate Concentration (mg/Nm^3)	NA	141	NA	141	10
Particulate Emission Rate (lb/hr)	NA	6.03	NA	6.03	0.38

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Table 5-8 (Continued)

	Period 1 (11/4-11/7)	**Period 2 (11/8-11/11)**	**Period 3 (11/11-11/13)**	**Total (11/4-11/13)**	**Std. Dev.**
Power II					
Syngas to GT-400 (lb/hr)					
Fuel Gas (Methane) to GT-400 (lb/hr)					
GT-400 Fuel (%Syngas)					
Syngas to GT-300 (lb/hr)					
GT-400 Stack Gas Rate (Nm^3/hr)				1.1x10^6	
Particulate Concentration (mg/Nm^3)	3.86	NA	NA	3.86	1.41
GT-400 Particulate Emission Rate (lb/hr)	9.3	NA	NA	9.3	3.3

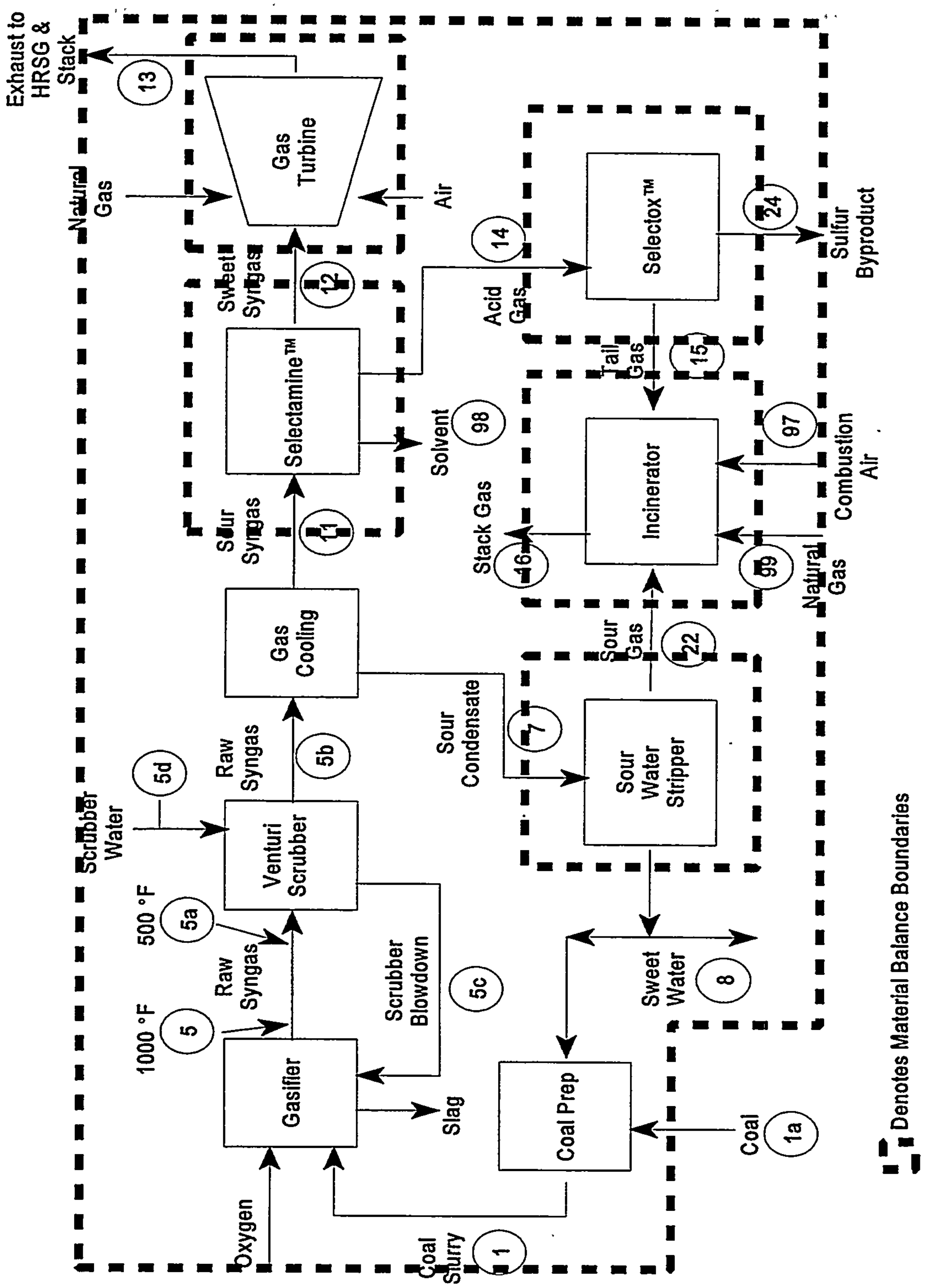

Figure 5-1
LGTI Block Flow Diagram with Material Balance Boundaries

Concerns with mass balance closures fall into three categories:

- Mass balance closure is outside target range of 70-130 percent.
- High uncertainty—uncertainty in closure exceeds ±50 percent.
- Clear bias—closure ± uncertainty does not encompass 100% closure.

For the overall plant closure, 76% of the mass balances performed fell within the target range. This compares to 59% for the total plant results from Radian's Phase I DOE project conducted at Plant Yates[1]. This overall high degree of closure is excellent, given the complexity of an IGCC process, when compared to that of a conventional coal-fired power plant. Also, the gas phase methods (EPA Method 29) used for the gaseous effluent streams (turbine and incinerator stacks) were developed specifically for these types of process streams, and historically produce very reliable data.

The percentage of mass balance closures that are within the target range for the individual subsystems were much lower. There are several factors that contribute to the lower percentages of elements that met the mass closure targets for the internal process streams. The sampling method issue was discussed previously. Two other factors contributing to poor mass balance closures were the inability to sample the sour water stripper off gas due to the high ammonium carbonate content of the stream, and to quantitate any accumulation of substances in the Selectamine™ system. The original intent was to analyze the Selectamine™ solvent at the beginning and again at the end of the test period. However, the Selectamine™ solvent system was treated or "regenerated" during the test period, and it was impossible to quantify the effects of this treatment on the accumulation of trace metals in the Selectamine™ system.

Additional factors that may cause inaccuracies in closing material balances around several of the units were the relatively low levels of most of the inorganic substances in the vapor phase of the gas streams flowing to and from the subsystems. Many of the measured vapor-phase compositions approach the analytical detection limits, and even when concentrations are above the detection limits, only small quantities of substances are being measured. Material balances were also hampered by the lack of particulate loading and composition data for most streams. Particulate loadings and compositions could only be measured in the incinerator and gas turbine stacks. Particulate loading was measured in the sweet syngas stream, but the loading was quite low and the amount of particulate collected was insufficient to characterize.

Table 5-9 presents material balance closures for the various sub-systems and target species. Again, none of these methods have been validated in the reducing atmospheres that exist in most of the internal process streams in gasification systems.

In developing the results summarized in Table 5-9, balances were not generally calculated (NC) if a substance was not detected in one of the major streams around the system. However, if the

Table 5-9
Material Balance Closures

Substance	Selectamine™ System		Selectox™ System		Sour Water Stripper		Incinerator		Gas Turbine		Combined Selectamine™ System and Gas Turbine		Overall Balance	
	Closure %	95% CI	Closure %	95% CI	Closure %	95% CI	Closure %	95% CI	Closure %	95% CI	Closure, %	95% CI	Closure %	95% CI
Ionic Species														
Chloride	NC	NC	NA	NC	230	214	NA	NC	280	NC	NA	NC	57	15
Fluoride	146	46	NA	NC	87	28	NA	NC	1,600	NC	NA	NC	22	6
Reduced Sulfur Species														
H_2S	73	NC	NA	NC	NA	NC	NA	NC	NA	NC	NA	NC	NA	NC
COS	108	NC	NA	NC	NA	NC	NA	NC	NA	NC	NA	NC	NA	NC
CS_2	NC	NC	NA	NC	NA	NC	NA	NC	NA	NC	NA	NC	NA	NC
Metals (Vapor-Phase AAS)														
Arsenic	NC	NC	NA	NC	NA	NC	NA	NC	NC	NC	NC	NC	NA	NC
Cadmium	NC	NC	NA	NC	NA	NC	NA	NC	160	NC	NC	NC	NA	NC
Chromium	NC	NC	NA	NC	NA	NC	NA	NC	NC	NC	16	NC	NA	NC
Lead	NC	NC	NA	NC	NA	NC	NA	NC	NC	NC	NC	NC	NA	NC
Mercury	63	NC	NA	NC	NA	NC	NA	NC	175	NC	107	NC	NA	NC
Nickel	4	NC	NA	NC	NA	NC	NA	NC	107	NC	5	NC	NA	NC
Selenium	34	NC	NA	NC	NA	NC	NA	NC	8	NC	3	NC	NA	NC
Zinc	NC	NC	NA	NC	NA	NC	NA	NC	NC	NC	NC	NC	NA	NC

Table 5-9 (Continued)

Substance	Selectamine™ System		Selectox™ System		Sour Water Stripper		Incinerator		Gas Turbine		Combined Selectamine™ System and Gas Turbine		Overall Balance	
	Closure %	95% CI	Closure %	95% CI	Closure %	95% CI	Closure %	95% CI	Closure %	95% CI	Closure, %	95% CI	Closure %	95% CI
Metals														
Aluminum	NC	NC	NC	NC	57	23	NC	NC	NC	NC	NC	NC	107	9
Antimony	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Arsenic	2	1	NC	NC	58	81	NC	NC	190	310	NC	NC	50	6
Barium	12	3	NC	NC	73	13	960	1,200	800	6,000	280	170	119	27
Beryllium	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	95	12
Boron	11	2	NC	NC	120	1,600	120	130	NC	NC	NC	NC	82	6
Cadmium	NC	NC	NC	NC	76	99	400	540	NC	NC	NC	NC	74	67
Calcium	NC	NC	NC	NC	47	8	140	160	NC	NC	NC	NC	111	8
Chromium	13	3	51	350	NC	NC	48	73	380	210	24	6	120	39
Cobalt	NC	NC	NC	NC	NC	NC	21	29	NC	NC	NC	NC	101	10
Copper	9	2	NC	NC	81	110	240	260	4,400	11,000	170	400	99	9
Iron	11	3	5	18	73	42	2,100	2,500	900	3,400	39	120	113	8
Lead	NC	NC	NC	NC	92	120	96	110	NC	NC	NC	NC	55	5
Magnesium	NC	NC	NC	NC	52	6	NC	NC	3,800	15,000	NC	NC	109	8
Manganese	9	10	NC	NC	78	93	4,500	8,700	NC	NC	150	630	99	9
Mercury	2	2	330	770	NC	NC	900	1,200	5,000	2,000	58	73	25	7
Molybdenum	10	3	NC	NC	NC	NC	3,000	3,900	2,300	3,200	84	110	132	19
Nickel	12	9	NC	NC	NC	NC	57	56	2,000	2,900	120	160	188	53
Phosphorus	NC	NC	NC	NC	40	10	NC	NC	NC	NC	NC	NC	103	16
Potassium	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	98	13
Selenium	NC	NC	NC	NC	68	99	NC	NC	8,100	8,500	NC	NC	34	16
Silicon	NC	NC	NC	NC	92	7	120	150	NC	NC	NC	NC	108	10
Sodium	NC	NC	NC	NC	150	7	280	340	NC	NC	NC	NC	117	8
Titanium	NC	NC	NC	NC	54	46	NC	NC	NC	NC	NC	NC	85	14
Vanadium	8	4	400	410	NC	NC	1,100	1,200	1,600	2,000	56	26	103	6
Zinc	NC	NC	NC	NC	78	94	180	190	22,000	9,100	NC	NC	102	8

effect of a particular "not detected" value was negligible in calculating the balances, the balances are shown.

Overall Plant Material Balances

Validated sampling methods only apply to the balances around the entire plant. The inlet streams are the coal, makeup water to the scrubber, natural gas, oxygen, and ambient combustion air. Outlet streams include the slag, sweet water (from the sour water stripper) leaving the plant, sulfur byproduct, incinerator exhaust, and turbine exhaust. The levels of the metals and other inorganic substances in the makeup water, oxygen, and combustion air were assumed to be negligibly small (they were not sampled), and these streams were not included in the overall balances.

There are six elements that did not meet the closure criteria of 70-130 percent:

≤ 70% Closure	≥ 130% Closure
Arsenic	Molybdenum
Mercury	Nickel
Lead	
Selenium	

The particular substances for which balance closures were below 70% were not unexpected. Measurements using the vapor-phase AAS suggest that some of the more volatile substances such as arsenic, mercury, and selenium may be partially removed in the Selectamine™ system.

One would also expect that lead and possibly nickel may form insoluble sulfides and be removed in the Selectamine™ system also. However, lead was generally not detected in either the sour or sweet syngas, so possible lead removal in the Selectamine™ unit can be neither confirmed nor refuted.

Selectamine™ System

The inlet stream to this unit is the sour syngas stream, and the outlet streams are the sweet syngas and the acid gas streams. Carbon adsorption and Method 29 techniques were used to sample all three streams, so complete mass balance closures could be determined independently from the results of each of the sampling methods.

The balances achieved with carbon adsorption appear to be biased low by about an order of magnitude. This large bias could be caused be one or more factors. The most obvious possible causes of such biased balances are 1) accumulation of the vapor-phase metals in the Selectamine™ solvent, 2) measured concentrations that are biased high in the sour syngas and/or biased low in the acid gas or sweet gas streams , and 3) inaccurate stream flow rates. The latter potential cause of bias seems very unlikely given the maturity of the plant and the consistency of the flow rates from day to day. In addition, the balances for fluoride and the reduced sulfur species appear to be quite reasonable, indicating accurate flow rates.

If the acid gas compositions were biased low, then the Selectox™ balances would tend to be biased high, since the acid gas is the inlet stream to the Selectox™ unit. Although only a few component balances could be determined about the Selectox™ unit, the results indicate the possibility of balances being biased somewhat high, but not of the magnitude found in the Selectamine™ balances. This indicates that the acid gas composition is probably not biased high to a great degree.

If the sweet syngas compositions were biased low, the gas turbine balances would be biased high, since the sweet syngas is an inlet stream to the turbine system. This is the case, as seen in Table 5-9, the closures around the turbine are high by one to two orders of magnitude. To further explore this issue, a balance was made around the combined Selectamine™ -gas turbine system. The inlet streams for this system are sour syngas and natural gas, while the outlets are the acid gas and turbine stack streams. The sweet syngas is not included in this balance. The results of those balances are also provided in Table 5-9. The balance closures are quite reasonable for most of the metals. Thus, it appears that the sweet syngas vapor-phase compositions measured with charcoal are all consistently low by substantial amounts.

One major difference between the sweet syngas composition and most of the other internal gas streams is the sulfide content. The reduced sulfur species are present at significant levels in the acid gas and sour syngas streams, while the concentrations in the sweet syngas are much lower. It is known that sulfided charcoal adsorbs mercury more effectively than untreated charcoal. Thus the presence of sulfides in the gas stream may enhance the effectiveness of adsorption of vapor-phase metals, while the absence of these sulfides may result in low adsorption efficiencies.

[Note: The balance closures for vapor-phase metals as determined from Method 29 measurements appear to be more reasonable than those found with the charcoal method. However, these results may be only fortuitous and not truly accurate (i.e., the measured concentrations in the sour and sweet syngas and in the acid gas may all be consistently low). This possibility is reinforced by the high closures found around the Selectox™ unit and gas turbine when using the Method 29 concentrations for the syngas and acid gas streams. Even the combined Selectamine™-turbine system closures are very high as determined by Method 29 results, indicating the probability of a significantly low bias in the sour syngas concentrations.]

Balances for mercury, zinc, and selenium were also calculated using the on-line AAS analyses. However, only the sweet and sour syngas streams were analyzed by this method, so the charcoal method results were used for the acid gas composition in performing the material balances. The closures around the Selectamine™ system for mercury and selenium using the AAS results were significantly better than those using only the charcoal results, although still appearing to be biased low. However, the closure for nickel was very low due to the high nickel concentration found by AAS in the sour syngas relative to the sweet syngas and gas turbine exhaust. The balances around the combined Selectamine™-turbine system were low for chromium, nickel, and selenium, but the mercury balance closure was 107 percent. The low closures would indicate that the measured concentrations of these metals in the sour syngas were high, that the levels in the acid gas and/or turbine exhaust were low, and/or that there was some accumulation of these substances in the Selectamine™ system.

Selectox™ System

The inlet stream to the Selectox™ system is the acid gas, and the outlet streams are the tail gas and the sulfur byproduct. Material balances around the Selectox™ system could only be performed for a few of the metals. Most of the metals were present in the sulfur byproduct at levels that were below the detection limits. However, at these detection limits, the amounts of many of the metals that might be present in the sulfur were very significant relative to the amounts in both the acid gas and tail gas streams. Thus, reliable balances could not be performed for most metals.

Balances were calculated using a combination of charcoal method (for the acid gas stream) and Method 29 results (for the tail gas stream). The Method 29 should be applicable to the tail gas, since the gas consists almost exclusively of CO_2. Balance calculations produced mixed results. The combined charcoal-Method 29 could only be used to calculate balances for four metals (chromium, iron, mercury, and vanadium). The closures ranged from 5% for iron to 397% for vanadium. There did not appear to be a consistent bias in the closures.

Sour Water Stripper

Incoming streams to the sour water stripper include sour condensate, steam drum blowdown, D-251 blowdown, and C-180 water purge. Outlet streams are sour gas and sweet water. The sour condensate rate is not measured, so the rate was estimated by subtracting the measured rates of the several clean water blowdown streams from the sweet water rate.

The sour gas rate and vapor-phase metals content of the sour gas could not be measured because of the sampling problems mentioned earlier. As a result, the balance was made on the assumption that the incoming stream was the sour condensate (estimated by difference) and the outgoing stream was the sweet water. The sour gas was not included in the balance. The balance results are varied, with closures for 9 of 17 metals falling within the target range of 70-130 percent. However, it appears that the closures may be biased a little low, with only two of the 17 closures being above 100 percent. The average closure is 75 percent. The low bias may indicate that the estimated rate for the sour condensate is somewhat low.

Incinerator Exhaust

There are five gas streams that feed into the incinerator. These streams are the tail gas from the Selectox™ process, the sour gas from the sour water stripper, vent gas stream, combustion air, and natural gas. The metals content was not determined for the vent stream and for the sour gas stream. For material balance purposes, the input streams were effectively the tail gas and natural gas. The outlet stream was the incinerator exhaust.

The material balance closures varied widely, ranging from 21% (cobalt) to 4500% (manganese). Most of the closures were high; only 4 of the 17 substance closures were below 100 percent. Four metals (iron, manganese, molybdenum, and vanadium) had closures that were above 1000 percent. The measurement of substance levels in the stack gas should be the most accurate of the three gas streams, since standard sampling methods are used and both vapor and particulate phases are measured in this stream. On the other hand, there are reasons to suspect the measured levels of some substances in the tail gas. One potential source of inaccuracy in the tail gas might stem from the possible presence of particulate in the tail gas. Particulate was not measured in the tail gas, but may have been present from the acid gas entering the Selectox™ or from the catalyst in the Selectox™ unit. It is interesting to note that the closures for iron, molybdenum, and vanadium were also among the highest around the gas turbine (molybdenum closures were not calculated around the turbine).

Gas Turbine Exhaust

Four gas streams are associated with this system. The inlet streams are the sweet syngas, combustion air, and natural gas streams, while the turbine exhaust is the only outlet stream. As with incinerator exhaust sampling, established methods were used to sample the turbine stack, so the stack testing results are expected to provide the most accurate and reliable concentrations of the three streams included in this balance.

The material balance closures for the metals are included in Table 5-9. Two sets of closures were determined using the results of two sampling methods (i.e., charcoal and on-line AAS) to measure the vapor-phase metals content in the sweet syngas. The material balance closures are high for all cases, but particularly when using the sweet syngas concentrations determined with either the charcoal or Method 29 techniques. As addressed previously in the discussion of material balances around the Selectamine™ system, the concentrations of the vapor- phase metals in the sweet syngas are thought to be significantly low. Inaccurately low concentrations in the sweet syngas would produce the high closures found in the material balances around the gas turbine.

In addition to the possible sources of inaccuracies described in the discussion of Selectamine™ material balances, another source of error could be present. The particulate-, as well as the vapor-phase metals, was collected during the sampling of the sweet syngas stream. The particulate loading was found to be quite low, but measurable. However, the amount of particulate collected was too small to analyze for the metals content. Thus, the total metals concentrations reported for the sweet syngas are low because the particulate contributions are not included. However, the stack gas composition does include the particulate matter concentrations. Thus, the closures around the turbine are inherently high. However, with the available data, it is not possible to assess the magnitude of the impact of any particulate in the sweet syngas to the material balance closures.

References

1. *A Study of Toxic Emissions from a Coal-Fired Power Plant Utilizing an ESP While Demonstrating the ICCT CT-121 FGD Project.* Prepared for U.S. Department of Energy, Contract No. DE-AC22-93PC93253, Radian Corporation, Austin, TX (June 1994).

6

DISCUSSION OF RESULTS

The major results of the testing at LGTI are summarized and briefly discussed in this section. The objectives of the LGTI testing included 1) the development of emission estimates and emission factors, and 2) the estimation of substance removals across some of the process units within the plant. Emission factors and substance removals are presented in this section of the report. Additionally, the fates and distributions of some selected inorganic and organic substances in the process are discussed.

Sampling of the hot synthesis gas was conducted in the spring of 1995. Although some results of this testing have already been described in other sections of this document, the hot gas and solids compositions are summarized and discussed in this section.

Fates and Distributions of Metals

The distribution of metals, chloride, fluoride, and sulfur are summarized in Tables 6-1, 6-2, and 6-3. These inorganic substances cannot be destroyed in the LGTI process, so they must exit the plant in one of the emission or discharge streams. In developing these distributions, it was assumed that there was no accumulation of these substances within the plant. As discussed in Section 5, there may indeed be some accumulation of some of the metals in the Selectamine™ system may occur; however, this could not be definitively determined.

The material balance envelope was drawn around the total plant, as shown in Figure 5-1. The slurry preparation, char dewatering, and slurry charge system were encompassed by the boundaries of the envelope, so the streams associated with these systems were not included as inlet or outlet streams in the balances or as destinations for substances of interest. In addition to the incoming coal and natural gas streams, there are other streams that come in to the plant which were not considered in the mass balances or definition of fates. These streams include the oxygen fed to the gasifier, the demineralized water sent to the scrubber, and the ambient combustion air used in both the incinerator and gas turbine. None of these streams are thought to contain significant amounts of the substances of interest. The outlet streams consist of the gasifier slag, sulfur byproduct, sweet water (from the sour water stripper), incinerator exhaust gas, and the turbine exhaust gas. Flow rates of the process streams were steady throughout the testing, and there was no evidence of significant bias in any of the reported flow rates.

Many of the metals were not detected in several of the various feed and discharge streams. In these cases, the analytical detection limits were used as an estimate of the substance

Table 6-1
Elemental Flows Around LGTI Process

Analyte	Overall Flows and Closure[a]							
	Coal Feed Flow, lb/hr	NG Flow, lb/hr	Slag Flow, lb/hr	Sulfur Flow, lb/hr	Sweet Water Flow, lb/hr	Incin Flow, lb/hr	GT Flow, lb/hr	Material Balance Closures, Out/In, %
Chloride	5.3		0.83		0.075	0.09	2	57
Fluoride	10		2.0		0.16	0.0012	0.1	22
Sulfur	380		3.0	240		38	170	119
Aluminum	850	2.1e-05	900	3.8e-03	4.2e-02	3.0e-03	2.0e-01	107
Antimony	0.02	3.1e-08	0.011	7.2e-04	6.5e-03	9.0e-05	1.1e-02	213
Arsenic	0.13	1.2e-07	0.059	7.2e-04	3.2e-04	2.9e-05	5.6e-03	50
Barium	49	6.8e-08	59	4.8e-04	4.5e-02	7.8e-05	9.5e-03	119
Beryllium	0.04	5.0e-08	0.034	4.8e-04	5.0e-05	2.7e-06	2.0e-04	95
Boron	4.3	7.1e-06	3.5	2.4e-03	3.3e-03	5.8e-04	2.4e-02	82
Cadmium	0.01	6.3e-07	0.002	4.8e-04	4.2e-04	8.3e-05	7.7e-03	74
Calcium	1,400	7.4e-05	1,600	4.7e-03	2.2e-01	3.6e-03	5.6e-01	111
Chromium	0.64	2.6e-06	0.76	9.6e-04	7.4e-04	1.6e-04	7.1e-03	120
Cobalt	0.26	9.4e-07	0.26	9.6e-04	3.5e-04	1.6e-05	1.5e-03	101
Copper	1.6	8.1e-08	1.5	4.8e-04	1.2e-03	1.1e-04	4.0e-02	99
Iron	330	1.0e-05	370	2.2e-03	1.0e-01	8.6e-03	3.9e-01	113
Lead	0.18	6.2e-06	0.03	7.2e-04	2.8e-02	9.3e-05	7.6e-03	55
Magnesium	300	1.9e-05	330	9.6e-04	8.5e-02	1.0e-03	7.9e-02	109
Manganese	1.3	8.3e-08	1.3	4.8e-04	2.0e-04	4.1e-04	8.0e-03	99
Mercury	0.01	6.0e-07	2.0e-04	2.3e-05		1.2e-03	3.4e-03	25
Molybdenum	0.07	2.4e-07	0.075	4.8e-03	9.7e-04	2.2e-04	1.8e-02	132
Nickel	0.21	1.3e-06	0.38	9.6e-04	1.8e-03	2.2e-04	1.0e-02	188
Phosphorus	40	4.5e-05	41	0.0e+00	2.1e-02	7.3e-03	7.0e-01	103
Potassium	28	3.3e-04	27	4.8e-03	7.7e-02	1.3e-02	9.4e-01	98
Selenium	0.45	2.4e-07	0.13	5.8e-03	2.7e-03	9.8e-06	8.0e-03	56
Silicon	1,500	4.1e-05	1,600	4.8e-03	6.1e-01	2.4e-03	1.9e-01	108
Sodium	140	4.8e-05	160	4.8e-03	3.2e-01	9.0e-03	1.0e+00	117
Titanium	78	5.7e-07	80	4.8e-04	1.7e-03	6.2e-05	1.6e-02	103
Vanadium	1.7	5.6e-08	1.7	4.8e-04	3.8e-04	5.5e-05	2.3e-03	102
Zinc	1.1	1.4e-05	0.47	3.5e-03	2.1e-02	1.1e-03	1.3e-01	60

[a] Shaded entries indicate that the substance was not detected at that location. Detection levels were used in computing flows and closures.

Table 6-2
Material Distributions as a Function of Material Input

Analyte	Material Flows. % of Input[a]						
	Coal Feed Flow, %	NG Flow, %	Slag Flow, %	Sulfur Flow, %	Sweet Water Flow, %	Incin. Flow, %	GT Flow, %
Chloride	100	0	16	0	1.4	1.7	38
Fluoride	100	0	23	0	1.5	<0.1	1
Sulfur	100	0	0.79	63	<0.1	10	46
Aluminum	100	<0.1	110	<0.1	<0.1	<0.1	<0.1
Antimony	100	<0.1	65	4.4	40	0.55	65
Arsenic	100	<0.1	45	0.55	0.24	<0.1	4.3
Barium	100	<0.1	120	<0.1	<0.1	<0.1	<0.1
Beryllium	100	<0.1	93	1.3	0.13	<0.1	0.68
Boron	100	<0.1	81	<0.1	<0.1	<0.1	0.55
Cadmium	100	<0.1	15	3.5	3.1	0.61	56
Calcium	100	<0.1	110	<0.1	<0.1	<0.1	<0.1
Chromium	100	<0.1	120	0.15	0.12	<0.1	1.1
Cobalt	100	<0.1	100	0.37	0.14	<0.1	0.6
Copper	100	<0.1	97	<0.1	<0.1	<0.1	2.5
Iron	100	<0.1	110	<0.1	<0.1	<0.1	0.12
Lead	100	<0.1	16	0.4	15	<0.1	4.2
Magnesium	100	<0.1	110	<0.1	<0.1	<0.1	<0.1
Manganese	100	<0.1	99	<0.1	<0.1	<0.1	0.6
Mercury	100	<0.1	1.4	0.16	<0.1	8.2	23
Molybdenum	100	<0.1	100	6.5	1.3	0.3	25
Nickel	100	<0.1	180	0.46	0.88	0.11	4.9
Phosphorus	100	<0.1	100	<0.1	<0.1	<0.1	1.7
Potassium	100	<0.1	94	<0.1	0.27	<0.1	3.3
Selenium	100	<0.1	49	2.1	0.6	<0.1	1.8
Silicon	100	<0.1	110	<0.1	<0.1	<0.1	<0.1
Sodium	100	<0.1	120	<0.1	0.23	<0.1	0.73
Titanium	100	<0.1	100	<0.1	<0.1	<0.1	<0.1
Vanadium	100	<0.1	100	<0.1	<0.1	<0.1	0.13
Zinc	100	<0.1	44	0.33	2	0.1	12

[a] Shaded entries indicate the substance was not detected at that location. Detection levels were used to compute material distributions.

Table 6-3
Material Distributions as a Function of Material Output

	Material Flows. % of Output[a]						
Analyte	**Coal Feed Flow, %**	**NG Flow, %**	**Slag Flow, %**	**Sulfur Flow, %**	**Sweet Water Flow, %**	**Incin. Flow, %**	**GT Flow, %**
Chloride	180	<0.1	28	<0.1	2.5	3	67
Fluoride	450	<0.1	89	<0.1	6.8	<0.1	4.5
Sulfur	84	<0.1	0.7	53	<0.1	8.4	38
Aluminum	94	<0.1	100	<0.1	<0.1	<0.1	<0.1
Antimony	57	<0.1	37	2.5	23	0.3	37
Arsenic	200	<0.1	90	1.1	0.5	<0.1	8.5
Barium	84	<0.1	100	<0.1	0.1	<0.1	<0.1
Beryllium	110	<0.1	98	1.4	0.1	<0.1	0.7
Boron	120	<0.1	99	0.1	0.1	<0.1	0.7
Cadmium	130	<0.1	19	4.5	3.9	0.8	72
Calcium	90	<0.1	100	<0.1	<0.1	<0.1	<0.1
Chromium	83	<0.1	99	0.1	0.1	<0.1	0.9
Cobalt	99	<0.1	99	0.4	0.1	<0.1	0.6
Copper	100	<0.1	97	<0.1	0.1	<0.1	2.5
Iron	88	<0.1	100	<0.1	<0.1	<0.1	0.1
Lead	270	<0.1	45	1.1	42	0.1	12
Magnesium	91	<0.1	100	<0.1	<0.1	<0.1	<0.1
Manganese	100	<0.1	99	<0.1	<0.1	<0.1	0.6
Mercury	300	<0.1	4.1	0.5	0.1	25	71
Molybdenum	74	<0.1	76	4.8	1	0.2	19
Nickel	53	<0.1	97	0.2	0.5	0.1	2.6
Phosphorus	98	<0.1	98	<0.1	0.1	<0.1	1.7
Potassium	100	<0.1	96	<0.1	0.3	<0.1	3.4
Selenium	300	<0.1	89	3.8	1.8	<0.1	5.3
Silicon	93	<0.1	100	<0.1	<0.1	<0.1	<0.1
Sodium	86	<0.1	99	<0.1	0.2	<0.1	0.6
Titanium	97	<0.1	100	<0.1	<0.1	<0.1	<0.1
Vanadium	98	<0.1	100	<0.1	<0.1	<0. 1	0.1
Zinc	170	<0.1	75	<0.1	3.3	0.2	21

[a] Shaded entries indicate the substance was not detected at that location. Detection levels were used to compute material distributions.

concentrations. In cases where this was done, the corresponding entry in Tables 6-1 through 6-2 was shaded to indicate that the value was calculated using the detection limit. Where calculated flows represent less than 0.1% of the total flow they are shown as such.

In Table 6-1, the mass flows of the individual inorganic substances in each stream are summarized. The mass balance closures around the entire plant are also shown for each of the substances. The two dominant streams are the coal fed to the unit and the slag leaving the gasifier. The natural gas contributes only negligible quantities of inorganic substances to the overall balance. Essentially all of these substances entering the system come in with the coal, and most of the inorganic substances leaving the plant are concentrated in the slag.

The distribution of the inorganic substances among the inlet and discharge streams are expressed as percentages of the incoming material (Table 6-2) and the discharged material (Table 6-3). In Table 6-2, the amount of each chemical substance in the discharge streams is expressed as a percent of the amount in the coal, so the sum of the percentages in the outlet streams can sum to more than 100 percent. In Table 6-3, on the other hand, the amount of each of the substances in each of the discharge streams is expressed as a percentage of the total amount of the substance in all of the discharge streams. Therefore, the percentages in the discharge stream sum to 100 percent.

The majority (19 of 29) substance material balances around the entire plant close within the targeted range of 70-130 percent. A few of the substances under discussion are either not concentrated almost exclusively in the slag, are present at significant levels in streams other than the slag, or manifest poor closures. These substances are considered further in the following discussion.

Antimony

The apparent closure for the antimony material balance is over 200%, but the distribution of this element is very uncertain, and the closure cannot be given a great deal of credence. Only a relatively small amount (equivalent to 0.02 lb/hr) of antimony is present in the coal. As shown in Table 6-3, the amounts of antimony in the sweet water and the turbine stack appear to be about the same as those in the slag. The problem may lie in the fact that these latter amounts were calculated using the detection limits as concentrations, since antimony was not detected in the sweet water nor in the gas turbine exhaust. Actual levels could be substantially lower, which would improve the balance closures.

The QA/QC results indicate the possibility of antimony concentrations being biased low in the sweet water stream and in the vapor-phase metals as measured with charcoal. Directionally, however, these biases would tend to show lower recoveries than were actually achieved.

Nickel

The mass balance closure for nickel is also high at nearly 200 percent. Almost all of the nickel, about 96% of the output, is concentrated in the slag. Based on the closure, it appears that either the coal or the slag analyses are inaccurate. The reported nickel concentrations in the coal range from 1 to 3 mg/kg and are reported to only one significant figure. The confidence interval about the average concentration of 1.6 mg/kg encompasses 3 mg/kg. The average concentration of nickel in the slag, on the other hand, is 38 mg/kg with a much narrower confidence interval. It would appear, then, that the nickel concentration in the coal may be biased low.

The possibility of contamination of gas and particulate samples from stainless steel sampling equipment can also exist for some sample sets. However, most of the nickel in the discharge streams is found in the slag. These samples should not be subject to contamination.

Chromium

The closure for chromium is 120 percent. Chromium is often a component of refractory material, and small amounts may shed or be eroded from the refractory and be incorporated into the slag. In this way, chromium may be "generated" in the plant and closures above 100% found. If this gradual shedding/erosion of the refractory occurs at the LGTI plant, it may explain the difficulty in obtaining an accurate chromium material balance. The reported chromium distributions, however, may be correct in spite of the high material balance. Chromium is also a constituent of stainless steel and could be present as a contamination in some samples. However, almost all of the chrome is discharged from the plant in the slag, so contaminant is not a likely cause of the somewhat high material balance closure.

Arsenic

Only about 50% of the arsenic found in the coal is accounted for in the discharge streams of the plant. About 90% of the 50% found is contained in the slag. There is no apparent reason for the discrepancy in the material balance closure. The arsenic analyses in both the coal and in the slag appear to be reasonably consistent. It is possible that some arsenic accumulates in the Selectamine™ system. The results of the QA/QC program have also raised the possibility that the measured levels of arsenic in the coal may be biased slightly high.

Lead

About one-half of the lead found in the coal is unaccounted for in the plant discharges. Of the 50% accounted for, about a third is included with the slag, and about two-thirds in the sweet water stream. Only a relatively small fraction leaves in the turbine stack exhaust. While the concentration of lead in the coal is low, the analytical results are quite consistent, and the variability is low. The concentrations of lead in the sweet water were variable, but this variability was not excessive. The cause of the poor overall balance is not known.

Mercury

Determining the fate of mercury in any coal combustion system is almost always a difficult task. The LGTI plant was no exception. Only about 25% of the mercury reported in the coal was accounted for in exit streams. Of that 25% identified, about 80% was in the turbine exhaust, and another 15% was discharged in the incinerator stack gas. The average mercury concentration in the coal was about 0.11 μg/g, and the concentrations were quite consistent for all nine coal samples.

The mercury levels in the turbine and incinerator stack gases were about the same concentration range, 0.010-0.015 $\mu g/Nm^3$. The 95% confidence interval is about 0.01 $\mu g/Nm^3$ for the turbine exhaust analysis and about 0.02 $\mu g/Nm^3$ for the incinerator stack gas. Even at the upper limits of the confidence interval, however, only an additional 25% of the incoming mercury would be identified. QA/QC results indicated the possibility of incomplete recovery of mercury from charcoal sorbents, potentially biasing low the measured mercury levels in some internal gas streams. However, the overall balance would not be affected by these internal balances. Thus, the fate of mercury in the LGTI plant was not accurately defined in this testing program.

Selenium

The material balance closure for selenium is low, with only about one-half of the amount in the coal being accounted for in the discharge streams. Most of the selenium that was found in the discharge streams is included in the slag. Selenium is another metal that is often difficult to analyze accurately in many streams and matrices. The measured levels in the coal are reasonably consistent, with the exception of one high value, which was deemed an outlier and excluded when determining the average concentration of selenium in the coal. The variability among the remaining analyses was not unreasonably high and would not account for the large discrepancy in the material balance. The slag analyses were variable, and one very low concentration was excluded as an outlier. While the variabilities of the selenium analyses in the coal and slag were significant, they would not alone be responsible for the poor material balance.

Cadmium

The mass balance closure for cadmium was 74%, within the targeted range. Cadmium is present in the coal closure around the turbine system (Table 5-9) was 159% using the on-line AA cadmium analysis for the sweet syngas composition. This result provides some confirmation of the relatively high fraction of cadmium found in the turbine exhaust. The analyses of cadmium in the particulate phase of the turbine exhaust gas were quite consistent, and the concentration in the particulate was of roughly the same magnitude (on a $\mu g/Nm^3$ basis) as that of the gas-phase levels. The variability of the gas-phase analyses was considerably greater than that of the particulate phase, however, with one of three concentrations being almost an order of magnitude higher than the other two. Even accounting for this uncertainty, the cadmium emitted in the turbine exhaust represents a significant fraction of the cadmium present in the coal being gasified.

Molybdenum

The material balance closure for this metal was 132%, slightly outside the acceptable range. About 22% of the molybdenum found in the coal was measured in the turbine exhaust. Molybdenum was also found in the sulfur byproduct and in the sweet water. According to the QA/QC results, molybdenum levels in the sweet water and other process water streams may be biased low. If this is the case, the calculated closure might be even higher than 132 percent. The material balance around the combined Selectamine™-gas turbine system closed within 84%, using the charcoal samples for the sour syngas and acid gas streams. The analyses of molybdenum in the coal was quite consistent. The molybdenum in the turbine exhaust was found only in the particulate phase: the metal was not detected in the vapor phase. There was a significant level of uncertainty in the particulate analyses. The average concentration was 3.8 $\mu g/Nm^3$, while the 95% confidence interval about the mean concentration was 3.3 $\mu g/Nm^3$.

Zinc

Only 60% of the zinc found in the coal was accounted for in the outlet streams. About 20% of the zinc leaving the LGTI plant appeared to exit in the turbine exhaust. A smaller amount, equivalent to about 5% of the zinc in the coal, was found in the sweet water. The concentrations of zinc measured in both the coal and slag samples were consistent, with relatively low variabilities. The zinc in the turbine exhaust was distributed equally between the particulate and vapor phases. The variabilities of both the vapor-phase and particulate-phase analyses were significant, with the 95% confidence intervals being about one- to two- times as great as the average measured concentrations. The internal zinc balances were almost universally poor, so no confirming information about the accuracy of the discharge stream measurements was available from that avenue. Thus, there is a considerable amount of uncertainty about the fate of zinc in the LGTI process.

Sulfur

The sulfur balance closure around the plant was 118%, well within the desired range. However, given the amount of sulfur present in the system, a somewhat better closure might have been expected. The sulfur content of the coal was low, but the analyses were very consistent. About 95% of the sulfur in the raw syngas was removed in the Selectamine™ unit. Overall, about half of the sulfur present in the coal (and in the acid gas stream from the Selectamine™ unit) was recovered as sulfur byproduct. The remainder left the system in the incinerator and turbine exhausts. The measured levels of H_2SO_4 and SO_2 in the turbine stack are more variable than those in the incinerator stack gas, where about 45% of the incoming sulfur leaves the plant. However, the variabilities are relatively small compared to the levels of sulfur compounds found in the stack gases. The rather low total sulfur removal is probably a result of using a very low-sulfur coal in the LGTI plant. The Selectox™ unit functions best with streams containing high levels of sulfides. The levels of sulfides in the acid gas are quite low at LGTI, so the Selectox™ unit is not particularly efficient in recovering the sulfur from the acid gas. In addition, there is no tail gas treatment system to reduce sulfur levels in the tail gas from the Selectox™ unit.

Chloride

The chloride material balance closure was about 54 percent. This represents the upper boundary of the actual closure, since chloride was not detected in the incinerator and turbine exhausts, and the detection limits were used to estimate amounts in these streams. Internal mass balance closures around the sour water stripper and the gas turbine were also poor, in the range of 200-300 percent. The average measured chloride level in the coal was 39 µg/g, with a standard deviation of 7.4 µg/g. Most of the chloride entering the plant in the coal would be expected to leave the system in the incinerator or turbine exhausts or in the stripped (sweet) water, but the measurements do not support this. Some chloride may also be fused into the slag matrix, and the slag analyzer may produce levels that are biased low. Therefore, a significant fraction of the chloride is unaccounted for in the plant.

Fluoride

The overall plant fluoride balance was poor, with a closure of only 28 percent. The average fluoride level of 66 µg/g in the coal was higher than the chloride content. However, these concentrations are still quite low and are subject to analytical uncertainty and imprecision, as indicated by QA/QC results. The standard deviation of the analysis was 16 µg/g, relatively high but not enough to significantly impact the material balance. Most of the fluoride found in the discharge streams was contained in the slag, with a much smaller amount exiting in the sweet water. The fluoride analyses of the slag were consistent, with a low level of variability. Less than 1% of the fluoride in the coal was found in the incinerator and turbine exhaust streams. The mode by which a substantial amount of fluoride leaves the plant is unknown, although its absence in the gas streams may indicate that the slag analysis was biased low and/or the coal analysis was biased high.

Distribution of Organic Compounds in the LGTI Process

Several of the internal streams as well as the gas and aqueous streams discharged from the plant were sampled for selected organic compounds. The organic compounds for which testing was conducted included aldehydes, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and semivolatile organic compounds (SVOCs). The distribution and fates of these substances within the LGTI plant are summarized and discussed below.

Aldehydes

Three aldehydes, acetaldehyde, benzaldehyde, and formaldehyde were found at low levels in several streams within the plant. Table 6-4 is a summary of the mass flows of the individual organic compounds, including the aldehydes, found in the process and discharge streams. Acetaldehyde and formaldehyde were found in most of the gas streams tested for aldehydes. The levels of the aldehydes found in the sweet syngas exiting the Selectamine™ system were higher than those found in the sour syngas entering the Selectamine™ system. It seems unlikely that

Table 6-4
Distribution of Organic Compounds in the LGTI Process

Compound	Raw Syngas (5b) Mass Flow, lb/hr	Sour Syngas Mass Flow, lb/hr	Sweet Syngas Mass Flow, lb/hr	Acid Gas Mass Flow, lb/hr	Tail Gas Mass Flow, lb/hr	Incinerator Exhaust Mass Flow, lb/hr	Turbine Exhaust Mass Flow, lb/hr	Sour Condensate Mass Flow, lb/hr	Sweet Water Mass Flow, lb/hr
Aldehydes									
Acetaldehyde		0.0026	0.039			3.0e-05	0.0026	1.8e-06	
Acrolein									
Benzaldehyde		2.1e-04					0.0043		
Formaldehyde		4.6e-04	6.3e-04			3.6e-05	0.024		
Volatile Organics									
C2 (ppmv)	4.5	2.9	3.3	0.04	0.02				
C3 (ppmv)	0.11	0.11	0.11	0.21	0.16				
C4 (ppmv)									
C5 (ppmv)	0.092	0.092	0.088						
Benzene						1.2e-04	0.0063		
C6 (ppmv)	260	250	230	15	15				
Toluene						4.3e-05			
C7 (ppmv)	8.3	14	3.3	0.11	0.14				
C8 (ppmv)					1.2				
PAHs/SVOCs									
2-Methylnaphthalene		0.017	0.0024			8.5e-07			
Acenaphthene		0.033		0.021	5.5e-04				
Acenaphthylene		0.075	0.0023	0.038		2.7e-07			
Anthracene		0.0024		0.0004					

Table 6-4 (Continued)

Compound	Raw Syngas (5b) Mass Flow, lb/hr	Sour Syngas Mass Flow, lb/hr	Sweet Syngas Mass Flow, lb/hr	Acid Gas Mass Flow, lb/hr	Tail Gas Mass Flow, lb/hr	Incinerator Exhaust Mass Flow, lb/hr	Turbine Exhaust Mass Flow, lb/hr	Sour Condensate Mass Flow, lb/hr	Sweet Water Mass Flow, lb/hr
Benzo(a)anthracene						3.5e-08			
Benzo(e)pyrene						3.4e-08			
Benzo(g,h,i)perylene							2.8e-06		
Benzoic acid						0.0034	0.33		0.0018
Dibenzofuran		0.0064		0.0033	0.0021				
Fluoranthene		0.0023						9.3e-04	5.0e-04
Fluorene				0.0081	1.4e-04				
Naphthalene		2	0.26	1.4	1.1	1.0e-06			
Pentachlorophenol									
Phenanthrene		0.016		0.0029					
Phenol		0.0022						0.084	0.075
Pyrene		0.0029						0.004	0.0021

aldehydes are formed in and/or removed from the Selectamine™ process, so the apparent increase in the mass of these substances is probably due to sampling and/or analytical difficulties.

The amount of acetaldehyde in the sweet syngas stream is reduced by about an order of magnitude as it is combusted in the gas turbine. However, the amount of formaldehyde in the turbine exhaust is about 40 times the mass entering in the sweet syngas. Formaldehyde can be formed as a trace product of combustion in the turbine, especially when natural gas is being fired in the turbine.

The distribution of the aldehydes in the acid gas, Selectox™, and tail gas systems was not measured. A very small amount of acetaldehyde was detected in the sour condensate stream, but the sweet water was not tested for aldehydes, so the fate of the acetaldehyde could not be determined. If it was stripped from the sour condensate in the sour water stripper, it would have been sent to the incinerator in the sour gas stream. Small amounts of acetaldehyde and formaldehyde were detected in the incinerator exhaust stream.

Volatile Organic Compounds

VOCs were measured by two different methods. In one method, samples of gas were collected in Tedlar® bags and analyzed on site using gas chromatography. This method provides results where compounds are grouped essentially by boiling point ranges and reported as fractions designated by the numbers of carbon atoms in the molecules (i.e., C_2 compounds, C_3 compounds, etc.). The other measurement method was the VOST method where VOCs are collected on an adsorbent and later eluted into a GC/MS to identify and quantify individual compounds (i.e., benzene, toluene, etc.).

Only small amounts of the C_2 - C_5 compounds were found in the syngas streams, with the maximum being 4.5 lb/hr in the raw syngas. The amount of C_6 compounds, however, in the raw syngas was 260 lb/hr. Most of the C_6 material is comprised of benzene produced by pyrolysis or reaction during the gasification process. There is little difference in the VOC content of the raw and sour syngas, so it does not appear that this material was condensed during scrubbing and cooling.

The level of the C_2,-C_5 VOC fraction in the sweet syngas is similar to that of the sour syngas, so there appears to be little if any removal of this fraction in the Selectamine™ process. However, the amount of C_6 VOC in the syngas stream decreased by about 20 lb/hr across the Selectamine™ absorber. Any VOC absorbed in the absorber will be stripped from the solvent in the stripper, and will appear in the acid gas stream. In the case of the C_6 fraction, about 15 lb/hr was measured in the acid gas stream. The presence of a trace amount of benzene in the incinerator exhaust gas provides additional evidence of the presence of some benzene in the acid gas stream.

The amount of the C_7 fraction decreases from about 14 lb/hr in the sour syngas to about 3 lb/hr in the sweet syngas. It is feasible that some components of this heavier fraction may have been absorbed in the Selectamine™ solvent. However, a corresponding increase in the C_7 content of the acid gas was not measured. Since the accumulation of approximately 10 lb/hr of the C_7 VOCs in the Selectamine™ system is implausible, a measurement error in either the sour syngas, sweet syngas, or acid gas streams is suspected. A significant amount of the C_7 fraction was measured in the raw syngas stream, adding credence to the levels measured in the sour syngas. The amount of C_7 found in the tail gas is similar to the level in the acid gas, giving some rough confirmation of the reported C_7 levels in the acid gas . It seems most likely, then, that the C_7 measured in the sweet syngas was low.

A small reduction in the amounts of most of the VOC across the Selectox™ system were noted. This is reasonable, since about a third of the acid gas is sent through the catalytic oxidation reactor of the Selectox™ unit. Some of the VOCs can be destroyed in this reactor.

Both the turbine and incinerator appear to be very efficient in destroying VOCs. Only very small residuals of benzene and toluene were found in the incinerator exhaust. A small amount of benzene was also detected in the turbine exhaust, but toluene was not found.

Polycyclic Aromatic Hydrocarbons/Semivolatile Organic Compounds

Several PAHs and SVOCs were detected in some of the plant streams. Naphthalene was found in several of the internal process streams at levels that were significantly higher than any other of the detected PAHs/SVOCs. These compounds generally appear to behave in similar fashions in the plant. Since naphthalene levels are highest and are most easily followed through the plant, this compound will be used an indicator for all of the PAHs and SVOCs in describing the distribution of these compounds in the process streams.

The amount of naphthalene in the syngas stream decreased significantly across the Selectamine™ system. The amount removed in the Selectamine™ absorber is apparently recovered in the stripper and appears in the acid gas stream. All of the acid gas stream is sent through the oxidation reactor of the Selectox™ unit. It might be expected that much of the naphthalene going to the oxidation reactor would be destroyed, while the amount of naphthalene in the unoxidized portion of the acid gas stream would remain virtually unchanged. Unreacted naphthalene would exit in the tail gas. It appears that this occurred, since the amount of naphthalene decreased by about 18% across the Selectox™ unit.

The naphthalene in the tail gas was destroyed in the incinerator; only a very small amount remained in the incinerator exhaust stream. The naphthalene that remained in the sweet syngas was destroyed in the turbine. The other detected PAHs and SVOCs were also destroyed in the incinerator or turbine, with only very small residual amounts left in the exhaust streams. It should be noted, however, that several of the compounds detected in the incinerator and/or turbine stack gas samples were also detected in the associated blank samples. These compounds were considered to be present only when the differences between the sample and blank concentrations were statistically significant.

There were a few compounds which appeared to be present in suspiciously high quantities compared to most of the other PAHs/SVOCs. These included benzoic acid, bis(2-ethylhexyl) phthalate, and di-n-butylphthalate. The phthalate esters are often found in samples collected for organic compound determination. Potential sources of these plasticizers can include plastic bottles, bags, tubing, etc. all of which are present in the field testing environment. The phthalate levels were not included in Table 6-4.

While benzoic acid was not detected in any of the internal process streams, this compound can be produced from both naphthalene and toluene. Naphthalene, found in the sweet syngas, can be oxidized to phthalic acid anhydride and then decarboxylated to benzoic acid. These reactions can occur with significant yields at temperatures as low as 300°C, so it is not unreasonable to assume that some benzoic acid could be produced by this path during the combustion process. Another general preparation method for carboxylic acids is the oxidation of carbon side chains.on ring compounds. Thus, benzoic acid might be produced by the oxidation of toluene, which is also found in the sweet syngas. This oxidation reaction can be catalyzed by vanadium, which was detected at low levels in the turbine exhaust stream. Benzoic acid may also be potentially produced as a degradation product of some XAD sorbent constituents (XAD sorbent is used as a sorbent in the SVOC sampling).

Small quantities of phenol, pyrene, and fluoranthene were found in the sour condensate. It appears that some fractions of these compounds were removed during the sour water stripping, because the amounts present in the sweet water are reduced compared to levels in the sour water. The stripped fractions would have gone to the incinerator as constituents of the sour gas stream.

Subsystem Removal Efficiencies

The removal efficiencies for some substances across plant subsystems were estimated from the results of the testing. The estimated removal efficiencies for selected substances across some systems are summarized in Tables 6-5 and 6-6. These efficiencies are calculated for each individual system, and are not expressed as cumulative removals for multiple systems. Removals could only be estimated for a limited combination of substances and subsystems. Meaningful inlet and outlet compositions needed to develop removal efficiencies were often unavailable.

Since particulate loadings could not be determined in any of the internal process streams, particulate removal efficiencies could not be estimated. As previously discussed, the vapor-phase metals compositions measured in the sweet syngas are highly questionable, so vapor-phase metals removal efficiencies were not developed for the Selectamine™ system.

Those removal efficiencies that could be estimated are discussed below.

Table 6-5
Removal of Vapor-Phase Trace Elements/Metals Across Scrubber

	Metals by Charcoal Adsorption	
Charcoal	**Removal, %**	**95% CI**
Antimony	NC	NC
Arsenic	-22	240
Barium	63	66
Beryllium	NC	NC
Boron	77	73
Cadmium	>77	125[a]
Chromium	-2	99
Cobalt	>16	20[c]
Copper	19	52
Iron	72	87
Lead	65	135
Manganese	72	130
Mercury	NC	NC
Molybdenum	13	28
Nickel	>12	312[a]
Selenium	NC	NC
Vanadium	1	84
Zinc	92	94

NC = Not calculated. One or more measurements needed to calculate removal is not available.

[a] Detection levels were used for outlet concentrations in calculating removals and uncertainties.

Table 6-6
Removal of Selected Compounds Across Systems in the LGTI Plant[a]

Compound	Scrubber	Syngas Cooling	Selectamine™	Selectox™	Incinerator	Turbine	Sour Water Stripper
Ionic Species							
Fluoride							
Cyanide							
Ammonia							
Reduced Sulfur Species							
H_2S							
COS							
Volatile Organics							
C2 (ppmv)							
C3 (ppmv)							
C5 (ppmv)							
Benzene							
C6 (ppmv)							
Toluene							
C7 (ppmv)							
PAHs/SVOCs							
2-Methylnaphthalene							
Acenaphthene							
Acenaphthylene							
Dibenzofuran							
Fluoranthene							
Fluorene							
Naphthalene							
Phenol							
Pyrene							

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[a] All values as percent removal.

[b] Removals were estimated using stack gas concentrations that were not blank corrected. Thus, they represent the minimum estimated removals; actual removals were higher, but they cannot be quantitated.

Scrubber System

Removal efficiencies for vapor-phase metals and a few VOCs could be estimated The vapor-phase metals were measured at the inlet and outlet to the scrubber using both charcoal adsorption and Method 29. Removal efficiencies were calculated from the results obtained with charcoal and are presented in Table 6-5. The inlet and outlet streams of the scrubber are saturated with water, and sampling vapor-phase metals was difficult at both of these locations. As a probable result of the sampling problems, it is not surprising that the estimated removals are quite variable, and their accuracy is very uncertain. Their is no particular pattern of removals that could be discerned from the results.

In a few cases, the metals were detected in the inlet stream but not in the outlet stream. The removal efficiencies were then estimated as being greater than the efficiencies calculated using the detection limit for the outlet stream. Obviously, removal efficiencies could not be calculated when the inlet concentration was not known, and these cases are designated as "NC" (not calculated). The mercury removal efficiency was not calculated because the inlet concentration was in obvious error (much more mercury was found in the inlet stream than was contained in the coal).

VOCs were measured around the scrubber using the on-site GC. C_2, C_5, C_6, and C_7 were detected in the inlet and outlet gas streams. The removal results are mixed, with the C_2 indicating a material gain across the scrubber, and the other three fractions exhibiting an apparent positive removal. Thus, some of the VOC material may have been condensed or absorbed in the scrubber water. However, with the exception of the C_6 fraction, all of the concentrations were quite low, and the apparent removals may have been artifacts. The C_6 concentration was higher than those of the other three fractions by as much as four orders of magnitude. But, as indicated from the estimated removal efficiency, the inlet and outlet concentrations were almost the same.

Syngas Cooling

After passing through the scrubber, the sour syngas stream is cooled to below 200 °F before entering the Selectamine™ system. During this cooling process, water is condensed, and some of the gas constituents are also condensed or absorbed in the sour condensate. As shown in Table 6-6, fluoride, cyanide, and ammonia levels in the syngas were reduced significantly. Hydrogen sulfide and carbonyl sulfide concentrations in the sour syngas stream remained essentially constant during the syngas cooling.

Selectamine™ System

The removals of several groups of compounds from the syngas as it passed through the Selectamine™ absorber are presented in Table 6-6. The Selectamine™ system is designed to remove sulfur compounds, primarily H_2S, and it removes about 97% of this compound. Also removed are cyanide, ammonia, and the heavier PAHs. The VOCs are not removed in the Selectamine™ process, with the exception of the C_7 fraction. This latter fraction is present at very low levels in both the sour and sweet syngas, so the calculated removal is questionable. However, if any of the VOCs were going to be absorbed in the Selectamine™ system, the heavier constituents, like the C_{7s}, would be the most susceptible.

In the Selectamine™ stripper, the absorbed compounds are stripped from the Selectamine™ solvent and all of them, including the C_7 VOC fraction, are found in the acid gas stream which is sent to the Selectox™ unit.

Selectox™ Unit

In the Selectox™ unit, one-third of the acid gas is sent through an oxidation reactor to oxidize the H_2S. The hydrocarbons present in this stream can also be oxidized. As shown in Table 6-6, a partial removal of several of the VOC fractions and PAHs apparently takes place. The C_7 VOC shows a negative removal, but as previously discussed, the levels of this fraction are very low in both the acid gas and tail gas streams (i.e., 2.1 $\mu g/Nm^3$ inlet and 2.7 $\mu g/Nm^3$ outlet). On the other hand, the levels of the PAHs in the acid gas are significant, so the high removals of acenaphthene and fluorene appear to be real.

Incinerator

The compounds present in the tail gas from the Selectox™ unit are oxidized and destroyed in the incinerator. Other streams sent to the incinerator include the sour gas from the sour water stripper and the vent gas (from air pulled across tanks in the process). The VOC and PAH/SVOC content of these streams are probably small (although fluoranthene, phenol, and pyrene were stripped from the sour condensate in the sour water stripper), and removals were estimated using only the acid gas composition as being representative of the inlet concentrations.

Although the removal of only five compounds could be estimated (input and output concentrations were available for only these compounds), their behavior can be viewed as indicators for other substances. Benzene and toluene were not speciated in the acid gas, but the C_6 and C_7 VOC fractions were predominantly benzene and toluene, respectively. They were used to estimate the removal of benzene and toluene.

As shown in Table 6-6, the incinerator is very effective in removing/destroying the organic compounds in the acid gas. Even those compounds like benzene and naphthalene, that are more resistant to oxidation, are very effectively destroyed in the incinerator.

Gas Turbine

Of the PAHs/VOCs detected in the exhaust from the gas turbine, only three were quantified in the sweet syngas, so removals could only be estimated for these three compounds (2-methylnaphthalene, acenaphthylene, and naphthalene). However, all three of these compounds detected in the turbine stack samples were also found in the associated blank samples. The differences between the sample and blank concentrations were not statistically significant for any of the compounds. The (blank) uncorrected levels of the three compounds in the stack gas were used to provide a quantitative estimate of the minimum removals across the turbine. These estimated minimum removals are reported in Table 6-6. Actual removals are higher but could not be quantified.

Sour Water Stripper

The sour water stripper is designed to strip sulfur and nitrogen compounds from the sour condensate. The composition of the sour condensate was compared to the composition of the sweet water to estimate removals. The sour gas rate and composition could not be accurately measured, so the calculated removals could not be confirmed based on the gas characteristics.

As shown in Table 6-6, the stripper is effective in removing ammonia and cyanide from the sour condensate. Very little of the chloride or fluoride in the condensate was removed by stripping, so these removals were not included in the table.

The heavier organics were also apparently stripped to some degree. About half of the fluorene and pyrene present in the condensate was removed. Only 11% of the phenol was removed, but this compound is difficult to strip from water. The stripped organics would be constituents in the sour gas sent to the incinerator.

Emission Factors

Emission factors for those constituents that were detected in the stack gases of the incinerator and turbine are presented in Table 6-7. Factors were developed for each of the exhaust streams. The sums of the factors for each of the two stack sources are the emission factors for the entire plant.

The emission factors are expressed as pounds per 10^{12} Btu of heat input to the entire plant. The average coal flow rate and coal heat content, as well as the natural gas feeding the incinerator and turbine stack for the test period, were used as a basis for calculating the factors.

The calculation of the emission factors for the incinerator was straightforward, but the determination of turbine emission factors was a little more complex. The composition of the gas was measured in one GT-400 turbine exhaust stack. It was assumed that this represented one-sixth of the total turbine exhaust, since there were six stacks (three associated with the GT-400 turbine and three with the GT-300 turbine).

Emission factors for di-n-butylphthalate, bis(2-ethylhexyl)phthalate, and halogenated hydrocarbons were not included, because the presence of these substances in test samples is almost certainly due to contamination from either field or laboratory operations.

Table 6-7
Emission Factors

	Incinerator			Turbine			Combined Stack Emissions		
	Emission Rate	Emission Factor		Emission Rate	Emission Factor		Emission Rate	Emission Factor	
	lb/hr	lb/10^{12} Btu	95% CI	lb/hr	lb/10^{12} Btu	95% CI	lb/hr	lb/10^{12} Btu	95% CI
Particulate Loading	6.0	3,750	600	19	6,900	200	25	9,100	6,000
Ionic Species									
Chloride	ND	NC	NC	2	1,100	185	2	740	180
Fluoride	ND	NC	NC	0.1	56	22	0.1	38	22
Sulfate	490	306,000	36,000	115	62,000	13,000	610	230,000	20,000
Ammonia as N	NA	NC	NC	1.2	650	430	1.2	440	430
Metals									
Aluminum	0.0022	1.4	0.05	0.2	74	31	0.2	75	31
Antimony	9.0e-05	0.054	0.07	0.01	3.9	5	0.011	4	4.7
Arsenic	2.9e-05	0.018	0.02	0.0056	3	2	0.0056	2.1	1.9
Barium	7.8e-05	0.049	0.02	0.0094	5.1	1.3	0.0096	3.5	1.3
Beryllium	2.7e-06	0.0018	0.0004	2.5e-04	0.92	0.03	2.5e-04	0.09	0.03
Boron	5.8e-04	0.36	0.45	0.024	8.7	10	0.024	8.9	10
Cadmium	8.3e-05	0.052	0.077	0.0077	4.2	4	0.0078	2.9	3.8
Calcium	0.0036	2.2	0.88	0.56	300	260	0.56	210	260
Chromium	1.6e-04	0.096	0.02	0.0071	3.8	0.64	0.0073	2.7	0.63
Cobalt	1.6e-05	0.010	0.01	0.0015	0.81	0.58	0.0015	0.57	0.58
Copper	1.1e-05	0.068	0.04	0.04	21	19	0.04	15	19
Iron	0.0086	5.4	2.3	0.39	210	280	0.4	150	270
Lead	9.3e-05	0.058	0.06	0.0076	4.0	1.5	0.0077	2.9	1.5
Magnesium	0.001	0.63	0.24	0.079	29	21	0.08	30	21
Manganese	4.1e-04	0.25	0.58	0.008	4.3	6.6	0.0083	3.1	6.5
Mercury	1.2e-04	0.74	0.08	0.0034	1.8	0.44	0.0046	1.7	0.43
Molybdenum	2.2e-04	0.14	0.01	0.018	9.9	5.7	0.019	6.9	5.6
Nickel	2.2e-04	0.14	0.05	0.01	5.6	3.6	0.011	3.9	3.6
Phosphorus	7.5	4.7	0.26	0.0062	3.4	8.1	0.014	5.2	8.1
Potassium	0.013	8.1	0.53	0.94	350	430	0.95	350	430
Selenium	9.6e-06	0.0061	0.01	0.008	4.3	1.3	0.008	2.9	1.3
Silicon	0.0024	1.5	0.43	0.19	100	34	0.19	72	34
Sodium	0.0090	5.6	2.3	1	540	80	1	370	79
Titanium	3.8e-05	0.024	0.012	0.016	8.7	8	0.016	5.9	8
Vanadium	5.5e-05	0.034	0.03	0.0022	1.2	0.22	0.0023	0.86	0.22
Zinc	0.0011	0.68	0.53	0.13	72	26	0.13	50	26

Table 6-7 (Continued)

	Incinerator			Turbine			Combined Stack Emissions		
	Emission Rate	Emission Factor		Emission Rate	Emission Factor		Emission Rate	Emission Factor	
	lb/hr	lb/10^{12} Btu	95% CI	lb/hr	lb/10^{12} Btu	95% CI	lb/hr	lb/10^{12} Btu	95% CI
Aldehydes									
Acetaldehyde	2.8e-05	0.017	0.025	0.0047	1.8	1	0.0048	1.8	1.5
Benzaldehyde	ND	NC	NC	0.0079	2.9	3	0.0079	2.9	2.6
Formaldehyde	3.3e-05	0.021	0.008	0.045	17	8	0.045	17	7.5
Volatile Organic Compounds									
Benzene	5.4e-05	0.034	0.08	0.012	4.4	2	0.012	4.4	1.7
Carbon Disulfide	0.0002	0.14	0.04	0.12	45	14	0.12	46	14
Toluene	5.3e-05	0.033	0.027	ND	NC	NC	5.3e-05	0.033	0.02
PAHs/SVOCs									
2-Methylnaphthalene	5.6e-06	2.8e-04	3.4e-04	9.8e-04	0.36	0.55	9.8e-04	0.36	0.55
Acenaphthylene	8.8e-07	6.6e-05	1.6e-04	7.0e-05	0.026	0.0076	7.1e-05	0.026	0.0075
Benzo(a)anthracene	5.2e-08	8.0e-06	8.0e-06	6.2e-06	0.0023	0.0002	6.2e-06	0.0023	0.0002
Benzo(e)pyrene	1.5e-07	1.5e-05	1.7e-05	1.5e-05	0.0055	0.0007	1.5e-05	0.0056	0.0007
Benzo(g,h,i)perylene	2.1e-07	3.1e-05	2.6e-05	2.6e-05	0.0095	0.0005	2.6e-05	0.0096	0.0005
Naphthalene	7.8e-06	9.6e-03	9.6e-03	1.1e-03	0.4	0.12	1.1e-03	0.4	0.12
Benzoic acid	0.0034	0.50	0.49	0.38	140	65	0.39	140	65

[a] ND = Substance not detected in this stream.

[b] NA = Not available. Concentrations of this substance were not measured.

Hot Synthesis Gas Composition

The hot gas was characterized for both vapor-phase species and particulate char at two locations upstream of the particulate scrubber. A preliminary shakedown test was done at a process temperature of 500 °F, and the follow-up "hot gas test" was done at a stream temperature of approximately 000 °F. Results are discussed in the following paragraphs.

Compositions of the char collected from the syngas at both 900 °F and 500 °F as well as from the recycle char stream are compared in Figure 6-1. The results are presented in order of increasing concentration. Although the char collected from the syngas was from two different sampling periods, the results are very similar for all of the metals listed. With the exception of phosphorus, the compositions of all three char streams are very similar for the major elements. The recycled char appears to be somewhat enriched in some of the volatile elements. Cadmium and mercury are statistically enriched (the amount of enrichment exceeds the 95% confidence

Figure 6-1
Comparison of Recycled and Gaseous Char

interval overlap). Other elements appear to be enriched (arsenic, selenium, and chromium); however, the confidence intervals for these elements overlap, so definitive statements about enrichment cannot be made. It is speculated that the enrichment mechanism is carbon adsorption by the carbon in the char in the relatively cooler and *quenched* environment of the particulate scrubber.

Results for vapor-phase species were not so well defined. Trace elements were collected and measured by both charcoal adsorption and the EPA Method 29 sampling train. Results using these techniques are presented in Figure 6-2. Only those elements whose results were above the detection limit have been graphed. Wide variations are exhibited between methods as well as between the two test locations for most of the elements. As discussed before, this is most likely due to inaccuracies in the sampling methodologies used.

Figure 6-2
Comparison of Vapor-Phase Elemental Results

7

COMPARISON OF METAL MEASUREMENT TECHNIQUES

Most of the EPA standard reference methods used in HAPs test programs for the utility industry were designed for the collection of samples from an oxidized or combustion gas source. In this test program, only the incinerator and turbine exhaust stacks fall into the combustion gas category. All of the internal process streams that were tested were primarily synthesis gas streams which are a reducing gas matrix. This means that trace elements, found primarily in the oxidized form in combustion gas matrices, may also be present in reduced forms such as the hydride or carbonyl, or even in an elemental form. The use of traditional EPA sampling methods, especially Method 29, for the collection of trace elements may not be applicable for the typical internal gas streams found in a gasification process.

With IGCC processes coming into greater use and with the current emphasis on hot gas cleanup processes, accurately characterizing the trace metal content of a syngas matrix is critical. In current IGCC systems, sulfur removal is typically achieved by cooling the hot syngas (which lowers the process efficiency), then removing the H_2S in an amine based absorbing solution, during which, several trace elements are also removed from the syngas. In a hot gas cleanup system, these elements may deactivate catalysts, or may not be removed and subsequently show up as a gaseous emission. The impacts of cleanup systems on trace metals and their ultimate fate requires effective measurement techniques on the hot gas.

Radian's prior experience with EPA Method 29 indicated that it was not an efficient collection technique for most trace elements in a reducing gas matrix. Therefore, two additional techniques were also used for the characterization of trace elements in the reduced gas environment. Quartz tubes containing specially prepared charcoal were used in conjunction with Method 29 at most internal process gas locations. Additionally, a method using a specially modified atomic absorption spectrophotometer to directly measure selected trace elements was used at the sour and sweet syngas locations. The charcoal tube collection technique and the vapor-phase AAS technique are described in Appendix B, Sampling Methodologies.

The average results of the measurements made by these three techniques are compared in Table 7-1. Mercury is not included in this comparison as it is discussed separately in Section 8 of this report. From Table 7-1, zinc is the only metal that is captured in the Method 29 train at levels exceeding those measured by the other two techniques.

Some of the differences in results between the three methods are illustrated in Figure 7-1. Arsenic, chromium, nickel and selenium determined by each method are plotted for the sour syngas stream. In general, the values determined by VPAAS are the highest, followed by charcoal, with Method 29 giving the lowest results. This information could be interpreted as:

- The VPAAS technique tends to yield the highest results. This is because the technique determines total elemental concentration, regardless of elemental species;
- Elemental adsorption onto charcoal *may* be species dependent, and could explain differences with the VPAAS technique;
- Low values obtained by the Method 29 sampling system are due to poor impinger absorption/ scrubbing efficiency for the nitric acid/peroxide absorbing solutions in a reduced gas matrix.

None of these three methods (Method 29, charcoal, or VPAAS) has been validated for this type of sample matrix; however, the wide range of resulting values from these three techniques suggests that if rigorous testing of the trace metals is required for syngas matrices, EPA Method 29 is not appropriate, and alternate techniques should be used. Ultimately method validation testing should be performed.

Table 7-1
Comparative Trace Element Analysis

	Sour Syngas, µg/M³			**Sweet Syngas, µg/M³**		
Element	**Charcoal**	**M-29**	**VPAAS**	**Charcoal**	**M-29**	**VPAAS**
Antimony	<1.1	<0.018		<0.039	<0.017	
Arsenic	270	0.5	870	6.0	0.42	<2,200
Barium	6.3	0.064		0.23	0.17	
Beryllium	<0.36	<0.033		<0.013	<0.03	
Boron	100	<4.1		3.2	7.1	
Cadmium	<0.85	0.27	<2.2	<0.031	0.44	9.5
Chromium	93	1.6	142	3.6	1.4	<39
Cobalt	<5.9	0.021		<0.22	0.038	
Copper	46	<0.046		1.8	3.7	
Iron	2,300	6.7	<85	85	7.8	<85
Lead	<0.85	0.75		<0.031	0.33	
Manganese	10	0.018		0.4	<0.017	
Molybdenum	45	0.16		1.6	0.13	
Nickel	17	2.3	500	0.94	1.2	19
Selenium	2.8	0.18	560	0.18	0.26	200
Vanadium	8.3	0.06		0.28	0.05	
Zinc	<3.8	8.71	<2.2	0.37	5.3	<2.2

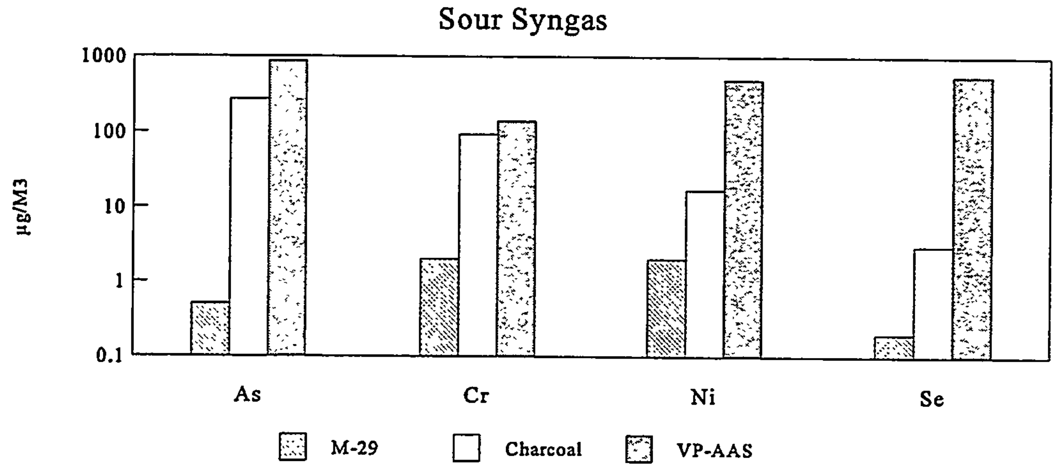

Figure 7-1
Trace Element Methods Comparison

8

MEASUREMENT OF MERCURY IN COAL SYNTHESIS GAS

Integrated gasification combined-cycle (IGCC) technologies represent an advanced power system with the potential for effective mercury emission control prior to combustion. Methods for measuring mercury (and other toxic trace elements) in syngas around existing and developing gas treatment systems are needed to determine the performance characteristics of these systems for mercury removal. However, due to the current focus on methods applicable to oxidized flue gases from conventional power systems, there is little public information available concerning mercury measurements in coal synthesis gas.

Radian Corporation has tested for HAPs at numerous commercial and pilot-scale coal gasification systems. It has been our experience that testing for mercury in the internal process gas streams presents sampling and analytical challenges not found in oxidized flue gas streams typical of conventional coal-fired boilers. Nitric acid/hydrogen peroxide and acidic potassium permanganate impingers commonly used for oxidized flue gases have been used for many years for sampling metals and mercury in syngas; however, poor collection efficiencies have prompted a search for alternative sampling techniques.

During this program, extensive research was performed to investigate alternative mercury measurement methods. Although not conclusive, the results to date are promising.

In Periods 1-3 of testing, this research focused on two gas streams—sour and sweet syngas. In Period 4, the hot, raw syngas was analyzed. Briefly, the following techniques were employed during the first three periods of testing.

- A modified Method 29 train was used (i.e., the acidic potassium permanganate impingers were not used). Prior work has demonstrated that H_2S quickly exhausts the permanganate, which allows mercury to pass through the impingers. This means that the only mercury captured was present in the nitric acid/peroxide impingers.

- A charcoal based absorbent was used to sample vapor-phase mercury.

- Various impinger solution combinations were employed with an on-line CVAAS. Both total and "speciated" mercury forms were measured with this technique.

The results of these tests, while not conclusive, demonstrated that if H_2S is removed from the gas stream, an oxidizing impinger such as potassium permanganate is capable of removing a large fraction of mercury. This observation was put in practice during Period 4 testing. In this test, the charcoal and Method 29 train (modified by the insertion of a caustic impinger) produced equivalent results.

Discussed below is a description of each method, with an emphasis on the impinger chemistry in a reduced atmosphere. Then, total mercury and speciated results are presented.

Method Descriptions

A full description of the mercury sampling and analytical methods used for Periods 1-3 and Period 4 testing is provided below. Each method's background and applicability, sample preparation activities, analysis, individual results, and quality control activities are discussed.

EPA Method 29

EPA Draft Method 29 consists of a filter substrate, which removes particulate matter, and a series of impingers. It is often assumed that substances collected in the impinger solutions represent vapor-phase metals, however it should be noted that extremely fine particulate matter ($<0.2\ \mu m$) may also contribute to the amount collected in the impingers if it passes through the filter. This method specifies the use of two impingers containing a 5% HNO_3/10% H_2O_2 solution, followed by two impingers containing a 4% $KMnO_4$/10% H_2SO_4 solution for total mercury collection. Current research is investigating the speciation capabilities of Method 29. Some studies indicate that oxidized forms of mercury preferentially report to the nitric/peroxide impingers and all forms of mercury are trapped in the permanganate impingers.[1] When this method is applied to syngas or other reducing gas matrices containing hydrogen sulfide (H_2S), the permanganate impinger solution is quickly reduced so it is ineffective at collecting mercury. The standard nitric acid solution (5% nitric/10% peroxide) has also been shown to be ineffective in syngas applications for the collection of total mercury and other trace elements.[2]

In an effort to enhance the collection efficiency of the nitric acid impingers for other vapor-phase metals in syngas, the concentrations of nitric acid and hydrogen peroxide were increased to 10% and 30%, respectively. Although the oxidation potential of this solution is enhanced, it will not effectively trap H_2S. The low pH of the impinger solution keeps the H_2S equilibrium shifted towards the gas phase. As such, H_2S will not dissociate so oxidation and removal will not occur. Therefore, permanganate impingers were not used in the sampling trains for the sweet and sour syngas samples collected during the Periods 1-3 test. The potential to collect valid elemental mercury with this configuration is minimal.

The Method 29 approach was modified for the Period 4 test on hot raw syngas by the insertion of two impingers containing a 2 N solution of sodium hydroxide (NaOH) immediately upstream of the acidic $KMnO_4$ impingers. Periods 1-3 test results using the CVAAS system (presented later in this section) indicated that a sodium hydroxide scrubbing solution was effective at removing H_2S from the sample gas and ineffective at collecting mercury.

Due to the high concentration of H_2S in the raw syngas and the limited amount of NaOH available in the scrubbing solutions, a gas sample volume of only 40 dry standard cubic feet (dscf) could be passed through the NaOH impingers before exhausting the NaOH capacity, assuming 100% collection efficiency. To avoid compromising the gas volume targeted for collecting other vapor-phase metals in the HNO_3 impingers, the NaOH and $KMnO_4$ impingers were disconnected from the sampling train after the first 30-40 dscf of sample had been collected. Sampling was continued with the remaining nitric acid impingers until approximately 100 dscf of syngas was collected. The individual gas sample volumes were considered in the calculation of vapor-phase mercury concentrations from each impinger solution during Period 4.

Sample Recovery and Analysis. The nitric acid/hydrogen peroxide impingers were recovered and rinsed into a 1000-mL plastic bottle. At the laboratory, a 50 mL aliquot was taken for mercury analysis by CVAAS (SW7470). Additional potassium permanganate was required to reduce the excess peroxide and render the sample susceptible to complete reduction by stannous chloride. Matrix-spiked and matrix-spiked duplicate samples were prepared and analyzed to assess the accuracy and precision of the digestion and CVAAS recovery and analytical system. Spike recovery from the syngas matrix for Periods 1-3 was 99% and 104 percent. Matrix spikes for raw syngas collected during Period 4 were recovered at 110% and 113 percent. These data indicate excellent analytical accuracy and precision for mercury collected in the 10% HNO_3/30% H_2O_2 solution; however, the data do not reflect the impinger solution's retention efficiency since no spikes were performed prior to sampling.

The caustic solution used for collecting H_2S (Period 4 only) was also collected and rinsed into 1000-mL plastic bottles. Visual inspection of these samples showed precipitation of ammonium carbonate/bicarbonate (a white crystalline powder) and a slight yellow color from the adsorption of sulfide. As expected, carbon dioxide and H_2S, both acid gases, react with NaOH in solution and begin neutralizing the NaOH until the drop in pH impairs ammonia collection. Once an equilibrium pH is established, the continuous addition of ammonia and CO_2 drives ammonium carbonate and/or bicarbonate salts out of solution. The removal efficiency for H_2S is, therefore, affected by the equilibrium pH which is approximately 10. In the laboratory, 50 mL aliquots were taken for mercury analysis by CVAAS (SW7470). The samples were filtered to remove most of the precipitated carbonate salts in order to avoid excessive CO_2 generation in the closed loop of the cold vapor generator. No mercury spikes were performed on this matrix; however, the samples were split and analyzed by the CVAAS system used on-site during Periods 1-3. That system used a gold plug to amalgamate and concentrate mercury vapor driven off from the sample during sample reduction with sodium borohydride, rather than recirculate the mercury vapor in a closed loop. The entire sample was well mixed and added to the gold amalgamation-CVAAS system so any mercury possibly removed by filtration of carbonate salts for the SW7470 test would be accounted for. The results for each sample were comparable by both analytical techniques indicating no detectable loss of mercury associated with the ammonium carbonate.

The acidic $KMnO_4$ impingers used for elemental mercury collection downstream of the NaOH impingers in the Period 4 test were recovered and rinsed into amber glass bottles. The impingers were rinsed a second time with 8N hydrochloric acid (HCl). These rinses were held in separate glass bottles for transportation to the laboratory where they were combined with their respective $KMnO_4$ impinger samples before analysis. Visual inspection of the samples during recovery, and again prior to adding the HCl rinses showed a loss of the characteristic purple color of the $KMnO_4$ solution. This indicates some sample reduction occurred during sampling and after sample collection, presumably from H_2S passing through the NaOH solution. Reduction of $KMnO_4$ during sample collection could bias the results low due to a reduction in the solution's oxidation potential and collection efficiency.

Similar to the NaOH samples, the $KMnO_4$ impinger samples were split and analyzed by both the SW7470 and the gold amalgamation-CVAAS systems. The initial matrix spikes of the $KMnO_4$ samples were recovered by SW7470 at 212% and 220%; however, spike levels were well below the concentration measured in the parent sample. This spiking error accounts for the poor recovery calculated. Analytical spikes at approximately 30% of the parent sample concentration were subsequently performed with recoveries of 52% and 47 percent. These spike recoveries indicate that mercury measured in the $KMnO_4$ impingers may be biased low, however parallel results by the gold amalgamation-CVAAS system were in close agreement.

Since the analytical results from SW7470 compared favorably with the gold amalgamation-CVAAS results and were supported by a standard reference method, they were used for calculating the vapor-phase mercury concentrations in each impinger solution. The results for each impinger sample are reported in Appendix Table G-1.

Charcoal Sorbents

Some industrial processes utilize charcoal sorbents in guard beds to protect catalysts from metal poisoning. Using the same principle, charcoal has also been demonstrated as a suitable sorbent for the collection of total mercury in flue gas.[3,4] In adapting this method to syngas, Radian takes coconut-based charcoal (20-40 mesh) subjected to an aggressive cleaning procedure using concentrated nitric acid. The charcoal is soaked in nitric acid overnight at 80°F and then the hot acid is decanted off and fresh nitric acid is added. This cycle is repeated for five consecutive days before the charcoal is rinsed with ultra-pure (Milli-Q) deionized water. The rinsed charcoal is then dried overnight at 150°C before being loaded into precleaned quartz tubes. The charcoal is held in place by plugs of pre-cleaned quartz wool.

For sampling, two charcoal tubes were placed in series using Teflon® tubing and plastic connectors. A total volume of 100 L of syngas was sampled through the tubes at ambient temperature at a maximum flow rate of 1 L/min. After sample collection, the charcoal tubes were sealed with plastic caps and sent to the laboratory for analysis. The charcoal sorbent was digested with nitric acid in a closed microwave digestion vessel to minimize the potential losses of volatile elements that might occur with open-vessel digestion techniques. This digestate was analyzed for mercury by CVAAS (SW7470).

During Period 4 sampling of the hot raw syngas, the addition of a condensate trap upstream of the charcoal sorbent tubes was required to remove excessive moisture from the syngas sample. The condensate collected during the entire charcoal sampling period was retained for analysis by SW7470. Sample analysis indicated 1.3 µg of mercury was retained in the condensate which was approximately 7.5% of the total mercury collected in the three pairs of sample tubes combined. The individual sample results presented in Appendix Table G-1 include the mercury collected in the condensate which was divided proportionately by sample volume across the three sample runs.

To assess the mercury recovery from the charcoal digestion procedure, blank charcoal media was spiked before digestion with a commercially-prepared aqueous standard solution. Duplicate spikes of blank charcoal tubes prepared for Periods 1-3 at 1 µg were recovered at 52 and 62 percent. This spiking regimen was repeated for Period 4 and both spikes were recovered at 75 percent. Analytical spikes introduced in the sweet syngas sample digestates (Periods 1-3) were recovered at 77 and 81 percent. Blank media was analyzed to provide a measure of background concentrations for correction of the sample results. Three blanks were analyzed with concentrations ranging from 0.08-0.10 µg mercury per tube. Blank media analyzed for Period 4 averaged 0.003 µg mercury per tube and was insignificant compared to the sample concentrations. Based on these quality control results, Periods 1-3 mercury data from the charcoal tube sampling method may be biased low. Quality control results for Period 4 indicate better analytical performance.

Gold Amalgamation-CVAAS

Method Background. For the past several years, Radian has participated in numerous investigations studying mercury (and other HAP) emissions from coal burning utility facilities. Initial work involved the determination of total mercury emissions; but more recently, attempts have been made to determine the oxidation state of mercury in the flue gas. Research has concentrated on separating the elemental (Hg^0) and oxidized (mono- and di-valent) forms of inorganic mercury in the gas during sampling.

Radian has conducted research studying possible ways to speciate mercury in coal-combustion flue gases using both classical and novel sampling methods.[5] This has included EPA Method 29 in which the solution components have been modified in attempts to separate the oxidized and elemental forms of mercury. As indicated earlier, results have shown that oxidized forms of mercury can be effectively trapped in most aqueous solutions. The very low aqueous solubility of elemental mercury enables it to pass through nearly all solutions, with the exception of strongly oxidizing solutions such as potassium permanganate. This solubility difference has been exploited by using appropriate impinger combinations to selectively trap, and thus separate, the different forms of mercury.

The use of such separation impingers has been coupled with cold vapor atomic absorption (CVAAS) spectrophotometry to create a semicontinuous method to measure and speciate mercury from an industrial gas stream. A sample is purged through an impinger train which may either trap various mercury species or reduce them all to the elemental form, depending upon the desired results. The mercury from the sample is then concentrated by amalgamating it on a gold surface downstream of the impinger train. The amalgamated mercury is released from the gold by thermal desorption and carried by an inert carrier gas to an atomic absorption spectrophotometer for analysis.

Advantages of this method include the low detection limits made possible by the amalgamation method (10-15 ng Hg per sample) as well as the ability to analyze mercury on a semicontinuous basis. The latter avoids the problems associated with mercury sample shelf-life since the analysis can be carried out immediately following sampling. In addition, the sampling method uses small-volume fritted impingers which enables smaller sampling volumes and shorter sampling times.

Laboratory tests have verified that the impinger-CVAAS method can effectively separate and measure elemental and oxidized forms of mercury from simulated flue gas streams.[5] In the context of oxidized flue gas, these tests have included an investigation into the effects of potential interferents such as SO_2, O_2 and HCl gases. The presence of reducing species, such as SO_2, may result in chemical reactions within the impinger solutions, resulting in the loss of captured mercury and thus, inaccurate results.[6] Solution modifications have been made to minimize the absorption of interferents such as SO_2. One example is the use of non-aqueous solutions, such as isopropyl alcohol (IPA), which can also be used in combination with mercury-binding chelants, such as diethyldithiocarbamic acid (DEDTC).

Sampling. Process gas was sampled from the LGTI sour and sweet syngas streams during Periods 1-3 and analyzed on a semicontinuous basis using a gold amalgamation-cold vapor atomic absorption (CVAAS) method. The sampling and analytical setup consisted of an impinger train, a gold amalgamation unit, CVAAS instrumentation, two gas scrubbing units and a gas volume measuring unit. A diagram of the gold amalgamation-CVAAS sampling system is shown in Figure 8-1.

Sweet and sour syngas samples were transferred from the sampling points to the impinger sampling train via Teflon® tubing. Care was taken to maintain the temperature of the sample stream to avoid water condensation within the sample line. A continuous flow was also maintained through the sample line by venting the sample back into the process stream when sampling was not actively being performed.

In general, sample gas was passed through the impinger train where either 1) all forms of mercury were reduced to the elemental form, 2) oxidized and elemental forms of mercury were selectively retained in the impinger train, or 3) oxidized forms were retained while elemental mercury was passed on to the gold amalgamation unit. Depending on the configuration, mercury was either allowed to concentrate on the gold trap during sample collection, or it was later purged with argon from the collecting impinger solutions after the introduction of a reducing agent (sodium borohydride). The sample gas was vented through additional scrubbing solutions before being metered with a dry gas meter. After the desired sample volume was delivered,

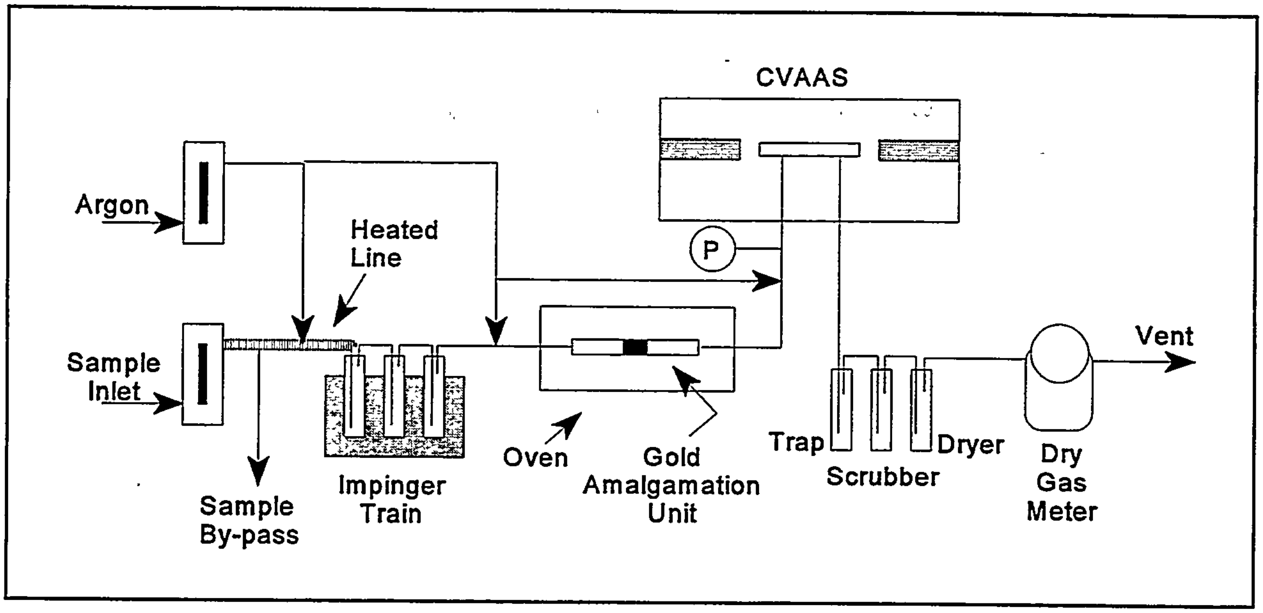

Figure 8-1
Schematic of CVAAS Sample Analysis System

enough argon was passed through the impingers to purge any remaining gaseous mercury through the system.

The various configurations of impinger solutions used to collect mercury are listed in Table 8-1. In most cases, the volume of solution in each impinger was 35 mL and the sample flow rate ranged between 0.75-1.5 L/min. As indicated in Table 8-1, the solutions in the impinger train serve a variety of functions. By varying the impinger configurations, the analyst can effectively collect or convert total mercury, or speciated mercury before the gas reaches the gold amalgamation unit where elemental mercury is trapped and concentrated.

The gold amalgamation unit consisted of a gas-permeable gold-mesh plug housed within a half-inch quartz tube. The tube was located in a temperature-controlled tubular oven capable of reaching a temperature of 950°F. During sample collection, the gold plug was maintained at ambient temperature to permit amalgamation of mercury either passing through the impinger train, or being generated from it after being retained in one or more collecting solutions. Once the sample was collected, the gold trap was heated to 750°F to thermally desorb the mercury from the gold where it passed to a flow cell held in the light path of an atomic absorption spectrophotometer (AAS).

The spectrophotometer used in this test was an ARL Model 93 AAS equipped with a 20-mL cold vapor flow cell through which the sample gas flowed for analysis. Mercury absorbance was measured at 253.3 nm and the results were recorded on an HP3390A integrator.

The gas scrubbing unit located downstream of the flow cell consists of separate impingers containing 1 N NaOH and 4% $KMnO_4$ solutions to scrub H_2S and Hg from the waste gas, respectively. A dry gas meter measured the volume of gas sampled. Calibrated flow meters were used to control the flow rates of sample and purge gases through the system.

Analysis. Total mercury concentrations were determined by flowing gas samples through a reducing impinger, such as sodium borohydride ($NaBH_4$) or stannous chloride ($SnCl_2$). These impinger train configurations are identified in Table 8-1 as Configurations No.1, 2, 2a, and No. 9, respectively. Here, all of the mercury present in the sample was reduced to the elemental form and passed directly to the gold amalgamation unit.[7]

Table 8-1
Gold Amalgamation-CVAAS Impinger Train Configurations

Configuration No.	Impinger Solutions				Function
	Impinger 1	Impinger 2	Impinger 3	Impinger 4	
1	50 mM $NaBH_4$	NA	NA	NA	Total Hg reduction to Hg^0
2	0.1 N NaOH	50 mM $NaBH_4$	NA	NA	Remove H_2S prior to total Hg reduction to Hg^0
2a	2M NaOH	50 mM $NaBH_4$	NA	NA	Remove H_2S prior to total Hg reduction to Hg^0
3	4% H_2O_2/5% HNO_3	0.1N NaOH	cold knockout	4% $KMnO_4$ /10% H_2SO_4	Collect oxidized and elemental Hg separately with H_2S removal
4	80% IPA / 0.1M DEDTC	0.1N NaOH	cold knockout	4% $KMnO_4$ /10% H_2SO_4	Collect oxidized and elemental Hg separately with H_2S removal
5	80% IPA / 0.1M DEDTC	0.1N NaOH	4% $KMnO_4$/10% H_2SO_4	NA	Collect oxidized and elemental Hg separately with H_2S removal
6	4% H_2O_2/5% HNO_3	cold knockout	4% $KMnO_4$ /10% H_2SO_4	NA	Collect oxidized and elemental Hg separately without H_2S removal
7	4% H_2O_2/5% HNO_3	50 mM $NaBH_4$	NA	NA	Collect oxidized Hg and reduce penetrated Hg
8	80% IPA / 0.1M DEDTC	50 mM $NaBH_4$	NA	NA	Collect oxidized Hg and reduce penetrated Hg
9	Sat'd $SnCl_2$ / 0.5N H_2SO_4	NA	NA	NA	Total Hg reduction to Hg^0

Collecting impingers, such as hydrogen peroxide (H_2O_2) or the combination of isopropyl alcohol (IPA) and diethyldithiocarbamic acid (DEDTC), were used in some tests to separate oxidized mercury species from the elemental form. In these tests (Configurations No. 7, 8), the amount of mercury that passed through the impinger was analyzed, as described above, as elemental mercury. The amount of mercury captured in the impinger was determined by reducing the collecting solution with 50 mM $NaBH_4$ and purging the released mercury over the cooled gold following the elemental mercury analysis. The measured amount was reported as "oxidized" mercury.

In some cases, a potassium permanganate ($KMnO_4$) solution was used to capture the elemental mercury (or other forms of mercury) that passed through the initial oxidizing impinger (Configurations No. 3,4,5,6). After the sample was obtained, the $KMnO_4$ solution was neutralized with hydroxylamine sulfate ($(NH_2OH)_2 \cdot H_2SO_4$) prior to reduction with $NaBH_4$. The sample was then purged and analyzed, as described above. Mercury measured in the $KMnO_4$ impingers was reported as elemental mercury.

Results

In addition to determining vapor-phase mercury concentrations in the sweet and sour syngas streams, the testing described in this section was conducted for the purpose of indicating differences between various collection techniques for mercury. Conventional mercury and vapor-phase metal sampling methods have proven unsatisfactory or unworkable for a reducing coal-syngas matrix. In the process of using and screening multiple measurement techniques, it is expected that a more accurate characterization of the syngas streams will be realized and potential solutions to existing sampling and analytical difficulties will be identified. Consequently, the results presented here should be considered semiquantitative in the absence of validated methods for mercury measurements in coal syngas.

Total Mercury Measurements

The three mercury sampling and analysis techniques were applied to the sour and sweet syngas during test Periods 1-3. These two syngas streams are virtually identical in composition except for the H_2S and moisture content. Hydrogen sulfide in the sour syngas measured about 900 ppmv compared to about 30 ppmv in the sweet syngas. The sweet syngas is virtually dry, while the sour syngas, although sampled downstream of a moisture knock-out, still contained a significant amount of water. Unfortunately, both H_2S and water can have an effect on some of the methods that were used. The average and 95% confidence intervals results obtained from the methods are compared in Tables 8-2 and 8-3. Note that several different impinger solutions were examined with the CVAAS technique.

Table 8-2
Mercury Measured in Sour Syngas

Method	Impingers	Hg, µg/Nm^3	95% CI
Charcoal	None	11	13
CVAAS	(1) 2N $NaOH/NaBH_4$	6.1	2.1
	(2) IPA/2N $NaOH/KMnO_4$	3.2	5.2
Method 29	HNO_3/H_2O_2 only	0.8	0.9

Table 8-3
Mercury Measured in Sweet Syngas

Method	Impingers	Hg, µg/Nm^3	95% CI
Charcoal	None	0.1	0.02
CVAAS	(1) 0.1N $NaOH/NaBH_4$	3.8	3.6
	(2) IPA/0.1N $NaOH/KMnO_4$	3.0	3.2
	(3) H_2O_2/0.1N $NaOH/KMnO_4$	3.6	2.3
	(4) IPA/0.1N $NaOH/NaBH_4$	3.1	1.5
Method 29	HNO_3/H_2O_2	0.2	0.2

The following observations were made during this method comparison for the sour gas:

- Although highly variable, the charcoal tube method reported the higher total mercury value. These values are the average of three daily measurements and do not coincide with the test period using the CVAAS technique.

- The presence of H_2S appears to have an effect on the impinger capture (or measurement) of total mercury. Case 2 results by CVAAS was lower than Case 1. During sample collection in Case 2, there was H_2S breakthrough from the NaOH scrubbing solution, which may have biased the results low.

- The Method 29 result, with only one type of impinger solution, indicates minimal capture.

The following observations were made regarding this data set for sweet syngas:

- Mercury collected on charcoal, with respect to the other collection/measurement methods, is significantly lower in the sweet syngas matrix. Commercial activated carbon for mercury control is usually sulfur impregnated. The absence (low level) of H_2S in this stream may be responsible for the poor capture efficiency.

- All of the impinger combinations used in the CVAAS study produced very similar results. Comparison with the charcoal or $NaBH_4$ results in Table 1 indicates 44-70% mercury removal across the Selectamine™ process.

- Other test results indicated the need for an H_2S scrubber upstream of the $KMnO_4$ or $NaBH_4$ impinger.

Period 4 testing of the hot raw syngas permitted the opportunity to test the effectiveness of an H_2S scrubbing solution (NaOH) upstream of the $KMnO_4$ impingers in the Method 29 train. The CVAAS system was not used at the raw syngas location. The results from the Method 29 train and charcoal were similar, when considering the 95% CI. Based upon the Hg value in the coal, a theoretical syngas concentration for Hg would be 58 µg/m^3, assuming all Hg in the coal was present in the syngas (an assumption that is probably valid given the volatility of Hg). The data obtained by both the charcoal (at this location) and the Method 29 (modified) compare favorably with a theoretical maximum Hg concentration. The results for each impinger solution and the total mercury captured in the Method 29 train and the results obtained from the charcoal sorbents are presented in Table 8-4.

Table 8-4
Mercury Measured in Raw Syngas

Method	Impingers	Hg, µg/Nm^3	95% CI
Charcoal	None		
Method 29	Total		
	(1) 10% HNO_3 / 30%H_2O_2		
	(2) 2 N NaOH		
	(3) 4%$KMnO_4$ / 10%H_2SO_4		

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The following observations were made during this method comparison for raw syngas:

- With the addition of NaOH scrubbers in the Method 29 train, total mercury collection was significantly improved (equivalent to total mercury collection by charcoal adsorption);
- The use of NaOH upstream of the $KMnO_4$ impingers appeared effective in collecting H_2S and protecting the $KMnO_4$ solution which collected 87% of the total Hg measured;
- The presence of oxidized mercury in the raw syngas stream (collected by HNO_3 / H_2O_2 solution) is measurable and accounts for 10% of the total mercury captured; and
- A small amount of Hg was retained in the NaOH impinger solution (3% of the total Hg collected); however, no post-sampling purge was performed.

CVAAS Speciation Results

A summary of the sampling runs performed with the gold amalgamation-CVAAS system are presented in Table 8-5. A comparison of mercury results by the various impinger solutions is presented in Table 8-6.

Sweet syngas samples applied directly to $NaBH_4$ impingers indicated that mercury could be detected using a minimum sample volume of 10 liters (SG-1-11/3 and SG-2-11/3). Relatively low spike recoveries using this method indicated that some type of matrix interference may be involved, so tests were repeated using $SnCl_2$ as the reductant. Sampling with this solution resulted in precipitation within the reductant impinger. It is believed that the syngas sulfide concentration played a role in this mechanism, so $SnCl_2$ was eliminated as a reductant for the sweet syngas samples.

Additional $NaBH_4$ tests were performed in which a NaOH scrubbing solution was placed upstream of the reductant to remove H_2S (SG-1-11/6 and SG-1-11/7). This increased the mercury recovery through the $NaBH_4$ and also resulted in better peak shapes during the CVAAS analysis. This indicated that in the previous samples, H_2S may have reacted with the gold surface, interfering with the thermal desorption of mercury and may be responsible for the low spike recoveries. It was determined that some type of H_2S scrubbing solution should be included upstream of the reductant impinger.

During these tests, no mercury was captured in the NaOH solution. To test mercury retention of the NaOH solution, an oxidized mercury standard ($HgCl_2$) was spiked before sampling. No oxidized mercury was detected in the spiked NaOH impinger solution after sampling. This suggests that reactions occurred within the impinger resulting in the reduction of the mercury present.

One sour syngas test (XG-1-11/7) was performed using a 2M NaOH impinger upstream of the reductant impinger. This was done to scrub H_2S from the sour syngas prior to reaching the

Table 8-5
Individual CVAAS Mercury Results by Impinger Train

Test ID Number-Date	Impinger Config.[a]	Mercury ($\mu g/Nm^3$)			Percent Oxidized	MDL[b] $\mu g/Nm^3$	Comments
		Hg°	Oxidized	Total			
Sweet Syngas (Total mercury determined by reduction through $NaBH_4$)							
SG-1-11/3	1	NA[c]	NA	1.87	–	1.07	No H_2S scrubber. Result biased low?
SG-2-11/3	1	NA	NA	<MDL	–	1.07	Sampling system leaks detected.
SG-1-11/6	2	3.82	<MDL	3.82	–	0.27	With H_2S scrubber. No Hg detected in NaOH solution.
SG-1-11/7	2	0.39	–[d]	–	–	0.27	NaOH analysis problems experienced.
Sweet Syngas (Hg^0 - $KMnO_4$, ox-Hg - HNO_3/H_2O_2)							
SGPK-1-11/6	3	–[e]	0.94	–	–	0.54	Hg^0 results out-of-range high.
SGPK-2-11/6	3	–[e]	0.73	–	–	0.54	Hg^0 results out-of-range high.
SGPK-3-11/6	3	2.21	1.37	3.58	0.34	1.07	
Sweet Syngas (Hg^0 - $NaBH_4$, ox-Hg - HNO_3/H_2O_2)							
SGP-1-11/4	7	NA[f]	0.63	–	–	0.36	
Sweet Syngas (Hg^0 - $KMnO_4$, ox-Hg - IPA/DEDTC)							
SGIPK-1-11/6	4	<MDL	<MDL	<MDL	–	0.54	?
SGPK-1-11/7	4	3.75	<MDL	3.85	–	0.20	
SGPK-2-11/7	4	3.82	0.72	4.54	0.14	0.20	
SGIP-3-11/6	5	3.61	NA[g]	–	–	0.65	Only analyzed $KMnO_4$ impinger solution.
Sweet Syngas (Hg^0 - $NaBH_4$, ox-Hg - IPA/DEDTC)							
SGIP-1-11/6	8	2.83	0.91	3.74	0.22	0.41	
SGIP-2-11/6	8	2.03	0.46	2.49	0.16	0.21	
Sour Syngas (Total mercury determined by reduction through $NaBH_4$)							
XG-1-11/8	1	–	–	5.12	–	0.51	No H_2S scrubber. Result biased low?
XG-2-11/8	1	–	–	5.63	–	0.46	
XG-1-11/7	2a	7.45	<MDL	7.45	–	0.90	With H_2S scrubber. No Hg detected in NaOH solution.

Table 8-5 (Continued)

Test ID Number-Date	Impinger Config.[a]	Mercury (µg/Nm^3)			Percent Oxidized	MDL[b] µg/Nm^3	Comments
		Hg^0	Oxidized	Total			
Sour Syngas (Hg^0 - KMnO$_4$, ox-Hg - IPA/DEDTC)							
XGIP-1-11/8	4	3.09	1.93	5.02	0.34	0.54	Hg breakthrough observed and linked to inefficient H_2S removal.
XGIPK-3	4	1.29	<MDL[h]	--	--	0.27	

[a] Impinger configurations are defined in Table 8-1.

[b] MDL = Method detection limit based on gas volume sampled.

[c] NA = Not analyzed/not applicable.

[d] Analytical problems experienced during analysis.

[e] Peak off-scale of recorder.

[f] Not analyzed for elemental Hg (instrument down).

[g] IPA/DEDTC solution not analyzed.

[h] Precipitation observed in impinger; results are suspect.

Table 8-6
Comparison of Mercury Results from Different Impingers

Sample Stream	Mercury Species	Impinger Solution	n[a]	Mercury, (µg/Nm^3) Average	S.D.	C.V.[b]
Sweet Syngas	Total	$NaBH_4$	4	2.98	0.96	32
		$KMnO_4$	3	3.99	0.49	12
		All	7	3.41	0.91	27
	Elemental	$NaBH_4$	4	2.27	1.45	64
		$KMnO_4$	4	3.35	0.76	23
		All	8	2.81	1.22	43
	Oxidized	H_2O_2	4	0.91	0.33	36
		IPA	3	0.70	0.23	33
		All	7	0.82	0.30	36
Sour Syngas	Total	$NaBH_4$	3	6.07	1.23	20
		$KMnO_4$	1	5.02	--	--
		All	4	5.81	1.13	19
	Elemental	$KMnO_4$	2	2.19	1.27	58
	Oxidized	IPA	1	1.93	--	--

[a] Number of data points included.

[b] C.V. = Coefficient of variation = [(standard deviation/average) x 100].

$NaBH_4$ solution. Analysis showed that the mercury captured in the NaOH was below the method detection limit. Results from the $NaBH_4$ impinger (XG-1-11/7) showed a slightly higher total mercury result (7.45 µg/Nm^3) than that measured by the other sour syngas tests performed without the NaOH scrubber (XG-1-11/8 and XG-2-11/8). The higher values consistently obtained from the sampling trains equipped with NaOH scrubbers suggests that this impinger combination warrants further investigation in future testing.

Solutions of 4% H_2O_2 /5% HNO_3 were used in some tests to test the collection of oxidized mercury. Initial sample and spike recovery results showed that the recovery of mercury from this impinger was very low. Mercury recovery was improved by increasing the pH of the impinger solution from approximately 0.5 to 7 prior to reduction with $NaBH_4$. A mercury spike recovery of 72% was achieved using this method, indicating a possible low bias for oxidized mercury recovery from this impinger solution. Mercury recoveries from peroxide solutions in the absence of the sample matrix were found to be acceptable (>80%).

A solution of 80% IPA with 0.1 M diethyldithiocarbamic acid (DEDTC) was also used as a collecting impinger solution for oxidized mercury. DEDTC has been shown in laboratory tests to be an effective complexing agent of mercury. Matrix spike recoveries for IPA/DEDTC impingers were found to be better (86%) than with peroxide. It is interesting, however, that the amount of captured mercury from the sweet syngas was generally lower in the IPA solutions than with H_2O_2. No sampling problems were observed with the IPA/DEDTC impingers, although they had to be kept well-chilled during sampling to prevent excessive IPA vaporization. In most IPA tests, a blank impinger was placed downstream of the former to act as a cold knockout trap.

Potassium permanganate impingers were used to verify the total mercury concentrations measured with $NaBH_4$ impingers. As indicated earlier, $KMnO_4$ impingers could not be used in EPA Method 29 sampling trains since they were readily reduced by the H_2S in the sample. However, the lower flow rates and volumes used with this testing along with the ability to scrub out a majority of the H_2S prior to the $KMnO_4$ solution enabled its use. Analysis of the $KMnO_4$ impingers generally produced higher elemental mercury concentrations than the $NaBH_4$ in the sweet syngas (Table 8-6). This may indicate that the latter was sensitive to some matrix effects. Total mercury results from $KMnO_4$ and $NaBH_4$ impingers were in closer agreement for the sour syngas, although only one $KMnO_4$ sample was analyzed and it reported lower results than the average result obtained by the $NaBH_4$ solution. Some breakthrough (approximately 11%) of elemental mercury was observed with the $KMnO_4$ impinger while sampling the sour syngas; no breakthrough was detected while sampling the sweet syngas. This indicates that some H_2S from the sour syngas was not efficiently removed by the single NaOH impinger. H_2S breakthrough would have reacted with the $KMnO_4$, reducing its oxidative potential and collection efficiency for mercury. A single NaOH impinger may not be sufficient to effectively scrub H_2S from gas streams with higher H_2S concentrations. The ability to detect this type of sampling problem is a good example of an advantage of this type of sampling and analysis technique.

Calibration and Quality Control

The CVAAS was calibrated using mercury vapor standards injected into the inert carrier gas upstream of the amalgamation unit. Standards were obtained by pulling vapor from the headspace of a sealed mercury reservoir held in a controlled temperature water bath. The concentration was calculated using the mercury vapor pressure as a function of the temperature. Analysis of the standards was carried out similarly to the samples by first amalgamating the mercury vapor onto the gold trap, and analyzing the mercury which is thermally desorbed from the trap under an argon carrier gas. A calibration curve was generated by varying the volume of the injected Hg^0 standard. A linear regression of the calibration curve was made from which the results of the process samples were compared.

Quality control samples were analyzed to verify the mercury calibration curve and recovery from the impinger solutions, as well as ensure proper control and operation of the CVAAS instrument. Control samples included both liquid and vapor standards. Liquid standards were obtained from a prepared solution of mercuric chloride ($HgCl_2$) and a commercially purchased AAS standard solution ($HgNO_3$). The calibration curve was checked periodically by either injecting a vapor standard directly to the gold amalgamation unit, or by reducing a liquid standard solution and purging the released mercury to the gold. Results were consistently within 10% of the calibration standard value.

Process gas streams contain matrix species which can react with mercury trapped in an impinger solution potentially influencing results. It was therefore necessary to verify the recovery of mercury from each impinger solution used. Sodium borohydride and potassium permanganate impingers were spiked with vapor (elemental) mercury standards while IPA, sodium hydroxide and hydrogen peroxide impingers were spiked with aqueous, oxidized mercury standards. Recoveries within 20% of the theoretical value were considered acceptable. Table 8-7 presents the spike recovery results.

Vapor standards were injected over the heated gold, in duplicate, after each sample analysis, as a sensitivity check of the CVAAS. The response and sensitivity of the CVAAS have been found to fluctuate throughout a given day, and such drifts can be compensated for by analyzing vapor standards following each sample. The instrument response was normalized for the measured amount of mercury in the vapor standard and the sample results were adjusted accordingly.

Mercury contamination present in many solutions can be substantial relative to the concentrations measured from gas samples. All impinger solutions were therefore analyzed for their mercury content by reducing them with $NaBH_4$ (similar to the sample analyses) and purged with argon over cooled gold. The results of the solution blank analyses, normalized for impinger volume, are given in Table 8-8. The initial $NaBH_4$ solution contained a relatively high mercury contamination whereas the subsequent preparations did not contain detectable amounts. The IPA solutions also contained relatively high blank values. This has been shown in laboratory studies to be related to mercury contamination of the DEDTC chelant.

The results of the sample analyses were normalized for the instrument sensitivity check and compared to the calibration curve from which the mass of mercury in the sample was calculated. The mercury concentration in the impinger (blank) solution was then subtracted from this total leaving the mercury content of the sample. The concentration of mercury in the gas stream was determined by normalizing for total sample volume. In reduction experiments, in which only one reducing impinger was used, the results were given as total mercury. In multiple impinger experiments, the amount as elemental mercury was added to the captured oxidized mercury observed to calculate the total mercury of the sample. The method detection limit (MDL) was determined for each sample by normalizing the instrumental detection limit for total sample volume; the former was calculated to be 10 ng for this testing.

Table 8-7
Results of QC Recoveries of Mercury Spikes

Test No.	QC Test	Impinger Type	Percent Hg Recovery
QC-1-11/3	Liquid Spike	4% H_2O_2	112
SGP-1-11/4	Liquid Spike	4% H_2O_2	72
QC-1-11/4	Vapor Standard	None	112
BIP-2-11/6	Liquid Spike	IPA/DEDTC	86
SGPK-2c-11/6	Vapor Spike	4% $KMnO_4$	72
QC-1-11/6	Vapor Standard	None	80
SG-2a-11/7	Vapor Spike	50 mM $NaBH_4$	124
SG-2b-11/7	Liquid Spike	0.1 N NaOH	0
QC-1-11/7	Liquid Spike	4% H_2O_2	107
XGIPK-2a-11/8	Liquid Spike	IPA/DEDTC	99
XGIPK-2b-11/8	Vapor Spike	$KMnO_4$	109

Table 8-8
Mercury Concentrations in Blank Impinger Solutions

Date	Impinger Solution	Mercury (ng/mL)
03-Nov-94	50 mM $NaBH_4$(1)	2.73
04-Nov-94	4% H_2O_2(1)	0.46
06-Nov-94	IPA/DEDTC* (1)	1.42
	4% H_2O_2(2)	0.50
	0.1N NaOH (1)	0.39
	4% $KMnO_4$	1.03
	50 mM $NaBH_4$	0
07-Nov-94	0.1N NaOH (2)	0
	IPA/DEDTC* (2)	3.70
	4% H_2O_2 (3)	0.50
	2M NaOH	0.29
	50 mM $NaBH_4$	0
08-Nov-94	IPA/DEDTC*	2.41

Conclusions and Recommendations

The results of this testing indicated that both elemental and oxidized mercury were present in the syngas at parts per trillion (pptv) levels. The result of all reductant and multiple-impinger tests using the gold-CVAAS system was a "total" mercury concentration in the sweet syngas of 3.41 $\mu g/Nm^3$ (381 pptv). This was lower than the average value determined for the sour syngas at 5.81 $\mu g/Nm^3$ (649 pptv). It should be noted that fewer sour syngas tests were performed during this testing. Although these results must be viewed as semiquantitative, the data indicate a higher mercury concentration in the sour syngas than in the sweet syngas.

