EPA-450/4-84-014u

NATIONAL DIOXIN STUDY
TIER 4 — COMBUSTION SOURCES

Final Test Report — Site 12
Sewage Sludge Incinerator SSI — C

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FOREWORD

This report is the result of a cooperative effort between the Office of Research and Development's Hazardous Waste Engineering Research Laboratory (HWERL) and the Office of Air Quality Planning and Standard's Monitoring and Data Analysis Division (MDAD). The overall management of Tier 4 of the National Dioxin Study was the responsibility of MDAD. In addition, MDAD provided technical guidance for the source test covered by this report. HWERL was directly responsible for the management and technical direction of the source test.

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1.0 INTRODUCTION

This draft report summarizes the results of a dioxin/furan* emissions test of a sewage sludge incinerator equipped with a wet scrubber system for particulate emissions control. The test was the twelfth in a series of twelve dioxin/furan emissions tests being conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources emit dioxins or furans. The secondary objective of Tier 4 is to quantify these emissions.

Sewage sludge incinerators are one of eight combustion device categories that have been tested in the Tier 4 program. The tested sewage sludge incinerator, hereafter referred to as Incinerator SSI-C, was selected for this test after an initial information screening and a one-day pretest survey visit.

This test report is organized as follows: A summary of test results and conclusions is provided in Section 2.0, followed by a detailed process description in Section 3.0. The source sampling and analysis plan is outlined in Section 4.0, and the dioxin test data are presented in section 5.0. Sections 6.0 through 9.0 present various testing details. These include descriptions of the sampling locations and procedures (Section 6.0), descriptions of the analytical procedures (Section 7.0), and a summary of the quality assurance/quality control results (Section 8.0). The appendices contain data generated during the field sampling and analytical activities.

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* The term "dioxin/furan" as used in this report refers to the polychlorinated dibenzo-p-dioxin and dibenzofuran isomers with four or more chlorine atoms.

2.0 SUMMARY AND CONCLUSIONS

2.1 SOURCE SAMPLING AND ANALYSIS OVERVIEW

The host plant (Site 12) is a large municipal wastewater treatment plant that operates several multiple hearth sewage sludge incinerators. The incinerator tested is a 12 hearth unit that was installed in 1974. A simplified diagram of the multiple hearth incinerator/wet scrubber system tested is shown in Figure 2-1.

Sampling for dioxin emissions was performed at the incinerator outlet and the scrubber exhaust stack during each of three test runs conducted on July 9, 10, and 11, 1985. All of the field sampling was performed by Radian Corporation. The gaseous, liquid, slurry, and solids sampling performed is summarized in Table 2-1. Dioxin sampling at the incinerator outlet and the scrubber exhaust stack followed (with two exceptions discussed in Section 6) the Modified Method 5 (MM5) sampling protocol developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. The MM5 train components and train rinses were analyzed by EMSL-RTP and ECL-Bay St. Louis, two of three EPA laboratories collectively known as Troika. The dioxin/furan analyses quantified 2,3,7,8-TCDD* and the tetra- through octa-dioxin/furan homologues present in the samples.

Sludge feed samples were obtained directly from the incinerator feed conveyor during the test. Analyses for dioxin/furan precursors were performed by Radian on sludge feed samples. The specific dioxin/furan precursors analyzed for included chlorophenols, chlorobenzenes, polychlorinated biphenyls (PCB), and total chlorine.

*The terms TCDD and TCDF as used in this report refer to tetrachlorodibenzo-p-dioxin and tetrachlorodibenzofuran respectively.

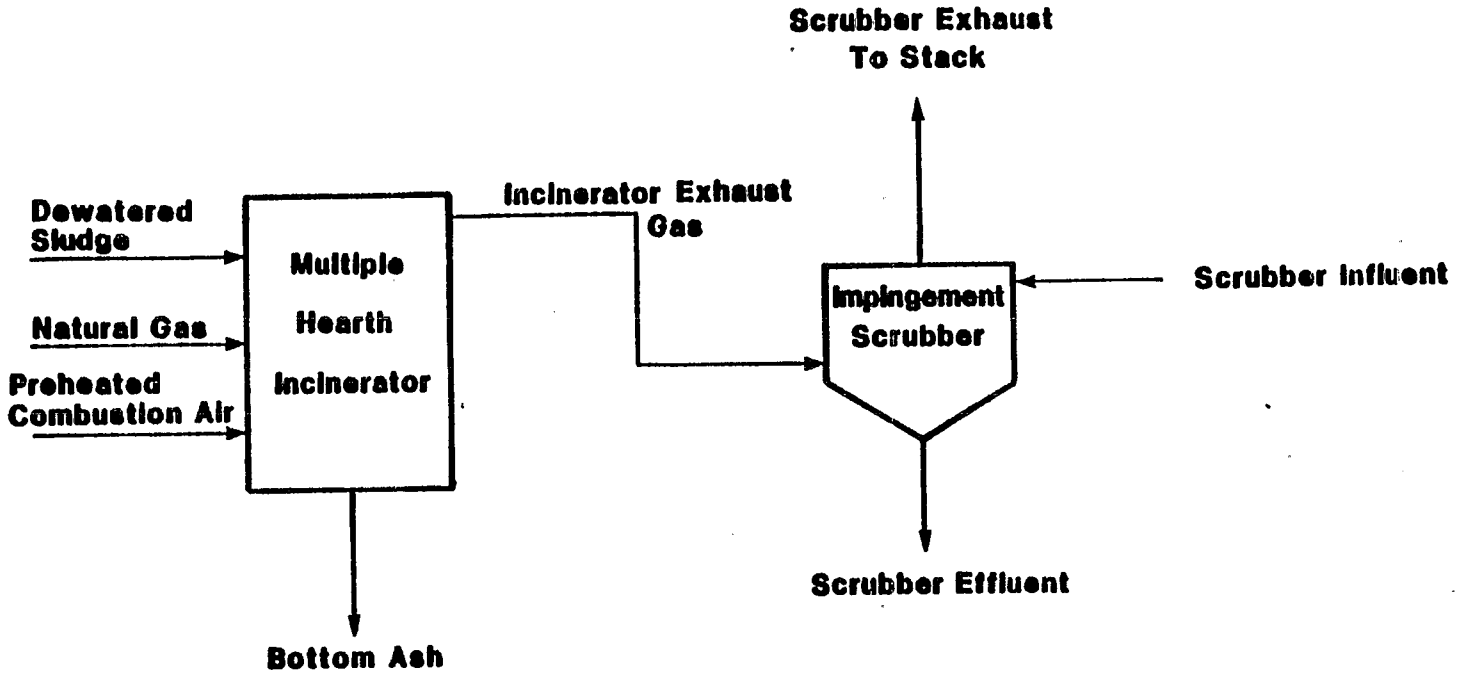


Figure 2-1. Simplified Flow Diagram of Sewage Sludge Incinerator Process.

TABLE 2-1. SOURCE SAMPLING ANALYSIS AND OVERVIEW

Item	Item Description
Number of test runs	Three identical test runs (Runs 1, 2, 3)
Gaseous sampling	MM5 sampling at inlet and outlet to scrubber (Runs 1, 2, 3). Dioxin/furan analysis.
	Continuous CO, CO_2, O_2, NO_x, and THC monitoring at scrubber outlet exhaust stack (Runs 1, 2, 3)
	EPA reference Methods 2 and 4 at inlet and outlet to scrubber (Runs 1, 2, 3). Gas velocity and moisture.
	Integrated bag sampling (EPA Reference Method 3) at inlet and outlet to scrubber (Runs 1, 2, 3). CO_2, O_2, and N_2 analysis for molecular weight determination.
Liquid and slurry sampling	Scrubber system effluent sampling/filtration (Runs 1, 2, 3). Dioxin/furan analysis of filtered solids and filtrate.
Solids sampling	Sludge feed sampling (Runs 1, 2, 3). Dioxin precursors.
	Incinerator bottom ash sampling (Runs 1, 2, 3). Dioxin/furan analyses.
	Soil sampling (one composite sample from 10 locations). Dioxin/furan analysis.

Continuous emissions monitoring (CEM) for O_2, CO, CO_2, NO_x, SO_2 and total hydrocarbons (THC) was performed at the incinerator outlet. These data will be used in conjunction with incinerator process data to document combustion conditions during the test and possibly to relate dioxin emissions to average combustion conditions during the test period.

Bottom ash samples were taken during each test run and analyzed for dioxin/furan content by Troika. Scrubber system blowdown slurry samples were also taken, and the samples were filtered to separate the solids from the aqueous filtrate. Both the filterable solids and the filtrate were analyzed for dioxin/furan content. The bottom ash and scrubber blowdown slurry data provides input to an ash screening effort being conducted as part of the Tier 4 program. Soil samples were also collected, but analysis of these samples has been deferred pending evaluation of the dioxin/furan emissions data.

2.2 SUMMARY OF RESULTS

Figure 2-2 summarizes the data obtained at Site SSI-C during the Tier 4 test program. The sewage sludge incinerator and wet scrubber system were operated under conditions representative of normal operation during the sampling periods. Detectable quantities were found for nearly all of the dioxin and furan species analyzed for in the stack gas emissions.

2.2.1 Scrubber Inlet Data

As shown in Table 2-2, average as-measured scrubber inlet gas concentrations of total PCDD and total PCDF were 39.1 and 172 ng/dscm, respectively. This corresponds to hourly mass emission rates of 1770 ug/hr total PCDD, and 7680 g/hr total PCDF. Speciation for the 2378 TCDD isomer was not performed for the scrubber inlet location. Valid dioxin and furan data were obtained only for Runs 02 and 03. The analytical results from Run 01 are considered invalid because the recoveries of analytical surrogates were below acceptable levels specified in the Tier 4 QA/QC plan.

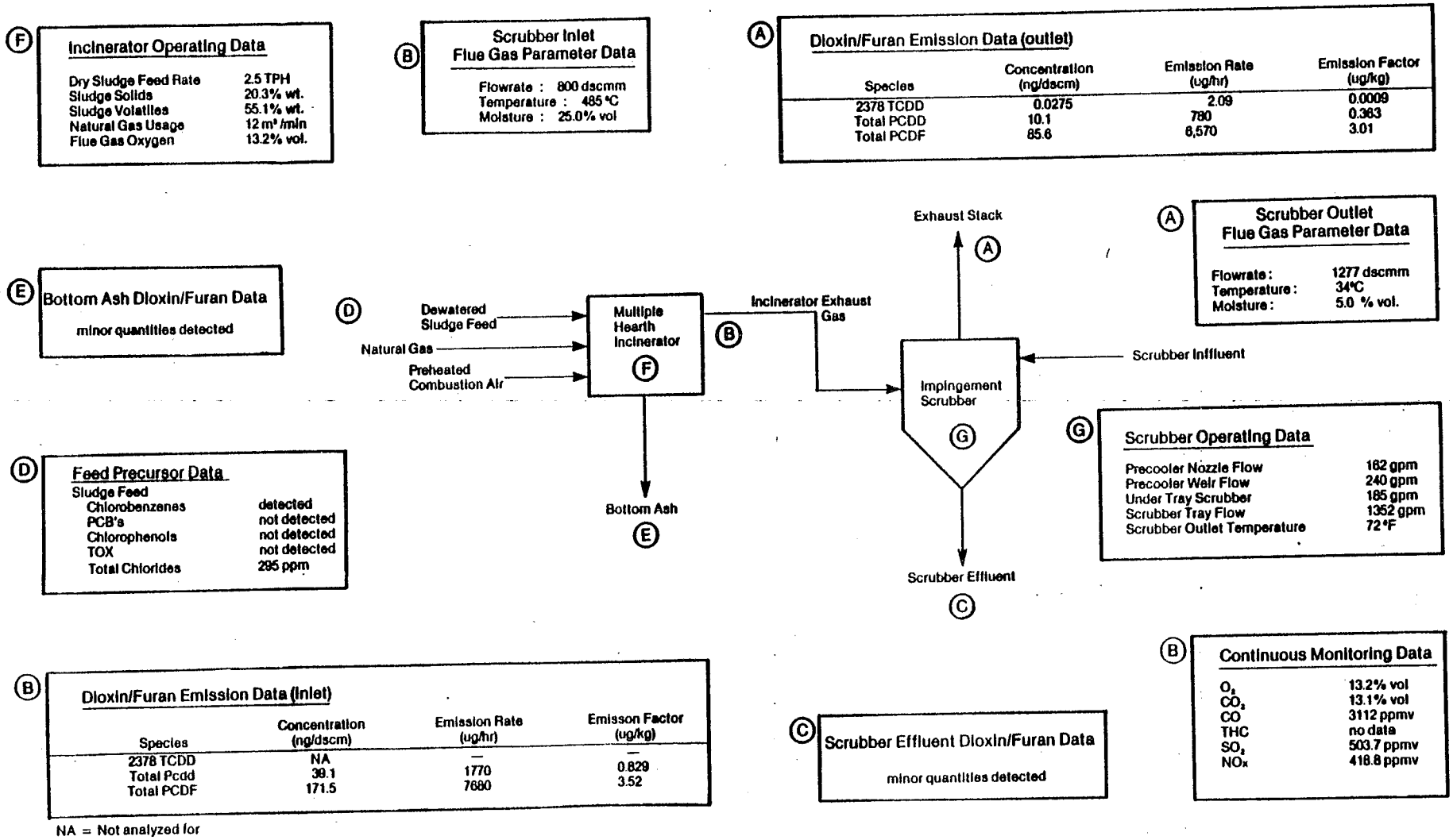


Figure 2 - 2. Data Summary for Site SSI - C.

TABLE 2-2. SUMMARY OF MEAN DIOXIN/FURAN FLUE GAS CONCENTRATIONS AT THE SCRUBBER INLET FOR SITE SSI-C

Parameter	2378 TCDD	Total PCDD	Total PCDF
Emissions Concentration (ng/dscm)			
As-Measured	NR	39.1	172
Corrected to 3% O_2	NR	114	507
Emissions Rate(ug/hr)	NR	1770	7680

NR = not reported by Troika.

2.2.2 Scrubber Outlet Data

As shown in Table 2-3, average as-measured stack gas concentrations of 2378 TCDD, total PCDD, and total PCDF were .03, 10, and 86 ng/dscm, respectively at the scrubber outlet. This corresponds to hourly mass emission rates of 2.09 ug/hr 2378 TCDD, 780 ug/hr total PCDD, and 6,570 ug/hr total PCDF. The emission rates were fairly well distributed among the dioxin and furan homologues.

2.2.3 Dioxin Precursor Data

Sludge feed samples were analyzed to determine the dioxin precursor level of the feed. The only precursors detected were chlorinated benzenes, at an average concentration of 11 ppb. The feed samples were also found to contain an average of 295 ppm total chloride.

2.2.4 Flue Gas Data

Average flue gas concentrations (corrected to 3% O_2) measured in the incinerater outlet exhaust stack breeching by the Radian continuous emissions monitoring system were: O_2, 13.2 vol%; CO_2, 13.1 vol%, CO, 3112 ppmv; SO_2, 504 ppmv: and NO_x 419 ppmv. Data on total hydrocarbon (THC) concentration are not available due to instrument malfunction. The average volumetric flow rate at the incinerator outlet was 800 dscmm. The average temperature and moisture content of this gas stream was 485^{o}C and 25 vol%, respectively.

TABLE 2-3. SUMMARY OF MEAN DIOXIN/FURAN CONCENTRATIONS AT THE SCRUBBER OUTLET FOR SITE SSI-C

Parameter	2378 TCDD	Total PCDD	Total PCDF
Emissions Concentration (ng/dscm)			
As-Measured	0.0275	10.1	85.6
Corrected to 3% O_2	0.142	52.7	446
Emissions Rate(ug/hr)	2.09	780	6,570

3.0 PROCESS DESCRIPTION

The wastewater treatment plant and sewage sludge incinerator tested at Site 12 are described in this section. The description includes a discussion of the heat recovery and air pollution control systems associated with the incinerator.

3.1 TREATMENT PLANT

Site 12 is a large municipal wastewater treatment plant that operates several multiple hearth sewage sludge incinerators. Plant influent consists of approximately 15 percent industrial waste and 85 percent domestic sewage. Industrial dischargers that may contribute dioxin precursors (chlorinated organics) to the wastewater influent include oil processing plants, refining and reclaiming plants, metal working and finishing plants, hospitals, and chemical manufacturers.

A wastewater treatment and sludge processing flow diagram for the facility is shown in Figure 3-1. Treatment of the wastewater includes screening, grit removal, iron and polymer addition, sludge sedimentation, oxygen aeration (i.e. sludge activation), secondary sludge sedimentation, and chlorination. The treatment plant effluent is discharged into a river.

Primary and secondary sludges are processed according to the diagram in Figure 3-1. A portion of the primary sludge is gravity thickened, dewatered with rotary vacuum filters, and incinerated. The rest of the thickened primary sludge is blended with thickened secondary sludge in a 2:1 ratio. The primary/secondary blend is dewatered with belt filter presses and incinerated. Excess secondary sludge is dewatered by centrifuge, mixed with lime, and landfilled off site.

3.2 INCINERATOR DESCRIPTION

Incinerator SSI-C is a Nichols twelve-hearth incinerator that was installed at the plant in 1974. A schematic diagram of the incinerator tested

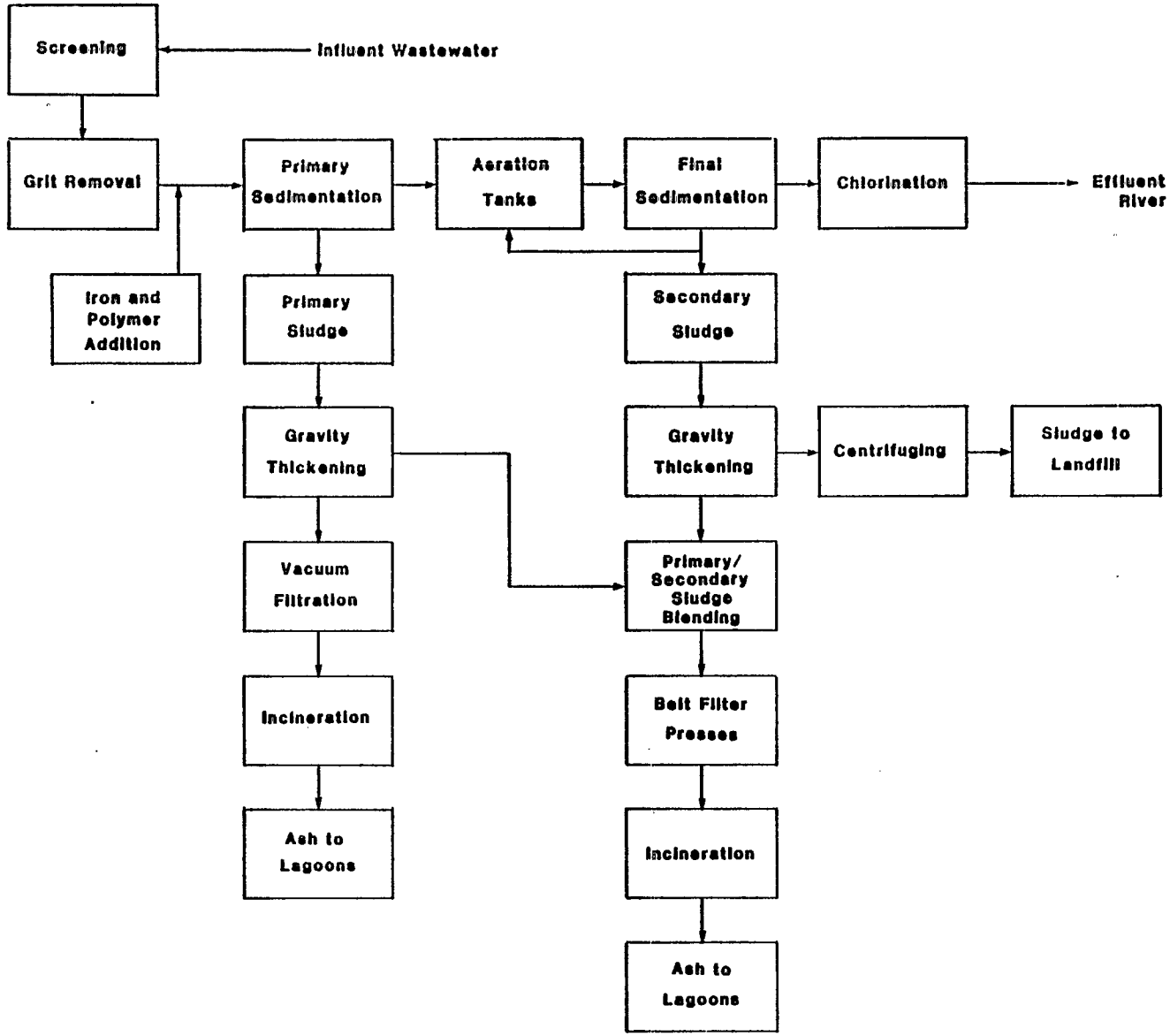


Figure 3-1. Wastewater Treatment and Sludge Processing.

and its air pollution control system is shown in Figure 3-2. Table 3-1 lists some of the more important design parameters of the incinerator.

Blended primary and secondary sludge with a solids content of about 20 percent by weight is fed to the top hearth of the incinerator (Hearth 1) at a rate of about 2.2 dry Mg (2.4 dry tons) per hour. The design capacity of the incinerator is 2.5 dry Mg (2.7 dry tons) per hour. The upper hearths are used for drying of the sludge cake, the middle hearths (Hearths 4 and 5) are used for burning, and the bottom hearths are used for cooling.

An auxiliary fuel system consisting of natural gas burners is used to maintain set point temperatures on the even-numbered hearths of the incinerator. The natural gas burners are located on Hearths 2, 4, 6, 8, 10 and 12. Combustion air for Incinerator SSI-C is mainly ambient air. A shaft cooling air system is used to prevent overheating of the rabble arm shaft. Some of the shaft cooling air exhaust is used as pre-heated combustion air for the incinerator. The remaining shaft cooling air is vented directly to the atmosphere via a stack separate from that used for the incinerator air pollution control system.

Incinerator SSI-C typically maintains a temperature of 760°C (1400°F) on Hearth 5. The natural gas feed rate is controlled to maintain this temperature. Combustion air intake dampers are controlled manually to maintain an incinerator exhaust gas oxygen concentration of 9 to 10 percent.

Under normal feed conditions, Incinerator SSI-C produces about 24 Mg (26 tons) per day of bottom ash, which is pneumatically conveyed to storage silos. The bottom ash is ultimately loaded onto trucks and hauled to an off-site disposal site. Scrubber water is sent to an on-site lagoon where the particulate entrained in the scrubber water settles out.

3.3 PARTICULATE CONTROL SYSTEM

Particulate emissions from Incinerator SSI-C are controlled by a three-tray impingement scrubber. The scrubber influent is the final effluent from the wastewater treatment process. The scrubber effluent, which contains approximately 1 percent solids, is recycled to the head of the wastewater treatment plant. Total water flow to the scrubber is approximately

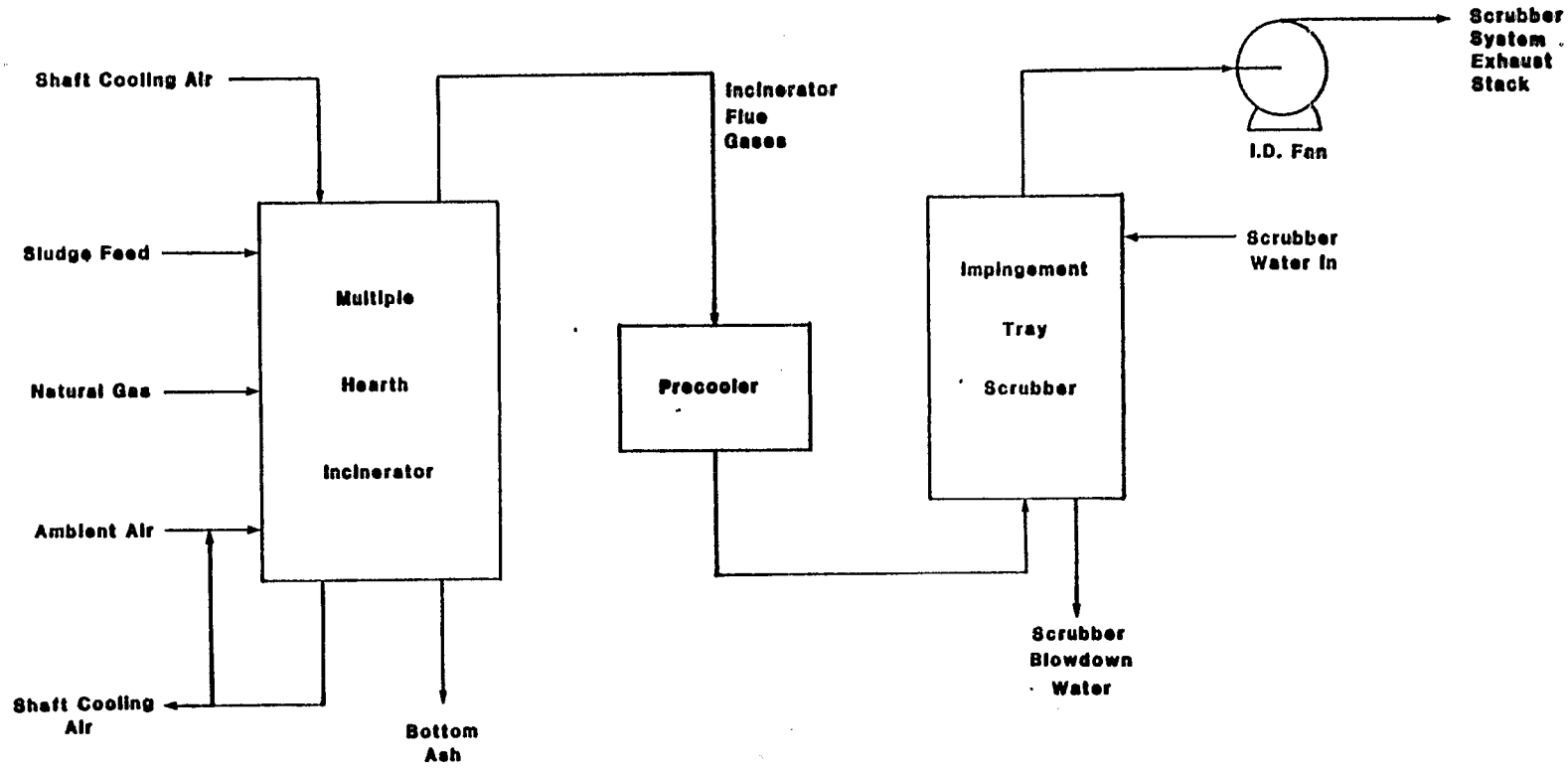


Figure 3-2. Schematic Diagram of Incinerator SSI-C and Associated Impingement Tray Scrubber.

TABLE 3-1. INCINERATOR AND SLUDGE-FEED DESIGN PARAMETERS FOR INCINERATOR SSI-C

DESIGN PARAMETER	VALUE
Incinerator	
1. Manufacturer	Nichols
2. Number of Hearths	12
3. Sludge burning capacity	3.6 dry tons/hr[a]
4. Exhaust gas oxygen content	9 - 10 percent
5. Bottom ash production	26 tons/day
6. Auxiliary Fuel	natural gas
Sludge Feed	
1. Sludge type	Blend of primary, secondary
2. Solids content	20 wt. percent

[a]Based on 18 wet tons/hr.

454 m^3/hr (2000 gal/min) and the gas side pressure drop is 2 kPa (8 inches of water).

Under upset or low-fire conditions, constant pressure drop across the scrubber is maintained by controlling an ambient air intake damper located just upstream of the scrubber. This damper was kept closed throughout the dioxin emissions testing.

4.0 TEST DESCRIPTION

This section describes the field sampling, process monitoring, and analytical activities that were performed at Site 12. The purpose of this section is to provide sufficient descriptive information about the test so that the test data presented in Section 5.0 can be easily understood. Specific testing details (specific sampling locations and procedures) will be presented later, in Section 6.0.

This section is divided into three parts. Section 4.1 summarizes field sampling activities, Section 4.2 summarizes process monitoring activities, and Section 4.3 summarizes analytical activities performed during the test program.

4.1 FIELD SAMPLING

Table 4-1 shows the source sampling and analysis matrix for Site 12. Three sets of dioxin/furan emissions tests were performed on consecutive days at the scrubber inlet and outlet sampling locations. These locations are shown as Points A and B in Figure 4-1. Dioxin/furan sampling followed (with two exceptions discussed in Section 6) the Modified Method 5 (MM5) sampling protocol developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. Sampling was performed isokinetically for a minimum of 4 hours per test run.

Continuous emissions monitoring (CEM) of O_2, CO, CO_2, NO_x, SO_2 and total hydrocarbons (THC) was performed at the scrubber inlet sampling location during the MM5 test runs. These data were obtained to assess variations in combustion conditions during the sampling periods. One-minute average concentrations of each species monitored were determined and recorded by the CEM system.

Three types of process samples were taken during the MM5 test periods: sewage sludge, bottom ash, and scrubber blowdown. The sewage sludge samples were taken to characterize dioxin/furan precursor contents of the materials fed to the incinerator. These samples were taken on an hourly basis, and

TABLE 4-1. SOURCE SAMPLING AND ANALYSIS MATRIX FOR SITE SSI-C

Sample Location	Sample Type or Parameter	Sampling Method	Analysis Method	Number of Samples or Frequency
Outlet exhaust stack (point E on Figure 4-1)	Dioxin and furan	Modified EPA Method 5 (MM5)	Gas chromatograph/mass spectrometer	Three test runs; one per test day. One field recovery blank
	Volumetric flow	EPA Method 2	NA[a]	Once per MM5 test run.
	Molecular weight	EPA Method 3	Gas chromatograph/thermal conductivity detector	Two integrated bag samples per MM5 test run.
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run.
Incinerator outlet location (point B on Figure 4-1)	Dioxin and furan	Modified EPA Method 5 (MM5)	Gas chromatograph/mass spectrometer	Three test runs; one per test day. One field recovery blank One lab proof blank.
	Volumetric flow	EPA Method 2	NA[a]	Once per MM5 test run.
	Molecular weight	EPA Method 3	Gas chromatograph/thermal conductivity detector	Two integrated bag samples per MM5 test run.
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run.
Dioxin and furan location (point B on Figure 4-1)	CO/CO_2	In-stack filter probe and heat-traced teflon line	Nondispersive infrared analysis	Continuously during MM5 test runs.
	O_2	Same as CO/CO_2	Paramagnetic analzer	Continuously during MM5 test runs.
	NO_x	Same as CO/CO_2	Chemiluminescent analyzer	Continuously during MM5 test runs.
	THC	Same as CO/CO_2	Flame ionization analyzer[b]	Continuously during MM5 test runs.
Sludge feed	Dioxin, furan and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite samples for each test run.
Bottom ash	Dioxin and furan	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite samples for each test run.
Scrubber blowdown	Scrubber blowdown solids for dioxin and furan	Pressure filtration	Gas chromatograph/mass spectrometer	One composite sample per MM5 test run.
	Scrubber blowdown filtrate for dioxin and furan	Pressure filtration	Gas chromatograph/mass spectrometer	One composite sample per MM5 test run.
	Scrubber blowdown for weight percent solids	Vacuum filtration	Gravimetric balance	One composite sample per MM5 test run.
Soils	Dioxin and furan	Grab samples	Gas chromatograph/mass spectrometer	One composite of 10 samples.

