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Emissions Testing of a Wet Cement Kiln at Hannibal, Missouri

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SECTION 1

INTRODUCTION

The Environmental Protection Agency, Office of Solid Waste (EPA/OSW) is developing regulations to control emissions of products of incomplete combustion (PICs) from cement kilns. The emission parameters planned for use in this regulation are total hydrocarbons (HCs) and carbon monoxide (CO). To investigate the use of these parameters as surrogates for PICs, more information from full-scale testing of wet cement kilns is needed. Data are also needed for development of regulations to control emissions of hydrogen chloride (HCl). As a part of this data-gathering effort, a test was conducted at the Continental Cement Company in Hannibal, Missouri. One reason that Continental was selected by EPA for the test is that the facility uses a wet process kiln and also burns both liquid and solid (powdered) hazardous waste as supplementary fuels in the kiln. All test activities were conducted for and under the direction of EPA/OSW, Waste Treatment Branch.

The remaining sections of this report present a detailed description of the test. Section 2 presents the conclusions drawn from the test. Section 3 presents a description of the project including the project objectives, facility operations, and test activities. A discussion of the results of this study is provided in Section 4.

Three appendices contain additional information as follows: Appendix A presents a detailed discussion of the sampling and analysis methods used in the study, Appendix B provides the experimental data from the study, and Appendix C is a review of quality assurance/quality control (QA/QC) activities.

SECTION 2

CONCLUSIONS

This section contains brief statements of the major conclusions based on analysis of the data generated during this project. Further discussion of these conclusions and other aspects of the data are presented in Section 4.

1. Total organic mass (TOM) levels during waste-burning conditions were marginally higher than those measured during the coal-plus-diesel fuel baseline tests. C_7-C_{17} hydrocarbon levels were higher when burning waste, but the $> C_{17}$ hydrocarbon levels were lower. The baseline (coal-only) TOM was significantly lower, although process upsets with high O_2 levels during this test run may have contributed to this effect.

2. The TOM, hot hydrocarbon (hot HC), and cold hydrocarbon (cold HC) levels generally maintained a consistent relationship to each other for all six test runs. The TOM levels were highest, with hot HC within 25% of the TOM value. Cold HC levels were about 50% to 70% of the hot HC readings.

3. Emission levels for both volatile and semivolatile products of incomplete combustion (PICs) were similar between coal-plus-waste and baseline (coal-plus-diesel) conditions. The baseline (coal-only) emissions were considerably lower than either of the above two conditions, although the process conditions in Run 1 most likely contributed to this effect. A comparison of the kiln PIC emissions to typical hazardous waste incinerators showed the kiln PICs to generally be at higher levels, although levels of some individual PICs were lower.

4. Dioxin/furan emissions followed trends similar to PICs. Run 1 (baseline coal-only) emission rates were lower than either of the other two test conditions. Coal-plus-waste and baseline (coal-plus-diesel) conditions both saw higher emissions at nearly the same levels. Total dioxin/furan emissions were on the order of 100 to 900 ng/dscm. The emissions of 2,3,7,8 dioxin/furan isomers and the 2,3,7,8 TCDD equivalent concentrations followed the same trend from run to run as the total dioxin/furan emissions.

5. The input rate of total organic carbon (TOC) in the kiln feed materials, mostly in the shale, ranged from 11 to 99 times the stack emission rate of hydrocarbons. Thus, TOC in the feed materials potentially contributed to the hydrocarbon emissions. Hydrocarbons originating from the TOC, however, could not be distinguished in this test from hydrocarbons originating from combustion of coal or waste in the kiln. Pyrolysis-GC/MS analysis of the shale showed most of the TOC was alkanes with 9 to 16 carbons.

6. Ammonia (NH_3) and hydrogen chloride (HCl) in the stack gases apparently react stoichiometrically to form ammonium chloride (NH_4Cl). At the stack gas temperature of about 300°F and the HCl sampling train filter temperature of 250°F, the NH_4Cl would be dissociated into NH_3 and HCl. These gases pass the sampling train filter and reform NH_4Cl in the train impingers. Thus, analysis of the impinger contents measures the chloride ion in NH_4Cl as HCl.

7. Results of the HCl dilution sampling train were not conclusive, but the results tended to show more condensed NH_4Cl particles on the ambient temperature filter than were observed on the heated filter in the stack HCl sampling train. This suggests that NH_4Cl condenses as the hot stack gases leave the stack and mix with and are cooled by ambient air.

8. The HCl monitor results agreed with the stack HCl sampling train results corrected for any HCl that could have reacted with NH_3. It is likely that NH_4Cl particles condensed and deposited in the cool sampling line to the monitor.

SECTION 3

PROJECT DESCRIPTION

This section presents the project objectives, a description of the Continental Cement Co. facility operations, the test design, and a summary of the sampling and analysis performed for these tests.

3.1 PROJECT OBJECTIVES

The test at the Continental Cement kiln was originally designed to gather emission data during two modes of process operation: one with no waste feeds (baseline coal-only) and, a second with powdered (solid) and liquid hazardous wastes fed to the kiln with the coal. Difficulties in operating the kiln under coal-only baseline conditions led to establishing a second set of baseline conditions firing both coal and diesel fuel. Data-gathering objectives were to characterize these modes of operation as follows:

1. Measure and compare emission levels of HCs (using both a heated and unheated hydrocarbon monitor system) and total organic mass as measured by field GC and the gravimetric fraction of the MM5 (semivolatiles) train.

2. Measure the levels of carbon monoxide (CO), carbon dioxide (CO_2), and oxygen (O_2) in the stack gas.

3. Measure PIC emissions, including dioxins, furans, and low molecular weight hydrocarbons, for comparison to historical data from other hazardous waste combustion devices.

4. Measure the emission levels of hydrogen chloride (HCl) using both an M5-style sampling train and a continuous HCl monitor for comparative purposes.

5. Determine if chloride emissions are in particulate form (e.g., ammonium chloride particles) or gaseous form (e.g., HCl) or both, after dilution and cooling with ambient air.

6. Measure the levels of total organic carbon (TOC) in the cement kiln lime slurry feed for comparison to total hydrocarbon emissions measured in the stack.

7. Obtain data on process operating conditions, as monitored by the facility and data from the facility that characterizes the fossil fuels and hazardous waste fed to the kiln.

3.2 PROCESS DESCRIPTION

The test site selected for the field sampling program was a wet process, coal and waste-fired cement kiln. A simplified flow diagram of this cement manufacturing facility is shown in Figure 3-1. The plant produces approximately 1,800 tons/d of cement clinker product from the kiln.

The facility consists of an Allis Chalmers rotary kiln which is designed to handle approximately 3,000 tons/d of wet slurry feed. The feed material consists of approximately 85% limestone and 15% shale (dry basis), in a slurry containing approximately 25% to 30% water. The refractory-lined kiln is 622 ft long with a diameter of 18 ft at the entrance (feed) and 16 feet at the exit (product). The feed material reaches a temperature of approximately 2800°F in the fuel combustion zone.

Normal coal feed rates are about 18 to 22 tons/h with a maximum of 24 tons/h. The coal feed is a mixture of high and medium sulfur-coals (and some petroleum coke). The coal sulfur content ranges from approximately 2.5% to 3.3%.

Liquid wastes, typically waste solvents and thinners, are also fired in the kiln, injected axially through the center of the single pulverized coal

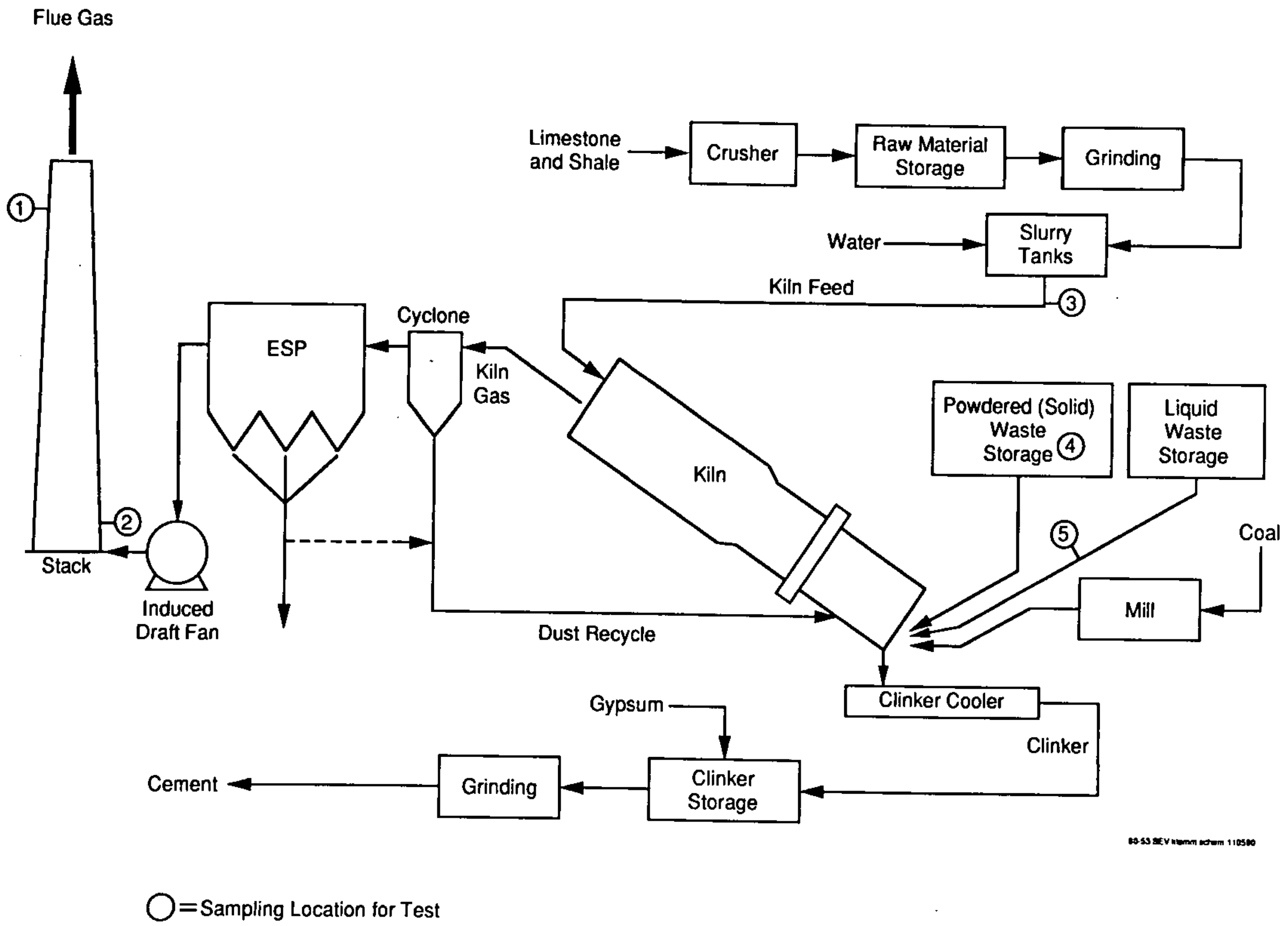


Figure 3-1. Process flow diagram.

burner. Liquid waste firing rates are limited by the facility to a maximum of 40 gpm and a maximum chlorine content of 10%. Solid (powdered) waste is injected into the kiln every 2-3 minutes in charges of about 10 gallons each. Total wastes are typically fired at a rate corresponding to about 20% of the total heat input to the kiln, with chlorine contents normally ranging from 1% to 4%. Wastes can be fired at a rate up to 50% of the total heat input to the kiln.

The kiln gases pass through the length of the kiln and dry the incoming feed slurry stream. The kiln gas exits the kiln, passes through a cyclone for dust recycle, and enters the electrostatic precipitator (a 4 field ESP manufactured by American Air Filter). Gas temperatures at the ESP are roughly 500° to 600°F. The flue gas then exits the ESP to an induced draft fan and is exhausted to the 150-ft-tall stack. Stack temperatures ranged from 400° to 500°F.

The kiln is equipped with an automatic process control system that monitors key operating variables. These include slurry, coal, and waste feed rates; burner zone temperatures; and kiln gas O_2, CO_2, and CO concentrations. The kiln operates 24 h/day, 7 days/week, except for maintenance shutdowns, averaging about 330 days of operation per year.

3.3 TEST DESCRIPTION

This section provides a description of the test program. The test objectives, sampling and analysis activities, and process monitoring are described. Appendix A provides complete descriptions of the sampling and analysis methods used for the test.

3.3.1 Test Matrix/Process Operations

The test program initially projected a matrix of five 2-h test runs at two defined kiln operating conditions. The first test condition (baseline) was to involve two test runs conducted at baseline operating conditions. The kiln was to be operated at essentially stable conditions with no waste feed to the system. Coal was to be the only fuel fired. The second test condition (coal-plus-waste) was to replace about half of the BTU input from coal with waste.

Actual field testing demonstrated that the initial choice of a coal-only baseline provided a relatively unstable and difficult to control process. Normal operations at Continental involve cofiring coal with hazardous waste. Consequently, the plant purchases lower-grade coal which proved to be a poor fuel when burned alone. Kiln temperature and oxygen levels continually fluctuated throughout the coal-only baseline test, while the facility normally maintains steady operations on both of these parameters. A poorer quality cement was also made during this run. As such, only one coal-only baseline test was actually performed. A different type of baseline condition was established in which coal and diesel fuel were both fired to the kiln without any hazardous waste. Two baseline tests were performed using coal and diesel fuel, thereby expanding the overall test program to six 2-h test runs. Table 3-1 shows the test matrix.

Wastes were fed during the second test condition, and three replicate test runs were performed at this condition. The kiln was operated at stable conditions with the maximum possible feed rate of solid wastes (powdered solids). Liquid waste was also cofired at a rate such that the combined liquid and solid waste heat input was 50% of the heat input to the kiln.

In addition to the three conditions described above (Baseline Coal-Only, Baseline Coal-plus-Diesel, Coal-plus-Waste Feeds), a 2-h HCl test was also performed under liquid waste plus coal burning conditions. No powdered wastes were fed during the special HCl test. Sampling activities during this special HCl test included only waste feeds, HCl train, HCl dilution air train, and HCl continuous monitoring.

Process data measured by Continental's process monitors were manually recorded every 15 min throughout each test run. Sampling activities were temporarily halted during any significant process upsets or instabilities.

Table 3-1. TEST MATRIX

Run	Condition
1	Baseline coal-only
2	Coal-plus-wastes (liquid and solid)
3	Coal-plus-wastes (liquid and solid)
4	Coal-plus-wastes (liquid and solid)
5	Baseline coal-plus-diesel fuel
6	Baseline coal-plus-diesel fuel
HCl test	Coal-plus-waste (liquid only)

3.3.2 Summary of Sampling and Analysis

Table 3-2 provides a summary of the test objectives and the measurement techniques used to meet those objectives. As shown in the table, more than one measurement technique was used in some cases to meet a single objective. Conversely, a single technique may have been used to meet more than one objective.

The frequency, number, type, and size (or quantity) of all samples collected during each run is presented in Table 3-3. The table also lists the sampling and analytical method(s) used for each sample. The matrix presented in Table 3-3 represents the sample collection scheme for one test run; i.e., the number of samples collected during a single 2-h test. Figure 3-1 shows the location of each sampling point. Combustion gases were sampled at either the stack or transition duct between the ESP and stack, as noted in Table 3-3 and shown in more detail in Figure 3-2.

Summary descriptions of the sample collection procedures are presented in Appendix A of this report. A summary of the sample preparation and analytical methods is presented in Appendix B.

TABLE 3-2. TEST OVERVIEW

Sampling and analysis objective	Measurement technique
• Measure HC with heated and unheated systems	• Modified EPA Method 25A[a]
• Measure organic mass	• Method 0010[b]--solvent extraction, evaporation and weighing
	• Field GC/FID[c] analysis
• Measure CO, CO_2, and O_2	• CO--Method 10 • O_2, CO_2--Method 3A
• Organic screen (PIC determination) including PCDD/PCDF[f]	• Method 0010[b]--GC/MS[d] analysis • VOST[e]--GC/MS analysis
• C_1 and C_2 hydrocarbons[g]	• Tedlar bag--GC/FID[c] analysis
• Measure HCl	• HCl sampling train, HCl dilution train, and HCl continuous monitor
• Determine TOC[h] in lime slurry and process water	• Solids--Combustion in LECO furnace and measurement of CO_2 evolved
	• Liquids--Catalytic combusion and measurement of CO_2 evolved

Note: The analytical methods associated with the above measurement techniques are defined in Table 3-3.

[a] HC measured using EPA Modified Method 25A systems equipped with flame ionization detector.
[b] SW-846 Method 0010 modified per Appendix A.
[c] GC/FID--Gas chromatography/flame ionization detector.
[d] GC/MS--Gas chromatography/mass spectrometry.
[e] VOST--Volatile organics sampling train (SW-846 Method 0030).
[f] PCDD/PCDF--Polychlorinated dibenzodioxin/polychlorinated dibenzofuran.
[g] Methane, ethane, ethylene, and acetylene.
[h] TOC--Total organic carbon.

TABLE 3-3. SUMMARY OF SAMPLING AND ANALYSIS ACTIVITIES

Sample	Sample location[a]	Sampling frequency for each run	Sampling method	Sample size	Analytical parameters	Preparation method[b]	Analytical method[b]
Stack gas	1	2-h composite per run	Method 0010	50-70 ft^3[c]	PCDD/PCDF[d]	Solvent extraction	GC/MS[e]
					> C17 organic mass	Solvent extraction	Gravimetric
					Organic screen	Solvent extraction	GC/MS
					Moisture	NA	Gravimetric
					Temperature	NA	Thermocouple
					Velocity	NA	Pitot tube
	1	2-h composite per run	HCl train[f]	52-54 ft^3[g]	Chlorides	NA	Ion chromatography (D4327-84)
					Potassium ion	NA	ICP-AES
					Ammonium ion	NA	Selective ion
	2	2-h composite per run	HCl dilution train	4-9 ft^3 of stack gas	Chlorides	NA	Ion chromatography (D4327-84)
					Potassium ion	NA	ICP-AES
					Ammonium ion	NA	Selective ion
	2	Three trap pairs at 30 min per pair	VOST (0030)[h]	~ 10 L per train pair	Organic screen	Thermal desorption	GC/MS
	1	Continuous 2 h	Integrated gas sample (Tedlar bag)	3-15 L (dry)	C_1 and C_2[i] Hydrocarbons	NA	GC/FID
	1	Sample injected every 10-15 min	Field GC	-	C1 - C17 Organic mass	NA	Field GC/FID
	1	Continuous	Method 10	-	CO	NA	EPA Method 10
			MM25A[j]	-	HC (cold)	NA	EPA MM25A
			Method 3A	-	CO_2	NA	EPA Method 3A
			Method 3A	-	O_2	NA	EPA Method 3A
			MM25A	-	HC (hot)	NA	EPA MM25A
			-	-	HCl	NA	Gas filter correlation
Lime slurry	3	One grab sample taken every 30 min, composited into one sample per run	Scoop (S007)	(Total) 1000 mL, 50 mL each grab	Total organic carbon	Filtered into solid and water fractions	Combustion by Leco furnace[k] (solids) and Method 415.1 (liquids), measurement of CO_2 evolved.

(continued)

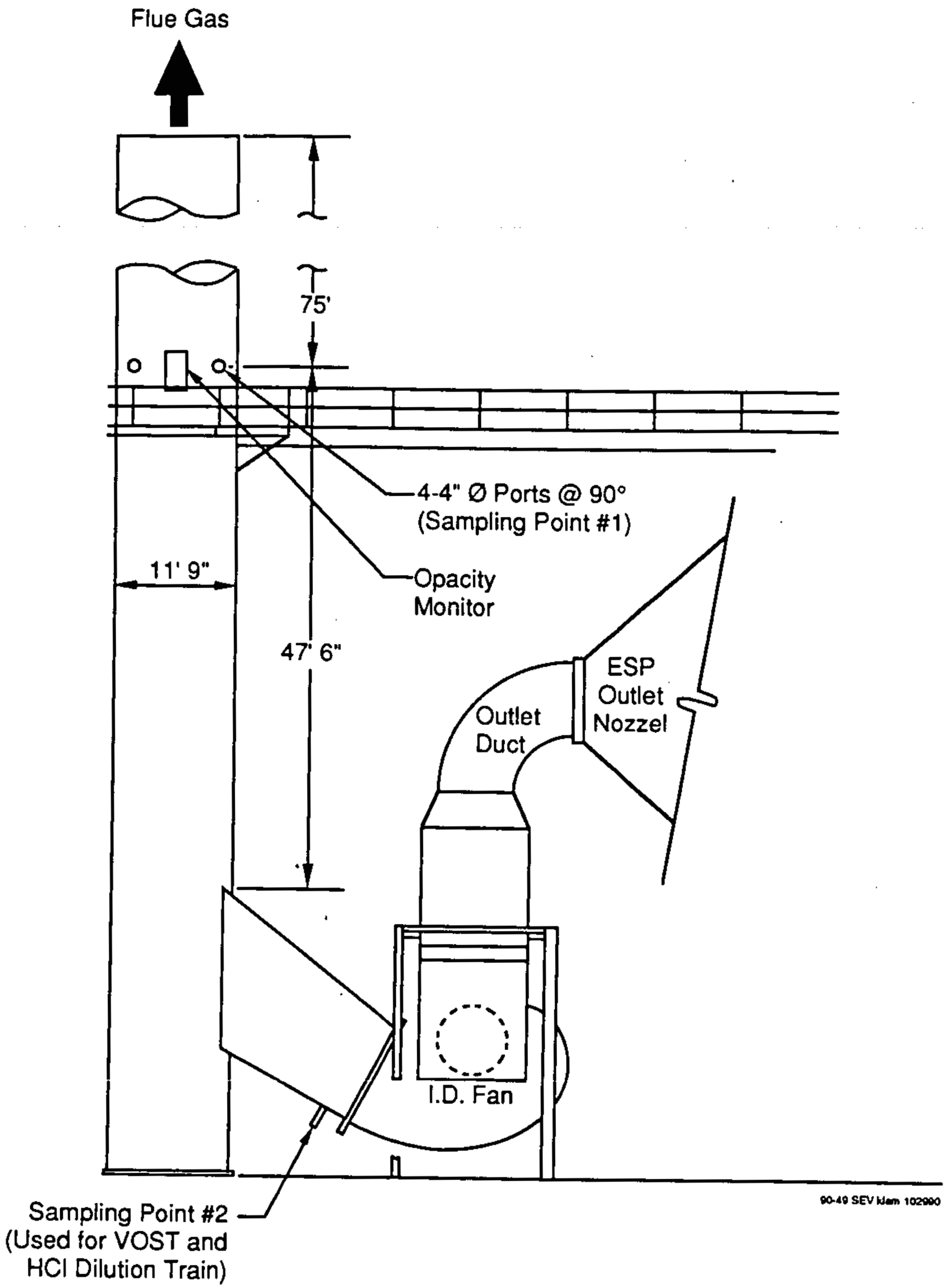


Figure 3-2. Detailed drawing of sampling ports.

3.3.3 HC and Organic Mass

HC emissions were measured using both a heated and unheated EPA Modified Method 25A (M25A) sampling systems, equipped with flame ionization detectors (FIDs). As a source of comparison to the HC measurements, organic carbon mass emissions were measured using a Method 0010 sampling train (i.e., SW-846 Method 0010) and a field gas chromatograph (GC). Samples from the Method 0010 train were analyzed gravimetrically after extraction and evaporation to determine the carbon fraction greater than C17 (> 300°C boiling point). The GC, equipped with an FID, was used to analyze syringe grab samples and determine C1 through C17 carbon fractions (up to 300°C boiling point). Summed together, the gravimetric and GC fractions provide a total organic mass value which can be quantitatively compared to the Modified M25A HC values. The comparison was made on the basis of HC emissions calculated as propane.

The organic mass sampling was modified from the existing EPA Level 1 testing protocols, as defined in the Level 1 Source Assessment Manual, IERL-RTP Procedures Manual: Level 1 Environmental Assessments (2nd Edition), EPA 600/7-78-201.

3.3.4 Organic Screen

The organic screen provides semiquantitative characterization of organic compounds, or PICs, present in exhaust gases. Volatile organics were determined using a volatile organic sampling train (VOST) as described in SW-846 Method 0030. VOST samples were analyzed by gas chromatography/mass spectrometry (GC/MS). Semivolatile organics were determined using the SW-846 Method 0010 sampling train (previously referenced above for organic mass determinations). Samples were analyzed by GC/MS. The screen provided a semiquantitative analysis of priority pollutants and the five largest additional GC peaks.

As a part of the organic screen, total polychlorinated dibenzodioxin and polychlorinated dibenzofuran (PCDD/PCDF) concentrations were determined in stack gas for samples from four of the six test runs. PCDDs/PCDFs were analyzed from a separate split of the extract from the above-referenced

Method 0010 sample train, as subsequently described in Appendix A-2 of this report.

3.3.5 C_1 and C_2 Hydrocarbons

An integrated stack gas sample for volatiles was collected using Tedlar gas bags. A 3- to 15-L sample was collected over the duration of each test run at a sampling rate of approximately 30 to 70 mL/min. Analysis of the bag sample was conducted for C_1 and C_2 hydrocarbons (methane, ethane, ethylene, and acetylene) by GC/FID, on site, at the end of each test run.

3.3.6 Hydrogen Chloride

Total HCl was determined in stack gas using an HCl sampling train. Samples were collected and analyzed based on the EPA's "Draft Method for the Determination of HCl Emissions from Municipal and Hazardous Waste Incinerators" (USEPA, Source Branch Quality Assurance Division, July 1988). The filter and impingers in the HCl train were analyzed separately for chloride ion to distinguish between particulate and gaseous chlorides. These samples were also analyzed for ammonium and potassium ions.

A second sampling train collected a stack gas sample which was diluted with ambient air before collection in the impingers. This train will be referred to as the "HCl Dilution Train." The filter and impingers in the HCl dilution train were analyzed separately for chloride ion to distinguish between particulate and gaseous chlorides. These samples were also analyzed for ammonium and potassium ions. Appendix A more fully describes the HCl dilution train.

An HCl continuous monitor was used for analysis of stack gases during run 5 and the special 2-h HCl test. The HCl monitor was operated concurrently with the HCl sampling trains in order for data comparisons to be made.

The HCl calculations (Appendix B-9) contain footnotes on data that are associated with estimates of several probe rinse and one run's impinger volumes. The actual volumes are not available. Approximations of the volumes were made by measuring the sample volume and estimating how much was used in the chemical analysis. These estimates should be within 5 mL (10% of the actual volumes), which does not affect the usefulness of the final data. Additionally, note that the rinse volume estimations will only affect front-half data.

3.3.7 Continuous Emissions Monitors

CO, CO_2, and O_2 were continuously monitored throughout the tests. CO was sampled and analyzed following EPA Reference Method 10. CO_2 and O_2 were sampled and analyzed according to procedures in Appendix B-3. HCl was monitored during run 5 and the HCl test as mentioned above in Section 3.3.6 using a separate sample line.

3.3.8 Total Organic Carbon

Lime slurry feed to the kiln was sampled and analyzed for TOC. Lime slurry samples were filtered prior to analysis into solid and liquid fractions. Solids were treated with hydrochloric acid to remove carbonate carbon, then combusted in a Leco furnace according to University of Texas A&M, Geochemical and Environmental Research Group, SOP-8907. Water samples were combusted according to EPA Method 415.1. In both cases, measurement by continuous monitor of the CO_2 evolved determined the TOC present.

3.3.9 Waste/Fuel Characterization

Liquid waste grab samples were collected about every half hour during runs 2, 3, and 4 of the test series as well as during the special HCl run. Each grab sample was about 50 to 100 mL, composited into one sample for each run. Samples were stored with ice and analyzed for higher heating value (HHV) and chlorine content by Galbraith Laboratories, Knoxville, Tennessee.

One powdered waste grab sample per run (runs 2, 3, and 4) was collected by Continental personnel for MRI. The samples were collected using a trier, being taken from the unloading truck prior to filling the powdered waste feed hopper. Samples were stored with ice and analyzed for higher heating value (HHV) and chlorine content by Galbraith Laboratories, Knoxville, Tennessee.

One pulverized coal grab sample per run was collected from the chute directly feeding to the kiln. Samples were stored with ice and archived.

Diesel fuel samples were collected in runs 5 and 6 and composited identically to the liquid waste samples. Samples were stored with ice and archived.

3.3.10 ESP Dust Sampling

Two dust grab samples were collected from each run, one of recycle dust (typically ESPs 1 and 2) and one of waste/landfill dust (typically ESPs 3 and 4). These samples were stored with ice and archived.

SECTION 4

DISCUSSION OF RESULTS

This section discusses the test results relative to the project objectives. The section is divided into three subsections. The first discusses process data and operation of the kiln. The second subsection discusses organic compound emissions, and the third discusses inorganic compound emissions.

4.1 PROCESS OPERATION

Table 4-1 presents average values of the principal process operating parameters for each test run. Raw data and min/max values for process data are in Appendix B-1, along with pertinent graphs and other information. Process operation was replicated closely from run to run, except for planned variations in the feed of coal, waste, and diesel fuel to the kiln for each test condition. Raw material (lime slurry) feed rate to the kiln was within 126 to 132 tons/h, except for run 1, which was 95 tons/h. Burner zone temperature (BZT), measured about 60 ft downstream of the kiln burners, ranged from 2260° to 2450°F.

Run 1 was conducted with the kiln firing coal only--no hazardous wastes or auxiliary fuels of any kind. Due to the relatively poor quality of coal available, plant operations during run 1 were unstable, requiring more frequent adjustments of kiln controls by the operator. Kiln rotational speed, lime slurry feed rate, dust feed rate, coal feed rate, and kiln temperatures were all considerably different during run 1 than in runs 2 to 6. Differences were also reflected in the ID fan amps and kiln amps.

Dust from the four-stage ESP is either recycled to the kiln entrance or disposed of as waste. Under normal operations, dusts from ESP stages 1 and 2 are recycled, while dust from stages 3 and 4 are treated as wastes. The rate monitored by process instruments is the recycled dust. The higher dust rates seen during the baseline tests (runs 1, 5, and 6) are because of the higher dust recycle necessary for process stability. Dust recycle was used for additional control of kiln temperatures.

Fuel/feed ratios were calculated for each run. For these calculations, fuel is the sum of coal and hazardous waste feeds in tons per hour. Feed is the sum of lime slurry and dust rates. The facility uses the fuel/feed ratio as an indicator of overall plant operations. Relative consistency was observed between the three replicate waste feed tests (runs 2, 3, 4) and again for the two baseline tests with diesel fuel (runs 5, 6).

TABLE 4-1. AVERAGE VALUES FOR PROCESS OPERATING PARAMETERS[a]

	Process condition						
	Baseline (coal only)	Waste fired			Baseline (coal & diesel)		Waste fired
Parameter	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	HCl test
Lime slurry feed rate, tons/h	95	129	132	132	126	127	110
Dust recycle rate, tons/h	18	3	4	2	9.5	9.9	2
Coal feed rate, tons/h	19	11.4	11.6	11.9	11.8	13.1	8.7
Diesel fuel feed rate, tons/h	NA	NA	NA	NA	4.9	3.8	NA
Waste fuel, tons/h equivalents[b]	NA	10.5	11.5	11.5	NA	NA	6.0
Liquid hazardous waste, tons/h	NA	7.9	9.2	10.0	NA	NA	6.2
Powdered hazardous waste, tons/h	NA	4.6	4.0	3.9	NA	NA	-
Fuel/feed ratio[c]	0.171	0.166	0.170	0.174	0.144	0.140	0.131
Kiln rotational speed, rev/h	51	67	70	70	66	66	57
Kiln amps	926	1136	1034	1005	1066	1041	1088
Burner zone temperature, °F	2447	2293	2274	2272	2261	2290	2244
Chain section temperature, °F	1619	1700	1766	1785	1590	1600	1693
Feed end temperature, °F	491	577	600	600	544	553	571
ESP inlet temperature, °F	443	502	540	540	469	480	494
ESP inlet O_2, %	3.1	1.9	2.0	1.9	2.0	2.0	3.5
ESP inlet SO_2, ppm	805	223	422	939	277	332	365
ESP inlet NO_x, ppm	916	619	939	1102	344	152	194
ID fan draft, in·H_2O	-2.0	-3.5	-3.7	-3.6	-4.1	-3.8	-2.9
ID fan % open	37	66	83	78	65	57	52
ID fan % of max. rotation	59	60	60	60	60	60	60
ID fan amps	65	73	76	77	75	76	70
Opacity, %	13	25	33	39	16	15	10
Stack temperature, °F	448	527	557	551	505	517	NA
Stack flow rate, dcsm/min	2710	2910	3000	3480	3150	3430	NA

NA = not applicable or not available

[a] All data are read directly or calculated from the facility's process control monitors, except stack temperature and stack flow rate, which are taken from MRI sampling data.

[b] These values are calculated by the plant and represent the coal Btu equivalent of waste feed in tons/h.

[c] Fuel/feed ratio is calculated using fuel = Coal + Waste fuel; feed = Lime slurry + Dust.

Supplemental fuel feed rate is the measure of either liquid hazardous waste (runs 2, 3, 4) or diesel fuel (runs 5, 6) used during the test. Neither type of feed was used during run 1, which fired coal only.

Process temperatures were measured at four separate locations. Burner Zone Temperature (BZT) measures temperature in the first 60 ft of the kiln. The chain section of the kiln begins about two thirds and ends about three fourths of the kiln length from the burners. Chain section temperature is monitored within this region. Feed end temperature is measured on the high end of the kiln, where lime slurry feed enters the kiln. ESP inlet temperature is monitored in the duct immediately upstream of the first ESP unit. Temperatures in each section were fairly consistent during replicate tests (runs 2, 3, 4, and runs 5 and 6, respectively). Temperatures were slightly higher during waste-burning test conditions (runs 2, 3 and 4).

Plant oxygen levels, monitored in the duct just upstream of the ESPs were kept near 2% for all tests except run 1 and the HCl test. Process instabilities during run 1 resulted in an average of 3.1% for that condition. MRI's continuous monitor data measured at the stack are shown in Table 4-2 (and Appendix B-3). Stack O_2 levels were consistently 2% to 3% higher than the facility's data, likely due to air inleakage in the process between the two locations. The higher O_2 levels for runs 1 and the HCl test were also observed at the stack. Notice that CO_2 values include CO_2 contributed from the limestone as well as combustion products.

TABLE 4-2. MRI CEM AVERAGE DATA[a]

Parameter	Units	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
O_2	%	5.9	3.9	4.2	4.1	4.4	4.5
CO_2	%	20.7	23.2	22.3	22.7	22.1	22.5
CO	ppm	198.4	279.5	326.3	264.8	271.1	243.1

[a] All are on a dry basis.

The plant CO monitor was not functional during the test series.

Plant SO_2 and NO_x monitors were located just upstream of the ID fan. Readings taken were instantaneous and not integrated over time, so there is considerable scatter in the data. Table 4-1 shows the average values for each run.

ID fan draft, fan % open (damper), fan % of maximum rotational speed, and fan amps were all monitored as indicators of fan operations. Operation was consistent for all runs except run 1 when the overall process throughput was somewhat lower.

Kiln amps were monitored as an indicator of solids buildup and clinker product within the kiln. Again, readings were fairly consistent with the exception of run 1, when product throughput rate was somewhat lower.

Opacity was measured in the stack and averaged below 40% for all test runs. All three of the baseline tests (runs 1, 5, and 6) had average opacities of 16% or less. For 10 min in run 5, opacity increased to 100% when a CO excursion triggered an ESP cutoff.

4.2 ORGANIC COMPOUND EMISSIONS

This section presents a discussion of organic compound emissions. Included are a description of: (1) total hydrocarbon (HC) and total organic mass (TOM) emissions; (2) emissions of semivolatile products of incomplete combustion (PICs); (3) the emissions of volatile PICs; (4) dioxin/furan emissions results; and (5) the total organic carbon content (TOC) of the raw material feed (i.e., crushed limestone and shale).

4.2.1 TOM and HC Emissions

Organic carbon mass emissions were quantified within boiling point ranges which roughly equate to ranges in the number of carbon atoms in organic compounds. Nonvolatile organic mass was measured using a SW-846 Method 0010 sampling train, and a field gas chromatograph (GC) was used for volatiles and semivolatiles. Samples from the Method 0010 train were analyzed gravimetrically following extraction and evaporation to determine the carbon fraction greater than C_{17} (> 300°C boiling point). The GC, equipped with an FID, was used to determine the C_1 through C_{17} carbon fraction (up to 300°C boiling point). GC samples were taken from the hot HC (subsequently defined) sample line. Summed together, the gravimetric and GC values provided a total organic mass (TOM) value which was compared to total hydrocarbon (HC) values. This comparison was made by converting the organic mass values to propane equivalent concentrations, since HC emissions are measured as propane.

HC emissions were measured by two different techniques identified here as hot and cold HC. The primary difference was that the hot HC measurement used a sample line and instrument heated to 150°C and the cold HC measurement used an ice cooled condensate trap near the duct sampling port and an unheated sample line. Both used a flame ionization detector (FID) as did the organic GC analyses. Both techniques are described in Appendix A-1, along with the field GC technique. The cold HC technique is more closely representative of historical HC monitoring techniques. The hot HC technique is under consideration as a measurement technique for regulation of hazardous waste incinerators, boilers, and industrial furnaces.

The following discussions of TOM and HC emission measurements is divided into two subsections. The first presents the total organic mass results determined by the gravimetric and GC sampling systems. The second presents the HC measurements and compares this data to TOM measurements.

4.2.1.1 TOM Emissions--

TOM was determined as three major organic fractions: C_1-C_7 volatile compounds, C_7-C_{17} semivolatile compounds, and $> C_{17}$ nonvolatile compounds. The average C_1-C_7 and C_7-C_{17} fractions were calculated from individual GC samples. An average value for the $> C_{17}$ fraction was generated from the gravimetric analysis of the Method 0010 sampling train. The reported total mass was calculated by summing the fractional carbon masses. All organic masses were calculated as propane on a dry basis. Appendix B-4 contains the analytical data for each GC sample.

A limited number of discrete or instantaneous GC samples were analyzed for TOM during each test run. These discrete samples may or may not have coincided with emissions peaks. If the GC samples were collected during short term emissions peaks, the TOM values would be biased high (or vice versa) for the respective run. Comparison of the sample times with the continuous HC data suggest any bias is probably small, except possibly for run 4. During run 4 there were two discrete GC samples that showed high C_7-C_{17} values (253.9 and 76.5 ppm). These two values quadrupled the semivolatile run averages. The samples were collected during periods when the presence or absence of a HC peak could not be confirmed, but, the highest value was near an ESP shutdown. Table 4-3 presents the GC data for the samples collected during run 4. The GC results for the remaining test runs are contained in Appendix B-4.

The distribution of the TOM among the three fractions is given in Table 4-4 and is illustrated graphically in Figure 4-1. Run 1 TOM levels were significantly lower than those measured during the remaining runs, but plant operating conditions varied throughout run 1. The plant does not normally operate under coal-firing alone conditions. Variations in the Btu value of the coal, combined with dust recycle problems, caused a series of high

TABLE 4-3. ORGANIC MASS DATA FOR RUN 4

Sample no.	Organic fractions (ppm propane, dry) Time	C_1-C_7	C_7-C_{17}	$> C_{17}$	Total mass (TOM, ppm propane, dry)
R4SS1	1053	36.2	1.3		
R4SS2	1112	49.6	1.5		
R4SS3	1130	19.3	253.9		
R4SS4	1148	45.7	24.4		
R4SS5	1207	33.6	39.1		
R4SS7	1232	43.9	4.8		
R4SS8	1251	61.5	2.5		
R4SS9	1309	43.2	1.0		
R4SS10	1327	35.5	76.5		
R4SS12	1346	39.4	7.9		
R4SS13	1404	64.7	4.5		
R4SS14	1422	68.3	3.2		
Run Average =		45.1	35.0	5.62	85.7

Note: Off-scale peak in C7-C17 region during 1130 sample, due to ESP shutdown.
Note: R4SS6 was taken during calibration and there was no R4SS11.

TABLE 4-4. ORGANIC MASS DISTRIBUTION

Run	Average organic mass (ppm propane, dry) C_1-C_7			Total mass (TOM)	Distribution percent of total mass C_1-C_7		
		C_7-C_{17}	$> C_{17}$			C_7-C_{17}	$> C_{17}$
1	17.7	3.2	1.73	22.6	78%	14%	8%
2	78.5	14.1	3.54	96.1	82%	15%	4%
3	67.0	20.5	5.31	92.8	72%	22%	6%
4	45.1	35.0	5.62	85.7	53%	41%	7%
5	72.3	5.0	8.22	85.5	85%	6%	10%
6	67.8	3.5	9.56	80.9	84%	4%	12%

Run 1--Baseline coal-only
Run 2,3,4--Coal-plus-waste feeds
Run 5,6--Baseline coal-plus-diesel fuel
Note: The run 4 C_7-C_{17} value may be biased high (see text).

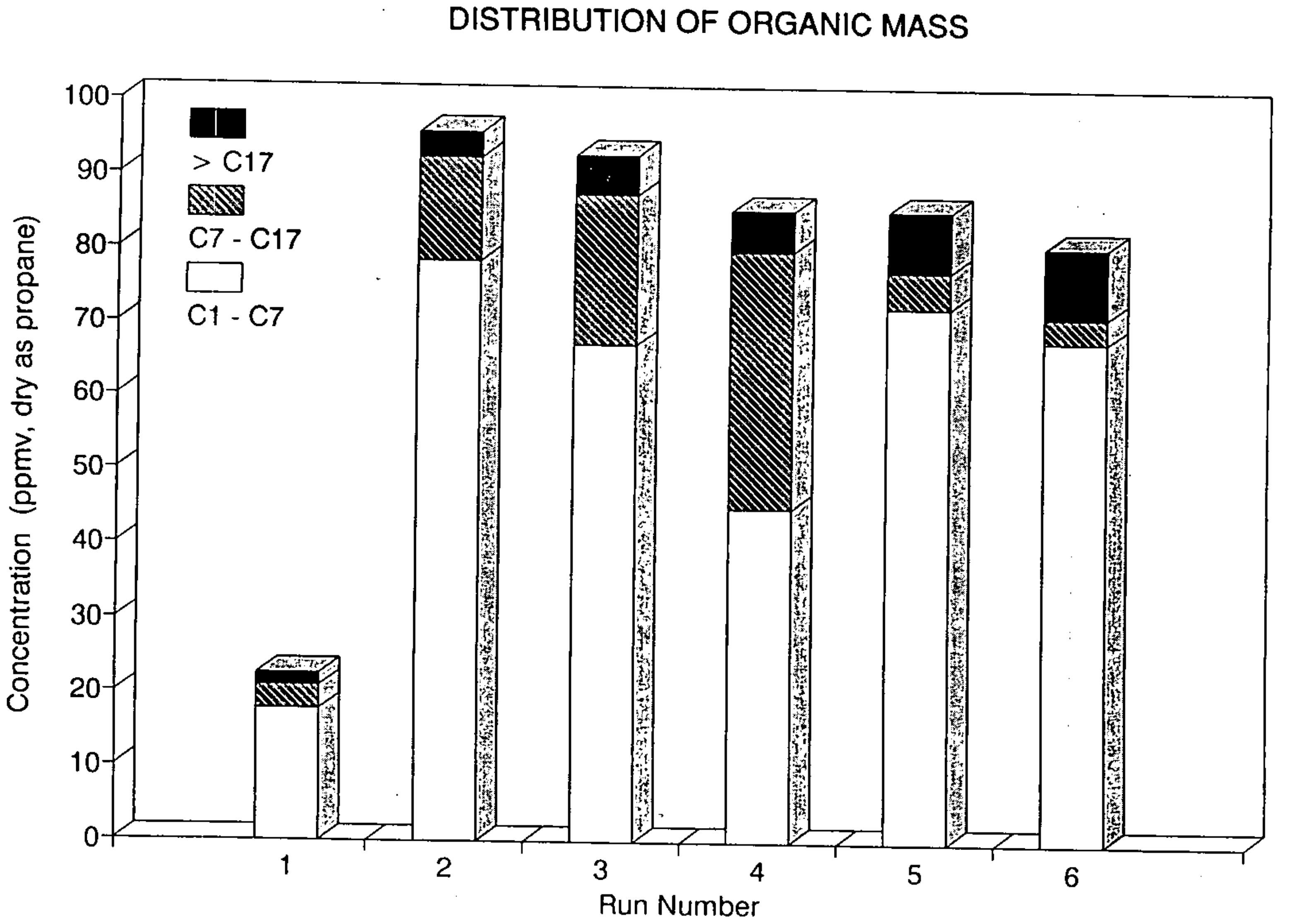

DISTRIBUTION OF ORGANIC MASS
Concentration (ppmv, dry as propane)
100
90
80
70
60
50
40
30
20
10
0
> C17
C7 - C17
C1 - C7
1
2
3
4
5
6
Run Number

Figure 4-1

temperature spikes within the kiln. The temperatures were cooled by introduction of air to the kiln, thus raising oxygen levels to 5 to 6% from the normal 2%. These higher oxygen levels potentially led to better combustion of the coal and lower TOM levels. However, the free lime measured in the clinker product was higher for run 1 (shown later in this section, Table 4-24), which may indicate a poorer quality cement produced.

Table 4-5 presents the average TOM determined for each process condition. The TOM levels measured during coal-plus-waste burning was slightly higher than those measured during coal-plus-diesel burning. This increase was primarily related to an increase in the C_7-C_{17} fraction that was not equaled by a decrease in the $> C_{17}$ fraction.

4.2.1.2 HC and TOM Emissions--

Table 4-6 shows the results for HC and TOM emissions measured in the stack. The results are shown for each of the three process conditions. The TOM results are presented as the mass in each of three fractions described earlier and as total mass. HC results are shown for both the hot and cold monitoring systems.

Figure 4-2 shows that the TOM, hot HC, and cold HC values generally were proportionally consistent to each other for all six test runs. The hot HC values were within 25% of the measured TOM values, except for run 4. During run 4, two C_7-C_{17} fraction spikes occurred while the THC monitor was off-line, thus possibly resulting in a biased TOM value. Flowrate to the GC was not steady during run 4, which could have contributed to any sample bias. The cold HC results were consistently lower than the other two measures, with the cold being 50% to 70% of the hot HC. Loss of organic compounds in the condensate trap on the cold HC sampling line is the most likely explanation for the lower cold HC values.