Measurement results for total mercury in sour syngas using charcoal sorbents were consistent with that of the gold amalgamation-CVAAS system; however, mercury values of sweet syngas measured by charcoal sorbents were significantly lower than the gold-CVAAS results. Since the sweet syngas has significantly reduced levels of H_2S and H_2O, their presence in the raw and sour syngas may introduce a desired matrix effect that improves mercury collection on charcoal. The effect of H_2S on charcoal may be related to previous studies demonstrating the effectiveness of sulfur-impregnated charcoal sorbents for mercury collection.[8] For comparison, H_2S concentrations in raw syngas are similar to those found in sour syngas. However, the total mercury in the hot raw syngas was measured at 64 $\mu g/Nm^3$ by charcoal. The average total mercury result for the sour syngas stream was 11 $\mu g/Nm^3$. Further investigations into the collection efficiency of coconut-based charcoal in syngas at various H_2S and H_2O levels and with various mercury species is warranted. The gold amalgamation-CVAAS system makes this testing possible by measuring the effluent gases from various collection systems.

The data showed relatively large variability. This was attributed to the low levels of mercury present in the syngas and the presence of matrix interferences. The variation did not appear to be related to specific impinger trains or solutions, but rather was observed with all combinations tested. The addition of a NaOH scrubber was necessary to protect reductant impingers as well as the gold surface from the syngas matrix. Reactions within the nitric/peroxide impingers also made it necessary to adjust the solution pH prior to the reduction step in order to obtain acceptable mercury recoveries using the gold-CVAAS system.

The ratio of oxidized mercury to elemental mercury varied from test to test with the calculated percentage of oxidized mercury ranging from 16 to 38% of the total mercury measured in the sweet syngas. Oxidized mercury in sour syngas was measured at 2.2 $\mu g/Nm^3$, approximately 38% of the average total mercury measured. Analysis of the raw syngas by Method 29 (adapted with NaOH impingers) indicates oxidized mercury present at approximately 10% of the total mercury collected. The average results of peroxide impinger tests using the gold-CVAAS indicated an oxidized mercury concentration in the sweet syngas of 0.9 $\mu g/Nm^3$, while IPA tests indicate 0.7 $\mu g/Nm^3$. These two impinger solution results (H_2O_2 and IPA) differed by 27% and the coefficients of variation were 36% and 33%, respectively.

Analysis of sodium borohydride impingers measured an elemental mercury concentration of 2.3 μg/Nm^3 in the sweet syngas, whereas mercury collected with the $KMnO_4$ impingers measured 3.3 μg/Nm^3. This represents a relative percent difference of 39% between the two methods.

Overall, favorable results were not found in this study for using charcoal sorbents to sample sweet syngas, although improved collection may be related to syngas streams with higher H_2S concentrations.

The best measurement technique identified during this methods comparison is the gold amalgamation-CVAAS technique. The gold-CVAAS system appears to provide complete mercury collection, assuming the quantitative retention of mercury on the gold mesh. By incorporating various impinger solutions designed to remove matrix interferents, this technique offered the most consistent results for the two primary gas streams analyzed.

The initial results by Method 29 (modified to include NaOH impingers) also indicate a promising alternative for total mercury collection, if not for its potential to separate elemental and oxidized mercury species. A more comprehensive testing of the Method 29 approach (with NaOH impingers) is needed to qualify the approach as an alternative to the gold-CVAAS system.

Recommendations for Further Testing

Direct CVAAS analyses performed on-site identified promising alternatives or modifications to the Method 29 approach which were investigated during Period 4 testing of the hot raw syngas stream. Future efforts at quantifying mercury in syngas should consider incorporating the following recommendations and assessing the results through a comprehensive quality control program.

- An H_2S scrubbing impinger (NaOH, etc.) is required upstream of any reductant impingers to eliminate matrix effects with both the impinger solution and the gold amalgam trap. Sodium hydroxide appeared to work well for this purpose without absorbing significant quantities of mercury. Particular attention to H_2S collection efficiency is necessary to prevent passing H_2S to the permanganate impinger solution.

- The Method 29 HNO_3/H_2O_2 impinger solution demonstrated the ability to absorb mercury, presumably in the oxidized form, from the syngas. The results of this testing indicate that the addition of H_2S scrubbing impingers, upstream of the $KMnO_4$ impinger, may be a suitable modification to this method to enable the collection of total mercury.

- Testing of charcoal sorbents in conjunction with the gold amalgamation-CVAAS system could 1) determine breakthrough potential of charcoal, and 2) indicate if charcoal adsorption of mercury is species dependent, or quantitative for all forms of mercury.

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APPENDIX A: QUALITY CONTROL

Table A-1
Analytical Results for Audit Samples

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
Multi-Metals Train								
Radian	Filter-Q-2608	Filter w/NBS 1633a Fly Ash	Aluminum	µg/g	132,000	143,000	91.7	75-125
			Antimony	µg/g	ND	6.8	NC	75-125
			Arsenic	µg/g	168	145	115	75-125
			Barium	µg/g	1,441	1,500	96.4	75-125
			Beryllium	µg/g	11.5	12	96.4	75-125
			Cadmium	µg/g	ND	1.00	NC	75-125
			Calcium	µg/g	10,500	11,100	94.4	75-125
			Chromium	µg/g	163	196	83.1	75-125
			Cobalt	µg/g	43.6	46	94.9	75-125
			Copper	µg/g	80.7	118	68.6	75-125
			Iron	µg/g	87,400	94,000	92.9	75-125
			Lead	µg/g	36.9	72.4	51.0	75-125
			Magnesium	µg/g	4,090	4,550	90.1	75-125
			Manganese	µg/g	175	179	98.2	75-125
			Mercury	µg/g	0.13	0.16	80.0	75-125
			Molybdenum	µg/g	14.1	29	48.3	75-125
			Nickel	µg/g	103	127	81.2	75-125
			Potassium	µg/g	1,900	NS	NC	75-125
			Selenium	µg/g	10.6	10.3	103	75-125
			Silicon	µg/g	17,500	18,800	93.2	75-125
			Sodium	µg/g	84.2	1,700	4.95	75-125
			Titanium	µg/g	7,580	8,000	94.8	75-125
			Vanadium	µg/g	273	297	92.1	75-125
			Zinc	µg/g	35.5	220	16.1	75-125
Radian	LGTI-TS-104	HNO_3 Impingers by ICP-AES and AAS	Aluminum	mg/L	0.0332	0.04	83.0	75-125
			Antimony	mg/L	0.00303	0.02	15.2	75-125
			Arsenic	mg/L	0.0374	0.04	93.5	75-125
			Barium	mg/L	0.0717	0.08	89.6	75-125
			Beryllium	mg/L	0.0356	0.04	89.0	75-125
			Boron	mg/L	0.00889	NS	NC	75-125
			Cadmium	mg/L	0.0412	0.04	103	75-125
			Calcium	mg/L	0.132	NS	NC	75-125
			Chromium	mg/L	0.00995	NS	NC	75-125
			Cobalt	mg/L	ND	NS	NC	75-125
			Copper	mg/L	0.0202	0.02	101	75-125
			Iron	mg/L	0.0284	NS	NC	75-125
			Lead	mg/L	ND	NS	NC	75-125
			Magnesium	mg/L	0.331	NS	NC	75-125
			Manganese	mg/L	0.0269	0.02	135	75-125

Table A-1 (Continued)

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
Radian	LGTI-TS-104	HNO_3 Impingers by ICP-AES and AAS (Cont'd)	Mercury	mg/L	NA	NS	NC	75-125
			Molybdenum	mg/L	0.00843	0.02	42.2	75-125
			Nickel	mg/L	0.0122	NS	NC	75-125
			Potassium	mg/L	0.799	NS	NC	75-125
			Selenium	mg/L	ND	NS	NC	75-125
			Silicon	mg/L	0.319	NS	NC	75-125
			Sodium	mg/L	0.224	NS	NC	75-125
			Titanium	mg/L	0.000930	NS	NC	75-125
			Vanadium	mg/L	0.00238	NS	NC	75-125
			Zinc	mg/L	0.0175	NS	NC	75-125
Harvard ICP/MS	LGTI-TS-104	HNO_3 Impingers	Antimony	mg/L	0.0177	0.02	88.3	75-125
			Arsenic	mg/L	0.0390	0.04	97.5	75-125
			Barium	mg/L	0.0791	0.08	98.9	75-125
			Beryllium	mg/L	0.0392	0.04	98.0	75-125
			Cadmium	mg/L	0.0353	0.04	88.2	75-125
			Chromium	mg/L	ND	NS	NC	75-125
			Cobalt	mg/L	0.00001	NS	NC	75-125
			Copper	mg/L	0.0239	0.02	119	75-125
			Lead	mg/L	0.0007	NS	NC	75-125
			Manganese	mg/L	0.0267	0.02	134	75-125
			Mercury	mg/L	0.0010	NS	NC	75-125
			Molybdenum	mg/L	0.011	0.02	55.5	75-125
			Nickel	mg/L	ND	NS	NC	75-125
			Selenium	mg/L	ND	NS	NC	75-125
			Vanadium	mg/L	0.00006	NS	NC	75-125
Radian	LGTI-TS-105	$KMnO_4$ Impingers	Mercury	mg/L	0.0176	0.6	2.93	75-125
Charcoal Tube								
Radian	LGTI-CMS-001 LGTI-CMS-002	Charcoal Tube	Aluminum	µg	4529/4659	5,000	90.6/93.2	75-125
			Antimony	µg	10.1/14.2	100	10.1/14.2	75-125
			Arsenic	µg	18.5/18.3	20.0	92.5/91.5	75-125
			Barium	µg	89.1/92.2	100	89.1/92.2	75-125
			Beryllium	µg	87.6/87.3	100	87.6/87.3	75-125
			Boron	µg	69.3/77.5	100	69.3/77.5	75-125
			Cadmium	µg	4.26/4.23	4.0	107/106	75-125
			Calcium	µg	4539/4549	5,000	90.8/91.0	75-125
			Chromium	µg	82.2/77.6	100	82.2/77.6	75-125
			Cobalt	µg	86.7/84.8	100	86.7/84.8	75-125
			Copper	µg	83.8/86.1	100	83.8/86.1	75-125
			Iron	µg	4157/4157	5,000	83.1/83.1	75-125

Table A-1 (Continued)

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
Radian	LGTI-CMS-001 LGTI-CMS-002	Charcoal Tube (Cont'd)	Lead	µg	21.3/21.1	20.0	107/106	75-125
			Magnesium	µg	4538/4608	5,000	90.8/92.2	75-125
			Manganese	µg	87.5/87.5	100	87.5/87.5	75-125
			Mercury	µg	0.52/0.62	1.00	52.4/61.6	75-125
			Molybdenum	µg	42.0/45.6	100	42.0/45.6	75-125
			Nickel	µg	89.7/86.6	100	89.7/86.6	75-125
			Potassium	µg	4028/4048	5,000	80.6/81.0	75-125
			Selenium	µg	4.76/4.63	5.0	95.2/92.6	75-125
			Silicon	µg	169/275	500	33.8/55.0	75-125
			Sodium	µg	4,607/4,797	5,000	92.1/95.9	75-125
			Titanium	µg	80.9/84.5	100	80.9/84.5	75-125
			Vanadium	µg	85.7/86.6	100	85.7/86.6	75-125
			Zinc	µg	86.7/82.5	100	86.7/82.5	75-125
Method 8 Train								
Radian	LGTI-TS-102	IPA Impingers	Sulfate	mg/L	5.22	3.86	135	80-120
	LGTI-TS-103	H_2O_2 Impingers	Sulfate	mg/L	10.2	12.1	84.3	80-120
Anions/Ammonia/Cyanide Train								
Radian	LGTI-AG-025	1% H_2SO_4 Impingers	Ammonia	mg/L	0.954	1.01	94.5	80-120
			Chloride	mg/L	ND	NS	NC	80-120
			Fluoride	mg/L	0.019	NS	NC	80-120
	LGTI-AG-026	ZnOAc Impingers	Cyanide	mg/L	3.74	3.07	122	75-125
	LGTI-TS-106	0.1N H_2SO_4 Impingers	Chloride	mg/L	4.06	0.20	2,030	80-120
			Fluoride	mg/L	0.299	0.32	93.4	80-120
Method 7E Train								
Radian	LGTI-INC-115	$KMnO_4$/NaOH Impingers	Nitrate	mg/L	60.0	66.6	90.2	80-120
Aqueous								
Radian	LGTI-MW-201	Aqueous	Aluminum	mg/L	0.0586	0.08	73.3	75-125
			Antimony	mg/L	0.0151	0.04	37.8	75-125
			Arsenic	mg/L	0.074	0.08	92.5	75-125
			Barium	mg/L	0.148	0.16	92.5	75-125
			Beryllium	mg/L	0.077	0.08	96.3	75-125
			Boron	mg/L	0.00876	NS	NC	75-125
			Cadmium	mg/L	0.0813	0.08	102	75-125
			Calcium	mg/L	0.0400	NS	NC	75-125
			Chromium	mg/L	ND	NS	NC	75-125
			Cobalt	mg/L	ND	NS	NC	75-125
			Copper	mg/L	0.0404	0.04	101	75-125

Table A-1 (Continued)

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
Radian	LGTI-MW-201	Aqueous (Cont'd)	Iron	mg/L	0.00465	NS	NC	75-125
			Lead	mg/L	0.000535	NS	NC	75-125
			Magnesium	mg/L	0.00594	NS	NC	75-125
			Manganese	mg/L	0.0345	0.04	86.3	75-125
			Molybdenum	mg/L	0.0181	0.04	45.3	75-125
			Nickel	mg/L	ND	NS	NC	75-125
			Potassium	mg/L	0.476	NS	NC	75-125
			Selenium	mg/L	ND	NS	NC	75-125
			Silicon	mg/L	0.0469	NS	NC	75-125
			Sodium	mg/L	0.0384	NS	NC	75-125
			Titanium	mg/L	0.00276	NS	NC	75-125
			Vanadium	mg/L	0.00110	NS	NC	75-125
			Zinc	mg/L	ND	NS	NC	75-125
			Ammonia	mg/L	771	884	87.2	80-120
			Chloride	mg/L	195	202.8	96.2	80-120
			Fluoride	mg/L	30.5	28.6	107	80-120
			Formate	mg/L	898	897.6	100	80-120
			Phosphate as P	mg/L	0.993	0.752	132	80-120
			Sulfate	mg/L	18.8	24.1	78.0	80-120
			COD	mg/L	2867	2,898	98.9	75-125
			Phenol	mg/L	1,180	1172	101	75-125
			Thiocyanate	mg/L	5.00	5.00	100	80-120
			Total Cyanide	mg/L	8.41	10.12	83.1	75-125
			Free Cyanide	mg/L	5.3	5.12	104	75-125
Slag								
CT & E	LGTI-SLG-401 (Not a SRM)	Slag	Aluminum	$\mu g/g$	59,300	50,000	119	75-125
			Antimony	$\mu g/g$	5	<9.0	NA	75-152
			Arsenic	$\mu g/g$	4	18	22.2	75-125
			Barium	$\mu g/g$	1,520	2,167	70.1	75-125
			Beryllium	$\mu g/g$	<1.0	0.46	NA	75-125
			Boron	$\mu g/g$	430	160	269	75-125
			Cadmium	$\mu g/g$	<1	<0.44	NA	75-125
			Calcium	$\mu g/g$	102,400	87,667	117	75-125
			Chromium	$\mu g/g$	650	957	67.9	75-125
			Cobalt	$\mu g/g$	20	15	133	75-125
			Copper	$\mu g/g$	670	897	74.7	75-125
			Iron	$\mu g/g$	86,300	74,667	116	75-125
			Lead	$\mu g/g$	32	28	114	75-125
			Magnesium	$\mu g/g$	14,000	12,000	117	75-125
			Manganese	$\mu g/g$	700	643	109	75-125
			Mercury	$\mu g/g$	0.16	0.11	145	75-125
			Molybdenum	$\mu g/g$	<10	49	NA	75-125

Table A-1 (Continued)

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
CT & E	LGTI-SLG-401 (Not a SRM)	Slag (Cont'd)	Nickel	μg/g	180	405	44.4	75-125
			Potassium	μg/g	5,600	8,467	66.1	75-125
			Selenium	μg/g	8	<0.77	NA	75-125
			Silicon	μg/g	213,100	76,333	279	75-125
			Sodium	μg/g	19,400	24,000	80.8	75-125
			Titanium	μg/g	6,300	6,400	98.4	75-125
			Vanadium	μg/g	170	114	149	75-125
			Zinc	μg/g	560	3,067	18.3	75-125
			Phosphorus Pentoxide	% in Ash	6.13	8.7	70.5	75-125
			Carbon	Wt. %	1.79	2.22	80.6	80-120
			Hydrogen	Wt. %	0.05	0.03	167	80-120
			Nitrogen	Wt. %	<0.01	0.13	NA	80-120
			Sulfur	Wt. %	0.12	0.11	109	80-120
			Ash	Wt. %	97.89	98	99.9	80-120
Radian	LGTI-SLG-401 (Not a SRM)	Slag	Chloride	μg/g	89.6/82.5	325	27.6/25.4	80-120
			Fluoride	μg/g	146/37.5	81	180/46.3	80-120
Harvard ICP/MS	LGTI-SLG-401 (Not a SRM)	Slag	Antimony	μg/g	4.21	<9.0	NC	75-125
			Arsenic	μg/g	5.65	18	31.4	75-125
			Beryllium	μg/g	2.08	0.46	452	75-125
			Cadmium	μg/g	3.90	<0.44	NC	75-125
			Chromium	μg/g	566	957	59.1	75-125
			Cobalt	μg/g	23.8	15	159	75-125
			Copper	μg/g	647	897	72.1	75-125
			Lead	μg/g	20.36	28	72.7	75-125
			Manganese	μg/g	537	643	83.5	75-125
			Mercury	μg/g	3.75	0.11	3,409	75-125
			Molybdenum	μg/g	61.2	49	125	75-125
			Nickel	μg/g	747	405	184	75-125
			Selenium	μg/g	22.73	<0.77	NC	75-125
			Vanadium	μg/g	157	114	138	75-125
Coals								
CT & E	LGTI-SLY33-401 (Round Robin D)	Coal	Antimony	μg/g	<1	0.47	NC	75-125
			Arsenic	μg/g	<1	1.24	NC	75-125
			Barium	μg/g	220	370	59.5	75-125
			Beryllium	μg/g	<0.4	0.42	NC	75-125
			Boron	μg/g	130	83.4	156	75-125
			Cadmium	μg/g	<0.2	0.058	NC	75-125
			Chromium	μg/g	5.00	4.40	114	75-125
			Cobalt	μg/g	1	0.86	116	75-125

Table A-1 (Continued)

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
CT & E	LGTI-SLY33-401 (Round Robin)	Coal (Cont'd)	Copper	µg/g	11	9.52	116	75-125
			Lead	µg/g	30	5.22	575	75-125
			Manganese	µg/g	220	145	152	75-125
			Mercury	µg/g	0.06	0.084	71.4	75-125
			Molybdenum	µg/g	<4	7.93	NC	75-125
			Nickel	µg/g	4	5.09	78.6	75-125
			Selenium	µg/g	2	0.84	238	75-125
			Vanadium	µg/g	15	9.36	160	75-125
			Alumina	% in Ash	19.16	16.48	116	75-125
			Silica	% in Ash	43.56	42.12	103	75-125
			Titania	% in Ash	0.86	0.88	97.7	75-125
			Calcium Oxide	% in Ash	11.77	7.79	151	75-125
			Ferric Oxide	% in Ash	6.64	6.07	109	75-125
			Magnesium Oxide	% in Ash	3.85	2.55	151	75-125
			Phosphorus Pentoxide	% in Ash	0.39	0.37	105	75-125
			Potassium Oxide	% in Ash	0.52	0.51	102	75-125
			Sodium Oxide	% in Ash	0.35	0.29	121	75-125
			Sulfur Trioxide	% in Ash	11.58	11.41	101	75-125
			Carbon	Wt. %	68.02	67.6	101	80-120
			Hydrogen	Wt. %	4.49	4.80	93.5	80-120
			Nitrogen	Wt. %	1.00	1.01	99.0	80-120
			Sulfur	Wt. %	0.97	1.15	84.4	80-120
			Chlorine	µg/g	<100	3.0	NC	80-120
			Ash	Wt. %	11.64	11.7	99.5	80-120
			HHV	Btu/lb	11,671	11,350	103	80-120
Radian	LGTI-SLY33-401 (Round Robin D)	Coal	Chloride	mg/kg	23.5	300	7.8	80-120
			Fluoride	mg/kg	32.4	44.3	73.1	80-120
Harvard ICP/MS	LGTI-SLY33-401 (Round Robin D)	Coal	Antimony	µg/g	0.42/0.39	0.47	89.4/83.7	75-125
			Arsenic	µg/g	1.90/1.72	1.24	153/138	75-125
			Beryllium	µg/g	0.37/0.42	0.42	88.1/99.9	75-125
			Cadmium	µg/g	0.12/0.07	0.058	207/126	75-125
			Chromium	µg/g	4.91/4.68	4.4	112/107	75-125
			Cobalt	µg/g	1.03/0.93	0.86	120/108	75-125
			Copper	µg/g	8.00/8.55	9.52	84.0/89.8	75-125
			Lead	µg/g	1.52/1.58	5.22	29.1/30.3	75-125
			Manganese	µg/g	84.5/80.3	145	58.3/55.4	75-125
			Mercury	µg/g	0.12/0.04	0.084	143/53.4	75-125
			Molybdenum	µg/g	6.72/6.88	7.93	84.7/86.8	75-125
			Nickel	µg/g	35.7/33.1	5.09	702/650	75-125

Table A-1 (Continued)

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
Harvard ICP/MS	LGTI-SLY33-401 (Round Robin D)	Coal (Cont'd)	Selenium	$\mu g/g$	4.10/2.20	0.84	488/262	75-125
			Vanadium	$\mu g/g$	8.11/7.92	9.36	86.6/84.7	75-125
CT & E	LGTI-SLY33a-401 (AR 2780)	Coal SRM	Alumina	% in Ash	11.83	14.4	82.2	75-125
			Silica	% in Ash	28.09	33.71	83.3	75-125
			Titania	% in Ash	0.51	0.73	69.9	75-125
			Calcium Oxide	% in Ash	0.57	0.54	106	75-125
			Ferric Oxide	% in Ash	38.85	46.35	83.8	75-125
			Magnesium Oxide	% in Ash	0.335	0.53	63.2	75-125
			Manganese Oxide	% in Ash	0.26	0.29	89.7	75-125
			Phosphorus Pentoxide	% in ash	ND	0.11	NC	75-125
			Potassium Oxide	% in Ash	1.22	1.43	85.3	75-125
			Sodium Oxide	% in Ash	0.27	0.17	159	75-125
			Strontium Oxide	% in Ash	ND	0.01	NC	75-125
			Sulfur Trioxide	% in Ash	0.66	0.53	125	75-125
			Carbon	Wt. %	72.01	70.87	102	80-120
			Hydrogen	Wt. %	4.77	5.05	94.5	80-120
			Nitrogen	Wt. %	1.46	1.58	92.4	80-120
			Sulfur	Wt. %	3.61	3.58	101	80-120
			Chlorine	$\mu g/g$	<100	0.00	NC	80-120
			Ash	Wt. %	9.90	8.23	120	80-120
			HHV	Btu/lb	12,713	12,748	99.7	80-120
			Volatile Matter	Wt. %	39.3	39.05	101	80-120
			Fixed Carbon	Wt. %	52.45	52.72	99.5	80-120
Radian	LGTI-SLY33a-401 (AR 2780)	Coal SRM	Chloride	mg/kg	1,050	1,260	83.3	80-120
			Fluoride	mg/kg	9.37	40	23.4	80-120
CT & E	LGTI-RC-401 (AR 1801)	Coal SRM	Antimony	$\mu g/g$	<1	0.9	NC	75-125
			Arsenic	$\mu g/g$	4	6.1	65.6	75-125
			Beryllium	$\mu g/g$	3.5	3.3	106	75-125
			Boron	$\mu g/g$	110	118	93.2	75-125
			Cadmium	$\mu g/g$	<0.2	<0.2	NC	75-125
			Chromium	$\mu g/g$	17	20	85.0	75-125
			Cobalt	$\mu g/g$	11	11	100	75-125
			Copper	$\mu g/g$	19	18	106	75-125
			Lead	$\mu g/g$	56	8	700	75-125
			Manganese	$\mu g/g$	15	14	107	75-125
			Mercury	$\mu g/g$	0.08	0.04	200	75-125
			Molybdenum	$\mu g/g$	<3	2	NC	75-125

Table A-1 (Continued)

Lab	Sample ID	Matrix	Analyte	Units	Lab Result	Reference Value	Percent Recovery	Audit Objective
CT & E	LGTI-RC-401 (AR 1801)	Coal SRM (Cont'd)	Nickel	μg/g	70	58	121	75-125
			Selenium	μg/g	3	2.6	115	75-125
			Vanadium	μg/g	25	28	89.3	75-125
			Zinc	μg/g	130	109	119	75-125
			Fluorine	μg/g	65	68	95.6	80-120
Harvard ICP/MS	LGTI-RC-401 (AR 1801)	Coal SRM	Antimony	μg/g	0.94/1.24	0.9	104/138	75-125
			Arsenic	μg/g	3.77/5.54	6.1	61.8/90.8	75-125
			Beryllium	μg/g	3.31/3.94	3.3	100/119	75-125
			Cadmium	μg/g	0.30/0.38	<0.2	NC/NC	75-125
			Chromium	μg/g	13.7/18.0	20	68.6/89.9	75-125
			Cobalt	μg/g	10.8/13.9	11	98.3/126	75-125
			Copper	μg/g	15.6/13.1	18	86.8/72.9	75-125
			Lead	μg/g	2.52/2.63	8	31.5/32.8	75-125
			Manganese	μg/g	14.6/19.7	14	105/141	75-125
			Mercury	μg/g	0.04/0.05	0.04	100/117	75-125
			Molybdenum	μg/g	0.68/0.87	2	34.0/43.4	75-125
			Nickel	μg/g	73.6/99.7	58	127/172	75-125
			Selenium	μg/g	1.39/2.73	2.6	53.5/105	75-125
			Vanadium	μg/g	19.0/24.5	28	68.0/87.6	75-125

NC = Not calculated.
ND = Not detected.
NS = Not spiked.
NA = Not applicable.
SRM = Standard Reference Material.

Table A-2
QC Blanks

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Laboratory Method Blank - Filter & PNR				
ICP-AES Metals				
Aluminum	1	1	3.89 µg	2.76 µg
Antimony	1	1	8.90 µg	5.86 µg
Barium	1	1	0.148 µg	0.0697 µg
Beryllium	1	0	ND	0.0329 µg
Calcium	1	1	5.30 µg	1.37 µg
Chromium	1	1	0.787 µg	0.197 µg
Cobalt	1	1	1.01 µg	0.538 µg
Copper	1	1	0.154 µg	0.502 µg
Iron	1	1	2.50 µg	0.509 µg
Magnesium	1	1	5.19 µg	9.63 µg
Manganese	1	0	ND	0.492 µg
Molybdenum	1	1	0.404 µg	0.384 µg
Nickel	1	1	0.669 µg	1.14 µg
Phosphorus	1	1	160 µg	10.9 µg
Potassium	1	1	17.0 µg	44.1 µg
Sodium	1	1	116 µg	3.05 µg
Titanium	1	0	ND	0.716 µg
Vanadium	1	1	0.763 µg	0.292 µg
Zinc	1	0	ND	0.347 µg
GFAAS and CVAAS Metals				
Arsenic	1	0	ND	0.0946 µg
Cadmium	1	0	ND	0.0238 µg
Lead	1	1	0.0800 µg	0.0800 µg
Mercury	1	0	ND	0.000033 µg
Selenium	1	0	ND	0.0802 µg
Reagent Blank - Filter & PNR				
ICP-AES Metals				
Aluminum	2	2	55.7-76.5 µg	2.76 µg
Antimony	2	0	ND	5.86 µg
Barium	2	2	2.08-3.72 µg	0.0697 µg
Beryllium	2	0	ND	0.0329 µg
Calcium	2	2	52.5-57.6 µg	1.37 µg
Chromium	2	2	1.56-1.67 µg	0.197 µg
Cobalt	2	2	0.673-1.35 µg	0.538 µg
Copper	2	2	0.772-1.00 µg	0.502 µg
Iron	2	2	13.6-20.4 µg	0.509 µg
Magnesium	2	2	10.7-11.4 µg	9.63 µg
Manganese	2	2	0.134-0.266 µg	0.492 µg
Molybdenum	2	2	8.36-11.8 µg	0.384 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Nickel	2	2	2.39-3.54 µg	1.14 µg
Phosphorus	2	2	326-360 µg	10.9 µg
Potassium	2	2	41.7-53.9 µg	44.1 µg
Sodium	2	2	108-188 µg	3.05 µg
Titanium	2	2	0.558-1.02 µg	0.716 µg
Vanadium	2	2	0.733-0.877 µg	0.292 µg
Zinc	2	2	2.37-2.40 µg	0.347 µg
GFAAS and CVAAS Metals				
Arsenic	2	1	0.748 µg	0.0946 µg
Cadmium	2	1	0.870 µg	0.0238 µg
Lead	2	2	0.250-0.256 µg	0.0800 µg
Mercury	2	2	0.0150-0.0160 µg	0.0033 µg
Selenium	2	0	ND	0.0802 µg
Field Blank - Filter & PNR				
ICP-AES Metals				
Aluminum	2	2	67.2-117 µg	2.76 µg
Antimony	2	1	4.31 µg	5.86 µg
Barium	2	2	2.43-3.77 µg	0.0697 µg
Beryllium	2	0	ND	0.0329 µg
Calcium	2	2	76.1-104 µg	1.37 µg
Chromium	2	2	1.97-4.20 µg	0.197 µg
Cobalt	2	2	0.331-0.840 µg	0.538 µg
Copper	2	2	2.94-5.41 µg	0.502 µg
Iron	2	2	39.4-63.5 µg	0.509 µg
Magnesium	2	2	15.8-20.0 µg	9.63 µg
Manganese	2	2	0.662-0.803 µg	0.492 µg
Molybdenum	2	2	8.28-13.7 µg	0.384 µg
Nickel	2	2	4.87-6.69 µg	1.14 µg
Phosphorus	2	2	333-359 µg	10.9 µg
Potassium	2	2	26.0-66.5 µg	44.1 µg
Sodium	2	2	230-334 µg	3.05 µg
Titanium	2	2	1.11-2.13 µg	0.716 µg
Vanadium	2	2	0.908-1.07 µg	0.292 µg
Zinc	2	2	14.3-42.2 µg	0.347 µg
GFAAS and CVAAS Metals				
Arsenic	2	1	0.410 µg	0.0946 µg
Cadmium	2	2	0.806-2.61 µg	0.0238 µg
Lead	2	2	0.877-1.79 µg	0.0800 µg
Mercury	2	2	0.0200-0.0230 µg	0.0033 µg
Selenium	2	0	ND	0.0802 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Laboratory Method Blank - HNO_3 /H_2O_2 Impingers				
ICP-AES Metals				
Aluminum	3	0	ND	0.0523 mg/L
Antimony	3	2	0.0301-0.0321 mg/L	0.0760 mg/L
Barium	3	1	0.00049 mg/L	0.00086 mg/L
Beryllium	3	0	ND	0.00051 mg/L
Boron	3	1	0.00888 mg/L	0.0176 mg/L
Calcium	3	3	0.0346-0.0573 mg/L	0.0175 mg/L
Chromium	3	1	0.00301 mg/L	0.00524 mg/L
Cobalt	3	0	ND	0.00407 mg/L
Copper	3	2	0.00154-0.0295 mg/L	0.00916 mg/L
Iron	3	3	0.00318-0.0490 mg/L	0.00452 mg/L
Magnesium	3	2	0.0136-0.0353 mg/L	0.0479 mg/L
Manganese	3	2	0.00130-0.00515 mg/L	0.00155 mg/L
Molybdenum	3	2	0.00124-0.00210 mg/L	0.00739 mg/L
Nickel	3	2	0.00563-0.0123 mg/L	0.0141 mg/L
Phosphorus	3	2	0.0483-0.116 mg/L	0.109 mg/L
Potassium	3	3	0.222-0.324 mg/L	0.822 mg/L
Silicon	3	2	0.0131-0.0332 mg/L	0.0318 mg/L
Sodium	3	3	0.0396-0.0465 mg/L	0.0401 mg/L
Titanium	3	2	0.00184-0.00275 mg/L	0.00159 mg/L
Vanadium	3	2	0.00015-0.00214 mg/L	0.00454 mg/L
Zinc	3	0	ND	0.00402 mg/L
GFAAS and CVAAS Metals				
Arsenic	2	0	ND	0.000647 mg/L
Cadmium	2	1	0.000320 mg/L	0.000270 mg/L
Lead	2	1	0.000230 mg/L	0.00205 mg/L
Mercury	3	1	0.000200 mg/L	0.000165 mg/L
Selenium	2	0	ND	0.00177 mg/L
Reagent Blank - HNO_3 /H_2O_2 Impingers				
ICP-AES Metals				
Aluminum	1	0	ND	0.0523 mg/L
Antimony	1	0	ND	0.0760 mg/L
Barium	1	1	0.00149 mg/L	0.00086 mg/L
Beryllium	1	0	ND	0.00051 mg/L
Boron	1	0	ND	0.0176 mg/L
Calcium	1	1	0.112 mg/L	0.0175 mg/L
Chromium	1	1	0.00451 mg/L	0.00524 mg/L
Cobalt	1	0	ND	0.00407 mg/L
Copper	1	1	0.00155 mg/L	0.00916 mg/L
Iron	1	1	0.0261 mg/L	0.00452 mg/L
Magnesium	1	1	0.0336 mg/L	0.0479 mg/L

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Manganese	1	1	0.00129 mg/L	0.00155 mg/L
Molybdenum	1	1	0.00211 mg/L	0.00739 mg/L
Nickel	1	0	ND	0.0141 mg/L
Phosphorus	1	1	0.0482 mg/L	0.109 mg/L
Potassium	1	1	0.347 mg/L	0.822 mg/L
Silicon	1	1	0.270 mg/L	0.0318 mg/L
Sodium	1	1	0.203 mg/L	0.0401 mg/L
Titanium	1	1	0.000930 mg/L	0.00159 mg/L
Vanadium	1	0	ND	0.00454 mg/L
Zinc	1	1	0.0176 mg/L	0.00402 mg/L
GFAAS and CVAAS Metals				
Arsenic	1	0	ND	0.000647 mg/L
Cadmium	1	0	ND	0.000270 mg/L
Lead	1	0	ND	0.000996 mg/L
Mercury	1	1	0.00080 mg/L	0.000165 mg/L
Selenium	1	0	ND	0.000592 mg/L
ICP-MS Metals				
Antimony	2	2	0.02-0.07 µg/L	0.077 µg/L
Arsenic	2	2	0.21-0.22 µg/L	0.138 µg/L
Barium	2	2	0.20-0.26 µg/L	NA
Beryllium	2	2	0.16-0.28 µg/L	0.142 µg/L
Cadmium	2	2	0.15-0.24 µg/L	0.160 µg/L
Chromium	2	2	6.19-14.76 µg/L	0.109 µg/L
Cobalt	2	2	0.10-0.17 µg/L	0.051 µg/L
Copper	2	1	8.97 µg/L	0.199 µg/L
Lead	2	2	0.31-0.38 µg/L	0.097 µg/L
Manganese	2	0	ND	0.080 µg/L
Mercury	2	0	ND	0.302 µg/L
Molybdenum	2	2	0.72-1.58 µg/L	0.134 µg/L
Nickel	2	2	2.85-8.54 µg/L	0.114 µg/L
Selenium	2	0	ND	0.591 µg/L
Vanadium	2	2	0.56-0.62 µg/L	0.068 µg/L
Field Blank - HNO_3/H_2O_2 Impingers				
ICP-AES Metals				
Aluminum	4	3	0.00734-0.0664 mg/L	0.0523 mg/L
Antimony	4	1	0.00312 mg/L	0.0760 mg/L
Barium	4	4	0.00049-0.0483 mg/L	0.00086 mg/L
Beryllium	4	0	ND	0.00051 mg/L
Boron	4	3	0.00006-0.0178 mg/L	0.0176 mg/L
Calcium	4	4	0.0919-0.277 mg/L	0.0175 mg/L
Chromium	4	4	0.00765-0.0130 mg/L	0.00524 mg/L
Cobalt	4	0	ND	0.00407 mg/L

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Copper	4	4	0.00155-0.0194 mg/L	0.00916 mg/L
Iron	4	4	0.0254-0.5140 mg/L	0.00452 mg/L
Magnesium	4	4	0.0101-0.0430 mg/L	0.0479 mg/L
Manganese	4	4	0.00001-0.0499 mg/L	0.00155 mg/L
Molybdenum	4	4	0.00036-0.00728 mg/L	0.00739 mg/L
Nickel	4	2	0.00845-0.0141 mg/L	0.0141 mg/L
Phosphorus	4	4	0.0269-0.0723 mg/L	0.109 mg/L
Potassium	4	4	0.405-0.694 mg/L	0.822 mg/L
Silicon	4	4	0.0741-0.222 mg/L	0.0318 mg/L
Sodium	4	4	0.106-0.232 mg/L	0.0401 mg/L
Titanium	4	4	0.00092-0.00276 mg/L	0.00159 mg/L
Vanadium	4	2	0.00431-0.00477 mg/L	0.00454 mg/L
Zinc	4	4	0.0176-0.0450 mg/L	0.00402 mg/L
GFAAS and CVAAS Metals				
Arsenic	4	0	ND	0.000647 mg/L
Cadmium	4	4	0.00001-0.00157 mg/L	0.000270 mg/L
Lead	4	1	0.00072 mg/L	0.000996 mg/L
Mercury	4	4	0.00080-0.00465 mg/L	0.000165 mg/L
Selenium	4	1	0.00243 mg/L	0.000592 mg/L
ICP-MS Metals				
Antimony	3	3	0.04-0.07 µg/L	0.077 µg/L
Arsenic	3	3	0.21-0.31 µg/L	0.138 µg/L
Barium	3	3	0.34-0.47 µg/L	NA
Beryllium	3	3	0.16-0.35 µg/L	0.142 µg/L
Cadmium	3	3	0.68-1.42 µg/L	0.160 µg/L
Chromium	3	3	5.64-11.21 µg/L	0.109 µg/L
Cobalt	3	3	0.10-0.14 µg/L	0.051 µg/L
Copper	3	2	17.82-19.67 µg/L	0.199 µg/L
Lead	3	3	0.88-1.18 µg/L	0.097 µg/L
Manganese	3	0	ND	0.080 µg/L
Mercury	3	1	2.19 µg/L	0.302 µg/L
Molybdenum	3	3	0.47-1.29 µg/L	0.134 µg/L
Nickel	3	3	2.89-6.50 µg/L	0.114 µg/L
Selenium	3	2	0.04-2.15 µg/L	0.591 µg/L
Vanadium	3	3	0.53-0.65 µg/L	0.068 µg/L
Laboratory Method Blank - $KMnO_4$ Impingers				
Mercury by CVAAS	1	0	ND	0.000033 mg/L
Reagent Blank - $KMnO_4$ Impingers				
Mercury by CVAAS	1	1	0.00015 mg/L	0.000033 mg/L
Field Blank - $KMnO_4$ Impingers				
Mercury by CVAAS	1	1	0.00001 mg/L	0.000033 mg/L

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Laboratory Method Blank - Charcoal Tube				
ICP-AES Metals				
Aluminum	1	1	0.403 µg	2.76 µg
Antimony	1	1	3.84 µg	5.86 µg
Barium	1	1	0.103 µg	0.0697 µg
Beryllium	1	0	ND	0.0329 µg
Boron	1	1	2.71 µg	0.938 µg
Calcium	1	1	4.52 µg	1.37 µg
Chromium	1	1	0.0120 µg	0.197 µg
Cobalt	1	0	ND	0.538 µg
Copper	1	1	0.0790 µg	0.502 µg
Iron	1	1	0.459 µg	0.509 µg
Magnesium	1	1	2.68 µg	9.63 µg
Manganese	1	0	ND	0.492 µg
Molybdenum	1	1	0.161 µg	0.384 µg
Nickel	1	0	ND	1.14 µg
Phosphorus	1	0	ND	10.9 µg
Potassium	1	1	7.16 µg	44.1 µg
Silicon	1	1	18.6 µg	29.3 µg
Sodium	1	1	30.2 µg	3.05 µg
Titanium	1	0	ND	0.716 µg
Vanadium	1	0	ND	0.292 µg
Zinc	1	1	0.0200 µg	0.347 µg
GFAAS and CVAAS Metals				
Arsenic	1	0	ND	0.118 µg
Cadmium	1	0	ND	0.0783 µg
Lead	1	0	ND	0.0776 µg
Mercury	3	0	ND	0.000033 µg
Selenium	1	0	ND	0.0802 µg
Reagent Blank - Charcoal Tube				
ICP-AES Metals				
Aluminum	2	2	17.8-42.8 µg	2.76 µg
Antimony	2	2	5.48-5.80 µg	5.86 µg
Barium	2	2	0.412-0.670 µg	0.0697 µg
Beryllium	2	0	ND	0.0329 µg
Boron	2	2	8.25-9.15 µg	0.938 µg
Calcium	2	2	16.2-22.6 µg	1.37 µg
Chromium	2	2	8.19-10.5 µg	0.197 µg
Cobalt	2	1	0.317 µg	0.538 µg
Copper	2	2	2.55-3.11 µg	0.502 µg
Iron	2	2	173-201 µg	0.509 µg
Magnesium	2	2	8.64-12.7 µg	9.63 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Manganese	2	2	0.479-1.53 µg	0.492 µg
Molybdenum	2	2	2.80-2.84 µg	0.384 µg
Nickel	2	2	0.380-1.52 µg	1.14 µg
Phosphorus	2	2	1.69-13.4 µg	10.9 µg
Potassium	2	2	326-370	44.1 µg
Silicon	2	2	79.4-115 µg	29.3 µg
Sodium	2	2	16.4-23.8 µg	3.05 µg
Titanium	2	2	3.30-4.53 µg	0.716 µg
Vanadium	2	2	0.565-0.776 µg	0.292 µg
Zinc	2	0	ND	0.347 µg
GFAAS and CVAAS Metals				
Arsenic	2	0	ND	0.118 µg
Cadmium	2	0	ND	0.0783 µg
Lead	2	0	ND	0.0776 µg
Mercury	2	2	0.169-0.181 µg	0.0033 µg
Selenium	2	0	ND	0.0802 µg
Mercury				
Field Blank - Charcoal Tube				
ICP-AES Metals				
Aluminum	1	1	33.7 µg	2.76 µg
Antimony	1	1	0.0410 µg	5.86 µg
Barium	1	1	0.463 µg	0.0697 µg
Beryllium	1	0	ND	0.0329 µg
Boron	1	1	9.16 µg	0.938 µg
Calcium	1	1	24.4 µg	1.37 µg
Chromium	1	1	7.80 µg	0.197 µg
Cobalt	1	1	0.652 µg	0.538 µg
Copper	1	1	4.14 µg	0.502 µg
Iron	1	1	204 µg	0.509 µg
Magnesium	1	1	14.4 µg	9.63 µg
Manganese	1	1	0.625 µg	0.492 µg
Molybdenum	1	1	4.25 µg	0.384 µg
Nickel	1	1	1.24 µg	1.14 µg
Phosphorus	1	1	11.0 µg	10.9 µg
Potassium	1	1	361 µg	44.1 µg
Silicon	1	1	126 µg	29.3 µg
Sodium	1	1	58.2 µg	3.05 µg
Titanium	1	1	2.93 µg	0.716 µg
Vanadium	1	1	1.05 µg	0.292 µg
Zinc	1	1	1.14 µg	0.347 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
GFAAS and CVAAS Metals				
Arsenic	1	0	ND	0.118 µg
Cadmium	1	1	0.0020 µg	0.0783 µg
Lead	1	0	ND	0.0776 µg
Mercury	1	1	0.196 µg	0.0033 µg
Selenium	1	0	ND	0.0802 µg
Mercury				
Laboratory Method Blank - Aqueous Samples				
ICP-AES Metals				
Aluminum	2	0	ND	0.0523 mg/L
Antimony	2	1	0.0321 mg/L	0.0760 mg/L
Barium	2	2	0.00049 mg/L	0.00086 mg/L
Beryllium	2	0	ND	0.00051 mg/L
Boron	2	0	ND	0.0176 mg/L
Calcium	2	2	0.0205-0.0384 mg/L	0.0175 mg/L
Chromium	2	1	0.00308 mg/L	0.00524 mg/L
Cobalt	2	0	ND	0.00407 mg/L
Copper	2	2	0.00154-0.00233 mg/L	0.00916 mg/L
Iron	2	2	0.00637-0.00965 mg/L	0.00452 mg/L
Magnesium	2	2	0.0227-0.0353 mg/L	0.0479 mg/L
Manganese	2	2	0.00128-0.00515 mg/L	0.00155 mg/L
Molybdenum	2	0	ND	0.00739 mg/L
Nickel	2	1	0.0123 mg/L	0.0141 mg/L
Phosphorus	2	1	0.116 mg/L	0.109 mg/L
Potassium	2	2	0.222-0.717 mg/L	0.822 mg/L
Silicon	2	2	0.0275-0.0332 mg/L	0.0318 mg/L
Sodium	2	2	0.0156-0.0465 mg/L	0.0401 mg/L
Titanium	2	1	0.00275 mg/L	0.00159 mg/L
Vanadium	2	1	0.00015 mg/L	0.00454 mg/L
Zinc	2	1	0.00003 mg/L	0.00402 mg/L
GFAAS and CVAAS Metals				
Arsenic	1	0	ND	0.000647 mg/L
Cadmium	1	0	ND	0.00027 mg/L
Lead	3	1	0.00029 mg/L	0.0022 mg/L
Mercury	1	0	ND	0.000033 mg/L
Selenium	1	0	ND	0.000592 mg/L
Laboratory Method Blank - Solid Samples				
ICP-MS Metals				
Antimony	3	3	0.10-0.33 µg/L	
Arsenic	3	2	0.02-0.08 µg/L	
Barium	3	3	0.65-2.23 µg/L	
Beryllium	3	0	ND	

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Cadmium	3	2	0.04-0.09 µg/L	
Chromium	3	3	2.19-2.70 µg/L	
Cobalt	3	2	0.01-0.34 µg/L	
Copper	3	1	0.09 µg/L	
Lead	3	3	0.19-0.51 µg/L	
Manganese	3	1	0.03 µg/L	
Mercury	3	2	0.21-0.27 µg/L	
Molybdenum	3	3	0.08-0.29 µg/L	
Nickel	3	0	ND	
Selenium	3	0	ND	
Vanadium	3	0	ND	
Laboratory Method Blank - Filter & PNR				
Anions				
Chloride (EPA 300)	1	0	ND	2.00 µg
Fluoride (EPA 340.2)	1	1	1.70 µg	2.35 µg
Sulfate (EPA 300)	1	1	102 µg	6.0 µg
Reagent Blank - Filter & PNR				
Anions				
Chloride (EPA 300)	2	2	10.3-13.2 µg	0.0225 mg/L
Fluoride (EPA 340.2)	2	2	1.69-1.89 µg	0.00551 mg/L
Sulfate (EPA 300)	2	2	116-1640 µg	0.0471 mg/L
Field Blank - Filter & PNR				
Anions				
Chloride (EPA 300)	1	1	24.8 µg	2.00 µg
Fluoride (EPA 340.2)	1	1	3.80 µg	2.35 µg
Sulfate (EPA 300)	1	1	607 µg	6.00 µg
Laboratory Method Blank - H_2SO_4 Impingers				
Anions				
Chloride (EPA 300)	4	0	ND	0.0281 mg/L
Fluoride (EPA 340.2)	2	2	0.0178-0.0193 mg/L	0.00551 mg/L
Ammonia in Stack Gas				
Ammonia (EPA 350.2)	3	2	0.0296-0.0371 mg/L	0.0156 mg/L
Reagent Blank -H_2SO_4 Impingers				
Anions				
Chloride (EPA 300)	1	0	ND	2.81 mg/L
Fluoride (EPA 340.2)	1	1	0.0318 mg/L	0.00551 mg/L
Ammonia in Stack Gas				
Ammonia (EPA 350.2)	1	1	0.348 mg/L	0.0624 mg/L
Field Blank - H_2SO_4 Impingers				
Anions				
Chloride (EPA 300)	2	0	ND	2.81 mg/L
Fluoride (EPA 340.2)	2	2	0.0245-0.0256 mg/L	0.00551 mg/L

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Ammonia in Stack Gas				
Ammonia (EPA 350.2)	3	3	0.446-1.17 mg/L	0.0624 mg/L
Laboratory Method Blank - Cyanide in Stack Gas				
Cyanide (SW 9012)	5	5	0.0017-0.0202 mg/L	0.00942 mg/L
Reagent Blank - Cyanide in Stack Gas				
Cyanide (SW 9012)	1	1	0.0006 mg/L	0.00942 mg/L
Field Blanks - Cyanide in Stack Gas				
Cyanide (SW 9012)	3	3	0.0006-0.274 mg/L	0.00942 mg/L
Laboratory Method Blank - $KMnO_4$/NaOH Impingers				
Nitrate (Method 7E)	1	0	ND	0.0280 mg/L
Reagent Blank - $KMnO_4$/NaOH Impingers				
Nitrate (Method 7d)	1	0	ND	0.0280 mg/L
Reagent Blank - IPA Impingers				
Sulfate (EPA 300)	1	1	3.15 mg/L	0.0471 mg/L
Field Blank - IPA Impingers				
Sulfate (EPA 300)	1	1	13.9 mg/L	0.0471 mg/L
Laboratory Method Blank - H_2O_2 Impingers				
Sulfate (EPA 300)	2	0	ND	0.0471 mg/L
Reagent Blank - H_2O_2 Impingers				
Sulfate (EPA 300)	1	1	1.99 mg/L	0.0471 mg/L
Field Blank - H_2O_2 Impingers				
Sulfate (EPA 300)	1	1	15.3 mg/L	0.0471 mg/L
Laboratory Method Blank - Aqueous Samples				
Anions				
Chloride (EPA 300)	1	0	ND	0.0281 mg/L
Fluoride (EPA 340.2)	1	1	0.0181 mg/L	0.00551 mg/L
Formate (IC)	1	0	ND	0.25 mg/L
Sulfate (EPA 300)	2	0	ND	0.0471 mg/L
Phosphate as Total Phosphorus (EPA 365.2)	1	0	ND	0.00692 mg/L
Thiocyanate	4	0	0.0259-0.2342 mg/L	
Ammonia in Aqueous				
Ammonia (EPA 350.2)	3	3	0.0063-0.0678 mg/L	0.0156 mg/L
Cyanide in Aqueous				
Cyanide (SW 9012)	5	5	0.0000104-0.0050 mg/L	0.00942 mg/L
Total Phenolics in Aqueous				
Total Phenolics (EPA 420.2)	2	2	0.00168-0.00307 mg/L	0.0108 mg/L
Laboratory Method Blank - Solid Samples				
Anions				
Chloride (Potentiometric)	1	0	ND	1.33 mg/kg
Chloride (EPA 300)	3	0	ND	0.0200 mg/kg
Fluoride (EPA 340.2)	1	2	12.1-13.7 mg/kg	11.8 mg/kg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Fluoride (EPA 300)	4	0	ND	0.0490 mg/kg
Laboratory Method Blank - Aldehydes in DNPH Impingers				
Formaldehyde	3	0	ND	0.50 µg
Acetaldehyde	3	0	ND	0.50 µg
Acrolein	3	0	ND	0.50 µg
Benzaldehyde	3	0	ND	0.50 µg
Reagent Blanks - Aldehydes in DNPH Impingers				
Formaldehyde	6	3	1.8-5.5 µg	0.50 µg
Acetaldehyde	6	1	0.66 µg	0.50 µg
Acrolein	6	0	ND	0.50 µg
Benzaldehyde	6	0	ND	0.50 µg
Field Blanks - Aldehydes in DNPH Impingers				
Formaldehyde	2	2	2.6-2.7 µg	0.50 µg
Acetaldehyde	2	1	0.52 µg	0.50 µg
Acrolein	2	0	ND	0.50 µg
Benzaldehyde	2	0	ND	0.50 µg
Laboratory Method Blank - Aldehydes in Aqueous Samples				
Formaldehyde	2	0	ND	0.010 µg/ml
Acetaldehyde	2	0	ND	0.010 µg/ml
Acrolein	2	0	ND	0.010 µg/ml
Benzaldehyde	2	0	ND	0.010 µg/ml
Laboratory Method Blank - VOST				
Volatile Organic Compounds				
Chloromethane	3	2	10-30 ng	10 ng
Vinyl Chloride	3	0	ND	10 ng
Bromomethane	3	1	10 ng	10 ng
Chloroethane	3	0	ND	10 ng
Trichlorofluoromethane	3	0	ND	10 ng
1,1-Dichloroethene	3	0	ND	10 ng
Carbon Disulfide	3	0	ND	10 ng
Acetone	3	0	ND	50 ng
Methylene Chloride	3	0	ND	10 ng
trans-1,2-Dichloroethene	3	0	ND	10 ng
1,1-Dichloroethane	3	0	ND	10 ng
Vinyl Acetate	3	0	ND	50 ng
2-Butanone	3	0	ND	50 ng
Chloroform	3	0	ND	10 ng
1,1,1-Trichloroethane	3	0	ND	10 ng
Carbon Tetrachloride	3	0	ND	10 ng
Benzene	3	0	ND	10 ng
1,2-Dichloroethane	3	0	ND	10 ng
Trichloroethene	3	0	ND	10 ng

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
1,2-Dichloropropane	3	0	ND	10 ng
Bromodichloromethane	3	0	ND	10 ng
trans-1,3-Dichloropropene	3	0	ND	10 ng
4-methyl-2-Pentanone	3	0	ND	50 ng
Toluene	3	0	ND	10 ng
cis-1,3-Dichloropropene	3	0	ND	10 ng
1,1,2-Trichloroethane	3	0	ND	10 ng
Tetrachloroethene	3	0	ND	10 ng
2-Hexanone	3	0	ND	50 ng
Dibromochloromethane	3	0	ND	10 ng
Chlorobenzene	3	0	ND	10 ng
Ethyl Benzene	3	0	ND	10 ng
m,p-Xylene	3	0	ND	10 ng
o-Xylene	3	0	ND	10 ng
Styrene	3	0	ND	10 ng
Bromoform	3	0	ND	10 ng
1,1,2,2-Tetrachloroethane	3	0	ND	10 ng
1,3-Dichlorobenzene	3	0	ND	10 ng
1,4-Dichlorobenzene	3	0	ND	10 ng
1,2-Dichlorobenzene	3	0	ND	10 ng
Trip Blank - VOST				
Volatile Organic Compounds				
Chloromethane	1	0	ND	10 ng
Vinyl Chloride	1	0	ND	10 ng
Bromomethane	1	0	ND	10 ng
Chloroethane	1	0	ND	10 ng
Trichlorofluoromethane	1	0	ND	10 ng
1,1-Dichloroethene	1	0	ND	10 ng
Carbon Disulfide	1	0	ND	10 ng
Acetone	1	0	ND	50 ng
Methylene Chloride	1	0	ND	10 ng
trans-1,2-Dichloroethene	1	0	ND	10 ng
1,1-Dichloroethane	1	0	ND	10 ng
Vinyl Acetate	1	0	ND	50 ng
2-Butanone	1	0	ND	50 ng
Chloroform	1	0	ND	10 ng
1,1,1-Trichloroethane	1	0	ND	10 ng
Carbon Tetrachloride	1	0	ND	10 ng
Benzene	1	0	ND	10 ng
1,2-Dichloroethane	1	0	ND	10 ng
Trichloroethene	1	0	ND	10 ng
1,2-Dichloropropane	1	0	ND	10 ng

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
trans-1,3-Dichloropropene	5	0	ND	10 ng
4-methyl-2-Pentanone	5	0	ND	50 ng
Toluene	5	0	ND	10 ng
cis-1,3-Dichloropropene	5	0	ND	10 ng
1,1,2-Trichloroethane	5	0	ND	10 ng
Tetrachloroethene	5	0	ND	10 ng
2-Hexanone	5	0	ND	50 ng
Dibromochloromethane	5	0	ND	10 ng
Chlorobenzene	5	0	ND	10 ng
Ethyl Benzene	5	0	ND	10 ng
m,p-Xylene	5	0	ND	10 ng
o-Xylene	5	0	ND	10 ng
Styrene	5	0	ND	10 ng
Bromoform	5	0	ND	10 ng
1,1,2,2-Tetrachloroethane	5	0	ND	10 ng
1,3-Dichlorobenzene	5	0	ND	10 ng
1,4-Dichlorobenzene	5	0	ND	10 ng
1,2-Dichlorobenzene	5	0	ND	10 ng
Trip Blank - Volatile Organic Compounds in Stack Gas - Canisters				
C-4 VOC	2	0	ND	
C-5 VOC	2	1	0.0002 ppmv	
Benzene	2	2	0.0002 ppmv	
Toluene	2	0	ND	
Ethyl Benzene	2	0	ND	
m,p-Xylene	2	0	ND	
o-Xylene	2	0	ND	
Isopropylbenzene	2	0	ND	
N-Propylbenzene	2	0	ND	
M-Ethyltoluene	2	0	ND	
P-Ethyltoluene	2	0	ND	
O-Ethyltoluene	2	0	ND	
1,3,5-Trimethylbenzene	2	0	ND	
1,2,4-Trimethylbenzene + T-Butylbenzene	2	0	ND	
Isobutylbenzene	2	0	ND	
1,2,3-Trimethylbenzene	2	0	ND	
P-Isopropyltoluene	2	0	ND	
M-Diethylbenzene	2	0	ND	
N-Butylbenzene	2	0	ND	
P-Diethylbenzene	2	0	ND	
Naphthalene	2	0	ND	

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Bromodichloromethane	1	0	ND	10 ng
trans-1,3-Dichloropropene	1	0	ND	10 ng
4-methyl-2-Pentanone	1	0	ND	50 ng
Toluene	1	0	ND	10 ng
cis-1,3-Dichloropropene	1	0	ND	10 ng
1,1,2-Trichloroethane	1	0	ND	10 ng
Tetrachloroethene	1	0	ND	10 ng
2-Hexanone	1	0	ND	50 ng
Dibromochloromethane	1	0	ND	10 ng
Chlorobenzene	1	0	ND	10 ng
Ethyl Benzene	1	0	ND	10 ng
m,p-Xylene	1	0	ND	10 ng
o-Xylene	1	0	ND	.10 ng
Styrene	1	0	ND	10 ng
Bromoform	1	0	ND	10 ng
1,1,2,2-Tetrachloroethane	1	0	ND	10 ng
1,3-Dichlorobenzene	1	0	ND	10 ng
1,4-Dichlorobenzene	1	0	ND	10 ng
1,2-Dichlorobenzene	1	0	ND	10 ng
Field Blank - VOST				
Volatile Organic Compounds				
Chloromethane	5	0	ND	10 ng
Vinyl Chloride	5	0	ND	10 ng
Bromomethane	5	0	ND	10 ng
Chloroethane	5	0	ND	10 ng
Trichlorofluoromethane	5	1	31 ng	10 ng
1,1-Dichloroethene	5	0	ND	10 ng
Carbon Disulfide	5	1	10 ng	10 ng
Acetone	5	0	ND	50 ng
Methylene Chloride	5	4	36-450 ng	10 ng
trans-1,2-Dichloroethene	5	0	ND	10 ng
1,1-Dichloroethane	5	0	ND	10 ng
Vinyl Acetate	5	0	ND	50 ng
2-Butanone	5	0	ND	50 ng
Chloroform	5	0	ND	10 ng
1,1,1-Trichloroethane	5	0	ND	10 ng
Carbon Tetrachloride	5	0	ND	10 ng
Benzene	5	0	ND	10 ng
1,2-Dichloroethane	5	0	ND	10 ng
Trichloroethene	5	0	ND	10 ng
1,2-Dichloropropane	5	0	ND	10 ng
Bromodichloromethane	5	0	ND	10 ng

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
4-Aminobiphenyl	4	0	ND	1.07-1.82 µg
Aniline	4	0	ND	0.809-0.951 µg
Anthracene	4	0	ND	0.510-0.539 µg
Benz(a)anthracene	4	0	ND	0.348-0.401 µg
Benz(a)pyrene	4	0	ND	0.540-0.625 µg
Benzidine	4	0	ND	20.0 µg
Benzo(b)fluoranthene	4	0	ND	0.983-0.959 µg
Benzo(g,h,i)perylene	4	0	ND	0.435-0.554 µg
Benzo(k)fluoranthene	4	0	ND	0.660-0.820 µg
Benzoic Acid	4	0	ND	2.99-6.03 µg
Benzyl Alcohol	4	0	ND	0.461-1.44 µg
4-Bromophenylphenylether	4	0	ND	0.543-0.610 µg
Butylbenzylphthalate	4	0	ND	0.528-0.751 µg
4-Chloro-3-methylphenol	4	0	ND	0.335-0.458 µg
p-Chloroaniline	4	0	ND	0.595-0.980 µg
bis(2-Chloroethoxy)methane	4	0	ND	0.276-0.334 µg
bis(2-Chloroethyl)ether	4	0	ND	0.397-0.466 µg
bis(2-Chloroisopropyl)ether	4	0	ND	0.434-0.571 µg
2-Chloronaphthalene	4	0	ND	0.625-0.899 µg
2-Chlorophenol	4	0	ND	0.328-0.452 µg
4-Chlorophenylphenylether	4	0	ND	0.732-0.755 µg
Chrysene	4	0	ND	0.274-0.585 µg
Di-n-butylphthalate	4	0	ND	0.310-0.438 µg
Di-n-octylphthalate	4	0	ND	0.442-0.582 µg
Dibenz(a,h)anthracene	4	0	ND	0.486-0.683 µg
Dibenzofuran	4	0	ND	0.360-0.391 µg
1,2-Dichlorobenzene	4	0	ND	0.306-0.641 µg
1,3-Dichlorobenzene	4	0	ND	0.286-0.712 µg
1,4-Dichlorobenzene	4	0	ND	0.485-0.707 µg
3,3-Dichlorobenzidine	4	0	ND	1.05-1.09 µg
2,4-Dichlorophenol	4	0	ND	0.314-0.581 µg
Diethylphthalate	4	0	ND	0.315-0.370 µg
P-Dimethylaminoazobenzene	4	0	ND	2.00-2.25 µg
2,4-Dimethylphenol	4	0	ND	1.26-1.27 µg
Dimethylphthalate	4	0	ND	0.323-0.471 µg
4,6-Dinitro-2-methylphenol	4	0	ND	0.731-0.758 µg
2,4-Dinitrophenol	4	0	ND	2.59-2.67 µg
2,4-Dinitrotoluene	4	0	ND	0.457-0.769 µg
2,6-Dinitrotoluene	4	0	ND	0.387-1.05 µg
Diphenylamine/N-NitrosoDPA	4	0	ND	0.744-0.764 µg
bis(2-Ethylhexyl)phthalate	4	1	1.84 µg	1.64-1.77 µg
Fluoranthene	4	0	ND	0.169-0.425 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Laboratory Method Blank - Volatile Organic Compounds in Aqueous Samples				
Chloromethane	2	0	ND	0.519 µg/L
Vinyl Chloride	2	0	ND	0.685 µg/L
Bromomethane	2	0	ND	0.539 µg/L
Chloroethane	2	0	ND	0.772 µg/L
1,1-Dichloroethene	2	0	ND	0.344 µg/L
Carbon Disulfide	2	0	ND	0.491 µg/L
Acetone	2	2	3.97-4.41 µg/L	2.87 µg/L
Methylene Chloride	2	2	2.05-5.70 µg/L	3.03 µg/L
trans-1,2-Dichloroethene	2	0	ND	0.541 µg/L
1,1-Dichloroethane	2	0	ND	0.590 µg/l
Vinyl Acetate	2	0	ND	0.638 µg/L
2-Butanone	2	0	ND	1.60 µg/L
Chloroform	2	0	ND	0.533 µg/L
1,1,1-Trichloroethane	2	0	ND	0.870 µg/L
Carbon Tetrachloride	2	0	ND	0.796 µg/L
Benzene	2	0	ND	0.462 µg/L
1,2-Dichloroethane	2	0	ND	0.822 µg/L
Trichloroethene	2	0	ND	0.455 µg/L
1,2-Dichloropropane	2	0	ND	0.161 µg/L
Bromodichloromethane	2	0	ND	0.370 µg/L
trans-1,3-Dichloropropene	2	0	ND	0.416 µg/L
4-methyl-2-Pentanone	2	0	ND	0.493 µg/L
Toluene	2	0	ND	0.409 µg/L
cis-1,3-Dichloropropene	2	0	ND	0.414 µg/L
1,1,2-Trichloroethane	2	0	ND	0.268 µg/L
Tetrachloroethene	2	0	ND	0.541 µg/L
2-Hexanone	2	0	ND	0.713 µg/L
Dibromochloromethane	2	0	ND	0.246 µg/L
Chlorobenzene	2	0	ND	0.319 µg/l
Ethyl Benzene	2	0	ND	0.588 µg/L
m,p-Xylene	2	0	ND	0.509 µg/L
o-Xylene	2	0	ND	0.402 µg/L
Styrene	2	0	ND	0.432 µg/L
Bromoform	2	0	ND	0.563 µg/L
1,1,2,2-Tetrachloroethane	2	0	ND	0.627 µg/L
1,4-Dichlorobenzene	2	0	ND	0.558 µg/L
Laboratory Method Blank - XAD & Condensate				
Semivolatile Organic Compounds by SW8270				
Acenaphthene	4	0	ND	0.411-0.482 µg
Acenaphthylene	4	0	ND	0.658-0.761 µg
Acetophenone	4	0	ND	0.338-0.355 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Fluorene	4	0	ND	0.284-0.345 µg
Hexachlorobenzene	4	0	ND	0.474-0.528 µg
Hexachlorobutadiene	4	0	ND	0.242-0.657 µg
Hexachlorocyclopentadiene	4	0	ND	1.64 µg
Hexachloroethane	4	0	ND	0.246-1.00 µg
Indeno(1,2,3)pyrene	4	0	ND	0.481-519 µg
Isophorone	4	0	ND	0.302-0.369 µg
2-Methylnaphthalene	4	0	ND	0.537-0.605 µg
4-Methylphenol/3-Methylphenol	4	0	ND	1.04-1.24 µg
2-Methylphenol	4	0	ND	0.790-1.15 µg
N-Nitrosodipropylamine	4	0	ND	0.569-0.785 µg
N-Nitrosodimethylamine	4	0	ND	0.417-0.783 µg
Naphthalene	4	2	0.923-1.15 µg	0.627-0.668 µg
2-Nitroaniline	4	0	ND	0.422-0.799 µg
3-Nitroaniline	4	0	ND	0.322-0.507 µg
4-Nitroaniline	4	0	ND	0.510-0.599 µg
Nitrobenzene	4	0	ND	0.325-0.389 µg
2-Nitrophenol	4	0	ND	0.425-0.502 µg
4-Nitrophenol	4	0	ND	0.455-0.631 µg
Pentachloronitrobenzene	4	0	ND	1.11-2.34 µg
Pentachlorophenol	4	0	ND	0.181-0.192 µg
Phenanthrene	4	0	ND	0.374-0.554 µg
Phenol	4	0	ND	0.535-1.01 µg
Pyrene	4	0	ND	0.244-0.462 µg
1,2,4-Trichlorobenzene	4	0	ND	0.192-0.218 µg
2,4,5-Trichlorophenol	4	0	ND	0.410-0.586 µg
2,4,6-Trichlorophenol	4	0	ND	0.377-0.485 µg
Trip Blank - XAD & Condensate				
Semivolatile Organic Compounds by SW8270				
Acenaphthene	2	0	ND	0.482 µg
Acenaphthylene	2	0	ND	0.658 µg
Acetophenone	2	1	0.549 µg	0.355 µg
4-Aminobiphenyl	2	0	ND	1.07 µg
Aniline	2	0	ND	0.951 µg
Anthracene	2	0	ND	0.539 µg
Benz(a)anthracene	2	0	ND	0.348 µg
Benz(a)pyrene	2	0	ND	0.540 µg
Benzidine	2	0	ND	20.0 µg
Benzo(b)fluoranthene	2	0	ND	0.959 µg
Benzo(g,h,i)perylene	2	0	ND	0.554 µg
Benzo(k)fluoranthene	2	0	ND	0.820 µg
Benzoic Acid	2	1	2.92 µg	2.99 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Benzyl Alcohol	2	0	ND	1.44 µg
4-Bromophenylphenylether	2	0	ND	0.610 µg
Butylbenzylphthalate	2	0	ND	0.751 µg
4-Chloro-3-methylphenol	2	0	ND	0.458 µg
p-Chloroaniline	2	0	ND	0.980 µg
bis(2-Chloroethoxy)methane	2	0	ND	0.334 µg
bis(2-Chloroethyl)ether	2	0	ND	0.466 µg
bis(2-Chloroisopropyl)ether	2	0	ND	0.571 µg
2-Chloronaphthalene	2	0	ND	0.899 µg
2-Chlorophenol	2	0	ND	0.328 µg
4-Chlorophenylphenylether	2	0	ND	0.732 µg
Chrysene	2	0	ND	0.585 µg
Di-n-butylphthalate	2	0	ND	0.310 µg
Di-n-octylphthalate	2	0	ND	0.582 µg
Dibenz(a,h)anthracene	2	0	ND	0.683 µg
Dibenzofuran	2	0	ND	0.391 µg
1,2-Dichlorobenzene	2	0	ND	0.641 µg
1,3-Dichlorobenzene	2	0	ND	0.712 µg
1,4-Dichlorobenzene	2	0	ND	0.707 µg
3,3-Dichlorobenzidine	2	0	ND	1.09 µg
2,4-Dichlorophenol	2	0	ND	0.581 µg
Diethylphthalate	2	0	ND	0.370 µg
P-Dimethylaminoazobenzene	2	0	ND	2.00 µg
2,4-Dimethylphenol	2	0	ND	1.27 µg
Dimethylphthalate	2	0	ND	0.471 µg
4,6-Dinitro-2-methylphenol	2	0	ND	0.731 µg
2,4-Dinitrophenol	2	0	ND	2.59 µg
2,4-Dinitrotoluene	2	0	ND	0.769 µg
2,6-Dinitrotoluene	2	0	ND	1.05 µg
Diphenylamine/N-NitrosoDPA	2	0	ND	0.764 µg
bis(2-Ethylhexyl)phthalate	2	0	ND	1.64 µg
Fluoranthene	2	0	ND	0.425 µg
Fluorene	2	0	ND	0.345 µg
Hexachlorobenzene	2	0	ND	0.528 µg
Hexachlorobutadiene	2	0	ND	0.657 µg
Hexachlorocyclopentadiene	2	0	ND	1.64 µg
Hexachloroethane	2	0	ND	1.00 µg
Indeno(1,2,3)pyrene	2	0	ND	0.481 µg
Isophorone	2	0	ND	0.302 µg
2-Methylnaphthalene	2	0	ND	0.605 µg
4-Methylphenol/3-Methylphenol	2	0	ND	1.24 µg
2-Methylphenol	2	0	ND	0.790 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
N-Nitrosodipropylamine	2	0	ND	0.785 µg
N-Nitrosodimethylamine	2	0	ND	0.783 µg
Naphthalene	2	2	2.02-2.40 µg	0.668 µg
2-Nitroaniline	2	0	ND	0.799 µg
3-Nitroaniline	2	0	ND	0.322 µg
4-Nitroaniline	2	0	ND	0.599 µg
Nitrobenzene	2	0	ND	0.389 µg
2-Nitrophenol	2	0	ND	0.425 µg
4-Nitrophenol	2	0	ND	0.631 µg
Pentachloronitrobenzene	2	0	ND	2.34 µg
Pentachlorophenol	2	0	ND	0.192 µg
Phenanthrene	2	0	ND	0.554 µg
Phenol	2	0	ND	1.01 µg
Pyrene	2	0	ND	0.462 µg
1,2,4-Trichlorobenzene	2	0	ND	0.192 µg
2,4,5-Trichlorophenol	2	0	ND	0.586 µg
2,4,6-Trichlorophenol	2	0	ND	0.485 µg
Laboratory Method Blank - Filter & PNR				
Semivolatile Organic Compounds by S8270				
Acenaphthene	1	0	ND	0.37 µg
Acenaphthylene	1	0	ND	0.22 µg
Acetophenone	1	0	ND	0.48 µg
4-Aminobiphenyl	1	0	ND	0.38 µg
Aniline	1	0	ND	0.36 µg
Anthracene	1	0	ND	0.29 µg
Benzo(a)anthracene	1	0	ND	0.44 µg
Benzo(a)pyrene	1	0	ND	0.51 µg
Benzidine	1	0	ND	0.65 µg
Benzo(b)fluoranthene	1	0	ND	0.47 µg
Benzo(g,h,i)perylene	1	0	ND	0.55 µg
Benzo(k)fluoranthene	1	0	ND	0.49 µg
Benzoic Acid	1	0	ND	1.28 µg
Benzyl Alcohol	1	1	0.82 µg	4.05 µg
4-Bromophenylphenylether	1	0	ND	1.40 µg
Butylbenzylphthalate	1	0	ND	0.53 µg
4-Chloro-3-methylphenol	1	0	ND	0.72 µg
p-Chloroaniline	1	0	ND	0.49 µg
bis(2-Chloroethoxy)methane	1	0	ND	0.54 µg
bis(2-Chloroethyl)ether	1	0	ND	0.63 µg
bis(2-Chloroisopropyl)ether	1	0	ND	0.98 µg
2-Chloronaphthalene	1	0	ND	0.34 µg
2-Chlorophenol	1	0	ND	0.56 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
4-Chlorophenylphenylether	1	0	ND	0.83 µg
Chrysene	1	0	ND	0.48 µg
Di-n-butylphthalate	1	1	3.19 µg	--
Di-n-octylphthalate	1	0	ND	0.27 µg
Dibenz(a,h)anthracene	1	0	ND	0.63 µg
Dibenzofuran	1	0	ND	0.25 µg
1,2-Dichlorobenzene	1	0	ND	0.57 µg
1,3-Dichlorobenzene	1	0	ND	0.53 µg
1,4-Dichlorobenzene	1	0	ND	0.53 µg
3,3-Dichlorobenzidine	1	0	ND	1.08 µg
2,4-Dichlorophenol	1	0	ND	0.71 µg
Diethylphthalate	1	1	4.70 µg	1.04 µg
P-Dimethylaminoazobenzene	1	0	ND	0.93 µg
2,4-Dimethylphenol	1	0	ND	0.65 µg
Dimethylphthalate	1	0	ND	0.32 µg
4,6-Dinitro-2-methylphenol	1	0	ND	2.23 µg
2,4-Dinitrophenol	1	0	ND	2.85 µg
2,4-Dinitrotoluene	1	0	ND	0.96 µg
2,6-Dinitrotoluene	1	0	ND	1.21 µg
bis(2-Ethylhexyl)phthalate	1	1	0.40 µg	--
Fluoranthene	1	0	ND	0.30 µg
Fluorene	1	0	ND	0.35 µg
Hexachlorobenzene	1	0	ND	1.04 µg
Hexachlorobutadiene	1	0	ND	1.31 µg
Hexachlorocyclopentadiene	1	0	ND	1.11 µg
Hexachloroethane	1	0	ND	1.08 µg
Indeno(1,2,3)pyrene	1	0	ND	0.50 µg
Isophorone	1	0	ND	0.35 µg
2-Methylnaphthalene	1	0	ND	0.34 µg
4-Methylphenol/3-Methylphenol	1	0	ND	0.61 µg
2-Methylphenol	1	0	ND	0.64 µg
N-Nitrosodipropylamine	1	0	ND	1.11 µg
N-Nitrosodimethylamine	1	0	ND	1.85 µg
Naphthalene	1	0	ND	0.22 µg
2-Nitroaniline	1	0	ND	1.29 µg
3-Nitroaniline	1	0	ND	1.17 µg
4-Nitroaniline	1	0	ND	1.31 µg
Nitrobenzene	1	0	ND	0.62 µg
2-Nitrophenol	1	0	ND	1.04 µg
4-Nitrophenol	1	0	ND	2.30 µg
Pentachloronitrobenzene	1	0	ND	2.94 µg
Pentachlorophenol	1	0	ND	1.75 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Phenanthrene	1	0	ND	0.28 µg
Phenol	1	0	ND	0.46 µg
Pyrene	1	0	ND	0.32 µg
1,2,4-Trichlorobenzene	1	0	ND	0.67 µg
2,4,5-Trichlorophenol	1	0	ND	1.13 µg
2,4,6-Trichlorophenol	1	0	ND	1.19 µg
PAHs by CARB 429				
Naphthalene	1	1	330 ng	--
2-Methylnaphthalene	1	1	189 ng	--
Acenaphthene	1	1	10.3 ng	--
2-Chloronaphthalene	1	0	ND	0.2 ng
Acenaphthylene	1	1	6.0 ng	--
Fluorene	1	1	30.1 ng	--
Phenanthrene	1	1	43.0 ng	--
Anthracene	1	1	3.3 ng	--
Fluoranthene	1	1	11.8 ng	--
Pyrene	1	1	15.9 ng	--
Benzo(a)anthracene	1	1	0.86 ng	--
Chrysene	1	1	1.8 ng	--
Perylene	1	1	0.26 ng	--
Benzo(b)fluoranthene	1	1	1.6 ng	--
Benzo(k)fluoranthene	1	1	0.50 ng	--
Benzo(a)pyrene	1	1	1.7 ng	--
Benzo(e)pyrene	1	1	5.8 ng	--
Benzo(g,h,i)perylene	1	1	9.9 ng	--
Indeno(1,2,3-cd)pyrene	1	1	1.3 ng	--
Dibenz(a,h)anthracene	1	0	ND	0.1 ng
Trip Blank - Filter & PNR				
Semivoltile Organic Compounds by SW8270				
Acenaphthene	2	0	ND	0.39-1.34 µg
Acenaphthylene	2	0	ND	0.23-0.75 µg
Acetophenone	2	1	0.15 µg	2.27 µg
4-Aminobiphenyl	2	0	ND	0.42-1.10 µg
Aniline	2	0	ND	0.38-1.89 µg
Anthracene	2	0	ND	0.31-0.78 µg
Benz(a)anthracene	2	0	ND	0.49-1.00 µg
Benz(a)pyrene	2	0	ND	0.57-1.48 µg
Benzidine	2	0	ND	0.73-1.55 µg
Benzo(b)fluoranthene	2	0	ND	0.52-1.21 µg
Benzo(g,h,i)perylene	2	0	ND	0.62-1.81 µg
Benzo(k)fluoranthene	2	0	ND	0.55-1.47 µg
Benzoic Acid	2	0	ND	1.30-5.56 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Benzyl Alcohol	2	1	0.80 µg	4.01 µg
4-Bromophenylphenylether	2	0	ND	1.53-3.28 µg
Butylbenzylphthalate	2	0	ND	0.59-1.63 µg
4-Chloro-3-methylphenol	2	0	ND	0.73-2.80 µg
p-Chloroaniline	2	0	ND	0.50-2.17 µg
bis(2-Chloroethoxy)methane	2	0	ND	0.55-2.61 µg
bis(2-Chloroethyl)ether	2	0	ND	0.67-3.78 µg
bis(2-Chloroisopropyl)ether	2	0	ND	1.05-3.01 µg
2-Chloronaphthalene	2	0	ND	0.37-1.11 µg
2-Chlorophenol	2	0	ND	0.60-2.73 µg
4-Chlorophenylphenylether	2	0	ND	0.88-1.95 µg
Chrysene	2	0	ND	0.54-1.16 µg
Di-n-butylphthalate	2	2	2.81-3.81 µg	--
Di-n-octylphthalate	2	0	ND	0.31-0.94 µg
Dibenz(a,h)anthracene	2	0	ND	0.70-1.95 µg
Dibenzofuran	2	0	ND	0.26-0.75 µg
1,2-Dichlorobenzene	2	0	ND	0.61-2.25 µg
1,3-Dichlorobenzene	2	0	ND	0.57-2.30 µg
1,4-Dichlorobenzene	2	0	ND	0.57-2.10 µg
3,3-Dichlorobenzidine	2	0	ND	1.21-2.61 µg
2,4-Dichlorophenol	2	0	ND	0.73-2.61 µg
Diethylphthalate	2	1	0.52 µg	0.87 µg
P-Dimethylaminoazobenzene	2	0	ND	1.04-3.18 µg
2,4-Dimethylphenol	2	0	ND	0.67-2.69 µg
Dimethylphthalate	2	0	ND	0.34-0.98 µg
4,6-Dinitro-2-methylphenol	2	0	ND	2.43-4.99 µg
2,4-Dinitrophenol	2	0	ND	3.03-7.97 µg
2,4-Dinitrotoluene	2	0	ND	1.02-2.73 µg
2,6-Dinitrotoluene	2	0	ND	1.28-3.97 µg
bis(2-Ethylhexyl)phthalate	2	1	0.68 µg	1.37 µg
Fluoranthene	2	0	ND	0.32-0.74 µg
Fluorene	2	0	ND	0.37-1.04 µg
Hexachlorobenzene	2	0	ND	1.13-2.40 µg
Hexachlorobutadiene	2	0	ND	1.34-3.18 µg
Hexachlorocyclopentadiene	2	0	ND	1.18-3.26 µg
Hexachloroethane	2	0	ND	1.16-3.99 µg
Indeno(1,2,3)pyrene	2	0	ND	0.56-1.49 µg
Isophorone	2	0	ND	0.36-1.45 µg
2-Methylnaphthalene	2	0	ND	0.35-1.39 µg
4-Methylphenol/3-Methylphenol	2	0	ND	0.65-2.98 µg
2-Methylphenol	2	0	ND	0.69-3.33 µg
N-Nitrosodipropylamine	2	0	ND	1.19-4.40 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
N-Nitrosodimethylamine	2	0	ND	1.99-7.71 µg
Naphthalene	2	0	ND	0.22-0.94 µg
2-Nitroaniline	2	0	ND	1.37-3.52 µg
3-Nitroaniline	2	0	ND	1.24-4.01 µg
4-Nitroaniline	2	0	ND	1.39-3.88 µg
Nitrobenzene	2	0	ND	0.63-2.53 µg
2-Nitrophenol	2	0	ND	1.06-4.08 µg
4-Nitrophenol	2	0	ND	2.45-4.57 µg
Pentachloronitrobenzene	2	0	ND	3.20-6.43 µg
Pentachlorophenol	2	0	ND	1.90-4.99 µg
Phenanthrene	2	0	ND	0.31-0.76 µg
Phenol	2	1	0.52 µg	2.60 µg
Pyrene	2	0	ND	0.36-0.68 µg
1,2,4-Trichlorobenzene	2	0	ND	0.68-2.13 µg
2,4,5-Trichlorophenol	2	0	ND	1.20-2.55 µg
2,4,6-Trichlorophenol	2	0	ND	1.27-2.69 µg
PAHs by CARB 429				
Naphthalene	2	2	180-218 ng	--
2-Methylnaphthalene	2	2	123-157 ng	--
Acenaphthene	2	2	8.5-27.4 ng	--
2-Chloronaphthalene	2	0	ND	0.05-0.13 ng
Acenaphthalene	2	2	3.8-4.3 ng	--
Fluorene	2	2	30.0-50.6ng	--
Phenanthrene	2	2	69.4-98.5 ng	--
Anthracene	2	2	3.2-4.1 ng	--
Fluoranthene	2	2	12.8-16.7 ng	--
Pyrene	2	2	13.3-14.3 ng	--
Benzo(a)anthracene	2	2	0.76-1.2 ng	--
Chrysene	2	2	2.4-6.3 ng	--
Perylene	2	1	0.18 ng	0.3 ng
Benzo(b)fluoranthene	2	2	1.6-2.9 ng	--
Benzo(k)fluoranthene	2	2	0.44-0.79 ng	--
Benzo(a)pyrene	2	2	0.75-1.1 ng	--
Benzo(e)pyrene	2	2	2.7-3.2 ng	--
Benzo(g,h,i)perylene	2	2	3.6-5.7 ng	--
Indeno(1,2,3-cd)pyrene	2	2	1.4-1.6 ng	--
Dibenz(a,h)anthracene	2	2	0.36 ng	0.3 ng
Field Blank - Filter & PNR				
Semivolatile Compounds by SW8270				
Acenaphthene	2	0	ND	0.43-1.34 µg
Acenaphthylene	2	0	ND	0.25-0.75 µg
Acetophenone	2	0	ND	0.54-2.16 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
4-Aminobiphenyl	2	0	ND	0.46-1.07 µg
Aniline	2	0	ND	0.40-1.80 µg
Anthracene	2	0	ND	0.35-0.77 µg
Benzo(a)anthracene	2	0	ND	0.60-1.00 µg
Benz(a)pyrene	2	0	ND	0.67-1.51 µg
Benzidine	2	0	ND	0.88-1.57 µg
Benzo(b)fluoranthene	2	0	ND	0.61-1.23 µg
Benzo(g,h,i)perylene	2	0	ND	0.72-1.85 µg
Benzo(k)fluoranthene	2	0	ND	0.65-1.50 µg
Benzoic Acid	2	0	ND	1.37-5.48 µg
Benzyl Alcohol	2	1	0.61 µg	3.82 µg
4-Bromophenylphenylether	2	0	ND	1.70-3.22 µg
Butylbenzylphthalate	2	0	ND	0.72-1.65 µg
4-Chloro-3-methylphenol	2	0	ND	0.77-2.76 µg
p-Chloroaniline	2	0	ND	0.52-2.14 µg
bis(2-Chloroethoxy)methane	2	0	ND	0.57-2.58 µg
bis(2-Chloroethyl)ether	2	0	ND	0.71-3.60 µg
bis(2-Chloroisopropyl)ether	2	0	ND	1.10-2.87 µg
2-Chloronaphthalene	2	0	ND	0.40-1.11 µg
2-Chlorophenol	2	0	ND	0.63-2.60 µg
4-Chlorophenylphenylether	2	0	ND	0.96-1.95 µg
Chrysene	2	0	ND	0.65-1.17 µg
Di-n-butylphthalate	2	2	3.64-7.53 µg	--
Di-n-octylphthalate	2	0	ND	0.36-0.96 µg
Dibenz(a,h)anthracene	2	0	ND	0.82-1.99 µg
Dibenzofuran	2	0	ND	0.29-0.75 µg
1,2-Dichlorobenzene	2	0	ND	0.63-2.15 µg
1,3-Dichlorobenzene	2	0	ND	0.60-2.19 µg
1,4-Dichlorobenzene	2	1	0.97 µg	2.00 µg
3,3-Dichlorobenzidine	2	0	ND	1.47-2.63 µg
2,4-Dichlorophenol	2	0	ND	0.76-2.58 µg
Diethylphthalate	2	1	0.57 µg	0.87 µg
P-Dimethylaminoazobenzene	2	0	ND	1.26-3.20 µg
2,4-Dimethylphenol	2	0	ND	0.70-2.65 µg
Dimethylphthalate	2	0	ND	0.37-0.98 µg
4,6-Dinitro-2-methylphenol	2	0	ND	2.71-4.89 µg
2,4-Dinitrophenol	2	0	ND	3.30-7.97 µg
2,4-Dinitrotoluene	2	0	ND	1.11-2.72 µg
2,6-Dinitrotoluene	2	0	ND	1.40-3.97 µg
bis(2-Ethylhexyl)phthalate	2	2	4.04-4.12 µg	--
Fluoranthene	2	0	ND	0.36-0.73 µg
Fluorene	2	0	ND	0.40-1.04 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Hexachlorobenzene	2	0	ND	1.26-2.35 µg
Hexachlorobutadiene	2	0	ND	1.41-3:14 µg
Hexachlorocyclopentadiene	2	0	ND	1.28-3.26 µg
Hexachloroethane	2	0	ND	1.21-3.80 µg
Indeno(1,2,3-cd)pyrene	2	0	ND	0.66-1.52 µg
Isophorone	2	0	ND	0.38-1.43 µg
2-Methylnaphthalene	2	0	ND	0.36-1.37 µg
4-Methylphenol/3-Methylphenol	2	0	ND	0.68-2.85 µg
2-Methylphenol	2	0	ND	0.72-3.18 µg
N-Nitrosodinpropylamine	2	0	ND	1.25-4.20 µg
N-Nitrosodimethylamine	2	0	ND	2.08-7.36 µg
Naphthalene	2	0	ND	0.23-0.93 µg
2-Nitroaniline	2	0	ND	1.49-3.52 µg
3-Nitroaniline	2	0	ND	1.35-4.01 µg
4-Nitroaniline	2	0	ND	1.51-3.88 µg
Nitrobenzene	2	0	ND	0.67-2.49 µg
2-Nitrophenol	2	0	ND	1.12-4.03 µg
4-Nitrophenol	2	0	ND	2.67-4.56 µg
Pentachloronitrobenzene	2	0	ND	3.56-6.31 µg
Pentachlorophenol	2	0	ND	2.12-4.89 µg
Phenanthrene	2	0	ND	0.34-0.74 µg
Phenol	2	1	0.46 µg	2.48 µg
Pyrene	2	0	ND	0.43-0.68 µg
1,2,4-Trichlorobenzene	2	0	ND	0.71-2.10 µg
2,4,5-Trichlorophenol	2	0	ND	1.31-2.55 µg
2,4,6-Trichlorophenol	2	0	ND	1.38-2.69 µg
PAHs by CARB 429				
Naphthalene	2	2	129-221 ng	--
2-Methylnaphthalene	2	2	105-149 ng	--
Acenaphthene	2	2	26.7-29.2 ng	--
2-chloronaphthalene	2	1	0.11 ng	0.2 ng
Acenaphthalene	2	2	3.7-4.7 ng	--
Fluorene	2	2	35.1-46.7 ng	--
Phenanthrene	2	2	93.7-99.6 ng	--
Anthracene	2	2	2.9-3.4 ng	--
Fluoranthene	2	2	16.0-18.9 ng	--
Pyrene	2	2	14.8-15.8 ng	--
Benzo(a)anthracene	2	2	0.70-0.78 ng	--
Chrysene	2	2	1.6-1.9 ng	--
Perylene	2	2	0.27-0.34 ng	--
Benzo(b)fluoranthene	2	2	1.7-1.8 ng	--
Benzo(k)fluoranthene	2	2	0.37-0.52 ng	--

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Benzo(a)pyrene	2	2	0.72-0.90 ng	--
Benzo(e)pyrene	2	2	2.7-3.3 ng	--
Benzo(g,h,i)perylene	2	2	5.4-5.8 ng	--
Indeno(1,2,3-cd)pyrene	2	2	1.4-1.5 ng	--
Dibenz(a,h)anthracene	2	0	ND	0.1 ng
Laboratory Method Blank - XAD & Condensate				
Semivolatile Organic Compounds by SW8270				
Acenaphthene	1	0	ND	1.59 µg
Acenaphthylene	1	0	ND	0.86 µg
Acetophenone	1	0	ND	2.20 µg
4-Aminobiphenyl	1	0	ND	1.27 µg
Aniline	1	0	ND	1.90 µg
Anthracene	1	0	ND	0.90 µg
Benz(a)anthracene	1	0	ND	1.37 µg
Benz(a)pyrene	1	0	ND	1.74 µg
Benzidine	1	0	ND	2.21 µg
Benzo(b)fluoranthene	1	0	ND	1.53 µg
Benzo(g,h,i)perylene	1	0	ND	2.02 µg
Benzo(k)fluoranthene	1	0	ND	1.65 µg
Benzoic Acid	1	1	34.9µg	--
Benzyl Alcohol	1	0	ND	4.05 µg
4-Bromophenylphenylether	1	0	ND	3.90 µg
Butylbenzylphthalate	1	0	ND	2.15 µg
4-Chloro-3-methylphenol	1	0	ND	3.06 µg
p-Chloroaniline	1	0	ND	2.34 µg
bis(2-Chloroethoxy)methane	1	0	ND	2.89 µg
bis(2-Chloroethyl)ether	1	0	ND	3.89 µg
bis(2-Chloroisopropyl)ether	1	0	ND	3.20 µg
2-Chloronaphthalene	1	0	ND	1.28 µg
2-Chlorophenol	1	0	ND	2.82 µg
4-Chlorophenylphenylether	1	0	ND	2.36 µg
Chrysene	1	1	0.97 µg	--
Di-n-butylphthalate	1	1	5.83 µg	--
Di-n-octylphthalate	1	0	ND	1.07 µg
Dibenz(a,h)anthracene	1	0	ND	2.33 µg
Dibenzofuran	1	0	ND	0.87 µg
1,2-Dichlorobenzene	1	0	ND	2.41 µg
1,3-Dichlorobenzene	1	0	ND	2.32 µg
1,4-Dichlorobenzene	1	0	ND	2.26 µg
3,3-Dichlorobenzidine	1	0	ND	3.63 µg
2,4-Dichlorophenol	1	0	ND	2.93 µg
Diethylphthalate	1	0	ND	1.04 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
P-Dimethylaminoazobenzene	1	0	ND	4.43 µg
2,4-Dimethylphenol	1	0	ND	2.91 µg
Dimethylphthalate	1	0	ND	1.17 µg
4,6-Dinitro-2-methylphenol	1	0	ND	5.54 µg
2,4-Dinitrophenol	1	0	ND	8.24 µg
2,4-Dinitrotoluene	1	0	ND	3.39 µg
2,6-Dinitrotoluene	1	0	ND	4.57 µg
bis(2-Ethylhexyl)phthalate	1	1	1.93 µg	--
Fluoranthene	1	0	ND	0.88 µg
Fluorene	1	0	ND	1.23 µg
Hexachlorobenzene	1	0	ND	2.89 µg
Hexachlorobutadiene	1	0	ND	3.67 µg
Hexachlorocyclopentadiene	1	0	ND	3.67 µg
Hexachloroethane	1	0	ND	4.08 µg
Indeno(1,2,3)pyrene	1	0	ND	1.75 µg
Isophorone	1	0	ND	1.68 µg
2-Methylnaphthalene	1	0	ND	1.51 µg
4-Methylphenol/3-Methylphenol	1	0	ND	3.06 µg
2-Methylphenol	1	0	ND	3.20 µg
N-Nitrosodipropylamine	1	0	ND	4.64 µg
N-Nitrosodimethylamine	1	0	ND	8.27 µg
Naphthalene	1	0	ND	1.04 µg
2-Nitroaniline	1	0	ND	4.13 µg
3-Nitroaniline	1	0	ND	4.73 µg
4-Nitroaniline	1	0	ND	4.89 µg
Nitrobenzene	1	0	ND	2.77 µg
2-Nitrophenol	1	0	ND	4.47 µg
4-Nitrophenol	1	0	ND	5.73 µg
Pentachloronitrobenzene	1	0	ND	7.45 µg
Pentachlorophenol	1	0	ND	4.76 µg
Phenanthrene	1	0	ND	0.87 µg
Phenol	1	0	ND	2.86 µg
Pyrene	1	0	ND	0.91 µg
1,2,4-Trichlorobenzene	1	0	ND	2.44 µg
2,4,5-Trichlorophenol	1	0	ND	3.02 µg
2,4,6-Trichlorophenol	1	0	ND	3.12 µg
PAHs by CARB 429				
Naphthalene	1	1	76.6 ng	--
2-Methylnaphthalene	1	1	164 ng	--
Acenaphthene	1	1	32.4 ng	--
2-Chloronaphthalene	1	0	ND	0.2 ng
Acenaphthylene	1	1	10.5 ng	--

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Fluorene	1	1	39.6 ng	--
Phenanthrene	1	1	150 ng	--
Anthracene	1	1	5.0 ng	--
Fluoranthene	1	1	25.4 ng	--
Pyrene	1	1	26.0 ng	--
Benzo(a)anthracene	1	1	1.5 ng	--
Chrysene	1	1	2.7 ng	--
Perylene	1	0	ND	0.2 ng
Benzo(b)fluoranthene	1	1	2.6 ng	--
Benzo(k)fluoranthene	1	1	0.61 ng	--
Benzo(a)pyrene	1	1	1.5 ng	--
Benzo(e)pyrene	1	1	3.6 ng	--
Benzo(g,h,i)perylene	1	1	9.7 ng	--
Indeno(1,2,3-cd)pyrene	1	1	2.9 ng	--
Dibenz(a,h)anthracene	1	0	ND	0.3 ng
Trip Blank - XAD & Condensate				
Semivolatile Organic Compounds by SW8270				
Acenaphthene	2	0	ND	1.56-1.70 µg
Acenaphthylene	2	0	ND	0.84-0.92 µg
Acetophenone	2	1	0.62 µg	2.38 µg
4-Aminobiphenyl	2	0	ND	1.30-1.43 µg
Aniline	2	0	ND	1.95-2.06 µg
Anthracene	2	0	ND	0.92-1.01 µg
Benz(a)anthracene	2	0	ND	1.18-1.38 µg
Benz(a)pyrene	2	0	ND	1.64-1.77 µg
Benzidine	2	0	ND	1.91-2.23 µg
Benzo(b)fluoranthene	2	0	ND	1.45-1.56 µg
Benzo(g,h,i)perylene	2	0	ND	1.91-2.05 µg
Benzo(k)fluoranthene	2	0	ND	1.56-1.68 µg
Benzoic Acid	2	2	26.55-47.52 µg	--
Benzyl Alcohol	2	0	ND	4.15-4.38 µg
4-Bromophenylphenylether	2	0	ND	3.98-4.39 µg
Butylbenzylphthalate	2	0	ND	1.86-2.17 µg
4-Chloro-3-methylphenol	2	0	ND	2.98-3.29 µg
p-Chloroaniline	2	0	ND	2.28-2.52 µg
bis(2-Chloroethoxy)methane	2	0	ND	2.82-3.11 µg
bis(2-Chloroethyl)ether	2	0	ND	3.99-4.21 µg
bis(2-Chloroisopropyl)ether	2	0	ND	3.27-3.46 µg
2-Chloronaphthalene	2	0	ND	1.26-1.37 µg
2-Chlorophenol	2	0	ND	2.89-3.05 µg
4-Chlorophenylphenylether	2	0	ND	2.31-2.52 µg
Chrysene	2	0	ND	1.34-1.57 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Di-n-butylphthalate	2	2	65.25-85.44 µg	--
Di-n-octylphthalate	2	0	ND	1.01-1.09 µg
Dibenz(a,h)anthracene	2	0	ND	2.20-2.37 µg
Dibenzofuran	2	0	ND	0.86-0.94 µg
1,2-Dichlorobenzene	2	0	ND	2.47-2.61 µg
1,3-Dichlorobenzene	2	0	ND	2.37-2.50 µg
1,4-Dichlorobenzene	2	0	ND	2.31-2.44 µg
3,3-Dichlorobenzidine	2	0	ND	3.13-3.66 µg
2,4-Dichlorophenol	2	0	ND	2.86-3.16 µg
Diethylphthalate	2	2	1.55 µg	1.12 µg
P-Dimethylaminoazobenzene	2	0	ND	3.82-4.47 µg
2,4-Dimethylphenol	2	0	ND	2.84-3.13 µg
Dimethylphthalate	2	0	ND	1.14-1.25 µg
4,6-Dinitro-2-methylphenol	2	0	ND	5.65-6.24 µg
2,4-Dinitrophenol	2	0	ND	8.09-8.82 µg
2,4-Dinitrotoluene	2	0	ND	3.33-3.63 µg
2,6-Dinitrotoluene	2	0	ND	4.48-4.89 µg
bis(2-Ethylhexyl)phthalate	2	2	3.68-5.41 µg	--
Fluoranthene	2	0	ND	0.90-0.99 µg
Fluorene	2	0	ND	1.21-1.32 µg
Hexachlorobenzene	2	0	ND	2.94-3.25 µg
Hexachlorobutadiene	2	0	ND	3.58-3.94 µg
Hexachlorocyclopentadiene	2	0	ND	3.60-3.92 µg
Hexachloroethane	2	0	ND	4.18-4.41 µg
Indeno(1,2,3)pyrene	2	0	ND	1.65-1.78 µg
Isophorone	2	0	ND	1.64-1.81 µg
2-Methylnaphthalene	2	1	0.21 µg	1.62 µg
4-Methylphenol/3-Methylphenol	2	0	ND	3.14-3.31 µg
2-Methylphenol	2	0	ND	3.28-3.46 µg
N-Nitrosodipropylamine	2	0	ND	4.75-5.02 µg
N-Nitrosodimethylamine	2	0	ND	8.47-8.94 µg
Naphthalene	2	1	0.99 µg	1.11 µg
2-Nitroaniline	2	0	ND	4.06-4.42 µg
3-Nitroaniline	2	0	ND	4.64-5.06 µg
4-Nitroaniline	2	0	ND	4.80-5.24 µg
Nitrobenzene	2	0	ND	2.70-2.98 µg
2-Nitrophenol	2	0	ND	4.36-4.81 µg
4-Nitrophenol	2	0	ND	5.63-6.14 µg
Pentachloronitrobenzene	2	0	ND	7.59-8.39 µg
Pentachlorophenol	2	0	ND	4.85-5.36 µg
Phenanthrene	2	0	ND	0.89-0.98 µg
Phenol	2	1	1.07 µg	3.09 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Pyrene	2	0	ND	0.78-0.92 µg
1,2,4-Trichlorobenzene	2	0	ND	2.38-2.63 µg
2,4,5-Trichlorophenol	2	0	ND	2.96-3.23 µg
2,4,6-Trichlorophenol	2	0	ND	3.06-3.33 µg
PAHs by CARB 429				
Naphthalene	2	2	418-684 ng	--
2-Methylnaphthalene	2	2	144-225 ng	--
Acenaphthene	2	2	23.5-34.3 ng	--
2-Chloronaphthalene	2	0	ND	0.16-0.3 ng
Acenaphthalene	2	2	12.9-22.0 ng	--
Fluorene	2	2	29.5-53.5 ng	--
Phenanthrene	2	2	108-187 ng	--
Anthracene	2	2	4.4-6.6 ng	--
Fluoranthene	2	2	22.6-40.2 ng	--
Pyrene	2	2	18.0-32.8 ng	--
Benzo(a)anthracene	2	2	2.0-2.6 ng	--
Chrysene	2	2	3.8-4.8 ng	--
Perylene	2	2	0.43-0.72 ng	--
Benzo(b)fluoranthene	2	2	3.4-4.8 ng	--
Benzo(k)fluoranthene	2	2	0.99-2.3 ng	--
Benzo(a)pyrene	2	2	1.2-1.9 ng	--
Benzo(e)pyrene	2	2	3.1-3.5 ng	--
Benzo(g,h,i)perylene	2	2	4.6-6.8 ng	--
Indeno(2,2,3-cd)pyrene	2	2	1.9-2.5 ng	--
Dibenz(a,h)anthracene	2	0	ND	0.2-0.3 ng
Field Blank - XAD & Condensate				
Semivolatile Organic Compounds by SW8270				
Acenaphthene	2	0	ND	1.73-1.79 µg
Acenaphthylene	2	0	ND	0.93-0.96 µg
Acetophenone	2	0	ND	2.45-2.51 µg
4-Aminobiphenyl	2	0	ND	1.43-1.44 µg
Aniline	2	0	ND	2.12-2.17 µg
Anthracene	2	0	ND	1.01-1.02 µg
Benz(a)anthracene	2	0	ND	1.35-1.41 µg
Benz(a)pyrene	2	0	ND	1.72-1.83 µg
Benzidine	2	0	ND	2.18-2.27 µg
Benzo(b)fluoranthene	2	0	ND	1.52-1.61 µg
Benzo(g,h,i)perylene	2	0	ND	2.00-2.13
Benzo(k)fluoranthene	2	0	ND	1.64-1.74 µg
Benzoic Acid	2	2	20.3-21.4 µg	--
Benzyl Alcohol	2	1	0.76 µg	4.52 µg
4-Bromophenylphenylether	2	0	ND	4.39-4.44 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Butylbenzylphthalate	2	0	ND	2.13-2.22 µg
4-Chloro-3-methylphenol	2	0	ND	3.25-3.36 µg
p-Chloroaniline	2	0	ND	2.48-2.57 µg
bis(2-Chloroethoxy)methane	2	0	ND	3.07-3.18 µg
bis(2-Chloroethyl)ether	2	0	ND	4.34-4.44 µg
bis(2-Chloroisopropyl)ether	2	0	ND	3.57-3.65 µg
2-Chloronaphthalene	2	0	ND	1.40-1.44 µg
2-Chlorophenol	2	0	ND	3.15-3.22 µg
4-Chlorophenylphenylether	2	0	ND	2.57-2.66 µg
Chrysene	2	0	ND	1.54-1.60 µg
Di-n-butylphthalate	2	2	25.2-26.0 µg	--
Di-n-octylphthalate	2	0	ND	1.06-1.13 µg
Dibenz(a,h)anthracene	2	0	ND	2.31-2.45 µg
Dibenzofuran	2	0	ND	0.95-0.98 µg
1,2-Dichlorobenzene	2	0	ND	2.69-2.75 µg
1,3-Dichlorobenzene	2	0	ND	2.58-2.64 µg
1,4-Dichlorobenzene	2	0	ND	2.52-2.58 µg
3,3-Dichlorobenzidine	2	0	ND	3.58-3.74 µg
2,4-Dichlorophenol	2	0	ND	3.12-3.22 µg
Diethylphthalate	2	1	1.03 µg	1.14 µg
P-Dimethylaminoazobenzene	2	0	ND	4.37-4.56 µg
2,4-Dimethylphenol	2	0	ND	3.09-3.20 µg
Dimethylphthalate	2	0	ND	1.27-1.31 µg
4,6-Dinitro-2-methylphenol	2	0	ND	6.24-6.31 µg
2,4-Dinitrophenol	2	0	ND	9.00-9.28 µg
2,4-Dinitrotoluene	2	0	ND	3.70-3.82 µg
2,6-Dinitrotoluene	2	0	ND	4.99-5.14 µg
bis(2-Ethylhexyl)phthalate	2	2	3.88-4.19 µg	--
Fluoranthene	2	0	ND	0.99-1.00 µg
Fluorene	2	0	ND	1.35-1.39 µg
Hexachlorobenzene	2	0	ND	3.25-3.28 µg
Hexachlorobutadiene	2	0	ND	3.89-4.03 µg
Hexachlorocyclopentadiene	2	0	ND	4.00-4.13 µg
Hexachloroethane	2	0	ND	4.55-4.66 µg
Indeno(1,2,3)pyrene	2	0	ND	1.73-1.84 µg
Isophorone	2	0	ND	1.78-1.84 µg
2-Methylnaphthalene	2	0	ND	1.60-1.66 µg
4-Methylphenol/3-Methylphenol	2	0	ND	3.42-3.49 µg
2-Methylphenol	2	0	ND	3.57-3.65 µg
N-Nitrosodipropylamine	2	0	ND	5.18-5.30 µg
N-Nitrosodimethylamine	2	0	ND	9.23-9.44 µg
Naphthalene	2	1	0.86 µg	1.10 µg

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
2-Nitroaniline	2	0	ND	4.51-4.65 µg
3-Nitroaniline	2	0	ND	5.17-5.33 µg
4-Nitroaniline	2	0	ND	5.34-5.51 µg
Nitrobenzene	2	0	ND	2.94-3.04 µg
2-Nitrophenol	2	0	ND	4.75-4.91 µg
4-Nitrophenol	2	0	ND	6.26-6.46 µg
Pentachloronitrobenzene	2	0	ND	8.39-8.47 µg
Pentachlorophenol	2	0	ND	5.36-5.41 µg
Phenanthrene	2	0	ND	0.98-0.99 µg
Phenol	2	1	0.89 µg	3.26 µg
Pyrene	2	0	ND	0.90-0.93 µg
1,2,4-Trichlorobenzene	2	0	ND	2.59-2.68 µg
2,4,5-Trichlorophenol	2	0	ND	3.30-3.40 µg
2,4,6-Trichlorophenol	2	0	ND	3.40-3.51 µg
PAHs by CARB 429				
Naphthalene	2	2	382-599 ng	--
2-Methylnaphthalene	2	2	140-234 ng	--
Acenaphthene	2	2	20.7-36.4 ng	--
2-Chloronaphthalene	2	1	0.09 ng	0.3 ng
Acenaphthalene	2	2	12.8-19.0 ng	--
Fluorene	2	2	34.6-49.3 ng	--
Phenanthrene	2	2	105-160 ng	--
Anthracene	2	2	4.3-6.0 ng	--
Fluoranthene	2	2	26.9-38.4 ng	--
Pyrene	2	2	17.8-30.9 ng	--
Benzo(a)anthracene	2	2	1.8-2.4 ng	--
Chrysene	2	2	3.1-4.0 ng	--
Perylene	2	1	0.65 ng	0.3 ng
Benzo(b)fluoranthene	2	2	3.8-5.6 ng	--
Benzo(k)fluoranthene	2	2	1.0-1.6 ng	--
Benzo(a)pyrene	2	2	1.5-1.7 ng	--
Benzo(e)pyrene	2	2	3.6-4.2 ng	--
Benzo(g,h,i)perylene	2	2	5.9-9.1 ng	--
Indeno(1,2,3-cd)pyrene	2	2	2.0-3.8 ng	--
Dibenz(a,h)anthracene	2	1	0.49 ng	0.4 ng
Laboratory Method Blank - Semivolatile Compounds in Aqueous Samples				
Acenaphthene	2	0	ND	0.604-0.669 µg/L
Acenaphthylene	2	0	ND	0.456-0.616 µg/L
Acetophenone	2	0	ND	0.539-0.594 µg/L
4-Aminobiphenyl	2	0	ND	3.81-4.09 µg/L
Aniline	2	0	ND	0.682-1.02 µg/L
Anthracene	2	0	ND	0.460-0.664 µg/L

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Benz(a)anthracene	2	0	ND	0.511-0.728 µg/L
Benz(a)pyrene	2	0	ND	0.661-0.682 µg/L
Benzidine	2	0	ND	20.0 µg/L
Benzo(b)fluoranthene	2	0	ND	0.649-0.768 µg/L
Benzo(g,h,i)perylene	2	0	ND	0.684-0.702 µg/L
Benzo(k)fluoranthene	2	0	ND	0.945-1.11 µg/L
Benzoic Acid	2	0	ND	3.11-6.03 µg/L
Benzyl Alcohol	2	0	ND	0.428-0.698 µg/L
4-Bromophenylphenylether	2	0	ND	0.288-0.752 µg/L
Butylbenzylphthalate	2	0	ND	0.474-0.896 µg/L
4-Chloro-3-methylphenol	2	0	ND	0.380-0.625 µg/L
p-Chloroaniline	2	0	ND	0.898-1.01 µg/L
bis(2-Chloroethoxy)methane	2	0	ND	0.546-0.673 µg/L
bis(2-Chloroethyl)ether	2	0	ND	0.595-0.670 µg/L
bis(2-Chloroisopropyl)ether	2	0	ND	0.555-1.11 µg/L
2-Chloronaphthalene	2	0	ND	0.797-0.962 µg/L
2-Chlorophenol	2	0	ND	0.537-0.637 µg/L
4-Chlorophenylphenylether	2	0	ND	0.451-0.898 µg/L
Chrysene	2	0	ND	0.618-0.737 µg/L
Di-n-butylphthalate	2	0	ND	0.343-0.475 µg/L
Di-n-octylphthalate	2	0	ND	0.646-0.673 µg/L
Dibenz(a,h)anthracene	2	0	ND	0.729-0.810 µg/L
Dibenzofuran	2	0	ND	0.535-0.608 µg/L
1,2-Dichlorobenzene	2	0	ND	0.604-0.704 µg/L
1,3-Dichlorobenzene	2	0	ND	0.405-0.760 µg/L
1,4-Dichlorobenzene	2	0	ND	1.04-1.59 µg/L
3,3-Dichlorobenzidine	2	0	ND	0.716-3.70 µg/L
2,4-Dichlorophenol	2	0	ND	0.404-0.701 µg/L
Diethylphthalate	2	0	ND	0.297-0.649 µg/L
P-Dimethylaminoazobenzene	2	0	ND	0.485-0.754 µg/L
2,4-Dimethylphenol	2	0	ND	0.65-0.658 µg/L
Dimethylphthalate	2	0	ND	0.405-0.444 µg/L
4,6-Dinitro-2-methylphenol	2	0	ND	0.457-2.89 µg/L
2,4-Dinitrophenol	2	0	ND	1.21-1.91 µg/L
2,4-Dinitrotoluene	2	0	ND	0.317-0.777 µg/L
2,6-Dinitrotoluene	2	0	ND	0.618-0.752 µg/L
Diphenylamine/N-NitrosoDPA	2	0	ND	0.649-0.658 µg/L
bis(2-Ethylhexyl)phthalate	2	0	ND	0.840-0.963 µg/L
Fluoranthene	2	0	ND	0.672-0.686 µg/L
Fluorene	2	0	ND	0.635-0.710 µg/L
Hexachlorobenzene	2	0	ND	0.537-1.51 µg/L
Hexachlorobutadiene	2	0	ND	0.714-0.983 µg/L

Table A-2 (Continued)

Analyte	Number of Blanks Analyzed	Number of Detects	Range of Compounds Detected	Detection Limit
Hexachlorocyclopentadiene	2	0	ND	0.850-1.98 µg/L
Hexachloroethane	2	0	ND	1.79-5.56 µg/L
Indeno(1,2,3)pyrene	2	0	ND	0.534-0.763 µg/L
Isophorone	2	0	ND	0.340-0.548 µg/L
2-Methylnaphthalene	2	0	ND	0.811-1.17 µg/L
4-Methylphenol/3-Methylphenol	2	0	ND	0.442-0.859 µg/L
2-Methylphenol	2	0	ND	0.477-0.575 µg/L
N-Nitrosodipropylamine	2	0	ND	0.567-0.804 µg/L
N-Nitrosodimethylamine	2	0	ND	0.506-0.832 µg/L
Naphthalene	2	1	1.78 µg/L	0.719-0.828 µg/L
2-Nitroaniline	2	0	ND	0.515-0.748 µg/L
3-Nitroaniline	2	0	ND	0.511-0.894 µg/L
4-Nitroaniline	2	0	ND	0.575-0.621 µg/L
Nitrobenzene	2	0	ND	0.544-0.841 µg/L
2-Nitrophenol	2	0	ND	0.773-1.08 µg/L
4-Nitrophenol	2	0	ND	0.761-1.15 µg/L
Pentachloronitrobenzene	2	0	ND	1.32-1.78 µg/L
Pentachlorophenol	2	0	ND	0.486-0.648 µg/L
Phenanthrene	2	0	ND	0.617-0.634 µg/L
Phenol	2	0	ND	0.429-0.707 µg/l
Pyrene	2	0	ND	0.798-0.814 µg/L
1,2,4-Trichlorobenzene	2	0	ND	0.498-0.645 µg/L
2,4,5-Trichlorophenol	2	0	ND	0.323-0.476 µg/L
2,4,6-Trichlorophenol	2	0	ND	0.385-0.450 µg/L