[a] NA = not applicable.

[b] The flame ionization analyzer was calibrated using propane standards.

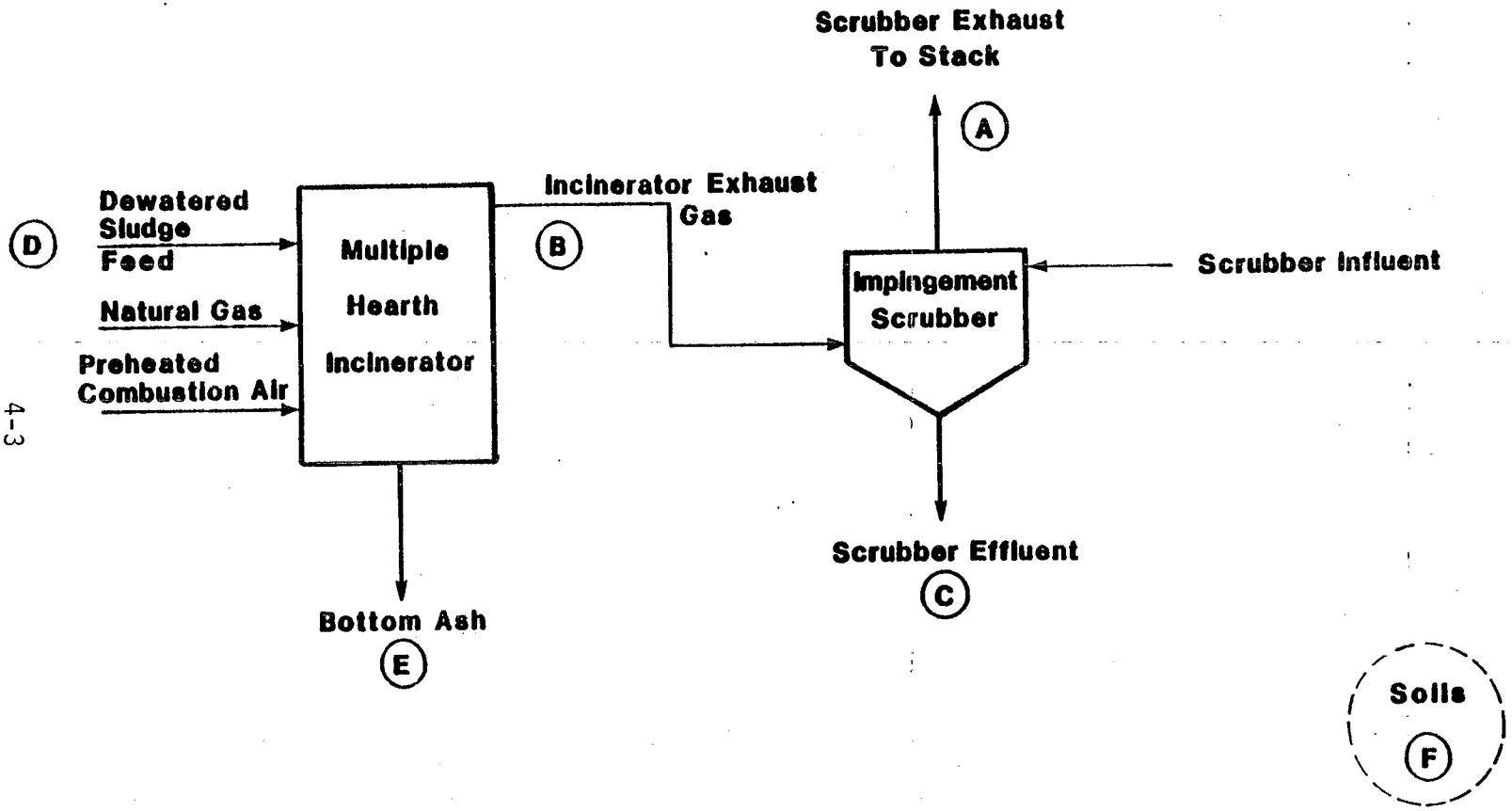


Figure 4-1. Sample Point Diagram For Incinerator SSI-C.

individual composite samples were prepared for each test run. The bottom ash and scrubber blowdown samples were taken to investigate the potential for using these materials as indicators of dioxin/furan emissions from sewage sludge incinerators. These samples were also taken on an hourly basis. Individual composite ash samples were prepared for each test run and scrubber blowdown samples were filtered on-site to provide separate composite samples of scrubber blowdown solids and aqueous filtrate.

Soil samples were collected from ten locations at the plant site and combined into a single composite. Analysis of the composite sample for dioxin/furan content has been deferred pending evaluation of the MM5 dioxin/furan emissions data.

4.2 PROCESS DATA COLLECTION

Process data were collected on-site to characterize the operation of the multiple hearth incinerator and wet scrubber system during the MM5 test periods. Incinerator process data obtained include hourly average sludge feed rates, continuous strip chart recordings of individual hearth temperatures, incinerator exit and stack breeching flue gas temperatures, and the shaft cooling air temperature. Also recorded were the incinerator draft, natural gas usage and percent oxygen at the top hearth. The sludge was analyzed daily for moisture content, volatiles content, heat content and ash content. These data will be used with the CEM data to evaluate and compare combustion conditions during the MM5 test periods.

Scrubber system process data obtained include scrubber water flow rates, precooler flowrates, and scrubber system inlet and outlet gas temperatures. These data will be used to characterize the consistency of the scrubber system operation during the three MM5 test periods.

4.3 LABORATORY ANALYSES

Two types of laboratory analyses were performed on samples from Site 12: dioxin/furan analyses and dioxin/furan precursor analyses. Samples analyzed

for dioxin/furan are discussed in Section 4.3.1, and samples analyzed for dioxin precursors are discussed in Section 4.3.2.

4.3.1 Dioxin/Furan Analyses

All dioxin/furan analyses for this test program were performed by two of three EPA laboratories collectively referred to as Troika. The two Troika laboratories are ECL-Bay St. Louis and EMSL-Research Triangle Park.

Field samples requiring dioxin/furan analysis were prioritized by Tier 4 based on their relative importance to the Tier 4 program. The priority levels, in order of decreasing importance, were designated Priority 1, Priority 2, and Priority 3.

Priority 1 samples were sent to Troika with instructions to perform immediate extraction and analysis. These included the MM5 train components and MM5 field blanks for the outlet exhaust stack and incinerator outlet, the MM5 lab proof blank, the bottom ash samples and the scrubber blowdown solids/filtrate samples.

Priority 2 samples were sent to Troika to be analyzed for dioxin/furan pending the results of the Priority 1 analyses. The only Priority 2 samples were the sludge feed samples, which were characterized for precursor content only.

The composite soil sample (Priority 3) is being kept at Radian's N.C. laboratory pending evaluation of results from the Priority 1 and 2 analyses.

4.3.2 Dioxin/furan Precursor Analyses

Dioxin/furan precursor analyses were performed by Radian on the sewage sludge feed samples. The specific dioxin/furan precursors analyzed for included chlorophenols, chlorobenzenes, PCB's and total chlorine. Composite feed samples were also analyzed for total chlorine by Parr bomb combustion followed by ion chromatography and for total organic halides by gas chromatography and Hall detector.

5.0 TEST RESULTS

The results of the Tier 4 dioxin/furan emissions test of Incinerator SSI-C are presented in this section. The individual test runs are designated as Runs 01-03. Process data obtained during the test runs are presented in Section 5.1. A summary of flue gas parameters is given in Section 5.2. Continuous monitoring results for O_2, CO, CO_2, and NO_x, are presented in Section 5.3. The flue gas dioxin/furan emissions data are contained in Section 5.4. Sludge feed dioxin precursor data are presented in Section 5.5 The results of dioxin/furan analyses of bottom ash and scrubber blowdown are contained in Section 5.6, and the results of soil sampling analyses are given in Section 5.7.

5.1 PROCESS DATA

Process data were obtained to document incinerator and scrubber system operation during the testing. The incinerator data are summarized in Section 5.1.1 and the scrubber system data are summarized in Section 5.1.2. Plant personnel indicated that incinerator and scrubber operation were normal during the testing.

5.1.1 Incinerator SSI-C Operating Data

Data summarizing the operation of multiple hearth sewage sludge incinerator SSI-C during three MM5 test runs are shown in Table 5-1. Conditions during the test runs were similar except that there was a slight variation in the average sludge feed rate between test runs. Sludge feed composition, natural gas usage, and flue gas oxygen concentrations were all similar for the three runs. Comparison of plant monitor and Radian monitor oxygen data shows a consistent difference of about 3 to 4 percent O_2. The reason for this difference is unknown. However, integrated bag samples collected and analyzed for the same location according to EPA Method 3 agreed well with the Radian monitor.

TABLE 5-1. MEAN INCINERATOR OPERATING CONDITIONS DURING DIOXIN TESTS AT SITE 12

Parameter	Run 1	Run 2	Run 3	Average
Wet Sludge Feed Rate [Mg/hr (tph)]	10.8 (11.9)	9.90 (10.9)	12.2 (13.4)	11.0 (12.1)
Dry Sludge Feed Rate [Mg/hr (tph)]	2.2 (2.4)	2.0 (2.2)	2.5 (2.7)	2.3 (2.5)
Sludge Solids (Weight %)	20.5	20.0	20.4	20.3
Sludge Volatiles (Weight % dry basis)	53.5	55.4	56.3	55.1
Sludge Heat Content [kJ/g dry (BTU/lb dry)]	15.6 (6700)	15.8 (6796)	16.3 (7016)	15.9 (6837)
Sludge Ash Content (Weight % dry basis)	46.5	44.6	43.7	44.9
Natural Gas Usage [m^3/min (1000 ft^3/hr)]	12 (26)	13 (27)	10 (22)	12 (25)
Flue Gas Oxygen[a] (Volume %)				
Plant data	9.2	9.6	9.8	9.5
Radian CEM data	13.0	12.7	13.8	13.2

[a]All oxygen data collected at incinerator outlet breeching upstream of scrubber.

Mean temperatures for the top nine hearths during the MM5 runs are shown in Table 5-2. The temperature profiles for the three test runs are similar. Temperatures on Hearths 6 through 9 during Run 3 are slightly lower than temperatures for these hearths during Runs 1 and 2.

5.1.2 Scrubber Operating Data

Scrubber operating data collected during the MM5 test runs are summarized in Table 5-3. Comparison of the data presented in Table 5-3 shows no significant between-run differences in scrubber operation.

5.2 FLUE GAS PARAMETER DATA

Table 5-4 summarizes flue gas temperature, moisture, volumetric flow rate, and oxygen concentration data obtained at Site SSI-C. These parameters were fairly consistent between test runs. The average flue gas temperature and moisture content measured at the scrubber inlet location were 485°C (905°F) and 25.0 vol%, respectively. The average gas flow rate at actual temperature and moisture conditions was 2830 acmm (99,900 acfm) and the average dry, standard flow rate was 800 dscmm (28,200 dscfm). Standard EPA conditions are 20°C (69°F) and 1 atm. The average scrubber outlet parameters for temperature, moisture, actual and dry flowrates were 34°C, 5.0%, 1496 acmm and 1277 dscmm respectively.

Flue gas oxygen concentration data for the scrubber inlet were obtained from the plant continuous emissions monitoring (CEM) system, the Radian CEM system, and integrated bag samples (EPA Method 4). The average O_2 concentrations of the flue gas as measured by these three techniques were 9.5 vol%, 13.2 vol%, and 14.9 vol%, respectively. The Radian CEM data will be used in subsequent section of this report when normalizing as-measured flue gas concentrations of other species (e.g., dioxin, furan, CO, SO_2, etc.) to a reference oxygen level.

5.3 CONTINUOUS MONITORING DATA

Mean concentrations and standard deviations for combustion gases monitored continuously at the incinerator outlet breeching are presented in

TABLE 5-2. AVERAGE HEARTH TEMPERATURES FOR INCINERATOR SSI-C DURING TESTING PERIODS

Hearth No.	Run 1 7-9-85 (^{o}F)	Run 2 7-10-85 (^{o}F)	Run 3 7-11-85 (^{o}F)	Average (^{o}F)
1	799	835	859	831
2	1027	1119	1135	1094
3	929	1034	1047	1003
4	1310	1300	1256	1289
5	1368	1386	1345	1366
6	995	1008	859	954
7	984	888	590	821
8	594	627	324	515
9	333	288	200	274

TABLE 5-3. WET SCRUBBER SYSTEM OPERATING DATA

Parameter	Run 1	Run 2	Run 3	Average
Precooler Nozzle flow (gpm)	162	162	162	162
Precooler weir flow (gpm)	239	241	241	240
Under tray scrubber flow (gpm)	186	185	183	185
Scrubber tray flow (gpm)	1347	1347	1363	1352
Scrubber outlet temperature (^{o}F)	98	92	89	93

TABLE 5-4. FLUE GAS PARAMETERS AT SITE SSI-C

Flue Gas Parameters	Run 01	Run 02	Run 03	Average
SCRUBBER INLET				
Temperature (^{o}C)	476	481	498	485
Moisture (vol.%)	19.3	30.6	25.2	25.0
Volumetric Flow Rate				
Actual (acmm)	2950	2990	2560	2830
Dry Standard (dscmm)	900	780	710	800
Oxygen Content (vol.%)				
Plant CEM	9.2	9.6	9.8	9.5
Radian CEM	13.0	12.7	13.8	13.2
EPA Method 4'	14.9	14.7	15.1	14.9
SCRUBBER OUTLET				
Temperature (^{o}C)	37	33	32	34
Moisture (vol.%)	5.8	4.6	4.7	5.0
Volumetric Flow Rate				
Actual (acmm)	1527	1572	1388	1496
Dry Standard (dscmm)	1281	1348	1202	1277
Oxygen Content (vol%)				
EPA Method 3	18.3	17.8	16.4	17.5

[a]Metric units are reported for all flue gas measurement data.
To convert to alternate units: ^{o}F = 1.8 x ^{o}C + 32
cfm = cmm x 35.3

Table 5-5. Concentrations of CO, CO_2, NO_x and SO_2 presented in Table 5-5 were corrected or normalized to 3 percent oxygen by volume. The O_2, CO, CO_2, and NO_x values were measured on a dry basis. No valid THC data could be obtained due to instrument malfunctioning.

Comparison of mean O_2 values in Table 5-5 shows similar values for all three test runs. The other compound concentrations (CO, CO_2, SO_2, and NO_x) varied, as expected with the sludge feed rate from run to run. Run 2 had the lowest feed rate (10.9 wet tons/hr), and the above-listed compound concentrations (excluding SO_2) were similarly low. Run 3 (which had the highest feed rate) and Run 1 (second highest) followed the same trend.

Figures 5-1 through 5-5 give the concentration histories for the testing periods for O_2, CO, CO_2, NO_x, and SO_2. These figures show that incinerator operation was fairly normal and consistent over the course of the testing period. The THC analysis was invalidated because of equipment malfunctions, and therefore these concentration histories are not included.

5.4 MM5 DIOXIN/FURAN EMISSIONS DATA.

5.4.1 Scrubber Inlet

Emission concentrations and emissions rate data measured at the scrubber inlet are shown in Tables 5-6 and 5-7 for the 2378 TCDD, total PCDD, and total PCDF species. The data include dioxin and furan collection in the entire MM5 train, including filter, XAD sorbent trap, impingers, and sample train clean-up rinses. The concentration and rate data presented pertain to Runs 2 and 3. Run 1 data were invalidated due to analytical difficulties, which will be discussed in Section 8.3.1.1.

Average as-measured emissions concentrations of total PCDD, and total PCDF species were 39 ng/dscm total PCDD and 172 ng/dscm total PCDF. When corrected to 3% O_2 using the Radian CEM oxygen concentration data, these values correspond to 114 ng/dscm @ 3% O_2; and 507 ng/dscm @ 3% O_2, respectively. Average emission rates for these species were 1770 ug/hr total PCDD and 7680 ug/hr total PCDF. The concentrations of total PCDD and total PCDF at the scrubber inlet were fairly consistent between the two test runs.

TABLE 5-5. MEAN VALUES AND STANDARD DEVIATIONS OF CONTINUOUSLY MONITORED COMBUSTION GASES [a,b]

Parameter[a,b,c]	Mean Concentration (Standard Deviation)			
	Run 1	Run 2	Run 3	Average
O_2 (% Vol.)	13.0 (0.6)	12.7 (2.0)	13.8 (0.6)	13.2
CO (ppmv @ 3% O_2)	3018.2 (401.8)	2418.5 (1176.8)	3900.7 (588.6)	3112
CO_2 (% vol @ 3% O_2)	13.9 (0.8)	10.6 (1.7)	14.9 (0.7)	13.1
SO_2 (ppmv @ 3% O_2)	c	516.9 (103.4)	490.4 (41.4)	503.7
NO_x (ppmv @ 3% O_2)	453.6 (38.9)	298.9 (96.3)	503.9 (29.1)	418.8
THC (ppmv @ 3% 02)	c	c	c	

[a]Continuous gas sampling for combustion parameters was performed at the incinerator outlet breeching (upstream of the scrubber).

[b]All concentrations expressed on a dry volume basis.

[c]Data not available due to instrument malfunction.

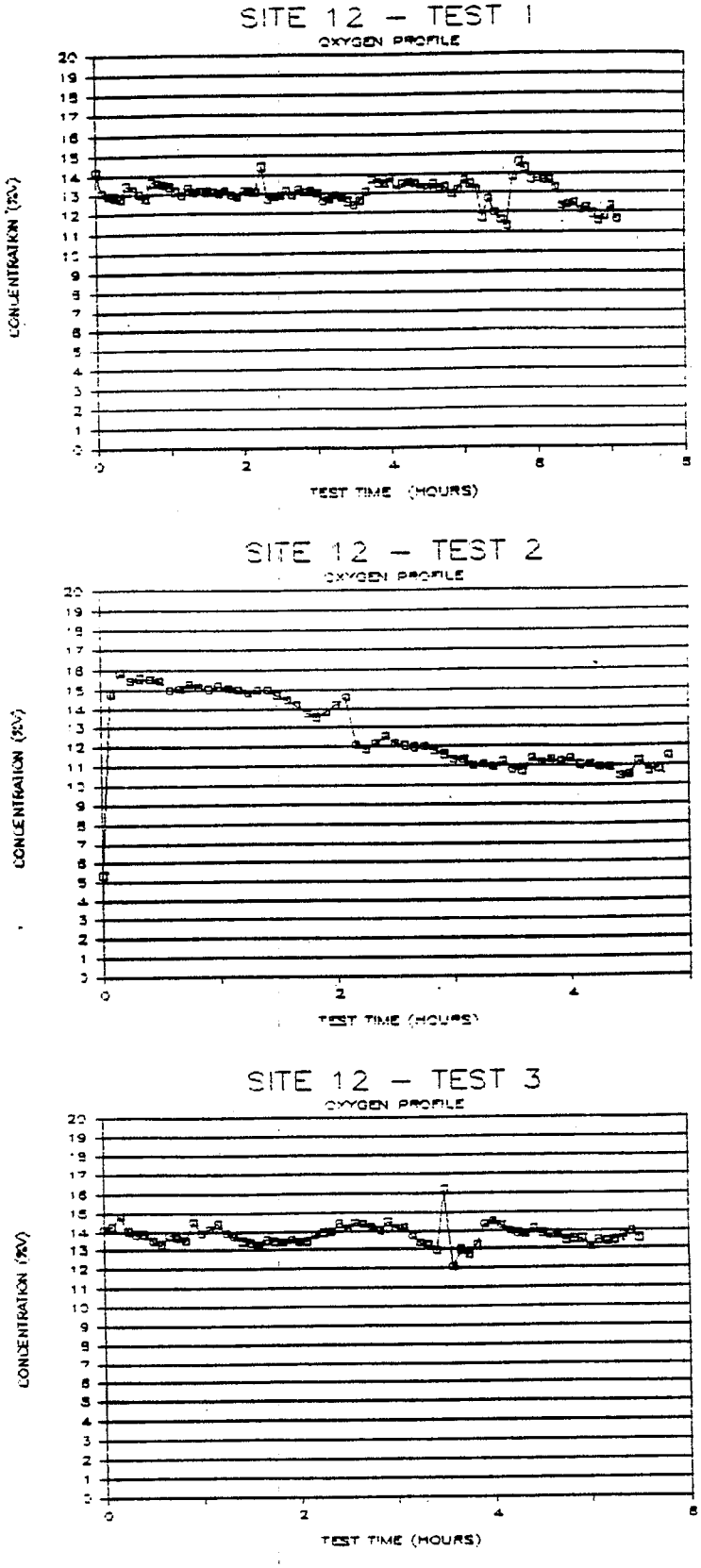


Figure 5-1. Oxygen concentration history.

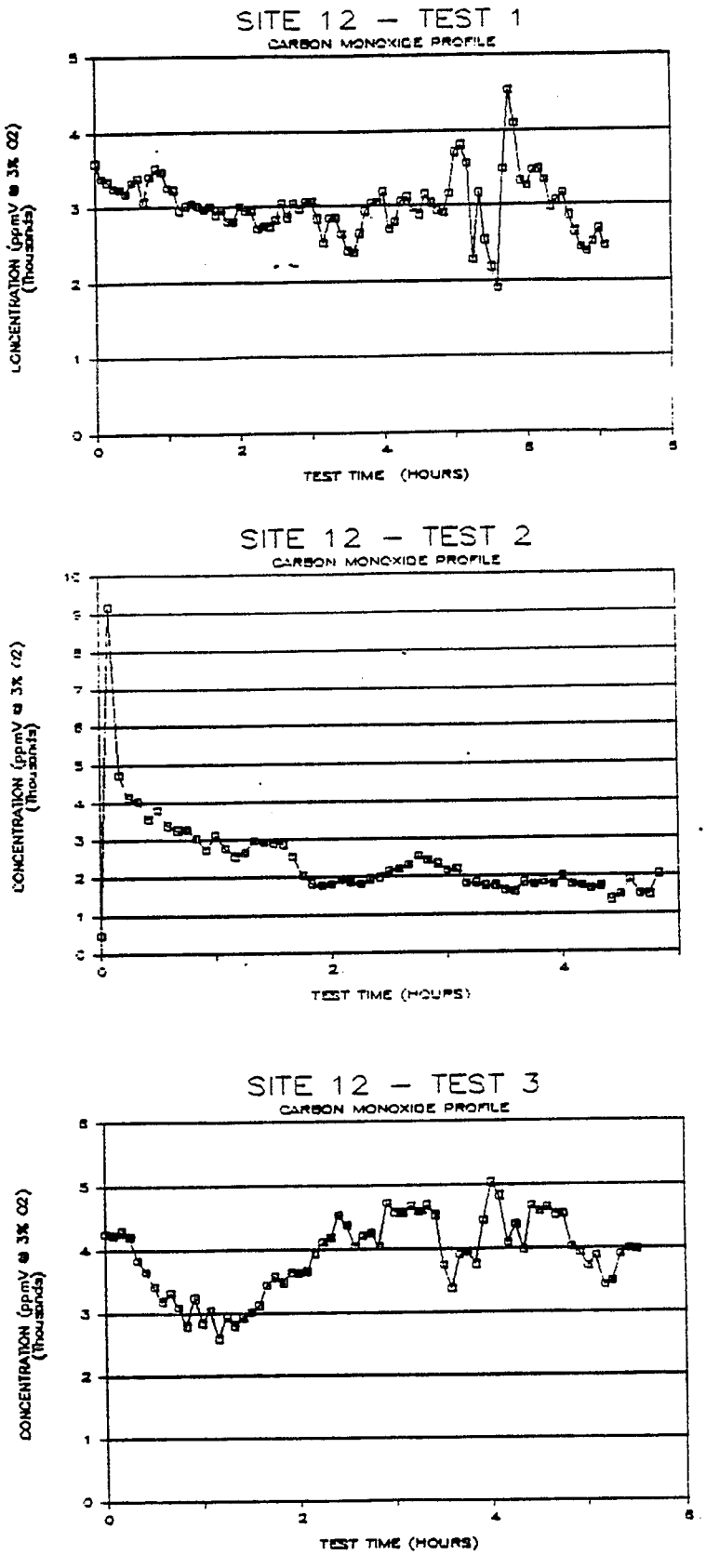


Figure 5-2. Carbon monoxide concentration history.

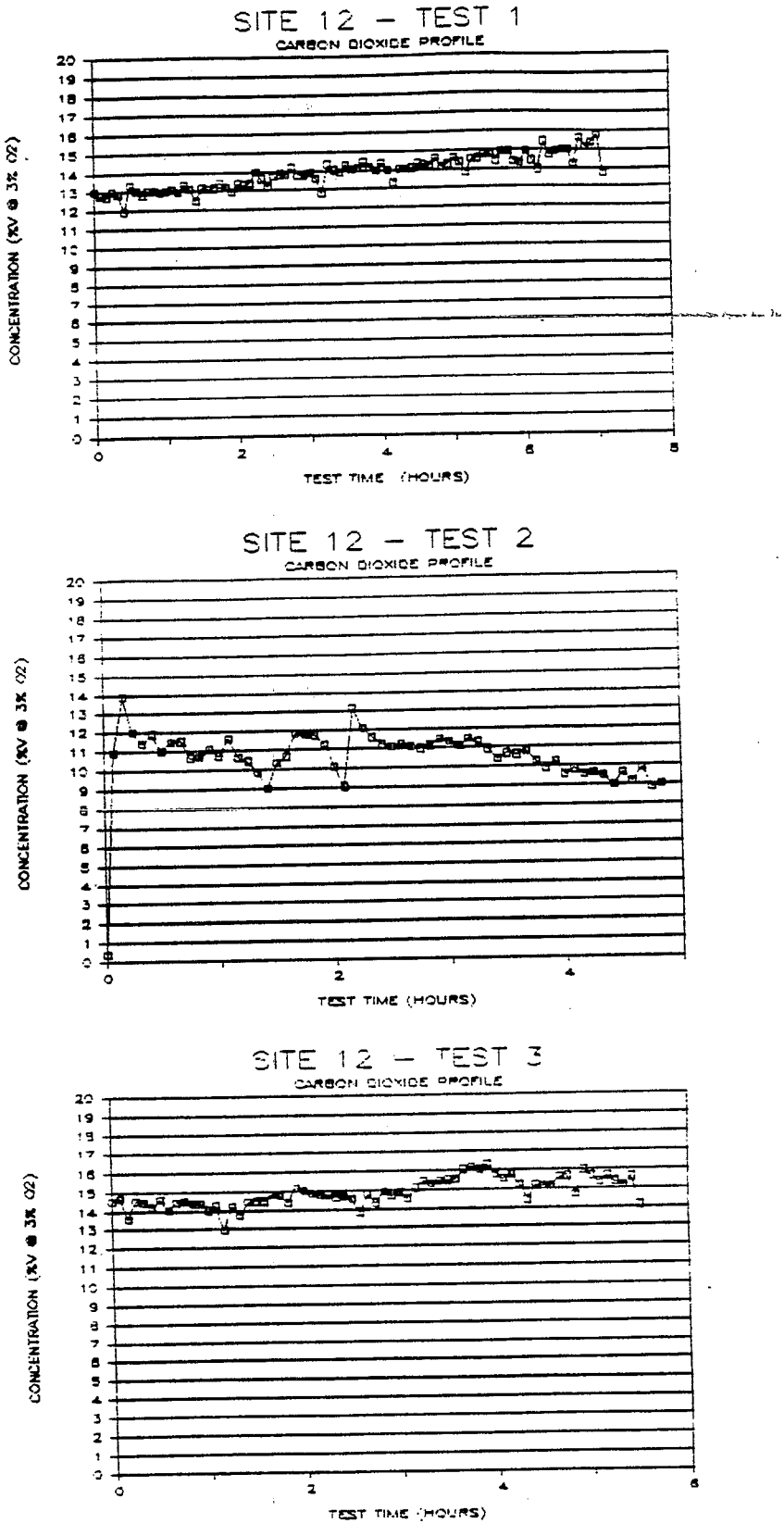


Figure 5-3. Carbon dioxide concentration history.