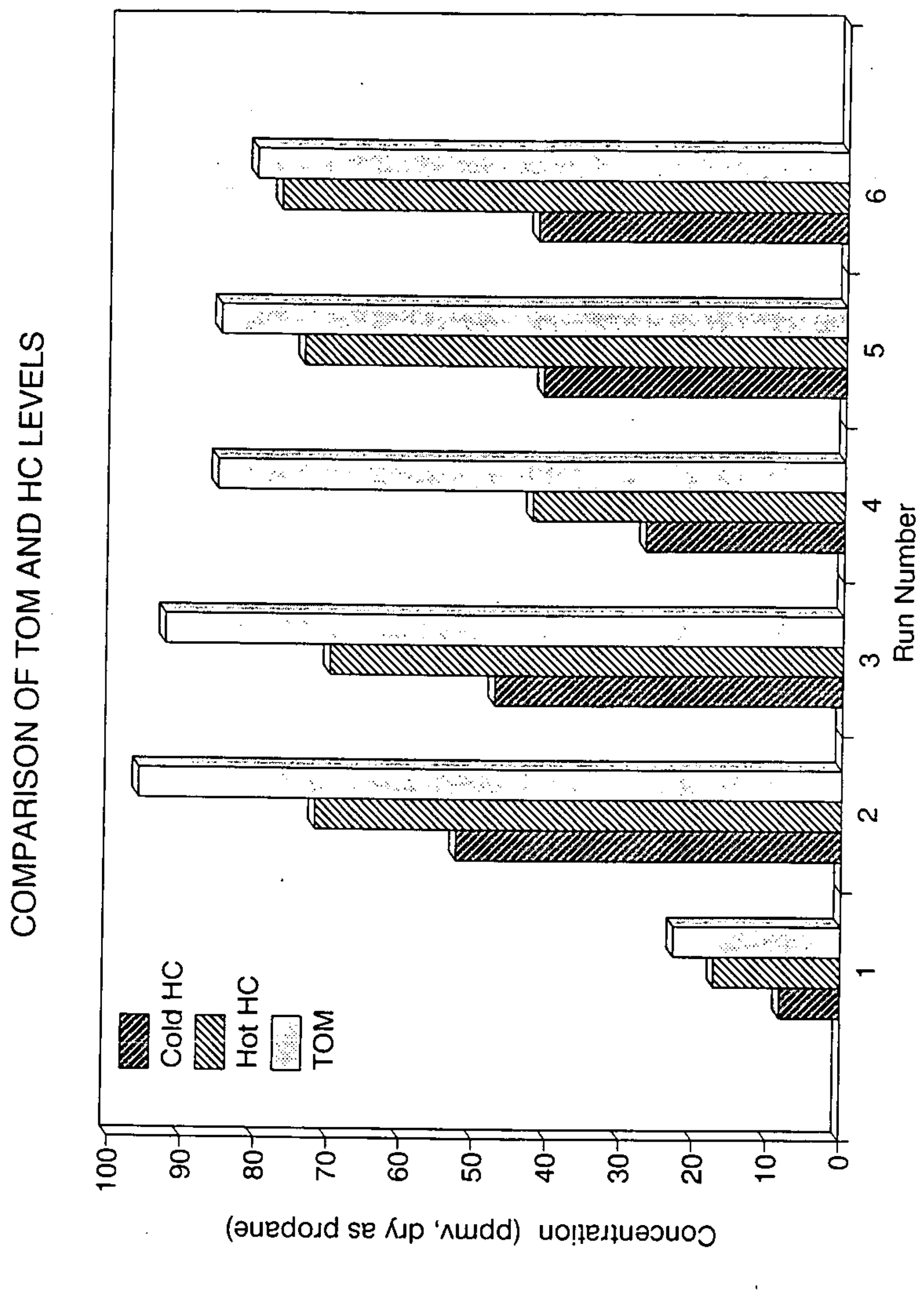
Table 4-7 shows the results of analyzing the grab bag samples collected during each run for C_1-C_2 compounds. Note that ethylene (C_2H_4) is not listed. Ethylene and ethane could not be resolved under field conditions. Bag samples from runs 2 to 6 were reanalyzed back at MRI's laboratory using the field GC and cryofocusing (cryogenically concentrating the sample). The

TABLE 4-5. AVERAGE ORGANIC MASS FOR EACH TEST CONDITION

Run	Average organic mass (ppm propane, dry)			Total mass (TOM)
	C_1-C_7	C_7-C_{17}	> C_{17}	
Baseline with coal only (Run 1)	17.7	3.2	1.73	22.6
Hazardous waste and coal (Runs 2-4)	63.5	23.2	4.82	91.6
Baseline with diesel and coal (Runs 5 & 6)	70.1	4.3	8.89	83.2

TABLE 4-6. HC AND TOM EMISSIONS

	Run	TOM, ppmv dry as propane C_1-C_7 mass	C_7-C_{17} mass	$> C_{17}$ mass	Total mass	HC, ppmv dry as propane Hot	Cold
Coal only	1	17.7	3.2	1.73	22.6	17.3	8.3
Hazardous waste and coal	2	78.5	14.1	3.54	96.1	71.9	52.6
	3	67.0	20.5	5.31	92.8	70.1	47.5
	4	45.1	35.0	5.62	85.7	42.6	27.1
Baseline with diesel and coal	5	72.3	5.0	8.22	85.5	74.1	41.3
	6	67.8	3.5	9.56	80.9	77.5	42.2



COMPARISON OF TOM AND HC LEVELS

Figure 4-2

TABLE 4-7. C_1 AND C_2 EMISSIONS

	Run	TOM total mass (ppmv,dry)	CH_4		C_2H_2		C_2H_6		C_1 and C_2 combined	
			ppmv,dry	% of TOM	ppmv,dry	% of TOM	ppmv,dry	% of TOM	ppmv,dry	% of TOM
Coal only	1	22.6	1.6	7	2.7	12	1.1	5	5.4	24
Hazardous waste and coal	2	96.1	14.8	15	16.9	18	5.4	6	37.1	39
	3	92.8	11.6	13	15.6	17	5.6	6	32.8	35
	4	85.7	6.4	7	9.8	11	4.4	5	20.6	24
Baseline with diesel and coal	5	85.5	7.6	9	10.7	13	2.3	3	20.6	24
	6	80.9	10.7	13	16.6	21	3.3	4	30.6	38

Note: C_2H_4 was not detected.

results showed virtually no ethylene present. The existing peaks were therefore quantified as ethane. The C_1 and C_2 fraction accounts for 24% to 39% of the measured TOM.

4.2.2 Semivolatile Organic Emissions Screen

Qualitative screening of the Method 0010 samples by GC/MS analysis was conducted to characterize the semivolatile organic compounds emitted as products of incomplete combustion (PICs). The GC/MS analyses were semiquantitative and were targeted to identify the compounds listed in Table 4-8. Table 4-9 presents the concentrations of compounds detected by these analyses. A blank entry indicates that the compound was not detected; detection levels were on the order of a few micrograms per dscm.

Table 4-10 presents the average concentrations of the compounds by test condition. During run 1, when only coal was being fired, the total number of compounds detected was lower than the other two test conditions. This may be attributed to the higher oxygen levels in the kiln during this run. Emission levels were very similar between the other two test conditions.

4.2.3 Volatile Organic Emissions

GC/MS analyses of the VOST Method 0030 samples were conducted to characterize the volatile organic compounds emitted as PICs. Although not formally required for this study as per the test plan, calibration curves were generated for all the PIC compounds contained in Table 4-11. Table 4-12 presents the concentrations of compounds detected by these analyses. A blank entry indicates that the compound was not detected; quantitation levels were about 2 to 5 ng/L for most compounds.

Table 4-13 presents the average concentrations of the compounds by test condition. Emission levels tend to be slightly lower during run 1 (baseline, coal only) for the majority of the compounds included in the analyses. As with the semivolatile emissions, levels are very similar for the other two test conditions.

TABLE 4-8. SEMIVOLATILE COMPOUNDS TARGETED IN GC/MS SCREEN

1	*N*-Nitrosodimethylaniline
2	Bis(2-chloroethyl) ether
3	Phenol
4	2-Chlorophenol
5	*N*-Nitroso-di-*n*-propylamine
6	1,3-Dichlorobenzene
7	1,4-Dichlorobenzene
8	1,2-Dichlorobenzene
9	Bis(2-chloroisopropyl) ether
10	Hexachloroethane
11	Nitrobenzene
12	Isophrone
13	2-Nitrophenol
14	2,4-Dimethylphenol
15	Bis(2-chloroethoxy)methane
16	2,4-Dichlorophenol
17	1,2,4-Trichlorobenzene
18	Naphthalene
19	Hexachloro-1,3-butadiene
20	4-Chloro-3-methylphenol
21	Hexachlorocyclopentadiene
22	2,4,6-Trichlorophenol
23	2,4,5-Trichlorophenol
24	2-Chloronaphthalene
25	2,6-Dinitrotoluene
26	Dimethyl phthalate
27	Acenaphthylene
28	Acenaphthene
29	2,4-Dinitrophenol
30	Dibenzofuran
31	4-Nitrophenol
32	2,4-Dinitrotoluene
33	2-Methylnaphthalene
34	Benzyl alcohol
35	Azobenzene
36	Fluorene
37	4-Chlorophenyl phenyl ether
38	Diethyl phthalate
39	4,6-Dinitro-2-methylphenol
40	Benzoic acid
41	*N*-Nitrosodiphenylamine
42	4-Bromophenyl phenyl ether
43	Hexachlorobenzene
44	2-Methylphenol
45	4-Methylphenol
46	Pentachlorophenol
47	Phenanthrene
48	Anthracene
49	Di-*n*-butyl phthalate
50	Aniline
51	Fluoranthene
52	Benzidine
53	Pyrene
54	Benzyl butyl phthalate
55	Chrysene
56	3,3'-Dichlorobenzidine
57	Benz[*a*]anthracene
58	Bis(2-ethylhexyl) phthalate
59	Di-*n*-octyl phthalate
60	Benzo[*b*]fluoranthene
61	Benzo[*k*]fluoranthene
62	Benzo[*a*]pyrene
63	Dibenz[*a*,*h*]anthracene
64	Benzo[*g*,*h*,*i*]perylene
65	Indeno[1,2,3-*c*,*d*]pyrene
66	4-Chloroaniline
67	2-Nitroaniline
68	3-Nitroaniline
69	4-Nitroaniline

TABLE 4-9. SEMIVOLATILE PIC SCREENING DATA

	Stack gas concentrations, ng/L or μg/dscm					
	Baseline coal only	Hazardous waste and coal			Baseline diesel and coal	
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Benzyl alcohol	700•	600•	500•	400•	600•	400•
Benzoic acid	1000•	600•	1000•	1000•	600•	200•
Phenol		77	169	54	67	137
2-Chlorophenol				9		
2-Methylphenol						15
4-Methylphenol		52	53	61	62	56
Naphthalene	145	600•	600•	600•	600•	500•
2-Methylnaphthalene	52	101	152	89	145	100•
2,4,6-Trichlorophenol		26		32		
Acenaphthylene		95	117	72	106	86
Dibenzofuran		101	146	94	129	91
Diethyl phthalate				26		
Fluorene		26	29		42	38
Phenanthrene	21	100•	158	83	162	100•
Anthracene		13	15		23	25
Fluoranthene		46	47		62	51
Pyrene		29	28		49	45
Benz[a]anthracene						10
Chrysene		23	22		32	32
Bis(2-ethylhexyl) phthalate					53	27

• Response was higher than the highest calibration point; value is an estimate only.

TABLE 4-10. AVERAGE SEMIVOLATILE PIC CONCENTRATION BY OPERATING CONDITION

	Stack gas concentrations, ng/L or μg/dscm		
	Baseline coal only	Hazardous waste and coal average	Baseline diesel and coal average
Benzyl alcohol	700	500	500
Benzoic acid	1000	900	400
Phenol		100	102
2-Chlorophenol		3	
2-Methylphenol			8
4-Methylphenol		55	59
Naphthalene	145	600	550
2-Methylnaphthalene	52	114	123
2,4,6-Trichlorophenol		19	
Acenaphthylene		95	96
Dibenzofuran		114	110
Diethyl phthalate		9	
Fluorene		18	40
Phenanthrene	21	114	131
Anthracene		9	24
Fluoranthene		31	56
Pyrene		19	47
Benz[a]anthracene			5
Chrysene		15	32
Bis(2-ethylhexyl) phthalate			40

Note: If the compound was not detected in one run, the value of zero was used in calculating the condition average.

TABLE 4-11. VOLATILE SCREEN TARGET LIST

1	Acetone
2	Acrolein
3	Acrylonitrile
4	Benzene
5	Bromodichloromethane
6	Bromoform
7	Carbon tetrachloride
8	Chloroform
9	Chlorobenzene
10	Dibromochloromethane
11	1,1-Dichloroethane
12	1,2-Dichloroethane
13	1,1-Dichloroethene
14	t-1,2-Dichloroethene
15	1,2-Dichloropropane
16	t-1,3-Dichloropropene
17	Diethyl ether
18	1,4-Dioxane
19	Ethylbenzene
20	Methylene chloride
21	Methyl ethyl ketone
22	1,1,2,2-Tetrachloroethane
23	Tetrachloroethene
24	Toluene
25	1,1,1-Trichloroethane
26	1,1,2-Trichloroethane
27	Trichloroethene

TABLE 4-12. VOLATILE PIC ANALYSIS DATA BY RUNS

	Stack gas concentrations, ng/L					
	Baseline coal only	Hazardous waste and coal			Baseline diesel and coal	
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Acrolein	160	240	87	130	750	570
1,1-Dichloroethene		2.4	0.6	0.1	0.1	
Acetone	210	510	480	390	960	830
Methylene chloride	72[a]	260[a]	12	10	14	4.1
Acrylonitrile	270	410	550	620	380	540
t-1,2-Dichloroethane	0.04	0.1	0.1	0.3	0.1	
1,1-Dichloroethane	0.2	2.6		2.0	1.0	2.7
Methyl ethyl ketone (MEK)	43	110	160	110	130	180
Chloroform	9.0	5.2	2.6	6.2	14	11
1,1,1-Trichloroethane	7.8	14	2.1	0.7		
Carbon tetrachloride	0.5	2.3				
Benzene	510	1800	2800	1400	2100	2100
1,2-Dichloropropane	3.5	16	38		0.1	0.1
Trichloroethene	3.6	2.3	2.1	1.6	3.6	3.2
1,2-Dichloropropane	0.5	3.0	2.1	1.7	2.5	2.7
p-Dioxane	27			0.6	8.0	
Bromodichloromethane	5.1	2.5	2.4	2.3	4.0	0.6
Toluene	160	580	910	450	950	960
t-1,3-Dichloropropene	0.3	5.7	5.8	6.4	12	12
1,1,2-Trichloroethane	3.5	24	8.1		2.1	5.7
Tetrachloroethene (Perc)	1.8	0.7	4.5	2.3	0.4	0.3
Dibromochloromethane	0.6	0.4	0.6	0.05	0.03	
Chlorobenzene (MCB)	33	50	62	42	33	33
Ethylbenzene	26	170	190	75	200	200
Bromoform	1.1	0.1	0.5			
1,1,2,2-Tetrachloroethane	10	18	12	14	14	14

[a] High value may be due to laboratory contamination.

TABLE 4-13. VOLATILE PIC CONCENTRATIONS BY OPERATING CONDITION

	Stack gas concentrations, ng/L or μg/dscm		
	Baseline coal only	Hazardous waste and coal average	Baseline diesel and coal average
Acrolein	160	150	660
1,1-Dichloroethene		1.0	0.1
Acetone	210	460	890
Methylene chloride	72[a]	95[a]	8.8
Acrylonitrile	270	530	460
t-1,2-Dichloroethene	0.04	0.2	0.1
1,1-Dichloroethane	0.2	1.5	1.9
Methyl ethyl ketone (MEK)	43	120	160
Chloroform	9.0	4.6	13
1,1,1-Trichloroethane	7.8	5.7	
Carbon tetrachloride	0.5	0.8	
Benzene	510	2000	2100
1,2-Dichloroethane	3.5	18	0.1
Trichloroethene	3.6	2.0	3.4
1,2-Dichloropropane	0.5	2.3	2.6
p-Dioxane	27	0.2	8.0
Bromodichloromethane	5.1	2.4	2.3
Toluene	160	640	960
t-1,3-Dichloropropene	0.3	6.0	12
1,1,2-Trichloroethane	3.5	11	3.9
Tetrachloroethene (Perc)	1.8	2.5	0.3
Dibromochloromethane	0.6	0.3	0.03
Chlorobenzene (MCB)	33	51	33
Ethylbenzene	26	140	200
Bromoform	1.1	0.2	
1,1,2,2-Tetrachloroethane	10	15	14

[a] High value may be due to laboratory contamination.

Table 4-14 provides a comparison of the PICs measured in the stack gas for this project to the PICs historically detected in stack gases from hazardous waste incinerators. The incinerator data include the most common PICs that were detected during tests at eight incinerators. Comparison of any individual compound concentrations should be made with caution, since only one kiln test is compared to a series of incinerator tests. Table 4-14 indicates that several compounds are common to combustion of waste in both kilns and incinerators. It also shows that the concentrations of PICs in the kiln stack gas were generally greater than those measured in the incinerator stack gases. As can be seen in Table 4-15, many additional compounds were detected in the kiln stack gas.

4.2.4 Dioxin/Furan Emissions

Dioxin and furan analysis was performed on MM5 samples from runs 1, 3, 4, and 5 of the test series. Table 4-16 presents the dioxin and furan results by homologs from analysis of the MM5 samples and the total dioxins and furans for each run. Quantities found below detection limits (< value) were considered to be at the detection limit to calculate the worst-case total emission values.

Table 4-17 presents dioxin and furan data for the 2,3,7,8-substituted isomers. Using these data and the toxic equivalents (Reference 1) for each isomer, Table 4-18 was generated. Toxic equivalencies were then summed into a single 2,3,7,8-TCDD equivalence values for each run. Results are presented in both concentration and mass emission rate units. Figure 4-3 compares the total PCDDs/PCDFs and 2,3,7,8-TCDD equivalents for each run.

4.2.5 Total Organic Carbon (TOC) Results

Total organic carbon (TOC) was measured in the raw feed materials for comparison to the total hydrocarbon emissions from the stack. Raw material samples collected included shale, limestone, and the lime slurry (a mixture of the shale, limestone and water). Shale and limestone samples were collected during a site survey prior to the test series, and lime slurry samples were collected during the actual test series. The slurry samples were filtered in

TABLE 4-14. COMPARISON OF CONTINENTAL CEMENT KILN AND INCINERATOR PIC CONCENTRATIONS

	Range of concentrations, ng/L	
	Kiln	Incinerators[a]
Benzene	510 - 2800	12 - 670
Bromodichloromethane	1 - 5	3 - 92
Bromoform	0 - 1	1 - 24
Chlorobenzene (MCB)	33 - 62	1 - 10
Chloroform	3 - 14	1 - 1300
Dibromochloromethane	0 - 1	1 - 12
Hexachlorobenzene	b	1 - 7
Methylene chloride	4 - 260[c]	2 - 27
Naphthalene	150 - 760	5 - 100
2-Nitrophenol	b	25 - 50
Phenol	0 - 170	4 - 22
Tetrachloroethene (PERC)	0 - 5	1 - 3
Toluene	160 - 960	2 - 75
1,1,1-Trichloroethane	1 - 14	1 - 2

[a] "Performance Evaluation of Full-Scale Hazardous Waste Incinerators, Volume 2," EPA-600/2-84-181b, PB85-129518, November 1984.

[b] BDL = below detection limits

[c] High value in range may be due to laboratory contamination.

TABLE 4-15. ADDITIONAL PICs DETECTED IN THE KILN EMISSIONS

	Range of concentrations (ng/L)		
Acenaphthylene	0	-	117
Acetone	212	-	963
Acrolein	87	-	750
Acrylonitrile	268	-	623
Anthracene	0	-	25
Benzoic acid	152	-	1400
Benzyl alcohol	443	-	691
Benz[a]anthracene	0	-	10
Bis(2-ethylhexyl) phthalate	0	-	53
Carbon tetrachloride	0	-	2.3
2-Chlorophenol	0	-	9
Chrysene	0	-	32
Dibenzofuran	0	-	146
1,1-Dichloroethane	0.2	-	2.7
1,1-Dichloroethene	0	-	2.4
1,2-Dichloroethane	1	-	37.5
1,2-Dichloropropane	0.5	-	3
t-1,2-Dichloroethene	0.04	-	0.3
t-1,3-Dichloropropene	0.3	-	12
Diethyl phthalate	0	-	26
p-Dioxane	0	-	27
Ethylbenzene	26	-	205
Fluoranthene	0	-	62
Fluorene	0	-	42
2-Methylnaphthalene	52	-	152
2-Methylphenol	0	-	15
4-Methylphenol	0	-	62
Methyl ethyl ketone (MEK)	43	-	178
Phenanthrene	21	-	162
Pyrene	0	-	49
Trichloroethene	2	-	4
1,1,2,2-Tetrachloroethane	10	-	18
1,1,2-Trichloroethane	0	-	24
2,4,6-Trichlorophenol	0	-	32

TABLE 4-16. DIOXIN/FURAN RESULTS FOR MM5 SAMPLES

Analyte	Blank train	Run 1	Run 3	Run 4	Run 5
Sample volume (dscm)		1.447	1.714	1.805	1.788
Stack flow rate (dscm/m)		2700	3000	3500	3100
Dioxins (pg)					
TCDD	1,530	12,100	53,100	121,000	52,600
PeCDD	1,340	17,100	151,000	284,000	531,000
HxCDD	3,150	82,100	276,000	615,000	1,010,000
HpCDD	845	9,490	25,300	48,100	87,300
OCDD	2,160	5,360	16,900	19,500	15,800
Total (pg)	9,030	126,200	522,000	1,088,000	1,700,000
Total (ng/dscm)		87.2	305	603	951
Total (µg/min)		237	916	2100	3000
Furans (pg)					
TCDF	2,280	16,900	164,000	322,000	99,100
PeCDF	568	5,810	38,300	179,000	70,600
HxCDF	240	2,510	14,200	21,500	11,900
HpCDF	ND	3,400	8,850	8,400	2,470
OCDF	228	< 7	< 10	< 27	< 4
Total (pg)	3,316	28,600	225,000	531,000	184,100
Total (ng/dscm)		19.8	131	294	103
Total (µg/min)		53.7	394	1020	324
Total dioxin/furan's (ng/dscm)		107	436	897	1050
Total dioxin/furan's (µg/min)		291	1310	3120	3320

TABLE 4-17. 2,3,7,8-SUBSTITUTED DIOXIN/FURAN FOR MM5 SAMPLES

Analyte	Run 1	Run 3	Run 4	Run 5
Sample volume (dscm)	1.447	1.714	1.805	1.788
Stack flow rate (dscm/m)	2700	3000	3500	3100
Dioxins (pg)				
2,3,7,8-TCDD	< 7	< 6	< 14	< 7
1,2,3,7,8-PeCDD	255	3,240	4,520	5,220
1,2,3,4,7,8-HxCDD	550	4,580	7,170	9,280
1,2,3,6,7,8-HxCDD	647	3,750	7,040	11,100
1,2,3,7,8,9-HxCDD	520	4,980	7,880	9,150
1,2,3,4,6,7,8-HpCDD	4,140	12,400	21,300	36,000
1,2,3,4,6,7,8,9-OCDD	5,360	16,900	19,500	15,800
Total (pg)	11,480	45,900	67,400	86,600
Total (ng/dscm)	7.93	26.8	37.3	48.4
Total (ng/min)	21,500	80,400	130,000	152,000
Furans (pg)				
2,3,7,8-TCDF	< 9	< 210[a]	< 10	< 21
1,2,3,7,8-PeCDF	< 6	< 6,490	< 10,400	< 3,720
2,3,4,7,8-PeCDF	< 2,320	14,900	< 27,400	10,800
1,2,3,4,7,8-HxCDF	1,140	4,970	7,440	3,720
1,2,3,6,7,8-HxCDF	571	2,350	3,960	2,000
1,2,3,7,8,0-HxCDF	< 137	565	< 741	275
1,2,3,4,6,7,8-HpCDF	2,050	4,750	4,860	1,400
1,2,3,4,7,8,9-HpCDF	356	546	624	190
1,2,3,4,6,7,8,9-OCDF	< 1,660	< 3,530	< 3,040	< 469
Total (pg)	< 8,500	< 39,000	< 60,200	< 23,800
Total (ng/dscm)	< 5.87	< 22.8	< 33.4	< 13.3
Total (ng/min)	< 15,900	< 68,300	< 116,000	< 41,900

Notes: Less than (<) is dropped from totals where the total values below detection limits are less than 10% of the total.

Run 4 data is questionable due to low surrogate recoveries.

[a] Based on pql rather than detection limit due to analytical difficulties.

TABLE 4-18. 2,3,7,8 TCDD EQUIVALENT EMISSIONS

Analyte	EPA equiv. factor	Run 1			Run 3			Run 4			Run 5		
		Sample volume (dscm) 1.447 Stack flow rate (dscm/m) 2,713			Sample volume (dscm) 1.714 Stack flow rate (dscm/m) 3,004			Sample volume (dscm) 1.805 Stack flow rate (dscm/m) 3,478			Sample volume (dscm) 1.788 Stack flow rate (dscm/m) 3,147		
		Total (pg)	(ng/dscm)	Equiv. (ng/dscm)	Total (pg)	(ng/dscm)	Equiv. (ng/dscm)	Total (pg)	(ng/dscm)	Equiv. (ng/dscm)	Total (pg)	(ng/dscm)	Equiv. (ng/dscm)
Dioxins													
2,3,7,8-TCDD	1	7	0.0660	0.0660	6	0.0210	0.0210	14	0.008	0.008	7	0.0151	0.0151
1,2,3,7,8-PeCDD	0.5	255	0.0516	0.0258	3,240	0.942	0.471	4,520	1.31	0.655	5,220	1.45	0.727
1,2,3,4,7,8-HxCDD	0.1	550	0.0843	0.00840	4,580	0.0497	0.00497	7,170	2.08	0.208	9,280	2.59	0.259
1,2,3,6,7,8-HxCDD	0.1	647	0.447	0.0447	3,750	1.09	0.109	7,040	2.04	0.204	11,100	3.09	0.309
1,2,3,7,8,9-HxCDD	0.1	520	0.359	0.0359	4,980	1.45	0.145	7,880	2.28	0.228	9,150	2.55	0.255
1,2,3,4,6,7,8-HpCDD	0.01	4,140	2.86	0.0286	12,400	3.60	0.0361	21,300	6.17	0.0617	36,000	10.0	0.100
OCDD	0.001	5,360	3.70	0.0037	16,900	4.91	0.00491	19,500	5.65	0.00565	15,800	4.40	0.00440
Furans													
2,3,7,8-TCDF	0.1	9	0.138	0.0138	NC	0.0	0.00	10	0.00	0.000	21	0.01	0.001
1,2,3,7,8-PeCDF	0.05	6	0.004	0.00021	6,490	1.89	0.0943	10,400	3.01	0.151	3,720	1.04	0.0518
2,3,4,7,8-PeCDF	0.5	2,320	1.60	0.802	14,900	4.33	2.17	27,400	7.94	3.97	10,800	3.01	1.51
1,2,3,4,7,8-HxCDF	0.1	1,140	0.788	0.0788	4,970	1.44	0.145	7,440	2.16	0.216	3,720	1.04	0.104
1,2,3,6,7,8-HxCDF	0.1	571	0.395	0.0395	2,350	0.683	0.0683	3,960	1.15	0.115	2,000	0.557	0.0560
2,3,4,6,7,8-HxCDF	0.1	225	0.155	0.0155	884	0.257	0.0257	1,720	0.498	0.0498	1,250	0.35	0.035
1,2,3,7,8,9-HxCDF	0.1	137	0.0968	0.00968	565	0.164	0.0164	741	0.215	0.0215	275	0.0766	0.00770
1,2,3,4,6,7,8-HpCD	0.01	2,050	1.42	0.0142	4,750	1.38	0.0138	4,860	1.41	0.0141	1,400	0.390	0.00390
1,2,3,4,7,8,9-HpCD	0.01	356	0.246	0.00246	546	0.159	0.00159	624	0.181	0.00181	190	0.0529	0.000500
OCDF	0.001	1,660	1.15	0.00115	3,530	1.03	0.00103	3,040	0.881	0.000880	469	0.131	0.000130
Total 2,3,7,8-TCDD equivalent concentration (ng/dscm) =				1.190			3.323			5.910			3.43
Emission (ng/min) =				3,228			9,980			20,550			10,790
Emission (g/hr) =				.0002			.0006			.0012			.0006

MRI FAX

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Date 9-24-91

To Drew Trenholm - NCO

From Pam Murowchick

5415-☐☐-☐☐
Overhead #, or Project, Task + Sub-Task

This transmission consists of 2 pages (including cover)

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MRI Facsimile Machine: RAPICOM 610 (816) 753-8420 GROUP III

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MESSAGE:

Drew,

Here is a corrected version of the 2378-TCDD equivalents table. There were mega mistakes in the original — I don't know ~~[illegible]~~ what the cause was.

Pam

014 PBX FAX [illegible] 012891

TABLE 3-3 (concluded)

Sample	Sample location[a]	Sampling frequency for each run	Sampling method	Sample size	Analytical parameters	Preparation method[b]	Analytical method[b]
Powdered waste	4	One grab sample from each container, composited into one sample per run	Trier	500 g each grab	HHV	NA	Calorimeter (D2015-77)
					Chlorine	NA	Chlorine (D808-81 and D4327-84) or (E442-81)[l]
Liquid waste	5	One grab sample taken every 30 min, composited into one sample per run	Tap (S004)	(Total) 1000 mL, 50 ml each grab	HHV	NA	Calorimeter (D2015-77)
					Chlorine	NA	Chlorine (D808-81 and D4327-84) or (E442-81)[l]

---

[a] Sample location as indicated in Figure 3-1.

[b] Sample preparation and analytical methods, as referenced in the A. D. Little, EPA 600, and SW-846 methods. Also draft EPA HCl sample protocol.

[c] Exact volume of gas sampled dependent on isokinetic sampling rate.

[d] PCDD/PCDF--Polychlorinated dibenzodioxins/polychlorinated dibenzofurans determined for runs 1, 3, 4 and 5.

[e] Gas chromatography/mass spectrometry.

[f] HCl train--HCl sampling train based on the EPA "Draft Method for the Determination of HCl Emissions from Municipal and Hazardous Waste Incinerators" (USEPA, QAD, July 1988).

[g] Runs 1 and 2 were operated at lower sampling rates, sampling only 7-9 ft^3 for those two runs.

[h] Volatile organic sampling train (EPA Method 0030).

[i] Methane, ethane, ethylene, and acetylene only.

[j] MM25A--Modified Method 25A.

[k] University of Texas A&M, Geochemical and Environmental Research Group, SOP-8907.

[l] E442-81 is used for samples with high (> 0.1%) concentrations, and D808-81 and D4327-84 are used for samples with low concentrations.

Table 3. 2,3,7,8 TCDD EQUIVALENT EMISSIONS

			Run 1			Run 3			Run 4				Run 5		
			Sample volume (dscm) =		1.447	Sample volume (dscm) =		1.714	Sample volume (dscm) =		1.805		Sample volume (dscm) =		1.788
	EPA		Stack flow rate (dscm/m) =		2,713	Stack flow rate (dscm/m) =		3,004	Stack flow rate (dscm/m) =		3,478		Stack flow rate (dscm/m) =		3,147
	equiv.		Total		Equiv.	Total		Equiv.	Total		Equiv.		Total		Equiv.
Analyte	factor		(pg)	(ng/dscm)	(ng/dscm)	(pg)	(ng/dscm)	(ng/dscm)	(pg)	(ng/dscm)	(ng/dscm)		(pg)	(ng/dscm)	(ng/dscm)
Dioxins															
2,3,7,8-TCDD	1	<	131	0.0905	0.0905	106	0.0618	0.0618	219	0.121	0.121	<	121	0.0677	0.0677
1,2,3,7,8-PeCDD	0.5		255	0.176	0.0881	3,240	1.89	0.945	4,520	2.50	1.25		5,220	2.92	1.46
1,2,3,4,7,8-HxCDD	0.1		550	0.380	0.0380	4,580	2.67	0.267	7,170	3.97	0.397		9,280	5.19	0.519
1,2,3,6,7,8-HxCDD	0.1		647	0.447	0.0447	3,750	2.19	0.219	7,040	3.90	0.390		11,100	6.21	0.621
1,2,3,7,8,9-HxCDD	0.1		520	0.359	0.0359	4,990	2.91	0.291	7,890	4.37	0.437		9,150	5.12	0.512
1,2,3,4,6,7,8-HpCD	0.01		4,140	2.86	0.0286	12,400	7.23	0.0723	21,300	11.8	0.118		36,000	20.1	0.201
OCDD	0.001		5,360	3.70	0.0037	16,900	9.86	0.0099	19,500	10.8	0.0108		15,800	8.84	0.00880
Furans															
2,3,7,8-TCDF	0.1	<	144	0.100	0.0100	210	0.123	0.0123	338	0.187	0.0187	<	472	0.264	0.0264
1,2,3,7,8-PeCDF	0.05	<	149	0.103	0.00515	6,490	3.79	0.189	10,400	5.76	0.288	<	3,720	2.08	0.104
2,3,4,7,8-PeCDF	0.5	<	2,320	1.60	0.802	14,900	8.69	4.35	27,400	15.2	7.59		10,800	6.04	3.02
1,2,3,4,7,8-HxCDF	0.1		1,140	0.788	0.0788	4,970	2.90	0.290	7,440	4.12	0.412		3,720	2.08	0.208
1,2,3,6,7,8-HxCDF	0.1		571	0.395	0.0395	2,350	1.37	0.137	3,960	2.19	0.219		2,000	1.12	0.112
2,3,4,6,7,8-HxCDF	0.1	<	534	0.369	0.0369	884	0.516	0.0516	1,720	0.953	0.0953		1,250	0.699	0.0699
1,2,3,7,8,9-HxCDF	0.1	<	387	0.0968	0.00968	565	0.0817	0.00817	741	0.0776	0.00776	<	303	0.0783	0.00783
1,2,3,4,6,7,8-HpCD	0.01		2,050	1.42	0.0142	4,750	2.77	0.0277	4,860	2.69	0.0269		1,400	0.783	0.00780
1,2,3,4,7,8,9-HpCD	0.01		356	0.246	0.00246	546	0.319	0.00319	643	0.356	0.00356	<	256	0.143	0.00143
OCDF	0.001	<	1,660	1.15	0.00115	3,530	2.06	0.00206	3,040	1.68	0.00168	<	606	0.339	0.000340
Total 2,3,7,8-TCDD equivalent concentration (ng/dscm) =					1.329			6.93			11.39				6.96
Emission (ng/min) =					3,606			20,800			39,610				21,900
Emission (g/hr) =					0.0002164			0.00125			0.002377				0.00131

Note: In calculating 2,3,7,8-equivalents for isomers below detection limits, the detection limit was used.

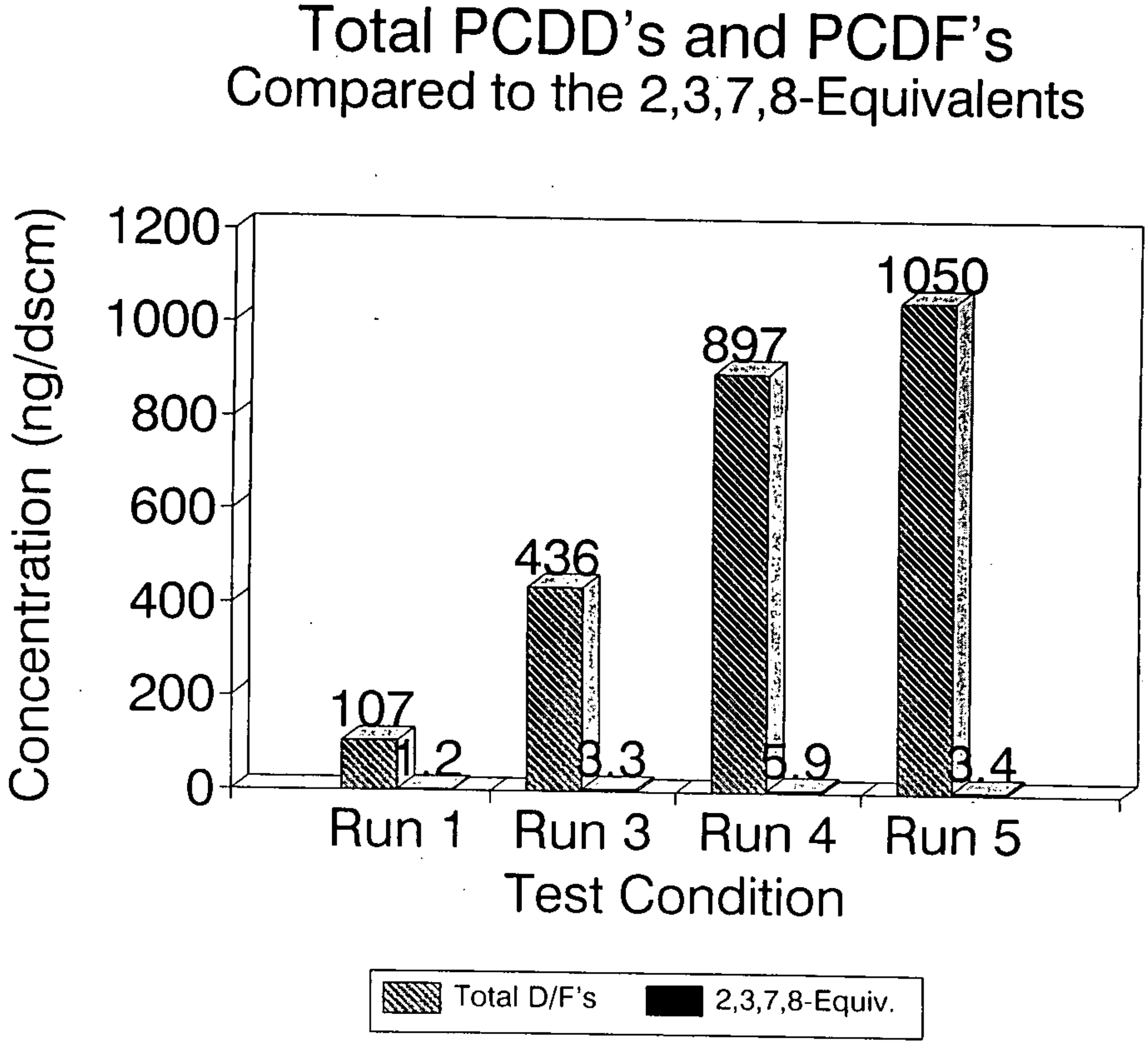

Total PCDD's and PCDF's
Compared to the 2,3,7,8-Equivalents
Concentration (ng/dscm)
1200
1000
800
600
400
200
0
107
1.2
436
3.3
897
5.9
1050
3.4
Run 1
Run 3
Run 4
Run 5
Test Condition
▨ Total D/F's
■ 2,3,7,8-Equiv.

Figure 4-3.

the laboratory to allow separate analysis of the solid dried filter cake and the water fraction by different methods. Analytical methods (Appendix A) were combustion in a Leco furnace (solids) and EPA Method 415.1 (water fraction). Table 4-19 presents the combined results. Calculations are in Appendix B-10. Analysis of the shale and limestone samples showed TOC levels of 1.8% and below detection limits, respectively.

The TOC, or organic carbon, input rates were compared to the stack emission or output of organic carbon based on the HC measurements. Percent TOC in the feed was converted into a mass input rate of carbon, while the hot HC emission rate (as ppm propane) was converted into carbon output rates. The ratio of carbon input to carbon output ranged from 11 to 99 as shown in Table 4-19. Thus, the carbon input was sufficient to account for the HC output from the stack.

In addition to the TOC analysis, a pyrolysis-GC/MS analysis was performed on the shale and limestone samples. These analyses provide information on the organic compounds which compose the TOC within each material. These samples presented some problems to the analyst due to inhomogeneity, and results may not be representative.

The pyrolysis analysis of the shale showed that the organics were aliphatic in nature, having 30 or fewer carbons. The most abundant aliphatic species observed correspond to normal and branched alkanes having between 9 and 16 carbons. Some aromatics, such as xylene, were detected in small quantities. Replicate analyses were performed on the one shale sample to verify compounds detected. Shale comprises about 15% of the solids fed to make the lime slurry.

The limestone sample was fairly inhomogeneous, part of it being fine and sandy, part being rocky. In general, the limestone showed relatively little organic material. Benzoic acid and acetic acid were detected, along with a few alkanes. However, the total of these compounds was far less than those detected in the shale. Limestone comprises about 85% of the solids fed to make the lime slurry. Appendix B-10 contains the raw data for the pyrolysis-GC/MS analysis.

TABLE 4-19. CALCULATION OF OVERALL TOC FOR LIME SLURRY SAMPLES

Run	Fraction	Lime slurry composition (% solids/liquids)	TOC in each fraction (mg/100g)[a]	Overall slurry TOC (%)
1	Solid	61.0	0.0732	
	Liquid	39.0	0.0002	
	Total		0.0734	0.073
2	Solid	59.3	0.3262	
	Liquid	40.7	0.0001	
	Total		0.3263	0.326
3	Solid	51.6	1.5686	
	Liquid	48.4	0.0003	
	Total		1.5689	1.57
4	Solid	66.1	0.3636	
	Liquid	33.9	0.0002	
	Total		0.3638	0.364
5	Solid	70.1	0.6169	
	Liquid	29.9	0.0002	
	Total		0.6171	0.617
6	Solid	68.6	0.2264	
	Liquid	31.4	0.0003	
	Total		0.2267	0.227

[a] Basis of 100 g sample of lime slurry, water density of 1 g/mL.

TABLE 4-20. CALCULATION OF TOC INPUT TO TOTAL HC OUTPUT RATIO

TOC Input

Run	TOC in lime slurry feed (%)	Lime slurry feed rate (ton/h)	TOC input rate in lime slurry (ton/h)	TOC input rate in lime slurry (g/h)
1	0.073	95	0.0694	63,000
2	0.326	129	0.4205	382,000
3*	1.570	132	2.0724	1,880,000
4	0.364	132	0.4805	426,000
5	0.617	126	0.7774	706,000
6	0.227	127	0.2883	262,000

Total HC Emissions

Run	Hot HC, dry ppm propane	HC conc. (μg/L)	Stack flow (dscm/min)	Total HC emission (g/h)
1	17.3	26	2700	4200
2	71.9	108	2900	19000
3	70.1	105	3000	19000
4	42.6	64	3500	13000
5	74.1	111	3100	21000
6	77.5	116	3400	24000

Overall Summary

Run	Input (g/h)	Output (g/h)	Ratio of input to output
1	63,000	4200	15
2	382,000	19000	20
3	1,880,000	19000	99
4	436,000	13000	33
5	706,000	21000	34
6	262,000	24000	11

Note: All ppm to concentration conversions assumed weight of carbon alone, for a correction factor of 1.5.

* TOC in lime slurry feed from run 3 is significantly higher than for the other runs. This could have been caused by inhomogeneity of the sample. No analytical explanation was observed by the laboratory.

4.3 CHLORIDE, POTASSIUM, AND AMMONIUM EMISSIONS

This section presents data from the HCl and HCl dilution air sampling trains and the HCl continuous monitor. The HCl train and monitor sampling were on the stack, while space limitations required the HCl dilution train to be operated from the base of the stack (same location as the VOST apparatus).

Analyses were performed for three separate species (Cl^-, K^+, and NH_3) on each of the four train components (probe rinse, filter, acid impinger, caustic impinger) of the two sampling trains. Cl^- analysis was by ion chromatograph, K^+ analysis was by ICP-AES, and NH_3 analysis was by selective ion monitoring. Appendix B-9 contains the supporting data and calculations. Table 4-21 presents the results, including a comparison of front half/back half results.

It should be noted that the HCl dilution train was an experimental design without any validation testing. The purpose of the train was to provide information on the front half/back half splits of the Cl^-, K^+, and NH_4^+ ions after the stack gases are diluted and cooled with ambient air. A direct quantitative comparison of the data from the two trains, designed and operated differently, is not appropriate. Some loss of chlorides in the dilution train probe was suspected.

The HCl train potassium ion results show that it is unlikely that fine particles can pass through the filter, the majority of the potassium being detected in the front half. Formation of potassium chloride salts was likely, and these salts would be in the form of fine solid particles.

Ammonium (NH_4^+) ions were detected as a large percentage in the back half, indicating that most of the NH_4^+ compounds passed the filter in gaseous form. Ammonia or ammonium chloride are two possibilities. Any ammonia present in the gas stream would easily pass through the filter and be captured in the impinger solutions. This is one possible way to explain the presence of ammonium ion in the impingers. However, ammonia and hydrogen chloride are highly reactive,

TABLE 4-21. ION PERCENTAGES FOUND IN SAMPLING TRAINS

			Dilution Train						Stack HCl Train					
			CL- emission (g/min)		K+ emission (g/min)		NH3 emission (g/min)		CL- emission (g/min)		K+ emission (g/min)		NH3 emission (g/min)	
Run 1	Front Half		73.44	17.0%	21.04	74.1%	1.23	50.0%	NA	NA	NA	NA	NA	NA
	Back Half	Acidic	321.93	74.4%	7.35	25.9%	1.23	50.0%	NA	NA	NA	NA	NA	NA
		Caustic	37.04	8.6%					NA	NA				
	Total		432.41		28.39		2.46		1080.43		71.43		17.54	
Run 2	Front Half		28.09	4.8%	56.18	96.3%	1.36	55.5%	NA	NA	NA	NA	NA	NA
	Back Half	Acidic	16.81	2.9%	2.18	3.7%	1.09	44.5%	NA	NA	NA	NA	NA	NA
		Caustic	544.81	92.4%					NA	NA				
	Total		589.71		58.36		2.45		387.00		4.42		38.66	
Run 3	Front Half		25.80	5.3%	74.02	94.2%	0.14	5.5%	3.73	0.3%	83.04	98.6%	0.55	1.8%
	Back Half	Acidic	297.54	60.8%	4.59	5.8%	2.46	94.5%	717.19	62.8%	1.22	1.4%	29.82	98.2%
		Caustic	166.23	34.0%					421.93	36.9%				
	Total		489.57		78.61		2.60		1142.85		84.26		30.37	
Run 4	Front Half		31.75	2.7%	101.60	97.8%	1.47	32.0%	32.28	2.2%	152.89	99.3%	0.81	3.0%
	Back Half	Acidic	848.72	73.0%	2.31	2.2%	3.13	68.0%	1005.50	69.9%	1.05	0.7%	26.54	97.0%
		Caustic	282.69	24.3%					401.00	27.9%				
	Total		1163.16		103.91		4.60		1438.78		153.94		27.35	
Run 5	Front Half		33.90	33.7%	43.21	93.6%	4.39	80.3%	39.15	NA	68.20	NA	2.76	NA
	Back Half	Acidic	52.23	51.9%	2.96	6.4%	1.08	19.7%	162.34	NA	0.59	NA	40.68	NA
		Caustic	14.54	14.4%					NA	NA				
	Total		100.67		46.17		5.47		NA		NA		NA	
Run 6	Front Half		19.50	54.0%	27.09	93.5%	3.11	2.4%	13.06	3.9%	35.91	58.3%	5.64	13.6%
	Back Half	Acidic	11.10	30.8%	1.87	6.5%	126.97	97.6%	151.18	45.5%	25.69	41.7%	35.90	86.4%
		Caustic	5.48	15.2%					168.10	50.6%				
	Total		36.08		28.96		130.08		332.34		61.60		41.54	
HCL Run	Front Half		23.51	20.0%	20.00	81.0%	0.20	11.1%	1.93	1.0%	92.29	99.1%	0.09	0.9%
	Back Half	Acidic	76.49	65.2%	4.68	19.0%	1.57	88.9%	194.82	96.3%	0.84	0.9%	10.07	99.1%
		Caustic	17.37	14.8%					5.46	2.7%				
	Total		117.37		24.68		1.77		202.21		93.13		10.16	

NOTES: 1. Shading indicates a complete data set.

2. NA=Not Available due to lost samples or data; see Appendix B-9.

3. Data for the front half rinse was lost for the dilution train Runs 2 and 3, thus, the front half values are low. The rinse, however, usually contained a small fraction of the total front half mass; see Appendix B-9.

and if both are present they would likely react to form ammonium chloride. A more reasonable explanation is that vaporized ammonium chloride (or dissociated ammonium chloride) passes the filter. The vapor pressure of ammonium chloride at the filter temperature of 250°F is 0.089 mm of mercury (Reference 2). This vapor pressure can account for the existence of up to 120 ppm of ammonium chloride, as vapor, in the sampled gas stream. Thus, it is possible for sufficient ammonium chloride vapor to pass through the filter at levels well above those measured in the impingers.