Table A-3
Matrix Spike/Duplicate Sample Results

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Metals in Gas Particulate Phase - ICP-AES									
Filter & PNR: Incinerator Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Aluminum		20	75-125	90	89	1.1			
Antimony		20	75-125	80	76	5.1			
Barium		20	75-125	98	96	2.1			
Beryllium		20	75-125	97	96	1.0			
Calcium		20	75-125	93	93	0			
Chromium		20	75-125	92	92	0			
Cobalt		20	75-125	89	88	1.1			
Copper		20	75-125	94	93	1.1			
Iron		20	75-125	93	93	0			
Magnesium		20	75-125	86	85	1.2			
Manganese		20	75-125	91	91	0			
Molybdenum		20	75-125	93	92	1.1			
Nickel		20	75-125	95	89	6.5			
Phosphorus		20	75-125	97	90	7.5			
Potassium		20	75-125	91	89	2.2			
Sodium		20	75-125	92	90	2.2			
Titanium		20	75-125	93	93	0			
Vanadium		20	75-125	93	91	2.2			
Zinc		20	75-125	85	84	1.2			
Filter & PNR: Turbine Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Aluminum		20	75-125	91	91	0			
Antimony		20	75-125	88	94	6.6			
Barium		20	75-125	98	98	0			
Beryllium		20	75-125	93	93	0			
Calcium		20	75-125	95	95	0			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Chromium		20	75-125	94	94	0			
Cobalt		20	75-125	91	89	2.2			
Copper		20	75-125	95	95	0			
Iron		20	75-125	94	94	0			
Magnesium		20	75-125	88	88	0			
Manganese		20	75-125	93	93	0			
Molybdenum		20	75-125	92	92	0			
Nickel		20	75-125	93	91	2.2			
Phosphorus		20	75-125	95	98	3.1			
Potassium		20	75-125	91	93	2.2			
Sodium		20	75-125	94	95	1.1			
Titanium		20	75-125	93	94	1.1			
Vanadium		20	75-125	94	94	0			
Zinc		20	75-125	88	87	1.1			
Metals in Gas Particulate Phase - GFAAS and CVAAS									
Filter & PNR: Incinerator Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Arsenic		20	75-125	100	97	3.0			
Cadmium		20	75-125	74 Q	85	14			
Lead		20	75-125	59 Q	62 Q	5.0			
Mercury (CVAAS)		20	75-125	112	111	0			
Selenium		20	75-125	18 Q	18 Q	0			
Filter & PNR: Turbine Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Arsenic		20	75-125	104	104	0			
Cadmium		20	75-125	86	87	1.2			
Lead		20	75-125	81	78	3.8			
Mercury (CVAAS)		20	75-125	110	111	0.9			
Selenium		20	75-125	83	85	2.4			

Table A-3 (Continued)

		Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
Measurement Parameter	How Measured	(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Metals in Gas Vapor Phase - ICP/MS									
HNO_3/H_2O_2 Impingers: Turbine Stack	Precision - NA								
	Accuracy - Matrix-spiked Sample								
Antimony		20	75-125	92					
Arsenic		20	75-125	105					
Barium		20	75-125	110					
Beryllium		20	75-125	112					
Cadmium		20	75-125	94					
Chromium		20	75-125	94					
Cobalt		20	75-125	87					
Copper		20	75-125	99					
Lead		20	75-125	107					
Manganese		20	75-125	95					
Mercury		20	75-125	56 Q					
Molybdenum		20	75-125	95					
Nickel		20	75-125	100					
Selenium		20	75-125	102					
Vanadium		20	75-125	101					
10% HNO_3/30% H_2O_2 Impingers: Raw Syngas	Precision - NA								
	Accuracy - Matrix-spiked Sample								
Antimony		20	75-125	92					
Arsenic		20	75-125	107					
Barium		20	75-125	98					
Beryllium		20	75-125	110					
Cadmium		20	75-125	95					
Chromium		20	75-125	99					
Cobalt		20	75-125	94					
Copper		20	75-125	101					
Lead		20	75-125	108					
Manganese		20	75-125	102					

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision (% RPD)	Bias (% Rec)	% Recovery		Precision (% RPD)	% Recovery		Precision (% RPD)
				Sample	Duplicate		Sample	Duplicate	
Mercury		20	75-125	149 Q					
Molybdenum		20	75-125	91					
Nickel		20	75-125	96					
Selenium		20	75-125	124					
Vanadium		20	75-125	129 Q					
10% HNO_3/30% H_2O_2 Impingers:	Precision - NA								
Tail Gas	Accuracy - Matrix-spiked Sample								
Antimony		20	75-125	79					
Arsenic		20	75-125	92					
Barium		20	75-125	95					
Beryllium		20	75-125	89					
Cadmium		20	75-125	87					
Chromium		20	75-125	59 Q					
Cobalt		20	75-125	73 Q					
Copper		20	75-125	77					
Lead		20	75-125	96					
Manganese		20	75-125	75					
Mercury		20	75-125	162 Q					
Molybdenum		20	75-125	81					
Nickel		20	75-125	70 Q					
Selenium		20	75-125	90					
Vanadium		20	75-125	81					
Metals in Gas Vapor Phase - ICP-AES									
HNO_3/H_2O_2 Impingers: Turbine Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Aluminum		20	75-125	91	90	1.1			
Antimony		20	75-125	86	83	3.6			
Barium		20	75-125	91	91	0			
Beryllium		20	75-125	93	92	1.1			
Boron		20	74-125	96	95	1.0			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision (% RPD)	Bias (% Rec)	% Recovery Sample	% Recovery Duplicate	Precision (% RPD)	% Recovery Sample	% Recovery Duplicate	Precision (% RPD)
Calcium		20	75-125	93	92	1.1			
Chromium		20	75-125	91	90	1.1			
Cobalt		20	75-125	88	88	0			
Copper		20	75-125	91	90	1.1			
Iron		20	75-125	93	91	2.2			
Magnesium		20	75-125	90	90	0			
Manganese		20	75-125	90	89	1.1			
Molybdenum		20	75-125	91	90	1.1			
Nickel		20	75-125	92	89	3.3			
Phosphorus		20	75-125	89	90	1.1			
Potassium		20	75-125	93	92	1.1			
Silicon		20	75-125	100	95	5.1			
Sodium		20	75-125	90	89	1.1			
Titanium		20	75-125	90	89	1.1			
Vanadium		20	75-125	92	90	2.2			
Zinc		20	75-125	90	89	1.1			
10% HNO_3/30% H_2O_2 Impingers:	Precision - Matrix-spiked Duplicate								
Raw Syngas	Accuracy - Matrix-spiked Sample								
Aluminum		20	75-125	91	89	2.2			
Antimony		20	75-125	85	92	7.9			
Barium		20	75-125	92	90	2.2			
Beryllium		20	75-125	94	92	2.2			
Boron		20	75-125	95	92	3.2			
Calcium		20	75-125	93	91	2.2			
Chromium		20	75-125	91	90	1.1			
Cobalt		20	75-125	89	89	0			
Copper		20	75-125	91	90	1.1			
Iron		20	75-125	92	90	2.2			
Magnesium		20	75-125	92	89	3.3			
Manganese		20	75-125	91	90	1.1			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Molybdenum		20	75-125	92	91	1.1			
Nickel		20	75-125	91	90	1.1			
Phosphorus		20	75-125	91	87	4.5			
Potassium		20	75-125	92	90	2.2			
Silicon		20	75-125	97	96	1.0			
Sodium		20	75-125	89	86	3.4			
Titanium		20	75-125	90	89	1.1			
Vanadium		20	75-125	91	90	1.1			
Zinc		20	75-125	89	89	0			
10% HNO_3/30% H_2O_2 Impingers:	Precision - Matrix-spiked Duplicate								
Tail Gas	Accuracy - Matrix-spiked Sample								
Aluminum		20	75-125	91	92	1.1	88	87	1.1
Antimony		20	75-125	98	94	4.2	86	87	1.2
Barium		20	75-125	60 Q	55 Q	8.7	64 Q	58 Q	9.8
Beryllium		20	75-125	101	102	0.98	95	95	0
Boron		20	75-125	93	91	2.2	89	92	3.3
Calcium		20	75-125	95	96	1	90	90	0
Chromium		20	75-125	91	91	0	89	89	0
Cobalt		20	75-125	91	91	0	87	88	1.1
Copper		20	75-125	90	91	1.1	90	88	2.2
Iron		20	75-125	94	94	0	90	89	1.1
Magnesium		20	75-125	90	90	0	86	86	0
Manganese		20	75-125	91	92	1.1	89	88	1.1
Molybdenum		20	75-125	92	91	1.1	90	90	0
Nickel		20	75-125	89	95	6.5	90	91	1.1
Phosphorus		20	75-125	95	101	6.1	95	96	1.0
Potassium		20	75-125	92	93	1.1	87	86	1.2
Silicon		20	75-125	94	94	0	92	91	1.1
Sodium		20	75-125	90	91	1.1	85	86	1.2
Titanium		20	75-125	93	93	0	89	88	1.1

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Vanadium		20	75-125	92		92		0		90		89		1.1	
Zinc		20	75-125	87		84		3.5		87		86		1.2	
Metals in Gas Vapor Phase - GFAAS and CVAAS															
HNO_3/H_2O_2 Impingers: Turbine Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Arsenic		20	75-125	95		97		2.1							
Cadmium		20	75-125	113		118		4.3							
Lead		20	75-125	89		91		2.2							
Mercury (CVAAS)		20	75-125	93		93		0							
Selenium		20	75-125	90		91		1.1							
10% HNO_3/30% H_2O_2 Impingers: Raw Syngas	Precision - Matrix-spiked Duplicate Accuracy - Matrix-spiked Sample														
Arsenic		20	75-125	93		95		2.1							
Cadmium		20	75-125	117		119		1.7							
Lead		20	75-125	100		105		4.9							
Mercury (CVAAS)		20	75-125	99		104		4.9							
Selenium		20	75-125	102		101		1.0							
10% HNO_3/30% H_2O_2 Impingers: Tail Gas	Precision - Matrix-spiked Duplicate Accuracy - Matrix-spiked Sample														
Arsenic		20	75-125	93		93		0							
Cadmium		20	75-125	129	Q	124		4.0		127	Q	134	Q	5.4	
Lead		20	75-125	101		100		1.0							
Mercury (CVAAS)		20	75-125	108		108		0							
Selenium		20	75-125	8.9	Q	24	Q	92	Q	8.5	Q	10	Q	16	Q
$KMnO_4$ Impingers: Turbine Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Mercury (CVAAS)		20	75-125	63	Q	80		24	Q	74	Q	86		15	

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Vapor Phase Metals on Charcoal - ICP-AES															
Charcoal Tubes: Sweet Syngas	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Aluminum		20	75-125	94		102		8.2		96		98		2.1	
Antimony		20	75-125	89		90		1.1		86		89		3.4	
Barium		20	75-125	84		77		8.7		80		83		3.7	
Beryllium		20	75-125	81		75		7.7		77		80		3.8	
Boron		20	75-125	84		74	Q	13		75		83		10	
Calcium		20	75-125	97		105		7.9		99		100		1.0	
Chromium		20	75-125	80		75		6.4		77		80		3.8	
Cobalt		20	75-125	79		72	Q	9.3		75		77		2.6	
Copper		20	75-125	81		74	Q	9		77		80		3.8	
Iron		20	75-125	95		102		7.1		97		98		1.0	
Magnesium		20	75-125	94		102		8.2		96		98		2.1	
Manganese		20	75-125	81		75		7.7		77		80		3.8	
Molybdenum		20	75-125	80		76		5.1		76		80		5.1	
Nickel		20	75-125	78		74	Q	5.3		70	Q	76		8.2	
Phosphorus		20	75-125	77		74	Q	4.0		73	Q	77		5.3	
Potassium		20	75-125	94		102		8.2		96		98		2.1	
Silicon		20	75-125	83		77		7.5		81		83		2.4	
Sodium		20	75-125	96		103		7.0		97		99		2.0	
Titanium		20	75-125	82		75		8.9		78		81		3.8	
Vanadium		20	75-125	82		76		7.6		78		82		5.0	
Zinc		20	75-125	75		68	Q	9.8		71	Q	73	Q	2.8	
Charcoal Tubes: Media Spike	Precision - Spiked Media Blank Duplicate														
	Accuracy - Spiked Media Blank Sample														
Aluminum		20	75-125	91		93		2.2							
Antimony		20	75-125	10	Q	14	Q	33.3	Q						
Barium		20	75-125	89		92		3.3							
Beryllium		20	75-125	88		87		1.1							

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Boron		20	75-125	69	78	12.2			
Calcium		20	75-125	91	91	0.0			
Chromium		20	75-125	82	78	5.0			
Cobalt		20	75-125	87	85	2.3			
Copper		20	75-125	84	86	2.4			
Iron		20	75-125	83	83	0.0			
Magnesium		20	75-125	91	92	1.1			
Manganese		20	75-125	88	88	0.0			
Molybdenum		20	75-125	42 Q	46 Q	9.1			
Nickel		20	75-125	90	87	3.4			
Potassium		20	75-125	81	81	0.0			
Silicon		20	75-125	34 Q	55	47.2 Q			
Sodium		20	75-125	92	96	4.3			
Titanium		20	75-125	81	85	4.8			
Vanadium		20	75-125	86	87	1.2			
Zinc		20	75-125	87	83	4.7			
Vapor Phase Metals on Charcoal - GFAAS and CVAAS									
Charcoal Tubes: Sweet Syngas	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Arsenic		20	75-125	102	105	2.9			
Cadmium		20	75-125	93	96	3.2			
Lead		20	75-125	103	104	0.97			
Mercury (CVAAS)		20	75-125	77	81	5.1			
Selenium		20	75-125	96	99	3.1			
Charcoal Tubes: Media Spike	Precision - Spiked Media Blank Duplicate								
	Accuracy - Spiked Media Blank Sample								
Arsenic		20	75-125	93	92	1.1			
Cadmium		20	75-125	107	106	0.9			
Lead		20	75-125	107	106	0.9			
Mercury (CVAAS)		20	75-125	52 Q	62 Q	17.5			

Table A-3 (Continued)

		Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
Measurement Parameter	How Measured	(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Selenium		20	75-125	95		93		2.1							
Metals in Process Solids - ICP/MS															
Matrix: Raw Coal	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Antimony		20	75-125	75		99		25.9	Q						
Arsenic		20	75-125	92		130	Q	30.1	Q						
Beryllium		20	75-125	86		117		29.4	Q						
Cadmium		20	75-125	73	Q	99		29.8	Q						
Chromium		20	75-125	50	Q	92		27.4	Q						
Cobalt		20	75-125	86		122		27.4	Q						
Copper		20	75-125	25	Q	92		29.0	Q						
Lead		20	75-125	31	Q	68	Q	49.4	Q						
Manganese		20	75-125	24	Q	84		30.8	Q						
Mercury		20	75-125	6	Q	55	Q	100.0	Q						
Molybdenum		20	75-125	84		117		30.1	Q						
Nickel		20	75-125	71	Q	155	Q	25.7	Q						
Selenium		20	75-125	-64	Q	-21	Q	34.6	Q						
Vanadium		20	75-125	17	Q	86		27.3	Q						
Matrix: Slurry 32	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Antimony		20	75-125	96		84		13.1							
Arsenic		20	75-125	124		109		11.7							
Beryllium		20	75-125	115		100		13.7							
Cadmium		20	75-125	96		87		9.3							
Chromium		20	75-125	95		75		13.0							
Cobalt		20	75-125	121		100		15.0							
Copper		20	75-125	83		46	Q	14.5							
Lead		20	75-125	41	Q	27	Q	25.9	Q						
Manganese		20	75-125	90		54	Q	15.3							
Mercury		20	75-125	22	Q	10	Q	73.1	Q						

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Molybdenum		20	75-125	114	99	12.8			
Nickel		20	75-125	83	25 Q	15.5			
Selenium		20	75-125	120	97	16.3			
Vanadium		20	75-125	81	43 Q	14.3			
Matrix: Slurry 33	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Antimony		20	75-125	98	97	0.7			
Arsenic		20	75-125	132 Q	131 Q	0.5			
Beryllium		20	75-125	116	115	0.7			
Cadmium		20	75-125	103	108	4.3			
Chromium		20	75-125	111	113	1.6			
Cobalt		20	75-125	130 Q	129 Q	0.6			
Copper		20	75-125	115	113	0.8			
Lead		20	75-125	78	69 Q	6.6			
Manganese		20	75-125	114	116	0.7			
Mercury		20	75-125	55 Q	49 Q	10.9			
Molybdenum		20	75-125	119	119	0.1			
Nickel		20	75-125	134 Q	134 Q	0.0			
Selenium		20	75-125	113	129 Q	9.6			
Vanadium		20	75-125	115	118	0.9			
Matrix: Recycled Char Solids	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Antimony		20	75-125	103	94	6.9			
Arsenic		20	75-125	131 Q	137 Q	1.9			
Beryllium		20	75-125	126 Q	122	2.6			
Cadmium		20	75-125	102	92	2.2			
Chromium		20	75-125	106	109	1.3			
Cobalt		20	75-125	129 Q	129 Q	0.1			
Copper		20	75-125	109	101	1.8			
Lead		20	75-125	49 Q	63 Q	1.5			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Manganese		20	75-125	101		98		1.3							
Mercury		20	75-125	45	Q	69	Q	40.8	Q						
Molybdenum		20	75-125	119		117		1.5							
Nickel		20	75-125	120		119		0.3							
Selenium		20	75-125	88		111		3.6							
Vanadium		20	75-125	102		100		0.7							
Matrix: Slag	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Antimony		20	75-125	90		96		6.7							
Arsenic		20	75-125	113		123		7.7							
Beryllium		20	75-125	115		115		0.1							
Cadmium		20	75-125	94		99		5.2							
Chromium		20	75-125	82		93		6.2							
Cobalt		20	75-125	107		112		3.4							
Copper		20	75-125	62	Q	74	Q	4.7							
Lead		20	75-125	74	Q	69	Q	6.7							
Manganese		20	75-125	67	Q	81		5.8							
Mercury		20	75-125	52	Q	52	Q	1.7							
Molybdenum		20	75-125	107		110		2.6							
Nickel		20	75-125	52	Q	79		6.4							
Selenium		20	75-125	96		106		7.9							
Vanadium		20	75-125	63	Q	80		5.8							
Metals in Process Solids - ICP-AES															
Matrix: Coal	Precision - NA														
Antimony	Accuracy - SRM 1633-b	20	75-125	120											
Barium	1633-b	20	75-125	98											
Beryllium	GBW 07103	20	75-125	96											
Boron	SARM 20	20	75-125	110											
Chromium	1633-b	20	75-125	101											
Cobalt	1633-b	20	75-125	93											

Table A-3 (Continued)

		Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
Measurement Parameter	How Measured	(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Copper	1633-b	20	75-125	103					
Molybdenum	GBW 07103	20	75-125	NC					
Manganese	1633-b	20	75-125	98					
Nickel	1633-b	20	75-125	109					
Vanadium	1633-b	20	75-125	99					
Zinc	1633-b	20	75-125	104					
Matrix: Slurry 33	Precision - Analytical Duplicate								
	Accuracy - NA								
Antimony		20	75-125	<1	<1	0.0			
Barium		20	75-125	460	490	6.3			
Beryllium		20	75-125	0.2	0.2	0.0			
Boron		20	75-125	390	380	2.6			
Boron		20	75-125	130	130	0.0			
Chromium		20	75-125	5	5	0.0			
Copper		20	75-125	13	14	7.4			
Cobalt		20	75-125	1	1	0.0			
Manganese		20	75-125	9	9	0.0			
Molybdenum		20	75-125	<2	<2	0.0			
Nickel		20	75-125	2	3	40.0 Q			
Vanadium		20	75-125	14	15	6.9			
Zinc		20	75-125	35	37	5.6			
Matrix: Slag	Precision - Analytical Duplicate								
	Accuracy - NA								
Antimony		20	75-125	<2	<2	0.0			
Barium		20	75-125	5500	5570	1.3			
Beryllium		20	75-125	1.9	1.9	0.0			
Chromium		20	75-125	64	66	3.1			
Copper		20	75-125	140	140	0.0			
Cobalt		20	75-125	32	27	16.9			
Manganese		20	75-125	110	110	0.0			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Molybdenum		20	75-125	<10		<10		0.0							
Nickel		20	75-125	38		34		11.1							
Vanadium		20	75-125	170		170		0.0							
Zinc		20	75-125	54		53		1.9							
Matrix: Sulfur	Precision - Analytical Duplicate														
	Accuracy - NA														
Aluminum		20	75-125	28		27		3.6							
Antimony		20	75-125	<3		<3		0.0							
Barium		20	75-125	<2		<2		0.0							
Beryllium		20	75-125	<2		<2		0.0							
Chromium		20	75-125	<2		<2		0.0							
Copper		20	75-125	<2		<2		0.0							
Cobalt		20	75-125	<4		<4		0.0							
Iron		20	75-125	7		5		33.3	Q						
Manganese		20	75-125	<2		<2		0.0							
Molybdenum		20	75-125	<20		<20		0.0							
Nickel		20	75-125	<4		<4		0.0							
Vanadium		20	75-125	<2		<2		0.0							
Zinc		20	75-125	<2		<2		0.0							
Metals in Process Solids - GFAAS and CVAAS															
Metals in Coal - GFAAS and CVAAS	Precision - NA														
Arsenic	Accuracy - SRM 1632-b	20	75-125	123											
Cadmium	1633-b	20	75-125	100											
Lead	1633-b	20	75-125	117											
Mercury	SARM 20	20	75-125	100											
Selenium	1632-b	20	75-125	65	Q										

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives Precision (% RPD)	Objectives Bias (% Rec)	Measurement 1 % Recovery Sample	Measurement 1 % Recovery Duplicate	Measurement 1 Precision (% RPD)	Measurement 2 % Recovery Sample	Measurement 2 % Recovery Duplicate	Measurement 2 Precision (% RPD)
Matrix: Slurry 33	Precision - Analytical Duplicate								
	Accuracy - NA								
Arsenic		20	75-125	<1	<1	0			
Cadmium		20	75-125	2.9	2.8	3.5			
Lead		20	75-125	5	5	0			
Mercury (CVAAS)		20	75-125	<0.02	<0.02	0			
Selenium		20	75-125	3	3	0			
Matrix: Slag	Precision - Analytical Duplicate								
	Accuracy - NA								
Arsenic		20	75-125	3	4	28.6 Q			
Cadmium		20	75-125	<1	<1	0			
Lead		20	75-125	3	3	0			
Matrix: Sulfur	Precision - Analytical Duplicate								
	Accuracy - NA								
Arsenic		20	75-125	<3	<3	0			
Cadmium		20	75-125	<2	<2	0			
Lead		20	75-125	<3	<3	0			
Selenium		20	75-125	10	10	0			
Metals in Process Solids - XRF									
Metals in Coal -XRF	Precision - NA								
	Accuracy - SRM (NBS 2689)								
Silicon		20	75-125	100					
Aluminum		20	75-125	154 Q					
Titanium		20	75-125	101					
Iron		20	75-125	100					
Calcium		20	75-125	1,234 Q					
Magnesium		20	75-125	115					
Potassium		20	75-125	103					
Sodium		20	75-125	114					
Phosphorus		20	75-125	100					

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1				Measurement 2		
		Precision	Bias	% Recovery			Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample		Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Strontium		20	75-125	133	Q					
Metals in Coal - XRF	Precision - NA									
	Accuracy - SRM (NBS 2690)									
Silicon		20	75-125	100						
Aluminum		20	75-125	99						
Titanium		20	75-125	93						
Iron		20	75-125	104						
Calcium		20	75-125	97						
Magnesium		20	75-125	97						
Potassium		20	75-125	100						
Sodium		20	75-125	114						
Sulfur		20	75-125	136	Q					
Phosphorus		20	75-125	102						
Strontium		20	75-125	83						
Manganese		20	75-125	50	Q					
Metals in Coal - XRF	Precision - NA									
	Accuracy - SRM (NBS 2691)									
Silicon		20	75-125	99						
Aluminum		20	75-125	100						
Titanium		20	75-125	101						
Iron		20	75-125	102						
Calcium		20	75-125	101						
Magnesium		20	75-125	99						
Potassium		20	75-125	110						
Sodium		20	75-125	95						
Sulfur		20	75-125	87						
Phosphorus		20	75-125	109						
Strontium		20	75-125	93						
Manganese		20	75-125	40	Q					

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Matrix: Recycled Char Solids	Precision - Sample Duplicate								
	Accuracy - NA								
Silicon		20	75-125	8.51	8.48	0.4			
Aluminum		20	75-125	5.45	5.43	0.4			
Titanium		20	75-125	0.50	0.50	0.0			
Iron		20	75-125	2.44	2.40	1.7			
Calcium		20	75-125	10.05	9.94	1.1			
Magnesium		20	75-125	2.06	2.02	2.0			
Potassium		20	75-125	0.23	0.22	4.4			
Sodium		20	75-125	1.10	1.09	0.9			
Phosphorus		20	75-125	0.35	0.34	2.9			
Matrix: Slag	Precision - Sample Duplicate								
	Accuracy - NA								
Silicon		20	75-125	21.31	21.09	1.0			
Aluminum		20	75-125	5.93	5.97	0.7			
Titanium		20	75-125	0.63	0.64	1.6			
Iron		20	75-125	8.63	8.59	0.5			
Calcium		20	75-125	10.24	10.5	2.5			
Magnesium		20	75-125	1.40	1.50	6.9			
Potassium		20	75-125	0.56	0.56	0.0			
Sodium		20	75-125	1.94	1.97	1.5			
Phosphorus		20	75-125	2.67	2.55	4.6			
Metals in Aqueous Samples - ICP-AES									
Matrix: Sweet Water	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Aluminum		20	75-125	95	97	2.1	93	94	1.1
Antimony		20	75-125	108	110	1.8	100	95	5.1
Barium		20	75-125	91	97	6.4	95	96	1.0
Beryllium		20	75-125	102	104	1.9	98	98	0
Boron		20	75-125	97	102	5.0	3.0 Q	100	188 Q

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Calcium		20	75-125	95	98	3.1	98	98	0
Chromium		20	75-125	94	95	1.1	94	93	1.1
Cobalt		20	75-125	94	94	0	93	92	1.1
Copper		20	75-125	92	96	4.3	91	91	0
Iron		20	75-125	95	97	2.1	96	96	0
Magnesium		20	75-125	94	98	4.2	94	94	0
Manganese		20	75-125	93	95	2.1	94	94	0
Molybdenum		20	75-125	97	98	1.0	0.12 Q	95	199 Q
Nickel		20	75-125	95	94	1.1	91	91	0
Phosphorus		20	75-125	89	95	6.5	96	94	2.1
Potassium		20	75-125	96	98	2.1	93	95	2.1
Silicon		20	75-125	88	102	15	6.6 Q	109	177 Q
Sodium		20	75-125	91	96	5.4	93	95	2.1
Titanium		20	75-125	94	96	2.1	0.84 Q	95	200 Q
Vanadium		20	75-125	95	96	1.0	94	94	0
Zinc		20	75-125	93	96	3.2	95	95	0
Matrix: Sour Condensate	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Aluminum		20	75-125	92	94	2.2			
Antimony		20	75-125	96	94	2.1			
Barium		20	75-125	91	94	3.2			
Beryllium		20	75-125	97	98	1.0			
Boron		20	75-125	100	96	4.1			
Calcium		20	75-125	95	97	2.1			
Chromium		20	75-125	94	94	0			
Cobalt		20	75-125	93	93	0			
Copper		20	75-125	93	93	0			
Iron		20	75-125	94	95	1.1			
Magnesium		20	75-125	91	94	3.2			
Manganese		20	75-125	94	94	0			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Molybdenum		20	75-125	93		93		0							
Nickel		20	75-125	93		94		1.1							
Phosphorus		20	75-125	87		92		5.6							
Potassium		20	75-125	92		95		3.2							
Silicon		20	75-125	95		100		5.1							
Sodium		20	75-125	91		93		2.2							
Titanium		20	75-125	93		94		1.1							
Vanadium		20	75-125	93		94		1.1							
Zinc		20	75-125	95		94		1.1							
Matrix: Recycle Char Filtrate	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Aluminum		20	75-125	95		96		1.0		88		91		3.4	
Antimony		20	75-125	100		97		3.0		91		95		4.3	
Barium		20	75-125	93		95		2.1		88		90		2.2	
Beryllium		20	75-125	102		103		1.0		95		96		1.0	
Boron		20	75-125	60	Q	79		27	Q	21	Q	65	Q	102	Q
Calcium		20	75-125	92		99		7.3		84		90		6.9	
Chromium		20	75-125	92		94		2.2		88		89		1.1	
Cobalt		20	75-125	91		93		2.2		86		88		2.3	
Copper		20	75-125	92		95		3.2		89		91		2.2	
Iron		20	75-125	94		100		6.2		89		95		6.5	
Magnesium		20	75-125	86		91		5.6		75		87		15	
Manganese		20	75-125	91		93		2.2		88		90		2.2	
Molybdenum		20	75-125	93		97		4.2		87		88		1.1	
Nickel		20	75-125	92		95		3.2		88		90		2.2	
Phosphorus		20	75-125	94		96		2.1		87		91		4.5	
Potassium		20	75-125	96		101		5.1		85		93		9.0	
Silicon		20	75-125	104		102		1.9		98		99		1.0	
Sodium		20	75-125	77		52	Q	39	Q	52	Q	59	Q	13	
Titanium		20	75-125	94		95		1.1		89		90		1.1	

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Vanadium		20	75-125	92		94		2.2		88		90		2.2	
Zinc		20	75-125	91		96		5.4		87		92		5.6	
Metals in Aqueous Samples - GFAAS and CVAAS															
Matrix: Sweet Water	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Arsenic		20	75-125	100		100		0		100		99		1.0	
Cadmium		20	75-125	116		115		0.87		94		85		5.0	
Lead		20	75-125	NA		174	Q	NC		93		56	Q	50	Q
Mercury (CVAAS)		20	75-125	114		112		1.8							
Selenium		20	75-125	108		111		2.7							
Matrix: Sour Condensate	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Arsenic		20	75-125	100		105		4.9		111					
Cadmium		20	75-125	105		100		4.9							
Lead		20	75-125	123		109		12		108					
Mercury (CVAAS)		20	75-125	119		118		0.84							
Selenium		20	75-125	78		84		7.4							
Matrix: Recycle Char Filtrate	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Arsenic		20	75-125	110		110		0		118		109		7.9	
Cadmium		20	75-125	114		117		2.6							
Lead		20	75-125	74	Q	57	Q	26	Q	71	Q	63	Q	12	
Mercury (CVAAS)		20	75-125	69	Q	74	Q	7.0							
Selenium		20	75-125	110		100		9.5							
Ionic Species in Gas Particulate Phase															
Filter/PNR: Incinerator Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	96		94		2.1							
Fluoride		20	80-120	97		100		3.0							
Sulfate		20	80-120	95		97		2.1							

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Filter/PNR: Turbine Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	91		90		1.1							
Fluoride		20	80-120	89		89		0							
Sulfate		20	80-120	94		94		0							
Ionic Species in Gas Vapor Phase															
0.1 N H_2SO_4 Impingers: Incinerator Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	129	Q	130	Q	0.77		124	Q	123	Q	0.81	
Fluoride		20	80-120	97		99		2.0							
Ammonia		20	80-120	106		88		19							
0.1 N H_2SO_4 Impingers: Turbine Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	109		105		3.7							
Fluoride		20	80-120	99		104		4.9							
Ammonia		20	80-120	87		90		3.4							
1% H_2SO_4 Impingers: Raw Syngas	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	78	Q	81		3.8		76	Q	82		7.6	
Fluoride		20	80-120	98		102		4.0							
Ammonia		20	80-120	94		89		5.5							
1% H_2SO_4 Impingers: Acid Gas	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	98		94		4.2							
M-8 IPA Impingers: Incinerator Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Sulfate		20	80-120	84		63	Q	29	Q	41	Q	41	Q	0	
M-8 IPA Impingers: Turbine Stack	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Sulfate		20	80-120	29	Q	33	Q	13		22	Q	19	Q	15	

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
M-8 H_2O_2 Impingers: Incinerator Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Sulfate		20	80-120	103	100	3.0			
M-8 H_2O_2 Impingers: Turbine Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Sulfate		20	80-120	106	106	0			
M-7E $KMnO_4$/NaOH Impingers: Incinerator Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Nitrate		20	80-120	86	110	24 Q			
ZnOAc Impingers: Turbine Stack	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Cyanide		20	75-125	99	100	1.0			
ZnOAc Impingers: Comb. Air	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Cyanide		20	75-125	101	91	10	104	97	7.0
Ionic Species in Process Solids									
Matrix: Slurry 33	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Chloride (D4208/IC)		20	80-120	101	99	2.0	101	103	2.0
Fluoride (D4208/IC)		20	80-120	104	107	2.8	103	107	3.8
Matrix: Slurry 33	Precision - Analytical Duplicate								
	Accuracy - None								
Chloride (D4208)		20	80-120	<100	<100	0.0			
Fluoride (D3761)		20	80-120	450	460	2.2			
Matrix: Coal	Precision - NA								
Chloride (D4208)	Accuracy - SRM 1632-b	20	80-120	93					
Fluoride (D3761)	ECR 40	20	80-120	110					

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
		(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Matrix: Recycled Char Solids	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride (D4208/IC)		20	80-120	92		98		6.3							
Fluoride (D4208/IC)		20	80-120	1.9	Q	-319	Q	202	Q	36	Q	-264	Q	263	Q
Matrix: Recycled Char Solids	Precision - Analytical Duplicate														
	Accuracy - None														
Chloride (D4208)		20	80-120	<100		<100		0.0							
Fluoride (D3761)		20	80-120	4200		4200		0.0							
Matrix: Slag	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride (SIE)		20	80-120	110		103		6.6							
Chloride (D4208/IC)		20	80-120	83		74	Q	11.5		83		76	Q	8.8	
Fluoride (SIE)		20	80-120	31	Q	69	Q	76	Q	27	Q	57	Q	71	Q
Fluoride (D4208/IC)		20	80-120	90		76		16.9		86		77		11.0	
Anions in Aqueous Samples															
Matrix: Sweet Water	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	95		89		6.5							
Fluoride		20	80-120	111		111		0							
Phosphate (as Total P)		20	75-125	97		101		4.0							
Sulfate		20	80-120	88		88		0							
Ammonia		20	80-120	100		112		11		104		114		9.2	
Cyanide		20	75-125	87		89		2.3							
Thiocyanate		20	80-120	128	Q	158	Q	20.7	Q	128	Q	109		16.7	
Matrix: Sour Condensate	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	20	Q	21	Q	4.9		21	Q	20	Q	4.9	
Fluoride		20	80-120	108		110		1.8							
Phosphate (as Total P)		20	75-125	89		96		7.6							
Sulfate		20	80-120	88		89		1.1							

Table A-3 (Continued)

		Objectives		Measurement 1						Measurement 2					
		Precision	Bias	% Recovery				Precision		% Recovery				Precision	
Measurement Parameter	How Measured	(% RPD)	(% Rec)	Sample		Duplicate		(% RPD)		Sample		Duplicate		(% RPD)	
Cyanide		20	75-125	96		96		0.0							
Matrix: Recycle Char Filtrate	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Chloride		20	80-120	87		89		2.3							
Fluoride		20	80-120	110		109		0.91							
Ammonia		20	80-120	99		100		1.0		98		100		2.0	
Cyanide		20	75-125	83		207	Q	86	Q	102		237	Q	80	Q
Water Quality Parameters															
Matrix: Sweet Water	Precision - Matrix-spiked Duplicate														
	Accuracy - Matrix-spiked Sample														
Total Phenolics		20	75-125	104		104		0.0							
Chemical Oxygen Demand		20	75-125	82		76		7.6							
Matrix: DI Water															
Chemical Oxygen Demand		20	75-125	85		80		6.1							
Aldehydes in Gas Vapor Phase															
Trip Spike	Precision - NA														
	Accuracy - Trip Spike														
Formaldehyde		50	50-150	77		95				95					
Acetaldehyde		50	70-130	79		92				95					
Field Spike	Precision - NA														
	Accuracy - Field Spike														
Formaldehyde		50	50-150	108						106					
Lab Spike	Precision - NA														
	Accuracy - Lab Spike														
Formaldehyde		50	50-150	92		97				100					
Acetaldehyde		50	70-130	104		84				88					
Acrolein		50	70-130	105		64	Q			NS					

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives Precision (% RPD)	Objectives Bias (% Rec)	Measurement 1 % Recovery Sample	Measurement 1 % Recovery Duplicate	Measurement 1 Precision (% RPD)	Measurement 2 % Recovery Sample	Measurement 2 % Recovery Duplicate	Measurement 2 Precision (% RPD)
Aldehydes in Aqueous Samples									
Lab Spike	Precision - NA								
	Accuracy - Lab Spike								
Formaldehyde		50	50-150	91			95		
Acetaldehyde		50	70-130	103			103		
Acrolein		50	70-130	105			104		
Matrix: Sweet Water	Precision - NA								
	Accuracy - Matrix Spike								
Formaldehyde		50	50-150	77			64		
Acetaldehyde		50	50-150	107			60		
Acrolein		50	50-150	110			70		
Volatile Organic Compounds in Gas Vapor Phase									
VOST Method Spike	Precision - NA								
	Accuracy - Method Spike								
Chloromethane		NA	D-273	106					
Vinyl Chloride		NA	D-251	115					
Bromomethane		NA	D-242	92					
Chloroethane		NA	NA	102					
Trichlorofluoromethane		NA	NA	66					
1,1-Dichloroethene		NA	D-234	110					
Carbon Disulfide		NA	NA	114					
Acetone		NA	NA	101					
Methylene Chloride		NA	D-221	112					
trans-1,2-Dichloroethene		NA	54-156	107					
1,1-Dichloroethane		NA	59-155	122					
Vinyl Acetate		NA	NA	140					
2-Butanone		NA	NA	43					
Chloroform		NA	51-138	118					
1,1,1-Trichloroethane		NA	52-162	122					
Carbon Tetrachloride		NA	70-140	127					

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Benzene		NA	37-151	106					
1,2-Dichloroethane		NA	49-155	106					
Trichloroethene		NA	71-157	86					
1,2-Dichloropropane		NA	D-210	106					
Bromodichloromethane		NA	35-155	101					
trans-1,3-Dichloropropene		NA	17-183	127					
4-Methyl-2-Pentanone		NA	NA	86					
Toluene		NA	47-150	110					
cis-1,3-Dichloropropene		NA	D-227	110					
1,1,2-Trichloroethane		NA	52-150	107					
Tetrachloroethene		NA	64-148	105					
2-Hexanone		NA	NA	56					
Dibromochloromethane		NA	53-149	116					
Chlorobenzene		NA	37-160	104					
Ethyl Benzene		NA	37-162	107					
m,p-Xylene		NA	NA	108					
o-Xylene		NA	NA	106					
Styrene		NA	NA	107					
Bromoform		NA	45-169	114					
1,1,2,2-Tetrachloroethane		NA	46-157	139					
1,3-Dichlorobenzene		NA	NA	103					
1,4-Dichlorobenzene		NA	NA	103					
1,2-Dichlorobenzene		NA	NA	100					
Volatile Organic Compounds in Aqueous Samples									
Matrix: Sour Condensate	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Benzene		50	37-151	36 Q	52	36			
Chloroethene		50	37-160	100	97	3.0			
1,1-Dichloroethene		50	D-234	87	81	7.1			
Toluene		50	47-150	101	98	3.0			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision (% RPD)	Bias (% Rec)	% Recovery Sample	% Recovery Duplicate	Precision (% RPD)	% Recovery Sample	% Recovery Duplicate	Precision (% RPD)
Trichloroethene		50	71-157	100	95	5.1			
Semivolatile Organic Compounds - Gas Vapor Phase									
XAD Resin Media Spike	Precision - Spiked Media Blank Duplicate Accuracy - Spiked Media Blank Sample								
Acenaphthene		50	47-145	89	93	4.4			
4-Chloro-3-methylphenol		70	22-147	83	87	4.7			
2-Chlorophenol		60	23-134	84	89	5.8			
1,4-Dichlorobenzene		50	20-124	89	93	4.4			
2,4-Dinitrotoluene		50	39-139	96	101	5.1			
N-nitrosodipropylamine		130	D-230	105	109	3.7			
4-Nitrophenol		80	D-132	78	83	6.2			
Pentachlorophenol		90	14-176	46	53	14			
Phenol		50	5-112	80	85	6.1			
Pyrene		50	52-115	83	90	8.1			
1,2,4-Trichlorobenzene		50	44-142	94	99	5.2			
XAD Resin Media Spike	Precision - Spiked Media Blank Duplicate Accuracy - Spiked Media Blank Sample								
Acenaphthene		50	47-145	87	88	1.1			
4-Chloro-3-methylphenol		70	22-147	85	86	1.2			
2-Chlorophenol		60	23-134	84	87	3.5			
1,4-Dichlorobenzene		50	20-124	90	92	2.2			
2,4-Dinitrotoluene		50	39-139	93	94	1.1			
N-nitrosodipropylamine		130	D-230	100	101	1.0			
4-Nitrophenol		80	D-132	88	90	2.2			
Pentachlorophenol		90	14-176	57	52	9.2			
Phenol		50	5-112	83	85	2.4			
Pyrene		50	52-115	80	83	3.7			
1,2,4-Trichlorobenzene		50	44-142	95	96	1.0			

Table A-3 (Continued)

Measurement Parameter	How Measured	Objectives		Measurement 1			Measurement 2		
		Precision	Bias	% Recovery		Precision	% Recovery		Precision
		(% RPD)	(% Rec)	Sample	Duplicate	(% RPD)	Sample	Duplicate	(% RPD)
Semivolatile Organic Compounds - Aqueous Samples									
Matrix: Sweet Water	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Acenaphthene		50	47-145	82	90	9.3			
4-Chloro-3-methylphenol		70	22-147	87	95	8.8			
2-Chlorophenol		60	23-134	76	85	11			
1,4-Dichlorobenzene		50	20-124	69	70	1.4			
2,4-Dinitrotoluene		50	39-139	76	86	12			
N-nitrosodipropylamine		130	D-230	114	128	12			
4-Nitrophenol		80	D-132	98	111	12			
Pentachlorophenol		90	14-176	45	65	36			
Phenol		50	5-112	46	83	57 Q			
Pyrene		50	52-115	72	87	19			
1,2,4-Trichlorobenzene		50	44-142	78	80	2.5			
Matrix: Sour Condensate	Precision - Matrix-spiked Duplicate								
	Accuracy - Matrix-spiked Sample								
Acenaphthene		50	47-145	85	89	4.6			
4-Chloro-3-methylphenol		70	22-147	89	91	2.2			
2-Chlorophenol		60	23-134	79	80	1.3			
1,4-Dichlorobenzene		50	20-124	66	73	10			
2,4-Dinitrotoluene		50	39-139	76	77	1.3			
N-nitrosodipropylamine		130	D-230	95	99	4.1			
4-Nitrophenol		80	D-132	105	115	9.1			
Pentachlorophenol		90	14-176	29	47	47			
Phenol		50	5-112	73	85	15			
Pyrene		50	52-115	67	70	4.4			
1,2,4-Trichlorobenzene		50	44-142	74	79	6.5			

Table A-4
Surrogate Spike Recovery Results

Measurement Parameter	Surrogate Spike Recovery (%)			Number Outside Objective
	Objective	Range of Recovery	Number Analyzed	
Volatile Organic Compounds - Vapor Phase				
VOST Tubes - Turbine Stack				
1,2-Dichloroethane-d4	51-145	126-139	9	0
Toluene d-8	77-122	96-121	9	0
4-Bromofluorobenzene	60-128	74-95	9	0
VOST Tubes - Incinerator Stack				
1,2-Dichloroethane-d4	51-145	19-149	10	3
Toluene d-8	77-122	96-528	10	4
4-Bromofluorobenzene	60-128	72-173	10	1
VOST Tubes - Turbine Field Blanks				
1,2-Dichloroethane-d4	51-145	120-121	2	0
Toluene d-8	77-122	99-109	2	0
4-Bromofluorobenzene	60-128	89	2	0
VOST Tubes - Incinerator Field Blanks				
1,2-Dichloroethane-d4	51-145	123-126	3	0
Toluene d-8	77-122	110-120	3	0
4-Bromofluorobenzene	60-128	89-91	3	0
VOST Tubes - Trip Blank				
1,2-Dichloroethane-d4	51-145	128	1	0
Toluene d-8	77-122	92	1	0
4-Bromofluorobenzene	60-128	88	1	0
Volatile Organic Compounds - Aqueous Samples				
Matrix: Sweet Water				
1,2-Dichloroethane-d4	76-114	85-87	4	0
Toluene d-8	88-110	101-103	4	0
1,4-Bromofluorobenzene	86-115	90-93	4	0
Matrix: Sour Condensate				
1,2-Dichloroethane-d4	76-114	85-87	6	0
Toluene d-8	88-110	100-104	6	0
1,4-Bromofluorobenzene	86-115	91-94	6	0
Semivolatile Organic Compounds (SW 8270) - Particulate Phase				
MM-5 Sampling Train (Front Half) - Turbine Stack Samples				
Phenol-d5	50-150	44-65	3	1
Nitrobenzene-d5	50-150	56-77	3	0
1,3,5-Trichlorobenzene-d3	50-150	53-71	3	0
1,4-Dibromobenzene-d4	50-150	54-72	3	0
2-Fluorobiphenyl	50-150	46-63	3	1
2,4,6-Tribromophenol	50-150	69-96	3	0

Table A-4 (Continued)

Measurement Parameter	**Surrogate Spike Recovery (%)**			**Number Outside Objective**
	Objective	**Range of Recovery**	**Number Analyzed**	
MM-5 Sampling Train (Front Half) - Incinerator Stack Samples				
Phenol-d5	50-150	49-52	3	1
Nitrobenzene-d5	50-150	70-73	3	0
1,3,5-Trichlorobenzene-d3	50-150	67-68	3	0
1,4-Dibromobenzene-d4	50-150	62-66	3	0
2-Fluorobiphenyl	50-150	54-58	3	0
2,4,6-Tribromophenol	50-150	79-80	3	0
MM-5 Sampling Train (Front Half) - Turbine Field Blanks				
Phenol-d5	50-150	69	1	0
Nitrobenzene-d5	50-150	78	1	0
1,3,5-Trichlorobenzene-d3	50-150	69	1	0
1,4-Dibromobenzene-d4	50-150	69	1	0
2-Fluorobiphenyl	50-150	60	1	0
2,4,6-Tribromophenol	50-150	66	1	0
MM-5 Sampling Train (Front Half) - Incinerator Field Blanks				
Phenol-d5	50-150	53	1	0
Nitrobenzene-d5	50-150	73	1	0
1,3,5-Trichlorobenzene-d3	50-150	68	1	0
1,4-Dibromobenzene-d4	50-150	68	1	0
2-Fluorobiphenyl	50-150	54	1	0
2,4,6-Tribromophenol	50-150	74	1	0
MM-5 Sampling Train (Front Half) - Trip Blanks				
Phenol-d5	50-150	56-77	2	0
Nitrobenzene-d5	50-150	72-86	2	0
1,3,5-Trichlorobenzene-d3	50-150	71-78	2	0
1,4-Dibromobenzene-d4	50-150	76-78	2	0
2-Fluorobiphenyl	50-150	51-69	2	0
2,4,6-Tribromophenol	50-150	68-71	2	0
Polycyclic Aromatic Hydrocarbons (PAHs by CARB 429) - Vapor Phase				
MM-5 Sampling Train (Back Half) - Turbine Stack Samples				
d10-Fluorene	50-150	65-86	4	0
d14-Terphenyl	50-150	125-150	4	0
MM-5 Sampling Train (Back Half) - Incinerator Stack Samples				
d10-Fluorene	50-150	66-69	3	0
d14-Terphenyl	50-150	112-151	3	1
MM-5 Sampling Train (Back Half) - Turbine Field Blank				
d10-Fluorene	50-150	71	1	0
d14-Terphenyl	50-150	260	1	1

Table A-4 (Continued)

Measurement Parameter	Surrogate Spike Recovery (%)			Number Outside Objective
	Objective	Range of Recovery	Number Analyzed	
MM-5 Sampling Train (Back Half) - Incinerator Field Blank				
d10-Fluorene	50-150	67	1	0
d14-Terphenyl	50-150	113	1	0
MM-5 Sampling Train (Back Half) - Trip Blanks				
d10-Fluorene	50-150	69-99	2	0
d14-Terphenyl	50-150	144-229	2	1
Semivolatile Organic Compounds (SW 8270) - Vapor Phase				
MM-5 Sampling Train (Back Half) - Turbine Stack Samples				
Phenol-d5	50-150	42-59	6	3
Nitrobenzene-d5	50-150	47-73	6	1
1,3,5-Trichlorobenzene-d3	50-150	41-64	6	1
1,4-Dibromobenzene-d4	50-150	52-78	6	0
2-Fluorobiphenyl	50-150	44-71	6	1
2,4,6-Tribromophenol	50-150	85-116	6	0
MM-5 Sampling Train (Back Half) - Incinerator Stack Samples				
Phenol-d5	50-150	52-63	3	0
Nitrobenzene-d5	50-150	65-71	3	0
1,3,5-Trichlorobenzene-d3	50-150	55-59	3	0
1,4-Dibromobenzene-d4	50-150	56-67	3	0
2-Fluorobiphenyl	50-150	59-66	3	0
2,4,6-Tribromophenol	50-150	101-119	3	0
MM-5 Sampling Train (Back Half) - Turbine Field Blank				
Phenol-d5	50-150	66	1	0
Nitrobenzene-d5	50-150	80	1	0
1,3,5-Trichlorobenzene-d3	50-150	66	1	0
1,4-Dibromobenzene-d4	50-150	82	1	0
2-Fluorobiphenyl	50-150	69	1	0
2,4,6-Tribromophenol	50-150	68	1	0
MM-5 Sampling Train (Back Half) - Incinerator Field Blank				
Phenol-d5	50-150	48	1	1
Nitrobenzene-d5	50-150	73	1	0
1,3,5-Trichlorobenzene-d3	50-150	58	1	0
1,4-Dibromobenzene-d4	50-150	58	1	0
2-Fluorobiphenyl	50-150	54	1	0
2,4,6-Tribromophenol	50-150	91	1	0

Table A-4 (Continued)

Measurement Parameter	Surrogate Spike Recovery (%)			Number Outside Objective
	Objective	Range of Recovery	Number Analyzed	
MM-5 Sampling Train (Back Half) - Trip Blanks				
Phenol-d5	50-150	50-53	2	0
Nitrobenzene-d5	50-150	64-69	2	0
1,3,5-Trichlorobenzene-d3	50-150	56-60	2	0
1,4-Dibromobenzene-d4	50-150	64	2	0
2-Fluorobiphenyl	50-150	48-56	2	1
2,4,6-Tribromophenol	50-150	89-93	2	0
Semivolatile Organic Compounds (SW 8270) - Internal Process Gas Streams				
MM-5 Sampling Train (Back Half) - Sweet Syngas				
2-Fluorobiphenyl	30-115	88-97	5	0
2-Fluorophenol	25-121	71-98	5	0
Nitrobenzene-d5	23-120	60-92	5	0
Phenol-d5	24-113	85-102	5	0
Terphenyl-d14	18-137	80-100	5	0
2,4,6-Tribromophenol	19-122	56-90	5	0
MM-5 Sampling Train (Back Half) - Sour Syngas				
2-Fluorobiphenyl	30-115	92-97	3	0
2-Fluorophenol	25-121	74-87	3	0
Nitrobenzene-d5	23-120	67-72	3	0
Phenol-d5	24-113	89-107	3	0
Terphenyl-d14	18-137	79	3	0
2,4,6-Tribromophenol	19-122	58-106	3	0
MM-5 Sampling Train (Back Half) - Tail Gas				
2-Fluorobiphenyl	30-115	88	1	0
2-Fluorophenol	25-121	63	1	0
Nitrobenzene-d5	23-120	NC	1	--
Phenol-d5	24-113	83	1	0
Terphenyl-d14	18-137	NC	1	--
2,4,6-Tribromophenol	19-122	73	1	0
MM-5 Sampling Train (Back Half) - Acid Gas				
2-Fluorobiphenyl	30-115	88-98	3	0
2-Fluorophenol	25-121	67-77	3	0
Nitrobenzene-d5	23-120	NC	3	--
Phenol-d5	24-113	81-96	3	0
Terphenyl-d14	18-137	65-70	3	0
2,4,6-Tribromophenol	19-122	60-73	3	0

Table A-4 (Continued)

Measurement Parameter	Surrogate Spike Recovery (%)			Number Outside Objective
	Objective	Range of Recovery	Number Analyzed	
Semivolatile Organic Compounds - Aqueous Samples				
Matrix: Sweet Water				
2-Fluorobiphenyl	43-116	48-72	8	0
2-Fluorophenol	21-100	65-86	8	0
Nitrobenzene-d5	35-114	60-93	8	0
Phenol-d5	10-94	68-96	8	1
Terphenyl-d14	33-141	72-104	8	0
2,4,6-Tribromophenol	10-123	67-87	8	0
Matrix: Sour Condensate				
2-Fluorobiphenyl	43-116	50-77	8	0
2-Fluorophenol	21-100	61-88	8	0
Nitrobenzene-d5	35-114	57-94	8	0
Phenol-d5	10-94	65-93	8	0
Terphenyl-d14	33-141	68-93	8	0
2,4,6-Tribromophenol	10-123	58-75	8	0

APPENDIX B: SAMPLING METHODS

Radian used established sampling methods, where possible, to collect representative samples from the various sampling locations within the LGTI and Power II plant sites.

For the gaseous emission sources (incinerator and turbine exhaust stacks), the sampling methods that were used are standard methods with known performance characteristics, specific for the collection of representative samples from these stream matrices. These standard methods, summarized in Table B-1, provide for data comparisons with industry standards and are comparable to those methods used in the EPRI-sponsored Field Chemical Emissions Monitoring (FCEM) programs. All of the internal process gas streams were sampled using techniques that, although they have not been validated for syngas matrices, are generally considered appropriate for representative sample collection. Some slight modifications to the methods were required, however. These method modifications are summarized in Table B-2. The sampling methods used during the toxics characteristics testing (Periods 1-3) are described first. Test procedures used during the testing of the hot syngas are described separately, as some minor changes were made to some of the methods, based upon the first set of results.

Gas Streams

Sampling methods are described by type in the following sections. The standard approach is described first. These were applied to the emission sources. Following the standard method descriptions, any deviations from the standard approach which were required to adapt the procedure to a syngas matrix are described.

Particulate Loading

EPA Method 5. EPA Reference Method 5 was performed to determine particulate emission loading. This method provides for isokinetic extraction of particulate matter on a glass fiber filter. However, since particulate loading was performed in conjunction with the determination of particulate and vapor-phase metals, quartz fiber filters were used in place of glass. The particulate mass, which includes all material that condenses at or above the filtration temperature, was determined gravimetrically, after the removal of uncombined water.

Table B-1
Summary of Standard Sampling Methods

Stream Type	Parameter	Frequency	Sampling Method
Solids	All	Three grab samples to form daily composite.	EPA Method S007 (trowel/ scoop). EPA Method S004 (slurry, slag).
Liquids	All inorganic & SVOC.	Three grab samples to form daily composite. VOC, aldehydes once per day.	EPA Method S004 (tap)
Turbine and Incinerator Stack Gases	Volatile organics	3 pairs of VOST traps over 2-hour time period	VOST (SW-846 Method 0030)
	Semivolatile organics—PAHs	Isokinetic, integrated 4- to 6-hour sample.	Modified Method 5 (SW-846) Method 0010, CARB 429
	Vapor-phase inorganic species, Cl^-, F^-, NH_3, HCN	Integrated sample over 1- to 2-hour time period	Absorption into various impinger solutions.
	Aldehydes	Integrated 1-2 hour sample.	Method 0011, absorption into DNPH solution
	Trace elements (metals)	Isokinetic, integrated 4- to 6-hour sample.	Method 29 multi-metals sampling train
	Reduced sulfur species	Integrated sample into Tedlar® bag	On-site analysis using GC-FPD (modified Method 16)
	SO_2, NO_x, CO	Continuous emission monitors	EPA Methods 6C, 7E, and 10.
	Particulate	Isokinetic, integrated 4-6 hour sample.	EPA Method 5
	PM10	Single point, semi-isokinetic, sample over appropriate time period	EPA Method 201A

Table B-2
Method Modifications

Parameter	Standard Method	Modification	Streams Affected
Metals	Method 29	Steel instead of glass lined components; Isokinetics are approximated; Fixed point sampling, no traversing; Increase nitric acid and peroxide content to 10 and 30%, respectively; and Filter housing not maintained at 250°F.	5a, 5b, 12, 14, 15, 22, Nat'l Gas
Metals	Method 29	Vapor phase only.	14, 15, 22, Nat'l Gas
Metals	Method 29	All listed above and no permanganate impinger solution.	5, 5a, 5b, 11, 14, 15, 22
Cyanide	ZnOAc absorbing solution	H_2S removal prior to absorbing solution via Pb salt solution (PbOAc).	All internal

The sampling was conducted at equal time intervals along selected traverse points as determined by EPA Reference Method 1.

Sample recovery includes the particulate that has been deposited inside the sample nozzle, heated probe liner, and filter holder (designated as the front half probe and nozzle rinse, PNR), as well as the particulate collected on the filter substrate.

PM-10, EPA Method 201A. EPA Method 201A was used to perform an in-stack measurement of particulate matter equal to or less than an aerodynamic diameter of nominally 10 µm. A gas sample was extracted at a constant rate through an in-stack sizing device. Variation from isokinetic sampling conditions were maintained within well defined limits. Particulate mass was determined gravimetrically after removal of uncombined water. A stainless steel impactor served as the sizing device, and a backup glass fiber filter was used to capture the fine particulate.

Particulate Loading Modifications. Particulate loading was attempted on the raw syngas stream in and out of the particulate removal system and on the sweet syngas. Due to high moisture content of the raw syngas in and out of the venturi scrubber, particulate loading samples could not be collected from these locations. The flow rate was monitored at the sweet syngas location with a differential pressure gauge across a flow orifice. The filter housing was constructed of stainless steel specifically designed for high pressure applications. Gas volumes were calculated by measuring gas flow and sampling duration. Also, there was no probe and nozzle rinse associated with this process system since the probe is not removable. No significant impact on the determination of particulate loading is expected from these modifications.

Particulate- and Vapor-Phase Metals

Sampling for particulate and vapor-phase metals was performed in conjunction with Method 5 using the procedures detailed in EPA Draft Method 29. Method 29 is similar to Method 5 with a few sample train modifications. Modifications to Method 5 include replacing the stainless steel nozzle and probe liner with glass components. The particulate material was collected on quartz fiber substrates, replacing the standard glass fiber filters normally used with Method 5. Vapor-phase metals are collected in a series of impinger solutions. The first two impingers contain a dilute nitric acid and hydrogen peroxide solution. The third impinger is empty. The next two impingers contain acidic potassium permanganate solution for elemental mercury collection. These impingers were followed by one dry impinger, and an impinger filled with silica gel. A minimum of 100 dry standard cubic feet of gas was collected isokinetically. A description of the sample train configuration and recovery procedures is presented in Table B-3.

Method 29 Modifications

The EPA Method 29 sampling train was designed for oxidizing atmospheres. In reducing atmospheres such as those found in gasification systems, the oxidizing potential of the absorbing solutions is rapidly consumed, leading to greatly reduced collection efficiency. In an effort to

Table B-3
Description and Recovery of Method 29 (Multi-Metals) Sampling Train

Component	Contents	Recovery [a]	Container
Probe Nozzle Rinse and front half of filter holder. rinse [b]	NA	Rinse probe, nozzle, and front half of filter holder with acetone into sample container.	500 mL amber glass bottle
Probe Nozzle Rinse and front half of filter holder rinse [b]	NA	Rinse probe, nozzle, and front half of filter holder with 0.1N HNO_3 into sample container.	500 mL amber glass bottle
Filter	Tared quartz filter	Place filter in sample container.	Plastic petri dish
Transfer Line Rinse	NA	Rinse transfer line with 0.1N HNO_3 into sample container.	Combine transfer line rinse and impingers 1 and 2 in a 1000 mL amber glass bottle
Impinger #1	5% nitric acid in 10% hydrogen peroxide (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with 0.1N HNO_3 into sample container.	
Impinger #2	5% nitric acid in 10% hydrogen peroxide (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with 0.1N HNO_3 into sample container.	
Impinger #3	Dry	Recover condensate, then rinse impinger and connecting glassware with fresh $KMnO_4$ solution into sample container.	Combine impingers 3,4, and 5 in a 1000 mL amber glass bottle.
Impinger #4	4% potassium permanganate in 10% sulfuric acid (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with fresh $KMnO_4$ solution into sample container.	
Impinger #5	4% potassium permanganate in 10% sulfuric acid (200 mL)	Recover impinger solution, then rinse impinger with fresh $KMnO_4$ solution into sample container.	
Impinger #4 - Second Rinse	NA	Rinse impinger with 8N HCl into sample container. Not to exceed 25 mL HCl.	250 mL amber glass bottle
Impinger #5 - Second Rinse	NA	Rinse impinger with 8N HCl into sample container. Not to exceed 25 mL HCl.	
Impinger #6	Silica Gel (300 g)	Replace when exhausted.	None

NA = Not applicable.

[a] All impingers will be weighed prior to recovery to determine gas sample moisture content by EPA Reference Method 4.

[b] Turbine exhaust and incinerator stack only.

offset the effects of the reducing gas matrix on the absorbing solutions, a modification was applied to all internal process gas streams. The hydrogen peroxide concentration in impingers one and two was increased from 10 to 30 percent. The permanganate impingers for the collection of elemental mercury were not used in those gas streams with high concentrations of H_2S as the permanganate solution would be rapidly consumed. Elemental mercury was determined at these locations by charcoal adsorption or on-line AAS techniques described below.

On-line AAS. Selected vapor-phase metals were determined directly using an atomic absorption spectrophotometer (AAS). The AAS was modified to accept syngas for a portion of the fuel gas going to the nebulizer mixing chamber and flame. In the flame, vapor-phase trace elements are atomized and absorb light energy from an element-specific light source just like aqueous samples in conventional AAS. The sample gas, fuel gas and air supplies are regulated and monitored to determine the syngas component going to the flame, and ultimately the elemental concentration in the gas sample stream. Absorbance and concentration are related by Beer's law and gas concentrations are determined by comparison with standard curves generated from aqueous standards. The following metals, were determined using the on-line AAS:

- Arsenic;
- Cadmium;
- Nickel;
- Mercury;
- Chromium;
- Lead;
- Selenium; and
- Zinc.

A schematic of the AAS system is shown in Figure B-1.

Charcoal Adsorption

Many gas-phase trace elements in gasification systems can be adsorbed onto charcoal. A slipstream of the particulate-free gas was drawn through specially prepared charcoal tubes at rates not exceeding 1 liter/minute. Previous studies for EPRI have shown charcoal to be a very effective sorbent for some metals, especially iron and nickel (which may be present as the carbonyl) and arsenic. Arsenic (in the form of arsine, AsH_3) is readily adsorbed on charcoal, but it is unknown whether other forms of arsenic are as effectively collected. Target species for

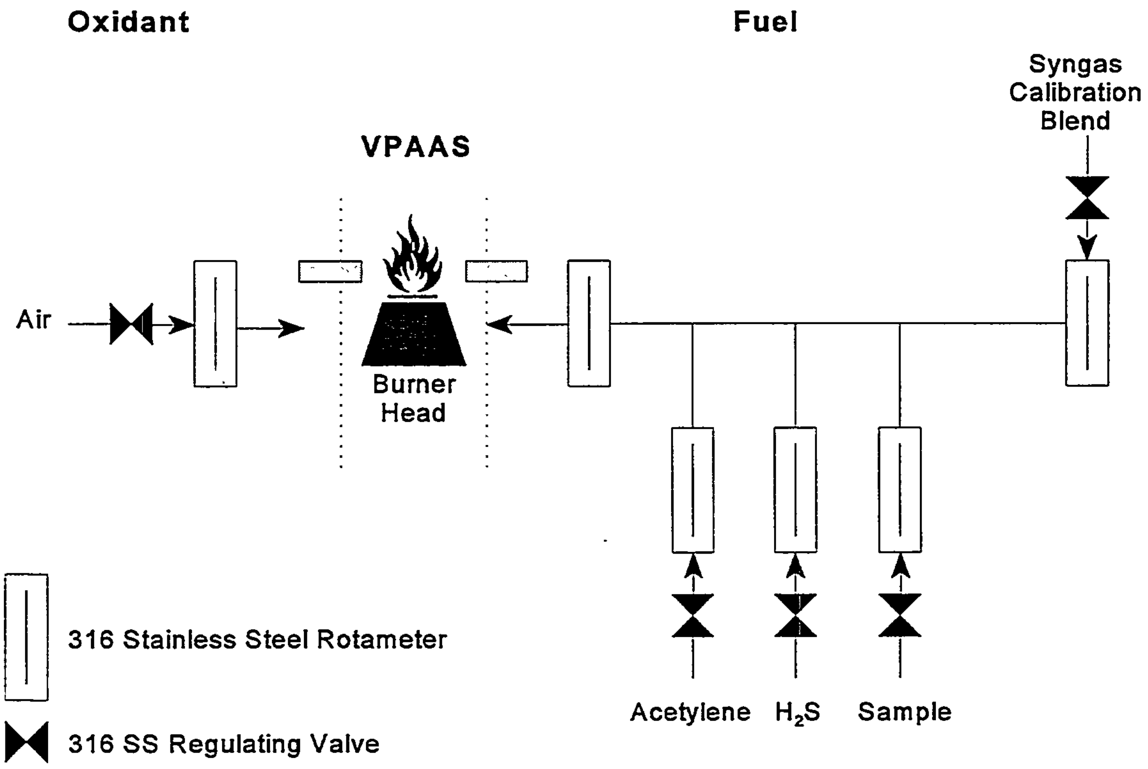

Figure B-1
Schematic of Online AAS

quantification using the charcoal tubes were antimony, arsenic, iron, lead, mercury, nickel, and zinc.

Coconut-based charcoal was aggressively cleaned using concentrated nitric acid followed by an ultra-pure deionized water rinse then dried over night. The charcoal was then loaded into precleaned quartz tubes. Two charcoal tubes were placed in series and exposed to a minimum volume of 50 liters of gas (100 liters typical). Following collection, the charcoal tubes were sealed with plastic caps and sent to the laboratory for analysis.

Sulfur Dioxide/Sulfuric Acid

Sulfur dioxide and sulfuric acid mist were determined on the two stacks using EPA Method 8. This method is identical to EPA Method 5 with the exception of the impinger contents. The first impinger contains an 80% isopropanol (IPA) mixture and the second and third impingers contain a 6% hydrogen peroxide solution. Sulfuric acid mist is collected in the IPA solution, sulfur dioxide in the peroxide solution.

Ammonia/Hydrogen Cyanide/Anions

The sample collection train for the determination of ammonia, hydrogen cyanide, and anions (acid gas) was similar to the EPA Method 5 train, except isokinetic sampling was not required. For the collection of ammonia and anions, dilute sulfuric acid was placed in the first two impingers of the condenser assembly. For the collection of cyanide, a dilute zinc acetate solution was placed in the fourth and fifth impingers of the condenser assembly. Sample volume for each run was typically 30 to 40 dry standard cubic feet, depending upon the location. A description of the sample train configuration and recovery procedures is presented in Table B-4.

Modifications

For internal gas streams, the sulfuric acid absorbing solution was increased to 5 percent. Also, for gas streams containing H_2S, an impinger(s) containing PbOAc ($pH<4$), was placed in front of the cyanide absorbing solution for H_2S removal.

Volatile Organics

The volatile organic compounds were collected using a volatile organic sampling train (VOST). The VOST is described in Method 0030 in SW-846, *Test Methods for Evaluating Solid Waste*, Third Edition, November 1986. In the VOST, volatile organics are removed from the sample gas by sorbent traps maintained at 20°C. The first sorbent trap contains Tenax resin and the second trap contains Tenax followed by petroleum-based charcoal. To increase the collection efficiency, the sample gas is cooled and dried by passing it through a water-cooled condenser prior to its contact with the sorbent trap. A dry gas meter is used to measure the volume of gas passed through the pair of traps. Sample volumes of 20 liters were collected on three separate pairs of traps at 0.5 liter per minute sampling rate.

Table B-4
Description and Recovery of Ammonia, Anions, and Hydrogen Cyanide Sampling Train

Component	Solution	Recovery[a]	Container
Transfer Line Rinse	NA	Rinse transfer line with 0.1N sulfuric acid into sample container.	1000 mL Nalgene bottle
Impinger #1 (NH_3)	0.1N H_2SO_4 (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with deionized water into sample container.	
Impinger #2 (NH_3)	0.1N H_2SO_4 (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with deionized water into sample container.	
Impinger #3	Dry	Recover condensate, then rinse impinger and connecting glassware with deionized water into sample container.	
Impinger #4 (CN)	2% w/v ZnOAc (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with deionized water into sample container.	1000 mL Nalgene bottle Cool to 4°C
Impinger #5 (CN)	2% w/v ZnOAc (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with deionized water into sample container.	
Impinger #6	Silica Gel (300 g)	Not recovered.	None

NA = Not applicable.

[a] All impingers were weighed prior to analysis.

Leak checks are performed before and after collection on each pair of resin traps. After the post-collection leak check was completed, the traps were sealed with their end caps and returned to their respective glass containers for storage and transport. During storage and transportation, the traps were kept cool (4 °C).

Aldehydes

Aldehydes were collected using an impinger train containing 2,4-dinitrophenylhydrazine (DNPH) as described in EPA Method 0011. The sampling system was cleaned prior to shipment according to the protocol method and transported to the site. After sampling, the impinger solutions were combined into one sample along with the methylene chloride glassware rinse. The solutions were sealed in amber glass containers with Teflon closures and stored at 4 °C. A description of the sample train configuration and recovery procedures is presented in Table B-5.

Semivolatile Organic Compounds and Selected Polycyclic Aromatic Hydrocarbons

Semivolatile organics (SVOCs) and polycyclic aromatic hydrocarbons (PAHs) were collected using a Modified Method 5 (MM5) sampling train. The probe washes, filter catches, XAD sorbent traps, and aqueous condensates were extracted and analyzed by a combination of analytical protocols, SW-846 Method 8270 and CARB Method 429 (PAHs).

The MM5 protocol is outlined as Method 0010 in SW-846, "Test Methods for Evaluating Solid Waste," Third Edition, November 1986. The sampling system consists of a heated probe, heated filter, sorbent module, and pumping and metering unit. A gooseneck nozzle of an appropriate diameter to allow isokinetic sample collection is attached to the probe. S-type pitot tube differential pressure is monitored to determine the isokinetic sampling rate.

Sampling of the stack gases was conducted in accordance with the published MM5 protocol. This involved collecting the samples isokinetically across two cross-sectional diameters of the stack. The sampling rate for each train was between 0.5 and 1.0 dscfm. A minimum of 100 dscf was collected by each train over a minimum sampling period of two hours.

Sampling train preparation and sample recovery were performed in a controlled environment to reduce the possibility of sample contamination. Prior to assembly, each component of the sampling train was thoroughly rinsed with methylene chloride. The XAD sorbent traps were prepared by the CARB 429 protocol and spiked with isotopically labeled surrogate PAHs. These traps are kept refrigerated after spiking to preserve the spike integrity.

After sample collection, the ends of the sampling train were once again sealed with solvent-rinsed foil and returned to the clean-up area for sample recovery. The filter was recovered and placed in a methylene chloride-rinsed glass petri dish. Aqueous condensate collected in the first two impingers and in the sorbent trap were transferred to methylene chloride-rinsed amber glass

Table B-5
Description and Recovery of Aldehydes Sampling Train

Component	Solution	Recovery	Container
Transfer Line Rinse	NA	Rinse transfer line with methylene chloride into sample container.	1000 mL amber glass bottle Cool to 4°C
Impinger #1	DNPH Solution (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with methylene chloride into sample container.	
Impinger #2	DNPH Solution (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with methylene chloride into sample container.	
Impinger #3	Dry	Recover condensate into sample container.	
Impinger #4	Silica Gel (300 g)	Not recovered.	None

NA = Not applicable.

bottles with Teflon®-lined screw cap closures. All components of the sampling train, from the nozzle through the sorbent module, including the probe, filter glassware, and impinger glassware were rinsed thoroughly with methylene chloride. The probe was cleaned using a nylon brush followed by rinsing with methylene chloride. The probe rinse and glassware rinses were combined with the recovered condensate sample. The XAD-2 resin cartridges were sealed and transferred to the laboratory. A description of the sample train configuration and recovery procedures is presented in Table B-6. Samples from the two emission stacks were analyzed according to the CARB Method 429, a high resolution GC/MS technique for selected PAHs.

Modifications. All internal stream samples were vapor phase only and were analyzed by standard GC/MS per Method 8270.

Majors, Reduced Sulfur, Hydrocarbons

Grab samples were collected for the characterization of major gases, reduced sulfur species and for C_1 - C_{10} hydrocarbons. Samples were collected into Tedlar® bags.

Table B-6
Description and Recovery of Modified Method 5 (Semivolatile and PAHs) Sampling Train

Component	Solution	Recovery	Container
Probe Nozzle Rinse [a]	NA	Rinse probe, nozzle, and front half of filter holder with methylene chloride into sample container.	500 mL amber glass bottle Cool to 4°C
Filter [a]	Pre-treated Quartz Filter	Place filter in sample container.	Glass petri dish Cool to 4°C
XAD Cartridge	XAD-2 Resin	Seal resin cartridge.	Wrap in aluminum foil. Cool to 4°C
Transfer Line Rinse	NA	Rinse transfer line with methylene chloride into sample container.	1000 mL amber glass bottle Cool to 4°C
Condenser	NA	Rinse condenser with methylene chloride into sample container.	
Impinger #1	Dry	Recover condensate, then rinse impinger and connecting glassware with methylene chloride into sample container.	
Impinger #2	Ultrapure Water (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with methylene chloride into sample container.	
Impinger #3	Ultrapure Water (200 mL)	Recover impinger solution, then rinse impinger and connecting glassware with methylene chloride into sample container.	
Impinger #4	Silica Gel (300 g)	Not recovered.	None

NA = Not applicable.

[a] Turbine exhaust and incinerator stack only.

Carbon Monoxide, Sulfur Dioxide, Nitrogen Oxides

Continuous emission monitors (CEMs) were used to determine the gas concentration of these species at the turbine and incinerator stacks. These instruments were operated according to the protocols of EPA Methods 10, 6C, and 7E, respectively.

Solid Sampling Procedures

Solid stream samples (raw coal, coal slurry, and slag) were collected using grab sampling techniques. Samples were collected three times per day and composited daily throughout all test periods. Daily composite samples of raw coal, coal slurry, and slag were mixed well and split to produce a 1 kilogram (minimum) sample which was placed in a plastic container and sealed for transportation to the laboratory. Coal slurry samples were collected from two locations, the primary and secondary stage feed lines. Slag samples were collected via the slag sample collection system currently in use by LGTI. This system diverts a slip-stream of the slag (that is continually being discharged from the reactor) through a strainer/filter. The collected slag was allowed to cool (without water washing) prior to sample recovery.

Liquid Sampling Procedures

Sour and sweet water samples were collected by grab-tap techniques. Samples were collected three times per day during Period 3 and combined to form a single daily composite. The grab samples are composited directly into appropriate containers and preserved as soon as possible after collection. In some cases the sample was added directly to bottles containing the preservative in order to reduce the loss of the more volatile species (e.g., NH_3, CN^-).

Process water samples collected for the analysis of volatile organic compounds and aldehydes present the only exception to the collection procedures described above. Due to the volatility of these analytes, these samples were collected once daily directly into amber glass containers without filtration. All samples for organic compounds were chilled to 4°C following collection.

Hot Gas Sampling System

Sample collection with the hot gas sampling system was very similar to those methods used for all syngas matrices. The following insertion of the hot gas probe, the hot gas was extracted at a rate of approximately 4 acfm. Vapor-phase samples were collected from heated sample taps as slip streams to the primary gas flow. Some minor sampling method modifications to those described for Periods 1-3 were made for the Period 4 (hot gas) testing, specifically for the multi-metals (M-29) sampling train and for the anions sampling train. Following are specifics regarding changes to the test methodologies.

Potassium permanganate impingers were added to the M-29 sampling train per the standard setup, except two impingers containing sodium hydroxide (2N) were placed in front of the potassium permanganate impingers to remove H_2S. While not entirely effective at removing all H_2S from the syngas, the caustic impingers did remove enough H_2S so that elemental mercury could be collected in the permanganate solution. The caustic scrubber as well as the permanganate impingers were removed from the M-29 sampling train after the collection of 30-40 cubic feet of gas had been sampled to minimize the degradation effect of the H_2S.

The scrubbing solution for anions was also changed for hot gas testing. Sulfuric acid (1%) was used during Periods 1-3. However, the high sulfate content interfered with the chloride analysis and the necessary sample dilution increased the detection limits. For the hot gas test phase, the absorbing solution was changed to a 0.3 mM sodium bicarbonate/2.4 mM sodium carbonate solution. This is basically the ion chromatograph eluent solution used in EPA Method 300. Use of this absorbing solution produced a transparent background for the analysis of chloride and fluoride.

Collection methods for metals by charcoal, ammonia, and cyanide were not changed from the methodologies used in Periods 1-3.

APPENDIX C: SAMPLE PREPARATION AND ANALYSIS

Like the selection of sampling methods, the analytical methods applied to process samples from coal gasification and other partial oxidation combustion systems require special attention to matrix effects and interferences from reduced species. Many process samples contain reactive substances (e.g., hydrogen sulfide) that undergo or create chemical changes before the sample is analyzed.

Before some samples can be analyzed, sample preparation is necessary to produce a suitable matrix for analysis. Once prepared, most of the chemical and instrumental methods for analysis are common to samples collected from the gas, solid, and liquid streams. This section describes the sample preparation and analysis scheme that correlates with the sample components listed for each gas sampling train and process sample described in Appendix B. This section also describes specialized analytical techniques, identifies subcontract laboratories and their roles, and presents the analytical method references. Samples collected in fulfillment of the EMP were analyzed by methods specified in the EMP. Complete lists of the target metals and ionic species, organic compounds, and radionuclide analytes for the HAPs measurement program are presented in Tables C-1 through C-3.

Gas Samples

Gas samples were collected from two distinctly different sources, internal process streams (reducing environment) and emissions sources (oxidized streams). Correspondingly, the discussion of sample preparation and analysis is presented in two parts. First, all sample preparation and analytical techniques common to both gas sources are presented. Second, the special preparation methods and analytical techniques required for the internal process streams are described.

In Table C-4, the methods that will be used in the analyses of EMP samples are summarized and compared to the analytical methods selected for the HAPs samples. The analytical methods are the same for many parameters. Where the methods differ, samples will be analyzed by both the EMP and HAPs protocols.

Table C-1
Analyte List for Inorganic Parameters

Trace Elements	Major Elements
Antimony [a]	Aluminum
Arsenic [a]	Calcium
Barium [a]	Iron
Beryllium [a]	Magnesium
Boron[b]	Potassium
Cadmium [a]	Silicon [b]
Chromium, total [a]	Sodium
Cobalt [a]	Titanium
Copper [a]	**Ultimate/Proximate Parameters**
Lead [a]	Carbon
Manganese [a]	Hydrogen
Mercury	Nitrogen
Molybdenum [a]	Sulfur
Nickel [a]	Ash
Selenium [a]	Volatile Matter
Vanadium [a]	Fixed Carbon
Zinc	Higher Heating Value (HHV)
Ionic Species	
Chloride (Cl^-)	
Fluoride (F^-)	
Phosphate (as Total P)	
Sulfate (SO_4^{-2})	
Ammonia	
Cyanide	
Sulfide	
Formate	
Thiocyanate	

[a] These elements analyzed by ICP-MS in the gas impinger samples.

[b] Silicon and boron not determined in gas particulate samples.

Table C-2
Analyte List for Organic Parameters

Volatile Organics [a] (Method 8240)	Semivolatile Organics (Method 8270/CARB 429 [b])	
Benzene	Acenaphthene [b]	2,4-Dimethylphenol
Bromoform	Acenaphthylene [b]	Dimethylphthalate
Carbon Disulfide	Acetophenone	4,6-Dinitro-2-methylphenol
Carbon Tetrachloride	4-Aminobiphenyl	2,4-Dinitrophenol
Chlorobenzene	Aniline	2,4-Dinitrotoluene
Chloroform	Anthracene [b]	2,6-Dinitrotoluene
1,4-Dichlorobenzene	Benzidine	bis(2-Ethylhexyl)phthalate
cis-1,3-Dichloropropene	Benzo(a)anthracene [b]	Fluoranthene [b]
trans-1,3-Dichloropropene	Benzo(a)pyrene [b]	Fluorene [b]
Ethylbenzene	Benzo(b)fluoranthene [b]	Hexachlorobenzene
Ethylchloride (Chloroethane)	Benzo(g,h,i)perylene [b]	Hexachlorobutadiene
Ethylene Dichloride (1,2-Dichloroethane)	Benzo(k)fluoranthene [b]	Hexachlorocyclopentadiene
Ethylidene Dichloride (1,1-Dichloroethane)	Benzoic Acid	Hexachloroethane
Methyl Bromide (Bromomethane)	Benzyl Alcohol	Indeno(1,2,3-cd)pyrene [b]
Methyl Chloride (Chloromethane)	4-Bromophenyl Phenyl Ether	Isophorone
Methyl Chloroform (1,1,1-Trichloroethane)	Butylbenzylphthalate	2-Methylnaphthalene [b]
Methyl Ethyl Ketone (2-Butanone)	4-Chloro-3-Methylphenol	2-Methylphenol (o-cresol)
Methylene Chloride (Dichloromethane)	p-Chloroaniline	4-Methylphenol (p-cresol)
Propylene Dichloride (1,2-Dichloropropane)	bis(2-Chloroethoxy)methane	N-Nitrosodimethylamine
Styrene	bis(2-Chloroethyl)ether	N-Nitrosodiphenylamine
1,1,2,2-Tetrachloroethane	bis(2-Chloroisopropyl)ether	N-Nitrosopropylamine
Tetrachloroethene	2-Chloronaphthalene [b]	Naphthalene [b]
Toluene	2-Chlorophenol	2-Nitroaniline

Table C-2 (Continued)

Volatile Organics [a] (Method 8240)	Semivolatile Organics (Method 8270/CARB 429 [b])	
1,1,2-Trichloroethane	4-Chlorophenyl Phenyl Ether	3-Nitroaniline
Trichloroethene	Chrysene [b]	4-Nitroaniline
Vinyl Acetate	Di-n-octylphthalate	Nitrobenzene
Vinyl Chloride	Dibenz(a,h)anthracene [b]	2-Nitrophenol
Vinylidene Chloride (1,1-Dichloroethene)	Dibenzofuran	4-Nitrophenol
m,p-Xylene	Dibutylphthalate	Pentachloronitrobenzene
o-Xylene	1,2-Dichlorobenzene	Pentachlorophenol
	1,3-Dichlorobenzene	Phenanthrene [b]
	1,4-Dichlorobenzene	Phenol
	3,3-Dichlorobenzidine	Pyrene [b]
	2,4-Dichlorophenol	1,2,4-Trichlorobenzene
	Diethylphthalate	2,4,5-Trichlorophenol
	p-Dimethylaminoazobenzene	2,4,6-Trichlorophenol

[a] These are the volatile organic compounds detected by VOST (Method 8240) that are listed in the Clean Air Act list of hazardous air pollutants.

[b] These semivolatile organic compounds analyzed in the gas samples by CARB Method 429 using high resolution GC/MS.

Table C-3
List of Radionuclides

Gamma Emitters	Nominal Detection Limits[a]
Actinium-228 @ 338 KeV	0.7
Actinium-228 @ 911 KeV	0.5
Actinium-228 @ 968 KeV	0.8
Bismuth-212 @ 727 KeV	1.7
Bismuth-214 @ 609.4 KeV	0.3
Bismuth-214 @ 1120.4 KeV	1.3
Bismuth-214 @ 1764.7 KeV	1.1
Lead-210 @ 46 KeV	2.8
Lead-212 @ 238 KeV	0.1
Lead-214 @ 295.2 KeV	0.4
Lead-214 @ 352.0 KeV	0.3
Potassium-40 @ 1460 KeV	2.0
Radium-226 @ 186.0 KeV	2.1
Thallium-208 @ 583 KeV	0.1
Thallium-208 @ 860 KeV	1.2
Thorium-234 @ 63.3 KeV	2.7
Thorium-234 @ 92.6 KeV	0.9
Uranium-235 @ 143 KeV	0.5

[a] Based on a four-hour count of a 100 g sample, dry basis.

Table C-4
Comparison of EMP and LGTI HAPs Analytical Methods

Stream	Parameter	Analytical Methods	
		EMP	LGTI HAPs
Sour Syngas	C_1 - C_{10}	GC	GC-FID
	Major Gases	GC	GC-TCD
Sweet Syngas	Particulate Loading	Gravimetric	Gravimetric
	H_2S	Titration	GC-FPD
	Major Gases	GC	GC-TCD
Turbine Exhaust	Particulate Loading	Gravimetric	Gravimetric
	SO_3/H_2SO_4	Ion Chromatography	Ion Chromatography
	PM-10	Gravimetric	Gravimetric
	Major Gases (CO_2, O_2, N_2)	Orsat	CEM
Incinerator Exhaust	Particulate Loading	Gravimetric	Gravimetric
	PM-10	Gravimetric	Gravimetric
	Volatile Organics	Cryogenic Focus GC-FID/PID/HECD	GC/MS
	Semivolatile Organics	EPA Method 8270 (GC-MS)	EPA Method 8270 (GC-MS) and CARB Method 429
	Total Chromatographical Organics	Sonication, GC-FID	NS [a]
	SO_3/H_2SO_4	Ion Chromatography	Ion Chromatography
	NO_x	Ion Chromatography	CEM

[a] NS = Not sampled as part of the LGTI HAPs program.

Particulate- and Vapor-Phase Metals

The sample fractions generated by the multi-metals sampling train and an overview of the sample handling process are shown in Figures C-1, C-2, and C-3. These particulate and vapor-phase sample fractions are prepared and analyzed separately for the elements listed in Table C-1.

Particulate-Phase Metals. All filter samples are desiccated and weighed to a constant weight (defined as successive weight determinations within 0.5 mg at 6-hour intervals). For all internal gas stream samples, there are no probe and nozzle rinses. For samples collected at the turbine exhaust stack and incinerator stack, the acetone probe and nozzle rinse (PNR) is evaporated, desiccated, and also weighed to a constant weight. The nitric acid PNR is added to the solids recovered from the acetone PNR, and the volume is reduced to 10 mL by evaporation on a hot plate. This volume is quantitatively transferred, along with the filter, to a microwave-digestion vessel. The total particulate sample from the collected gas is microwave digested[1] with a mixture of hydrofluoric, hydrochloric, and nitric acids. The digestate is then analyzed for metals (except boron) by a combination of techniques including inductively coupled plasma atomic emission spectroscopy (ICP-AES)[2] and graphite furnace atomic absorption spectroscopy (GFAAS).[3,4,5,6] Mercury is determined from an aliquot of the microwave digestate by cold vapor atomic absorption spectroscopy (CVAAS).[7]

Boric acid is added to the digestate to solubilize metal fluorides that precipitate during the digestion. This addition of boric acid makes the analysis of boron in these samples impractical; however, boron was determined in the collected ash samples from the raw gas and char streams where sufficient sample material permits a separate preparation procedure for boron analysis.

Vapor-Phase Metals. The two HNO_3/H_2O_2 impinger samples were combined, digested,[8,9] and analyzed for metals by ICP-AES and GFAAS. An undigested aliquot is taken for ICP/MS[10] analysis. Another aliquot is removed for mercury analysis and the excess peroxide in the sample matrix eliminated by the addition of solid $KMnO_4$ until a pale pink color persists. The sample is digested in $KMnO_4$/ H_2SO_4 solution and analyzed for mercury by CVAAS.

The contents of the third impinger, the two $KMnO_4/H_2SO_4$ impingers, and the hydrogen chloride (HCl) impinger rinse are combined and an aliquot is digested in $KMnO_4$/ H_2SO_4 solution and analyzed for mercury by CVAAS.

The direct analysis of vapor-phase metals by Radian's vapor-phase trace element atomic absorption spectrophotometer (VPTE-AAS) and the analysis of the charcoal sorbent for metals are described in special techniques later in this section.

Anions

A description of the sampling train and sample fraction recovery for the Method 5 anions sampling train is presented in Table B-4. The sample fractions generated by the anions/acid gas sampling train and an overview of the sample handling process are shown in Figures C-4 and

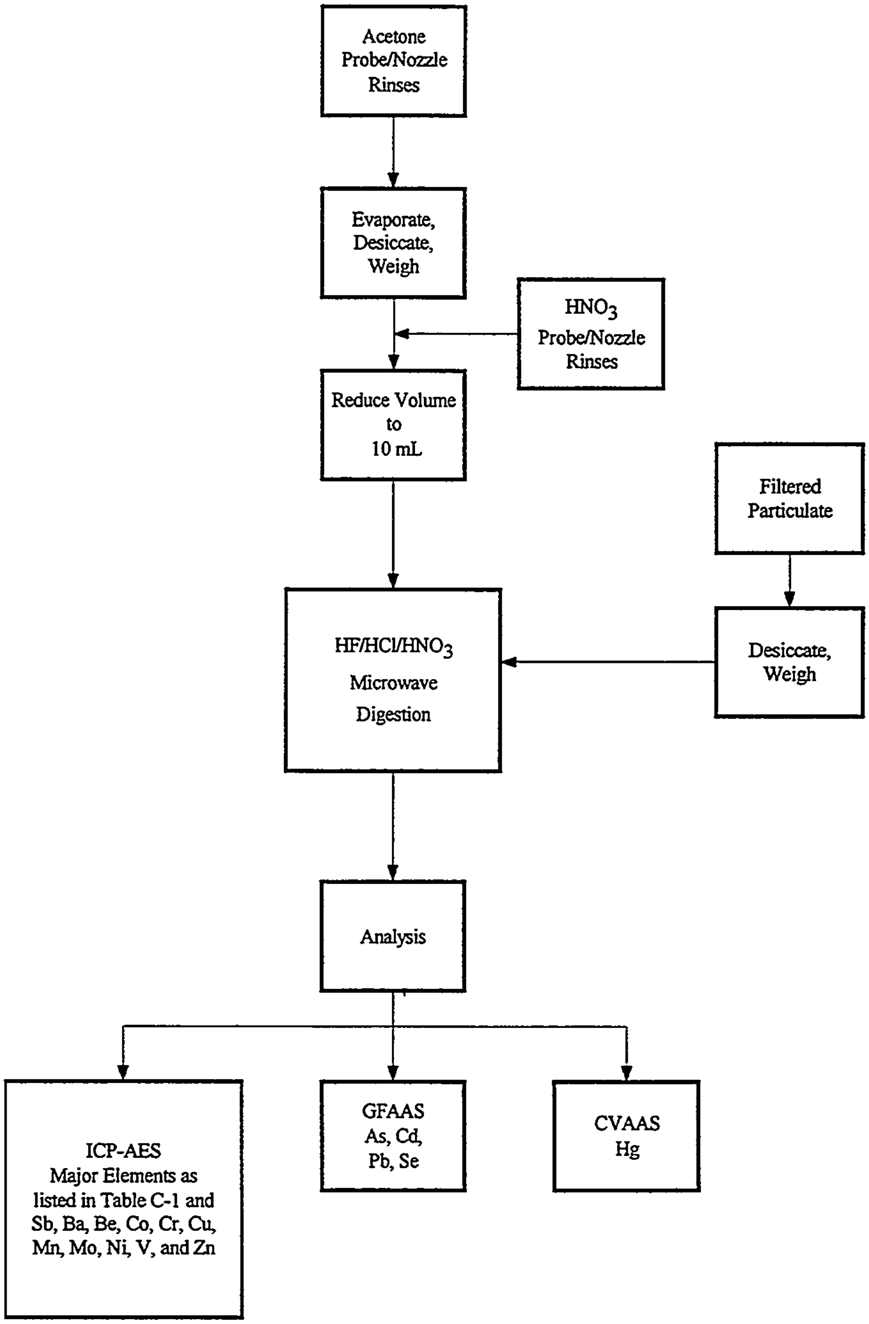

Figure C-1
Gas Particulate Sample Preparation and Analytical Plan for Metals

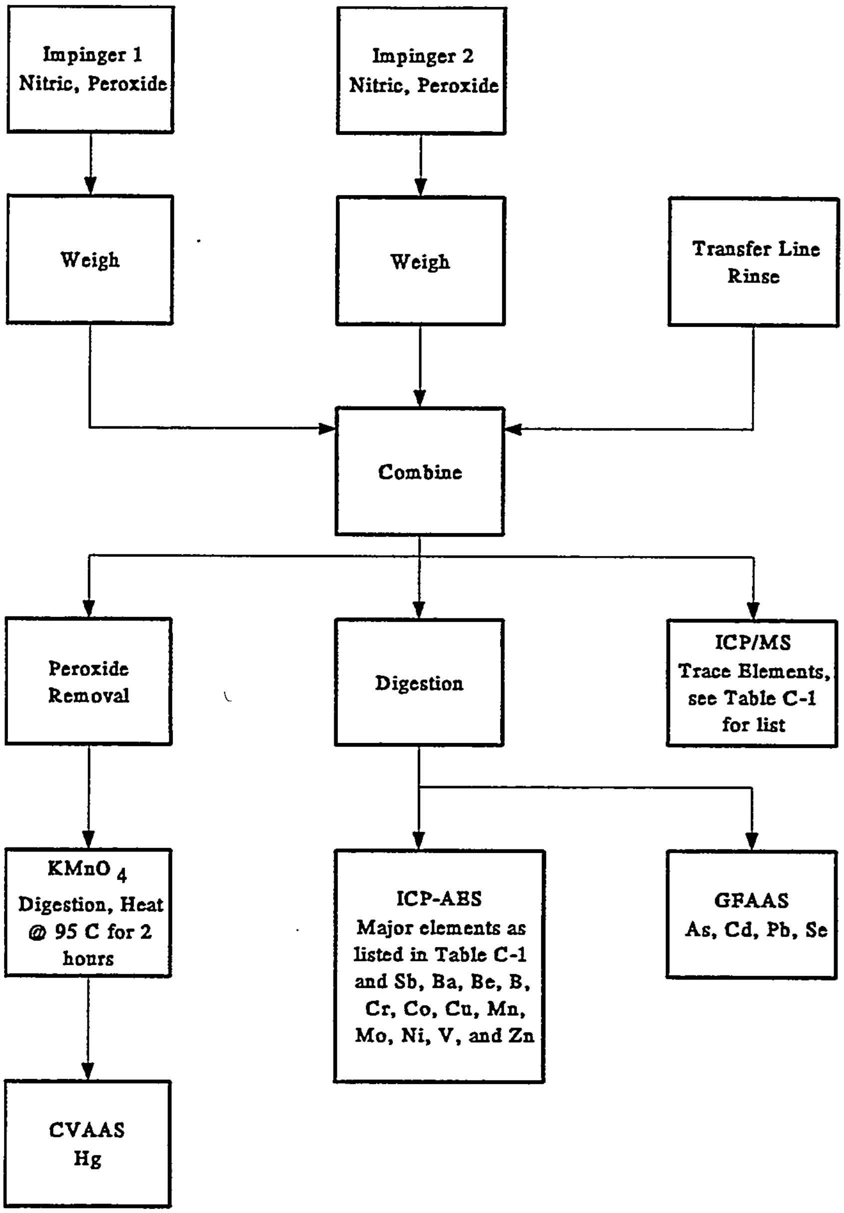

Figure C-2
Gas Impinger Sample Preparation and Analytical Plan for Metals

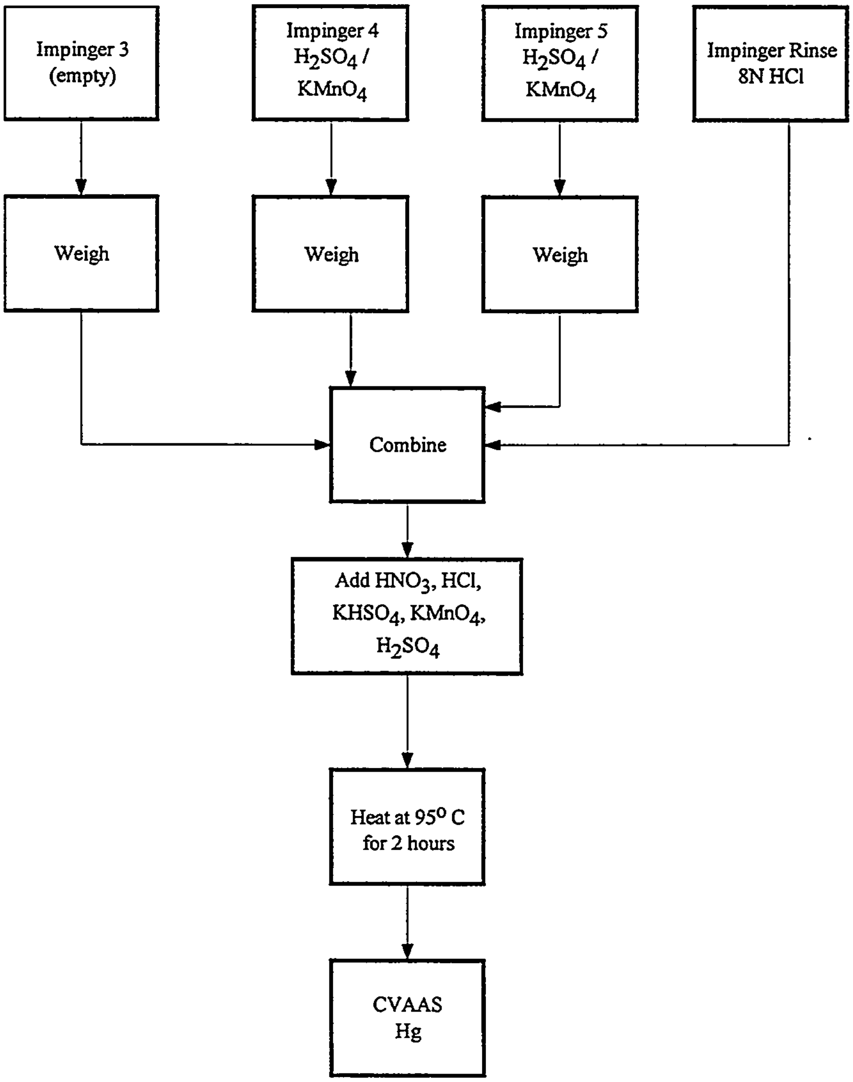

Figure C-3
Gas Impinger Sample Preparation and Analytical Plan for Mercury

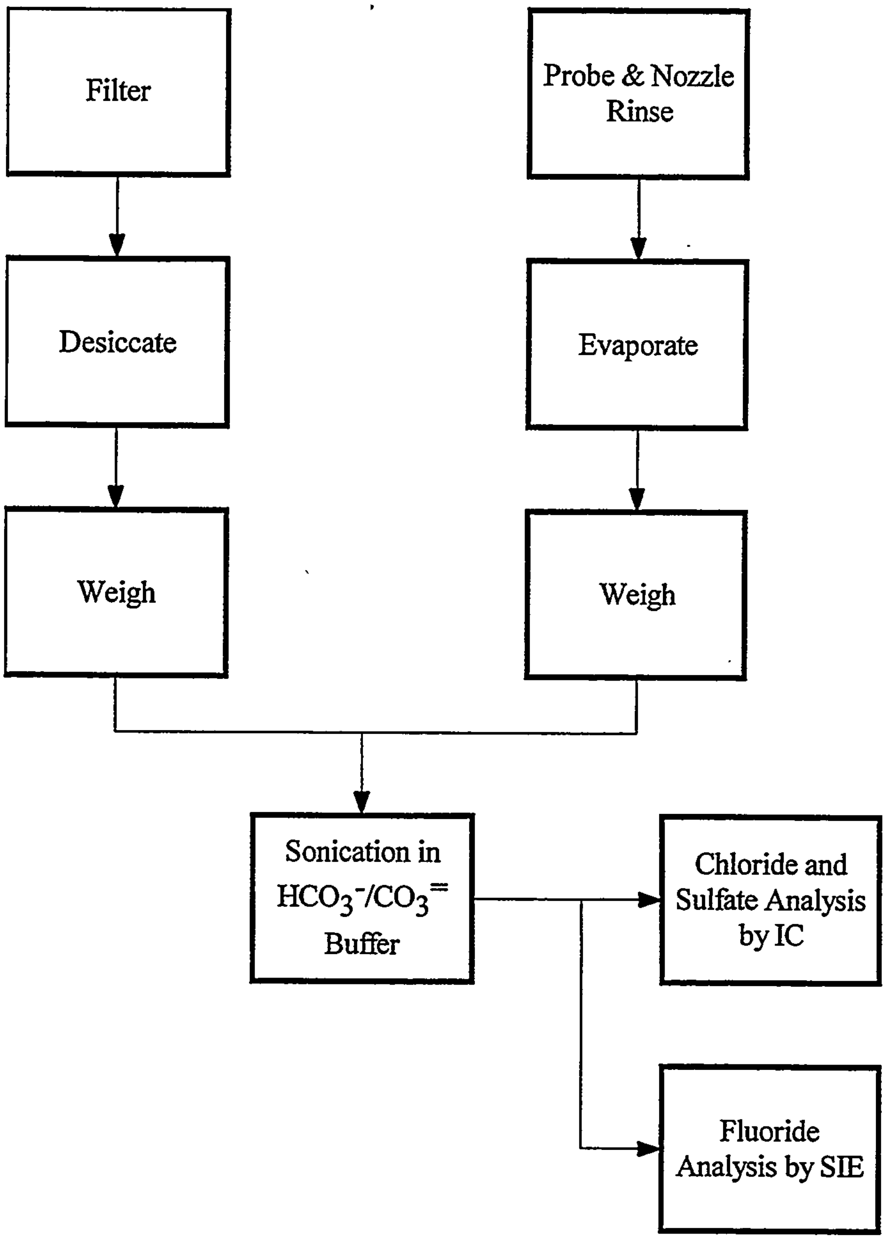

Figure C-4
Gas Particulate Sample Preparation and Analytical Plan for Anions

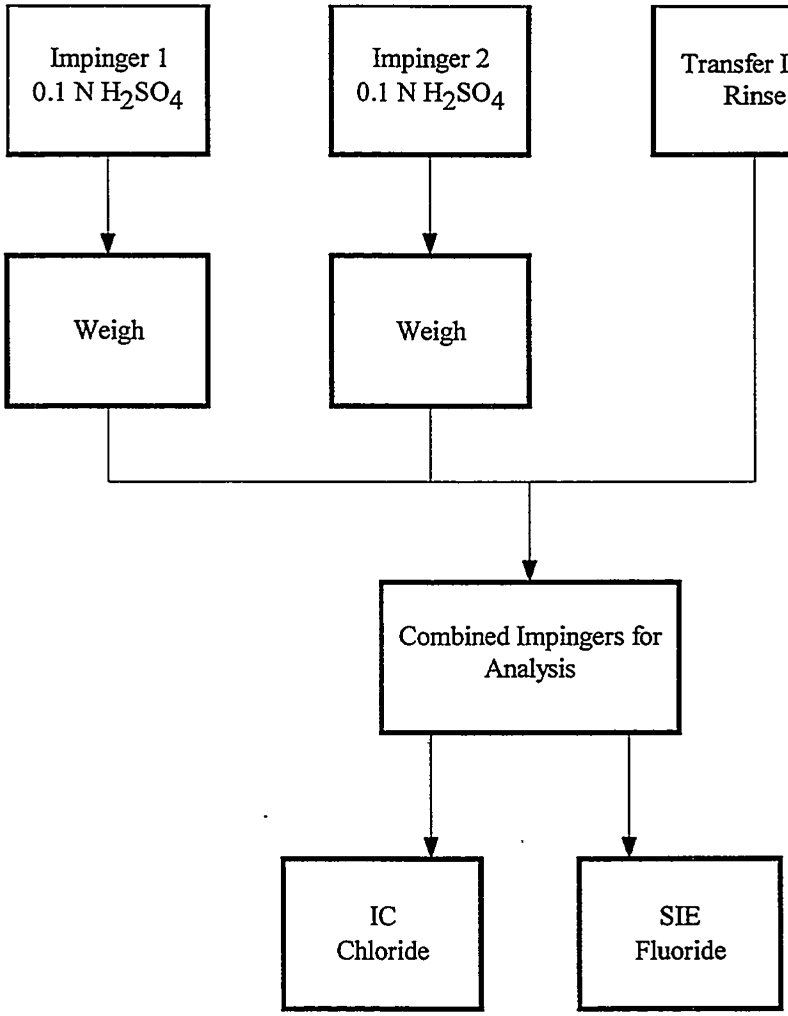

Figure C-5
Gas Impinger Sample Preparation and Analytical Plan for Anions

C-5. The particulate and vapor phases are prepared and analyzed separately for chloride and fluoride.

Particulate-Phase Anions. All filters are desiccated and weighed prior to extraction. For samples collected with probe and nozzle rinses (turbine exhaust stack and incinerator stack), the PNR sample is evaporated, desiccated, and weighed before being combined with the filter sample for extraction. The particulate matter is then sonicated with 100 mL of fresh carbonate/bicarbonate solution and analyzed for chloride and sulfate by ion chromatography (IC)[11] and for fluoride by specific ion electrode (SIE).[12]

Vapor-Phase Anions. The impinger solutions received from the test site are sent directly to the analytical laboratory for chloride analysis by IC, and fluoride analysis by SIE. Sulfate analysis of the IPA and peroxide impingers collected at the emission sources by EPA Method 8 were analyzed by IC.

Ammonia/Hydrogen Cyanide

A description of the sampling train and sample fraction recovery for the combined ammonia/hydrogen cyanide trains is presented in Table B-4. This combined sampling train is applicable only to the two emissions gas streams. Ammonia and cyanide collection trains are operated independently for most internal gas streams. For all gas stream samples, the sample fractions generated by the ammonia sampling train are sent directly to the laboratory for analysis as shown in Figure C-6. The sulfuric acid impinger solutions (0.1N and 1% H_2SO_4) are prepared for analysis by distillation according to EPA Method 350.2,[13] and the recovered distillates are analyzed by EPA 350.1,[14] an automated colorimetric method. All cyanide impinger samples (2% zinc acetate) are digested and analyzed according to EPA Method 9012.[15] A description of the cyanide collection and analysis method for internal gas streams is presented in the special techniques section.

Aldehydes

A description of the sampling train and sample fraction recovery for the aldehydes sampling train is presented in Table B-5. The sample fractions generated by the aldehydes sampling train and an overview of the sample handling process are shown in Figure C-7. The aqueous and methylene chloride layers of the sample are separated, and the aqueous fraction is then extracted with fresh methylene chloride. The methylene chloride portion of the sample and the aqueous extract are then combined. For process stream samples where low levels of aldehydes are expected, an aliquot of this extract may be concentrated during a solvent exchange procedure into acetonitrile. The resulting extract is then analyzed by high performance liquid chromatography (HPLC) for acetaldehyde, benzaldehyde, formaldehyde, and acrolein according to EPA Method 0011A.[16] Air Toxics, Ltd. was subcontracted to perform these analyses.

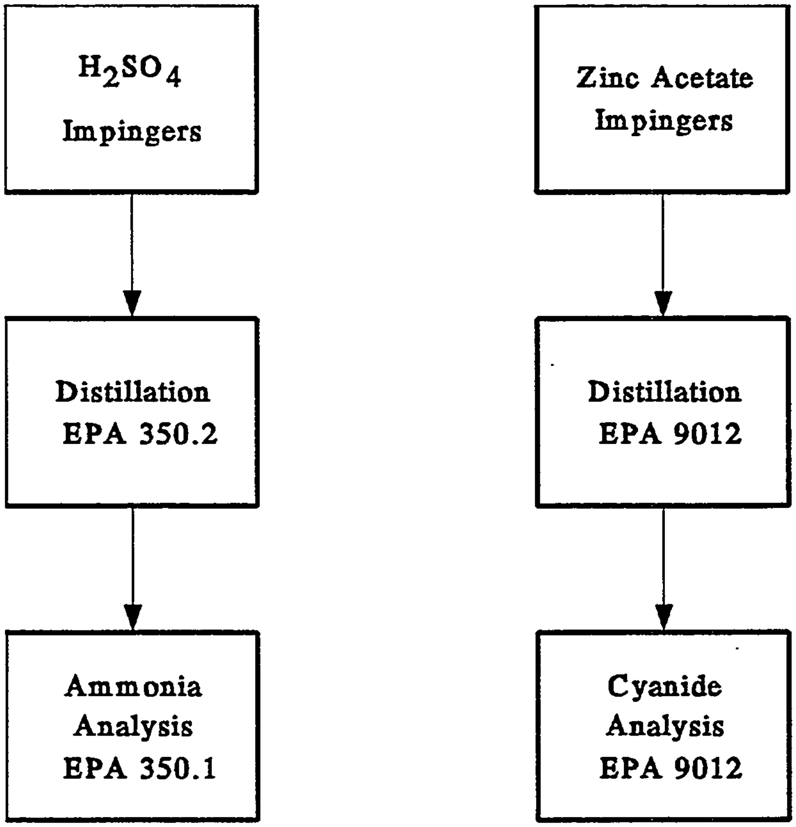

Figure C-6
Gas Impinger Sample Preparation and Analytical Plan for Ammonia and Cyanide

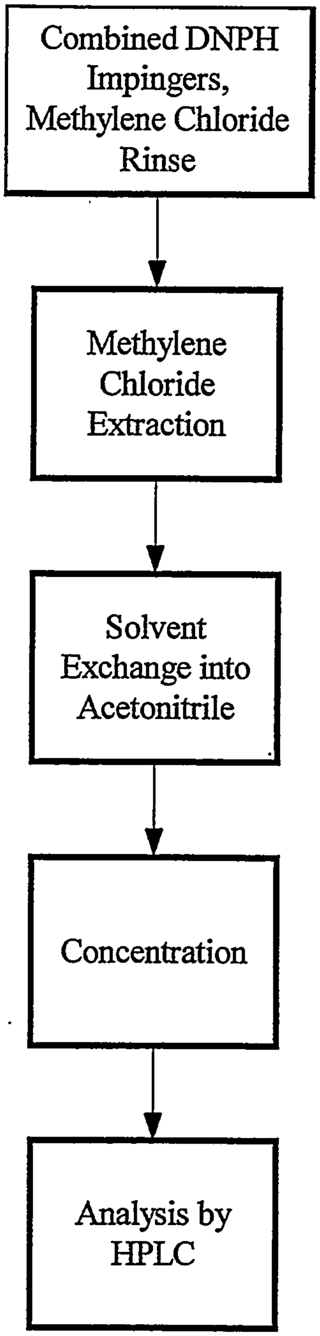

Figure C-7
Gas Impinger Sample Preparation and Analytical Plan for Aldehydes

Volatile Organics

The sample fractions generated by the VOST and an overview of the sample handling process are shown in Figure C-8. Volatile organic compound analysis is performed on the Tenax and Tenax/charcoal cartridges returned directly from the test site to the analytical laboratory. The contents of the Tenax and Tenax/charcoal cartridges are spiked with internal standards and surrogates and then thermally desorbed according to EPA Method 5040[17] and directly analyzed for the compounds listed in Table C-2 by GC/MS according to EPA Method 8240.[18] Air Toxics, Ltd. was subcontracted to perform VOST analyses.

Field blanks are performed during each run at each location. This is to account for the high probability of contamination from methylene chloride and acetone which are commonly used in the recovery of other sampling trains. The internal process streams were analyzed directly for benzene, toluene, and xylene by gas chromatography with a flame ionization detector (GC-FID). This procedure is explained further in the special techniques section.

Semivolatile Compounds and Polycyclic Aromatic Hydrocarbons (PAHs)

A description of the sampling train and sample fraction recovery for the MM5 sampling train is presented in Table B-6. The sample fractions generated by the MM5 sampling train and an overview of the sample handling process are shown in Figure C-9. The particulate-phase and vapor-phase sample fractions are analyzed separately for the semivolatile organic compounds and PAHs presented in Table C-2. The sample extracts are split to provide analysis of the particulate-phase and vapor-phase samples by SW-8270.[19] The turbine stack and incinerator stack gas samples will be analyzed by both SW-8270 and CARB Method 429[20] protocols.

The particulate phase consists of the particulate filter and front half acetone/methylene chloride probe and nozzle rinses (where applicable). The vapor phase consists of the back half acetone/ methylene chloride rinse, the XAD resin, and the impinger condensate. The acetone/methylene chloride PNR fraction, the filter, and the XAD fractions are soxhlet-extracted with methylene chloride. The impinger condensate fraction is liquid-liquid extracted with methylene chloride. The XAD extract and the impinger condensate extract are then combined, concentrated to 1 mL and analyzed by gas chromatography/mass spectrometry (GC/MS) according to EPA Method 8270, and by high resolution GC/MS according to CARB Method 429. Triangle Laboratories, Inc. was subcontracted to perform these analyses.

Solid Streams

There are six solid process streams identified for sampling and analysis: coal, slurry (two streams), recycled scrubber solids (char), slag, and sulfur byproduct. The sample preparation and analytical approach for each of these streams is presented in this section.