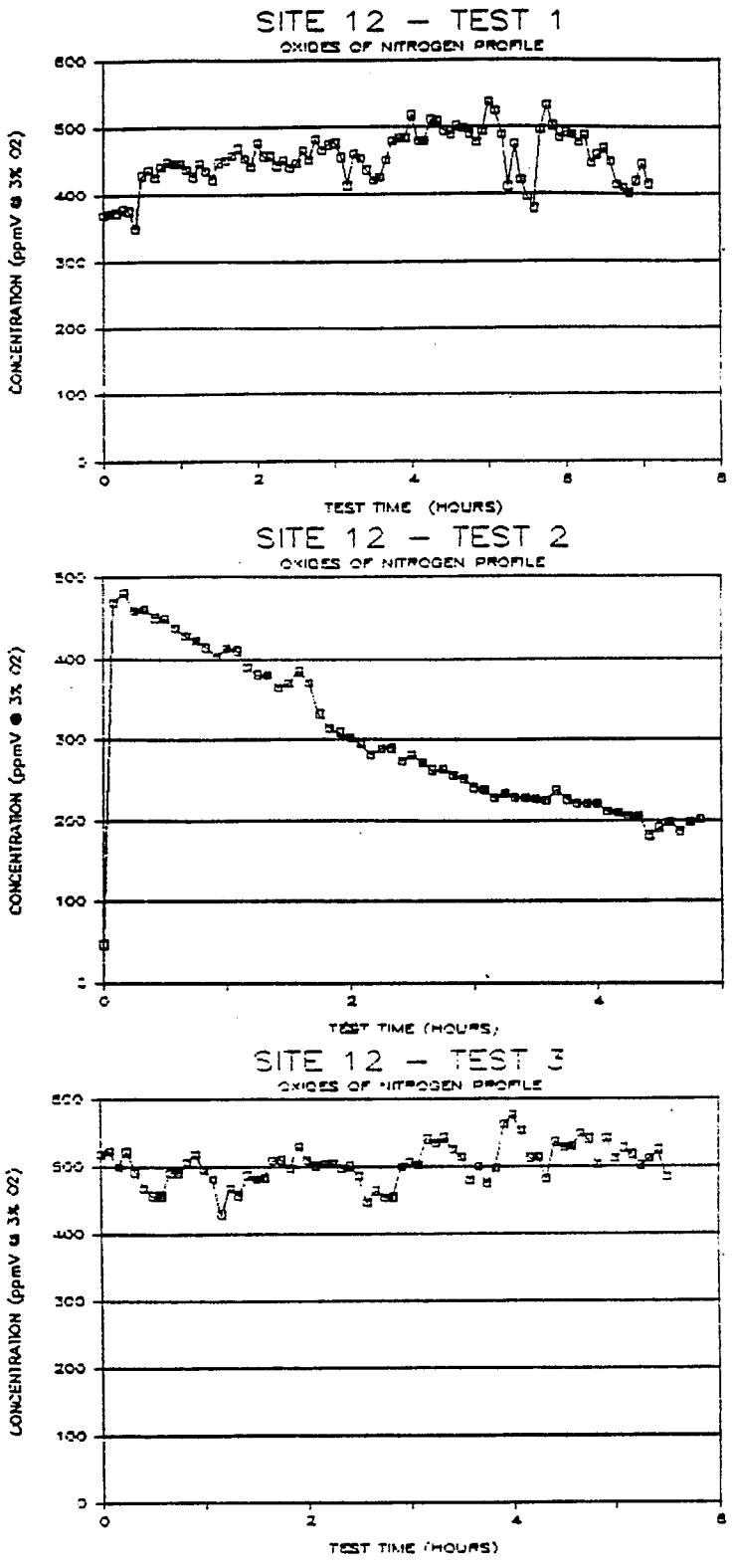


Figure 5-4. Oxides of nitrogen concentration history.

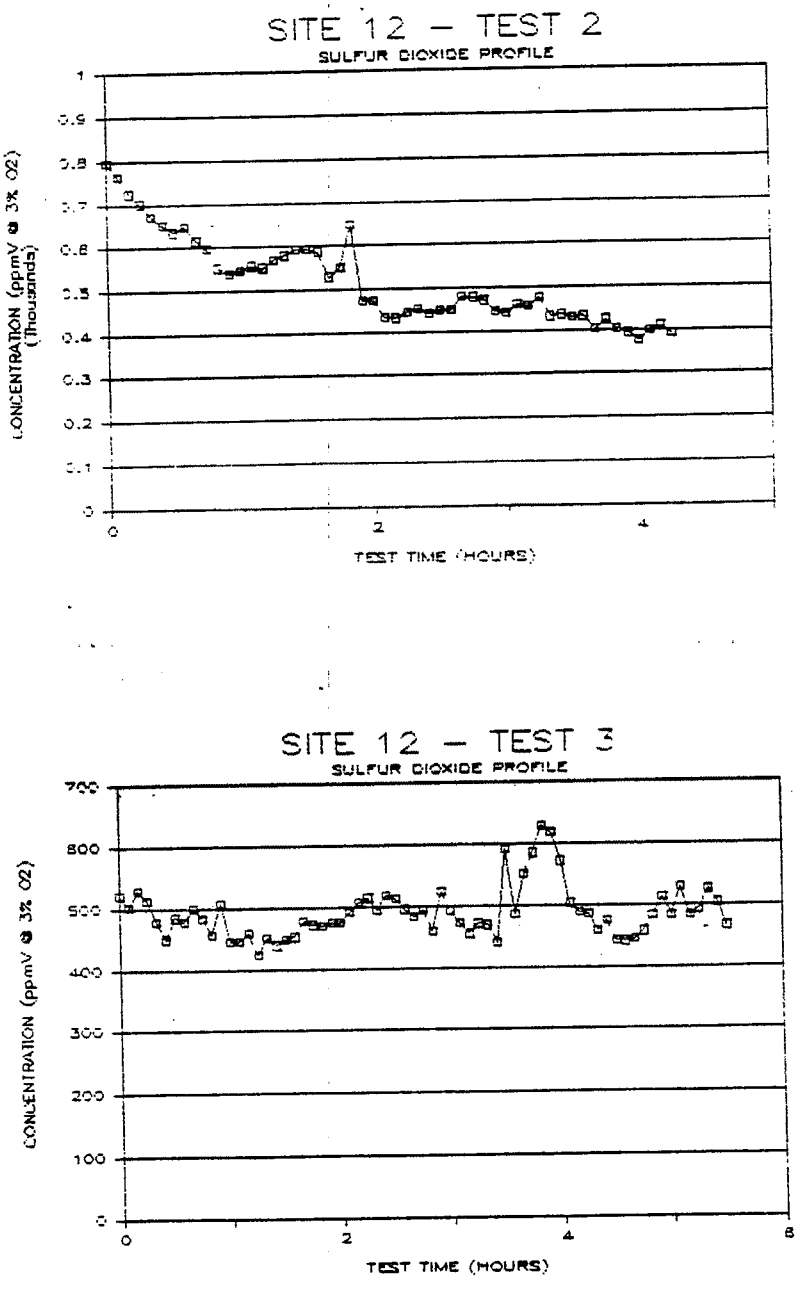


FIGURE 5-5. Sulfur Dioxide Concentration History

TABLE 5-6. OVERVIEW OF DIOXIN/FURAN CONCENTRATION DATA FOR SITE SSI-C (Scrubber Inlet)

Run Number	2378 TCDD	Total PCDD	Total PCDF
Emissions Concentration (as measured, ng/dscm)			
Run 02	NR	49.5	175
Run 03	NR	28.6	168
Average	--	39.1	172
Emissions Rate Concentration (corrected to 3% O_2, ng/dscm @ 3% O_2)			
Run 02	NR	141	500
Run 03	NR	87.2	513
Average	--	114	507

NR = not reported by Troika.
Note: Results from Run 01 are invalid because the recoveries of analytical surrogates were below acceptable levels specified in the Tier 4 QA/QC Plan. See Section 8.3.1.1.

TABLE 5-7. SUMMARY OF DIOXIN AND FURAN EMISSIONS RATE DATA FOR SITE SSI-C (Scrubber Inlet)

Run Number	Dioxin/Furan Emission Rate (ug/hr)		
	2378 TCDD	Total PCDD	Total PCDF
Run 02	NR	2320	8210
Run 03	NR	1220	7150
Average	--	1770	7680

Note: Results from Run 01 are invalid.

NR = Data not reported by Troika.

Isomer- and homologue-specific emission concentration data for the scrubber inlet are summarized in Tables 5-8 and 5-9 for Runs 2 and 3. Run-specific data tables showing homologue emission concentrations in both ng/dscm and parts-per-trillion units and homologue emission rates in ug/hr units are included in Appendix D. Figure 5-6 is a histogram that shows the relative distributions of the 2378 TCDD/TCDF isomers and the tetra- through octa- PCDD/PCDF homologues in the scrubber inlet stream. The distribution of dioxin species was fairly consistent for Runs 2 and 3. The hepta- and octa-CDD homologues each accounted for roughly 40 percent of the dioxins found. The furan species were also fairly well distributed. The tetra- and penta-CDF homologues each accounted for roughly 30 percent of the furans found, while the hepta- and octa-CDF homologues each contributed roughly 12 percent to total furan emissions.

Emission factors for the scrubber inlet at SSI-C are shown in Table 5-10. Average emission factors for total PCDD and total PCDF were 0.829 ug total PCDD emitted per Kg feed, and 3.52 ug total PCDF emitted per Kg feed. Emission factors for the various dioxin and furan homologues varied considerably between test runs. The emission factors are based on the dry sludge feed rate.

5.4.2 Scrubber Outlet

Emissions concentration and emissions rate data measured at the scrubber outlet sampling location are presented in Tables 5-11 and 5-12 for the 2378 TCDD, total PCDD, and total PCDF species. The data include dioxin and furan captured by the entire MM5 train, including the filter, primary XAD sorbent trap, back-up XAD sorbent trap, impingers and sample train clean-up rinses.

Average as-measured emissions concentrations of the 2378 TCDD, total PCDD, and PCDF species were 0.03 ng/dscm 2378 TCDD; 10.1 ng/dscm total PCDD; and 85.6 ng/dscm total PCDF. When corrected to 3% O_2 using the Radian CEM oxygen concentration data, these values correspond to 0.142 ng/dscm @ 3% O_2; 52.7 ng/dscm @ 3% O_2; and 446 ng/dscm @ 3% O_2, respectively. Average emission rates for the three species were 2.1 ug/hr 2378 TCDD, 780 ug/hr total PCDD, and 6,570 ug/hr total PCDF. Emissions of 2378 TCDD varied little between runs, while the total PCDD and PCDF emissions showed greater variability. The emissions concentration of 2378 TCDD varied by 50 percent between runs and the

TABLE 5-8. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE SSI-C INLET

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm) Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	NR	NR	NR	NR
Other TCDD	NR	1.39E+00	4.23E+00	2.81E+00
Penta-CDD	NR	ND(7.88E-01)	2.42E-01	1.21E-01
Hexa-CDD	NR	2.85E+00	3.32E+00	3.09E+00
Hepta-CDD	NR	2.16E+01	9.82E+00	1.57E+01
Octa-CDD	NR	2.37E+01	1.10E+01	1.74E+01
Total PCDD	NR	4.95E+01	2.86E+01	3.91E+01
FURANS				
2378 TCDF	NR	1.65E+01	3.94E+01	2.80E+01
Other TCDF	NR	4.00E+01	5.86E+01	4.93E+01
Penta-CDF	NR	3.60E+01	5.28E+01	4.44E+01
Hexa-CDF	NR	4.09E+00	4.95E+00	4.52E+00
Hepta-CDF	NR	3.92E+01	5.77E+00	2.25E+01
Octa-CDF	NR	3.93E+01	6.62E+00	2.30E+01
Total PCDF	NR	1.75E+02	1.68E+02	1.72E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.
NR = not reported by Troika.
ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year

TABLE 5-9. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE SSI-C INLET
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen) Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	NR	NR	NR	NR
Other TCDD	NR	3.98E+00	1.29E+01	8.44E+00
Penta-CDD	NR	ND(2.25E+00)	7.37E-01	3.69E-01
Hexa-CDD	NR	8.14E+00	1.01E+01	9.12E+00
Hepta-CDD	NR	6.16E+01	3.00E+01	4.58E+01
Octa-CDD	NR	6.76E+01	3.35E+01	5.06E+01
Total PCDD	NR	1.41E+02	8.72E+01	1.14E+02
FURANS				
2378 TCDF	NR	4.71E+01	1.20E+02	8.36E+01
Other TCDF	NR	1.14E+02	1.79E+02	1.47E+02
Penta-CDF	NR	1.03E+02	1.61E+02	1.32E+02
Hexa-CDF	NR	1.17E+01	1.51E+01	1.34E+01
Hepta-CDF	NR	1.12E+02	1.76E+01	6.48E+01
Octa-CDF	NR	1.12E+02	2.02E+01	6.61E+01
Total PCDF	NR	5.00E+02	5.13E+02	5.07E+02

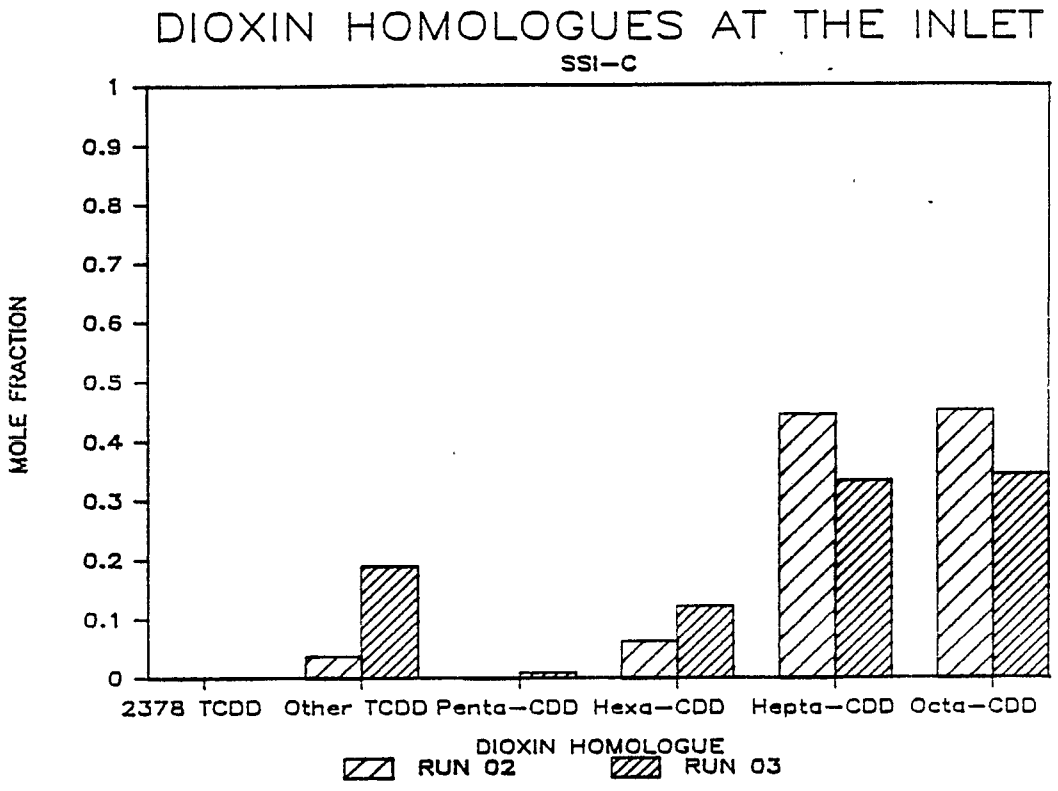
NOTE: Isomer concentrations shown are corrected to 3% oxygen.
NR = not reported by Troika.
ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year

TABLE 5-10. DIOXIN/FURAN EMISSION FACTORS FOR SITE SSI-C INLET

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	NR	NR	NR	NR
Other TCDD	NR	3.27E-02	7.34E-02	5.31E-02
Penta-CDD	NR	ND(1.85E-02)	4.19E-03	2.10E-03
Hexa-CDD	NR	6.68E-02	5.77E-02	6.23E-02
Hepta-CDD	NR	5.06E-01	1.70E-01	3.38E-01
Octa-CDD	NR	5.55E-01	1.90E-01	3.73E-01
Total PCDD	NR	1.16E+00	4.96E-01	8.29E-01
FURANS				
2378 TCDF	NR	3.87E-01	6.84E-01	5.36E-01
Other TCDF	NR	9.39E-01	1.02E+00	9.80E-01
Penta-CDF	NR	8.44E-01	9.16E-01	8.80E-01
Hexa-CDF	NR	9.60E-02	8.60E-02	9.10E-02
Hepta-CDF	NR	9.19E-01	1.00E-01	5.10E-01
Octa-CDF	NR	9.22E-01	1.15E-01	5.19E-01
Total PCDF	NR	4.11E+00	2.92E+00	3.52E+00

NOTE: Emission factors are defined as the ug of dioxin/furan emitted per kg dry sludge feed to the incinerator.

NR = not reported by Troika.
ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
8760 operating hours per year



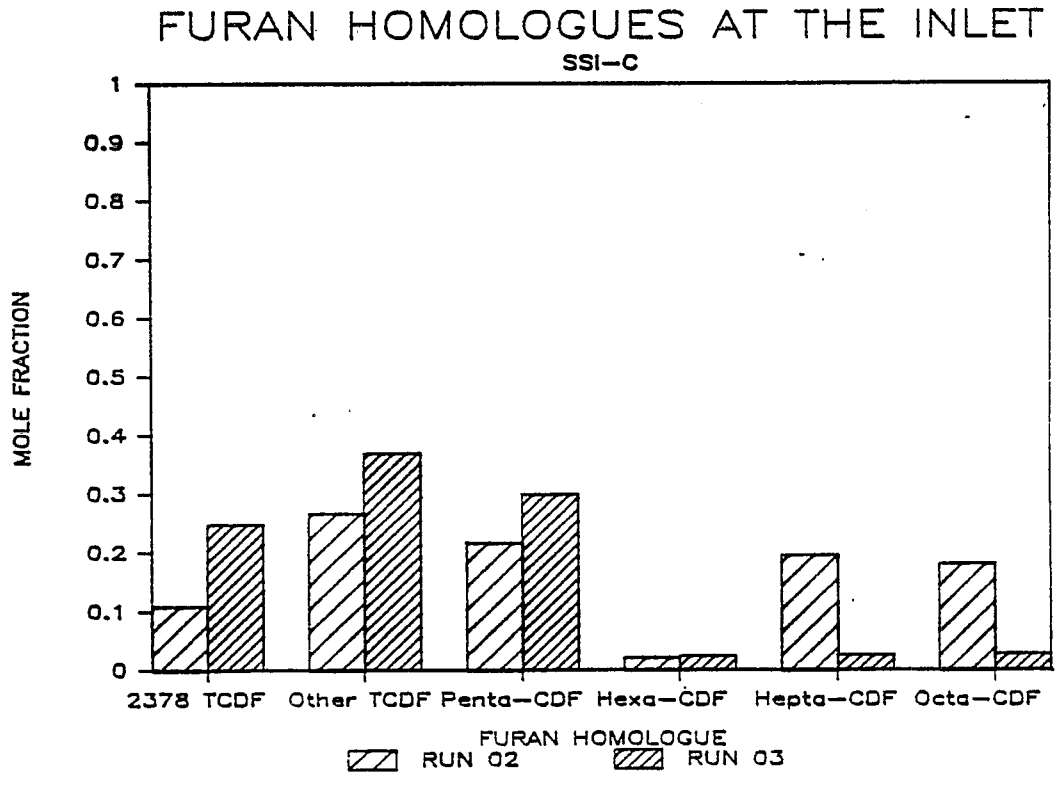


Figure 5-6. Dioxin and furan homologue distributions of the wet scrubber inlet emissions for Site SSI-C

TABLE 5-11. OVERVIEW OF DIOXIN AND FURAN EMISSIONS CONCENTRATION DATA FOR SITE SSI-C (Outlet)

Run Number	Emissions Concentration, ng/dscm		
	2378 TCDD	Total PCDD	Total PCDF
ng/dscm (as-measured)			
Run 01	0.02	4.7	54.1
Run 02	0.02	15.5	108.0
Run 03	0.04	10.2	94.5
Average	0.03	10.1	85.6
ng/dscm @ 3% O_2 [a]			
Run 01	0.16	31.0	360
Run 02	0.13	87.2	608
Run 03	0.14	39.8	370
Average	0.14	52.7	446

[a] Flue gas concentration data corrected to 3% O_2 using the EPA Method 3 data in Table 5-4.

TABLE 5-12. SUMMARY OF DIOXIN AND FURAN EMISSION RATE DATA FOR SITE SSI-C (Outlet)

Run Number	Dioxin/Furan Emission Rate, ug/hr		
	2378 TCDD	Total PCDD	Total PCDF
Run 01	1.8	357	4,150
Run 02	1.9	1,250	8,750
Run 03	2.6	734	6,810
Average	2.1	780	6,570

concentrations of total PCDF and total PCDD varied by factors of 2 and 3, respectively.

Isomer- and homologue-specific emission concentration data are summarized in Table 5-13 and 5-14 for the three test runs. Run specific data tables showing homologue emission concentrations in both ng/dscm and parts-per-trillion units, and homologue emission rates in ug/hr units are included in Appendix D. Detectable quantities of each targeted dioxin and furan species were found in the flue gas samples.

Figure 5-7 is a histogram that shows the relative distributions of the 2378 TCDD/TCDF isomers and the tetra- through octa- PCDD/PCDF homologues in the scrubber outlet emissions (mole basis). The distribution of dioxin/furan species varied widely between the different homologues, and varied to a less extent from run-to-run. The 2378 TCDD isomer accounted for less than 1 percent of the total dioxins analyzed for, and roughly 1 to 2 percent of the tetra-homologue total for individual test runs. The contributions of the tetra- through octa-chlorinated dioxin homologues to the total PCDD emissions were: tetra, 13-33%; penta, 1-3%; hexa, 11-19%; hepta, 26-40%; and octa, 19-29%. The contributions of the tetra through octa-chlorinated furan homologues to the total PCDF emissions were: tetra, 41-63%; penta, 18-29%; hexa, 4-8%; hepta, 2-19%; and octa, 1-14%.

Emission factors for the various dioxin and furan homologues were reasonably consistent between test runs. Emission factors based on the dry sludge feed rates are shown in Table 5-15. Average emission factors were 0.0009 ug 2378 TCDD emitted per kg dry sludge feed; 0.363 ug total PCDD emitted per kg dry sludge feed; and 3.01 ug total PCDF emitted per kg dry sludge feed.

5.4.3 Summary of Scrubber Inlet/Outlet Dioxin and Furan Emissions Data for Site SSI-C

The dioxin/furan removal efficiency of the control device is calculated from the difference of the inlet and outlet concentration of each dioxin/furan homologue divided by the inlet concentration of each homologue.

TABLE 5-13. SUMMARY OF DIOXIN/FURAN EMISSIONS CONCENTRATION DATA FOR SITE SSI-C OUTLET

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm) Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	2.33E-02	2.30E-02	3.62E-02	2.75E-02
Other TCDD	1.26E+00	1.56E+00	1.85E+00	1.55E+00
Penta-CDD	1.33E-01	1.97E-01	3.08E-01	2.13E-01
Hexa-CDD	8.80E-01	1.56E+00	1.61E+00	1.35E+00
Hepta-CDD	1.30E+00	7.27E+00	3.55E+00	4.04E+00
Octa-CDD	1.06E+00	4.90E+00	2.83E+00	2.93E+00
Total PCDD	4.65E+00	1.55E+01	1.02E+01	1.01E+01
FURANS				
2378 TCDF	1.01E+01	9.18E+00	1.12E+01	1.02E+01
Other TCDF	2.25E+01	2.95E+01	3.41E+01	2.87E+01
Penta-CDF	1.67E+01	1.91E+01	2.44E+01	2.01E+01
Hexa-CDF	2.77E+00	8.59E+00	7.48E+00	6.28E+00
Hepta-CDF	1.30E+00	2.35E+01	1.00E+01	1.16E+01
Octa-CDF	5.98E-01	1.83E+01	7.36E+00	8.74E+00
Total PCDF	5.41E+01	1.08E+02	9.45E+01	8.56E+01

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

TABLE 5-14. SUMMARY OF DIOXIN/FURAN EMISSIONS CONCENTRATION DATA FOR SITE SSI-C OUTLET
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen) Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	1.55E-01	1.30E-01	1.42E-01	1.42E-01
Other TCDD	8.37E+00	8.75E+00	7.23E+00	8.12E+00
Penta-CDD	8.86E-01	1.11E+00	1.21E+00	1.07E+00
Hexa-CDD	5.87E+00	8.79E+00	6.31E+00	6.99E+00
Hepta-CDD	8.64E+00	4.09E+01	1.39E+01	2.11E+01
Octa-CDD	7.09E+00	2.76E+01	1.11E+01	1.52E+01
Total PCDD	**3.10E+01**	**8.72E+01**	**3.98E+01**	**5.27E+01**
FURANS				
2378 TCDF	6.76E+01	5.16E+01	4.38E+01	5.43E+01
Other TCDF	1.50E+02	1.66E+02	1.33E+02	1.50E+02
Penta-CDF	1.12E+02	1.08E+02	9.56E+01	1.05E+02
Hexa-CDF	1.85E+01	4.83E+01	2.93E+01	3.20E+01
Hepta-CDF	8.64E+00	1.32E+02	3.91E+01	6.00E+01
Octa-CDF	3.99E+00	1.03E+02	2.88E+01	4.52E+01
Total PCDF	3.60E+02	6.08E+02	3.70E+02	4.46E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

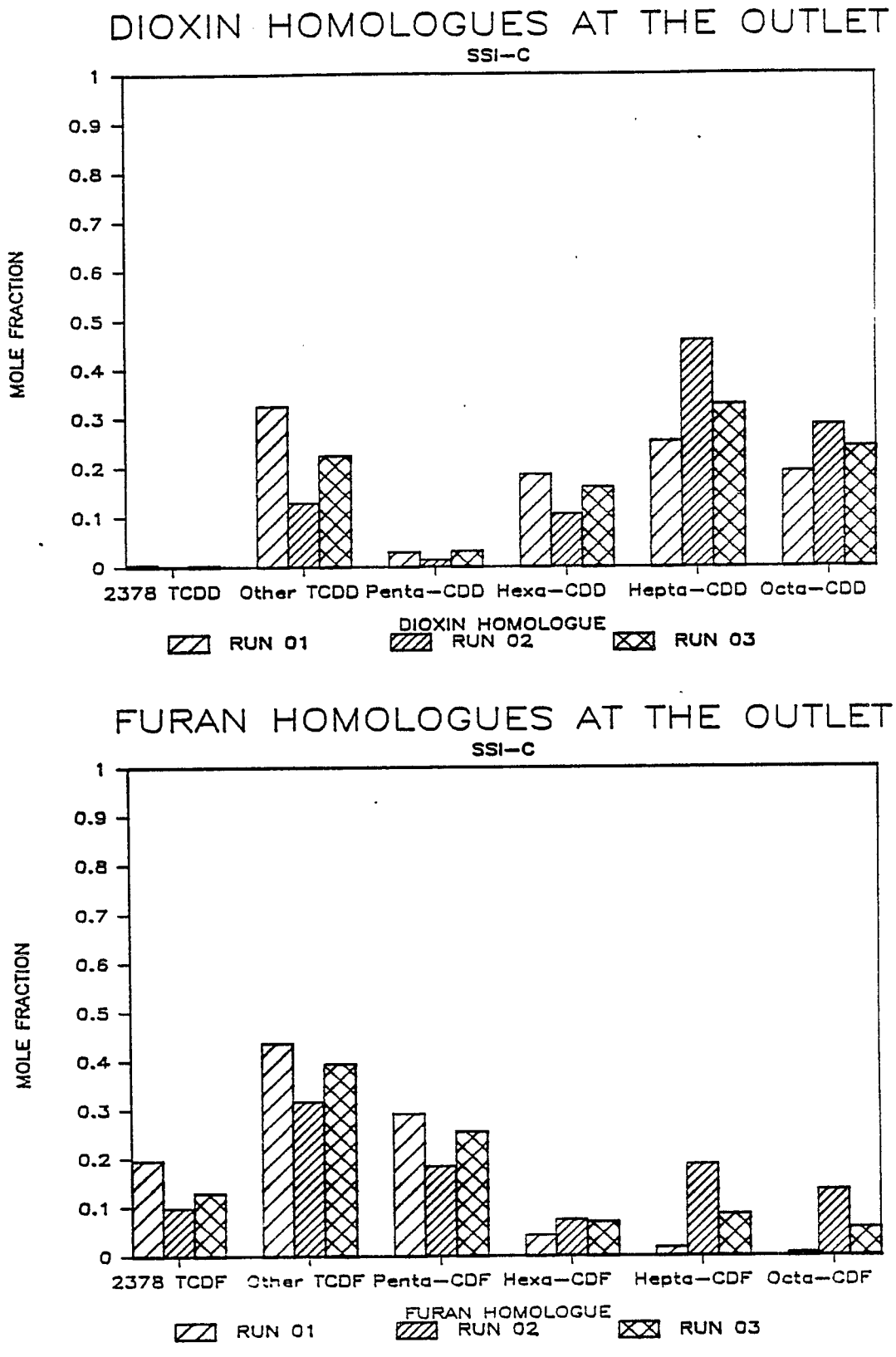


Figure 5-7. Dioxin and furan homologue distributions of the wet scrubber outlet emissions for Site SSI-C

TABLE 5-15. DIOXIN/FURAN EMISSION FACTORS FOR SITE SSI-C OUTLET

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	8.12E-04	9.31E-04	1.07E-03	9.37E-04
Other TCDD	4.39E-02	6.29E-02	5.44E-02	5.37E-02
Penta-CDD	4.64E-03	7.98E-03	9.06E-03	7.23E-03
Hexa-CDD	3.08E-02	6.32E-02	4.74E-02	4.71E-02
Hepta-CDD	4.53E-02	2.94E-01	1.04E-01	1.48E-01
Octa-CDD	3.71E-02	1.98E-01	8.32E-02	1.06E-01
Total PCDD	1.62E-01	6.27E-01	3.00E-01	3.63E-01
FURANS				
2378 TCDF	3.54E-01	3.71E-01	3.29E-01	3.52E-01
Other TCDF	7.86E-01	1.19E+00	1.00E+00	9.94E-01
Penta-CDF	5.85E-01	7.73E-01	7.19E-01	6.92E-01
Hexa-CDF	9.69E-02	3.47E-01	2.20E-01	2.21E-01
Hepta-CDF	4.53E-02	9.50E-01	2.94E-01	4.30E-01
Octa-CDF	2.09E-02	7.38E-01	2.16E-01	3.25E-01
Total PCDF	1.89E+00	4.37E+00	2.78E+00	3.01E+00

NOTE: Emission Factors are defined as the ug of dioxin/furan emitted per kg of dry sludge feed to the incinerator.

ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
8760 operating hours per year
kg = 1.0E+03g

Each homologue concentration value is considered to have an analytical uncertaintly of ± 50%. An analysis of the uncertainty of the control device efficiency (contained in Appendix G) indicated that with a measured efficiency of greater than 66.7%, the removal efficiency is most likely positive. With measured efficiencies between 66.7% and -200%, a definite conclusion cannot be drawn concerning the true removal efficiency, and below -200%, the removal efficiency is most likely negative.