Literature sources indicate that ammonium chloride is a crystalline solid which sublimes without melting and is almost completely dissociated into ammonia and hydrogen chloride in the vapor phase (References 3 and 4). At average stack gas temperatures (300°F) and stack gas concentrations (2 to 10 ppm HCl; equivalent to 3 to 15 ppm NH_4Cl), essentially all of the ammonium chloride would be vaporized and dissociated into ammonia and hydrogen chloride.

The above data lead to the conclusion that when HCl and ammonia are present in the stack gas they will react to form ammonium chloride. The ammonium chloride will be in the form of particles at low temperatures and will be dissociated at higher temperatures. The ammonium chloride will pass through a heated filter and be collected in the sampling train impingers and measured as HCl.

Table 4-21 also shows data from the HCl dilution train in a fashion similar to the data for the HCl stack train. Data from this train were evaluated to determine if the dilution and cooling, as happens to the stack gas after it is emitted, would condense ammonium chloride particles. If particles form, they should be collected on the filter at ambient temperature; i.e., the ammonium ion should be found on the filter, not in the impingers. The results were highly variable, although higher percentages of the ammonium ion were generally found on the filter than for the stack HCl train. It should be noted that this experiment was only a rough approximation of the process of mixing stack gases with the atmosphere, thus firm conclusions are not possible.

Table 4-22 compares the HCl continuous monitor data with the stack HCl train, which were operated concurrently during two runs (HCl test and run 5). Stack gas sample for the continuous monitor was pulled through a sampling probe fitted with a heated filter, a heated Permapure membrane to remove moisture, then a 50-ft length of unheated 1/4-in diameter Teflon tubing to the monitor. This unheated sampling line would cause the stack gas to cool and would allow for deposition of condensed ammonium chloride on the walls of the line. These data indicate that the monitor results closely matched the sampling train results, after excluding any chloride that could have reacted with the ammonium ions present in the stack gas. It is likely that ammonium chloride condensed in the unheated sampling line and deposited on the walls of the line.

Table 4-23 summarizes the chlorine and hydrogen chloride emissions from the stack HCl train. The chlorine concentrations can be compared to HCl concentrations with and without an adjustment for formation of ammonium chloride.

TABLE 4-22. COMPARISON OF HCl MONITOR AND STACK SAMPLING TRAIN RESULTS

	Sampling train				
	Measured stack emissions				
Run	Cl^- g mol/min	NH_4^+ g mol/min	Remaining Cl^- after formation of NH_4Cl g mol/min	Equivalent HCl (a) g/min	Monitor HCl g/min
5	4.58	2.39	2.19	79.96	71.16
HCl	5.5	0.59	4.91	179.3	159.6

(a) Excluding chloride which could have reacted with the NH_4^+ present in the stack gas.

TABLE 4-23. SUMMARY OF CHLORINE AND HYDROGEN CHLORIDE EMISSIONS

Run	Conc. HCl (a) (ppm)	Conc. HCl excluding potential formation of NH_4Cl (ppm)	Conc. Cl_2 (b) (ppm)
3	162	148	47.7
4	196	185	39.1
5	35.0	16.7	(c)
6	29.9	15.1	16.6
HCl	41.3	36.9	0.56

Note: Data not available for Runs 1 and 2 (see appendices calculations)

(a) These values assume that all Cl ions collected in the acidic solution were in the form of HCl.

(b) Determined by the Cl ions collected in the caustic impinger in the MM5 sampling train.

(c) Sample container was broken during shipment.

4.4 PROCESS SAMPLES

Samples of the liquid organic waste and powdered waste from runs 2, 3, 4, and the HCl test were analyzed for % Cl and higher heating value (HHV). Table 4-24 presents the results.

Data on cement quality (free lime) is shown in Table 4-25. These data were obtained from the facility's laboratory for the time periods of each run. Note that the free lime for run 1 is high compared to the other runs, possibly due to the unstable process conditions during that run.

TABLE 4-24. WASTE FEED ANALYSIS RESULTS

	Run 2	Run 3	Run 4[a]	HCl test
% Cl				
Liq. org. waste	1.83	1.57	1.69/1.62	1.72
Powdered waste	1.01	1.35	1.69/1.51	NA
HHV (Btu/lb)				
Liq. org. waste	10,498	9,837	10,713/10,396	12,630
Powdered waste	7,828	8,158	8,709/8,932	NA

NA = not applicable

[a] Replicate analysis.

TABLE 4-25. CEMENT QUALITY

Run	Run time	Sample time	Free lime
1	1118-1448	1200	0.67
		1400	0.78
2	1230-1546	1400	0.22
		1600	0.50
3	1135-1720	1400	0.39
		1600	0.39
		1800	0.34
4	1055-1435	1200	0.22
		1400	0.28
5	1047-1535	1200	0.50
		1400	0.45
		1600	0.34
6	1900-2152	2000	0.45
		2200	0.39
HCl	1647-1847	1800	0.17

SECTION 5

REFERENCES

1. Interim Procedures for Estimating Risks Associated With Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans (CDDs and CDFs) and 1989 Update. EPA/625/3-89/016. March 1989.

2. International Critical Tables. Volume I, First Edition. McGraw-Hill Publishers, 1928. p. 207.

3. Mellor, J. W. Inorganic and Theoretical Chemistry. Volume II. 1946. p. 566.

4. Goldfinger, L., and G. Verhaegen. Stability of Gaseous Ammonium Chloride Molecule. J. Chemical Physics, 50(3):1467, 1969.

5. IERL-RTP Procedures Manual: Level I Environmental Assessment (2nd Edition) EPA 600/7-78-201, NTIS NO. PB293-795 (10/78).

APPENDIX A

SAMPLING AND ANALYSIS PROCEDURES

Test objectives were met by the sampling and subsequent analysis of stack gases, lime slurry, process water, fuel oil, solid, and powdered wastes. This appendix summarizes the sampling and analysis procedures used during the test burn. Preparation of the sampling equipment, sampling procedures, and equipment calibration are addressed in Appendix A. The Project QAP more specifically addresses equipment calibration. Sample handling (transport and storage) and sample analysis procedures are addressed in Appendix A-2.

The attached memo from July 24, 1990 briefly summarizes the day to day sampling activities of the test series.

July 24, 1990

TO: Shiva Garg
FROM: Drew Trenholm, Scott Klamm
SUBJECT:

Daily History of Continental Cement Kiln Field Test
June 18-July 5, 1990

Testing of the Continental Cement Wet Process Kiln in Hannibal, Missouri, took place June 18-July 5, 1990. The kiln typically burns pulverized coal (60-80% of BTU load) cofired with liquid and powdered hazardous wastes (20-40% of BTU load). The test series was designed to allow testing of the kiln under "baseline" conditions--coal fired only, and "waste burning" conditions--50% coal, 50% hazardous waste. Dust from the plant's four ESP cells is typically split: 1&2 are recycled to the kiln, 3&4 are disposed of as waste.

June 18 -- Setup day

No testing was performed. Equipment was set up and prepared.

June 19 -- No test

Plant fuels were switched over to coal (only) to allow baseline testing. Plant conditions were unstable and testing was postponed.

June 20 -- Run 1, Baseline

A baseline test using coal (only) was performed. The process was not very stable throughout most of the run. Normally, the plant burns a mixture of coal and hazardous waste, and has operated in this manner for several years. As a consequence, high grade coal is no longer purchased by Continental. Upon attempting to operate firing coal alone, the low grade coal presently available provided poor process stability. Resultant instabilities caused a series of temperature spikes and fluctuating oxygen levels within the kiln. Dust from ESP cells 1,2,and 3 were recycled during Run 1 as an attempt to achieve greater stability. ESP 4 dust was still disposed of separately.

No sampling equipment failures or malfunctions occurred during the test, with the exception of the HCl continuous monitor. It was identified that the monitor's pressure transducer had failed, prohibiting data collection by the instrument. At that time it was unknown how to fix the monitor.

June 21 -- Run 2, Waste Burning

Liquid and powdered hazardous wastes were cofired with coal at 50% of the total kiln BTU rate. Process conditions were relatively stable throughout the test. No significant upsets ocurred.

The HCl analyzer was still not operational. The manufacturer, TECO, was contacted for suggestions without success. It became clear that, as a minimum, a new pressure transducer was necessary to get the monitor operational, but was not available on short notice.

June 22 -- Run 3, Waste Burning

Wastes cofired with coal. Again, the waste firing rate was 50% of total kiln BTU input. The process was again stable with one exception noted below.

During the run, moisture was detected in the hot THC line and rotameter. All sampling activities were stopped for 20 minutes (1255-1315) to clean out the lines.

At 1331, the plant switched waste feed tanks. Such action causes a temporary instability and fluctuations in temperature/oxygen levels for about 30-45 minutes until the BTU value of waste from the new tank is established. Although this is a common occurrance for the plant, it was felt that such instability presented a significant bias in the data given a 2-4 hour test period. Sampling activities were, therefore, stopped from 1331-1519.

A broken probe liner in the HCl sampling train invalidated any sample collected by the train prior to 1331. When sampling activities were stopped at 1331, the broken liner was discovered and corrected. The HCl train was rebuilt and began a 2-hour sampling phase at 1519. Continuation of other sampling activities was held until the HCl train had restarted, allowing coincidental samples to be taken.

June 23 -- Run 4, Waste Burning

Wastes cofired with coal. Again, the waste firing rate was 50% of total kiln BTU input. The process was again stable.

The MM5 sampling train suffered a broken probe liner as it was removed from the stack following the 3rd traverse. The train therefore failed its final leak check, but all indications show the sample as valid. The broken liner was replaced for use in the 4th traverse.

Again, the HCl continuous monitor was not operational.

June 24 -- No Testing. Day off for test crew.

June 25 to July 1 -- No testing.

The kiln was shut down due to "hot spots" on the shell. Upon shutdown it was discovered that about 25 feet of refractory within the kiln needed replacement.

July 2 -- HCl Test Run

Attempts to operate the kiln on coal (alone) were unsuccessful. Testing would have provided a second baseline test identical to that performed on June 20. It was decided that a more typical, stable baseline test would require another fuel source in addition to the coal. Diesel fuel would be made available by Continental for such a baseline test on the 5th of July.

After aborting the coal (only) run on July 2, the plant switched fuels back to coal plus hazardous waste. After a two hour "purge time" MRI performed an HCl test involving waste feed sampling, HCl continuous monitoring (now operable), HCl train, and HCl dilution train. The test was two hours long. Wastes were cofired, but at a slightly lower rate than for the previous tests (about 40% of BTU input). The 40% rate is more normal of plant operations.

July 3 and 4 -- No testing.

July 5 -- Run 5, Baseline with Diesel Fuel and Coal

The plant was operated with coal and diesel fuel. No hazardous wastes were fed. The process was generally stable, although not as stable as the coal plus hazardous waste runs. Diesel fuel is a "hotter" fuel (higher BTU value) than the liquid wastes, so it was a bit trickier for the operators to fine tune and tweek the system. Occasional oxygen and temperature blips happened during the run, but nowhere near the instability of Run 1 (Baseline with coal only).

Equipment failure on the MM5 sample train invalidated sample collected during the first traverse (1115). All sampling activities were put on hold to allow rebuilding the train.

At 1120 the plant saw high CO levels, triggering the ESP's to shut off. Particulate levels rose significantly and opacity read 100%. Sampling equipment was not operating. However, CEM probes were still within the stack. Some pluggage of CEM lines was later experienced.

By 1220, the MM5 train was again operational. Sampling of all systems was restarted. The remainder of the run was completed without incident.

July 6 -- Run 6, Baseline with Diesel Fuel and Coal

A baseline test with coal and diesel fuel, no hazardous wastes was conducted. Process stability was essentially the same as for Run 5.

Prior to beginning the test, the HCl monitor was dead; a victim of pluggage due to lime dust. The filtering system for the monitor was probably overloaded when the ESP's went down during Run 5.

At 1943, a minor process upset occured. The main fan feeding coal to the kiln went dead. O2 levels immediately rose up to 6%. The fan was restarted within two minutes and sampling activities were not interrupted.

Throughout most of this test, dust from ESP's 2,3,and 4 was recycled. ESP #1 was not operable.

This appendix contains brief descriptions of the sampling and analytical procedures used during the testing at Continental Cement Company, Hannibal, Missouri.

APPENDIX A-1

SAMPLING PROCEDURES

APPENDIX A-1

SAMPLING PROCEDURES

Test objectives were met by the sampling and subsequent analysis of stack gases, lime slurry, process water, fuel oil, solid, and powdered wastes. This appendix summarizes the sampling and analysis procedures used during the test burn. Preparation of the sampling equipment, sampling procedures, and equipment calibration are addressed in Appendix A. The Project QAP more specifically addresses equipment calibration. Sample handling (transport and storage) and sample analysis procedures are addressed in Appendix A-2.

1.0 STACK GAS TESTING

The following sampling systems were used to collect stack gas samples during the test:

- Method 0010 sampling train--Used to determine PCDD/PCDF emission concentrations to determine an organic mass fraction, and to screen for a specific array of semivolatile organics.

- HCl train--Used to determine HCl emission concentrations. Ammonium and potassium ion concentrations were also determined in these samples.

- HCl dilution train--Used to determine HCl emission concentrations following a dilution with ambient air. Ammonium and potassium ion concentrations were also determined in these samples.

- VOST--Used to screen for a specific array of volatile organics.

- Field GC system--Equipped with FID. Used to determine an organic mass fraction.

- Tedlar bags--Used to collect gas samples for quantitation of C_1 and C_2 hydrocarbons by GC/FID.

- Continuous emission monitors (CEMs)--Used to monitor hot and cold HCs using Modified Method 25A systems equipped with FIDs. CO, CO_2, and O_2 emission concentrations also measured following EPA Reference Method 10 and 3A. HCl monitoring was performed for purposes of comparison to the HCl train.

- Orsat--Method 3 sampling system used to determine O_2 and CO_2 emission concentrations using an Orsat analyzer.

These sampling systems are further defined in the subsequent discussion.

1.1 Method 0010 Train

The Method 0010 sampling train was used to measure carbon fractions greater than C17 (i.e., organic mass fraction) and to define specific semivolatile organics (i.e., organic screen analysis). The carbon fraction was determined by gravimetric analysis; semivolatile organics were determined by GC/MS analysis. This train was also used to measure PCDDs/PCDFs.

The sampling procedure consists of isokinetically sampling a volume of the exhaust gas. Due to the short test period, only ~ 60 ft^3 of gas, corrected to dry standard conditions, was collected rather than the 105.9 ft^3 prescribed by Method 0010. In general, the sampling procedures parallel those specified in 40 CFR 60, Methods 1 through 5, for particulate analysis.

The design of the Method 0010 sampling train was based on the apparatus described in SW-846, Method 0010 (September 1986 edition). The train consisted of a stainless steel nozzle, a heated borosilicate glass probe liner, and a borosilicate filter. The control module used to control the gas sampling rate and monitor the stack gas parameters contained a leakless vacuum pump; a dry gas meter; an orifice meter; and the appropriate valves, gauges, temperature controllers, and associated hardware. The impingers and their contents are described below:

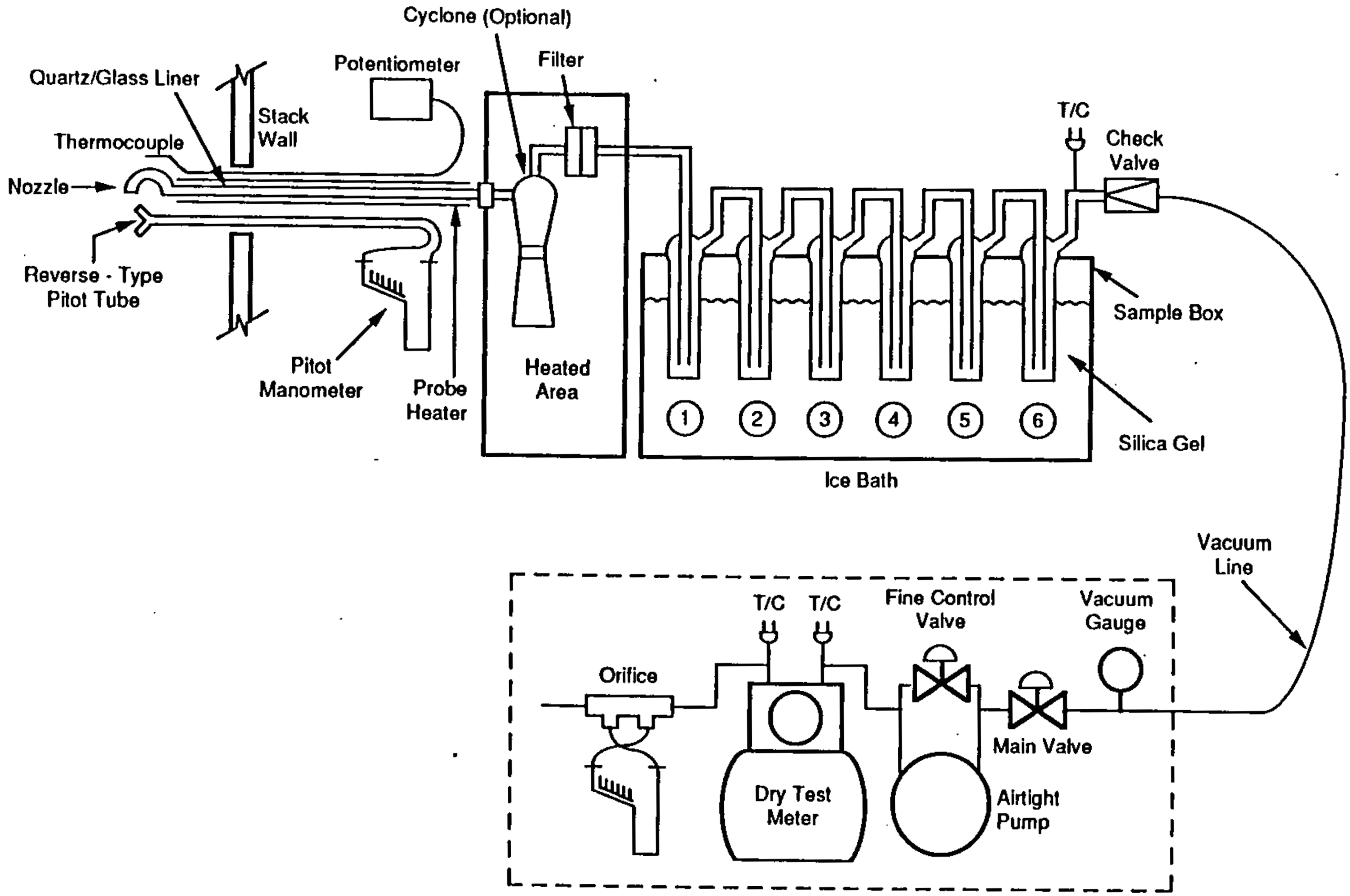
- The first impinger is a spiral condenser to cool the sample gas.
- The second impinger is an MRI-designed XAD module containing 70 g of XAD.
- The third impinger is a modified Greenburg-Smith (GBS) containing 100 mL of double-distilled-in-glass water to catch any carryover from the first two impingers.
- The fourth impinger is a GBS and will contain 100 mL of double-distilled-in-glass water.
- The fifth impinger is an empty modified GBS.
- The sixth impinger is a modified GBS, containing approximately 200 g of blue indicating silica gel.

All glass-to-glass connections are made from threaded glass and Teflon ferrules. Schematics of the train are shown in Figures A1-1 and A1-2.

Calibration--The sampling equipment was calibrated, checked for proper operation, and cleaned for use prior to arrival on-site.

As a minimum, the following equipment will be calibrated:

1. Dry gas meter/orifice
2. Stack temperature thermocouple



① Condenser
② XAD module, 70 g XAD
③ Modified Greenburg-Smith, 100 mL double-distilled H_2O
④ Greenburg-Smith, 100 mL double-distilled H_2O
⑤ Modified Greenburg-Smith, empty
⑥ Modified Greenburg-Smith, silica gel

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Figure A1-1. Diagram of MM5 train.

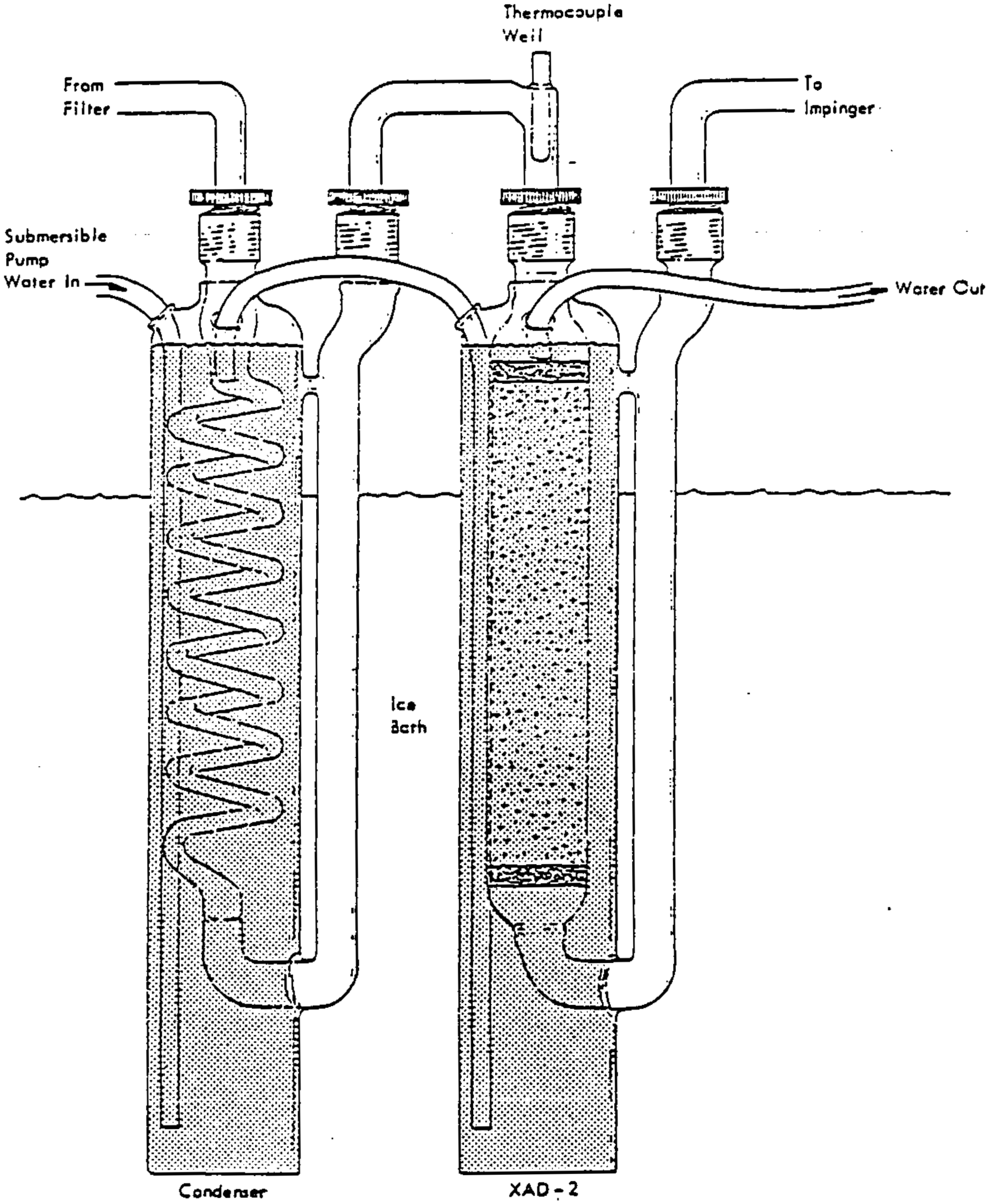

Figure A1-2. MM5 condenser and XAD resin cartridge.

3. Filter oven thermocouple
4. Thermocouple and pyrometer for gas meter
5. Probe nozzles
6. Pitot tube (by comparison to pitot tube in wind tunnel)

Copies of all calibration data will be placed in the project calibration data file. The calibration procedures used are from the "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III--Stationary Source Specific Methods," USEPA 600/4-77-027b.

All surfaces in the sampling train that came into contact with the sample gas stream were thoroughly cleaned. The cleaning procedure is discussed in more detail later in this section. To minimize the potential for contamination of sampling train glassware, all glassware components were sealed with aluminum foil prior to being packed for storage and transport. All remaining sampling train components were cleaned and prepared in accordance with EPA Method 5 procedures.

Sample collection--Sample collection, including leak-checking, was conducted in accordance with EPA Method 5 procedures. The samples were collected isokinetically over a complete traverse of the stack. Twelve traverse points were sampled using two sample ports located across the width of each duct. About 60 ft^3 were collected at a sampling rate of ~ 0.75 ft_3/min. Two-hour samples will be collected.

Sample recovery--At the end of a test run after the final leak check, the sampling train was disassembled into two parts, the probe and the sample box, which were transferred to the field laboratory for recovery. The inlet to the sample box was covered, and both ends of the probe were sealed to prevent sample loss and contamination. In a designated section of the field laboratory, sample components were recovered from the sample box and the nozzle. The sample component from the probe was recovered in a clean, ventilated area. All liquid sample components were transferred to amber glass, precleaned bottles. Sample components were recovered as follows.

- Container 1--Filter. Use Teflon-coated or stainless steel forcepts to recover the filter; place the filter in the labeled glass petri dish.
- Container 2--XAD-2 resin. Cap the XAD-2 resin module with threaded glass plugs (Teflon ferrules).
- Container 3--Front-half rinse. Rinse and brush the probe nozzle, probe, and all glassware up to and including the front-half of the filter with methanol, methanol/methylene chloride, and toluene; three times each. Retain the rinse.

- Container 4--Back-half rinse. Rinse all glassware from the filter back-half up to the XAD resin cartridge including the condenser with methanol, methanol/methylene chloride, and toluene; retain the rinse.

- Container 5--Condensate. After weighing, collect the first, second, and third impinger condensates. Record the total final volume of condensate. Rinse all impingers three times with methanol, methanol/methylene chloride, and toluene, and add these rinses to the condensate container.

Cleaning glassware--All glass parts of the train including the empty XAD sorbent tube were cleaned in MRI's laboratory prior to use as follows:

1. Scrub and soak in hot, soapy water.
2. Hot water rinse.
3. Distilled water rinse.
4. Methanol.
5. Methanol/methylene chloride rinse.
6. Toluene rinse.
7. Bake in 100°C oven until dry.
8. Cap ends in methanol/methylene chloride rinsed aluminum foil (dull side in).
9. Store.

Note: Chromic acid rinse to remove grease was not required because all fittings are designed as greaseless and have never been used with grease.

Blank train--A blank train was fully assembled in the field, heated, leak checked, and then recovered using the same procedures as a normal sample recovery.

1.2 HCl Sampling Train

HCl present in exhaust gas was collected using an HCl sampling train. The sampling procedure consisted of sampling a predetermined volume of stack gas using the proposed sampling procedures specified in EPA's "Draft Method for the Determination of HCl Emissions from Municipal and Hazardous Waste Incinerators" (USEPA, QAD, July 1988), adapted for use with an M5 train.

The HCl sampling train consisted of a heat-traced borosilicate glass probe. A heated quartz fiber filter holder is located at the back end of the probe. A flow control module was used to permit control and monitoring of the gas sample. The module contained a leakless vacuum pump; a dry test meter;

and the appropriate valves, gauges, temperature controllers, and associated hardware. The impingers and their contents are described below:

- The first and second GBS impingers contained 50 mL of 0.1 N H_2SO_4 each. These impingers were used to collect condensate and HCl.
- The third and fourth modified impingers contained 50 mL of 0.1 N NaOH. These impingers were used to absorb Cl_2.
- The fifth modified impinger was filled with blue-indicating silica gel.

All glass-to-glass connections were glass and Teflon. A schematic of the HCl train is shown in Figure A1-3.

Calibration--The HCl sampling equipment was calibrated, checked for proper operation, and cleaned for use prior to arrival on-site.

As a minimum, the following equipment was calibrated:

1. Dry gas meter/orifice
2. Stack temperature thermocouple
3. Filter oven thermocouple
4. Thermocouple and pyrometer for gas meter
5. Probe nozzles
6. Pitot tube (by comparison to pitot tube in wind tunnel.)

Copies of all calibration data will be placed in the project calibration data file. The calibration procedures used are from the "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III--Stationary Source Specific Methods," USEPA 600/4-77-027b, and/or from the previously referenced EPA draft method for the determination of HCl emissions.

All surfaces in the HCl sampling train that came into contact with the sample gas stream were thoroughly cleaned. The cleaning procedure is discussed in detail below. To minimize the potential for contamination of sampling train glassware, all glassware components were sealed with aluminum foil prior to being packed for storage and transport. All remaining sampling train components were cleaned and prepared in accordance with appropriate EPA reference procedures (i.e., EPA Method 5).

All glassware, rinse bottles, and associated apparatus used for in-field sampling and recovery were thoroughly cleaned and conditioned. All sample containers were polyethylene.

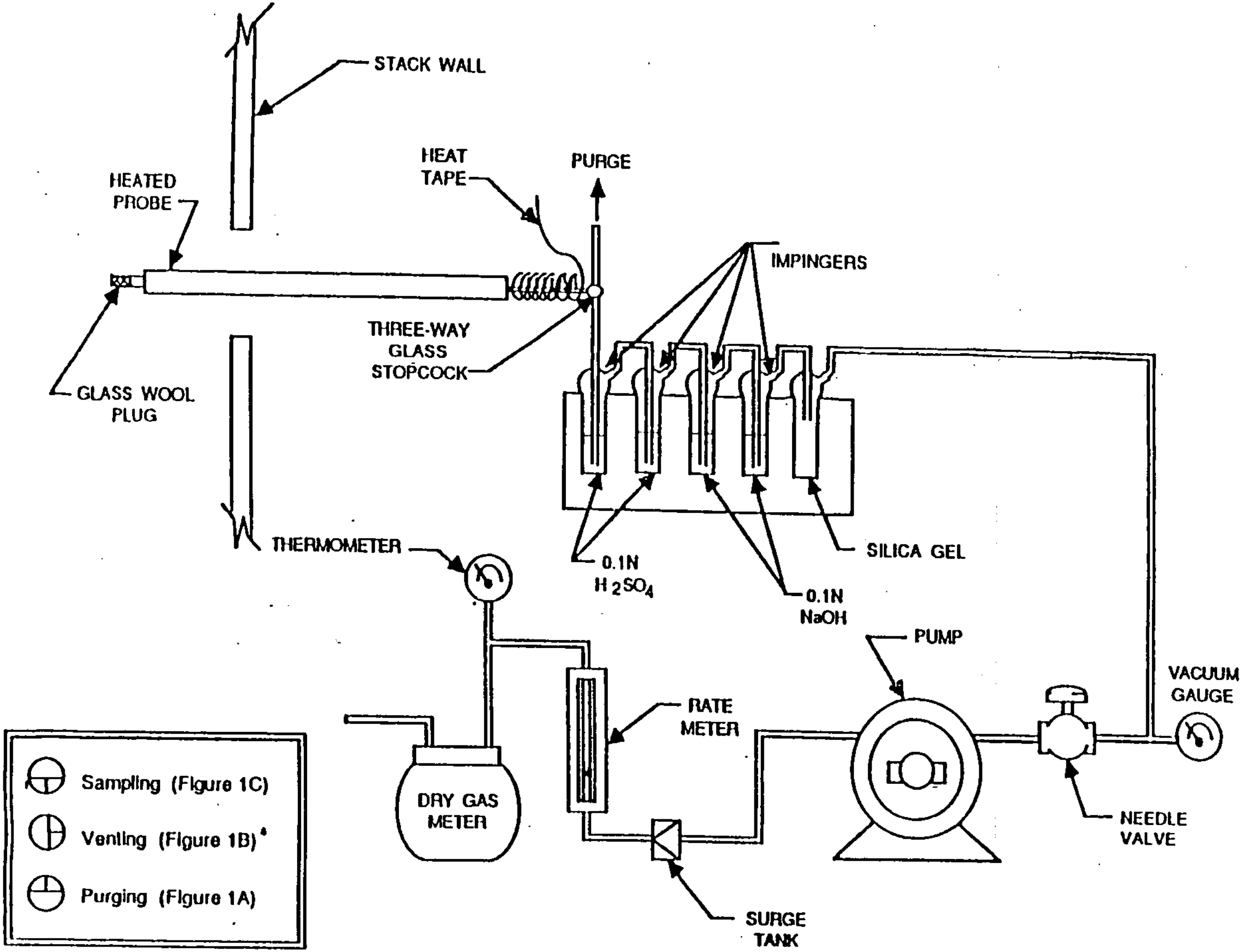

Figure A1-3. Schematic of the HCl train.

Cleaning glassware--All glass parts of the train were cleaned in MRI's laboratory prior to use as follows:

1. Scrub and soak in hot, soapy water.
2. Rinse in hot water.
3. Rinse in distilled water.
4. Rinse in acetone.
5. Bake in 100°C oven until dry.
6. Cap ends in acetone-rinsed aluminum foil (dull side in).

Sample bottles--All sample bottles required for recovery of HCl condensate were polyethylene. The sample bottles were rinsed with distilled water.

Sample collection--Sample collection, including leak-checking, was conducted in accordance with the procedures described in the EPA draft protocol, "Draft Method for the Determination of HCl Emissions from Municipal and Hazardous Waste Incinerators." Even though this draft method is directly applied to incineration systems, the proposed methods may be equally applied to other industrial combustion systems, such as the cement kiln.

Samples were collected at a single point in the duct. A sampling rate of approximately 10 L/min was maintained through a 2-h sample period.

Sample recovery--At the end of the test after the final leak check, the sample train was taken to the laboratory to recover the sample. The samples from the HCl train were recovered as follows:

- Container 1--Condensate, HCl, and rinsate. Combine contents of impingers 1 and 2. Rinse these impingers with water, and add the rinsate to the combined impinger volume.
- Container 2--Caustic, Cl_2, and rinsate. Combine contents of impingers 3 and 4. Rinse these impingers with water, and add the rinsate to the combined impinger volume.

1.3 Dilution HCl Train

MRI designed and built a dilution HCl system (Fig. A1-4) to generate and collect combustion gas samples that have been mixed with ambient air in a way that is similar to the mixing which occurs for combustion gas leaving a stack. EPA wanted to consider the possible formation of ammonium chloride particles after being emitted from a wet cement plant stack. The dilution HCl train was designed to dilute the combustion gas sample with ambient air so as to achieve a temperature approximately 10°F above ambient. The diluted gas was filtered through a quartz glass filter at ambient temperature and bubbled sequentially through solutions of 0.1 N H_2SO_4 and 0.1 N NaOH. The filter,

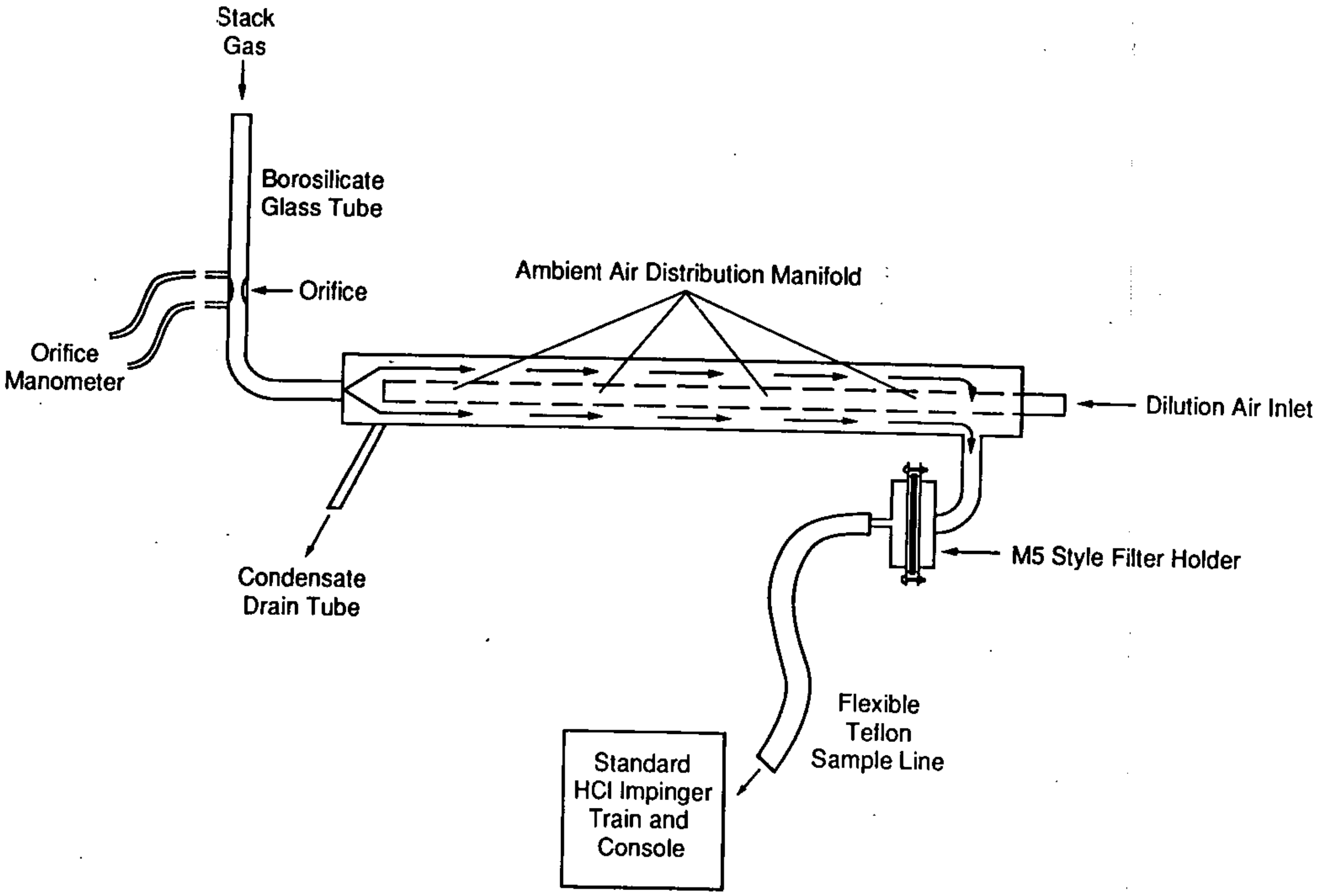

Figure A1-4. HCl dilution probe system.

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both impinger solutions, and rinse water were each analyzed for Cl^- and for ammonium ion (NH^{+_4}) and potassium ion (K^+).

The HCl dilution train's experimental design may have contributed to some loss of chlorides or other ions within the probe itself. Dilution air was mixed with stack gas along the length of the probe, with gas temperatures dropping from about 400°F to near ambient (85°F). A condensate drain tube was fitted to one end of the probe, but there was no visible accumulation of condensate during any of the tests. Trace condensation may have occurred inside the probe itself, possibly contributing to low results for the train. Nonetheless, the train's purpose of displaying front half/back half splits of the three ions is still valid.

A dilution factor of approximately 20:1 was used in preliminary design calculations, but air temperature was the target parameter of the dilution process. Airflow volume through the sampling system was measured using a dry test meter. Airflow rate through the probe was measured using an orifice and manometer (Fig. A1-5). Materials that are nonreactive to HCl were used in construction of the sampling system. The probe was constructed of borosilicate glass and the manifold of polyvinyl chloride and Teflon. Stainless steel thermocouples were used to monitor the temperature gradient in the manifold. All other parts of the system were glass or Teflon except the quartz fiber filter.

Combustion gas was drawn through the probe into the centerline manifold as shown in Figure A1-6. The Teflon tube along the centerline acts as an air distribution manifold with twenty 7/64-in diameter holes arranged in 5 sets of 4 through which ambient dilution air is supplied. Temperature is monitored in the probe, at the entrance of the probe to the manifold, at six equidistant points downstream of the manifold inlet, at the outlet of the manifold to the filter, and at the dilution air inlet.

The manifold was 44.25 in long and made of 2-in i.d. PVC pipe. Combustion gas at approximately 550°F and 35% moisture was observed to cool to ambient temperature at a 20:1 dilution rate within the first 8 in of the manifold during construction of the system. The manifold was insulated with a blanket of refractory fiber for the first 20 in and the combustion gas cooled to ambient at a 35:1 dilution rate at the exit of the manifold. The glass probe was heat-traced and insulated with refractory fiber. The probe was maintained at approximately 550°F; the flue gas temperature.

Calibration--Before and after each test run, the system was calibrated in the following manner:

1. The dilution inlet was plugged, and combustion gas was drawn through the system at a ΔH of approximately 1.5 in H_2O.
2. The volume was measured for 2 min, and a flow rate was calculated.
3. The dilution inlet was opened and the combustion gas flow (ΔH) into the system was adjusted to that observed in step 1.

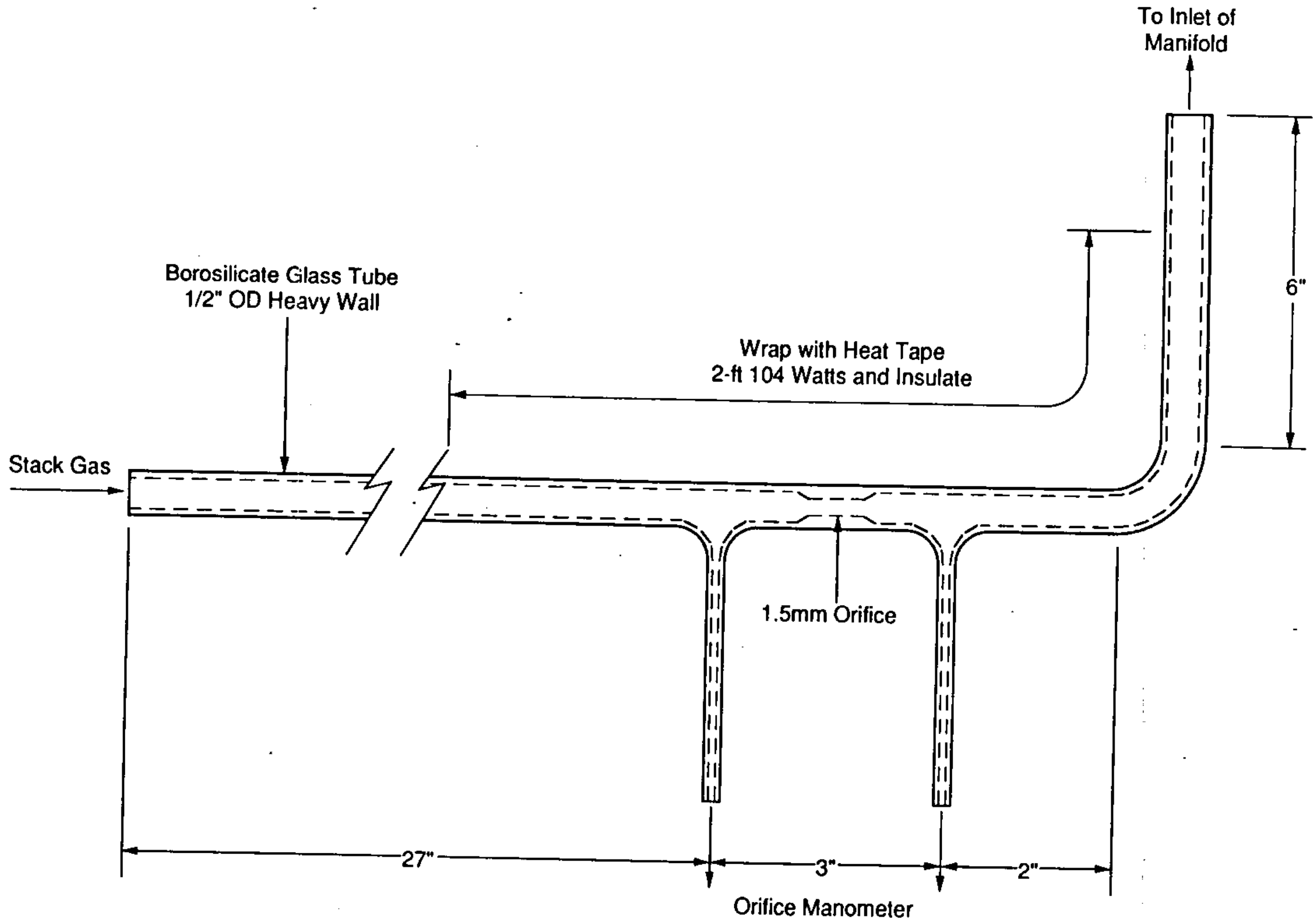

Figure A1-5. Schematic of HCl dilution probe.

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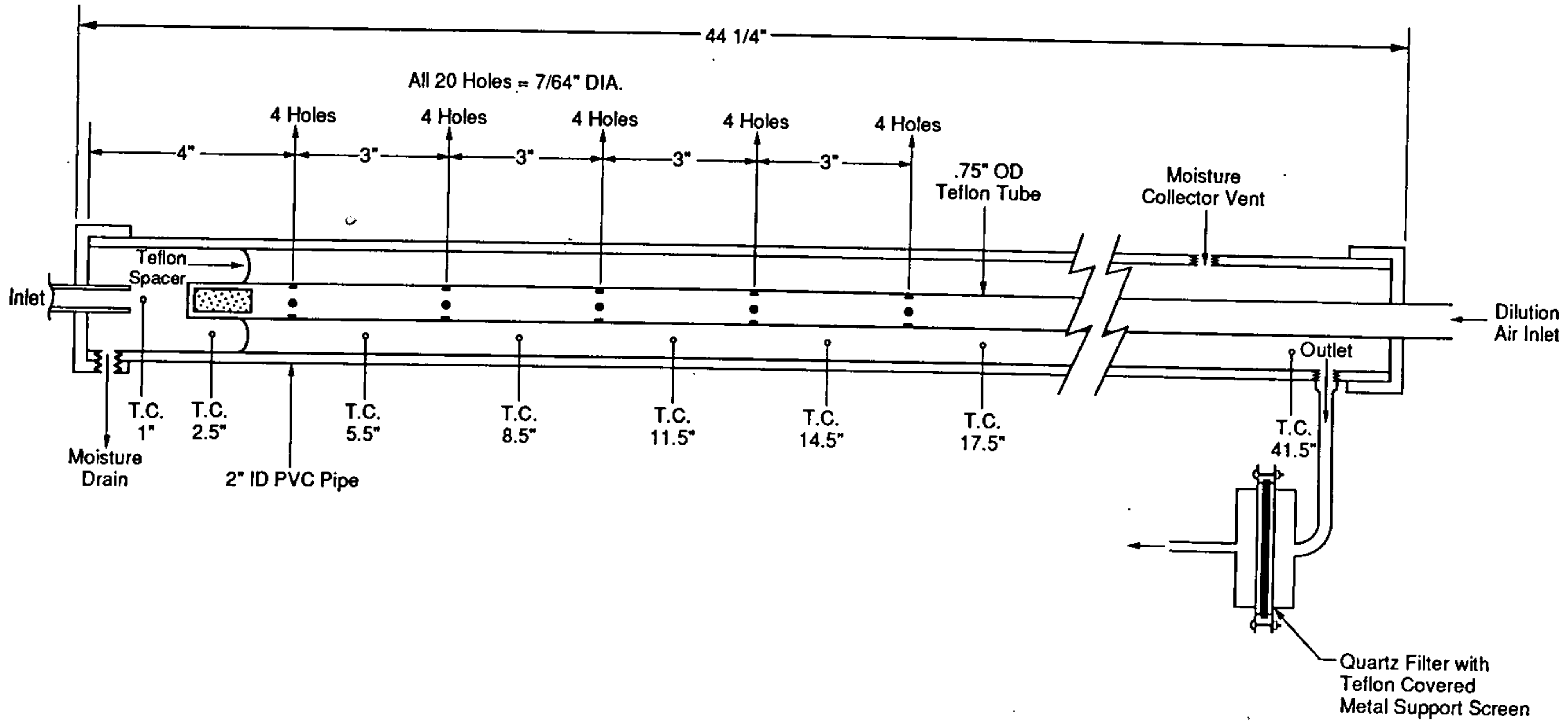

Figure A1-6. Detail of Dilution Air System.