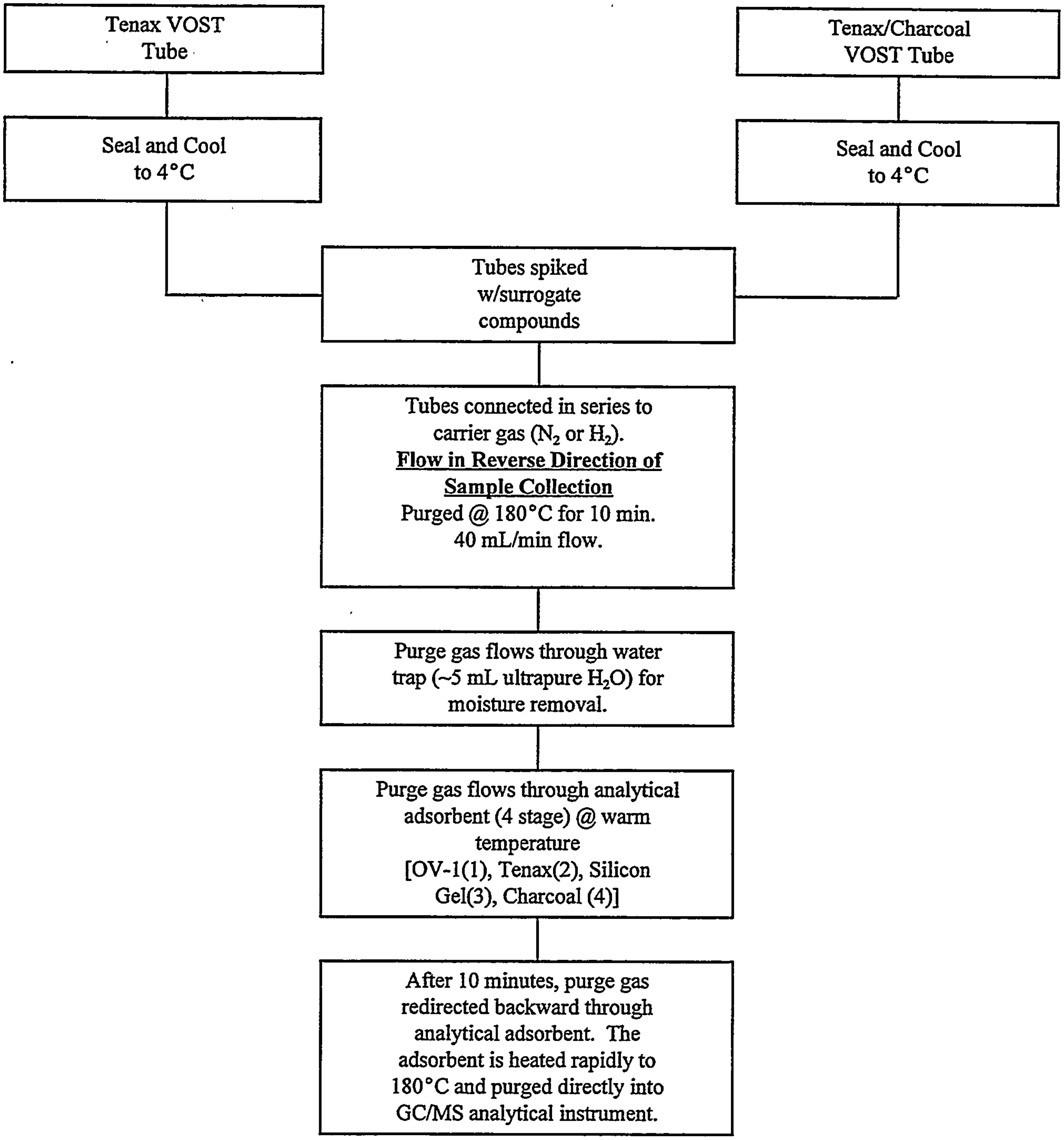

Figure C-8
VOST Sorbent Sample Preparation and Analytical Plan for Volatile Organic Compounds

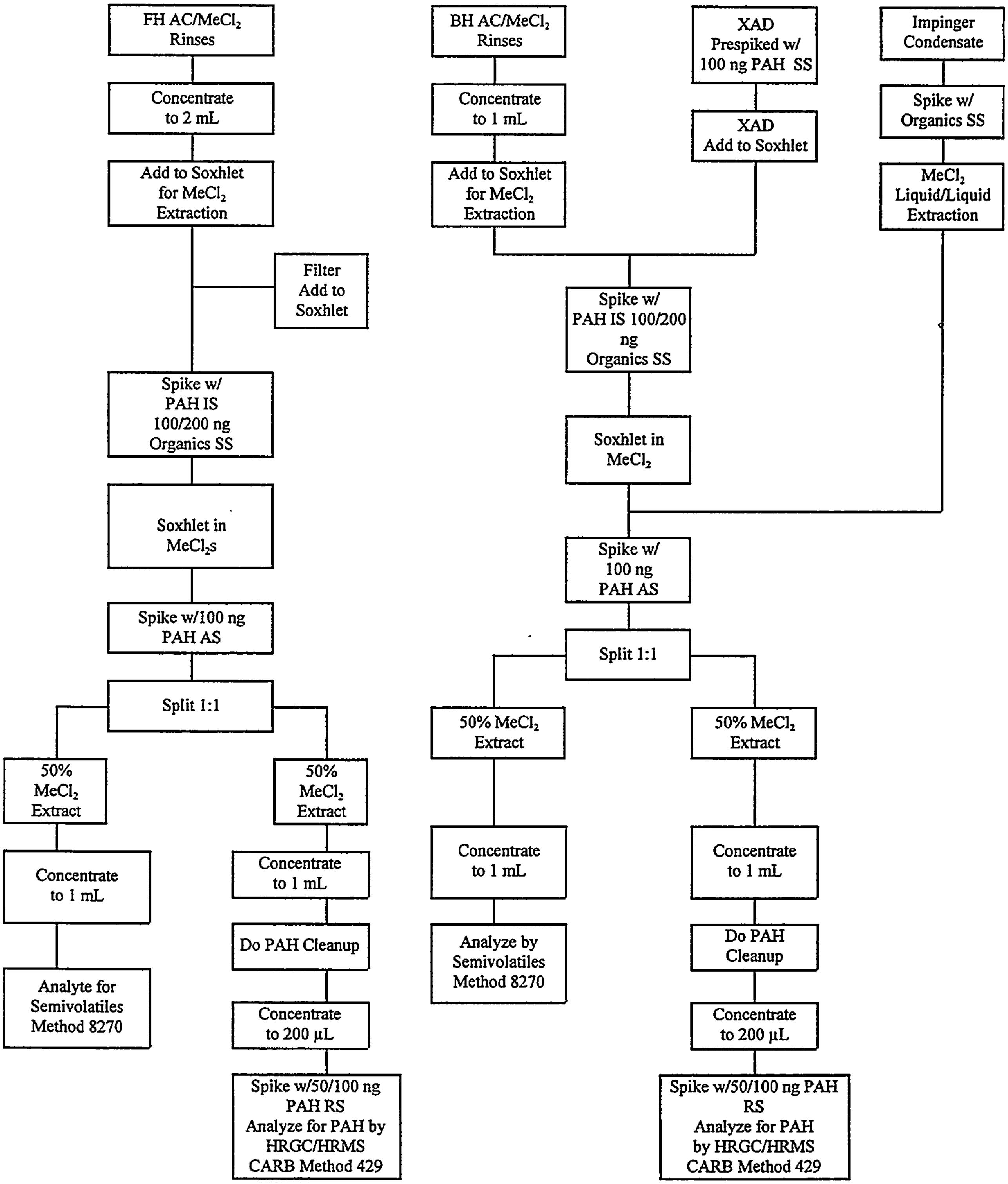

Figure C-9
Gas Sample Preparation and Analytical Plan for Semivolatile Organic Compounds and PAHs

Coal, Slurry, and Char

Each coal/slurry composite is thoroughly mixed and subsampled for drying. Weights are obtained on one subsample of the coal/slurry before and after drying at 104°C to determine the weight percent solids. A second subsample is air dried, ground to -60 mesh, and sealed in plastic bags for the analyses shown in Figure C-10. All results are reported on a dry coal basis. Char samples were also prepared and analyzed according to the plan shown in Figure C-10 and results were reported on a dry basis. Commercial Testing and Engineering Company was subcontracted to perform these analyses.

Metals. Coal and char samples were prepared for metals analysis by a variety of techniques. Samples were prepared according to ASTM D3683[21] for trace and minor elements. This method requires ashing and digesting the sample with mixed acids. Boron analysis was performed on the coal and char samples by ICP-AES after fusion with sodium carbonate. Mercury was determined by combusting a sample and trapping the mercury vapors using a double gold amalgamation technique. The amalgamated mercury is thermally desorbed and analyzed by cold vapor atomic absorption spectrophotometry (DGA-CVAA).[22] Major ash minerals were determined by X-ray fluorescence (XRF) according to ASTM Method D4326.[23]

Due to the low levels of trace elements expected in this coal matrix, an additional method was used to determine selected trace elements in the coal and char samples. A modification of ASTM D3683 was performed to provide a nitric acid matrix suitable for ICP/MS analysis. In place of the open vessel digestion specified in ASTM D3683, a mixed acid microwave digestion was performed on the ashed sample in a closed vessel to prevent loss of volatile elements. The digestate was brought to near dryness on a hot plate at low temperature. The residue was then re-digested with nitric acid to provide the sample for ICP/MS analysis. This preparation procedure eliminates the high chloride and fluoride concentrations in the analytical matrix and reduces mass spectral interferences.

Anions. Chlorine and fluorine in the dried coal slurry and char were determined by ASTM D4208[24] and D3761,[25] respectively. Prepared samples were combusted in a closed oxygen combustion bomb containing a dilute basic solution. The bomb washings were analyzed by SIE and/or IC.

Ultimate, Proximate, and Higher Heating Value. In conjunction with the other analyses, higher heating value (HHV), proximate (intrinsic moisture, volatile and fixed carbon, and ash), and ultimate (percent carbon, hydrogen, nitrogen, sulfur, oxygen, and ash) analyses were performed according to the ASTM procedures[26,27,28] listed in Table C-5.

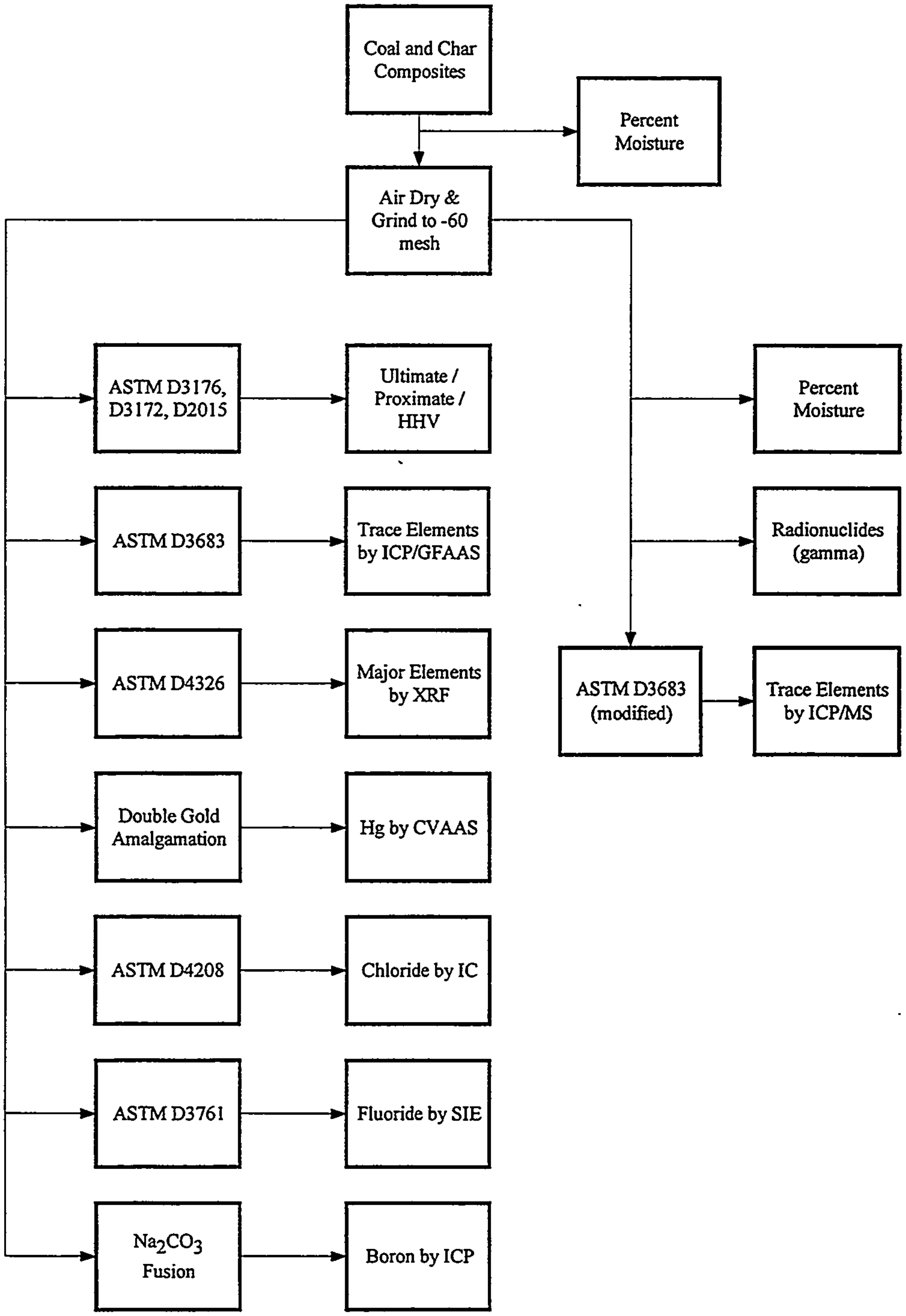

Figure C-10
Coal and Char Sample Preparation and Analytical Plan

Table C-5
Summary of Ultimate/Proximate Analytical Methods

Analyte	Analytical Method
Moisture, total	ASTM D3302
Ash	ASTM D3174
Carbon, Hydrogen, Nitrogen	ASTM D5373
Sulfur	ASTM D4239
Volatile Matter	ASTM D3175
Fixed Carbon	ASTM D3172
Heating Value	ASTM D2015

ASTM = American Society for Testing and Materials, *Annual Book of ASTM Standards,* Vol. 05.05.

Radionuclides. Coal samples were analyzed by EPA Method 901.1.[29] This method uses gamma emitting spectrometry to measure radioactivity through gamma decay.

Slag

Figure C-11 presents the sampling handling and preparation procedures for slag sample analysis. Commercial Testing and Engineering Company was subcontracted to perform these analyses.

Metals. Slag samples were air dried and ground to pass a 60-mesh sieve prior to taking aliquots for analysis. Sample preparation and analysis for metals followed the same procedures described for coal and char samples in the preceding section.

Anions. Separate preparatory techniques were necessary for the analysis of fluoride, chloride, and sulfur in slag. All sample aliquots were taken from the ground, air-dried material prepared for trace element analysis. Fluoride sample aliquots were prepared by fusion of the slag with sodium hydroxide (McQuaker-Gurney).[30] The fusion melt is dissolved in hydrochloric acid and analyzed potentiometrically by fluoride-specific ion electrode. Slag samples for chloride analysis were prepared by mild digestion in nitric acid. The digestate was analyzed potentiometrically by chloride-specific ion electrode.

Ultimate Analysis. An ultimate analysis (percent carbon, hydrogen, nitrogen, sulfur, oxygen, and ash) was performed on slag samples according to the ASTM procedures listed in Table C-5.

Radionuclides. Slag samples are analyzed by EPA Method 901.1. This method uses gamma emitting spectrometry to measure radioactivity through gamma decay.

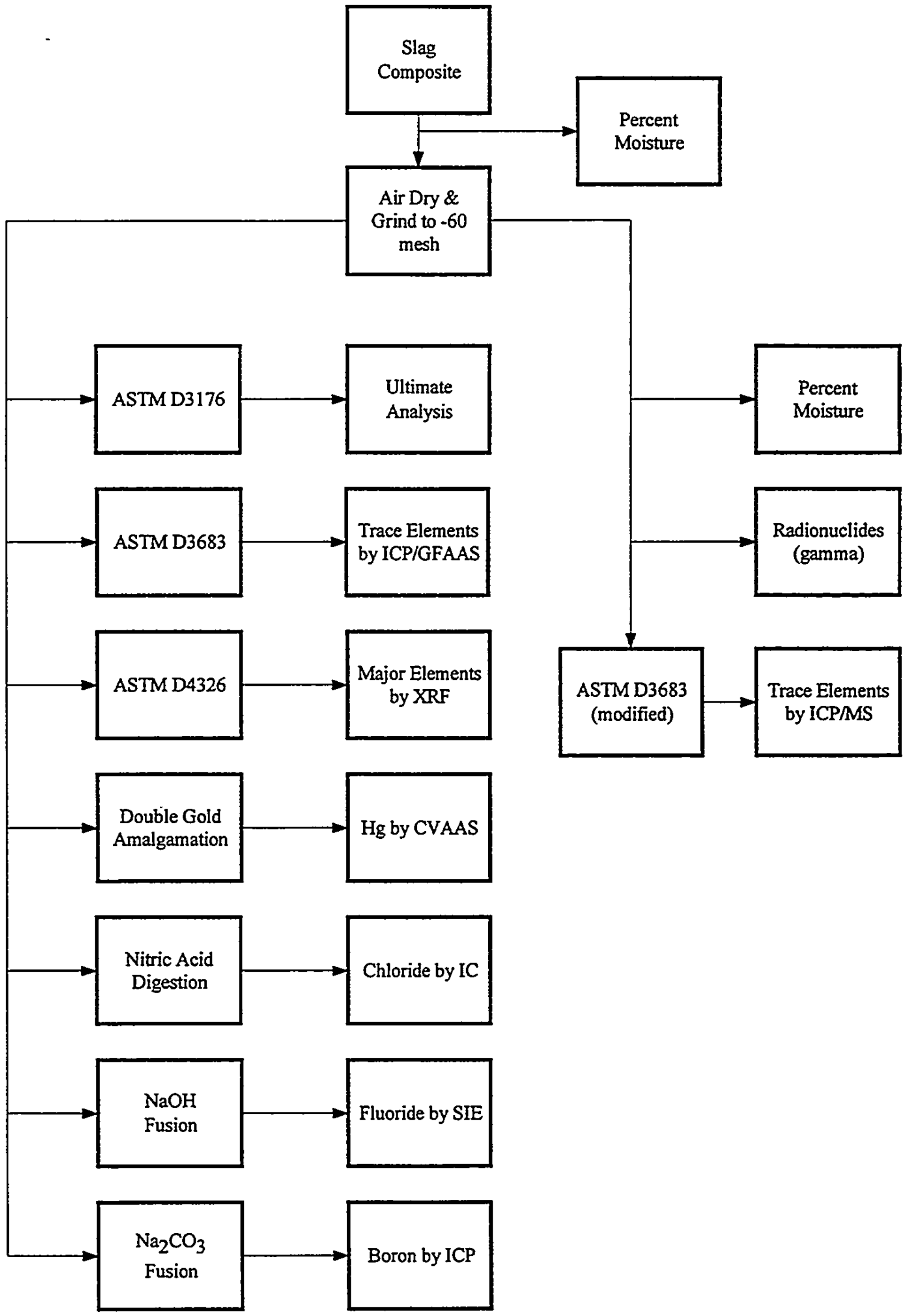

Figure C-11
Slag Sample Preparation and Analytical Plan

Sulfur Byproduct

The sulfur sample is analyzed for metals, ash, and percent sulfur as shown in Figure C-12.

Process Waters

Plant process waters sampled for analysis include the sour condensate, sweet water, and scrubber inlet and blowdown streams. The daily composite samples were preserved on site in accordance with the EPA protocols listed in Table C-6. Figure C-13 illustrates the process water sample preparation and analytical procedures.

Metals

The unfiltered water samples were prepared for total metal analysis according to EPA Methods 3005 and 3020. The samples were vigorously digested in concentrated nitric acid to dissolve any suspended material that may be present. The digestates were diluted to a known volume and analyzed by ICP-AES and GFAAS. Mercury was determined by EPA Method 7470.

Anions

Samples for the analysis of anions (chloride, fluoride, sulfate, phosphate, and formate) were filtered before analysis. Chloride, sulfate, and formate were determined by IC according to EPA Method 300.0. Fluoride was determined potentiometrically by fluoride SIE. Phosphate was determined spectrophotometrically as a measure of total phosphorus after the sample was digested according to EPA Method 365.1.[31]

Ammonia, Phenol, and Chemical Oxygen Demand (COD)

Process water samples collected for ammonia, phenol, and COD were split for each analysis. Ammonia fractions were prepared for analysis by distillation according to EPA Method 350.2, and the recovered distillates analyzed by EPA 350.1, an automated colorimetric method.

Aliquots for phenol analysis were prepared and analyzed by EPA Method 420.1,[32] and COD analysis performed by EPA Method 410.1.[33]

Cyanide and Thiocyanate

Total cyanide, free (amenable) cyanide, and thiocyanate process water samples were prepared and analyzed by EPA Methods 335.2,[34] 335.1,[35] and Standard Method 412K,[36] respectively.

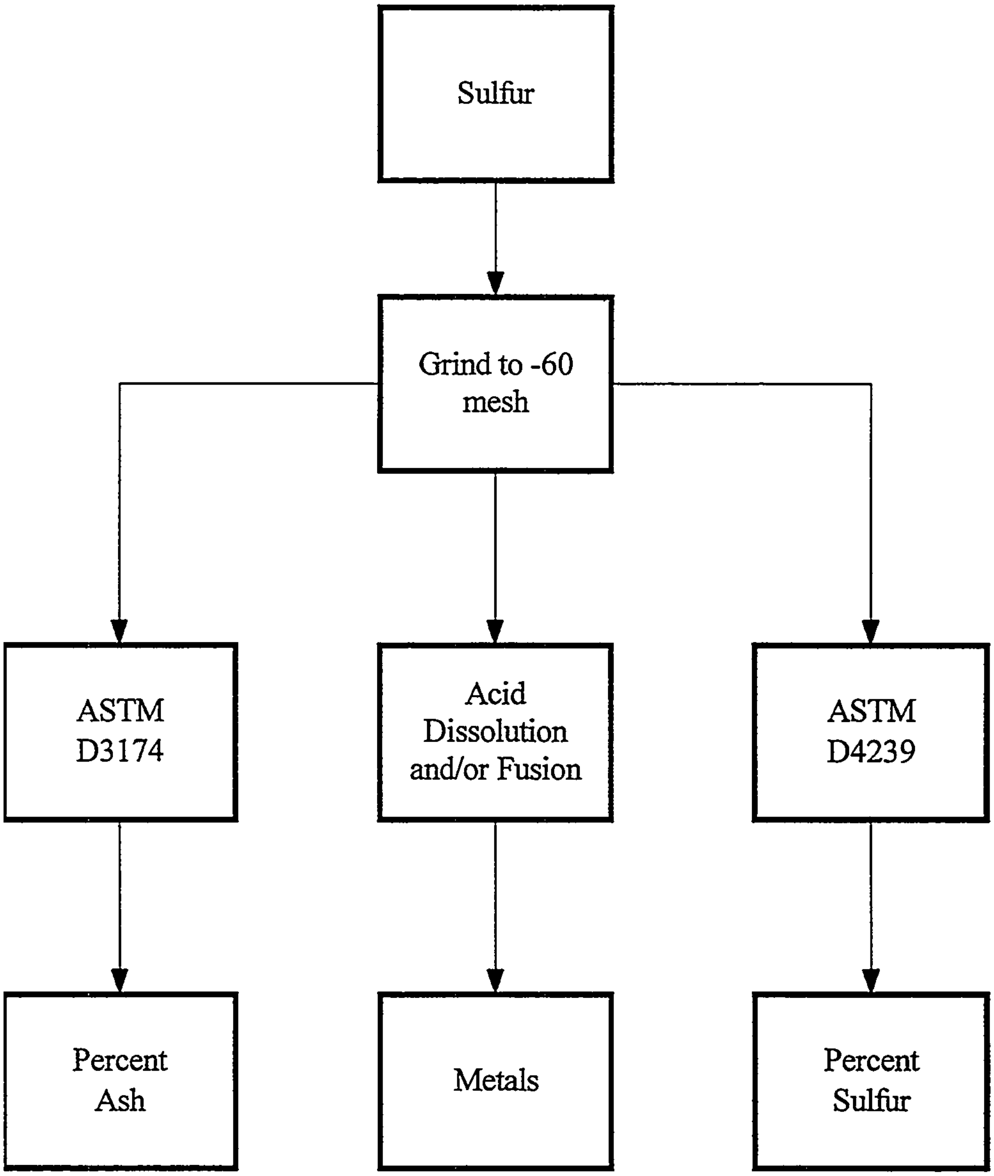

Figure C-12
Sulfur Sample Preparation and Analytical Plan

Table C-6
Aqueous Sample Preservation Requirements and Hold Times

Container[a]	Parameter	Preservation Technique	Holding Time[b]
1,000 p	pH	Cool 4°C	Immediately
	Conductivity		28
	TSS		7
500 p	Chloride	Cool 4°C	28
	Fluoride		28
	Formate		14
	Phosphate		28
	Sulfate		28
125 p	Sulfide	50 mL SAOB, Cool 4°C	7
1,000 p	Total Cyanide	$PbCO_3$, filter, pH>12 with lime	14
1,000 p	Free Cyanide	As above	14
250 p	Thiocyanate	As above	28
1,000 g	COD	pH <2 with H_2SO_4, Cool 4°C	28
	Phenol		28
	Ammonia		28
500 p	Metals, Total	pH <2 with HNO_3	180[c]
1,000 g	SVOCs[d]	Cool 4°C	7/40[e]
4x40 g[f]	VOA, purgeable	Cool 4°C	7 w/o HCl

[a] Container size provides adequate sample for all analysis listed in the group. Number specifics volume in mL, while letter specifics polypropylene (p) or glass (g) container.

[b] Holding times in days from SW-846, 1986.

[c] Holding time is 28 days for mercury, and 180 days for all other metals.

[d] See Table C-2 for SVOCs.

[e] Holding time for sample before/after extraction.

[f] Four, 40 mL vials.

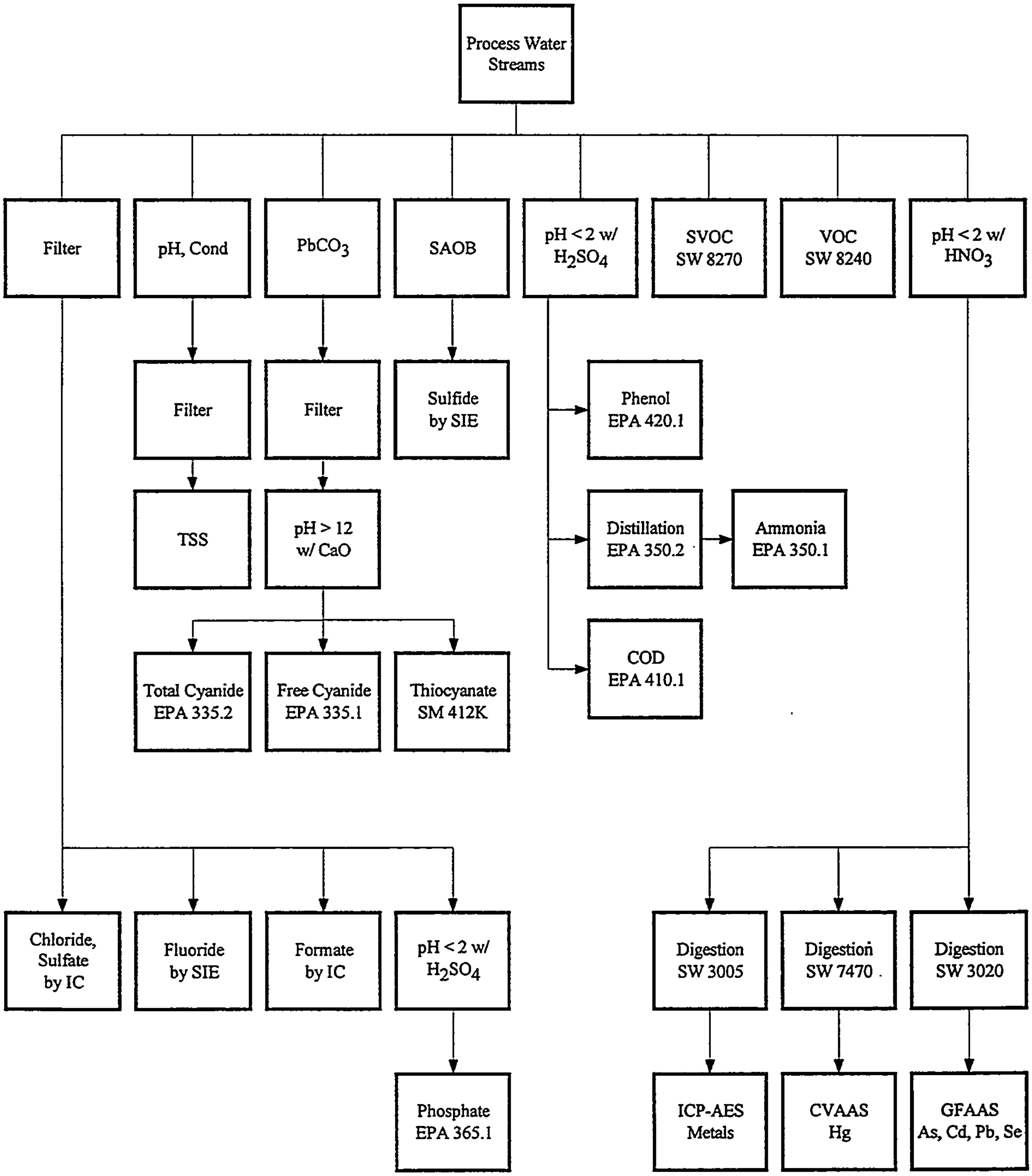

Figure C-13
Process Water Sample Preparation and Analytical Plan

Sulfide

Sulfide samples were analyzed on-site to prevent sample degradation from sulfide oxidation. Samples were preserved with sulfide anti-oxidant buffer (SAOB) and titrated with a standard lead perchlorate solution to a potentiometric endpoint using a sulfide-specific electrode.[37]

Water Quality Parameters (pH/Conductivity/Total Suspended Solids)

Process water samples were analyzed on-site for hydrogen ion concentration (pH)[38] and specific conductivity[39] as a measure of total dissolved solids. Total suspended solids (TSS) were measured by filtration and gravimetric determination of the filtered solids mass.[40]

Volatile Organic Compounds

Purgeable volatile organic compounds were determined in process water samples by Method SW-8240, purge and trap GC-MS. The samples were not preserved with hydrochloric acid to a $pH<2$ because the predominance of carbonates, typically found in these process waters, generates carbon dioxide bubbles in the vial. These bubbles may cause overpressurization of the sample vial or VOC losses in the resulting head space. The holding time for unpreserved samples is one week.

Aldehydes

Process water samples were prepared for analysis of acetaldehyde, benzaldehyde, formaldehyde, and acrolein by proposed Method SW-8315.[41] In this procedure, aldehydes present in the water samples are derivatized with 2,4-dinitrophenyl hydrazine (DNPH) and extracted in methylene chloride. The extracts are concentrated during solvent exchange into acetonitrile before HPLC analysis. Air Toxics, Ltd. was subcontracted to perform this analysis.

Semivolatile Organic Compounds

Liquid samples for semivolatile organic compound analyses are serially extracted using a separatory funnel with methylene chloride by EPA Method 3510.[42] The extracts are then analyzed by gas chromatography/mass spectrometry according to EPA Method 8270.

Selectamine™ Solvent

The Selectamine™ solvent samples were evaluated for ash, solids, and heat stable salts as an indication of substance accumulation that may impact material balance closures around the sulfur removal process.

Special Techniques

Some of the techniques recommended for sample analysis have not been promulgated as standard analytical protocols, although they are based on established principles of quantitative analysis. This section identifies and describes the alternative techniques and nonstandard methods recommended for selected process sample analysis.

Vapor-Phase Trace Elements by Atomic Absorption Spectrophotometry

Radian Corporation has successfully developed and demonstrated an on-line analysis technique for vapor-phase trace elements using an atomic absorption spectrophotometer (AAS). The AAS is modified to accept a syngas sample stream as part of the fuel supply going to the nebulizer mixing chamber and flame. In the flame, vapor-phase trace elements are atomized and absorb light energy from an element-specific light source just like aqueous samples in conventional AAS. The sample gas, fuel gas, and air supplies are regulated and monitored to determine the syngas component going to the flame, and ultimately the elemental concentration in the gas sample stream. Absorbance and concentration are related by Beer's law and gas concentrations are determined by comparison with standard curves generated from aqueous standards.

The following trace elements were identified for analysis by this technique:

- Arsenic;
- Cadmium;
- Nickel;
- Chromium;
- Lead;
- Selenium; and
- Zinc.

The only exception to the flame AAS analysis is mercury. Mercury was analyzed by adapting the AAS with a flow cell designed for cold vapor analysis. Mercury analysis was discussed in detail in Section 8 of this report.

Vapor-Phase Trace Elements by Charcoal Adsorption

Charcoal sorbents have been used in a number of industrial processes as guard beds to protect catalysts from metal poisoning. The same principle has been applied successfully by Radian Corporation to collect and measure selected vapor-phase trace elements in syngas samples. The charcoal sorbent is rigorously cleaned with concentrated nitric acid before being rinsed, dried, and loaded into quartz sampling tubes. After sampling, the charcoal sorbent is recovered and digested with nitric acid in a closed vessel for ICP-AES, GFAAS,[43] and CVAAS analysis. Table C-7 lists the trace elements targeted for analysis, the analytical techniques applicable, and their respective detection limits.

Gas Chromatography

Table C-8 summarizes the on-site gas chromatographic analyses performed on selected sample streams. On-site analysis normally provides more accurate and representative process data by minimizing sample degradation and reaction time.

Analytical Subcontractors

Analytical subcontractors were selected to perform a number of specialized analytical techniques. Table C-9 summarizes the role of each subcontract laboratory and identifies the primary contact at each laboratory.

Table C-7
Trace Element Analysis of Charcoal Sorbents

Element	Analysis Method	Detection Limit (µg/Nm^3)[a]
Antimony	GFAA	1.0
Arsenic	GFAA	1.0
Barium	ICP-AES	0.6
Beryllium	ICP-AES	0.6
Cadmium	GFAA	3.0
Chromium	ICP-AES	3.0
Cobalt	ICP-AES	5.0
Copper	ICP-AES	3.0
Iron	ICP-AES	300
Lead	GFAA	0.8
Manganese	ICP-AES	0.1
Mercury	CVAA	0.05
Molybdenum	ICP-AES	3.0
Nickel	ICP-AES	11
Selenium	GFAA	1.0
Vanadium	ICP-AES	4.0
Zinc	ICP-AES	3.0

[a] DL based on 100 liter (0.1 Nm^3) gas sample.

Table C-8
Gas Chromatography Analysis Summary

Gas Components	Gas Streams	Units	Column	Detector
Major Gases (H_2, CO, CO_2, N_2, Ar)	All	mol. %	Carboxen-1000	TCD
Hydrocarbons (C_1 - C_8)	Internal only	ppmv	SP-1000	FID
Reduced Sulfur Species (H_2S, COS, CS_2)	Internal only	ppmv	Supelpak-S	FPD
Benzene, Toluene, Xylene	Internal only	ppmv	SP-1000	FID

Table C-9
Subcontract Analytical Laboratories

Laboratory	Shipping Address	Primary Contact	Analytical Service
Harvard University Department of Earth and Planetary Sciences	20 Oxford Street Cambridge, MA 02138	Dr. Ron Pflaum Phone: 617/496-8021 Fax: 617/495-8839	ICP/MS Analysis
Triangle Laboratories	801-10 Capitola Drive Durham, NC 27713	Dr. Hani Karam Phone: 919/544-5835 Fax: 919/544-5491	HRGC/MS
Air Toxics, Ltd.	180 Blue Ravine Road Suite B Folsom, CA 95630	Alexis Meredith Phone: 916/985-1000 Fax: 916/985-1020	GC/MS, HPLC
Commercial Testing & Engineering Company	4665 Paris Street Suite B-200 Denver, CO 80239	Byron Caton Phone: 303/373-4772 Fax: 303/373-4791	Solids Analysis
Accu-Labs Research, Inc.	4663 Table Mountain Dr. Golden, CO 80403	Bud Summers Phone: 303/277-9514 Fax: 303/277-9512	Radiochemical Analysis

11. J.W. O'Dell, J.D. Pfaff, M.E. Gales, and G.D. McKee. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory. "Test Method: The Determination of Inorganic Anions in Water by Ion Chromatography—Method 300.0." EPA-600/4-84-017. Cincinnati, OH (March 1984).

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13. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory. "Method 350.2: Nitrogen, Ammonia (Colorimetric, Titrimetric, Potentiometric Distillation Procedure," *Methods for Chemical Analysis of Water and Wastes.* EPA-600/4-79-020. Cincinnati, OH (March 1983).

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15. U.S. Environmental Protection Agency, Office of Solid Waste. "Method 9012: Total and Amenable Cyanide (Colorimetric, Automated UV)," *Test Methods for Evaluating Solid Waste.* SW-484, 3rd ed. Washington, DC (November 1986).

16. Title 40, Part 266, Appendix IX, Section 3.5. "Sampling for Aldehyde and Ketone Emissions from Stationary Sources (Method 0011)," *Code of Federal Regulations.*

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3. U.S. Environmental Protection Agency, Office of Solid Waste. "Method 7060: Arsenic (AA, Furnace Technique)," *Test Methods for Evaluating Solid Waste.* SW-846, 3rd ed. Washington, DC (November 1986).

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9. U.S. Environmental Protection Agency, Office of Solid Waste. "Method 3020: Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by GFAA Spectroscopy," *Test Methods for Evaluating Solid Waste.* SW-846, 3rd ed. Washington, DC (November 1986).

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32. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory. "Method 420.1: Phenolics, Total Recoverable," *Methods for Chemical Analysis of Water and Waste.* EPA-600/4-79-020. Cincinnati, OH (March 1983).

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Coefficient of Variation

The CV is also known as the relative standard deviation (RSD), or the standard deviation expressed as a percentage of the mean. The CV is calculated as:

$$CV = \left(\frac{S}{\bar{x}}\right) * 100\% \qquad \text{(eq. 2)}$$

95% Confidence Interval

Most of the stream concentration results presented in this document are provided with 95% confidence intervals as uncertainty ranges. When an average analytical result is reported, the uncertainty in terms of the standard deviation depends upon the level of confidence placed on the average, or mean result. At the 95% confidence level, the uncertainty around the mean can be statistically determined using the "t" distribution as a function of the number of results included in the mean. The 95% confidence interval is calculated as:

$$95\%\ CI = \frac{S * t}{\sqrt{n}} \qquad \text{(eq. 3)}$$

where: t is defined in Table D-1 for the number of samples (n) included in the calculation of the mean.

Table D-1
Values of *t* by sample number, n

As an example, the three sample results obtained for arsenic in the turbine stack gas particulate are 1.81, 0.673, and 0.782 μg/Nm^3. The mean, standard deviation, and 95% confidence interval are calculated below:

$$\text{Mean} = \frac{1.81 + 0.673 + 0.782}{3} = 1.09$$

$$S = \sqrt{\frac{(1.81 - 1.09)^2 + (0.673 - 1.09)^2 + (0.782 - 1.09)^2}{(3 - 1)}} = 0.63, \text{ and}$$

$$95\%\ \text{CI} = \frac{0.63 * 4.30}{\sqrt{3}} = 1.6$$

The vapor-phase component, calculated by the same formula, determined the mean concentration of the three samples at 0.0839 μg/Nm^3, S = 0.036, and the 95%CI = 0.089. The statistical confidence interval around the mean total gas concentration (i.e. the sum of the particulate- and vapor-phase mean results) is not the sum of the confidence intervals. The average standard deviation (S_{avg}) must first be determined and is calculated as:

$$S_{avg} = \sqrt{S_1^2 + S_2^2} \qquad \text{(eq. 4)}$$

where: S_1 and S_2 are the standard deviations for the 1st and 2nd set of results being added.

The *t* factor (Table D-1) is based on the degree of freedom which is calculated as:

$$Df = \frac{\left(S_1^2 + S_2^2\right)^2}{\frac{S_1^4}{(n_1 - 1)} + \frac{S_2^4}{(n_2 - 1)}} \qquad \text{(eq. 5)}$$

The 95% confidence interval for the sum of two separately determined mean results is then calculated as:

$$95\%\ CI = \frac{t_{Df} * S_{avg}}{\sqrt{n_1 + n_2}} \qquad \text{(eq. 6)}$$

Using the turbine stack gas results for particulate and vapor-phase arsenic as an example, the following variables are given:

$S_1 = 0.63$

$S_2 = 0.036$

$n_1 = n_2 = 3$

Calculating S_{avg},

$$S_{avg} = \sqrt{(0.63)^2 + (0.036)^2} = 0.63$$

The degrees of freedom are determined as:

$$Df = \frac{[(0.63)^2 + (0.036)^2]^2}{\frac{(0.63)^4}{(3-1)} + \frac{(0.036)^4}{(3-1)}} = 2$$

From Table D-1, the value of t_{Df} with 2 degrees of freedom is 4.30, and the 95%CI is calculated as:

$$95\%\ CI = \frac{4.30 * 0.63}{\sqrt{6}} = 1.1$$

The arsenic results calculated in these examples are found in Table 4-2.

Relative Percent Difference

The RPD is used to express the precision of two duplicate measurements such as duplicate analytical results for the same sample. RPD is calculated as:

$$\mathrm{RPD} = \frac{|M - m|}{\left(\frac{M + m}{2}\right)} * 100\% \qquad \text{(eq. 7)}$$

where: M = first measurement value; and
m = second measurement value

Percent Recovery

In this program, percent recovery of matrix and surrogate spikes, control standards, and standard reference materials was used to indicate analytical accuracy. Percent recovery is calculated as:

$$\%\ \text{Recovery} = \frac{\text{Measured Value}}{\text{Actual Value}} * 100 \qquad \text{(eq. 8)}$$

The percent spike recovery is calculated as:

$$\%\ \text{Spike Recovery} = \frac{(\text{Value of Sample Plus Spike}) - (\text{Value of Unspiked Sample})}{\text{Value of Spike Added}} * 100 \qquad \text{(eq. 9)}$$

APPENDIX E: MATERIAL BALANCE, REMOVAL EFFICIENCY & EMISSION FACTOR CALCULATIONS

Mass Balance

A general mass balance equation which applies to any system is:

$$\begin{bmatrix}\text{Accumulation of}\\ \text{Mass in System}\end{bmatrix} = \begin{bmatrix}\text{Mass into}\\ \text{System}\end{bmatrix} - \begin{bmatrix}\text{Mass out}\\ \text{of System}\end{bmatrix} + \begin{bmatrix}\text{Mass Generated}\\ \text{in System}\end{bmatrix}$$

For all species, the generation term in equation E-1 is equal to zero. Ash is considered to be a component of coal and is not generated. Mass balance closure is defined by the following expression:

$$\text{Mass Balance Closure (\%)} = 100 * \left[\frac{\text{Total Mass Out}}{(\text{Mass In} - \text{Mass Accumulated})}\right]$$

The mass flow rate (Q) for a given specie (i), can be defined as:

$$Q_{s,i} = F_s * C_i$$

where:

F_s = Stream mass flow rate,

C_i = Concentration of specie, i, and

$Q_{s,i}$ = Mass flow rate of specie (i) for a given process stream (s).

Therefore, the following equations apply to the determination of mass balances:

Mass Balance Around the Plant

$$\%\ \text{Closure} = \frac{Q_{\text{turbine stack, i}} + Q_{\text{incin, i}} + Q_{\text{slag, i}} + Q_{\text{sulfur, i}} + Q_{\text{sweet water, i}}}{Q_{\text{coal, i}}} * 100$$

Mass Balance Around Selectamine™

$$\%\ \text{Closure} = \frac{Q_{\text{sweet water, i}} + Q_{\text{acid gas, i}}}{Q_{\text{sour syngas, i}}} * 100$$

Mass Balance Around the Turbine Stack

$$\%\ \text{Closure} = \frac{Q_{\text{turbine stack, i}}}{Q_{\text{sweet syngas, i}} + Q_{\text{nat'l gas, i}}} * 100$$

Mass Balance Around Selectox™

$$\%\ \text{Closure} = \frac{Q_{\text{tail gas, i}} + Q_{\text{sulfur, i}}}{Q_{\text{acid gas, i}}} * 100$$

Mass Balance Around the Sour Water Stripper

$$\%\ \text{Closure} = \frac{Q_{\text{sweet water, i}} + Q_{\text{sour gas, i}}}{Q_{\text{sour condensate, i}}} * 100$$

Mass Balance Around the Incinerator

$$\%\ \text{Closure} = \frac{Q_{\text{incinerator stack, i}}}{Q_{\text{sour gas, i}} + Q_{\text{tail gas, i}} + Q_{\text{nat'l gas, i}}} * 100$$

Removal Efficiency

The general removal efficiency equation which can be applied to any system is:

$$\% \text{ Removal} = \frac{\text{Mass In} - \text{Mass Out}}{\text{Mass In}} * 100$$

Emission Factors

Emission factors (for the plant) are typically expressed as pounds per trillion (10^{12}) Btu and were calculated according to the following equation:

$$\frac{\text{lb}_i}{10^{12}\ \text{Btu}} = \frac{\left(Q_{\text{turbine},\ i} + Q_{\text{incin},\ i}\right) * Q_{\text{coal},\ i}}{\text{Coal Heating Value}} * 10^{12}$$

APPENDIX F: SAMPLING DATA SUMMARY SHEETS

Plant Name **Dow - LGTI**
Location **Raw Gas, 5a**
Test Parameter **Ammonia, Anions**

Run No.	1	2	3	Average
Date	11-12-94	11-12-94	11-13-94	-
Time Start	1242	1510	839	-
Time Finish	1400	1636	1038	-
Operator	JWM	JDH	JWM	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.997	0.997	0.974	0.989
Barometric Pressure ("Hg)	30.06	30.06	30.00	30.04
Meter Volume (acf)	31.020	30.320	31.446	30.929
Average delta H (" H2O)	3.00	2.00	3.50	2.83
Average DGM Temp (F)	73.0	74.0	78.0	75.0
Meter Volume (dscf @ 68 F)	31.006	30.176	30.398	30.527
Meter Volume (M3 @ 0 C)	0.818	0.796	0.802	0.805

Plant Name **Dow - LGTI**
Location **Raw Gas, 5a**
Test Parameter **Cyanide**

Run No.	1	2	3	Average
Date	11-12-94	11-12-94	11-13-94	-
Time Start	1215	1702	1045	-
Time Finish	1251	1737	1140	-
Operator	JWM	JDH	JWM	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.974	0.997	0.974	0.982
Barometric Pressure ("Hg)	30.06	30.06	30.00	30.04
Meter Volume (acf)	10.368	9.990	10.260	10.206
Average delta H (" H2O)	3.00	2.00	2.50	2.50
Average DGM Temp (F)	74.0	73.0	83.0	76.7
Meter Volume (dscf @ 68 F)	10.105	9.961	9.803	9.956
Meter Volume (M3 @ 0 C)	0.267	0.263	0.259	0.263

Plant Name	**Dow - LGTI**
Location	**Raw Gas, 5a**
Test Parameter	**Metals**

Run No.	1	2	3	Average
Date	11-12-94	11-13-94	11-13-94	-
Time Start	1330	826	1352	-
Time Finish	1826	1237	906	-
Operator	JDH	JWM	JWM	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.974	0.997	0.974	0.982
Barometric Pressure ("Hg)	30.06	30	30.00	30.02
Meter Volume (acf)	102.209	103.194	102.044	102.482
Average delta H (" H2O)	4.00	2.70	4.50	3.73
Average DGM Temp (F)	74.0	79.0	80.0	77.7
Condensed Water (g)	154.1	510.4	86.5	250.3
Meter Volume (dscf @ 68 F)	99.861	101.723	98.517	100.034
Meter Volume (M3 @ 0 C)	2.635	2.684	2.599	2.640
Flue Gas Moisture (%)	6.8	19.1	4.0	10.0

Plant Name	**Dow - LGTI**
Location	**Raw Gas, 5a**
Test Parameter	**Metals, Charcoal**

Run No.	1	2	3	Average
Date	11-12-94	11-13-94	11-13-94	-
Time Start	1600	850	1253	-
Time Finish	1745	1128	1628	-
Operator	JWM	JWM	JWM	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.000	1.000	1.000	1.000
Barometric Pressure ("Hg)	30.06	30.00	30.00	30.02
Meter Volume (L)	100.770	103.775	103.580	102.708
Average delta H (" H2O)	0.00	0.00	0.00	0.00
Average DGM Temp (F)	73.0	75.0	73.0	73.7
Meter Volume (L @ 0 C)	93.454	95.689	95.868	95.004
Meter Volume (M3 @ 0 C)	0.09345	0.09569	0.09587	0.0950

Plant Name **Dow - LGTI**
Location **Raw Gas, 5b**
Test Parameter **Ammonia, Anions**

Run No.	1	2	3	Average
Date	11-12-94	11-13-94	11-13-94	-
Time Start	1156	828	1152	-
Time Finish	1625	1029	1416	-
Operator	JPL	JPL	JPL	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.981	0.959	0.959	0.966
Barometric Pressure ("Hg)	30.06	30.00	30.00	30.02
Meter Volume (acf)	27.655	30.601	31.247	29.834
Average delta H (" H2O)	3.00	2.00	1.50	2.17
Average DGM Temp (F)	80.0	84.0	87.0	83.7
Condensed Water (g)	6.9	21.2	17.5	15.2
Meter Volume (dscf @ 68 F)	26.846	28.699	29.109	28.218
Meter Volume (M3 @ 0 C)	0.708	0.757	0.768	0.745
Flue Gas Moisture (%)	1.2	3.4	2.8	2.4

Plant Name **Dow - LGTI**
Location **Raw Gas, 5b**
Test Parameter **Cyanide**

Run No.	1	2	3	Average
Date	11-12-94	11-13-94	11-13-94	-
Time Start	1604	805	1035	-
Time Finish	1736	920	1143	-
Operator	JPL	JPL	JPL	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.992	0.981	0.959	0.977
Barometric Pressure ("Hg)	30.06	30.00	30.00	30.02
Meter Volume (acf)	10.115	10.601	11.756	10.824
Average delta H (" H2O)	2.00	1.00	1.50	1.50
Average DGM Temp (F)	69.0	75.0	88.0	77.3
Condensed Water (g)	6.5	8.2	4.2	6.3
Meter Volume (dscf @ 68 F)	10.111	10.316	10.932	10.453
Meter Volume (M3 @ 0 C)	0.267	0.272	0.288	0.276
Flue Gas Moisture (%)	2.9	3.6	1.8	2.8

Plant Name	**Dow - LGTI**
Location	**Raw Gas, 5b**
Test Parameter	**Metals**

Run No.	1	2	3	Average
Date	11-12-94	11-13-94	11-13-94	-
Time Start	1741	1357	1511	-
Time Finish	1352	816	1009	-
Operator	JPL	JPL	JPL	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.992	0.992	0.959	0.981
Barometric Pressure ("Hg)	30.06	30.00	30.00	30.02
Meter Volume (acf)	89.892	96.009	88.028	91.310
Average delta H (" H2O)	1.50	2.00	2.60	2.03
Average DGM Temp (F)	75.0	83.0	95.0	84.3
Condensed Water (g)	34.5	69.1	62.7	55.4
Meter Volume (dscf @ 68 F)	88.742	93.313	81.040	87.698
Meter Volume (M3 @ 0 C)	2.342	2.462	2.138	2.314
Flue Gas Moisture (%)	1.8	3.4	3.5	2.9

Plant Name	**Dow - LGTI**
Location	**Raw Gas, 5b**
Test Parameter	**Metals, Charcoal**

Run No.	1	2	3	Average
Date	11-13-94	11-13-94	11-13-94	-
Time Start	935	1319	1622	-
Time Finish	1247	1602	926	-
Operator	JPL	JPL	JPL	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.000	1.000	1.000	1.000
Barometric Pressure ("Hg)	30.00	30.00	30.00	30.00
Meter Volume (L)	100.484	116.089	100.520	105.698
Average delta H (" H2O)	0.70	0.50	0.50	0.57
Average DGM Temp (F)	81.0	83.0	85.0	83.0
Meter Volume (L @ 0 C)	91.784	105.596	91.099	96.160
Meter Volume (M3 @ 0 C)	0.092	0.106	0.091	0.096

Plant Name	**DOW - LGTI**
Location	**Sour Syngas - #11**
Test Parameter	**Ammonia, anions**

Run No.	3	5	6	Average
Date	11-07-94	11-11-94	11-11-94	-
Time Start	0821	1035	1207	-
Time Finish	1042	1330	1424	-
Operator	JPL	JPL	JPL	-
Dry Gas Meter Calibration (Yd)	1.018	0.998	1.032	1.016
Barometric Pressure ("Hg)	30.00	30.04	30.04	30.03
Meter Volume (acf)	32.075	30.686	30.497	31.086
Average delta H (" H2O)	5.00	2.50	3.70	3.73
Average Stack Temperature (F)	68	67	72	69
Average DGM Temp (F)	80.6	70.6	65.0	72.1
Test Duration (minutes)	141.0	175.0	137.0	151.0
Meter Volume (dscf @ 68 F)	32.368	30.782	32.068	31.739
Meter Volume (M3 @ 0 C)	0.8541	0.8122	0.8461	0.837

Plant Name	**Dow - LGTI**
Location	**Sour Syngas - #11**
Test Parameter	**Cyanide**

Run No.	3	5	6	Average
Date	11-07-94	11-10-94	11-11-94	-
Time Start	0814	0945	0850	-
Time Finish	0915	1030	0940	-
Operator	JPL	JPL	JPL	-
Dry Gas Meter Calibration (Yd)	0.997	0.998	1.032	1.009
Barometric Pressure ("Hg)	30.00	30.02	30.04	30.02
Static Pressure (PSI)	375	375	375	375
Meter Volume (acf)	10.608	10.878	10.149	10.545
Average delta H (" H2O)	5.00	3.83	3.20	4.01
Average DGM Temp (F)	72.6	71.2	60.0	67.9
Test Duration (minutes)	61.0	45.0	50.0	52.0
Meter Volume (dscf @ 68 F)	10.641	10.929	10.761	10.777
Meter Volume (M3 @ 0 C)	0.2808	0.2884	0.2839	0.2844

Plant Name	**Dow - LGTI**
Location	**Sour Syngas - #11**
Test Parameter	**Metals**

Run No.	3	5	6	Average
Date	11-07-94	11-10-94	11-11-94	-
Time Start	0920	0921	0746	-
Time Finish	1522	1321	1314	-
Operator	JPL	JPL	JPL	-
Dry Gas Meter Calibration (Yd)	0.997	0.959	0.998	0.985
Barometric Pressure ("Hg)	30.00	30.02	30.04	30.02
Static Pressure (PSI)	375	375	375	375
Meter Volume (acf)	100.218	100.742	100.982	100.647
Average delta H (" H2O)	5.00	6.75	4.90	5.55
Average Stack Temperature (F)	70	67	71	69
Average DGM Temp (F)	88.0	74.4	65.0	75.8
Test Duration (minutes)	362.0	240.0	314.0	305.3
Meter Volume (dscf @ 68 F)	97.706	97.361	102.983	99.350
Meter Volume (M3 @ 0 C)	2.5781	2.5690	2.7173	2.621

Plant Name	**Dow - LGTI**
Location	**Sour Syngas - #11**
Test Parameter	**Metals, Charcoal**

Run No.	1	2	3	Average
Date	11-3-94	11-4-94	11-7-94	-
Time Start	1437	1149	1355	-
Time Finish	1730	1354	1643	-
Operator	JPL	JPL	JPL	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.986	0.986	0.986	0.986
Barometric Pressure ("Hg)	30.06	29.94	30.00	30.00
Meter Volume (L)	105.040	105.560	100.408	103.669
Average delta H (" H2O)	0.03	0.05	5.00	1.69
Average DGM Temp (F)	91.3	84.1	78.4	84.6
Meter Volume (L @ 0 C)	92.869	94.190	91.824	92.961
Meter Volume (M3 @ 0 C)	0.09287	0.09419	0.09182	0.0930

Plant Name	**Dow - LGTI**
Location	**Sour Syngas - #11**
Test Parameter	**Aldehydes**

Run No.	3	5	6	Average
Date	11-07-94	11-11-94	11-11-94	-
Time Start	1530	0953	1443	-
Time Finish	1737	1200	1708	-
Operator	JPL	JPL	JPL	-
Dry Gas Meter Calibration (Yd)	0.997	1.032	1.032	1.020
Barometric Pressure ("Hg)	30.00	30.04	30.04	30.03
Static Pressure (PSI)	375	375	375	375
Meter Volume (acf)	29.751	30.300	30.284	30.112
Average delta H (" H2O)	3.39	3.80	3.40	3.53
Average Stack Temperature (F)	72	70	72	71
Average DGM Temp (F)	78.9	63.0	65.0	69.0
Test Duration (minutes)	127.0	127.0	145.0	133.0
Meter Volume (dscf @ 68 F)	29.379	31.990	31.820	31.063
Meter Volume (M3 @ 0 C)	0.7752	0.8441	0.8396	0.8196

Plant Name	**Dow - LGTI**
Location	**Sour Syngas - #11**
Test Parameter	**Semi-Volatiles**

Run No.	3	5	6	Average
Date	11-07-94	11-10-94	11-11-94	-
Time Start	1052	1349	1119	-
Time Finish	1737	1022	1730	-
Operator	JPL	JPL	JPL	-
Dry Gas Meter Calibration (Yd)	1.018	0.959	0.959	0.979
Barometric Pressure ("Hg)	30.00	30.02	30.04	30.02
Static Pressure (PSI)	375	375	375	375
Meter Volume (acf)	91.078	95.387	100.442	95.636
Average delta H (" H2O)	5.00	2.90	3.70	3.87
Average Stack Temperature (F)	71	68	71	70
Average DGM Temp (F)	83.5	71.0	73.0	75.8
Test Duration (minutes)	405.0	453.0	371.0	409.7
Meter Volume (dscf @ 68 F)	91.421	91.912	96.671	93.334
Meter Volume (M3 @ 0 C)	2.4123	2.4252	2.5508	2.463

Plant Name	**Dow - LGTI**
Location	**Sweet Syngas - #12**
Test Parameter	**Ammonia, Anions**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	1548	1458	0952	-
Time Finish	1719	1631	1135	-
Operator	RMM	RMM	RMM	-
Dry Gas Meter Calibration (Yd)	0.981	0.974	0.974	0.976
Barometric Pressure ("Hg)	30.06	30.09	29.95	30.03
Meter Volume (acf)	31.505	30.812	31.177	31.165
Average delta H (" H2O)	7.00	7.30	6.65	6.98
Average DGM Temp (F)	86.7	83.0	71.1	80.3
Test Duration (minutes)	91.0	93.0	103.0	95.7
Condensed Water (g)	2.7	7.3	8.6	6.2
Meter Volume (dscf)	30.502	29.871	30.714	30.363
Meter Volume (M3 @ 0 C)	0.805	0.788	0.810	0.801
Flue Gas Moisture (%)	0.4	1.1	1.3	1.0

Plant Name **Dow - LGTI**
Location **Sweet Syngas - #12**
Test Parameter **Cyanide**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	1640	1515	1418	-
Time Finish	1723	1618	1510	-
Operator	RMM	RMM	RMM	-
Dry Gas Meter Calibration (Yd)	0.974	0.981	0.974	0.976
Barometric Pressure ("Hg)	30.06	29.94	29.95	29.98
Meter Volume (acf)	11.360	10.535	11.430	11.108
Average delta H (" H2O)	5.50	3.50	3.30	4.10
Average DGM Temp (F)	82.0	87.5	85.3	84.9
Test Duration (minutes)	43.0	58.0	58.0	53.0
Meter Volume (dscf @ 68 F)	10.975	10.059	10.878	10.637
Meter Volume (M3 @ 0 C)	0.290	0.265	0.287	0.281

Plant Name **Dow - LGTI**
Location **Sweet Syngas - #12**
Test Parameter **Metals**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	0900	0822	0820	-
Time Finish	1400	1302	1412	-
Operator	RMM	RMM	RMM	-
Dry Gas Meter Calibration (Yd)	0.981	0.981	0.981	0.981
Barometric Pressure ("Hg)	30.06	30.09	29.95	30.03
Meter Volume (acf)	104.111	102.977	106.238	104.442
Average delta H (" H2O)	6.50	7.19	7.00	6.90
Average DGM Temp (F)	86.0	83.0	70.6	79.9
Test Duration (minutes)	300.0	280.0	352.0	310.7
Condensed Water (g)	8.8	14.9	6.7	10.1
Meter Volume (dscf @ 68 F)	100.806	100.533	105.597	102.312
Meter Volume (M3 @ 0 C)	2.660	2.653	2.786	2.700
Flue Gas Moisture (%)	0.4	0.7	0.3	0.5

Plant Name	**Dow - LGTI**
Location	**Sweet Syngas - #12**
Test Parameter	**Metals, Charcoal**

Run No.	1	2	3	Average
Date	11-3-94	11-4-94	11-7-94	-
Time Start	1418	1057	1204	-
Time Finish	1644	1328	1430	-
Operator				-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.016	1.016	1.016	1.016
Barometric Pressure ("Hg)	30.06	30.06	29.95	30.02
Meter Volume (L)	101.470	102.640	105.990	103.367
Average delta H (" H2O)	0.00	1.90	1.80	1.23
Average DGM Temp (F)	81.0	82.3	74.9	79.4
Meter Volume (L @ 0 C)	94.195	95.494	99.587	96.425
Meter Volume (M3 @ 0 C)	0.09419	0.09549	0.09959	0.0964

Plant Name **Dow - LGTI**
Location **Sweet Syngas - #12**
Test Parameter **Hydrogen Sulfide, M-11**

Run No.	1	2	3	Average
Date	11-11-94	11-11-94	11-11-94	-
Time Start	1110	1440	1701	-
Time Finish	1153	1547	1730	-
Operator				-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.000	1.000	1.000	1.000
Barometric Pressure ("Hg)	30.04	30.04	30.04	30.04
Meter Volume (L)	24.670	23.432	20.520	22.874
Average delta H (" H2O)	0.50	0.50	0.50	0.50
Average DGM Temp (F)	62.5	60.0	63.0	61.8
Meter Volume (L @ 0 C)	23.352	22.286	19.405	21.681
Meter Volume (M3 @ 0 C)	0.02335	0.02229	0.01940	0.0217

Plant Name Dow - LGTI
Location Sweet Syngas - #12
Test Parameter Aldehydes

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	1407	1314	1143	-
Time Finish	1531	1450	1324	-
Operator	RMM	RMM	RMM	-
Dry Gas Meter Calibration (Yd)	0.981	0.981	0.974	0.979
Barometric Pressure ("Hg)	30.06	30.09	29.95	30.03
Meter Volume (acf)	30.567	34.579	31.051	32.066
Average delta H (" H2O)	7.10	7.50	6.70	7.10
Average DGM Temp (F)	88.9	87.6	78.0	84.8
Test Duration (minutes)	84.0	96.0	101.0	93.7
Meter Volume (dscf @ 68 F)	29.483	33.497	30.200	31.060
Meter Volume (M3 @ 0 C)	0.778	0.884	0.797	0.820

Plant Name **Dow - LGTI**
Location **Sweet Syngas - #12**
Test Parameter **Semivolatile Organics**

Run No.	3	5	6	Average
Date	11-10-94	11-11-94	11-12-94	-
Time Start	1356	1043	1709	-
Time Finish	0936	1628	1153	-
Operator	WAW	WAW	WAW	-
Dry Gas Meter Calibration (Yd)	1.018	1.018	1.018	1.018
Barometric Pressure ("Hg)	30.02	30.04	30.06	30.04
Meter Volume (acf)	110.082	112.920	105.600	109.534
Average delta H (" H2O)	4.94	5.38	4.00	4.77
Average DGM Temp (F)	62.7	63.4	65.0	63.7
Test Duration (minutes)	386.0	341.0	324.0	350.3
Meter Volume (dscf @ 68 F)	114.957	117.952	109.684	114.198
Meter Volume (M3 @ 0 C)	3.033	3.112	2.894	3.013

Plant Name **Dow - LGTI**
Location **Acid Gas - #14**
Test Parameter **Anions/ Ammonia**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	1240	1307	1305	-
Time Finish	1326	1340	1330	-
Operator	JLM	JLM	JLM	-
Initial Leak Rate	0.000	0.000	0.000	-
Final Leak Rate		0.000		-
Dry Gas Meter Calibration (Yd)	0.992	0.992	0.992	0.992
Barometric Pressure ("Hg)	29.97	29.94	30.00	29.97
Meter Volume (acf)	11.750	13.402	10.923	12.025
Average delta H (" H2O)	5.00	9.00	8.00	7.33
Average DGM Temp (F)	81.0	79.0	74.0	78.0
Test Duration (minutes)	46.0	33.0	25.0	34.7
Condensed Water (g)	7.3	13.7	12.6	11.2
Meter Volume (dscf @ 68 F)	11.535	13.320	10.953	11.936
Meter Volume (M3 @ 0 C)	0.304	0.351	0.289	0.315
Flue Gas Moisture (%)	2.9	4.6	5.2	4.2

Plant Name	**Dow - LGTI**
Location	**Acid Gas - #14**
Test Parameter	**Cyanide**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	1750	1307	1305	-
Time Finish	1800	1325	1315	-
Operator	JLM	JLM	JLM	-
Initial Leak Rate	0	0	0	-
Final Leak Rate	0	0	0	-
Dry Gas Meter Calibration (Yd)	0.998	0.998	0.998	0.998
Barometric Pressure ("Hg)	29.97	29.94	30.00	29.97
Meter Volume (acf)	2.350	2.073	2.240	2.221
Average delta H (" H2O)	2.00	2.00	2.00	2.00
Average DGM Temp (F)	79.0	88.5	83.5	83.7
Test Duration (minutes)	10.0	18.0	10.0	12.7
Meter Volume (dscf @ 68 F)	2.313	2.003	2.188	2.168
Meter Volume (M3 @ 0 C)	0.0610	0.0528	0.0577	0.0572
Flue Gas Moisture (%)	3.5	3.4	3.6	3.5

Plant Name **Dow - LGTI**
Location **Acid Gas - #14**
Test Parameter **Metals - Impinger**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	0720	0746	0810	-
Time Finish	1145	1210	1235	-
Operator	JLM	JLM	JLM	-
Initial Leak Rate	0.002	0.000	0.000	-
Final Leak Rate	0.000	0.000		-
Dry Gas Meter Calibration (Yd)	0.998	0.998	0.998	0.998
Barometric Pressure ("Hg)	29.97	29.94	30.00	29.97
Meter Volume (acf)	104.638	102.703	101.423	102.921
Average delta H (" H2O)	10.00	9.00	10.00	9.67
Average DGM Temp (F)	82.5	83.0	74.6	80.0
Test Duration (minutes)	265.0	264.0	255.0	261.3
Condensed Water (g)	80.7	80.0	76.8	79.2
Meter Volume (dscf @ 68 F)	104.305	101.937	102.689	102.977
Meter Volume (M3 @ 0 C)	2.752	2.690	2.710	2.717
Flue Gas Moisture (%)	3.5	3.6	3.4	3.5

Plant Name	**Dow - LGTI**
Location	**Acid Gas**
Test Parameter	**Metals - Charcoal Tubes**

Run No.	1	2	3	Average
Date	11-3-94	11-4-94	11-7-94	-
Time Start	1446	1325	1350	-
Time Finish	1545	1450	1610	-
Operator	JWM	JWM	JWM	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.000	1.000	1.000	1.000
Barometric Pressure ("Hg)	29.97	29.94	30.00	29.97
Meter Volume (L)	66.870	54.070	52.000	57.647
Average delta H (" H2O)	0.00	0.00	0.00	0.00
Average DGM Temp (F)	84.0	82.0	78.5	81.5
Meter Volume (L @ 0 C)	60.579	49.115	47.637	52.444
Meter Volume (M3 @ 0 C)	0.06058	0.04911	0.04764	0.0524

Plant Name	**Dow - LGTI**
Location	**Acid Gas - #14**
Test Parameter	**Semivols**

Run No.	3	5	6	Average
Date	11-07-94	11-10-94	11-10-94	-
Time Start	0810	1018	1412	-
Time Finish	1230	1245	1642	-
Operator	JLM	JLM	JLM	-
Initial Leak Rate	0.000	0.001	0	-
Final Leak Rate		0.001	0	-
Dry Gas Meter Calibration (Yd)	0.992	0.992	0.992	0.992
Barometric Pressure ("Hg)	30.00	30.02	30.02	30.01
Meter Volume (acf)	104.405	101.262	106.645	104.104
Average delta H (" H2O)	10.00	9.50	4.00	7.8
Average DGM Temp (F)	66.0	69.6	70.1	68.6
Test Duration (minutes)	260.0	147.0	150.0	185.667
Meter Volume (dscf @ 68 F)	106.796	102.815	106.761	105.458
Meter Volume (M3 @ 0 C)	2.818	2.713	2.817	2.783
Flue Gas Moisture (%)	4.2	4.2	4.2	4.2

Plant Name	**Dow - LGTI**
Location	**Sour Gas - #22**
Test Parameter	**Ammonia**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-09-94	-
Time Start	1613	0749	1026	-
Time Finish	1619	0754	1030	-
Operator	JPL	JPL	JPL	-
Dry Gas Meter Calibration (Yd)	0.973	0.973	0.973	0.973
Barometric Pressure ("Hg)	29.85	30.00	30.00	29.95
Meter Volume (acf)	1.069	1.142	1.146	1.119
Average delta H (" H2O)	0.00	0.00	0.00	0.00
Average DGM Temp (F)	79.0	73.0	73.5	75.2
Test Duration (minutes)	6.0	5.0	4.0	5.0
Condensed Water (g)	41.2	30.3	40.2	37.2
Meter Volume (dscf @ 68 F)	1.484	1.497	1.567	1.516
Meter Volume (M3 @ 0 C)	0.0391	0.0395	0.0413	0.0400
Flue Gas Moisture (%)	56.7	48.9	54.8	53.5

Note, total volume adjusted to account for volume of ammonia that was removed

Plant Name **Dow - LGTI**
Location **Sour Gas - #22**
Test Parameter **Cyanide**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-09-94	-
Time Start	1634	0826	1104	-
Time Finish	1642	0833	1110	-
Operator	JPL	JPL	JPL	-
Dry Gas Meter Calibration (Yd)	0.973	0.973	0.973	0.973
Barometric Pressure ("Hg)	29.85	30.00	30.00	29.95
Meter Volume (acf)	2.315	2.199	1.550	2.021
Average delta H (" H2O)	0.00	0.00	0.00	0.00
Average DGM Temp (F)	79.5	73.0	76.0	76.2
Test Duration (minutes)	8.0	7.0	6.0	7.0
Meter Volume (dscf @ 68 F)	2.199	2.125	1.490	1.938
Meter Volume (M3 @ 0 C)	0.0580	0.0561	0.0393	0.0511

Plant Name	**Dow - LGTI**
Location	**Tail Gas - #15**
Test Parameter	**Ammonia**

Run No.	1-1	1-2	1-3	2-1	2-2	2-3	Average
Date	11-03-94	11-04-94	11-07-94	11-08-94	11-09-94	11-09-94	-
Time Start	1548	1526	1144	1334	0912	1248	-
Time Finish	1710	1700	1315	1500	1040	1413	-
Operator	JWM	JWM	JWM	JWM	JWM	JWM	-
Initial Leak Rate	0.004	0.008	0.018	0.010	0.003	0.020	-
Final Leak Rate	0.002	0.015	0.016	0.006	0.001	0.004	-
Dry Gas Meter Calibration (Yd)	0.964	1.032	1.032	1.032	1.032	1.032	1.021
Barometric Pressure ("Hg)	30.06	29.94	30.00	29.85	30.00	30.00	29.98
Meter Volume (acf)	24.590	39.881	32.030	31.778	30.475	31.354	31.685
Average delta H (" H2O)	5.30	8.00	7.13	8.13	7.33	7.67	7.26
Average DGM Temp (F)	87.0	88.0	80.8	87.0	84.3	93.9	86.8
Test Duration (minutes)	82.0	94.0	91.0	86.0	88.0	85.0	87.7
Meter Volume (dscf @ 68 F)	23.286	40.461	32.927	32.214	31.142	31.507	31.923
Meter Volume (M3 @ 0 C)	0.6144	1.0676	0.8688	0.8500	0.8217	0.8314	0.842

Plant Name	**Dow - LGTI**
Location	**Tail Gas - #15**
Test Parameter	**Cyanide**

Run No.	1-1	1-2	1-3	2-1	2-2	2-3	Average
Date	11-03-94	11-04-94	11-07-94	11-08-94	11-09-94	11-09-94	-
Time Start	1812	1643	1331	1506	0921	1106	-
Time Finish	1844	1722	1407	1543	0956	1142	-
Operator	JWM	JWM	JWM	JWM	JWM	JWM	-
Initial Leak Rate	0.000	0.004	0.007	0.001	0.004	0.002	-
Final Leak Rate	0.005	0.002	0.004	0.001	0.001	0.000	-
Dry Gas Meter Calibration (Yd)	0.964	0.964	1.032	0.964	0.964	0.964	0.987
Barometric Pressure ("Hg)	30.06	29.94	30.00	29.85	30.00	30.00	30.00
Meter Volume (acf)	4.448	10.314	10.169	10.284	11.021	10.106	8.310
Average delta H (" H2O)	2.50	4.40	5.50	7.00	5.00	6.00	4.13
Average DGM Temp (F)	79.0	85.0	85.3	83.5	83.7	86.3	83.1
Test Duration (minutes)	32.0	39.0	36.0	37.0	35.0	36.0	35.7
Meter Volume (dscf @ 68 F)	4.246	9.743	10.327	9.774	10.472	9.580	8.105
Meter Volume (M3 @ 0 C)	0.1120	0.2571	0.2725	0.2579	0.2763	0.2528	0.214
Flue Gas Moisture (%)	6.7	6.7	6.7	6.7	6.7	6.7	6.7

Plant Name	**Dow - LGTI**
Location	**Tail Gas - #15**
Test Parameter	**Metals**

Run No.	1	2		Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	0840	0946	810	-
Time Finish	1520	1500	1336	-
Operator	JWM	JWM	JWM	-
Initial Leak Rate	0.015	0.011	0.002	-
Final Leak Rate	0.022	0.016	0.004	-
Dry Gas Meter Calibration (Yd)	0.964	1.032	0.964	0.987
Barometric Pressure ("Hg)	30.06	29.94	30.00	30.00
Meter Volume (acf)	104.279	103.196	102.197	103.224
Average delta H (" H2O)	5.00	7.06	6.04	6.03
Average DGM Temp (F)	86.0	85.7	74.6	82.1
Test Duration (minutes)	418.0	314.0	326.0	352.7
Condensed Water (g)	222.7	110.3	128.4	153.8
Meter Volume (dscf @ 68 F)	98.860	104.897	99.006	100.921
Meter Volume (M3 @ 0 C)	2.6086	2.7678	2.6124	2.6629
Flue Gas Moisture (%)	9.6	4.7	5.8	6.7

Plant Name	**Dow - LGTI**
Location	**Tail gas - #15**
Test Parameter	**Semivolatiles**

Run No.	1-1	1-2	1-3	2-1	2-2	2-3	Average
Date	11-03-94	11-04-94	11-07-94	11-08-94	11-10-94	11-10-94	-
Time Start	0840	1019	0853	1130	0912	1219	-
Time Finish	1355	1625	1113	1425	1130	1439	-
Operator	JWM	JWM	JWM	JWM	JWM	JWM	-
Initial Leak Rate	0.007	0.005	0.002	0.003	0.005	0.004	-
Final Leak Rate	0.017	0.004	0.018	0.006	0.007	0.004	-
Dry Gas Meter Calibration (Yd)	1.032	0.964	1.032	0.964	1.032	1.032	1.009
Barometric Pressure ("Hg)	30.06	29.94	30.00	29.85	30.02	30.02	29.98
Meter Volume (acf)	103.488	103.775	57.425	57.542	50.659	52.023	70.819
Average delta H (" H2O)	7.00	5.42	8.25	7.25	7.67	6.00	6.93
Average DGM Temp (F)	85.0	87.1	71.1	85.8	67.7	66.2	77.1
Test Duration (minutes)	253.0	366.0	140.0	175.0	138.0	140.0	202.0
Meter Volume (dscf @ 68 F)	105.732	97.901	60.265	54.489	53.474	54.849	71.118
Meter Volume (M3 @ 0 C)	2.7899	2.5832	1.5902	1.4378	1.4110	1.4473	1.877
Flue Gas Moisture (%)	6.7	6.7	6.7	6.7	6.7	6.7	6.7

Plant Name	**Dow - LGTI**
Location	**Combustion Air, K250**
Test Parameter	**Ammonia - Anions**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-09-94	-
Time Start	0944	0830	1358	-
Time Finish	1126	1047	1720	-
Operator	RMM	JWM	JPL	-
Dry Gas Meter Calibration (Yd)	0.981	0.981	0.981	0.981
Barometric Pressure ("Hg)	29.85	30	30	29.95
Meter Volume (acf)	30.705	32.304	27.199	30.069
Average delta H (" H2O)	6.63	5.29	2.70	4.87
Average DGM Temp (F)	80.5	84.9	90.2	85.2
Test Duration (minutes)	102.0	147.0	202.0	150.3
Condensed Water (g)	81.4	96.7	11.5	63.2
Meter Volume (dscf @ 68 F)	29.836	31.189	25.844	28.956
Meter Volume (M3 @ 0 C)	0.787	0.823	0.682	0.764
Flue Gas Moisture (%)	11.4	12.8	2.1	8.7

Plant Name **Dow - LGTI**
Location **Combustion Air, K250**
Test Parameter **Cyanide**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-10-94	-
Time Start	1132	1054	0735	-
Time Finish	1255	1349	1055	-
Operator	RMM	JPL	JWM	-
Dry Gas Meter Calibration (Yd)	0.981	0.981	0.981	0.981
Barometric Pressure ("Hg)	29.85	30	30.02	29.96
Meter Volume (acf)	22.503	20.246	31.942	24.897
Average delta H (" H2O)	5.90	2.17	3.19	3.75
Average DGM Temp (F)	87.6	88.7	74.5	83.6
Test Duration (minutes)	83.0	175.0	200.0	152.7
Meter Volume (dscf)	21.544	19.266	31.300	24.037
Meter Volume (M3 @ 0 C)	0.568	0.508	0.826	0.634

Plant Name	**Dow - LGTI**
Location	**Natural Gas**
Test Parameter	**Metals**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-10-94	-
Time Start	0826	0817	1415	-
Time Finish	1250	1302	0945	-
Operator	RMM	JWM	JPL	-
Dry Gas Meter Calibration (Yd)	0.974	0.974	0.974	0.974
Barometric Pressure ("Hg)	29.85	30.00	30.02	29.96
Meter Volume (acf)	100.935	100.390	101.628	100.984
Average delta H (" H2O)	6.60	5.55	4.57	5.57
Average DGM Temp (F)	77.3	82.4	82.7	80.8
Test Duration (minutes)	264	285	323	291
Condensed Water (g)	2.3	5.4	2.3	3.3
Meter Volume (dscf @ 68 F)	97.950	96.735	97.712	97.465
Meter Volume (M3 @ 0 C)	2.5845	2.5525	2.5782	2.5718
Flue Gas Moisture (%)	0.1	0.3	0.1	0.2
Molecular Weight (Wet) (g/g-mole)	16.00	16.00	16.00	16.00

Plant Name	**Dow - LGTI**
Location	**Incinerator Stack, 16**
Test Parameter	**Anions / Ammonia / Cyanide**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-09-94	-
Time Start	0845	0736	1156	-
Time Finish	1025	0926	1338	-
Operator	MAB	MAB	MAB/TJB	-
Initial Leak Rate	0.010	0.000	0.010	-
Final Leak Rate	0.008	0.008	0.012	-
Stack Diameter (ft)	2.0	2.0	2.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	0.974	1.001	0.974	0.983
Nozzle Diameter (inches)	0.1500	0.1500	0.1500	-
Barometric Pressure ("Hg)	30.12	30.00	30.00	30.04
Static Pressure ("H2O)	4.5	4.5	5.3	4.8
Meter Volume (acf)	53.870	55.776	56.206	55.284
Average square root of delta p	2.1213	1.9748	2.0976	2.0646
Average delta H (" H2O)	1.20	1.04	1.15	1.13
Average Stack Temperature (F)	515	519	524	519
Average DGM Temp (F)	80.7	86.4	99.8	88.9
Test Duration (minutes)	100.0	110.0	102.0	104.0
Condensed Water (g)	204.4	235.7	204.1	214.7
% CO2	38.5	38.5	38.5	38.5
% O2	3.5	3.5	3.5	3.5
% N2	58.0	58.0	58.0	58.0
Meter Volume (dscf @ 68 F)	51.731	54.238	51.920	52.629
Meter Volume (M3 @ 0 C)	1.3650	1.4311	1.3700	1.3887
Flue Gas Moisture (%)	15.7	17.0	15.7	16.1
Molecular Weight (Wet) (g/g-mole)	31.74	31.53	31.75	31.67
Absolute Stack Pressure (" Hg)	30.45	30.33	30.39	30.39
Absolute Stack Temperature (R)	975	979	984	979
Average Gas Velocity (f/sec)	152.99	143.49	152.15	149.55
Avg Flow Rate (acfm)	28,838	27,048	28,680	28,189
Avg Flow Rate (dscfm)	13,393	12,266	13,174	12,944
Isokinetic Sampling Rate (%)	98.90	102.93	98.93	100.25

Plant Name	**Dow - LGTI**
Location	**Incinerator Stack, 16**
Test Parameter	**Loading, Metals**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-10-94	-
Time Start	0844	0738	0731	-
Time Finish	1234	1128	1114	-
Operator	TJB	TJB/MAB	DJV/MAB	-
Initial Leak Rate	0.010	0.004	0.004	-
Final Leak Rate	0.005	0.005	0.008	-
Stack Diameter (ft)	2.0	2.0	2.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	1.001	0.974	0.974	0.983
Nozzle Diameter (inches)	0.1500	0.1500	0.1500	-
Barometric Pressure ("Hg)	30.16	30.00	30.02	30.06
Static Pressure ("H2O)	4.5	5.3	4.6	4.8
Meter Volume (acf)	107.084	111.149	108.971	109.068
Average square root of delta p	1.8645	1.9645	1.9964	1.9418
Average delta H (" H2O)	0.93	1.02	1.04	0.99
Average Stack Temperature (F)	518	518	514	517
Average DGM Temp (F)	87.6	91.2	76.2	85.0
Test Duration (minutes)	216.0	216.0	216.0	216.0
Condensed Water (g)	405.6	411.5	412.0	409.7
Filter Weight Gain (g)	0.2354	0.1585	0.1964	0.1968
PNR Weight Gain (g)	0.1769	0.1980	0.2029	0.1926
% CO2	38.5	38.5	38.5	38.5
% O2	3.5	3.5	3.5	3.5
% N2	58.0	58.0	58.0	58.0
Meter Volume (dscf @ 68 F)	104.423	104.239	105.128	104.597
Meter Volume (M3 @ 0 C)	2.7553	2.7505	2.7739	2.7599
Flue Gas Moisture (%)	15.5	15.7	15.6	15.6
Molecular Weight (Wet) (g/g-mole)	31.77	31.74	31.76	31.76
Absolute Stack Pressure (" Hg)	30.49	30.39	30.36	30.41
Absolute Stack Temperature (R)	978	978	974	977
Average Gas Velocity (f/sec)	134.55	142.03	144.13	140.24
Avg Flow Rate (acfm)	25,362	26,773	27,168	26,435
Avg Flow Rate (dscfm)	11,782	12,373	12,601	12,252
Isokinetic Sampling Rate (%)	105.06	99.86	98.90	101.27
Particulate Concentration (gr/dscf)	0.0609	0.0528	0.0586	0.0574
Particulate Concentration (mg/M3)	149.64	129.61	143.95	141.07
Particulate Emission (lbs/hour)	6.15	5.60	6.33	6.03

Plant Name **Dow - LGTI**
Location **Incinerator Stack, 16**
Test Parameter **PM-10**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-10-94	-
Time Start	1222	1115	0740	-
Time Finish	1615	1522	1417	-
Operator	TJB/MAB	MAB/TJB	DJV/MAB	-
Initial Leak Rate	0.015	0.004	0.005	-
Final Leak Rate	ND	ND	ND	-
Stack Diameter (ft)	2.0	2.0	2.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	0.974	1.001	1.001	0.992
Nozzle Diameter (inches)	0.1370	0.1370	0.1370	-
Barometric Pressure ("Hg)	30.12	30	30.02	30.05
Static Pressure ("H2O)	4.5	5.3	4.6	4.8
Meter Volume (acf)	101.131	103.232	108.237	104.200
Average square root of delta p	1.9493	1.9748	1.9748	1.9663
Average delta H (" H2O)	0.71	0.68	0.68	0.69
Average Stack Temperature (F)	517	518	515	517
Average DGM Temp (F)	97.7	101.0	71.2	90.0
Test Duration (minutes)	233.0	247.0	256.0	245.3
Condensed Water (g)	365.7		357.1	361.4
Filter Weight Gain (g)	0.0011	0.0018	0.0013	0.0014
PNR Weight Gain (g)	0.0023	0.0046	0.0092	0.0054
% CO2	38.5	38.5	38.5	38.5
% O2	3.5	3.5	3.5	3.5
% N2	58.0	58.0	58.0	58.0
Meter Volume (dscf @ 68 F)	94.042	97.679	108.232	99.985
Meter Volume (M3 @ 0 C)	2.4814	2.5774	2.8559	2.6382
Flue Gas Moisture (%)	15.5	15.5	13.5	14.8
Molecular Weight (Wet) (g/g-mole)	31.77	31.77	32.10	31.88
Absolute Stack Pressure (" Hg)	30.45	30.39	30.36	30.40
Absolute Stack Temperature (R)	977	978	975	977
Average Gas Velocity (f/sec)	140.67	142.72	141.86	141.75
Avg Flow Rate (acfm)	26,515	26,902	26,739	26,719
Avg Flow Rate (dscfm)	12,317	12,460	12,705	12,494
Isokinetic Sampling Rate (%)	100.58	97.42	102.14	100.05
Particulate Concentration (gr/dscf)	0.0006	0.0010	0.0015	0.0010
Particulate Concentration (mg/M3)	1.36	2.47	3.68	2.50
Particulate Emission (lbs/hour)	0.06	0.11	0.16	0.11

Plant Name	**Dow - LGTI**
Location	**Incinerator Stack, 16**
Test Parameter	**Oxides of Nitrogen, M 7**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-09-94	-
Time Start	0850	0758	1311	-
Time Finish	1023	0920	1431	-
Operator	JLM	JLM	JLM	-
Initial Leak Rate	0.002	0.02	0.000	-
Final Leak Rate	0.002			-
Stack Diameter (ft)	2.0	2.0	2.0	-
Dry Gas Meter Calibration (Yd)	1.016	1.016	1.016	1.016
Barometric Pressure ("Hg)	30.12	30.00	30.00	30.04
Meter Volume (liters)	31.500	33.330	31.290	32.040
Average delta H (" H2O)	1.38	1.40	1.40	1.39
Average DGM Temp (F)	71.3	78.7	86.0	78.7
Test Duration (minutes)	93.0	82.0	80.0	85.0
Condensed Water (g)	18.7	17.9	17.1	17.9
% CO2	38.5	38.5	38.5	38.5
% O2	3.5	3.5	3.5	3.5
% N2	58.0	58.0	58.0	58.0
Meter Volume (liters, dry, 0 C)	29.938	31.117	28.822	29.959
Flue Gas Moisture (%)	2.9	2.6	2.7	2.7
Molecular Weight (Wet) (g/g-mole)	33.83	33.87	33.86	33.85

Plant Name	**Dow - LGTI**
Location	**Incinerator Stack**
Test Parameter	**Sulfur Dioxide, M-8**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-09-94	-
Time Start	1105	1004	1420	-
Time Finish	1140	1040	1500	-
Operator	MAB	MAB	TJB	-
Initial Leak Rate	0.008	0.013	0.010	-
Final Leak Rate	0.005	0.008	0.005	
Stack Diameter (ft)	2.0	2.0	2.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	0.974	1.001	0.974	0.983
Nozzle Diameter (inches)	0.1500	0.1500	0.1500	-
Barometric Pressure ("Hg)	30.12	30.00	30.00	30.04
Static Pressure ("H2O)	4.5	5.3	5.3	5.0
Meter Volume (acf)	20.112	21.039	20.499	20.550
Average square root of delta p	2.0494	1.9748	1.9748	1.9997
Average delta H (" H2O)	1.10	1.10	1.10	1.10
Average Stack Temperature (F)	517	519	526	521
Average DGM Temp (F)	96.0	91.0	101.3	96.1
Test Duration (minutes)	35.0	39.0	38.0	37.3
Condensed Water (g)	79.4	78.2	83.0	80.2
% CO2	38.5	38.5	38.5	38.5
% O2	3.5	3.5	3.5	3.5
% N2	58.0	58.0	58.0	58.0
Meter Volume (dscf @68 F)	18.777	20.289	18.884	19.317
Meter Volume (M3 @ 0 C)	0.4955	0.5354	0.4983	0.5097
Flue Gas Moisture (%)	16.6	15.4	17.2	16.4
Molecular Weight (Wet) (g/g-mole)	31.59	31.79	31.50	31.63
Absolute Stack Pressure (" Hg)	30.45	30.39	30.39	30.41
Absolute Stack Temperature (R)	977	979	986	981
Average Gas Velocity (f/sec)	148.32	142.76	143.90	144.99
Avg Flow Rate (acfm)	27,958	26,909	27,125	27,331
Avg Flow Rate (dscfm)	12,814	12,467	12,218	12,499
Isokinetic Sampling Rate (%)	107.20	106.85	104.15	106.07

Plant Name **Dow - LGTI**
Location **Incinerator Stack, 16**
Test Parameter **Hydrogen Sulfide, M-11**

Run No.	2-1	2-2	2-3	Average
Date	11-12-94	11-12-94	11-12-94	-
Time Start	736	904	1100	-
Time Finish	816	954	1149	-
Operator				-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.016	1.016	1.016	1.016
Barometric Pressure ("Hg)	30.04	30.04	30.04	30.04
Meter Volume (L)	20.420	21.400	27.148	22.989
Average delta H (" H2O)	1.40	1.40	1.40	1.40
Average DGM Temp (F)	64.5	74.0	74.5	71.0
Meter Volume (L @ 0 C)	19.606	20.182	25.578	21.789
Meter Volume (M3 @ 0 C)	0.01961	0.02018	0.02558	0.0218

Plant Name	**Dow - LGTI**
Location	**Incinerator Stack, 16**
Test Parameter	**Aldehyde**

Run No.	1	2	3	Average
Date	11-08-94	11-09-94	11-09-94	-
Time Start	1040	0816	1435	-
Time Finish	1255	1140	1600	-
Operator	JLM	JLM	JLM	-
Initial Leak Rate	0.015	0.002	0.001	-
Final Leak Rate	0.010		0.001	-
Stack Diameter (ft)	2.0	2.0	2.0	-
Dry Gas Meter Calibration (Yd)	1.031	1.031	1.031	1.031
Barometric Pressure ("Hg)	30.12	30.00	30.00	30.04
Meter Volume (acf)	56.103	31.607	34.280	40.663
Average delta H (" H2O)	0.80	0.53	0.78	0.70
Average DGM Temp (F)	80.0	80.5	85.0	81.8
Test Duration (minutes)	135.0	204.0	85.0	141.3
% CO2	38.5	38.5	38.5	38.5
% O2	3.5	3.5	3.5	3.5
% N2	58.0	58.0	58.0	58.0
Meter Volume (dscf @ 68 F)	57.046	31.959	34.398	41.134
Meter Volume (M3 @ 0 C)	1.5052	0.8433	0.9076	1.0854
Flue Gas Moisture (%)	15.5	15.7	15.7	15.6
Molecular Weight (Wet) (g/g-mole)	31.77	31.74	31.74	31.75

Plant Name	**Dow - LGTI**
Location	**Incinerator Stack, 16**
Test Parameter	**Semivolatiles, CARB 429**

Run No.	1	2	3	Average
Date	11-10-94	11-11-94	11-11-94	-
Time Start	1330	0755	1530	-
Time Finish	1740	1414	2000	-
Operator	DJV/MAB	MAB/DJV	DJV/MAB	-
Initial Leak Rate	0.002	0.004	0.015	-
Final Leak Rate	0.002	0.014	0.018	-
Stack Diameter (ft)	2.0	2.0	2.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	0.974	0.978	0.974	0.975
Nozzle Diameter (inches)	0.1500	0.1500	0.1500	-
Barometric Pressure ("Hg)	30.02	30.04	30.04	30.03
Static Pressure ("H2O)	5.1	4.6	5.4	5.0
Meter Volume (acf)	118.130	115.756	113.646	115.844
Average square root of delta p	1.9685	1.9540	1.9330	1.9518
Average delta H (" H2O)	1.02	0.99	0.98	1.00
Average Stack Temperature (F)	514	518	517	516
Average DGM Temp (F)	73.9	68.6	74.3	72.3
Test Duration (minutes)	240.0	240.0	235.0	238.3
% CO2	38.5	38.5	38.5	38.5
% O2	3.5	3.5	3.5	3.5
% N2	58.0	58.0	58.0	58.0
Meter Volume (dscf @ 68 F)	114.448	113.811	110.085	112.781
Meter Volume (M3 @ 0 C)	3.0199	3.0030	2.9047	2.9759
Flue Gas Moisture (%)	15.5	15.5	15.5	15.5
Molecular Weight (Wet) (g/g-mole)	31.77	31.77	31.77	31.77
Absolute Stack Pressure (" Hg)	30.40	30.38	30.44	30.40
Absolute Stack Temperature (R)	974	978	977	976
Average Gas Velocity (f/sec)	141.97	141.22	139.49	140.89
Avg Flow Rate (acfm)	26,761	26,619	26,292	26,557
Avg Flow Rate (dscfm)	12,447	12,329	12,216	12,331
Isokinetic Sampling Rate (%)	98.10	98.48	98.19	98.26

Plant Name **Dow - LGTI**
Location **Incinerator Stack, 16**
Test Parameter **TCO**

Run No.	2-1	2-2	2-3	Average
Date	11-9-94	11-9-94	11-10-94	-
Time Start	1048	1311	0740	-
Time Finish	1255	1550	0940	-
Operator				-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.016	1.016	1.016	1.016
Barometric Pressure ("Hg)	30.00	30.00	30.02	30.01
Meter Volume (L)	102.560	102.730	103.430	102.907
Average delta H (" H2O)	2.40	1.40	2.00	1.93
Average DGM Temp (F)	84.7	86.8	71.5	81.0
Meter Volume (L @ 0 C)	94.926	94.488	98.078	95.831
Meter Volume (M3 @ 0 C)	0.09493	0.09449	0.09808	0.0958

Plant Name **Dow - LGTI**
Sample Location **Incinerator Stack, 16**
Test Parameter **VOST**

Run No.	Date	Time	Sample Volume	DGM Temp	Delta H	Pbar	Meter Yd	Sample Volume (Std. L @ 0 C)
1a	11-11-94	0816-0904	20.910	59.0	1.8	30.04	1.016	20.309
1b	11-11-94	0911-0949	20.820	62.0	1.8	30.04	1.016	20.106
1c	11-11-94	0956-1036	22.230	61.0	1.8	30.04	1.016	21.508
2a	11-11-94	1052-1132	22.000	64.0	1.4	30.04	1.016	21.143
2b	11-11-94	1140-1220	23.150	64.0	1.4	30.04	1.016	22.249
2c	11-11-94	1227-1315	23.700	65.0	1.4	30.04	1.016	22.734
3a	11-11-94	1325-14095	19.870	68.0	1.4	30.04	1.016	18.952
3b	11-11-94	1411-1458	22.840	66.0	1.4	30.04	1.016	21.867
3c	11-11-94	1504-1645	18.840	66.0	1.4	30.04	1.016	18.038

Plant Name **Dow LGTI**
Location **Turbine Stack, 13**
Test Parameter **Anions / Ammonia / Cyanide**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	0745	0756	0739	-
Time Finish	0925	0946	0915	-
Operator	MSS	MSS	MSS	-
Initial Leak Rate	0.008	0.004	0.01	-
Final Leak Rate	0.004	0.004	0.005	-
Stack Diameter (ft)	10.0	10.0	10.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	1.001	1.001	1.001	1.001
Nozzle Diameter (inches)	0.1930	0.1930	0.1930	-
Barometric Pressure ("Hg)	29.97	29.94	30.06	29.99
Static Pressure ("H2O)	0.7	0.7	0.6	0.67
Meter Volume (acf)	58.036	56.425	56.093	56.851
Average square root of delta p	1.0923	1.1290	1.0954	1.1056
Average delta H (" H2O)	1.22	1.30	1.20	1.24
Average Stack Temperature (F)	308	307	307	307
Average DGM Temp (F)	80.9	80.4	70.5	77.2
Test Duration (minutes)	100.0	94.0	96.0	96.7
Condensed Water (g)	122.0	119.1	92.1	111.1
% CO2	6.0	6.0	6.0	6.0
% O2	15.0	15.0	15.0	15.0
% N2	79.0	79.0	79.0	79.0
Meter Volume (dscf @ 68 F)	56.977	55.401	56.311	56.230
Meter Volume (M3 @ 0 C)	1.5034	1.4618	1.4858	1.4837
Flue Gas Moisture (%)	9.2	9.2	7.2	8.5
Molecular Weight (Wet) (g/g-mole)	28.50	28.50	28.73	28.58
Absolute Stack Pressure (" Hg)	30.02	29.99	30.10	30.04
Absolute Stack Temperature (R)	768	767	767	767
Average Gas Velocity (f/sec)	74.30	76.81	74.08	75.06
Avg Flow Rate (acfm)	350,141	361,946	349,071	353,719
Avg Flow Rate (dscfm)	219,366	226,659	224,361	223,462
Isokinetic Sampling Rate (%)	100	101	101	101

Plant Name	**Dow - LGTI**
Location	**Turbine Stack, 13**
Test Parameter	**Loading/Metals**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	0756	0745	0808	-
Time Finish	1109	1058	1114	-
Operator	TJB	TJB	TJB	-
Initial Leak Rate	0.010	0.005	0.008	-
Final Leak Rate	0.008	0.010	0.004	-
Stack Diameter (ft)	10.0	10.0	10.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	0.974	1.031	0.974	0.993
Nozzle Diameter (inches)	0.1930	0.1930	0.1930	-
Barometric Pressure ("Hg)	30.06	29.94	30.06	30.02
Static Pressure ("H2O)	0.66	0.63	0.82	0.70
Meter Volume (acf)	111.351	102.897	107.911	107.386
Average square root of delta p	1.1280	1.1615	1.1284	1.1393
Average delta H (" H2O)	1.04	1.32	1.28	1.21
Average Stack Temperature (F)	306	304	306	305
Average DGM Temp (F)	80.8	83.0	81.7	81.8
Test Duration (minutes)	176.0	176.0	176.0	176.0
Condensed Water (g)	231.7	224.5	206.8	221.0
Filter Weight Gain (g)	0.0013	0.0008	0.0000	0.0007
PNR Weight Gain (g)	0.0141	0.0082	0.0077	0.0100
% CO2	6.0	6.0	6.0	6.0
% O2	15.0	15.0	15.0	15.0
% N2	79.0	79.0	79.0	79.0
Meter Volume (dscf @ 68 F)	106.654	103.559	103.249	104.488
Meter Volume (M3 @ 0 C)	2.8142	2.7325	2.7244	2.7570
Flue Gas Moisture (%)	9.3	9.3	8.6	9.1
Molecular Weight (Wet) (g/g-mole)	28.48	28.49	28.56	28.51
Absolute Stack Pressure (" Hg)	30.11	29.99	30.12	30.07
Absolute Stack Temperature (R)	766	764	766	765
Average Gas Velocity (f/sec)	76.55	78.89	76.44	77.29
Avg Flow Rate (acfm)	360,751	371,745	360,206	364,234
Avg Flow Rate (dscfm)	226,868	233,458	228,419	229,582
Isokinetic Sampling Rate (%)	103	97	99	100
Particulate Concentration (gr/dscf)	0.00223	0.00134	0.00115	0.00157
Particulate Concentration (mg/M3)	5.47	3.29	2.83	3.86
Particulate Emission (lbs/hour)	4.33	2.68	2.25	3.09

Plant Name	**Dow - LGTI**
Location	**Turbine Stack, 13**
Test Parameter	**PM-10**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	0808	0813	0803	-
Time Finish	1408	1413	1300	-
Operator	RWM	RWM	TJB	-
Initial Leak Rate	0.010	0.010	0.015	-
Final Leak Rate	NA	NA	NA	-
Stack Diameter (ft)	10.0	10.0	10.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	0.971	0.971	0.971	0.971
Nozzle Diameter (inches)	0.1870	0.1870	0.1870	-
Barometric Pressure ("Hg)	29.97	29.94	30.06	29.99
Static Pressure ("H2O)	0.7	0.7	0.6	0.67
Meter Volume (acf)	199.977	200.127	163.539	187.881
Average square root of delta p	1.0950	1.0954	1.0950	1.0951
Average delta H (" H2O)	1.08	1.08	1.00	1.05
Average Stack Temperature (F)	313	311	312	312
Average DGM Temp (F)	92.0	93.8	85.7	90.5
Test Duration (minutes)	360.0	360.0	297.0	339.0
Condensed Water (g)	410.2	403.6	313.5	375.8
Filter Weight Gain (g)	0.0040	0.0040	0.0041	0.0040
PNR Weight Gain (g)	0.0084	0.0215	0.0181	0.0160
% CO2	6.0	6.0	6.0	6.0
% O2	15.0	15.0	15.0	15.0
% N2	79.0	79.0	79.0	79.0
Meter Volume (dscf @ 68 F)	186.539	185.878	154.747	175.721
Meter Volume (M3 @ 0 C)	4.9221	4.9046	4.0832	4.6366
Flue Gas Moisture (%)	9.4	9.3	8.7	9.1
Molecular Weight (Wet) (g/g-mole)	28.47	28.49	28.55	28.50
Absolute Stack Pressure (" Hg)	30.02	29.99	30.10	30.04
Absolute Stack Temperature (R)	773	771	772	772
Average Gas Velocity (f/sec)	74.78	74.71	74.54	74.68
Avg Flow Rate (acfm)	352,377	352,080	351,275	351,910
Avg Flow Rate (dscfm)	218,711	219,219	220,429	219,453
Isokinetic Sampling Rate (%)	98	97	97	97
Particulate Concentration (gr/dscf)	0.00102	0.00212	0.00221	0.00179
Particulate Concentration (mg/M3)	2.51	5.21	5.44	4.38
Particulate Emission (lbs/hour)	1.92	3.98	4.18	3.36

Plant Name	**Dow - LGTI**
Location	**Turbine Stack, 13**
Test Parameter	**Sulfur Dioxide, M-8**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	1055	0750	0809	-
Time Finish	1258	1016	1051	-
Operator	DJV	TJB, DJV	DJV	-
Initial Leak Rate	0.005	0.005	0.004	-
Final Leak Rate	0.005	0.005	0.002	-
Stack Diameter (ft)	10.0	10.0	10.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	1.031	0.974	1.031	1.012
Nozzle Diameter (inches)	0.1930	0.1930	0.1930	-
Barometric Pressure ("Hg)	29.97	29.94	30.06	29.99
Static Pressure ("H2O)	0.7	0.63	0.73	0.69
Meter Volume (acf)	56.038	62.631	78.654	65.774
Average square root of delta p	1.1140	1.1220	1.1680	1.1347
Average delta H (" H2O)	1.28	1.26	1.40	1.31
Average Stack Temperature (F)	305	305	305	305
Average DGM Temp (F)	93.0	79.0	77.8	83.3
Test Duration (minutes)	96.0	101.0	128.0	108.3
Condensed Water (g)	119.1	127.5	318.5	188.4
% CO2	6.0	6.0	6.0	6.0
% O2	15.0	15.0	15.0	15.0
% N2	79.0	79.0	79.0	79.0
Meter Volume (dscf @ 68 F)	55.429	59.983	80.269	65.227
Meter Volume (M3 @ 0 C)	1.4626	1.5827	2.1180	1.7211
Flue Gas Moisture (%)	9.2	9.1	15.8	11.4
Molecular Weight (Wet) (g/g-mole)	28.50	28.51	27.74	28.25
Absolute Stack Pressure (" Hg)	30.02	29.99	30.11	30.04
Absolute Stack Temperature (R)	765	765	765	765
Average Gas Velocity (f/sec)	75.65	76.22	80.27	77.38
Avg Flow Rate (acfm)	356,490	359,195	378,245	364,643
Avg Flow Rate (dscfm)	224,060	225,719	221,246	223,675
Isokinetic Sampling Rate (%)	100	102	110	104

Plant Name	**Dow - LGTI**
Location	**Turbine Stack, 13**
Test Parameter	**Aldehyde**

Run No.	1	2	3	Average
Date	11-03-94	11-04-94	11-07-94	-
Time Start	0940	1001	0926	-
Time Finish	1040	1101	1026	-
Operator	MSS	MSS	MSS	-
Initial Leak Rate	0.002	0.005	0.005	-
Final Leak Rate	0.010	0.005	0.005	-
Stack Diameter (ft)	10.0	10.0	10.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	1.001	1.001	1.001	1.001
Nozzle Diameter (inches)	0.1930	0.1930	0.1930	-
Barometric Pressure ("Hg)	29.97	29.94	30.06	29.99
Static Pressure ("H2O)	0.7	0.63	0.82	0.72
Meter Volume (acf)	35.762	35.682	35.311	35.585
Average square root of delta p	1.0950	1.0950	1.0950	1.0950
Average delta H (" H2O)	1.22	1.20	1.20	1.21
Average Stack Temperature (F)	307	307	307	307
Average DGM Temp (F)	90.9	91.0	78.1	86.7
Test Duration (minutes)	60.0	60.0	60.0	60.0
Condensed Water (g)	NA	NA	NA	0.0
% CO2	6.0	6.0	6.0	6.0
% O2	15.0	15.0	15.0	15.0
% N2	79.0	79.0	79.0	79.0
Meter Volume (dscf @ 68 F)	34.470	34.351	34.949	34.590
Meter Volume (M3 @ 0 C)	0.9095	0.9064	0.9222	0.9127
Flue Gas Moisture (%)	9.0	9.0	9.0	9.0
Molecular Weight (Wet) (g/g-mole)	28.52	28.52	28.52	28.52
Absolute Stack Pressure (" Hg)	30.02	29.99	30.12	30.04
Absolute Stack Temperature (R)	767	767	767	767
Average Gas Velocity (f/sec)	74.42	74.47	74.30	74.40
Avg Flow Rate (acfm)	350,719	350,925	350,144	350,596
Avg Flow Rate (dscfm)	220,362	220,233	220,724	220,440
Isokinetic Sampling Rate (%)	101	101	102	101

Plant Name **Dow - LGTI**
Location **Turbine Stack, 13**
Test Parameter **Semivolatiles, CARB 429**

Run No.	5	6	3-1	Average
Date	11-11-94	11-11-94	11-12-94	-
Time Start	0751	1214	0737	-
Time Finish	1109	1525	1047	-
Operator	TJB	TJB	TJB	-
Initial Leak Rate	0.010	0.010	0.01	-
Final Leak Rate	0.005		0.005	-
Stack Diameter (ft)	10.0	10.0	10.0	-
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	-
Dry Gas Meter Calibration (Yd)	0.971	0.971	0.971	-
Nozzle Diameter (inches)	0.1900	0.1900	0.1900	-
Barometric Pressure ("Hg)	30.04	29.97	30.06	30.02
Static Pressure ("H2O)	0.65	0.56	0.63	0.61
Meter Volume (acf)	114.956	111.996	111.392	112.781
Average square root of delta p	1.0954	1.0954	1.0920	1.094
Average delta H (" H2O)	1.20	1.20	1.20	1.20
Average Stack Temperature (F)	311	313	315	313
Average DGM Temp (F)	79	84	85	83
Test Duration (minutes)	188	191	190	190
% CO2	6.0	6.0	6.0	6.0
% O2	15.0	15.0	15.0	15.0
% N2	79.0	79.0	79.0	79.0
Meter Volume (dscf @ 68 F)	110.105	106.062	105.587	107.251
Meter Volume (M3 @ 0 C)	2.9053	2.7986	2.7861	2.8300
Flue Gas Moisture (%)	9.2	9.2	9.2	9.200
Molecular Weight (Wet) (g/g-mole)	28.50	28.50	28.50	28.50
Absolute Stack Pressure (" Hg)	30.09	30.01	30.11	30.07
Absolute Stack Temperature (R)	771	773	775	773
Average Gas Velocity (f/sec)	74.59	74.80	74.53	75
Avg Flow Rate (acfm)	351,514	352,506	351,224	351,748
Avg Flow Rate (dscfm)	219,719	219,101	218,537	219,119
Isokinetic Sampling Rate (%)	106	101	101	103

Plant Name **Dow LGTI**
Sampling Location **Turbine Stack, 13**
Test Parameter **VOST**

Run No.	Date	Time	Sample Volume	DGM Temp	Delta H	Pbar	Meter Yd	Sample Volume (Std. L @ 0 C)
3a	11-10-94	0824-0904	20.250	65.0	1.2	30	0.995	18.988
3b	11-10-94	0913-0953	20.070	66.0	1.2	30	0.995	18.784
3c	11-10-94	1001-1041	20.610	66.0	1.2	30	0.995	19.289
5a	11-10-94	1047-1127	20.160	66.0	1.2	30	0.995	18.868
5b	11-10-94	1135-1215	20.050	66.0	1.2	30	0.995	18.765
5c	11-10-94	1222-1302	20.090	66.0	1.2	30	0.995	18.803
6a	11-10-94	1313-1353	20.390	65.5	1.2	30	0.995	19.102
6b	11-10-94	1359-1439	20.350	65.0	1.2	30	0.995	19.082
6c	11-10-94	1451-1531	20.510	64.0	1.2	30	0.995	19.269

PERIOD 4—HOT GAS TESTING

Plant Name **Dow - LGTI**
Location **Raw Gas, 5**
Test Parameter **Ammonia**

Run No.	1	2	3	Average
Date	05/18/95	05/18/95	05/19/95	-
Time Start	11:10 AM	02:25 PM	02:13 PM	-
Time Finish	11:50 AM	02:50 PM	03:08 PM	-
Operator	WAW	WAW	WAW	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.003	1.003	1.000	1.002
Barometric Pressure ("Hg)	30.00	30.00	30.00	30
Meter Volume (acf)	11.682	10.294	11.140	11.039
Average delta H (" H2O)	0.24	0.40	0.00	0.21
Average DGM Temp (F)	87.3	92.2	76.0	85.2
Meter Volume (dscf @ 68 F)	11.341	9.908	11.003	10.751
Meter Volume (M3 @ 0 C)	0.299	0.261	0.290	0.284

Plant Name **Dow - LGTI**
Location **Raw Gas, 5**
Test Parameter **Anions**

Run No.	1	2	3	Average
Date	05/18/95	05/19/95	05/19/95	-
Time Start	11:57 AM	03:05 PM	03:50 PM	-
Time Finish	01:42 PM	04:30 PM	05:14 PM	-
Operator	WAW	WAW	WAW	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate'	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.003	1.003	0.968	0.991
Barometric Pressure ("Hg)	30.00	30.00	30.00	30
Meter Volume (acf)	46.545	36.183	39.086	40.605
Average delta H (" H2O)	0.48	0.39	0.49	0.45
Average DGM Temp (F)	91.1	91.9	94.9	92.6
Meter Volume (dscf @ 68 F)	44.900	34.846	36.141	38.629
Meter Volume (M3 @ 0 C)	1.185	0.919	0.954	1.019

Plant Name **Dow - LGTI**
Location **Raw Gas, 5**
Test Parameter **Cyanide**

Run No.	1	2	3	Average
Date	05/18/95	05/19/95	05/19/95	-
Time Start	01:48 PM	10:30 AM	01:38 PM	-
Time Finish	02:12 PM	10:46 AM	02:10 PM	-
Operator	WAW	WAW	WAW	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.003	0.968	1.000	0.990
Barometric Pressure ("Hg)	30.00	30.00	30.00	30
Meter Volume (acf)	7.030	5.230	4.980	5.747
Average delta H (" H2O)	0.30	0.25	0.00	0.18
Average DGM Temp (F)	92.0	78.3	76.0	82.1
Meter Volume (dscf @ 68 F)	6.768	4.982	4.919	5.556
Meter Volume (M3 @ 0 C)	0.179	0.131	0.130	0.147

Plant Name	**Dow - LGTI**
Location	**Raw Gas, 5**
Test Parameter	**Metals, Charcoal**

Run No.	1	2	3	Average
Date	05/18/95	05/19/95	05/19/95	-
Time Start	12:22 PM	03:00 PM	11:31 AM	-
Time Finish	02:52 PM	11:21 AM	01:05 PM	-
Operator	WAW	WAW	WAW	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	1.000	1.000	1.000	1.000
Barometric Pressure ("Hg)	30.00	30.00	30.00	30
Meter Volume (acf)	4.039	3.818	3.550	3.802
Average delta H (" H2O)	0.00	0.00	0.00	0.00
Average DGM Temp (F)	86.0	74.0	72.0	77.3
Meter Volume (dscf @ 68 F)	3.916	3.785	3.533	3.745
Meter Volume (M3 @ 0 C)	0.103	0.100	0.093	0.099

Plant Name **Dow - LGTI**
Location **Raw Gas, 5**
Test Parameter **Metals, M-29**

Run No.	1	2	3	Average
Date	05/18/95	05/19/95	05/19/95	-
Time Start	10:03 AM	10:09 AM	10:57 AM	-
Time Finish	03:22 PM	03:00 PM	03:37 PM	-
Operator	WAW	WAW	WAW	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.968	1.003	0.968	0.980
Barometric Pressure ("Hg)	30.00	30.00	30.00	30
Meter Volume (acf)	73.920	90.227	84.583	82.910
Average delta H (" H2O)	0.14	0.22	0.21	0.19
Average DGM Temp (F)	89.9	85.4	87.2	87.5
Meter Volume (dscf @ 68 F)	68.912	87.892	79.256	78.687
Meter Volume (M3 @ 0 C)	1.818	2.319	2.091	2.076

Plant Name	**Dow - LGTI**
Location	**Raw Gas, 5**
Test Parameter	**Metals-Hg, M-29**

Run No.	1	2	3	Average
Date	05/18/95	05/19/95	05/19/95	-
Time Start	10:03 AM	10:09 AM	10:57 AM	-
Time Finish	01:56 PM	12:20 PM	01:01 PM	-
Operator	WAW	WAW	WAW	-
Initial Leak Rate	NA	NA	NA	-
Final Leak Rate	NA	NA	NA	-
Dry Gas Meter Calibration (Yd)	0.968	1.003	0.968	0.980
Barometric Pressure ("Hg)	30.00	30.00	30.00	30
Meter Volume (acf)	58.172	40.125	29.428	42.575
Average delta H (" H2O)	0.14	0.21	0.17	0.17
Average DGM Temp (F)	89.1	82.9	84.2	85.4
Meter Volume (dscf @ 68 F)	54.310	39.266	27.724	40.433
Meter Volume (M3 @ 0 C)	1.433	1.036	0.732	1.067

APPENDIX G: DETAILED ANALYTICAL RESULTS

Table G-1. Analytical Results Used in Calculations

Stream: Raw Syngas @ 1000 deg F (5)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Vapor Phase								
Ammonia as N	EPA 350.1	ug/Nm3	4					
Chloride	EPA 300.0	ug/Nm3	4					
Cyanide	SW9012	ug/Nm3	4					
Fluoride	EPA 340.2	ug/Nm3	4					
Metals-Vapor Phase (Charcoal)								
Antimony	SW7041	ug/Nm3	4					
Arsenic	SW7060	ug/Nm3	4					
Barium	SW6010	ug/Nm3	4					
Beryllium	SW6010	ug/Nm3	4					
Boron	SW6010	ug/Nm3	4					
Cadmium	SW7131	ug/Nm3	4					
Chromium	SW6010	ug/Nm3	4					
Cobalt	SW6010	ug/Nm3	4					
Copper	SW6010	ug/Nm3	4					
Iron	SW6010	ug/Nm3	4					
Lead	SW7421	ug/Nm3	4					
Manganese	SW6010	ug/Nm3	4					
Mercury	SW7471	ug/Nm3	4					
Molybdenum	SW6010	ug/Nm3	4					
Nickel	SW6010	ug/Nm3	4					
Selenium	SW7740	ug/Nm3	4					
Vanadium	SW6010	ug/Nm3	4					
Zinc	SW6010	ug/Nm3	4					
Metals-Vapor Phase (M-29)								
Aluminum	SW6010	ug/Nm3	4					
Antimony	ICP/MS	ug/Nm3	4					
Arsenic	ICP/MS	ug/Nm3	4					
Barium	ICP/MS	ug/Nm3	4					
Beryllium	ICP/MS	ug/Nm3	4					
Boron	SW6010	ug/Nm3	4					
Cadmium	ICP/MS	ug/Nm3	4					
Calcium	SW6010	ug/Nm3	4					

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Table G-1. Analytical Results Used in Calculations

Stream: Raw Syngas @ 1000 deg F (5)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29) (continued)								
Chromium	ICP/MS	ug/Nm3	4					
Cobalt	ICP/MS	ug/Nm3	4					
Copper	ICP/MS	ug/Nm3	4					
Iron	SW6010	ug/Nm3	4					
Lead	ICP/MS	ug/Nm3	4					
Magnesium	SW6010	ug/Nm3	4					
Manganese	ICP/MS	ug/Nm3	4					
Mercury, Nitric	SW7470	ug/Nm3	4					
Mercury, NaO	SW7470	ug/Nm3	4					
Mercury, KMn	SW7470	ug/Nm3	4					
Mercury, Total	SW7470	ug/Nm3	4					
Molybdenum	ICP/MS	ug/Nm3	4					
Nickel	ICP/MS	ug/Nm3	4					
Phosphorus	SW6010	ug/Nm3	4					
Potassium	SW6010	ug/Nm3	4					
Selenium	ICP/MS	ug/Nm3	4					
Silicon	SW6010	ug/Nm3	4					
Sodium	SW6010	ug/Nm3	4					
Titanium	SW6010	ug/Nm3	4					
Vanadium	ICP/MS	ug/Nm3	4					
Zinc	SW6010	ug/Nm3	4					

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Table G-1. Analytical Results Used in Calculations