The measured scrubber removal efficiencies for each dioxin/furan homologue at Site SSI-C are summarized in Table 5-16. Concentrations corrected to 3 percent oxygen were used for the calculations. Removal efficiencies varied widely and inconclusively. Run 01 inlet data were not available due to inadequate surrogate recoveries of labeled isomers.

5.5 SLUDGE FEED PRECURSOR DATA

As discussed in section 4.1 composite sewage sludge samples were taken for each run, and analyzed for dioxin/furan precursors. Table 5-17 summarizes the results of the precursor analyses performed. The only precursors detected were dichlorobenzenes at an average concentration of 11 ppb. Concentrations of chlorinated biphenyls and chlorinated phenols were below detectable limits. A total organic halide (TOX) analysis was performed on the sludge feed sample from Run 01, but the TOX levels were found to be below the detectable limit (i.e., < 10 ppm).

In addition, composite feed samples and the fuel oil were analyzed for total chloride and total organic halides. The results of theses analyses are summarized in Table 5-18. The total chlorine content of the sludge averaged 295 ppm (analyzed on an as-is basis.)

5.6 BOTTOM ASH AND SCRUBBER BLOWDOWN DIOXIN/FURAN DATA

Hourly samples of incinerator bottom ash and scrubber blowdown water were taken during the test runs and composited for analysis. The dioxin/furan concentrations in the bottom ash are shown in Table 5-19. The only detected isomers, all detected in quantities less than 1 ppb, were: TCDF, hexa-CDF, hepta-CDF, and OCDD.

TABLE 5-16. SCRUBBER REMOVAL EFFICIENCIES AT SITE SSI-C[a]

Homologue	Scrubber Removal Efficiency, (%)			
	Run 01	Run 02	Run 03	Average
Dioxins				
2378 TCDD	NA	NA	NA	NA
Other TCDD	NA	-119.9	44.0	-38.0
Penta-CDD	NA	NA	-64.2	-64.2
Hexa-CDD	NA	-8.0	37.5	14.8
Hepta-CDD	NA	33.6	53.7	43.7
Octa-CDD	NA	59.2	66.9	63.1
Total PCDD	NA	38.2	54.4	46.3
Furans				
2378 TCDF	NA	-9.6	63.5	27.0
Other TCDF	NA	-45.6	25.7	-10.0
Penta-CDF	NA	-4.9	40.6	17.9
Hexa-CDF	NA	-312.8	-94.0	-203.4
Hepta-CDF	NA	-17.9	-122.2	-70.1
Octa-CDF	NA	8.0	-42.6	-17.3
Total PCDF	NA	-21.6	27.9	3.2

[a]Concentrations used in the calculation were corrected to 3 percent oxygen.

NA = not applicable. Inlet results for Run 01 and the 2378 TCDD isomer were invalid for all three runs. Additionally, the penta-CDD isomer was not detected in the Run 02 inlet sample.

TABLE 5-17. SUMMARY OF DIOXIN PRECURSOR DATA FOR SITE SSI-C FEED SAMPLES

Precursor Categories	Precursor Concentration, ug/g (ppm) Sludge Feed Sample			
	Run 1	Run 2	Run 3	Average
Total Chlorinated Benzenes	0.003	0.03	ND	.011
Total Chlorinated Biphenyls	ND	ND	ND	ND
Total Chlorinated Phenols	ND	ND	ND	ND

ND = not detected.

TABLE 5-18. SUMMARY OF TOTAL CHLORIDE AND TOTAL ORGANIC HALIDE DATA FOR SEWAGE SLUDGE FEED

Test Run	Total Chloride (ppm)	Total Organic Halogen (TOX)
Run 01	304.4	ND
Run 02	279.7	NA
Run 03	300.9	NA
Average	295.0	--

ND = not detected
NA = not available. Only Run 1 sludge feed sample was analyzed for TOX.

TABLE 5-19. DIOXIN/FURAN CONCENTRATIONS IN THE BOTTOM ASH AT SITE SSI-C

Dioxin/Furan Isomer	Dioxin/Furan Content (parts per billion) Run 01	Run 02	Run 03
Dioxins			
2378 TCDD	ND	ND	ND
All TCDD	ND	ND	ND
Penta CDD	ND	ND	ND
Hexa CDD	ND	ND	ND
Hepta CDD	ND	ND	ND
Octa CDD	0.02	0.02	0.02
Total PCDD	0.02	0.02	0.02
Furans			
2378 TCDF	ND	ND	ND
All TCDF	ND	0.12	ND
Penta CDF	ND	ND	ND
Hexa CDF	0.06	ND	ND
Hepta CDF	0.03	ND	ND
Octa CDF	ND	ND	ND
Total PCDF	0.09	0.12	ND

ND = not detected. Detection limits ranged from 0.001 to 0.1 ppb, with an average detection limit of 0.01 ppb.

The scrubber water samples were filtered, resulting in two distinct components: filterable scrubber solids, and scrubber filtrate. The results of the dioxin/furan analyses for the solids are given in Table 5-20 and the filtrate analyses are given in Table 5-21. The between-run dioxin/furan concentrations were fairly consistent for both sample components. The vast majority (over 95 percent) of the dioxin/furans in the solids were found in the tetra-, penta-, and hexa-CDF isomers. Only minor quantities (less than 3 parts per trillion of any given isomer) were detected in the filtrate.

5.7 SOIL SAMPLING DATA

Dioxin/furan analyses have not yet been performed on the soil sample obtained at Site SSI-C.

5.8 AMBIENT AIR SAMPLING

During the test period at Site SSI-C, ambient air samples were taken. In all, 24 hours of continuous ambient air samples were taken (8 hours for 3 days) and composited into one sample for dioxin/furan analysis. The results of the analysis are shown in Table 5-22. Minor quantities of some PCDD/PCDF homologues were detected in the ambient air.

TABLE 5-20. DIOXIN/FURAN CONTENT OF THE SCRUBBER BLOWDOWN SOLIDS AT SITE SSI-C

Dioxin/Furan Isomer	Amount of Dioxin/Furan Detected (nanograms)[a] Run 01	Run 02	Run 03
Dioxins			
2378 TCDD	ND	ND	ND
All TCDD	2.3	3.3	4.1
Penta CDD	0.3	0.5	ND
Hexa CDD	2.4	2.4	3.3
Hepta CDD	1.8	2.3	2.8
Octa CDD	1.4	2.3	2.3
Total PCDD	8.2	10.8	12.5
Furans			
2378 TCDF	18.9	20.6	27.2
All TCDF	84.0	95.5	122.8
Penta CDF	38.1	43.9	62.5
Hexa CDF	14.1	12.5	17.8
Hepta CDF	1.5	1.5	1.8
Octa CDF	0.2	0.2	0.2
Total PCDF	156.8	174.2	232.3

ND = not detected.
[a]Approximately 15 litres of scrubber blowdown water was filtered each run.

TABLE 5-21. DIOXIN/FURAN CONCENTRATIONS IN SCRUBBER FILTRATE AT SITE SSI-C

Dioxin/Furan Isomer	Dioxin/Furan Content (parts per trillion) Run 01	Run 02	Run 03
Dioxins			
2378 TCDD	ND	ND	ND
All TCDD	ND	0.1	0.1
Penta CDD	ND	ND	ND
Hexa CDD	ND	0.2	ND
Hepta CDD	ND	ND	ND
Octa CDD	0.2	0.1	0.1
Total PCDD	0.2	0.4	0.2
Furans			
2378 TCDF	ND	ND	ND
All TCDF	ND	3.0	3.0
Penta CDF	0.1	2.0	2.0
Hexa CDF	0.1	0.8	0.7
Hepta CDF	0.2	0.1	0.1
Octa CDF	ND	ND	ND
Total PCDF	0.4	5.9	5.8

ND = not detected.

TABLE 5-22. DIOXIN/FURAN CONTENT OF AMBIENT AIR SAMPLES AT SITE SSI-C

Dioxins/Furans	Amount of Dioxin/Furan Detected ng/dscm
Dioxins	
2378 TCDD	ND (0.0004)
Other TCDD	ND (0.005)
Penta CDD	0.005
Hexa CDD	0.003
Hepta CDD	0.005
Octa CDD	0.01
Total PCDD	0.023
Furans	
2378 TCDF	0.02
Other TCDF	0.09
Penta CDF	0.035
Hexa CDF	0.015
Hepta CDF	ND (0.01)
Octa CDF	ND (0.002)
Total PCDF	0.16

ND = not detected at specified minimum limits of detection.

6.0 SAMPLING LOCATIONS AND PROCEDURES

Samples were collected from six different locations around the Site 12 incinerator. The specific sampling locations were shown previously in Figure 4-1. Two of the locations were for gaseous sampling, one was for liquid/slurry sampling, and three were for solids sampling. The source sampling and analysis matrix previously shown in Table 4-1 gave the sample locations, the parameters measured, the sampling methods, and the analysis methods.

Details on the sampling locations and methods are discussed in Sections 6.1 through 6.3. Analytical procedures for continuous monitoring samples and molecular weight determinations are included in section 6.1. All other analytical procedures are discussed in Section 7.

6.1 GASEOUS SAMPLING

Three types of gaseous samples were taken during this test program: Modified Method 5 (MM5), EPA Method 3, and continuous emissions monitoring (CEM). The sampling locations and methods are further discussed in this section.

6.1.1 Gaseous Sampling Locations

6.1.1.1 Scrubber Exhaust Stack. The scrubber exhaust stack sampling location for Incinerator SSI-C was shown as Point A in Figure 4-1. This location was used for dioxin/furan sampling according to MM5 procedures described in Section 6.1.2. EPA Methods 2, 3, and 4 were also performed to determine the volumetric flow rate, molecular weight and moisture content of the exhaust gas, respectively.

The sample port locations and dimensions are shown in Figure 6-1. The inside diameter of the stack was 1.3m (4.3 ft.). Two 4-inch diameter ports, oriented 90 degrees apart, were used for sampling. The sampling platform was approximately six stories above ground level and enclosed in the incinerator

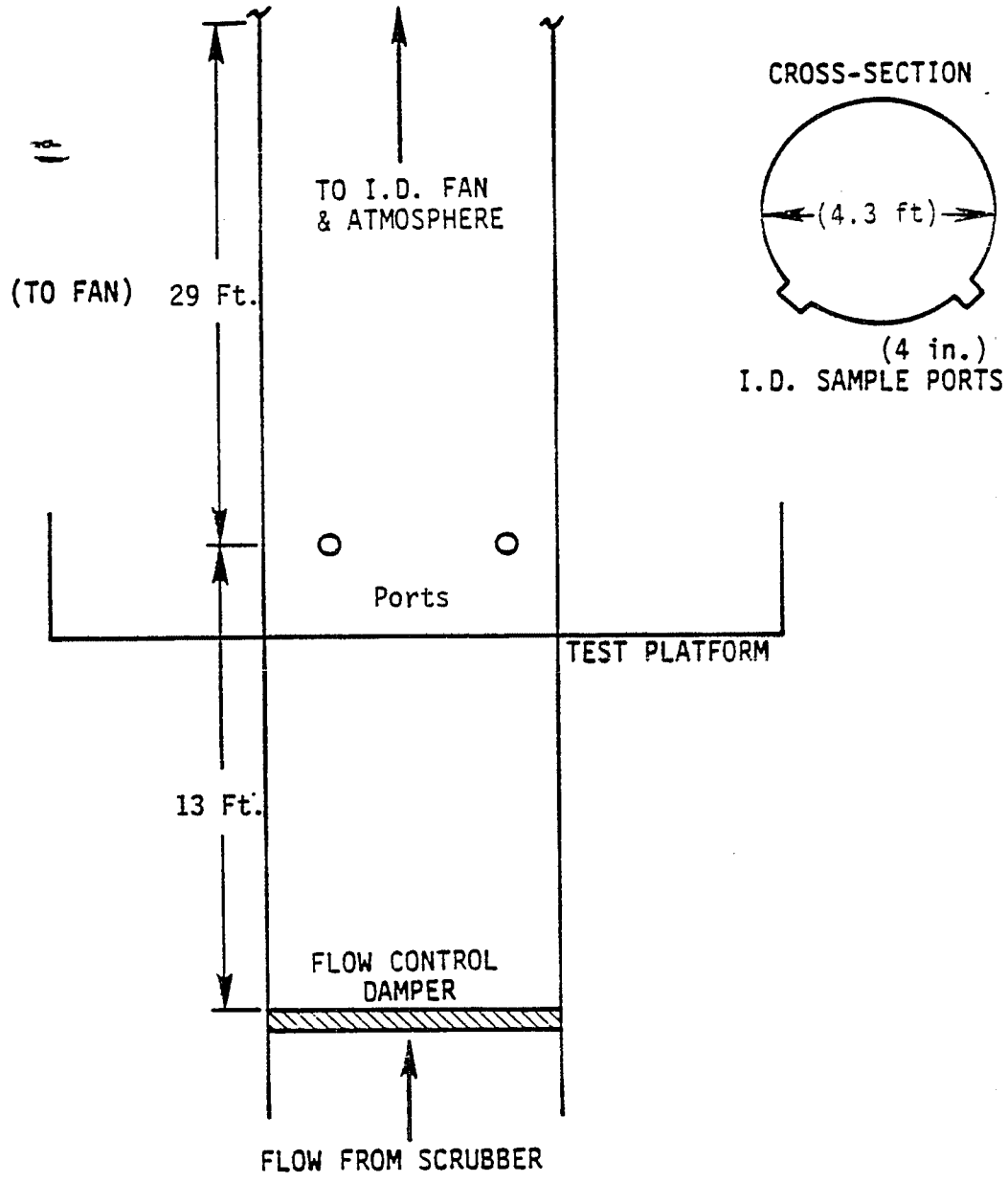


Figure 6-1. Incinerator SSI-C existing scrubber outlet sampling location.

building. The sample ports were 12 feet (approximately three equivalent stack diameters) downstream of a flow control damper and 30 feet (approximately seven equivalent stack diameters) upstream of the induced draft fan. The static pressure was -13 inches of water at the sample ports, and the gas stream temperature averaged 90^{0}F during the test periods.

Sampling was conducted using 24 traverse points. Sampling was conducted for 10 minutes per traverse point for a total of four hours of on-line sampling.

6.1.1.2 Scrubber Inlet (Incinerator Outlet). The scrubber inlet sampling location (i.e., incinerator outlet) was shown as Point B on Figure 4-1. This location was used for dioxin/furan sampling according to the MM5 procedure described in Section 6.1.2 and also for continuous monitoring of O_2, CO, CO_2, SO_2, NO_x and THC. EPA Methods 2, 3, and 4 were also performed to determine the volumetric flow rate, molecular weight of the exhaust gas, and moisture content of the exhaust gas, respectively.

The sample port locations and dimensions are shown in Figure 6-2. The inlet sampling location was a rectangular 10-feet wide by 7-feet high, horizontal duct. The duct had six 4-inch ports spaced approximately one foot apart vertically on the duct.

The ports were approximately 40 inches downstream from the top of the incinerator and eight feet upstream of a 90^{0} bend in the duct. The gas temperature averaged 904^{0}F during the test periods.

This location did not meet the minimum specifications for sample port locations as outlined in EPA Method 1. Forty-eight traverse points were used. Each point was sampled for 5 minutes, for a total of four hours of on-line sampling.

Continuous monitoring was conducted at this location using a port not in service for the dioxin/furan train. The heat-traced sample line was routed through a window and down the side of the building to the mobile laboratory. Approximately 150 feet of heat-traced sample line was required.

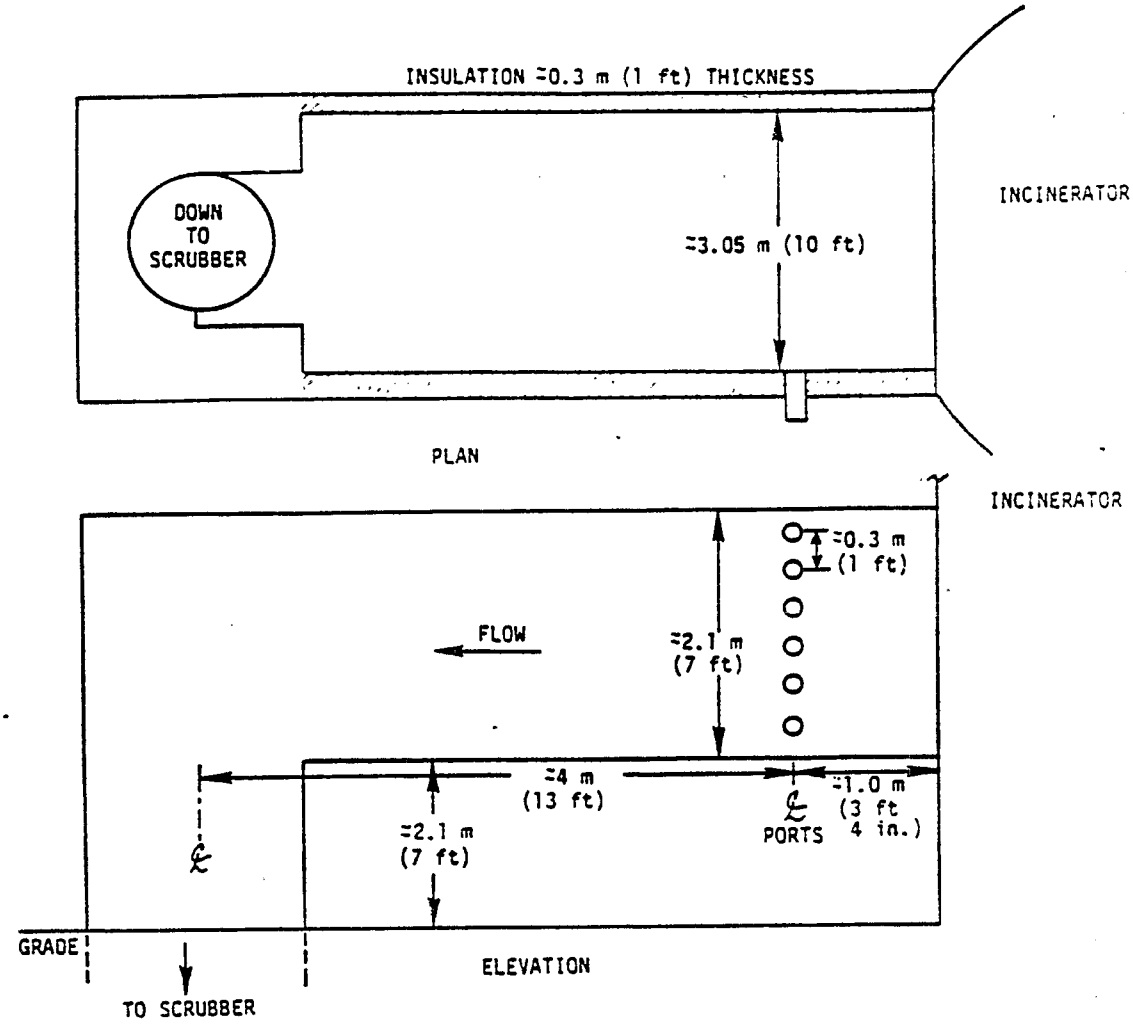


Figure 6-2. Incinerator SSI-C scrubber inlet sampling location.

6.1.2 Gas Sampling Procedures

Gas sampling procedures used during this program are discussed in detail in the Tier 4 QAPP.[1] A summary of the gas sampling methods used at Site SSI-C is given in Table 6-1, and a brief description of each method is provided in the following sections.

6.1.2.1 Modified Method 5 (MM5). Gas sampling for dioxins was conducted according to the October 1984 draft of the ASME chlorinated organic compound sampling protocol with two exceptions. This sampling method is a modified version of EPA Method 5 that includes a solid sorbent module for trapping vapor phase organics. The only differences in the sampling protocol which were not discussed in the Tier 4 QAPP are:

(1) Benzene was substituted for hexane or toluene as both the cleanup and extractant solvent for both the MM5 filters and the XAD-2 resin. This was caused by a discrepancy between the draft ASME sampling protocol and the draft ASME analytical protocol. (November 16, 1985)

(2) Methylene chloride was substituted for hexane as the final field rinse solvent for the MM5 train. Methylene chloride was also substituted for hexane in the glassware cleaning procedure. This was caused by a high field blank train. (February 27, 1985)

At the exhaust stack location, the MM5 samples were collected over a 4-hour sample period in an attempt to provide a targeted minimum sample volume of 3.4 dscm (120dscf). The nozzle selected was slightly smaller than the ideal diameter, but the next nozzle size was too large. Thus a slightly smaller sample volume was collected (about 105 dscf).

The MM5 samples were collected within the ± 10% isokinetic error range except for Run 2. Run 2 was 86% isokinetic; however, this is not expected to affect the dioxin results.

TABLE 6-1. SUMMARY OF GAS SAMPLING METHODS FOR SITE SSI-C

Sample Location	Sample Type or Parameter	Sample Collection Method
Scrubber Outlet Exhaust Stack (Point A in Figure 4-1)	Dioxin/furan	Modified EPA Method 5
	Volumetric flow	EPA Method 2
	Molecular weight	EPA Method 3
	Moisture	EPA Method 4
Scrubber Inlet (Point B in Figure 4-1)	Dioxin/furan	Modified EPA Method 5
	Volumetric flow	EPA Method 2
	Molecular weight	EPA Method 3
	Moisture	EPA Method 4
	CO, CO_2, O_2, NO_x, SO_2, and THC	Continuous Monitors

At the incinerator outlet the MM5 samples were collected isokinetically over a four hour sampling period providing a minimum sample volume of 2.5 dscm (90 dscf).

Based on the QAPP, the MM5 sampling rate at both locations was targeted to be between 0.014 and 0.021 scmm (0.5 and 0.75 scfm). Due to the smaller nozzle size at the exhaust stack location, the sampling rate was about 0.45 scfm. At the incinerator outlet the sampling rate ranged from 0.65 to 0.73 scfm.

Following sample recovery, the various parts of the sample (filter, solvent rinses, sorbent trap, etc.) were sent to the EPA's Troika laboratories to quantify 2,3,7,8-TCDD, the tetra- through octa-PCDD homologues, and the tetra- through octa-PCDF homologues present in the samples.

A schematic diagram of the MM5 sampling train is shown in Figure 6-3. Flue gas is pulled from the stack through a nozzle and a glass-lined probe. Particulate matter is removed from the gas stream by means of a glass fiber filter housed in a teflon-sealed glass filter holder maintained at $120^{o}C \pm 14^{o}C$ ($248 \pm 25^{o}F$). The gas passes through a sorbent trap similar to that illustrated in Figure 6-4 for removal of organic constituents. The trap consists of separate sections for cooling the gas stream, and adsorbing the organic compounds on Amberlite XAD-2^{R} resin (XAD). A chilled impinger train following the sorbent trap is used to remove water from the flue gas, and a dry gas meter is used to measure the sample gas flow.

6.1.2.2 Volumetric Gas Flow Rate Determination. The volumetric gas flow rate was determined using EPA Method 2. Based on this method, the volumetric gas flow rate is determined by measuring the average velocity of the flue gas and the cross-sectional area of the duct. The average flue gas velocity is calculated from the average gas velocity pressure (P) across an S-type pitot tube, the average flue gas temperature, the wet molecular weight, and the absolute static pressure.

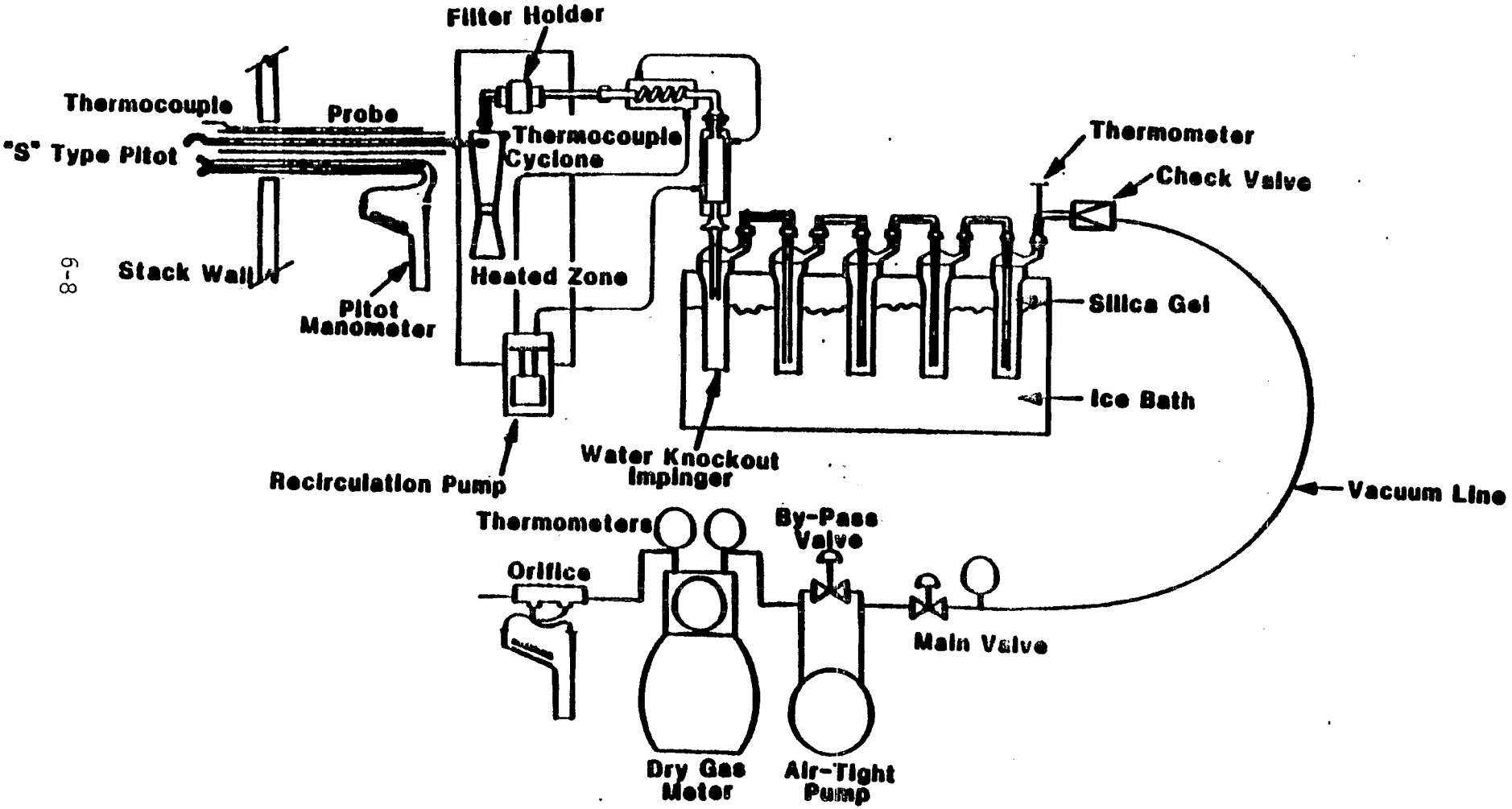


Figure 6-3 Modified Method 5 train.

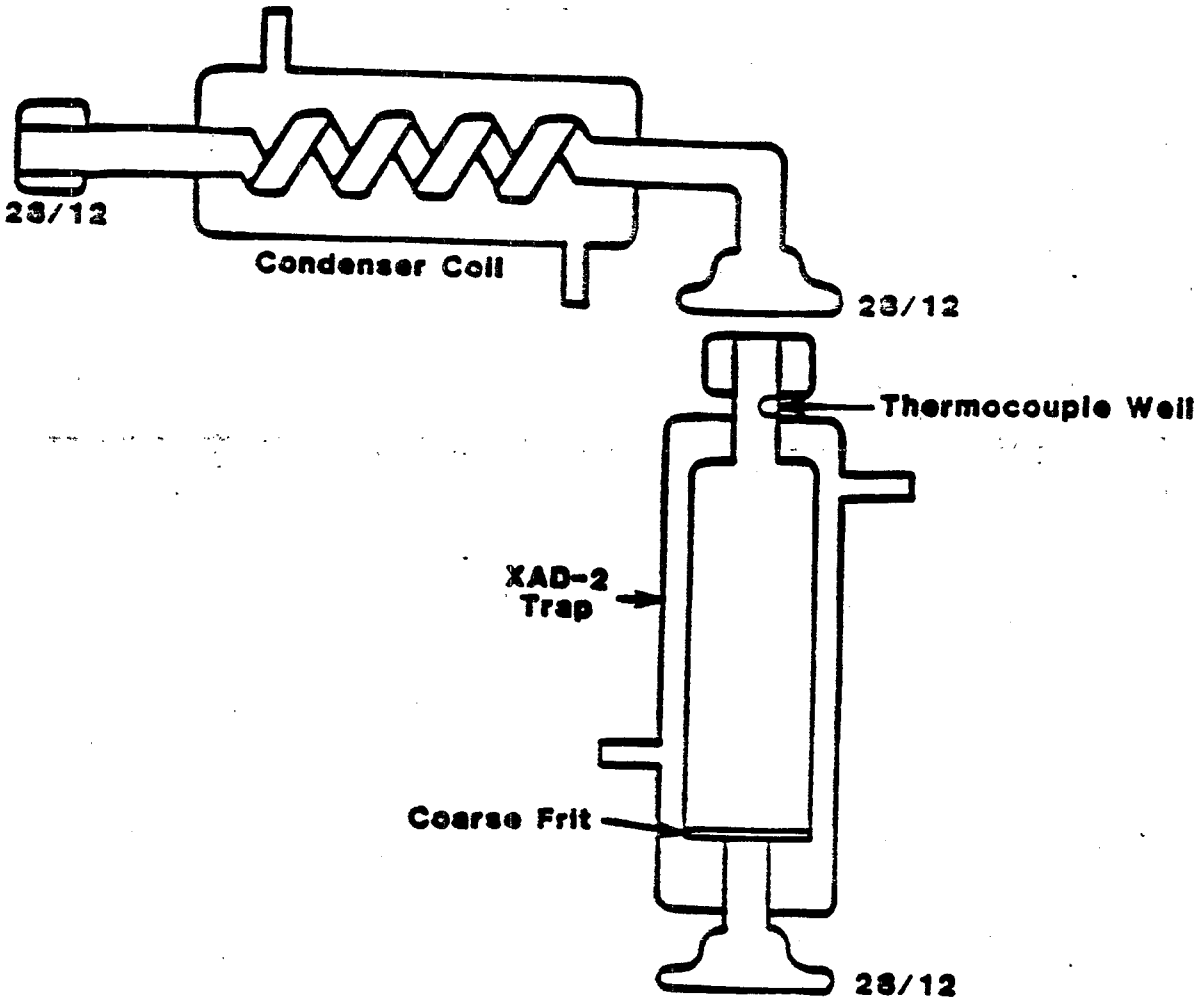


Figure 6-4 Adsorbent sampling system.