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4. The volume was measured, and a flow rate was calculated.

5. A dilution factor (DF) was calculated for each run by the equation:

$$DF = \frac{Vol_{Com} - Vol_{CG}}{Vol_{Com}}$$

where: Vol_{Com} = volume of air through probe and dilution air combined

Vol_{CB} = volume of air (combustion gas) through probe

Sample Collection--The HCl dilution train was operated at a single point in the duct. Isokinetic sampling was not possible with this system. The train was operated for a 2-h period, maintaining the ΔH at all times roughly at the calibrated ΔH. Post-test calibrations of a different ΔH were performed as necessary. The HCl dilution train used the same port as the VOST, due to availability of sample ports.

During run 1 the HCl train was operated using midget impingers, VOST console, and low sampling volume (~ 9 ft^3). In run 2 the train used standard MS-style impingers but again collected a low comple volume (~ 7 ft^3). Runs 3 through 6 and the special HCl test all used M5-style impingers and a higher sampling rate (52 to 54 ft^3 total value).

Combustion gas temperature ranged from 520° to 557°F and the moisture ranged from 30% to 37.7%. Daily dilution factors ranged from 33:1 to 42:1 during the seven test runs. Ambient temperature ranged from 81° to 96°F, and the final temperature of the diluted gas in the manifold ranged from 99° to 105°F.

Sample Recovery--Sample recovery was identical to the standard HCl train.

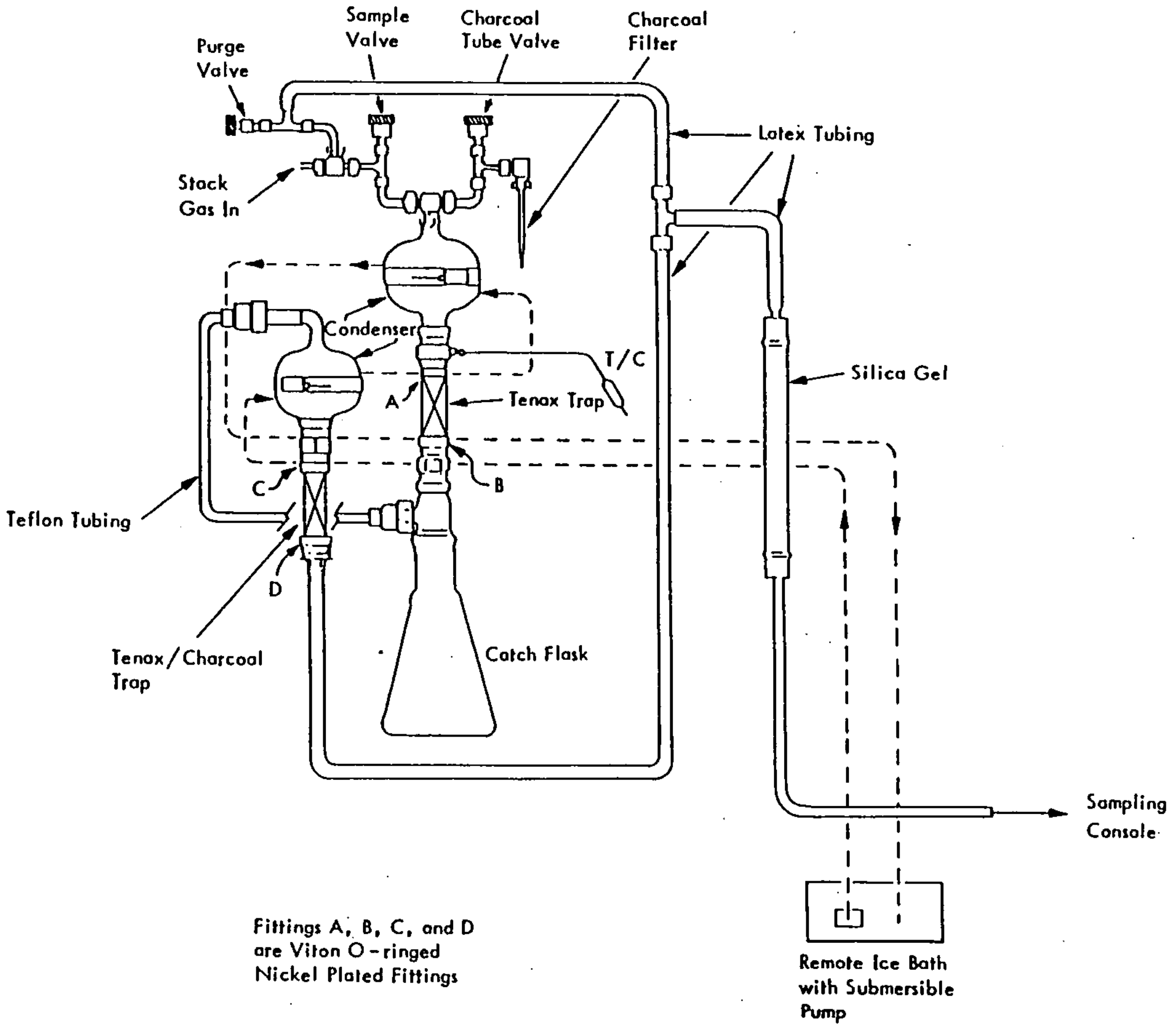
Glassware cleaning--Glassware preparation was identical to the standard HCl train.

1.4 Volatile Organics Sampling Train

Volatile organics were collected from exhaust gases using a VOST. VOST samples were collected from a single point in the duct at the stack base.

The VOST method involved collecting a 10-L exhaust gas sample at a flow rate of approximately 0.33 L/min. The gas sample was cooled to 20°C by passage through a water-cooled condenser, and volatiles were collected on a pair of sorbent resin traps. Liquid condensate was collected in a catch flask placed between the two resin traps. The first resin trap (front trap) contained approximately 1.6 g of Tenax, and the second trap (back trap) contained approximately 1 g each of Tenax and petroleum-based charcoal, 2:1 by volume.

A diagram of the VOST component arrangement is presented in Figure A1-7. The sample goes from the probe to a valve train, a water-cooled



Fittings A, B, C, and D
are Viton O-ringed
Nickel Plated Fittings

Figure A1-7. Volatile organic sampling train (VOST).

glass condenser, a sorbent cartridge containing Tenax (1.6 g), an empty catch flask for condensate removal, a second water-cooled glass condenser, a second sorbent cartridge containing Tenax and petroleum-based charcoal (2:1 by volume, approximately 1 g of each in separate layers), a silica gel drying tube, a rotameter, a sampling pump, and a dry gas meter.

The gas pressure during sampling and for leak-checking was monitored by pressure gauges which are in line with and downstream of the silica gel drying tube.

The probe is constructed of borosilicate glass or Teflon in a stainless steel outer sheath. The temperature of the probe was maintained above 135°C but low enough to ensure a resin temperature of 20°C.

An isolation valve was used to isolate the VOST apparatus from the sample probe. The isolation valve consisted of a greaseless stopcock and sliding Teflon plug. The charcoal tube valve was also used to direct a hydrocarbon-free gas (charcoal-filtered air) to the inlet of the sample train. This gas was used to prevent contamination during leak-check procedures.

The condensers were of sufficient capacity to cool the gas stream to 20°C or less prior to passage through the first sorbent cartridge.

The sorbent cartridges for the VOST were of the inside-inside (I/I) configuration in which only a single glass tube was used for each of the two tubes. The second sorbent cartridge was placed in the sample train so that the sample gas stream passed through the Tenax layer first and then through the charcoal layer. The sorbent cartridges were glass tubes with approximate dimensions of 10 cm (long) by 1.6 cm i.d. The resin was held in place by Teflon-coated stainless steel screens and clips at each end of the resin layer. Threaded end caps were placed on the sorbent cartridges after packing with sorbent to protect the sorbent from contamination during storage and transport.

The metering system for VOST consisted of vacuum gauges, a leak-free pump, a rotameter for monitoring the gas flow rate, a dry gas meter (low volume) with 2% accuracy at the required sampling rate and related valves and equipment. All sample transfer lines used with the VOST up to and including the second resin cartridge were Teflon or glass with connecting fittings that were capable of forming leak-free, vacuum-tight connections without the use of sealing grease.

Calibration--All VOST equipment was calibrated, checked for proper operation, and cleaned for use prior to arrival on-site. The gas meter and condenser thermocouple were calibrated before and after the test.

The gas meter was calibrated against a wet test meter. The thermocouple was calibrated against a mercury-in-glass thermometer. The calibration procedures are presented in the QAP.

Glassware cleaning--All glass parts of the VOST train were cleaned as follows:

- Washed with Alconox and hot water.
- Rinsed with tap water.
- Rinsed with distilled water.
- Oven-dried at 150°C for 2 h.
- Capped with aluminum foil or Teflon caps until used.

Tenax preparation--The sorbent tube cartridges were packed with Tenax and conditioned by flowing, organic-free nitrogen (30 mL/min) through the resin while heating to 175°C for at least 4 h.

During the thermal conditioning, the Tenax cartridges were installed in a specially designed manifold which permits the nitrogen purge from the traps to be individually monitored by an FID. The conditioning was continued until the FID response indicates the traps are clean (less than 5 ppb total hydrocarbon as propane). If after 24 h of purging the trap was still contaminated, it was discarded.

Charcoal (SKC petroleum base or equivalent)--Procedures for reconditioning charcoal are the same as those described for Tenax above.

Sample cartridges--"Primary" VOST cartridges were packed with 1.6 to 1.8 g of prepared Tenax, and "secondary" cartridges were packed with approximately 1 g each of prepared Tenax and prepared petroleum-based charcoal (SKC Lot 104 or equivalent), 2:1 by volume. The packed cartridges were conditioned as described above.

After the tubes were conditioned, the tubes were capped and placed into a steel can which was sealed for shipment. The can contained a small amount of charcoal for shipment. During each test each tube was marked directly with an identifier.

VOST sample collection--Sample collection was conducted in accordance with procedures described in the USEPA document SW-846, Method 0030, except as noted below. Samples were collected from each exhaust duct at a single sample point for three 40-min sample periods during each test condition.

The following are exceptions and/or additions to the procedures in the above-referenced document.

1. After collection of the 20-L sample, the two sorbent cartridges were removed from the train, capped at the ends, and placed into the metal transport can which contains charcoal. The cans were stored and transported in insulated containers packed with ice to maintain temperature of the tubes below 20°C at all times.

2. Field blanks, trip blanks, and other conditioned (clean) sorbent tubes were stored and transported as described above for the sample tubes.

The volatile organic sample train was assembled as shown in Figure A1-7. A leak check of the train was made at 250 mmHg with the sample valve at the inlet from the probe to the condenser closed. After all leak checks, the vacuum was released by admitting charcoal-filtered air through the charcoal-tube valve.

The probe was next purged with stack gas by drawing stack gas through the probe via the purge valve with a pump. After this purge of the probe, the sample was collected following these steps:

- Record the dry gas meter reading.
- Position the valve train to connect the condenser with the probe.
- Turn on the pump and open the coarse metering valve.
- Operate the train at the sampling rate of 0.33 L/min for the next 30 min.
- Collect readings as required by the VOST data sheet each 5 min throughout the run.
- Ensure the sampling rate remains constant throughout the run.
- Ensure the temperature of the gas entering the first sample tube remains below 20°C throughout the run.
- Ensure the probe remains above 135°C throughout the run.
- At the end of the sampling period, turn off the pump and close the sampling valve.

After the sample was collected, the final meter volume was recorded and a final leak check done at the highest vacuum recorded during the sampling period. The cartridges just used were removed and replaced with fresh cartridges. No cleaning of the condenser or other VOST equipment was required between subsamples. A new pair of traps was installed in the system, and sampling was continued as described above.

One set of field blanks was obtained by removing the end caps from a pair of traps and exposing them to the atmosphere while placing a pair of sample traps into the VOST train and again while removing the sample traps from the VOST train.

A set of trip blanks were retained for analysis from the set of tubes used during the test.

Condensate collected in the catch flask was transferred to a VOA (volatile organic analysis vial) following each run; or as traps were changed out during the run as necessary if a significant volume was collected.

VOST sample recovery--The VOST traps and VOA vials used in the sample train were immediately capped. A label was placed on the end cap or VOA bottle to indicate the sample run number for ease in identification. Each trap tube was permanently marked with a unique identification number. This identification number was recorded on the data form and sample traceability form to ensure proper sample identification. This trap number was used as the primary sample identification number.

The sealed trap was replaced in the trap storage/transport can and the labeled VOA bottle appropriately wrapped. All samples to be analyzed for volatile organics were kept in a cooler with ice during the duration of the test and during storage on-site.

VOA vials used to collect train condensate were capped, stored, and shipped at 4°C. Partially full vials were weighed and topped off with deionized water and weighed again.

1.5 Field GC

The field GC was utilized to identify C1 through C17 carbon fractions.

GC samples were split directly off the hot HC pump exit, placing the GC sampling lines under positive pressure. The entire sampling system was leak-checked as a unit.

The standard were nominal 100-ppm, 50-ppm and 20-ppm propane EPA protocol cylinders. All results were reported as parts per million of propane equivalent. A separate analysis of a mixture containing C7 and C17 will be analyzed to establish retention times for these compounds.

The GC conditions were as follows:

Analyzer:	Shimadzu GC with dual FID
Column:	30-m DB-1, 5.0-µM megabore
Temperature program:	100°C to 250°C at 20°C/min, hold for 6 min at 250°C.
Detector temperature:	275°C
Carrier gas:	He, 7 to 10 mL/min
Sample loops:	Approximately 1 mL
Valve temperature:	150°C

Two of the three propane standard concentrations were analyzed each day. The lower of the two concentration propane standards was analyzed prior to each test run to check instrument linearity. The higher propane standard was analyzed prior to and after each test run to generate an average response factor. The average response factors were used to calculate the C1-C7 and C7-C17 carbon fractions.

1.6 Integrated Gas Bag Sampling for Volatile Organics

A Tedlar Bag was used during each test run to collect an integrated bag sample for C_1-C_2 analysis. The samples were collected from an available exit on the CEM manifold. Various gauge needles were used to restrict sample flow to within a 30 to 70 mL/min range. A 3- to 15-L bag sample was collected over the duration of each test period. A blank bag was filled with prepurified nitrogen and placed near the sampling location. The blank bag was analyzed along with and in the same manner as the sample bags. When sampling was completed, the blank and sample bags were analyzed on-site within 24 hr. All sample bags were leak-checked in the laboratory prior to shipment to the test site.

Tedlar bag samples and blanks were analyzed by GC-FID within 24 h of sample collection. The injection volume for the gas samples was 0.5 mL. The GC conditions for C_1-C_2 analysis (bag fraction) were as follows:

Analyzer:	FID
Column:	30-m GS-Q megabore
Temperature program:	40°C to 120°C at 6°C/min
Detector temperature:	275°C
Injector temperature:	100°C
Carrier gas:	Helium at 7 to 10 mL/min
Make-up gas:	Helium at 20 mL/min

Tedlar bags were used for the collection of the integrated sample. They were 15-L bags and are used only once. Before use, the bags were purged three times with prepurified nitrogen. Blank bags were always employed for each run to measure any contamination that may have occurred

1.7 Continuous Emission Monitoring

Samples were collected at each exhaust duct to measure CO, CO_2, O_2, and hot and cold HC, and HCl.

1.7.1 HC Measurement--

HC emissions were measured using EPA MM25A sampling systems, equipped with FIDs. This HC measurement was compared to an organic mass measurement (subsequently discussed).

Heated and unheated HC emission concentrations were measured using the MM25A systems. This method essentially measured hydrocarbons expressed in terms of propane.

To measure heated HC concentrations, the following changes were made to the MM25A system:

- The entire sample system from probe to detector was heated to > 300°F (150°C).
- A Beckman 402 HC analyzer or equivalent was used.

- Propane was used as the calibration gas.

- EPA protocol 1 cylinder standards of 5, 10, 20, 50, and 100 ppm propane in nitrogen were available; the three cylinders that best covered the sample concentration were used.

In measuring unheated HC concentrations, the following changes were made to the M25A system:

- An ice-cooled water knockout trap was used to remove condensibles.

- An unheated Teflon sample line was used to conduct the sample through a stainless steel pump to the FID.

- Propane was used as the calibration gas.

- EPA protocol 1 cylinder standards of 5, 10, 20, 50, and 100 ppm propane in nitrogen were available; the three cylinders which best covered the native sample concentration were used.

Figure A1-8 illustrates the general configuration of the HC gas sampling system. At each sample point (i.e., exhaust duct), combustion gas was sampled using a single probe with a sintered metal filter. Immediately after extraction, the gas sample was split into "heated" and "unheated" sample fractions. The heated sample fraction was transferred to a hot HC analyzer via a heated sample line. The sample line, along with in-line tees and valves, were maintained at over 300°F (150°C). Pumps were used to maintain constant purging of all sampling lines.

The unheated sample fraction was passed through a condensate trap (i.e., a modified GBS impinger placed in an ice bath) which was located adjacent to the sample port. Using a Teflon sample line, the sample was then transferred to the FID, carbon monoxide, carbon dioxide, and oxygen analyzers.

During the test the condensate trap was operated at "contact" and "noncontact" conditions. Contact conditions were characterized by the sample gas bubbling through collected condensate. Noncontact conditions were achieved early in the day's test and were characterized by the sample gas passing through the condensate trap without contact with collected condensate.

The HC monitors used included a Beckman 400 series model and a comparable MRI in-house designed model. A data logger was used to record all necessary information. The monitors were spanned and zeroed prior to and/or immediately following each run with 99.26 ppm propane, NBS-traceable EPA protocol 1 gas, and prepurified nitrogen. A linearity check was conducted in the field prior to initiating the first test run using 49.09 ppm propane and 20.35 ppm propane NBS-traceable EPA protocol 1 gases. Monitor response times also were checked (90% of full scale).

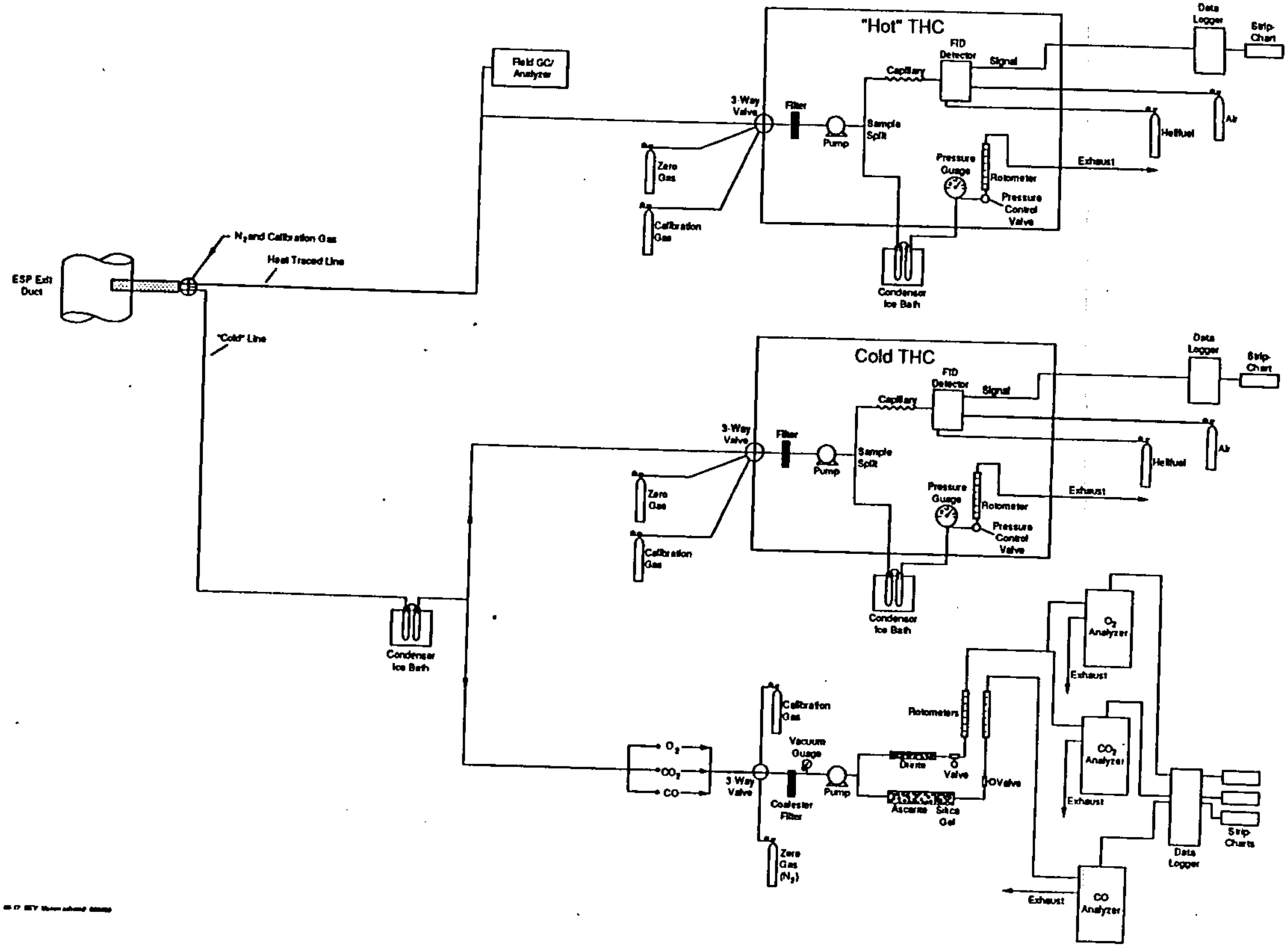


Figure A1-8. HC and CEM equipment layout associated with each exit duct.

1.7.2 Carbon Monoxide, Carbon Dioxide, and Oxygen Measurement--

Figure A1-8 is a schematic of the CEM system. As illustrated, CEM samples were split from the cold HC MM25A sample line. In the MM25A system, immediately after extraction, the gas sample was passed through a condensate trap. The sample was then transferred via TFE Teflon sample line and split for CO_2, O_2, CO, and cold HC analysis. CO_2 was independently monitored and used to volume-correct the CO reading to account for the CO_2 removed. A Horiba Model PIR-2000S nondispersive infrared (NDIR) analyzer was used to measure CO_2. O_2 was also independently monitored and was used to correct the CO reading to 7% oxygen concentrations. A Horiba PMA-200 paramagnetic sensor and a Teledyne Model 320AX polarographic sensor were used to measure O_2. Each manifold maintained a constant purge of the two cold TFE sample lines.

Total CO concentration was determined using Horiba Model PIR-2000L NDIRs. After a CO sample was split from the cold HC MM25A sample line, it passed through an ascarite/silica gel cartridge containing approximately 200 g of ascarite and 20 g of silica gel. The ascarite trap removes carbon dioxide, which is an interference to the CO monitor, and the silica gel removes the last traces of moisture prior to the monitor. The sample fraction was then pumped to the NDIR analyzer.

Zero drift was determined by checking the zero calibration before and after each run and comparing the two. Calibration drift was determined by checking the span gas calibration before and after a given period of time (usually the same time as the zero drift was done). The response time was determined by adding a calibration gas while the instrument was at the zero calibration in the end of the probe and determining the length of time for the instrument to reach 90% of the corresponding span value. The calibration error (usually referred to as the linearity check) was done by zeroing and spanning the instrument and then adding a midlevel calibration gas and comparing the instrument value with the real gas value. Zero and calibration drift must be less than ±3% of the span value, while the calibration error must be less than ±5% of the calibration gas value.

Possible bias from organics retained on the sampling lines was also checked by introducing zero gas at the sample probe before and after each run (HC only). Also after each run, each HC monitor was switched to obtain ambient air readings from just outside the trailer.

The performance checks for the analyzers are summarized below:

Zero drift: 3% of span
Span drift: 3% of span
Linearity checks: 5% of cylinder gas value
Leak checks: < 4% of normal flow, before and after each run
Nominal gas concentrations:

	Linearity
HC--span 100 ppm propane	50, 20 ppm
CO--800 ppm	400, 200 ppm
CO_2--14%	7%
O_2--14%	7%

1.7.3 HCl monitoring--

HCl continuous monitoring was performed by a Thermo-electron Model 15 gas filter correlation infrared unit. The instrument used its own heated Teflon sample line and conditioning system. Stack gas was dried using a Permapure dryer.

The system was leak-checked before each run. The monitor was zeroed using prepurified nitrogen and spanned using the lowest calibration gas available, as historical data from the facility showed quite low levels of HCl present. Operation of the monitor was checked hourly and fed span gases to verify response as necessary. Following each run, a final zero and span were performed and the monitor was purged for at least 30 min with nitrogen before shutting down. Zero drift, span drift, and response times were measured identically to the CO, CO_2, and O_2 monitors (Section 1.7.2). A linearity check was performed using the mid-level calibration gas the first day only. The system was within 10% agreement of the gas true value.

1.8 Orsat

An integrated multipoint stack gas sample was taken during each test run and subsequently analyzed for percentage oxygen (O_2) and carbon dioxide (CO_2) according to EPA Reference Method 3 (40 CFR 60). The sample was taken from a connection at the exhaust from the Method 0010 sampling console. This provided a sample from which particulate and moisture have already been removed in the Method 0010 sampling train, and automatically provided a multipoint integrated sample.

The integrated sample was taken over the entire 2-hr sampling period, simultaneously with the Method 0010 sampling.

The sampling systems leak checks required in Method 3 were conducted prior to sampling. These include:

1. Leak check of bags.

2. Sampling system leak check.

All bags were leak checked in the laboratory prior to being shipped to the field. The bag sample collected was analyzed within 4 hours using an Orsat analyzer.

2.0 FEED STREAM SAMPLING

The lime slurry liquid waste was sampled once every 30 min during each test run. Grab samples of 100 mL were composited into a single sample for each run. Upon return to MRI, samples were filtered into their solid and water fractions and sent to separate labs for TOC analysis.

Sample containers for lime slurry samples were purchased from I-Chem. All such glassware was certified precleaned by I-Chem for organics sampling usage. All bottles used for samples were made of polyethylene or glass.

Powdered waste was sampled from each feed truck as it is unloaded to the secured containment hopper. The facility provided these samples to MRI. Precleaned sample containers were purchased from I-Chem to contain these samples.

Liquid waste samples were collected every 30 minutes along the line which feeds directly to the kiln. The collection point was just downstream of the feed pump. Grab samples of 100 mL were composited into a single sample for each run. All glassware used was purchased precleaned and certified by I-Chem.

APPENDIX A-2

SAMPLE HANDLING AND ANALYSIS

APPENDIX A-2

SAMPLE HANDLING AND ANALYSIS

The following sections briefly describe the procedures employed during the analysis of the samples collected during this project. These procedures cover the analysis of all emission samples, lime slurry samples, and waste samples.

1.0 METHOD 0010 SAMPLES

The following sections summarize the procedures utilized in analyzing Method 0010 samples for estimates of semivolatile compounds, quantitation of dioxins and furans, and gravimetric analysis to combine with GC/FID data for total organic mass.

1.1 Sample Handling

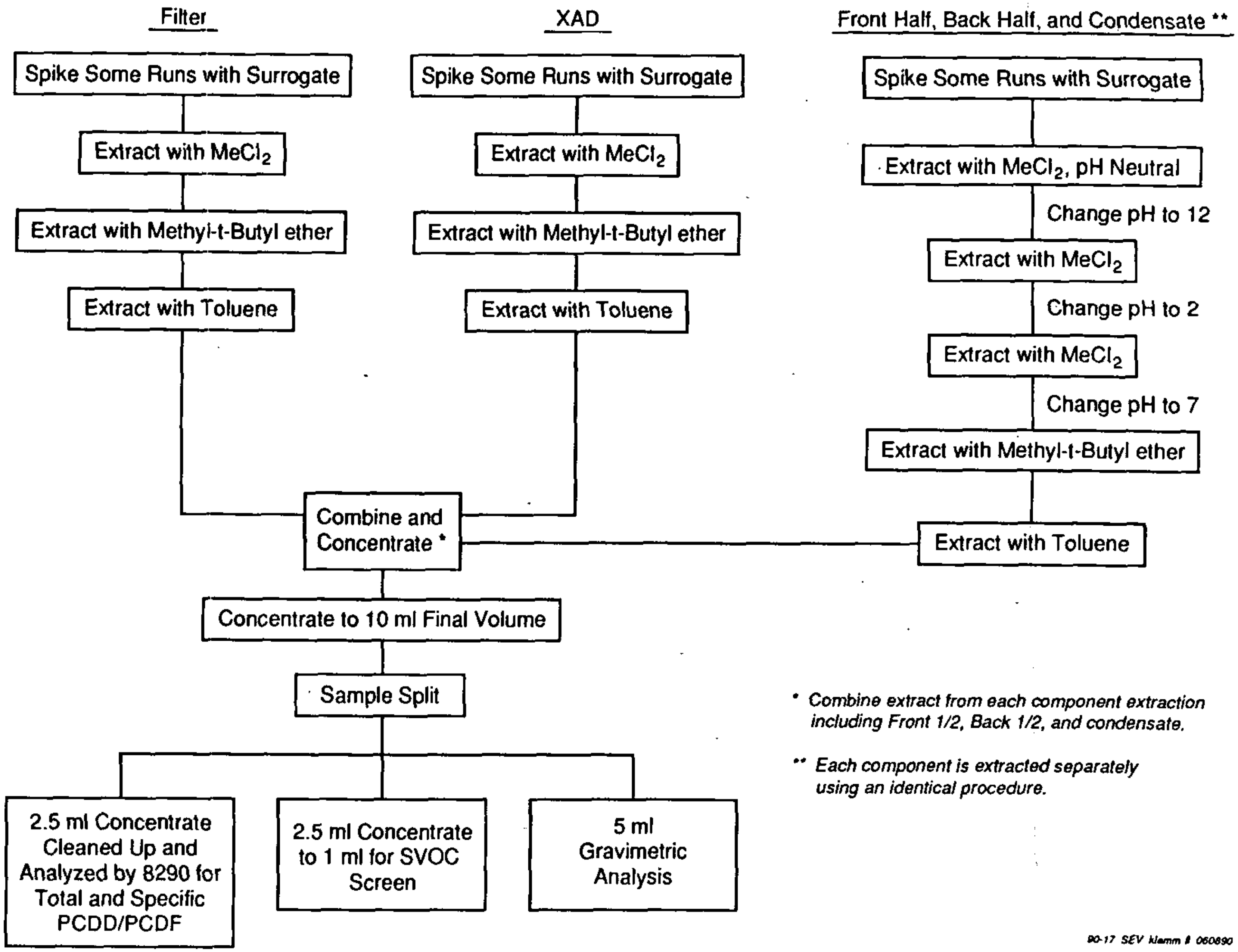
All samples were sealed, labeled, and stored in insulated containers in the field and during transport. All samples that were to undergo organic analysis were stored on ice in the field and during transport. Upon receipt in the laboratory the samples were removed from the insulated containers and were placed in cold storage (< 4°C). Each of the samples included the following fractions:

1. Filter
2. Sorbent trap
3. Front-half organic rinse
4. Back-half organic rinse
5. Condensate (first and second impinger contents and rinse)

1.2 Sample Analysis

Figure A2-1 presents a schematic of the analytical scheme of the samples for semivolatiles, PCDDs/PCDFs, and gravimetric analyses. Prior to extraction, each component was spiked with PCDD/PCDF internal standards. The PCDD/PCDF internal standards are listed in Table A2-1. The semivolatile surrogates included 2,4,6-tribromophenol and D10-pyrene.

Each train component was triple-extracted using methylene chloride, methyl *t*-butyl ether, and toluene. The solvent fractions generated through the extraction and concentration process were then ultimately combined, concentrated to a 10-mL final volume, and split into analytical aliquots.



** Combine extract from each component extraction including Front 1/2, Back 1/2, and condensate.*

*** Each component is extracted separately using an identical procedure.*

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Figure A2-1. Sample analysis flow.

TABLE A2-1. SEMIVOLATILE COMPOUNDS TARGETED IN GC/MS SCREEN

1	*N*-Nitrosodimethylaniline
2	Bis(2-chloroethyl) ether
3	Phenol
4	2-Chlorophenol
5	*N*-Nitroso-di-*n*-propylamine
6	1,3-Dichlorobenzene
7	1,4-Dichlorobenzene
8	1,2-Dichlorobenzene
9	Bis(2-chloroisopropyl) ether
10	Hexachloroethane
11	Nitrobenzene
12	Isophrone
13	2-Nitrophenol
14	2,4-Dimethylphenol
15	Bis(2-chloroethoxy)methane
16	2,4-Dichlorophenol
17	1,2,4-Trichlorobenzene
18	Naphthalene
19	Hexachloro-1,3-butadiene
20	4-Chloro-3-methylphenol
21	Hexachlorocyclopentadiene
22	2,4,6-Trichlorophenol
23	2,4,5-Trichlorophenol
24	2-Chloronaphthalene
25	2,6-Dinitrotoluene
26	Dimethyl phthalate
27	Acenaphthylene
28	Acenaphthene
29	2,4-Dinitrophenol
30	Dibenzofuran
31	4-Nitrophenol
32	2,4-Dinitrotoluene
33	2-Methylnaphthalene
34	Benzyl alcohol
35	Azobenzene
36	Fluorene
37	4-Chlorophenyl phenyl ether
38	Diethyl phthalate
39	4,6-Dinitro-2-methylphenol
40	Benzoic acid
41	*N*-Nitrosodiphenylamine
42	4-Bromophenyl phenyl ether
43	Hexachlorobenzene
44	2-Methylphenol
45	4-Methylphenol
46	Pentachlorophenol
47	Phenanthrene
48	Anthracene
49	Di-*n*-butyl phthalate
50	Aniline
51	Fluoranthene
52	Benzidine
53	Pyrene
54	Benzyl butyl phthalate
55	Chrysene
56	3,3'-Dichlorobenzidine
57	Benz[*a*]anthracene
58	Bis(2-ethylhexyl) phthalate
59	Di-*n*-octyl phthalate
60	Benzo[*b*]fluoranthene
61	Benzo[*k*]fluoranthene
62	Benzo[*a*]pyrene
63	Dibenz[*a,h*]anthracene
64	Benzo[*g,h,i*]perylene
65	Indeno[1,2,3-*c,d*]pyrene
66	4-Chloroaniline
67	2-Nitroaniline
68	3-Nitroaniline
69	4-Nitroaniline

The Method 0010 samples from test runs 1, 3, and 4 were split for semivolatile organics analysis, PCDD/PCDF determination, and gravimetric analysis. Samples from the blank train and test runs 2 and 5 were split for semivolatile organics analysis and gravimetric analysis.

A 2.5-mL to 5.0-mL aliquot was separated for the semivolatile organic screen. A 2.5-mL aliquot was separated for PCDD/PCDF determination, and a 5.0-mL aliquot was separated for gravimetric analysis. Detailed Standard Operating Procedures are included in Appendix A-4.

1.2.1 Sample Preparation and Analysis for Semivolatile Organics--

The semivolatile (SV) extraction procedures for rinses and condensates were adopted from SW-846, Methods 0010 and 3510 (separatory funnel extraction). The SV extraction procedures for the XAD and filter components were adopted from SW-846, Methods 0010 and 3540 (Soxhlet extraction). The extracts did not undergo column cleanup, because an organic screen was required.

SV analysis was conducted following SW-846, Method 8270, guidelines. This method is a capillary column full-scan GC/MS method applicable to a variety of semivolatile compounds. Table A2-2 lists the compounds screened in the SV analysis. A 5-point calibration curve using standards containing the target compounds in the EPA Contract Laboratory Program (CLP, 1990 Statement of Work) was analyzed. Continuing calibration checks were made by analyzing daily mid-level standard verification (±30%). Quantification was accomplished by the internal standard method, using a relative response factor from the calibration curve.

1.2.2 Sample Preparation and Analysis for PCDD/PCDFs--

The final 2.5-mL aliquot for PCDD/PCDF analysis was solvent-exchanged to hexane and cleaned up according to SW-846 Method 8280 and analyzed for tetra through octa PCDD and PCDF congener groups. Samples were analyzed by high resolution gas chromatography mass spectrometry (HRGC/MS), using SW-846 Draft Method 8290. A 60-m x 0.25-mm DB-5 fused silica capillary column (FSCC) was utilized.

The levels of dioxins and furans were calculated by comparison of the response samples to calibration standards (listed in Table A2-2). Isomer-specific quantitation was not completed; total concentrations of each congener group were determined. Congeners were tabulated (by comparison to the appropriate response factor determined from the calibration curve. Table A2-2 lists the analytes, standard compounds, and surrogates used in PCDD/PCDF analysis.

1.2.3 Sample Preparation for Gravimetric Analysis--

Semivolatile and nonvolatile sample extraction were performed following the procedure given in "POHCs and PICs Screening Protocol" (Southern Research Institute), Section III.C. As mentioned in Section 5.1, all solvent rinses, filter, and XAD were combined and extracted with methylene chloride, again with methyl *t*-butyl ether, and a third time with toluene.

TABLE A2-2. LIST OF ANALYTES, STANDARDS, AND SURROGATES FOR DIOXIN/FURAN ANALYSES

Analyte	Compounds in calibration standard	Internal standard	Recovery standard[b]
Tetra-CDD	2,3,7,8-TCDD	$^{13}C_{12}$-2,3,7,8-TCDD	$^{13}C_{12}$-1,2,3,4-TCDD
Tetra-CDF	2,3,7,8-TCDF	$^{13}C_{12}$-2,3,7,8-TCDF	
Penta-CDD	1,2,3,7,8-PCDD		
Penta-CDF	1,2,3,7,8-PCDF	$^{13}C_{12}$-1,2,3,7,8-PCDD	
	2,3,4,7,8-PCDF	$^{13}C_{12}$-1,2,3,7,8-PCDF	
Hexa-CDD	1,2,3,4,8,9-HxCDD		
	1,2,3,4,7,8-HxCDD		
	1,2,3,6,7,8-HxCDD	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD
Hexa-CDF	1,2,3,7,8,9-HxCDF	$^{13}C_{12}$-1,2,3,5,7,8-HxCDF	
	2,3,4,6,7,8-HxCDF		
	1,2,3,6,7,8-HxCDF		
	1,2,3,4,7,8-HxCDF		
Hepta-CDD	1,2,3,4,6,7,8-HpCDD		
Hepta-CDF	1,2,3,4,6,7,8-HpCDF	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	
	1,2,3,4,7,8,9-HpCDF	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	
OCDD	Octa-CDD	$^{13}C_{12}$-OCDD	
OCDF	Octa-CDF		

[a] Added to sample prior to extraction and used for quantitation of dioxins/furans in sample.

[b] Added to extract at time of injection into GC/MS.

The methylene chloride, *t*-butyl methyl ether, and toluene extracts from the train components were combined and gravimetrically analyzed without deviation in accordance with the procedure in Section III.F. of "POHCs and PICs Screening Protocol." The precision and accuracy of duplicate analyses were based on two criteria:

- Duplicate sample weights were to be within ±20% of the average sample weight.
- The difference between replicate weights were to be < 0.1 mg (the required extent of accuracy).

A sample could fail the first test but still be within the limits of required accuracy; hence a sample was reanalyzed only if it did not pass the second test.

The respective method blank was subtracted from each sample. The remainder was then multiplied by a numerical factor to obtain the total µg per sample. Dividing by the dry standard sample volume allowed for µg/L calculation based on the air sampled. To obtain the ppm propane equivalent, it was assumed that half of the sample molecular weight had no FID response; thus ppm propane was calculated as follows:

(µg of sample/L of air sampled)•(0.5)•(24.1 µL per µmol of gas/44 µ propane per µmol propane)

2.0 METHOD 0030 SAMPLES

Volatile compounds present in stack gases were collected on Tenax and Tenax/charcoal sorbent cartridges using a volatile organic sampling train (VOST). Methods 5040 and 8240 in SW-846, third edition, describe in detail procedural steps required to desorb VOST cartridges and analyze the effluent gas stream for volatile organic compounds. Modifications to these methods are contained in Table A2-3. An SOP is also provided in Appendix A-3 that basically follows Methods 5040 and 8240, but only addresses the quantitation of one each POHC, surrogate, and internal standard. The VOST samples were analyzed for the compounds listed in Table A2-4. Identification of target analytes in the VOST samples was performed using the Target Compound Analysis (TCA) procedure. The TCA program uses experimentally determined retention times and response factors to locate and quantitate any target analyte.

The contents of the sorbent cartridges were spiked with an internal standard and thermally desorbed for approximately 10 min at 180°C with organic-free nitrogen or helium gas (at a flow rate of 40 mL/min), bubbled through a tower to impinger water desorbed from the cartridges. Target analytes were trapped on an analytical adsorbent trap. After the 10-min desorption, the analytical adsorbent trap was rapidly heated to 180°C with the carrier gas flow reversed. Volatile organic compounds were desorbed from the analytical trap and vented directly to the gas chromatograph. The VOCs were separated by temperature-programmed gas chromatography and detected by low-resolution mass spectrometry. Concentrations of the POHC were calculated using the internal standard technique. PIC compounds were quantitated using a single-point calibration and by internal standard method using RRFs equal to 1.0.

TABLE A2-3. MODIFICATIONS FROM SW-846 METHODS

11.1 METHOD 8240 "GAS CHROMATOGRAPHY/MASS SPECTROMETRY FOR VOLATILE ORGANICS"

METHOD 8240 SECTION NO.	MODIFICATION
4.12.3 5.5 7.2.2 7.3.1	100 ng of BFB is injected rather than 50 ng. This gives better instrument response on the lower intensity ions.
5.1.3	Purities < 100% (or 99+%) are corrected.
5.3 5.4 5.7	Concentrations of stock solutions will vary according to analysis needs. Usually, surrogate and RIS solutions are such that 100 ng per analysis is achieved. RIS and surrogates are prepared as a mix for VOST, water samples, and system blanks. A three point calibration curve is acceptable.
5.6	Calibration standards are prepared in methanol rather than reagent water and they are used until signs of degradation become evident.
5.8	standard solutions are stored in clear vials and placed in a closed container to protect from light.
6.1	New bottles and vials are cleaned according to Introductory Chapter, Section 4.1.2. Sample bottles and vials are not reused, they are decontaminated with methanol and disposed of. Reactivials and volumetric flasks are decontaminated after use, then cleaned as in Section 4.1.2.
7.2.5	Calibration standards are prepared as a mix which includes analytes, surrogates, and RIS. This standard is spiked directly into the glass syringe containing 5.0 mL VOA water, mixed, and added to the purge tower.
7.2.9	The GC/MS data system (INCOS) uses n rather than n-1 for %RSD calculations. If a %RSD falls within 3% of the cut-off value, then this %RSD is recalculated manually using n-1 to achieve a more accurate value.
7.4.1	Water samples are not pre-screened as they generally contain a very low concentration of analytes.
7.4.1.5	Purge gas is nitrogen at 40 mL/min. Carrier gas is helium at 30 cm/sec.

TABLE A2-3 (continued)

7.4.1.7.3	Only one aliquot for analysis is taken from any given VOA vial. If replicates are required, then these aliquots are taken from individual VOA vials. If dilutions are necessary, then an aliquot is taken from a fresh VOA vial.
7.5.2	Quantitation for PICs and unknowns will be by the internal standard method using RRFs of 1.000 (or historical) rather than RRFs generated by standard injections.
8.5.1 8.5.2	Concentrations of analytes will vary depending on the analysis needs.

TABLE A2-4. VOLATILE SCREEN TARGET LIST

1	Acetone
2	Acrolein
3	Acrylonitrile
4	Benzene
5	Bromodichloromethane
6	Bromoform
7	Carbon tetrachloride
8	Chloroform
9	Chlorobenzene
10	Dibromochloromethane
11	1,1-Dichloroethane
12	1,2-Dichloroethane
13	1,1-Dichloroethene
14	*t*-1,2-Dichloroethene
15	1,2-Dichloropropane
16	*t*-1,3-Dichloropropene
17	Diethyl ether
18	1,4-Dioxane
19	Ethylbenzene
20	Methylene chloride
21	Methyl ethyl ketone
22	1,1,2,2-Tetrachloroethane
23	Tetrachloroethene
24	Toluene
25	1,1,1-Trichloroethane
26	1,1,2-Trichloroethane
27	Trichloroethene

3.0 HCl TRAIN SAMPLES

The contents of the condensate impingers from the HCl and HCl dilution trains were analyzed for HCl using ion chromatography, ASTM Method D4327-84. Concentrations as low as 0.1 mg/L can be determined.

In the analysis, a filtered aliquot of the sample is injected into an ion chromatograph. The sample is pumped through three different ion exchange columns and into a conductivity detector. The first two columns, a precolumn and separator column, are packed with a low-capacity anion exchanger. Ions are separated based on their affinity for the exchange sites of the resin. The last column is a suppressor column that contains cation exchange resin in the hydrogen form. The suppressor column reduces the background conductivity of the eluent to a low or negligible level and converts the anions in the sample to their corresponding acids. The separated anions in their acid form are measured using an electrical-conductivity cell. Anions are identified based on their retention times compared to known standards. Quantitation is accomplished by measuring the peak height or area and comparing it to a calibration curve generated from known standards.

The HCl and HCl dilution samples were also analyzed for potassium using inductively coupled plasma-atomic emissions spectrometry (ICP-AES). The samples were analyzed for ammonium using gas chromatograph/mass spectrometry-selective ion measurement (GC/MS-SIM). Galbraith Laboratories, Knoxville, TN performed these analyses.

4.0 LIME SLURRY AND WASTE FEED SAMPLE HANDLING

Lime slurry samples were split in MRI's labs into their solid and water fractions. Solids were dried and sent to the Geochemical and Environmental Research Group (GERG), College Station, TX for TOC analysis using a LECO furnace and GERG SOP-8907. Water fractions were analyzed for TOC by Galbraith Laboratories, Knoxville, TN, using EPA Method 415.1.

Powdered and liquid waste samples were analyzed for Higher Heating Value (HHV) and chlorine content by Galbraith Labs, using ASTM methods D2015-77 and D808-81/D4327-84/E442-81 respectively.

APPENDIX A-3

VOLATILES ANALYTICAL METHODS

The analytical procedures used by MRI for volatile organic analysis are based on EPA SW-846 Method 5040, "Protocol for Analysis of Sorbent Cartridges from Volatile Organic Sampling Train" and Method 8240, "Gas Chromatography/Mass Spectrometry for Volatile Organics." Any deviations from these SW-846 methods normally used by MRI are noted in the procedures.

1.0 GLASSWARE PREPARATION

1.1 FIELD SAMPLING

1.1.1 All containers for field sampling are glass and have Teflon-lined caps or Teflon-lined septa. Samples for volatile organic analysis (VOA) are protected from light as much as possible to avoid degradation of halogenated compounds. Amber bottles are useful for this purpose. If amber bottles are not used, the sample bottle can be wrapped with foil or stored in a container to protect from light.

1.1.2 When possible, 40-mL screw cap septum vials (VOA vials) that have been manufacturer precleaned according to EPA protocol are used for the collection of water and waste samples. However, these vials are currently available in clear glass only. If contract specifications require amber VOA vials, these must be prepared according to the procedure in Section 1.2.

1.1.3 Other containers may be required for VOA sampling and these will be specified by the field programs crew chief prior to each burn. If other containers are required, they are also be prepared according to the procedure in Section 1.2.

1.1.4 Water field blanks are prepared for each field sampling trip by adding VOA water (see Section 2.1 for prep of VOA water) to clean VOA vials and sending them to the field with the other containers. These field blanks demonstrate that no contamination of samples has occurred due to ambient conditions at the site or during shipment.