Stream: Raw Syngas (5a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Vapor Phase								
Ammonia as N	EPA 350.1	ug/Nm3	3					
Chloride	EPA 300.0	ug/Nm3	3					
Cyanide	SW9012	ug/Nm3	3					
Fluoride	EPA 340.2	ug/Nm3	3					
Metals-Vapor Phase (Charcoal)								
Antimony	SW7041	ug/Nm3	3					
Arsenic	SW7060	ug/Nm3	3					
Barium	SW6010	ug/Nm3	3					
Beryllium	SW6010	ug/Nm3	3					
Boron	SW6010	ug/Nm3	3					
Cadmium	SW7131	ug/Nm3	3					
Chromium	SW6010	ug/Nm3	3					
Cobalt	SW6010	ug/Nm3	3					
Copper	SW6010	ug/Nm3	3					
Iron	SW6010	ug/Nm3	3					
Lead	SW7421	ug/Nm3	3					
Manganese	SW6010	ug/Nm3	3					
Mercury	SW7471	ug/Nm3	3					
Molybdenum	SW6010	ug/Nm3	3					
Nickel	SW6010	ug/Nm3	3					
Selenium	SW7740	ug/Nm3	3					
Vanadium	SW6010	ug/Nm3	3					
Zinc	SW6010	ug/Nm3	3					
Metals-Vapor Phase (M-29)								
Aluminum	SW6010	ug/Nm3	3					
Antimony	ICP/MS	ug/Nm3	3					
Arsenic	ICP/MS	ug/Nm3	3					
Barium	ICP/MS	ug/Nm3	3					
Beryllium	ICP/MS	ug/Nm3	3					
Boron	SW6010	ug/Nm3	3					
Cadmium	ICP/MS	ug/Nm3	3					
Calcium	SW6010	ug/Nm3	3					

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Table G-1. Analytical Results Used in Calculations

Stream: Raw Syngas (5a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29) (continued)								
Chromium	ICP/MS	ug/Nm3	3					
Cobalt	ICP/MS	ug/Nm3	3					
Copper	ICP/MS	ug/Nm3	3					
Iron	SW6010	ug/Nm3	3					
Lead	ICP/MS	ug/Nm3	3					
Magnesium	SW6010	ug/Nm3	3					
Manganese	ICP/MS	ug/Nm3	3					
Mercury	SW7470	ug/Nm3	3					
Molybdenum	ICP/MS	ug/Nm3	3					
Nickel	ICP/MS	ug/Nm3	3					
Phosphorus	SW6010	ug/Nm3	3					
Potassium	SW6010	ug/Nm3	3					
Selenium	ICP/MS	ug/Nm3	3					
Silicon	SW6010	ug/Nm3	3					
Sodium	SW6010	ug/Nm3	3					
Titanium	SW6010	ug/Nm3	3					
Vanadium	ICP/MS	ug/Nm3	3					
Zinc	SW6010	ug/Nm3	3					

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Table G-1. Analytical Results Used in Calculations

Stream: Scrubbed Raw Syngas (5b)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Vapor Phase								
Ammonia as N	EPA 350.1	ug/Nm3	3					
Chloride	EPA 300.0	ug/Nm3	3					
Cyanide	SW9012	ug/Nm3	3					
Fluoride	EPA 340.2	ug/Nm3	3					
Metals-Vapor Phase (Charcoal)								
Antimony	SW7041	ug/Nm3	3					
Arsenic	SW7060	ug/Nm3	3					
Barium	SW6010	ug/Nm3	3					
Beryllium	SW6010	ug/Nm3	3					
Boron	SW6010	ug/Nm3	3					
Cadmium	SW7131	ug/Nm3	3					
Chromium	SW6010	ug/Nm3	3					
Cobalt	SW6010	ug/Nm3	3					
Copper	SW6010	ug/Nm3	3					
Iron	SW6010	ug/Nm3	3					
Lead	SW7421	ug/Nm3	3					
Manganese	SW6010	ug/Nm3	3					
Mercury	SW7471	ug/Nm3	3					
Molybdenum	SW6010	ug/Nm3	3					
Nickel	SW6010	ug/Nm3	3					
Selenium	SW7740	ug/Nm3	3					
Vanadium	SW6010	ug/Nm3	3					
Zinc	SW6010	ug/Nm3	3					
Metals-Vapor Phase (M-29)								
Aluminum	SW6010	ug/Nm3	3					
Antimony	ICP/MS	ug/Nm3	3					
Arsenic	ICP/MS	ug/Nm3	3					
Barium	ICP/MS	ug/Nm3	3					
Beryllium	ICP/MS	ug/Nm3	3					
Boron	SW6010	ug/Nm3	3					
Cadmium	ICP/MS	ug/Nm3	3					
Calcium	SW6010	ug/Nm3	3					

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Table G-1. Analytical Results Used in Calculations

Stream: Scrubbed Raw Syngas (5b)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29) (continued)								
Chromium	ICP/MS	ug/Nm3	3					
Cobalt	ICP/MS	ug/Nm3	3					
Copper	ICP/MS	ug/Nm3	3					
Iron	SW6010	ug/Nm3	3					
Lead	ICP/MS	ug/Nm3	3					
Magnesium	SW6010	ug/Nm3	3					
Manganese	ICP/MS	ug/Nm3	3					
Mercury	SW7470	ug/Nm3	3					
Molybdenum	ICP/MS	ug/Nm3	3					
Nickel	ICP/MS	ug/Nm3	3					
Phosphorus	SW6010	ug/Nm3	3					
Potassium	SW6010	ug/Nm3	3					
Selenium	ICP/MS	ug/Nm3	3					
Silicon	SW6010	ug/Nm3	3					
Sodium	SW6010	ug/Nm3	3					
Titanium	SW6010	ug/Nm3	3					
Vanadium	ICP/MS	ug/Nm3	3					
Zinc	SW6010	ug/Nm3	3					

Table G-1. Analytical Results Used in Calculations

Stream: Sour Syngas (11)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Vapor Phase								
Ammonia as N	EPA 350.1	ug/Nm3	1	2,710	4,670	2,810	3,400	2,700
Chloride	EPA 300.0	ug/Nm3	1	< 1,800	< 2,100	< 2,000	< 2,100	---
Cyanide	SW9012	ug/Nm3	1	317	9,180	7,420	5,640	12,000
Fluoride	EPA 340.2	ug/Nm3	1	11.5	15.5	16.4	14.5	6.5
Metals-Vapor Phase (Direct AAS)								
Arsenic	Radian	ug/Nm3	1				870	---
Cadmium	Radian	ug/Nm3	1				< 2.2	---
Chromium	Radian	ug/Nm3	1				142	---
Lead	Radian	ug/Nm3	1				< 85	---
Mercury	Radian	ug/Nm3	1				6.1	2.1
Nickel	Radian	ug/Nm3	1				498	---
Selenium	Radian	ug/Nm3	1				564	---
Zinc	Radian	ug/Nm3	1				< 2.2	---
Metals-Vapor Phase (Charcoal)								
Antimony	SW7041	ug/Nm3	1	< 1.1	< 1.1	< 1.1	< 1.1	---
Arsenic	SW7060	ug/Nm3	1	149	280	369	266	270
Barium	SW6010	ug/Nm3	1	6.09	5.47	7.3	6.29	2.3
Beryllium	SW6010	ug/Nm3	1	< 0.35	< 0.35	< 0.36	< 0.36	---
Boron	SW6010	ug/Nm3	1	109	97.3	100	102	15
Cadmium	SW7131	ug/Nm3	1	< 0.84	< 0.83	< 0.85	< 0.85	---
Chromium	SW6010	ug/Nm3	1	97.6	86.6	94.4	92.9	14
Cobalt	SW6010	ug/Nm3	1	< 5.8	< 5.7	< 5.9	< 5.9	---
Copper	SW6010	ug/Nm3	1	45.4	42.3	50.3	46	10
Iron	SW6010	ug/Nm3	1	2,390	2,280	2,240	2,300	190
Lead	SW7421	ug/Nm3	1	< 0.84	< 0.82	< 0.85	< 0.85	---
Manganese	SW6010	ug/Nm3	1	11	8.07	11	10	4.2
Mercury	SW7471	ug/Nm3	1	5.59	12.4	15.5	11.2	13
Molybdenum	SW6010	ug/Nm3	1	51.4	35.8	47.3	44.8	20
Nickel	SW6010	ug/Nm3	1	23.6	< 12	21.8	17.1	24
Selenium	SW7740	ug/Nm3	1	1.51	1.33	5.5	2.78	5.9
Vanadium	SW6010	ug/Nm3	1	8.1	9.5	7.31	8.3	2.8
Zinc	SW6010	ug/Nm3	1	< 3.7	< 3.7	< 3.8	< 3.8	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Syngas (11)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Aluminum	SW6010	ug/Nm3	1	< 11	< 12	< 12	< 12	---
Antimony	ICP/MS	ug/Nm3	1	< 0.017 C	< 0.018 C	< 0.017 C	< 0.018	---
Arsenic	ICP/MS	ug/Nm3	1	0.597 C	0.358 C	0.556 C	0.504	0.32
Barium	ICP/MS	ug/Nm3	1	0.0686 C	0.046 C	0.0782 C	0.0643	0.041
Beryllium	ICP/MS	ug/Nm3	1	< 0.031 C	< 0.033 C	< 0.032 C	< 0.033	---
Boron	SW6010	ug/Nm3	1	< 3.8	< 4.1	< 4	< 4.1	---
Cadmium	ICP/MS	ug/Nm3	1	0.194 C	0.325 C	0.3 C	0.273	0.17
Calcium	SW6010	ug/Nm3	1	38.1	58.7	48.9	48.6	26
Chromium	ICP/MS	ug/Nm3	1	1.46 C	1.49 C	1.74 C	1.56	0.38
Cobalt	ICP/MS	ug/Nm3	1	0.0201 C	0.0288 C	0.013 C	0.0206	0.02
Copper	ICP/MS	ug/Nm3	1	< 0.044 C	< 0.046 C	< 0.045	< 0.046	---
Iron	SW6010	ug/Nm3	1	5.01	8.79	6.34	6.71	4.8
Lead	ICP/MS	ug/Nm3	1	0.129 C	1.73 C	0.399 C	0.753	2.1
Magnesium	SW6010	ug/Nm3	1	< 10	< 11	< 11	< 11	---
Manganese	ICP/MS	ug/Nm3	1	0.0372	< 0.018	< 0.018	0.0184	0.04
Mercury	SW7470	ug/Nm3	1	0.525	1.23	0.668	0.808	0.93
Molybdenum	ICP/MS	ug/Nm3	1	0.151 C	0.171 C	0.147 C	0.156	0.032
Nickel	ICP/MS	ug/Nm3	1	1.33 C	3.99 C	1.44 C	2.25	3.7
Phosphorus	SW6010	ug/Nm3	1	< 24	< 25	< 25	< 25	---
Potassium	SW6010	ug/Nm3	1	< 180	< 190	< 190	< 190	---
Selenium	ICP/MS	ug/Nm3	1	< 0.13	0.417	< 0.13	0.182	0.5
Silicon	SW6010	ug/Nm3	1	30.8	29.9	17.5	26.1	18
Sodium	SW6010	ug/Nm3	1	25.8	30.9	23.3	26.7	9.6
Titanium	SW6010	ug/Nm3	1	< 0.35	< 0.37	< 0.36	< 0.37	---
Vanadium	ICP/MS	ug/Nm3	1	0.063 C	0.0543 C	0.0612 C	0.0595	0.011
Zinc	SW6010	ug/Nm3	1	7.74	9.9	8.49	8.71	2.7
Aldehydes								
Acetaldehyde	SW0011	ug/Nm3	1	8.77	9.36	9.53	9.22	0.99
Acrolein	SW0011	ug/Nm3	1	< 0.65	< 0.59	< 0.6	< 0.65	---
Benzaldehyde	SW0011	ug/Nm3	1	1.16	0.711	< 0.6	0.724	1.1
Formaldehyde	SW0011	ug/Nm3	1	1.94	0.865	2.02	1.61	1.6

Table G-1. Analytical Results Used in Calculations

Stream: Sour Syngas (11)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase												
1,2,4-Trichlorobenzene	SW8270	ug/Nm3	1	<	1.8	<	18	<	1.7	<	1.8	---
1,2-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.13	<	25	<	2.4	<	2.4	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.12	<	24	<	2.2	<	2.2	---
1,4-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.2	<	40	<	3.8	<	3.8	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	1	<	0.17	<	34	<	3.2	<	3.2	---
2,4,6-Trichlorophenol	SW8270	ug/Nm3	1	<	0.16	<	31	<	3	<	3	---
2,4-Dichlorophenol	SW8270	ug/Nm3	1	<	2.6	<	26	<	2.5	<	2.6	---
2,4-Dimethylphenol	SW8270	ug/Nm3	1	<	10	<	100	<	9.9	<	10	---
2,4-Dinitrophenol	SW8270	ug/Nm3	1	<	1.1	<	220	<	21	<	21	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	1	<	0.19	<	38	<	3.6	<	3.6	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	1	<	0.16	<	32	<	3	<	3	---
2-Chloronaphthalene	SW8270	ug/Nm3	1	<	0.26	<	52	<	4.9	<	4.9	---
2-Chlorophenol	SW8270	ug/Nm3	1		0.359	<	37	<	3.5	<	3.5	---
2-Methylnaphthalene	SW8270	ug/Nm3	1		64.7		49.1		63.1		60	21
2-Methylphenol	SW8270	ug/Nm3	1	<	0.48	<	85	<	9	<	9	---
2-Nitroaniline	SW8270	ug/Nm3	1	<	0.17	<	35	<	3.3	<	3.3	---
2-Nitrophenol	SW8270	ug/Nm3	1	<	4.1	<	41	<	3.9	<	4.1	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	1	<	0.44	<	87	<	8.2	<	8.2	---
3-Nitroaniline	SW8270	ug/Nm3	1	<	0.21	<	42	<	4	<	4	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	1	<	0.31	<	63	<	5.9	<	5.9	---
4-Aminobiphenyl	SW8270	ug/Nm3	1	<	0.75	<	150	<	14	<	14	---
4-Bromophenylphenyl ether	SW8270	ug/Nm3	1	<	0.23	<	45	<	4.3	<	4.3	---
4-Chloro-3-methylphenol	SW8270	ug/Nm3	1	<	2.8	<	28	<	2.6	<	2.8	---
4-Chlorophenylphenyl ether	SW8270	ug/Nm3	1	<	6.3	<	62	<	5.9	<	6.3	---
4-Methylphenol/3-Methylphenol	SW8270	ug/Nm3	1	<	0.43	<	86	<	8.2	<	8.2	---
4-Nitroaniline	SW8270	ug/Nm3	1	<	0.21	<	42	<	4	<	4	---
4-Nitrophenol	SW8270	ug/Nm3	1	<	0.19	<	38	<	3.6	<	3.6	---
Acenaphthene	SW8270	ug/Nm3	1		120		116		105		114	19
Acenaphthylene	SW8270	ug/Nm3	1		255		264		270		263	19
Acetophenone	SW8270	ug/Nm3	1	<	0.14	<	26	<	2.7	<	2.7	---
Aniline	SW8270	ug/Nm3	1	<	0.34	<	67	<	6.3	<	6.3	---
Anthracene	SW8270	ug/Nm3	1		8.48	<	42		8.47		8.48	0.06

Table G-1. Analytical Results Used in Calculations

Stream: Sour Syngas (11)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
Benz(a)anthracene	SW8270	ug/Nm3	1	<	0.17	<	33	<	3.1	<	3.1	---
Benz(a)pyrene	SW8270	ug/Nm3	1	<	0.26	<	52	<	4.9	<	4.9	---
Benzidine	SW8270	ug/Nm3	1	<	8.3	<	1,600	<	160	<	160	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	<	0.41	<	81	<	7.7	<	7.7	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	<	0.18	<	36	<	3.4	<	3.4	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	<	0.27	<	54	<	5.2	<	5.2	---
Benzoic acid	SW8270	ug/Nm3	1	<	50	<	500	<	47	<	50	---
Benzyl alcohol	SW8270	ug/Nm3	1	<	0.19	<	38	<	3.6	<	3.6	---
Butylbenzylphthalate	SW8270	ug/Nm3	1	<	0.22	<	44	<	4.1	<	4.1	---
Chrysene	SW8270	ug/Nm3	1	<	0.11	<	23	<	2.1	<	2.1	---
Di-n-butylphthalate	SW8270	ug/Nm3	1	<	0.18	<	36	<	3.4	<	3.4	---
Di-n-octylphthalate	SW8270	ug/Nm3	1	<	0.18	<	36	<	3.5	<	3.5	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	<	0.2	<	40	<	3.8	<	3.8	---
Dibenzofuran	SW8270	ug/Nm3	1		21.8	<	30		22.9		22.4	7
Diethylphthalate	SW8270	ug/Nm3	1	<	0.13	<	26	<	2.5	<	26	---
Dimethylphthalate	SW8270	ug/Nm3	1	<	0.13	<	27	<	2.5	<	27	---
Diphenylamine/N-NitrosoDPA	SW8270	ug/Nm3	1	<	0.31	<	61	<	5.8	<	61	---
Fluoranthene	SW8270	ug/Nm3	1		8	<	14		8		8	---
Fluorene	SW8270	ug/Nm3	1	<	0.12	<	23		72.9		28.2	97
Hexachlorobenzene	SW8270	ug/Nm3	1	<	0.2	<	39	<	3.7	<	3.7	---
Hexachlorobutadiene	SW8270	ug/Nm3	1	<	2	<	20	<	1.9	<	2	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	1	<	0.68	<	140	<	13	<	13	---
Hexachloroethane	SW8270	ug/Nm3	1	<	0.1	<	20	<	1.9	<	1.9	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	<	0.22	<	43	<	4.1	<	4.1	---
Isophorone	SW8270	ug/Nm3	1	<	3.1	<	30	<	2.9	<	3.1	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	1	<	0.24	<	47	<	4.5	<	4.5	---
N-Nitrosodimethylamine	SW8270	ug/Nm3	1	<	0.17	<	34	<	3.3	<	3.3	---
Naphthalene	SW8270	ug/Nm3	1		6,300		7,170		7,290		6,920	1,300
Nitrobenzene	SW8270	ug/Nm3	1	<	2.7	<	27	<	2.5	<	2.7	---
Pentachloronitrobenzene	SW8270	ug/Nm3	1	<	0.46	<	92	<	8.7	<	8.7	---
Pentachlorophenol	SW8270	ug/Nm3	1		43.9	<	15	<	1.4		17.4	58
Phenanthrene	SW8270	ug/Nm3	1		65.5	<	31		82.7		54.6	87

Table G-1. Analytical Results Used in Calculations

Stream: Sour Syngas (11)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)								
Phenol	SW8270	ug/Nm3	1	10.4	< 44	4.82	7.61	35
Pyrene	SW8270	ug/Nm3	1	9.29	< 20	10.8	10	9.6
bis(2-Chloroethoxy)methane	SW8270	ug/Nm3	1	< 2.3	< 23	< 2.2	< 2.3	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	1	< 0.16	< 33	< 3.1	< 3.1	---
bis(2-Chloroisopropyl)ether	SW8270	ug/Nm3	1	< 0.18	< 36	< 3.4	< 3.4	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	1	2.59	< 150	< 14	< 14	---
p-Chloroaniline	SW8270	ug/Nm3	1	< 4.9	< 49	< 4.7	< 4.9	---
p-Dimethylaminoazobenzene	SW8270	ug/Nm3	1	< 0.93	< 190	< 18	< 18	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Syngas (12)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Vapor Phase								
Ammonia as N	EPA 350.1	ug/Nm3	1	363	181	374	306	270
Chloride	EPA 300.0	ug/Nm3	1	< 1,700	< 2,400	< 2,200	< 2,400	---
Cyanide	SW9012	ug/Nm3	1	50.3	121	153	108	130
Fluoride	EPA 340.2	ug/Nm3	1	21	22.4	19.5	21	3.6
Metals-Vapor Phase (Direct AAS)								
Arsenic	Radian	ug/Nm3	1				< 217	---
Cadmium	Radian	ug/Nm3	1				9.5	---
Chromium	Radian	ug/Nm3	1				< 39	---
Lead	Radian	ug/Nm3	1				< 85	---
Mercury	Radian	ug/Nm3	1				3.8	3.6
Nickel	Radian	ug/Nm3	1				19	---
Selenium	Radian	ug/Nm3	1				201	---
Zinc	Radian	ug/Nm3	1				< 2.2	---
Metals-Vapor Phase (Charcoal)								
Antimony	SW7041	ug/Nm3	1	< 0.04	< 0.039	< 0.038	< 0.04	---
Arsenic	SW7060	ug/Nm3	1	6.64	6.23	4.99	5.95	2.1
Barium	SW6010	ug/Nm3	1	0.165	0.266	0.255	0.229	0.14
Beryllium	SW6010	ug/Nm3	1	< 0.013	< 0.013	< 0.013	< 0.013	---
Boron	SW6010	ug/Nm3	1	3.32	3.27	3.14	3.24	0.23
Cadmium	SW7131	ug/Nm3	1	< 0.032	< 0.031	< 0.03	< 0.032	---
Chromium	SW6010	ug/Nm3	1	3.2	4.37	3.14	3.57	1.7
Cobalt	SW6010	ug/Nm3	1	< 0.22	< 0.21	0.248	< 0.22	---
Copper	SW6010	ug/Nm3	1	1.79	1.8	1.67	1.75	0.18
Iron	SW6010	ug/Nm3	1	80.9	90.5	83.3	84.9	12
Lead	SW7421	ug/Nm3	1	< 0.031	< 0.031	< 0.03	< 0.031	---
Manganese	SW6010	ug/Nm3	1	0.303	0.663	0.241	0.402	0.57
Mercury	SW7471	ug/Nm3	1	0.0877	0.104	0.105	0.0989	0.024
Molybdenum	SW6010	ug/Nm3	1	1.56	1.85	1.25	1.55	0.75
Nickel	SW6010	ug/Nm3	1	< 0.46	1.17	1.41	0.937	1.5
Selenium	SW7740	ug/Nm3	1	0.146	0.143	0.252	0.18	0.15
Vanadium	SW6010	ug/Nm3	1	0.185	0.421	0.234	0.28	0.31
Zinc	SW6010	ug/Nm3	1	0.22	0.456	0.43	0.369	0.32

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Syngas (12)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Aluminum	SW6010	ug/Nm3	1	< 12	< 11	< 10	< 12	---
Antimony	ICP/MS	ug/Nm3	1	< 0.017 C	0.0181 C	< 0.015 C	< 0.017	---
Arsenic	ICP/MS	ug/Nm3	1	0.428 C	0.456 C	0.379 C	0.421	0.097
Barium	ICP/MS	ug/Nm3	1	0.301 C	0.141 C	0.0684 C	0.17	0.3
Beryllium	ICP/MS	ug/Nm3	1	< 0.031 C	< 0.03 C	< 0.028 C	< 0.031	---
Boron	SW6010	ug/Nm3	1	17.6	< 3.7	< 3.4	7.05	23
Cadmium	ICP/MS	ug/Nm3	1	0.499 C	0.429 C	0.391 C	0.44	0.14
Calcium	SW6010	ug/Nm3	1	61.8	26.9	31	39.9	47
Chromium	ICP/MS	ug/Nm3	1	1.38 C	1.39 C	1.35 C	1.37	0.052
Cobalt	ICP/MS	ug/Nm3	1	0.0581 C	0.0318 C	0.0254 C	0.0384	0.043
Copper	ICP/MS	ug/Nm3	1	< 0.044	11 C	< 0.039	3.68	16
Iron	SW6010	ug/Nm3	1	8.82	5.49	8.98	7.76	4.9
Lead	ICP/MS	ug/Nm3	1	0.532 C	0.303 C	0.151 C	0.329	0.48
Magnesium	SW6010	ug/Nm3	1	22.9	< 10	< 9	< 10	---
Manganese	ICP/MS	ug/Nm3	1	< 0.018	< 0.017	< 0.016	< 0.018	---
Mercury	SW7470	ug/Nm3	1	0.187	0.168	0.333	0.229	0.22
Molybdenum	ICP/MS	ug/Nm3	1	0.122 C	0.148 C	0.112 C	0.127	0.046
Nickel	ICP/MS	ug/Nm3	1	1.21 C	1.26 C	1.03 C	1.17	0.3
Phosphorus	SW6010	ug/Nm3	1	< 24	< 23	< 21	< 24	---
Potassium	SW6010	ug/Nm3	1	< 180	< 170	< 160	< 180	---
Selenium	ICP/MS	ug/Nm3	1	< 0.13	< 0.12	0.649	0.258	0.84
Silicon	SW6010	ug/Nm3	1	40.2	28.8	28.4	32.5	17
Sodium	SW6010	ug/Nm3	1	67.7	30.3	22	40	60
Titanium	SW6010	ug/Nm3	1	0.611	< 0.33	< 0.31	< 0.33	---
Vanadium	ICP/MS	ug/Nm3	1	0.0576 C	0.0451 C	0.0462 C	0.0496	0.017
Zinc	SW6010	ug/Nm3	1	5.17	4.46	6.16	5.26	2.1
Aldehydes								
Acetaldehyde	SW0011	ug/Nm3	1	154	124	151	143	41
Acrolein	SW0011	ug/Nm3	1	< 1.3	< 1.1	< 1.3	< 1.3	---
Benzaldehyde	SW0011	ug/Nm3	1	< 1.3	< 1.1	< 1.3	< 1.3	---
Formaldehyde	SW0011	ug/Nm3	1	2.83	2.83	1.25	2.3	2.3

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Syngas (12)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
PAHs/SVOCs-Vapor Phase								
1,2,4-Trichlorobenzene	SW8270	ug/Nm3	1	< 1.4	< 1.4	< 1.5	< 1.5	---
1,2-Dichlorobenzene	SW8270	ug/Nm3	1	< 2	< 2	< 2.1	< 2.1	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	1	< 1.9	< 1.8	< 2	< 2	---
1,4-Dichlorobenzene	SW8270	ug/Nm3	1	< 3.2	< 3.1	< 3.4	< 3.4	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	1	< 2.7	< 2.6	< 2.8	< 2.8	---
2,4,6-Trichlorophenol	SW8270	ug/Nm3	1	< 2.5	< 2.4	< 2.6	< 2.6	---
2,4-Dimethylphenol	SW8270	ug/Nm3	1	< 8.3	< 8.1	< 8.7	< 8.7	---
2,4-Dinitrophenol	SW8270	ug/Nm3	1	< 18	< 17	< 18	< 18	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	1	< 3	< 2.9	< 3.2	< 3.2	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	1	< 2.6	< 2.5	< 2.7	< 2.7	---
2-Chloronaphthalene	SW8270	ug/Nm3	1	< 4.1	< 4	< 4.3	< 4.3	---
2-Chlorophenol	SW8270	ug/Nm3	1	< 3	< 2.9	< 3.1	< 3.1	---
2-Fluorophenol	SW8270	ug/Nm3	1	52.8	45.3	49.8	49.3	9.4
2-Methylnaphthalene	SW8270	ug/Nm3	1	9.89	9.32	7.6	8.94	3
2-Methylphenol	SW8270	ug/Nm3	1	< 7.6	< 7.4	< 7.9	< 7.9	---
2-Nitroaniline	SW8270	ug/Nm3	1	< 2.8	< 2.7	< 2.9	< 2.9	---
2-Nitrophenol	SW8270	ug/Nm3	1	< 3.3	< 3.2	< 3.5	< 3.5	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	1	< 6.9	< 6.7	< 7.3	< 7.3	---
3-Nitroaniline	SW8270	ug/Nm3	1	< 3.3	< 3.2	< 3.5	< 3.5	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	1	< 5	< 4.9	< 5.3	< 5.3	---
4-Aminobiphenyl	SW8270	ug/Nm3	1	< 12	< 12	< 13	< 13	---
4-Bromophenylphenyl ether	SW8270	ug/Nm3	1	< 3.6	< 3.5	< 3.8	< 3.8	---
4-Chloro-3-methylphenol	SW8270	ug/Nm3	1	< 2.2	< 2.2	< 2.3	< 2.3	---
4-Chlorophenylphenyl ether	SW8270	ug/Nm3	1	< 5	< 4.9	< 5.2	< 5.2	---
4-Methylphenol/3-Methylphenol	SW8270	ug/Nm3	1	< 6.9	< 6.7	< 7.2	< 7.2	---
4-Nitroaniline	SW8270	ug/Nm3	1	< 3.4	< 3.3	< 3.5	< 3.5	---
4-Nitrophenol	SW8270	ug/Nm3	1	< 3	< 2.9	< 3.1	< 3.1	---
Acenaphthene	SW8270	ug/Nm3	1	< 2.7	< 2.6	< 2.8	< 2.8	---
Acenaphthylene	SW8270	ug/Nm3	1	9.23	8.8	7.26	8.43	2.6
Acetophenone	SW8270	ug/Nm3	1	< 2.2	< 2.2	< 2.3	< 2.3	---
Aniline	SW8270	ug/Nm3	1	< 5.3	< 5.2	< 5.6	< 5.6	---
Anthracene	SW8270	ug/Nm3	1	< 3.4	< 3.3	< 3.5	< 3.5	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Syngas (12)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)								
Benz(a)anthracene	SW8270	ug/Nm3	1	< 2.6	< 2.6	< 2.8	< 2.8	---
Benz(a)pyrene	SW8270	ug/Nm3	1	< 4.1	< 4	< 4.3	< 4.3	---
Benzidine	SW8270	ug/Nm3	1	< 130	< 130	< 140	< 140	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	< 6.5	< 6.3	< 6.8	< 6.8	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	< 2.9	< 2.8	< 3	< 3	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	< 4.4	< 4.2	< 4.6	< 4.6	---
Benzoic acid	SW8270	ug/Nm3	1	< 40	< 39	< 42	< 42	---
Benzyl alcohol	SW8270	ug/Nm3	1	< 3	< 3	< 3.2	< 3.2	---
Butylbenzylphthalate	SW8270	ug/Nm3	1	< 3.5	< 3.4	< 3.7	< 3.7	---
Chrysene	SW8270	ug/Nm3	1	< 1.8	< 1.8	< 1.9	< 1.9	---
Di-n-butylphthalate	SW8270	ug/Nm3	1	< 2.9	< 2.8	< 3	< 3	---
Di-n-octylphthalate	SW8270	ug/Nm3	1	< 2.9	< 2.8	< 3.1	< 3.1	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	< 3.2	< 3.1	< 3.4	< 3.4	---
Dibenzofuran	SW8270	ug/Nm3	1	< 2.4	< 2.3	< 2.5	< 2.5	---
Diethylphthalate	SW8270	ug/Nm3	1	< 2.1	< 2	< 2.2	< 2.2	---
Dimethylphthalate	SW8270	ug/Nm3	1	< 2.1	< 2.1	< 2.2	< 2.2	---
Diphenylamine/N-NitrosoDPA	SW8270	ug/Nm3	1	< 4.9	< 4.8	< 5.1	< 5.1	---
Fluoranthene	SW8270	ug/Nm3	1	< 1.1	< 1.1	< 1.2	< 1.2	---
Fluorene	SW8270	ug/Nm3	1	< 1.9	< 1.8	< 2	< 2	---
Hexachlorobenzene	SW8270	ug/Nm3	1	< 3.1	< 3	< 3.3	< 3.3	---
Hexachlorobutadiene	SW8270	ug/Nm3	1	< 1.6	< 1.6	< 1.7	< 1.7	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	1	< 11	< 11	< 11	< 11	---
Hexachloroethane	SW8270	ug/Nm3	1	< 1.6	< 1.6	< 1.7	< 1.7	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	< 3.4	< 3.3	< 3.6	< 3.6	---
Isophorone	SW8270	ug/Nm3	1	< 2.4	< 2.4	< 2.6	< 2.6	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	1	< 3.8	< 3.7	< 3.9	< 3.9	---
N-Nitrosodimethylamine	SW8270	ug/Nm3	1	< 2.7	< 2.7	< 2.9	< 2.9	---
Naphthalene	SW8270	ug/Nm3	1	992	922	950	955	88
Nitrobenzene	SW8270	ug/Nm3	1	< 2.1	< 2.1	< 2.2	< 2.2	---
Pentachloronitrobenzene	SW8270	ug/Nm3	1	< 7.3	< 7.1	< 7.7	< 7.7	---
Pentachlorophenol	SW8270	ug/Nm3	1	< 1.2	< 1.2	< 1.3	< 1.3	---
Phenanthrene	SW8270	ug/Nm3	1	< 2.5	< 2.4	4.56	< 2.5	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Syngas (12)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
Phenol	SW8270	ug/Nm3	1	<	3.5	<	3.4	<	3.7	<	3.7	---
Pyrene	SW8270	ug/Nm3	1	<	1.6	<	1.6	<	1.7	<	1.7	---
bis(2-Chloroethoxy)methane	SW8270	ug/Nm3	1	<	1.8	<	1.8	<	1.9	<	1.9	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	1	<	2.6	<	2.6	<	2.7	<	2.7	---
bis(2-Chloroisopropyl)ether	SW8270	ug/Nm3	1	<	2.9	<	2.8	<	3	<	3	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	1	<	12	<	11	<	12	<	12	---
p-Chloroaniline	SW8270	ug/Nm3	1	<	3.9	<	3.8	<	4.1	<	4.1	---
p-Dimethylaminoazobenzene	SW8270	ug/Nm3	1	<	15	<	14	<	16	<	16	---

Table G-1. Analytical Results Used in Calculations

Stream: Acid Gas (14)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Ionic Species												
Ammonia as N	EPA 350.1	ug/Nm3	1		18,100		23,600		14,200		18,600	12,000
Chloride	EPA 300.0	ug/Nm3	1	<	5,100	<	5,600	<	5,100	<	5,600	---
Cyanide	SW9012	ug/Nm3	1		1,330		1,350		1,440		1,370	150
Fluoride	EPA 340.2	ug/Nm3	1		39.9		50.1		36.3		42.1	18
Metals-Vapor Phase (Charcoal)												
Antimony	SW7041	ug/Nm3	1	<	1.6		2.42		2.12		1.78	2.1
Arsenic	SW7060	ug/Nm3	1		3.37		8.25		2.98		4.87	7.3
Barium	SW6010	ug/Nm3	1		11.1		14.7		10.8		12.2	5.4
Beryllium	SW6010	ug/Nm3	1	<	0.54	<	0.67	<	0.69	<	0.69	---
Boron	SW6010	ug/Nm3	1		151		187		192		177	56
Cadmium	SW7131	ug/Nm3	1		1.49		2.1	<	1.6	<	1.6	---
Chromium	SW6010	ug/Nm3	1		170		218		229		206	78
Cobalt	SW6010	ug/Nm3	1	<	9	<	11	<	11	<	11	---
Copper	SW6010	ug/Nm3	1		48.7		63.3		61.9		58	20
Iron	SW6010	ug/Nm3	1		3,280		4,500		4,160		3,980	1,600
Lead	SW7421	ug/Nm3	1	<	1.3		4.76		23.5		9.64	30
Manganese	SW6010	ug/Nm3	1	<	8.1		23.4	<	10.3		10.9	27
Mercury	SW7471	ug/Nm3	1		3.52		4.26		4.3		4.03	1.1
Molybdenum	SW6010	ug/Nm3	1		70.2		68.6		78.5		72.4	13
Nickel	SW6010	ug/Nm3	1		28.2	<	23		34		24.6	29
Selenium	SW7740	ug/Nm3	1	<	1.3	<	1.6	<	1.7	<	1.7	---
Vanadium	SW6010	ug/Nm3	1		10.8		6.21		12.6		9.87	8.2
Zinc	SW6010	ug/Nm3	1	<	5.7	<	7.1	<	7.3	<	7.3	---
Metals-Vapor Phase (M-29)												
Aluminum	SW6010	ug/Nm3	1		16.8	<	12	<	11	<	12	---
Antimony	ICP/MS	ug/Nm3	1		0.0607 C		0.0446 C		0.0791 C		0.0615	0.043
Arsenic	ICP/MS	ug/Nm3	1		4.6 C		2.96 C		0.64 C		2.73	4.9
Barium	ICP/MS	ug/Nm3	1		0.595 C		0.254 C		0.561 C		0.47	0.47
Beryllium	ICP/MS	ug/Nm3	1	<	0.036 C	<	0.034 C	<	0.031 C	<	0.036	---
Boron	SW6010	ug/Nm3	1		9.05		6.36	<	3.8		5.77	9
Cadmium	ICP/MS	ug/Nm3	1		0.477 C		0.47 C		0.289 C		0.412	0.26
Calcium	SW6010	ug/Nm3	1		144		70.3		70.5		94.9	110

Table G-1. Analytical Results Used in Calculations

Stream: Acid Gas (14)

Analyte	Method	Units	Test Period		Result 1			Result 2			Result 3			Average	95% CI
Metals-Vapor Phase (M-29) (continued)															
Chromium	ICP/MS	ug/Nm3	1		85.5	C		95.4	C		13.5	C		64.8	110
Cobalt	ICP/MS	ug/Nm3	1		1.96	C		1.06	C		0.499	C		1.17	1.8
Copper	ICP/MS	ug/Nm3	1		22	C		16.3	C		5.09	C		14.5	21
Iron	SW6010	ug/Nm3	1		232			113			85.6			144	190
Lead	ICP/MS	ug/Nm3	1		0.948	C		0.378	C		0.654	C		0.66	0.71
Magnesium	SW6010	ug/Nm3	1		34.6			14.8			12.5			20.6	30
Manganese	ICP/MS	ug/Nm3	1		39.4			12.5			4.99			19	45
Mercury	SW7470	ug/Nm3	1		0.801			0.653			1.52			0.991	1.2
Molybdenum	ICP/MS	ug/Nm3	1		7.85	C		3.48	C		2.31	C		4.55	7.3
Nickel	ICP/MS	ug/Nm3	1		378	C		209	C		110	C		232	340
Phosphorus	SW6010	ug/Nm3	1		72.7			144			48.5			88.4	120
Potassium	SW6010	ug/Nm3	1	<	210		<	200		<	180		<	210	---
Selenium	ICP/MS	ug/Nm3	1		2.83			7.9			0.231			3.65	9.7
Silicon	SW6010	ug/Nm3	1		90.5			68.9			62.8			74.1	36
Sodium	SW6010	ug/Nm3	1		129			61.5			43.8			78.1	110
Titanium	SW6010	ug/Nm3	1		0.948			1.1			0.403			0.817	0.91
Vanadium	ICP/MS	ug/Nm3	1		0.636	C		2.05	C		0.125	C		0.937	2.5
Zinc	SW6010	ug/Nm3	1		6.18			6.62			30			14.3	34
PAHs/SVOCs-Vapor Phase															
1,2-Dichlorobenzene	SW8270	ug/Nm3	1	<	2.2		<	4.5		<	4.3		<	4.5	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	1	<	2		<	4.2		<	4		<	4.2	---
1,4-Dichlorobenzene	SW8270	ug/Nm3	1	<	3.4		<	7.2		<	6.9		<	7.2	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	1	<	2.9		<	6		<	5.8		<	6	---
2,4,6-Tribromophenol	SW8270	ug/Nm3	1		26.1			22.5			21.3			23.3	6.2
2,4,6-Trichlorophenol	SW8270	ug/Nm3	1	<	2.7		<	5.6		<	5.4		<	5.6	---
2,4-Dinitrophenol	SW8270	ug/Nm3	1	<	19		<	39		<	38		<	39	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	1	<	3.2		<	6.7		<	6.5		<	6.7	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	1	<	2.7		<	5.7		<	5.5		<	5.7	---
2-Chloronaphthalene	SW8270	ug/Nm3	1	<	4.4		<	9.2		<	8.9		<	9.2	---
2-Chlorophenol	SW8270	ug/Nm3	1	<	3.2		<	6.7		<	6.4		<	6.7	---
2-Fluorobiphenyl	SW8270	ug/Nm3	1		17.4			17.2			15.7			16.8	2.3
2-Fluorophenol	SW8270	ug/Nm3	1		27.3			26			23.8			25.7	4.4

Table G-1. Analytical Results Used in Calculations

Stream: Acid Gas (14)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
2-Methylnaphthalene	SW8270	ug/Nm3	1	<	640	<	560	<	540	<	640	---
2-Methylphenol	SW8270	ug/Nm3	1	<	8	<	17	<	16	<	17	---
2-Nitroaniline	SW8270	ug/Nm3	1	<	3	<	6.2	<	6	<	6.2	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	1	<	7	<	15	<	15	<	15	---
3-Nitroaniline	SW8270	ug/Nm3	1	<	3.6	<	7.5	<	7.2	<	7.5	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	1	<	5.4	<	11.2	<	10.8	<	11.2	---
4-Aminobiphenyl	SW8270	ug/Nm3	1	<	13	<	27	<	26	<	27	---
4-Bromophenylphenyl ether	SW8270	ug/Nm3	1	<	3.9	<	8	<	7.7	<	8	---
4-Chlorophenylphenyl ether	SW8270	ug/Nm3	1	<	5.4	<	11.1	<	10.7	<	11.1	---
4-Methylphenol/3-Methylphenol	SW8270	ug/Nm3	1	<	7	<	15	<	15	<	15	---
4-Nitroaniline	SW8270	ug/Nm3	1	<	3.6	<	7.5	<	7.2	<	7.5	---
4-Nitrophenol	SW8270	ug/Nm3	1	<	3.2	<	6.7	<	6.5	<	6.7	---
Acenaphthene	SW8270	ug/Nm3	1		1,850		1,650		1,500		1,670	440
Acenaphthylene	SW8270	ug/Nm3	1		3,080		3,360		2,720		3,050	800
Acetophenone	SW8270	ug/Nm3	1	<	2.4	<	5	<	4.8	<	5	---
Aniline	SW8270	ug/Nm3	1	<	5.7	<	11.9	<	11.5	<	11.9	---
Anthracene	SW8270	ug/Nm3	1		22.5		33.5		36.2		30.7	18
Benz(a)anthracene	SW8270	ug/Nm3	1	<	2.8	<	5.9	<	5.7	<	5.9	---
Benz(a)pyrene	SW8270	ug/Nm3	1	<	4.4	<	9.2	<	8.9	<	9.2	---
Benzidine	SW8270	ug/Nm3	1	<	140	<	290	<	280	<	290	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	<	7	<	14	<	14	<	14	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	<	3.1	<	6.4	<	6.2	<	6.4	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	<	4.7	<	9.7	<	9.4	<	9.7	---
Benzyl alcohol	SW8270	ug/Nm3	1	<	3.3	<	6.8	<	6.5	<	6.8	---
Butylbenzylphthalate	SW8270	ug/Nm3	1	<	3.8	<	7.8	<	7.5	<	7.8	---
Chrysene	SW8270	ug/Nm3	1	<	1.9	<	4.1	<	3.9	<	4.1	---
Di-n-butylphthalate	SW8270	ug/Nm3	1	<	3.1	<	6.5	<	6.2	<	6.5	---
Di-n-octylphthalate	SW8270	ug/Nm3	1	<	3.1	<	6.5	<	6.3	<	6.5	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	<	3.4	<	7.2	<	6.9	<	7.2	---
Dibenzofuran	SW8270	ug/Nm3	1		296		268		230		265	82
Diethylphthalate	SW8270	ug/Nm3	1	<	2.2	<	4.6	<	4.5	<	4.6	---
Dimethylphthalate	SW8270	ug/Nm3	1	<	2.3	<	4.8	<	4.6	<	4.8	---

Table G-1. Analytical Results Used in Calculations

Stream: Acid Gas (14)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
Diphenylamine/N-NitrosoDPA	SW8270	ug/Nm3	1	<	5.3	<	11	<	11	<	11	---
Fluoranthene	SW8270	ug/Nm3	1	<	1.2	<	2.5	<	2.4	<	2.5	---
Fluorene	SW8270	ug/Nm3	1		653		651		660		655	12
Hexachlorobenzene	SW8270	ug/Nm3	1	<	3.4	<	7	<	6.7	<	7	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	1	<	12	<	24	<	23	<	24	---
Hexachloroethane	SW8270	ug/Nm3	1	<	1.7	<	3.6	<	3.5	<	3.6	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	<	3.7	<	7.7	<	7.4	<	7.7	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	1	<	4	<	8.4	<	8.1	<	8.4	---
N-Nitrosodimethylamine	SW8270	ug/Nm3	1	<	3	<	6.2	<	5.9	<	6.2	---
Naphthalene	SW8270	ug/Nm3	1		114,000		118,000		96,600		110,000	28,000
Pentachloronitrobenzene	SW8270	ug/Nm3	1	<	8	<	16	<	16	<	16	---
Pentachlorophenol	SW8270	ug/Nm3	1	<	1.3	<	2.7	<	2.6	<	2.7	---
Phenanthrene	SW8270	ug/Nm3	1		104		282		324		237	290
Phenol	SW8270	ug/Nm3	1		6.39	<	7.9	<	7.6	<	7.9	---
Pyrene	SW8270	ug/Nm3	1	<	1.7	<	3.6	<	3.5	<	3.6	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	1	<	2.8	<	5.9	<	5.6	<	5.9	---
bis(2-Chloroisopropyl)ether	SW8270	ug/Nm3	1	<	3.1	<	6.4	<	6.2	<	6.4	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	1	<	13	<	26	<	25	<	26	---
p-Dimethylaminoazobenzene	SW8270	ug/Nm3	1	<	16	<	33	<	32	<	33	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Gas (22)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Vapor Phase								
Ammonia as N	EPA 350.1	vol.%	2	37.7	29.3	34.2	33.7	11
Cyanide	SW9012	ug/Nm3	2	184,000	233,000	143,000	187,000	110,000

Table G-1. Analytical Results Used in Calculations

Stream: Tall Gas (15)

Analyte	Method	Units	Test Period		Result 1			Result 2			Result 3			Average	95% CI
Ionic Species-Vapor Phase															
Ammonia as N	EPA 350.1	ug/Nm3	1		98,400			44,300			67,200			70,000	67,000
Ammonia as N	EPA 350.1	ug/Nm3	2		123,000			43,800			144,000			104,000	130,000
Cyanide	SW9012	ug/Nm3	1		924			895			266			695	920
Cyanide	SW9012	ug/Nm3	2		79,400			95,000			93,900			89,400	22,000
Metals-Vapor Phase (M-29)															
Aluminum	SW6010	ug/Nm3	1	<	14		<	118		<	14		<	118	---
Antimony	ICP/MS	ug/Nm3	1	<	0.021	C		0.177	C		0.0269	C		0.0715	0.23
Arsenic	ICP/MS	ug/Nm3	1		0.143	C		0.952	C		0.106	C		0.4	1.2
Barium	ICP/MS	ug/Nm3	1		0.281	C		1.57	C		0.231	C		0.694	1.9
Beryllium	ICP/MS	ug/Nm3	1	<	0.04	C	<	0.32	C	<	0.04	C	<	0.32	---
Boron	SW6010	ug/Nm3	1	<	5		<	40			4.81		<	40	---
Cadmium	ICP/MS	ug/Nm3	1		0.316	C		4.33	C		0.57	C		1.74	5.6
Calcium	SW6010	ug/Nm3	1		79.2			489			92.5			220	580
Chromium	ICP/MS	ug/Nm3	1		2.02	C		76.9	C		2.99	C		27.3	110
Cobalt	ICP/MS	ug/Nm3	1		0.0772	C		18.1	C		1.27	C		6.48	25
Copper	ICP/MS	ug/Nm3	1	<	0.05			7.23	C		4.22	C		3.83	9
Iron	SW6010	ug/Nm3	1		11			76.3			15.3			34.2	91
Lead	ICP/MS	ug/Nm3	1		0.869	C		19.3	C		3.13	C		7.77	25
Magnesium	SW6010	ug/Nm3	1		30.5		<	109		<	13		<	109	---
Manganese	ICP/MS	ug/Nm3	1		1.61		<	0.182			0.592			0.764	1.9
Mercury	SW7470	ug/Nm3	1		3.62			25.8			4.51			11.3	31
Molybdenum	ICP/MS	ug/Nm3	1		0.21	C		1.39	C		0.214	C		0.605	1.7
Nickel	ICP/MS	ug/Nm3	1		24.9	C		60.4	C		13.9	C		33.1	60
Phosphorus	SW6010	ug/Nm3	1	<	600		<	5,000		<	300		<	5,000	---
Potassium	SW6010	ug/Nm3	1	<	220		<	1,900		<	220		<	1,900	---
Selenium	ICP/MS	ug/Nm3	1	<	0.16		<	1.3		<	0.16		<	1.3	---
Silicon	SW6010	ug/Nm3	1		41.1			387			71.3			166	480
Sodium	SW6010	ug/Nm3	1		63.5			612			135			270	740
Titanium	SW6010	ug/Nm3	1		0.503		<	3.6		<	0.4		<	3.6	---
Vanadium	ICP/MS	ug/Nm3	1		0.12	C		0.995	C		0.146	C		0.42	1.2
Zinc	SW6010	ug/Nm3	1		9.52			106			33.8			49.8	120

Table G-1. Analytical Results Used in Calculations

Stream: Tail Gas (15)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase												
1,2,4-Trichlorobenzene	SW8270	ug/Nm3	1	<	60	<	7.7	<	130	<	60	---
1,2-Dichlorobenzene	SW8270	ug/Nm3	1	<	3.8	<	11	<	440	<	11	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	1	<	3.6	<	10	<	490	<	10	---
1,4-Dichlorobenzene	SW8270	ug/Nm3	1	<	6.1	<	17	<	490	<	17	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	1	<	5.2	<	15	<	400	<	15	---
2,4,6-Trichlorophenol	SW8270	ug/Nm3	1	<	4.7	<	13	<	340	<	13	---
2,4-Dichlorophenol	SW8270	ug/Nm3	1	<	180	<	11	<	400	<	180	---
2,4-Dimethylphenol	SW8270	ug/Nm3	1	<	400	<	45	<	860	<	400	---
2,4-Dinitrophenol	SW8270	ug/Nm3	1	<	34	<	95	<	1,800	<	95	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	1	<	5.7	<	16	<	830	<	16	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	1	<	4.9	<	14	<	730	<	14	---
2-Chloronaphthalene	SW8270	ug/Nm3	1	<	7.9	<	22	<	620	<	22	---
2-Chlorophenol	SW8270	ug/Nm3	1	<	5.7	<	16	<	230	<	16	---
2-Methylnaphthalene	SW8270	ug/Nm3	1	<	520		624	<	420	<	520	---
2-Methylphenol	SW8270	ug/Nm3	1	<	14	<	41	<	550	<	41	---
2-Nitroaniline	SW8270	ug/Nm3	1	<	5.3	<	15	<	650	<	15	---
2-Nitrophenol	SW8270	ug/Nm3	1	<	130	<	18	<	290	<	130	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	1	<	13	<	37	<	750	<	37	---
3-Nitroaniline	SW8270	ug/Nm3	1	<	6.4	<	18	<	220	<	18	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	1	<	9.6	<	27	<	510	<	27	---
4-Aminobiphenyl	SW8270	ug/Nm3	1	<	23	<	64	<	740	<	64	---
4-Bromophenylphenyl ether	SW8270	ug/Nm3	1	<	6.9	<	19	<	420	<	19	---
4-Chloro-3-methylphenol	SW8270	ug/Nm3	1	<	140	<	12	<	320	<	140	---
4-Chlorophenylphenyl ether	SW8270	ug/Nm3	1	<	9.5	<	27	<	510	<	27	---
4-Methylphenol/3-Methylphenol	SW8270	ug/Nm3	1	<	13	<	37	<	860	<	37	---
4-Nitroaniline	SW8270	ug/Nm3	1	<	6.4	<	18	<	410	<	18	---
4-Nitrophenol	SW8270	ug/Nm3	1	<	5.7	<	16	<	440	<	16	---
Acenaphthene	SW8270	ug/Nm3	1		54.7		32.4	<	330		43.6	140
Acenaphthylene	SW8270	ug/Nm3	1		19.5	<	27	<	450	<	27	---

Table G-1. Analytical Results Used in Calculations

Stream: Tail Gas (15)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
Acetophenone	SW8270	ug/Nm3	1		11.1	<	12	<	250	<	12	---
Aniline	SW8270	ug/Nm3	1	<	10	<	29	<	580	<	29	---
Anthracene	SW8270	ug/Nm3	1	<	6.4	<	18	<	370	<	18	---
Benz(a)anthracene	SW8270	ug/Nm3	1	<	5	<	14	<	240	<	14	---
Benz(a)pyrene	SW8270	ug/Nm3	1	<	7.9	<	22	<	370	<	22	---
Benzidine	SW8270	ug/Nm3	1	<	250	<	710	<	14,000	<	710	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	<	12	<	35	<	660	<	35	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	<	5.5	<	15	<	380	<	15	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	<	8.3	<	23	<	570	<	23	---
Benzoic acid	SW8270	ug/Nm3	1	<	940	<	210	<	2,100	<	940	---
Benzyl alcohol	SW8270	ug/Nm3	1	<	5.8	<	16	<	990	<	16	---
Butylbenzylphthalate	SW8270	ug/Nm3	1	<	6.7	<	19	<	520	<	19	---
Chrysene	SW8270	ug/Nm3	1	<	3.4	<	9.7	<	400	<	9.7	---
Di-n-butylphthalate	SW8270	ug/Nm3	1	<	5.5	<	16	<	210	<	16	---
Di-n-octylphthalate	SW8270	ug/Nm3	1	<	5.6	<	16	<	400	<	16	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	<	6.1	<	17	<	470	<	17	---
Dibenzofuran	SW8270	ug/Nm3	1		197		128	<	270		163	440
Diethylphthalate	SW8270	ug/Nm3	1	<	4	<	11	<	280	<	11	---
Dimethylphthalate	SW8270	ug/Nm3	1	<	4.1	<	11	<	330	<	11	---
Diphenylamine/N-NitrosoDPA	SW8270	ug/Nm3	1	<	9.4	<	26	<	530	<	26	---
Fluoranthene	SW8270	ug/Nm3	1	<	2.1	<	6	<	290	<	6	---
Fluorene	SW8270	ug/Nm3	1		17.7	<	10	<	240		11.4	81
Hexachlorobenzene	SW8270	ug/Nm3	1	<	6	<	17	<	360	<	17	---
Hexachlorobutadiene	SW8270	ug/Nm3	1	<	210	<	8.6	<	450	<	210	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	1	<	21	<	58	<	1,100	<	58	---
Hexachloroethane	SW8270	ug/Nm3	1	<	3.1	<	8.7	<	690	<	8.7	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	<	6.5	<	18	<	330	<	18	---
Isophorone	SW8270	ug/Nm3	1	<	95	<	13	<	210	<	95	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	1	<	7.2	<	20	<	540	<	20	---
N-Nitrosodimethylamine	SW8270	ug/Nm3	1	<	5.2	<	15	<	540	<	15	---
Naphthalene	SW8270	ug/Nm3	1		98,100		71,600		97,400		89,000	38,000
Nitrobenzene	SW8270	ug/Nm3	1	<	120	<	11	<	270	<	120	---

Table G-1. Analytical Results Used in Calculations

Stream: Tail Gas (15)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
Pentachloronitrobenzene	SW8270	ug/Nm3	1	<	14	<	39	<	1,600	<	39	---
Pentachlorophenol	SW8270	ug/Nm3	1	<	2.3	<	6.4	<	130	<	6.4	---
Phenanthrene	SW8270	ug/Nm3	1	<	150		128	<	360	<	150	---
Phenol	SW8270	ug/Nm3	1	<	6.7	<	19	<	700	<	19	---
Pyrene	SW8270	ug/Nm3	1	<	3.1	<	8.6	<	320	<	8.6	---
bis(2-Chloroethoxy)methane	SW8270	ug/Nm3	1	<	110	<	9.8	<	230	<	110	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	1	<	5	<	14	<	320	<	14	---
bis(2-Chloroisopropyl)ether	SW8270	ug/Nm3	1	<	5.5	<	15	<	390	<	15	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	1	<	22	<	63	<	1,100	<	63	---
p-Chloroaniline	SW8270	ug/Nm3	1	<	310	<	21	<	830	<	310	---
p-Dimethylaminoazobenzene	SW8270	ug/Nm3	1	<	28	<	80	<	1,400	<	80	---

Table G-1. Analytical Results Used in Calculations

Stream: Combustion Air (K250)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Vapor Phase								
Ammonia as N	EPA 350.1	ug/Nm3	2	442,000	448,000	483,000	458,000	55,000
Cyanide	SW9012	ug/Nm3	2	11,400	9,520	10,100	10,300	2,400

Table G-1. Analytical Results Used in Calculations

Stream: Natural Gas (99)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Aluminum	SW6010	ug/Nm3	2	<	11	<	12	<	11	<	12	---
Antimony	ICP/MS	ug/Nm3	2	<	0.016 C	<	0.018 C	<	0.016 C	<	0.018	---
Arsenic	ICP/MS	ug/Nm3	2		0.0716 C		0.0773 C		0.0537 C		0.0675	0.031
Barium	ICP/MS	ug/Nm3	2		0.0336 C		0.0591 C		0.0258 C		0.0395	0.043
Beryllium	ICP/MS	ug/Nm3	2	<	0.029 C		0.0494 C	<	0.029 C	<	0.029	---
Boron	SW6010	ug/Nm3	2	<	3.6	<	4.1	<	3.6	<	4.1	---
Cadmium	ICP/MS	ug/Nm3	2		0.284 C		0.483 C		0.332 C		0.366	0.26
Calcium	SW6010	ug/Nm3	2		34.4		49.6		44.3		42.8	19
Chromium	ICP/MS	ug/Nm3	2		1.42 C		1.59 C		1.54 C		1.52	0.22
Cobalt	ICP/MS	ug/Nm3	2		0.0138 C		0.0272 C		1.59 C		0.544	2.3
Copper	ICP/MS	ug/Nm3	2	<	0.041	<	0.047	<	0.041	<	0.047	---
Iron	SW6010	ug/Nm3	2		4.42		7.03		6.55		6	3.5
Lead	ICP/MS	ug/Nm3	2		0.0989 C		9.22 C		1.47 C		3.6	12
Magnesium	SW6010	ug/Nm3	2	<	10	<	11	<	10	<	11	---
Manganese	ICP/MS	ug/Nm3	2	<	0.016		0.129	<	0.017		0.0485	0.17
Mercury	SW7470	ug/Nm3	2		0.307		0.317		0.422		0.349	0.16
Molybdenum	ICP/MS	ug/Nm3	2		0.112 C		0.155 C		0.144 C		0.137	0.055
Nickel	ICP/MS	ug/Nm3	2		1.03 C		1.18 C	<	0.024 C		0.741	1.6
Phosphorus	SW6010	ug/Nm3	2	<	22	<	26		29.9	<	26	---
Potassium	SW6010	ug/Nm3	2	<	170	<	190	<	170	<	190	---
Selenium	ICP/MS	ug/Nm3	2	<	0.12	<	0.14	<	0.12	<	0.14	---
Silicon	SW6010	ug/Nm3	2		19.6		28		24.5		24	10
Sodium	SW6010	ug/Nm3	2		25.6		33.6		25.1		28.1	12
Titanium	SW6010	ug/Nm3	2	<	0.33		0.435	<	0.33	<	0.33	---
Vanadium	ICP/MS	ug/Nm3	2		0.0496 C		0.026 C		0.0215 C		0.0324	0.037
Zinc	SW6010	ug/Nm3	2		7.2		8.72		8.88		8.27	2.3

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Particulate Phase								
Chloride	EPA 300.0	ug/Nm3	2	< 150	< 140	< 150	< 150	---
Fluoride	EPA 340.2	ug/Nm3	2	< 1.7	< 1.6	< 1.7	< 1.7	---
Sulfate	EPA 300.0	ug/Nm3	2	136,000	131,000	146,000	138,000	19,000
Ionic Species-Vapor Phase								
Chloride	EPA 300.0	ug/Nm3	2	< 2,100	< 1,600	1,020	< 2,100	---
Fluoride	EPA 340.2	ug/Nm3	2	35.5	24.6	17.8	26	22
H2SO4 (as sulfate)	EPA 300.0	ug/Nm3	2	284,000	243,000	286,000	271,000	60,000
Sulfur dioxide (as sulfate)	EPA 300.0	ug/Nm3	2	11,100,000	10,200,000	12,100,000	11,100,000	2,400,000
Sulfur oxides (as sulfate)	EPA 300.0	ug/Nm3	2	11,400,000	10,400,000	12,400,000	11,400,000	1,700,000
Ammonia as N	EPA 350.1	ug/Nm3	2	570	304	1,360	745	1,400
Cyanide	SW9012	ug/Nm3	2	8.15	5.13	< 3.6	5.03	7.9
Metals-Particulate Phase								
Aluminum	SW6010	ug/Nm3	2	51.9	52.4	52.6	52.3	0.9
Antimony	SW6010	ug/Nm3	2	< 2.1	< 2.1	< 2.1	< 2.1	---
Arsenic	SW7060	ug/Nm3	2	0.347	< 0.034	0.17	0.178	0.41
Barium	SW6010	ug/Nm3	2	1.44	2.17	1.54	1.72	0.98
Beryllium	SW6010	ug/Nm3	2	< 0.012	< 0.012	< 0.012	< 0.012	---
Cadmium	SW7131	ug/Nm3	2	0.37	0.516	0.447	0.444	0.18
Calcium	SW6010	ug/Nm3	2	40.7	42.2	44	42.3	4.1
Chromium	SW6010	ug/Nm3	2	2.64	2.4	3.33	2.79	1.2
Cobalt	SW6010	ug/Nm3	2	0.468	0.292	0.23	0.33	0.31
Copper	SW6010	ug/Nm3	2	2.38	1.63	1.73	1.91	1
Iron	SW6010	ug/Nm3	2	244	165	150	186	130
Lead	SW7421	ug/Nm3	2	0.295	0.0691	0.443	0.269	0.47
Magnesium	SW6010	ug/Nm3	2	7.84	7.05	7.03	7.31	1.1
Manganese	SW6010	ug/Nm3	2	1.48	1.07	1.56	1.37	0.65
Mercury	SW7471	ug/Nm3	2	0.0171	0.00764	0.0216	0.0154	0.018
Molybdenum	SW6010	ug/Nm3	2	5.19	4.91	5.3	5.13	0.5
Nickel	SW6010	ug/Nm3	2	3.74	1.63	3.86	3.08	3.1
Phosphorus	SW6010	ug/Nm3	2	180	171	173	175	12
Potassium	SW6010	ug/Nm3	2	21.1	16.1	< 16	< 16	---
Selenium	SW7740	ug/Nm3	2	0.0541	< 0.029	< 0.029	< 0.029	---

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Particulate Phase (continued)								
Sodium	SW6010	ug/Nm3	2	194	91.3	88.3	125	150
Titanium	SW6010	ug/Nm3	2	1.11	0.774	0.8	0.895	0.46
Vanadium	SW6010	ug/Nm3	2	0.49	0.56	0.584	0.545	0.12
Zinc	SW6010	ug/Nm3	2	10.2	6.25	12.1	9.52	7.4
Metals-Vapor Phase (M-29)								
Aluminum	SW6010	ug/Nm3	2	< 19	< 18	< 17	< 18	---
Antimony	ICP/MS	ug/Nm3	2	0.0402 C	< 0.027 C	< 0.025 C	< 0.028	---
Arsenic	ICP/MS	ug/Nm3	2	0.285 C	0.178 C	1.07 C	0.511	1.2
Barium	ICP/MS	ug/Nm3	2	0.201 C	0.0695 C	0.0476 C	0.106	0.21
Beryllium	ICP/MS	ug/Nm3	2	0.0577 C	< 0.049 C	< 0.046 C	< 0.051	---
Boron	SW6010	ug/Nm3	2	15.9	18.7	5.8	13.5	17
Cadmium	ICP/MS	ug/Nm3	2	3.41 C	0.8 C	0.31 C	1.51	4.1
Calcium	SW6010	ug/Nm3	2	64.1	34.8	28	42.3	48
Chromium	ICP/MS	ug/Nm3	2	1.36 C	0.631 C	0.523 C	0.838	1.1
Cobalt	ICP/MS	ug/Nm3	2	0.0828 C	0.0417 C	0.0189 C	0.0478	0.08
Copper	ICP/MS	ug/Nm3	2	1.88 C	< 0.069	< 0.065	0.649	2.6
Iron	SW6010	ug/Nm3	2	18.9	17.5	11.5	16	9.8
Lead	ICP/MS	ug/Nm3	2	2.04 C	3.01 C	0.651 C	1.9	2.9
Magnesium	SW6010	ug/Nm3	2	< 17	< 17	< 16	< 17	---
Manganese	ICP/MS	ug/Nm3	2	22.3	< 0.028	2.37	8.23	30
Mercury, Nitric Imps.	SW7470	ug/Nm3	2	3.1	5.01	5.6	4.57	3.2
Mercury, KMnO4 Imps.	SW7470	ug/Nm3	2	24.2	24.4	21.4	23.3	4.2
Mercury, Total Vapor Phase	SW7470	ug/Nm3	2	27.3	29.41	27	27.87	3.3
Molybdenum	ICP/MS	ug/Nm3	2	0.05 C	0.0733 C	< 0.044 C	0.0484	0.064
Nickel	ICP/MS	ug/Nm3	2	2.67 C	2.05 C	1.57 C	2.1	1.4
Phosphorus	SW6010	ug/Nm3	2	< 780	< 760	< 720	< 760	---
Potassium	SW6010	ug/Nm3	2	340	< 290	< 270	< 290	---
Selenium	ICP/MS	ug/Nm3	2	< 0.21	< 0.21	< 0.19	< 0.21	---
Silicon	SW6010	ug/Nm3	2	60.6	61.2	49.1	57	17
Sodium	SW6010	ug/Nm3	2	140	63	53.4	85.5	120
Titanium	SW6010	ug/Nm3	2	< 0.57	< 0.55	< 0.52	< 0.55	---
Vanadium	ICP/MS	ug/Nm3	2	0.284 C	0.325 C	1.6 C	0.736	1.9

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29) (continued)												
Zinc	SW6010	ug/Nm3	2		28.7		11.5		7.69		16	28
Aldehydes												
Acetaldehyde	SW0011	ug/Nm3	2		0.638		1.04	<	0.55		0.651	0.95
Acrolein	SW0011	ug/Nm3	2	<	0.33	<	0.59	<	0.55	<	0.59	---
Benzaldehyde	SW0011	ug/Nm3	2	<	0.33	<	0.59	<	0.55	<	0.59	---
Formaldehyde	SW0011	ug/Nm3	2		0.864		0.83		0.65		0.781	0.29
Volatile Organic Compounds												
1,1,1-Trichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,1,1-Trichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,1,1-Trichloroethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,1,2,2-Tetrachloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,1,2,2-Tetrachloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,1,2,2-Tetrachloroethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,1,2-Trichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,1,2-Trichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,1,2-Trichloroethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,1-Dichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,1-Dichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,1-Dichloroethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,1-Dichloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,1-Dichloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,1-Dichloroethene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,2-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,2-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,2-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,2-Dichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,2-Dichloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,2-Dichloroethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,2-Dichloropropane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,2-Dichloropropane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,2-Dichloropropane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,3-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Volatile Organic Compounds (continued)												
1,3-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,3-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
1,4-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
1,4-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
1,4-Dichlorobenzene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
2-Butanone	SW8240	ug/Nm3	2		3.12	<	2.5	<	2.8	<	2.8	---
2-Butanone	SW8240	ug/Nm3	2	<	2.6	<	2.4	<	2.5	<	2.7	---
2-Butanone	SW8240	ug/Nm3	2	<	2.6	<	2.4	<	3	<	3	---
2-Hexanone	SW8240	ug/Nm3	2	<	2.6	<	2.5	<	2.8	<	2.8	---
2-Hexanone	SW8240	ug/Nm3	2	<	2.7	<	2.4	<	2.5	<	2.5	---
2-Hexanone	SW8240	ug/Nm3	2	<	2.5	<	2.4	<	3	<	3	---
4-Methyl-2-Pentanone	SW8240	ug/Nm3	2	<	2.6	<	2.5	<	2.8	<	2.8	---
4-Methyl-2-Pentanone	SW8240	ug/Nm3	2	<	2.7	<	2.4	<	2.5	<	2.5	---
4-Methyl-2-Pentanone	SW8240	ug/Nm3	2	<	2.5	<	2.4	<	3	<	3	---
Acetone	SW8240	ug/Nm3	2	<	2.6	<	2.5	<	2.8	<	2.8	---
Acetone	SW8240	ug/Nm3	2	<	2.7	<	2.4	<	2.5	<	2.5	---
Acetone	SW8240	ug/Nm3	2	<	2.5	<	2.4	<	3	<	3	---
Benzene	SW8240	ug/Nm3	2		12.7		1.44		1.55		5.23	16
Benzene	SW8240	ug/Nm3	2		1.98		0.482		1.27		1.24	1.9
Benzene	SW8240	ug/Nm3	2		1.76		1.08		0.595		1.15	1.5
Bromodichloromethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Bromodichloromethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
Bromodichloromethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Bromoform	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Bromoform	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
Bromoform	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Bromomethane	SW8240	ug/Nm3	2	<	0.51	<	0.53		5.99		2.17	8.2
Bromomethane	SW8240	ug/Nm3	2		6.09		4.82		8.5		6.47	4.6
Bromomethane	SW8240	ug/Nm3	2		5.21		2.4	<	0.59		2.64	6.1
Carbon Disulfide	SW8240	ug/Nm3	2	<	0.53		5.23		5.99		3.83	7.7
Carbon Disulfide	SW8240	ug/Nm3	2		6.09		6.27		7.08		6.48	1.3
Carbon Disulfide	SW8240	ug/Nm3	2		6.79		3.58		5.12		5.16	4

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Volatile Organic Compounds (continued)												
Carbon Tetrachloride	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Carbon Tetrachloride	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Carbon Tetrachloride	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Chlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Chlorobenzene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Chlorobenzene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Chloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Chloroethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Chloroethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Chloroform	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Chloroform	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Chloroform	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Chloromethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Chloromethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Chloromethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
cis-1,3-Dichloropropene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
cis-1,3-Dichloropropene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
cis-1,3-Dichloropropene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Dibromochloromethane	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Dibromochloromethane	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Dibromochloromethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Ethyl Benzene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Ethyl Benzene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Ethyl Benzene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
m,p-Xylene	SW8240	ug/Nm3	2	<	0.53	<	0.51		0.906	<	0.53	---
m,p-Xylene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
m,p-Xylene	SW8240	ug/Nm3	2	<	0.5	<	0.47		0.595	<	0.5	---
Methylene Chloride	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.53	---
Methylene Chloride	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.53	---
Methylene Chloride	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
o-Xylene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
o-Xylene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Volatile Organic Compounds (continued)												
o-Xylene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Styrene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Styrene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
Styrene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Tetrachloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Tetrachloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
Tetrachloroethene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Toluene	SW8240	ug/Nm3	2		3.06	<	0.51	<	0.57		1.2	4
Toluene	SW8240	ug/Nm3	2		3.36	<	0.48	<	0.49		1.28	4.5
Toluene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
trans-1,2-Dichloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
trans-1,2-Dichloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
trans-1,2-Dichloroethene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
trans-1,3-Dichloropropene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
trans-1,3-Dichloropropene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
trans-1,3-Dichloropropene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Trichloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Trichloroethene	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
Trichloroethene	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Trichlorofluoromethane	SW8240	ug/Nm3	2		2.01	<	0.51	<	0.57		0.85	2.5
Trichlorofluoromethane	SW8240	ug/Nm3	2	<	0.53	<	0.48		0.687	<	0.53	---
Trichlorofluoromethane	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
Vinyl Acetate	SW8240	ug/Nm3	2	<	2.6	<	2.5	<	2.8	<	2.8	---
Vinyl Acetate	SW8240	ug/Nm3	2	<	2.7	<	2.4	<	2.5	<	2.5	---
Vinyl Acetate	SW8240	ug/Nm3	2	<	2.5	<	2.4	<	3	<	3	---
Vinyl Chloride	SW8240	ug/Nm3	2	<	0.53	<	0.51	<	0.57	<	0.57	---
Vinyl Chloride	SW8240	ug/Nm3	2	<	0.53	<	0.48	<	0.49	<	0.49	---
Vinyl Chloride	SW8240	ug/Nm3	2	<	0.5	<	0.47	<	0.59	<	0.59	---
PAHs/SVOCs-Particulate Phase												
1,2,4-Trichlorobenzene	SW8270	ug/Nm3	2	<	0.69	<	0.76	<	0.73	<	0.76	---
1,2-Dichlorobenzene	SW8270	ug/Nm3	2	<	0.65	<	0.73	<	0.71	<	0.73	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	2	<	0.67	<	0.75	<	0.72	<	0.75	---

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
1,4-Dichlorobenzene	SW8270	ug/Nm3	2	<		<		<		<	0	---
2,2'-oxybis(1-Chloropropane)	SW8270	ug/Nm3	2	<	0.87	<	0.98	<	0.95	<	0.98	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	2	<	0.86	<	0.93	<	0.91	<	0.93	---
2,4,6-Trichlorophenol	SW8270	ug/Nm3	2	<	0.91	<	0.98	<	0.96	<	0.98	---
2,4-Dichlorophenol	SW8270	ug/Nm3	2	<	0.84	<	0.93	<	0.9	<	0.93	---
2,4-Dimethylphenol	SW8270	ug/Nm3	2	<	0.86	<	0.96	<	0.92	<	0.96	---
2,4-Dinitrophenol	SW8270	ug/Nm3	2	<	2.7	<	2.9	<	2.8	<	2.9	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	2	<	0.92	<	0.99	<	0.97	<	0.99	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	2	<	1.3	<	1.4	<	1.4	<	1.4	---
2-Chloronaphthalene	CARB 429	ug/Nm3	2		0.000037 E	<	0.000077	<	0.000060	<	0.000077	---
2-Chlorophenol	SW8270	ug/Nm3	2	<	0.79	<	0.89	<	0.86	<	0.89	---
2-Methylnaphthalene	CARB 429	ug/Nm3	2		0.071		0.0655		0.058		0.0648	0.016
2-Methylphenol	SW8270	ug/Nm3	2	<	1	<	1.1	<	1.1	<	1.1	---
2-Nitroaniline	SW8270	ug/Nm3	2	<	1.2	<	1.3	<	1.3	<	1.3	---
2-Nitrophenol	SW8270	ug/Nm3	2	<	1.3	<	1.4	<	1.4	<	1.4	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	2	<	0.87	<	0.89	<	0.95	<	0.95	---
3-Nitroaniline	SW8270	ug/Nm3	2	<	1.4	<	1.5	<	1.4	<	1.5	---
3/4-Methylphenol	SW8270	ug/Nm3	2	<	0.86	<	0.97	<	0.94	<	0.97	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	2	<	1.8	<	1.7	<	1.9	<	1.9	---
4-Aminobiphenyl	SW8270	ug/Nm3	2	<	0.38	<	0.38	<	0.41	<	0.41	---
4-Bromophenyl-phenylether	SW8270	ug/Nm3	2	<	1.2	<	1.1	<	1.2	<	1.2	---
4-Chloro-3-methylphenol	SW8270	ug/Nm3	2	<	0.9	<	0.99	<	0.96	<	0.99	---
4-Chloroaniline	SW8270	ug/Nm3	2	<	0.7	<	0.77	<	0.74	<	0.77	---
4-Chlorophenyl-phenylether	SW8270	ug/Nm3	2	<	0.66	<	0.71	<	0.69	<	0.71	---
4-Nitroaniline	SW8270	ug/Nm3	2	<	1.3	<	1.4	<	1.4	<	1.4	---
4-Nitrophenol	SW8270	ug/Nm3	2	<	1.5	<	1.7	<	1.6	<	1.7	---
Acenaphthene	CARB 429	ug/Nm3	2		0.0125		0.0098		0.00676		0.00969	0.0071
Acenaphthylene	CARB 429	ug/Nm3	2		0.00401		0.00308		0.0024		0.00316	0.002
Acetophenone	SW8270	ug/Nm3	2	<	0.66	<	0.74	<	0.72	<	0.74	---
Aniline	SW8270	ug/Nm3	2	<	0.55	<	0.62	<	0.6	<	0.62	---
Anthracene	CARB 429	ug/Nm3	2		0.00227		0.0015		0.00121		0.00166	0.0014
Benzidine	SW8270	ug/Nm3	2	<	0.52	<	0.53	<	0.56	<	0.56	---

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
Benzo(a)anthracene	CARB 429	ug/Nm3	2		0.000368		0.000342		0.000402		0.000371	0.000075
Benzo(a)pyrene	CARB 429	ug/Nm3	2		0.000263		0.000413		0.000336		0.000337	0.00019
Benzo(b)fluoranthene	CARB 429	ug/Nm3	2		0.000699		0.000859		0.000859		0.000806	0.00023
Benzo(e)pyrene	CARB 429	ug/Nm3	2		0.00177		0.00114		0.0015		0.00147	0.00079
Benzo(g,h,i)perylene	CARB 429	ug/Nm3	2		0.00227		0.00281		0.00233		0.00247	0.00074
Benzo(k)fluoranthene	CARB 429	ug/Nm3	2		0.00201		0.000204		0.000164		0.000793	0.0026
Benzoic acid	SW8270	ug/Nm3	2	<	1.8	<	2	<	1.9	<	2	---
Benzyl alcohol	SW8270	ug/Nm3	2	<	1.2	<	1.3	<	1.3	<	1.3	---
Butylbenzylphthalate	SW8270	ug/Nm3	2	<	0.55	<	0.56	<	0.6	<	0.6	---
Chrysene	CARB 429	ug/Nm3	2		0.00133		0.00078		0.000856		0.000989	0.00074
Di-n-butylphthalate	SW8270	ug/Nm3	2	<		<			12.4		4.13	18
Di-n-octylphthalate	SW8270	ug/Nm3	2	<	0.32	<	0.35	<	0.34	<	0.35	---
Dibenz(a,h)anthracene	CARB 429	ug/Nm3	2	<	0.000052	<	0.000059	<	0.000042	<	0.000059	---
Dibenzofuran	SW8270	ug/Nm3	2	<	0.25	<	0.27	<	0.27	<	0.27	---
Diethylphthalate	SW8270	ug/Nm3	2	<		<	0.32	<		<	0.32	---
Dimethylaminoazobenzene	SW8270	ug/Nm3	2	<	1.1	<	1.1	<	1.1	<	1.1	---
Dimethylphthalate	SW8270	ug/Nm3	2	<	0.33	<	0.36	<	0.35	<	0.36	---
Fluoranthene	CARB 429	ug/Nm3	2		0.00508		0.00593		0.00713		0.00605	0.0026
Fluorene	CARB 429	ug/Nm3	2		0.0222		0.0169		0.0158		0.0183	0.0085
Hexachlorobenzene	SW8270	ug/Nm3	2	<	0.84	<	0.84	<	0.9	<	0.9	---
Hexachlorobutadiene	SW8270	ug/Nm3	2	<	1	<	1.1	<	1.1	<	1.1	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	2	<	1.1	<	1.2	<	1.2	<	1.2	---
Hexachloroethane	SW8270	ug/Nm3	2	<	1.2	<	1.3	<	1.3	<	1.3	---
Indeno(1,2,3-cd)pyrene	CARB 429	ug/Nm3	2		0.000499		0.000738		0.000586		0.000608	0.0003
Isophorone	SW8270	ug/Nm3	2	<	0.47	<	0.51	<	0.5	<	0.51	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	2	<	1.3	<	1.4	<	1.4	<	1.4	---
Naphthalene	CARB 429	ug/Nm3	2		0.085		0.095		0.0825		0.0875	0.016
Nitrobenzene	SW8270	ug/Nm3	2	<	0.81	<	0.9	<	0.87	<	0.9	---
Pentachloronitrobenzene	SW8270	ug/Nm3	2	<	2.3	<	2.3	<	2.4	<	2.4	---
Pentachlorophenol	SW8270	ug/Nm3	2	<	1.8	<	1.7	<	1.9	<	1.9	---
Perylene	CARB 429	ug/Nm3	2		0.000113		0.000138		0.000087		0.000113	0.000063
Phenanthrene	CARB 429	ug/Nm3	2		0.0285		0.0355		0.0336		0.0325	0.009

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2			Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)													
Phenol	SW8270	ug/Nm3	2	<	0.76	<	0.85		<	0.82	<	0.85	---
Pyrene	CARB 429	ug/Nm3	2		0.00559		0.00575			0.00631		0.00588	0.00094
bis(2-Chloroethoxy)methane	SW8270	ug/Nm3	2	<	0.84	<	0.93		<	0.9	<	0.93	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	2	<	1.1	<	1.2		<	1.2	<	1.2	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	2	<		<			<		<	0	---
n-Nitrosodimethylamine	SW8270	ug/Nm3	2	<	2.2	<	2.5		<	2.4	<	2.5	---
PAHs/SVOCs-Vapor Phase													
1,2,4-Trichlorobenzene	SW8270	ug/Nm3	2	<	0.81	<	0.86		<	0.87	<	0.87	---
1,2-Dichlorobenzene	SW8270	ug/Nm3	2	<	0.79	<	0.82		<	0.88	<	0.88	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	2	<	0.81	<	0.84		<	0.9	<	0.9	---
1,4-Dichlorobenzene	SW8270	ug/Nm3	2	<	0.74	<	0.76		<	0.82	<	0.82	---
2,2'-oxybis(1-Chloropropane)	SW8270	ug/Nm3	2	<	1.1	<	1.1		<	1.2	<	1.2	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	2	<	1.1	<	1.1		<	1.1	<	1.1	---
2,4,6-Trichlorophenol	SW8270	ug/Nm3	2	<	1.1	<	1.1		<	1.2	<	1.2	---
2,4-Dichlorophenol	SW8270	ug/Nm3	2	<	1	<	1.1		<	1.1	<	1.1	---
2,4-Dimethylphenol	SW8270	ug/Nm3	2	<	1	<	1.1		<	1.1	<	1.1	---
2,4-Dinitrophenol	SW8270	ug/Nm3	2	<	3.3	<	3.3		<	3.4	<	3.4	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	2	<	1.1	<	1.1		<	1.2	<	1.2	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	2	<	1.7	<	1.6		<	1.7	<	1.7	---
2-Chloronaphthalene	CARB 429	ug/Nm3	2		0.000133		0.000088	E		0.000072		0.000098	0.000079
2-Chlorophenol	SW8270	ug/Nm3	2	<	1	<	1		<	1.1	<	1.1	---
2-Methylnaphthalene	CARB 429	ug/Nm3	2		0.0656		0.061			0.0703		0.0656	0.012
2-Methylphenol	SW8270	ug/Nm3	2	<	1.2	<	1.2		<	1.3	<	1.3	---
2-Nitroaniline	SW8270	ug/Nm3	2	<	1.5	<	1.5		<	1.5	<	1.5	---
2-Nitrophenol	SW8270	ug/Nm3	2	<	1.6	<	1.7		<	1.7	<	1.7	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	2	<	1.3	<	1.1		<	1.2	<	1.2	---
3-Nitroaniline	SW8270	ug/Nm3	2	<	1.7	<	1.7		<	1.7	<	1.7	---
3/4-Methylphenol	SW8270	ug/Nm3	2	<	1.1	<	1.1		<	1.2	<	1.2	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	2	<	2.1	<	2.1		<	2.1	<	2.1	---
4-Aminobiphenyl	SW8270	ug/Nm3	2	<	0.46	<	0.46		<	0.47	<	0.47	---
4-Bromophenyl-phenylether	SW8270	ug/Nm3	2	<	1.4	<	1.4		<	1.4	<	1.4	---
4-Chloro-3-methylphenol	SW8270	ug/Nm3	2	<	1.1	<	1.1		<	1.1	<	1.1	---

Table G-1. Analytical Results Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
4-Chloroaniline	SW8270	ug/Nm3	2	<	0.82	<	0.88	<	0.89	<	0.89	---
4-Chlorophenyl-phenylether	SW8270	ug/Nm3	2	<	0.82	<	0.81	<	0.84	<	0.84	---
4-Nitroaniline	SW8270	ug/Nm3	2	<	1.6	<	1.6	<	1.7	<	1.7	---
4-Nitrophenol	SW8270	ug/Nm3	2	<	1.9	<	1.9	<	2	<	2	---
Acenaphthene	CARB 429	ug/Nm3	2		0.00882		0.0118		0.0124		0.011	0.0048
Acenaphthylene	CARB 429	ug/Nm3	2		0.0132		0.0112		0.0115		0.012	0.0027
Acetophenone	SW8270	ug/Nm3	2	<		<		<		<	0	---
Aniline	SW8270	ug/Nm3	2	<	0.67	<	0.69	<	0.74	<	0.74	---
Anthracene	CARB 429	ug/Nm3	2		0.00146		0.00162		0.000993		0.00136	0.00081
Benzidine	SW8270	ug/Nm3	2	<	0.75	<	0.67	<	0.69	<	0.69	---
Benzo(a)anthracene	CARB 429	ug/Nm3	2		0.000721		0.000855		0.000965		0.000847	0.0003
Benzo(a)pyrene	CARB 429	ug/Nm3	2		0.000611		0.000576		0.000483		0.000557	0.00016
Benzo(b)fluoranthene	CARB 429	ug/Nm3	2		0.00164		0.00207		0.00209		0.00193	0.00063
Benzo(e)pyrene	CARB 429	ug/Nm3	2		0.00216		0.00216		0.00177		0.00203	0.00056
Benzo(g,h,i)perylene	CARB 429	ug/Nm3	2		0.00212		0.00199		0.0029		0.00234	0.0012
Benzo(k)fluoranthene	CARB 429	ug/Nm3	2		0.000427		0.000491		0.000524		0.000481	0.00012
Benzoic acid	SW8270	ug/Nm3	2		89.2		79.4		73.1		80.6	20
Benzyl alcohol	SW8270	ug/Nm3	2	<	1.4	<		<		<	0	---
Butylbenzylphthalate	SW8270	ug/Nm3	2	<	0.78	<	0.7	<	0.72	<	0.72	---
Chrysene	CARB 429	ug/Nm3	2		0.00179		0.00222		0.000202		0.0014	0.0026
Di-n-butylphthalate	SW8270	ug/Nm3	2		28.7		44.1		21.2		31.3	29
Di-n-octylphthalate	SW8270	ug/Nm3	2	<	0.42	<	0.4	<	0.4	<	0.4	---
Dibenz(a,h)anthracene	CARB 429	ug/Nm3	2		0.000168		0.000172	<	0.00015	<	0.00015	---
Dibenzofuran	SW8270	ug/Nm3	2	<	0.31	<	0.31	<	0.32	<	0.32	---
Diethylphthalate	SW8270	ug/Nm3	2	<		<		<		<	0	---
Dimethylaminoazobenzene	SW8270	ug/Nm3	2	<	1.5	<	1.5	<	1.4	<	1.5	---
Dimethylphthalate	SW8270	ug/Nm3	2	<	0.41	<	0.41	<	0.42	<	0.42	---
Fluoranthene	CARB 429	ug/Nm3	2		0.0138		0.0132		0.0161		0.0144	0.0038
Fluorene	CARB 429	ug/Nm3	2		0.0125		0.0142		0.0133		0.0133	0.0021
Hexachlorobenzene	SW8270	ug/Nm3	2	<	1	<	1	<	1	<	1	---
Hexachlorobutadiene	SW8270	ug/Nm3	2	<	1.2	<	1.3	<	1.3	<	1.3	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	2	<	1.4	<	1.4	<	1.4	<	1.4	---

Table G-1. Analytical Results Used in Calculations

Stream: *Incinerator (16)*

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
Hexachloroethane	SW8270	ug/Nm3	2	<	1.4	<	1.5	<	1.6	<	1.6	---
Indeno(1,2,3-cd)pyrene	CARB 429	ug/Nm3	2		0.000737		0.000874		0.000673		0.000761	0.00026
Isophorone	SW8270	ug/Nm3	2	<	0.55	<	0.59	<	0.6	<	0.6	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	2	<	1.6	<	1.6	<	1.7	<	1.7	---
Naphthalene	CARB 429	ug/Nm3	2		0.0127		0.261		0.0099		0.0945	0.36
Nitrobenzene	SW8270	ug/Nm3	2	<	1	<	1	<	1	<	1	---
Pentachloronitrobenzene	SW8270	ug/Nm3	2	<	2.7	<	2.7	<	2.8	<	2.8	---
Pentachlorophenol	SW8270	ug/Nm3	2	<	2.1	<	2.1	<	2.1	<	2.1	---
Perylene	CARB 429	ug/Nm3	2		0.000245		0.0002		0.000367		0.000271	0.00021
Phenanthrene	CARB 429	ug/Nm3	2		0.039		0.0428		0.0403		0.0407	0.0048
Phenol	SW8270	ug/Nm3	2	<		<		<		<	0	---
Pyrene	CARB 429	ug/Nm3	2		0.0121		0.0188		0.0346		0.0218	0.029
bis(2-Chloroethoxy)methane	SW8270	ug/Nm3	2	<	1	<	1.1	<	1.1	<	1.1	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	2	<	1.3	<	1.4	<	1.5	<	1.5	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	2	<		<			16		5.33	23
n-Nitrosodimethylamine	SW8270	ug/Nm3	2	<	2.7	<	2.8	<	3	<	3	---

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Ionic Species-Particulate Phase								
Chloride	EPA 300.0	ug/Nm3	1	160	21.8	22.6	68.1	200
Fluoride	EPA 340.2	ug/Nm3	1	2.45	3.81	< 1.6	2.35	3.7
Sulfate	EPA 300.0	ug/Nm3	1	772	1,310	1,120	1,070	680
Ionic Species-Vapor Phase								
Chloride	EPA 300.0	ug/Nm3	1	371	329	< 1,130	350	270
Fluoride	EPA 340.2	ug/Nm3	1	25.8	20.4	11.3	19.2	18
H2SO4 (as sulfate)	EPA 300.0	ug/Nm3	1	3,910	2,080	2,520	2,840	2,400
Sulfur dioxide (as sulfate)	EPA 300.0	ug/Nm3	1	22,600	22,400	15,300	20,100	10,000
Sulfur oxides (as sulfate)	EPA 300.0	ug/Nm3	1	26,510	24,480	17,820	22,900	7,500
Ammonia as N	EPA 350.1	ug/Nm3	1	191	296	90.6	193	260
Cyanide	SW9012	ug/Nm3	1	< 3.3	< 2.6	< 3.2	< 3.3	---
Metals-Particulate Phase								
Aluminum	SW6010	ug/Nm3	1	40.9	26.7	34.5	34	18
Antimony	SW6010	ug/Nm3	1	< 2.1	< 2.1	< 2.2	< 2.2	---
Arsenic	SW7060	ug/Nm3	1	1.81	0.673	0.782	1.09	1.6
Barium	SW6010	ug/Nm3	1	1.73	1.05	2.08	1.62	1.3
Beryllium	SW6010	ug/Nm3	1	< 0.012	< 0.012	< 0.012	< 0.012	---
Cadmium	SW7131	ug/Nm3	1	0.636	0.615	0.609	0.62	0.035
Calcium	SW6010	ug/Nm3	1	177	34.8	34.8	82.2	200
Chromium	SW6010	ug/Nm3	1	1.3	0.948	0.826	1.02	0.61
Cobalt	SW6010	ug/Nm3	1	0.284	0.49	< 0.2	0.291	0.48
Copper	SW6010	ug/Nm3	1	13.2	8.05	1.19	7.48	15
Iron	SW6010	ug/Nm3	1	181	23.2	16.9	73.7	230
Lead	SW7421	ug/Nm3	1	1.66	0.725	0.573	0.986	1.5
Magnesium	SW6010	ug/Nm3	1	15.5	6.84	7.56	9.97	12
Manganese	SW6010	ug/Nm3	1	1.06	0.2	< 0.18	0.45	1.3
Mercury	SW7471	ug/Nm3	1	0.00782	0.00805	0.0151	0.0103	0.01
Molybdenum	SW6010	ug/Nm3	1	2.83	3.33	5.32	3.83	3.3
Nickel	SW6010	ug/Nm3	1	0.917	1.22	0.808	0.982	0.53
Phosphorus	SW6010	ug/Nm3	1	127	131	130	129	5.2
Potassium	SW6010	ug/Nm3	1	197	39.2	< 16	81.4	250
Selenium	SW7740	ug/Nm3	1	0.995	0.283	0.0455	0.441	1.2

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Particulate Phase (continued)												
Sodium	SW6010	ug/Nm3	1		151		173		108		144	82
Titanium	SW6010	ug/Nm3	1		5.61		2.4		0.58		2.86	6.3
Vanadium	SW6010	ug/Nm3	1		0.318		0.329		0.459		0.369	0.19
Zinc	SW6010	ug/Nm3	1		19.4		10.3		10.2		13.3	13
Metals-Vapor Phase (M-29)												
Aluminum	SW6010	ug/Nm3	1	<	13	<	12	<	15	<	15	---
Antimony	ICP/MS	ug/Nm3	1	<	0.02 C	<	0.018 C		0.0336 C	<	0.02	---
Arsenic	ICP/MS	ug/Nm3	1		0.124 C		0.0549 C		0.0727 C		0.0839	0.089
Barium	ICP/MS	ug/Nm3	1		0.594 C		0.0995 C		0.376 C		0.357	0.62
Beryllium	ICP/MS	ug/Nm3	1	<	0.036 C	<	0.033 C	<	0.04 C	<	0.04	---
Boron	SW6010	ug/Nm3	1		6.83		4.13	<	4.9	<	4.9	---
Cadmium	ICP/MS	ug/Nm3	1		0.326 C		0.197 C		2.44 C		0.988	3.1
Calcium	SW6010	ug/Nm3	1		29.8		25.8		46.6		34.1	27
Chromium	ICP/MS	ug/Nm3	1		0.646 C		0.213 C		0.562 C		0.474	0.57
Cobalt	ICP/MS	ug/Nm3	1		0.0274 C		0.0184 C		0.0392 C		0.0283	0.026
Copper	ICP/MS	ug/Nm3	1	<	0.051 C	<	0.046 C		2.25 C		0.766	3.2
Iron	SW6010	ug/Nm3	1		7.68		5.9		10.4		7.99	5.6
Lead	ICP/MS	ug/Nm3	1		0.241 C		0.58 C		0.982 C		0.601	0.92
Magnesium	SW6010	ug/Nm3	1	<	12	<	11	<	13	<	13	---
Manganese	ICP/MS	ug/Nm3	1	<	0.021	<	0.019		3.61		1.21	5.2
Mercury, Nitric Imps.	SW7470	ug/Nm3	1		0.347		0.313		0.224		0.295	0.16
Mercury, KMnO4 Imps.	SW7470	ug/Nm3	1		0.277		0.54		0.396		0.404	0.33
Mercury, Total Vapor Phase	SW7470	ug/Nm3	1		0.624		0.853		0.62		0.699	0.19
Molybdenum	ICP/MS	ug/Nm3	1	<	0.034 C		0.0612 C	<	0.037 C	<	0.037	---
Nickel	ICP/MS	ug/Nm3	1		0.463 C		0.542 C		2.53 C		1.18	2.9
Phosphorus	SW6010	ug/Nm3	1	<	28	<	25	<	31	<	31	---
Potassium	SW6010	ug/Nm3	1	<	210	<	190	<	230	<	230	---
Selenium	ICP/MS	ug/Nm3	1		1.67		1.22		0.766		1.22	1.1
Silicon	SW6010	ug/Nm3	1		32.9		48.5		38.4		39.9	20
Sodium	SW6010	ug/Nm3	1		51.1		46.2		93.1		63.5	64
Titanium	SW6010	ug/Nm3	1		0.473	<	0.37		0.777		0.478	0.74
Vanadium	ICP/MS	ug/Nm3	1		0.201 C		0.0396 C		0.0668 C		0.102	0.21

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29) (continued)								
Zinc	SW6010	ug/Nm3	1	6.04	10.9	26.3	14.4	26
Aldehydes								
Acetaldehyde	SW0011	ug/Nm3	1	1.32	1.02	0.629	0.99	0.86
Acrolein	SW0011	ug/Nm3	1	< 0.55	< 0.55	< 0.54	< 0.55	---
Benzaldehyde	SW0011	ug/Nm3	1	2.09	1.88	0.976	1.65	1.5
Formaldehyde	SW0011	ug/Nm3	1	11	9.71	7.48	9.4	4.4
Volatile Organic Compounds								
1,1,1-Trichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1,1-Trichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1,1-Trichloroethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,1,2,2-Tetrachloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1,2,2-Tetrachloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1,2,2-Tetrachloroethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,1,2-Trichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1,2-Trichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1,2-Trichloroethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,1-Dichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1-Dichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1-Dichloroethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,1-Dichloroethene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1-Dichloroethene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,1-Dichloroethene	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,2-Dichlorobenzene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,2-Dichlorobenzene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,2-Dichlorobenzene	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,2-Dichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,2-Dichloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,2-Dichloroethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,2-Dichloropropane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,2-Dichloropropane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
1,2-Dichloropropane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
1,3-Dichlorobenzene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Volatile Organic Compounds (continued)												
1,3-Dichlorobenzene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
1,3-Dichlorobenzene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
1,4-Dichlorobenzene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
1,4-Dichlorobenzene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
1,4-Dichlorobenzene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
2-Butanone	SW8240	ug/Nm3	1	<	2.8	<	2.8	<	2.8	<	2.8	---
2-Butanone	SW8240	ug/Nm3	1	<	2.9	<	2.9	<	2.8	<	2.9	---
2-Butanone	SW8240	ug/Nm3	1	<	2.8	<	2.9	<	2.8	<	2.9	---
2-Hexanone	SW8240	ug/Nm3	1	<	2.8	<	2.8	<	2.8	<	2.8	---
2-Hexanone	SW8240	ug/Nm3	1	<	2.9	<	2.9	<	2.8	<	2.9	---
2-Hexanone	SW8240	ug/Nm3	1	<	2.8	<	2.9	<	2.8	<	2.9	---
4-Methyl-2-Pentanone	SW8240	ug/Nm3	1	<	2.8	<	2.8	<	2.8	<	2.8	---
4-Methyl-2-Pentanone	SW8240	ug/Nm3	1	<	2.9	<	2.9	<	2.8	<	2.9	---
4-Methyl-2-Pentanone	SW8240	ug/Nm3	1	<	2.8	<	2.9	<	2.8	<	2.9	---
Acetone	SW8240	ug/Nm3	1	<	2.8	<	2.8	<	2.8	<	2.8	---
Acetone	SW8240	ug/Nm3	1	<	2.9	<	2.9	<	2.8	<	2.9	---
Acetone	SW8240	ug/Nm3	1	<	2.8	<	2.9	<	2.8	<	2.9	---
Benzene	SW8240	ug/Nm3	1		2.37		2.46		0.67		1.83	2.5
Benzene	SW8240	ug/Nm3	1		1.82		1.37		5.37		2.85	5.4
Benzene	SW8240	ug/Nm3	1		1.91		3.21		2.84		2.65	1.7
Bromodichloromethane	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Bromodichloromethane	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Bromodichloromethane	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Bromoform	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Bromoform	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Bromoform	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Bromomethane	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Bromomethane	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Bromomethane	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Carbon Disulfide	SW8240	ug/Nm3	1		0.791		0.914		6.68		2.8	8.4
Carbon Disulfide	SW8240	ug/Nm3	1		0.569	<	0.57	<	0.56	<	0.57	---
Carbon Disulfide	SW8240	ug/Nm3	1		0.618		0.619	<	0.56	<	0.56	---

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Volatile Organic Compounds (continued)								
Carbon Tetrachloride	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Carbon Tetrachloride	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Carbon Tetrachloride	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
Chlorobenzene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chlorobenzene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chlorobenzene	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
Chloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chloroethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chloroethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
Chloroform	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chloroform	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chloroform	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
Chloromethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chloromethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Chloromethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
cis-1,3-Dichloropropene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
cis-1,3-Dichloropropene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
cis-1,3-Dichloropropene	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
Dibromochloromethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Dibromochloromethane	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Dibromochloromethane	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
Ethyl Benzene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Ethyl Benzene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
Ethyl Benzene	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
m,p-Xylene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
m,p-Xylene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
m,p-Xylene	SW8240	ug/Nm3	1	< 0.56	< 0.57	< 0.56	< 0.57	---
Methylene Chloride	SW8240	ug/Nm3	1	55.4	6.86	328 E	130	430
Methylene Chloride	SW8240	ug/Nm3	1	1.31	< 0.57	11.1	4.23	15
Methylene Chloride	SW8240	ug/Nm3	1	56.2	24.7	9.47	30.1	59
o-Xylene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---
o-Xylene	SW8240	ug/Nm3	1	< 0.57	< 0.57	< 0.56	< 0.57	---

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Volatile Organic Compounds (continued)												
o-Xylene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Styrene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Styrene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Styrene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Tetrachloroethene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Tetrachloroethene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Tetrachloroethene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Toluene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Toluene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Toluene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
trans-1,2-Dichloroethene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
trans-1,2-Dichloroethene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
trans-1,2-Dichloroethene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
trans-1,3-Dichloropropene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
trans-1,3-Dichloropropene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
trans-1,3-Dichloropropene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Trichloroethene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Trichloroethene	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Trichloroethene	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
Trichlorofluoromethane	SW8240	ug/Nm3	1		32.2		2.63		178		70.9	230
Trichlorofluoromethane	SW8240	ug/Nm3	1	<	0.57	<	0.57		1.43		0.667	1.6
Trichlorofluoromethane	SW8240	ug/Nm3	1		13.5		1.86		0.557		5.31	18
Vinyl Acetate	SW8240	ug/Nm3	1	<	2.8	<	2.8	<	2.8	<	2.8	---
Vinyl Acetate	SW8240	ug/Nm3	1	<	2.9	<	2.9	<	2.8	<	2.9	---
Vinyl Acetate	SW8240	ug/Nm3	1	<	2.8	<	2.9	<	2.8	<	2.9	---
Vinyl Chloride	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Vinyl Chloride	SW8240	ug/Nm3	1	<	0.57	<	0.57	<	0.56	<	0.57	---
Vinyl Chloride	SW8240	ug/Nm3	1	<	0.56	<	0.57	<	0.56	<	0.57	---
PAHs/SVOCs-Particulate Phase												
1,2,4-Trichlorobenzene	SW8270	ug/Nm3	1	<	0.87	<	0.23	<	0.55	<	0.55	---
1,2-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.88	<	0.21	<	0.54	<	0.54	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.89	<	0.19	<	0.54	<	0.54	---

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
1,4-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.1	<	0.1	<	0.1	<	0.1	---
2,2'-oxybis(1-Chloropropane)	SW8270	ug/Nm3	1	<	1.17	<	0.36	<	0.76	<	0.76	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	1	<	1.05	<	0.41	<	0.73	<	1.1	---
2,4,6-Trichlorophenol	SW8270	ug/Nm3	1	<	1.11	<	0.43	<	0.77	<	1.1	---
2,4-Dichlorophenol	SW8270	ug/Nm3	1	<	1.07	<	0.25	<	0.66	<	1.1	---
2,4-Dimethylphenol	SW8270	ug/Nm3	1	<	1.1	<	0.23	<	0.66	<	1.1	---
2,4-Dinitrophenol	SW8270	ug/Nm3	1	<	3.3	<	1	<	2.1	<	3.3	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	1	<	1.13	<	0.35	<	0.73	<	1.13	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	1	<	1.6	<	0.4	<	1	<	1.6	---
2-Chloronaphthalene	CARB 429	ug/Nm3	1		0.000068		0.000076 E	<	0.000054		0.000057	0.000065
2-Chlorophenol	SW8270	ug/Nm3	1	<	1.06	<	0.2	<	0.63	<	1.1	---
2-Methylnaphthalene	CARB 429	ug/Nm3	1		0.281		0.0614		0.0543		0.132	0.32
2-Methylphenol	SW8270	ug/Nm3	1	<	1.3	<	0.24	<	0.76	<	1.3	---
2-Nitroaniline	SW8270	ug/Nm3	1	<	1.45	<	0.46	<	0.95	<	1.5	---
2-Nitrophenol	SW8270	ug/Nm3	1	<	1.7	<	0.4	<	1	<	1.7	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	1	<	1.07	<	0.38	<	0.73	<	1.1	---
3-Nitroaniline	SW8270	ug/Nm3	1	<	1.7	<	0.4	<	1	<	1.7	---
3/4-Methylphenol	SW8270	ug/Nm3	1	<	1.16	<	0.22	<	0.69	<	1.2	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	1	<	2.2	<	0.8	<	1.4	<	2.2	---
4-Aminobiphenyl	SW8270	ug/Nm3	1	<	0.48	<	0.14	<	0.29	<	0.48	---
4-Bromophenyl-phenylether	SW8270	ug/Nm3	1	<	1.43	<	0.49	<	0.9	<	1.4	---
4-Chloro-3-methylphenol	SW8270	ug/Nm3	1	<	1.15	<	0.25	<	0.69	<	1.2	---
4-Chloroaniline	SW8270	ug/Nm3	1	<	0.89	<	0.17	<	0.52	<	0.89	---
4-Chlorophenyl-phenylether	SW8270	ug/Nm3	1	<	0.8	<	0.3	<	0.55	<	0.8	---
4-Nitroaniline	SW8270	ug/Nm3	1	<	1.6	<	0.5	<	1	<	1.6	---
4-Nitrophenol	SW8270	ug/Nm3	1	<	1.9	<	0.8	<	1.4	<	1.9	---
Acenaphthene	CARB 429	ug/Nm3	1		0.00929		0.00339		0.00451		0.00573	0.0078
Acenaphthylene	CARB 429	ug/Nm3	1		0.00481		0.00179		0.00175		0.00278	0.0044
Acetophenone	SW8270	ug/Nm3	1	<	0.88	<	0.8	<	0.43	<	0.88	---
Aniline	SW8270	ug/Nm3	1	<	0.74	<	0.13	<	0.43	<	0.74	---
Anthracene	CARB 429	ug/Nm3	1		0.00252		0.00107		0.00109		0.00156	0.0021
Benzidine	SW8270	ug/Nm3	1	<	0.64	<	0.23	<	0.44	<	0.64	---

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
Benzo(a)anthracene	CARB 429	ug/Nm3	1		0.000338		0.000277		0.000271		0.000295	0.000092
Benzo(a)pyrene	CARB 429	ug/Nm3	1		0.000353		0.000332		0.000351		0.000345	0.000029
Benzo(b)fluoranthene	CARB 429	ug/Nm3	1		0.000705		0.000654		0.000616		0.000658	0.00011
Benzo(e)pyrene	CARB 429	ug/Nm3	1		0.00129		0.00121		0.00151		0.00134	0.00039
Benzo(g,h,i)perylene	CARB 429	ug/Nm3	1		0.00312		0.00297		0.00284		0.00298	0.00035
Benzo(k)fluoranthene	CARB 429	ug/Nm3	1		0.000226		0.000165		0.000178		0.00019	0.00008
Benzoic acid	SW8270	ug/Nm3	1	<	2.3	<	0.4	<	1.3	<	2.3	---
Benzyl alcohol	SW8270	ug/Nm3	1	<	1.6	<	1.7	<	0.8	<	1.7	---
Butylbenzylphthalate	SW8270	ug/Nm3	1	<	0.67	<	0.19	<	0.43	<	0.67	---
Chrysene	CARB 429	ug/Nm3	1		0.000631		0.000551		0.000688		0.000623	0.00017
Di-n-butylphthalate	SW8270	ug/Nm3	1	<	0.33	<	0.33	<	0.33	<	0.33	---
Di-n-octylphthalate	SW8270	ug/Nm3	1	<	0.39	<	0.09	<	0.25	<	0.25	---
Dibenz(a,h)anthracene	CARB 429	ug/Nm3	1	<	0.000048	<	0.000040	<	0.000038	<	0.000048	---
Dibenzofuran	SW8270	ug/Nm3	1	<	0.31	<	0.09	<	0.2	<	0.31	---
Diethylphthalate	SW8270	ug/Nm3	1	<	0.87	<	0.84	<	0.17	<	0.87	---
Dimethylaminoazobenzene	SW8270	ug/Nm3	1	<	0.32	<	0.45	<	0.85	<	0.85	---
Dimethylphthalate	SW8270	ug/Nm3	1	<	0.41	<	0.11	<	0.26	<	0.41	---
Fluoranthene	CARB 429	ug/Nm3	1		0.00695		0.00431		0.00477		0.00534	0.0035
Fluorene	CARB 429	ug/Nm3	1		0.0399		0.0119		0.0117		0.0212	0.04
Hexachlorobenzene	SW8270	ug/Nm3	1	<	1.05	<	0.36	<	0.66	<	1.1	---
Hexachlorobutadiene	SW8270	ug/Nm3	1	<	1.3	<	0.46	<	0.88	<	1.3	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	1	<	1.34	<	0.4	<	0.86	<	1.3	---
Hexachloroethane	SW8270	ug/Nm3	1	<	1.55	<	0.39	<	0.97	<	1.6	---
Indeno(1,2,3-cd)pyrene	CARB 429	ug/Nm3	1		0.000599		0.000584		0.000564		0.000582	0.000044
Isophorone	SW8270	ug/Nm3	1	<	0.59	<	0.13	<	0.36	<	0.59	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	1	<	1.7	<	0.4	<	1.1	<	1.7	---
Naphthalene	CARB 429	ug/Nm3	1		0.0336		0.0294		0.0795		0.0475	0.069
Nitrobenzene	SW8270	ug/Nm3	1	<	1.04	<	0.22	<	0.62	<	1	---
Pentachloronitrobenzene	SW8270	ug/Nm3	1	<	2.8	<	1	<	1.8	<	2.8	---
Pentachlorophenol	SW8270	ug/Nm3	1	<	2.2	<	0.6	<	1.3	<	2.2	---
Perylene	CARB 429	ug/Nm3	1		0.000105		0.000115		0.000149		0.000123	0.000057
Phenanthrene	CARB 429	ug/Nm3	1		0.0481		0.0247		0.0261		0.033	0.033

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
Phenol	SW8270	ug/Nm3	1	<	1.6	<	1.7	<	1.7	<	1.7	---
Pyrene	CARB 429	ug/Nm3	1		0.00636		0.00419		0.00556		0.00537	0.0027
bis(2-Chloroethoxy)methane	SW8270	ug/Nm3	1	<	1.07	<	0.19	<	0.62	<	1.1	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	1	<	1.47	<	0.23	<	0.84	<	1.5	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	1		12.7	<		<			4.23	18
n-Nitrosodimethylamine	SW8270	ug/Nm3	1	<	3	<	0.7	<	1.8	<	3	---
PAHs/SVOCs-Vapor Phase												
1,2,4-Trichlorobenzene	SW8270	ug/Nm3	1	<	0.8	<	0.87	<	0.92	<	0.92	---
1,2-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.82	<	0.89	<	0.96	<	0.96	---
1,3-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.83	<	0.9	<	0.92	<	0.92	---
1,4-Dichlorobenzene	SW8270	ug/Nm3	1	<	0.78	<	0.85	<	0.9	<	0.9	---
2,2'-oxybis(1-Chloropropane)	SW8270	ug/Nm3	1	<	1.1	<	1.2	<	1.3	<	1.3	---
2,4,5-Trichlorophenol	SW8270	ug/Nm3	1	<	1	<	1	<	1.2	<	1.2	---
2,4,6-Trichlorophenol	SW8270	ug/Nm3	1	<	1.2	<	1.2	<	1.2	<	1.2	---
2,4-Dichlorophenol	SW8270	ug/Nm3	1	<	1	<	1.1	<	1.1	<	1.1	---
2,4-Dimethylphenol	SW8270	ug/Nm3	1	<	0.9	<	1	<	1.1	<	1.1	---
2,4-Dinitrophenol	SW8270	ug/Nm3	1	<	2.5	<	2.5	<	3.2	<	3.2	---
2,4-Dinitrotoluene	SW8270	ug/Nm3	1	<	1.1	<	1.1	<	1.3	<	1.3	---
2,6-Dinitrotoluene	SW8270	ug/Nm3	1	<	1.6	<	1.6	<	1.8	<	1.8	---
2-Chloronaphthalene	CARB 429	ug/Nm3	1		0.000136		0.000080		0.000105		0.000107	0.000070
2-Chlorophenol	SW8270	ug/Nm3	1	<	0.89	<	0.97	<	1.1	<	1.1	---
2-Methylnaphthalene	CARB 429	ug/Nm3	1		0.0818		0.0721		0.0626		0.0722	0.024
2-Methylphenol	SW8270	ug/Nm3	1	<		<	1.3	<	1.3	<	1.3	---
2-Nitroaniline	SW8270	ug/Nm3	1	<	1.4	<	1.4	<	1.6	<	1.6	---
2-Nitrophenol	SW8270	ug/Nm3	1	<	1.5	<	1.6	<	1.7	<	1.7	---
3,3'-Dichlorobenzidine	SW8270	ug/Nm3	1	<	0.75	<	0.69	<	1.4	<	1.4	---
3-Nitroaniline	SW8270	ug/Nm3	1	<	1.5	<	1.5	<	1.8	<	1.8	---
3/4-Methylphenol	SW8270	ug/Nm3	1	<	1.1	<	1.2	<	1.2	<	1.2	---
4,6-Dinitro-2-methylphenol	SW8270	ug/Nm3	1	<	1.7	<	1.7	<	2.1	<	2.1	---
4-Aminobiphenyl	SW8270	ug/Nm3	1	<	0.51	<	0.51	<	0.49	<	0.51	---
4-Bromophenyl-phenylether	SW8270	ug/Nm3	1	<	1.3	<	1.3	<	1.5	<	1.5	---
4-Chloro-3-methylphenol	SW8270	ug/Nm3	1	<	1	<	1.1	<	1.1	<	1.1	---

Table G-1. Analytical Results Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)												
4-Chloroaniline	SW8270	ug/Nm3	1	<	0.77	<	0.84	<	0.88	<	0.88	---
4-Chlorophenyl-phenylether	SW8270	ug/Nm3	1	<	0.82	<	0.81	<	0.9	<	0.9	---
4-Nitroaniline	SW8270	ug/Nm3	1	<	1.4	<	1.4	<	1.9	<	1.9	---
4-Nitrophenol	SW8270	ug/Nm3	1	<	1.5	<	1.5	<	2.2	<	2.2	---
Acenaphthene	CARB 429	ug/Nm3	1		0.00938		0.00915		0.00818		0.0089	0.0016
Acenaphthylene	CARB 429	ug/Nm3	1		0.00605		0.00713		0.00478		0.00599	0.0029
Acetophenone	SW8270	ug/Nm3	1	<		<		<		<	0	---
Aniline	SW8270	ug/Nm3	1	<	0.76	<	0.75	<	0.75	<	0.76	---
Anthracene	CARB 429	ug/Nm3	1		0.00175		0.00249		0.00261		0.00228	0.0012
Benzidine	SW8270	ug/Nm3	1	<	0.8	<	0.82	<	0.82	<	0.82	---
Benzo(a)anthracene	CARB 429	ug/Nm3	1		0.000925		0.00129		0.000766		0.000994	0.00067
Benzo(a)pyrene	CARB 429	ug/Nm3	1		0.000493		0.000816		0.000597		0.000635	0.00041
Benzo(b)fluoranthene	CARB 429	ug/Nm3	1		0.00161		0.00207		0.00177		0.00182	0.00058
Benzo(e)pyrene	CARB 429	ug/Nm3	1		0.00151		0.00173		0.00205		0.00176	0.00067
Benzo(g,h,i)perylene	CARB 429	ug/Nm3	1		0.00175		0.00303		0.00229		0.00236	0.0016
Benzo(k)fluoranthene	CARB 429	ug/Nm3	1		0.000419		0.000563		0.000334		0.000439	0.00029
Benzoic acid	SW8270	ug/Nm3	1		70.4		97.5		71.4		79.8	38
Benzyl alcohol	SW8270	ug/Nm3	1	<	1.5	<	1.5	<	1.5	<	1.5	---
Butylbenzylphthalate	SW8270	ug/Nm3	1	<	0.41	<	0.37	<	0.8	<	0.8	---
Chrysene	CARB 429	ug/Nm3	1		0.00186		0.00207		0.00185		0.00193	0.00031
Di-n-butylphthalate	SW8270	ug/Nm3	1		26.1		269 E		17.5		104	350
Di-n-octylphthalate	SW8270	ug/Nm3	1	<	0.21	<	0.18	<	0.41	<	0.41	---
Dibenz(a,h)anthracene	CARB 429	ug/Nm3	1		0.000159	<	0.00016		0.000149	<	0.00016	---
Dibenzofuran	SW8270	ug/Nm3	1	<	0.31	<	0.31	<	0.34	<	0.34	---
Diethylphthalate	SW8270	ug/Nm3	1	<	1.4	<	1.4	<	1.4	<	1.4	---
Dimethylaminoazobenzene	SW8270	ug/Nm3	1	<	1.5	<	1.6	<	1.6	<	1.6	---
Dimethylphthalate	SW8270	ug/Nm3	1	<	0.39	<	0.39	<	0.45	<	0.45	---
Fluoranthene	CARB 429	ug/Nm3	1		0.0124		0.0161		0.0149		0.0145	0.0047
Fluorene	CARB 429	ug/Nm3	1		0.0149		0.0135		0.0164		0.0149	0.0036
Hexachlorobenzene	SW8270	ug/Nm3	1	<	0.9	<	1	<	1.1	<	1.1	---
Hexachlorobutadiene	SW8270	ug/Nm3	1	<	1.2	<	1.4	<	1.4	<	1.4	---
Hexachlorocyclopentadiene	SW8270	ug/Nm3	1	<	1.8	<	1.8	<	1.4	<	1.8	---