6.1.2.3 Flue Gas Moisture Determination. The moisture content of the flue gas was determined using EPA Method 4. Based on this method, a known volume of particulate-free gas is pulled through a chilled impinger train. The quantity of condensed water was determined gravimetrically and then related to the volume of gas sample to determine the moisture content.

6.1.2.4 Flue Gas Molecular Weight Determination. The integrated sampling technique described in EPA Method 3 was used to obtain a composite flue gas sample for fixed gas (O_2, CO_2, N_2) analysis. The fixed gas analysis was used to determine the molecular weight of the gas stream. A small diaphragm pump and a stainless steel probe were used to extract single point flue gas samples. The samples were collected at the sampling ports using Tedlar^R bags. Moisture was removed from the gas sample by a water-cooled condenser so that the fixed gas analysis was on a dry basis.

The composition of the gas sample was determined using a Shimadzu Model 3BT analyzer instead of the Fyrite or Orsat analyzer prescribed in Method 3. The Shimadzu instrument employs a gas chromatograph and a thermal conductivity detector to determine the fixed gas composition of the sample.

6.1.2.5 Continuous Emissions Monitoring. Continuous emissions monitoring was performed in the exhaust stack for O_2, CO_2, CO, NO_x, SO_2 and THC throughout the period that dioxin sampling was being conducted each test day. The primary intent of the continuous monitoring effort was to observe fluctuations in flue gas parameters, and to provide an indication of combustion conditions. Sample acquisition was accomplished using an in-stack filter probe and Teflon^R sample line connected to a mobile laboratory. The heat-traced sample line was maintained at a temperature of at least 102^{o}C (250^{o}F) to prevent condensation in the sample line. The stack gas sample was drawn through the filter and sample line using pumps located in the mobile laboratory. Sample gas to be analyzed for O_2, CO_2, CO, SO_2 and NO_x was pumped through a sample gas conditioner, which consisted of an ice bath and knockout trap. The sample gas conditioner removes moisture and thus provides a dry gas stream for analysis. A separate unconditioned gas stream was supplied to the THC analyzer for analysis on a wet basis.

An Anarad Model 412 nondispersive infrared analyzer was used to measure CO and CO_2; a Beckman Model 755 paramagnetic analyzer was used to measure O_2; and a Beckman Model 402 flame ionization analyzer was used to measure THC. Also, a Teco Model 10AR chemiluminescence analyzer was used to measure NO_x; and a Teco Model 40 pulsed fluorescence analyzer was used to measure SO_2. Calibration of the continuous monitors was performed according to the procedures outlined in the QAPP. These procedures included a three point (two upscale plus zero) linearity check on the first test day, single point and zero point calibration checks daily, and single point drift checks at the end of each test day.

6.2 SLURRY SAMPLING

For each test run, three composite samples of scrubber effluent were collected. The scrubber effluent was sampled hourly from a sampling tap on a 1-inch pipe near the bottom of the scrubber. The line was flushed before each sample was taken.

Troika had requested that the scrubber effluent be filtered into a filterable solids sample and a corresponding filtrate sample. The hourly scrubber effluent samples were filtered using a pressurized filtration system shown schematically in Figure 6-5. The apparatus consisted of a pressure filtration vessel, Whatman^R No. 42 filters, a tank of high-purity nitrogen, a two-stage regulator, and a container for filtrate collection. Approximately one gallon of scrubber blowdown slurry was filtered each hour. About 1/4 gallon at a time was poured into the pressure vessel and the vessel was slowly pressurized with the nitrogen to a maximum pressure of 50 psig. The time required to filter a gallon was approximately 20 to 30 minutes.

The filters used to separate the scrubber solids and aqueous filtrate have a rated collection efficiency of greater than 99 percent for particles larger than 3 microns. To minimize the required filtering time, the filters were replaced after every two liters of scrubber blowdown were filtered. The used filters and collected solids were removed from the pressure device with pre-cleaned teflon-coated tweezers and placed in a precleaned Petri dish.

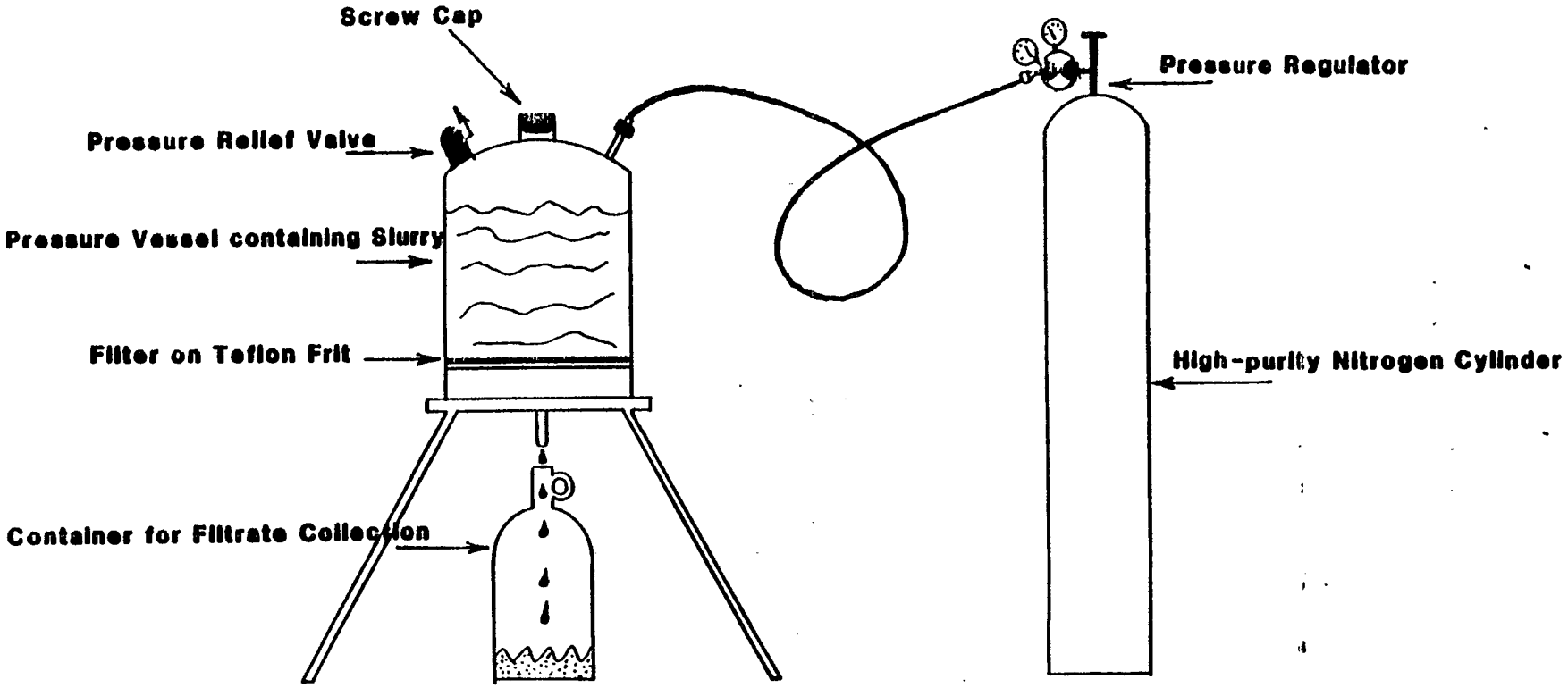


Figure 6-5. APPARATUS FOR PRESSURE FILTRATION OF SCRUBBER BLOWDOWN SLURRY

About six gallons of scrubber effluent were sampled for each test run producing about 1 gram of filterable solids each run. A one gallon composite of the scrubber effluent filtrate and the filterable solids were submitted to Troika. The scrubber effluent samples analyzed for chlorinated styrene and chlorinated napthalene were filtered in a similar manner. In addition to the filtered scrubber effluent samples, one liter composite samples of unfiltered scrubber effluent were collected for each run. These samples were returned to Radian for determination of solids content (weight percent solids).

6.3 SOLIDS SAMPLING

At Site SSI-C, solid samples were collected of the feed sludge, the incinerator bottom ash and the soil surrounding the plant. The sampling locations and methods are discussed in the following sections.

6.3.1 Feed Sludge Sampling

Four identical composite samples of the feed sludge were prepared from hourly grab samples for each test run. The sludge was collected from the feed conveyor using a scoop. The hourly samples were placed in a covered Tier 4-cleaned stainless steel bucket and thoroughly mixed with a drill with a mixing attachment for compositing. The samples were sent to Radian/RTP for dioxin precursor analysis, to Research Triangle Institute for total chloride analysis, to Region V for chlorinated styrene and chlorinated naphthalene analysis and to Troika for dioxin/furan analysis (which was not performed).

6.3.2 Bottom Ash Sampling

Two identical composite samples of the incinerator bottom ash were prepared from the hourly samples for each test run. The ash was collected from the bottom hearth of the incinerator and composited in a covered Tier 4-cleaned stainless steel bucket. The samples were sent to Troika for dioxin/furan analysis and to Region V for chlorinated styrene and chlorinated naphthalene analysis.

6.3.3 Soil Sampling

The third solid sample collected was a single composite soil sample comprised of 10 individual soil samples. Soil sampling protocol for Tiers 3, 5, 6, and 7 of the National Dioxin Study are specified in the document, "Sampling Guidance Manual for the National Dioxin Study." A similar protocol was used for soil sampling at Site SSI-C. A total of 10 soil sampling locations were selected according to the directed site selection approach described in the above document. The 10 individual soil sampling locations were discussed and determined in conjunction with plant personnel on-site. The 10 individual soil sampling locations are shown in Figure 6-6.

Soil samples were collected by forcing a bulb planter into the soil to a depth of three inches. The soil samples were composited in a Tier 4-cleaned stainless steel bucket. Five hundred grams of the composite were placed in a 950 ml glass amber bottle and archived at Radian for potential dioxin/furan analysis by Troika.

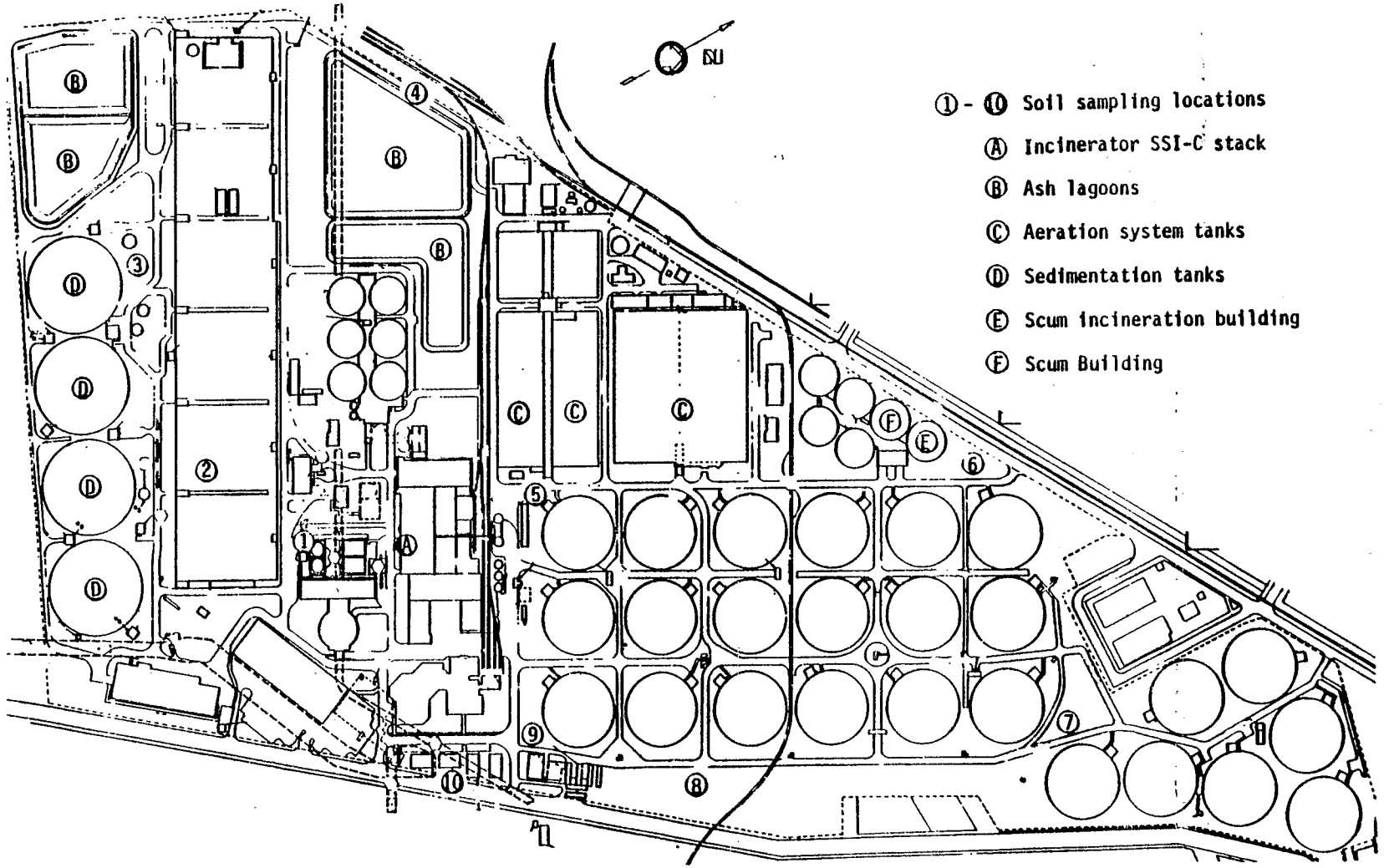


FIGURE 6-6. Site Plot Plan and Soil Sampling Locations for Site SSI-C.

7.0 ANALYTICAL PROCEDURES

Laboratory procedures used to quantify dioxins/furans and dioxin/furan precursors in the Tier 4 samples are described in this section. MM5 train samples were analyzed by EPA's Troika laboratories for dioxin/furan content. Procedures used for these analyses are described in detail in the Analytical Procedures and QA Plan for the Analysis of Tetra through Octa CDD's and CDF's in Samples from Tier 4 Combustion and Incineration Processes (addendum to EPA/600/3-85-019, April 1985). These procedures are summarized in Section 7.1.

Combustion device feed samples from Site SSI-C were analyzed by Radian to determine concentrations of chlorinated phenols (CP), chlorobenzenes (CB), polychlorinated biphenyls (PCBs), total organic halogen (TOX) and total chlorine. Procedures used for these analyses are detailed in Section 7.2.

7.1 DIOXINS/FURANS

The analytical procedures summarized in this section were used by Troika for dioxin/furan analysis of MM5 train samples from Site SSI-C. Samples consisting of organic solvents, aqueous solutions, and solids were prepared for analysis using slightly different procedures. The organic solvent samples consisted of rinses from the MM5 probe, nozzle, filter housing and condenser coil. Aqueous samples consisted of impinger catch solutions, and solid samples included filters and XAD resin. Isotopically-labeled surrogate compounds were added to all samples prior to extraction to allow determination of method efficiency and for quantification purposes.

Organic liquid samples (e.g., acetone and methylene chloride-based MM5 train rinses) were concentrated using a nitrogen blowdown apparatus. The residue, which contained particulate matter from the MM5 train probe and nozzle, was combined with the filter and handled as a solid sample. Solid samples were extracted with benzene in a Soxhlet apparatus for a period of at least 16 hours. The extract was concentrated by nitrogen blowdown and subjected to chromatographic cleanup procedures.

Aqueous solutions (e.g., MM5 train impinger samples) were extracted with hexane by vigorous shaking for a three hour period. This extraction procedure

was repeated three times, with the organic fractions ultimately being combined and concentrated for chromatographic cleanup.

The cleanup procedure involved using liquid chromatographic columns to separate the compounds of interest from other compounds present in the samples. Four different types of columns were used: a combination acid and base modified silica gel column, a basic alumina column, a PX-21 carbon/celite 545 column and a silica/diol micro column. These were used in successive steps, with the last two being used only if necessary.

The cleaned samples were analyzed using high resolution gas chromatography/high resolution mass spectrometry (GC/MS). The conditions for the analyses were as follows:

Gas Chromatograph - Injector configured for capillary column, splitless injection; injector temperature 280°C; helium carrier gas at 1.2 ml/min; initial column temperature 100°C: final column temperature 240°C; interface temperature 270°C.

Mass Spectrometer - Varian/MAT Model 311A; electron energy 70ev; filament emission 1MA; mass resolution 8000 to 10,000; ion source temperature 270°C.

7.2 DIOXIN/FURAN PRECURSORS

Feed samples for Site SSI-C were analyzed by Radian/RTP for chlorophenols (CP), chlorobenzenes (CB) and polychlorinated biphenyls (PCBs) by GC/MS; total organic halides (TOX) by GC/Hall detector; total chlorine by Parr Bomb combustion followed by ion chromatography. Analytical procedures are discussed in the following sections.

7.2.1 GC/MS Analyses

The analytical procedures used for determining CP, CB, and PCB concentrations in feed samples are modified versions of procedures typically used for the analysis of MM5 train components. These procedures involve

initial extraction of the sample with an appropriate solvent, preliminary separation of the compounds of interest by solvent partitioning and liquid chromatography, and analysis of the processed fractions. Solutions containing CB and PCB are injected directly into the GC/MS, and solutions containing CP are derivatized prior to injection. Details on the procedures used for Site SSI-C samples are provided in the sections below.

7.2.1.1 Sample Preparation

A flow chart for the sample preparation procedure used for Site SSI-C feed samples is shown in Figure 7-1. The first step in the procedure involved adding labeled surrogate compounds to provide a measure of extraction method efficiency. The next step involved adding a mixture of 50/50 $MeCl_2$/Hexanes to the sample and sonicating the sample for 30 minutes. The sonicated sample was filtered and the filtrate was extracted three times in a separatory funnel with 50 ml 0.5 N NaOH and the aqueous and organic fractions were saved for derivatization and/or further cleanup. The aqueous fraction (or acids portion) was acidified to pH2 with 1:1 H_2SO_4 and then extracted three times with 50 ml $MeCl_2$. The $MeCl_2$ from this extraction was dried with anhydrous Na_2SO_4, exchanged to benzene, and concentrated using a nitrogen blowdown apparatus. Acetylation of any CP present in the sample involved the following steps:

1. 2.0 mL isooctane, 2.0 mL acetonitrile, 50 uL pyridine, and 20 uL acetic anhydride were added to the extract. The test tube containing the extract was placed in a 60°C water bath for 15 minutes and was shaken 30 seconds every 2 minutes.
2. 6 mL of 0.01 N H_3PO_4 to the test tube, and the sample was agitated for 2 minutes on a wrist action shaker.
3. The organic layer was removed and the quantitation standard was added. The sample was concentrated in a Reacti-Vial at room temperature (using prepurified N_2) to 1 mL prior to GC/MS analysis.

Cleanup of the organic (or base/neutrals) layer from the first 0.5 N NaOH extraction involved successively washing the extract with concentrated H_2SO_4 and double-distilled water. The acid or water was added in a 20 mL portion

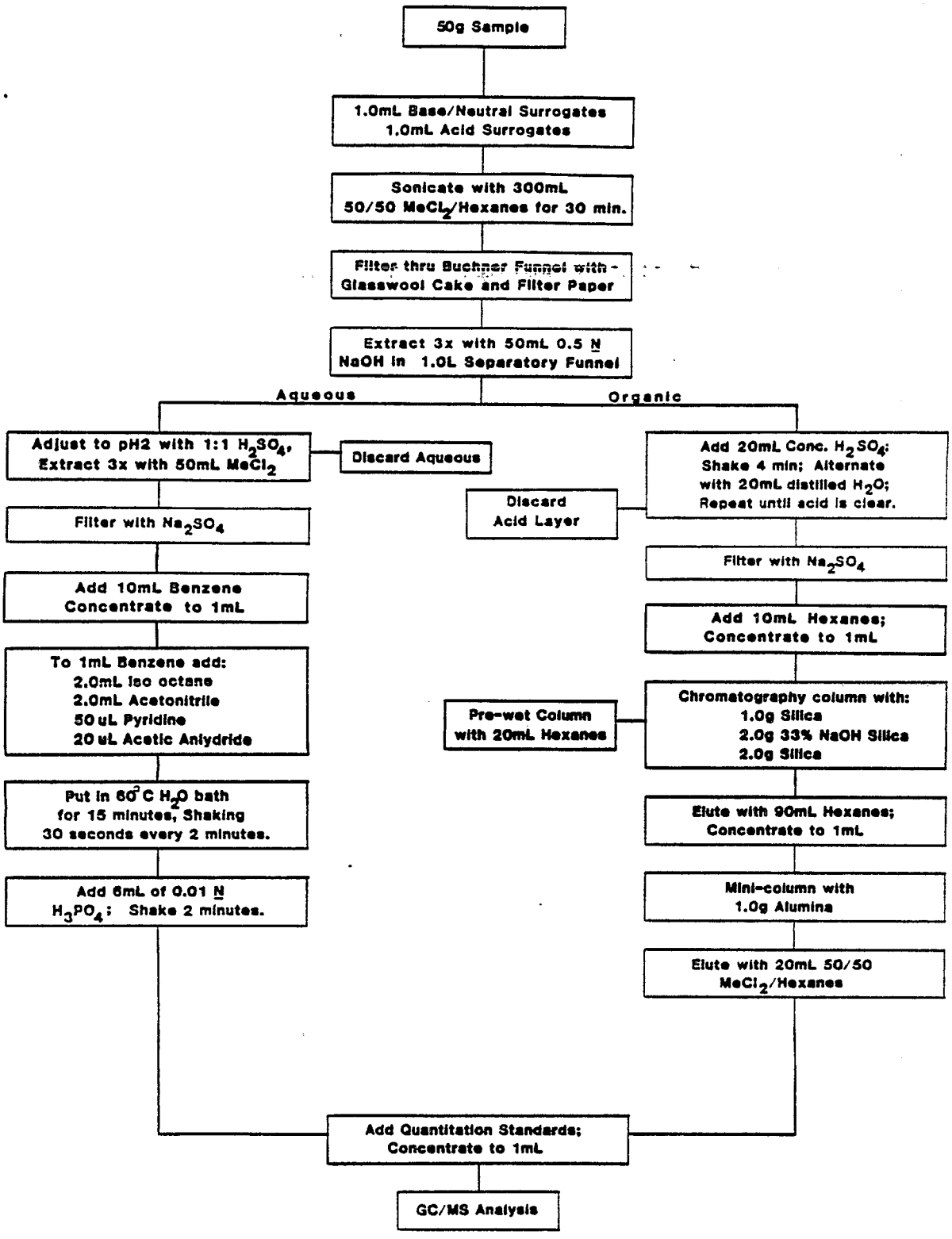


Figure 7-1. Sample Preparation Flow Diagram for Site SSI-C Precursor Analyses

and the sample was shaken for four minutes. After the aqueous (or acid) and organic layers were completely separated, the acid layer was discarded. The acid washing procedure was repeated until the acid layer was colorless. The organic fraction from the final wash was dried with anhydrous Na_2SO_4, exchanged to hexane and concentrated. Final cleanup of the sample by column chromatography involved the following procedure.

A glass macro-column, 20 mm o.d. x 230 mm in length, tapered to 6 mm o.d. on one end was prepared. The column was packed with a plug of silanized glass wool, followed successively by 1.0 g silica, 2.0 g silica containing 33% (w/w) 1 N NaOH, and 2.0 g silica. The concentrated extract was quantitatively transferred to the column and eluted with 90 mL hexane. The entire eluate was collected and concentrated to a volume of 1 mL in a centrifuge tube.

A disposable liquid chromatography mini-column was constructed by cutting off a 5-mL Pyrex disposable pipette at the 2.0 mL mark and packing the lower portion of the tube with a small plug of silanized glass wool, followed by 1 g of Woehlm basic alumina. The alumina had been previously activated for at least 16 hours at 600°C in a muffle furnace and cooled in a desiccator for 30 minutes just before use. The concentrated eluate from above was quantitatively transferred onto the liquid chromatography column. The centrifuge tube was rinsed consecutively with two 0.3-mL portions of a 3 percent $MeCl_2$: hexane solution, and the rinses were transferred to the liquid chromatography column.

The liquid chromatography column was eluted with 20 mL of a 50 percent (v/v) $MeCl_2$:hexane solution, and the eluate was concentrated to a volume of approximately 1 mL by heating the tubes in a water bath while passing a stream of prepurified N_2 over the solutions. The quantitation standard was added and the final volume was adjusted to 1.0 mL prior to GC/MS analysis.

7.2.1.2 Analysis

Analyses for CP, CB and PCBs present in the feed sample extracts were performed with a Finnigan Model 5100 mass spectrometer using selected ion monitoring. A fused silica capillary column was used for chromatographic separation of the compounds of interest. Analytical conditions for the GC/MS analysis are shown in Table 7-1.

TABLE 7-1. INSTRUMENT CONDITIONS FOR GC/MS PRECURSOR ANALYSES

Parameter	Chlorobenzenes/ Polychlorinated biphenyls	Chlorophenols
Column	30 m WB DB-5 (1.0 u film thickness) fused silica capillary	
Injector Temperature	290°C	290°C
Separator Oven Temperature	290°C	290°C
Column Head Pressure	9 psi	9 psi
He flow rate	1 mL/min	1 mL/min
GC program	40(4)-290°C, 10°/min & hold	40(1)-290°C, 12°/min & hold
Emission Current	0.50 ma	0.50 ma
Electron Energy	70 ev	70 ev
Injection Mode	Splitless 0.6 min, then 10:1 split	
Mode	Electron ionization, Selected Ion Monitoring	

Tuning of the GC/MS was performed daily as specified in the Tier 4 QA Project Plan. An internal-standard calibration procedure was used for sample quantitation. Compounds of interest were calibrated against a fixed concentration of either d_{12}-chrysene (for CB, PCB) or d_8-naphthalene (for CP). Components of the calibration solution are shown in Table 7-2. For multi-point calibrations, this solution was injected at levels of 10, 50, 100, and 150 ng/ul.

Compound identification was confirmed by comparison of chromatographic retention times and mass spectra of unknowns with retention times and mass spectra of reference compounds. Since the selected ion monitoring technique was necessary for the samples analyzed, care was taken to monitor a sufficiently wide mass region to avoid the potential for reporting false positives.

The instrument detection limit for the analytes of interest (i.e., CP, CB, and PCB) was estimated to be approximately 500 pg on column. For a 50 g sample and 100 percent recovery of the analyte, this corresponds to a feed sample detection limit of 10 ppb.

7.3 TOX ANALYSIS

Incinerator feed samples were analyzed for total organic halide (TOX) by short-column GC and a Hall detector (GC/Hall). Solid samples were extracted with benzene for at least 16 hours in a Soxhlet apparatus. The extracts were washed three times with 100 mL portions of reagent-grade water concentrated to 10 mL.

An attempt to use a fused silica capillary column to separate surrogates from target compounds was unsuccessful due to the complexity of the sample constituents. Determinations for TOX were therefore performed on samples without surrogates and no measure of extraction efficiency is available.

Instrument conditions are shown in Table 7-3. Sample quantitation was based on an average response factor developed from a mixture of chlorinated benzenes and brominated biphenyls. Individual CP, CB and PCBs were also injected at various concentrations to develop a calibration curve for comparison to the mixture response factors.

TABLE 7-2. COMPONENTS OF THE CALIBRATION SOLUTION

Base/Neutrals	Acids
4-chlorobiphenyl	2,5-dichlorophenol
3,3'-dichlorobiphenyl	2,3-dichlorophenol
2,4',5-trichlorobiphenyl	2,6-dichlorophenol
3,3'4,4'-tetrachlorobiphenyl	3,5-dichlorophenol
2,2',6,6'-tetrachlorobiphenyl	3,4-dichlorophenol
2,2,4,5,6-pentachlorobiphenyl	2,3,5-trichlorophenol
2,2',4,4',5,5'-hexachlorobiphenyl	2,3,6-trichlorophenol
2,2',3,4,4',5',6-heptachlorobiphenyl	3,4,5-trichlorophenol
2,2',3,3',4,4',5,5'-octachlorobiphenyl	2,4,5-trichlorophenol
2,2',3,3',4,4',5,6,6'-nonachlorobiphenyl	2,3,4-trichlorophenol
decachlorobiphenyl	2,3,5,6-tetrachlorophenol
p-dichlorobenzene	pentachlorophenol
1,2,4-trichlorobenzene	d_6-phenol (SS)
1,2,3,5-tetrachlorobenzene	d_4-2-chlorophenol (SS)
pentachlorobenzene	$^{13}C_6$-pentachlorophenol (SS)
hexachlorobenzene	d_8-naphthalene (QS)
d_4-1,4-dichlorobenzene (SS)[1]	2,4,6-tribromophenol (QS)
3-bromobiphenyl (SS)	d_{10}-phenanthrene (QS)
2,2',5,5'-tetrabromobiphenyl (SS)	d_{12}chrysene (QS)
2,2',4,4',6,6'-hexabromobiphenyl (SS)	
octachloronaphthalene (QS)[2]	
d_{10}-phenanthrene (QS)	
d_{12}-chrysene (QS)	

[1]Surrogate standard.
[2]Quantitation standard.

TABLE 7-3. ANALYTICAL CONDITIONS FOR TOX ANALYSIS

Hall Detector Conditions
Reactor temperature - 850°C
Solvent - n-propanol
Hydrogen flow rate - 35 mL/min
GC Conditions (Varian 3700)
Injection volume (1 - 5 uL)
Helium carrier gas flow rate - 60 mL/min
Column - 3-ft packed column with 1 in 10% OV 101
Column temperature - 200°C isothermal

7.4 TOTAL CHLORINE ANALYSIS

Total chlorine concentrations in feed samples were determined by Parr Bomb combustion followed by ion chromatography (IC). A 0.5g sample was placed in the Parr Bomb with 10 mL of a 50 g/L Na_2CO_3 solution. After combustion of the samples according to standard procedures (ASTM 2015), the contents of the bomb were rinsed into a 100 mL flask and diluted to 100 mL. The resulting solution was analyzed for chloride concentration (Cl^-) by IC using standard anion conditions. For samples difficult to combust (such as sludges), 25 drops of paraffin oils were added to the bomb prior to combustion.