1.2 GLASSWARE CLEANING

1.2.1 Preparation of glassware to be used in the collection or preparation of samples for volatile organic analysis (VOA) is performed in a laboratory free from organic solvents other than methanol.

1.2.2 All glassware (amber VOA vials, sampling bottles, compositing bottles, volumetric flasks, etc.) is prepared according to the following procedure:

1.2.2.1 Wash in hot soapy water using Micro (or equivalent) and a clean brush.

1.2.2.2 Rinse thoroughly in tap water (3 x), deionized water (3 x), and distilled-in-glass methanol (B&J or equivalent).

1.2.2.3 Any glassware that does not appear to be clean, i.e., does not "sheet" when rinsed with water or methanol, is cleaned by soaking in concentrated sulfuric acid, then rinsed as in Section 1.2.2.2.

1.2.2.4 Allow the glassware to air dry and then place in a clean glassware drying oven at ~ 110°C for at least 1 h.

1.2.2.5 After removing bottles from the oven, allow to cool to room temperature, then cap with Teflon lined lids. If glassware is not used immediately, cover the open ends with methanol rinsed aluminum foil and store.

1.2.3 Rinse Teflon liners and Teflon-lined septum thoroughly with distilled-in-glass methanol. Allow to either air dry or bake at ~ 110°C for no longer than 1 h.

1.2.4 New reactivials and 2-dram screw cap vials are rinsed with methanol and baked at ~110°C for at least 1 h. After removing from the oven, they are allowed to cool and then capped with Teflon lined lids.

1.2.5 Syringes should be thoroughly cleaned with methanol. This is done as soon as possible after use to avoid contamination of the syringe. Syringes are not routinely baked because high temperatures will weaken the adhesive used to affix the needle to the barrel.

2.0 REAGENTS

2.1 REAGENT WATER (VOA WATER)

2.1.1 Reagent water is defined as a water in which compounds that interfere with the analytes are not observed at the method detection limit.

2.1.2 Reagent water is prepared by pouring Milli-Q (or equivalent) through a carbon bed into a chromatography column. The column is maintained at a temperature of approximately 50°C with a gentle flow of prepurified nitrogen. Other methods of generating reagent water can be found in SW-846 method 8240 "GAS CHROMATOGRAPHY/MASS SPECTROMETRY FOR VOLATILE ORGANICS."

2.1.3 Reagent water is used to prepare matrix spikes, field blanks, and system blanks for the GC/MS system.

2.2 METHANOL

2.2.1 Only distilled-in-glass (pesticide quality, B&J or equivalent) methanol is used for glassware prep, preparation of standards, and preparation of samples.

2.2.2 Store methanol in an area not contaminated by solvent vapors.

2.2.3 Bulk methanol may be used for decontamination of bottles and vials prior to disposal and decontamination of glassware prior to cleaning for re-use.

2.3 TENAX AND TENAX/CHARCOAL TRAPS

2.3.1 VOST traps of tenax and tenax/charcoal are prepared by field sampling personnel. Details on preparation of traps are available in the appropriate field sampling standard operating procedures (SOP) documents.

2.4 SCREENING AND BLANKS

2.4.1 To ensure that no contaminants are present in the reagents, blanks of each matrix type are analyzed by the appropriate GC/MS method.

3.0 SAMPLE TRACEABILITY AND CHAIN-OF-CUSTODY

3.1 SAMPLE TRACEABILITY

3.1.1 Each sample taken in the field is given a unique number by field personnel. In the case of Volatile Organic Sampling Train (VOST) samples and gas bags, this number is carried throughout field sampling and analysis. Water and waste samples are also given a unique number by field personnel. However, these samples are composited in the laboratory prior to analysis. Afterwards, the sample composite is given a new number by laboratory personnel. A record of sample composition and their new numbers are recorded in the appropriate laboratory notebook.

3.1.2 A record of who was responsible for each sample and where the sample was during the sampling and analysis procedures is kept using the forms in Figures A3-1 and A3-2.

3.1.2.1 Figure A3-1 is the form used by the field sampling personnel. This form contains sampling information as well as the field sample numbers. This form accompanies the samples from the time they are taken in the field until their receipt by analytical personnel.

3.1.2.2 Figure A3-2 is the form used by analytical personnel. This form is used to transfer samples within the analytical sections or to instrument facilities.

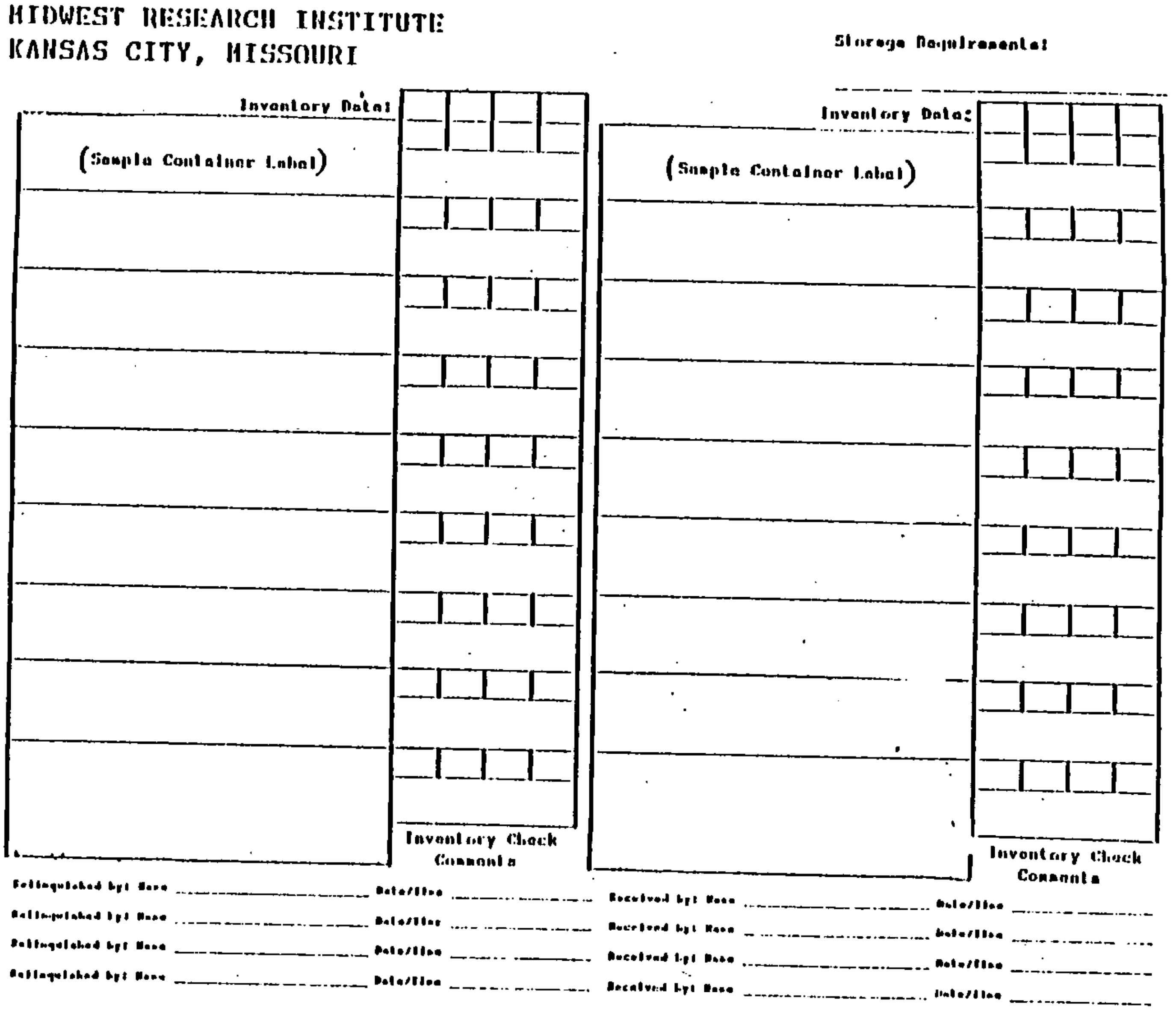
3.2 CHAIN-OF-CUSTODY

3.2.1 In the event a contract requires chain-of-custody, the samples are stored in a locked cold room which has restricted access. During the sample preparation or analysis, the samples must be within the sight of the person who has custody, in a locked container, or in a container sealed with evidence tape which has been appropriately signed and dated.

3.2.2 The forms in Figures A3-1 and A3-2 are appropriate for chain-of-custody so long as this is noted on the form.

4.0 SAMPLE RECEIPT

4.1 Volatile samples are usually shipped daily from the field site. These can be shipped by an overnight delivery service such as Federal Express or by airport counter-to-counter service. The samples are shipped with sufficient quantities of wet ice or "blue ice" to keep the samples cool. Dry ice is not recommended for water samples due to freezing of the samples which will, in turn, break the vials.



MIDWEST RESEARCH INSTITUTE
KANSAS CITY, MISSOURI

Storage Requirements: ______________

Inventory Date:

(Sample Container Label)

Inventory Check Comments

Inventory Date:

(Sample Container Label)

Inventory Check Comments

Relinquished by: Name ______________ Date/Time ______________ Received by: Name ______________ Date/Time ______________
Relinquished by: Name ______________ Date/Time ______________ Received by: Name ______________ Date/Time ______________
Relinquished by: Name ______________ Date/Time ______________ Received by: Name ______________ Date/Time ______________
Relinquished by: Name ______________ Date/Time ______________ Received by: Name ______________ Date/Time ______________

Figure A3-1. Sample traceability record.

LABORATORY CHAIN OF CUSTODY OR TRACEABILITY RECORD

① ☐ Chain of Custody Record
② ☐ Traceability Log
③ Project Number ______________
④ Date of Laboratory Check-In ______
⑤ Location ______________
⑥ Type of Samples ______________
⑦ Container Type ______________
⑧ Custody Office Storage Location ______

⑨ Laboratory Sample No.	⑩ Field Sample No.	⑪ Sample Description	⑫ Amount of Sample Removed (give date)	⑬ Comments

Laboratory/Area	⑭ Relinquished by: (signature)	⑮ Date/Time	⑯ Received by: (signature)	⑰ Date/Time
Custody Office				
Sample Preparation				
Metals				
GC/MS				
Other (Identify)				

⑱ Notebook Reference Pages ☐ ⑲ Notebook No. ☐

⑳ Analyst Comments ______________________________

Figure A3-2

4.2 Once the samples arrive, they are inventoried and examined for breakage as soon as possible. In the event the samples cannot be inspected right away, they are stored in a cold room in the shipping container until such time as the inspection can be accomplished.

4.3 The inventory of the samples is performed in a volatile free laboratory and includes the following items:

4.3.1 The temperature of the shipping container is observed. The samples should still feel cool. If they are found to be above room temperature, this is noted either on the traceability sheet or in the appropriate laboratory notebook.

4.3.2 The samples are inventoried against the enclosed traceability sheets. If no traceability sheets accompany the samples, then the inventory is recorded in the appropriate laboratory notebook. During the inventory, the condition of the samples is noted as well as the labeling information. The label should be legible and contain the sample number as well as sample collection information.

4.3.3 After inventory, the samples are stored in a cold room to maintain sample integrity.

5.0 PREPARATION OF CALIBRATION STANDARDS, SPIKING SOLUTIONS, MATRIX SPIKES, AND MATRIX BLANKS

5.1 PRIMARY STANDARD SOLUTIONS

5.1.1 Standards may be prepared from the purest available standard materials or purchased as certified solutions.

5.1.2 The name, manufacturer, lot number, and purity of each compound used to prepare primary stock solutions is recorded in the appropriate laboratory notebook.

5.1.3 The following gravimetric method of standard preparation is used to prepare primary standard solutions:

5.1.3.1 With an analytical balance accurate to 0.0001 g, obtain initial and final weights.

5.1.3.2 Calibrate the balance using class "S" weights if available. This calibration should bracket the expected working range of the standards. Record the calibration in the appropriate laboratory notebook.

5.1.3.3 Place about 9.0 mL methanol in a clean 10.0 mL class "A" volumetric flask. Allow the flask to stand until all methanol wetted surfaces have dried. Stopper the flask and obtain an initial weight.

5.1.3.4 LIQUIDS: Determine the target concentration for the stock solution and use the density of the chemical to determine an approximate volume to add to the flask. Add the appropriate amount of the standard material to the flask using a syringe. The liquid must fall directly onto the surface of the methanol without touching the neck of the flask. Also, care should be taken to not touch the surface of the methanol with the end of the syringe as this would change the initial weight of the methanol and the flask. The flask is immediately restoppered.

5.1.3.5 GASES: To prepare standards for any compounds that boil below 30°C (e.g. bromomethane, chloroethane, chloromethane, and vinyl chloride), fill a 5.0 mL valved gas-tight syringe with the reference standard to the 5.0 mL mark. Lower the needle to 5 mm above the methanol meniscus. Slowly introduce the reference standard above the surface of the liquid. The heavy gas will rapidly dissolve in the methanol. Standards may also be prepared by using a lecture bottle equipped with a Hamilton Lecture Bottle Septum (#86600). Attach Teflon tubing to the side-arm relief valve and direct a gentle stream of gas into the methanol meniscus. Immediately restopper the flask.

5.1.3.6 Obtain a final weight on the flask. Dilute to volume, stopper, and mix by inverting the flask several times. Calculate the concentration in mg/mL from the net gain in weight. Unless the compound purity is stated to be 99+%, then the concentration must be corrected for compound purity.

5.1.4 The primary stock solution is transferred to a clean (see Section 1.2.4) 2-dram vial, capped with a Teflon lined lid, and sealed with Teflon tape. The vial is filled so that a minimum amount of headspace remains in the top of the vial. The vial is labeled with the name of the compound, concentration, solvent, date prepared, initials of person preparing, and the notebook reference for preparation. Store the vial at -10° to -20°C and protect from light.

5.1.5 Prepare fresh standards every two months for gases. Reactive compounds such as 2-chloroethyl vinyl ether may need to be prepared more frequently. All other standards must be replaced after six months, or sooner if comparison with check standards indicates a problem.

5.2 INTERMEDIATE DILUTION STANDARDS

5.2.1 Using primary stock solutions, prepare intermediate dilution standards in methanol either singly or as a combined mix.

5.2.2 Use volumetric glassware and syringes for all dilutions.

5.2.3 Allow the primary stock to reach room temperature before preparing the intermediate solution. Check the stock solution for signs of degradation or evaporation. The level of the liquid in the vial is marked after each use, if possible, therefore once the solution has reached room temperature the meniscus should match the mark on the vial. Gently mix the vial by inversion prior to removing an aliquot of the primary stock.

5.2.4 Add a small amount of methanol to the volumetric flask. Then add the appropriate amount of primary stock solution(s). Dilute to volume, stopper, and gently mix by inversion.

5.2.5 Transfer and store intermediate dilutions as described for primary standard solutions (see Section 5.1.4).

5.3 CALIBRATION STANDARDS

5.3.1 Calibration standards containing the POHCs, surrogates, and internal standards at a minimum of three concentration levels are prepared from intermediate or primary stock solutions (Sections 5.1 and 5.2). Prepare these solutions in methanol according to the procedure outlined in Section 5.2 for preparation of intermediate stock solution. Transfer an aliquot to a reactivial with minimum headspace, cap with a mininert valve and label. Transfer and store the remainder as in Section 5.1.4.

5.3.2 One of the concentration levels should be at a concentration near, but above, the method detection limit (usually 10 ng total). The remaining concentration levels should correspond to the expected range of concentrations found in real samples or should not exceed the working range of the GC/MS system. Each standard contains all analytes for detection by this method. In addition, the recovery internal standards (RIS) and surrogates are included in the calibration standard mixes.

5.3.3 The calibration standards are replaced when signs of degradation are evident (typical replacement time is 2 weeks). If the standards fail to pass the established curve or fail to pass the other calibration requirements (see Section 8.5), then the calibrations standards are reprepared.

5.4 SURROGATE AND RECOVERY INTERNAL STANDARD (RIS) SPIKING SOLUTIONS

5.4.1 Surrogates are organic compounds which are similar to analytes of interest in chemical composition, extraction, and chromatography, but which are not normally found in environmental samples. These compounds are spiked into all blanks, standards, samples, and spiked samples prior to analysis. Percent recoveries are calculated for each surrogate and should not vary from the expected values by more than ±35%. d8-Toluene, 4-bromofluorobenzene, and d4-1,2-dichloroethane are typically used as surrogate compounds, as recommended by SW-846 method 8240.

5.4.2 Recovery internal standards (RIS) are compounds added to all standards, blanks, and samples which are used to quantitate the analytes. The RIS chosen should be similar in analytical behavior to the compounds of interest. It must be demonstrated that the measurement of the internal standard is unaffected by method or matrix interferences. Bromochloromethane, 1,4-difluorobenzene, and d5-chlorobenzene are recommended by method 8240 as RIS compounds. (Bromochloromethane, however, is sometimes found as a "native" in samples, in which case its value as a surrogate is limited.) Method 5040, "PROTOCOL FOR ANALYSIS OF SORBENT CARTRIDGES FROM VOLATILE ORGANIC SAMPLING TRAIN" requires d6-benzene as a RIS for VOST analysis. Other compounds may be used depending on the analysis requirements. D6-benzene may be used as the RIS for all sample types.

5.4.3 A spiking solution containing each of the RIS and surrogate compounds is prepared in methanol according to the procedure in Section 5.2, INTERMEDIATE STOCK SOLUTIONS. Transfer an aliquot to a reactivial with a mininert valve and continue as in Section 5.1.4. The final concentrations of each surrogate and RIS are approximately 50 ng/µL). Two microliters (2 µL) are used to spike each VOST trap, gas bag sample, water sample, and system blank prior to analysis. This will yield 100 ng total per analysis for each surrogate and RIS. Alternate spiking volumes and concentrations may be used but will still yield approximately 100 ng total per analysis.

5.5 BROMOFLUOROBENZENE (BFB) FOR INSTRUMENT TUNING

5.5.1 A solution of 4-bromofluorobenzene in methanol with a concentration of 50 ng/µL is prepared according to the procedure in Section 5.2. This solution is used to tune the mass spectrometer according to SW-846 method 8240 specifications. (See Section 7.5.2.)

5.6 MATRIX SPIKING STANDARDS

5.6.1 Matrix spiking standards, if applicable, are prepared in methanol from compounds representative of those being investigated. This solution is used to prepare check samples and matrix spikes. No internal standards or surrogates are added to this mix as these are added to these samples during the routine prep of the samples. This solution is prepared according to the procedure outlined in Section 5.2.

5.7 QC CHECK SAMPLES

5.7.1 A QC check sample is analyzed during the initial GC/MS calibration (see Section 7.5.8) to verify the ratio of instrument response to analyte amount. Analysis of this sample also serves to verify the preparation of the calibration standards. This solution is prepared independently of the intermediate stocks used to prepare the calibration standards. The final concentrations of the analytes should fall within the calibration curve. This solution is prepared according to the procedure outlined in Section 5.2. It contains all analytes of specific quantitative interest.

6.0 PREPARATION OF SAMPLES, BLANKS, CHECK SAMPLES, MATRIX SPIKES, AND REPLICATES

6.1 HOLDING TIMES

6.1.1 Unless otherwise specified by the trial burn plan, QA plan, or the project leader, the holding time from date of sampling to date of analysis for VOST samples is 2-6 weeks (see SW-846 method 5040 Section 6.2), and for water samples, the holding time is 10 days.

6.2 VOST AND INTEGRATED GAS BAG SAMPLES (for analysis by purge and trap desorption GC/MS)

6.2.1 VOST traps are glass tubes filled with either Tenax (2,6-diphenylene oxide polymer) only or one half each Tenax and charcoal. The ends of these tube are tightly capped. One trap of each type constitutes a "pair." There are generally three or four sample "pairs" per run. Each trap is analyzed separately. In addition, the field sampling crew prepares a field blank pair for each run and a trip blank pair for each shipment container. The field blank pair is opened briefly in the field. These samples are used to demonstrate that there is no contamination from ambient conditions at the site. The trip blank pair is never opened and accompanies each respective sample batch of samples returning to the laboratory. These samples are to demonstrate that there is no contamination from the shipping process.

6.2.2 The VOST samples need no preparation prior to analysis. These samples are stored in the cold room until analysis and are spiked with a mixed RIS and surrogate solution by the GC/MS analyst immediately prior to analysis. A daily system blank is analyzed (see Section 8.5.3) by spiking a clean trap with the RIS/surrogate solution. This is to ensure the cleanliness of the GC/MS system and also serves as a blank sample for each day's analysis. Each VOST trap is only valid for one analysis, therefore replicate analyses and matrix spikes cannot be performed.

6.2.3 After analysis, the spent VOST traps and gas bags are returned to field programs where they will be recycled.

6.3 WATER AND VOST CONDENSATE SAMPLES (for analysis by purge and trap GC/MS)

6.3.1 Water samples are samples taken of various water streams as specified by the trial burn plan for each project. These are usually called scrubber waters and are usually of two types, inlets and outlets. Occasionally other types of water samples are taken, for example, VOST condensates, but they are prepared in the same manner.

6.3.2 The preparation of the water samples is performed in a volatile free laboratory (VOA lab).

6.3.3 Water samples are sampled at either 15- or 30-min intervals during each field test and are typically composited prior to analysis.

6.3.4 The samples are sorted according to run number and type. Then, all of the VOA vials of each run and type are composited by pouring the contents of the vial into a larger clean compositing bottle. The composite is gently mixed and the composited sample is returned to the original VOA vials filling them in such a manner as to have no headspace in the vials. This is done as quickly as possible to avoid loss of volatile compounds. The vials are labeled as having been composited. Each vial is typically used for only one analysis, with different VOA vial of the composited sample being used for each replicate analysis. The remainder of the vials are stored in the cold room (4°C).

6.3.5 Replicate analyses of samples should be performed at least once every 20 samples. The project QA plan should be consulted for specific requirements.

6.3.6 Laboratory blanks for the water samples are performed using VOA water with the addition of mixed surrogate and RIS spiking solution. This is done on a daily basis and also functions as the "system blank" for the GC/MS system. In addition, the water field blanks (Section 1.1.4) shipped with the samples are analyzed.

6.3.7 Five milliliters (5.0 mL) of each composited sample is analyzed by GC/MS purge and trap. The GC/MS analyst spikes each sample with the mixed RIS and surrogate spiking solution immediately prior to analysis.

7.0 GC/MS ANALYSIS OF WATER SAMPLES BY PURGE AND TRAP

7.1 SUMMARY OF METHOD

7.1.1 Five milliliters (5 mL) of the sample is poured into a glass syringe, spiked with surrogate and RIS, then added to a glass purge tower. An inert gas is bubbled through the solution at ambient temperature and the volatile components are efficiently transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent column where the volatile components are trapped. After purging is completed, the sorbent column is heated and backflushed with inert gas to desorb the components onto a gas chromatographic column. The volatile POHCs are separated by temperature programmed gas chromatography and detected by mass spectrometry. The concentrations of the POHCs are calculated using the internal standard technique.

7.1.2 Refer to SW-846 method 8240 "GAS CHROMATOGRAPHY/MASS SPECTROMETRY FOR VOLATILE ORGANICS" for complete details of this analytic method. Any deviations from SW-846 are listed in Section 11.0 of this document.

7.2 PURGE AND TRAP DEVICE

7.2.1 The purge and trap device consists of three separate pieces of equipment: the sample purger, the analytic trap, and the desorber. It is recommended that any surface to come in contact with the samples be constructed entirely of glass and Teflon.

7.2.2 The recommended purging chamber is designed to accept 5-mL samples with a water column at least 3 cm deep. The gaseous headspace between the water column and the trap must have a total volume of less than 15 mL. The purge gas must pass through the water column as finely divided bubbles with a diameter of less than 3 mm at the origin. The purge gas must be introduced no more than 5 mm from the base of the water column. The sample purger, illustrated in Figure A3-3 meets these design criteria. Alternate sample purge devices with 20-25 mL headspace may also be utilized. These have been demonstrated to yield equivalent sample recoveries and are useful for analysis of waste samples dispersed in PEG since line contamination is minimized.

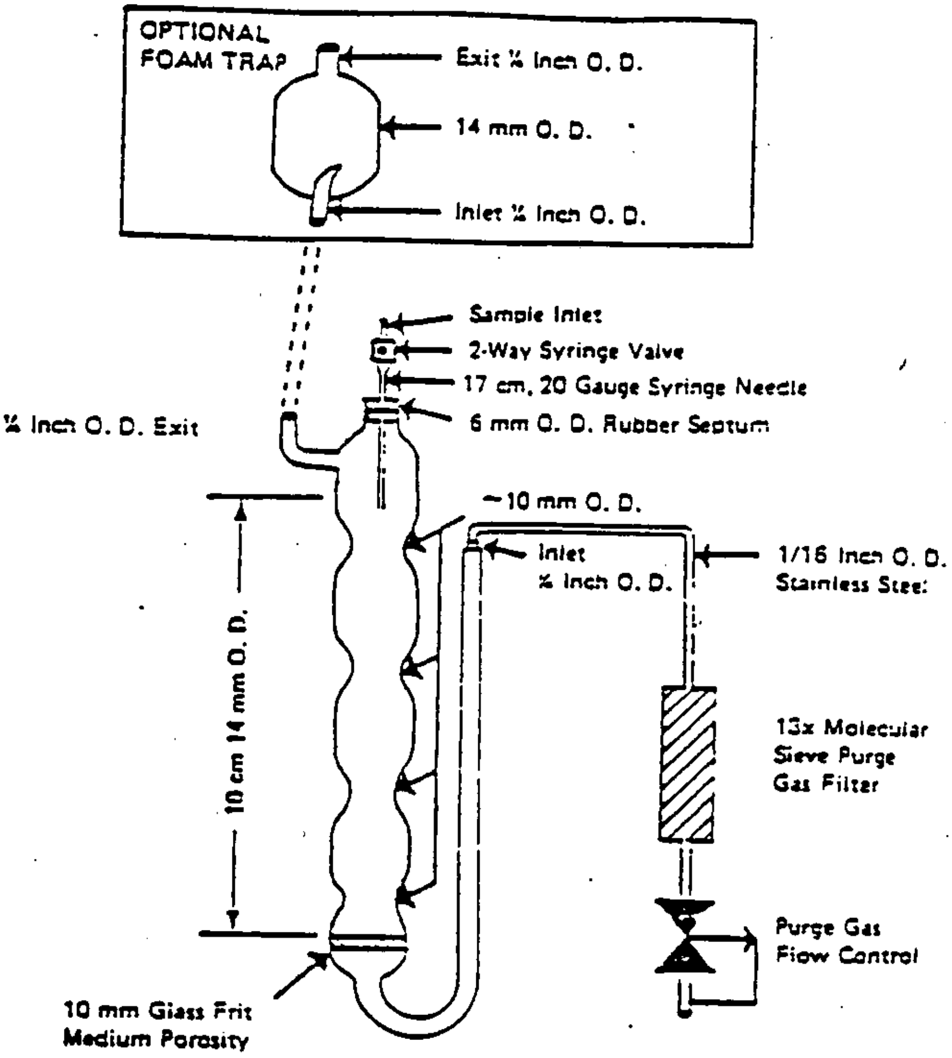


Figure A3-3. Purging chamber.

7.2.3 The trap must be at least 25 cm long and have an inside diameter of at least 0.105 in. Starting from the inlet, the trap is packed with the following: 1.0 cm of methyl silicone coated packing (3% SP2100 on 60/80 Chromosorb WAW or equivalent to prolong the life of the trap); 15 cm 2,6-diphenylene oxide polymer 60/80 mesh chromatographic grade (Tenax GC or equivalent); 8 cm silica gel 35/60 mesh (Davison, grade 15 or equivalent). If analysis for dichlorodifluoromethane or other fluorocarbons of similar volatility is required, then the trap should be packed with equal parts of coconut charcoal, Tenax, and silica gel with 1.0 cm of methyl silicone coated packing at the inlet. The coconut charcoal is prepared from Barnebey Cheney, CA-580-26 lot #M-2649 by crushing through 26 mesh screen. If only compounds boiling above 35°C are to be analyzed, then the trap should be packed with only the methyl silicone packing and Tenax. Before initial use, the trap should be conditioned overnight at 180°C by backflushing with an inert gas flow of at least 20 mL/min. Vent the trap effluent to the room, not to the analytical column. Prior to daily use, the trap should be conditioned for 10 min at 180°C with backflushing. The trap may be vented to the analytical column during daily conditioning, however, the column must be run through the temperature program prior to analysis of samples.

7.2.4 The desorber should be capable of rapidly heating the trap to 180°C for desorption. The polymer section of the trap should not be heated higher than 180°C and the remaining sections should not exceed 220°C during bake-out mode. The desorber design in Figure A3-4 meets these criteria.

7.2.5 The purge-and-trap device may be assembled as a separate unit or may be coupled to a gas chromatograph as shown in Figures A3-5 and A3-6.

7.3 GAS CHROMATOGRAPHY/MASS SPECTROMETRY SYSTEM

7.3.1 GAS CHROMATOGRAPH: An analytical system complete with a temperature programmable gas chromatograph and all required accessories including syringes, analytical columns, and gases.

7.3.2 COLUMN: 6 ft x 0.1 in i.d. glass, packed with 1% SP 1000 on Carbopak-B, 60/80 mesh, or equivalent. In some cases, an 8 ft column with similar packing provides better resolution of coeluting compound such as carbon tetrachloride and 1,1,1-trichloroethane. Alternatively, a 30-m DB-624 megabore capillary column can be used. This column has resolution and retention order comparable to the SP 1000, however, analysis time is shortened. (This column was not commercially available at the time SW-846 was published.)

7.3.3 MASS SPECTROMETER: Capable of scanning from 40-260 amu every 3 s or less, using 70 electron volts (nominal) electron energy in the electron impact mode and producing a mass spectrum that meets all the criteria in Table A3-1 when 100 ng of 4-bromofluorobenzene (BFB) are injected through the gas chromatographic inlet. Typically a MAT CH4, or Finnigan OWA, or Varian 312A is used.

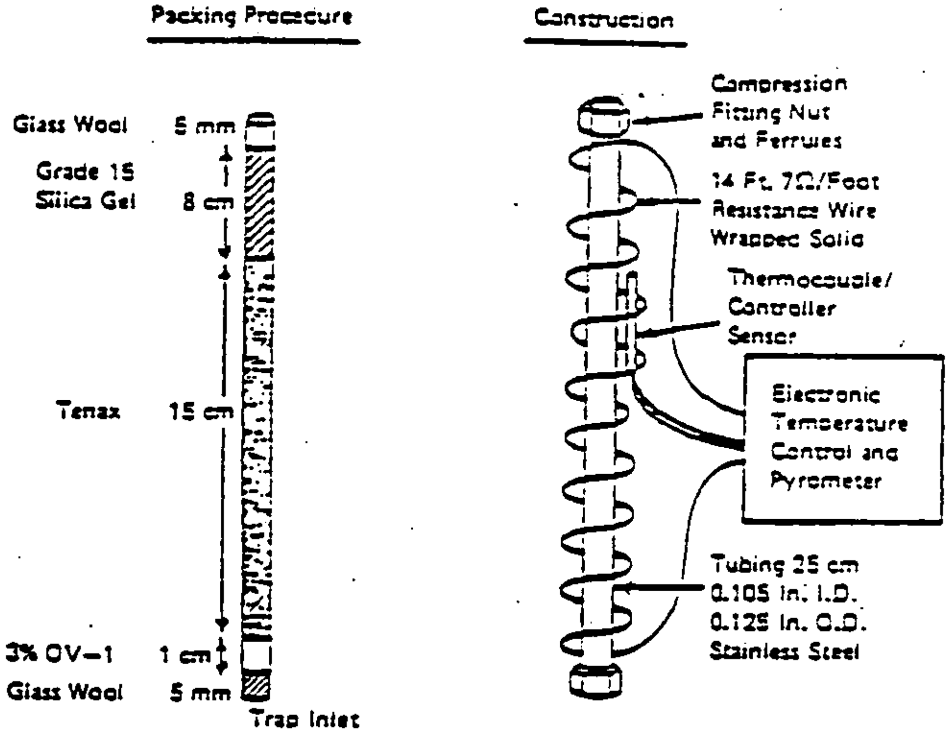


Figure A3-4. Trap packings and construction to include desorb capability.

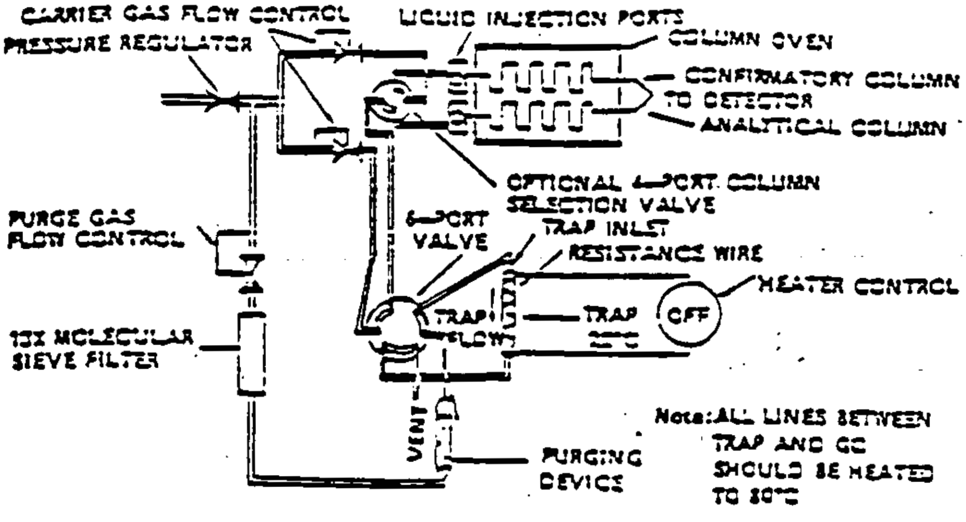


Figure A3-5. Schematic of purge-and-trap device--purge mode.

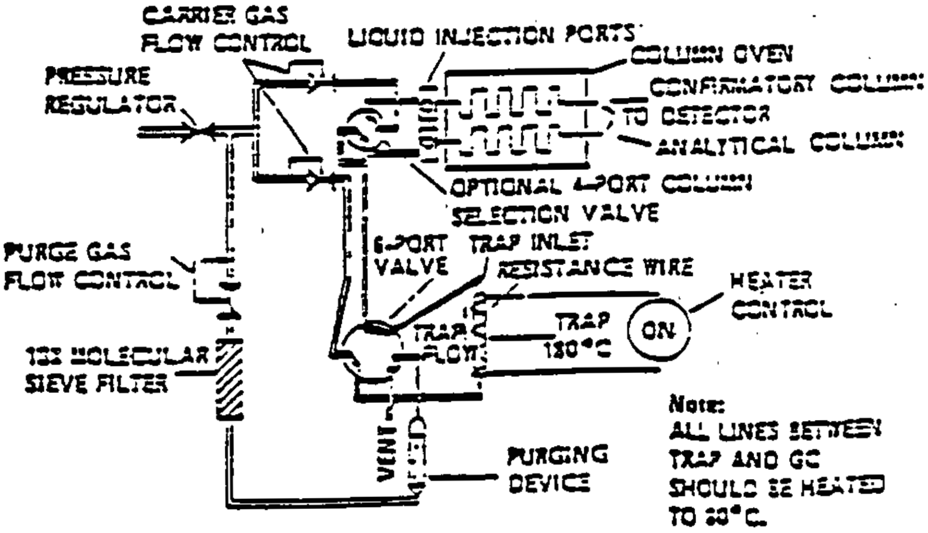


Figure A3-6. Schematic of purge-and-trap device--desorb mode.

7.3.4 GC/MS INTERFACE: Any GC-to-MS interface that gives acceptable performance criteria may be used. GC-to-MS interfaces constructed entirely of glass or of glass-lined materials are recommended. Glass can be deactivated by silanizing with dichlorodimethylsilane.

7.3.5 DATA SYSTEM: A computer system that allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program must be interfaced to the mass spectrometer. The computer must have software that allows searching any GC/MS data file for ions of a specified mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP). Software must also be available that allows integrating the abundances in any EICP between specified time or scan-number limits. The most recent version of the EPA/NIH Mass Spectral Library should also be available.

7.4 GC/MS OPERATING CONDITIONS

Electron energy:	70 electron volts (nominal)
Mass range:	40-260 (40-280 amu for the MAT CH4 mass spectrometer)
Scan time:	To give 5 scans per peak but not to exceed 7 s/scan.
Initial column temperature:	45°C
Initial column holding time:	3 min
Column temperature program:	8°C/min
Final column temperature:	220°C
Final column holding time:	Analyte and matrix dependent
Injector temperature:	200-225°C
Source temperature:	According to manufacturer's specifications
Transfer line temperature:	250-300°C
Carrier gas:	Helium at 30 cm/sec
Purge flow:	Nitrogen at 40 mL/min

7.5 INITIAL CALIBRATION

7.5.1 Each mass spectrometer will be calibrated for mass scale using perfluorokerosene (PFK) or perfluorotributylamine (FC-43) according to manufacturer's specifications.

7.5.2 Each GC/MS system must be hardware tuned to meet the criteria in Table A3-1 for a 100 ng injection of BFB (see Section 5.5). Analysis must not begin until these criteria are met.

7.5.3 A system blank consisting of five milliliters (5.0 mL) reagent (VOA) water spiked with the surrogate/RIS solution will be analyzed (as outlined in Sections 7.5.4.1 through 7.5.4.5) to ensure that the GC/MS system is contaminant free. This shall be done immediately before and after the calibration curve injections. Should the system prove to be contaminated, then the following measures are taken.

TABLE A3-1. BFB ION ABUNDANCE CRITERIA

Mass	Ion abundance criteria
50	15% to 40% of mass 95
75	30% to 60% of mass 95
95	Base peak, 100% relative abundance
96	5% to 9% of mass 95
173	Less than 2% of mass 174
174	Greater than 50% of mass 95
175	5% to 9% of mass 174
176	Greater than 95% but less than 101% of mass 174
177	5% to 9% of mass 176

7.5.3.1 Perform a "bake-out" of the analytic system by running through the temperature program and heating the analytic trap. Occasionally, an overnight bake-out of the system may be necessary to rid the system of gross contamination.

7.5.3.2 Ensure that the purge towers and syringes have been properly cleaned.

7.5.3.3 Obtain fresh VOA water to rule out contaminated water.

7.5.3.4 If necessary, the spiking solution will be reprepared to rule out contamination during the preparation.

7.5.3.5 If these measures prove to be unsuccessful in eliminating the contamination, then the GC/MS supervisor or project leader should be consulted for further action to be taken.

7.5.4 A five-point calibration curve will be established using the following procedure:

7.5.4.1 After allowing the standards to warm to room temperature, spike the calibration standards (see Section 5.3) into an all glass syringe containing 5 mL VOA water. Be sure the standard solution is expelled beneath the surface of the water and away from the delivering syringe needle.

7.5.4.2 This solution is then mixed by inversion and added to the purge tower. Purge the standard for 11.0 min at ambient temperature.

7.5.4.3 At the conclusion of the purge time, desorb the analytic trap, begin the GC temperature program, start the GC/MS data acquisition. Concurrently, introduce the trapped materials to the column by rapidly heating the trap to 180°C while backflushing the trap with inert gas between 20 and 60 mL/min for 4 min.

7.5.4.4 While the trap is being desorbed into the GC, empty the purge tower. Wash with a minimum of two 5 mL flushes of reagent water (or methanol followed by reagent water) to avoid carryover into subsequent analyses.

7.5.4.5 After desorbing the standard for 4 min, recondition the trap by returning the purge-and-trap device to the purge mode. Maintain flow through the trap. The trap temperature should be maintained at 180°C. Trap temperatures up to 220° may be employed, however, the higher temperatures will shorten the useful life of the trap. After approximately 7 min, turn off the trap heater and open the valve to stop the gas flow through the trap. When cool, the trap is ready for the next sample.

7.5.5 Tabulate the area response of the characteristic ions (see Table A3-2) against concentration for each organic compound of interest, surrogate, and each internal standard. This is calculated for each point in the curve. Calculate response factors (RF) for each compound relative to the internal standard.

TABLE A3-2. RETENTION TIMES AND CHARACTERISTIC IONS FOR VOLATILE COMPOUNDS

Compound	Retention time (min)	Primary ion	Secondary ion(s)
Acetone	--	43	58
Acrolein	--	56	55, 58
Acrylonitrile	--	53	52, 51
Benzene	17.0	78	52, 77
Bromodichloromethane	14.3	83	85, 129
Bromoform	19.8	173	171, 175, 252
Carbon tetrachloride	13.7	117	119, 121
Chlorodibromomethane	--	129	208, 206
2-Chloroethyl vinyl ether	18.6	63	65, 106
Chloroform	11.4	83	85, 47
1,1-Dichloroethane	--	63	65, 83
1,2-Dichloroethane	--	62	64, 98
1,1-Dichloroethene	9.0	96	61, 98
trans-1,2-Dichloroethene	10.0	96	61, 98
1,2-Dichloropropane	15.7	63	62, 41
cis-1,3-Dichloropropene	15.9	75	77, 39
trans-1,3-Dichloropropene	17.2	75	77, 39
Diethyl ether			
Ethylbenzene	26.4	106	91
Methylene chloride	6.4	84	49, 51, 86
Methyl ethyl ketone			
1,1,2,2-Tetrachloroethane	22.1	83	85, 131, 133
Tetrachloroethene	22.2	164	129, 131, 166
Toluene	23.5	92	91, 65
1,1,1-Trichloroethane	13.4	97	99, 117
1,1,2-Trichloroethane	17.2	97	83, 85, 99
Trichloroethene	16.5	130	95, 97, 132
Trichlorofluoromethane	8.3	101	103, 66

The RF is calculated as follows:

$$RF = (AxCis)/(AisCx)$$

where:

Ax = Area of the characteristic ion for the compound being measured.
Ais = Area of the characteristic ion for the specific internal standard.
Cis = Amount (ng) of the specific internal standard.
Cx = Amount (ng) of the compound being measured.

7.5.6 Tabulate the area response of the characteristic ions of each organic compound of interest and surrogate against the concentration of the internal standards as described in Section 7.5.5.

7.5.7 Calculate the average RF for each compound. If the RF value over the working range is a constant (±20% RSD), the RF can be assumed to be invariant, and the average RF can be used for calculations. This variability range may be expanded to ±30% RSD with the approval of the project leader. The ability to meet this criteria is dependent upon the concentration range of the calibration standards; i.e., a wider range will have a larger RSD. Alternatively, the results can be used to plot a calibration curve of response ratios As/Ais versus RF.

7.5.8 Analyze a QC check sample by the procedure described beginning in Section 7.5.4.1. The recoveries should fall within ±20% of the expected value.

7.6 DAILY CALIBRATION

7.6.1 Perform the calibration steps as described in Sections 7.5.1 and 7.5.2 on a daily basis. In addition, the BFB tuning requirement must be demonstrated every 12 h during extended work days.

7.6.2 Analyze an aliquot of reagent water. This will serve as both a system blank and a reagent blank.

7.6.3 Daily calibration checks are performed by analyzing the midrange standard at least once every 12 h.

7.6.3.1 The internal standard responses are examined for retention time shifts. If the retention times have shifted more than 30 s from the last calibration check, the chromatographic system must be inspected for malfunctions and corrections made.

7.6.3.2 If the EICP area for any of the internal standards changes by a factor of two from the last daily calibration check standard, the mass spectrometer must be inspected for malfunctions and corrections made as appropriate.

7.6.3.3 When corrections are made, reanalysis of samples analyzed while the system was malfunctioning are necessary.

7.7 ANALYSIS OF WATER SAMPLES

7.7.1 Once the initial and/or daily calibration requirements have been met, analysis of samples may begin.

7.7.2 An aliquot of the well mixed water sample prepared in Section 6.3 is poured into an all glass syringe. The volume of the water sample is adjusted to 5.0 mL. The sample is then spiked with the surrogate/RIS spiking solution and mixed by inversion.

7.7.3 Analysis then continues as described in Section 7.5.4 using 5.0 mL of sample and spiking with the RIS/surrogate solution.

7.7.4 If analysis of the sample shows any analyte to be outside the calibration range of the instrument, this sample must be diluted as described in 7.7.4.1 and 7.7.4.2. If the high level sample saturates any of the quantitation ion, a system blank must be analyzed to assure no carryover to the next analysis.

7.7.4.1 Dilutions are made from a different VOA vial of the composited sample than was used for the first analysis whenever possible.

7.7.4.2 Allow the water sample to be diluted and the VOA water to reach room temperature. Add an aliquot of the sample to a volumetric flask and dilute to volume with the VOA water. An aliquot of this dilution is analyzed as in Section 7.5.4 using 5.0 mL of the diluted sample and the RIS/surrogate solution.

7.7.5 Surrogate recoveries must be ±35% from the expected value. Reanalysis of the sample is necessary if recoveries fall out of this range.

7.7.6 A replicate analysis is performed for every 20 samples unless otherwise specified by the project specific trial burn plan or the QA plan.

8.0 GC/MS ANALYSIS OF VOST SAMPLES

8.1 SUMMARY OF METHOD

8.1.1 The traps are spiked with an internal standard solution using the flash evaporation technique. They are then thermally desorbed for 11 min at 180°C with organic-free nitrogen, bubbled through 5 mL of organic-free water, and trapped on the analytical trap. After the 11-min desorption, the analytical trap is rapidly heated to 180°C with the carrier gas reversed so that the effluent flow from the analytical trap is directed into the GC/MS. The volatile POHCs are separated by temperature-programmed gas chromatography and detected by low-resolution mass spectrometry. The concentrations of the volatile POHCs are calculated using the internal standard technique.

8.1.2 Refer to SW-846 method 5040 "PROTOCOL FOR ANALYSIS OF SORBENT CARTRIDGES FROM VOLATILE ORGANIC SAMPLING TRAIN" for complete details of this analytic method. Deviations are listed in Section 11.0 of this document.

8.2 APPARATUS

8.2.1 Trap spiking apparatus:

8.2.1.1 Internal standards are introduced into each VOST trap prior to analysis using a special accessory. This consists of a trap holder, a heated GC-type septum injector, and a supply of helium gas. The injector is maintained at a temperature of 220°C and the helium flow is about 50 mL/min.

8.2.2 Thermal desorption unit:

8.2.2.1 The thermal desorption unit is capable of heating the traps to 180°C with flow of organic-free nitrogen through the traps. For inside/inside VOST traps, use the Supelco "clamshell" heater; for inside/outside VOST traps, a user fabricated heater is required.

8.2.3 Purge and trap device:

8.2.3.1 The purge and trap unit is as described in Section 7.2.

8.3 GC/MS SYSTEM

8.3.1 The GC/MS system is as described in Section 7.3.

8.4 GC/MS OPERATING CONDITIONS

8.4.1 The GC/MS operating conditions are as described in Section 7.4.

8.5 INITIAL CALIBRATION

8.5.1 Each mass spectrometer will be calibrated for mass scale using perfluorokerosene (PFK) or perfluorotributylamine (FC-43) according to manufacturer's specifications.

8.5.2 Each GC/MS system must be hardware tuned to meet the criteria in Table A3-1 for a 100-ng injection of BFB (see Section 5.5). Analyses must not begin until these criteria are met.

8.5.3 A system blank is performed immediately before and after analysis of the calibration curve standards according to the following procedure:

8.5.3.1 Turn the helium flow on. Insert a clean trap into the spiking accessory and seal with the knurled nut.

8.5.3.2 Using an exact volume technique, slowly inject the internal standard solution into the vaporizing port of the spiking accessory. After 15 seconds, shut off the gas flow, and remove trap. The total flow of gas through the trap during addition of internal standards should be 25 mL or less.