Table G-1. Analytical Results Used in Calculations

Stream: ***Turbine Exhaust Gas (13)***

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
PAHs/SVOCs-Vapor Phase (continued)								
Hexachloroethane	SW8270	ug/Nm3	1	< 1.5	< 1.6	< 1.6	< 1.6	---
Indeno(1,2,3-cd)pyrene	CARB 429	ug/Nm3	1	0.000841	0.00106	0.00103	0.000977	0.00029
Isophorone	SW8270	ug/Nm3	1	< 0.54	< 0.59	< 0.63	< 0.63	---
N-Nitroso-di-n-propylamine	SW8270	ug/Nm3	1	< 1.8	< 2	< 1.8	< 2	---
Naphthalene	CARB 429	ug/Nm3	1	0.0113	0.276	0.245	0.177	0.36
Nitrobenzene	SW8270	ug/Nm3	1	< 0.91	< 0.99	< 1.04	< 1.04	---
Pentachloronitrobenzene	SW8270	ug/Nm3	1	< 3	< 3	< 2.9	< 3	---
Pentachlorophenol	SW8270	ug/Nm3	1	< 1.4	< 1.4	< 1.8	< 1.8	---
Perylene	CARB 429	ug/Nm3	1	0.000138	0.000417	0.00023	0.000262	0.00035
Phenanthrene	CARB 429	ug/Nm3	1	0.0449	0.0386	0.0527	0.0454	0.018
Phenol	SW8270	ug/Nm3	1	< 0.74	< 0.74	< 0.74	< 0.74	---
Pyrene	CARB 429	ug/Nm3	1	0.0117	0.0182	0.0122	0.014	0.009
bis(2-Chloroethoxy)methane	SW8270	ug/Nm3	1	< 1	< 1.1	< 1.1	< 1.1	---
bis(2-Chloroethyl)ether	SW8270	ug/Nm3	1	< 1.2	< 1.3	< 1.5	< 1.5	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/Nm3	1	< 0.65	< 0.65	< 0.65	< 0.65	---
n-Nitrosodimethylamine	SW8270	ug/Nm3	1	< 3.3	< 3.3	< 3.3	< 3.3	---

Table G-1. Analytical Results Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate/Proximate/HHV									
Moisture, total	D3302	Wt. %	1	29.1	28.2	28.4		28.6	1.2
Moisture, total	D3302	Wt. %	2	29.0	28.7	28.6	28.6	28.8	0.52
Moisture, total	D3302	Wt. %	3	29.1	28.9	28.7		28.9	0.5
Ash	D3174	Wt. %	1	6.61	6.56	7.33		6.83	1.1
Ash	D3174	Wt. %	2	6.55	6.29	7.33		6.72	1.3
Ash	D3174	Wt. %	3	6.88	6.79	6.31		6.66	0.76
Carbon	D5373	Wt. %	1	69.3	70.6	70.1		70	1.6
Carbon	D5373	Wt. %	2	70.4	70.3	69.7		70.1	0.94
Carbon	D5373	Wt. %	3	69.4	70.2	69.5		69.7	1.1
Fixed Carbon	D3172	Wt. %	1	47.2	47.8	47.2		47.4	0.86
Fixed Carbon	D3172	Wt. %	2	47	48	46.7		47.2	1.7
Fixed Carbon	D3172	Wt. %	3	46.2	47.2	47.7		47	1.9
HHV	D2015	Btu/lb	1	11,900	11,800	12,100		11,900	380
HHV	D2015	Btu/lb	2	12,000	12,000	11,900		12,000	140
HHV	D2015	Btu/lb	3	12,000	11,900	11,900		11,900	140
Hydrogen	D5373	Wt. %	1	4.5	4.63	4.65		4.59	0.2
Hydrogen	D5373	Wt. %	2	4.6	4.6	4.58		4.59	0.029
Hydrogen	D5373	Wt. %	3	4.75	4.62	4.83		4.73	0.26
Nitrogen	D5373	Wt. %	1	1.04	0.99	0.98		1	0.08
Nitrogen	D5373	Wt. %	2	0.98	1	0.99		0.99	0.025
Nitrogen	D5373	Wt. %	3	0.97	0.98	0.97		0.973	0.014
Oxygen (by difference)	D3176	Wt. %	1	18.2	17	16.7		17.3	2
Oxygen (by difference)	D3176	Wt. %	2	17.2	17.5	17.1		17.3	0.52
Oxygen (by difference)	D3176	Wt. %	3	17.7	17.1	18.1		17.6	1.3
Sulfur	D4239	Wt. %	1	0.29	0.27	0.27		0.277	0.029
Sulfur	D4239	Wt. %	2	0.28	0.29	0.29		0.287	0.014
Sulfur	D4239	Wt. %	3	0.29	0.29	0.29		0.29	---
Volatile Matter	D3175	Wt. %	1	46.2	45.6	45.5		45.8	0.94
Volatile Matter	D3175	Wt. %	2	46.5	45.7	46		46.1	1
Volatile Matter	D3175	Wt. %	3	46.9	46	46		46.3	1.3

Table G-1. Analytical Results Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208/IC	ug/g	1	41.5	36.6	35.8		38	7.7
Chloride	D4208/IC	ug/g	2	34.9	49.5	28		37.5	27
Chloride	D4208/IC	ug/g	3	48.9	32.2	43.2		41.4	21
Fluoride	D3751/IC	ug/g	1	90.9	161	62.9		105	130
Fluoride	D3751/IC	ug/g	2	75.3	52.4	58.8		62.2	29
Fluoride	D3751/IC	ug/g	3	79.4	44.8	60.2		61.5	43
Metals									
Aluminum	D4326	Wt. %	1	0.57	0.65	0.73		0.65	0.2
Aluminum	D4326	Wt. %	2	0.61	0.6	0.67		0.627	0.094
Aluminum	D4326	Wt. %	3	0.63	0.62	0.56		0.603	0.094
Antimony	ICP/MS	ug/g	1	0.111 C	0.113 C	0.194 C		0.139	0.12
Antimony	ICP/MS	ug/g	2	0.0881 C	0.132 C	0.126 C		0.115	0.059
Antimony	ICP/MS	ug/g	3	0.109 C	0.119 C	0.0999 C		0.109	0.024
Arsenic	ICP/MS	ug/g	1	1.04 C	0.863 C	1.09 C		0.998	0.3
Arsenic	ICP/MS	ug/g	2	0.983 C	0.87 C	1.09 C		0.981	0.27
Arsenic	ICP/MS	ug/g	3	0.939 C	1.01 C	0.926 C		0.958	0.11
Barium	SW6010	ug/g	1	41	330	400		257	470
Barium	SW6010	ug/g	2	400	410	440		417	52
Barium	SW6010	ug/g	3	400	410	450		420	66
Beryllium	ICP/MS	ug/g	1	0.21	0.253	0.292		0.252	0.1
Beryllium	ICP/MS	ug/g	2	0.281	0.274	0.262		0.272	0.024
Beryllium	ICP/MS	ug/g	3	0.287	0.348	0.248		0.294	0.13
Boron	SW6010	ug/g	1	31	31	30		30.7	1.4
Boron	SW6010	ug/g	2	31	31	34		32	4.3
Boron	SW6010	ug/g	3	33	32	31		32	2.5
Cadmium	ICP/MS	ug/g	1	0.121 C	0.08 C	0.0756 C		0.0922	0.062
Cadmium	ICP/MS	ug/g	2	0.106 C	0.064 C	0.0991 C		0.0897	0.056
Cadmium	ICP/MS	ug/g	3	0.151 C	0.0353 C	0.185 C		0.124	0.19
Calcium	D4326	Wt. %	1	0.99	1.08	1.05		1.04	0.11
Calcium	D4326	Wt. %	2	1.04	1.07	1.19		1.1	0.2
Calcium	D4326	Wt. %	3	1.04	1.06	1.01		1.04	0.063
Chromium	ICP/MS	ug/g	1	6.64 C	4.05 C	5.49 C		5.39	3.2

Table G-1. Analytical Results Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Chromium	ICP/MS	ug/g	2	3.86 C	3.85 C	5.62 C		4.44	2.5
Chromium	ICP/MS	ug/g	3	4.36 C	4.37 C	4.32 C		4.35	0.066
Cobalt	ICP/MS	ug/g	1	1.99 C	1.74 C	2.16 C		1.96	0.52
Cobalt	ICP/MS	ug/g	2	1.77 C	1.73 C	2.05 C		1.85	0.43
Cobalt	ICP/MS	ug/g	3	1.87 C	1.88 C	1.89 C		1.88	0.025
Copper	ICP/MS	ug/g	1	11.8 C	10.8 C	12.6 C		11.7	2.2
Copper	ICP/MS	ug/g	2	10.2 C	10.2 C	13.2 C		11.2	4.3
Copper	ICP/MS	ug/g	3	11.8 C	12.1 C	11.6 C		11.8	0.63
Iron	D4326	Wt. %	1	0.23	0.24	0.24		0.237	0.014
Iron	D4326	Wt. %	2	0.24	0.24	0.27		0.25	0.043
Iron	D4326	Wt. %	3	0.23	0.25	0.23		0.237	0.029
Lead	ICP/MS	ug/g	1	1.39 C	1.13 C	1.87 C		1.46	0.93
Lead	ICP/MS	ug/g	2	1.37 C	1.1 C	1.36 C		1.28	0.38
Lead	ICP/MS	ug/g	3	1.47 C	0.99 C	1.4 C		1.29	0.64
Magnesium	D4326	Wt. %	1	0.21	0.23	0.22		0.22	0.025
Magnesium	D4326	Wt. %	2	0.22	0.22	0.25		0.23	0.043
Magnesium	D4326	Wt. %	3	0.22	0.22	0.21		0.217	0.014
Manganese	ICP/MS	ug/g	1	9.98 C	9.12 C	10.3 C		9.8	1.5
Manganese	ICP/MS	ug/g	2	8.94 C	8.93 C	11.3 C		9.72	3.4
Manganese	ICP/MS	ug/g	3	9.99 C	9.49 C	10.6 C		10	1.4
Mercury	DGA/CVAA	ug/g	1	0.13	0.13	0.09		0.117	0.057
Mercury	DGA/CVAA	ug/g	2	0.11	0.09	0.12		0.107	0.038
Mercury	DGA/CVAA	ug/g	3	0.11	0.1	0.09		0.1	0.025
Molybdenum	ICP/MS	ug/g	1	0.642 C	0.473 C	0.625 C		0.58	0.23
Molybdenum	ICP/MS	ug/g	2	0.531 C	0.549 C	0.617 C		0.566	0.11
Molybdenum	ICP/MS	ug/g	3	0.572 C	0.478 C	0.453 C		0.501	0.16
Nickel	SW6010	ug/g	1	3	1	1		1.67	2.9
Nickel	SW6010	ug/g	2	2	1	2		1.67	1.4
Nickel	SW6010	ug/g	3	2	1	1		1.33	1.4
Phosphorus	D4326	Wt. %	1	0.03	0.03	0.03		0.03	---
Phosphorus	D4326	Wt. %	2	0.03	0.03	0.03		0.03	---
Phosphorus	D4326	Wt. %	3	0.03	0.03	0.03		0.03	---

Table G-1. Analytical Results Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Potassium	D4326	Wt. %	1	0.02	0.02	0.03		0.0233	0.014
Potassium	D4326	Wt. %	2	0.02	0.02	0.02		0.02	---
Potassium	D4326	Wt. %	3	0.02	0.02	0.02		0.02	---
Selenium	ICP/MS	ug/g	1	2.64	2.14	12.3		5.69	14
Selenium	ICP/MS	ug/g	2	2.26	1.72	2.56		2.18	1.1
Selenium	ICP/MS	ug/g	3	2.28	1.8	2.47		2.18	0.86
Silicon	D4326	Wt. %	1	1.15	1.02	1.28		1.15	0.32
Silicon	D4326	Wt. %	2	1.01	0.97	1.17		1.05	0.26
Silicon	D4326	Wt. %	3	1.13	1.12	0.99		1.08	0.19
Sodium	D4326	Wt. %	1	0.1	0.1	0.1		0.1	---
Sodium	D4326	Wt. %	2	0.1	0.1	0.11		0.103	0.014
Sodium	D4326	Wt. %	3	0.11	0.1	0.1		0.103	0.014
Strontium	D4326	Wt. %	1	0.02	0.02	0.02		0.02	---
Strontium	D4326	Wt. %	2	0.02	0.02	0.02		0.02	---
Strontium	D4326	Wt. %	3	0.02	0.02	0.02		0.02	---
Titanium	D4326	Wt. %	1	0.05	0.06	0.07		0.06	0.025
Titanium	D4326	Wt. %	2	0.05	0.05	0.07		0.0567	0.029
Titanium	D4326	Wt. %	3	0.07	0.05	0.05		0.0567	0.029
Vanadium	ICP/MS	ug/g	1	13	12.1	14.8		13.3	3.4
Vanadium	ICP/MS	ug/g	2	11.5	11.4	13.9		12.3	3.5
Vanadium	ICP/MS	ug/g	3	12.3	11.9	12.5		12.2	0.76
Zinc	SW6010	ug/g	1	9	8	6		7.67	3.8
Zinc	SW6010	ug/g	2	8	7	8		7.67	1.4
Zinc	SW6010	ug/g	3	9	7	9		8.33	2.9
Radionuclides									
Actinium-228 @338 KeV	gamma	pCi/g	3	0.05	-0.07	0.16		0.047	0.29
Actinium-228 @911 KeV	gamma	pCi/g	3	-0.06	0.3	0.11		0.12	0.45
Actinium-228 @968 KeV	gamma	pCi/g	3	0.02	0.53	-0.12		0.14	0.85
Bismuth-212 @727 KeV	gamma	pCi/g	3	0.41	-0.5	-0.71		-0.27	1.5
Bismuth-214 @1120 KeV	gamma	pCi/g	3	0.34	0.26	0.33		0.31	0.11
Bismuth-214 @1764 KeV	gamma	pCi/g	3	0.6	0.15	0.21		0.32	0.61
Bismuth-214 @609 KeV	gamma	pCi/g	3	0.25	0.12	0.11		0.16	0.19

Table G-1. Analytical Results Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Radionuclides (continued)									
Lead-210 @46 KeV	gamma	pCi/g	3	1.2	0	0.00		0.4	1.7
Lead-212 @238 KeV	gamma	pCi/g	3	0.14	0.12	0.12		0.13	0.029
Lead-214 @295 KeV	gamma	pCi/g	3	0.26	0.2	0.17		0.21	0.11
Lead-214 @351 KeV	gamma	pCi/g	3	0.13	0.14	0.18		0.15	0.066
Potassium-40 @1460 KeV	gamma	pCi/g	3	-0.09	-0.024	0.00		-0.038	0.12
Radium-226 @226 KeV	gamma	pCi/g	3	0.06	0.04	0.07		0.057	0.038
Thallium-208 @583 KeV	gamma	pCi/g	3	0.01	0.03	0.07		0.037	0.076
Thallium-208 @860 KeV	gamma	pCi/g	3	0.21	-0.44	-0.46		-0.23	0.95
Thorium-234 @63 KeV	gamma	pCi/g	3	0.24	0.14	0.01		0.13	0.29
Thorium-234 @92 KeV	gamma	pCi/g	3	-0.13	0.13	0.14		0.047	0.38
Uranium-235 @143 KeV	gamma	pCi/g	3	0.03	0.00	-0.1		-0.023	0.17

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate/Proximate/HHV									
% Solids in Slurry	D3302	Wt. %	1	55.4	54.2	54.8		54.8	1.5
% Solids in Slurry	D3302	Wt. %	2	54.5	54.7	54.4		54.5	0.38
% Solids in Slurry	D3302	Wt. %	3	54.7	55.1	54.3	54.6	54.7	0.99
Ash	D3174	Wt. %	1	6.35	6.26	6.5		6.37	0.3
Ash	D3174	Wt. %	2	6.52	6.29	6.39		6.4	0.29
Ash	D3174	Wt. %	3	6.33	6.48	6.3	6.09	6.37	0.24
Carbon	D5373	Wt. %	1	70.1	69.5	68.9		69.5	1.5
Carbon	D5373	Wt. %	2	68.2	68.7	68.6		68.5	0.66
Carbon	D5373	Wt. %	3	69.3	69.1	68.8	69.3	69.1	0.63
Fixed Carbon	D3172	Wt. %	1	47.5	48	47.1		47.5	1.1
Fixed Carbon	D3172	Wt. %	2	47.9	48	48.2		48	0.38
Fixed Carbon	D3172	Wt. %	3	47.9	48.2	48.5	48.3	48.2	0.75
HHV	D2015	Btu/lb	1	12,000	12,000	12,000		12,000	---
HHV	D2015	Btu/lb	2	12,000	12,000	12,000		12,000	---
HHV	D2015	Btu/lb	3	11,900	11,900	11,900	12,000	11,900	---
Hydrogen	D5373	Wt. %	1	4.64	4.74	4.74		4.71	0.14
Hydrogen	D5373	Wt. %	2	4.84	4.94	4.79		4.86	0.19
Hydrogen	D5373	Wt. %	3	4.67	4.63	4.91	4.75	4.74	0.38
Nitrogen	D5373	Wt. %	1	1.03	1.03	0.99		1.02	0.057
Nitrogen	D5373	Wt. %	2	1.02	1.05	1.06		1.04	0.052
Nitrogen	D5373	Wt. %	3	1.03	1.03	1.02	1.03	1.03	0.014
Oxygen (by difference)	D3176	Wt. %	1	17.6	18.2	18.6		18.1	1.3
Oxygen (by difference)	D3176	Wt. %	2	19.1	18.7	18.9		18.9	0.5
Oxygen (by difference)	D3176	Wt. %	3	18.4	18.4	18.7	18.6	18.5	0.43
Sulfur	D4239	Wt. %	1	0.29	0.27	0.27		0.277	0.029
Sulfur	D4239	Wt. %	2	0.27	0.28	0.28		0.277	0.014
Sulfur	D4239	Wt. %	3	0.28	0.29	0.28	0.28	0.283	0.014
Volatile Matter	D3175	Wt. %	1	46.1	45.7	46.4		46.1	0.87
Volatile Matter	D3175	Wt. %	2	45.6	45.8	45.5		45.6	0.38
Volatile Matter	D3175	Wt. %	3	45.7	45.3	45.2	45.6	45.4	0.66

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208/IC	ug/g	1	61.5	36.2	50.5		49.4	32
Chloride	D4208/IC	ug/g	2	33.8	39.3	34.3		35.8	7.6
Chloride	D4208/IC	ug/g	3	49.3	42.1	42.15		44.5	10
Fluoride	D3751/IC	ug/g	1	42.1	37.7	42.6		40.8	6.7
Fluoride	D3751/IC	ug/g	2	41	41	46.6		42.9	8
Fluoride	D3751/IC	ug/g	3	52.1	58.3	41.95		50.8	21
Metals									
Aluminum	D4326	Wt. %	1	0.55	0.59	0.61		0.583	0.076
Aluminum	D4326	Wt. %	2	0.6	0.57	0.57		0.58	0.043
Aluminum	D4326	Wt. %	3	0.57	0.59	0.58	0.55	0.58	0.025
Antimony	ICP/MS	ug/g	1	0.181 C	0.0749 C	0.12 C		0.125	0.13
Antimony	ICP/MS	ug/g	2	0.0746 C	0.0876 C	0.103 C		0.0884	0.035
Antimony	ICP/MS	ug/g	3	0.0367 C	0.111 C	0.109 C	0.101 C	0.0856	0.11
Arsenic	ICP/MS	ug/g	1	0.801 C	0.566 C	0.843 C		0.737	0.37
Arsenic	ICP/MS	ug/g	2	0.621 C	0.75 C	0.864 C		0.745	0.3
Arsenic	ICP/MS	ug/g	3	0.441 C	0.89 C	0.907 C	0.894 C	0.746	0.66
Barium	SW6010	ug/g	1	390	410	390		397	29
Barium	SW6010	ug/g	2	400	380	390		390	25
Barium	SW6010	ug/g	3	390	380	410	410	393	38
Beryllium	ICP/MS	ug/g	1	0.241	0.193	0.21		0.215	0.06
Beryllium	ICP/MS	ug/g	2	0.165	0.232	0.213		0.203	0.086
Beryllium	ICP/MS	ug/g	3	0.0955	0.238	0.272	0.227	0.202	0.23
Boron	SW6010	ug/g	1	30	26	28		28	5
Boron	SW6010	ug/g	2	28	28	26		27.3	2.9
Boron	SW6010	ug/g	3	26	19	24	30	23	9
Cadmium	ICP/MS	ug/g	1	0.0617 C	0.0778 C	0.0537 C		0.0644	0.03
Cadmium	ICP/MS	ug/g	2	0.0623 C	0.064 C	0.106 C		0.0774	0.061
Cadmium	ICP/MS	ug/g	3	0.054 C	0.108 C	0.08 C	0.113 C	0.0807	0.067
Calcium	D4326	Wt. %	1	1.03	1.01	1		1.01	0.038
Calcium	D4326	Wt. %	2	1.02	0.98	1.03		1.01	0.066
Calcium	D4326	Wt. %	3	1.04	1.05	1.04	0.98	1.04	0.014
Chromium	ICP/MS	ug/g	1	3.84 C	2.73 C	4.09 C		3.55	1.8

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Chromium	ICP/MS	ug/g	2	2.52 C	2.36 C	3.91 C		2.93	2.1
Chromium	ICP/MS	ug/g	3	2.18 C	3.72 C	4.21 C	4.06 C	3.37	2.6
Cobalt	ICP/MS	ug/g	1	1.84 C	1.21 C	1.58 C		1.54	0.79
Cobalt	ICP/MS	ug/g	2	1.14 C	1.65 C	1.72 C		1.5	0.79
Cobalt	ICP/MS	ug/g	3	0.985 C	1.74 C	2.02 C	1.81 C	1.58	1.3
Copper	ICP/MS	ug/g	1	10.5 C	7.7 C	10.1 C		9.43	3.8
Copper	ICP/MS	ug/g	2	6.71 C	10.6 C	10.4 C		9.24	5.4
Copper	ICP/MS	ug/g	3	6.75 C	11 C	12.3 C	11.5 C	10	7.2
Iron	D4326	Wt. %	1	0.23	0.21	0.22		0.22	0.025
Iron	D4326	Wt. %	2	0.22	0.22	0.23		0.223	0.014
Iron	D4326	Wt. %	3	0.23	0.24	0.24	0.22	0.237	0.014
Lead	ICP/MS	ug/g	1	1.01 C	0.573 C	0.878 C		0.82	0.56
Lead	ICP/MS	ug/g	2	0.602 C	0.803 C	1.06 C		0.822	0.57
Lead	ICP/MS	ug/g	3	0.59 C	1 C	1.1 C	1.01 C	0.897	0.67
Magnesium	D4326	Wt. %	1	0.21	0.22	0.21		0.213	0.014
Magnesium	D4326	Wt. %	2	0.22	0.21	0.21		0.213	0.014
Magnesium	D4326	Wt. %	3	0.22	0.22	0.21	0.21	0.217	0.014
Manganese	ICP/MS	ug/g	1	9.17 C	6.52 C	8.58 C		8.09	3.5
Manganese	ICP/MS	ug/g	2	5.83 C	8.55 C	9.41 C		7.93	4.6
Manganese	ICP/MS	ug/g	3	5.29 C	8.75 C	10.1 C	9.51 C	8.05	6.2
Mercury	DGA/CVAA	ug/g	1	0.1	0.1	0.1		0.1	---
Mercury	DGA/CVAA	ug/g	2	0.1	0.08	0.2		0.127	0.16
Mercury	DGA/CVAA	ug/g	3	0.08	0.1	0.1	0.08	0.0933	0.029
Molybdenum	ICP/MS	ug/g	1	0.574 C	0.37 C	0.49 C		0.478	0.25
Molybdenum	ICP/MS	ug/g	2	0.362 C	0.534 C	0.566 C		0.487	0.27
Molybdenum	ICP/MS	ug/g	3	0.286 C	0.592 C	0.606 C	0.573 C	0.495	0.45
Nickel	SW6010	ug/g	1	2	2	1		1.67	1.4
Nickel	SW6010	ug/g	2	2	2	1		1.67	1.4
Nickel	SW6010	ug/g	3	2	1	3	< 1	2	2.5
Phosphorus	D4326	Wt. %	1	0.03	0.03	0.03		0.03	---
Phosphorus	D4326	Wt. %	2	0.03	0.02	0.03		0.0267	0.014
Phosphorus	D4326	Wt. %	3	0.03	0.03	0.03	0.03	0.03	---

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Potassium	D4326	Wt. %	1	0.02	0.02	0.02		0.02	---
Potassium	D4326	Wt. %	2	0.02	0.02	0.02		0.02	---
Potassium	D4326	Wt. %	3	0.02	0.02	0.02	0.02	0.02	---
Selenium	ICP/MS	ug/g	1	2.04	0.722	1.44		1.4	1.6
Selenium	ICP/MS	ug/g	2	0.787	1.54	1.9		1.41	1.4
Selenium	ICP/MS	ug/g	3	<	1.76	1.99	2.09	1.25	2.7
Silicon	D4326	Wt. %	1	0.97	0.96	1.04		0.99	0.11
Silicon	D4326	Wt. %	2	1.02	0.98	0.97		0.99	0.066
Silicon	D4326	Wt. %	3	0.96	1.01	0.96	0.94	0.977	0.072
Sodium	D4326	Wt. %	1	0.1	0.1	0.1		0.1	---
Sodium	D4326	Wt. %	2	0.1	0.1	0.1		0.1	---
Sodium	D4326	Wt. %	3	0.1	0.1	0.1	0.1	0.1	---
Strontium	D4326	Wt. %	1	0.02	0.02	0.02		0.02	---
Strontium	D4326	Wt. %	2	0.02	0.02	0.02		0.02	---
Strontium	D4326	Wt. %	3	0.02	0.02	0.02	0.02	0.02	---
Titanium	D4326	Wt. %	1	0.05	0.06	0.06		0.0567	0.014
Titanium	D4326	Wt. %	2	0.07	0.05	0.05		0.0567	0.029
Titanium	D4326	Wt. %	3	0.05	0.05	0.05	0.05	0.05	---
Vanadium	ICP/MS	ug/g	1	11.3	8.98	11.8		10.7	3.7
Vanadium	ICP/MS	ug/g	2	8.28	11.3	11.3		10.3	4.3
Vanadium	ICP/MS	ug/g	3	6.9	11.2	12.4	11.6	10.2	7.2
Zinc	SW6010	ug/g	1	8	6	8		7.33	2.9
Zinc	SW6010	ug/g	2	7	8	17		10.7	14
Zinc	SW6010	ug/g	3	8	7	8	8	7.67	1.4

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 4	Average	95% CI
Ultimate/Proximate/HHV									
Ash	D3174	Wt. %	4	6.30	6.27	6.46	6.47	6.38	0.17
Ionic Species									
Chloride	D4208/IC	ug/g	4	59.4	73.5	123	62.1	79.5	47
Fluoride	D3751/IC	ug/g	4	34.3	34.8	36.7	37.9	35.9	2.7
Metals									
Aluminum	D4326	Wt. %	4	0.534	0.513	0.54	0.534	0.53	0.019
Antimony	SW7041	ug/g	4	0.158	0.103	0.118	0.125	0.126	0.037
Arsenic	SW7060	ug/g	4	0.655	0.671	0.736	0.738	0.7	0.069
Barium	D4326	Wt. %	4	0.0358	0.0448	0.0448	0.0448	0.0426	0.0071
Beryllium	SW6010a	ug/g	4	0.193	0.174	0.208	0.196	0.193	0.022
Boron	SW6010	ug/g	4	35	36	41	39	37.8	4.4
Cadmium	SW7131	ug/g	4	0.0249	0.0308	0.0303	0.122	0.0521	0.075
Calcium	D4326	Wt. %	4	1.02	0.994	1	0.958	0.994	0.043
Chromium	SW6010a	ug/g	4	3.07	2.92	3.12	3.32	3.11	0.26
Cobalt	SW6010a	ug/g	4	1.29	1.21	1.31	1.35	1.29	0.094
Copper	SW6010a	ug/g	4	9.77	9.22	9.24	9.06	9.32	0.49
Iron	D4326	Wt. %	4	0.231	0.203	0.21	0.21	0.213	0.019
Lead	SW7421	ug/g	4	1.78	2.07	2.4	2.77	2.25	0.68
Magnesium	D4326	Wt. %	4	0.199	0.199	0.199	0.199	0.199	---
Manganese	SW6010a	ug/g	4	6.8	6.52	6.78	7.64	6.94	0.77
Mercury	DGA/CVAA	ug/g	4	0.08	0.08	0.09	0.07	0.08	0.013
Molybdenum	SW6010a	ug/g	4	0.353	0.322	0.414	0.425	0.378	0.079
Nickel	SW6010a	ug/g	4	2.02	2.08	2.06	2.31	2.12	0.21
Phosphorus	D4326	Wt. %	4	0.0305	0.0305	0.0349	0.0305	0.0316	0.0035
Potassium	D4326	Wt. %	4	0.0083	0.0083	0.0166	0.0166	0.0125	0.0076
Selenium	SW7740	ug/g	4	0.687	0.709	0.724	0.731	0.712	0.031
Silicon	D4326	Wt. %	4	0.892	0.85	0.906	0.92	0.892	0.048
Sodium	D4326	Wt. %	4	0.0816	0.089	0.0816	0.089	0.0853	0.0068
Strontium	D4326	Wt. %	4	0.00846	0.0169	0.0169	0.0169	0.0148	0.0067
Titanium	D4326	Wt. %	4	0.048	0.048	0.048	0.048	0.048	---
Vanadium	SW6010a	ug/g	4	10.3	9.97	10.3	11.8	10.6	1.3
Zinc	SW6010a	ug/g	4	5.47	5.23	5.45	8.35	6.12	2.4

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate/Proximate/HHV									
% Solids in Slurry	D3302	Wt. %	1	53.2	52.1	52.0		52.4	1.7
% Solids in Slurry	D3302	Wt. %	2	52.3	52.7	52.6		52.5	0.52
% Solids in Slurry	D3302	Wt. %	3	52.0	51.3	51.7		51.7	0.87
Ash	D3174	Wt. %	1	7.57	7.89	8.05		7.84	0.61
Ash	D3174	Wt. %	2	7.85	7.52	7.47		7.61	0.51
Ash	D3174	Wt. %	3	7.81	7.84	7.61		7.75	0.31
Carbon	D5373	Wt. %	1	68.8	68.8	69		68.9	0.29
Carbon	D5373	Wt. %	2	69.5	69.2	69.9		69.5	0.87
Carbon	D5373	Wt. %	3	68.7	69.4	69.4		69.2	1
Fixed Carbon	D3172	Wt. %	1	47.2	47.9	46.9		47.3	1.3
Fixed Carbon	D3172	Wt. %	2	46.3	47.6	47.1		47	1.6
Fixed Carbon	D3172	Wt. %	3	46.3	47	48.3		47.2	2.5
HHV	D2015	Btu/lb	1	11,800	11,800	11,800		11,800	---
HHV	D2015	Btu/lb	2	11,800	11,800	11,900		11,800	140
HHV	D2015	Btu/lb	3	11,700	11,700	11,800		11,700	140
Hydrogen	D5373	Wt. %	1	4.75	4.65	4.79		4.73	0.18
Hydrogen	D5373	Wt. %	2	4.77	4.85	4.74		4.79	0.14
Hydrogen	D5373	Wt. %	3	4.74	4.59	4.59		4.64	0.22
Nitrogen	D5373	Wt. %	1	0.98	1	1		0.993	0.029
Nitrogen	D5373	Wt. %	2	1.04	1.06	1.08		1.06	0.05
Nitrogen	D5373	Wt. %	3	1.02	1.14	1.2		1.12	0.23
Oxygen (by difference)	D3176	Wt. %	1	17.6	17.4	16.9		17.3	0.9
Oxygen (by difference)	D3176	Wt. %	2	16.5	17.1	16.5		16.7	0.86
Oxygen (by difference)	D3176	Wt. %	3	17.5	16.8	16.9		17.1	0.94
Sulfur	D4239	Wt. %	1	0.29	0.27	0.27		0.277	0.029
Sulfur	D4239	Wt. %	2	0.28	0.27	0.28		0.277	0.014
Sulfur	D4239	Wt. %	3	0.28	0.29	0.28		0.283	0.014
Volatile Matter	D3175	Wt. %	1	45.2	44.2	45.1		44.8	1.4
Volatile Matter	D3175	Wt. %	2	45.8	44.9	45.4		45.4	1.1
Volatile Matter	D3175	Wt. %	3	45.9	45.1	44.1		45	2.2

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208/IC	ug/g	1	80.4	50.8	68.1		66.4	37
Chloride	D4208/IC	ug/g	2	59.5	48	42.6		50	21
Chloride	D4208/IC	ug/g	3	48.2	50.1	52		50.1	4.7
Fluoride	D3751/IC	ug/g	1	196	277	265		246	110
Fluoride	D3751/IC	ug/g	2	250	188	204		214	80
Fluoride	D3751/IC	ug/g	3	287	312	364		321	98
Metals									
Aluminum	D4326	Wt. %	1	0.68	0.74	0.77		0.73	0.11
Aluminum	D4326	Wt. %	2	0.74	0.7	0.69		0.71	0.066
Aluminum	D4326	Wt. %	3	0.71	0.73	0.7		0.713	0.038
Antimony	ICP/MS	ug/g	1	0.342 C	0.465 C	0.512 C		0.44	0.22
Antimony	ICP/MS	ug/g	2	0.517 C	0.38 C	0.393 C		0.43	0.19
Antimony	ICP/MS	ug/g	3	0.401 C	0.468 C	0.426 C		0.43	0.084
Arsenic	ICP/MS	ug/g	1	1.64 C	2.56 C	2.24 C		2.15	1.2
Arsenic	ICP/MS	ug/g	2	2.18 C	1.69 C	1.88 C		1.92	0.61
Arsenic	ICP/MS	ug/g	3	2.73 C	2.71 C	2.44 C		1.92	0.4
Barium	SW6010	ug/g	1	510	540	560		537	63
Barium	SW6010	ug/g	2	490	480	480		483	14
Barium	SW6010	ug/g	3	480	470	450		467	38
Beryllium	ICP/MS	ug/g	1	0.193	0.295	0.327		0.272	0.17
Beryllium	ICP/MS	ug/g	2	0.338	0.327	0.284		0.316	0.071
Beryllium	ICP/MS	ug/g	3	0.371	0.305	0.342		0.316	0.082
Boron	SW6010	ug/g	1	35	35	36		35.3	1.4
Boron	SW6010	ug/g	2	35	34	33		34	2.5
Boron	SW6010	ug/g	3	36	34	34		34.7	2.9
Cadmium	ICP/MS	ug/g	1	0.387 C	1.21 C	1.27 C		0.956	1.2
Cadmium	ICP/MS	ug/g	2	1.57 C	0.925 C	1.09 C		1.2	0.83
Cadmium	ICP/MS	ug/g	3	2.79 C	3.27 C	3.59 C		1.2	1
Calcium	D4326	Wt. %	1	1.25	1.29	1.26		1.27	0.052
Calcium	D4326	Wt. %	2	1.26	1.19	1.22		1.22	0.087
Calcium	D4326	Wt. %	3	1.31	1.26	1.28		1.28	0.063
Chromium	ICP/MS	ug/g	1	3.76 C	5.05 C	5.52 C		4.78	2.3

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Chromium	ICP/MS	ug/g	2	5.44 C	4.88 C	4.86 C		5.06	0.82
Chromium	ICP/MS	ug/g	3	6.37 C	5.65 C	5.18 C		5.06	1.5
Cobalt	ICP/MS	ug/g	1	1.77 C	2.06 C	2.11 C		1.98	0.46
Cobalt	ICP/MS	ug/g	2	2.27 C	2.03 C	2.18 C		2.16	0.3
Cobalt	ICP/MS	ug/g	3	2.42 C	2.36 C	2.3 C		2.16	0.15
Copper	ICP/MS	ug/g	1	11.2 C	13.6 C	15.1 C		13.3	4.9
Copper	ICP/MS	ug/g	2	15 C	13.6 C	14.6 C		14.4	1.8
Copper	ICP/MS	ug/g	3	15.8 C	18.7 C	15.5 C		14.4	4.4
Iron	D4326	Wt. %	1	0.29	0.3	0.29		0.293	0.014
Iron	D4326	Wt. %	2	0.29	0.27	0.27		0.277	0.029
Iron	D4326	Wt. %	3	0.3	0.29	0.29		0.293	0.014
Lead	ICP/MS	ug/g	1	4.1 C	10.4 C	8.27 C		7.59	8
Lead	ICP/MS	ug/g	2	7.77 C	5.01 C	6.1 C		6.29	3.5
Lead	ICP/MS	ug/g	3	9.46 C	11.8 C	11.6 C		6.29	3.2
Magnesium	D4326	Wt. %	1	0.26	0.28	0.27		0.27	0.025
Magnesium	D4326	Wt. %	2	0.27	0.25	0.26		0.26	0.025
Magnesium	D4326	Wt. %	3	0.28	0.26	0.26		0.267	0.029
Manganese	ICP/MS	ug/g	1	8.81 C	10.7 C	11 C		10.2	2.9
Manganese	ICP/MS	ug/g	2	11.3 C	10.2 C	11.7 C		11.1	1.9
Manganese	ICP/MS	ug/g	3	11.8 C	12.2 C	11.7 C		11.1	0.66
Mercury	DGA/CVAA	ug/g	1	0.08	0.08	0.08		0.08	---
Mercury	DGA/CVAA	ug/g	2	0.1	0.09	0.1		0.0967	0.014
Mercury	DGA/CVAA	ug/g	3	0.08	0.07	0.1		0.0833	0.038
Molybdenum	ICP/MS	ug/g	1	0.554 C	0.686 C	0.681 C		0.64	0.19
Molybdenum	ICP/MS	ug/g	2	0.761 C	0.633 C	0.766 C		0.72	0.19
Molybdenum	ICP/MS	ug/g	3	0.816 C	0.804 C	0.842 C		0.72	0.048
Nickel	SW6010	ug/g	1	1	1	< 1		< 1	---
Nickel	SW6010	ug/g	2	< 1	2	1		1.17	1.9
Nickel	SW6010	ug/g	3	1	< 1	< 1		< 1	---
Phosphorus	D4326	Wt. %	1	0.03	0.04	0.03		0.0333	0.014
Phosphorus	D4326	Wt. %	2	0.03	0.03	0.03		0.03	---
Phosphorus	D4326	Wt. %	3	0.03	0.03	0.03		0.03	---

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Potassium	D4326	Wt. %	1	0.02	0.02	0.03		0.0233	0.014
Potassium	D4326	Wt. %	2	0.02	0.02	0.02		0.02	---
Potassium	D4326	Wt. %	3	0.02	0.02	0.02		0.02	---
Selenium	ICP/MS	ug/g	1	2.16	4.28	4.62		3.69	3.3
Selenium	ICP/MS	ug/g	2	4.79	3.6	4.65		4.35	1.6
Selenium	ICP/MS	ug/g	3	6.21	7.07	7.63		3.69	1.8
Silicon	D4326	Wt. %	1	1.18	1.23	1.3		1.24	0.15
Silicon	D4326	Wt. %	2	1.25	1.22	1.16		1.21	0.11
Silicon	D4326	Wt. %	3	1.21	1.25	1.18		1.21	0.087
Sodium	D4326	Wt. %	1	0.13	0.13	0.13		0.13	---
Sodium	D4326	Wt. %	2	0.13	0.13	0.13		0.13	---
Sodium	D4326	Wt. %	3	0.13	0.13	0.13		0.13	---
Strontium	D4326	Wt. %	1	0.02	0.02	0.02		0.02	---
Strontium	D4326	Wt. %	2	0.02	0.02	0.02		0.02	---
Strontium	D4326	Wt. %	3	0.02	0.02	0.02		0.02	---
Titanium	D4326	Wt. %	1	0.06	0.07	0.07		0.0667	0.014
Titanium	D4326	Wt. %	2	0.07	0.07	0.07		0.07	---
Titanium	D4326	Wt. %	3	0.07	0.07	0.07		0.07	---
Vanadium	ICP/MS	ug/g	1	11.3	14	15.2		13.5	5
Vanadium	ICP/MS	ug/g	2	15.1	13.8	14		14.3	1.7
Vanadium	ICP/MS	ug/g	3	14.6	14.9	14.3		14.3	0.75
Zinc	SW6010	ug/g	1	39	51	57		49	23
Zinc	SW6010	ug/g	2	49	36	44		43	16
Zinc	SW6010	ug/g	3	44	50	140		78	130

Table G-1. Analytical Results Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 4	Average	95% CI
Ultimate/Proximate/HHV									
Ash	D3174	Wt. %	4	7.54	7.60	7.37	7.54	7.51	0.16
Ionic Species									
Chloride	D4208/IC	ug/g	4	161	92.1	84	96	108	56
Fluoride	D3751/IC	ug/g	4	376	414	311	241	336	120
Metals									
Aluminum	D4326	Wt. %	4	0.635	0.619	0.624	0.63	0.627	0.011
Antimony	SW7041	ug/g	4	0.973	0.813	0.833	0.636	0.814	0.22
Arsenic	SW7060	ug/g	4	1.67	1.69	1.63	1.61	1.65	0.056
Barium	D4326	Wt. %	4	0.0448	0.0448	0.0538	0.0538	0.0493	0.0082
Beryllium	SW6010a	ug/g	4	0.243	0.209	0.264	0.26	0.244	0.04
Boron	SW6010	ug/g	4	44	36	38	39	39.3	5.4
Cadmium	SW7131	ug/g	4	0.95	1.09	1.01	0.95	0.999	0.1
Calcium	D4326	Wt. %	4	1.24	1.2	1.17	1.15	1.19	0.059
Chromium	SW6010a	ug/g	4	4.03	3.64	3.85	4.15	3.92	0.35
Cobalt	SW6010a	ug/g	4	1.63	1.43	1.61	1.61	1.57	0.15
Copper	SW6010a	ug/g	4	14	12.9	12.5	12.4	13	1.2
Iron	D4326	Wt. %	4	0.28	0.252	0.245	0.252	0.257	0.025
Lead	SW7421	ug/g	4	38.5	41.2	31.5	30.3	35.4	8.4
Magnesium	D4326	Wt. %	4	0.241	0.241	0.235	0.235	0.238	0.0055
Manganese	SW6010a	ug/g	4	8.07	7.59	8.33	9.12	8.28	1
Mercury	DGA/CVAA	ug/g	4	0.07	0.07	0.07	0.07	0.07	---
Molybdenum	SW6010a	ug/g	4	0.554	0.542	0.612	0.606	0.579	0.057
Nickel	SW6010a	ug/g	4	2.62	2.36	2.6	2.77	2.59	0.26
Phosphorus	D4326	Wt. %	4	0.0392	0.0436	0.0436	0.0436	0.0425	0.0035
Potassium	D4326	Wt. %	4	0.0166	0.0166	0.0166	0.0166	0.0166	---
Selenium	SW7740	ug/g	4	4.08	4.67	4.08	3.59	4.1	0.71
Silicon	D4326	Wt. %	4	1.08	1.01	1.05	1.08	1.05	0.055
Sodium	D4326	Wt. %	4	0.111	0.111	0.104	0.111	0.109	0.0059
Strontium	D4326	Wt. %	4	0.0169	0.0169	0.0169	0.0169	0.0169	---
Titanium	D4326	Wt. %	4	0.054	0.06	0.054	0.054	0.0555	0.0048
Vanadium	SW6010a	ug/g	4	12.7	11.9	12.4	12.7	12.4	0.61
Zinc	SW6010a	ug/g	4	44.3	45.8	40.9	37.8	42.2	5.7

Table G-1. Analytical Results Used in Calculations

Stream: Raw Gas Char-Filtered @1000 deg F (5)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate/Proximate/HHV									
Ash	D3174	Wt. %	4						
Ionic Species									
Chloride	D4208/IC	ug/g	4						
Fluoride	D3751/IC	ug/g	4						
Metals									
Aluminum	D4326	Wt. %	4						
Antimony	GFAAS	ug/g	4						
Arsenic	GFAAS	ug/g	4						
Barium	D4326	Wt. %	4						
Beryllium	SW6010a	ug/g	4						
Boron	SW6010	ug/g	4						
Cadmium	GFAAS	ug/g	4						
Calcium	D4326	Wt. %	4						
Chromium	SW6010a	ug/g	4						
Cobalt	SW6010a	ug/g	4						
Copper	SW6010a	ug/g	4						
Iron	D4326	Wt. %	4						
Lead	GFAAS	ug/g	4						
Magnesium	D4326	Wt. %	4						
Manganese	SW6010a	ug/g	4						
Mercury	DGA/CVAA	ug/g	4						
Molybdenum	SW6010a	ug/g	4						
Nickel	SW6010a	ug/g	4						
Phosphorus	D4326	Wt. %	4						
Potassium	D4326	Wt. %	4						
Selenium	GFAAS	ug/g	4						
Silicon	D4326	Wt. %	4						
Sodium	D4326	Wt. %	4						
Strontium	D4326	Wt. %	4						
Titanium	D4326	Wt. %	4						
Vanadium	SW6010a	ug/g	4						
Zinc	SW6010a	ug/g	4						

Table G-1. Analytical Results Used in Calculations

Stream: Raw Gas Char-Filtered @500 deg F (5a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate/Proximate/HHV									
Ash	D3174	Wt. %	4						
Ionic Species									
Chloride	D4208/IC	ug/g	4						
Fluoride	D3751/IC	ug/g	4						
Metals									
Aluminum	D4326	Wt. %	4						
Antimony	GFAAS	ug/g	4						
Arsenic	GFAAS	ug/g	4						
Barium	D4326	Wt. %	4						
Beryllium	SW6010a	ug/g	4						
Boron	SW6010	ug/g	4						
Cadmium	GFAAS	ug/g	4						
Calcium	D4326	Wt. %	4						
Chromium	SW6010a	ug/g	4						
Cobalt	SW6010a	ug/g	4						
Copper	SW6010a	ug/g	4						
Iron	D4326	Wt. %	4						
Lead	GFAAS	ug/g	4						
Magnesium	D4326	Wt. %	4						
Manganese	SW6010a	ug/g	4						
Mercury	DGA/CVAA	ug/g	4						
Molybdenum	SW6010a	ug/g	4						
Nickel	SW6010a	ug/g	4						
Phosphorus	D4326	Wt. %	4						
Potassium	D4326	Wt. %	4						
Selenium	GFAAS	ug/g	4						
Silicon	D4326	Wt. %	4						
Sodium	D4326	Wt. %	4						
Strontium	D4326	Wt. %	4						
Titanium	D4326	Wt. %	4						
Vanadium	SW6010a	ug/g	4						
Zinc	SW6010a	ug/g	4						

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Table G-1. Analytical Results Used in Calculations

Stream: Recycled Char Solids (5c)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate/Proximate/HHV									
Ash	D3174	Wt. %	3						
Carbon	D5373	Wt. %	3						
Fixed Carbon	D3172	Wt. %	3						
HHV	D2015	Btu/lb	3						
Hydrogen	D5373	Wt. %	3						
Nitrogen	D5373	Wt. %	3						
Oxygen (by diff	D3176	Wt. %	3						
Sulfur	D4239	Wt. %	3						
Volatile Matter	D3175	Wt. %	3						
Ionic Species									
Chloride	D4208/IC	ug/g	3						
Fluoride	D3751/IC	ug/g	3						
Metals									
Aluminum	D4326	Wt. %	3						
Antimony	ICP/MS	ug/g	3						
Arsenic	ICP/MS	ug/g	3						
Barium	SW6010	ug/g	3						
Beryllium	ICP/MS	ug/g	3						
Boron	SW6010	ug/g	3						
Cadmium	ICP/MS	ug/g	3						
Calcium	D4326	Wt. %	3						
Chromium	ICP/MS	ug/g	3						
Cobalt	ICP/MS	ug/g	3						
Copper	ICP/MS	ug/g	3						
Iron	D4326	Wt. %	3						
Lead	ICP/MS	ug/g	3						
Magnesium	D4326	Wt. %	3						
Manganese	ICP/MS	ug/g	3						
Mercury	DGA/CVAA	ug/g	3						
Molybdenum	ICP/MS	ug/g	3						
Nickel	SW6010	ug/g	3						
Phosphorus	D4326	Wt. %	3						

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Table G-1. Analytical Results Used in Calculations

Stream: Recycled Char Solids (5c)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Potassium	D4326	Wt. %	3						
Selenium	ICP/MS	ug/g	3						
Silicon	D4326	Wt. %	3						
Sodium	D4326	Wt. %	3						
Strontium	D4326	Wt. %	3						
Titanium	D4326	Wt. %	3						
Vanadium	ICP/MS	ug/g	3						
Zinc	SW6010	ug/g	3						

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Table G-1. Analytical Results Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate Analysis									
Ash	D3174	Wt. %	1	96.2	84.7	93.6		91.5	15
Ash	D3174	Wt. %	2	90.3	93.9	93.8	95	92.7	5.1
Ash	D3174	Wt. %	3	93.9	86.51	75.34		85.3	23
Carbon	D5373	Wt. %	1	2.78	14.5	6.12		7.8	15
Carbon	D5373	Wt. %	2	9.35	5.98	5.78	4.86	7.04	5
Carbon	D5373	Wt. %	3	3.83	12.94	23.97		13.6	25
Hydrogen	D5373	Wt. %	1	0.1	0.31	0.08		0.163	0.32
Hydrogen	D5373	Wt. %	2	0.14	0.08	0.14	0.07	0.12	0.086
Hydrogen	D5373	Wt. %	3	0.08	0.2	0.26		0.18	0.23
Nitrogen	D5373	Wt. %	1	< 0.01	0.09	< 0.01		0.0333	0.12
Nitrogen	D5373	Wt. %	2	0.01	< 0.01	< 0.01	< 0.01	< 0.01	---
Nitrogen	D5373	Wt. %	3	< 0.01	0.06	0.17		0.0783	0.21
Oxygen (by difference)	D3176	Wt. %	1	0.87	0.43	0.17		0.49	0.88
Oxygen (by difference)	D3176	Wt. %	2	0.2	0.05	0.21	0.01	0.153	0.22
Oxygen (by difference)	D3176	Wt. %	3	0.08	0.24	0.19		0.17	0.2
Sulfur	D4239	Wt. %	1	0.03	0.04	0.01		0.0267	0.038
Sulfur	D4239	Wt. %	2	0.03	0.02	0.01	0.02	0.02	0.025
Sulfur	D4239	Wt. %	3	0.02	0.05	0.07		0.0467	0.063
Ionic Species									
Chloride	SIE	ug/g	1	68.4	98.6	260		142	260
Chloride	SIE	ug/g	2	< 27	52.5	31.1	69.1	32.4	49
Chloride	SIE	ug/g	3	76.6	43.9	99.9		73.5	70
Fluoride	NaOH/SIE	ug/g	1	254	199	112		188	180
Fluoride	NaOH/SIE	ug/g	2	210	131	195	219 B	179	100
Fluoride	NaOH/SIE	ug/g	3	166	321	245		244	190
Metals									
Aluminum	D4326	Wt. %	1	9.56	8.69	9.77		9.34	1.4
Aluminum	D4326	Wt. %	2	9.29	9.51	9.45	9.4	9.42	0.28
Aluminum	D4326	Wt. %	3	9.41	8.67	7.56		8.55	2.3
Antimony	ICP/MS	ug/g	1	1.24 C	1.72 C	1.03 C		1.33	0.88
Antimony	ICP/MS	ug/g	2	0.779 C	0.707 C	1.37 C	0.581 C	0.952	0.9
Antimony	ICP/MS	ug/g	3	0.83 C	0.833 C	1.11 C		0.924	0.4

Table G-1. Analytical Results Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period		Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)										
Arsenic	ICP/MS	ug/g	1		4.31 C	6.19 C	5.74 C		5.41	2.4
Arsenic	ICP/MS	ug/g	2		5.74 C	4.42 C	6.32 C	6.34 C	5.49	2.4
Arsenic	ICP/MS	ug/g	3		8.08 C	7.49 C	5.61 C		7.06	3.2
Barium	SW6010	ug/g	1		5,900	5,600	6,400		5,970	1000
Barium	SW6010	ug/g	2		6,200	5,880	6,700	6,020	6,260	1000
Barium	SW6010	ug/g	3		6,020	5,540	4,960		5,510	1,300
Beryllium	ICP/MS	ug/g	1		3.87	3.27	3.42		3.52	0.78
Beryllium	ICP/MS	ug/g	2		3.16	3.6	4.11	3.8	3.62	1.2
Beryllium	ICP/MS	ug/g	3		3.82	3.19	2.48		3.16	1.7
Boron	SW6010	ug/g	1		390	300	370		353	120
Boron	SW6010	ug/g	2		370	330	390	360	363	76
Boron	SW6010	ug/g	3		370	340	280		330	110
Cadmium	ICP/MS	ug/g	1		0.181 C	0.18 C	0.198 C		0.186	0.025
Cadmium	ICP/MS	ug/g	2	<	C	0.0308 C	0.185 C	0.198 C	0.0719	0.25
Cadmium	ICP/MS	ug/g	3		0.462 C	0.27 C	0.333 C		0.355	0.24
Calcium	D4326	Wt. %	1		17.8	15.3	16.3		16.5	3.1
Calcium	D4326	Wt. %	2		15.9	16.5	17.1	17.2	16.5	1.5
Calcium	D4326	Wt. %	3		17.1	15.4	13.5		15.3	4.5
Chromium	ICP/MS	ug/g	1		85.9 C	66.6 C	74.5 C		75.7	24
Chromium	ICP/MS	ug/g	2		68.2 C	94 C	79.8 C	79.2 C	80.7	32
Chromium	ICP/MS	ug/g	3		84.6 C	71.3 C	60.5 C		72.1	30
Cobalt	ICP/MS	ug/g	1		29.1 C	19.3 C	24.6 C		24.3	12
Cobalt	ICP/MS	ug/g	2		24.7 C	25.3 C	29.3 C	27.7 C	26.4	6.2
Cobalt	ICP/MS	ug/g	3		30.4 C	27.6 C	21.7 C		26.6	11
Copper	ICP/MS	ug/g	1		162 C	146 C	152 C		153	20
Copper	ICP/MS	ug/g	2		151 C	147 C	172 C	166 C	157	33
Copper	ICP/MS	ug/g	3		173 C	148 C	125 C		149	60
Iron	D4326	Wt. %	1		4.12	3.51	3.83		3.82	0.76
Iron	D4326	Wt. %	2		3.63	3.8	3.91	3.96	3.78	0.35
Iron	D4326	Wt. %	3		3.92	3.61	3.12		3.55	1
Lead	ICP/MS	ug/g	1		3.02 C	3.89 C	2.57 C		3.16	1.7
Lead	ICP/MS	ug/g	2		1.73 C	1.41 C	2.41 C	5.5 C	1.85	1.3

Table G-1. Analytical Results Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Lead	ICP/MS	ug/g	3	4.5 C	3.38 C	4.04 C		3.97	1.4
Magnesium	D4326	Wt. %	1	3.7	3.12	3.43		3.42	0.72
Magnesium	D4326	Wt. %	2	3.35	3.49	3.53	3.52	3.46	0.23
Magnesium	D4326	Wt. %	3	3.55	3.19	2.76		3.17	0.98
Manganese	ICP/MS	ug/g	1	143 C	120 C	119 C		127	34
Manganese	ICP/MS	ug/g	2	121 C	125 C	152 C	149 C	133	42
Manganese	ICP/MS	ug/g	3	155 C	140 C	112 C		136	54
Mercury	DGA/CVAA	ug/g	1	< 0.02	0.03	0.02		0.02	0.025
Mercury	DGA/CVAA	ug/g	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	---
Mercury	DGA/CVAA	ug/g	3	0.02	0.02	0.03		0.0233	0.014
Molybdenum	ICP/MS	ug/g	1	7.58 C	7.48 C	7 C		7.35	0.77
Molybdenum	ICP/MS	ug/g	2	7.77 C	7.04 C	9 C	8.19 C	7.94	2.5
Molybdenum	ICP/MS	ug/g	3	8.16 C	7.25 C	6.85 C		7.42	1.7
Nickel	SW6010	ug/g	1	37	35	47		39.7	16
Nickel	SW6010	ug/g	2	34	41	43	39	39.3	12
Nickel	SW6010	ug/g	3	43	36	30		36.3	16
Phosphorus	D4326	Wt. %	1	0.43	0.42	0.42		0.423	0.014
Phosphorus	D4326	Wt. %	2	0.4	0.4	0.43	0.44	0.41	0.043
Phosphorus	D4326	Wt. %	3	0.44	0.4	0.35		0.397	0.11
Potassium	D4326	Wt. %	1	0.28	0.26	0.32		0.287	0.076
Potassium	D4326	Wt. %	2	0.29	0.31	0.27	0.27	0.29	0.05
Potassium	D4326	Wt. %	3	0.27	0.26	0.21		0.247	0.08
Selenium	ICP/MS	ug/g	1	5.61	0.0842	14.2		6.63	18
Selenium	ICP/MS	ug/g	2	11.8	12.7	16.9	18.6	13.8	6.8
Selenium	ICP/MS	ug/g	3	26.1	17.7	16.1		20	13
Silicon	D4326	Wt. %	1	16.7	14.5	16.4		15.9	3
Silicon	D4326	Wt. %	2	15.8	16.6	16.1	16.4	16.2	1
Silicon	D4326	Wt. %	3	16.1	15.1	12.9		14.7	4.1
Sodium	D4326	Wt. %	1	1.75	1.52	1.67		1.65	0.29
Sodium	D4326	Wt. %	2	1.62	1.62	1.68	1.66	1.64	0.086
Sodium	D4326	Wt. %	3	1.65	1.48	1.27		1.47	0.47
Strontium	D4326	Wt. %	1	0.25	0.22	0.24		0.237	0.038

Table G-1. Analytical Results Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Strontium	D4326	Wt. %	2	0.23	0.24	0.25	0.25	0.24	0.025
Strontium	D4326	Wt. %	3	0.25	0.23	0.19		0.223	0.076
Titanium	D4326	Wt. %	1	0.86	0.77	0.89		0.84	0.16
Titanium	D4326	Wt. %	2	0.83	0.86	0.85	0.86	0.847	0.038
Titanium	D4326	Wt. %	3	0.76	0.77	0.69		0.74	0.11
Vanadium	ICP/MS	ug/g	1	182	169	175		175	16
Vanadium	ICP/MS	ug/g	2	168	176	193	187	179	32
Vanadium	ICP/MS	ug/g	3	194	170	137		167	71
Zinc	SW6010	ug/g	1	32	46	53		43.7	27
Zinc	SW6010	ug/g	2	51	39	46	44	45.3	15
Zinc	SW6010	ug/g	3	52	54	50		52	5
Radionuclides									
Actinium-228 @338 KeV	gamma	pCi/g	3	2.6	2.4	1.9		2.3	0.9
Actinium-228 @911 KeV	gamma	pCi/g	3	2.8	2.7	2.0		2.5	1.1
Actinium-228 @968 KeV	gamma	pCi/g	3	2.9	2.6	2.0		2.5	1.1
Bismuth-212 @727 KeV	gamma	pCi/g	3	3.3	2.8	2.4		2.8	1.1
Bismuth-214 @1120 KeV	gamma	pCi/g	3	3.1	2.6	2.4		2.7	0.9
Bismuth-214 @1764 KeV	gamma	pCi/g	3	3.1	2.7	2.0		2.6	1.4
Bismuth-214 @609 KeV	gamma	pCi/g	3	3.2	2.7	2.2		2.7	1.2
Lead-210 @46 KeV	gamma	pCi/g	3	1.0	0.00	0.00		0.33	1.4
Lead-212 @238 KeV	gamma	pCi/g	3	2.6	2.3	1.9		2.3	0.87
Lead-214 @295 KeV	gamma	pCi/g	3	3.3	2.8	2.3		2.8	1.2
Lead-214 @351 KeV	gamma	pCi/g	3	3.3	2.8	2.3		2.8	1.2
Potassium-40 @1460 KeV	gamma	pCi/g	3	2.6	2.1	1.2		2	1.8
Radium-226 @226 KeV	gamma	pCi/g	3	4.0	3.4	3.0		3.5	1.3
Thallium-208 @583 KeV	gamma	pCi/g	3	0.95	0.84	0.68		0.82	0.34
Thallium-208 @860 KeV	gamma	pCi/g	3	1.3	1.1	0.88		1.1	0.52
Thorium-234 @63 KeV	gamma	pCi/g	3	3.0	1.4	1.4		1.9	2.3
Thorium-234 @92 KeV	gamma	pCi/g	3	1.7	1.3	1.1		1.4	0.76
Uranium-235 @143 KeV	gamma	pCi/g	3	0.16	0.1	-0.26		0	0.56

Table G-1. Analytical Results Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 4	Average	95% CI
Ultimate/Proximate/HHV									
Ash	D3174	Wt. %	4	98.6	97.1	99.1	98.6	98.3	1.4
Ionic Species									
Chloride	SIE	ug/g	4	< 27	< 27	< 25	< 25	< 27	---
Fluoride	NaOH/SIE	ug/g	4	89.4	184	154	117	136	66
Metals									
Aluminum	D4326	Wt. %	4	9.94	9.77	9.77	10.1	9.88	0.22
Antimony	SW7041	ug/g	4	2.68	0.693	1.87	4.99	2.56	2.9
Arsenic	SW7060	ug/g	4	5.54	4.75	3.91	4.55	4.68	1.1
Barium	D4326	Wt. %	4	0.757	0.797	0.735	0.78	0.767	0.043
Beryllium	SW6010a	ug/g	4	3.47	3.26	3.55	3.42	3.43	0.19
Boron	SW6010	ug/g	4	550	560	580	520	553	40
Cadmium	SW7131	ug/g	4	0.277	0.412	0.331	0.337	0.339	0.088
Calcium	D4326	Wt. %	4	18.8	18.7	18.6	18.1	18.5	0.49
Chromium	SW6010a	ug/g	4	144	355	123	397	255	230
Cobalt	SW6010a	ug/g	4	22.3	21	21.7	21.9	21.7	0.87
Copper	SW6010a	ug/g	4	180	178	177	167	176	9.7
Iron	D4326	Wt. %	4	3.96	3.94	4.37	3.94	4.05	0.34
Lead	SW7421	ug/g	4	7.8	5.99	6.77	5.18	6.43	1.8
Magnesium	D4326	Wt. %	4	3.77	3.72	3.59	3.71	3.7	0.12
Manganese	SW6010a	ug/g	4	119	118	125	131	123	9.3
Mercury	DGA/CVAA	ug/g	4	0.04	0.04	0.04	0.03	0.0375	0.008
Molybdenum	SW6010a	ug/g	4	7.53	7.85	6.65	7.2	7.31	0.81
Nickel	SW6010a	ug/g	4	38.2	36.4	37	37.6	37.3	1.3
Phosphorus	D4326	Wt. %	4	0.608	0.619	0.571	0.606	0.601	0.033
Potassium	D4326	Wt. %	4	0.191	0.183	0.199	0.232	0.201	0.035
Selenium	SW7740	ug/g	4	6.14	5.91	6.58	6.41	6.26	0.47
Silicon	D4326	Wt. %	4	16.1	15.5	16.5	16.3	16.1	0.65
Sodium	D4326	Wt. %	4	1.69	1.66	1.56	1.63	1.64	0.091
Strontium	D4326	Wt. %	4	0.309	0.305	0.305	0.305	0.306	0.0034
Titanium	D4326	Wt. %	4	0.918	0.882	0.846	0.87	0.879	0.048
Vanadium	SW6010a	ug/g	4	191	185	190	186	188	4.6
Zinc	SW6010a	ug/g	4	45.7	45.2	38.5	34	40.8	8.9

Table G-1. Analytical Results Used in Calculations

Stream: Sulfur by-product (24)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ultimate Analysis									
Sulfur	D4239	Wt. %	3	99.2					
Sulfur	D4239	Wt. %	3	98.1					
Metals									
Aluminum	SW6010	ug/g	3	< 8					
Aluminum	SW6010	ug/g	3	28					
Antimony	SW7041	ug/g	3	< 3					
Antimony	SW7041	ug/g	3	< 3					
Arsenic	SW7060	ug/g	3	< 3					
Arsenic	SW7060	ug/g	3	< 3					
Barium	SW6010	ug/g	3	< 2					
Barium	SW6010	ug/g	3	< 2					
Beryllium	SW6010	ug/g	3	< 2					
Beryllium	SW6010	ug/g	3	< 2					
Boron	SW6010	ug/g	3	< 10					
Boron	SW6010	ug/g	3	< 10					
Cadmium	SW7131	ug/g	3	< 2					
Cadmium	SW7131	ug/g	3	< 2					
Calcium	SW6010	ug/g	3	27					
Calcium	SW6010	ug/g	3	12					
Chromium	SW6010	ug/g	3	7					
Chromium	SW6010	ug/g	3	< 2					
Cobalt	SW6010	ug/g	3	< 4					
Cobalt	SW6010	ug/g	3	< 4					
Copper	SW6010	ug/g	3	< 2					
Copper	SW6010	ug/g	3	< 2					
Iron	SW6010	ug/g	3	12					
Iron	SW6010	ug/g	3	6					
Lead	SW7421	ug/g	3	< 3					
Lead	SW7421	ug/g	3	< 3					
Magnesium	SW6010	ug/g	3	6					
Magnesium	SW6010	ug/g	3	< 4					
Manganese	SW6010	ug/g	3	< 2					

Table G-1. Analytical Results Used in Calculations

Stream: Sulfur by-product (24)

Analyte	Method	Units	Test Period		Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)										
Manganese	SW6010	ug/g	3	<	2					
Mercury	DGA/CVAA	ug/g	3		0.11					
Mercury	DGA/CVAA	ug/g	3		0.08					
Molybdenum	SW6010	ug/g	3	<	20					
Molybdenum	SW6010	ug/g	3	<	20					
Nickel	SW6010	ug/g	3	<	4					
Nickel	SW6010	ug/g	3	<	4					
Potassium	SW6010	ug/g	3	<	20					
Potassium	SW6010	ug/g	3	<	20					
Selenium	SW7740	ug/g	3		38					
Selenium	SW7740	ug/g	3		10					
Silicon	SW6010	ug/g	3	<	20					
Silicon	SW6010	ug/g	3	<	20					
Sodium	SW6010	ug/g	3	<	20					
Sodium	SW6010	ug/g	3	<	20					
Titanium	SW6010	ug/g	3		3					
Titanium	SW6010	ug/g	3	<	2					
Vanadium	SW6010	ug/g	3	<	2					
Vanadium	SW6010	ug/g	3	<	2					
Zinc	SW6010	ug/g	3		28					
Zinc	SW6010	ug/g	3	<	2					

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Water Quality Parameters									
Chemical Oxygen Demand	EPA 410.1	mg/L	2	47.4	41.2	28.4	35.4	39	24
Specific conductance	EPA 120.1	umhos	2	19,100	18,600	18,400	19,000	18,700	900
TSS	EPA 160.2	mg/L	2	3.04	18.6	< 1	< 1	7.38	24
Total phenolics	EPA 420.2	mg/L	2	0.738	0.895	0.95	0.916	0.861	0.27
pH	EPA150.1		2	8.25	7.9	8.03	8.18	8.06	0.44
Ionic Species									
Ammonia as N	EPA 350.1	mg/L	2	2,450	2,340	2,540	2,660	2,440	250
Chloride	EPA 300.0	mg/L	2	0.715	0.217	0.359	0.179	0.43	0.64
Cyanide, amenable	SW9012	mg/L	2	11.6	7.54	12	9.92	10.4	6.1
Cyanide, total	SW9012	mg/L	2	14.8	10.6	14.8	12.8	13.4	6
Fluoride	EPA 340.2	mg/L	2	2.56	2.1	2.63	2.61	2.43	0.72
Formate	IC	mg/L	2	3.49	3.2	3	3	3.23	0.61
Phosphate, total (as P)	EPA 365.1	mg/L	2	0.76	0.635	0.699	0.697	0.698	0.16
Sulfate	EPA 300.0	mg/L	2	8.8	6.68	3.98	7.48	6.49	6
Thiocyanate	SM412K	mg/L	2	8.75	14.9	8.75	10.3	10.8	8.8
Metals, total									
Aluminum	SW6010	mg/L	2	0.782	1.26	0.941	1.06	0.994	0.6
Antimony	SW6010	mg/L	2	< 0.076	< 0.076	< 0.076	< 0.076	< 0.076	---
Arsenic	SW7060	mg/L	2	< 0.00065	0.0217	< 0.00065	< 0.00065	0.00745	0.031
Barium	SW6010	mg/L	2	0.749	0.831	0.912	0.926	0.831	0.2
Beryllium	SW6010	mg/L	2	< 0.00051	< 0.00051	< 0.00051	< 0.00051	< 0.00051	---
Boron	SW6010	mg/L	2	0.0449	0.0273	0.0363	0.0271	0.0362	0.022
Cadmium	SW7131	mg/L	2	0.00172	0.0188	0.00205	0.0018	0.00752	0.024
Calcium	SW6010	mg/L	2	5.83	6.52	6.9	7.02	6.42	1.3
Chromium	SW6010	mg/L	2	< 0.0052	< 0.0052	< 0.0052	< 0.0052	< 0.0052	---
Cobalt	SW6010	mg/L	2	< 0.0041	< 0.0041	< 0.0041	< 0.0041	< 0.0041	---
Copper	SW6010	mg/L	2	0.0109	0.0458	< 0.0092	< 0.0092	0.0204	0.055
Iron	SW6010	mg/L	2	1.21	2.01	2.4	1.55	1.87	1.5
Lead	SW7421	mg/L	2	0.0474	1.14	0.0441	0.0632	0.411	1.6
Magnesium	SW6010	mg/L	2	2.08	2.2	2.33	2.37	2.2	0.31
Manganese	SW6010	mg/L	2	0.00186	0.00483	0.00376	0.00459	0.00348	0.0037
Mercury	SW7470	mg/L	2	< 0.000033	0.00231	0.000060	0.000050	0.000796	0.0033

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Metals (continued)														
Molybdenum	SW6010	mg/L	2	<	0.0074	<	0.0074	<	0.0074		0.00783	<	0.0074	---
Nickel	SW6010	mg/L	2	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014	---
Phosphorus	SW6010	mg/L	2		0.666		0.732		0.709		0.734		0.702	0.083
Potassium	SW6010	mg/L	2		0.918	<	0.82	<	0.82		0.956	<	0.82	---
Selenium	SW7740	mg/L	2	<	0.0006		0.159		0.0007		0.00434		0.0533	0.23
Silicon	SW6010	mg/L	2		8.82		9.41		8.8		8.97		9.01	0.86
Sodium	SW6010	mg/L	2		2.89		3.03		2.98		3.02		2.97	0.18
Titanium	SW6010	mg/L	2		0.0199		0.0751		0.031		0.042		0.042	0.073
Vanadium	SW6010	mg/L	2	<	0.0045	<	0.0045	<	0.0045	<	0.0045	<	0.0045	---
Zinc	SW6010	mg/L	2		0.0938		0.828		0.164		0.0939		0.362	1
Aldehydes														
Acetaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01		0.023	<	0.01		0.011	0.026
Acrolein	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Benzaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Formaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Volatile Organic Compounds														
1,1,1-Trichloroethane	SW8240	ug/L	2	<	11	<	11	<	22	<	22	<	22	---
1,1,2,2-Tetrachloroethane	SW8240	ug/L	2	<	8	<	8	<	16	<	16	<	16	---
1,1,2-Trichloroethane	SW8240	ug/L	2	<	3.5	<	3.5	<	6.7	<	6.7	<	6.7	---
1,1-Dichloroethane	SW8240	ug/L	2	<	8	<	8	<	15	<	15	<	15	---
1,1-Dichloroethene	SW8240	ug/L	2	<	4.5	<	4.5	<	8.6	<	8.6	<	8.6	---
1,2-Dichloroethane	SW8240	ug/L	2	<	11	<	11	<	21	<	21	<	21	---
1,2-Dichloropropane	SW8240	ug/L	2	<	2.1	<	2.1	<	4	<	4	<	4	---
1,4-Bromofluorobenzene	SW8240	ug/L	2		614		599		1,140		1,140		784	770
1,4-Dichlorobenzene	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
2-Hexanone	SW8240	ug/L	2	<	9	<	9	<	18	<	18	<	18	---
4-Methyl-2-pentanone(MIBK)	SW8240	ug/L	2	<	6.4	<	6.4	<	12.3	<	12.3	<	12.3	---
Acetone	SW8240	ug/L	2		87.7		96.3		134		145		106	61
Benzene	SW8240	ug/L	2		2,300		2,670		2,250		2,970		2,410	570
Bromodichloromethane	SW8240	ug/L	2	<	4.8	<	4.8	<	9.3	<	9.3	<	9.3	---
Bromomethane	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
Carbon disulfide	SW8240	ug/L	2	<	6.4	<	6.4	<	12.3	<	12.3	<	12.3	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Volatile Organic Compounds (continued)														
Carbon tetrachloride	SW8240	ug/L	2	<	10	<	10	<	20	<	20	<	20	---
Chlorobenzene	SW8240	ug/L	2	<	4.1	<	4.1	<	8	<	8	<	8	---
Chloroethane	SW8240	ug/L	2	<	10	<	10	<	19	<	19	<	19	---
Chloroform	SW8240	ug/L	2	<	7	<	7	<	13	<	13	<	13	---
Chloromethane	SW8240	ug/L	2	<	6.8	<	6.8	<	13	<	13	<	13	---
Dibromochloromethane	SW8240	ug/L	2	<	3.2	<	3.2	<	6.2	<	6.2	<	6.2	---
Ethyl benzene	SW8240	ug/L	2	<	8	<	8	<	15	<	15	<	15	---
Methyl ethyl ketone	SW8240	ug/L	2	<	21	<	21	<	40	<	40	<	40	---
Methylene chloride	SW8240	ug/L	2		103		89.2		120		128		104	38
Styrene	SW8240	ug/L	2	<	5.6	<	5.6	<	10.8	<	10.8	<	10.8	---
Tetrachloroethene	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
Toluene	SW8240	ug/L	2	<	5.3	<	5.3	<	10.2	<	10.2	<	10.2	---
Tribromomethane(Bromoform)	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
Trichloroethene	SW8240	ug/L	2	<	5.9	<	5.9	<	11.4	<	11.4	<	11.4	---
Vinyl acetate	SW8240	ug/L	2	<	8	<	8	<	16	<	16	<	16	---
Vinyl chloride	SW8240	ug/L	2	<	9	<	9	<	17	<	17	<	17	---
cis-1,3-Dichloropropene	SW8240	ug/L	2	<	5.4	<	5.4	<	10.4	<	10.4	<	10.4	---
m&p-Xylene	SW8240	ug/L	2	<	6.6	<	6.6	<	12.7	<	12.7	<	12.7	---
o-Xylene	SW8240	ug/L	2	<	5.2	<	5.2	<	10	<	10	<	10	---
trans-1,2-Dichloroethene	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
trans-1,3-Dichloropropene	SW8240	ug/L	2	<	5.4	<	5.4	<	10.4	<	10.4	<	10.4	---
Semivolatile Organic Compounds														
1,2,4-Trichlorobenzene	SW8270	ug/L	2	<	0.54	<	0.55	<	0.55	<	0.54	<	0.55	---
1,2-Dichlorobenzene	SW8270	ug/L	2	<	0.66	<	0.66	<	0.66	<	0.66	<	0.66	---
1,3-Dichlorobenzene	SW8270	ug/L	2	<	0.44	<	0.45	<	0.45	<	0.44	<	0.45	---
1,4-Dichlorobenzene	SW8270	ug/L	2	<	1.7	<	1.8	<	1.8	<	1.7	<	1.8	---
2,4,5-Trichlorophenol	SW8270	ug/L	2	<	0.35	<	0.36	<	0.36	<	0.35	<	0.36	---
2,4,6-Tribromophenol	SW8270	ug/L	2		139		127		158		145		141	39
2,4,6-Trichlorophenol	SW8270	ug/L	2	<	0.42	<	0.42	<	0.42	<	0.42	<	0.42	---
2,4-Dichlorophenol	SW8270	ug/L	2	<	0.44	<	0.44	<	0.44	<	0.44	<	0.44	---
2,4-Dimethylphenol	SW8270	ug/L	2	<	0.72	<	0.72	<	0.72	<	0.72	<	0.72	---
2,4-Dinitrophenol	SW8270	ug/L	2	<	1.3	<	1.3	<	1.3	<	1.3	<	1.3	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)														
2,4-Dinitrotoluene	SW8270	ug/L	2	<	0.35	<	0.35	<	0.35	<	0.35	<	0.35	---
2,6-Dinitrotoluene	SW8270	ug/L	2	<	0.67	<	0.68	<	0.68	<	0.67	<	0.68	---
2-Chloronaphthalene	SW8270	ug/L	2	<	0.87	<	0.88	<	0.88	<	0.87	<	0.88	---
2-Chlorophenol	SW8270	ug/L	2	<	0.58	<	0.59	<	0.59	<	0.58	<	0.59	---
2-Fluorobiphenyl	SW8270	ug/L	2		71.3		62.2		76.8		60.9		70.1	18
2-Fluorophenol	SW8270	ug/L	2		155		138		183		158		159	56
2-Methylnaphthalene	SW8270	ug/L	2	<	0.88	<	0.89	<	0.89	<	0.88	<	0.89	---
2-Methylphenol	SW8270	ug/L	2	<	0.52	<	0.52	<	0.52	<	0.52	<	0.52	---
2-Nitroaniline	SW8270	ug/L	2	<	0.56	<	0.57	<	0.57	<	0.56	<	0.57	---
2-Nitrophenol	SW8270	ug/L	2	<	0.84	<	0.85	<	0.85	<	0.84	<	0.85	---
3,3'-Dichlorobenzidine	SW8270	ug/L	2	<	4	<	4.1	<	4.1	<	4	<	4.1	---
3-Nitroaniline	SW8270	ug/L	2	<	0.56	<	0.56	<	0.56	<	0.56	<	0.56	---
4,6-Dinitro-2-methylphenol	SW8270	ug/L	2	<	3.1	<	3.2	<	3.2	<	3.1	<	3.2	---
4-Aminobiphenyl	SW8270	ug/L	2	<	4.5	<	4.5	<	4.5	<	4.5	<	4.5	---
4-Bromophenylphenyl ether	SW8270	ug/L	2	<	0.31	<	0.32	<	0.32	<	0.31	<	0.32	---
4-Chloro-3-methylphenol	SW8270	ug/L	2	<	0.41	<	0.42	<	0.42	<	0.41	<	0.42	---
4-Chlorophenylphenyl ether	SW8270	ug/L	2	<	0.49	<	0.5	<	0.5	<	0.49	<	0.5	---
4-Methylphenol/3-Methylphenol	SW8270	ug/L	2		1.47 F		0.97 F		1.43 F	<	0.48		1.29	0.69
4-Nitroaniline	SW8270	ug/L	2	<	0.68	<	0.68	<	0.68	<	0.68	<	0.68	---
4-Nitrophenol	SW8270	ug/L	2	<	0.83	<	0.84	<	0.84	<	0.83	<	0.84	---
Acenaphthene	SW8270	ug/L	2	<	0.66	<	0.66	<	0.66	<	0.66	<	0.66	---
Acenaphthylene	SW8270	ug/L	2	<	0.67	<	0.68	<	0.68	<	0.67	<	0.68	---
Acetophenone	SW8270	ug/L	2	<	0.59	<	0.59	<	0.59	<	0.59	<	0.59	---
Aniline	SW8270	ug/L	2	<	1.1	<	1.1	<	1.1	<	1.1	<	1.1	---
Anthracene	SW8270	ug/L	2		0.782	<	0.73		1.02		0.735	<	0.73	---
Benz(a)anthracene	SW8270	ug/L	2	<	0.79	<	0.8	<	0.8	<	0.79	<	0.8	---
Benz(a)pyrene	SW8270	ug/L	2	<	0.72	<	0.73	<	0.73	<	0.72	<	0.73	---
Benzidine	SW8270	ug/L	2	<	22	<	22	<	22	<	22	<	22	---
Benzo(b)fluoranthene	SW8270	ug/L	2	<	0.71	<	0.71	<	0.71	<	0.71	<	0.71	---
Benzo(g,h,i)perylene	SW8270	ug/L	2	<	0.76	<	0.77	<	0.77	<	0.76	<	0.77	---
Benzo(k)fluoranthene	SW8270	ug/L	2	<	1	<	1	<	1	<	1	<	1	---
Benzoic acid	SW8270	ug/L	2	<	6.6	<	6.6	<	6.6	<	6.6	<	6.6	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)														
Benzyl alcohol	SW8270	ug/L	2	<	0.47	<	0.47	<	0.47	<	0.47	<	0.47	---
Butylbenzylphthalate	SW8270	ug/L	2	<	0.52	<	0.52	<	0.52	<	0.52	<	0.52	---
Chrysene	SW8270	ug/L	2	<	0.8	<	0.81	<	0.81	<	0.8	<	0.81	---
Di-n-butylphthalate	SW8270	ug/L	2	<	0.52	<	0.52	<	0.52	<	0.52	<	0.52	---
Di-n-octylphthalate	SW8270	ug/L	2	<	0.7	<	0.71	<	0.71	<	0.7	<	0.71	---
Dibenz(a,h)anthracene	SW8270	ug/L	2	<	0.88	<	0.89	<	0.89	<	0.88	<	0.89	---
Dibenzofuran	SW8270	ug/L	2	<	0.66	<	0.67	<	0.67	<	0.66	<	0.67	---
Diethylphthalate	SW8270	ug/L	2	<	0.71	<	0.71	<	0.71	<	0.71	<	0.71	---
Dimethylphthalate	SW8270	ug/L	2	<	0.44	<	0.45	<	0.45	<	0.44	<	0.45	---
Diphenylamine/N-NitrosoDPA	SW8270	ug/L	2	<	0.71	<	0.71	<	0.71	<	0.71	<	0.71	---
Fluoranthene	SW8270	ug/L	2		5.34		3.35		8.16		6.83		5.62	6
Fluorene	SW8270	ug/L	2	<	0.77	<	0.78	<	0.78	<	0.77	<	0.78	---
Hexachlorobenzene	SW8270	ug/L	2	<	0.58	<	0.59	<	0.59	<	0.58	<	0.59	---
Hexachlorobutadiene	SW8270	ug/L	2	<	0.78	<	0.79	<	0.79	<	0.78	<	0.79	---
Hexachlorocyclopentadiene	SW8270	ug/L	2	<	2.2	<	2.2	<	2.2	<	2.2	<	2.2	---
Hexachloroethane	SW8270	ug/L	2	<	2	<	2	<	2	<	2	<	2	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/L	2	<	0.83	<	0.84	<	0.84	<	0.83	<	0.84	---
Isophorone	SW8270	ug/L	2	<	0.37	<	0.37	<	0.37	<	0.37	<	0.37	---
N-Nitroso-di-n-propylamine	SW8270	ug/L	2	<	0.62	<	0.62	<	0.62	<	0.62	<	0.62	---
N-Nitrosodimethylamine	SW8270	ug/L	2	<	0.55	<	0.56	<	0.56	<	0.55	<	0.56	---
Naphthalene	SW8270	ug/L	2	<	0.78	<	0.79	<	0.79	<	0.78	<	0.79	---
Nitrobenzene	SW8270	ug/L	2	<	0.59	<	0.6	<	0.6	<	0.59	<	0.6	---
Pentachloronitrobenzene	SW8270	ug/L	2	<	1.9	<	2	<	2	<	1.9	<	2	---
Pentachlorophenol	SW8270	ug/L	2	<	0.53	<	0.53	<	0.53	<	0.53	<	0.53	---
Phenanthrene	SW8270	ug/L	2		2.12	<	0.7		2.79		2.32	<	2.1	---
Phenol	SW8270	ug/L	2		520		444		563		504		509	150
Pyrene	SW8270	ug/L	2		22.5		15.7		34.3		29.4		24.2	23
bis(2-Chloroethoxy)methane	SW8270	ug/L	2	<	0.59	<	0.6	<	0.6	<	0.59	<	0.6	---
bis(2-Chloroethyl)ether	SW8270	ug/L	2	<	0.65	<	0.65	<	0.65	<	0.65	<	0.65	---
bis(2-Chloroisopropyl)ether	SW8270	ug/L	2	<	0.6	<	0.61	<	0.61	<	0.6	<	0.61	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/L	2	<	1.1	<	1.1	<	1.1	<	1.1	<	1.1	---
p-Chloroaniline	SW8270	ug/L	2	<	0.98	<	0.99	<	0.99	<	0.98	<	0.99	---

Table G-1. Analytical Results Used In Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Semivolatile Organic Compounds (continued)									
p-Dimethylaminoazobenzene	SW8270	ug/L	2	< 0.53	< 0.53	< 0.53	< 0.53	< 0.53	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Water Quality Parameters														
Chemical Oxygen Demand	EPA 410.1	mg/L	2		54.8		52.1		52.1		50.1		53	3.9
Specific conductance	EPA 120.1	umhos	2		76		76		63.3		62.8		71.8	18
TSS	EPA 160.2	mg/L	2		1		3.47		1.18		2.22		1.88	3.4
Total phenolics	EPA 420.2	mg/L	2		0.498		0.564		0.576		0.578		0.546	0.1
pH	EPA150.1		2		8.7		8.7		8.85		8.88		8.75	0.22
Ionic Species														
Ammonia as N	EPA 350.1	mg/L	2		7.19		8.8		5.91		5.56		7.3	3.6
Chloride	EPA 300.0	mg/L	2		0.946		0.861		0.83		0.837		0.879	0.15
Cyanide, amenable	SW9012	mg/L	2	<	0.01		0.019		0.0815		0.116		0.0352	0.1
Cyanide, total	SW9012	mg/L	2		1.99		1.25		1.13		1.16		1.46	1.2
Fluoride	EPA 340.2	mg/L	2		2.01		1.51		1.99		1.94		1.84	0.7
Formate	IC	mg/L	2		3.32		3.14		2.99		2.97		3.15	0.41
Phosphate, total (as P)	EPA 365.1	mg/L	2		0.301		0.25		0.22		0.245		0.257	0.1
Sulfate	EPA 300.0	mg/L	2	<	0.047	<	0.047	<	0.047	<	0.047	<	0.047	---
Thiocyanate	SM412K	mg/L	2		1.15		0.608		0.707		0.904		0.822	0.72
Metals, total														
Aluminum	SW6010	mg/L	2		0.432		0.518		0.535		0.591		0.495	0.14
Antimony	SW6010	mg/L	2	<	0.076	<	0.076	<	0.076	<	0.076	<	0.076	---
Arsenic	SW7060	mg/L	2		0.00268		0.00426		0.00446		0.0047		0.0038	0.0024
Barium	SW6010	mg/L	2		0.507		0.516		0.56		0.567		0.528	0.07
Beryllium	SW6010	mg/L	2		0.00115	<	0.00051	<	0.00051	<	0.00051		0.000553	0.0013
Boron	SW6010	mg/L	2		0.027		0.0626		0.0269		0.0359		0.0388	0.051
Cadmium	SW7131	mg/L	2		0.00392		0.00528		0.00578		0.00546		0.00499	0.0024
Calcium	SW6010	mg/L	2		2.64		2.57		2.65		2.87		2.62	0.11
Chromium	SW6010	mg/L	2		0.00766		0.01		0.00845		0.0106		0.0087	0.003
Cobalt	SW6010	mg/L	2	<	0.0041	<	0.0041	<	0.0041	<	0.0041	<	0.0041	---
Copper	SW6010	mg/L	2		0.0124		0.0155		0.0155		0.017		0.0145	0.0044
Iron	SW6010	mg/L	2		1.22		1.12		1.22		1.29		1.19	0.14
Lead	SW7421	mg/L	2		0.213 S		0.385 S		0.388 S		0.384 S		0.329	0.25
Magnesium	SW6010	mg/L	2		1		1.03		0.984		0.996		1	0.058
Manganese	SW6010	mg/L	2		0.00317	<	0.0016		0.00317		0.00579		0.00238	0.0034
Mercury	SW7470	mg/L	2		0.000060	<	0.000033	<	0.000033	<	0.000033	<	0.000033	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Metals (continued)														
Molybdenum	SW6010	mg/L	2		0.0128		0.0123		0.009	<	0.0074		0.0114	0.0051
Nickel	SW6010	mg/L	2		0.0404		0.0178	<	0.014		0.0366		0.0217	0.042
Phosphorus	SW6010	mg/L	2		0.26		0.26		0.211		0.163		0.244	0.07
Potassium	SW6010	mg/L	2		1.16	<	0.82		1.14	<	0.82		0.903	1.1
Selenium	SW7740	mg/L	2		0.0226		0.0361		0.0364		0.0353		0.0317	0.02
Silicon	SW6010	mg/L	2		7.14		7.39		7.15		7.21		7.23	0.35
Sodium	SW6010	mg/L	2		3.79		3.8		3.77		3.99		3.79	0.038
Titanium	SW6010	mg/L	2		0.015		0.0214		0.0232		0.0232		0.0199	0.011
Vanadium	SW6010	mg/L	2	<	0.0045	<	0.0045	<	0.0045	<	0.0045	<	0.0045	---
Zinc	SW6010	mg/L	2		0.188		0.27		0.28		0.272		0.246	0.13
Aldehydes														
Acetaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Acrolein	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Benzaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Formaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01		0.01	<	0.01	---
Volatile Organic Compounds														
1,1,1-Trichloroethane	SW8240	ug/L	2	<	0.87	<	0.87	<	0.87	<	0.87	<	0.87	---
1,1,2,2-Tetrachloroethane	SW8240	ug/L	2	<	0.63	<	0.63	<	0.63	<	0.63	<	0.63	---
1,1,2-Trichloroethane	SW8240	ug/L	2	<	0.27	<	0.27	<	0.27	<	0.27	<	0.27	---
1,1-Dichloroethane	SW8240	ug/L	2	<	0.59	<	0.59	<	0.59	<	0.59	<	0.59	---
1,1-Dichloroethene	SW8240	ug/L	2	<	0.34	<	0.34	<	0.34	<	0.34	<	0.34	---
1,2-Dichloroethane	SW8240	ug/L	2	<	0.82	<	0.82	<	0.82	<	0.82	<	0.82	---
1,2-Dichloropropane	SW8240	ug/L	2	<	0.16	<	0.16	<	0.16	<	0.16	<	0.16	---
1,4-Bromofluorobenzene	SW8240	ug/L	2		46.1		45.2		45.4		46.7		45.6	1.2
1,4-Dichlorobenzene	SW8240	ug/L	2	<	0.56	<	0.56	<	0.56	<	0.56	<	0.56	---
2-Hexanone	SW8240	ug/L	2	<	0.71	<	0.71	<	0.71	<	0.71	<	0.71	---
4-Methyl-2-pentanone(MIBK)	SW8240	ug/L	2	<	0.49	<	0.49	<	0.49	<	0.49	<	0.49	---
Acetone	SW8240	ug/L	2		4.75		4.19		6.63		5.1		5.19	3.2
Benzene	SW8240	ug/L	2	<	0.46	<	0.46	<	0.46	<	0.46	<	0.46	---
Bromodichloromethane	SW8240	ug/L	2	<	0.37	<	0.37	<	0.37	<	0.37	<	0.37	---
Bromomethane	SW8240	ug/L	2	<	0.54	<	0.54	<	0.54	<	0.54	<	0.54	---
Carbon disulfide	SW8240	ug/L	2	<	0.49	<	0.49	<	0.49	<	0.49	<	0.49	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Volatile Organic Compounds (continued)														
Carbon tetrachloride	SW8240	ug/L	2	<	0.8	<	0.8	<	0.8	<	0.8	<	0.8	---
Chlorobenzene	SW8240	ug/L	2	<	0.32	<	0.32	<	0.32	<	0.32	<	0.32	---
Chloroethane	SW8240	ug/L	2	<	0.77	<	0.77	<	0.77	<	0.77	<	0.77	---
Chloroform	SW8240	ug/L	2	<	0.53	<	0.53	<	0.53	<	0.53	<	0.53	---
Chloromethane	SW8240	ug/L	2	<	0.52	<	0.52	<	0.52	<	0.52	<	0.52	---
Dibromochloromethane	SW8240	ug/L	2	<	0.25	<	0.25	<	0.25	<	0.25	<	0.25	---
Ethyl benzene	SW8240	ug/L	2	<	0.59	<	0.59	<	0.59	<	0.59	<	0.59	---
Methyl ethyl ketone	SW8240	ug/L	2	<	1.6	<	1.6	<	1.6	<	1.6	<	1.6	---
Methylene chloride	SW8240	ug/L	2	<	3		3.63		3.66		3.5	<	3	---
Styrene	SW8240	ug/L	2	<	0.43	<	0.43	<	0.43	<	0.43	<	0.43	---
Tetrachloroethene	SW8240	ug/L	2	<	0.54	<	0.54	<	0.54	<	0.54	<	0.54	---
Toluene	SW8240	ug/L	2	<	0.41	<	0.41	<	0.41	<	0.41	<	0.41	---
Tribromomethane(Bromoform)	SW8240	ug/L	2	<	0.56	<	0.56	<	0.56	<	0.56	<	0.56	---
Trichloroethene	SW8240	ug/L	2	<	0.46	<	0.46	<	0.46	<	0.46	<	0.46	---
Vinyl acetate	SW8240	ug/L	2	<	0.64	<	0.64	<	0.64	<	0.64	<	0.64	---
Vinyl chloride	SW8240	ug/L	2	<	0.69	<	0.69	<	0.69	<	0.69	<	0.69	---
cis-1,3-Dichloropropene	SW8240	ug/L	2	<	0.41	<	0.41	<	0.41	<	0.41	<	0.41	---
m&p-Xylene	SW8240	ug/L	2	<	0.51	<	0.51	<	0.51	<	0.51	<	0.51	---
o-Xylene	SW8240	ug/L	2	<	0.4	<	0.4	<	0.4	<	0.4	<	0.4	---
trans-1,2-Dichloroethene	SW8240	ug/L	2	<	0.54	<	0.54	<	0.54	<	0.54	<	0.54	---
trans-1,3-Dichloropropene	SW8240	ug/L	2	<	0.42	<	0.42	<	0.42	<	0.42	<	0.42	---
Semivolatile Organic Compounds														
1,2,4-Trichlorobenzene	SW8270	ug/L	2	<	0.54	<	0.5	<	0.53	<	0.49	<	0.53	---
1,2-Dichlorobenzene	SW8270	ug/L	2	<	0.66	<	0.6	<	0.64	<	0.6	<	0.64	---
1,3-Dichlorobenzene	SW8270	ug/L	2	<	0.44	<	0.41	<	0.43	<	0.4	<	0.43	---
1,4-Dichlorobenzene	SW8270	ug/L	2	<	1.7	<	1.6	<	1.7	<	1.6	<	1.7	---
2,4,5-Trichlorophenol	SW8270	ug/L	2	<	0.35	<	0.32	<	0.34	<	0.32	<	0.34	---
2,4,6-Tribromophenol	SW8270	ug/L	2		177		157		153		152		162	32
2,4,6-Trichlorophenol	SW8270	ug/L	2	<	0.42	<	0.39	<	0.41	<	0.38	<	0.41	---
2,4-Dichlorophenol	SW8270	ug/L	2	<	0.44	<	0.4	<	0.43	<	0.4	<	0.43	---
2,4-Dimethylphenol	SW8270	ug/L	2	<	0.72	<	0.66	<	0.7	<	0.65	<	0.7	---
2,4-Dinitrophenol	SW8270	ug/L	2	<	1.3	<	1.2	<	1.3	<	1.2	<	1.3	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)														
2,4-Dinitrotoluene	SW8270	ug/L	2	<	0.35	<	0.32	<	0.34	<	0.31	<	0.34	---
2,6-Dinitrotoluene	SW8270	ug/L	2	<	0.67	<	0.62	<	0.65	<	0.61	<	0.65	---
2-Chloronaphthalene	SW8270	ug/L	2	<	0.87	<	0.8	<	0.84	<	0.79	<	0.84	---
2-Chlorophenol	SW8270	ug/L	2	<	0.58	<	0.54	<	0.57	<	0.53	<	0.57	---
2-Fluorobiphenyl	SW8270	ug/L	2		58.8		56.5		68.2		61.9		61.2	15
2-Fluorophenol	SW8270	ug/L	2		175		154		150		143		160	33
2-Methylnaphthalene	SW8270	ug/L	2	<	0.88	<	0.81	<	0.86	<	0.8	<	0.86	---
2-Methylphenol	SW8270	ug/L	2	<	0.52	<	0.48	<	0.51	<	0.47	<	0.51	---
2-Nitroaniline	SW8270	ug/L	2	<	0.56	<	0.52	<	0.55	<	0.51	<	0.55	---
2-Nitrophenol	SW8270	ug/L	2	<	0.84	<	0.77	<	0.82	<	0.77	<	0.82	---
3,3'-Dichlorobenzidine	SW8270	ug/L	2	<	4	<	3.7	<	3.9	<	3.7	<	3.9	---
3-Nitroaniline	SW8270	ug/L	2	<	0.56	<	0.51	<	0.54	<	0.51	<	0.54	---
4,6-Dinitro-2-methylphenol	SW8270	ug/L	2	<	3.1	<	2.9	<	3.1	<	2.9	<	3.1	---
4-Aminobiphenyl	SW8270	ug/L	2	<	4.5	<	4.1	<	4.3	<	4.1	<	4.3	---
4-Bromophenylphenyl ether	SW8270	ug/L	2	<	0.31	<	0.29	<	0.31	<	0.29	<	0.31	---
4-Chloro-3-methylphenol	SW8270	ug/L	2	<	0.41	<	0.38	<	0.4	<	0.38	<	0.4	---
4-Chlorophenylphenyl ether	SW8270	ug/L	2	<	0.49	<	0.45	<	0.48	<	0.45	<	0.48	---
4-Methylphenol/3-Methylphenol	SW8270	ug/L	2	<	0.48		0.994 F	<	0.47	<	0.44		0.49	1.1
4-Nitroaniline	SW8270	ug/L	2	<	0.68	<	0.62	<	0.66	<	0.62	<	0.66	---
4-Nitrophenol	SW8270	ug/L	2	<	0.83	<	0.76	<	0.81	<	0.75	<	0.81	---
Acenaphthene	SW8270	ug/L	2	<	0.66	<	0.6	<	0.64	<	0.6	<	0.64	---
Acenaphthylene	SW8270	ug/L	2	<	0.67	<	0.62	<	0.65	<	0.61	<	0.65	---
Acetophenone	SW8270	ug/L	2	<	0.59	<	0.54	<	0.57	<	0.53	<	0.57	---
Aniline	SW8270	ug/L	2	<	1.1	<	1	<	1.1	<	1	<	1.1	---
Anthracene	SW8270	ug/L	2	<	0.72	<	0.66	<	0.7	<	0.66	<	0.7	---
Benz(a)anthracene	SW8270	ug/L	2	<	0.79	<	0.73	<	0.77	<	0.72	<	0.77	---
Benz(a)pyrene	SW8270	ug/L	2	<	0.72	<	0.66	<	0.7	<	0.65	<	0.7	---
Benzidine	SW8270	ug/L	2	<	22	<	20	<	21	<	20	<	21	---
Benzo(b)fluoranthene	SW8270	ug/L	2	<	0.71	<	0.65	<	0.69	<	0.64	<	0.69	---
Benzo(g,h,i)perylene	SW8270	ug/L	2	<	0.76	<	0.7	<	0.74	<	0.7	<	0.74	---
Benzo(k)fluoranthene	SW8270	ug/L	2	<	1.03	<	0.95	<	1	<	0.94	<	1	---
Benzoic acid	SW8270	ug/L	2		21.5	<	6	<	6.4	<	6		9.23	26

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)														
Benzyl alcohol	SW8270	ug/L	2	<	0.47	<	0.43	<	0.45	<	0.42	<	0.45	---
Butylbenzylphthalate	SW8270	ug/L	2	<	0.52	<	0.47	<	0.5	<	0.47	<	0.5	---
Chrysene	SW8270	ug/L	2	<	0.8	<	0.74	<	0.78	<	0.73	<	0.78	---
Di-n-butylphthalate	SW8270	ug/L	2	<	0.52	<	0.48	<	0.5	<	0.47	<	0.5	---
Di-n-octylphthalate	SW8270	ug/L	2	<	0.7	<	0.65	<	0.68	<	0.64	<	0.68	---
Dibenz(a,h)anthracene	SW8270	ug/L	2	<	0.88	<	0.81	<	0.86	<	0.8	<	0.86	---
Dibenzofuran	SW8270	ug/L	2	<	0.66	<	0.61	<	0.64	<	0.6	<	0.64	---
Diethylphthalate	SW8270	ug/L	2	<	0.71	<	0.65	<	0.69	<	0.64	<	0.69	---
Dimethylphthalate	SW8270	ug/L	2	<	0.44	<	0.41	<	0.43	<	0.4	<	0.43	---
Diphenylamine/N-NitrosoDPA	SW8270	ug/L	2	<	0.71	<	0.65	<	0.69	<	0.64	<	0.69	---
Fluoranthene	SW8270	ug/L	2		2.23		3.07		2.54		3.29		2.61	1.1
Fluorene	SW8270	ug/L	2	<	0.77	<	0.71	<	0.75	<	0.7	<	0.75	---
Hexachlorobenzene	SW8270	ug/L	2	<	0.58	<	0.54	<	0.57	<	0.53	<	0.57	---
Hexachlorobutadiene	SW8270	ug/L	2	<	0.78	<	0.71	<	0.76	<	0.71	<	0.76	---
Hexachlorocyclopentadiene	SW8270	ug/L	2	<	2.2	<	2	<	2.1	<	2	<	2.1	---
Hexachloroethane	SW8270	ug/L	2	<	2	<	1.8	<	1.9	<	1.8	<	1.9	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/L	2	<	0.83	<	0.76	<	0.81	<	0.76	<	0.81	---
Isophorone	SW8270	ug/L	2	<	0.37	<	0.34	<	0.36	<	0.34	<	0.36	---
N-Nitroso-di-n-propylamine	SW8270	ug/L	2	<	0.62	<	0.57	<	0.6	<	0.56	<	0.6	---
N-Nitrosodimethylamine	SW8270	ug/L	2	<	0.55	<	0.51	<	0.54	<	0.5	<	0.54	---
Naphthalene	SW8270	ug/L	2	<	0.78	<	0.72	<	0.76	<	0.71	<	0.76	---
Nitrobenzene	SW8270	ug/L	2	<	0.59	<	0.54	<	0.58	<	0.54	<	0.58	---
Pentachloronitrobenzene	SW8270	ug/L	2	<	1.9	<	1.8	<	1.9	<	1.8	<	1.9	---
Pentachlorophenol	SW8270	ug/L	2	<	0.53	<	0.49	<	0.51	<	0.48	<	0.51	---
Phenanthrene	SW8270	ug/L	2	<	0.67	<	1.89		0.861	<	0.61	<	1.89	---
Phenol	SW8270	ug/L	2		380		434		372		392		395	84
Pyrene	SW8270	ug/L	2		9.1		13.6		11		14.4		11.2	5.6
bis(2-Chloroethoxy)methane	SW8270	ug/L	2	<	0.59	<	0.55	<	0.58	<	0.54	<	0.58	---
bis(2-Chloroethyl)ether	SW8270	ug/L	2	<	0.65	<	0.6	<	0.63	<	0.59	<	0.63	---
bis(2-Chloroisopropyl)ether	SW8270	ug/L	2	<	0.6	<	0.56	<	0.59	<	0.55	<	0.59	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/L	2	<	1.05	<	0.96	<	1.02	<	0.95	<	1.02	---
p-Chloroaniline	SW8270	ug/L	2	<	0.98	<	0.9	<	0.95	<	0.89	<	0.95	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Semivolatile Organic Compounds (continued)									
p-Dimethylaminoazobenzene	SW8270	ug/L	2	< 0.53	< 0.49	< 0.51	< 0.48	< 0.51	---

Table G-1. Analytical Results Used in Calculations

Stream: Scrubber Water

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Water Quality Parameters									
TSS	EPA 160.2	Wt. %	3						
Ionic Species									
Ammonia as N	EPA 350.1	mg/L	3						
Chloride	EPA 300.0	mg/L	3						
Cyanide, amenabl	SW9012	mg/L	3						
Cyanide, total	SW9012	mg/L	3						
Fluoride	EPA 340.2	mg/L	3						
Thiocyanate	SM412K	mg/L	3						
Metals, total									
Aluminum	SW6010	mg/L	3						
Antimony	SW6010	mg/L	3						
Arsenic	SW7060	mg/L	3						
Barium	SW6010	mg/L	3						
Beryllium	SW6010	mg/L	3						
Boron	SW6010	mg/L	3						
Cadmium	SW7131	mg/L	3						
Calcium	SW6010	mg/L	3						
Chromium	SW6010	mg/L	3						
Cobalt	SW6010	mg/L	3						
Copper	SW6010	mg/L	3						
Iron	SW6010	mg/L	3						
Lead	SW7421	mg/L	3						
Magnesium	SW6010	mg/L	3						
Manganese	SW6010	mg/L	3						
Mercury	SW7470	mg/L	3						
Molybdenum	SW6010	mg/L	3						
Nickel	SW6010	mg/L	3						
Phosphorus	SW6010	mg/L	3						
Potassium	SW6010	mg/L	3						
Selenium	SW7740	mg/L	3						
Silicon	SW6010	mg/L	3						
Sodium	SW6010	mg/L	3						

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Table G-1. Analytical Results Used in Calculations

Stream: Scrubber Water

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Titanium	SW6010	mg/L	3						
Vanadium	SW6010	mg/L	3						
Zinc	SW6010	mg/L	3						

Table G-1. Analytical Results Used in Calculations

Stream: Recycled Char Filtrate

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Water Quality Parameters									
TSS	EPA 160.2	Wt. %	3						
Ionic Species									
Ammonia as N	EPA 350.1	mg/L	3						
Chloride	EPA 300.0	mg/L	3						
Cyanide, amenabl	SW9012	mg/L	3						
Cyanide, total	SW9012	mg/L	3						
Fluoride	EPA 340.2	mg/L	3						
Thiocyanate	SM412K	mg/L	3						
Metals, soluble									
Aluminum	SW6010	mg/L	3						
Antimony	SW6010	mg/L	3						
Arsenic	SW7060	mg/L	3						
Barium	SW6010	mg/L	3						
Beryllium	SW6010	mg/L	3						
Boron	SW6010	mg/L	3						
Cadmium	SW7131	mg/L	3						
Calcium	SW6010	mg/L	3						
Chromium	SW6010	mg/L	3						
Cobalt	SW6010	mg/L	3						
Copper	SW6010	mg/L	3						
Iron	SW6010	mg/L	3						
Lead	SW7421	mg/L	3						
Magnesium	SW6010	mg/L	3						
Manganese	SW6010	mg/L	3						
Mercury	SW7470	mg/L	3						
Molybdenum	SW6010	mg/L	3						
Nickel	SW6010	mg/L	3						
Phosphorus	SW6010	mg/L	3						
Potassium	SW6010	mg/L	3						
Selenium	SW7740	mg/L	3						
Silicon	SW6010	mg/L	3						
Sodium	SW6010	mg/L	3						

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Table G-1. Analytical Results Used in Calculations

Stream: Recycled Char Filtrate

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Titanium	SW6010	mg/L	3						
Vanadium	SW6010	mg/L	3						
Zinc	SW6010	mg/L	3						

Table G-1. Analytical Results Used in Calculations

Stream: Selectamine Solvent

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ash	D3174	Wt. %	1						
Ash	D3174	Wt. %	3						
Density	Density	g/mL	1						
Density	Density	g/mL	3						
HSS	titration	Wt. %	1						
HSS	titration	Wt. %	3						
TSS	EPA 160.2	mg/L	1						
TSS	EPA 160.2	mg/L	3						

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Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Syngas (5a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Antimony	SW6010	ug/Nm3	3					
Arsenic	SW7060	ug/Nm3	3					
Barium	SW6010	ug/Nm3	3					
Beryllium	SW6010	ug/Nm3	3					
Cadmium	SW7131	ug/Nm3	3					
Chromium	SW6010	ug/Nm3	3					
Cobalt	SW6010	ug/Nm3	3					
Copper	SW6010	ug/Nm3	3					
Lead	SW7421	ug/Nm3	3					
Manganese	SW6010	ug/Nm3	3					
Mercury	ICP/MS	ug/Nm3	3					
Molybdenum	SW6010	ug/Nm3	3					
Nickel	SW6010	ug/Nm3	3					
Selenium	SW7740	ug/Nm3	3					
Vanadium	SW6010	ug/Nm3	3					

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Table G-2. Analytical Results Not Used in Calculations

Stream: Scrubbed Raw Syngas (5b)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Antimony	SW6010	ug/Nm3	3					
Arsenic	SW7060	ug/Nm3	3					
Barium	SW6010	ug/Nm3	3					
Beryllium	SW6010	ug/Nm3	3					
Cadmium	SW7131	ug/Nm3	3					
Chromium	SW6010	ug/Nm3	3					
Cobalt	SW6010	ug/Nm3	3					
Copper	SW6010	ug/Nm3	3					
Lead	SW7421	ug/Nm3	3					
Manganese	SW6010	ug/Nm3	3					
Mercury	ICP/MS	ug/Nm3	3					
Molybdenum	SW6010	ug/Nm3	3					
Nickel	SW6010	ug/Nm3	3					
Selenium	SW7740	ug/Nm3	3					
Vanadium	SW6010	ug/Nm3	3					

Table G-2. Analytical Results Not Used in Calculations

Stream: Sour Syngas (11)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	1	<	16.6	<	17.5	<	17.2	<	17	---
Arsenic	SW7060	ug/Nm3	1		0.337		0.18		0.274		0.264	0.66
Barium	SW6010	ug/Nm3	1	<	0.188		0.228		0.224	<	0.19	---
Beryllium	SW6010	ug/Nm3	1	<	0.112	<	0.117	<	0.116	<	0.12	---
Cadmium	SW7131	ug/Nm3	1		0.28		0.371		0.328		0.326	0.81
Chromium	SW6010	ug/Nm3	1		2.78		2.46		2.18		2.47	6.1
Cobalt	SW6010	ug/Nm3	1	<	0.89	<	0.937	<	0.922	<	0.94	---
Copper	SW6010	ug/Nm3	1	<	2	<	2.11	<	2.07	<	2.1	---
Lead	SW7421	ug/Nm3	1	<	0.218		1.53	<	0.226		0.584	1.5
Manganese	SW6010	ug/Nm3	1	<	0.339	<	0.357	<	0.351	<	0.36	---
Mercury	ICP/MS	ug/Nm3	1		0.754		1.34		0.51		0.868	2.2
Molybdenum	SW6010	ug/Nm3	1	<	1.62	<	1.7	<	1.67	<	1.7	---
Nickel	SW6010	ug/Nm3	1	<	3.08		6.06	<	3.19	<	3.2	---
Selenium	SW7740	ug/Nm3	1	<	0.129	<	0.136	<	0.134	<	0.14	---
Vanadium	SW6010	ug/Nm3	1	<	0.993	<	1.05	<	1.03	<	1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Sweet Syngas (12)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	1	<	16.7	<	16	<	14.9	<	17	---
Arsenic	SW7060	ug/Nm3	1	<	0.142		0.162		0.274		0.169	0.42
Barium	SW6010	ug/Nm3	1		0.328		0.208		0.292		0.276	0.69
Beryllium	SW6010	ug/Nm3	1	<	0.112	<	0.107	<	0.1	<	0.11	---
Cadmium	SW7131	ug/Nm3	1		0.532		0.49		0.425		0.482	1.2
Chromium	SW6010	ug/Nm3	1		2.57		2.23		2.12		2.31	5.7
Cobalt	SW6010	ug/Nm3	1	<	0.895	<	0.856	<	0.798	<	0.9	---
Copper	SW6010	ug/Nm3	1	<	2.01		11.8	<	1.8		4.57	11
Lead	SW7421	ug/Nm3	1	<	0.219	<	0.21	<	0.195	<	0.22	---
Manganese	SW6010	ug/Nm3	1	<	0.341	<	0.326	<	0.304	<	0.34	---
Mercury	ICP/MS	ug/Nm3	1	<	0.0664	<	0.0635	<	0.0592	<	0.066	---
Molybdenum	SW6010	ug/Nm3	1	<	1.63		1.77	<	1.45	<	1.6	---
Nickel	SW6010	ug/Nm3	1	<	3.1	<	2.97	<	2.76	<	3.1	---
Selenium	SW7740	ug/Nm3	1	<	0.13	<	0.125	<	0.116	<	0.13	---
Vanadium	SW6010	ug/Nm3	1	<	0.998	<	0.955	<	0.89	<	1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Acid Gas (14)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Antimony	SW6010	ug/Nm3	1	< 19.3	< 18	< 16.4	< 19	---
Arsenic	SW7060	ug/Nm3	1	1.44	0.636	0.354	0.81	2
Barium	SW6010	ug/Nm3	1	2.9	0.589	0.321	1.27	3.2
Beryllium	SW6010	ug/Nm3	1	< 0.13	< 0.121	< 0.11	< 0.13	---
Cadmium	SW7131	ug/Nm3	1	0.628	0.43	0.358	0.472	1.2
Chromium	SW6010	ug/Nm3	1	105	28.5	14.9	49.5	120
Cobalt	SW6010	ug/Nm3	1	2.09	< 0.966	< 0.878	1	2.5
Copper	SW6010	ug/Nm3	1	6.66	6.22	7.49	6.79	17
Lead	SW7421	ug/Nm3	1	0.869	< 0.487	0.733	0.615	1.5
Manganese	SW6010	ug/Nm3	1	42.7	13.4	4.19	20.1	50
Mercury	ICP/MS	ug/Nm3	1	0.541	0.708	1.68	0.976	2.4
Molybdenum	SW6010	ug/Nm3	1	9.56	3.44	3.65	5.55	14
Nickel	SW6010	ug/Nm3	1	633	275	137	348	870
Selenium	SW7740	ug/Nm3	1	0.577 S	0.473 S	< 0.382 S	0.414	1
Vanadium	SW6010	ug/Nm3	1	1.62	< 1.08	< 0.979	< 1.1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Tall Gas (15)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Antimony	SW6010	ug/Nm3	1	< 20.5	< 172	< 20.6	< 170	---
Arsenic	SW7060	ug/Nm3	1	< 0.175	< 1.47	< 0.176	< 1.5	---
Barium	SW6010	ug/Nm3	1	0.403	< 1.95	< 0.234	< 1.9	---
Beryllium	SW6010	ug/Nm3	1	< 0.138	< 1.16	< 0.138	< 1.2	---
Cadmium	SW7131	ug/Nm3	1	0.349	5.12	0.885	2.12	5.3
Chromium	SW6010	ug/Nm3	1	3.08	25.8	2.72	10.5	26
Cobalt	SW6010	ug/Nm3	1	< 1.1	18.8	< 1.11	6.63	16
Copper	SW6010	ug/Nm3	1	2.95	45.3	9.61	19.3	48
Lead	SW7421	ug/Nm3	1	< 0.269	8.79	3.86	4.26	11
Manganese	SW6010	ug/Nm3	1	< 0.419	< 3.51	< 0.421	< 3.5	---
Mercury	ICP/MS	ug/Nm3	1	3.4	27.8	5.43	12.2	30
Molybdenum	SW6010	ug/Nm3	1	< 2	< 16.7	< 2.01	< 17	---
Nickel	SW6010	ug/Nm3	1	22.6	< 31.9	14.2	< 32	---
Selenium	SW7740	ug/Nm3	1	< 0.16	< 40.1	< 4.81	< 40	---
Vanadium	SW6010	ug/Nm3	1	1.67	< 10.3	< 1.23	< 10	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Natural Gas (99)