8.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

This section summarizes results of quality assurance and quality control (QA/QC) activities for field sampling at Site 12. The flue gas and ash dioxin/furan data for this site were generally within the QC specifications presented in the Tier 4 Quality Assurance Project Plan (QAPP). All of the surrogate recoveries for labeled TCDD's were within the specified limits of 50 to 120 percent, except for the Run 01 inlet samples. However, the surrogate recoveries for the three inlet runs also did not meet the QC limits of 40 to 120 percent for hepta- and octa- CDD's. The results of the analysis of the fortified labroatory QC sample were all within 25 percent of the true value which is well within the Tier 4 objective of $\pm$50 percent. These data indicate that the dioxin/furan results are generally within accuracy criteria specified for Tier 4.

For the dioxin/furan precursor analysis of the feed samples, surrogate recoveries varied considerably. Several of the recoveries were below the specified QC limits of $\pm$ 50 percent. In spite of the low recoveries of the surrogate species, the dioxin/furan precursor results are considered a reasonable approximation of the true precursor concentration in the feed samples.

The following sections summarize the results of all Site 12 QA/QC activities. Manual gas sampling methods are considered in Seciton 8.1 and continuous emission monitoring and molecular weight determinations are considered in Section 8.2. The laboratory analysis QA/QC activities are summarized in Section 8.3.

8.1 MANUAL GAS SAMPLING

Manual gas sampling methods at Site 12 included Modified Method 5 (MM5), and EPA Methods 1 through 4. These methods are discussed in Section 6.0. Quality assurance and quality control (QA/QC) activities for the manual sampling methods centered around (1) equipment calibration, (2) glassware pre-cleaning, (3) procedural QC checks, and (4) sample custody procedures. Key activities and QC results in each of these areas are discussed in this section. Also discussed are problems encountered that may have affected data quality.

8.1.1 Equipment Calibration and Glassware Preparation

Pre-test calibrations or inspections were conducted on pitot tubes, sampling nozzles, temperature sensors and analytical balances. Both pre-test and post-test calibrations were performed on the dry gas meters. All of the field test equipment met the calibration criteria specified in the Tier 4 QAPP. Differences in the pre-test and post-test dry gas meter calibrations were less than 2 percent (%).

An extensive cleaning procedure was used for all sample train glassware and sample containers. This cleaning procedure, which is outlined in Table 8-1, was implemented to minimize the potential for sample contamination with substances that could interfere with the dioxin/furan analysis. To minimize the potential for contamination in the field, all sample train glassware was capped with foil prior to use and stored in a dust controlled environment.

A clean sample trailer was maintained for train assembly and sample recovery.

8.1.2 Procedural QC Activities/Manual Gas Sampling

Procedural QC activities during the manual gas sampling focused on:

- visual equipment inspections,
- utilization of sample train blanks,
- ensuring the proper location and number of traverse points,
- conducting pre-test and post-test sample train leak checks,
- maintaining proper temperature at the filter housing, sorbent trap and impinger train,
- maintaining isokinetic sampling rates, and
- recording all data on preformatted field data sheets.

Problems occurred during sampling as explained in Table 8-2. The problems are not expected to affect the validity of the dioxin concentration results.

Results of the isokinetic calculations for the MM5 test runs are shown in Table 8-3. The average isokinetic sampling rate for all sampling runs was within the QA objective of 100 $\pm$10 percent with the exception of Run 02 at the

TABLE 8-1. GLASSWARE PRECLEANING PROCEDURE

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot soapy water (Alconox^R) 50^{o}C or higher.
2. Distilled/deionized H_2O rinse (X3).[a]
3. Chromerge^R rinse if glass, otherwise skip to 6.
4. High purity liquid chromatography grade H_2O rinse (X3).
5. Acetone rinse (X3), (pesticide grade).
6. Methylene chloride rinse (X3), (pesticide grade).
7. Cap glassware with clean glass plugs or methylene chloride rinsed aluminum foils.

[a](X3) = three times.

TABLE 8-2. SAMPLING PROBLEMS ENCOUNTERED DURING TESTING AT SITE 12

Test No.	Problem	Resolution
Run 01 - outlet	Train fell, probe broke during port change	Leak check from filter back was good, changed probe liner, recovered both liners.
Run 01 - inlet	Front half filter housing breakage discovered during final leak check	The breakage occurred during sampling of the last two ports. The dioxin concentrations will be reported as a range. The higher concentration will be based on the sample volume at the end of the fourth port and the lower concentration will be based on the volume at the end of the sixth and final port.
Run 02 - inlet	Probe liner broke at end of run due to bent sheath.	Recovered liner in sections.
Run 03 - inlet	Remaining spare liners broke while trying to insert into sheath. Switched to a six foot probe.	Half the duct was sampled at 20 min per 24 points. Entire duct was transversed to verify that velocity profile was similar to Runs 1 and 2.

TABLE 8-3. SUMMARY OF ISOKINETIC RESULTS FOR SITE 12

Run	Incinerator Outlet	Meets QA Objective?[a]	Outlet Exhaust Stack	Meets QA Objective?[a]
01	95.1	yes	99.3	yes
02	90.7	yes	86.2	no
03	106.7	yes	97.1	yes

[a]The quality assurance objective for MM5 sampling was isokinetics of 100±10 percent.

outlet stack location. The isokinetic rate for Run 02 - outlet was 86.2 percent. This deviation from the QA objective is not expected to effect the validity of the dioxin concentration results.

Initial, final and port change leak checks for the MM5 and HCl sample trains were acceptable for all of the test runs except as noted for Run 01 at the inlet sample location. None of the reported sample volumes required correction for sample train leakage. All leak check data are noted on the MM5 field data sheets.

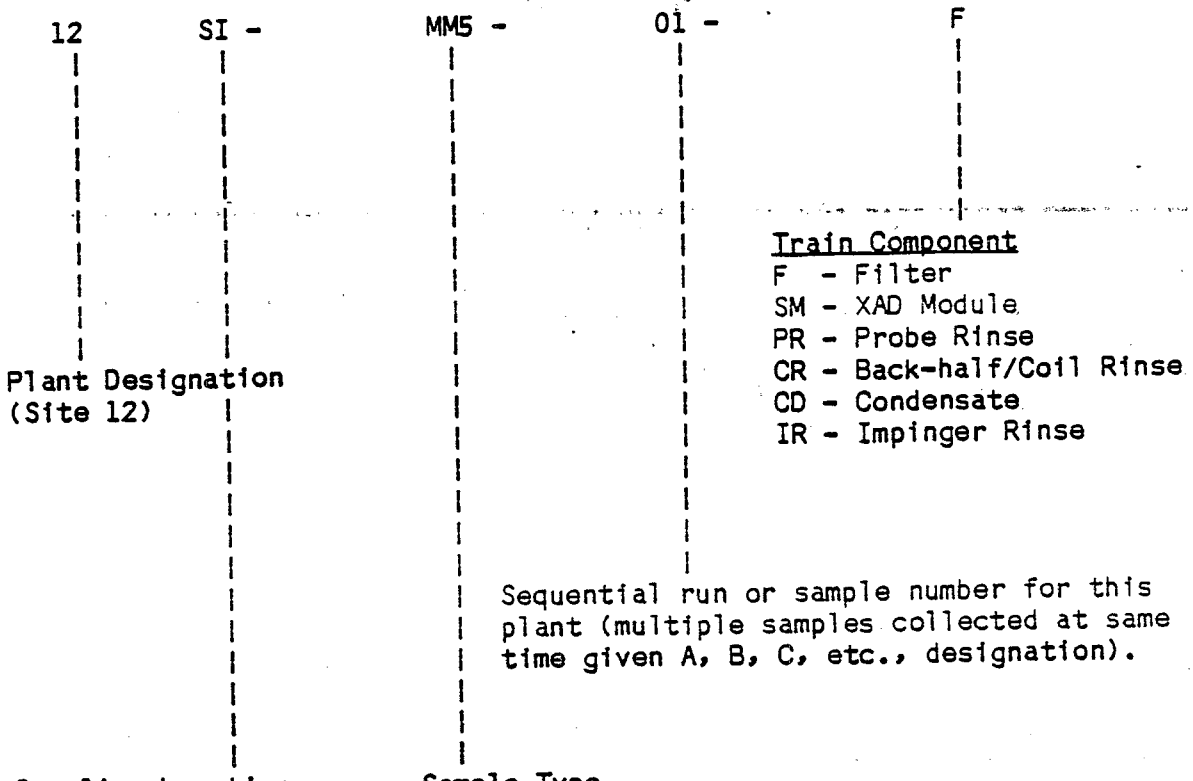
A blank sample train was used at the MM5 sample locations to determine the background levels of contaminants that might interfere with dioxin and furan analysis. The blank sample trains were treated as normal sample trains. The trains were transported to and assembled at the sample locations. Recovery was performed in the same sequence as a normal test run. All solvents used in the recovery of blanks came from the same container as was used for normal test runs.

8.1.3 Sample Custody

Sample custody procedures used during this program emphasized careful documentation of the samples collected and the use of chain-of-custody records for samples transported to the laboratory for analysis. Steps taken to identify and document samples collected included labeling each sample with a unique alphanumeric code shown in Figure 8-1 and logging the sample in a master logbook. All samples shipped to Troika or returned to Radian-RTP were also logged on chain-of-custody records that were signed by the field sample custodian upon shipment and also signed upon receipt at the laboratory. Samples for dioxin analysis were shipped to Troika from the field. A sample shipment letter was sent with the samples detailing their analysis priority which is contained in Appendix G. Each sample container lid was individually sealed to ensure that samples were not tampered with. No evidence of loss of sample integrity was reported for samples collected at this site.

8.2 CONTINUOUS MONITORING/MOLECULAR WEIGHT DETERMINATION

Flue gas parameters measured continuously at the inlet location during the MM5 test runs include CO, CO_2, O_2, SO_2, total hydrocarbons (THC) and NO_x.



Sampling Location

SI - Scrubber Inlet

SO - Scrubber Outlet

Sample Type

MM5 - Modified Method 5 train
O_2 - Oxygen
CO_2 - Carbon dioxide
CO - Carbon monoxide
NO_x - Nitrogen oxides
SO_2 - Sulfur dioxide
THC - Total hydrocarbon
IB - Integrated bag (Method 3)
BA - Bottom ash
SF - Sludge feed
S - Soil
SES - Scrubber Effluent Solids
SEF - Scrubber Effluent Filtrate
SE - Scrubber Effluent (Unfiltered)

FIGURE 8-1. ALPHANUMERIC SAMPLING CODE FOR SITE SSI-C

The concentration of O_2, CO_2, and N_2 were also determined for integrated bag samples of the flue gas. Quality control results for these analyses are discussed in this section.

Drift check results for the continuously monitored flue gas parameters are summarized in Table 8-4. Data reduction was performed by assuming a linear drift of the instrument response over the test day based on drift checks at the beginning and end of the day. The largest calibration drift was observed for the THC analyzer, which exceeded QC target goals of ± 10 percent drift during Run 3. The smallest instrument instrument drift was observed in the oxygen monitor.

The quality control standards for this program consisted of mid-range concentration standards that were intended for QC purposes and not for instrument calibration. The QC gases were analyzed immediately after calibration each day to provide data on day-to-day instrument variability. The acceptance criteria for the analysis of each QC standard was agreement within ± 10 percent of the running mean value. The criteria was met in all cases.

Molecular weight was determined by analyzing integrated bag samples of flue gas for O_2, CO_2 and N_2. Quality control for this analysis involved duplicate analyses of calibration gases immediately before and after sample analysis. Analysis of the calibration gases was repeated until two consecutive analyses within ±5 percent were obtained. This same criteria of ±5 percent applied to duplicate analyses required for sample quantification. These criteria were met for all molecular weight determination.

8.3 LABORATORY ANALYSIS

QA/QC activities were carried out for dioxin/furan, precursor, and total chloride analyses performed on Site SSI-C samples. The dioxin/furan analyses of MM5 train samples performed by Troika are considered in Section 8.3.1; the precursor and total chlorine analyses of sewage sludge feed samples performed by Radian/RTP and Research Triangle Institute are considered in Section 8.3.2; and the total chloride analyses of HCl train samples and process samples performed by Radian/Austin are considered in Section 8.3.3.

TABLE 8-4. SUMMARY OF DRIFT CHECK AND CONTROL STANDARD RESULTS

Test Date	Test Run	Param	Drift Check			QC Standard			
			Input Conc.	Instrument Drift, %[a]	Meets QC?[b]	Input Conc.	Output Conc.	Diff. from Running Mean, %	Meets QC?[c]
7/09/85	01	O2	18.2% V	1.05	Yes	11.9% V	11.8	--	Yes
7/10/85	02	O2	18.2% V	1.05	Yes	11.9% V	11.9	0.42	Yes
7/11/85	03	O2	18.2% V	-0.39	Yes	11.9% V	11.9	0.34	Yes
7/09/85	01	CO	5425 ppmV	8.44	Yes	2500 ppmV	2857.0	--	Yes
7/10/85	02	CO	5425 ppmV	-1.95	Yes	2500 ppmV	2789.7	-1.19	Yes
7/11/85	03	CO	5425 ppmV	1.93	Yes	2500 ppmV	2798.9	-0.58	Yes
7/09/85	01	CO2	19.1% V	16.9	No	9.74% V	—9.9	--	Yes
7/10/85	02	CO2	19.1% V	-21.8	No	9.74% V	10.7	3.8	Yes
7/11/85	03	CO2	19.1% V	12.87	No	9.74% V	10.3	0.0	Yes
7/09/85	01	SO2	-d	-d	-d	-d	-d	-d	-d
7/10/85	02	SO2	83.1 ppmV	-e	-e	19.6 ppmv	18.11	--	Yes
7/11/85	03	SO2	83.1 ppmV	9.57	Yes	19.6 ppmV	17.12	-5.78	Yes
7/09/85	01	NOx	1052 ppmV	-2.4	Yes	84.6 ppmV	84.96	--	Yes
7/10/85	02	NOx	1052 ppmV	1.59	Yes	84.6 ppmV	79.24	6.76	Yes
7/11/85	03	NOx	1052 ppmV	6.19	Yes	84.6 ppmV	79.66	4.45	Yes
7/09/85	01	THC	-d	-d	-d	-d	-d	-d	-d
7/10/85	02	THC	-d	-d	-d	-d	-d	-d	-d
7/11/85	03	THC	90 ppmV	34.98	No	19.6 ppmV	16.5	--	Yes

[a]Instrument drift is defined as the percent difference between the instrument response to the input concentration at the beginning and end of the test run.

[b]QC criteria was instrument drift within +/-10 percent.

[c]QC criteria was output concentration within +/-10 percent of the running mean concentration for this test site.

[d]Not available due to instrument malfunction.

[e]Not available due to instrument range change during test run.

8.3.1 Dioxin/Furan Analyses

Two individual topics related to the dioxin/furan analyses at Site SSI-C are discussed in this section. Analytical recoveries of labeled surrogate compounds spiked onto MM5 train samples are reported in Section 8.3.1.1. Sample blank data are reported in Section 8.3.1.2.

8.3.1.1 Surrogate Recoveries of the Test Samples

Table 8-5 presents the analytical recovery data reported by Troika for three isotopically labeled surrogate compounds spiked onto the MM5 inlet and outlet train samples. Samples were spiked with only three of the four surrogates normally used for the Tier 4 program. Surrogate recoveries ranged from 0 to 94 percent for the inlet samples; 40 to 112 percent for the outlet samples. Labeled internal standards were not detected for the Run 01 inlet sample. Similarly, recoveries for Run 02 and 03 inlet sample isotopes were below the acceptable QA objectives of 40 to 120 percent recovery. Therefore, the results from the Run 01 inlet sample analysis are invalid, and, the results of Runs 02 and 03 samples should be considered estimates. The results of the outlet analyses satisfied the QA requirements.

8.3.1.2 Sample Blanks

Table 8-6 summarizes the analytical results reported by Troika for internal laboratory blanks, laboratory fortified quality control (QC) samples, and proof blank MM5 train samples. In general, the data showed good surrogate recoveries, with values ranging from 40 to 110 percent. The internal lab blank was found to be clean with the exception of 0.2 ng of octa-CDD. The proof blank was found to contain 0.2 ng TCDD; 0.4 ng TCDF; 0.1 ng penta-CDF; 0.3 ng hexa-CDF; 0.3 ng hepta-CDF; 0.4 ng octa-CDF; and 0.4 ng octa-CDD. The fortified lab QC sample analyses provided values within 25 percent of the known isomer concentrations. Emissions data reported in Section 5.4 are not blank-corrected.

8.3.2. Precursor Analyses

Table 8-7 presents analytical recovery efficiencies for seven isotopically labeled compounds used as surrogates for the target precursor

TABLE 8-5. PERCENT SURROGATE RECOVERIES FOR SITE SSI-C DIOXIN/FURAN ANALYSES

Sample	$^{13}C_{12}$ TCDD	$^{37}Cl_4$ Hepta-CDD	$^{13}C_{12}$ Octa-CDD
MM5 Train Samples			
Inlet			
Run 01[a]	0	0	0
Run 02	90	25	14
Run 03	94	14	26
Outlet			
Run 01	98	42	40
Run 02	112	68	46
Run 03	112	40	43

[a]Labeled internal standards were not detected in this sample.

TABLE 8-6. ANALYSIS RESULTS FOR QUALITY CONTROL SAMPLES

Compound	Flue Gas Quality Control Samples			
	Laboratory Blank	Fortified Laboratory QC Samples		Proof Blank MM5 Train
		Measured Value	True Value[a,b]	
	Amount Detected (Nanograms per Sample)			
Dioxins				
2378 TCDD	ND	0.2	0.2 (0)	ND
Other TCDD	ND	ND	ND (0)	0.2
Penta CDD	ND	ND	ND (0)	ND
Hexa CDD	ND	0.9	0.8 (+13)	ND
Hepta CDD	ND	2.0	2.4 (-17)	ND
Octa CDD	0.2	2.5	3.2 (-22)	0.4
Furans				
2378 TCDF	ND	0.2	0.2 (0)	ND
Other TCDF	ND	ND	ND (0)	0.4
Penta CDF	ND	0.34	0.4 (-15)	0.1
Hexa CDF	ND	0.7	0.8 (-13)	0.3
Hepta CDF	ND	2.5	2.4 (+4)	0.3
Octa CDF	ND	2.4	3.2 (-25)	0.4
	Surrogate Recoveries (Percent)			
$^{37}Cl_4$-TCDD	--	--	NA	--
$^{13}C_{12}$-TCDD	100	98	NA	110
$^{37}Cl_4$-Hepta CDD	41	41	NA	76
$^{13}C_{12}$-Octa CDD	40	46	NA	71

[a]True values represent the amounts of each homologue spiked into the laboratory fortified QC samples.

[b]Value shown in parenthesis is the percentage difference between the measured and the true value:

$$\% = \frac{\text{Measured Value - True Value}}{\text{True Value}} \times 100$$

ND = Not Detected
NA = Not Applicable
TCDD = Tetra-chlorinated dibenzo-p-dioxin

TABLE 8-7. PERCENT SURROGATE RECOVERIES FOR SITE SSI-C FEED SAMPLES

Surrogate Compound	Percent Surrogate Recovery Sewage Sludge Feed			
	Run 01	Run 02	Run 03	Average
d_4-dichlorobenzene	20	84	15	51
bromobiphenyl	29	86	119	80
2', 5, 5' tetrabromobiphenyl	16	32	46	32
2', 4, 4', 6, 6' hexabromobiphenyl	ND	10	ND	3
d_6-phenol	4	14	ND	8
d_4-2-chlorophenol	6	21	1	12
^{13}C-pentachlorophenol	9	20	9	14

ND = Not detected.

analytes in the Site SSI-C feed samples. The surrogate recovery values in Table 8-7 vary considerably by specific surrogate species and also between runs for the same species. Several of the recoveries are below the 50 percent objective stated in the Tier 4 QA Project Plan and are below those generally considered achievable when analyzing for similar compounds in water or from MM5 train components. In spite of the relatively low surrogate recovery values for some of the feed samples, the resulting analytical sensitivity for the target analytes was considered acceptable for the purpose of this study.

APPENDIX A
FIELD SAMPLING DATA

APPENDIX A-1

INCINERATOR OUTLET MODIFIED METHOD 5 AND EPA METHODS 1-4 FIELD RESULTS

R A D I A N S O U R C E T E S T
E P A M E T H O D 2 - 5
(R A W D A T A)

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL , XX
SAMPLING LOCATION : INCINERATOR OUTLET
TEST # : 12-MM5-SI-01
DATE : 07/09/85
TEST PERIOD : 1510-2019

PARAMETER	VALUE
Sampling time (min.)	240
Barometric Pressure (in.Hg)	29.1
Sampling nozzle diameter (in.)	.498
Meter Volume (cu.ft.)	159.102
Meter Pressure (in.H2O)	1.416875
Meter Temperature (F)	122.375
Stack dimension (sq.in.)	10080
Stack Static Pressure (in.H2O)	-.9
Stack Moisture Collected (gm)	712.3
Absolute stack pressure(in Hg)	29.03382
Average stack temperature (F)	888.0834
Percent CO2	4.95
Percent O2	14.86
Percent N2	80.2
Delps Subroutine result	9.6933
DGM Factor	.9994
Pitot Constant	.84

RADIAN SOURCE TEST
EPA METHODS 2 - 5
FINAL RESULTS

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL , XX
SAMPLING LOCATION : INCINERATOR OUTLET
TEST # : 12-MM5-SI-01
DATE : 07/09/85
TEST PERIOD : 1510-2019

PARAMETER	RESULT
Vm(dscf)	140.7115
Vm(dscm)	3.98495
Vw gas(scf)	33.58495
Vw gas (scm)	.9511256
% moisture	19.26886
Md	.8073115
MWd	29.3892
MW	27.19463
Vs(fpm)	1486.359
Vs (mpm)	453.1584
Flow(acfm)	104045.2
Flow(acmm)	2946.559
Flow(dscfm)	31924.4
Flow(dscmm)	904.0991
% I	95.09616
% EA	235.3948

Program Revision:1/16/84

R A D I A N S O U R C E T E S T
E P A M E T H O D 2 - 5
(R A W D A T A)

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL , XX
SAMPLING LOCATION : SCRUBBER INLET
TEST # : 12-MM5-SI-02
DATE : 07/10/85
TEST PERIOD : 1316-1838

PARAMETER	VALUE
Sampling time (min.)	240
Barometric Pressure (in.Hg)	29.08
Sampling nozzle diameter (in.)	.499
Meter Volume (cu.ft.)	131.612
Meter Pressure (in.H2O)	1.345
Meter Temperature (F)	121.2
Stack dimension (sq.in.)	10080
Stack Static Pressure (in.H2O)	-.9
Stack Moisture Collected (gm)	1091.9
Absolute stack pressure(in Hg)	29.01382
Average stack temperature (F)	897.0209
Percent CO2	5.22
Percent O2	14.65
Percent N2	80.5
Delps Subroutine result	9.607474
DGM Factor	.9994
Pitot Constant	.84

R A D I A N S O U R C E T E S T
E P A M E T H O D S 2 - 5
F I N A L R E S U L T S

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL , XX
SAMPLING LOCATION : SCRUBBER INLET
TEST # : 12-MM5-SI-02
DATE : 07/10/85
TEST PERIOD : 1316-1838

PARAMETER	RESULT
Vm(dscf)	116.5334
Vm(dscm)	3.300226
Vw gas(scf)	51.48309
Vw gas (scm)	1.458001
% moisture	30.64169
Md	.6935831
MWd	29.5248
MW	25.99341
Vs(fpm)	1507.374
Vs (mpm)	459.5652
Flow(acfm)	105516.2
Flow(acmm)	2988.218
Flow(dscfm)	27612.66
Flow(dscmm)	781.9905
% I	90.68926
% EA	221.9025

Program Revision:1/16/84

R A D I A N S O U R C E T E S T
E P A M E T H O D 2 - 5
(R A W D A T A)

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL ,
SAMPLING LOCATION : INCINERATOR OUTLET
TEST # : 12-MM5-SI-03
DATE : 07/11/85
TEST PERIOD : 1152-1718

PARAMETER	VALUE
Sampling time (min.)	240
Barometric Pressure (in.Hg)	29.25
Sampling nozzle diameter (in.)	.499
Meter Volume (cu.ft.)	128.603
Meter Pressure (in.H20)	.8981251
Meter Temperature (F)	108.4688
Stack dimension (sq.in.)	10710
Stack Static Pressure (in.H20)	-.9
Stack Moisture Collected (gm)	837.02
Absolute stack pressure(in Hg)	29.18382
Average stack temperature (F)	928.625
Percent CO2	4.39
Percent O2	15.1
Percent N2	80.5
Delps Subroutine result	7.82278
DGM Factor	.9994
Pitot Constant	.84

R A D I A N S O U R C E T E S T
E P A M E T H O D S 2 - 5
F I N A L R E S U L T S

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL ,
SAMPLING LOCATION : INCINERATOR OUTLET
TEST # : 12-MM5-SI-03
DATE : 07/11/85
TEST PERIOD : 1152-1718

PARAMETER	RESULT
Vm(dscf)	116.9665
Vm(dscm)	3.312491
Vw gas(scf)	39.4655
Vw gas (scm)	1.117663
% moisture	25.22854
Md	.7477147
MWd	29.3036
MW	26.45187
Vs(fpm)	1213.131
Vs (mpm)	369.857
Flow(acfm)	90226.61
Flow(acmm)	2555.218
Flow(dscfm)	25020.74
Flow(dscmm)	708.5873
% I	106.7343
% EA	245.4487

Program Revision:1/16/84

APPENDIX A-2

SCRUBBER OUTLET MODIFIED METHOD 5 AND EPA METHODS 1-4 FIELD RESULTS

R A D I A N S O U R C E T E S T
E P A M E T H O D 2 - 5
(R A W D A T A)

PLANT : SITE 12
PLANT SITE : CONFINDENTIAL , XX
SAMPLING LOCATION : SCRUBBER OUTLET
TEST # : 12-MM5-SO-01
DATE : 07/09/85
TEST PERIOD : 1430-2145

PARAMETER	VALUE
Sampling time (min.)	240
Barometric Pressure (in.Hg)	29.1
Sampling nozzle diameter (in.)	.176
Meter Volume (cu.ft.)	120.674
Meter Pressure (in.H20)	.8787755
Meter Temperature (F)	123.3438
Stack dimension (sq.in.)	2463.015
Stack Static Pressure (in.H20)	-13
Stack Moisture Collected (gm)	138.5
Absolute stack pressure(in Hg)	28.14412
Average stack temperature (F)	97.88001
Percent CO2	3.2
Percent O2	18.3
Percent N2	78.5
Delps Subroutine result	20.75543
DGM Factor	.9993
Pitot Constant	.84

RADIAN SOURCE TEST
EPA METHODS 2 - 5
FINAL RESULTS

PLANT	: SITE 12
PLANT SITE	: CONFINDENTIAL , XX
SAMPLING LOCATION	: SCRUBBER OUTLET
TEST #	: 12-MM5-SO-01
DATE	: 07/09/85
TEST PERIOD	: 1430-2145

PARAMETER	RESULT
Vm(dscf)	106.3931
Vm(dscm)	3.013053
Vw gas(scf)	6.530276
Vw gas (scm)	.1849374
% moisture	5.782925
Md	.9421708
MWd	29.244
MW	28.59377
Vs(fpm)	3152.449
Vs (mpm)	961.1124
Flow(acfm)	53920.33
Flow(acmm)	1527.024
Flow(dscfm)	45227.38
Flow(dscmm)	1280.839
% I	99.29061
% EA	754.9505

Program Revision:1/16/8

R A D I A N S O U R C E T E S T
E P A M E T H O D 2 - 5
(R A W D A T A)

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL ,
SAMPLING LOCATION : SCRUBBER OUTLET
TEST # : 12-MM5-SO-02
DATE : 07/10/85
TEST PERIOD : 1315-1815

PARAMETER	VALUE
Sampling time (min.)	240
Barometric Pressure (in.Hg)	29.08
Sampling nozzle diameter (in.)	.185
Meter Volume (cu.ft.)	121.703
Meter Pressure (in.H2O)	.8979166
Meter Temperature (F)	122.7292
Stack dimension (sq.in.)	2463.015
Stack Static Pressure (in.H2O)	-13
Stack Moisture Collected (gm)	110.05
Absolute stack pressure(in Hg)	28.12412
Average stack temperature (F)	92.125
Percent CO2	3.07
Percent O2	17.82
Percent N2	78.57
Delps Subroutine result	21.34023
DGM Factor	.9993
Pitot Constant	.84

R A D I A N S O U R C E T E S T
E P A M E T H O D S 2 - 5
F I N A L R E S U L T S

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL ,
SAMPLING LOCATION : SCRUBBER OUTLET
TEST # : 12-MM5-SO-02
DATE : 07/10/85
TEST PERIOD : 1315-1815

PARAMETER	RESULT
Vm(dscf)	107.3451
Vm(dscm)	3.040012
Vw gas(scf)	5.188858
Vw gas (scm)	.1469484
% moisture	4.610928
Md	.9538907
MWd	29.0528
MW	28.54316
Vs(fpm)	3245.297
Vs (mpm)	989.4198
Flow(acfm)	55508.44
Flow(acmm)	1571.999
Flow(dscfm)	47596.11
Flow(dscmm)	1347.922
% I	86.15659
% EA	609.7562

Program Revision:1/16/8

R A D I A N S O U R C E T E S T
E P A M E T H O D 2 - 5
(R A W D A T A)

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL ,
SAMPLING LOCATION : SCRUBBER OUTLET
TEST # : 12-MM5-SO-03
DATE : 07/11/85
TEST PERIOD : 1210-1730

PARAMETER	VALUE
Sampling time (min.)	240
Barometric Pressure (in.Hg)	29.22
Sampling nozzle diameter (in.)	.176
Meter Volume (cu.ft.)	109.078
Meter Pressure (in.H2O)	.7262501
Meter Temperature (F)	117.0938
Stack dimension (sq.in.)	2463.015
Stack Static Pressure (in.H2O)	-13
Stack Moisture Collected (gm)	102.87
Absolute stack pressure(in Hg)	28.26412
Average stack temperature (F)	88.8125
Percent CO2	3.6
Percent O2	16.41
Percent N2	81.06
Delps Subroutine result	19.03307
DGM Factor	.9993
Pitot Constant	.84

R A D I A N S O U R C E T E S T
E P A M E T H O D S 2 - 5
F I N A L R E S U L T S

PLANT : SITE 12
PLANT SITE : CONFIDENTIAL ,
SAMPLING LOCATION : SCRUBBER OUTLET
TEST # : 12-MM5-SO-03
DATE : 07/11/85
TEST PERIOD : 1210-1730

PARAMETER	RESULT
Vm(dscf)	97.57355
Vm(dscm)	2.763283
Vw gas(scf)	4.850321
Vw gas (scm)	.1373611
% moisture	4.735538
Md	.9526446
MWd	29.532
MW	28.9859
Vs(fpm)	2865.125
Vs (mpm)	873.5138
Flow(acfm)	49005.87
Flow(acmm)	1387.846
Flow(dscfm)	42429
Flow(dscmm)	1201.589
% I	97.06558
% EA	328.8683

Program Revision:1/16/8

APPENDIX A-3

CONTINUOUS EMISSIONS MONITORING RESULTS

TABLE A-3. CEM Data, RUN 1

FACTOR FOR 3% O2 NORMALIZATION OF OTHER PROCESS GASES	NORMALIZED / CORRECTED DATA WITH ACTUAL O2				
	TIME	O2 (%V)	CO (PPMV) @ 3% O2	CO2 (%V) @ 3% O2	NOX (PPMV) @ 3% O2
2.6623	1430	14.2	3601.7	13.6	370.5
2.2994	1435	13.1	3393.0	12.8	372.0
2.2574	1440	13.0	3348.5	12.7	373.9
2.2415	1445	12.9	3255.0	13.0	378.6
2.2174	1450	12.8	3235.0	12.9	377.8
2.4056	1455	13.5	3175.0	11.9	343.8
2.3373	1500	13.2	3370.3	13.3	429.9
2.2708	1505	13.0	3393.1	13.0	427.6
2.2134	1510	12.8	3073.0	12.8	426.2
2.4594	1515	13.6	3416.7	13.0	442.0
2.4488	1520	13.6	3520.1	13.0	449.4
2.4203	1525	13.5	3474.4	12.9	447.6
2.3859	1530	13.4	3263.4	13.0	446.3
2.3070	1535	13.1	3228.3	13.1	448.3
2.2585	1540	13.0	2957.4	13.0	427.1
2.3674	1545	13.3	3013.9	13.3	446.3
2.2937	1550	13.1	3038.2	13.1	454.8
2.3143	1555	13.2	3011.4	12.5	412.6
2.3125	1600	13.2	2961.6	13.2	434.2
2.2977	1605	13.1	3005.4	13.1	451.6
2.2715	1610	13.0	2998.4	13.1	454.3
2.2259	1615	13.2	2960.3	13.4	468.8
2.2569	1620	13.0	2808.7	13.2	455.
2.2280	1625	12.9	2816.3	13.0	442.
2.3136	1630	13.2	2968.5	13.4	4
2.3112	1635	13.2	2944.6	13.3	4
2.2973	1640	13.1	2942.9	13.1	4
2.7512	1645	14.4	3215.2	14.0	44
2.1880	1650	12.5	2996.5	13.5	4
2.3312	1655	13.3	3043.3	13.	4
2.2536	1700	13.0	2827.9	13.2	4
2.3016	1705	13.2	3041.6	13.8	4
2.2548	1710	13.	2857.	13.8	4
2.3425	1715	13.3	3046.0	14.2	4
2.3027	1720	13.1	2968.8	13.9	4
2.3106	1725	13.2	3061.8	13.7	4
2.2778	1730	13.0	3065.1	13.7	4
2.1701	1735	12.7	2838.2	13.6	455.4
2.1893	1740	12.7	2813.6	13.8	4
2.2783	1745	13.0	2853.7	14.2	4
2.3045	1750	13.3	2859.5	14.0	4
2.1556	1755	12.6	2653.4	13.9	4
2.1080	1800	12.1	2419.4	14.3	4
2.1694	1805	12.6	2387.3	14.0	4
2.2916	1810	13.1	2643.2	14.1	451.4
2.4869	1815	13.7	2936.1	14.4	479.7
2.4746	1820	13.5	3044.5	14.1	484.1
2.4186	1825	13.5	3048.3	14.0	487.
2.5216	1830	13.8	3137.7	14.4	518.
2.3201	1835	13.2	2696.7	13.9	479.