8.5.3.3 Place the spiked trap into the thermal desorption unit and attach the "clamshell" heater. Check the flow to ensure a 40-mL/min nitrogen flow rate. Heat trap and desorb for 11 min.

8.5.3.4 The desorbed components pass into the bottom of the water column, are purged from the water, and are collected on the analytic trap. After the 11-min desorption period, the compounds are desorbed from the analytical trap into the GC/MS system by rapidly heating the analytic trap and backflushing with inert gas for 4 min.

8.5.3.5 If the system proves to be contaminated, then the corrective action outlined in Section 7.5.3 is initiated.

8.5.4 A minimum of calibration standards at three levels are used to prepare the calibration curve. Each standard is analyzed on three Tenax traps spiked with calibration standards to establish a calibration curve. These traps are spiked and analyzed as described beginning in Section 8.5.3.1.

8.5.5 Tabulate the area response of the characteristic ions of each analyte (surrogate and compound of interest) against the concentration of the internal standards as described in Section 7.5.5.

8.5.6 Calculate the average RF for each compound. If the RF value over the working range is a constant (±20% RSD), the RF can be assumed to be invariant, and the average RF can be used for calculations. This variability range may be expanded to ±30% RSD with the approval of the project leader. The ability to meet this criteria is dependent upon the concentration range of the calibration standards; i.e., a wider range will have a larger RSD. Alternatively, the results can be used to plot a calibration curve of response ratios As/Ais versus RF.

8.5.7 Analyze AQC check sample by the procedure described beginning in Section 8.5.3.2. The recoveries should fall within ±20% of the expected value.

8.6 DAILY CALIBRATION

8.6.1 Perform the calibration steps outlined in Sections 7.5.1 and 7.5.2. In addition, the BFB tuning requirement must be demonstrated every 12 h during extended work days.

8.6.2 A system blank is analyzed as outlined in Section 8.5.3.

8.6.3 A daily calibration check is performed by spiking a Tenax trap with the mid range calibration standard. The response factors calculated from this injection must not vary by more than ±20% for any analyte. This variability range may be expanded to ±30% with the approval of the project leader.

8.7 ANALYSIS OF VOST SAMPLES

8.7.1 Each sample trap, field blank trap, and trip blank trap is analyzed by the procedure described beginning in Section 8.5.3.

8.7.2 If analysis shows any analyte to be outside the calibration range of the instrument, then a higher level standard is prepared and analyzed to bracket that sample.

8.7.3 If samples are encountered that have concentrations of analytes above the highest point in the calibration curve, the cleanliness of the system must be proved by analyzing a system blank as in Section 8.5.3. If this system blank proves to be clean, this establishes a new lower limit for the analysis of system blanks. If, on subsequent analyses, a sample is encountered that is above this new limit, a system blank must be analyzed. Once again, if this proves the system to be clean, then this higher limit is established. This continues until an amount of analyte is found that does not clean up from the system during the usual operating procedure. When this occurs, a longer bake-out of the system is required.

9.0 DATA INTERPRETATION

9.1 QUALITATIVE ANALYSIS

9.1.1 An analyte is identified by comparison of the sample mass spectrum with the mass spectrum of a standard of the suspected compound (standard reference spectrum). Mass spectra for standard references are obtained on the user's GC/MS within the same 12 h as the sample analysis. These standard reference spectra may be obtained through analysis of the calibration standards. Two criteria must be satisfied to verify identification: (1) elution of sample component at the same GC relative retention time (RRT) as those of the standard component; and (2) correspondence of the sample component and the standard component mass spectrum.

9.1.2 The sample component RRT must compare within ±0.06 RRT units of the RRT of the standard component. For reference, the standard must be run within the same 12 h as the sample. If coelution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT is assigned by using extracted ion current profiles for ions unique to the component of interest.

9.1.3 Every ion plot and mass spectrum will be visually inspected to ensure that (1) All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum. (2) The relative intensities of ions specified in (1) must agree within ±20% between the standard and sample spectra. (Example: for an ion with an abundance of 50% in the standard spectra, the corresponding sample abundance must be between 30% and 70%.) These criteria may be relaxed slightly if, in the best professional judgment of the data analyst, a compound lacking all criteria is still deemed to be a "hit."

9.1.4 If the project specific trial burn plan indicates that compounds other than the analytes of interest (i.e., PICs or unknowns) are to be identified, this work is performed by personnel experienced in mass spectral interpretation. A computer search of the NBS mass spectral library is obtained for each unknown spectrum, followed by manual evaluation of the spectra and search results. Manual searches of mass spectral libraries are also used to facilitate identifications. In some cases it is not possible to identify a compound based on its electron impact mass spectrum alone. To the extent possible, these compounds will at least be characterized by class; for example, as "hydrocarbon", "amine", etc. Unknown and PIC compounds may also be semiquantitated by calculating ng amounts as outline in Section 7.5.9 using total ion areas for both unknown and internal standard and assuming a response factor of 1.000.

9.2 QUANTITATIVE ANALYSIS

9.2.1 Specific quantitation information based on response factors for compounds (Section 9.5.6) will be done for surrogates and POHCs only. Quantitation for PICs and unknowns will be calculated using RFs of 1.000 or historical response factors if available.

9.2.2 When a compound has been identified, the quantification of that compound will be based on the integrated abundance from the EICP of the primary characteristic ion. For VOST samples only, if the primary ion is saturated or has an interference, then a secondary ion is used for quantification. However, a new RF should be established for the secondary ion. Quantification will take place using the internal standard technique.

9.2.3 Calculate the total ng per analysis of each identified analyte in the sample as follows:

$$\text{total ng} = [Aa/Ais] \times [Cis/RFa]$$

where:

Aa = Area of the characteristic ion for the analyte to be measured.
Ais = Area of the characteristic ion for the specific internal standard.
Cis = Amount (ng) of the specific internal standard.
RFa = Calculated average response factor for the analyte.

9.2.4 The "TCA" quantitation report values may be used in place of manual calculations for the total ng per analysis.

9.2.5 VOST samples are reported as total ng per trap or total ng per pair.

9.2.6 Water samples are reported in ng/mL by the following:
µg/L = ng/mL = total ng found / purge volume (5.0 mL)

9.2.7 Waste feeds are reported in µg/g by the following:

µg/g = [µg found/injection volume (mL)] x [dilution (mL)/sample wt(g)]

9.2.8 Report results without correction for recovery data. When duplicates, matrix spikes, and check samples are analyzed, report all data with sample results.

10.0 QUALITY CONTROL

Specific QC requirements are included in the section where appropriate, however, a summary of the QC performed with sample preparation and analysis is summarized in this section.

10.1 BLANKS

10.1.1 Field blanks are analyzed to ensure that no contamination of the samples has occurred during the sampling and shipping processes. Trip blanks are a specific type of field blank and are utilized for VOST analysis to segregate the sampling process from the shipping process. See Section 6.2.1 for further explanation of VOST trip and field blanks. The preparation of water field blanks is outlined in Section 1.1.4.

10.1.2 System blanks for the GC/MS system are performed on each instrument on a daily basis. These analyses are to demonstrate that the GC/MS system is free from contaminants. These may also function as reagent blanks (Section 10.1.3).

10.1.3 Reagent blanks are performed by spiking the various reagents with RIS and surrogate and are analyzed according to the procedure for that type of sample. This is done for each batch or lot number of reagent.

10.2 SAMPLE QA REQUIREMENTS

10.2.1 For all water samples spiked with surrogates. Recoveries are calculated for all these samples and must fall within ±35%.

10.2.2 Replicate analyses water samples are performed at least once per 20 samples. However, the project specific QA plan is consulted for additional replicate analyses.

10.3 INITIAL INSTRUMENT CALIBRATION REQUIREMENTS

10.3.1 Each instrument is calibrated for mass scale using PFK or FC-43 according to manufacturer's specifications prior to the initial calibration curve.

10.3.2 Each instrument is tuned to meet the criteria in Table A3-1 for a 100-ng injection of BFB.

10.3.3 A calibration curve is established and acceptable performance demonstrated prior to the analysis of samples. Initial calibration procedures are dependent on sample type and are outlined in Sections 7.5, 8.4, and 8.5.

10.4 DAILY INSTRUMENT CALIBRATION REQUIREMENTS

10.4.1 Each instrument is calibrated for mass scale with PFK or FC-43 on a daily basis.

10.4.2 The BFB performance criteria in Table A3-1 must be demonstrated every 12 h.

10.4.3 Daily calibration requirements are dependent on sample type and are outlined in Sections 7.6 and 8.6.

11.0 MODIFICATIONS FROM SW-846 METHODS

11.1 METHOD 8240 "GAS CHROMATOGRAPHY/MASS SPECTROMETRY FOR VOLATILE ORGANICS"

METHOD 8240 SECTION NO.	MODIFICATION
4.12.3 5.5 7.2.2 7.3.1	100 ng of BFB is injected rather than 50 ng. This gives better instrument response on the lower intensity ions.
5.1.3	Purities < 100% (or 99+%) are corrected.
5.3 5.4 5.7	Concentrations of stock solutions will vary according to analysis needs. Usually, surrogate and RIS solutions are such that 100 ng per analysis is achieved. RIS and surrogates are prepared as a mix for VOST, water samples, and system blanks. A three point calibration curve is acceptable.
5.6	Calibration standards are prepared in methanol rather than reagent water and they are used until signs of degradation become evident.
5.8	standard solutions are stored in clear vials and placed in a closed container to protect from light.
6.1	New bottles and vials are cleaned according to Introductory Chapter, Section 4.1.2. Sample bottles and vials are not reused, they are decontaminated with methanol and disposed of. Reactivials and volumetric flasks are decontaminated after use, then cleaned as in Section 4.1.2.

7.2.5	Calibration standards are prepared as a mix which includes analytes, surrogates, and RIS. This standard is spiked directly into the glass syringe containing 5.0 mL VOA water, mixed, and added to the purge tower.
7.2.9	The GC/MS data system (INCOS) uses n rather than n-1 for %RSD calculations. If a %RSD falls within 3% of the cutoff value, then this %RSD is recalculated manually using n-1 to achieve a more accurate value.
7.4.1	Water samples are not prescreened as they generally contain a very low concentration of analytes.
7.4.1.5	Purge gas is nitrogen at 40 mL/min. Carrier gas is helium at 30 cm/s.
7.4.1.7.3	Only one aliquot for analysis is taken from any given VOA vial. If replicates are required, then these aliquots are taken from individual VOA vials. If dilutions are necessary, then an aliquot is taken from a fresh VOA vial.
7.5.2	Quantitation for PICs will be performed via internal standards method, using RFs generated from a single-point composite standard analysis. Unknowns will be quantified by using RRFs of 1.000.
8.5.1 8.5.2	Concentrations of analytes will vary depending on the analysis needs.

11.2 METHOD 5040 "PROTOCOL FOR ANALYSIS OF SORBENT CARTRIDGES FROM VOLATILE ORGANIC SAMPLING TRAIN"

METHOD 5040 SECTION NO.	MODIFICATION
5.3.2	Stock solutions are maintained for 2 months for reactive compounds and gases, 6 months for all others. They are replaced sooner if signs of degradation are evident. (per method 8240)
5.5	100 ng BFB used for better instrument response on 7.1 the lower intensity ions.
5.6	Concentrations of stock solutions will vary depending on analysis needs.
7.2.3	Internal standard amounts are typically 100 ng per analysis.
8.4.1	Acceptable range for internal standard areas is ±35% from run to run, or a factor of two (-50% to +100%) from the last daily standard per method 8240.

APPENDIX A-4

SEMIVOLATILES ANALYTICAL METHODS

APPENDIX A-4

SEMIVOLATILES ANALYTICAL METHODS

1.0 GLASSWARE PREPARATION

1.1 Standard Procedures

All glassware for field sampling and analysis of semivolatile organic compounds is prepared according to the following procedures.

1.1.1 Wash all glassware in hot, soapy water (use ISOCLEAN nonionic soap, Micro, Alconox, or equivalent synthetic detergents and a clean brush).

1.1.2 Rinse with tap water (5X), deionized water (3X), and bulk acetone (2X).

1.1.3 Air dry and cover open ends of glassware with solvent-rinsed aluminum foil and store in appropriate drawers.

1.1.4 Any glassware that gives an indication of still being dirty, i.e., the water and acetone rinses do not "sheet," should be recleaned by soaking in concentrated sulfuric acid overnight then rinsed as in Section 1.2.2.2.

1.1.5 Before actual use, clean glassware and Teflon liners from storage drawers should be rinsed with high purity acetone followed by a 2X rinse with the appropriate solvent to be used in the method. Glassware for field sampling should be rinsed a final time with methylene chloride (DCM).

1.1.6 Glassware used for extraction, concentration, and cleanup procedures are numbered as a set. Such glassware is to be used in a set.

1.1.7 A final rinse of the glassware sets with the appropriate solvent should be collected in a vial, labeled to note glassware type and set, and archived as a glassware rinse.

1.1.8 The dram vials, reacti-vials, and autosampler vials are rinsed 2X with the solvent to be used and allowed to air dry.

1.1.9 When required, dram vials may be precalibrated by dispensing a measured volume of the appropriate solvent into the vial and etching the glass at the bottom of the miniscus. Precalibrated vials are to be rerinsed with the appropriate solvent and allowed to dry.

1.1.10 Vial caps are to be lined with solvent-rinsed Teflon liners.

1.1.11 After use, glassware is to be rinsed once with extraction solvent and once with bulk acetone before detergent washing.

1.2 SW-846 Method Modifications, Deviations, and Enhancements

The following modifications, deviations, and enhancement from SW-846 and other standard methods will be employed during this study. None are expected to impact the quality of the results submitted. The glassware cleaning procedure deviates from SW-846, Chapter 4 recommended method, as follows.

1.2.1 SW-846 recommends using methanol rather than bulk acetone in Steps 1.1.2 and 1.1.11.

1.2.2 SW-846 suggests using a hot (≥ 50°C) soap water soak and a hot water rinse.

1.2.3 SW-846 recommends a soak with hot chromic acid solution to destroy traces of organic compounds.

2.0 SORBENT CLEANUP AND PREPARATION

2.1 XAD-2 Cleanup and Trap Preparation

2.1.1 Extraction and Fluidation--A batch of XAD-2 adsorbent (Alltech Assoc./Applied Science, 20/50 mesh, 90 Å pore size, precleaned) is placed into a Soxhlet extraction apparatus and extracted for 22 h with methylene chloride (DCM) as outlined in Section 2.3.2.

The XAD-2 is then placed into an evaporating dish lined with methylene chloride-rinsed aluminum foil, placed in a hood and dried for 12 h. The evaporating dish is lined with aluminum foil to prevent possible contamination of the XAD-2 resin from the dish. Prerinsed aluminum foil is placed over the XAD-2 to keep particulate matter from falling into the evaporating dish during drying.

Glass wool (preextracted with methylene chloride as outlined in Section 2.4.1) is placed in the bottom of a 1-L continuous extraction column. The XAD-2 adsorbent is next placed into the column (~ 1,000 g/extraction column). A stream of high purity gaseous nitrogen is passed for 16 h through a bed of 50% activated carbon/50% molecular seive and then through the extraction column. The rate of N_2 flow should gently dry the resin. Excessive fluidation may cause the XAD-2 particles to break up. The activated charcoal/molecular sieve trap consists of a 8 x 1 1/2 in stainless steel case with stainless steel frits on the inlet and outlet. All lines connecting the N_2 tank to the column should be Teflon or precleaned copper tubing.

2.1.2 Storage of Extracted XAD-2--Precleaned XAD-2 resin not to be used immediately (within 2 weeks) should be stored under high purity methanol.

2.1.3 Packing the XAD Trap--

2.1.3.1 Dry method--Place a wad of glass wool (preextracted with methylene chloride) into the bottom of a precleaned XAD-2 cartridge. The XAD trap is packed just prior to use in the field (not to extend longer than 2 weeks prior to use). Use just enough glass wool to cover the glass frit. Add XAD-2 resin to fill the cartridge to the top of the curved section. Do not tap the cartridge. Packing the resin too tightly may plug the sample train during sampling. Add enough glass wool (preextracted) into the top of the cartridge to ensure the resin will not leak out. Cover both ends of the cartridge tightly with methanol-rinsed aluminum foil. Wrap the cartridge with bubble pack and tape to ensure safe delivery to the field site.

2.2 Cleanup and Preparation of Solid Materials Used in the Analytical Procedures

2.2.1 The following adsorbents are to be extracted in the giant Soxhlet extractor.

- Na_2SO_4 (anhydrous, granular, Fisher Scientific or equivalent)
- Florisil (pesticide grade, 60/100 mesh)

2.2.2 Soxhlet Extraction Procedure for the 12-L Giant Soxhlet--

2.2.2.1 Charge the Soxhlet by adding 6 L DCM in the 12-L round bottom flask.

2.2.2.2 Add boiling chips (silicon carbide) to the 12-L round bottom flask.

2.2.2.3 Place preextracted regular glass wool in bottom of Soxhlet extractor to prevent solids from entering into the Soxhlet arm. Add the solid material and wet with 1 L DCM.

2.2.2.4 Extract overnight, 16 to 22 h at a turnover rate of 2 cycles/h.

2.2.2.5 Remove the solid material from the extractor and air dry in methylene chloride-rinsed aluminum foil-lined evaporating dishes until solvent odor is no longer detected (~ 4 h).

2.2.3 Adsorbent and Drying Agent Activation Procedure--

2.2.3.1 Na_2SO_4--Ensure that the Na_2SO_4 is dry. Transfer the air-dried Na_2SO_4 to small evaporating dishes and heat in a muffle furnace at 400°C for 4 h.

Store the Na_2SO_4 in a clean glass jar covered with methylene chloride-rinsed foil in an oven at 130°C.

2.2.3.2 Florisil--Activate a batch of Florisil by heating at 130°C for 16 h. Store in a desiccator.

2.2.3.3 Carbopak C/Celite 545--Prepare by mixing 3.6 g of Carbopak C (80/100 mesh) and 16.4 g of Celite 545 in a 40-mL vial (different amounts may be mixed in the same proportions). Place sorbent mixture on rock tumbler and tumble for 3 h. Activate at 130°C for 6 h. Store in a desiccator.

2.3 Cleanup and Preparation of Glass Wool and Boiling Chips

2.3.1 Glass Wool (Soxhlet Extraction)--

2.3.1.1 Add approximately 6 L of methylene chloride to a 12-L round bottom flask. Add boiling chips (silicon carbide) to the 12-L round bottom flask.

2.3.1.2 Place regular or silanized glass wool in Soxhlet and wet with 1 L methylene chloride.

2.3.1.3 Extract overnight, 16 to 22 h at a rate of 2 cycles/h.

2.3.1.4 Air dry on methylene chloride-rinsed aluminum foil.

2.3.1.5 Store on bench in clean glass jar with Teflon-lined screw cap.

2.3.2 Boiling Chips--

2.3.2.1 Silicon carbide boiling chips (Soxhlet extraction)--

2.3.2.1.1 Add approximately 500 mL of methylene chloride to a 1-L round bottom flask. Add boiling chips (silicon carbide) to the round bottom flask.

2.3.2.1.2 Place preextracted regular glass wool in the bottom of a 71/60 Soxhlet extractor. Add the silicon carbide boiling chips to be extracted and wet with approximately 200 mL of methylene chloride.

2.3.2.1.3 Extract overnight, 16 to 22 h.

2.3.2.1.4 Air dry on methylene chloride-rinsed aluminum foil.

2.3.2.1.5 Store on bench in a clean glass jar with a Teflon-lined lid.

2.3.2.2 Berl saddle boiling chips--Simply crush the Berl saddles to small pieces and store in a methylene chloride-rinsed vial or jar with Teflon-lined lid.

2.4 SW-846 Method Modifications, Deviations, and Enhancements

The following modifications, deviations, and enhancement from SW-846 and other standard methods will be employed during this study. None are expected to impact the quality of the results submitted.

2.4.1 Appendix A of SW-846 Method 0010 suggests two XAD-2 cleanup methods.

2.4.1.1 Initial rinse of XAD-2 resin in Type II water (2X) in a beaker, followed by Soxhlet extraction with water (8 h), methanol (22 h), and two separate methylene chloride extractions, each for a duration of 22 h.

2.4.1.2 Using an XAD-2 cleanup extraction apparatus which includes a three-necked flask, air-jacketed Snyder distillation column, and an XAD-2 canister in which the resin is held light spring tension between a pair of coarse and fine screens. Solvent is refluxed through the Snyder column, and the distillate is continuously cycled upward through the XAD-containing canister for extraction and returned to the flask. The resin is first water-washed by pumping 20 L of distilled water upward through the canister. The resin is then solvent-rinsed with methanol and methylene chloride (2X) for 10 to 20 h using the described distillation apparatus.

2.4.1.3 MRI will extract the XAD-2 for 22 h using methylene chloride (Section 2.1.1). The resin purchased will have been precleaned by the manufacturer. A subsample of the cleaned resin will be solvent extracted and analyzed by GC/MS to ensure that the resin has been efficiently cleaned.

2.4.2 Appendix A of Method 0010 suggests two XAD-2 drying techniques. MRI will use a method similar to the second option recommended, modified as follows. The high purity nitrogen will be passed through a stainless steel case (approximately 200 cm^3 capacity) containing a mix of activated carbon and molecular sieve (in equal proportions).

2.4.3 Method 0010 recommends that cleaned XAD-2 be stored in an airtight, wide-mouth amber jar or in one of the glass sorbent modules sealed with Teflon film and elastic bands for no more than 4 weeks. MRI will modify this procedure by storing the precleaned resin in a jar under high purity methanol if it will not be used within 2 weeks after preparation.

2.4.4 Method 0010 recommends the use of Teflon boiling chips for all sample preparation procedures (Soxhlet extraction, Kuderna Danish volume reduction). MRI will use silicon carbide or Berl saddle boiling chips instead.

3.0 EXTRACTION OF FIELD SAMPLES FOR SEMIVOLATILE ORGANIC COMPOUNDS

3.1 Sample Train and Aqueous Sample Extraction

The components of the Modified Method 5 (MM5) sampling train that need to be extracted are as follows:

- Particulate filter/probe rinse
- XAD-2 resin/back half rinse
- Condensate water

These and several other additional aqueous samples (e.g., scrubber water, lean water) from the trial burns will be spiked with a method internal standard (i.e., surrogates) compounds and solvent extracted. The MM5 components will be solvent-extracted using procedures consistent with SW-846 Method 0010, while the additional aqueous and ash samples will be extracted using SW-846 3500-series methods.

The extracts from the MM5 sampling train components may be combined into a single extract, thus generating a new composite, as described below. Because they will be composited, only the particulate/XAD resin extracts will be spiked with method internal standards.

3.1.1 Extraction of Probe Rinse and Back Half Rinse--

The probe rinse and back half rinse are treated separately but in the same way. Each is composed of combined acetone and toluene rinses which may contain water.

3.1.1.1 If the rinse sample contains particulate matter, set up a glass fiber filter folded in quarters and held with a powder funnel such that it drains into a separatory funnel. Record the glassware identification numbers in the lab record book (LRB), collect all proper glassware rinses, and archive.

3.1.1.2 Filter the sample into the separatory funnel. The filter and filter catch will be extracted with the particulate filter and XAD-2 resins (Section 3.1.2). Rinse the powder funnel (used to hold the filter, if applicable) with toluene into the separatory funnel.

3.1.1.3 Rinse the sample container with toluene and pour the rinsates into the separatory funnel.

3.1.1.4 Back extract the rinses by adding enough reagent water to the separatory funnel so that its volume is 3X the volume of the field sample rinses. Drain the acetone/water layer from the bottom of the separatory funnel and save (see 3.1.1.5). Drain the toluene phase into a separate clean bottle.

3.1.1.5 Pour the acetone/water phase back into the separatory funnel and extract two more times with toluene. Combine these toluene extracts with the toluene extract from step 3.1.1.4.

3.1.1.6 Save this extract for combination with the particulates, XAD, and condensate extracts and proceed to Section 4.0.

3.1.1.7 At least one method blank (consisting of 1 L of reagent water spiked with the method internal standards) is to be extracted with each set of samples extracted by this method.

3.1.2 Extraction of Particulate Filters and XAD Resin--

3.1.2.1 Set up a ₮55/50 Soxhlet extraction apparatus with 200 mL toluene in a 500-mL boiling flask along with several boiling chips. Record the identification numbers of glassware and lot numbers of the solvent used in the lab record book (LRB). Collect all glassware rinses and archive.

3.1.2.2 Put preextracted regular glass wool in the bottom of the Soxhlet extractor to prevent particulates from entering the Soxhlet arm. Confirm that the probe rinses do not contain any particulate matter (refer to Section 3.1.2.1). If the probe rinses contain particulates, add the filter containing the particulates to the Soxhlet extractor.

3.1.2.3 Carefully fold the MM5 train filter in half. Do not allow any particulate material to be lost from the filter. Add the particulates sample to the Soxhlet extractor using tweezers, being careful not to lose any particulate material from the filter. Rinse the sample container with three 5-mL portions of toluene and add to the boiling flask.

3.1.2.4 Add the entire contents of the XAD-2 resin module (±75 g) from the sampling train to the Soxhlet extractor. Cover the XAD-2 resin with preextracted glass wool to ensure that the resin is held in the extractor. Soxhlet extractors should not be filled more than one half full with resin. Rinse the resin module thoroughly with toluene into the Soxhlet extractor.

3.1.2.5 Spike the sample with the method internal standards (surrogate) solution (see Tables 3 and 5).

3.1.2.6 Extract the sample for at least 16 h at a solvent cycling rate of 3 cycles/h.

3.1.2.7 Drain the solvent extract into the boiling flask. If there is an aqueous layer in the extract, transfer the extract into a separatory funnel and drain the water layer off.

3.1.2.8 Save the solvent extracts for combining with the condensate, the front half, and back half rinse extracts and proceed to Section 4.0.

3.1.3 MM5 Train Condensates--Each of the aqueous samples will be extracted according to SW-846 3500-series methods as described below. The MM5 train condensate samples will be extracted using toluene and will be combined with the filter, front half, and back half rinse extracts.

3.1.3.1 <u>Separatory funnel extraction (SW-846-3510)</u>--

This method is designed to quantitatively extract semivolatile organic compounds from aqueous samples using a separatory funnel. If emulsions present a significant problem during sample extraction, the sample will be drained into a continuous liquid-liquid extractor (Section 3.1.3.2) and the extraction continued.

3.1.3.1.1 The liquid samples will be extracted using a 2-L separatory funnel. Record the glassware identification numbers in the LRB and collect the appropriate glassware rinses for archiving.

3.1.3.1.2 Mark on the sample bottle the level of the meniscus for subsequent determination of total sample volume.

3.1.3.1.3 Shake the sample container for 30 s and pour a 1-L portion of the sample into a graduated cylinder. Add the 1-L portion to the separatory funnel. If the sample exhibits two separate phases, transfer the balance of the sample to the separatory funnel. Drain each phase into separate containers. The aqueous phase will be transferred back to the original sample container. The organic layer will be drained into a clean bottle and treated as described in Section 4.0.

3.1.3.1.4 Mark the level of the meniscus on the side of the sample container for determination of the aqueous phase volume. Measure a 1-L portion of the aqueous phase and pour it back into the separatory funnel.

3.1.3.1.5 Spike the sample with the method internal standards mix (see Tables 3 and 5) and gently swirl the solution. **DO NOT SPIKE CONDENSATE SAMPLES FROM THE MM5 SAMPLING TRAIN WITH METHOD INTERNAL STANDARDS.**

3.1.3.1.6 Check the pH of the aqueous sample using a glass stirring rod to apply several drops of the sample to a piece of multirange pH paper.

3.1.3.1.7 Adjust the pH of the sample to about 8 using either a 6N NaOH solution for acidic samples or a 6N H_2SO_4 solution for alkaline samples. Add the acid or base, swirl the contents of the separatory funnel, check the pH, and readjust as necessary until a neutral pH is attained.

3.1.3.1.8 Add 60 mL of the extraction solvent to the original sample container, cap, and shake 30 s to rinse it.

3.1.3.1.9 Transfer the solvent rinse to the separatory funnel and extract the sample by shaking vigorously for 2 min with periodic venting to release excess vapor pressure. Record solvent lot number in the LRB.

3.1.3.1.10 Allow the organic layer to separate from the aqueous phase. When using methylene chloride as a solvent, drain the organic phase into a clean bottle. If the solvent employed is toluene, drain the aqueous phase into the original sample bottle, and drain the organic phase into a clean bottle. Transfer the aqueous phase back to the separatory funnel.

3.1.3.1.11 Repeat steps 3.1.3.1.8 to 3.1.3.1.10 two more times, combining each of the three extracts in the same bottle and proceed to Section 4.0.

3.1.3.1.12 At least one method blank (consisting of 1 L of reagent water spiked with the method internal standards) is to be extracted with each set of samples extracted by this method.

3.1.3.1.13 Measure the volume of the aqueous phase and of the total sample described above by adding water to the sample bottle to the marks made. Pour the water into a graduated cylinder and record the volume of sample extracted.

3.1.3.2 Continuous liquid extraction (SW-846-3520)--

This method is designed to quantitatively extract semivolatile organic compounds from aqueous samples using a continuous liquid-liquid extractor. This method is to be used only for samples that form emulsions when extracted using a separatory funnel. The samples that form emulsions during step 3.1.3.1.9 should be transferred directly to the continuous liquid extractor and the extraction continued using the device.

3.1.3.2.1 The liquid samples will be extracted using a continuous liquid-liquid extractor. Record the glassware identification numbers in the LRB and collect the appropriate glassware rinses for archiving.

3.1.3.2.2 Assemble the device and add 200 mL of the appropriate solvent to the extractor. Add 300 mL of the appropriate solvent to the 500 mL boiling flask together with several boiling chips and install on the device.

3.1.3.2.3 Measure 1 L of sample into a 1-L graduated cylinder. If the sample to be extracted by this method is from the separatory funnel method described above, transfer the entire sample into the continuous liquid-liquid extractor, rinse the separatory funnel 3X with 25 mL of solvent and proceed to step 3.1.3.2.8.

3.1.3.2.4 Spike the sample with the method internal standards mix (see Tables 3 and 5) and gently swirl the solution. DO NOT SPIKE CONDENSATE SAMPLES FROM THE MM5 SAMPLING TRAIN WITH METHOD INTERNAL STANDARDS.

3.1.3.2.5 Check the pH of the aqueous sample using a glass stirring rod to apply several drops of the sample to a piece of multirange pH paper.

3.1.3.2.6 Adjust the pH of the sample to about 8 using either a 6N NaOH solution for acidic samples or a 6N H_2SO_4 solution for alkaline samples. Add the acid or base, swirl the contents of the separatory funnel, check the pH, and readjust as necessary until a neutral pH is attained.

3.1.3.2.7 Transfer the sample to the extractor. Rinse the graduated cylinder 3X with 30 mL of solvent and add to the extractor.

3.1.3.2.8 Turn on the cooling water to the condenser and the heating mantle and extract the sample for at least 18 h.

3.1.3.2.9 Treat the sample extract as described in Section 4.0.

3.1.3.2.10 At least one method blank (consisting of 1 L of reagent water spiked with the method internal standards) is to be extracted with each set of samples extracted by this method.

3.2 SW-846 Method Modifications, Deviations, and Enhancements

The following modifications, deviations, and enhancements from SW-846 and other standard methods will be employed during this study. None are expected to impact the quality of the results submitted.

3.2.1 SW-846 Method 3510 and 3520 require that samples extracted from an aqueous matrix be extracted first under basic conditions and subsequently under acidic conditions. Because of the nature of the target analytes, performing the extractions under nonneutral pH conditions may result in their degradation. Furthermore, the analysis is not directed toward base/neutral and acidic compounds, but rather to neutral compounds only.

3.2.2 SW-846 Method 0010 specifies that methylene chloride be used as the organic solvent for extraction of MM5 components. However, during the conduct of independent studies to test the effectiveness of various solvents in extracting PCDD/PCDFs from dynamically spiked MM5 train components, MRI scientists discovered that toluene is a more effective solvent. Therefore, toluene will be used as the preferred organic solvent for extracting MM5 components.

3.2.3 SW-846 Method 0010 specifies that each individual MM5 sampling train component be spiked with surrogates (i.e., method internal standards) prior to solvent extraction. Analysis of each MM5 component separately would increase analytical costs significantly. Furthermore, independent studies conducted by MRI scientists on dynamically spiked MM5 sampling trains indicated that the bulk of the organic analytes recovered from MM5 sampling trains is found in the particulate filter catch and XAD-2 trap. Therefore, the particulate filter catch will be coextracted with the XAD-2 resin components, and only this sample will be surrogate-spiked.

3.2.4 SW-846 Method 0010 specifies that the train solvent rinses are treated as a single sample during extraction. MRI will treat the probe and back half rinses separately.

3.2.5 SW-846 Method 0010 specifies that, during liquid-liquid extraction of MM5 train solvent rinses and condensate, the sample be initially extracted under acidic conditions and subsequently under basic conditions. Since the analytes of interest (PCDD/PCDFs, PCBs) are neutral, the samples will be extracted under neutral conditions.

4.0 EXTRACT CONCENTRATION AND COLUMN CLEANUP FOR SEMIVOLATILE ORGANIC COMPOUNDS

Each of the sample extracts from the various extraction procedures will be concentrated for GC/MS analysis. Depending on the type of compounds to be analyzed, concentration of the samples may be followed by a column cleanup procedure and then further concentrated. Column cleanup procedures for analysis of PCDD/PCDFs are based on those described in SW-846 Draft Method 8290. Method 0010 for the analysis of MM5 sampling train components has no provisions for extract cleanup. However, through long experience with the analysis of PCDD/PCDFs, MRI chemists have determined that the MM5 samples have sufficient interferences that make extract cleanup compulsory.

4.1 KD Concentration of Extracts

4.1.1 Place a small plug of preextracted silanized glass wool in a powder funnel and fill with approximately 20 g of preextracted anhydrous granular Na_2SO_4.

4.1.2 Transfer sample from the original extract container via the sodium sulfate packed funnel to a 500-mL KD flask fitted with a 25-mL graduated concentrator tube containing two clean boiling chips. Make sure the concentrator tube is firmly in place (with clamp or elastic bands) in order to avoid loosing sample or allowing steam to condense in the sample. Pour in enough sample extract to fill the KD flask no more than one-half full. Since the volume of the MM5 sampling train extracts will likely exceed the capacity of the KD flask, several transfers to the KD flask may be necessary.

4.1.3 Attach a 3-ball Snyder column to the KD flask and rinse with 1 mL of the appropriate solvent.

4.1.4 Place the KD apparatus on a steam bath outlet such that the entire lower rounded surface of the KD flask is bathed with steam. At the proper rate of distillation, the balls in the Snyder column will constantly chatter, but the chambers will not flood with condensed solvent.

4.1.5 When all of the contents of the original extract containers have been added to the KD flask, rinse the containers three times with 25 mL of the appropriate solvent and add the rinses to the KD flask through the sodium sulfate packed funnel.

4.1.6 Concentrate the extract to a final volume of 5 mL.

4.1.7 Add 50 mL of hexane to the KD flask, add a fresh boiling chip to the flask, reattach the Snyder column, and concentrate the sample extract to approximately 5 mL.

4.1.8 Rinse the flask and lower joint of the KD apparatus with two 5-mL portions of hexane and adjust the final extract volume to 20 mL.

4.1.8.1 If the sample is to be analyzed for both PCBs and PCDD/PCDFs (composited MM5 sampling train extracts), the sample extract will be split into two 10-mL portions. Dispense 10 mL of the extract into two separate vials.

4.1.8.2 If the sample is to be analyzed for PCBs only (ash, scrubber effluent, lean water samples), the volume is further reduced to 10 mL and stored in a vial.

4.2 Column Cleanup Procedures

The following column cleanup procedure is based on the methods described in SW-846 Draft Method 8290.

4.2.1 Transfer the 10-mL aliquot of the extract slated for analysis of PCDD/PCDFs into a 125-mL separatory funnel.

4.2.2 Add 40 mL of a 20% (w/v) aqueous KOH solution to the extract. Shake the contents for 2 min and rapidly drain and discard the aqueous (bottom) phase. Repeat the base washing until no color is visible in the aqueous layer to a maximum of four washings. Strong base is known to degrade certain PCDD/PCDFs, so contact time with the base must be minimized.

4.2.3 After the aqueous phase of the last base washing has been drained, add 40 mL of a 5% (w/v) aqueous NaCl solution. Shake for 2 min. Drain and discard the aqueous phase.

4.2.4 Add 40 mL concentrated H_2SO_4 to the sample extract. Shake for 2 min. Drain and discard the sulfuric acid (bottom) phase. Repeat the acid washing until no color is visible in the acid layer to a maximum of four washings.

4.2.5 After the acid phase of the last acidic washing has been drained, add 40 mL of a 5% (w/v) aqueous NaCl solution. Shake for 2 min. Remove and discard the aqueous (bottom) layer.

4.2.6 Transfer the extract to a 50-mL boiling flask by passing it through a powder funnel packed with anhydrous granular Na_2SO_4 as described above. Rinse the sodium sulfate with two 15-mL portions of hexane into the boiling flask, and concentrate the sample extract to near-dryness using a rotary evaporator (35°C water bath), making sure that all traces of toluene (when applicable) have been removed.

4.2.7 Dry pack a gravity column (glass, 300 mm x 10.5 mm) fitted with a PTFE stopcock in the following manner:

4.2.7.1 Insert a precleaned plug of silanized glass wool in the bottom of the column.

4.2.7.2 Add a 4-g layer of sodium sulfate to the column.

4.2.7.3 Add a 4-g layer of Woelm Super I neutral alumina and tap the top of the column gently. Woelm Super I neutral alumina does not need to be activated or cleaned prior to use, but it should be stored at all times in a sealed desiccator.

4.2.7.4 Add a 4-g layer of anhydrous granular sodium sulfate to cover the alumina.

4.2.7.5 Elute the column with 10 mL hexane and close the stopcock just before the level of the solvent reaches the top layer of sodium sulfate. Discard the eluate and check the column for channeling. If channeling is present, discard the packing and repack the column.

4.2.8 Adjust the volume of the acid and base washed extract to 2 mL with hexane and gently apply the extract to the top of the column. Open the stopcock to draw the sample into the column and close the stopcock. Rinse the sample container with three 1-mL portions of hexane and add to the column, always drawing the rinse into the column before applying the next rinse. Discard the eluate.

4.2.9 Elute the column with 10 mL of an 8% (v/v) methylene chloride in hexane solution. Collect this fraction and archive.

4.2.10 Elute the PCDD/PCDFs from the column using 15 mL of a 60% (v/v) methylene chloride in hexane solution. Collect this fraction in a 15-mL conical vial.

4.2.11 Pack a carbon column for further cleanup of the sample as follows:

4.2.11.1 Cut off both ends of a 10-mL disposable serological pipet such that a 4-in column remains.

4.2.11.2 Insert a preextracted silanized glass wool plug at one end of the column and pack the column with 0.64 g of the activated Carbopak C/Celite 545 mixture to form a 2-cm-long adsorbent bed. Cap the packing with another silanized glass wool plug.

4.2.12 Concentrate the alumina column eluate (step 4.2.1.10) using a nitrogen evaporator as follows:

4.2.12.1 Rinse the disposable pipettes to be used as needles in the N_2 evaporator with hexane.

4.2.12.2 Insert the sample vial in the rack and direct the flow of N_2 into the sample. Adjust the flow such that gentle waves are noticeable on the surface of the sample extract.

4.2.12.3 Concentrate the sample extract to < 1 mL, add 5 mL hexane, and concentrate to 2 mL.

4.2.13 Rinse the Carbopak C/Celite 545 column with the following solvents:

- 5 mL toluene
- 2 mL of a 75:20:5 (v/v) methylene chloride/methanol/ benzene mix
- 1 mL of a 1:1 (v/v) cyclohexane/methylene chloride mix
- 5 mL hexane

4.2.14 The flow rate should be less than 0.5 mL/min. Discard the rinsates.

4.2.15 While the column is still wet with hexane, add the sample concentrate to the top of the column. Rinse the sample extract container twice with 1-mL hexane portions and add the rinsates to the top of the column. Elute the column sequentially with:

- Two 2-mL portions of hexane
- One 2-mL portion of a 1:1 (v/v) cyclohexane/methylene chloride mix
- One 2-mL portion of a 75:20:5 (v/v) methylene chloride/ methanol/benzene mix

4.2.16 These eluates can be collected in the same container. Archive these the combined eluates for checks on column efficiency.

4.2.17 Invert the column and elute the PCDD/PCDF fraction with 20 mL toluene into a 50-mL boiling flask. Verify that there are no carbon fines in the eluate.

4.2.18 Concentrate the toluene fraction to about 1 mL on a rotary evaporator (water bath at 50°C). Carefully transfer the sample into a graduated 1-mL conical vial, and reduce the volume to about 100 µL using a nitrogen evaporator. Rinse the boiling flask three times with 300 µL of a 1% (v/v) toluene in methylene chloride solution and add to the cleaned-up extract. Reduce the volume to 100 µL once again.

4.2.19 Store the sample at room temperature in the dark.

5.0 PREPARATION AND USE OF CALIBRATION STANDARDS, METHOD INTERNAL STANDARDS (SURROGATES), AND RECOVERY INTERNAL STANDARDS

Recovery internal standards are compounds added to the native sample matrix just prior to GC/MS analysis to determine the recovery of method internal standards and relative response factors of the calibration standards. Method internal standards (surrogates) are compounds added to the native sample matrix prior to sample extraction to determine if any sample matrix effects and extraction problems prevent good recovery of the compounds from the sample.

5.1 General Procedures for Standard Preparation

5.1.1 Preparation and/or acquisition of accurate calibration standards, method internal standards, and recovery internal standards are extremely crucial in achieving accurate quantification of sample components and determination of analytical quality. It is also important that the standards be prepared in the correct solvent, since the standards are used both for direct analysis and for spiking.

5.1.2 As many as possible of the pure compounds and diluted calibration standards will be obtained from the EPA Quality Assurance Branch, EMSL/CI, and the Reference Standards Repository EPA/RTP.

5.1.3 The source, lot number, and purity of all standards will be recorded in the LRB. All standard solutions will contain the following information on its respective vial:

- Concentration of standard
- Date of preparation
- Solvent used
- Project number of sample ID
- Initials of person preparing solution
- Expiration date of solution

5.1.4 Primary stock solutions of the various target analytes will be prepared. All neat standards will be weighed on an analytical balance and diluted to the mark in a Class A volumetric flask with the appropriate solvent. Secondary standard mixes will be prepared by combining the appropriate volumes of the primary stock solutions in a Class A volumetric flask and diluting to the mark with the appropriate solvent.

5.1.4.1 Calibrate the analytical balance prior to weighing standards by using certified Class S weights which are in the range of the standard weighings.

5.1.4.2 Dilutions of the secondary standard mixed solutions will be prepared by serial dilution. Preparation of final working solutions will be recorded and dilution records maintained.

5.1.4.3 The various standard solutions will be stored at 4°C in a Teflon-lined screw-cap amber vial with the solution level marked on the vial.

5.2 Standards Used in the Analysis of PCDD/PCDF Organic Compounds

The semivolatile organic compounds consist of liquids and solids. The solid and liquid compounds will be weighed and diluted to volume in Class A volumetric flasks. Wash all glassware used in the standard preparation as outlined in Section 1.2.2 of Section 1.0. All standards are stored at $\leq$ 4°C in amber vials with Teflon-lined screw cap.

Recovery internal, method internal (surrogate), native calibration and GC performance check standard solutions for PCDD/PCDF analysis should be obtained from the MRI repository of dioxin/furan standards. See Table A4-1 for a complete list of dioxin/furan analytes, method internal standards, and recovery internal standards. Dioxin/furan native calibration standard, method internal standard (surrogate) and recovery internal standard solutions will be:

- Dissolved in anisole or toluene and diluted with tridecane for analysis by GC/MS. The method internal standards will be prepared in isooctane for spiking into samples.
- Prepared in quantities of at least 1 mL. Prepare enough method internal standard to last the entire project.
- Prepared in concentrations listed in Table A4-2. Each working standard solution will be prepared to contain the same concentration of each of the isotopically stable labeled method internal standards but a different concentration of native calibration standards. The ratio of native calibration standards to method internal standards will range from 0.05 to 4.
- Replaced after 6 months or sooner if comparison with quality control check samples indicates compound degradation or concentration change.

The GC performance check mixture will be per Table A4-3 with each isomer at a concentration equivalent to DF50 from Table A4-2.

TABLE A4-1. LIST OF ANALYTES, METHOD INTERNAL STANDARDS (SURROGATES), AND RECOVERY INTERNAL STANDARDS FOR DIOXIN/FURAN ANALYSIS

Analyte	Compounds in calibration standard	Method internal standard[a]	Recovery internal standard[b]
Tetra-CDD	2,3,7,8-TCDD	$^{13}C_{12}$-2,3,7,8-TCDD	$^{13}C_{12}$-1,2,3,4-TCDD[c]
Tetra-CDF	2,3,7,8-TCDF	$^{13}C_{12}$-2,3,7,8-TCDF	
Penta-CDD	1,2,3,7,8-PeCDD	$^{13}C_{12}$-1,2,3,7,8-PeCDD	
Penta-CDF	1,2,3,7,8-PeCDF	$^{13}C_{12}$-1,2,3,7,8-PeCDF	
Penta CDF	2,3,4,7,8-PeCDF		
Hexa-CDD	1,2,3,4,7,8-HxCDD	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	
Hexa-CDD	1,2,3,6,7,8-HxCDD		
Hexa-CDD	1,2,3,7,8,9-HxCDD		$^{13}C_{12}$-1,2,3,7,8,9-HxCDD[d]
Hexa-CDF	1,2,3,4,7,8-HxCDF	$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	
Hexa-CDF	1,2,3,6,7,8-HxCDF		
Hexa-CDF	2,3,4,6,7,8-HxCDF		
Hexa-CDF	1,2,3,7,8,9-HxCDF		
Hepta-CDD	1,2,3,4,6,7,8-HpCDD	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	
Hepta-CDF	1,2,3,4,6,7,8-HpCDF	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	
Hepta-CDF	1,2,3,4,7,8,9-HpCDF		
Octa-CDD	OCDD	$^{13}C_{12}$-OCDD	
Octa-CDF	OCDF		

[a] Added to sample prior to extraction.

[b] Added to sample at time of injection into GC/MS.

[c] Used for recovery determinations of TCDD, TCDF, PeCDD, and PeCDF method internal standards.

[d] Used for recovery determinations of HxCDD, HxCDF, HpCDD, HpCDF, and OCDD method internal standards.