Analyte	Method	Units	Test Period		Result 1			Result 2			Result 3			Average	95% CI
Metals-Vapor Phase (M-29)															
Antimony	SW6010	ug/Nm3	2	<	15.5		<	17.9		<	15.7		<	18	---
Arsenic	SW7060	ug/Nm3	2	<	0.132		<	0.152		<	0.133		<	0.15	---
Barium	SW6010	ug/Nm3	2		0.202		<	0.202			0.204		<	0.2	---
Beryllium	SW6010	ug/Nm3	2	<	0.104		<	0.12		<	0.105		<	0.12	---
Cadmium	SW7131	ug/Nm3	2		0.368			0.543			0.393			0.435	1.1
Chromium	SW6010	ug/Nm3	2		1.89			1.43			2.86			2.06	5.1
Cobalt	SW6010	ug/Nm3	2	<	0.832		<	0.956		<	0.838		<	0.96	---
Copper	SW6010	ug/Nm3	2	<	1.87		<	2.15		<	1.89		<	2.2	---
Lead	SW7421	ug/Nm3	2	<	0.419			10.1			1.89			4.07	10
Manganese	SW6010	ug/Nm3	2	<	0.317		<	0.364		<	0.319		<	0.36	---
Mercury	ICP/MS	ug/Nm3	2	<	0.0617		<	0.0709		<	0.0622		<	0.071	---
Molybdenum	SW6010	ug/Nm3	2	<	1.51		<	1.74		<	1.52		<	1.7	---
Nickel	SW6010	ug/Nm3	2	<	2.88		<	3.31		<	2.9		<	3.3	---
Selenium	SW7740	ug/Nm3	2	<	0.362	S		0.479	S		0.55	S		0.403	1
Vanadium	SW6010	ug/Nm3	2	<	0.929		<	1.07		<	0.935		<	1.1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	2	<	27.2	<	26.4	<	24.9	<	27	---
Arsenic	SW7060	ug/Nm3	2	<	0.232	<	0.225	<	0.212	<	0.23	---
Barium	SW6010	ug/Nm3	2		0.534	<	0.299	<	0.282	<	0.3	---
Beryllium	SW6010	ug/Nm3	2	<	0.183	<	0.177	<	0.167	<	0.18	---
Cadmium	SW7131	ug/Nm3	2		4.52		0.957		0.468		1.98	4.9
Chromium	SW6010	ug/Nm3	2		2.01	<	1.82	<	1.72	<	1.8	---
Cobalt	SW6010	ug/Nm3	2	<	1.46	<	1.42	<	1.33	<	1.5	---
Copper	SW6010	ug/Nm3	2		7.81	<	3.19		3.8		4.4	11
Lead	SW7421	ug/Nm3	2	<	0.357		0.873	<	0.326		0.405	1
Manganese	SW6010	ug/Nm3	2		25.2	<	0.539		2.1		9.19	23
Mercury	ICP/MS	ug/Nm3	2		4.35		6.29		7.72		6.12	15
Molybdenum	SW6010	ug/Nm3	2		4.09	<	2.57		3.73		3.04	7.5
Nickel	SW6010	ug/Nm3	2	<	5.05	<	4.91	<	4.62	<	5.1	---
Selenium	SW7740	ug/Nm3	2	<	0.212	<	0.206	<	0.194	<	0.21	---
Vanadium	SW6010	ug/Nm3	2	<	1.63	<	1.58	<	1.49	<	1.6	---
PAHs/SVOCs-Particulate Phase												
2-Chloronaphthalene	SW8270	ug/Nm3	2	<	0.374	<	0.403	<	0.392	<	0.4	---
2-Methylnaphthalene	SW8270	ug/Nm3	2	<	0.447	<	0.493	<	0.479	<	0.49	---
Acenaphthene	SW8270	ug/Nm3	2	<	0.454	<	0.49	<	0.479	<	0.49	---
Acenaphthylene	SW8270	ug/Nm3	2	<	0.252	<	0.273	<	0.265	<	0.27	---
Anthracene	SW8270	ug/Nm3	2	<	0.275	<	0.276	<	0.293	<	0.29	---
Benzo(a)anthracene	SW8270	ug/Nm3	2	<	0.331	<	0.34	<	0.361	<	0.36	---
Benzo(a)pyrene	SW8270	ug/Nm3	2	<	0.51	<	0.546	<	0.537	<	0.55	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	2	<	0.414	<	0.443	<	0.437	<	0.44	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	2	<	0.623	<	0.666	<	0.658	<	0.67	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	2	<	0.507	<	0.539	<	0.534	<	0.54	---
Chrysene	SW8270	ug/Nm3	2	<	0.387	<	0.393	<	0.42	<	0.42	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	2	<	0.672	<	0.716	<	0.709	<	0.72	---
Fluoranthene	SW8270	ug/Nm3	2	<	0.262	<	0.26	<	0.279	<	0.28	---
Fluorene	SW8270	ug/Nm3	2	<	0.354	<	0.38	<	0.372	<	0.38	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	2	<	0.513	<	0.549	<	0.541	<	0.55	---
Naphthalene	SW8270	ug/Nm3	2	<	0.301	<	0.333	<	0.324	<	0.33	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
Phenanthrene	SW8270	ug/Nm3	2	<	0.265	<	0.266	<	0.282	<	0.28	---
Pyrene	SW8270	ug/Nm3	2	<	0.225	<	0.23	<	0.248	<	0.25	---
PAHs/SVOCs-Vapor Phase												
2-Chloronaphthalene	SW8270	ug/Nm3	2	<	0.464	<	0.46	<	0.475	<	0.48	---
2-Methylnaphthalene	SW8270	ug/Nm3	2	<	0.53	<	0.563	<	0.572	<	0.57	---
Acenaphthene	SW8270	ug/Nm3	2	<	0.563	<	0.556	<	0.575	<	0.57	---
Acenaphthylene	SW8270	ug/Nm3	2	<	0.311	<	0.31	<	0.32	<	0.32	---
Anthracene	SW8270	ug/Nm3	2	<	0.331	<	0.33	<	0.337	<	0.34	---
Benzo(a)anthracene	SW8270	ug/Nm3	2	<	0.477	<	0.426	<	0.441	<	0.48	---
Benzo(a)pyrene	SW8270	ug/Nm3	2	<	0.662	<	0.623	<	0.637	<	0.66	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	2	<	0.54	<	0.51	<	0.52	<	0.54	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	2	<	0.811	<	0.763	<	0.778	<	0.81	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	2	<	0.656	<	0.619	<	0.63	<	0.66	---
Chrysene	SW8270	ug/Nm3	2	<	0.553	<	0.496	<	0.513	<	0.55	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	2	<	0.871	<	0.823	<	0.837	<	0.87	---
Fluoranthene	SW8270	ug/Nm3	2	<	0.315	<	0.313	<	0.32	<	0.32	---
Fluorene	SW8270	ug/Nm3	2	<	0.437	<	0.433	<	0.448	<	0.45	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	2	<	0.666	<	0.626	<	0.64	<	0.67	---
Naphthalene	SW8270	ug/Nm3	2		ND		ND		ND		ND	---
Phenanthrene	SW8270	ug/Nm3	2	<	0.318	<	0.32	<	0.327	<	0.33	---
Pyrene	SW8270	ug/Nm3	2	<	0.325	<	0.29	<	0.3	<	0.32	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	1	<	19.5	<	17.6	<	21.3	<	21	---
Arsenic	SW7060	ug/Nm3	1	<	0.166	<	0.15	<	0.182	<	0.18	---
Barium	SW6010	ug/Nm3	1		0.894		0.23		0.558		0.561	1.4
Beryllium	SW6010	ug/Nm3	1	<	0.131	<	0.118	<	0.143	<	0.14	---
Cadmium	SW7131	ug/Nm3	1		0.38		0.216		2.73		1.11	2.8
Chromium	SW6010	ug/Nm3	1		2.17	<	1.22	<	1.47	<	1.5	---
Cobalt	SW6010	ug/Nm3	1	<	1.05	<	0.945	<	1.14	<	1.1	---
Copper	SW6010	ug/Nm3	1	<	2.35	<	2.13		3.06	<	2.4	---
Lead	SW7421	ug/Nm3	1	<	0.256	<	0.231	<	0.279	<	0.28	---
Manganese	SW6010	ug/Nm3	1	<	0.398	<	0.36		4.32		1.57	3.9
Mercury	ICP/MS	ug/Nm3	1		0.108	<	0.0701	<	0.0847	<	0.085	---
Molybdenum	SW6010	ug/Nm3	1	<	1.9	<	1.72	<	2.07	<	2.1	---
Nickel	SW6010	ug/Nm3	1		5.55	<	3.27	<	3.96	<	4	---
Selenium	SW7740	ug/Nm3	1		0.953		0.671		0.533		0.719	1.8
Vanadium	SW6010	ug/Nm3	1	<	1.17	<	1.05	<	1.27	<	1.3	---
PAHs/SVOCs-Particulate Phase												
2-Chloronaphthalene	SW8270	ug/Nm3	1	<	0.458	<	0.125	<	0.287	<	0.46	---
2-Methylnaphthalene	SW8270	ug/Nm3	1	<	ERR	<	0.118	<	0.341	<	0.34	---
Acenaphthene	SW8270	ug/Nm3	1	<	0.554	<	0.132	<	0.339	<	0.55	---
Acenaphthylene	SW8270	ug/Nm3	1	<	0.306	<	0.0786	<	0.19	<	0.31	---
Anthracene	SW8270	ug/Nm3	1	<	0.341	<	0.1	<	0.206	<	0.34	---
Benzo(a)anthracene	SW8270	ug/Nm3	1	<	0.41	<	0.157	<	0.284	<	0.41	---
Benzo(a)pyrene	SW8270	ug/Nm3	1	<	0.613	<	0.168	<	0.411	<	0.61	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	<	0.499	<	0.154	<	0.345	<	0.5	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	<	0.747	<	0.182	<	0.488	<	0.75	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	<	0.606	<	0.161	<	0.404	<	0.61	---
Chrysene	SW8270	ug/Nm3	1	<	0.475	<	0.172	<	0.325	<	0.48	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	<	0.805	<	0.207	<	0.531	<	0.81	---
Fluoranthene	SW8270	ug/Nm3	1	<	0.324	<	0.104	<	0.201	<	0.32	---
Fluorene	SW8270	ug/Nm3	1	<	0.43	<	0.125	<	0.275	<	0.43	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	<	0.616	<	0.164	<	0.411	<	0.62	---
Naphthalene	SW8270	ug/Nm3	1	<	0.386	<	ERR	<	0.228	<	0.39	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
Phenanthrene	SW8270	ug/Nm3	1	<	0.33	<	0.1	<	0.201	<	0.33	---
Pyrene	SW8270	ug/Nm3	1	<	0.279	<	0.114	<	0.197	<	0.28	---
PAHs/SVOCs-Vapor Phase												
2-Chloronaphthalene	SW8270	ug/Nm3	1	<	0.485	<	0.486	<	0.492	<	0.49	---
2-Methylnaphthalene	SW8270	ug/Nm3	1	<	0.52	<	0.568	<	0.564	<	0.57	---
Acenaphthene	SW8270	ug/Nm3	1	<	0.561	<	0.561	<	0.61	<	0.61	---
Acenaphthylene	SW8270	ug/Nm3	1	<	0.317	<	0.318	<	0.33	<	0.33	---
Anthracene	SW8270	ug/Nm3	1	<	0.293	<	0.297	<	0.345	<	0.34	---
Benzo(a)anthracene	SW8270	ug/Nm3	1	<	0.268	<	0.247	<	0.51	<	0.51	---
Benzo(a)pyrene	SW8270	ug/Nm3	1	<	0.348	<	0.297	<	0.66	<	0.66	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	<	0.324	<	0.275	<	0.581	<	0.58	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	<	0.355	<	0.3	<	0.768	<	0.77	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	<	0.324	<	0.275	<	0.628	<	0.63	---
Chrysene	SW8270	ug/Nm3	1	<	0.303	<	0.275	<	0.578	<	0.58	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	<	0.423	<	0.357	<	0.887	<	0.89	---
Fluoranthene	SW8270	ug/Nm3	1	<	0.203	<	0.207	<	0.337	<	0.34	---
Fluorene	SW8270	ug/Nm3	1	<	0.427	<	0.425	<	0.474	<	0.47	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	<	0.31	<	0.264	<	0.664	<	0.66	---
Naphthalene	SW8270	ug/Nm3	1	<	ERR	<	0.39	<	0.388	<	0.39	---
Phenanthrene	SW8270	ug/Nm3	1	<	0.279	<	0.286	<	0.334	<	0.33	---
Pyrene	SW8270	ug/Nm3	1	<	0.196	<	0.179	<	0.337	<	0.34	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208	ug/g	1	< 100	< 100	< 100		< 100	---
Chloride	D4208	ug/g	2	< 100	< 100	< 100		< 100	---
Chloride	D4208	ug/g	3	< 100	< 100	< 100		< 100	---
Fluoride	D3751/SIE	ug/g	1	90	80	90		86.7	220
Fluoride	D3751/SIE	ug/g	2	100	80	100		93.3	230
Fluoride	D3751/SIE	ug/g	3	90	80	100		90	220
Metals									
Antimony	SW7041	ug/g	1	< 1	< 1	< 1		< 1	---
Antimony	SW7041	ug/g	2	< 1	< 1	< 1		< 1	---
Antimony	SW7041	ug/g	3	< 1	< 1	< 1		< 1	---
Arsenic	SW7060	ug/g	1	< 1	< 1	1		< 1	---
Arsenic	SW7060	ug/g	2	6	< 1	1		2.5	6.2
Arsenic	SW7060	ug/g	3	< 1	< 1	3		1.33	3.3
Beryllium	SW6010	ug/g	1	< 0.2	< 0.2	< 0.2		< 0.2	---
Beryllium	SW6010	ug/g	2	< 0.2	< 0.2	< 0.2		< 0.2	---
Beryllium	SW6010	ug/g	3	< 0.2	0.2	< 0.2		< 0.2	---
Cadmium	SW7131	ug/g	1	< 0.2	< 0.2	< 0.2		< 0.2	---
Cadmium	SW7131	ug/g	2	0.8	< 0.2	< 0.2		0.333	0.83
Cadmium	SW7131	ug/g	3	< 0.2	< 0.2	< 0.2		< 0.2	---
Chromium	SW6010	ug/g	1	5	4	4		4.33	11
Chromium	SW6010	ug/g	2	4	4	6		4.67	12
Chromium	SW6010	ug/g	3	4	4	5		4.33	11
Cobalt	SW6010	ug/g	1	2	2	3		2.33	5.8
Cobalt	SW6010	ug/g	2	1	3	2		2	5
Cobalt	SW6010	ug/g	3	2	3	3		2.67	6.6
Copper	SW6010	ug/g	1	11	11	11		11	27
Copper	SW6010	ug/g	2	11	11	14		12	30
Copper	SW6010	ug/g	3	2	12	12		8.67	22
Lead	SW7421	ug/g	1	3	2	2		2.33	5.8
Lead	SW7421	ug/g	2	2	2	3		2.33	5.8
Lead	SW7421	ug/g	3	3	1	3		2.33	5.8
Manganese	D4326	Wt. %	1	< 0.01	< 0.01	0.01		< 0.01	---

Table G-2. Analytical Results Not Used in Calculations

Stream:* *Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Manganese	D4326	Wt. %	2	< 0.01	< 0.01	0.01		< 0.01	---
Manganese	D4326	Wt. %	3	< 0.01	< 0.01	< 0.01		< 0.01	---
Manganese	SW6010	ug/g	1	8	8	8		8	20
Manganese	SW6010	ug/g	2	8	8	10		8.67	22
Manganese	SW6010	ug/g	3	9	10	10		9.67	24
Molybdenum	SW6010	ug/g	1	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	2	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	3	< 2	< 2	< 2		< 2	---
Nickel	ICP/MS	ug/g	1	21.3	18.9	19.6	11.4	19.9	50
Nickel	ICP/MS	ug/g	2	18.6	18.3	21.1		19.3	48
Nickel	ICP/MS	ug/g	3	19.3	18.9	18.9		19	47
Selenium	SW7740	ug/g	1	2	< 1	1		1.17	2.9
Selenium	SW7740	ug/g	2	3	8	< 1		3.83	9.5
Selenium	SW7740	ug/g	3	2	3	< 1		1.83	4.6
Vanadium	SW6010	ug/g	1	13	13	14		13.3	33
Vanadium	SW6010	ug/g	2	13	12	16		13.7	34
Vanadium	SW6010	ug/g	3	14	13	14		13.7	34

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Ionic Species														
Chloride	D4208	ug/g	1	<	100	<	100	<	100			<	100	---
Chloride	D4208	ug/g	2	<	100	<	100	<	100			<	100	---
Chloride	D4208	ug/g	3	<	100	<	100	<	100	<	100	<	100	---
Fluoride	D3751/SIE	ug/g	1		80		80		90				83.3	210
Fluoride	D3751/SIE	ug/g	2		80		80		60				73.3	180
Fluoride	D3751/SIE	ug/g	3		70		80		80		80		76.7	190
Metals														
Antimony	SW7041	ug/g	1	<	1	<	1	<	1			<	1	---
Antimony	SW7041	ug/g	2	<	1	<	1	<	1			<	1	---
Antimony	SW7041	ug/g	3	<	1	<	1	<	1	<	1	<	1	---
Arsenic	SW7060	ug/g	1	<	1		1	<	1			<	1	---
Arsenic	SW7060	ug/g	2		2		2		1				1.67	4.1
Arsenic	SW7060	ug/g	3	<	1	<	1		1		1	<	1	---
Beryllium	SW6010	ug/g	1	<	0.2	<	0.2	<	0.2			<	0.2	---
Beryllium	SW6010	ug/g	2	<	0.2	<	0.2	<	0.2			<	0.2	---
Beryllium	SW6010	ug/g	3	<	0.2	<	0.2	<	0.2	<	0.2	<	0.2	---
Cadmium	SW7131	ug/g	1	<	0.2	<	0.2	<	0.2			<	0.2	---
Cadmium	SW7131	ug/g	2	<	0.2	<	0.2	<	0.2			<	0.2	---
Cadmium	SW7131	ug/g	3	<	0.2	<	0.2	<	0.2	<	0.2	<	0.2	---
Chromium	SW6010	ug/g	1		4		4		4				4	9.9
Chromium	SW6010	ug/g	2		4		4		4				4	9.9
Chromium	SW6010	ug/g	3		4		3		4		4		3.67	9.1
Cobalt	SW6010	ug/g	1		3		2		2				2.33	5.8
Cobalt	SW6010	ug/g	2		2		2		2				2	5
Cobalt	SW6010	ug/g	3		3		2		3		2		2.67	6.6
Copper	SW6010	ug/g	1		11		11		11				11	27
Copper	SW6010	ug/g	2		11		11		11				11	27
Copper	SW6010	ug/g	3		11		11		11		10		11	27
Lead	SW7421	ug/g	1		2		2		2				2	5
Lead	SW7421	ug/g	2		2		2		1				1.67	4.1
Lead	SW7421	ug/g	3		2		2		2		1		2	5
Manganese	D4326	Wt. %	1	<	0.01		0.01	<	0.01			<	0.01	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Manganese	D4326	Wt. %	2	< 0.01	< 0.01	0.01		< 0.01	---
Manganese	D4326	Wt. %	3	< 0.01	0.01	< 0.01	< 0.01	< 0.01	---
Manganese	SW6010	ug/g	1	8	8	8		8	20
Manganese	SW6010	ug/g	2	8	8	9		8.33	21
Manganese	SW6010	ug/g	3	8	9	9	8	8.67	22
Molybdenum	SW6010	ug/g	1	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	2	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	3	< 2	< 2	< 2	< 2	< 2	---
Nickel	ICP/MS	ug/g	1	18	13.1	17.6		16.2	40
Nickel	ICP/MS	ug/g	2	11.4	17	17.8		15.4	38
Nickel	ICP/MS	ug/g	3	9.54	16.9	19.7	20.1	15.4	38
Selenium	SW7740	ug/g	1	< 1	< 1	2		1	2.5
Selenium	SW7740	ug/g	2	3	2	1		2	5
Selenium	SW7740	ug/g	3	4	< 1	< 1	1	1.67	4.1
Vanadium	SW6010	ug/g	1	13	13	13		13	32
Vanadium	SW6010	ug/g	2	13	13	13		13	32
Vanadium	SW6010	ug/g	3	13	13	13	12	13	32
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4	356	357	347	368	357	13
Boron	SW6010a	ug/g	4	21.5	38.3	36.4	36.3	33.1	12
Calcium	SW6010a	ug/g	4	9,770	9,470	9,240	9,320	9,450	370
Iron	SW6010a	ug/g	4	2,000	1,940	2,450	2,010	2,100	370
Magnesium	SW6010a	ug/g	4	1,780	1,720	1,690	1,720	1,730	65
Potassium	SW6010a	ug/g	4	98.9	103	120	122	111	19
Sodium	SW6010a	ug/g	4	995	915	853	867	908	100
Titanium	SW6010a	ug/g	4	437	437	436	435	436	1.3

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208	ug/g	1	< 100	< 100	< 100		< 100	---
Chloride	D4208	ug/g	2	< 100	< 100	< 100		< 100	---
Chloride	D4208	ug/g	3	< 100	< 100	< 100		< 100	---
Fluoride	D3751/SIE	ug/g	1	330	330	360		340	840
Fluoride	D3751/SIE	ug/g	2	400	300	240		313	780
Fluoride	D3751/SIE	ug/g	3	360	410	460		410	1,000
Metals									
Antimony	SW7041	ug/g	1	< 1	< 1	< 1		< 1	---
Antimony	SW7041	ug/g	2	< 1	< 1	< 1		< 1	---
Antimony	SW7041	ug/g	3	< 1	< 1	< 1		< 1	---
Arsenic	SW7060	ug/g	1	2	1	3		2	5
Arsenic	SW7060	ug/g	2	1	2	1		1.33	3.3
Arsenic	SW7060	ug/g	3	2	< 1	< 1		1	2.5
Beryllium	SW6010	ug/g	1	< 0.2	< 0.2	< 0.2		< 0.2	---
Beryllium	SW6010	ug/g	2	< 0.2	0.2	0.2		< 0.2	---
Beryllium	SW6010	ug/g	3	0.2	0.2	0.2		0.2	0.5
Cadmium	SW7131	ug/g	1	< 0.2	< 0.2	1.7		0.633	1.6
Cadmium	SW7131	ug/g	2	< 0.2	1.4	< 0.2		0.533	1.3
Cadmium	SW7131	ug/g	3	2.9	2.9	< 0.2		1.97	4.9
Chromium	SW6010	ug/g	1	5	6	6		5.67	14
Chromium	SW6010	ug/g	2	5	5	4		4.67	12
Chromium	SW6010	ug/g	3	5	5	4		4.67	12
Cobalt	SW6010	ug/g	1	2	3	2		2.33	5.8
Cobalt	SW6010	ug/g	2	2	1	1		1.33	3.3
Cobalt	SW6010	ug/g	3	2	2	2		2	5
Copper	SW6010	ug/g	1	14	15	14		14.3	36
Copper	SW6010	ug/g	2	15	14	14		14.3	36
Copper	SW6010	ug/g	3	15	14	14		14.3	36
Lead	SW7421	ug/g	1	5	6	11		7.33	18
Lead	SW7421	ug/g	2	7	5	6		6	15
Lead	SW7421	ug/g	3	8	24	23		18.3	46
Manganese	D4326	Wt. %	1	0.01	0.01	0.01		0.01	0.025

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Manganese	D4326	Wt. %	2	0.01	< 0.01	< 0.01		< 0.01	---
Manganese	D4326	Wt. %	3	0.01	0.01	0.01		0.01	0.025
Manganese	SW6010	ug/g	1	10	10	10		10	25
Manganese	SW6010	ug/g	2	9	9	10		9.33	23
Manganese	SW6010	ug/g	3	10	10	9		9.67	24
Molybdenum	SW6010	ug/g	1	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	2	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	3	< 2	< 2	< 2		< 2	---
Nickel	ICP/MS	ug/g	1	16.9	21.8	22.9		20.5	51
Nickel	ICP/MS	ug/g	2	23.2	21.2	22.7		22.4	56
Nickel	ICP/MS	ug/g	3	157	205	155		172	430
Selenium	SW7740	ug/g	1	2	< 1	4		2.17	5.4
Selenium	SW7740	ug/g	2	< 1	2	< 1		1	2.5
Selenium	SW7740	ug/g	3	2	3	1		2	5
Vanadium	SW6010	ug/g	1	15	16	17		16	40
Vanadium	SW6010	ug/g	2	15	14	14		14.3	36
Vanadium	SW6010	ug/g	3	14	14	13		13.7	34
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4	465	432	447	457	450	22
Boron	SW6010a	ug/g	4	33.1	39.1	35.6	40.2	37	5.2
Calcium	SW6010a	ug/g	4	11,600	10,800	11,400	11,400	11,300	560
Iron	SW6010a	ug/g	4	2,430	2,220	2,360	2,420	2,360	150
Magnesium	SW6010a	ug/g	4	2,090	1,950	2,060	2,100	2,050	110
Potassium	SW6010a	ug/g	4	130	116	133	152	133	24
Sodium	SW6010a	ug/g	4	1,120	1,030	1,080	1,620	1,210	440
Titanium	SW6010a	ug/g	4	535	535	503	504	519	29

Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Gas Char-Filtered @1000 deg F (5)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4						
Boron	SW6010a	ug/g	4						
Calcium	SW6010a	ug/g	4						
Iron	SW6010a	ug/g	4						
Magnesium	SW6010a	ug/g	4						
Potassium	SW6010a	ug/g	4						
Sodium	SW6010a	ug/g	4						
Titanium	SW6010a	ug/g	4						

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Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Gas Char-Filtered @500 deg F (5a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4						
Boron	SW6010a	ug/g	4						
Calcium	SW6010a	ug/g	4						
Iron	SW6010a	ug/g	4						
Magnesium	SW6010a	ug/g	4						
Potassium	SW6010a	ug/g	4						
Sodium	SW6010a	ug/g	4						
Titanium	SW6010a	ug/g	4						

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Table G-2. Analytical Results Not Used in Calculations

Stream: Recycled Char Solids (5c)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208	ug/g	3						
Fluoride	D3751/SIE	ug/g	3						
Metals									
Antimony	SW7041	ug/g	3						
Arsenic	SW7060	ug/g	3						
Beryllium	SW6010	ug/g	3						
Cadmium	SW7131	ug/g	3						
Chromium	SW6010	ug/g	3						
Cobalt	SW6010	ug/g	3						
Copper	SW6010	ug/g	3						
Lead	SW7421	ug/g	3						
Manganese	D4326	Wt. %	3						
Manganese	SW6010	ug/g	3						
Molybdenum	SW6010	ug/g	3						
Nickel	ICP/MS	ug/g	3						
Selenium	SW7740	ug/g	3						
Vanadium	SW6010	ug/g	3						

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Table G-2. Analytical Results Not Used In Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208/IC	ug/g	1	53.8	NA	NA		53.8	---
Chloride	D4208/IC	ug/g	2	NA	NA	51.8		51.8	---
Chloride	D4208/IC	ug/g	3	NA	46.6	NA		46.6	---
Fluoride	D4208/IC	ug/g	1	21.8	NA	NA		21.8	---
Fluoride	D4208/IC	ug/g	2	NA	NA	47.5		47.5	---
Fluoride	D4208/IC	ug/g	3	NA	97.5	NA		97.5	---
Metals									
Antimony	SW7041	ug/g	1	3	< 2	< 2		< 2	---
Antimony	SW7041	ug/g	2	< 2	< 2	< 2	< 2	< 2	---
Antimony	SW7041	ug/g	3	< 2	< 2	< 2		< 2	---
Arsenic	SW7060	ug/g	1	4	5	5		4.67	12
Arsenic	SW7060	ug/g	2	< 2	4	6	6	3.67	9.1
Arsenic	SW7060	ug/g	3	5	4	7		5.33	13
Beryllium	SW6010	ug/g	1	2.2	1.9	2.6		2.23	5.5
Beryllium	SW6010	ug/g	2	2.1	2.1	2.5	2.2	2.23	5.5
Beryllium	SW6010	ug/g	3	2.2	1.9	1.7		1.93	4.8
Cadmium	SW7131	ug/g	1	< 1	< 1	< 1		< 1	---
Cadmium	SW7131	ug/g	2	< 1	< 1	< 1	< 1	< 1	---
Cadmium	SW7131	ug/g	3	< 1	< 1	< 1		< 1	---
Chromium	SW6010	ug/g	1	78	72	84		78	190
Chromium	SW6010	ug/g	2	72	93	81	73	82	200
Chromium	SW6010	ug/g	3	68	65	57		63.3	160
Cobalt	SW6010	ug/g	1	35	29	32		32	79
Cobalt	SW6010	ug/g	2	29	29	33	27	30.3	75
Cobalt	SW6010	ug/g	3	32	30	24		28.7	71
Copper	SW6010	ug/g	1	160	150	170		160	400
Copper	SW6010	ug/g	2	150	150	170	160	157	390
Copper	SW6010	ug/g	3	160	140	130		143	360
Lead	SW7421	ug/g	1	< 2	3	2		2	5
Lead	SW7421	ug/g	2	2	< 2	< 2	< 2	< 2	---
Lead	SW7421	ug/g	3	2	3	5		3.33	8.3
Manganese	D4326	Wt. %	1	0.05	0.04	0.05		0.0467	0.12

Table G-2. Analytical Results Not Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Manganese	D4326	Wt. %	2	0.04	0.06	0.05	0.05	0.05	0.12
Manganese	D4326	Wt. %	3	0.05	0.05	0.04		0.0467	0.12
Manganese	SW6010	ug/g	1	130	110	120		120	300
Manganese	SW6010	ug/g	2	110	110	130	120	117	290
Manganese	SW6010	ug/g	3	120	110	98		109	270
Molybdenum	SW6010	ug/g	1	< 10	< 10	< 10		< 10	---
Molybdenum	SW6010	ug/g	2	< 10	< 10	< 10	< 10	< 10	---
Molybdenum	SW6010	ug/g	3	< 10	< 10	< 10		< 10	---
Nickel	ICP/MS	ug/g	1	295	247	270		271	670
Nickel	ICP/MS	ug/g	2	263	280	320	309	288	710
Nickel	ICP/MS	ug/g	3	323	279	229		277	690
Selenium	SW7740	ug/g	1	< 2	10	3		4.67	12
Selenium	SW7740	ug/g	2	17	13	6	< 2	12	30
Selenium	SW7740	ug/g	3	6	8	29		14.3	36
Vanadium	SW6010	ug/g	1	200	170	210		193	480
Vanadium	SW6010	ug/g	2	180	180	200	190	187	460
Vanadium	SW6010	ug/g	3	190	170	150		170	420
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4	6890	6870	6970	6750	6870	140
Boron	SW6010a	ug/g	4	492	432	351	458	433	96
Calcium	SW6010a	ug/g	4	172,000	169,000	169,000	164,000	168,000	5,200
Iron	SW6010a	ug/g	4	36,000	35,500	35,700	35,300	35,600	450
Magnesium	SW6010a	ug/g	4	30,100	29,600	29,600	29,100	29,600	640
Potassium	SW6010a	ug/g	4	1,510	1,450	1,630	1,790	1,590	240
Sodium	SW6010a	ug/g	4	16,900	14,500	14,900	17,000	15,800	2,100
Titanium	SW6010a	ug/g	4	8,400	8,060	8,190	7,920	8,140	320

APPENDIX H: DESIGN DETAIL, HOT GAS PROBE

Preamble

The requirements, design and operation of the source sampling equipment for acquiring valid samples of hot syngas are addressed in this Design Description. Only those activities related to collecting samples of hot syngas are included. The sampling strategy, test methods, QA/QC procedures, analytical methods, and data analysis procedures are discussed in the document entitled "Hazardous Air Pollutant Testing at the LGTI Gasification Plant: Draft Test Plan."

Section 2 of this Design Description includes a summary of the design requirements for the hot syngas sampling device. The design philosophy, approach, and description are included in Section 3. The operation of the sampling system is described in Section 4. The detailed isolation valve information is included in Attachment A, while example heat transfer, stress, and other design calculations are given in Attachments B through G. The operational check list is provided in Attachment H.

Design Requirements

The purpose of the equipment described in this document is to obtain samples for subsequent analysis of hot raw synthesis gas and particulate matter produced by the Louisiana Gas Technology, Inc. (LGTI) gasifier. The gas and particulate matter samples were collected at a location immediately downstream of the heat recovery boiler. This location was sampled as part of a comprehensive emissions measurement program to characterize and quantify hazardous air pollutant (HAP) emissions from the LGTI facility, to define the HAP levels in selected internal process streams, and to determine the fate of HAPs in the gasification system.

Facility Description

The LGTI facility produces medium Btu synthetic gas (syngas) which is used by the existing gas turbine power generation units at Dow Chemical Company, Louisiana Division, chemical complex near Plaquemine, Louisiana. At capacity, the facility produces 30,000 MM Btu of syngas per day from approximately 2,200 tons per day of western subbituminous coal. The LGTI facility consists of a high-temperature, entrained-flow, slagging gasifier with auxiliary systems including coal slurry preparation, particulate recycle, heat recovery, Selectamine® acid gas removal, Selectox® sulfur recovery, tail gas incineration, and wastewater treatment. Oxygen for the gasifier is supplied from an over-the-fence air separation unit.

The raw, particulate-laden syngas from the gasifier is partially cooled in a heat recovery train, in which steam is generated. The particulate is then removed in a wet scrubbing system. The particulate (char) removed from the syngas is recycled to the gasifier. The syngas is further cooled through a series of heat exchangers before entering the H_2S removal process.

Advanced gasification concepts include high-temperature processes for removing particulate and reduced sulfur species. These processes would operate at temperatures as high as 1200°F to improve the thermal efficiency of the gasification/power generation system. Sampling the hot raw syngas at LGTI will help provide data that can be used in the design and operation of such high-temperature gas cleanup processes.

Sampling Methods

Representative samples of the hot raw synthesis gas were collected using reference methods, modifications of standard test methods, and methods developed by Radian for sampling synthesis gas streams. Methods that were used during the hot gas testing at LGTI include the following:

- Multi Metals (EPA Standard Method 29[1]);
- Ammonia, chloride, fluoride; Impinger collection (EPA Method 26 - modified);
- Multi Metals: Charcoal adsorption (Radian development);
- Cyanide: Impinger collection (Texas Air Control Board Method); and
- Particulate Matter: Grab sample collected in an in-stack thimble (modification of EPA Standard Method 17[2]).

Environment

The location, availability, process conditions, sampling requirements, and nitrogen needs associated with the hot gas sampling program are described in this section of the report.

The sampling port was installed through an existing 20-inch manway. The manway centerline is horizontal and is located approximately 25½ inches above the metal grating floor, which is raised above the floor of level 8. The mating portion of the manway flange which is welded to the vessel is not a standard ANSI B16.5 nozzle. This flange is made from a pierced right circular cylindrical piece of metal. The OD is approximately 30½ inches and the ID is nearly 23¼ inches. The bolt circle has been drilled and tapped, and studs have been inserted. There are no nuts on the process vessel side of the flange bolts nor has the backside of the nozzle been relieved for use of nuts. The distance between the face of the manway flange and the outside of the vessel is approximately 5½ inches.

The insulating plug which normally fills the manway during plant operation is 14 inches deep. The first 7 inches is comprised of refractory, which is backed with 7 inches of Kaowool®. There is a ring pull in the center of the plug which is used for removing the plug for vessel entry and/or inspection. There is a 1-inch high metallic retaining ring around the ID surface of the manway to position the plug and prevent it from falling into the vessel. This ring is essentially an extension of the metallic liner which protects the refractory lining on the inside of the pipe.

The area directly above the manway and the probe position is crisscrossed with structural steel and floor grating that can be used to support the isolation valves and probe assembly. A grated access platform, parallel to the centerline of the manway, is approximately 6 feet by 8 feet and is located immediately adjacent to and centered on the centerline of the manway. The platform has a standard handrail, midspan rail and kick board on all open sides. This platform is approximately 3 feet above level 8 of the facility.

Process Conditions. The approximate conditions of the process gas at the sampling location are:

- Temperature: 850-1200°F [450-650°C];
- Pressure: 350-450 psig;

- Gas flow rate: approximately 120,000 dscfm;
- Approximate composition, volume percent:

H_2O	30
H_2	28
CO	23
CO_2	16
CH_4	1.3
N_2	1.7

Lower concentrations of H_2S, COS, and NH_3 are also present in the process gas. The particulate loading in the syngas is relatively high at this point in the process..

There is considerable open (unoccupied) area immediately adjacent to the access platform on Level 8. This area is open on the sides to weather, although the manway itself is, in general, protected from direct rain and sunlight.

Sampling System Requirements. The existing manway cover and insulation plug were bored through to provide access for the sampling probe, and the manway cover were modified to accept the two, three-inch isolation valves and probe assembly. Modifications to the manway cover and insulation plug will be provided be LGTI.

The general requirements for the hot gas sampling location were:

- Port access must be secured when not being used for sampling purposes.
- Port must pass a right circular cylinder 3 inches in diameter.
- A clear space coincident to the center line of the access port must be provided equal to a rectangle approximately 48 inches square by approximately 12 feet long.

The sample stream or gas sample was drawn at flow rates of 1 to 4 scfm through the sampling probe. The temperature of the sampled gas in the probe was to be maintained above 400°F to avoid condensation and was not to exceed the maximum design temperature of the process.

Nitrogen. Up to 200 lb/hr of gaseous nitrogen at 500 psig and ambient temperature is needed at this sampling location. Taps were provided so that nitrogen that had been used in the adjacent idle dry filter portion of the process and was made available for use by the sampling crew.

Mechanical Class

All of the sampling equipment is temporary and not intended for installation beyond what is required to acquire the samples. As such, the equipment was ruggedly constructed and met nominal commercial construction requirements. Stress, earthquake, and thermal analysis formal reports were not required.

Electrical Class

All of the sampling equipment is temporary and not intended for installation beyond what is required to acquire the samples. As such, the equipment was of rugged construction and met nominal construction requirements for wet and combustible atmospheres. Good grounding practice were used throughout.

At least four 115 V outlets were located on the exterior handrails at points which could be used if needed. The plugs for these outlets are Crouse Hinds Hazardous environment connectors.

Design Description

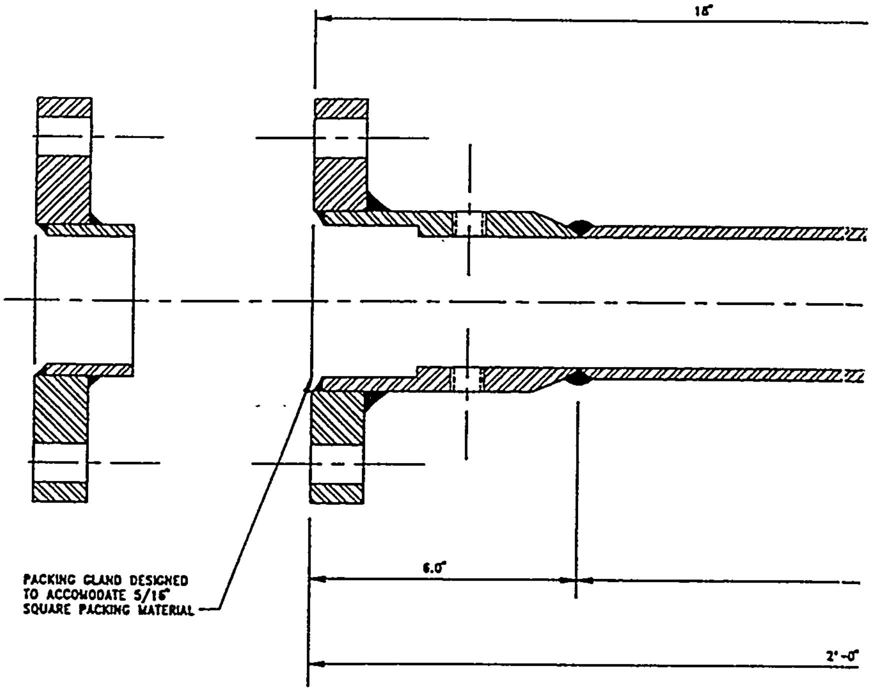
The hot gas probe design philosophy, approach, and description of the equipment to meet the design requirements are described in this section. The design is further detailed in drawings as set forth in Table 1. These drawings are included in this section. Analytical computations and detailed engineering analysis have been performed, and the calculational procedures are provided in Appendices A through G of this document.

Table 1
Drawing Hierarchy for Hot Gas Probe

Drawing Number	Title or Contents
643-004-30-02, sheet A	Sampling Gland
643-004-30-02, sheet B	Sampling Probe
643-004-30-02, sheet C	Probe Trolley
643-004-30-02, sheet D	Probe Unit: Trolley Assembly and Stiffleg
643-004-30-02, sheet E	Probe Unit: Trolley Assembly (winches on opposite end of the assembly)

Interface

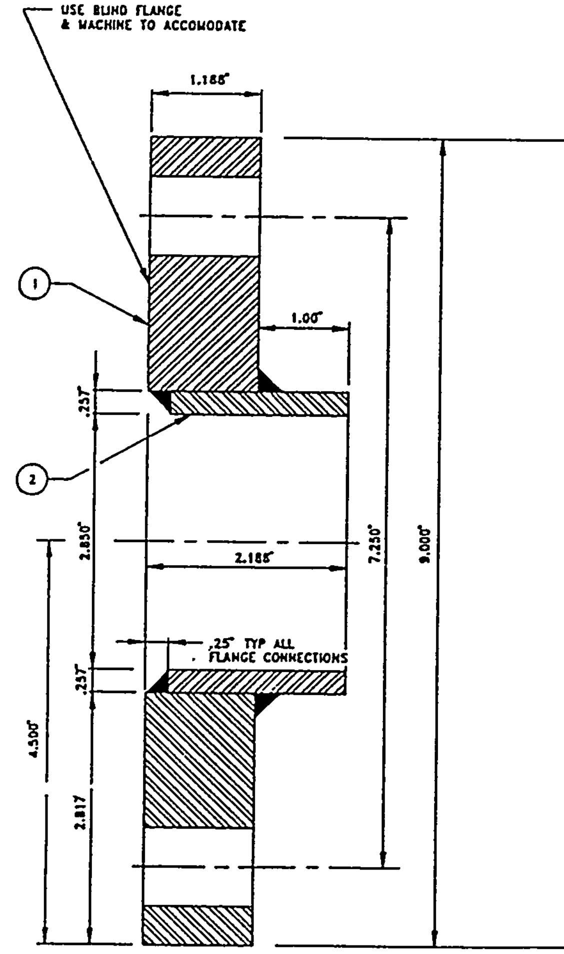
The interface between the LGTI process and Radian's sampling equipment is the inboard flange on the first (inboard) isolation valve provided by Radian, as indicated in Radian Drawing No.



TOP VIEW

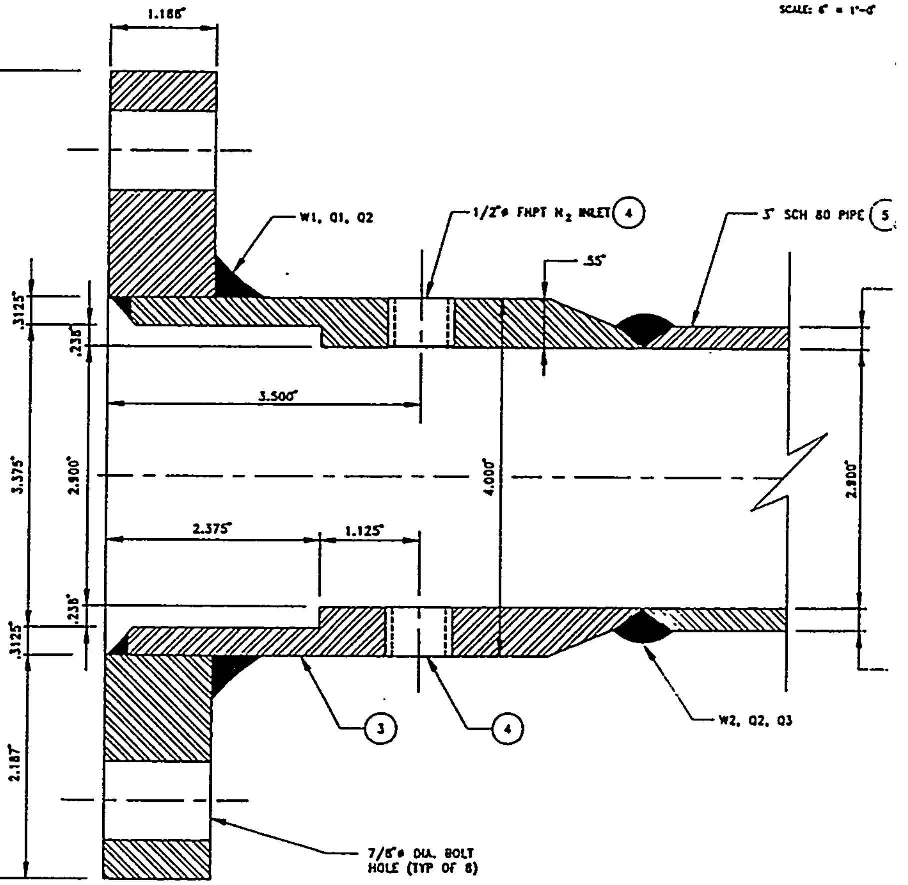
GLAND ASS

SCALE: 6" = 1'-0"



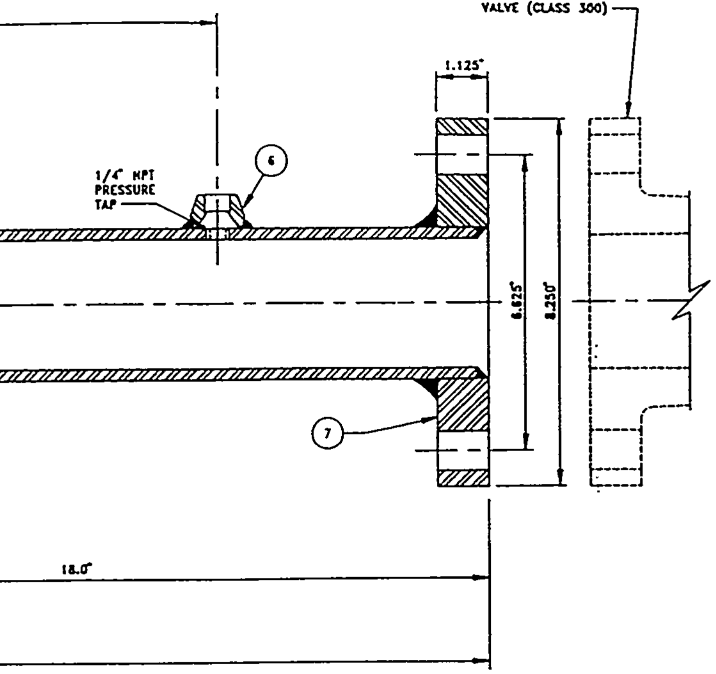
PACKING RETAINER

SCALE: 1:1



GLAND

SCALE: 1:1



MBLY

Parts List		
Item No.	Description	Quantity
1	Retainer Flange, 3.5" Blind Flange, 300#, Machined as Shown. ASTM A182, Grade F316	1
2	Retainer Tube, 5" Schedule 160 Pipe, Machined as Shown. ASTM A312, Grade TP316	1
3	Packing Gland, 3.5" XXS Pipe, Machined as Shown. ASTM A312, Grade TP316	1
4	Nitrogen Inlet Taps	2
5	Gland, 3" Schedule 80 Pipe ASTM A312, Grade TP316	1.5ft.
6	Bonney Forge 1/4" FNPT, 3000# Threadolet	1
7	5" Flange, 300# ASTM A182, Grade F316	1

Weld Specifications:

W1 = Fillet Welding Procedures
W2 = Butt Welding Procedures

Inspection Procedures:

Q1 = Dye Penetrant
Q2 = Leak Test
Q3 = Pressure Test (Hydrostatic)

Notes:

All metal components in contact with flow stream are Type 316 stainless.
All other metal components carbon steel unless noted.
All bolts will be grade B7.

NOTES:

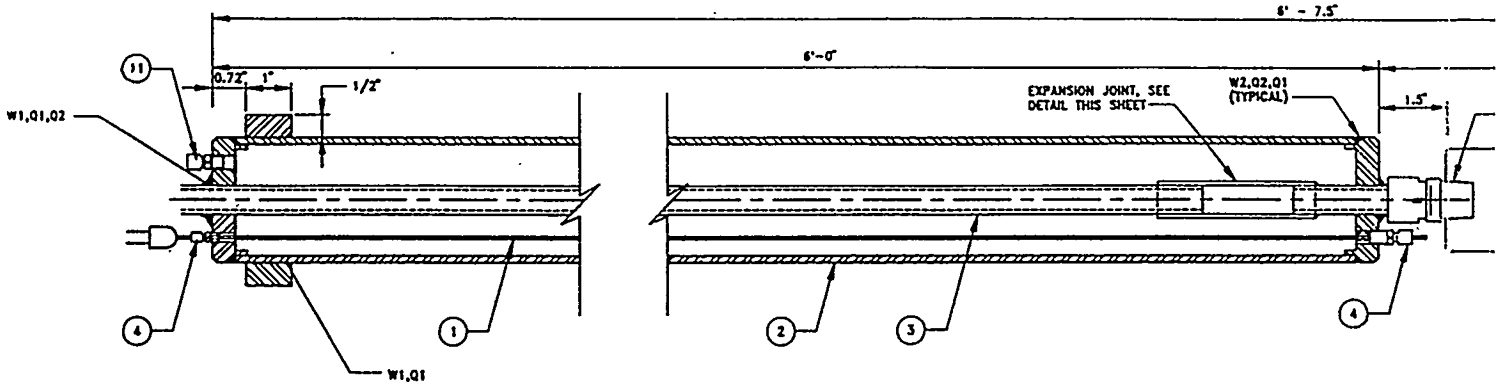
1. ITEM 3 & 5 TO BE CONCENTRIC WITHIN 0.010" TIR AFTER WELDING.
2. BORE I.D. 2" BEYOND CIRCUMFERENTIAL WELD TO CLEANUP I.D. SURFACE AFTER WELDING.

Revisions			
Number	Descriptions	Date	Approved

RADIAN
CORPORATION
Austin, Texas 78720-1088

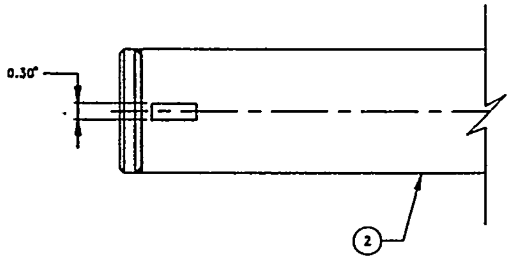
Scale: AS SHOWN		DOW HOT GAS SAMPLING GLAND		
Designed by: J.J.Z.	Date:			
Drawn by: R.D.F.	Date: 6-01-94			
Checked by:	Date: 6-01-94			
Approved By:	Date:	Contract No.:	Drawing No.:	Rev:
Tolerance (unless otherwise stated) ±.xxx 0.005 ±.xx 0.01 ±.xxx 0.01		643-004-30-02	A	A

810828A 09.22.94

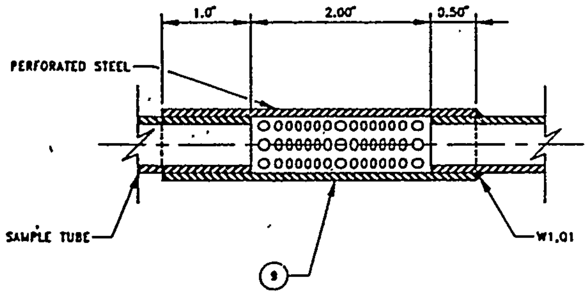


PROBE ASSEMBLY

SCALE: 6" = 1'-6"

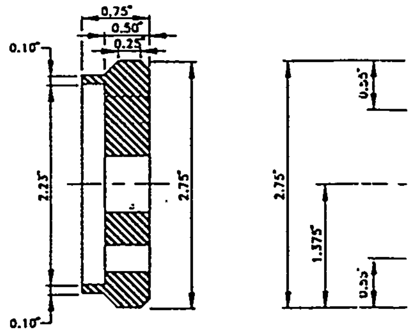


PROBE ASSEMBLY TOP VIEW



EXPANSION JOINT DETAIL

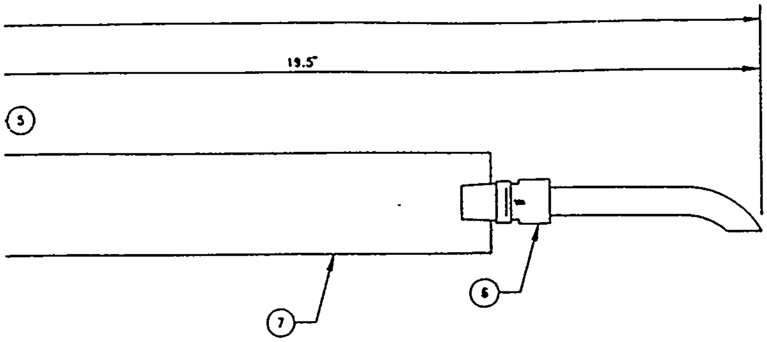
SCALE: 1:1

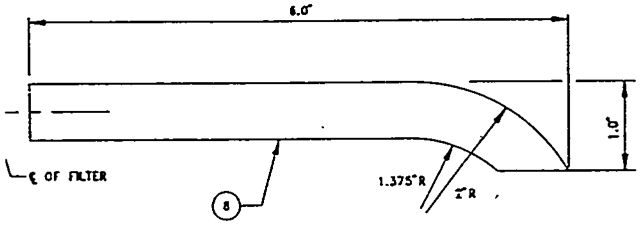


SAMPLE END AND A

BULKHEAD D

SCALE: 1:1





NOZZLE DETAIL

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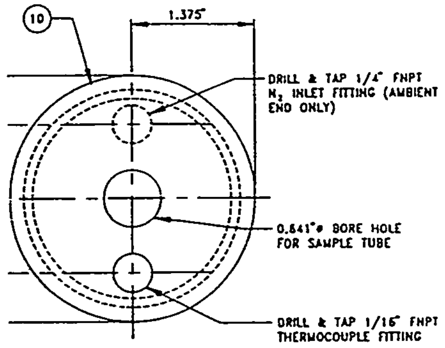


BIENT END

ETAILS

Parts List

Item No.	Description	Quantity
1	Thermocouple, Omega CASS-18G-60	1
2	Sample Sheath, 2 3/4" Stainless steel tubing, 0.188" wall thickness ASTM A213, type 316, Seamless, H or C Finish	6ft.
3	Sample tube, 5/8" Stainless steel tubing, 0.085" wall thickness ASTM A213, type 316, Seamless, H or C Finish	6ft.
4	Thermocouple fitting, Swagelock SS-200-1-2-BT	2
5	Sample tube fitting, Swagelock SS-1010-1-8	1
6	Nozzle fitting, Swagelock SS-1010-1-8	1
7	Filter assembly, 130 mm filter	[illegible]
8	Nozzle, 5/8" Stainless steel tubing, 0.085" wall thickness, formed as shown ASTM A213, type 316, Seamless, H or C Finish	1ft.
9	Expansion joint/N_2 inlet, 16ga. perforated stainless steel sheet, 1/8" holes, 40% open	1ft^2
10	Sample sheath bulkheads, stainless steel stock, machined as shown ASTM A240, type 316	
11	N_2 Inlet, Swagelock SS-600-1-4	1

Weld Specifications:

W1= Filter Welding Procedure

W2= Butt Welding Procedure

Inspection Procedure:

Q1= Dye Penetrant

Q2= Leak test

Q3= Pressure test (Hydrostatic)

Notes:

All metal components in contact with flow stream are Type 316 stainless.

All other metal components carbon steel unless noted.

All bolts will be grade B7.

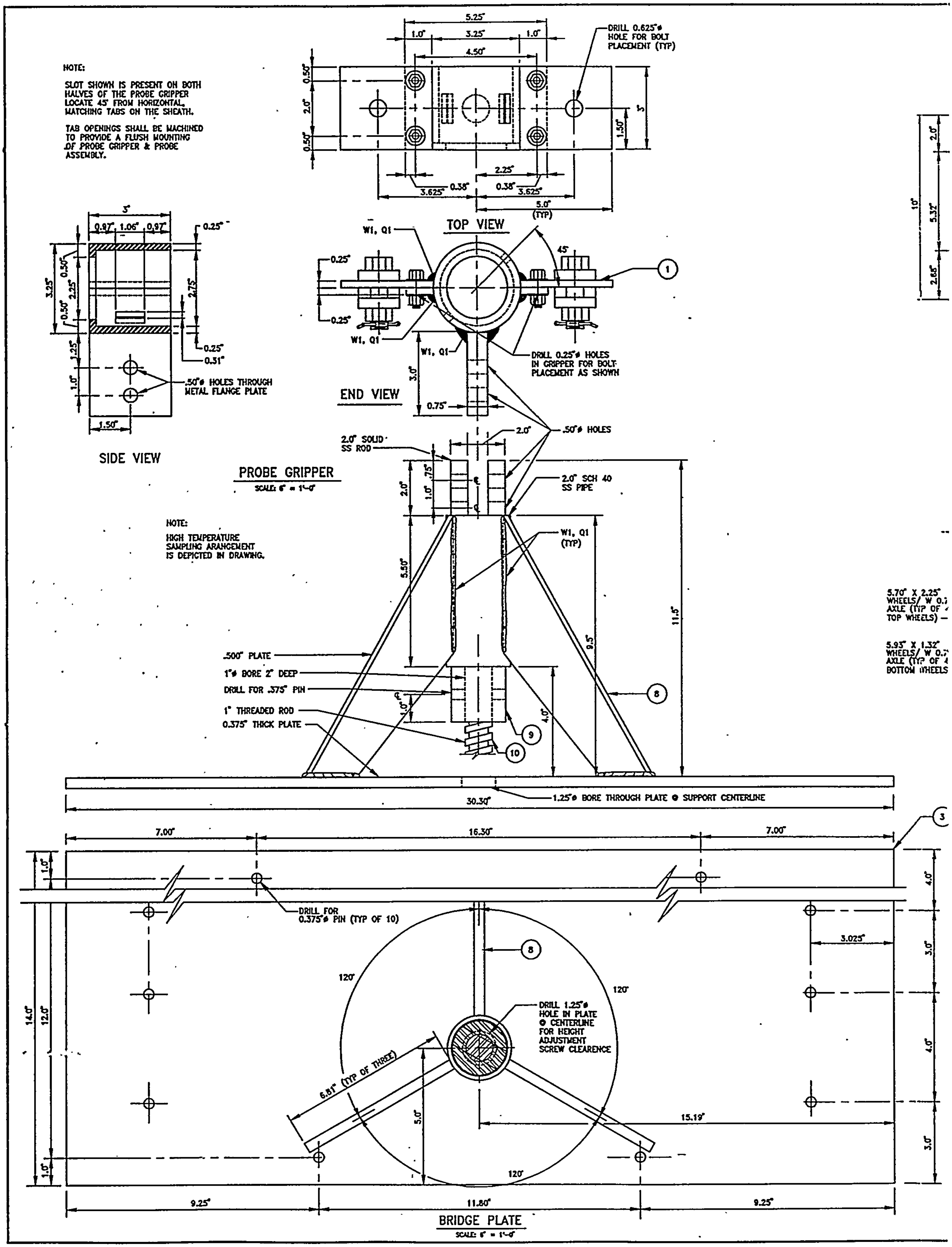
Revisions

Number	Descriptions	Date	Approved

RADIAN
CORPORATION
Austin, Texas 78720-1088

Scale: AS SHOWN		**DOW HOT GAS SAMPLING PROBE**
Designed by: J.J.Z.	Date:	
Drawn by: R.O.F.	Date: 6-01-94	
Checked by:	Date: 6-01-94	
Approved By:	Date:	Contract No.: 643-004-30-02 / Drawing No.: B / Rev: A
Tolerance (unless otherwise stated) ±.xxx 0.005 ±.xx 0.01		

B108288 09.22.94



NOTE:

SLOT SHOWN IS PRESENT ON BOTH HALVES OF THE PROBE GRIPPER LOCATE 45° FROM HORIZONTAL, MATCHING TABS ON THE SHEATH.

TAB OPENINGS SHALL BE MACHINED TO PROVIDE A FLUSH MOUNTING OF PROBE GRIPPER & PROBE ASSEMBLY.

PROBE GRIPPER

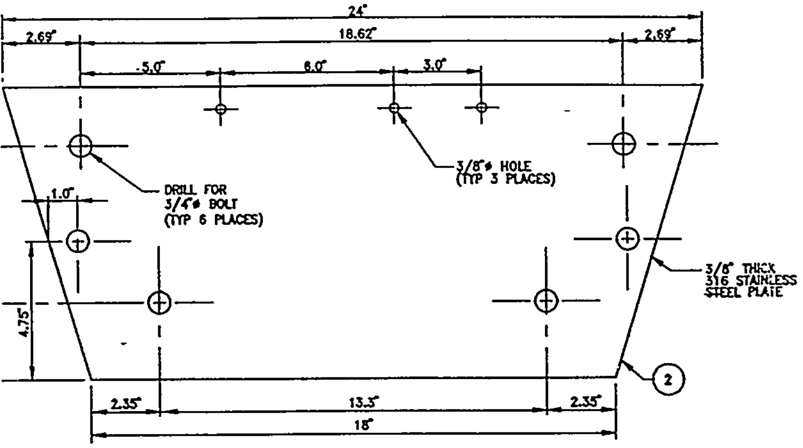
SCALE: 6" = 1'-0"

NOTE:

HIGH TEMPERATURE SAMPLING ARANGEMENT IS DEPICTED IN DRAWING.

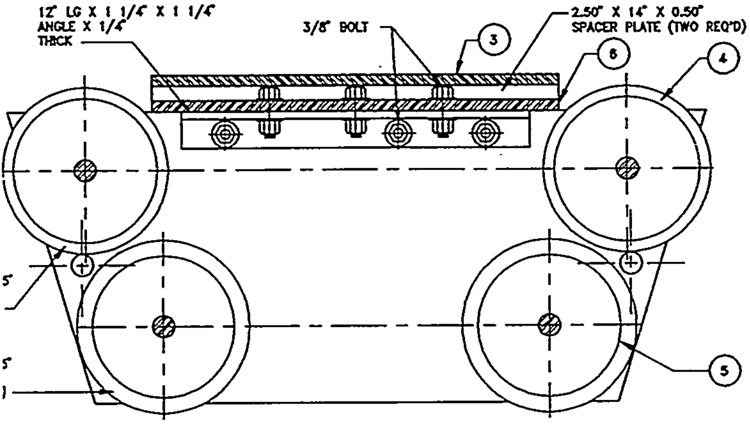
BRIDGE PLATE

SCALE: 6" = 1'-0"



SIDE PLATE

SCALE: 4" = 1'-0"



TROLLEY LONGITUDINAL SECTION

SCALE: 4" = 1'-0"

DOW Probe Parts List		
Item No.	Description	Quantity
1	Probe Grip, Fabricated from 3.5" XXS, 3/8" steel side tabs, and 3/4" plate for tounge	1
2	Trolley side plate, 3/8" A-666 type 316 HRAP	4
3	Probe bridge, 3/4" A-666 type 316 HRAP	1
4	Upper trolley wheels	8
5	Lower trolley wheels	8
6	Trolley bridge, 3/8" A-666 type 316 HRAP	2
7	6" I-Beam, standard weight, A-36	2012"
8	Gusset, 1/2" steel, A-666 type 316 HRAP	3
9	Grip adjuster, 2" steel stock	1
10	1" Threaded rod, 5 ACME threads/inch	1

Weld Specifications:

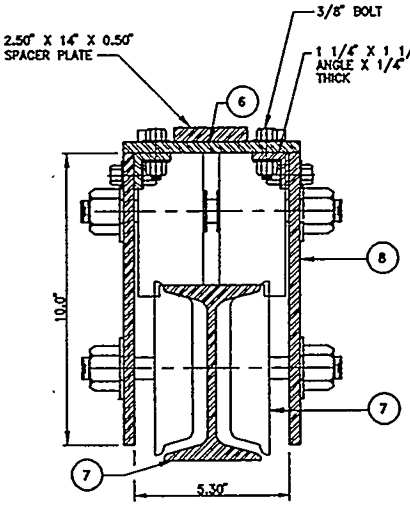
W1 = Fillet Welding Procedures
W2 = Butt Welding Procedures

Inspection Procedures:

Q1 = Dye Penetrant
Q2 = Leak Test
Q3 = Pressure Test (Hydrostatic)

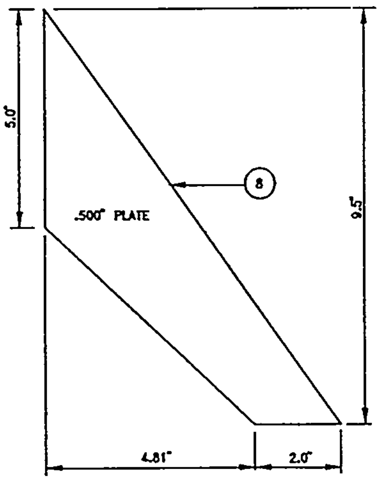
Notes:

All metal components in contact with flow stream are Type 316 stainless.
All other metal components carbon steel unless noted.
All bolts will be grade B7



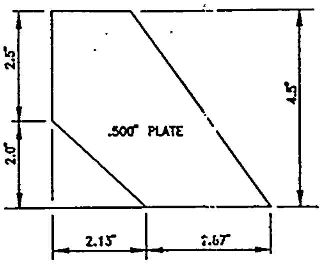
TROLLEY CROSS SECTION

SCALE: 4" = 1'-0"



HIGH TEMPERATURE GUSSET DETAIL

SCALE: 6" = 1'-0"



LOW TEMPERATURE GUSSET DETAIL

SCALE: 6" = 1'-0"

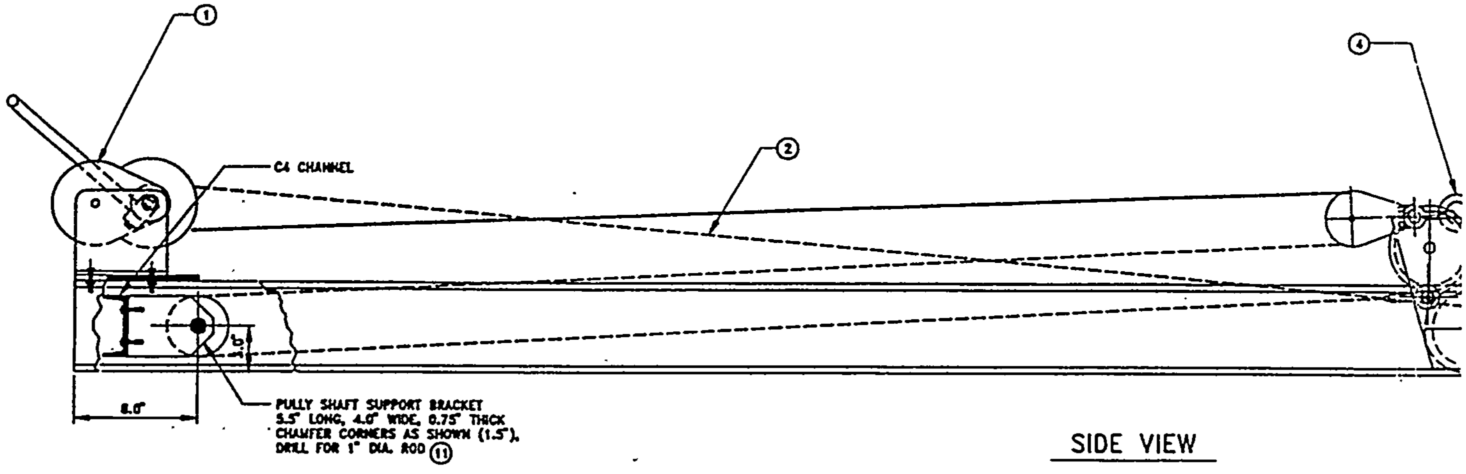
PROBE TROLLEY DETAILS

Revisions			
Number	Descriptions	Date	Approved
1	Item 3 changed from 3/8" to 3/4"	[illegible]	[illegible]
2	Item 8 changed from 3/8" to 1/2"	[illegible]	[illegible]

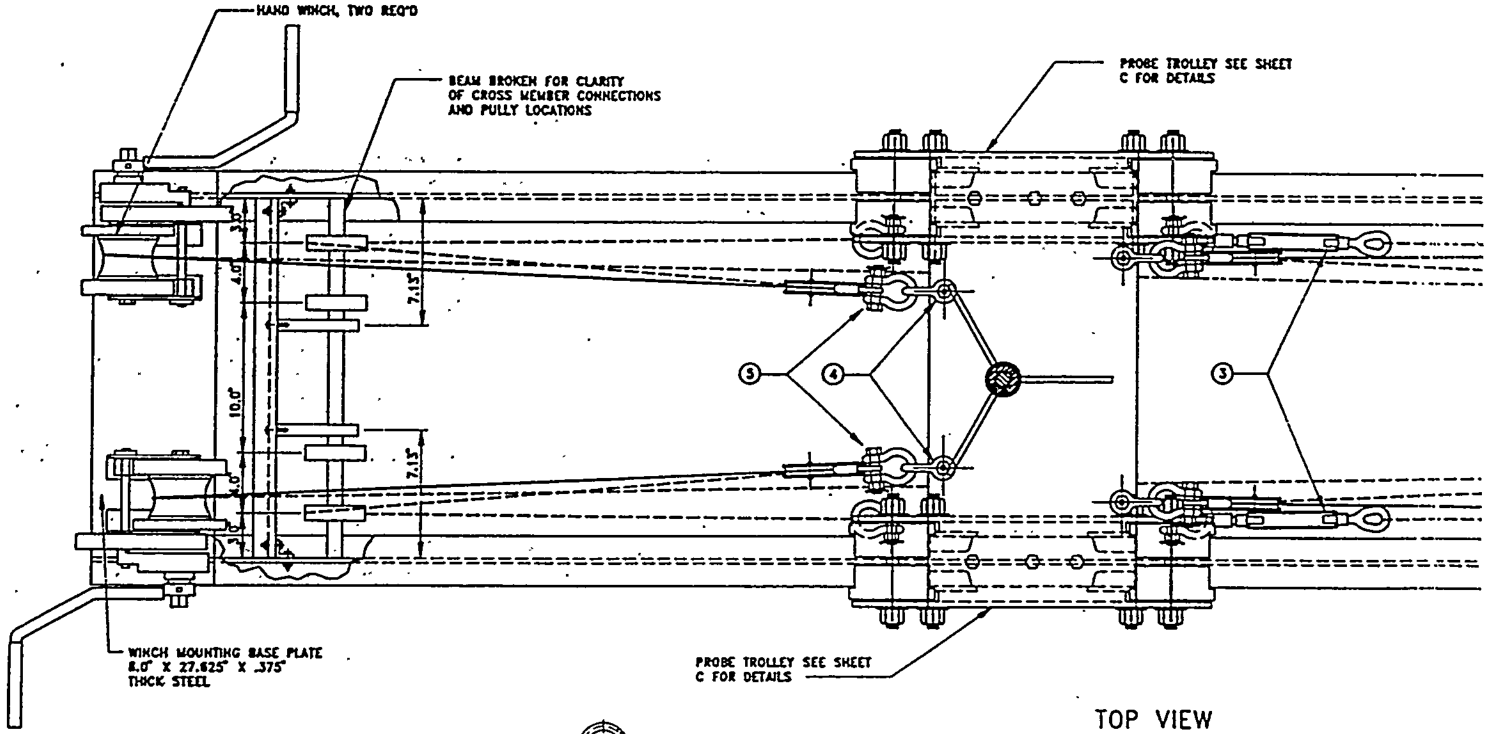
RADIAN CORPORATION
Austin, Texas 78720-1088

Scale: AS SHOWN		
Designed by: J.J.Z.	Date: 8-29-94	**DOW HOT GAS PROBE TROLLEY**
Drawn by: R.D.F.	Date: 8-29-94	
Checked by:	Date: 8-29-94	
Approved By:	Date:	Contract No.: 643-004-30-02
Tolerance: (unless otherwise stated) x.xxx± 0.005 x.xx± 0.01		Drawing No.: C
		Rev: A

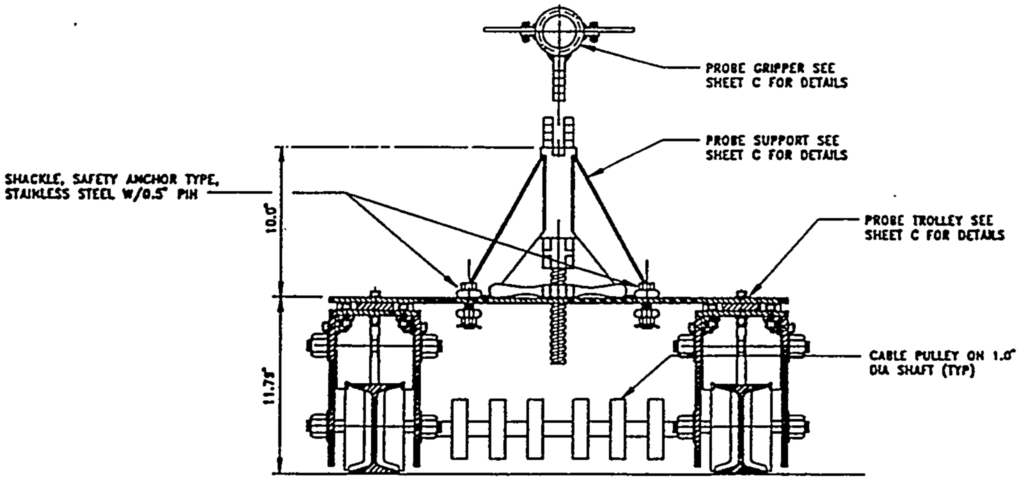
B10901 09.19.95



SIDE VIEW

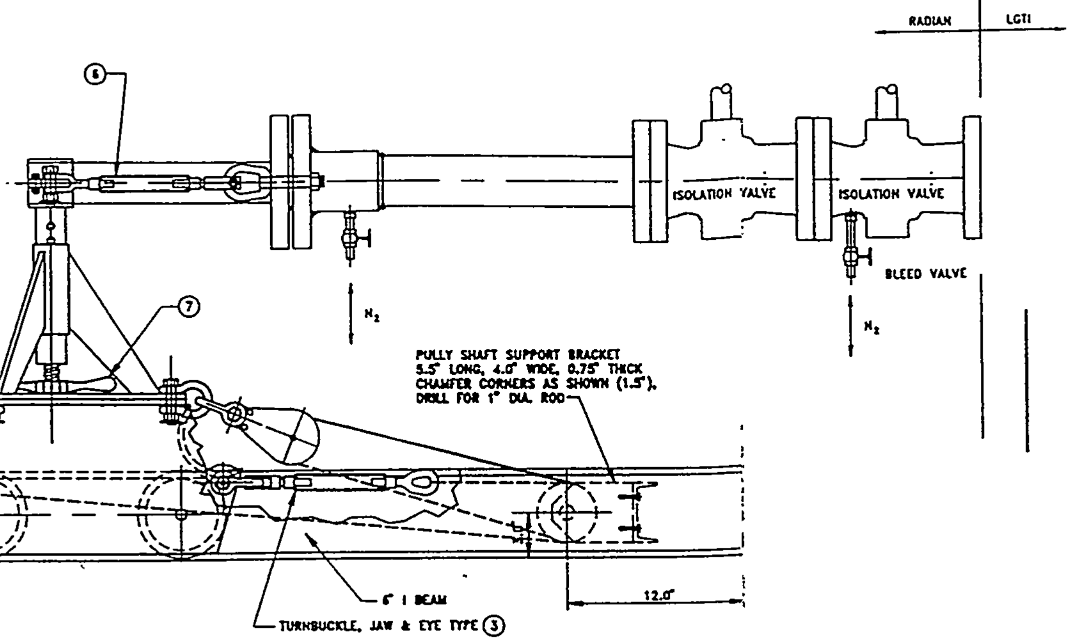


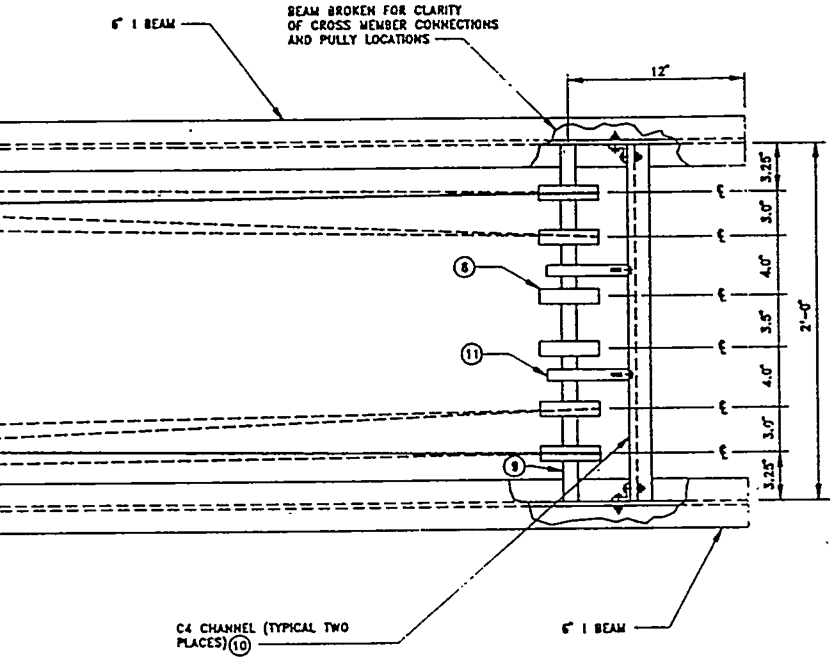
TOP VIEW



TROLLEY END VIEW

PROBE T





NOTE:

SLEEVES ON THE 1" SHAFT, BETWEEN PULLEYS ARE USED TO POSITION AND SUPPORT SHEAVES ALONG AXIS. NOT SHOWN

DOW Probe Parts List

Item No.	Description	Quantity
1	Two speed winch, with brake, 2000 lb. rating	2
2	1/4" Wire rope, 7 x 19 strand core	200'
3	3/8" Trunbuckle, Jaw and Eye type, 1160 lb rating McMaster Carr 3022T43	2
4	1/2" Shackle, 1890 lb rating, McMaster Carr 3860T55	4
5	3/8" Schockle, 1000 lb rating, McMaster Carr 3860153	2
6	Turnbuckle, Jaw and Jaw type, 1/2" bolt diameter	4'
7	Wing Nut for 1" hub, Crosby 460307	1
8	4" sheave for 1/4" cable, 1" hub, Crosby 460307	10
9	Sheave axle, 1" solid, 24" long	.2
10	Axle Strong back, C4 channel	2
11	Axle Support, Aluminum	

Weld Specifications:

W1 = Fillet Welding Process
W2 = Butt Welding Procedures

Inspection Procedures

Q1 = Dye Penetrant
Q2 = Leak Test
Pressure Test (Hydrostatic)

NOTES:

All metal components in contact with flow stream are Type 316 stainless.
All other metal components carbon steel unless noted.

All bolts will be grade 97

ROLLEY ASSEMBLY

SCALE: 1" = 6"

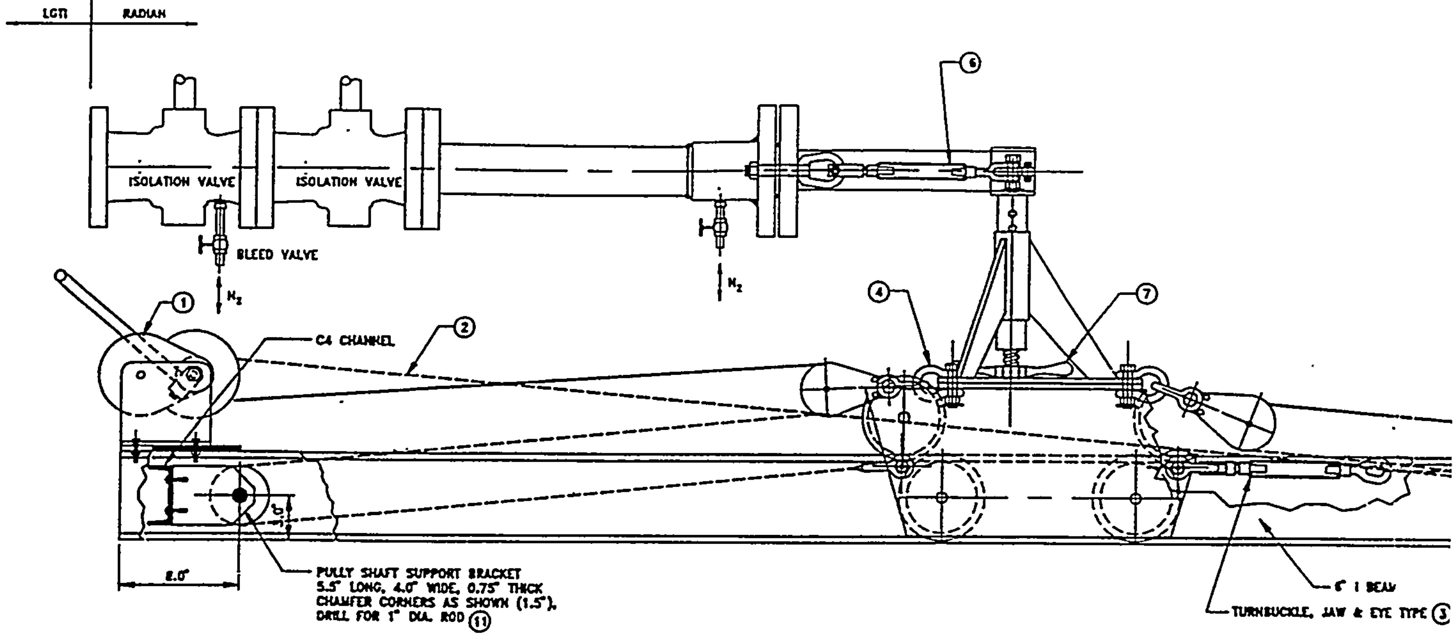
Revisions			
Number	Descriptions	Date	Approved

RADIAN
CORPORATION
Austin, Texas 78720-1088

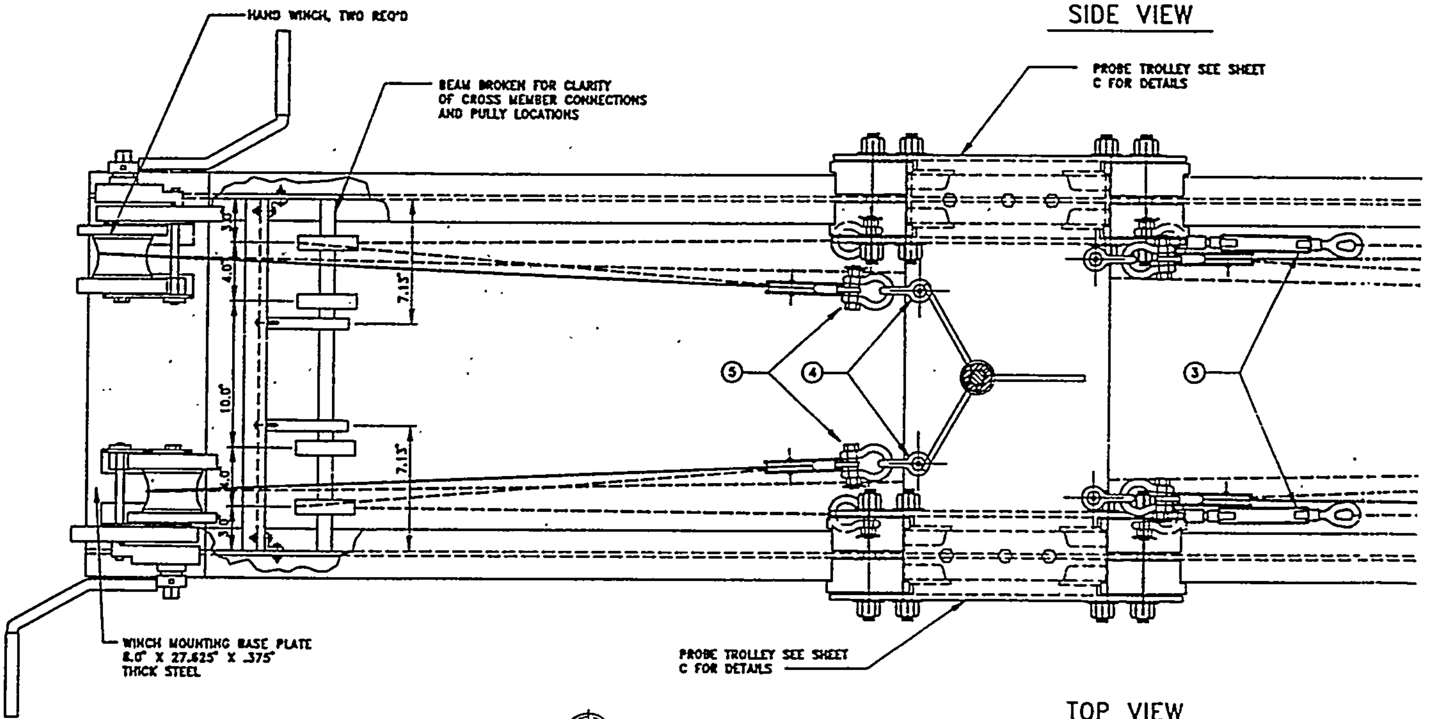
Scale: AS SHOWN	
Designed by: J.J.Z.	Date: 9-13-94
Drawn by: R.D.F.	Date: 9-13-94
Checked by:	Date: 9-13-94
Approved By:	Date:
Tolerance (unless otherwise stated) x.xxx 0.005 x.xx 0.01	

B10901A 01.13.95

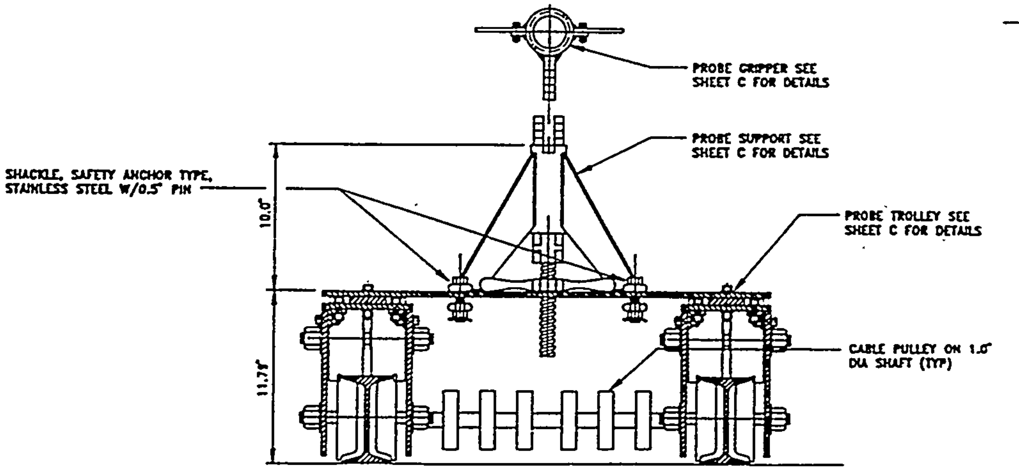
Contract No:	Drawing No.:	Rev
643-004-30-02	D	A



SIDE VIEW

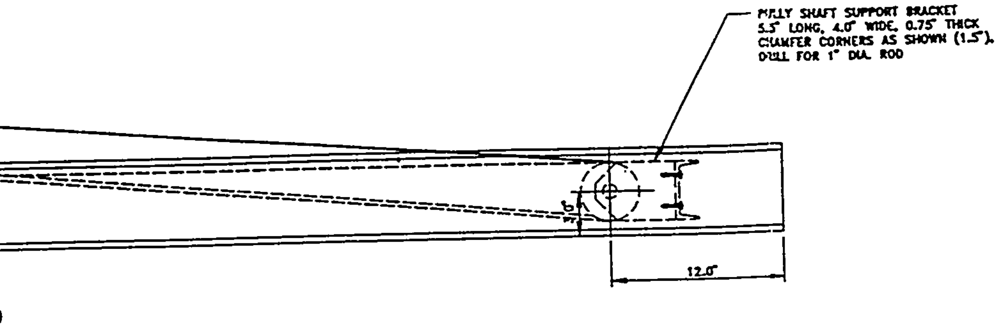


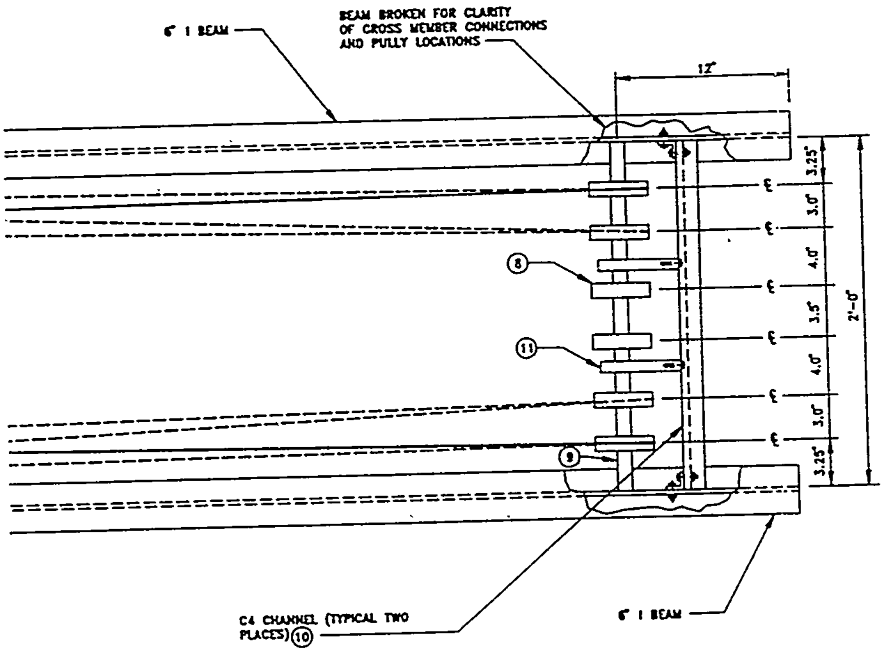
TOP VIEW



TROLLEY END VIEW

PROBE





NOTE:

SLEEVES ON THE 1" SHAFT, BETWEEN PULLEYS ARE USED TO POSITION AND SUPPORT SHEAVES ALONG AXIS. NOT SHOWN

DOW Probe Parts List

Item No.	Description	Quantity
1	Two speed winch, with brake, 2000 lb. rating	2
2	1/4" Wire rope, 7 x 19 strand core	200'
3	3/8" Trunbuckle, Jaw and Eye type, 1160 lb rating McMaster Carr 3022T43	2
4	1/2" Shackle, 1950 lb rating, McMaster Carr 3860T55	4
5	3/8", Schackle, 1000 lb rating, McMaster Carr 3860153	2
6	Turnbuckle, Jaw and Jaw type, 1/2" bolt diameter	4'
7	Wing Nut for 1" hub, Crosby 460307	1
8	4" sheave for 1/4" cable, 1" hub, Crosby 460307	10
9	Sheave axle, 1" solid, 24" long	2
10	Axle Strong back, C4 channel	2
11	Axle Support, Aluminum	

Weld Specifications:

W1 = Fillet Welding Process
W2 = Butt Welding Procedures

Inspection Procedures

Q1 = Dye Penetrant
Q2 = Leak Test
Pressure Test (Hydrostatic)

NOTES:

All metal components in contact with flow stream are Type 316 stainless.
All other metal components carbon steel unless noted.

All bolts will be grade 87

TROLLEY ASSEMBLY

SCALE: 1" = 1'

Revisions			
Number	Descriptions	Date	Approved

RADIAN CORPORATION
Austin, Texas 78720-1088

Scale: AS SHOWN	
Designed by: J.J.Z.	Date: 9-13-94
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Checked by:	Date: 9-13-94
Approved By:	Date:
Tolerances (unless otherwise stated) x.xxx 0.005 x.xx 0.01	

DOW HOT GAS PROBE UNIT

Contract No.:	Drawing No.:	Rev
643-004-30-02	E	A

8109018 01.16.95

643-004-30-02, Sheet D. This valve mates with the cover flange of the existing 20-inch manway. The isolation valves provided by Radian are equipped with 3-inch, 300#, ANSI B 16.5, raised-face, bolted flanges. LGTI provided the gaskets and bolting necessary to mount these valves to the manway cover.

The manway cover had provisions for the flange seating surface and the mounting bolts. In addition, a 3-inch diameter hole, on center with the bore of the manway, was needed. The 3-inch diameter hole penetrated the entire length of the insulation plug which normally resides on the inside of the manway cover.

Radian required clean, pressurized nitrogen for use as a purge and syngas sample quench gas. The existing nitrogen source at 500 psig and ambient temperature with a maximum flow rate of 200 lb/hr was adequate for all of the needs of this sampling program.

No electrical power was required for the probe or the probe positioner, but electrical power was needed for the sampling/analytical equipment.

Isolation Valves

Radian supplied two 3-inch, Neles-Jamesbury 300#, AISI type 316 SS body, full port, ball valves with metallic ball seals and graphite packing stem seals for isolation of the sample port. These valves were arranged in a double block and bleed arrangement (Manufacturer's Data Sheet provided in Attachment A). The valve located closest to the process vessel is the one which sees the most severe duty. According to the manufacturers literature (provided in Attachment A), the operation of these valves at 500 psi and 450°F is within the operating envelope of the valve. Heat transfer calculations were performed by Radian assuming that the 3-inch diameter probe access hole through the insulating plug is open, and the valve is exposed to 1200°F gas in the duct. Based upon these calculations (which are provided in Attachment B), the temperature of the face of the ball in the ball valve should not exceed 450°F. When the probe is inserted and process gas is being extracted, the valve temperature should be below 450°F, as shown in the calculations presented in Attachment C. Thus, the valves will operate within their design envelope under all foreseeable operating conditions. As with most equipment, short excursions outside the operating envelope will not likely lead to catastrophic failure. The selected valves were considered safe for the intended service in this sampling program.

The outboard isolation valve was tapped (in the inboard end) with a 1/4-inch female NPT opening to provide for the injection of high pressure nitrogen (500 psi) for purging the valve and probe sheath assembly to keep them clear of particulate buildup. During insertion and withdrawal of the probe assembly, this port was used to pressure/depressure the enclosure and to purge the enclosure of air or syngas. A pressure gage was attached to the port line to monitor the pressure between the two isolation valves.

Packing Gland

The pressure seal at the outboard end of the probe sheath was provided by a packing gland. The gland spool piece consisted of a 4-inch O.D. x 2-15/16 inch i.d. AISI Type 316 SS pipe and was capable of operating at 500 psig and the full 1200°F maximum syngas stream temperature. Details of the packing gland are shown in Radian Drawing No. 643-002-30-02, Sheet A.

High-temperature Graphoil packing was used; bolts in the packing gland retainer were provided for tightening and loosening of the packing for probe insertion and withdrawal. The inboard end of the gland assembly consisted of a standard 3-inch 300# flange for mating with the outboard isolation valve. A ½-inch NPT port was machined into the gland pipe. Nitrogen was introduced through this port for purging and to raise the pressure of the gland assembly to slightly above system pressure before opening the ball valves. A pressure gage (Omega Model No. PGH-45L-600) was also installed at this location. Depressuring during extraction of the probe assembly could also be accomplished through this port. A continuous purge of nitrogen was introduced into the rear most vent connection to reduce potential penetration of particulate into the open valves and the probe hole in the refractory during testing.

All gases extracted from the process pipe during sampling, except the gas trapped between the double block valves during probe withdrawal, were routed either to a location remote from the immediate sampling area.

Sampling Probe

The sampling probe is an adaptation of probes used by Radian for similar sampling in other projects. Details of the probe are shown in Radian Drawing No. 643-004-30-02, Sheet B. The essence of the design is that sample gas was allowed to pass through the probe, while particulate material was either collected or prevented from entering the probe by use of an in-stack thimble or filter. After passing into the probe, the collected gas can be quenched with nitrogen, if needed, to a temperature less than 850°F. Nitrogen quench gas flow can be controlled such that the temperature of the sample gas does not fall below 400°F at the outlet end of the sample probe.

The components which fit on the in-stack end of the probe are commercial products. Two different tips were provided; one with a nozzle and in-stack filter housing to collect samples of particulate, and another tip which consisted of a filter only to exclude particulate when collecting gas samples.

The probe design provides for a balanced pressure. The quench nitrogen flows in the annular space between the sheath and the sample tube in a direction from the cool end of the probe toward the end inserted into the process pipe. The quench nitrogen enters the sample gas line near the front of the probe through the perforated expansion joint in the sample line tube, mix with the sample and flow in the opposite direction to the exit end of the probe. The probe thus functions as a counter current heat exchanger with very low Reynolds numbers for the gas passes. In addition, the perforated metal expansion section of the sample line provides for differential thermal expansion between the sample line and the probe sheath. The probe sheath and the sample line are designed to withstand 500 psig at 1200°F as either an internal or external pressure without failure, as shown in the analysis presented in Attachment D.

AISI type 316 stainless steel was selected for probe construction. This material performed well during sampling. There are many factors which went into this selection process but paramount was safety and performance for the intended duration of service. The life of the probe is anticipated to be several hundred hours. Probe life expectancy is governed more by handling and duration of sampling effort than on material degradation properties. On this basis, hot strength, both yield and tensile, and hot Young's Modulus are of much greater concern than creep strength and creep elongation. Additionally, AISI 316 is stable and does not suffer major degradation from the contents of the process gas stream at temperatures up to 1200°F. The material was selected for all of the reasons above, but in addition, it is readily available in many forms and shapes and is competitive in price.

The probe is separate from the positioner and can be replaced or shifted without disassembling either the gland or the positioner and supporting structure. Thus, probes can be changed with very little lost time or effort other than that associated with moving the probes and isolating them from the process pipe.

Probe Insertion Mechanism

There is approximately 3,000 lbs. of force exerted on the probe from the process stream when in the sampling configuration. The method selected to control the motion and position of the probe was a trolley that is moved by a system of wire ropes/cables and capstans. Details of the probe trolley assembly are provided in Radian Drawing 643-004-30-02. Sheet C. The arrangement of this mechanism is shown in Radian Drawing 643-004-30-02, Sheets D and E. Stress calculations for trolley components are given in Appendices E and F. Several pulleys are used to keep the load per strand at reasonable levels and to keep the wire rope from becoming too heavy and stiff. Redundant sets of pulleys and wire rope are used on each side of the trolley to reduce binding, to distribute the loads, and to provide a means of controlling the trolley position should one of the cables should break. The positioner was set up to either push or pull the probe and to maintain the probe in position. Withdrawing the probe was somewhat easier than insertion. Initially, it was thought that caking of char around the probe sheath might make probe motion difficult unless the probe could be worked back and forth, and/or a force could be exerted to withdraw the probe.. Thus, the positioner can push or pull with equal ease (char buildup proved to be no problem during the sampling). Each side of the positioner has a mechanical advantage of 3 on force applied. This reduces the cable tension to reasonable levels of 500 lbs per strand. Aircraft control cable of ¼ inch, 7x19 IWRC stainless steel was selected for the positioners.

Motion of the probe is achieved through the use of "boat" winches used as capstans. The wire is not stored on the winches but is wrapped and discharged. Thus the probe is moved by passing cable around the capstan. The capstans have two speeds, are reversing, and have mechanical brakes. This provided very good control, "feel," and accuracy, and safe positioning of the probe was possible under all test conditions. The capstans were hand cranked for extremely positive control at all times..

Mechanical Support

The cool end of the probe is restrained from motion in the vertical plane by use of stiff leg attached to the cold end of the probe and a trolley which runs on a rail mounted to the deck. This system is shown in Radian Drawing No. 643-004-30-02, Sheet C. The trolley is nothing more than a modification of a standard I-beam hoist trolley. The principal modification was the addition of rollers such that the trolley could sustain positive and negative vertical loads.

As it was heated from a cold (ambient) condition, the process vessel was expected to move several inched vertically relative to the access platform. Thus, provision were made to adjust the height of the stiff leg using a power screw. The power screw allowed for height adjustments up to ± 2 inches of travel, which was sufficient to match the vertical movement of the manway port..

Probe Operation

The probe testing and operating procedures, including safety considerations, are described in this section. Only those procedures associated with operating the probe assembly are discussed here. Other activities related to the actual gas sampling are described in the Test Plan.

Safety Considerations

A primary consideration in operating the sampling probe was safety. Every effort was made to ensure safe operation. A set of detailed and comprehensive check lists were prepared for each sampling operation (e.g., probe insertion, probe withdrawal). The appropriate check list was followed during each sampling effort. As each individual required action was performed in the sequence of activities, the task leader for the hot gas sampling effort checked off the action on the check list. An example check list is included in Attachment H.

One potential safety problem was leakage of raw syngas through the gland seal. Before inserting the probe into the syngas through the isolation valves, the probe assembly was purged with nitrogen. The assembly was then pressurized with nitrogen, and the gland seal was checked for leaks by monitoring the pressure drop in the assembly over a given period of time.

During the actual sampling, the gland seal was periodically monitored for leaks using portable CO and H_2S monitors. The annular space between the probe sheath and the probe assembly was continually purged with nitrogen, so any gas leaking through the packing gland was predominantly nitrogen. However, if significant syngas leakage was indicated, the packing gland can be tightened until the leak has been stopped. If the leak cannot be adequately controlled by this action, the sampling can be stopped and the probe withdrawn.

When withdrawing the probes, small quantities of syngas may enter the gland assembly. During depressuring of the gland assembly, the vented gas was routed to a line vented to the atmosphere at a location removed from the immediate sampling area.

Bench Testing

After the sampling system was fabricated and assembled, it was bench-tested at Radian's Austin laboratories. The assembly was completely pressure-tested (hydrostatically) to validate the integrity of the system. Then, the probe assembly was attached to a simulated 3-inch gasifier port, and a hydrostatic resistance was supplied at the sampling end of the probe to simulate the anticipated pressure of the gasifier. The probe insertion and withdrawal operations was successfully tested with this system. Minor deficiencies were identified and corrected before shakedown testing was conducted at the LGTI facility.

Initial System Shakedown

The initial system shakedown was conducted at a lower temperature location (~500°F) on the heat exchange vessel. The probe assembly was installed in this location at the LGTI facility during a scheduled shutdown. Shortly after the plant was started up, initial shakedown of the gas sampling system was conducted. All of the testing operations were performed during this test of the probe system. These operations include sampling probe insertion, gas sampling, particulate collection, and sampling probe withdrawal. Minor deficiencies in a few of these operations were identified and corrected before the sampling effort was conducted at the higher temperature location. Particulate collection times and potential blinding of the filters with particulate were evaluated during this shakedown period and found to be satisfactory.

The operation of the sampling probe system during each of the major activities is described below.

Sample Probe Insertion. Insertion of the sampling probe is described below.

Before inserting the probe, the packing gland was removed so that the sample probe could be more easily positioned in the gland assembly section. The back end of the probe was fastened to and supported on the support trolley. The packing material was inserted into the gland, the retainer/follower was then be partially tightened. The nitrogen purge through the purge valve in the gland assembly was started, and the assembly system was purged with nitrogen to remove all oxygen in the system. At the same time, the flow of dilution nitrogen was started to purge the probe. When all of the oxygen was purged from the gland assembly, the gas outlet valve between the inboard and outboard valves was closed. The probe assembly system was then pressured with nitrogen to approximately 25 psi above the gasification system pressure. When the selected pressure was achieved, the system was blocked in, and the pressure drop in the system (due to nitrogen leaking from the packing gland) was monitored If excessive nitrogen leakage (pressure decline) occurred, the packing gland nuts were tightened to reduce the leakage to an acceptable level.

After the leak rate through the packing gland had been reduced to an acceptable level, the system was once more pressured up to process pressure (with nitrogen). The isolation valves were then opened. The winches were used to move the probe through the inboard valve and into the syngas stream. The probe tip was positioned at the desired location and held in place with the winch system. Retainers were then attached to positively restrain the probe and prevent any possibility of an unplanned retraction. If necessary, the packing gland was tightened further to reduce leakage while collecting gas samples. The nitrogen purge flow through the gland assembly inlet valve was adjusted to a rate sufficient to keep the annular space between the probe sleeve and the refractory relatively free of particulate accumulations. The nitrogen quench flow was designed to maintain the temperature of the sampled gas at approximately 500°F. In actual sampling at the high temperature location, the gas temperatures were low enough that dilution/quench nitrogen was unnecessary. Gas samples were then collected. During the gas sampling, the packing gland was regularly monitored for CO and H_2S leakage. If leakage of these syngas constituents was observed (it was not observed during the testing), the packing gland could be tightened further. If the leakage could not be stopped, sampling was to be halted, and the probe withdrawn.

Sampling Probe Withdrawal. The withdrawal of the sampling probe is described below.

The sampling probe was withdrawn immediately after the planned sampling was completed. Before beginning to withdraw the probe, the packing gland can be loosened slightly, if needed. Possible leakage of syngas through the packing gland did not occur, because of the continuous nitrogen purge through the probe assembly. Nevertheless, gland leakage was monitored with portable CO and H_2S monitors while the plug probe was being withdrawn.

Using the mechanical winches, the probe was withdrawn past both isolation valves. The inboard isolation valve was then closed, and the nitrogen purge was temporarily shut off. The gland assembly section and the area between the two isolation valves was then depressured through the outlet valve located between the two isolation valves. When the system was completely depressured, the nitrogen purge was again started. The purge nitrogen entered through the valve located in the gland assembly and exited through the valve located between the two isolation valves. The exiting nitrogen was monitored for CO and H_2S. When the CO and H_2S levels in the exiting nitrogen fell to an acceptable level, the purge nitrogen floe was stopped. The outboard isolation valve was then closed The probe sheath was also purged with nitrogen. After purging was complete, the probe was completely withdrawn. This completed the sampling sequence.

References

1. 40 CFR 266, Subpart A. "Method 29: Determination of Metals Emissions in Exhaust Gases from Hazardous Waste Incineration and Similar Combustion Processes: Proposed Method."

2. 40 CFR 60, Appendix A. Test Methods. "Method 17: Determination of Particulate Emissions from Stationary Sources (In-Stack Filtration Method)."

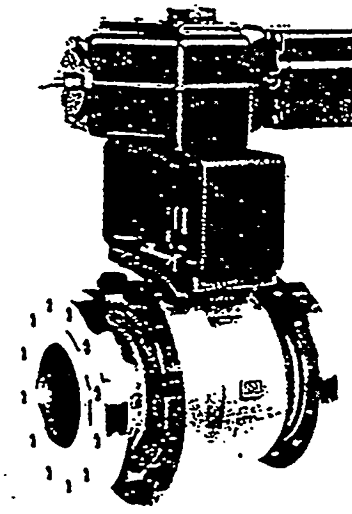
ATTACHMENT A

MANUFACTURERS DATA SHEET

ISOLATION VALVES

3-INCH - CLASS 300

2" – 12" MBV ANSI CLASS 150 AND 300 METAL-SEATED FLOATING BALL FULL PORT FLANGED BALL VALVES



Series MBV metal-seated ball valves are suitable for a wide range of applications in both on/off and control service. The valves are used in handling a variety of liquids, gases and abrasive slurries for industries ranging from chemical and petroleum to power and pulp and paper.

MBV metal-seated ball valves are particularly well suited for minimizing the erosive effects associated with high velocities and the problems related to high temperature sealing. MBV valves are rated for ANSI Class 150 - 300 and are available in sizes 2" -12". In addition, the 8" through 12" sizes are available in ANSI 300 short pattern allowing replacement of most gate valves without changing existing piping.

FEATURES:

WIDE RANGE OF METAL SEATS

- Metal seat designs are available for handling the most severe application conditions. Standard seat construction is a scraper design to eliminate build up on the sealing surfaces of the ball.

PROVEN SIDE-SPLIT BODY DESIGN

- The off-center split body is designed with a spiral wound body seal to virtually eliminate the potential for body leakage.
- Capable of withstanding high pipeline stresses without adversely affecting the body seal.

FULL BORE

- Full bore design resists plugging and bridging in slurries, pulp, polymers and solids handling applications.
- Highest C_V per valve size means the smallest possible valve can be used, resulting in easier installation and lower costs.

RELIABLE STEM SEAL

- Adjustable packing of V-Ring PTFE or die-formed graphite provides for long life.
- Optional live-loaded packing designs are also available.

SUPERIOR STEM TO BALL CONNECTION

- Splined shaft and drive plate provides superior strength required for high pressure, slurries and solids handling processes.
- Minimizes deadband and hysteresis, providing excellent control.
- Large diameter shaft provides high transfer torque capability.
- Inherent stem retention.

TIGHT SHUTOFF IN EITHER DIRECTION

- Shutoff to ANSI/FCI 70-2, Class V.
- Superior shutoff even in low pressure applications.

FIRE TESTED

- Series MBV metal-seated ball valves are fire-tested to meet API 607 and BS6755 Part 2.

SUPERIOR CONTROL CHARACTERISTICS

- Equal percentage flow characteristics and dynamic stability identical in both directions.
- Wide rangeability - 100:1 to 300:1 depending on size.

TWO-STAGE THROTTLING

- Total pressure drop generated on both sides of valve so flow velocity is lower than a single restriction valve.
- Reduced tendency for cavitation, erosion, dewatering, etc.

EASY TO AUTOMATE - SINGLE SOURCE RESPONSIBILITY

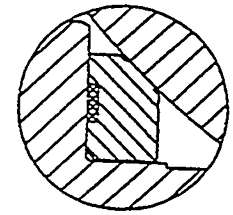
- Manual gear, pneumatic double-acting or spring-return actuators for on-off applications.
- For control applications, dedicated limit switches and pneumatic and electro-pneumatic positioners.

VALVE BODY RATINGS

These are maximum working pressure ratings of the valve body only. The differential pressure/temperature ratings, shown on the preceding page, determine the practical pressure limitations according to actual service conditions. Test pressures are for hydrostatic test with ball half open.

Temp ° F	Body Rating – psi (bar)			
	316 Stainless Steel		Carbon Steel	
	150 lb.	300 lb.	150 lb.	300 lb
-20 to 100 (-29 to 38)	275 (19)	720 (50)	285 (20)	740 (5
200 (93)	240 (17)	620 (43)	260 (18)	675 (4
400 (204)	195 (13)	515 (36)	200 (14)	635 (4
600 (316)	140 (10)	450 (31)	140 (10)	550 (3
800 (427)	80 (6)	415 (29)	80 (6)	410 (2
1000 (538)	20 (1)	365 (25)	—	—
Test Pressure	425 (29)	1100 (76)	450 (31)	1125 (7

SEAT DESIGNS



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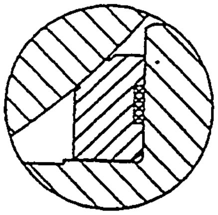

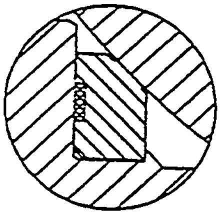

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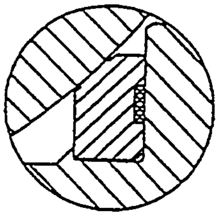

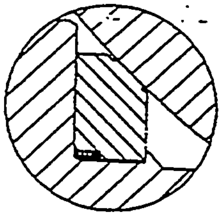

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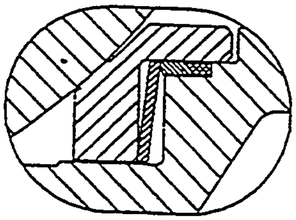


S SEAT – SCRAPING GENERAL SERVICE (BIDIRECTIONAL)

Application advantages: General services with unloc seat requirement.
Seat Material: AISI 316 + Celsit® 50 Nb
Seals: PTFE
Temp Range: -50°F to +450°F (-45°C to +232°C)

K SEAT – SCRAPING LOCKED SEAT (BIDIRECTIONAL)

Application advantages: Locked scraper seat for use sulphite service, low pH applications, pulp stock, as well hydrocarbon liquids and vapors.
Seat Material: AISI 316 + *Celsit* 50 Nb
Seals: PTFE
Temp Range: -50°F to +450°F (-45°C to +232°C)

H SEAT – HIGH TEMPERATURE LOCKED SEA (BIDIRECTIONAL)

Application advantages: Ideal for high temperatures, l pressure differentials, and abrasive solids applications incl ing ash and coal gasification.
Seat Material: AISI 316 + *Celsit* 50 Nb
Seals: Graphite
Spring: Ni based Superalloy
Temp Range: with 316/HCR ball -320°F to +800°F (-195 to +427°C); with Nickel boron coated ball -320°F to 1000°F (-195°C to 538°C).

Celsit® is a registered trademark of Bohler Bros.

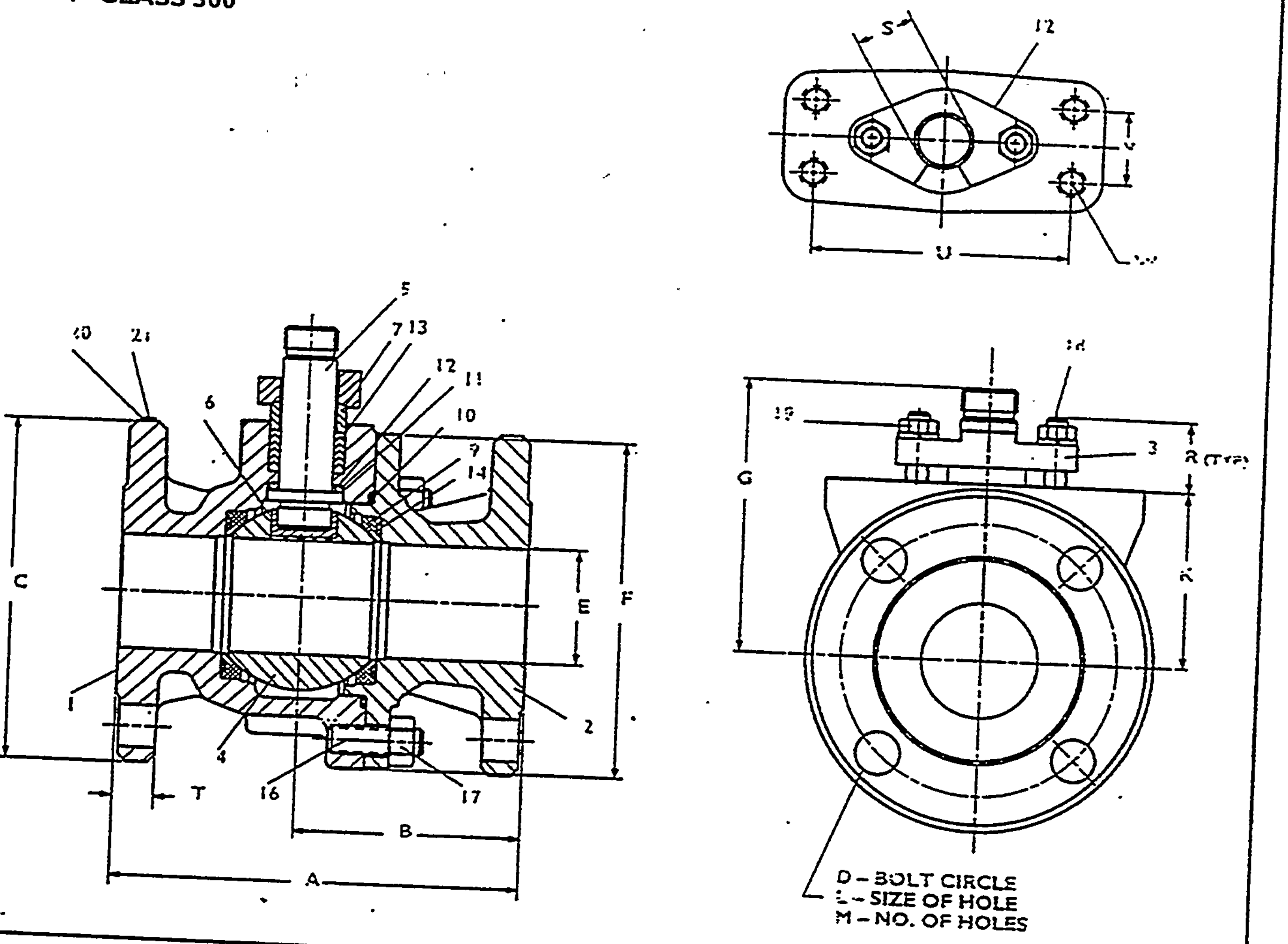
STANDARDS AND SPECIFICATIONS

Series MBV valves covered in this bulletin are available to conform to the following industry standards and specifications:

API 6D	American Petroleum Institute – Specifications for Pipeline Valves
API 607 rev. 3	American Petroleum Institute – Fire Test for Soft Seated Valves (Division of refining)
API 598	American Petroleum Institute – Valve inspection and testing
ANSI B16.10	American National Standard – Face-to-Face and End-to-End Dimensions of Ferrous Valves
ANSI B16.5	American National Standard – Steel Pipe Flanges and Flanged Fittings
ANSI B16.34	American National Standard – Steel Valves – Flanged and Buttwelded End
ANSI B31.1	American National Standard – Power Piping
ANSI B31.3	American National Standard – Chemical Plant and Petroleum Refinery Piping
ANSI/FCI 70-2-1976	American National Standard – For Control Valve Seat Leakage
NACE Standard MR-01-75	National Association of Corrosion Engineers – Sulfide Stress Cracking Resistant Materials for Oilfield Equipment
BS 6755, Part 2	Testing of valves – specification for fire type-testing requirements
MSS SP-25	Manufacturers Standardization Society – Standard marking System for Valves
MSS-SP-55	Manufacturers Standardization Society – Quality Standards for Steel Castings
ISO 5752:1982	International Standard for Organization Metal Valves for use in Flanged Piping Systems
BS2080:1974	British Standards Institute – Specification for face-to-face dimensions of flanged and buttweld steel valves.