TABLE A-3. CEM Data, Run 1 (Continued).

**	2.4253	*	1840	13.5	2750.7	13.3	478.9
**	2.4426	*	1845	13.6	3056.0	14.0	511.0
**	2.4715	*	1850	13.5	3110.9	14.0	507.3
**	2.3340	*	1855	13.2	2969.7	14.1	495.0
**	[illegible]	*	1900	13.2	2880.9	14.3	489.0
**	2.4??	*	1905	13.5	3148.1	14.3	502.0
**	[illegible]	*	[illegible]	[illegible]	3075.?	14.?	49?.?
**	[illegible]	*	19??	13.3	297?.?	14.?	[illegible]
**	?.518	*	1920	1?.0	2904.4	14.1	?77.?
**	2.3207	*	1925	13.2	3156.7	14.2	494.3
**	2.449?	*	1930	13.7	3715.9	14.?	538.0
**	2.4036	*	1935	13.5	3810.6	14.4	527.4
**	2.3356	*	1940	13.2	3569.6	13.8	488.3
**	1.9570	*	1945	11.8	2793.2	14.5	410.9
**	2.1899	*	1950	12.7	3170.5	14.5	475.0
**	2.0100	*	1955	12.0	2549.5	14.7	421.7
**	1.7???	*	2000	[illegible]	217?.?	14.?	3?5.0
**	1.9705	*	2005	11.3	1961.5	14.4	338.1
**	?.5186	*	2010	13.0	3486.3	14.?	45?.5
**	2.9177	*	2015	14.5	4542.9	14.?	5??.6
**	2.?557	*	2020	14.?	4??9.5	14.1	501.?
**	2.4835	*	2025	13.7	3325.8	14.3	494.8
**	2.5045	*	2030	13.?	3253.9	14.?	492.7
**	2.4752	*	2035	13.7	3475.0	14.4	487.0
**	2.4651	*	2040	13.6	3483.0	13.9	4?7.8
**	2.3392	*	2045	13.2	3338.2	15.4	468.6
**	2.0848	*	2050	12.3	2976.6	14.6	443.5
**	2.1097	*	2055	13.4	3036.9	14.9	459.4
**	2.1267	*	2100	13.5	3155.4	15.0	469.1
**	2.0307	*	2105	12.1	2840.7	15.0	449.4
**	2.0672	*	2110	12.2	2644.9	14.7	413.8
**	1.9915	*	2115	11.9	2445.9	15.6	408.8
**	1.9142	*	2120	11.5	2367.3	15.1	401.2
**	1.9747	*	2125	11.8	2517.8	15.4	420.1
**	2.0916	*	2130	12.3	2686.4	15.8	446.0
**	1.9756	*	2135	11.7	2456.4	13.7	415.5

NO. PTS.	86	NO. PTS.	86	86	86	86
MEAN	2.2923	MEAN	13.0	3018.?	13.7	453.6
STD. DEV.	0.2	STD. DEV.	0.6	401.8	0.8	38.9

* CO, CO2 and NOx values are corrected to 3% O2. To obtain actual measured values, divide values in the table by the corresponding normalization factor.

TABLE A-3. CEM Data, Run 2

FACTOR FOR 3% O2 NORMALIZATION OF OTHER PROCESS GASES	TIME	O2 (%V)	CO (PPMV) @ 3% O2	CO2 (%V) @ 3% O2	SO2 (PPMV) @ 3% O2	NOx (PPMV) @ 3% O2
		NORMALIZED / CORRECTED DATA – WITH ACTUAL O2 *				
1.1576	1405	5.4	494.0	0.4		[illegible]
2.9264	1410	14.3	9172.0	11.0		470.3
3.5172	1415	15.8	4731.3	13.9		481.7
3.2755	1420	15.4	4135.1	12.0		459.8
3.3427	1425	15.5	4073.8	11.4		[illegible]
3.3404	1430	15.5	3559.8	11.9	794.6	451.5
3.2856	1435	15.5	3797.6	11.0	745.0	450.4
3.0709	1440	15.0	3394.1	11.5	723.7	439.1
3.0507	1445	15.0	[illegible]	11.3	700.1	[illegible]
3.1962	1450	15.3	3291.3	10.7	[illegible]	[illegible]
3.1080	1455	15.1	[illegible]	[illegible]	[illegible]	[illegible]
3.3390	1500	15.0	2759.8	11.1	574.1	[illegible]
3.1197	1505	15.2	[illegible]	10.7	[illegible]	417.5
[illegible]	1510	15.1	2791.2	11.7	615.1	[illegible]
[illegible]	1515	15.0	2577.0	10.6	575.5	[illegible]
2.9564	1520	14.8	2667.0	10.4	552.0	[illegible]
3.0147	1525	15.0	2930.4	7.8	537.5	380.5
3.0313	1530	15.0	2938.9	9.0	545.5	[illegible]
2.8864	1535	[illegible]	2727.8	10.3	556.3	[illegible]
2.7600	1540	14.4	2887.6	10.7	552.1	365.5
2.6347	1545	[illegible]	2573.2	11.8	570.6	370.0
2.4874	1550	13.7	2054.3	11.8	580.5	372.5
2.4314	1555	13.5	1924.2	11.8	592.3	[illegible]
[illegible]	1600	13.8	1774.1	11.3	593.4	[illegible]
[illegible]	1605	14.2	1820.5	10.1	[illegible]	[illegible]
2.8794	1610	14.6	1729.8	9.0	528.6	294.0
2.0779	1615	12.1	1359.7	13.2	549.3	[illegible]
1.9803	1620	11.9	1807.1	12.1	646.4	[illegible]
2.0578	1625	[illegible]	1946.3	11.6	[illegible]	[illegible]
2.1468	1630	12.6	1788.4	11.2	471.3	[illegible]
[illegible]	1635	12.2	2152.7	11.1	[illegible]	[illegible]
[illegible]	1640	12.1	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1645	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1650	[illegible]	2544.6	[illegible]	454.4	[illegible]
[illegible]	1655	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1700	[illegible]	[illegible]	11.3	[illegible]	[illegible]
[illegible]	1705	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1710	11.7	[illegible]	[illegible]	481.5	[illegible]
[illegible]	1715	[illegible]	[illegible]	11.5	[illegible]	[illegible]
[illegible]	1720	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1725	10.9	[illegible]	[illegible]	[illegible]	[illegible]
1.6583	1730	11.7	1757.2	10.4	[illegible]	[illegible]
1.7643	1735	10.8	1607.7	10.7	[illegible]	[illegible]
[illegible]	1740	10.7	1570.2	[illegible]	456.0	[illegible]
[illegible]	1745	11.4	[illegible]	10.8	[illegible]	[illegible]
[illegible]	1750	11.2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1755	11.3	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	10.2	470.5	[illegible]
[illegible]	1805	11.4	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1810	11.0	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1815	11.1	[illegible]	9.5	477.1	[illegible]
1.7929	1820	10.9	[illegible]	9.6	402.2	[illegible]
[illegible]	1825	11.0	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1830	10.5	[illegible]	9.0	[illegible]	[illegible]
[illegible]	1835	10.5	1492.8	[illegible]	[illegible]	[illegible]
1.8471	1840	11.3	[illegible]	9.1	408.2	197.4
[illegible]	1845	10.7	[illegible]	9.8	[illegible]	[illegible]
1.7767	1850	10.8	1489.3	9.8		[illegible]
[illegible]	1855	11.5	[illegible]	9.0		[illegible]
59	NO. RDGS.	59	59	59	[illegible]	[illegible]
[illegible]	MEAN	12.7	[illegible]	10.6	[illegible]	[illegible]
0.6	STD. DEV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* CO, CO2, NOx and SO2 values are corrected to 3% O2. To obtain actual measured values, divide values in this table by the corresponding normalization factor.

TABLE A-3. CEM Data, Run 3

NORMALIZED / CORRECTED DATA · WITH ACTUAL O2 *

FACTOR FOR 3% O2 NORMALIZATION OF OTHER PROCESS GASES	*	TIME	O2 (%V)	CO (PPMV) @ 3% O2	CO2 (%V) @ 3% O2	SO2 (PPMV) @ 3% O2	NOX (PPMV) @ 3% O2	THC (PPMV) @ 3% O2
2.6308	*	1210	14.1	4259.3	14.5	521.9	519.1	9.8
2.5923	*	1215	14.3	4241.5	14.7	503.2	533.1	25.3
2.3558	*	1220	14.8	4293.3	13.6	529.8	499.2	[illegible]
2.5933	*	1225	14.0	4221.4	14.5	514.1	[illegible]	[illegible]
2.5351	*	1230	13.8	3838.7	14.4	478.7	492.5	25.5
2.5389	*	1235	13.8	3648.0	14.2	449.1	460.0	19.8
2.4161	*	1240	13.5	3419.3	14.6	484.8	451.0	15.7
2.3568	*	1245	13.3	3196.3	14.0	478.4	457.3	12.7
2.5119	*	1250	13.8	3728.3	14.4	499.8	491.0	12.6
2.4670	*	1255	13.6	3099.9	14.5	484.0	491.7	12.5
2.4209	*	1300	13.5	2802.0	14.3	455.2	507.8	8.0
2.7934	*	1305	14.5	3246.5	14.4	508.1	519.4	4.4
2.5509	*	1310	13.9	2851.2	14.0	445.7	495.7	4.6
[illegible]	*	1315	14.1	3079.7	14.2	445.1	481.5	[illegible]
[illegible]	*	1320	14.4	2597.4	13.0	[illegible]	495.1	5.4
2.5449	*	1325	13.9	2938.4	14.2	423.7	[illegible]	11.4
2.5016	*	1330	13.7	2802.5	13.8	450.9	457.0	14.6
2.4053	*	1335	13.5	2942.9	14.5	478.9	[illegible]	8.1
2.3347	*	1340	13.4	3030.5	14.5	448.4	[illegible]	[illegible]
2.3503	*	1345	13.3	3124.9	14.5	452.1	464.1	23.2
2.4319	*	1350	13.5	3448.2	14.8	476.7	510.8	50.1
2.4645	*	1355	13.5	3572.5	14.7	471.6	511.2	53.2
2.3962	*	1400	13.4	3477.0	14.4	469.0	478.5	53.5
2.4398	*	1405	13.6	3644.4	15.1	474.6	531.2	53.3
2.3913	*	1410	13.4	3629.0	15.0	475.5	510.6	54.6
2.4099	*	1415	13.5	3667.0	14.8	492.4	502.0	56.2
2.5337	*	1420	13.8	3946.8	14.8	509.5	506.0	67.2
2.5709	*	1425	13.9	4126.9	14.8	514.4	505.3	73.3
2.5721	*	1430	13.9	4195.7	14.6	495.2	497.6	[illegible]
2.7520	*	1435	14.4	4533.9	14.7	518.0	501.8	96.3
2.6507	*	1440	14.1	4376.7	14.5	513.7	485.5	92.3
2.7683	*	1445	14.4	4054.6	13.8	495.5	447.2	91.6
2.7262	*	1450	14.3	4214.2	14.8	483.8	464.4	93.5
2.6648	*	1455	14.2	4255.9	14.3	494.6	451.1	91.8
2.5745	*	1500	14.0	4054.0	14.9	458.1	454.6	95.4
2.7865	*	1505	14.5	4723.8	14.6	524.1	499.8	111.5
2.6440	*	1510	14.1	4576.7	14.9	492.7	[illegible]	[illegible]
2.6636	*	1515	14.2	4572.7	14.5	472.2	503.1	[illegible]
[illegible]	*	1520	13.7	4679.3	15.1	[illegible]	541.8	[illegible]
[illegible]	*	1525	13.4	4577.3	13.4	[illegible]	[illegible]	[illegible]
[illegible]	*	1530	13.2	4489.0	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	*	1535	13.0	4529.2	15.4	[illegible]	[illegible]	[illegible]
[illegible]	*	1540	16.2	[illegible]	15.5	[illegible]	[illegible]	[illegible]
2.0359	*	1545	12.1	3377.3	15.5	486.7	[illegible]	[illegible]
[illegible]	*	1550	13.0	3917.4	16.0	551.2	[illegible]	[illegible]
[illegible]	*	1555	12.7	3950.7	14.2	585.4	[illegible]	[illegible]
[illegible]	*	1600	13.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	*	1605	14.4	4473.4	15.3	[illegible]	564.2	[illegible]
[illegible]	*	1610	14.5	5043.1	15.0	[illegible]	[illegible]	[illegible]
[illegible]	*	1615	14.3	4833.2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	*	1620	14.0	[illegible]	[illegible]	489.1	[illegible]	110.6
2.5775	*	1625	13.8	4733.2	15.2	486.7	514.8	[illegible]
[illegible]	*	1630	13.9	3982.9	14.4	[illegible]	481.6	110.2
2.6223	*	1635	14.1	4674.4	15.2	474.8	536.9	119.6
2.5349	*	1640	13.8	4587.1	15.1	442.4	[illegible]	[illegible]
2.5085	*	1645	13.8	4647.5	15.1	441.1	531.1	126.6
2.4969	*	1650	13.7	4529.1	15.6	[illegible]	[illegible]	[illegible]
2.4116	*	1655	13.5	4532.6	15.6	457.6	541.0	117.7
[illegible]	*	1700	13.5	4030.4	14.7	483.3	[illegible]	[illegible]
2.4285	*	1705	13.5	3932.0	16.0	511.1	[illegible]	[illegible]
2.2998	*	1710	13.1	3725.9	[illegible]	[illegible]	[illegible]	[illegible]
2.4096	*	1715	13.5	3884.2	15.3	527.8	[illegible]	[illegible]
2.3795	*	1720	13.4	3421.6	15.6	487.2	[illegible]	[illegible]
2.4074	*	1725	13.5	3490.4	15.3	493.7	[illegible]	[illegible]
2.4960	*	1730	13.7	3705.5	15.1	525.8	[illegible]	[illegible]
2.5680	*	1735	13.9	4002.8	15.6	504.2	524.8	[illegible]
2.4314	*	1740	13.5	3984.0	14.1	465.4	[illegible]	[illegible]
67		NO. PTS.	67	67	67	67	[illegible]	[illegible]
2.5352		MEAN	13.8	3900.7	[illegible]	490.4	[illegible]	[illegible]
0.2		STD. DEV.	0.6	[illegible]	0.7	41.4	[illegible]	[illegible]

* CO, CO2 NOx, SO2 and THC values are corrected to 3% O2. To obtain actual measured values, divide values in the table by the corresp[illegible] normalization factor.

APPENDIX A-4
MODIFIED METHOD 5 SAMPLE CALCULATIONS

RADIAN SOURCE TEST
EPA METHODS 2 - 5
DEFINITION OF TERMS

PARAMETER	DEFINITION
Tt(min.)	TOTAL SAMPLING TIME
Dn(in.)	SAMPLING NOZZLE DIAMETER
Ps(in.H2O)	ABSOLUTE STACK STATIC GAS PRESSURE
Vm(cu.ft.)	ABSOLUTE VOLUME OF GAS SAMPLE MEASURED BY DGM
Vw(gm.)	TOTAL STACK MOISTURE COLLECTED
Pm(in.H2O)	AVERAGE STATIC PRESSURE OF DGM
Tm(F)	AVERAGE TEMPERATURE OF DGM
Pb(in.Hg.)	BAROMETRIC PRESSURE
% CO2	CARBON DIOXIDE CONTENT OF STACK GAS
% O2	OXYGEN CONTENT OF STACK GAS
% N2	NITROGEN CONTENT OF STACK GAS
SQR(DELPS)	AVE. SQ. ROOT OF S-PITOT DIFF. PRESSURE-TEMP. PRODUCT
As(sq.in.)	CROSS-SECTIONAL AREA OF STACK(DUCT)
Ts(F)	TEMPERATURE OF STACK
Vm(dscf)	STANDARD VOLUME OF GAS SAMPLED ,Vm(std),AS DRY STD.
Vm(dscm)	STANDARD VOLUME OF GAS SAMPLED,Vm(std),AS DRY STD. C
Vw gas(scf)	VOLUME OF WATER VAPOR IN GAS SAMPLE,STD
% moisture	WATER VAPOR COMPOSITION OF STACK GAS
Md	PROPORTION, BY VOLUME,OF DRY GAS IN GAS SAMPLE
MWd	MOLECULAR WEIGHT OF STACK GAS,DRY BASIS LB/LB-MOLE
MW	MOLECULAR WEIGHT OF STACK GAS,WET BASIC LB/LB-MOLE
Vs(fpm)	AVERAGE STACK GAS VELOCITY
Flow(acfm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(acmm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(dscfm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
Flow(dscmm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
% I	PERCENT ISOKINETIC
% EA	PERCENT EXCESS AIR IN STACK GAS
DGM	DRY GAS METER
Y	DRY GAS METER CORRECTION FACTOR
Pg	STACK STATIC GAS PRESSURE
Cp	PITOT COEFFICIENT
dH	ORIFICE PLATE DIFF. PRESS. VALUE
dP	PITOT DIFF. PRESS. VALUE
*** EPA STANDARD CONDITIONS	Temperature = 68 deg-F (528 deg-R) Pressure = 29.92 in. Hg.

RADIAN SOURCE TEST
EPA METHOD 2-5
SAMPLE CALCULATION

PLANT	: SITE 12
PLANT SITE	: CONFIDENTIAL ,
SAMPLING LOCATION	: INCINERATOR OUTLET
TEST #	: 12-MM5-SI-01
DATE	: 07/09/85
TEST PERIOD	: 1510-2019

1) Volume of dry gas sampled at standard conditions (68 deg-F ,29.92 in. Hg

$$Vm(std) = \frac{Y \times Vm \times [T(std) + 460] \times [Pb + (Pm/13.6)]}{P(std) \times (Tm + 460)}$$

$$Vm(std) = \frac{.9994 \times 159.102 \times 528 \times [29.1 + (1.416875/13.6)]}{29.92 \times (122.375 + 460)}$$

$$Vm(std) = 140.712 dscf$$

2) Volume of water vapor at standard conditions:

$$Vw(gas) = 0.04715\ cf/gm \times W(1)\ gm$$

$$Vw(gas) = 0.04715 \times 712.3 = 33.585\ scf$$

3) Percent Moisture in stack gas :

$$\%M = \frac{100 \times Vw(gas)}{Vm(std) + Vw(gas)}$$

$$\%M = \frac{100 \times 33.585}{140.712 + 33.585} = 19.27\ \%$$

4) Mole fraction of dry stack gas :

$$Md = \frac{100 - \%M}{100} = \frac{100 - 19.27}{100} = .8073115$$

SAMPLE CALCULATION
PAGE TWO

)Average Molecular Weight of DRY stack gas :

MWd = (.44 x %CO2) + (.32 x %O2) + (.28 x %N2)

MWd = (.44 x 4.95) + (.32 x 14.86) + (.28 x 80.2) = 29.3892

)Average Molecular Weight of wet stack gas :

MW = MWd x Md + 18(1 - Md)

MW = 29.3892 x .8073115 + 18(1 - .8073115) = 27.19463

7) Stack gas velocity in feet-per-minute (fpm) at stack conditions :

Vs = KpxCp x [SQRT (dP)]{ave} x SQRT [Ts {avg}] x SQRT [1/(PsxMW)] x 60sec/mi

Vs = 85.49 x .84 x 60 x 9.6933 x SQRT[1/(29.03382 X 27.19463)]

Vs = 1486.359 FPM

8) Average stack gas dry volumetric flow rate (DSCFM) :

$$Qsd = \frac{Vs \times As \times Md \times T(std) \times Ps}{144 \text{ cu.in./cu.ft.} \times (Ts + 460) \times P(std)}$$

$$Qsd = \frac{1486.359 \times 10080 \times .8073115 \times 528 \times 29.03382}{144 \times 1348.083 \times 29.92}$$

Qsd = 31924.4 dscfm

SAMPLE CALCULATION
PAGE THREE

9) Isokinetic sampling rate (%) :

Dimensional Constant C = K4 x 60 x 144 x [1 / (Pi /4)]
K4 = .0945 FOR ENGLISH UNITS

$$I\% = \frac{C \times Vm(std) \times (Ts + 460)}{Vs \times Tt \times Ps \times Md \times (Dn)^2}$$

$$I\% = \frac{1039.574 \times 140.7115 \times 1348.083}{1486.359 \times 240 \times 29.03382 \times .8073115 \times (.498)^2}$$

I% = 95.09616

10) Excess air (%) :

$$EA = \frac{100 \times \%O2}{(.264 \times \%N2) - \%O2} = \frac{100 \times 14.86}{(.264 \times 80.2) - 14.86}$$

EA = 235.39

11) Particulate Concentration :

Cs = (grams part.) / Vm(std) = 0 / 140.7115

Cs = 0.0000000 Grams/DSCF

$$Ca = \frac{T(std) \times Md \times Ps \times Cs}{P(std) \times Ts}$$

$$Ca = \frac{528 \times .8073115 \times 29.03382 \times 0.0000000}{29.92 \times 1348.083}$$

Ca = 0.0000000 Grams/ACF

LBS/HR = Cs x 0.002205 x Qsd x 60

LBS/HR = 0.0000000x 0.002205 x 31924.4 x 60

LBS/HR = 0

Program Revision: 1/16/

APPENDIX B
SAMPLE SHIPMENT LETTERS

July 12, 1985

U.S. EPA ECC Toxicant Analysis Center
Building 1105
Bay St. Louis, MS 39529

Attention: Danny McDaniel

Subject: Tier 4 - Analysis Instructions

Dear Sir:

The objective of this letter is to clarify instructions and priorities for individual samples from specific Tier 4 combustion sites. This instruction letter is No. 14 and pertains to EPA Site No. 12.

The Episode No. is 2708, and SCC numbers assigned to this site were numb D0005600 through D0005699.

SCC numbers D0005601 through D0005606 have been assigned to Troika for internal QA/QC purposes. SCC numbers D0005607 through D0005634 have been assigned to samples included in this shipment. All remaining SCC numbers are unused.

The sample shipment for EPA Site No. 12 (SSI-C) consists of 5 boxes containing 76 samples of 70 components. The boxes were shipped under Federal Express, Airbill Nos. 289783443 and 289783432.

Instructions for extraction and analysis follow.

1. Priority #1 samples include the sample train components, the bottom ash, scrubber effluent samples, the lab proof blank, and the resp blanks. These samples require immediate extraction and analysis.

MM5 TRAIN SAMPLES (* indicates two samples per component)

Radian Run # 12-MM5-SI-01 (Total of 6 train components)

SCC No.	Container	Fraction
D0005609	1	Filter
D0005609	2*	Probe Rinse
D0005609	3*	Back Half/Coil Rinse
D0005609	4	Condensate
D0005609	5	Impinger Solution
D0005609	6	XAD Module

Radian Run # 12-MM5-SO-01 (Total of 6 train components)

ECC No.	Container	Fraction
DQ005610	1	Filter
DQ005610	2	Probe Rinse
DQ005610	3	Back Half/Coil Rinse
DQ005610	4	Condensate
DQ005610	5	Impinger Solution
DQ005610	6	XAD Module

Radian Run # 12-MM5-SI-02 (Total of 6 train components)

DQ005616	1	Filter
DQ005616	2*	Probe Rinse
DQ005616	3	Back Half/Coil Rinse
DQ005616	4*	Condensate
DQ005616	5	Impinger Solution
DQ005616	6	XAD Module

Radian Run # 12-MM5-SO-02 (Total of 6 train components)

DQ005617	1	Filter
DQ005617	2	Probe Rinse
DQ005617	3	Back Half/Coil Rinse
DQ005617	4	Condensate
DQ005617	5	Impinger Solution
DQ005617	6	XAD Module

Radian Run # 12-MM5-SI-FBL (Total of 6 train components)

DQ005621	1	Filter
DQ005621	2	Probe Rinse
DQ005621	3	Back Half/Coil Rinse
DQ005621	4	Condensate
DQ005621	5	Impinger Solution
DQ005621	6	XAD Module

Radian Run # 12-MM5-SO-FBL (Total of 6 train components)

DQ005622	1	Filter
DQ005622	2*	Probe Rinse
DQ005622	3	Back Half/Coil Rinse
DQ005622	4	Condensate
DQ005622	5	Impinger Solution
DQ005622	6	XAD Module

Radian Run # 12-MM5-SI-03 (Total of 6 train components)

SCC No.	Container	Fraction
DQ005623	1	Filter
DQ005623	2*	Probe Rinse
DQ005623	3	Back Half/Coil Rinse
DQ005623	4*	Condensate
DQ005623	5	Impinger Solution
DQ005623	6	XAD Module

Radian Run # 12-MM5-SO-03 (Total of 6 train components)

DQ005624	1	Filter
DQ005624	2	Probe Rinse
DQ005624	3	Back Half/Coil Rinse
DQ005624	4	Condensate
DQ005624	5	Impinger Solution
DQ005624	6	XAD Module

LABORATORY PROOF BLANK

SCC No.	Container	Fraction
DQ005608	1	Filter
DQ005608	2	Probe Rinse, Back Half/Coil Rinse and Impinger Soln.
DQ005608	3	XAD Module

REAGENT BLANKS

SCC No.	Sample
DQ005628	HPLC grade water blank
DQ005629	Acetone blank
DQ005630	Methylene chloride blank

BOTTOM ASH - PROCESS SAMPLE

SCC No.	Sample
D0005614	Bottom Ash, Run 01
D0005620	Bottom Ash, Run 02
D0005627	Bottom Ash, Run 03

SCRUBBER EFFLUENT - PROCESS SAMPLE

SCC No.	Sample
D0005611	Filterable Solids, Run 01
D0005618	Filterable Solids, Run 02
D0005625	Filterable Solids, Run 03
D0005612	Filtrate, Run 01
D0005631	Filtrate, Run 02
D0005632	Filtrate, Run 03

AUDIT SAMPLES*

D0005633	TCDD Audit Sample A
D0005634	TCDD Audit Sample B

*Documentation: See Attachment

1. The Feed sludge and Ambient Sample are Priority #2 samples. The samp
should be held at Troika pending the results of the Priority #1 sampl

FEED SLUDGE - PROCESS SAMPLE

SCC No.	Sample
D0005613	Feed Sludge, Run 01
D0005619	Feed Sludge, Run 02
D0005626	Feed Sludge, Run 03

AMBIENT SAMPLE

SCC No.	Container	Fraction
D0005607	1	Probe Rinse
D0005607	2	XAD Module

5. The soil sample is a Priotity #3 sample. This sample will be held at Radian pending results or Priority #1 and Priority #2 analysis. The SCC number for this sample is DQ005615 and the Radian sample code is 12-8.