TABLE A4-2. SUGGESTED CONCENTRATIONS OF CONGENERS IN TCDD/TCDF-OCDD/OCDF CALIBRATION STANDARDS, METHOD INTERNAL STANDARDS (SURROGATES), AND RECOVERY INTERNAL STANDARDS FOR SIM ANALYSIS

Compound	Concentration (pg/µL)				
	DF2.5	DF5	DF10	DF50	DF200
Unlabeled Analytes					
2,3,7,8-TCDD	2.5	5	10	50	200
2,3,7,8-TCDF	2.5	5	10	50	200
1,2,3,7,8-PeCDD	2.5	5	10	50	200
1,2,3,7,8-PeCDF	2.5	5	10	50	200
2,3,4,7,8-PeCDF	2.5	5	10	50	200
1,2,3,4,7,8-HxCDD	6.25	12.5	25	125	500
1,2,3,6,7,8-HxCDD	6.25	12.5	25	125	500
1,2,3,7,8,9-HxCDD	6.25	12.5	25	125	500
1,2,3,4,7,8-HxCDF	6.25	12.5	25	125	500
1,2,3,6,7,8-HxCDF	6.25	12.5	25	125	500
1,2,3,7,8,9-HxCDF	6.25	12.5	25	125	500
2,3,4,6,7,8-HxCDF	6.25	12.5	25	125	500
1,2,3,4,6,7,8-HpCDD	6.25	12.5	25	125	500
1,2,3,4,6,7,8-HpCDF	6.25	12.5	25	125	500
1,2,3,4,7,8,9-HpCDF	6.25	12.5	25	125	500
OCDD	12.5	25	50	250	1,000
OCDF	12.5	25	50	250	1,000
Internal Standards					
$^{13}C_{12}$-2,3,7,8-TCDD	50	50	50	50	50
$^{13}C_{12}$-2,3,7,8-TCDF	50	50	50	50	50
$^{13}C_{12}$-1,2,3,7,8-PeCDD	50	50	50	50	50
$^{13}C_{12}$-1,2,3,7,8-PeCDF	50	50	50	50	50
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	125	125	125	125	125
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	125	125	125	125	125
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	125	125	125	125	125
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	125	125	125	125	125
$^{13}C_{12}$-OCDD	250	250	250	250	250
Recovery Standards					
$^{13}C_{12}$-1,2,3,4-TCDD[a]	50	50	50	50	50
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD[b]	125	125	125	125	125

[a] Used for recovery determinations of TCDD, TCDF, PeCDD, and PeCDF internal standards.

[b] Used for recovery determinations of HxCDD, HxCDF, HpCDD, HpCDF, and OCDD internal standards.

TABLE A4-3. PCDD AND PCDF CONGENERS PRESENT IN THE GC PERFORMANCE EVALUATION SOLUTION AND USED FOR DEFINING THE HOMOLOGOUS GC RETENTION TIME WINDOWS ON A 60-m DB-5 COLUMN[a]

No. of chlorine atoms	PCDD-positional isomer		PCDF-positional isomer	
	Early eluter	Late eluter	Early eluter	Late eluter
4[b]	1,3,6,8	1,2,8,9	1,3,6,8	1,2,8,9
5	1,2,4,6,8/ 1,2,4,7,9	1,2,3,8,9	1,3,4,6,8	1,2,3,8,9
6	1,2,3,4,6,8	1,2,3,4,6,7	1,2,3,4,6,8	1,2,3,4,8,9
7	1,2,3,4,6,7,8	1,2,3,4,6,7,9	1,2,3,4,6,7,8	1,2,3,4,6,7,9
8		1,2,3,4,6,7,8,9		1,2,3,4,6,7,8,9

[a] Tetra- and penta-CDD and CDFs will be at 50 pg/µL, hexa- and hepta-CDD and CDFs will be at 125 pg/µL, and octa-CDD and CDFs will be at 250 pg/µL.

[b] In addition to these two PCDD isomers, the 1,2,3,4-, 1,2,3,7-, 1,2,3,8-, 2,3,7,8-, $^{13}C_{12}$-2,3,7,8-, and 1,2,3,9-TCDD isomers must also be present.

6.0 GC/MS ANALYSIS OF PCDD/PCDFs

Analysis for PCDD/PCDFs will be performed in accordance to SW-846 Draft Method 8290. This method employs high resolution gas chromatography/ high resolution mass spectrometry techniques to measure parts-per-trillion and lower levels of PCDD/PCDFs in soil, sediment, and aqueous samples. MRI has adapted the method for analysis of PCDD/PCDFs in MM5 sampling train components.

MRI will use in-house developed software to reduce and quantify the results for all samples. In addition, the data from a selected number of samples will be reduced manually to validate the results obtained from the MRI developed software.

6.1 Instrument Requirements and Operating Conditions

The following analytical instrument requirements and operating conditions will be used for the analysis of PCDD/PCDFs by GC/HRMS.

- Mass spectrometer--double focusing, capable of maintaining static resolving power at a minimum of 10,000 (10% valley). Should be operated in the electron impact mode at a nominal electron energy of 70 eV. The mass spectrometer must be operated in the selected ion monitoring (SIM) mode. System must be capable of acquiring data at a minimum of 10 ions per scan.
- Scan time--1 s or less (including voltage reset time).
- Scan range--202 to 472 amu, SIM mode monitoring the ions listed in Table A4-4.
- Resolution--10,000.
- Analytical column--DB-5, 60-m x 0.32-mm ID, 25-µm film thickness.
- Carrier gas--Helium, 20 to 40 cm/s.
- Injector--Grob type, splitless mode at 270°C, splitless valve time of 45 s.
- Injection volume--1 to 2 µL, same volume used for all standards and samples.
- Transfer line temperature--350°C.
- Temperature program--200°C (2-min hold), increase to 220°C at 5°C/min (16-min hold), increase to 235 at 5°C/min (7-min hold), increase to 330°C at 5°C/min (5-min hold).

TABLE A4-4. IONS MONITORED FOR HRGC/HRMS ANALYSIS OF PCDD/PCDFs (S = INTERNAL/RECOVERY STANDARD)

Descriptor	Accurate(a) Mass	Ion ID	Elemental Composition	Analyte
1	303.9016	M	$C_{12}H_4{}^{35}Cl_4O$	TCDF
	305.8987	M+2	$C_{12}H_4{}^{35}Cl_3{}^{37}ClO$	TCDF
	315.9419	M	${}^{13}C_{12}H_4{}^{35}Cl_4O$	TCDF (S)
	317.9389	M+2	${}^{13}C_{12}H_4{}^{35}Cl_3{}^{37}ClO$	TCDF (S)
	319.8965	M	$C_{12}H_4{}^{35}Cl_4O_2$	TCDD
	321.8936	M+2	$C_{12}H_4{}^{35}Cl_3{}^{37}ClO_2$	TCDD
	331.9368	M	${}^{13}C_{12}H_4{}^{35}Cl_4O_2$	TCDD (S)
	333.9339	M+2	${}^{13}C_{12}H_4{}^{35}Cl_3{}^{37}ClO_2$	TCDD (S)
	375.8364	M+2	$C_{12}H_4{}^{35}Cl_6O$	HxCDPE
	[354.9792]	LOCK	C_9F_{13}	PFK
2	339.8597	M+2	$C_{12}H_3{}^{35}Cl_4{}^{37}ClO$	PeCDF
	341.8567	M+4	$C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O$	PeCDF
	351.9000	M+2	${}^{13}C_{12}H_3{}^{35}Cl_4{}^{37}ClO$	PeCDF (S)
	353.8970	M+4	${}^{13}C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O$	PeCDF (S)
	355.8546	M+2	$C_{12}H_3{}^{35}Cl_4{}^{37}ClO_2$	PeCDD
	357.8516	M+4	$C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O_2$	PeCDD
	367.8949	M+2	${}^{13}C_{12}H_3{}^{35}Cl_4{}^{37}ClO_2$	PeCDD (S)
	369.8919	M+4	${}^{13}C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O_2$	PeCDD (S)
	409.7974	M+2	$C_{12}H_3{}^{35}Cl_7O$	HpCDPE
	[354.9792]	LOCK	C_9F_{13}	PFK

(Continued)

TABLE A4-4 (continued)

Descriptor	Accurate Mass	Ion ID	Elemental Composition	Analyte
3	373.8208	M+2	$C_{12}H_2{}^{35}Cl_5{}^{37}ClO$	HxCDF
	375.8178	M+4	$C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O$	HxCDF
	383.8642	M	${}^{13}C_{12}H_2{}^{35}Cl_6O$	HxCDF (S)
	385.8610	M+2	${}^{13}C_{12}H_2{}^{35}Cl_5{}^{37}ClO$	HxCDF (S)
	389.8156	M+2	$C_{12}H_2{}^{35}Cl_5{}^{37}ClO_2$	HxCDD
	391.8127	M+4	$C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O_2$	HxCDD
	401.8559	M+2	${}^{13}C_{12}H_2{}^{35}Cl_5{}^{37}ClO_2$	HxCDD (S)
	403.8529	M+4	${}^{13}C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O_2$	HxCDD (S)
	445.7555	M+4	$C_{12}H_2{}^{35}Cl_6{}^{37}Cl_2O$	OCDPE
	[354.9792]	LOCK	C_9F_{13}	PFK
4	407.7818	M+2	$C_{12}H{}^{35}Cl_6{}^{37}ClO$	HpCDF
	409.7789	M+4	$C_{12}H{}^{35}Cl_5{}^{37}Cl_2O$	HpCDF
	417.8253	M	${}^{13}C_{12}H{}^{35}Cl_7O$	HpCDF (S)
	419.8220	M+2	${}^{13}C_{12}H{}^{35}Cl_6{}^{37}ClO$	HpCDF (S)
	423.7766	M+2	$C_{12}H{}^{35}Cl_6{}^{37}ClO_2$	HpCDD
	425.7737	M+4	$C_{12}H{}^{35}Cl_5{}^{37}Cl_2O_2$	HpCDD
	435.8169	M+2	${}^{13}C_{12}H{}^{35}Cl_6{}^{37}ClO_2$	HpCDD (S)
	437.8140	M+4	${}^{13}C_{12}H{}^{35}Cl_5{}^{37}Cl_2O_2$	HpCDD (S)
	479.7165	M+4	$C_{12}H{}^{35}Cl_7{}^{37}Cl_2O$	NCDPE
	[430.9728]	LOCK	C_9F_{17}	PFK

(Continued)

TABLE A4-4 (continued)

Descriptor	Accurate Mass	Ion ID	Elemental Composition	Analyte
5	441.7428	M+2	$C_{12}{}^{35}Cl_7{}^{37}ClO$	OCDF
	443.7399	M+4	$C_{12}{}^{35}Cl_6{}^{37}Cl_2O$	OCDF
	457.7377	M+2	$C_{12}{}^{35}Cl_7{}^{37}ClO_2$	OCDD
	459.7348	M+4	$C_{12}{}^{35}Cl_6{}^{37}Cl_2O_2$	OCDD
	469.7779	M+2	${}^{13}C_{12}{}^{35}Cl_7{}^{37}ClO_2$	OCDD (S)
	471.7750	M+4	${}^{13}C_{12}{}^{35}Cl_6{}^{37}Cl_2O_2$	OCDD (S)
	513.6775	M+4	$C_{12}{}^{35}Cl_8{}^{37}Cl_2O$	DCDPE
	[430.9728]	LOCK	C_9F_{17}	PFK

(a)The following nuclidic masses were used:

H = 1.007825

C = 12.000000

13C = 13.003355

O = 15.994915

${}^{35}Cl$ = 34.968853

${}^{37}Cl$ = 36.965903

6.2 Instrument Tuning and Calibration

The GC/MS must be tuned and calibrated every day during which samples are to be analyzed. The following tests must be performed at the beginning and end of each 12-h period (except as specified below) of sample analysis.

6.2.1 Mass Calibration--

The following tests are used to check the mass spectrometer's resolving power and mass accuracy. These tests are conducted because the mass of the ions monitored are exact (to four decimal places), and even slight instrumental drift may result in incorrect masses being monitored. These tests are to be performed at the beginning and end of each 12-h period of consecutive analysis.

6.2.1.1 Introduce a small amount of PFK (perfluorokerosene) into the system by molecular leak. The level of PFK introduced into the system should be adjusted so that the amplitude of the most intense lock-mass ion signal does not exceed 10% of the full-scale deflection.

6.2.1.2 The mass resolution check is accomplished by recording the peak profiles of m/z 304.9824 and 380.9760 of PFK on a calibrated mass scale (horizontal axis, amu or ppm per division) and measuring the width of the latter peak at the 5% abundance level over a 200-ppm range. The peak width must not exceed 100 ppm (or 0.038 amu).

6.2.1.3 Confirm that the exact mass of m/z 380.9760 is within 5 ppm of the required value.

6.2.2 GC Column Performance Check--

A GC column performance check mixture contains the known first and last chromatographic eluters for each group of PCDD/PCDF congeners, such that all of the congeners within a homologous series will elute between the first and last eluters. In addition, the GC performance check mixture contains 2,3,7,8-TCDD and several other TCDD congeners which elute close to 2,3,7,8-TCDD. This solution is analyzed to establish the retention times at which the ions monitored will be switched to a different set of ions, and also to determine the chromatographic resolution between 2,3,7,8-TCDD and the closest eluting TCDD congener. The GC column performance mix will be analyzed once at the beginning of each 12-h analysis, after performing the mass resolution and accuracy test described above.

6.2.2.1 Inject 2 µL of the GC performance check mixture (Table 3) and acquire SIM data as described in Table 4.

6.2.2.2 Determine the chromatographic resolution between 2,3,7,8-TCDD and the closest eluting TCDD peak. This is accomplished by the following equation:

$$\text{Resolution (\% valley)} = (x \div y) \times 100$$

where: x = total height of the valley (from baseline) separating 2,3,7,8-TCDD and the closest eluting TCDD

y = total peak height (from baseline) of 2,3,7,8-TCDD

6.2.2.3 The resolution must be ≤ 25%.

6.2.2.4 Determine the retention time (or scan number) of the first and last eluter for each homologous series. Print out an RIC (reconstructed ion chromatogram) for each of the five homologous series (Cl_4 to Cl_8) and label each peak together with an "F" for the first eluter and an "L" for the last eluter in the series. These retention times will be used to establish the switching times for the SIM descriptors.

6.2.2.5 Allowable tolerance on the daily verification of the GC performance check mixture will be ±10-s drift on the absolute retention times of all components.

6.2.3 Instrument Calibration--

Before any samples can be analyzed, an initial five-point calibration will be performed. This calibration will be verified at the beginning and end of each 12-h period of sample analysis.

6.2.3.1 Initial calibration--Initial calibration is required before any samples may be analyzed, but after all of the tests described above have been successfully completed. Initial calibration is also required if any continuous calibration check is not successful.

6.2.3.1.1 Analyze 2 µL of each of the five calibration solutions. Note that prior to analysis, each solution must be spiked with the appropriate amount of the recovery internal standards mix (50 pg/µL of ^{13}C-1,2,3,4-TCDD and 125 pg/µL of ^{13}C-1,2,3,7,8,9-HxCDD).

6.2.3.1.2 Confirm that the ratio of the areas for each of the two ions monitored for each homologous set of congeners and for the ^{13}C-labeled internal standards are within the control limits indicated in Table A4-5.

6.2.3.1.3 Confirm that the signal-to-noise (S/N) ratio for each target compound is ≥ 2.5.

6.2.3.1.4 Calculate the relative response factors (RRF) for each of the 17 unlabeled PCDD/PCDF target analytes relative to the appropriate method internal standards (surrogates) and for each of the 9 labeled PCDD/PCDF internal standards relative to the appropriate recovery internal standards.

6.2.3.1.5 Calculate the average RRF and the percent relative standard deviation (RSD) for each target compound. For the initial calibration to be acceptable, the % RSD of the average RRFs must be < 20%.

TABLE A4-5. THEORETICAL ION ABUNDANCE RATIOS AND THEIR CONTROL LIMITS FOR PCDDs AND PCDFs

Number of Chlorine Atoms	Ion Type	Theoretical Ratio	Control Limits	
			lower	upper
4	$\frac{M}{M+2}$	0.77	0.65	0.89
5	$\frac{M+2}{M+4}$	1.55	1.24	1.86
6	$\frac{M+2}{M+4}$	1.24	1.05	1.43
6(a)	$\frac{M}{M+2}$	0.51	0.43	0.59
7(b)	$\frac{M}{M+2}$	0.44	0.37	0.51
7	$\frac{M+2}{M+4}$	1.04	0.88	1.20
8	$\frac{M+2}{M+4}$	0.89	0.76	0.89

(a) Used only for ^{13}C-HxCDF (IS).
(b) Used only for ^{13}C-HpCDF (IS).

6.2.3.2 Continuing calibration--Continuing calibration must be conducted at the beginning of each 12-h period of analysis after successful mass accuracy and resolution GC resolution performance checks. Continuous calibration is also required at the end of a 12-h shift, before the final mass resolution and accuracy check. If the continuing calibration does not meet criteria, the initial calibration must be repeated and the samples reanalyzed except as noted below.

6.2.3.2.1 Analyze 2 µL of the midlevel calibration solutions. Note that prior to analysis, each solution must be spiked with the appropriate amount of the recovery internal standards mix (50 pg/µL of ^{13}C-1,2,3,4-TCDD and 125 pg/µL of ^{13}C-1,2,3,7,8,9-HxCDD).

6.2.3.2.2 Confirm that the ratio of the areas for each of the two ions monitored for each homologous set of congeners and for the ^{13}C-labeled internal standards must be within control limits.

6.2.3.2.3 Calculate the relative response factors (RRF) for each of the 17 unlabeled PCDD/PCDF target analytes relative to the appropriate method internal standards (surrogates) and for each of the 9 labeled PCDD/PCDF internal standards relative to the appropriate recovery internal standards.

6.2.3.2.3.1 For the continuing calibration to be acceptable, the RRFs must be within ±20% of the average RRF from the initial calibration.

6.2.3.2.3.2 If the end-of-the-day continuing calibration check standard has RRFs that are not within 20% but are within ±25% of the average RRF from the curve, samples analyzed during that 12-h period will be calculated using the average RRF from the beginning-of-day and the end-of-day standards.

6.2.3.2.3.3 If the end-of-day continuing calibration check standard has RRFs that are not within 25% of the average RRF from the curve, all positive samples analyzed during that 12-h period are invalidated and must be reanalyzed.

6.3 Sample Analysis

Samples may be analyzed only after the initial tuning and calibration requirements have been met. In addition, a solvent blank must be analyzed before any samples can be injected.

6.3.1 Adjust the volume of each sample to be analyzed to the final amount.

6.3.2 Add recovery internal standards to each sample or portion thereof such that there are 50 pg/µL of ^{13}C-1,2,3,4-TCDD and 125 pg/µL of ^{13}C-1,2,3,7,8,9-HxCDD.

6.3.3 Inject 2 µL of a hexane solvent blank. If the the blank contains any of the 2,3,7,8-substituted congeners at more than 10% of the detection limit, the results of all positive samples analyzed on that 12-h shift are invalidated and will require reanalysis.

6.3.4 Analyze 2 µL of each sample.

6.4 Data Reduction

Data reduction of each sample run consists of confirmation of target compounds identification and quantification of the compounds detected.

6.4.1 Documentation--

For each sample analyzed, the following documentation must accompany analytical results for the purpose of their validation.

6.4.1.1 Reconstructed ion chromatogram (RIC) with a header identifying the sample or standard by a unique laboratory designator.

6.4.1.2 Extracted current ion profiles (EICPs) for each compound detected within the appropriate retention time window. For each compound, there must be one EICP page which will include the name of the compound monitored in the page header, and the following information. All peaks must include scan numbers and areas found. The primary and secondary quantitation ions must be printed together with the appropriate PCDPE interferent ion.

6.4.2 Compound Identification Criteria--

For a GC peak to be positively identified as a PCDD/PCDF, it must meet all of the following criteria:

6.4.2.1 For 2,3,7,8-substituted congeners which have an equivalent ^{13}C-labeled method or recovery internal standard in the sample extract, the retention times of the unlabeled congeners must be within -1 and +3 s of the retention time of the equivalent ^{13}C-labeled congener.

6.4.2.2 For 2,3,7,8-substituted congeners that do not have an equivalent ^{13}C-labeled congener in the sample extract, the relative retention time (RRT) of the unlabeled congener must be within the established GC retention window for its homologous series.

6.4.2.3 For non-2,3,7,8-substituted congeners, the retention time must be within the established GC retention window for its homologous series.

6.4.2.4 The ion current responses for the primary and secondary ions used for confirmation and quantification purposes must reach their apex within ±2 s of each other.

6.4.2.5 The ion abundance ratios of both ions used for quantitative purposes must be within the tolerance limits for the homologous series to which the peak is assigned.

6.4.2.6 Signal-to-noise ratios must be ≥ 2.5 for compounds tentatively identified.

6.4.2.7 Because polychlorinated diphenyl ethers (PCDPE) are a common interferent for analysis of PCDFs, the extracted ion current plot of the corresponding PCDPE must have a S/N ratio < 2.5.

6.4.3 Quantification--

The amount of each 2,3,7,8-substituted congener included in the calibration standards will be calculated together with total tetra- to octa-PCDD/PCDFs using the formula:

$$C_x = \frac{(\text{area}_{\text{quantitation ion}} \times \text{amount}_{\text{internal standard [}\mu\text{g]}})}{(\text{area}_{\text{internal standard}} \times \text{RRF}_{\text{average}} \times \text{amount extracted [g or L]})}$$

where: C_x = concentration [µg/g or µg/L] or total amount [µg] found in the sample. If convenient, the units may be changed to reflect the magnitude of the value of C_x.

$\text{RRF}_{\text{average}}$ is the average RRF for each individual congener in the calibration mixtures or is representative of the RRF for that homologous group of congeners.

- For congeners that belong to a homologous series containing only one isomer (i.e., OCDD and OCDF) or only one 2,3,7,8-substituted congener (TCDDs, PeCDDs, HpCDDs and TCDFs), the average RRF to be used will be the same as that used for the individual compounds.
- For congeners that belong to a homologous series containing more than one 2,3,7,8-substituted congener (i.e., HxCDD, PeCDF, HxCDF, and HpCDF), the average RRF to be used will be the mean of the average RRFs calculated for the 2,3,7,8-substituted congeners representative of that homologous series analyzed during calibration.
- Please be sure to note Sections 6.2.3.2.3.1 to 6.2.3.2.3.3 for specific cases in which the average RRF from the curve will not be used.

6.5 SW-846 Method Modifications, Deviations, and Enhancements

The following modifications, deviations, and enhancements from SW-846 and other standard methods will be employed during this study. None are expected to impact the quality of the results submitted.

6.5.1 Method 8290 specifies that before any samples are analyzed, a method blank associated to the samples be analyzed. MRI will instead analyze a solvent blank to confirm that there is no carryover in the chromatographic system. If any method blank presents contamination problems, the specific causes of the problem will be investigated and reported.

6.4.2.7 Because polychlorinated diphenyl ethers (PCDPE) are a common interferent for analysis of PCDFs, the extracted ion current plot of the corresponding PCDPE must have a S/N ratio < 2.5.

6.4.3 Quantification--

The amount of each 2,3,7,8-substituted congener included in the calibration standards will be calculated together with total tetra- to octa-PCDD/PCDFs using the formula:

$$C_x = \frac{(\text{area}_{\text{quantitation ion}} \times \text{amount}_{\text{internal standard}}\ [\mu g])}{(\text{area}_{\text{internal standard}} \times \text{RRF}_{\text{average}} \times \text{amount extracted}\ [g\ \text{or}\ L])}$$

where: C_x = concentration [µg/g or µg/L] or total amount [µg] found in the sample. If convenient, the units may be changed to reflect the magnitude of the value of C_x.

$\text{RRF}_{\text{average}}$ is the average RRF for each individual congener in the calibration mixtures or is representative of the RRF for that homologous group of congeners.

- For congeners that belong to a homologous series containing only one isomer (i.e., OCDD and OCDF) or only one 2,3,7,8-substituted congener (TCDDs, PeCDDs, HpCDDs and TCDFs), the average RRF to be used will be the same as that used for the individual compounds.
- For congeners that belong to a homologous series containing more than one 2,3,7,8-substituted congener (i.e., HxCDD, PeCDF, HxCDF, and HpCDF), the average RRF to be used will be the mean of the average RRFs calculated for the 2,3,7,8-substituted congeners representative of that homologous series analyzed during calibration.
- Please be sure to note Sections 6.2.3.2.3.1 to 6.2.3.2.3.3 for specific cases in which the average RRF from the curve will not be used.

6.5 SW-846 Method Modifications, Deviations, and Enhancements

The following modifications, deviations, and enhancements from SW-846 and other standard methods will be employed during this study. None are expected to impact the quality of the results submitted.

6.5.1 Method 8290 specifies that before any samples are analyzed, a method blank associated to the samples be analyzed. MRI will instead analyze a solvent blank to confirm that there is no carryover in the chromatographic system. If any method blank presents contamination problems, the specific causes of the problem will be investigated and reported.

APPENDIX A-5

TOC ANALYSIS METHODS

TOTAL ORGANIC AND CARBONATE CARBON CONTENT OF SEDIMENTS

1.0 INTRODUCTION

Precise measurements of total organic and carbonate carbon are necessary for interpreting trace organic contamination. Carbon concentrations are determined on freeze-dried (or oven-dried at 40° to 50°C) sediment using a LECO Model 523-300 induction furnace (or equivalent) to burn samples in an oxygen atmosphere. The carbon dioxide that is produced is swept out of the furnace's combustion chamber by the oxygen flow. The gases then pass through a dust trap and two reaction tubes. The first of these is a two-stage chamber with the first stage consisting of manganese dioxide. The manganese dioxide absorbs the sulfur oxides that may have formed during combustion. The second stage is made of anhydrone which removes water vapor from the gas stream. The second tube, filled with platinized silica, is maintained at an elevated temperature by an external heating case. The contents of this tube act as a catalyst to convert any carbon monoxide present into carbon dioxide. Carbon dioxide is detected and quantified with a Horiba PIR-2000 infrared detector. The output signal from the Horiba is sent to a HP 3396A integrator which reports the quantity of carbon dioxide as a peak area.

Total organic carbon is determined after sample acidification. Carbonate carbon is determined as the difference between total carbon and total organic carbon.

2.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

2.1 Sample Collection

Sediment should be collected in precleaned and/or pre-combusted (400°C) glass jars, or core liners and frozen (-20°C) in the field.

2.2 Sample Preservation and Storage

Sediment samples are shipped frozen to the laboratory and stored at -20°C until analysis. After subsampling excess sample is archived at -20°C in the dark.

3.0 APPARATUS AND MATERIALS

3.1 Labware and Apparatus

The following labware and equipment is needed to perform the total organic carbon and total carbon analyses:

Freeze Drier: Capable of freeze drying sediment at -40°C.

Mortar and Pestal: 500-ml mortar or other suitable container.

LECO Model 523-300 Induction Furnace

Horiba PIR-2000 Infrared Detector: Or other suitable detector.

HP 3396A Integrator: Or other suitable recorder/integrator.

Glass Measuring Scoop

Drying Oven: Capable of maintaining 40° to 50°C.

Analytical Balance: Capable of weighing to 1 mg.

Rotameter: Part No. 112-02, Cole-Parmer, Inc.

Flow Controller: Part No. 42300513, Veriflo Corp.

Note: Volumetric glassware for accelerator measurement and analytical balances must be calibrated.

3.2 Reagents

The following reagents are required:

10% HCl in Methanol (V:V)

LECO Iron Chip Accelerator: Part No. 501--077, Leco Corp.

LECO Copper Metal Accelerator: Part No. 501-263, Leco Corp.

LECO Combustion Crucibles

LECO Pin and Ring Carbon Standards: Range: 0.1 to 1.0% carbon.

4.0 PROCEDURE

4.1 Leco System Preparation

The first step in operating the LECO furnace is to turn it on by flipping all switches on the front panel to the "ON" (up) position. The "Grid Tap Switch" should be set to the "MED" position. The instrument then needs a warm-up period of at least 30 minutes. When the furnace has had time to warm-up, close the oven on the right side of the instrument (pedestal up) and open the valve on the oxygen tank; set the regulator pressure to 40 psi. Open the toggle valve and allow oxygen to flow through the system for 15 seconds and then check the flow rate using the rotameter. Set to the 150 mark on the rotameter tube with the knob on the flow controller to the right of the rotameter. After 30 seconds of correct flow, zero the panel meter on the front of the Horiba Infrared Analyzer. Set the Horiba Infrared Analyzer detector range to 3, and the span to 0.

4.2 Total Carbon Determination

4.2.1 Sample Preparation

Weigh 10 to 500 mg of freeze dried (or oven dried) sediment into a tared crucible. The amount of sample depends upon the expected carbon concentration. Ideally between 0.5 mg and 8.6 mg of carbon should be combusted to fall within the range of the standard curve.

Add one scoop each of the copper and iron chip accelerators to all the weighed crucibles containing samples. All crucibles should be kept covered with aluminum foil prior to analyses.

4.2.2 Sample Analyses

Place the crucible on the oven pedestal. Close the oven and start the oxygen flow. Allow the oxygen to flow for 15 seconds and then check the flow rate on the rotameter and adjust the flow, if needed. After 15 seconds of correct flow, push the pedestal lever in to start the induction furnace. At the same time push the "START" button on the HP integrator. About 20 seconds after the furnace is activated the metals should begin to burn. After about another 20 seconds the detector should begin to register carbon dioxide in the gas flow and the integrator should begin to show a peak. At this point carefully pull the lever out to turn the furnace OFF -- be sure that you don't open the combustion chamber. Once the integrator has returned to baseline, carefully open the oven and press STOP on the integrator. Use a pair of large tweezers or tongs to take the hot crucible off the oven pedestal and place it on a non-flammable heat-resistant surface to cool. Repeat this procedure for all crucibles to be run.

4.2.3 Standard Analyses

Stardard Leco pin and ring carbon standards are placed into an empty crucible with one scoop of the copper accelerator. Standards are analyzed per the identical procedure as outlined in Section 4.2.2.

4.3 Total Organic Carbon Determination

4.3.1 Sample Preparation

Weigh an appropriate amount of freeze dried (or oven dried) sample as per step 4.2.1 into a tared crucible. Add small amounts of 10% HCl in methanol solution slowly to the sample until all bubbling stops. Use a minimal amount of acid. Dry the treated samples overnight at $50^{O}C$ in the drying oven.

4.3.2 Sample Analyses

Combust and analyze as indicated in Section 4.2.2.

4.3.3 Standard Analyses

Standards are analyzed per the identical procedure as outlined in Section 4.2.3.

4.4 Total Carbonate Carbon Content

Carbonate content is determined by subtracting the total organic carbon concentration from the total carbon concentration. To express as percent calcium carbonate, instead of total carbonate carbon content, multiply this result by 8.33.

5.0 STANDARDIZATION AND CALCULATIONS

Prior to combusting samples, a set of standards is run to determine a standard curve. Standard curves vary slightly from day to day.

5.1 To determine the curve, combust a set of five standards at varying concentrations. Several standard rings and/or pins may need to be run initially to bring the system to correct operating conditions; the data collected will be discarded. The values of the standards in the set should be selected to cover the 0.1 to 1.0% carbon range (1 gram basis).

5.2 A graphics package on a Macintosh (such as Kaleidagraph) is used to make a graph of carbon percentage vs. integrator counts. This software is used to determine a best fit equation for the data. R should be no less than .99 or the data set should be discarded and another set of five calibration points should be run and plotted. This equation will be used to determine the carbon percentage of samples for that day.

5.3 The counts reported by the integrator for a sample are simply entered for X in the equation and Y becomes an intermediate value. The Y value is divided by the sample weight in grams to determine the percent carbon.

6.0 QUALITY CONTROL

Quality control samples are processed in an identical manner as the actual samples.

6.1 A method blank is run with every 20 samples, or with every sample set, whichever is more frequent. Blank levels should be no more than 3x method detection limit (MDL).

6.2 Duplicate samples are run every 20 samples, or with every sample set. Duplicates should be ± 20% for low level (<1.0% carbon) samples and ± 10% for normal/high level (>1.0% carbon) sample. Duplicates may be somewhat less precise for very inhomogeneous samples (i.e., peats, samples containing twigs, grasses, etc.).

6.3 Reference Materials: Leco pin and ring carbon standards are run as reference materials and standards.

7.0 REPORTNG AND PERFORMANCE CRITERIA

7.1 Reporting Units

Reporting units are percent organic carbon (on a dry weight basis) and percent carbonate carbon (on a dry weight basis).

7.2 Minimum Method Performance Criteria

The minimum method performance standard for the method is detection of 0.02 percent carbon in a sample.

7.3 Significant Figures

Results are reported to two (2) significant figures.

7.4 Duplicate Analyses

All duplicate analyses are reported. Duplicate analyses are run at least every 20 samples.

7.5 Reference Materials

Leco pin and ring carbon standards are analyzed as reference materials and standards.

ORGANIC CARBON, TOTAL

Method 415.1 (Combustion or Oxidation)

STORET NO. Total 00680
Dissolved 00681

1. Scope and Application
   - 1.1 This method includes the measurement of organic carbon in drinking, surface and saline waters, domestic and industrial wastes. Exclusions are noted under Definitions and Interferences.
   - 1.2 The method is most applicable to measurement of organic carbon above 1 mg/1.
2. Summary of Method
   - 2.1 Organic carbon in a sample is converted to carbon dioxide (CO_2) by catalytic combustion or wet chemical oxidation. The CO_2 formed can be measured directly by an infrared detector or converted to methane (CH_4) and measured by a flame ionization detector. The amount of CO_2 or CH_4 is directly proportional to the concentration of carbonaceous material in the sample.
3. Definitions
   - 3.1 The carbonaceous analyzer measures all of the carbon in a sample. Because of various properties of carbon-containing compounds in liquid samples, preliminary treatment of the sample prior to analysis dictates the definition of the carbon as it is measured. Forms of carbon that are measured by the method are:
     - A) soluble, nonvolatile organic carbon; for instance, natural sugars.
     - B) soluble, volatile organic carbon; for instance, mercaptans.
     - C) insoluble, partially volatile carbon; for instance, oils.
     - D) insoluble, particulate carbonaceous materials, for instance; cellulose fibers.
     - E) soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter; for instance, oily matter adsorbed on silt particles.
   - 3.2 The final usefulness of the carbon measurement is in assessing the potential oxygen-demanding load of organic material on a receiving stream. This statement applies whether the carbon measurement is made on a sewage plant effluent, industrial waste, or on water taken directly from the stream. In this light, carbonate and bicarbonate carbon are not a part of the oxygen demand in the stream and therefore should be discounted in the final calculation or removed prior to analysis. The manner of preliminary treatment of the sample and instrument settings defines the types of carbon which are measured. Instrument manufacturer's instructions should be followed.

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4. Sample Handling and Preservation

4.1 Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples. NOTE 1: A brief study performed in the EPA Laboratory indicated that distilled water stored in new, one quart cubitainers did not show any increase in organic carbon after two weeks exposure.

4.2 Because of the possibility of oxidation or bacterial decomposition of some components of aqueous samples, the lapse of time between collection of samples and start of analysis should be kept to a minimum. Also, samples should be kept cool (4°C) and protected from sunlight and atmospheric oxygen.

4.3 In instances where analysis cannot be performed within two hours (2 hours) from time of sampling, the sample is acidified ($pH \leq 2$) with HCl or H_2SO_4.

5. Interferences

5.1 Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be removed or accounted for in the final calculation.

5.2 This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter type syringe or pipette. The openings of the syringe or pipette limit the maximum size of particles which may be included in the sample.

6. Apparatus

6.1 Apparatus for blending or homogenizing samples: Generally, a Waring-type blender is satisfactory.

6.2 Apparatus for total and dissolved organic carbon:

6.2.1 A number of companies manufacture systems for measuring carbonaceous material in liquid samples. Considerations should be made as to the types of samples to be analyzed, the expected concentration range, and forms of carbon to be measured.

6.2.2 No specific analyzer is recommended as superior.

7. Reagents

7.1 Distilled water used in preparation of standards and for dilution of samples should be ultra pure to reduce the carbon concentration of the blank. Carbon dioxide-free, double distilled water is recommended. Ion exchanged waters are not recommended because of the possibilities of contamination with organic materials from the resins.

7.2 Potassium hydrogen phthalate, stock solution, 1000 mg carbon/liter: Dissolve 0.2128 g of potassium hydrogen phthalate (Primary Standard Grade) in distilled water and dilute to 100.0 ml.

NOTE 2: Sodium oxalate and acetic acid are not recommended as stock solutions.

7.3 Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with distilled water.

7.4 Carbonate-bicarbonate, stock solution, 1000 mg carbon/liter: Weigh 0.3500 g of sodium bicarbonate and 0.4418 g of sodium carbonate and transfer both to the same 100 ml volumetric flask. Dissolve with distilled water.

7.5 Carbonate-bicarbonate, standard solution: Prepare a series of standards similar to step 7.3.

NOTE 3: This standard is not required by some instruments.

7.6 Blank solution: Use the same distilled water (or similar quality water) used for the preparation of the standard solutions.

8. Procedure

8.1 Follow instrument manufacturer's instructions for calibration, procedure, and calculations.

8.2 For calibration of the instrument, it is recommended that a series of standards encompassing the expected concentration range of the samples be used.

9. Precision and Accuracy

9.1 Twenty-eight analysts in twenty-one laboratories analyzed distilled water solutions containing exact increments of oxidizable organic compounds, with the following results:

Increment as TOC mg/liter	Precision as Standard Deviation TOC, mg/liter	Accuracy as Bias, %	Accuracy as Bias, mg/liter
4.9	3.93	+15.27	+0.75
107	8.32	+ 1.01	+1.08

(FWPCA Method Study 3, Demand Analyses)

Bibliography

1. Annual Book of ASTM Standards, Part 31, "Water", Standard D 2574–79, p 469 (1976).
2. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 532, Method 505, (1975).

APPENDIX B

SAMPLING AND ANALYSIS DATA

This appendix presents data collected during the test at the Continental Cement wet kiln in Hannibal, MO. Data are presented as follows:

APPENDIX B-1

PROCESS DATA MEASURED BY CONTINENTAL

This appendix contains process data obtained from the facility's process control instruments.

The following terms are used in the process data tables to note readings of the various monitors.

Speed - Rotational speed of the kiln in revolutions per hour.

Feed - Lime slurry feedrate to the kiln in tons per hour.

Dust - Recycle rate of dust from ESP's to the kiln in tons per hour.

Coal - Feedrate of coal to the kiln in tons per hour.

Waste Fuel - Total waste feedrate (solid plus liquid) expressed as equivalent tons per hour of coal based on heating value.

Fuel/Feed - Ratio of total fuels to total feeds. Fuel is the sum of Coal and Waste Fuel. Feed is the sum of Feed and Dust.

Supp.Fuel - Supplemental fuel feedrate in pounds per minute. Supplemental fuel is either liquid waste or diesel fuel for this test program.

KSWF - Kiln Solid Waste Fuel feedrate expressed as equivalent tons per hour of coal based on heating value.

KSWF (chart) - Kiln Solid Waste Fuel expressed as a numerical value which allows reading a calibration graph to determine solid waste feedrate in tons per hour.

BZT - Burner Zone Temperature is the temperature in Fahrenheit measured at the low (burner) end of the kiln where wastes are fed.

Feed End - Temperature in Fahrenheit of the high end of the kiln, where lime slurry feed is introduced.

Chain - Temperature in Fahrenheit of the chain section of the kiln, located about 2/3 to 3/4 of the way up the kiln.

ESP Inlet - Temperature in Fahrenheit of the inlet to the ESP's.

O2 - Plant oxygen levels in percent. Monitored just upstream of ESP's.

CO - Plant carbon monoxide levels in ppm. Monitor inoperable during all tests conducted.

SO2 - Plant sulfur dioxide levels in ppm. Monitored just upstream of the ID fan.

NOx - Plant nitrogen oxides levels in ppm. Monitored just upstream of the ID fan.

ID Draft - Draft of the ID fan measured in inches of water.

ID % Open - Percent open of the damper on the ID fan.

ID Fan % - Percent of full speed for the ID fan.

ID Fan Amps - Amperage drawn by operation of the ID fan.

Kiln Amps - Total amperage drawn by two motors which turn the kiln.

Opacity - Percent opacity measured by transmissometer on the stack.

Table 1. Summary of Process Data

Run #	Speed (rph)	Feed (tph)	Dust (tph)	Coal (tph)	Waste Fuel	Fuel/Feed	Supp.Fuel (lb/min)	KSWF
Run 1								
Avg.	51	95	18	19.0	0	0.171	0	0
Min.	45	82	0	14.3	0	0.108	0	0
Max.	60	110	24	20.7	0	0.204	0	0
Run 2								
Avg.	67	129	3	11.4	10.5	0.166	264	2
Min.	67	126	1	10.5	10.5	0.152	242	2
Max.	67	129	16.8	12.1	10.5	0.174	276	2
Run 3								
Avg.	70	132	4	11.6	11.5	0.170	306	2
Min.	70	132	1	11.3	11.5	0.164	281	2
Max.	70	132	8	12.2	11.5	0.178	335	2
Run 4								
Avg.	70	132	2	11.9	11.5	0.174	334	2
Min.	70	132	2	11.5	11.5	0.172	326	2
Max.	70	132	5	12.2	11.5	0.177	341	2
Run 5								
Avg.	66	126	9.5	11.8	8	0.144	162	0
Min.	66	126	9.5	11.1	7	0.141	115	0
Max.	66	126	9.5	12.8	8	0.151	200	0
Run 6								
Avg.	66	127	9.9	13.1	6	0.140	126	0
Min.	66	126	9.5	12.6	6	0.135	110	0
Max.	66	128	12	13.8	6	0.144	145	0
HCl Run								
Avg.	57	110	2	8.7	6	0.131	207	0
Min.	50	98	2	4.9	6	0.109	150	0
Max.	66	126	2	12.7	6	0.152	235	0

Run #	KSWF(chart)	BZT (F)	Feed End (F)	Chain (F)	ESP Inlet (F)	O2 (%)	CO (ppm)	SO2 (ppm)
Run 1								
Avg.	0	2447	491	1619	443	3.1	0	805
Min.	0	2240	420	1590	410	1.9	0	274
Max.	0	2530	550	1650	470	5.4	0	1669
Run 2								
Avg.	109	2293	577	1700	502	1.9	0	223
Min.	96	2230	560	1700	500	1.5	0	130
Max.	116	2340	590	1700	510	2.1	0	304
Run 3								
Avg.	76	2274	600	1766	540	2.0	0	422
Min.	30	2200	600	1750	540	1.8	0	282
Max.	88	2375	600	1800	540	2.8	0	572
Run 4								
Avg.	75	2272	600	1785	540	1.9	0	939
Min.	72	2230	600	1760	540	1.7	0	622
Max.	78	2340	600	1800	540	2	0	1180
Run 5								
Avg.	0	2261	544	1590	469	2.0	0	277
Min.	0	2225	530	1590	450	1.6	0	205
Max.	0	2300	560	1590	480	2.6	0	352
Run 6								
Avg.	0	2290	553	1600	480	2.0	0	332
Min.	0	2250	550	1600	480	1.4	0	220
Max.	0	2330	560	1600	480	2.3	0	458
HCl Run								
Avg.	0	2244	571	1693	494	3.5	0	365
Min.	0	2180	560	1660	480	1.6	0	215
Max.	0	2380	580	1740	500	6	0	728

Run #	NOx (ppm)	ID Draft (in.H2O)	ID % Open	ID Fan %	ID Fan Amps	Kiln Amps	Opacity (%)
Run 1							
Avg.	916	-2.0	37	59	65	926	13
Min.	40	-2.4	24	56	63	800	4
Max.	2084	-1.2	46	60	68	980	20
Run 2							
Avg.	619	-3.5	66	60	73	1136	25
Min.	291	-3.8	56	58	70	1050	18
Max.	1043	-3.2	78	60	75	1200	48
Run 3							
Avg.	939	-3.7	83	60	76	1034	33
Min.	273	-4	76	60	75	960	22
Max.	2039	-3.8	90	60	77	1100	53
Run 4							
Avg.	1102	-3.6	78	60	77	1005	39
Min.	817	-3.8	70	60	75	960	31
Max.	1591	-3.4	82	60	77	1050	46
Run 5							
Avg.	344	-4.1	65	60	75	1066	16
Min.	37	-4.2	56	60	75	1000	0
Max.	2017	-3.8	70	60	78	1200	100
Run 6							
Avg.	152	-3.8	57	60	76	1041	15
Min.	48	-4	54	60	75	1000	6
Max.	487	-3.7	58	60	78	1150	22
HCl Run							
Avg.	194	-2.9	52	60	70	1088	10
Min.	23	-3.2	42	60	65	1040	3
Max.	1237	-2.4	60	60	75	1150	22

Run 1 Process Data

Time	Speed	Feed	Dust	Coal	Waste Fuel	Fuel/Feed	Supp.Fuel
1st-3rd Trav.							
1115	49	92	12.5	19.7	0	0.189	0
1130	49	92	0	18.8	0	0.204	0
1145	49	90	8	18.8	0	0.192	0
1200	49	92	15	20	0	0.187	0
1215	50	92	16	20	0	0.185	0
1230	49	93	16	20	0	0.183	0
1245	50	92	20	20.5	0	0.183	0
1300	50	92	20	20.7	0	0.185	0
1315	56	102	20	19.6	0	0.161	0
1330	56	102	22	19.6	0	0.158	0
1345	56	102	24	17.9	0	0.142	0
1400	60	110	24	17.2	0	0.128	0
4th Traverse							
1415	60	110	22	14.3	0	0.108	0
1430	50	94	22	17.7	0	0.153	0
1445	45	84	22	18.9	0	0.178	0
1500	45	82	22	20.6	0	0.198	0
Avg.Trv.1-3							
Average=	52	96	16	19.4	0	0.175	0
Min=	49	90	0	17.2	0	0.128	0
Max=	60	110	24	20.7	0	0.204	0
Avg.Trv.4							
Average=	50	93	22	17.9	0	0.159	0
Min=	45	82	22	14.3	0	0.108	0
Max=	60	110	22	20.6	0	0.198	0
Overall Run							
Average=	51	95	18	19.0	0	0.171	0
Min=	45	82	0	14.3	0	0.108	0
Max=	60	110	24	20.7	0	0.204	0

Time	KSWF	BZT	Feed End	Chain	ESP Inlet	O2	CO
1st-3rd Tra							
1115	0	2400	510	1620	460	2	NA
1130	0	2450	490	1620	450	2.2	NA
1145	0	2400	480	1620	440	2.7	NA
1200	0	2440	480	1620	440	2.1	NA
1215	0	2460	480	1620	435	1.9	NA
1230	0	2460	490	1620	440	2.3	NA
1245	0	2425	510	1620	450	3	NA
1300	0	2490	540	1620	460	2.9	NA
1315	0	2500	550	1620	470	2.6	NA
1330	0	2530	540	1640	470	2.6	NA
1345	0	2475	520	1650	470	4.1	NA
1400	0	2525	470	1650	450	2.6	NA
4th Travers							
1415	0	2525	440	1600	420	5.4	NA
1430	0	2505	420	1600	410	5.1	NA
1445	0	2240	450	1590	410	4.2	NA
1500	0	2320	490	1590	420	4	NA
Avg.Trv.1-3							
Average=	0	2463	505	1627	453	2.6	0
Min=	0	2400	470	1620	435	1.9	0
Max=	0	2530	550	1650	470	4.1	0
Avg.Trv.4							
Average=	0	2398	450	1595	415	4.7	0
Min=	0	2240	420	1590	410	4	0
Max=	0	2525	490	1600	420	5.4	0
Overall Run							
Average=	0	2447	491	1619	443	3.1	0
Min=	0	2240	420	1590	410	1.9	0
Max=	0	2530	550	1650	470	5.4	0

Time	SO2	NOx	ID Draft	ID % Open	ID Fan %	ID Fan Amps	Kiln Amps
1st-3rd Tra							
1115	850	1554	-1.8	32	60	65	960
1130	1669	1149	-1.6	30	60	63	960
1145	1096	704	-1.9	38	58	65	960
1200	763	1469	-1.8	32	56	65	960
1215	862	2084	-1.8	35	60	65	960
1230	898	1534	-2.1	40	60	65	960
1245	896	1035	-2.1	42	59	65	960
1300	794	1455	-2	38	60	65	980
1315	724	1277	-2	38	58	65	960
1330	1083	1330	-2.1	40	59	65	900
1345	593	314	-2.4	46	59	65	880
1400	1259	445	-1.2	24	60	63	880
4th Travers							
1415	498	75	-2.2	40	60	65	900
1430	342	40	-2.1	38	59	68	910
1445	275	78	-2.1	38	59	65	800
1500	274	112	-2.2	40	59	65	880
Avg.Trv.1-3							
Average=	957	1196	-1.9	36	59	65	943
Min=	593	314	-2.4	24	56	63	880
Max=	1669	2084	-1.2	46	60	65	980
Avg.Trv.4							
Average=	347	76	-2.2	39	59	66	873
Min=	274	40	-2.2	38	59	65	800
Max=	498	112	-2.1	40	60	68	910
Overall Run							
Average=	805	916	-2.0	37	59	65	926
Min=	274	40	-2.4	24	56	63	800
Max=	1669	2084	-1.2	46	60	68	980