DIMENSIONS

2" - 6" CLASS 150
2" - 4" CLASS 300



CLASS 150

Valve Size	A	B	C	D	E	F	G	K	L	M	R	S	T	U	V	W	Weight lbs. (kg)
	APPROXIMATE DIMENSIONS, inches (mm)																
2 (50)	7.00 (178)	3.95 (100)	6.00 (152)	4.75 (121)	2.00 (50)	5.90 (150)	4.95 (126)	3.09 (78)	.75 (19)	4	1.24 (31)	.98 (25)	.75 (19)	4.33 (110)	1.26 (32)	1/2-13	24 (11)
3 (80)	8.00 (203)	4.00 (102)	7.50 (191)	6.00 (152)	3.00 (80)	7.38 (187)	4.95 (126)	3.90 (99)	.75 (19)	4	1.24 (31)	.98 (25)	.94 (24)	4.33 (110)	1.26 (32)	1/2-13	50 (23)
4 (100)	9.00 (229)	4.60 (117)	9.00 (229)	7.50 (191)	4.00 (100)	9.50 (241)	7.50 (191)	5.51 (140)	.75 (19)	8	1.73 (44)	1.36 (35)	.94 (24)	5.10 (130)	1.26 (32)	1/2-13	97 (44)
6 (150)	15.50 (394)	8.25 (210)	11.00 (279)	9.50 (241)	6.00 (150)	13.50 (343)	11.96 (304)	7.25 (184)	.88 (22)	8	1.72 (44)	1.77 (44)	1.00 (25)	6.30 (160)	1.58 (40)	5/8-11	200 (90)

CLASS 300

Valve Size	A	B	C	D	E	F	G	K	L	M	R	S	T	U	V	W	Weight lbs. (kg)
	APPROXIMATE DIMENSIONS, inches (mm)																
2 (50)	8.50 (216)	3.75 (95)	6.50 (165)	5.00 (127)	2.00 (50)	5.67 (144)	4.95 (126)	3.06 (78)	.75 (19)	8	1.24 (31)	.98 (25)	.88 (22)	4.33 (110)	1.26 (32)	1/2-13	36 (16)
3 (80)	11.13 (283)	4.88 (124)	8.25 (210)	6.63 (168)	3.00 (80)	7.94 (202)	7.50 (191)	4.69 (119)	.88 (22)	8	1.73 (44)	1.36 (35)	1.13 (29)	5.10 (130)	1.26 (32)	1/2-13	75 (34)
4 (100)	12.00 (305)	6.63 (168)	10.00 (254)	7.88 (200)	4.00 (100)	9.94 (252)	8.91 (226)	5.63 (143)	.88 (22)	8	1.72 (44)	1.77 (45)	1.38 (35)	6.30 (160)	1.58 (40)	5/8-11	145 (65)

BILL OF MATERIALS

Part No.	Part Name	Material	
1	Body	Carbon Steel ASTM A216 Type WCB	316 Stainless Steel ASTM A351 Type CF8M
2	Body Cap	Carbon Steel ASTM A216 Type WCB	316 Stainless Steel ASTM A351 Type CF8M
3	Compression Plate	Carbon Steel	316 Stainless Steel
4	Ball	316 Stainless Steel	
5	Stem	316 Stainless Steel or Nitronic® 50	
6	Spline Driver	316 Stainless Steel	
7	Compression Ring	316 Stainless Steel	
9	Seat	316 Stainless Steel and *Celsit* 50 Nb	
10	Body Seal	Spiral Wound PTFE/Stainless Steel or Graphite/Stainless Steel	
11	Secondary Stem Seal	Graphite	
12	Lower Stem Seal	PTFE	
13	Upper Stem Seal	PTFE (V-type), Graphite	
14	Back Seal	PTFE	
15	Seat Spring*	Nickel based Superalloy	
16	Body Stud	ASTM A193 Gr B7 or B8	
17	Body Stud Nut	ASTM A194 Gr 2H or 8B	
18	Bonnet Stud	ASTM A193 Gr B7 or B8	
19	Bonnet Stud Nut	ASTM A194 Gr 2H or 8B	
20	ID Tag	Stainless Steel	
21	Rivets	Stainless Steel	

*With H seat construction only.

Inconel is a registered trademark of Inco.
Nitronic is a registerd trademark of Armco Stainless Steel Div.

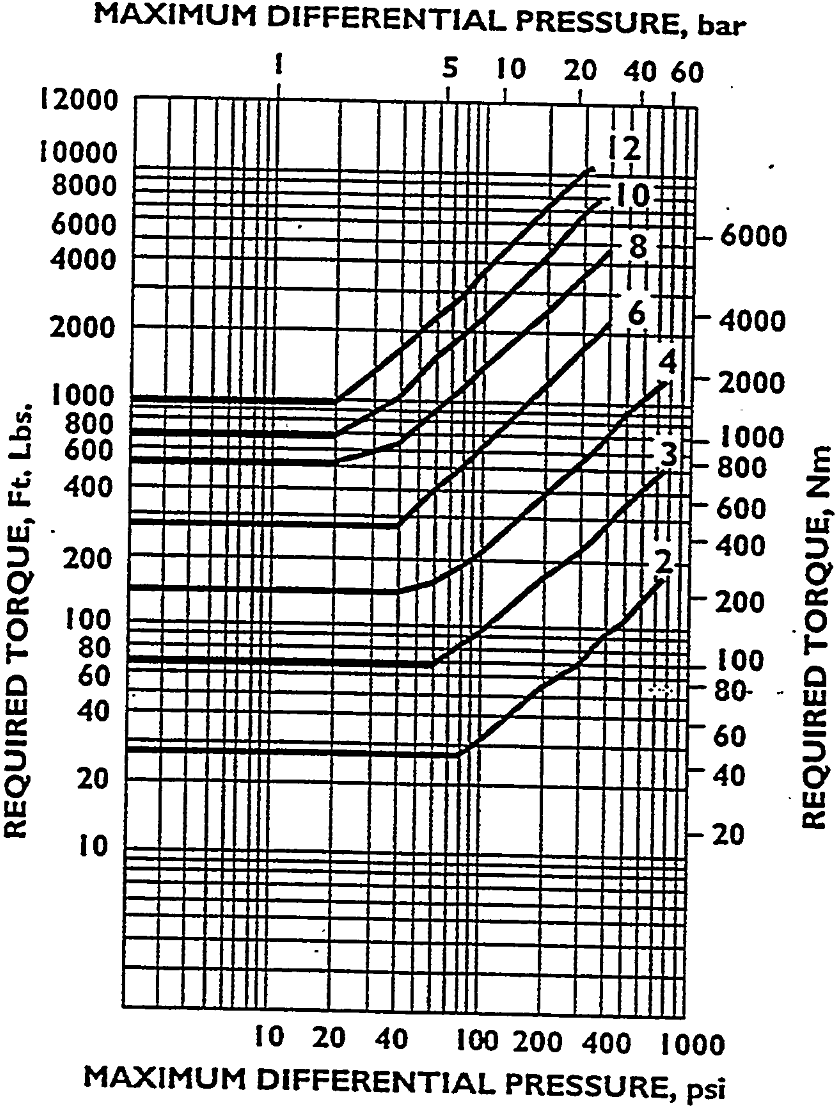
OPENING TORQUE – S, K AND H SEATS

The torque chart for MBV valves is to be used as a guide for actuator selection. Additional requirements may be imposed by media characteristics, trim and frequency of valve operation. The charts are for for S, K and H seats on clean liquids and dry gases.

For difficult services such as slurries, semi-solids and oxygen, please consult the factory. If in doubt, select the larger actuator.

Torque output values and actuator selection tables for the different types of Neles-Jamesbury actuators are contained in bulletins listed below:

Manual Gear Actuators	A100-1
Handgear Actuators	A100-2
Cylinder Actuators	A107-1
Spring-Diaphragm Actuators	A110-1
Spring-Diaphragm Actuators	A110-2
Electric Actuators	A120-2
Enhanced Electric Actuators	A121-1



S, K & H SEATS

OPERATING HANDLES

Series MBV metal seated ball valves are optionally available with manual handles in sizes 2" through 4" provided the differential pressure does not exceed the values shown in the table below.

Pressure Class	Valve Designation	Handle Length inches (mm)	Handle Designation	Maximum Differential psi (bar)
150	MT0200C_	12 (305)	BHK-058	285 (20)
	MT0300C_	12 (305)	BHK-058	110 (8)
	MT0400C_	18 (457)	BHK-059	50 (3.5)
300	MA0200D_	12 (305)	BHK-058	450 (31)
	MA0300D_	18 (457)	BHK-059	170 (12)
	MA0400D_	18 (457)	BHK-060	50 (3.5)

HOW TO ORDER

To specify an MBV Full port ball valve, make a selection from each of the boxes shown below.

1	2	3	4	5	6	7	8	9	10	11
MA	0600	D	A	GA	J2	SH	KTT	A	—	—

Example: This example is for a 6" ANSI Class 300 long pattern, full bore ball valve of standard construction with a carbon steel body, hard chrome plated stainless steel ball, stainless steel stem, *Celsit*-TFE style "K" seat, TFE packing, and B7 body bolting.

1	Valve Series & Style
MA	Full bore, Class 300, long pattern
MS*	Full bore, Class 300, short pattern
MT	Full bore, Class 150

*8" - 12" Class 300 valves only.

2	Size
0200	2" (50 mm)
0300	3" (80 mm)
0400	4" (100 mm)
0600	6" (150 mm)
0800	8" (200 mm)
1000	10" (250 mm)
1200	12" (300 mm)

3	Pressure Class
C	ANSI Class 150
D	ANSI Class 300

4	End Connectors
A	Raised Face (ANSI B16.5)

5	Special Construction
GA	Standard
NA	NACE

6	Body Material
J2	Carbon Steel (WCB)
S6	316 Stainless Steel (CF8M)

7	Ball & Stem Material
SH	316/HCR & 316
SL	316/Nibo & *Nitronic 50* XM-19

8	Seat & Seal Material
STT	Unlocked (S-profile)/ *Celsit*-TFE/TFE
KTT	Locked (K-profile)/ *Celsit*-TFE/TFE
HGG	Locked (H-profile)/ *Celsit* graphite/graphite

9	Body Bolting	
	Bolts	Nuts
A	Carbon Steel A193 Gr B7	Carbon Steel A194 Gr 2H
B	Stainless Steel A193 Gr B8	Stainless Steel A194 Gr 8B

10	Model Code
	Not Required for Ordering

11	Modifier Code
	Please Describe, Factory will supply code.

INTERNATIONAL MANUFACTURING and SALES LOCATIONS

UNITED STATES	CANADA	MEXICO	BRAZIL	FINLAND	ENGLAND	FRANCE	PEOPLE'S REPUBLIC of CHINA
Glens Falls, New York Worcester, Massachusetts	Ottawa, Ontario	San Juan del Rio Queretaro Mexico	Sao Jose dos Campos	Helsinki	Basingstoke Hampshire	Wittenheim	Shanghai

Our products are available through Neles-Jamesbury sales offices in Australia, Austria, Belgium, Germany, Italy, Japan, The Netherlands, Norway, Portugal, Saudi Arabia, Singapore, South Korea, Spain, Sweden, Switzerland, United Arab Emerites, Venezuela as well as through a world-wide network of representatives.

NELES-JAMESBURY

Neles-Jamesbury, Inc.
640 Lincoln Street, Box 15004
Worcester, Massachusetts 01615-0004 U.S.A.
Phone: (508) 852-0200 Telex: 92-0448 Fax: (508) 852-8172

ATTACHMENT B

HEAT TRANSFER CALCULATIONS

NO PROBE IN SAMPLE CAVITY

NO PROBE - ESTIMATE OF FIRST ISOLATION VALVE TEMPERATURE

Direct Radiation

Determine the heat which could be transmitted through the hole in the refractory of the process pipe. Assume the hole is black, the receptor gray, and the gas does not interact with the radiant heat transfer. Compare this energy with the energy which could be lost through natural convection at the valve body to estimate the maximum likely temperature of the face of the ball in the first isolation valve.

Assume

$T_1 := (1200 + 460) \cdot R$

$T_{amb} := (100 + 460) \cdot R$

Disc dimensions

Ref: Rohsenow, Warren W. and James P. Hartnett, "Handbook of Heat Transfer," McGraw Hill, 1973, pg 15-44, Fig 4a, configuration 3.

$a := 1.5 \cdot in$

$b := 1.5 \cdot in$

$c := 0.25 \cdot in$ $\qquad X := \frac{a}{c} \qquad Y := \frac{c}{b}$

$Z := 1 + \left(1 + X^2\right) \cdot Y^2$

$F_{A111} := \frac{1}{2} \cdot \left(Z - \sqrt{Z^2 - 4 \cdot X^2 \cdot Y^2}\right)$ $\qquad F_{A111} = 0.847$

$A_1 := \pi \cdot a^2$ $\qquad \sigma := 0.173 \cdot 10^{-8} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R^4}$

Assume

$T_{10} := (300 + 460) \cdot R$

$Q_{110} := \sigma \cdot A_1 \cdot F_{A111} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right)$

$Q_{110} = 521.959 \cdot \frac{BTU}{hr}$

This is the energy input to the valve body due to radiant heat transfer.

Next estimate the heat loss through the sides of the first isolation valve body. Assume natural convection from the sides but no energy transfer from the ends of the valve. Further, assume the valve body can be represented by a hollow right circular cylinder of diameter 6 inches by 8 inches long.

$D_o := 6 \cdot in$ $L := 8 \cdot in$

$A_{10} := \pi \cdot D_o \cdot L$ $A_{10} = 150.796 \cdot in^2$

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{(D_o)} \cdot \frac{ft}{R} \right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

Ref: McAdams, "Heat Transmission," McGraw Hill, 1954, pg 177, eqn (7-7a)

$Q_{10} := A_{10} \cdot h_c \cdot (T_{10} - T_{amb})$

$Q_{10} = 252.893 \cdot \frac{BTU}{hr}$ This is the energy lost through natural convection at the valve body

---

Determine the valve temperature if Q10 = Q110

$Q_{10} := Q_{110}$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb}$$

$T_{10} = 972.79 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$

$t_{10} = 512.79 \cdot R$ This temperature is F

With this temperature, re-estimate the heat loss to the environment and recompute.

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{(D_o)} \cdot \frac{ft}{R} \right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$Q_{10} := A_{10} \cdot h_c \cdot (T_{10} - T_{amb})$

$Q_{10} = 625.621 \cdot \frac{BTU}{hr}$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb}$$

$T_{10} = 877.737 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$

$t_{10} = 417.737 \cdot R$ This temperature is F

Another iteration

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{\left(D_o\right)} \cdot \frac{ft}{R}\right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$$Q_{10} := A_{10} \cdot h_c \cdot \left(T_{10} - T_{amb}\right)$$

$Q_{10} = 451.06 \cdot \frac{BTU}{hr}$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb}$$

$T_{10} = 914.515 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$

$t_{10} = 454.515 \cdot R$ This temperature is F

Another iteration

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{\left(D_o\right)} \cdot \frac{ft}{R}\right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$$Q_{10} := A_{10} \cdot h_c \cdot \left(T_{10} - T_{amb}\right)$$

$Q_{10} = 517.241 \cdot \frac{BTU}{hr}$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb}$$

$T_{10} = 899.72 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$

$t_{10} = 439.72 \cdot R$ This temperature is F

Another iteration

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{\left(D_o\right)} \cdot \frac{ft}{R} \right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$$Q_{10} := A_{10} \cdot h_c \cdot \left(T_{10} - T_{amb}\right)$$

$$Q_{10} = 490.402 \cdot \frac{BTU}{hr}$$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb} \qquad T_{10} = 905.56 \cdot R$$

$t_{10} := T_{10} - 460 \cdot R$ $t_{10} = 445.56 \cdot R$ This temperature is F

Another iteration

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{\left(D_o\right)} \cdot \frac{ft}{R} \right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$$Q_{10} := A_{10} \cdot h_c \cdot \left(T_{10} - T_{amb}\right)$$

$$Q_{10} = 500.962 \cdot \frac{BTU}{hr}$$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb} \qquad T_{10} = 903.239 \cdot R$$

$t_{10} := T_{10} - 460 \cdot R$ $t_{10} = 443.239 \cdot R$ This temperature is F

The ball valve may achieve a temperature near 450 F if no plug is present to block radiation and all of the other assumptions are valid. This represents an upper bound estimate of the temperature since the radiant energy will interact with the gas, the re-radiation from the walls of the hole in the insulation will not act as a black surface, and there will be heat loss at locations other than the valve body.

ATTACHMENT C

ESTIMATING THE TEMPERATURE OF THE ISOLATION VALVES DURING SYNGAS SAMPLING (PROBE INSERTED)

Summary

The temperature of the inboard isolation valve must remain below 450°F at all times. The probe assembly system with the sampling probe in position during the gas sampling period was simulated. The calculations showed that the temperature of the probe sheath at the inboard isolation valve should be less than 118°F. Therefore, we have concluded that the temperature of the inboard isolation valve should be well below the maximum operating temperature of approximately 450°F during the gas sampling periods. However, we feel that it would be prudent to monitor the temperature of the valve at all times.

Approach

To simulate the system with the gas sampling probe in place, we chose a countercurrent heat exchanger model, assuming no heat loss to the surroundings (Figure 1). This model provides a conservative estimate of the gas temperature profile in the shell side. Since the shell wall temperature cannot be greater that the shell gas temperature, the isolation valve temperature should not be greater than the shell gas temperature. Therefore, the objective of this analysis is to find the temperature profile of the shell gas and to use the profile to obtain the maximum temperature of the isolation valves.

To meet this objective, an analytical solution for convective heat transfer to the shell gas was derived, assuming that the heat transfer coefficients and gas properties could be expressed by their values at the appropriate average gas temperatures. The radiation heat transfer was also computed, but it was found to be negligibly small compared to the convective heat transfer. Therefore, the solution presented here only considers convective heat transfer.

The analytical solution is expressed as follows:

$$T_{shell,gas} = \frac{\left(\alpha - \phi_{1a}\ e^{-\beta a}\right)}{\beta}$$

where

$$\alpha = U_o * \left(\frac{T_{2a}}{W_1 * C_1} - \frac{T_{1a}}{W_2 * C_2}\right)$$

$$\beta = U_o * \left(\frac{1}{W_1 * C_1} - \frac{1}{W_2 * C_2}\right)$$

$$\phi_{1a} = \alpha - \beta T_{1a}$$

and

U_o = Overall outside heat transfer coefficient at average temperature;

W_1 = Mass flow rate of nitrogen through the shell side;

W_2 = Mass flow rate of mixed gas through the tube side;

C_1 = Heat capacity of nitrogen at average shell gas temperature;

C_2 = Heat capacity of mixed gas at average tube gas temperature;

T_{1a} = Nitrogen temperature at entrance of shell (70°F);

T_{2a} = Mixed gas temperature at outlet of tube (500°F); and

A = Outside heat transfer surface area, ft^2.

We assumed that the quench nitrogen flowed through the shell side of the probe sheath and mixed with the syngas in the probe The mixed gas flows through the probe (tube side of the heat exchanger model). A process simulation program (MAX by Aspen Technologies) was used to calculate flow rates and properties of the various gas streams (i.e., shell side inlet and outlet, mixed gas inlet and outlet, and syngas). The specifications for the simulator program (Table 1) were the shell nitrogen inlet temperature (70°F), the process gas composition, the syngas temperature (1,200°F), and the temperature of the mixed gas at the outlet of the sampling probe (500°F). The simulator calculated the required flow rates.

An iterative procedure was used to obtain average transport properties that were used in the heat transfer calculations. For the first iteration, the shell gas outlet temperature was assumed. The simulator program results were entered into a spreadsheet containing the analytical solution. The spreadsheet calculated a shell gas outlet temperature, which was then entered into the simulator program to recalculate the gas properties. This iteration on the shell gas outlet temperature was continued until the simulator value converged to the analytical value.

Results

Table 2 and Figure 2 present the results for the calculated temperature profile. The results show that the maximum temperature of the shell gas is 118°F near the location of the inboard isolation valve. From this result, we have concluded that, with the sampling probe in place, the temperature of the isolation valves will be well below the maximum temperature rating of 450°F at 500 psig.

Table 1. Required Data

Probe Geometry

Tube O.D.	0.625	inch
Tube wall	0.083	inch
Tube ID	0.459	inch
External Area	0.164	ft2/ft length
Internal Area	0.0011	ft2
Shell ID	2.454	inch
Shell wall	0.148	inch
Internal Area	0.647	ft2/ft length
Annulus X-Section	0.0307	ft2
Length	5.00	ft
Annulus D	0.1524	ft
4*x-Area/Wet Perim	0.1524	ft

Transport Properties

H.T. Coef. tube gas to tube:	21.803	Btu/(hr-ft2-F)
H.T. Coef. tube to shell gas:	0.583	Btu/(hr-ft2-F)
Overall H.T. coeff. (outside area)	0.556	Btu/(hr-ft2-F)
Nitrogen heat capacity (105 F)	7.284	Btu/(lbmol-R)
Mixed Gas heat capacity (522 F)	7.599	Btu/(lbmol-R)
Nitrogen Viscosity (105 F)	0.045	lb mass/ft-hr
Mixed Gas Viscosity (522 F)	0.066	lb mass/ft-hr
Nitrogen Density (105 F)	1.976	lb/ft3
Mixed Gas Density (522 F)	0.958	lb/ft3
Tube Side Reynolds # (522 F)	8101	
Shell Side Reynolds # (105 F)	1309	
Tube Side Prandtl # (522 F)	0.623	
Shell Side Prandtl # (105 F)	0.754	
Tube Side Thermal Cond. (522 F)	0.032	BTU-ft/(hr-ft2-F)
Shell Side Thermal Cond. (105 F)	0.015	BTU-ft/(hr-ft2-F)

Shell Gas

Inlet Temp	70	F
Inlet Pressure	425	psia
Mass flow	0.003	lb/sec
Mass flow	11.75	lb/hr
Mol. Wt	28.01	
Calculated Shell flow	2.65	scfm

Tube Gas

Inlet Temp	1200	F
Outlet Temp	500	F
Inlet Pressure	400	psia
Mass flow	0.004	lb/sec
Mass flow	16.04	lb/hr
Mol. Wt	25.36	
Calculated mixed gas flow	4.00	scfm

Table 2. Estimated Shell and Tube Temperatures as a Function of Axial Position

Distance Along H.E. (inches)	Total Area as f(distance) (ft^2)	Calculated Nitrogen Temperature (F)	Calculated Mixed Gas Temperature (F)
0.00	0.0000	70	500.0
6.00	0.0818	76	504.1
12.00	0.1636	83	508.1
18.00	0.2454	89	512.1
24.00	0.3272	95	516.1
30.00	0.4091	102	520.1
36.00	0.4909	108	524.0
42.00	0.5727	114	527.9
48.00	0.6545	120	531.8
54.00	0.7363	126	535.7
60.00	0.8181	132	539.6

Aspen Sensitivity Study Results

N2 Block Outlet Temperature (F)	Mixed Gas Temp (F)	Average Shell Gas Temp (F)	Average Tube Gas Temp (F)
80.00	506.00	75	503
90.00	513.00	80	507
100.00	519.00	85	510
110.00	525.00	90	513
120.00	532.00	95	516
130.00	538.00	100	519
140.00	544.00	105	522
150.00	551.00	110	526
160.00	557.00	115	529

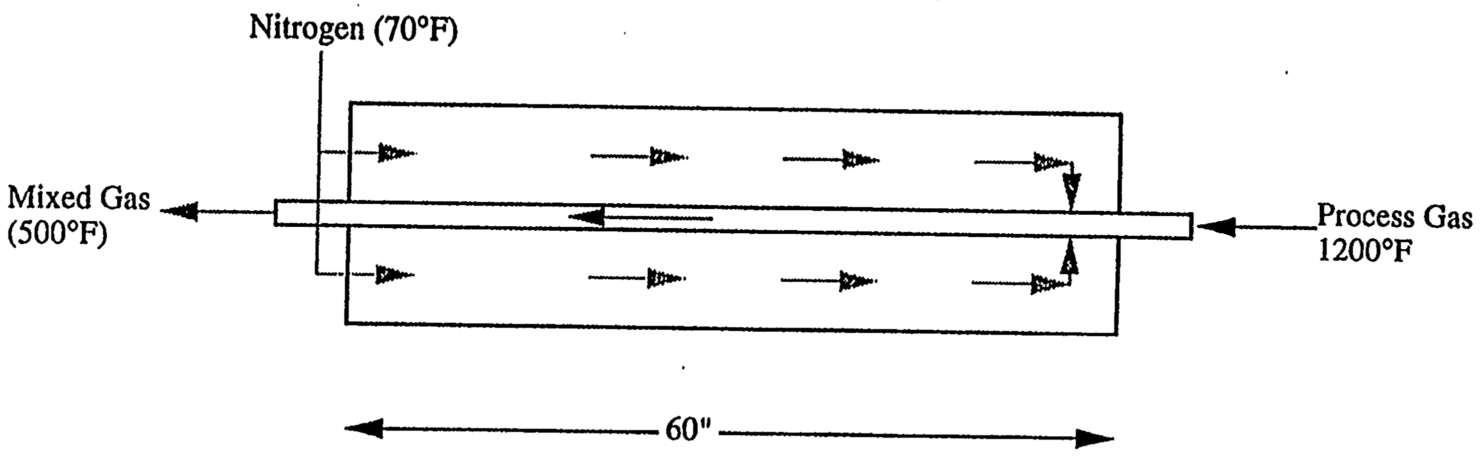


Figure 1. Simplified diagram for heat-exchange portion of sampling probe.

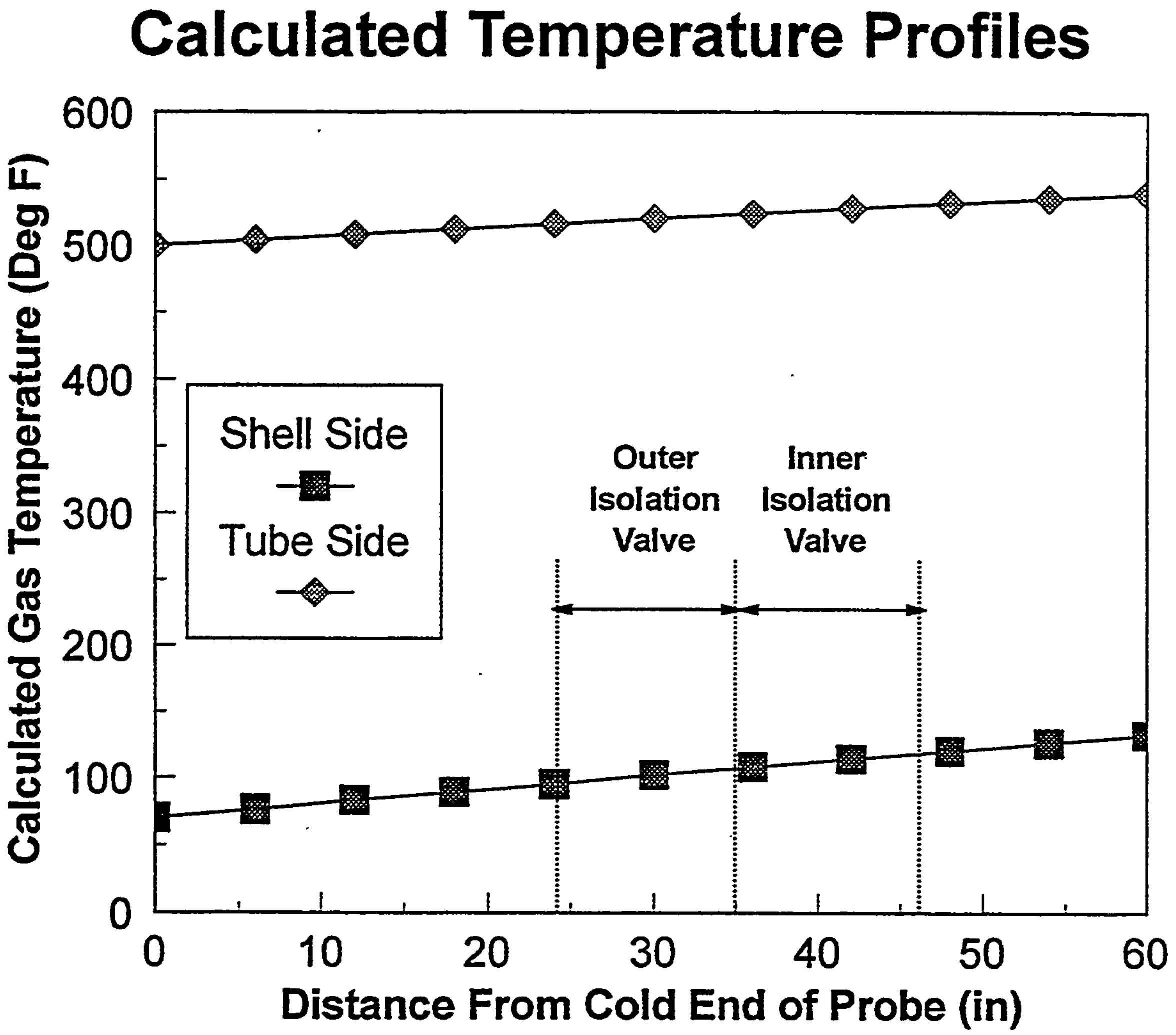


Figure 2. Calculated Temperature Profiles for Shell- and Tube-gases.

ATTACHMENT D

COLLAPSE PRESSURE OF PROBE SHEATH AND SAMPLE TUBE

Pressure Calculations for Probe

Compute minimum wall thickness for probe sheath and for sample line. Use methods and data from ANSI B31.3, "Chemical Plant and Petroleum Refining Piping."

Assume a 500 psig differential can exist across either one in either an internal or external pressure situation.

Sample Line

$D_c := \frac{5}{8} \cdot in$ $t_c := 0.083 \cdot in$ $z_c := \frac{D_c}{6}$ $z_c = 0.104 \cdot in$

Allowable stress per B31.3, tbl A-1, pg 174-175

Joint Efficiency, Quality Factor, B31-3 tbl A-1A

Therefore t < Dc/6 and equation 3b of B31.3, para 304.1.2, 1993 applies for internal pressure

$w_c := \frac{D_c}{t_c}$ $w_c = 8$

$S := 7400$ psi @ 1200 F

$E := 1$

For Internal Pressure

$P_{c1} := \frac{2 \cdot S \cdot E \cdot t_c}{D_c}$ Para 304.1.2, eqn 3b, pg 20

$P_{c1} = 1965$

For External Pressure

From BPVC, Sec VIII, Div 1, para UG-28 for external pressure

$A_c := \frac{1.1}{w_c}$ $A_c = 0.146$

$S_1 := 1.5 \cdot S$ $S_1 = 11100$

$S_2 := 0.9 \cdot 30000$ $S_2 = 27000$

Above allowable stresses per UG-28

$A_c := 0.10$ Per code

$B_c := 10000$ Per Fig 5, UHA 28.2

$$p_{a1} := \left[\frac{2.167}{\left(\frac{D_c}{t_c}\right)} - 0.0833 \right] \cdot B_c$$

$p_{a1} = 2045$ This is in psi

$$p_{a2} := \frac{2 \cdot S_1}{\left(\frac{D_c}{t_c}\right)} \cdot \left[1 - \frac{1}{\left(\frac{D_c}{t_c}\right)} \right]$$

$p_{a2} = 2557$ This is in psi

The lower of these pressures, 2045 psi, defines the maximum allowable external pressure in accordance with B31.3
The maximum allowable internal pressure is 1965

==

Sheath

$D_s := 2.75 \cdot in$ $t_s := 0.148 \cdot in$

$z_s := \frac{D_s}{6}$ $z_s = 0.458 \cdot in$

For Internal Pressure

Therefore t < Dc/6 and equation 3b of B31.3, para 304.1.2, 1993 applies for internal pressure

$S := 7400$

$E := 1$

$$P_{s1} := \frac{2 \cdot S \cdot E \cdot t_s}{D_s}$$

$P_{s1} = 797$

This is the maximum allowable internal pressure for the sheath

---

For External Pressure

$L_s := 72 \cdot in$

Same references and procedures as above.

$v_s := \frac{L_s}{D_s}$ $v_s = 26$ $w_s := \frac{D_s}{t_s}$ $w_s = 19$

$A_s := 0.003$ per Fig 5, UGO 28.0

$B_s := 7800$ Per Fig 5, UHA 28.2

$S_1 := 1.5 \cdot S$ $S_1 = 11100$

$S_2 := 0.9 \cdot 30000$ $S_2 = 27000$

$$p_{b1} := \frac{4 \cdot B_s}{3 \cdot \left(\frac{D_s}{t_s}\right)}$$

$p_{b1} = 560$ This is in psi

The maximum allowable internal pressure is 790 psi, and the maximum allowable external pressure is 560 psi.

Both of the tubes can withstand a maximum pressure differential of 560 psi from either side, i.e. external pressure or internal pressure.

ATTACHMENT E

STRESS CALCULATIONS FOR TROLLEY COMPONENTS

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CALCULATION SHEET

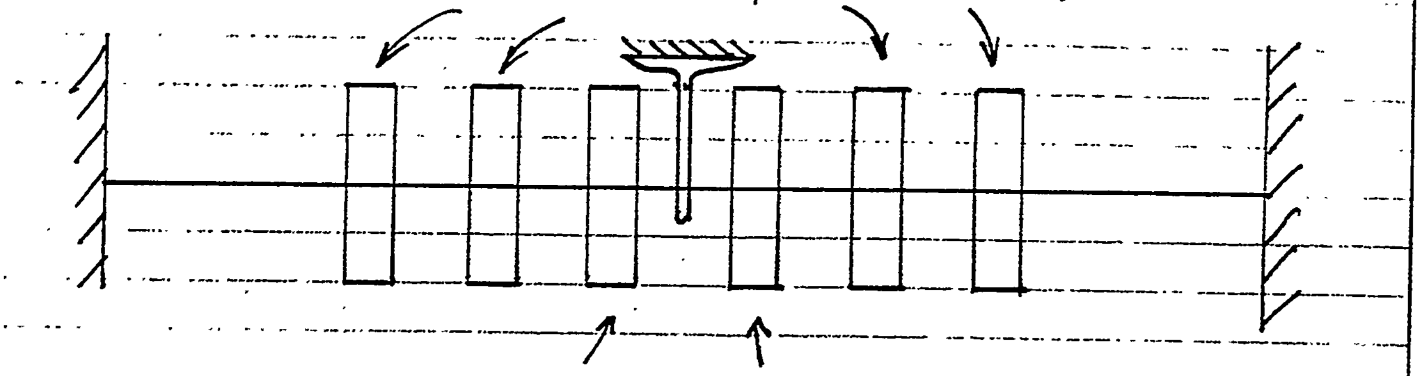
CALC. NO.

IGNATURE DATE CHECKED DATE

ROJECT Dow Hot Gas JOB NO.

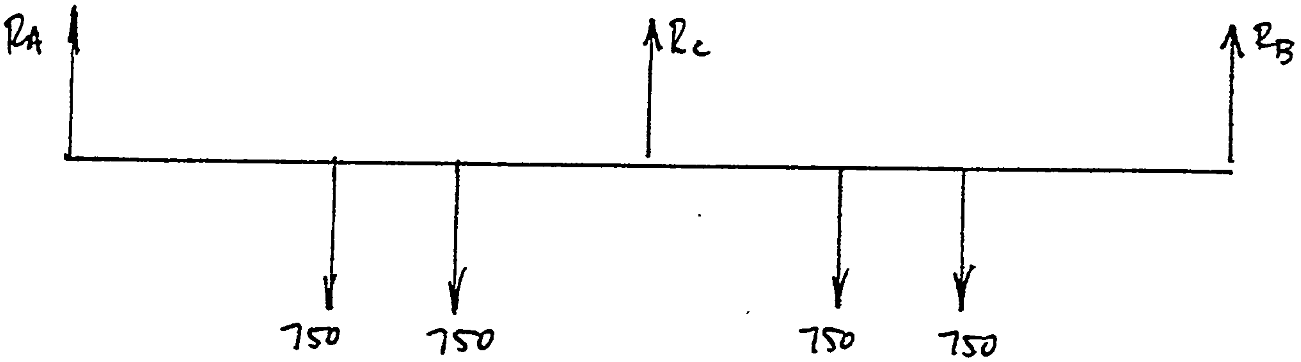
UBJECT Pulley Axle - Stress Calcs SHEET 1 OF 7 SHEETS

Used to move probe into vessel



Used to move probe out of vessel

Assume that none of the cables have broken
Probe is going in.



With the addition of the center bearing support, Rc, this becomes a statically indeterminate structure. Although there are several methods which will solve this, I'll use the method of superposition, adding the deflection of each force linearly.

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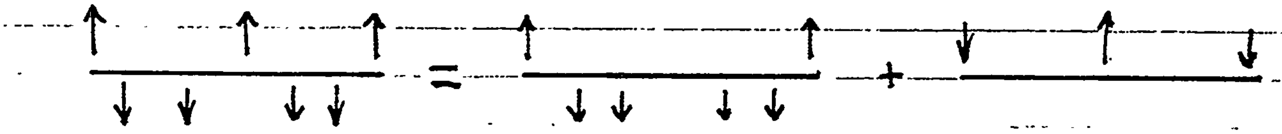
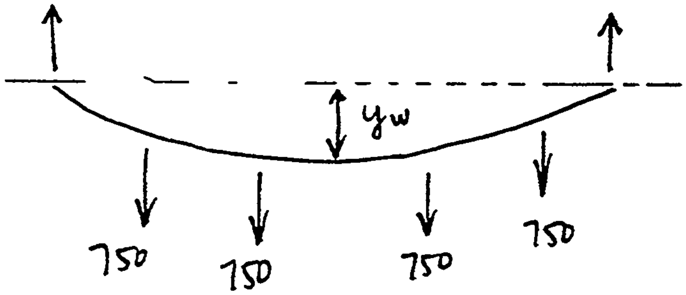
PROJECT Dow Hot Gas JOB NO.

SUBJECT Pulley Axle - Stress Calcs SHEET 2 OF 7 SHEETS

Reference: Mechanics of Materials, A. Higdon, E.H. Ohlsen, et. al. p. 429, Appendix D.





Now, examine the deflection of each force independantly & add together the resulting deflections of all forces

$$y_{center} = -\frac{Pb\,(3L^2 - 4b^2)}{48EI}$$

b = dist from simply supported end

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PROJECT Dow Hot Gas JOB NO.________

SUBJECT Pulley Axle - Stress Calcs SHEET 3 OF 7 SHEETS

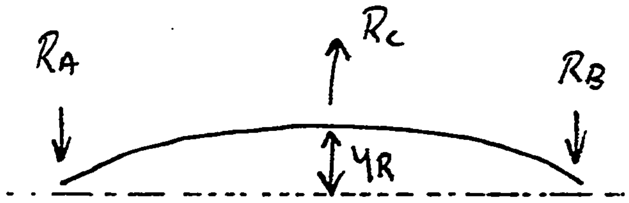
Looking at the forces on the left side.

$$\frac{1}{2} y_W = -\frac{750 \cdot 5.5 \,(3 \cdot 24^2 - 4 \cdot 5.5^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64} 1^4}$$

$$- \frac{750 \cdot 8 \,(3 \cdot 24^2 - 4 \cdot 8^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64} 1^4}$$

$$\frac{1}{2} y_W = -0.094 - 0.125$$

y_W = 0.44" down } due to the load of ~~foo~~ four 750# forces



$$y_R = \frac{R_c L^3}{48EI}$$

$y_W + y_R = 0$ due to the presence of the bearing @ R_c

CALCULATION SHEET

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PROJECT Dow Hot Gas JOB NO.

SUBJECT Pulley Axle - Stress Calcs SHEET 4 OF 7 SHEETS

$$-0.44 + \frac{R_c L^3}{48EI} = 0$$

$$R_c = \frac{0.44 \cdot 48EI}{L^3} = \frac{0.44 \cdot 48 \cdot 30\times10^6 \cdot \frac{\pi}{64}}{24^3}$$

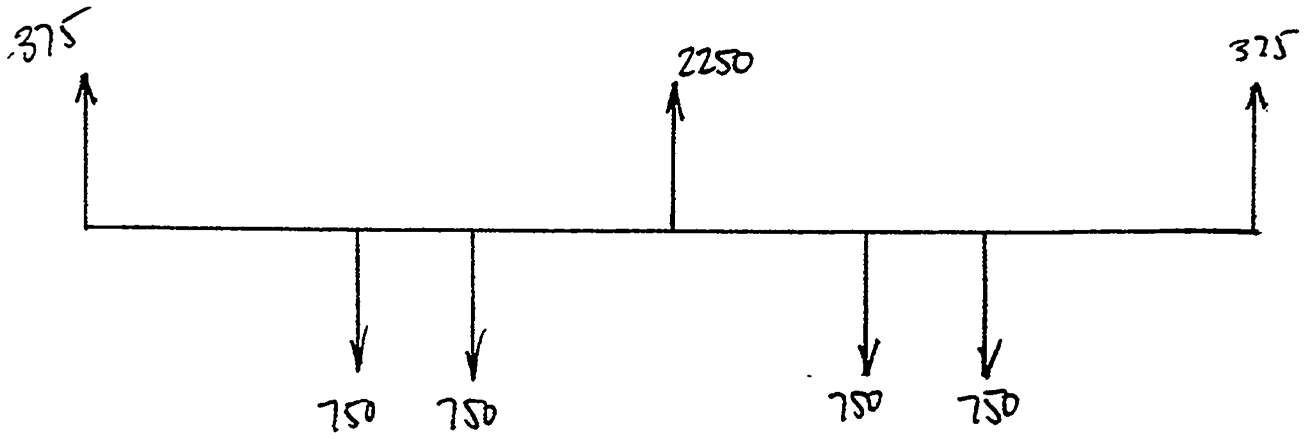
$$R_c = 2250 \text{ lb.}$$

$$+\uparrow \Sigma F_y = 0$$

$$R_A + R_B + R_c = 3000$$

$R_A = R_B$ so, $2R_A = 3000 - 2250$

$$R_A = R_B = 375 \text{ lb.}$$



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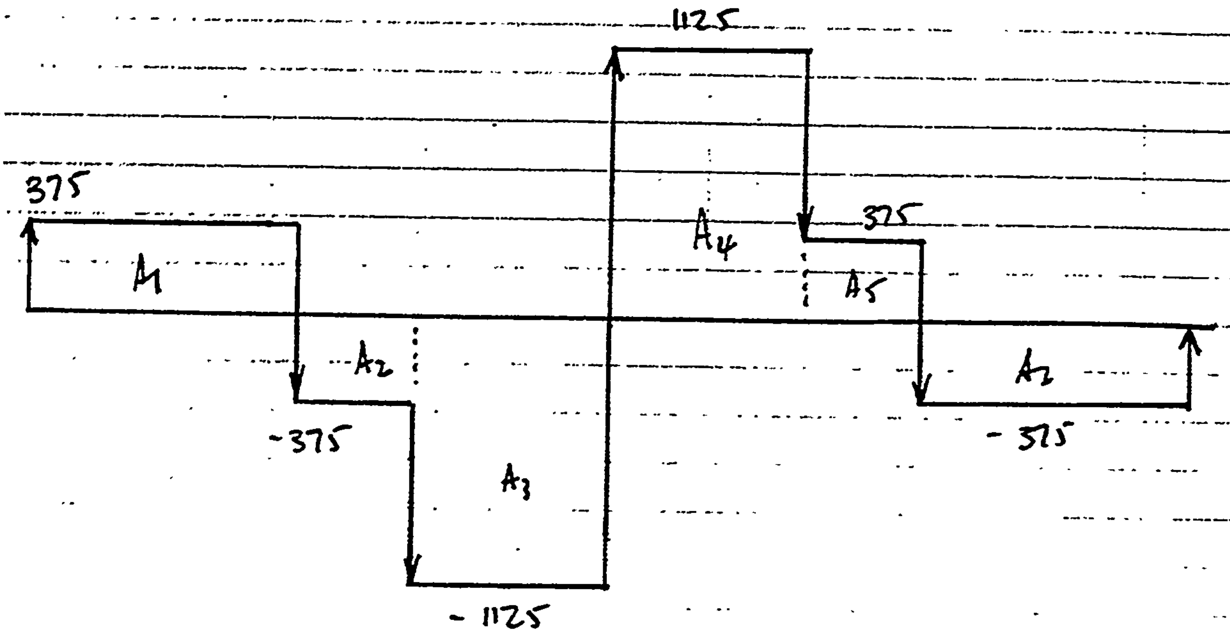
PROJECT DOW Hot Gas JOB NO.

SUBJECT Pulley Axle – Stress Calcs SHEET 5 OF 7 SHEETS

Shear Diagram (lb) | Square = 200#

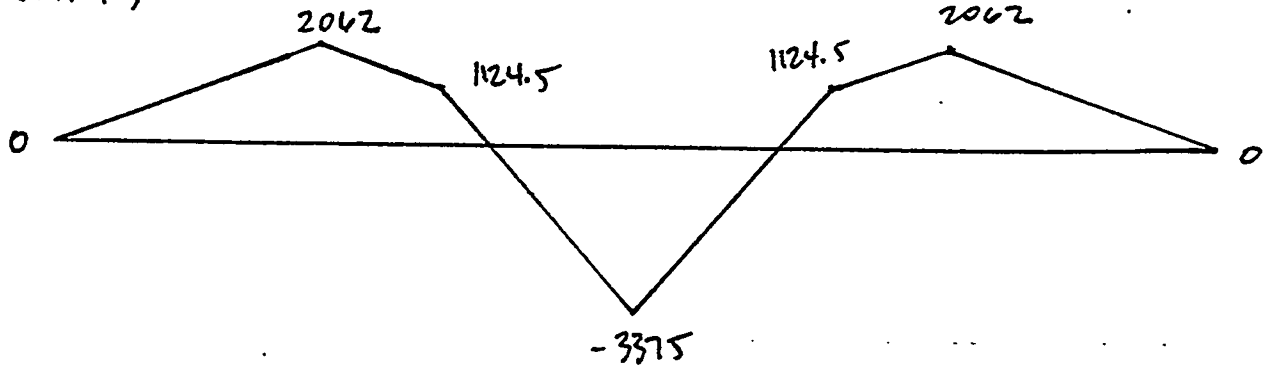


$A_1 = A_6 = 5.5 \cdot 375 = 2062$

$A_2 = A_5 = 2.5 \cdot 375 = 937.5$

$A_3 = A_4 = 4 \cdot 1125 = 4500$

Moment Diagram (in·lb) | square = 1000 in·lb



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PROJECT Dow Hot Gas JOB NO.

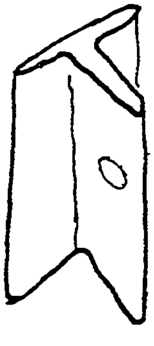
SUBJECT Pulley Axle - Stress Calcs SHEET 6 OF 7 SHEETS

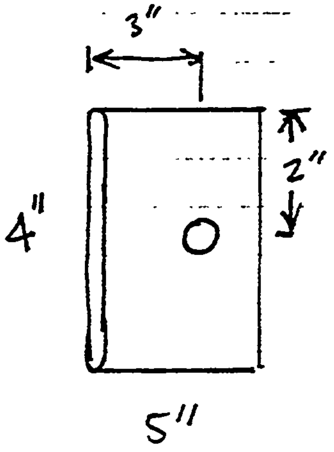
$$\sigma = \frac{Mc}{I}$$

The largest moment acting on the shaft is at the center bearing.

$$\sigma = \frac{(3375 \text{ in-lb})(0.5 \text{ in})}{\frac{\pi}{64}(1 \text{ in})^4} = 34.4 \text{ ksi}$$

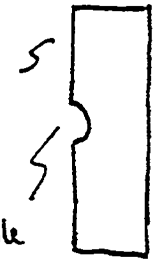
Now check the stress at the bearing.





web thickness = 0.230"

A.



$A = 3 \text{ in} \cdot 0.230 \text{ in} = 0.69 \text{ in}^2$

$P = 2250 \text{ lb.}$ (from shear diagram)

$\sigma = \frac{P}{A} \cdot K_T$ Due to the presence of the hole, $K_T = 2$.

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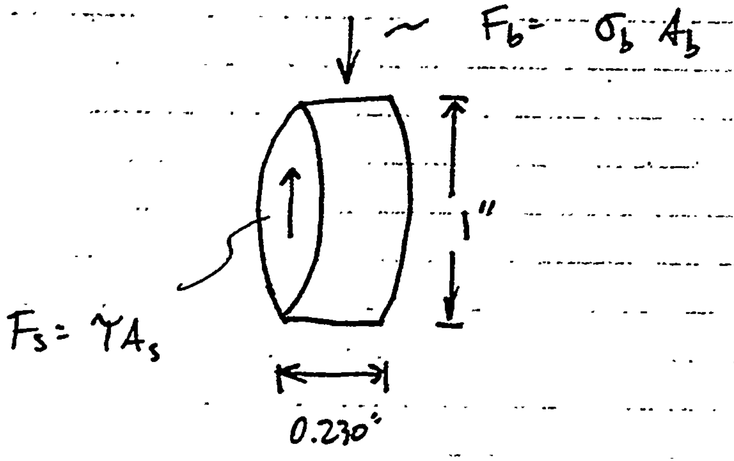
ROJECT Dow hot Gas JOB NO.

UBJECT Pulley Axle - Stress Calcs SHEET 7 OF 7 SHEETS

$$\sigma = \frac{2250 \text{ lb}}{0.69 \text{ in}^2} \cdot 2 = 6523 \text{ psi}$$

6.5 ksi is acceptable for structural steel

Look at the bearing stresses, & shear stresses



$$F_b = 2250 \text{ lb} = \sigma_b \cdot (1 \text{in})(.230 \text{ in})$$

$$\sigma_b = 9.8 \text{ ksi}$$

$$F_s = 2250 \text{ lb} = \tau \cdot \frac{\pi}{4} (1 \text{in}^2)$$

$$\tau = 2.9 \text{ ksi}$$

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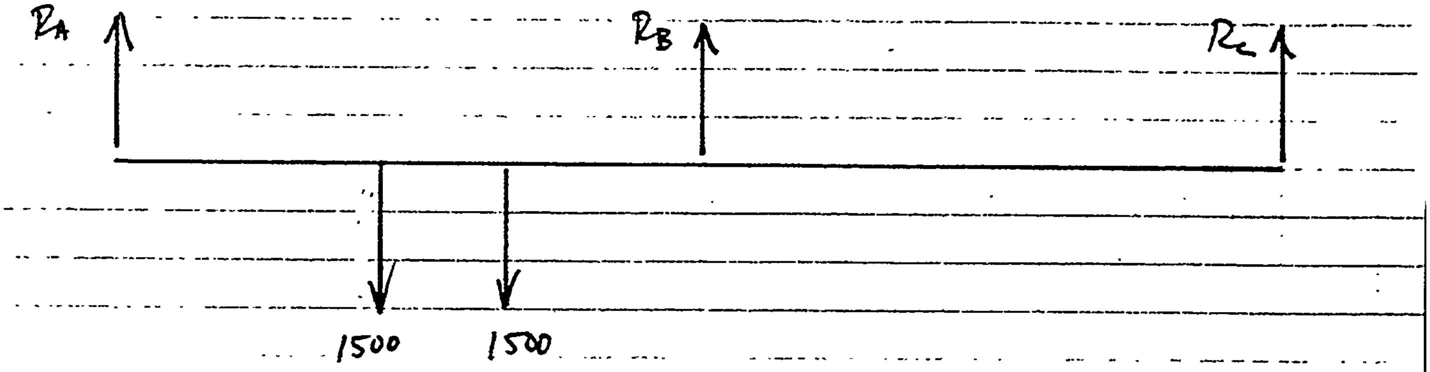
PROJECT Dow Hot Gas JOB NO.

SUBJECT Pulley Axle - Stress Calcs SHEET 1 OF 4 SHEETS



This is the type of loadings if one of the cables breaks.

Use the superposition method.

Due to the 1500* force on the left:

$$y_w = - \frac{-Pb\,(3L^2 - 4b^2)}{48EI}$$

$$y_w = - \frac{1500 \cdot 5.5\,(3 \cdot 24^2 - 4 \cdot 5.5^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64}} - \frac{1500 \cdot 8\,(3 \cdot 24^2 - 4 \cdot 8^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64}}$$

$$y_w = -0.1876 - 0.25 = -.44$$

$$y_r = \frac{R_b L^3}{48EI}$$

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PROJECT Dow Hot Gas JOB NO.

SUBJECT Stress Calcs - Pulley Axle SHEET 2 OF 4 SHEETS

$y_w + y_R = 0$

$$\frac{R_b L^3}{48EI} = 0.44$$

$$R_b = \frac{0.44 \cdot 48EI}{L^3} = \frac{0.44 \cdot 48 \cdot 30 \cdot 10^6 \frac{\pi}{64}}{24^3}$$

$R_b = 2250$ lb.

$\Sigma M_A = 0$

$-1500 \cdot 5.5 - 1500 \cdot 8 + R_b \cdot 12 + R_c \cdot 24 = 0.$

$-8250 - 12000 + 2250 \cdot 12 + R_c \cdot 24 = 0$

$R_c = -281$ lb.

$\Sigma F_y = 0$

$R_A + R_B + R_c = 3000$

$R_A = 3000 - R_B - R_c = 3000 - 2250 + 281$

$R_A = 1031$ lb.

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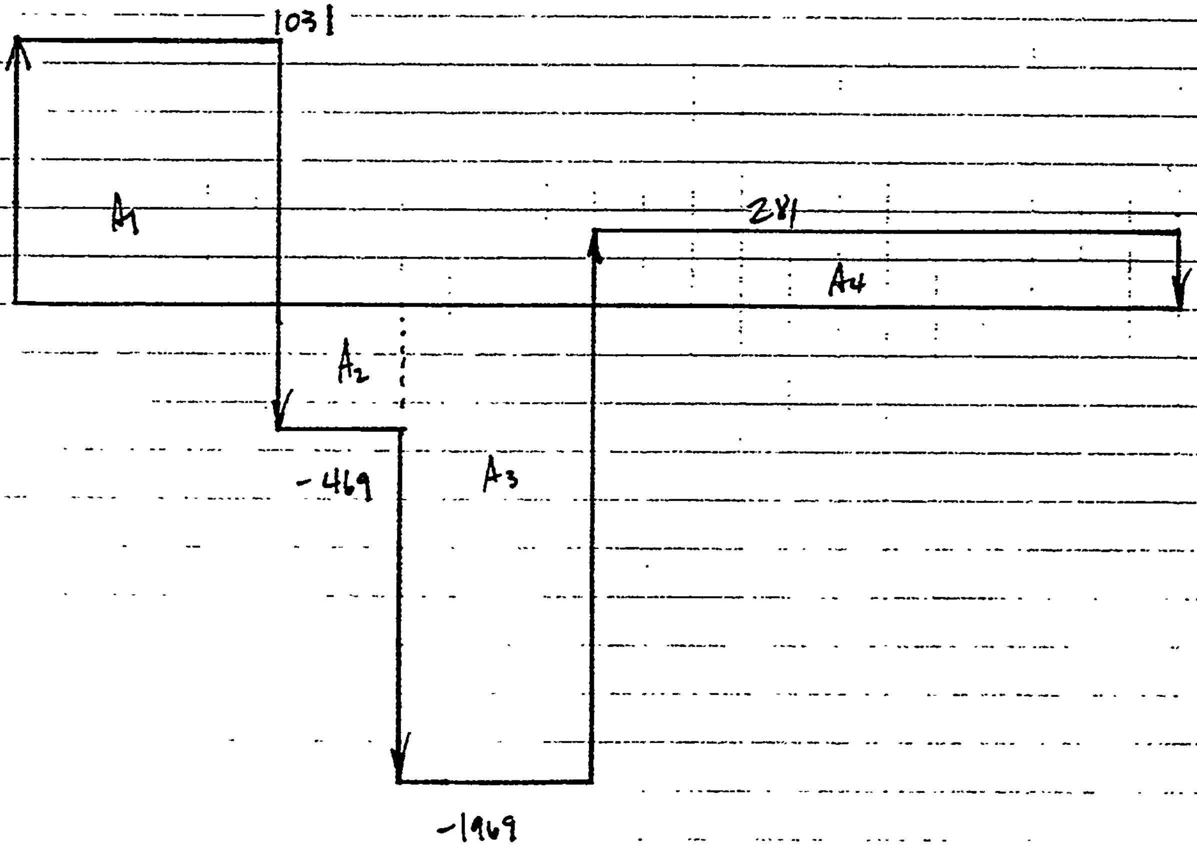
PROJECT Dow Hot Gas JOB NO.

SUBJECT Pulley Axle - Stress Calcs. SHEET 3 OF 4 SHEETS

Shear Diagram



$A_1 = 5.5 \cdot 1031 = 5670$

$A_2 = 2.5 \cdot -469 = 1172.5$

$A_3 = 4 \cdot -1969 = 7876.$

$A_4 = 12 \cdot 281 = 3375$

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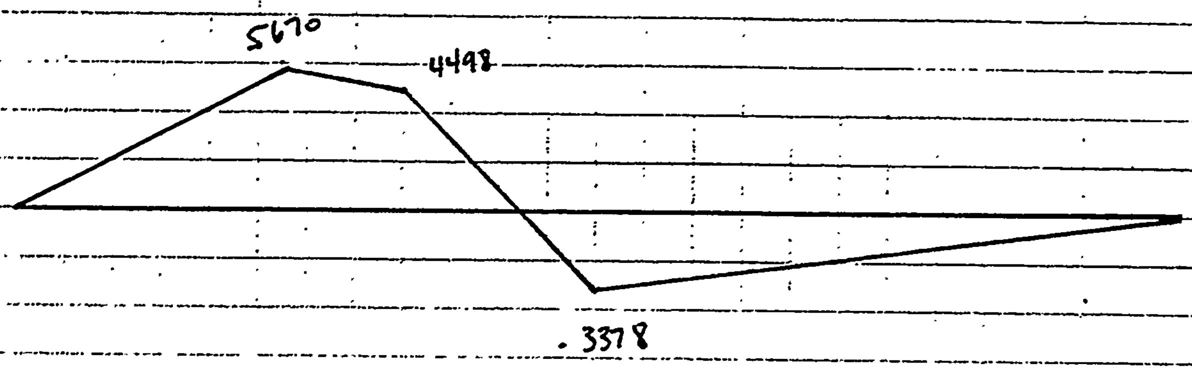
SUBJECT Pulley Axle - Stress Calcs SHEET 4 OF 4 SHEETS

1 square = 2000 in·lb



$$\sigma_{max} = \frac{M_{max}\, c}{I}$$

$$\sigma_{max} = \frac{(5670\ \text{in}\cdot\text{lb})(0.5\ \text{in})}{\frac{\pi}{64}(1\ \text{in})^4} = 57.7\ \text{ksi}$$

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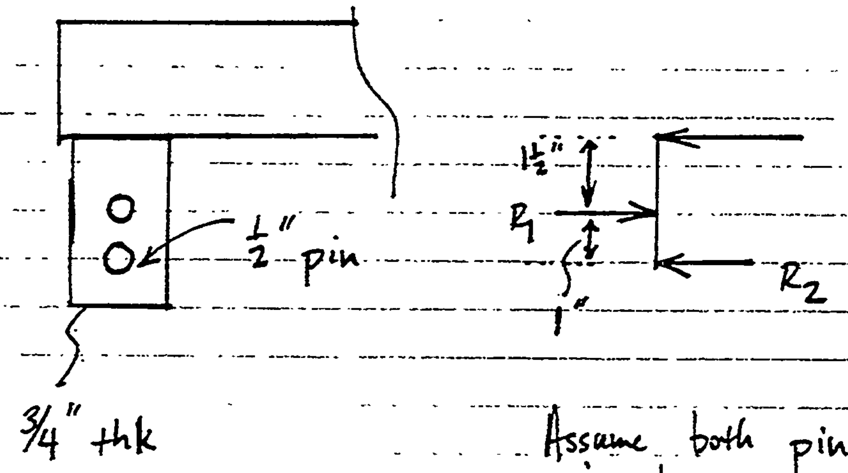
PROJECT Dow Hot Gas JOB NO.

SUBJECT Probe Gripper Stresses SHEET 1 OF 2 SHEETS



Assume both pins are in tact.

F_0 = Force of the probe = 3000 lbs.

R_1 = Reaction force of top pin

R_2 = Reaction force of bottom pin

$\curvearrowleft + \quad \Sigma M_{R_2} = 0$

$$F \cdot 2.5 - R_1 \cdot 1 = 0$$

$$R_1 = 2.5 \cdot F = 2.5 \cdot 3000$$

$$R_1 = 7500 \text{ lbs.}$$

$\xrightarrow{+} \quad \Sigma F_x = 0$

$$-F + R_1 - R_2 = 0$$

$$R_2 = 7500 - 3000 = 4500. \text{ lbs.}$$

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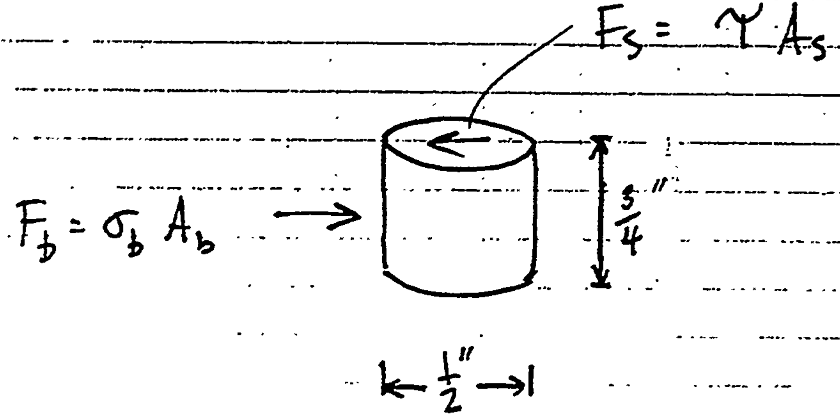
ROJECT Dow Hot Gas JOB NO.

UBJECT Probe Gripper Stresses SHEET 2 OF 2 SHEETS

Pin Cross-section



Shear Stress on the top pin

$$7500 = \tau \, \frac{\pi}{4} (0.5)^2$$

shear stress = τ = 38.2 ksi

shear stress per side = $38.2 \text{ ksi}/2$ = 19.1 ksi.

Bearing Stress on the top pin

$$7500 = \sigma_b \left(\tfrac{1}{2}''\right)\left(\tfrac{3}{4}''\right)$$

$$\sigma_b = 20 \text{ ksi}$$

* Shear & Bearing stresses will be less on bottom pin.

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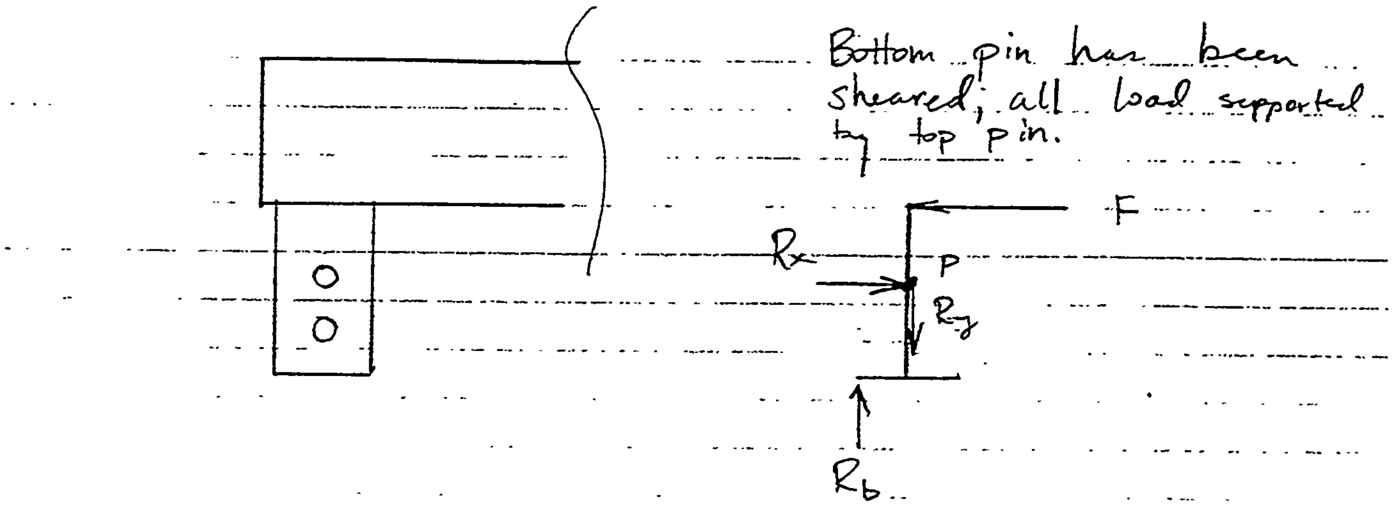
SUBJECT Probe Gripper Stresses SHEET 1 OF 4 SHEETS



Bottom pin has been sheared; all load supported by top pin.

F = Force of the probe = 3000 lbs.

R_x = Reaction force in the x-direction

R_y = Reaction force in the y-direction

R_b = Reaction force at the bottom of the tounge; results from the shearing of one pin

$\circlearrowleft + \quad \Sigma M_p = 0$

$F \cdot 1.5 - R_b \cdot 1 = 0$

$R_b = 1.5 \cdot F = 4500 \text{ lb}$

$+\uparrow \quad \Sigma F_y = 0$

$R_b - R_y = 0$

$R_y = R_b = 4500$

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ROJECT Dow Hot Gas JOB NO. ________

UBJECT Probe Gripper Stresses SHEET 2 OF 4 SHEETS

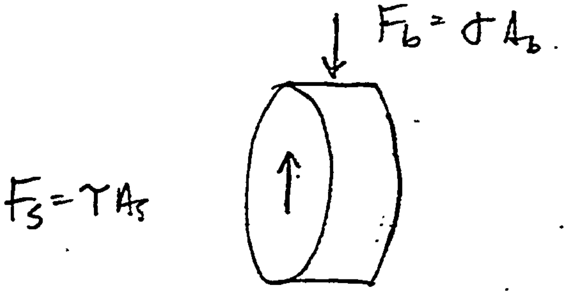
$\overset{+}{\rightarrow} \; \Sigma F_x = 0$

$R_x - F = 0$

$R_x = F = 3000 \text{ lb.}$

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{3000^2 + 4500^2}$

$R = 5408 \text{ lb.}$



$F_s = 5408 \text{ lb} = \tau \left(\frac{\pi}{4}\right)(0.5\text{ in})^2$

$\tau = 27.5 \text{ ksi}$

$F_b = 5408 \text{ lb} = \sigma \, (0.5\text{ in})(0.75\text{ in})$

$\sigma = 14.4 \text{ Ksi}$

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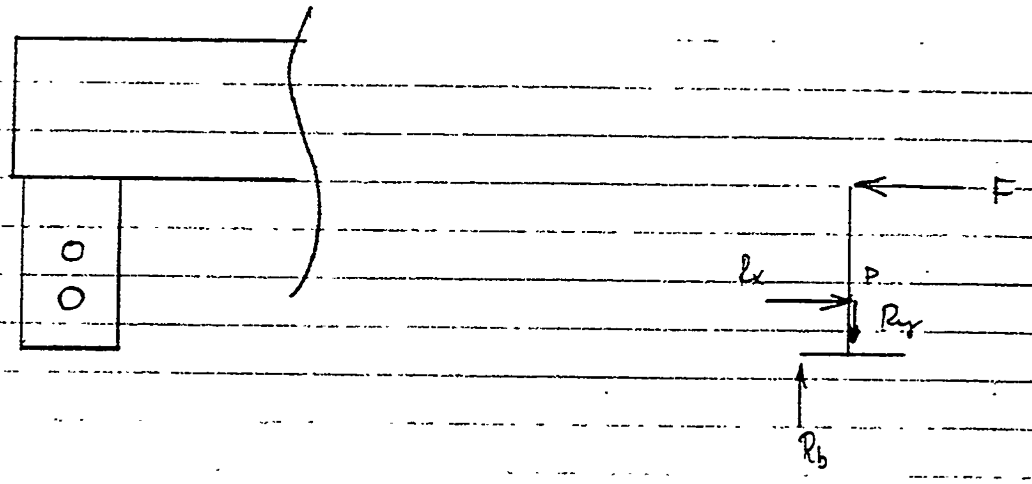
PROJECT Dow Hot Gas JOB NO.

SUBJECT Probe Gripper - Stresses SHEET 3 OF 4 SHEETS



Top pin has been sheared; all load supported by bottom pin.

F = Force of the probe = 3000 lbs

Rx = Reaction force in the x-direction

Ry = Reaction force in the y-direction

Rb = Reaction force at the bottom of the tounge; results from shearing one pin

$$\circlearrowleft + \quad \Sigma M_p = 0$$

$$F \cdot 2.5 - R_b \cdot 1 = 0$$

$$R_b = 2.5 \cdot F = 7500$$

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ROJECT Dow Hot Gas JOB NO.

UBJECT Probe Gripper - Stresses SHEET 4 OF 4 SHEETS

$+\uparrow \quad \Sigma F_y = 0$

$R_b - R_y = 0$

$R_b = R_y = 7500$

$\xrightarrow{+} \quad \Sigma F_x = 0$

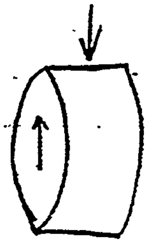
$R_x - F = 0$

$R_x = F = 3000$

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{3000^2 + 7500^2}$

$R = 8078$ lb

$F_b = \sigma A_b$



$F_s = \tau A_s$

$F_s = \tau \cdot A_s$

$8078 = \tau \frac{\pi}{4} (0.5)^2$

$\tau = 41.1$ Ksi

$F_b = \sigma A_b$

$8078 = \sigma (0.5 \text{ in})(0.75 \text{ in})$

$\sigma = 21.5$ Ksi

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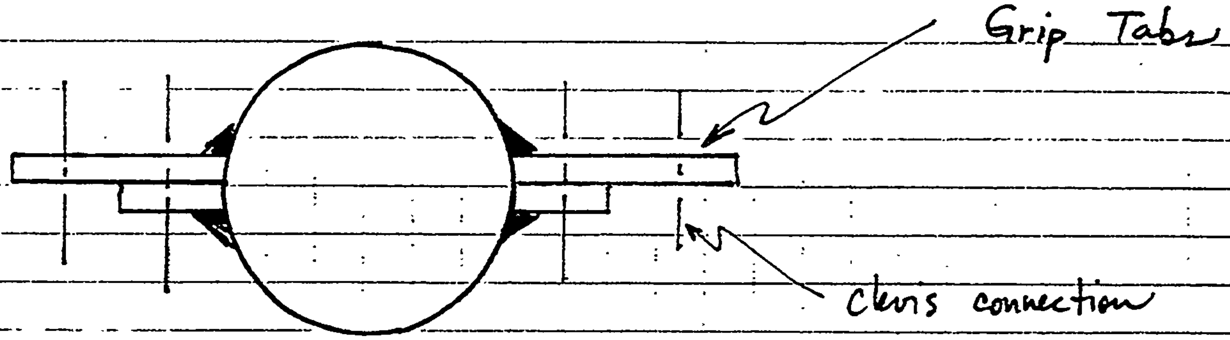
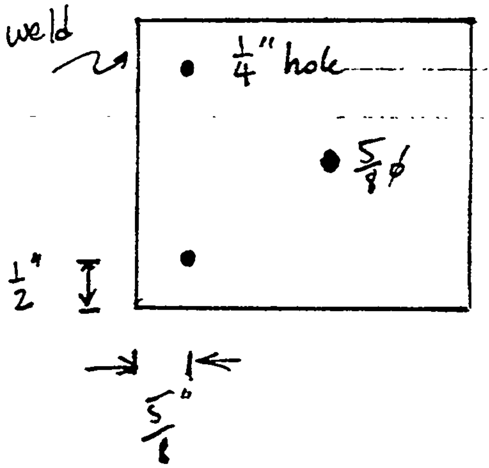
PROJECT Dow Hot Gas JOB NO.

SUBJECT Probe Grip Tabs SHEET 1 OF 2 SHEETS

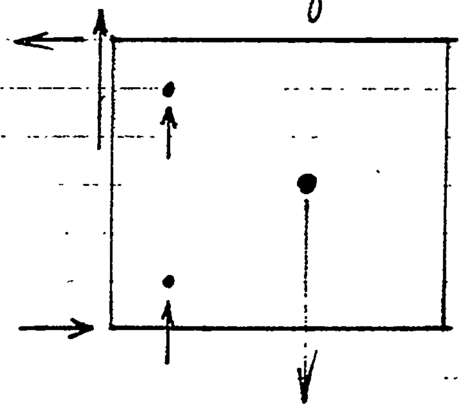


The grip tabs will be connected to clevis pins & hold the probe in position during the sampling process.

Top View of Tab.



FBD of Tab.



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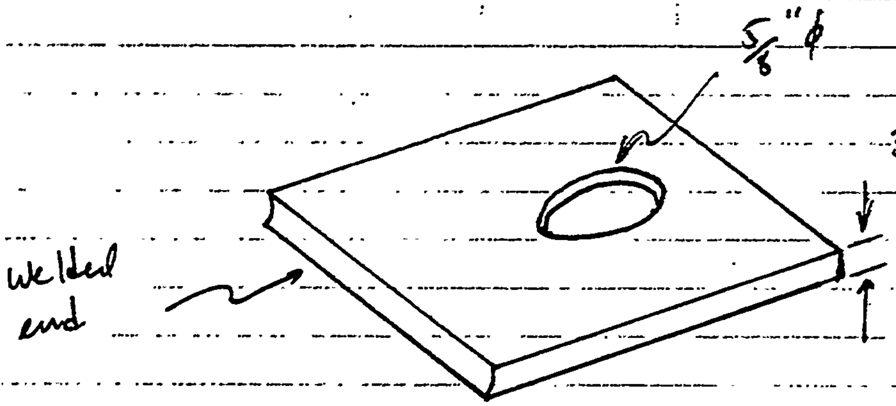
ROJECT Dow Hot Gas JOB NO.

UBJECT Probe Grip Tabs SHEET 2 OF 2 SHEETS

The point of the highest load concentration will be at the clevis connection (i.e. the $\frac{5}{8}$" hole).



Bearing Stress

$$F_b = \sigma A_b = 1500$$

$$1500 = \sigma \cdot \left(\frac{5}{8} \cdot \frac{3}{8}\right)$$

$$\sigma = 6400 \text{ psi}$$

Shear Stress

$$F_S = \tau A$$

$$1500 = \tau \cdot \frac{\pi}{4} \left(\frac{5}{8}\right)^2$$

$$\tau = 4890 \text{ psi}$$

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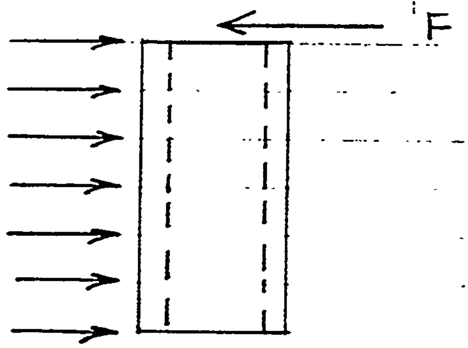
PROJECT JOB NO.

SUBJECT Vertical Support Stresses SHEET 1 OF 3 SHEETS

Assume the Force, F = 3000 lbs, is distributed equally over the length of the 2" pipe.

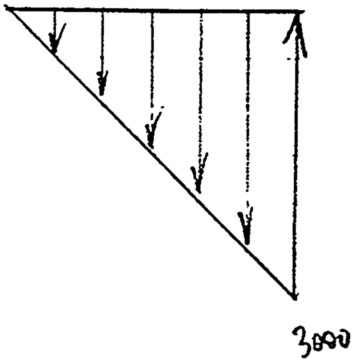


F = 3000 lb.

Load/length = 500 lb/in

Shear Diagram

✓



Moment Diagram

Area = $\frac{1}{2} b \cdot h$

$= \frac{1}{2} 6 \cdot 3000 = 9000$ in/lb

$M_{max} = 9000$ in-lb

$$\sigma_{max} = \frac{M_{max}\, c}{I}$$

$$\sigma_{max} = \frac{(9000 \text{ in-lb})(1 \text{ in})}{\frac{\pi}{64}(2.375^4 - 2.067^4)}$$

$\sigma_{max} = 13{,}518$ psi

H-72

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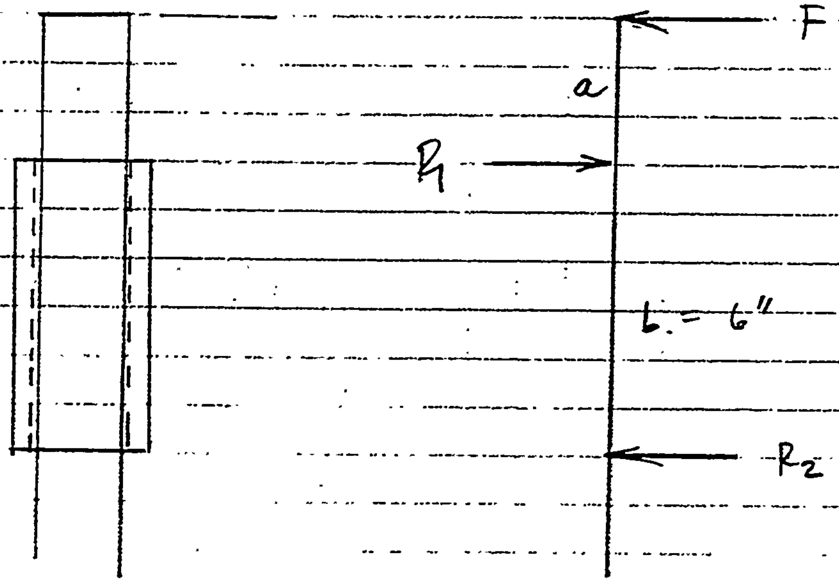
SUBJECT Vertical Support - Stresses SHEET 2 OF 3 SHEETS



Looking at the forces on the 2" rod which moves up & down

$$\circlearrowleft + \sum M_1 = 0$$

$$F \cdot a = R_2 \cdot 6$$

$$R_2 = \frac{F \cdot a}{6}$$

In a worst case scenario, a = 6".

$$R_2 = F = 3000 \text{ lb}$$

$$\xrightarrow{+} \sum F_x = 0$$

$$R_1 - F - R_2 = 0 \qquad R_1 = 6000 \text{ lbs}$$

CALCULATION SHEET

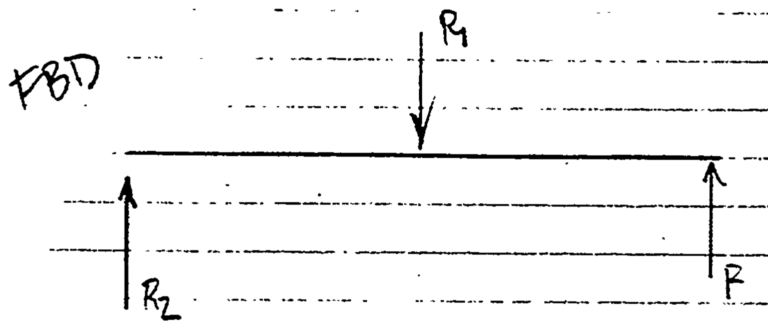
CALC. NO.

SIGNATURE DATE CHECKED DATE

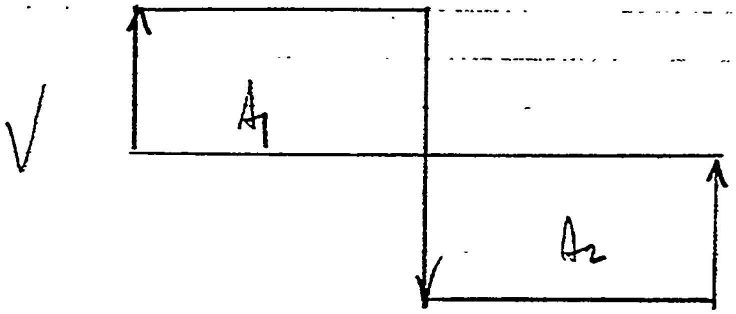
PROJECT JOB NO.

SUBJECT Vertical Support - Stresses SHEET 3 OF 3 SHEETS

FBD

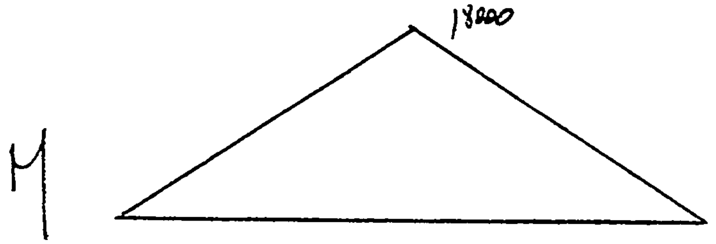


V



$A_1 = A_2 = 3000 \cdot 6 = 18000.$

M



$M_{max} = 18{,}000 \text{ in·lb}$

$$\sigma_{max} = \frac{M_{max}\, c}{I}$$

$$\sigma_{max} = \frac{18000 \text{ in·lb} \cdot 1 \text{ in}}{\frac{\pi}{64} \cdot (2 \text{ in})^4}$$

$\sigma_{max} = 22{,}918$ psi

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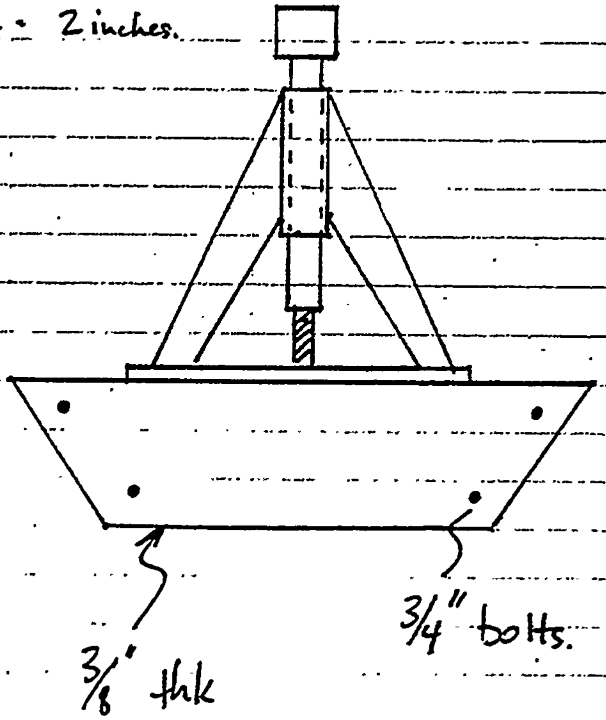
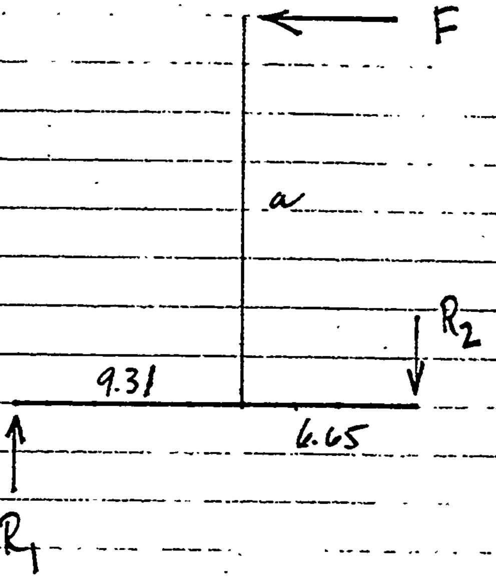
ROJECT DOW Hot Gas JOB NO.

UBJECT Trolley Wheel Stresses SHEET 1 OF 2 SHEETS

1 square = 2 inches.





* Please note - this analysis is for a single car. In our design we will have two cars supporting the vert. supports

$$\circlearrowleft + \quad \Sigma M_{R_1} = 0$$

$$F \cdot a - R_2 \cdot (9.31 + 6.65) = 0$$

$$R_2 = \frac{F \cdot a}{15.96}$$

$$+\uparrow \quad \Sigma F_y = 0$$

$$R_1 = R_2 = \frac{F \cdot a}{15.96}$$

The load on each wheel is $\frac{1}{2}$ the reaction force shown (i.e. load $= \frac{1}{2} R_1 = \frac{1}{2} R_2$).

RADIAN
CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE DATE CHECKED DATE

PROJECT Dow Hot Gas JOB NO.

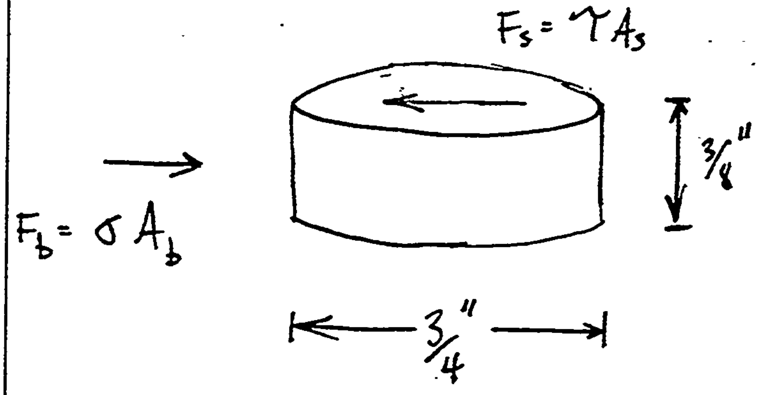
SUBJECT Trolley Wheel Stresses SHEET 2 OF 2 SHEETS

Assume $F = 3000$ lbs. $a = 15''$

$$R_1 = R_2 = \frac{3000 \cdot 15}{15.96} = 2819 \text{ lbs.}$$

load per wheel = 1410 lbs

Check the shear force / stresses on the axle



This represents a hole in the trolley side plate which the bolt (axle) passes through

Shear Force = $F_s = \tau A_s$

$$1410 \text{ lbs} = \tau \left(\frac{\pi}{4}\right)(0.75 \text{ in})^2$$

shear stress = $\tau = 3192$ psi

Bearing Force = $F_b = \sigma_b A_b$

$$1410 \text{ lbs} = \sigma_b \left(\frac{3}{8} \text{ in}\right)\left(\frac{3}{4} \text{ in}\right)$$

bearing stress = $\sigma_b = 5013$ psi

ATTACHMENT F

CALCULATIONS FOR VALVE SUPPORT

RADIAN CORPORATION

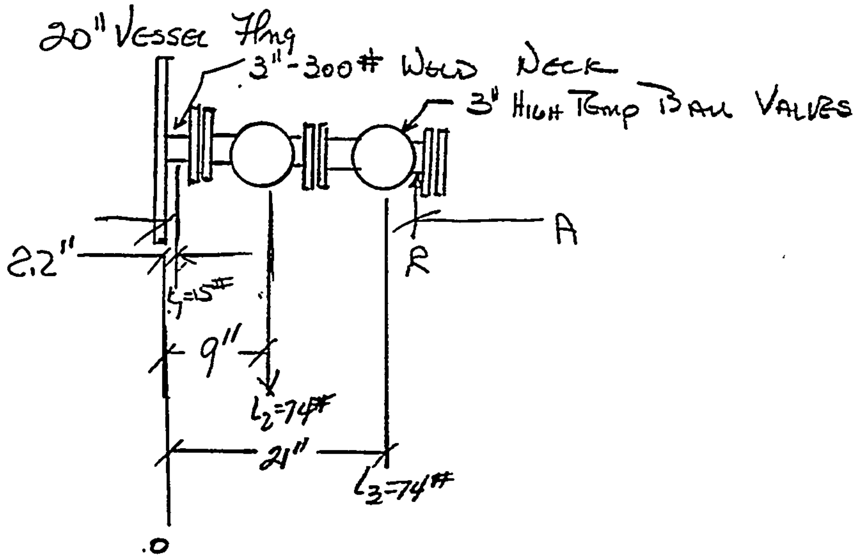
CALCULATION SHEET

CALC. NO.

SIGNATURE C Thomas DATE 10/14/94 CHECKED DATE

PROJECT HGTI JOB NO.

SUBJECT Valve Support W/o GLAND SHEET 1 OF 1 SHEETS



Install Valves with Ball Located toward outboard End of Train

Needed - Weight R to Reduce Bending & Shear Load at outside of 20" Flange to minimum.
This is a temporary weight until gland & probe are installed

Assume Dimension A = 26"

Moments About Edge of outside surface of 20" Flange

$$\Sigma M_0 = -(L_1 * 2.2) - (L_2 * 9") - (L_3 * 21) + R * 26$$

$$= -(15)(2.2) - (74)(9) - 74(21) + (R)26$$

$$R = \frac{2253}{26} \text{ lb}$$

$$= 87 \text{ lb}$$

If double strand supported as shown in final $R_2 = 44$ lb

H-79

Stress at Weld Neck Flange to Vessel Flange Joint

Given

Load diagram on the following page.

Compute the center of gravity and weight of the probe.

2 3/4 Dia x 0.148 wall $w_o := 4.113 \cdot \frac{lb}{ft}$ $L_p := 7 \cdot ft + \left(7 + \frac{1}{2}\right) \cdot in$

5/8 Dia x .083 wall $w_i := 0.4805 \cdot \frac{lb}{ft}$ $L_p = 7.625 \cdot ft$

End Cap $w_e := 1.683 \cdot \frac{lb}{in}$ $w_p := \left(w_o + w_i\right) \cdot L_p + 2 \cdot w_e \cdot \frac{1}{2} \cdot in$

$w_p = 36.708 \cdot lb$

Center of Gravity $L_{pcg} := \frac{L_p}{2}$ $L_{pcg} = 3.813 \cdot ft$

Measured from nose of probe.

Taking Moments around outside edge of vessel flange

Loads

$i := 1 .. 14$

$L_1 := 15 \cdot lb$

$L_2 := 74 \cdot lb$

$L_3 := L_2$

$L_4 := 97 \cdot lb$

$L_5 := w_p$

$A_i := 28 + i \cdot 2$

Probe Withdrawn

$$R_i := \frac{L_1 \cdot 2.2 + L_2 \cdot 9 + L_3 \cdot 21 + L_4 \cdot 39 + L_5 \cdot 65}{A_i}$$

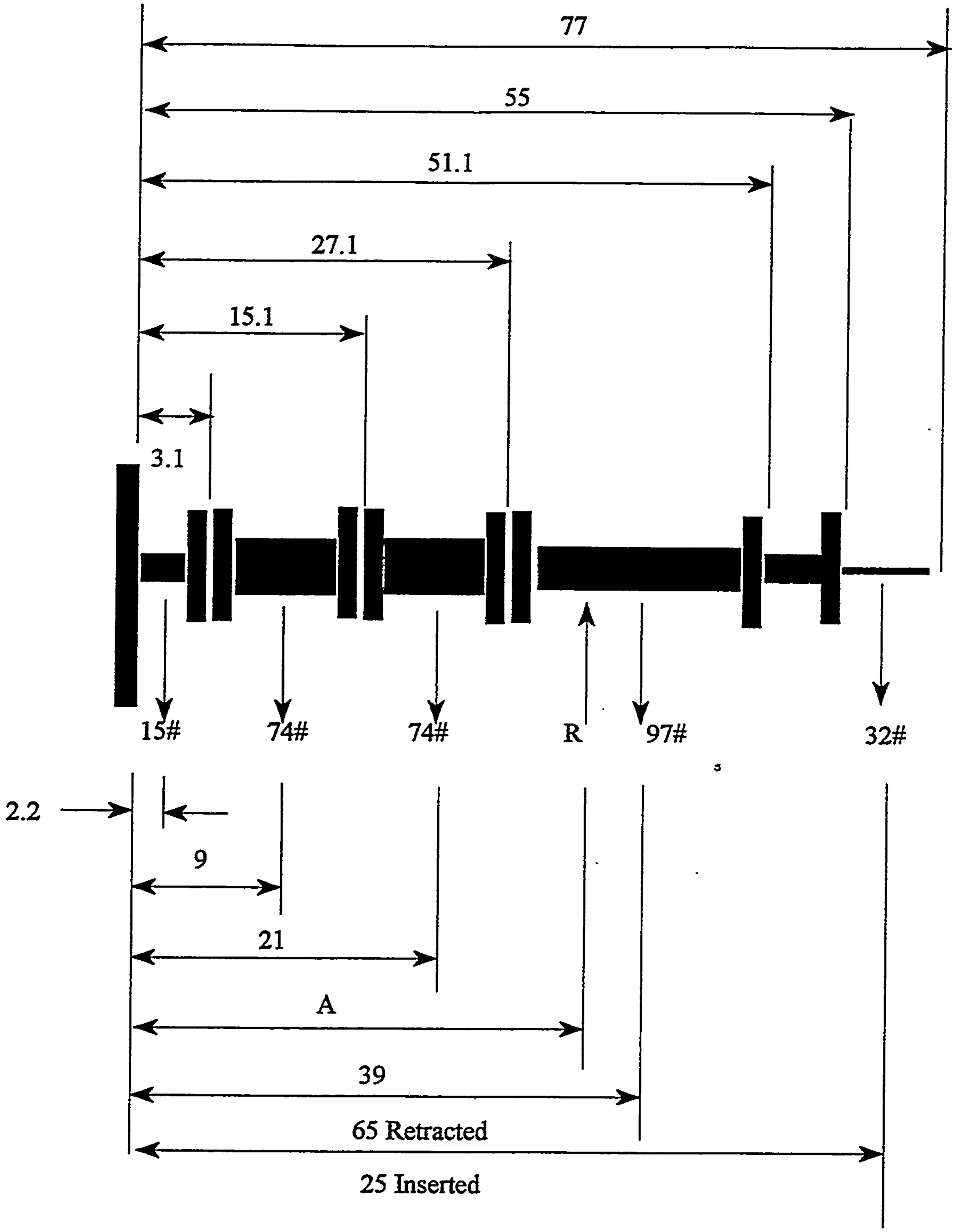
A =

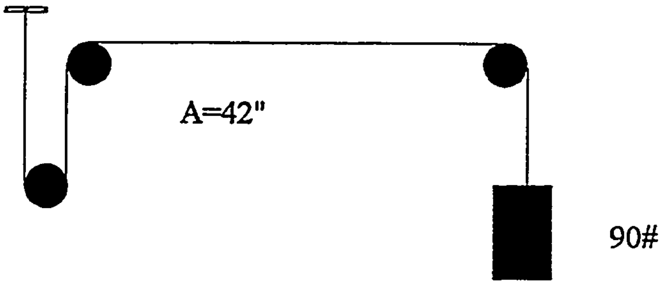
	0
0	0
1	30
2	32
3	34
4	36
5	38
6	40
7	42
8	44
9	46
10	48
11	50
12	52
13	54
14	56

R =

	0
0	0
1	280.735
2	263.189
3	247.707
4	233.946
5	221.633
6	210.551
7	200.525
8	191.41
9	183.088
10	175.459
11	168.441
12	161.962
13	155.964
14	150.394

•lb


77
55
51.1
27.1
15.1
3.1
15#
74#
74#
R
97#
32#
2.2
9
21
A
39
65 Retracted
25 Inserted


A=42"
90#

Select Then

$A := 42 \cdot in$ $R := 180 \cdot lb$

Sum of Forces in Vertical Direction

$$V := L_1 + L_2 + L_3 - R + L_4 + L_5$$

$$V = 116.708 \cdot lb$$

Moment at the weld neck-vessel flange joint.

Probe Withdrawn

$$M_w := \left(L_1 \cdot 2.2 + L_2 \cdot 9 + L_3 \cdot 21 + L_4 \cdot 39 + L_5 \cdot 65\right) \cdot in - R \cdot A$$

$$M_w = 71.837 \cdot ft \cdot lb$$

Probe Inserted

$$M_i := \left(L_1 \cdot 2.2 + L_2 \cdot 9 + L_3 \cdot 21 + L_4 \cdot 39 + L_5 \cdot 25\right) \cdot in - R \cdot A$$

$$M_i = -50.524 \cdot ft \cdot lb$$

These are the loads which are imposed on the weld neck-vessel flange joint by the sampling port.

ATTACHMENT G

STRESS CALCULATIONS FOR TROLLEY PLATE

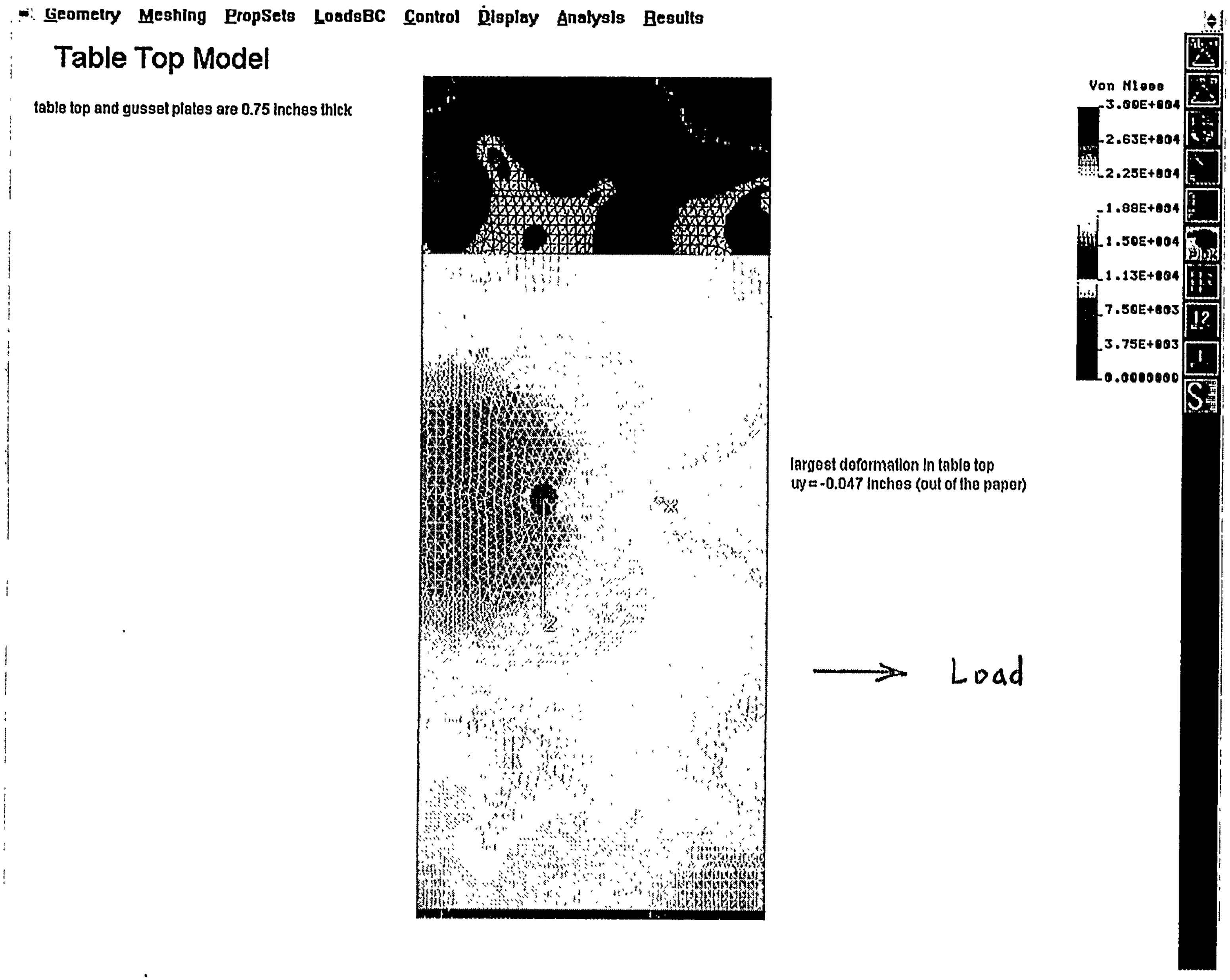


Table Top Model

table top and gusset plates are 0.75 inches thick

largest deformation in table top
uy= -0.047 inches (out of the paper)

2-D View of 3/4" Table Top (Top View)

ATTACHMENT H

EXAMPLE CHECKLIST FOR PROBE OPERATION

Hot Gas Sampling Probe Operation: Check List

Run ID___________ **Start Time** ________ **Probe Tip**_______________
Date _____________ **Stop Time** _________

Operation	Activity	Done
Configure Probe Tip	Attach thimble/thimble holder (particulate samples) or sintered metal filter (gas samples) to probe tip	
	Tighten connection to probe tip (nozzle orientation (_______)	
Configure Valves for Initial Insertion	Both isolation (3-inch ball valves) are in the closed position	
	Sheath inlet/outlet valve (9) is closed	
	Probe outlet valve (10) is closed	
	Nitrogen purge valve (3) on gland is closed	
	Gland outboard vent valve (4) is closed	
	Gland inboard vent valve (2) is open	
	Isolation valve vent valve (12) is open - valves (11) & (1) closed	
	Probe dilution nitrogen manifold valve (7) is disconnected from probe sheath inlet (@ quiick-connect)	
	Probe outlet manifold [valves (6) & (8) are connected and valve (CV-3)] is disconnected from probe outlet	
	Packing gland nuts are loosened	
	Nitrogen regulators (R-1) and (R-2) are adjusted to an outlet pressure of 400 psig	
Insert Probe into Gland	Align probe with packing gland inlet	
	Adjust vertical position of probe as necessary for proper alignment	
	Using winches, insert probe into gland to a depth of about 22 inches (as marked on probe sheath and/or on trolley rails)	
	Fasten retaining clamps on rail behind trolley wheels	
	Partially tighten (snug) packing gland nuts	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ____________

Operation	Activity	Done
Purge Air from Gland	Gland inboard vent valve **(2)** is open	
	Open nitrogen purge valve **(3)**	
	Set nitrogen purge rate to gland at 1 scfm using control valve **CV-1**	
	Purge gland for 3 minutes with nitrogen at 1 scfm	
Purge Air from Probe	Open probe outlet valve **(10)** to atmosphere	
	Close gland inboard vent valve **(2)**	
	Continue nitrogen purge rate to gland at 1 scfm through control valve **CV-1**	
	Purge probe for 3 minutes with nitrogen at 1 scfm	
Purge Air from Probe Sheath	Open sheath inlet/outlet valve **(9)** and valve **(5)** to atmosphere	
	Close probe outlet valve **(10)**	
	Continue nitrogen purge rate to gland at 1 scfm through control valve **CV-1**	
	Purge probe sheath for 3 minutes with nitrogen at 1 scfm	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ______________

Operation	Activity	Done
Adjust Nitrogen Leak Rate through Packing Gland	Close sheath inlet/outlet valve **(9)** and valve **(5)**	
	Continue nitrogen purge rate at 1 scfm through nitrogen purge valve **(3)** until pressure in probe assembly is 400 psig **(PI-3** and **PI-2)**	
	Monitor pressure between the isolation valves **(PI-1)**. Pressure _________ psig	
	Close nitrogen purge valve **(3)** to seal probe assembly	
	Measure pressure loss in probe assembly for 10 minutes. Pressure loss _________ psi /10 minutes	
	If pressure loss in gland assembly is greater than 25 psi in 10 minutes, tighten packing gland nuts	
	Open nitrogen purge valve **(3)** and repressure gland assembly to 400 psig	
	Monitor pressure loss again in the gland assembly	
	Continue adjusting packing gland nuts and monitoring pressure until pressure loss is less than 25 psi/10 minutes	
	Final pressure loss is __________psi in 10 minutes	
Prepare for Full Probe Insertion	Probe outlet valve **(10)** is closed	
	Sheath inlet/outlet valve **(9)** is closed	
	Gland inboard vent valve **(2)** is closed	
	Gland outboard vent valve **(4)** is closed	
	Isolation valve vent system [valves **(1)** and **(11)**] are closed	
	Nitrogen purge valve **(3)** is closed	
	Pressure in gland assembly **(PI-2** and **PI-3)** is 350 (___) psig	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ______________

Operation	Activity	Done
Purge Air/Syngas from Void Space Between the Isolation Valves	Record pressure in void space between the isolation valves (PI-1). Pressure is ___________	
	Open Isolation valve vent valve **(1)** to depressure void space to atmosphere	
	After depressuring, close vent valve **(1)**	
	Leave vent valve **(12)** open	
	Open valve **(11)** to direct nitrogen to void space between the isolation valves	
	Adjust nitrogen flow rate to about 1 scfm, using valve **CV-1** to control flow	
	Continue nitrogen flow until pressure between the isolation valves reaches 400 psig (PI-1)	
	Close nitrogen valve **(11)** in preparation for depressuring	
	Open vent valve **(1)** to depressure the void space to atmosphere	
	Close vent valve **(1)**	
	Open nitrogen valve **(11)** to repressure void space between the isolation valves	
	Repressure void space to 400 psig	
	Close nitrogen valve **(11)** in preparation for depressuring	
	Open vent valve **(1)** to depressure the void space a second time	
	Close vent valve **(1)**	
	Open nitrogen valve **(11)** to repressure the void space for the last time	
	Repressure the void space to 400 psig	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ____________

Operation	Activity	Done
Adjust Pressure in Probe to 450 psig	Adjust pressure in gland and probe system to approximately 400 psig	
	Open valve (3). **PI-1 = PI-2 =** ______ psig	
	Open outboard isolation valve **(LGTI PERSONNEL MUST OPEN/CLOSE THE ISOLATION VALVES)**	
	Open nitrogen purge valve **(3)**	
	Adjust nitrogen flow, using **CV-1**, to gland and probe to about 0.5 scfm	
	Increase the pressure in the probe system up to 450 psig **(PI-2)**, or to 50 psig above process pressure	
	Close nitrogen valve **(11)**	
Insert Probe Fully into Vessel	Be sure that valve **(9)** is closed	
	Be sure that valve **(10)** is closed	
	With probe system at 450 psig (or 15 psig above process pressure), open inboard isolation valve **(LGTI PERSONNEL MUST OPEN/CLOSE THE ISOLATION VALVES)**	
	Be sure that nitrogen purge valve **(3)** is open	
	Adjust nitrogen purge rate to 1 scfm using **(CV-1)**	
	Using the winch system, insert the probe into the vessel to the predetermined position	
	With probe inserted, secure the positioner with turnbuckles	
	Secure the rail clamps at the rear wheels of the trolley	
	Monitor CO/H_2S levels at the packing gland to detect leaks	
	If CO or H_2S levels are above 100 or 25 ppmv, respectively, at the gland, tighten the packing gland nuts	
	Continue tightening gland nuts and monitoring until CO and H_2S levels are below 100 and 25 ppmv, respectively	
	With retainers (turnbuckles) in place, disconnect, if practical, (but leave in position) the probe gripper from the probe itself	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ____________

Operation	Activity	Done
Prepare for Sampling	Maintain nitrogen purge rate through nitrogen control valve (CV-1) and nitrogen purge valve (3) - N_2 rate ______ scfm	
	Connect dilution nitrogen manifold valves (5) and (7) to probe	
	Connect probe outlet manifold [valve (6), valve (8), filter, and probe outlet control valve (CV-3)] to probe outlet	
	Close valves (5), (7), (6), and (8)	
	Connect sampling manifold to probe outlet manifold (CV-3)	
	Connect outlet of sampling manifold to syngas vent line	
	Connect and check operation of all thermocouples	
Particulate Collection	Open valve (10)	
	Open valve (8). Record start time for particulate collection. Time __________	
	Using control valve (CV-3), set syngas rate at the target flow rate (1-4 scfm) through the probe and sampling manifold.	
	Open valve (7)	
	Open valve (9)	
	Monitor temperature at orifice and ΔP across orifice	
	If needed for temperature control, usi control valve (CV-2), to adjust dilution nitrogen flow to the probe sheath at the target flow rate (0-2 scfm)	
	Maintain flows at the target rates for an elapsed time of ______ minutes or until the pressure drop across the thimble and filter has reached 25 psi (pressure at PI-3 is _______psi)	
	After the target elapsed time or pressure drop has been reached, close valve (9) to stop flow of dilution nitrogen	
	Close valve (10) to stop syngas flow. Record stop time for particulate collection. Time ___________	
	Close valve (7)	
	Close valve (8)	
	Prepare for probe withdrawal (see withdrawal procedures)	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ___________

Operation	Activity	Done
Syngas Sample Collection	Open valve **(10)**	
	Open valve **(8)**	
	Using control valve **(CV-3)**, set syngas rate at the target flow rate (1-4 scfm) through the probe and sampling manifold.	
	Open valve **(7)**	
	Open valve **(9)**	
	Using control valve **(CV-2)**, adjust dilution nitrogen flow to the probe sheath at the target flow rate (0-2 scfm)	
	Connect gas sampling trains to sampling manifold, and proceed with gas sampling	
	Begin collecting integrated gas sample (for verifying nitrogen flow rate). Start time __________	
	Maintain flows at the target rates until all scheduled gas sampling has been completed or until the pressure drop across the thimble and filter has reached _25_ psi (pressure at PI-3 is _______psi)	
	After syngas sampling has been completed or maximum allowable pressure drop has been reached, close valve **(9)** to stop flow of dilution nitrogen	
	Discontinue collecting the integrated gas sample. Stop time __________	
	Close valve **(10)** to stop syngas flow	
	Close valve **(7)**	
	Close valve **(8)**	
	Prepare for probe withdrawal (see withdrawal procedures)	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ___________

Operation	Activity	Done
Prepare for Probe Withdrawal	Nitrogen purge valve **(3)** open , with purge nitrogen flow at 1 scfm	
	Isolation vent valves **(1)** and **(11)** closed	
	Gland vent valves **(2)** and **(4)** closed	
	Sheath inlet/outlet valve **(9)** closed	
	Dilution nitrogen valve **(7)** closed	
	Probe outlet valve **(10)** closed	
	System is at process pressure of approximately _____psig	
	Restraints (turnbuckles) attached	
	Packing gland nuts are tight	
	Connect probe to probe gripper	
Withdraw Probe into Gland	Detach dilution nitrogen manifold [valves **(5)** and **(7)**] from probe assembly (quick- disconnect)	
	Maintain purge nitrogen flow at 1 scfm through nitrogen purge valve **(3)**	
	Secure and disconnect sample manifold from probe system	
	Disconnect probe outlet manifold [valves **(6)**, **(8)** and **CV-3**] from probe outlet valve **(10)**	
	Disconnect turnbuckles (restraints) from probe	
	Remove (or move back) rail clamps from rail behind trolley	
	Withdraw the probe, using the winch mechanism, just clear of the outboard isolation valve (clear of both isolation valves)	
	Probe sheath will be hot - Use caution in handling!	
	If resistance to withdrawal is high, loosen packing gland nuts slightly (no more than 1/4 turn)	
	After loosening packing gland nuts, check for excessive leakage (using CO/H_2S monitor) around packing gland	
	After the probe clears both isolation valves, close inboard isolation valve. **(LGTI personnel must open/close the isolation valves)**	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID___________

Operation	Activity	Done
Depressure Probe and Probe System	Close the nitrogen purge valve **(3)** to stop the flow of purge nitrogen	
	Open the probe outlet valve **(10)** slightly to slowly depressure the probe system to the syngas vent line	
Purge Probe and Probe Gland with Nitrogen	After system has been completely depressured, open valves **(11)** and **(12)** to direct nitrogen purge to the probe	
	Adjust nitrogen purge rate to1 (____) scfm, using valve **(CV-1)** to control the nitrogen flow rate	
	Purge system for 5 minutes, venting the purge nitrogen through the probe outlet valve **(10)** and syngas vent line	
Purge Probe Sheath with Nitrogen	Continue nitrogen purge at 1 (_____) scfm through valve **(12)**	
	Open sheath inlet/outlet valve **(9)** and valve **(5)** to atmosphere	
	Close probe outlet valve **(10)**	
	Allow nitrogen purge to flow out to atmosphere through valves **(9)** and **(5)**	
	Monitor purge nitrogen stream at the outlet of the sheath inlet/outlet valve **(9)** and valve **(5)**	
	When CO and H_2S levels in the nitrogen purge are below 25 ppm and 5 ppm, respectively, purge may be stopped	
	Close valves **(11)** and **(9)** to stop nitrogen purge	
	Close the outboard isolation valve. **(LGTI personnel must close this valve)**	

Hot Gas Sampling Probe Operation: Check List (contd.)

Operation	Activity	Done
Withdraw Probe from Gland	Unfasten restraints from trolley rails	
	Disconnect valves **(10)**, **(8)**, and **(6)** assembly	
	Withdraw probe completely clear of gland **USE CAUTION - PROBE MAY BE VERY HOT!**	
	Support the free end of the probe on the probe support until probe is cool enough to handle	

APPENDIX I: GLOSSARY

AAS	Atomic absorption spectrophotometry
Btu	British Thermal Unit
CI	Confidence interval
CVAAS	Cold vapor atomic absorption spectrophotometry
CVAFS	Cold vapor atomic fluorescence spectrophotometry
DL	Detection limit
dscfm	Dry standard cubic feet per minute (1 atm., 60°F)
ESP	Electrostatic precipitator
FCEM	Field Chemical Emissions Monitoring
GC/MS	Gas chromatography/mass spectroscopy
GFAAS	Graphite furnace atomic absorption spectrophotometry
HGAAS	Hydride generation atomic absorption spectrophotometry
HHV	Higher heating value
IC	Ion chromatography
ICP-AES	Inductively coupled plasma argon emissions spectrometry
IS	Invalid sample
MS/MSD	Matrix spike/matrix spike duplicate
NA	Not analyzed
NC	Not calculated
ND	Not detected
NIST	National Institute of Standards and Technology (formerly NBS)
Nm^3	Normal cubic meter (1 atm, 0°C)
NO_x	Nitrogen oxides
NS	Not able to obtain a sample
PAH	Polynuclear aromatic hydrocarbons
POM	Polycyclic organic matter
QA/QC	Quality assurance/quality control
RPD	Relative percent difference
VOC	Volatile organic compound
VOST	Volatile organic sampling train
XAD	Trade name for a resin used in gaseous sample collection