If any questions arise concerning this sample shipment, please contact either Mike Palazzolo or Robert Jongleux at Radian Corporation at (919) 541-9100 or (919) 481-0212.

Sincerely,

TEST TEAM LEADER

cc: E. Hanks/EPA/AMTB
A. Miles/Radian
Radian Field File - RTP/PPK

July 12, 1985

Dr. Doug Kuehl
U.S. EPA/ERL-Duluth
6201 Congdon Blvd.
Duluth, Minnesota 55804

Dear Doug:

As directed by Mr. Peter L. Wise, Director of the Great Lakes National Program Office (GLNPO), the split process samples from Test Site 12 of Tier 4 of the National Dioxin Study are enclosed. The samples were shipped by Federal Express Airbill No. 351716820 on July 12, 1985.

The sample containers were prepared in the following manner: chromerge rinse, distilled water rinses, acetone rinses and methylene cloride rinses. The filter papers were benzene-extracted, and the scrubber water was pressure-filtered under nitrogen. The samples are daily composites of hourly grab samples from the test days. The samples are coded as follows:

RadianSampleCode	Description
Bottom Ash	
12-BA-01-D	Bottom Ash, Run 1
12-BA-02-D	Bottom Ash, Run 2
12-BA-03-D	Bottom Ash, Run 3
Sludge Feed	
12-SF-01-D	Sludge Feed, Run 1
12-SF-02-D	Sludge Feed, Run 2
12-SF-03-D	Sludge Feed, Run 3
Scrubber Water	
12-SES-01-D	Scrubber Effluent Solids, Run 1
12-SES-02-D	Scrubber Effluent Solids, Run 2
12-SES-03-D	Scrubber Effluent Solids, Run 3
12-SEF-01-D	Scrubber Effluent Filtrate, Run 1
12-SEF-02-D	Scrubber Effluent Filtrate, Run 2
12-SEF-03-D	Scrubber Effluent Filtrate, Run 3

If you have any questions concerning this shipment, please call Mike Palazzolo or Bob Jongleux at (919) 541-9100.

Sincerely,

Test Team Leader
Radian Corporation

cc: Peter L. Wise, GLNPO
Larry Fink, GLNPO

APPENDIX C

DIOXIN/FURAN ANALYTICAL DATA FOR GASEOUS SAMPLES
SCRUBBER INLET AND OUTLET

TABLE C-1. DIOXIN/FURAN ANALYTICAL DATA FOR MM5 INLET TRAINS

Isomer/Homologue	Amount Detected Picograms Per Sample Train[a,b] Run 02	Run 03
Dioxins		
2378 TCDD	ND	ND
Other TCDD	4,600	14,000
Penta CDD	ND	800
Hexa CDD	9,400	11,000
Hepta CDD	71,200	32,500
Octa CDD	78,100	36,300
Total PCDD	163,300	94,600
Furans		
2378 TCDF	54,400	130,500
Other TCDF	132,100	194,050
Penta CDF	118,700	174,800
Hexa CDF	13,500	16,400
Hepta CDF	129,300	19,100
Octa CDF	129,700	21,900
Total PCDF	577,700	556,750

[a]Includes back-up XAD trap.

[b]Run 01 data were not reported.

TABLE C-2. DIOXIN/FURAN ANALYTICAL DATA FOR MM5 OUTLET TRAINS

Isomer/Homologue	Amount Detected Picograms Per Sample Train[a] Run 01	Run 02	Run 03
Dioxins			
2378 TCDD	70	70	100
Other TCDD	3,780	4,730	5,100
Penta CDD	400	600	850
Hexa CDD	2,650	4,750	4,450
Hepta CDD	3,900	22,100	9,800
Octa CDD	3,200	14,900	7,800
Total PCDD	14,000	47,150	28,100
Furans			
2378 TCDF	30,500	27,900	30,900
Other TCDF	67,750	89,750	94,000
Penta CDF	50,400	58,100	67,400
Hexa CDF	8,350	26,100	20,650
Hepta CDF	3,900	22,100	9,800
Octa CDF	1,800	55,500	20,300
Total PCDF	162,700	279,450	243,050

[a]Includes back-up XAD trap.

APPENDIX D

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA

APPENDIX D-1

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA
(As-Measured Concentrations)

TABLE D-1. DIOXIN/FURAN EMISSIONS DATA FOR RUN 2, SITE SSI-C INLET

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	1.39E+00(N/A)	1.04E-01(N/A)	6.54E+01
Penta-CDD	ND (7.88E-01)	ND (5.32E-02)	ND (3.70E+01)
Hexa-CDD	2.85E+00(N/A)	1.75E-01(N/A)	1.34E+02
Hepta-CDD	2.16E+01(N/A)	1.22E+00(N/A)	1.01E+03
Octa-CDD	2.37E+01(N/A)	1.24E+00(N/A)	1.11E+03
Total PCDD	4.95E+01	2.74E+00	2.32E+03
FURANS			
2378 TCDF	1.65E+01(N/A)	1.30E+00(N/A)	7.73E+02
Other TCDF	4.00E+01(N/A)	3.15E+00(N/A)	1.88E+03
Penta-CDF	3.60E+01(N/A)	2.54E+00(N/A)	1.69E+03
Hexa-CDF	4.09E+00(N/A)	2.62E-01(N/A)	1.92E+02
Hepta-CDF	3.92E+01(N/A)	2.30E+00(N/A)	1.84E+03
Octa-CDF	3.93E+01(N/A)	2.13E+00(N/A)	1.84E+03
Total PCDF	1.75E+02	1.17E+01	8.21E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-2. DIOXIN/FURAN EMISSIONS DATA FOR RUN 3, SITE SSI-C INLET

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	4.23E+00(N/A)	3.16E-01(N/A)	1.80E+02
Penta-CDD	2.42E-01(N/A)	1.63E-02(N/A)	1.03E+01
Hexa-CDD	3.32E+00(N/A)	2.04E-01(N/A)	1.41E+02
Hepta-CDD	9.82E+00(N/A)	5.56E-01(N/A)	4.17E+02
Octa-CDD	1.10E+01(N/A)	5.74E-01(N/A)	4.66E+02
Total PCDD	2.86E+01	1.67E+00	1.22E+03
FURANS			
2378 TCDF	3.94E+01(N/A)	3.10E+00(N/A)	1.68E+03
Other TCDF	5.86E+01(N/A)	4.61E+00(N/A)	2.49E+03
Penta-CDF	5.28E+01(N/A)	3.74E+00(N/A)	2.25E+03
Hexa-CDF	4.95E+00(N/A)	3.18E-01(N/A)	2.11E+02
Hepta-CDF	5.77E+00(N/A)	3.39E-01(N/A)	2.45E+02
Octa-CDF	6.62E+00(N/A)	3.58E-01(N/A)	2.81E+02
Total PCDF	1.68E+02	1.25E+01	7.15E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-3. DIOXIN/FURAN EMISSIONS DATA FOR RUN 1, SITE SSI-C OUTLET

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	2.33E-02(N/A)	1.74E-03(N/A)	1.79E+00
Other TCDD	1.26E+00(N/A)	9.38E-02(N/A)	9.65E+01
Penta-CDD	1.33E-01(N/A)	8.98E-03(N/A)	1.02E+01
Hexa-CDD	8.80E-01(N/A)	5.42E-02(N/A)	6.77E+01
Hepta-CDD	1.30E+00(N/A)	7.33E-02(N/A)	9.96E+01
Octa-CDD	1.06E+00(N/A)	5.56E-02(N/A)	8.17E+01
Total PCDD	4.65E+00	2.88E-01	3.57E+02
FURANS			
2378 TCDF	1.01E+01(N/A)	7.97E-01(N/A)	7.79E+02
Other TCDF	2.25E+01(N/A)	1.77E+00(N/A)	1.73E+03
Penta-CDF	1.67E+01(N/A)	1.18E+00(N/A)	1.29E+03
Hexa-CDF	2.77E+00(N/A)	1.78E-01(N/A)	2.13E+02
Hepta-CDF	1.30E+00(N/A)	7.62E-02(N/A)	9.96E+01
Octa-CDF	5.98E-01(N/A)	3.24E-02(N/A)	4.60E+01
Total PCDF	5.41E+01	4.04E+00	4.15E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-4. DIOXIN/FURAN EMISSIONS DATA FOR RUN 2, SITE SSI-C OUTLET

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	2.30E-02(N/A)	1.72E-03(N/A)	1.86E+00
Other TCDD	1.56E+00(N/A)	1.16E-01(N/A)	1.26E+02
Penta-CDD	1.97E-01(N/A)	1.33E-02(N/A)	1.60E+01
Hexa-CDD	1.56E+00(N/A)	9.61E-02(N/A)	1.26E+02
Hepta-CDD	7.27E+00(N/A)	4.11E-01(N/A)	5.88E+02
Octa-CDD	4.90E+00(N/A)	2.56E-01(N/A)	3.96E+02
Total PCDD	1.55E+01	8.95E-01	1.25E+03
FURANS			
2378 TCDF	9.18E+00(N/A)	7.21E-01(N/A)	7.42E+02
Other TCDF	2.95E+01(N/A)	2.32E+00(N/A)	2.39E+03
Penta-CDF	1.91E+01(N/A)	1.35E+00(N/A)	1.55E+03
Hexa-CDF	8.59E+00(N/A)	5.51E-01(N/A)	6.94E+02
Hepta-CDF	2.35E+01(N/A)	1.38E+00(N/A)	1.90E+03
Octa-CDF	1.83E+01(N/A)	9.89E-01(N/A)	1.48E+03
Total PCDF	1.08E+02	7.32E+00	8.75E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-5. DIOXIN/FURAN EMISSIONS DATA FOR RUN 3, SITE SSI-C OUTLET

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	3.62E-02(N/A)	2.71E-03(N/A)	2.61E+00
Other TCDD	1.85E+00(N/A)	1.38E-01(N/A)	1.33E+02
Penta-CDD	3.08E-01(N/A)	2.08E-02(N/A)	2.22E+01
Hexa-CDD	1.61E+00(N/A)	9.92E-02(N/A)	1.16E+02
Hepta-CDD	3.55E+00(N/A)	2.01E-01(N/A)	2.56E+02
Octa-CDD	2.83E+00(N/A)	1.48E-01(N/A)	2.04E+02
Total PCDD	1.02E+01	6.10E-01	7.34E+02
FURANS			
2378 TCDF	1.12E+01(N/A)	8.80E-01(N/A)	8.07E+02
Other TCDF	3.41E+01(N/A)	2.68E+00(N/A)	2.46E+03
Penta-CDF	2.44E+01(N/A)	1.73E+00(N/A)	1.76E+03
Hexa-CDF	7.48E+00(N/A)	4.80E-01(N/A)	5.39E+02
Hepta-CDF	1.00E+01(N/A)	5.88E-01(N/A)	7.21E+02
Octa-CDF	7.36E+00(N/A)	3.98E-01(N/A)	5.30E+02
Total PCDF	9.45E+01	6.75E+00	6.81E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX D-2

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA
(Concentrations corrected to 3 percent Oxygen)

TABLE D-6. DIOXIN/FURAN EMISSIONS DATA FOR RUN 2, SITE SSI-C INLET
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	3.98E+00(N/A)	2.98E-01(N/A)	6.54E+01
Penta-CDD	ND (2.25E+00)	ND (1.52E-01)	ND (3.70E+01)
Hexa-CDD	8.14E+00(N/A)	5.01E-01(N/A)	1.34E+02
Hepta-CDD	6.16E+01(N/A)	3.49E+00(N/A)	1.01E+03
Octa-CDD	6.76E+01(N/A)	3.54E+00(N/A)	1.11E+03
Total PCDD	1.41E+02	7.82E+00	2.32E+03
FURANS			
2378 TCDF	4.71E+01(N/A)	3.70E+00(N/A)	7.73E+02
Other TCDF	1.14E+02(N/A)	8.99E+00(N/A)	1.88E+03
Penta-CDF	1.03E+02(N/A)	7.27E+00(N/A)	1.69E+03
Hexa-CDF	1.17E+01(N/A)	7.50E-01(N/A)	1.92E+02
Hepta-CDF	1.12E+02(N/A)	6.58E+00(N/A)	1.84E+03
Octa-CDF	1.12E+02(N/A)	6.08E+00(N/A)	1.84E+03
Total PCDF	5.00E+02	3.34E+01	8.21E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-7. DIOXIN/FURAN EMISSIONS DATA FOR RUN 3, SITE SSI-C INLET
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	1.29E+01(N/A)	9.64E-01(N/A)	1.80E+02
Penta-CDD	7.37E-01(N/A)	4.98E-02(N/A)	1.03E+01
Hexa-CDD	1.01E+01(N/A)	6.24E-01(N/A)	1.41E+02
Hepta-CDD	3.00E+01(N/A)	1.70E+00(N/A)	4.17E+02
Octa-CDD	3.35E+01(N/A)	1.75E+00(N/A)	4.66E+02
Total PCDD	8.72E+01	5.08E+00	1.22E+03
FURANS			
2378 TCDF	1.20E+02(N/A)	9.46E+00(N/A)	1.68E+03
Other TCDF	1.79E+02(N/A)	1.41E+01(N/A)	2.49E+03
Penta-CDF	1.61E+02(N/A)	1.14E+01(N/A)	2.25E+03
Hexa-CDF	1.51E+01(N/A)	9.70E-01(N/A)	2.11E+02
Hepta-CDF	1.76E+01(N/A)	1.04E+00(N/A)	2.45E+02
Octa-CDF	2.02E+01(N/A)	1.09E+00(N/A)	2.81E+02
Total PCDF	5.13E+02	3.80E+01	7.15E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-8. DIOXIN/FURAN EMISSIONS DATA FOR RUN 1, SITE SSI-C OUTLET
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	1.55E-01(N/A)	1.16E-02(N/A)	1.79E+00
Other TCDD	8.37E+00(N/A)	6.25E-01(N/A)	9.65E+01
Penta-CDD	8.86E-01(N/A)	5.99E-02(N/A)	1.02E+01
Hexa-CDD	5.87E+00(N/A)	3.61E-01(N/A)	6.77E+01
Hepta-CDD	8.64E+00(N/A)	4.89E-01(N/A)	9.96E+01
Octa-CDD	7.09E+00(N/A)	3.71E-01(N/A)	8.17E+01
Total PCDD	3.10E+01	1.92E+00	3.57E+02
FURANS			
2378 TCDF	6.76E+01(N/A)	5.31E+00(N/A)	7.79E+02
Other TCDF	1.50E+02(N/A)	1.18E+01(N/A)	1.73E+03
Penta-CDF	1.12E+02(N/A)	7.90E+00(N/A)	1.29E+03
Hexa-CDF	1.85E+01(N/A)	1.19E+00(N/A)	2.13E+02
Hepta-CDF	8.64E+00(N/A)	5.08E-01(N/A)	9.96E+01
Octa-CDF	3.99E+00(N/A)	2.16E-01(N/A)	4.60E+01
Total PCDF	3.60E+02	2.69E+01	4.15E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-9. **DIOXIN/FURAN EMISSIONS DATA FOR RUN 2, SITE SSI-C OUTLET**
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	1.30E-01(N/A)	9.68E-03(N/A)	1.86E+00
Other TCDD	8.75E+00(N/A)	6.54E-01(N/A)	1.26E+02
Penta-CDD	1.11E+00(N/A)	7.50E-02(N/A)	1.60E+01
Hexa-CDD	8.79E+00(N/A)	5.41E-01(N/A)	1.26E+02
Hepta-CDD	4.09E+01(N/A)	2.31E+00(N/A)	5.88E+02
Octa-CDD	2.76E+01(N/A)	1.44E+00(N/A)	3.96E+02
Total PCDD	8.72E+01	5.04E+00	1.25E+03
FURANS			
2378 TCDF	5.16E+01(N/A)	4.06E+00(N/A)	7.42E+02
Other TCDF	1.66E+02(N/A)	1.31E+01(N/A)	2.39E+03
Penta-CDF	1.08E+02(N/A)	7.61E+00(N/A)	1.55E+03
Hexa-CDF	4.83E+01(N/A)	3.10E+00(N/A)	6.94E+02
Hepta-CDF	1.32E+02(N/A)	7.77E+00(N/A)	1.90E+03
Octa-CDF	1.03E+02(N/A)	5.56E+00(N/A)	1.48E+03
Total PCDF	6.08E+02	4.12E+01	8.75E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-10. DIOXIN/FURAN EMISSIONS DATA FOR RUN 3, SITE SSI-C OUTLET
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	1.42E-01(N/A)	1.06E-02(N/A)	2.61E+00
Other TCDD	7.23E+00(N/A)	5.40E-01(N/A)	1.33E+02
Penta-CDD	1.21E+00(N/A)	8.14E-02(N/A)	2.22E+01
Hexa-CDD	6.31E+00(N/A)	3.88E-01(N/A)	1.16E+02
Hepta-CDD	1.39E+01(N/A)	7.86E-01(N/A)	2.56E+02
Octa-CDD	1.11E+01(N/A)	5.78E-01(N/A)	2.04E+02
Total PCDD	3.98E+01	2.39E+00	7.34E+02
FURANS			
2378 TCDF	4.38E+01(N/A)	3.44E+00(N/A)	8.07E+02
Other TCDF	1.33E+02(N/A)	1.05E+01(N/A)	2.46E+03
Penta-CDF	9.56E+01(N/A)	6.76E+00(N/A)	1.76E+03
Hexa-CDF	2.93E+01(N/A)	1.88E+00(N/A)	5.39E+02
Hepta-CDF	3.91E+01(N/A)	2.30E+00(N/A)	7.21E+02
Octa-CDF	2.88E+01(N/A)	1.56E+00(N/A)	5.30E+02
Total PCDF	3.70E+02	2.64E+01	6.81E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = Not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX E
RUN-SPECIFIC RISK MODELING INPUT DATA

TABLE E-1. RISK MODELING PARAMETERS FOR RUN 2, SITE SSI-C INLET

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (N/A)	ND (N/A)	1.000	ND (N/A)
Other TCDD	1.39E+00	6.54E+01	.010	5.73E+00
2378 TCDF	1.65E+01	7.73E+02	.100	6.78E+02
Other TCDF	4.00E+01	1.88E+03	.001	1.65E+01
Penta-CDD	ND (7.88E-01)	ND (3.70E+01)	.500	ND (1.62E+02)
Penta-CDF	3.60E+01	1.69E+03	.100	1.48E+03
Hexa-CDD	2.85E+00	1.34E+02	.040	4.68E+01
Hexa-CDF	4.09E+00	1.92E+02	.010	1.68E+01
Hepta-CDD	2.16E+01	1.01E+03	.001	8.87E+00
Hepta-CDF	3.92E+01	1.84E+03	.001	1.61E+01
Octa-CDD	2.37E+01	1.11E+03	.000	.00E+00
Octa-CDF	3.93E+01	1.84E+03	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				2.27E+03

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE E-2 . RISK MODELING PARAMETERS FOR RUN 3, SITE SSI-C INLET

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (N/A)	ND (N/A)	1.000	ND (N/A)
Other TCDD	4.23E+00	1.80E+02	.010	1.58E+01
2378 TCDF	3.94E+01	1.68E+03	.100	1.47E+03
Other TCDF	5.86E+01	2.49E+03	.001	2.18E+01
Penta-CDD	2.42E-01	1.03E+01	.500	4.50E+01
Penta-CDF	5.28E+01	2.25E+03	.100	1.97E+03
Hexa-CDD	3.32E+00	1.41E+02	.040	4.95E+01
Hexa-CDF	4.95E+00	2.11E+02	.010	1.85E+01
Hepta-CDD	9.82E+00	4.17E+02	.001	3.66E+00
Hepta-CDF	5.77E+00	2.45E+02	.001	2.15E+00
Octa-CDD	1.10E+01	4.66E+02	.000	.00E+00
Octa-CDF	6.62E+00	2.81E+02	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				3.59E+03

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE E-3. RISK MODELING PARAMETERS FOR RUN 1, SITE SSI-C OUTLET

Stack Height (From Grade Level) = 44 m
Stack Diameter (ID) = 1.32 m
Flue Gas Flow Rate (Dry Standard) = 1280.839 dscmm
Flue Gas Exit Temperature = 310 K
Flue Gas Exit Velocity (Actual) = 961 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	2.33E-02	1.79E+00	1.000	1.57E+01
Other TCDD	1.26E+00	9.65E+01	.010	8.45E+00
2378 TCDF	1.01E+01	7.79E+02	.100	6.82E+02
Other TCDF	2.25E+01	1.73E+03	.001	1.52E+01
Penta-CDD	1.33E-01	1.02E+01	.500	4.47E+01
Penta-CDF	1.67E+01	1.29E+03	.100	1.13E+03
Hexa-CDD	8.80E-01	6.77E+01	.040	2.37E+01
Hexa-CDF	2.77E+00	2.13E+02	.010	1.87E+01
Hepta-CDD	1.30E+00	9.96E+01	.001	8.72E-01
Hepta-CDF	1.30E+00	9.96E+01	.001	8.72E-01
Octa-CDD	1.06E+00	8.17E+01	.000	.00E+00
Octa-CDF	5.98E-01	4.60E+01	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				1.94E+03

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE E-4. RISK MODELING PARAMETERS FOR RUN 2, SITE SSI-C OUTLET

Stack Height (From Grade Level) = 44 m
Stack Diameter (ID) = 1.32 m
Flue Gas Flow Rate (Dry Standard) = 1347.922 dscmm
Flue Gas Exit Temperature = 306 K
Flue Gas Exit Velocity (Actual) = 989 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	2.30E-02	1.86E+00	1.000	1.63E+01
Other TCDD	1.56E+00	1.26E+02	.010	1.10E+01
2378 TCDF	9.18E+00	7.42E+02	.100	6.50E+02
Other TCDF	2.95E+01	2.39E+03	.001	2.09E+01
Penta-CDD	1.97E-01	1.60E+01	.500	6.99E+01
Penta-CDF	1.91E+01	1.55E+03	.100	1.35E+03
Hexa-CDD	1.56E+00	1.26E+02	.040	4.43E+01
Hexa-CDF	8.59E+00	6.94E+02	.010	6.08E+01
Hepta-CDD	7.27E+00	5.88E+02	.001	5.15E+00
Hepta-CDF	2.35E+01	1.90E+03	.001	1.66E+01
Octa-CDD	4.90E+00	3.96E+02	.000	.00E+00
Octa-CDF	1.83E+01	1.48E+03	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				2.25E+03

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE E-5. RISK MODELING PARAMETERS FOR RUN 3, SITE SSI-C OUTLET

Stack Height (From Grade Level) = 44 m
Stack Diameter (ID) = 1.32 m
Flue Gas Flow Rate (Dry_Standard) = 1201.589 dscmm
Flue Gas Exit Temperature = 305 K
Flue Gas Exit Velocity (Actual) = 874 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	3.62E-02	2.61E+00	1.000	2.29E+01
Other TCDD	1.85E+00	1.33E+02	.010	1.17E+01
2378 TCDF	1.12E+01	8.07E+02	.100	7.07E+02
Other TCDF	3.41E+01	2.46E+03	.001	2.15E+01
Penta-CDD	3.08E-01	2.22E+01	.500	9.73E+01
Penta-CDF	2.44E+01	1.76E+03	.100	1.54E+03
Hexa-CDD	1.61E+00	1.16E+02	.040	4.07E+01
Hexa-CDF	7.48E+00	5.39E+02	.010	4.73E+01
Hepta-CDD	3.55E+00	2.56E+02	.001	2.24E+00
Hepta-CDF	1.00E+01	7.21E+02	.001	6.32E+00
Octa-CDD	2.83E+00	2.04E+02	.000	.00E+00
Octa-CDF	7.36E+00	5.30E+02	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				2.50E+03

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

APPENDIX F

COMPOUND-SPECIFIC PRECURSOR RESULTS

TABLE F-1. COMPOUND-SPECIFIC DIOXIN PRECURSOR DATA FOR SITE SSI-C FEED SAMPLES

Precursor Compounds	Precursor Concentration, ug/g (ppm) Sludge Feed Samples		
	Run 1	Run 2	Run 3
Base Neutrals Fraction			
Chlorinated Benzenes:			
Dichlorobenzenes	0.003	0.03	ND
Trichlorobenzenes	ND	ND	ND
Tetrachlorobenzenes	ND	ND	ND
Pentachlorobenzenes	ND	ND	ND
Hexachlorobenzenes	ND	ND	ND
Total Chlorinated Benzenes	0.003	0.03	0
Chlorinated Biphenyls:			
Chlorobiphenyls	ND	ND	ND
Dichlorobiphenyls	ND	ND	ND
Trichlorobiphenyls	ND	ND	ND
Tetrachlorobiphenyls	ND	ND	ND
Pentachlorobiphenyls	ND	ND	ND
Hexachlorobiphenyls	ND	ND	ND
Heptachlorobiphenyls	ND	ND	ND
Octachlorobiphenyls	ND	ND	ND
Nonachlorobiphenyls	ND	ND	ND
Decachlorobiphenyls	ND	ND	ND
Total Chlorinated Biphenyls	0	0	0
Acids Fraction			
Chlorinated Phenols:			
Dichlorophenols	ND	ND	ND
Trichlorophenols	ND	ND	ND
Tetrachlorophenols	ND	ND	ND
Pentachlorophenols	ND	ND	ND
Total Chlorinated Phenols	0	0	0

ND = not detected

APPENDIX G

ERROR ANALYSIS OF CONTROL DEVICE EFFICIENCY CALCULATIONS

APPENDIX G
ERROR ANALYSIS: CONTROL DEVICE EFFICIENCY CALCULATIONS

Objective: Given the analytical uncertainty of the dioxin/furan analyses (± 50% accuracy), estimate the uncertainty of the control device efficiency calculations.

Let: $C_{out,meas}$ = the measured concentration of a given dioxin/furan homologue at the outlet location.

$C_{in,meas}$ = the measured concentration of a given dioxin/furan homologue at the inlet location.

$C_{out,max}$ = the maximum possible concentration of the dioxin/furan homologue given the measured value $C_{out,meas}$.

$C_{out,min}$ = the minimum possible concentration of the dioxin/furan homologue given the measured value $C_{out,meas}$.

$C_{in,max}$ = the maximum possible concentration of the dioxin/furan homologue, given the measured value $C_{in,meas}$.

$C_{in,min}$ = the minimum possible concentration of the dioxin/furan homologue, given the measured value $C_{in,meas}$.

E = the removal efficiency of the control device

Assuming ± 50 percent analytical accuracy:

$$C_{min} = C_{meas} - 0.5\ C_{meas} = 0.5\ C_{meas}$$

$$C_{max} = C_{meas} + 0.5\ C_{meas} = 1.5\ C_{meas}$$

Note that: $$E_{max} = \frac{C_{in,max} - C_{out,min}}{C_{in,max}} = 1 - \frac{C_{out,min}}{C_{in,max}}$$

$$E_{max} = 1 - \frac{0.5\ C_{out,meas}}{1.5\ C_{in,meas}} = 1 - {}^{1}/_{3}\ (1 - E_{meas})$$

$$= {}^{2}/_{3} + {}^{1}/_{3}\ E_{meas}$$

and:

$$E_{min} = \frac{C_{in,min} - C_{out,max}}{C_{in,min}} = 1 - \frac{C_{out,max}}{C_{in,min}}$$

$$= 1 - \frac{1.5\ C_{out,meas}}{0.5\ C_{in,meas}}$$

$$= 1 - 3\ (1 - E_{meas})$$

$$E_{min} = 3\ E_{meas} - 2$$

Now, $E_{min} > 0$ positive control (i.e., emissions reduction across the control device)

$$(3E_{meas} - 2) > 0$$

$$E_{meas} > {}^{2}/_{3}$$

Therefore, if E_{meas} is larger than 66.7 percent, the true removal efficiency can safely be assumed to be greater than zero.

And, $E_{max} < 0$ negative control (i.e., emissions increase across the control device)

$${}^{2}/_{3} + {}^{1}/_{3}\ E_{meas} < 0$$

$$E_{meas} < -2$$

Therefore, if E_{meas} is less than -200 percent, the true efficiency can safely be assumed to be less than zero.

To summarize:

$E_{meas} > 66.7$ percent	positive control
$-200 < E_{meas} < 66.7$ percent	no definitive conclusions can be drawn
$E_{meas} < 200$ percent	no negative control

TABLE G.1 VALUES OF E_{max} and E_{min} FOR VARIOUS MEASURED CONTROL EFFICIENCIES

Control Device Efficiency (%)		
E_{meas}	E_{max}	E_{min}
100	100	100
95	98.3	85
90	96.7	70
85	95.0	55
80	93.4	40
75	91.7	25
50	83.4	-50
25	75.0	-125
0	66.7	-200
-25	58.4	-275
-50	50.0	-350
-100	33.4	-500
-200	0	-800

$$E_{max} = (200 + E_{meas})/3$$

$$E_{min} = 3E_{meas} - 200$$

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

This draft report summarizes the results of a dioxin/furan emissions test of a sewage sludge incinerator equipped with a wet scrubber system for particulate emissions control. The test was the 12th in a series of thirteen dioxin/furan emissions tests being conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources emnit dioxins or furans. The secondary objective of Tier 4 is to quantify these emissions.

Sewage sludge incinerators are one of eight combustion device categories that have been tested in the Tier 4 program. The tested sewage sludge incinerator, hereafter referred to as incinerator SSI-C, was selected for this test after an initial information screening and a one-day pretest survey visit.

Data presented in the report include dioxin (tetra through octa homologue + 2378 TCDD) and furan (tetra through octa homologue +2378 TCDF) results for both stack samples and ash samples. In addition, process data collected during sampling are also presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Emissions Combustion Sources Dioxin Furans 2,3,7,8 Tetrachlorodibenzo-p-dioxin Sewage Sludge Incinerator Incineration	Air Pollution Emissions Data	

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