Time	Opacity
1st-3rd Tra	
1115	13
1130	10
1145	14
1200	18
1215	14
1230	17
1245	19
1300	20
1315	19
1330	19
1345	15
1400	8
4th Travers	
1415	4
1430	4
1445	6
1500	9
Avg.Trv.1-3	
Average=	16
Min=	8
Max=	20
Avg.Trv.4	
Average=	6
Min=	4
Max=	9
Overall Run	
Average=	13
Min=	4
Max=	20

Run 2 Process Data

Time	Speed	Feed	Dust	Coal	Waste Fuel	Fuel/Feed	Supp.Fuel
Trv. 1							
1230	67	126	3	11.8	10.5	0.173	242
1245	67	128	16.8	11.5	10.5	0.152	249
1300	67	128	4	11.1	10.5	0.164	252
Trv. 2-4							
1315	67	129	3	10.5	10.5	0.159	271
1330	67	129	3	10.8	10.5	0.161	250
1345	67	129	1	11.1	10.5	0.166	264
1400	67	129	1	12.1	10.5	0.174	266
1415	67	129	3	11	10.5	0.163	264
1430	67	129	4	11.8	10.5	0.168	269
1445	67	129	1	11.8	10.5	0.172	273
1500	67	129	1	10.8	10.5	0.164	274
1515	67	129	1	11.5	10.5	0.169	275
1530	67	129	1	11.7	10.5	0.171	271
1545	67	129	1	11.4	10.5	0.168	276
Avg. Trv.1							
Average=	67	127	7.9	11.5	10.5	0.163	248
Min=	67	126	3	11.1	10.5	0.152	242
Max=	67	128	16.8	11.8	10.5	0.173	252
Avg. Trv.2 -4							
Average=	67	129	1.8	11.3	10.5	0.167	268
Min=	67	129	1	10.5	10.5	0.159	250
Max=	67	129	4	12.1	10.5	0.174	276
Overall Run							
Average=	67	129	3	11.4	10.5	0.166	264
Min=	67	126	1	10.5	10.5	0.152	242
Max=	67	129	16.8	12.1	10.5	0.174	276

Time	KSWF	KSWF(chart)	BZT	Feed End	Chain	ESP Inlet	O2
Trv. 1							
1230	2	116	2340	575	1700	500	1.9
1245	2	116	2325	575	1700	500	1.9
1300	2	114	2325	560	1700	500	1.8
Trv. 2-4							
1315	2	96	2300	560	1700	500	1.9
1330	2	101	2290	560	1700	500	1.9
1345	2	112	2320	565	1700	500	2.1
1400	2	112	2290	570	1700	500	2.1
1415	2	106	2325	575	1700	500	1.6
1430	2	110	2310	585	1700	500	1.5
1445	2	115	2280	590	1700	500	1.8
1500	2	105	2280	590	1700	500	1.6
1515	2	105	2250	590	1700	510	1.9
1530	2	105	2240	590	1700	510	1.9
1545	2	107	2230	590	1700	510	2
Avg. Trv.1							
Average=	2	115	2330	570	1700	500	1.9
Min=	2	114	2325	560	1700	500	1.8
Max=	2	116	2340	575	1700	500	1.9
Avg. Trv.2							
Average=	2	107	2283	579	1700	503	1.8
Min=	2	96	2230	560	1700	500	1.5
Max=	2	115	2325	590	1700	510	2.1
Overall Ru							
Average=	2	109	2293	577	1700	502	1.9
Min=	2	96	2230	560	1700	500	1.5
Max=	2	116	2340	590	1700	510	2.1

Time	CO	SO2	NOx	ID Draft	ID % Open	ID Fan %	ID Fan Amps
Trv. 1							
1230	NA	217	587	-3.6	59	60	70
1245	NA	241	443	-3.4	56	59	70
1300	NA	257	851	-3.5	58	58	70
Trv. 2-4							
1315	NA	173	415	-3.4	56	60	70
1330	NA	130	568	-3.2	56	60	72
1345	NA	204	291	-3.4	60	60	72
1400	NA	282	471	-3.5	60	60	72
1415	NA	225	589	-3.5	62	60	75
1430	NA	213	922	-3.8	72	60	75
1445	NA	194	1043	-3.8	78	60	75
1500	NA	206	789	-3.8	78	60	75
1515	NA	228	946	-3.6	78	60	75
1530	NA	248	439	-3.4	78	60	75
1545	NA	304	317	-3.6	78	60	75
Avg. Trv.1							
Average=	0	238	627	-3.5	58	59	70
Min=	0	217	443	-3.6	56	58	70
Max=	0	257	851	-3.4	59	60	70
Avg. Trv.2							
Average=	0	219	617	-3.5	69	60	74
Min=	0	130	291	-3.8	56	60	70
Max=	0	304	1043	-3.2	78	60	75
Overall Ru							
Average=	0	223	619	-3.5	66	60	73
Min=	0	130	291	-3.8	56	58	70
Max=	0	304	1043	-3.2	78	60	75

Time	Kiln Amps	Opacity
Trv. 1		
1230	1200	18
1245	1200	20
1300	1200	27
Trv. 2-4		
1315	1200	27
1330	1200	20
1345	1200	21
1400	1200	22
1415	1150	25
1430	1050	24
1445	1050	27
1500	1050	23
1515	1050	25
1530	1100	27
1545	1050	48
Avg. Trv.1		
Average=	1200	22
Min=	1200	18
Max=	1200	27
Avg. Trv.2		
Average=	1118	26
Min=	1050	20
Max=	1200	48
Overall Ru		
Average=	1136	25
Min=	1050	18
Max=	1200	48

Run 3 Process Data

Time	Speed	Feed	Dust	Coal	Waste Fuel	Fuel/Feed	Supp.Fuel
1145	70	132	8	11.5	11.5	0.164	281
1200	70	132	8	11.4	11.5	0.164	284
1215	70	132	6	11.3	11.5	0.165	296
1230	70	132	6	11.6	11.5	0.167	287
1245	70	132	6	11.5	11.5	0.167	291
1300	70	132	4	11.6	11.5	0.170	286
1315	70	132	4	11.4	11.5	0.168	282
1330	70	132	3	11.4	11.5	0.170	314
1345	70	132	3	11.5	11.5	0.170	335
1400	70	132	4	11.5	11.5	0.169	308
1415	70	132	4	11.6	11.5	0.170	299
1430	70	132	4	11.6	11.5	0.170	314
1515	70	132	3	11.4	11.5	0.170	307
1530	70	132	1	11.9	11.5	0.176	331
1545	70	132	1	12.1	11.5	0.177	322
1600	70	132	1	12.2	11.5	0.178	315
1615	70	132	5	12.1	11.5	0.172	319
1630	70	132	5	11.7	11.5	0.169	323
1645	70	132	6	11.6	11.5	0.167	312
1700	70	132	6	11.6	11.5	0.167	312
1715	70	132	6	11.8	11.5	0.169	301
Average=	70	132	4	11.6	11.5	0.170	306
Min=	70	132	1	11.3	11.5	0.164	281
Max=	70	132	8	12.2	11.5	0.178	335

Time	KSWF	KSWF(chart)	BZT	Feed End	Chain	ESP Inlet	O2
1145	2	87	2240	600	1760	540	1.9
1200	2	87	2270	600	1780	540	1.9
1215	2	85	2270	600	1760	540	2
1230	2	79	2240	600	1760	540	2
1245	2	69	2240	600	1760	540	2.1
1300	2	71	2240	600	1760	540	2.1
1315	2	71	2260	600	1750	540	2.1
1330	2	44	2260	600	1760	540	2.8
1345	2	30	2280	600	1760	540	2.6
1400	2	77	2275	600	1760	540	2.1
1415	2	79	2250	600	1760	540	2
1430	2	79	2275	600	1760	540	1.9
1515	2	79	2210	600	1760	540	2
1530	2	79	2220	600	1760	540	1.9
1545	2	79	2200	600	1760	540	1.8
1600	2	79	2275	600	1760	540	1.8
1615	2	83	2310	600	1760	540	1.8
1630	2	84	2360	600	1780	540	1.8
1645	2	82	2360	600	1800	540	2
1700	2	83	2375	600	1800	540	2
1715	2	88	2340	600	1780	540	2.1
Average=	2	76	2274	600	1766	540	2.0
Min=	2	30	2200	600	1750	540	1.8
Max=	2	88	2375	600	1800	540	2.8

Time	CO	SO2	NOx	ID Draft	ID % Open	ID Fan %	ID Fan Amps
1145	NA	295	1538	NA	76	60	75
1200	NA	422	1563	-3.8	78	60	75
1215	NA	406	838	-3.8	80	60	75
1230	NA	455	749	-3.9	86	60	75
1245	NA	374	925	-3.9	86	60	75
1300	NA	421	717	-3.9	86	60	75
1315	NA	298	703	-3.9	86	60	75
1330	NA	374	354	-4	86	60	75
1345	NA	439	273	-4	90	60	75
1400	NA	472	776	-3.8	86	60	75
1415	NA	350	1538	-3.9	82	60	77
1430	NA	357	2039	-3.9	82	60	77
1515	NA	282	764	-4	82	60	77
1530	NA	310	659	-4	82	60	77
1545	NA	477	763	-3.8	82	60	77
1600	NA	438	789	-3.8	82	60	77
1615	NA	502	1280	-4	82	60	77
1630	NA	572	1356	-3.8	80	60	77
1645	NA	501	736	-3.8	82	60	77
1700	NA	558	707	-3.8	82	60	77
1715	NA	567	648	-3.8	80	60	77
Average=	0	422	939	-3.7	83	60	76
Min=	0	282	273	-4	76	60	75
Max=	0	572	2039	-3.8	90	60	77

Time	Kiln Amps	Opacity
1145	960	30
1200	1050	31
1215	1050	34
1230	1040	38
1245	1040	32
1300	1000	35
1315	1050	43
1330	1040	33
1345	1040	26
1400	1040	53
1415	960	34
1430	1000	25
1515	1040	28
1530	1050	28
1545	1020	22
1600	1100	27
1615	1050	46
1630	1040	33
1645	1060	30
1700	1050	29
1715	1040	28
Average=	1034	33
Min=	960	22
Max=	1100	53

Run 4 Process Data

Time	Speed	Feed	Dust	Coal	Waste Fuel	Fuel/Feed	Supp.Fuel
1100	70	132	2	11.7	11.5	0.173	340
1115	70	132	2	11.7	11.5	0.173	341
1130	70	132	2	11.5	11.5	0.172	326
1145	70	132	2	12	11.5	0.175	338
1200	70	132	2	12	11.5	0.175	329
1215	70	132	2	11.9	11.5	0.175	330
1230	70	132	2	12.2	11.5	0.177	336
1245	70	132	2	11.8	11.5	0.174	334
1300	70	132	2	12.2	11.5	0.177	341
1315	70	132	2	11.5	11.5	0.172	330
1400	70	132	2	11.9	11.5	0.175	337
1415	70	132	2	12.1	11.5	0.176	329
1430	70	132	5	12.1	11.5	0.172	328
Average=	70	132	2	11.9	11.5	0.174	334
Min=	70	132	2	11.5	11.5	0.172	326
Max=	70	132	5	12.2	11.5	0.177	341

Time	KSWF	KSWF(chart)	BZT	Feed End	Chain	ESP Inlet	O2
1100	2	74	2275	600	1760	540	2
1115	2	73	2260	600	1760	540	2
1130	2	73	2260	600	1780	540	2
1145	2	72	2250	600	1780	540	2
1200	2	73	2250	600	1780	540	2
1215	2	74	2240	600	1780	540	2
1230	2	75	2230	600	1780	540	2
1245	2	76	2260	600	1780	540	1.9
1300	2	75	2280	600	1800	540	1.8
1315	2	75	2275	600	1800	540	2
1400	2	76	2290	600	1800	540	1.8
1415	2	75	2340	600	1800	540	1.8
1430	2	78	2320	600	1800	540	1.7
Average=	2	75	2272	600	1785	540	1.9
Min=	2	72	2230	600	1760	540	1.7
Max=	2	78	2340	600	1800	540	2

Time	CO	SO2	NOx	ID Draft	ID % Open	ID Fan %	ID Fan Amps
1100	NA	1075	1247	-3.6	82	60	77
1115	NA	949	1264	-3.8	80	60	77
1130	NA	855	1217	-3.6	80	60	77
1145	NA	954	1061	-3.6	82	60	77
1200	NA	622	919	-3.6	82	60	77
1215	NA	917	961	-3.8	82	60	77
1230	NA	782	817	-3.6	78	60	77
1245	NA	984	1043	-3.6	78	60	77
1300	NA	841	1591	-3.6	78	60	77
1315	NA	1078	892	-3.6	78	60	77
1400	NA	1180	951	-3.4	72	60	75
1415	NA	791	930	-3.6	70	60	75
1430	NA	1174	1432	-3.7	72	60	75
Average=	0	939	1102	-3.6	78	60	77
Min=	0	622	817	-3.8	70	60	75
Max=	0	1180	1591	-3.4	82	60	77

Time	Kiln Amps	Opacity
1100	1000	39
1115	1000	37
1130	1040	39
1145	1040	39
1200	1040	46
1215	960	43
1230	1050	40
1245	960	36
1300	960	43
1315	960	35
1400	1050	36
1415	1040	31
1430	960	45
Average=	1005	39
Min=	960	31
Max=	1050	46

Run 5 Process Data

Time	Speed	Feed	Dust	Coal	Waste Fuel *	Fuel/Feed	Supp.Fuel *
1045	66	126	9.5	12.1	7	0.141	149
1100	66	126	9.5	12.6	7	0.145	160
1115	66	126	9.5	12.8	7	0.146	148
1130	66	126	9.5	12.6	7	0.145	182
1215	66	126	9.5	11.9	8	0.147	158
1230	66	126	9.5	11.1	8	0.141	170
1245	66	126	9.5	11.5	8	0.144	169
1300	66	126	9.5	11.6	8	0.145	115
1315	66	126	9.5	11.5	8	0.144	200
1330	66	126	9.5	11.5	8	0.144	155
1345	66	126	9.5	11.5	8	0.144	175
1400	66	126	9.5	11.5	8	0.144	154
1415	66	126	9.5	11.4	8	0.143	158
1430	66	126	9.5	11.5	8	0.144	165
1445	66	126	9.5	12.4	8	0.151	172
1500	66	126	9.5	11.4	8	0.143	161
1515	66	126	9.5	11.4	8	0.143	171
1530	66	126	9.5	11.4	8	0.143	160
Average=	66	126	9.5	11.8	8	0.144	162
Min=	66	126	9.5	11.1	7	0.141	115
Max=	66	126	9.5	12.8	8	0.151	200

* Diesel fuel for this run

Time	KSWF	BZT	Feed End	Chain	ESP Inlet	O2	CO
1045	NA	2300	550	1590	470	1.8	NA
1100	NA	2250	530	1590	470	1.7	NA
1115	NA	2225	530	1590	460	1.6	NA
1130	NA	2240	530	1590	460	2.6	NA
1215	NA	2260	550	1590	470	1.8	NA
1230	NA	2240	560	1590	480	1.8	NA
1245	NA	2280	550	1590	480	2	NA
1300	NA	2280	550	1590	480	2.2	NA
1315	NA	2275	550	1590	480	1.6	NA
1330	NA	2280	550	1590	480	2.2	NA
1345	NA	2260	550	1590	470	2	NA
1400	NA	2240	550	1590	470	2.1	NA
1415	NA	2260	550	1590	470	2.4	NA
1430	NA	2250	550	1590	470	2.4	NA
1445	NA	2260	550	1590	470	1.8	NA
1500	NA	2280	540	1590	470	2.1	NA
1515	NA	2250	530	1590	450	1.6	NA
1530	NA	2275	530	1590	450	1.8	NA
Average=	0	2261	544	1590	469	2.0	0
Min=	0	2225	530	1590	450	1.6	0
Max=	0	2300	560	1590	480	2.6	0

Time	SO2	NOx	ID Draft	ID % Open	ID Fan %	ID Fan Amps	Kiln Amps
1045	297	209	-4.1	58	60	75	1000
1100	278	587	-4.1	58	60	75	1150
1115	217	2017	-4	58	60	75	1040
1130	219	1212	-4.2	64	60	75	1150
1215	205	230	-4.2	70	60	75	1000
1230	274	161	-4.2	70	60	75	1040
1245	251	78	-4	70	60	75	1000
1300	285	118	-4.1	70	60	75	1000
1315	279	285	-4.2	70	60	75	1000
1330	283	125	-4.1	70	60	75	1000
1345	313	137	-3.9	70	60	75	1100
1400	352	91	-4.1	70	60	75	1100
1415	313	57	-4	70	60	75	1150
1430	274	37	-4.2	70	60	78	1050
1445	314	82	-3.9	60	60	75	1200
1500	288	197	-3.9	58	60	77	1050
1515	281	252	-3.8	56	60	75	1050
1530	255	324	-3.9	58	60	75	1100
Average=	277	344	-4.1	65	60	75	1066
Min=	205	37	-4.2	56	60	75	1000
Max=	352	2017	-3.8	70	60	78	1200

Time	Opacity
1045	12
1100	25
1115	16
1130	100
1215	9
1230	6
1245	0
1300	0
1315	6
1330	0
1345	0
1400	18
1415	6
1430	12
1445	20
1500	16
1515	20
1530	24
Average=	16
Min=	0
Max=	100

Run 6 Process Data

Time	Speed	Feed	Dust	Coal	Waste Fuel *	Fuel/Feed	Supp.Fuel *
1900	66	128	9.5	13.8	6	0.144	139
1915	66	128	9.5	13.1	6	0.139	110
1930	66	128	9.5	13.2	6	0.140	116
1945	66	126	9.5	13.3	6	0.142	128
2000	66	126	9.5	13	6	0.140	131
2015	66	126	9.5	13	6	0.140	125
2030	66	126	9.5	13	6	0.140	120
2045	66	126	9.5	12.8	6	0.139	145
2100	66	126	9.5	13.1	6	0.141	120
2115	66	126	9.5	13.1	6	0.141	130
2130	66	126	12	12.7	6	0.136	127
2145	66	126	12	12.6	6	0.135	124
Average=	66	127	9.9	13.1	6	0.140	126
Min=	66	126	9.5	12.6	6	0.135	110
Max=	66	128	12	13.8	6	0.144	145

* Diesel fuel for this run.

Time	KSWF	BZT	Feed End	Chain	ESP Inlet	O2	CO
1900	NA	2300	560	1600	480	1.4	NA
1915	NA	2310	560	1600	480	2.1	NA
1930	NA	2250	560	1600	480	2.2	NA
1945	NA	2260	550	1600	480	2	NA
2000	NA	2280	550	1600	480	2.2	NA
2015	NA	2280	550	1600	480	2.3	NA
2030	NA	2290	550	1600	480	2	NA
2045	NA	2300	550	1600	480	2	NA
2100	NA	2310	550	1600	480	2.2	NA
2115	NA	2275	550	1600	480	2	NA
2130	NA	2330	550	1600	480	2	NA
2145	NA	2300	550	1600	480	2	NA
Average=	0	2290	553	1600	480	2.0	0
Min=	0	2250	550	1600	480	1.4	0
Max=	0	2330	560	1600	480	2.3	0

Time	SO2	NOx	ID Draft	ID % Open	ID Fan %	ID Fan Amps	Kiln Amps
1900	220	487	-4	58	60	75	1000
1915	275	250	-4	58	60	75	1000
1930	307	141	-4	58	60	78	1150
1945	316	301	-3.8	56	60	78	1000
2000	281	103	-3.8	56	60	75	1040
2015	308	74	-4	56	60	78	1050
2030	299	120	-3.8	58	60	75	1150
2045	311	70	-3.7	58	60	77	1000
2100	428	69	-3.8	56	60	77	1000
2115	458	88	-3.7	56	60	75	1050
2130	373	48	-3.7	54	60	75	1000
2145	402	73	-3.7	54	60	75	1050
Average=	332	152	-3.8	57	60	76	1041
Min=	220	48	-4	54	60	75	1000
Max=	458	487	-3.7	58	60	78	1150

Time	Opacity
1900	17
1915	6
1930	10
1945	19
2000	14
2015	12
2030	8
2045	22
2100	15
2115	18
2130	16
2145	19
Average=	15
Min=	6
Max=	22

HCl Test Process Data

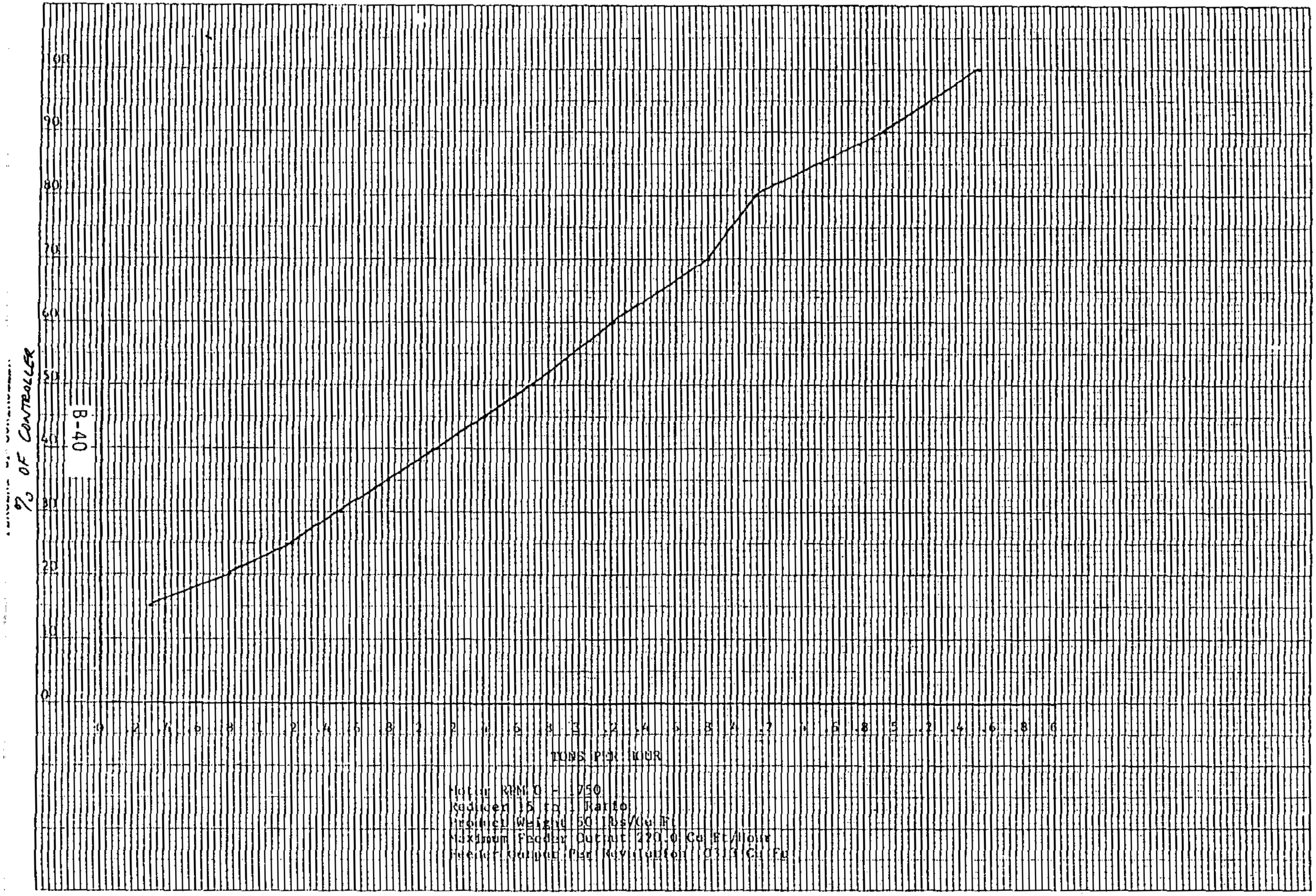
Time	Speed	Feed	Dust	Coal	Waste Fuel	Fuel/Feed	Supp.Fuel
1645	66	126	2	12.7	6	0.146	233
1700	66	124	2	8.4	6	0.114	202
1715	50	98	2	4.9	6	0.109	216
1730	53	100	2	5.9	6	0.117	226
1745	53	102	2	6.4	6	0.119	230
1800	55	106	2	9.2	6	0.141	235
1815	55	106	2	9.7	6	0.145	150
1830	57	110	2	11	6	0.152	195
1845	61	116	2	10	6	0.136	175
Average=	57	110	2	8.7	6	0.131	207
Min=	50	98	2	4.9	6	0.109	150
Max=	66	126	2	12.7	6	0.152	235

Time	KSWF	BZT	Feed End	Chain	ESP Inlet	O2	CO
1645	NA	2290	575	1740	500	1.6	NA
1700	NA	2380	575	1740	500	3.8	NA
1715	NA	2280	570	1720	500	6	NA
1730	NA	2280	580	1700	500	5	NA
1745	NA	2190	580	1700	500	4.1	NA
1800	NA	2190	570	1660	490	2.6	NA
1815	NA	2180	570	1660	490	3.2	NA
1830	NA	2180	560	1660	490	2.4	NA
1845	NA	2225	560	1660	480	2.8	NA
Average=	0	2244	571	1693	494	3.5	0
Min=	0	2180	560	1660	480	1.6	0
Max=	0	2380	580	1740	500	6	0

Time	SO2	NOx	ID Draft	ID % Open	ID Fan %	ID Fan Amps	Kiln Amps
1645	728	1237	-3.2	60	60	70	1150
1700	531	190	-3.2	60	60	75	1150
1715	292	73	-3.2	60	60	73	1100
1730	321	41	-2.4	42	60	68	1050
1745	254	23	-2.6	42	60	65	1100
1800	215	67	-2.6	50	60	70	1050
1815	309	37	-2.8	52	60	70	1040
1830	324	32	-3	52	60	70	1100
1845	309	43	-3	54	60	70	1050
Average=	365	194	-2.9	52	60	70	1088
Min=	215	23	-3.2	42	60	65	1040
Max=	728	1237	-2.4	60	60	75	1150

Time	Opacity
1645	22
1700	12
1715	8
1730	7
1745	7
1800	10
1815	3
1830	9
1845	13
Average=	10
Min=	3
Max=	22

SOLID WASTE FUEL FEEDER MODEL 105Z-N



APPENDIX B-2

SOLID WASTE CHARACTERIZATION

This appendix contains solid waste feed data supplied to MRI by Continental.

Environmental Engineering and Waste Management
RIEDEL INDUSTRIAL WASTE MANAGEMENT
A Subsidiary of Riedel Environmental Technologies, Inc.
"Imagineering A Cleaner World"

August 9, 1990

Mr. Scott Klamm
Midwest Research Institute
425 Volker Boulevard
Kansas City, MO 64110

Dear Scott:

The following table is the lists of powdered fuels fed to Continental Cement during the testing day. Densities are also included. Rotational speed chart versus feed rate is not the only parameter Continental Cement relies on for feeding the powders. Instead, they trade one ton equivalent of coal for one ton of solid fuel and make adjustments as needed based on kiln operating parameters.

Solid Fuels

		Weight		Density	Feed Rate
6/20	Mobay	44,150	lbs.	.724	2.0
	IFR	3,780	"	.744	2.0
6/21	Mobay	48,550	"	.690	1.0
6/22	IFR	14,450	"	.721	1.5
	Mobay	46,750	"	.656	1.5
7/06	IFR	22,140	"	.790	2.0
7/07	Mobay	45,100	"	.767	1.0
	IFR	39,620	"	.605	1.0

Sincerely,
Resource Recovery, Inc.

Chris Schreiber
Facility Engineer

cc: Bill Nelson

CHS/cjc

Riedel Industrial Waste Management
22 North Euclid
St. Louis, MO 63108
(314) 361-3838
FAX (314) 361-4545

Lafser & Schreiber, Inc.
22 North Euclid
St. Louis, MO 63108
(314) 361-3838
FAX (314) 361-4545

Solvent Recovery Corp.
301 Mulberry
Kansas City, MO 64101
(816) 474-1391
FAX (816) 474-1275

Resource Recovery, Inc.
P.O. Box 902
Hannibal, MO 63401
(314) 248-0700

24-hour Hotline: 1-800-334-0004

APPENDIX B-3

CEM DATA MEASURED BY MRI

This appendix contains a description of the MRI CEM system used during the test series, gases used for calibration, QA/QC checks and minute-by-minute readings of each instrument.

Continuous emission monitoring (CEM) data were collected during all six test runs at the Continental Cement Company from June 20 to July 5, 1990. An additional run was conducted July 2 for hydrochloric acid (HCl) only. All sampling runs were of 2-h duration in conjunction with semivolatile, volatile, and HCl sampling at other points in the system. The CEM probe was inserted in the east or north port of the stack at the 75 ft level for all sampling. Heated and unheated HC emissions were measured using EPA M25A sampling systems, equipped with FIDs. This method essentially measures hydrocarbons expressed in terms of propane.

To measure heated HC concentrations, the following changes were made to the M25A system:

- The entire sample system from probe to detector was heated to 250°F.
- An MRI designed HC analyzer with a GOW-MAC electrometer was used.
- Propane in air was used as the calibration gas. EPA protocol 1 cylinder standards of 19.84, 50.11, and 99.44 ppm were used.

In measuring unheated HC concentrations, the following changes were made to the M25A system:

- An ice-cooled water knockout trap was used to remove condensibles.
- An unheated Teflon sample line was used to conduct the sample through a stainless steel pump to the FID.
- Propane in air was used as the calibration gas. EPA protocol 1 cylinder standards of 19.84, 50.11, and 99.44 ppm were used.

At the sample point (i.e., stack), combustion gas was collected using a single probe with a sintered metal filter. Immediately after extraction, the gas sample was split into "heated" and "unheated" sample fractions. The heated sample fraction was transferred to a hot HC analyzer via a heated sample line. The sample line, along with in-line tees and valves, was maintained at over 250°F. Pumps were used to maintain constant purging of all sampling lines. The entire sampling system from the probe to the manifold was leak checked each day before and after the test run.

The unheated sample fraction passed through a condensate trap (i.e., a modified GBS impinger placed in an ice bath) which was located adjacent to the sample port. Using a Teflon sample line, the sample was transferred to the FID.

During the test the condensate trap was operated at a "noncontact" condition. The noncontact condition is characterized by the sample gas passing through the iced condensate trap without contact with collected condensate.

The HC monitors used included two MRI in-house designed models. A data logger was used to record all necessary information. The monitors were spanned and zeroed prior to and immediately following each run with 99.44 ppm propane, NBS-traceable EPA protocol 1 gas, and prepurified nitrogen. A linearity check was conducted each day using 50.11 ppm propane and 19.84 ppm propane NBS-traceable EPA protocol 1 gases. Monitor response times were also checked before the first run.

CO, CO_2, and O_2 samples were split from the hot HC M25A sample line. The sample was transferred via a heat traced TFE Teflon sample line and split for CO_2, O_2, CO, and hot HC analysis. CO_2 was independently monitored and used to volume-correct the CO reading to account for the CO_2 removed. A Horiba Model PIR-2000S nondispersive infrared (NDIR) analyzer was used to measure CO_2. O_2 was independently monitored and used to correct the CO and hot and cold HC readings to 7% O_2 concentrations. A Horiba PMA-200 paramagnetic sensor was used to measure O_2.

Total CO concentration was determined using a Horiba Model PIR-2000L NDIR. After the CO sample was split from the hot HC M25A sample line, it was passed through an ascarite/silica gel cartridge containing approximately 200 g of ascarite and 20 g of silica gel. The ascarite trap removed carbon dioxide, which is an interference to the CO monitor, and the silica gel removed the last traces of moisture prior to the monitor. The sample fraction was then pumped to the NDIR analyzer.

Zero drift was determined by checking the zero calibration before and after each run and comparing the two. Calibration drive was determined by checking the span gas calibration before and after each run. The response time was determined by adding a calibration gas while the instrument is at the zero calibration in the end of the probe and determining the length of time for the instrument to reach 90% of the corresponding span value. The calibration error (usually referred to as the linearity check) was performed by zeroing and spanning the instrument and then adding a midlevel calibration gas and comparing the instrument value with the real gas value. Zero and calibration drift were less than ±3% of the span value, while the calibration error (linearity check) was less than ±5% of the calibration gas value for each run.

Possible bias from organics retained on the sampling lines was checked on Run 3 by introducing zero gas at the sample probe after the run (HC only). No organics were found.

The performance checks for the analyzers are summarized below:

Zero drift: 3% of span
Span drift: 3% of span
Linearity checks: 5% of cylinder gas value
Leak checks: < 4% of normal flow, before and after each run
Nominal gas concentrations:

	Linearity
HC--span 99.84 ppm propane	50.11, 19.84 ppm
CO--786.7 ppm (392.8 ppm for run 1)	201.4 ppm
CO_2--11.93%	5.95%
O_2--11.89%	6.04%
HCl--span 513.3 ppm	204.9, 103.1 ppm

HCl continuous monitoring was performed by a Thermo-electron Model 15 gas filter correlation infrared unit. The instrument used its own heated Teflon sample line and conditioning system. Stack gas was dried using two Permapure dryers in sequence.

The system was leak-checked before and after each run at less than 200 mmHg. The monitor was zeroed using prepurified nitrogen and spanned using the lowest calibration gas available. Operation of the monitor was checked hourly and fed span gases to verify response as necessary. Following each run, a final zero and span was performed and the monitor purged for at least 30 min with nitrogen before shutting down. Zero drift, span drift, and response times were measured identically to the CO, CO_2, and O_2 monitors. A linearity check will be performed using the midlevel calibration gas the first day only. The system will be within 10% agreement of the gases true value.

Raw data from the field CEM print outs were reviewed for completeness and any notations of the operator. Data presented here were collected only during semivolatile sampling on the stack. Invalid data periods due to maintenance activities on the sampling system have also been removed from these data tables. Runs 5 and 6 have noticeable gaps of some monitors but all test runs were above the 80% data recovery target selected for this project. Some extra data from short intervals when the semivolatile trains were not sampling is included. Carbon monoxide and hot and cold hydrocarbons have been corrected to 7%. The correction is by the equation:

$$\text{Raw Conc.}_{(\text{ppm})} \times \frac{21 - 7}{21 - O_2\ \text{Conc.}} = \text{Conc.}_{(\text{ppm, } 7\%\ O_2)}$$

Additionally, the THC-H has been corrected for moisture content by the equation:

$$\text{Raw Conc.}_{(\text{ppm, wet})} \times \frac{100}{100 - \%\ \text{Moisture}} = \text{Conc.}_{(\text{ppm, dry})}$$

The percent moisture of the stack gas was calculated from the Method 0010 semivolatile train. Run 5A (HCl test) moisture content is an average of the other six runs since no moisture train was run that day. O_2, CO, and CO_2 are all expressed in dry units in the raw data and no moisture correction is necessary. The same holds true for the hydrochloric acid and cold hydrocarbon monitors.

STANDARD GASES [BALANCE IS N_2 UNLESS SPECIFIED]

Gas	Source	ID No.	Conc. (ppm)	Expiration date
HCl	Scott Specialty Gases	AO 17710	103.1	5% nonpro*
HCl	Scott Specialty Gases	AO 17721	204.9	5% nonpro*
HCl	Scott Specialty Gases	AO 17719	513.3	5% nonpro*
HCl	Scott Specialty Gases	AO 13227	955.3	5% nonpro*
O_2	Scott Specialty Gases	ALm 2904	6.044%	9/29/90
O_2	Scott Specialty Gases	ALM 4752	11.885%	3/1/91
CO (A)**	Scott Specialty Gases	ALM 10517	201.4	7/23/90
CO (A)**	Scott Specialty Gases	ALM 2211	392.8	1/6/91
CO	Scott Specialty Gases	AAL 9967	786.7	11/19/90
CO	Scott Specialty Gases	AAL 3453	5.96%	9/30/90
CO_2	Scott Specialty Gases	AAL 12906	11.93%	3/1/91
Propane (A)**	Scott Specialty Gases	ALM 9901	19.84	6/28/91
Propane (A)**	Scott Specialty Gases	ALM 9898	50.11	6/28/91
Propane (A)**	Scott Specialty Gases	ALM 8883	99.44	7/23/91
Propane (A)**	Scott Specialty Gases	ALM 9902	10.12	7/23/91
Propane (A)**	Scott Specialty Gases	ALM 9890	4.99	7/23/91

* Protocol cylinders not available. Within 5%.

** Air.

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- Propane in air was used as the calibration gas. EPA protocol 1 cylinder standards of 19.84, 50.11, and 99.44 ppm were used.

At the sample point (i.e., stack), combustion gas was collected using a single probe with a sintered metal filter. Immediately after extraction, the gas sample was split into "heated" and "unheated" sample fractions. The heated sample fraction was transferred to a hot HC analyzer via a heated sample line. The sample line, along with in-line tees and valves, was maintained at over 250°F. Pumps were used to maintain constant purging of all sampling lines. The entire sampling system from the probe to the manifold was leak checked each day before and after the test run.

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CO, CO_2, and O_2 samples were split from the hot HC M25A sample line. The sample was transferred via a heat traced TFE Teflon sample line and split for CO_2, O_2, CO, and hot HC analysis. CO_2 was independently monitored and used to volume-correct the CO reading to account for the CO_2 removed. A Horiba Model PIR-2000S nondispersive infrared (NDIR) analyzer was used to measure CO_2. O_2 was independently monitored and used to correct the CO and hot and cold HC readings to 7% O_2 concentrations. A Horiba PMA-200 paramagnetic sensor was used to measure O_2.

Total CO concentration was determined using a Horiba Model PIR-2000L NDIR. After the CO sample was split from the hot HC M25A sample line, it was passed through an ascarite/silica gel cartridge containing approximately 200 g of ascarite and 20 g of silica gel. The ascarite trap removed carbon dioxide, which is an interference to the CO monitor, and the silica gel removed the last traces of moisture prior to the monitor. The sample fraction was then pumped to the NDIR analyzer.

Zero drift was determined by checking the zero calibration before and after each run and comparing the two. Calibration drive was determined by checking the span gas calibration before and after each run. The response time was determined by adding a calibration gas while the instrument is at the zero calibration in the end of the probe and determining the length of time for the instrument to reach 90% of the corresponding span value. The calibration error (usually referred to as the linearity check) was performed by zeroing and spanning the instrument and then adding a midlevel calibration gas and comparing the instrument value with the real gas value. Zero and calibration drift were less than ±3% of the span value, while the calibration error (linearity check) was less than ±5% of the calibration gas value for each run.

Possible bias from organics retained on the sampling lines was checked on Run 3 by introducing zero gas at the sample probe after the run (HC only). No organics were found.

The performance checks for the analyzers are summarized below:

Zero drift: 3% of span
Span drift: 3% of span
Linearity checks: 5% of cylinder gas value
Leak checks: < 4% of normal flow, before and after each run
Nominal gas concentrations:

	Linearity
HC--span 99.84 ppm propane	50.11, 19.84 ppm
CO--786.7 ppm (392.8 ppm for run 1)	201.4 ppm
CO_2--11.93%	5.95%
O_2--11.89%	6.04%
HCl--span 513.3 ppm	204.9, 103.1 ppm

HCl continuous monitoring was performed by a Thermo-electron Model 15 gas filter correlation infrared unit. The instrument used its own heated Teflon sample line and conditioning system. Stack gas was dried using two Permapure dryers in sequence.

The system was leak-checked before and after each run at less than 200 mmHg. The monitor was zeroed using prepurified nitrogen and spanned using the lowest calibration gas available. Operation of the monitor was checked hourly and fed span gases to verify response as necessary. Following each run, a final zero and span was performed and the monitor purged for at least 30 min with nitrogen before shutting down. Zero drift, span drift, and response times were measured identically to the CO, CO_2, and O_2 monitors. A linearity check will be performed using the midlevel calibration gas the first day only. The system will be within 10% agreement of the gases true value.

Raw data from the field CEM print outs were reviewed for completeness and any notations of the operator. Data presented here were collected only during semivolatile sampling on the stack. Invalid data periods due to maintenance activities on the sampling system have also been removed from these data tables. Runs 5 and 6 have noticeable gaps of some monitors but all test runs were above the 80% data recovery target selected for this project. Some extra data from short intervals when the semivolatile trains were not sampling is included. Carbon monoxide and hot and cold hydrocarbons have been corrected to 7%. The correction is by the equation:

$$\text{Raw Conc.}_{(\text{ppm})} \times \frac{21 - 7}{21 - O_2\ \text{Conc.}} = \text{Conc.}_{(\text{ppm, } 7\%\ O_2)}$$

Additionally, the THC-H has been corrected for moisture content by the equation:

$$\text{Raw Conc.}_{(\text{ppm, wet})} \times \frac{100}{100 - \%\ \text{Moisture}} = \text{Conc.}_{(\text{ppm, dry})}$$

The percent moisture of the stack gas was calculated from the Method 0010 semivolatile train. Run 5A (HCl test) moisture content is an average of the other six runs since no moisture train was run that day. O_2, CO, and CO_2 are all expressed in dry units in the raw data and no moisture correction is necessary. The same holds true for the hydrochloric acid and cold hydrocarbon monitors.

CEM DATA REDUCTION

Raw data were refined, as follows, to generate final data values (i.e., averages, etc.).

- The CEM raw data were first converted from percent of full-scale values to percent (O_2 and CO_2) or ppm (CO and THC values using a data logging program. This conversion was based upon the average of initial and final zero and span calibration data.

- Hot THC data were corrected from a wet to a dry basis following applicable EPA Method 4 (40 CFR 60) protocols. The volume of moisture collected in the Method 0010 semivolatiles sampling train and the associated dry gas metered volume were used to determine a moisture content during each run.

- CO, hot THC, and cold THC data were corrected to 7% oxygen conditions using the following formula: (uncorrected value) x $(14/[21-O_2])$ = corrected value. Oxygen data collected during each run was used to make this correction.

- At various points during each test, the THC analyzers were taken off-line to zero and span the instrument. Available data points within the sample period were utilized to interpolate 1-min rolling averages, if necessary.

APPENDIX B-4

ORGANIC MASS DATA

This appendix contains a summary of each run's organic mass data as measured by the field GC and gravimetric fraction of the semivolatiles train. Individual syringe injection times and values are reported.

For the field GC data analysis, areas integrated under each peak were summed to give a total peak area for each run. This value was then divided by the average daily reference factor for propane, resulting in a total organics concentration for ppm propane equivalent. The average daily reference factor was obtained from an average of peak areas for a standard propane sample of known concentration.

Carbon fractions (i.e., C1 - C7 and C7 - C17 fractions) were determined by comparing sample peak retention times to standard peak retention times.

Aliquots of a C17 in a C7 solution were analyzed to establish standard peak retention times. The following standard retention time ranges were determined in the test:

C1-C7: 0-132s C7-C17: 133-556s

For gravimetric data reduction, method blank weight was subtracted from each sample analysis value to determine a net gravimetric value. This net value was then multiplied by a numerical factor to obtain the organic mass in µg per sample. The dry standard sample volume was then utilized to generate a µg/L emission concentration. The ppm propane equivalent was then calculated by assuming that half of the sample molecular weight has no FID response; calculated as follows:

$$\frac{\mu\text{g of sample}}{\text{L of air sampled}} \times 0.5 \times \frac{24.1\ \mu\text{L gas per }\mu\text{mol of gas}}{44\ \mu\text{L propane per }\mu\text{mol propane}} = \text{ppm propane equivalent}$$

TABLE B-4-1. ORGANIC MASS DATA FOR RUN 1

			Carbon fractions (ppm propane)					Total mass
Run Time (24-h)	Sample No.	Time	C1-C7 (wet)	C1-C7 (dry)	C7-C17 (wet)	C7-C17 (dry)	> C17 (dry)	(TOM) (dry)
1118-1448	620SS1	1114	13.2	19.5	0.9	1.3		
	620SS2	1132	15.5	22.9	3.3	4.9		
	R1ASS3	1151	11.0	16.3	1.4	2.1		
	R1ASS4	1209	13.1	19.4	1.2	1.8		
	R1ASS5	1228	12.8	18.9	1.5	2.2		
	R1ASS6	1246	8.4	12.4	0.8	1.2		
	R1ASS7	1305	13.9	20.6	1.1	1.6		
	R1ASS8	1324	15.0	22.2	1.4	2.1		
	R1ASS9	1343	15.0	22.2	9.1	13.5		
	R1ASS10	1402	14.8	21.9	2.6	3.8		
	R1ASS11	1422	6.9	10.2	1.5	2.2		
	R1ASS12	1440	4.0	5.9	1.3	1.9		
	Run Average =			17.7		3.2	1.73	22.6

TABLE B-4-2. ORGANIC MASS DATA FOR RUN 2

			Carbon fractions (ppm propane)					Total mass
Run Time (24-h)	Sample No.	Time	C1-C7 (wet)	C1-C7 (dry)	C7-C17 (wet)	C7-C17 (dry)	> C17 (dry)	(TOM) (dry)
1230-1546	R2SS1	1228	39.9	64.0	1.6	2.6		
	R2SS2	1246	47.1	75.6	3.5	5.6		
	R2SS3	1305	61.6	98.9	2.7	4.3		
	R2SS4	1324	37.5	60.2	62.8	100.8		
	R2SS5	1343	40.2	64.5	5.0	8.0		
	R2SS6	1402	65.2	104.7	2.9	4.7		
	R2SS7	1421	49.7	79.8	4.7	7.5		
	R2SS8	1439	57.2	91.8	4.9	7.9		
	R2SS9	1458	62.6	100.5	4.0	6.4		
	R2SS10	1516	35.7	57.3	2.3	3.7		
	R2SS11	1535	41.1	66.0	2.2	3.5		
	Run Average =			78.5		14.1	3.54	96.1

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TABLE B-4-3. ORGANIC MASS DATA FOR RUN 3

Run Time (24-h)	Sample No.	Carbon fractions (ppm propane)						Total mass (TOM) (dry)
		Time	C1-C7 (wet)	C1-C7 (dry)	C7-C17 (wet)	C7-C17 (dry)	> C17 (dry)	
1135-1720	R3SS1	1133	61.6	95.8	3.7	5.8		
	R3SS2	1151	58.8	91.4	2.1	3.3		
	R3SS3	1209	34.5	53.7	2.3	3.6		
	R3SS4	1227	33.0	51.3	1.7	2.6		
	R3SS5	1246	35.7	55.5	2.2	3.4		
	R3SS6	1309	39.3	61.1	5.7	8.9		
	R3SS7	1328	23.0	35.8	0.8	1.2		
	R3SS8	1518	68.2	106.1	5.3	8.2		
	R3SS9	1536	38.5	59.9	9.2	14.3		
	R3SS10	1559	56.3	87.6	2.5	3.9		
	R3SS11	1617	48.8	75.9	2.3	3.6		
	R3SS12	1636	51.1	79.5	3.1	4.8		
	R3SS13	1654	36.8	57.2	1.2	1.9		
	R3SS14	1713	17.9	27.8	142.0	220.8		
	Run Average =			67.0		20.5	5.31	92.8

Note: Off-scale peak in C1-C7 region during 1518 sample.

TABLE B-4-4. ORGANIC MASS DATA FOR RUN 4

Run Time (24-h)	Sample No.	Carbon fractions (ppm propane)						Total mass (TOM) (dry)
		Time	C1-C7 (wet)	C1-C7 (dry)	C7-C17 (wet)	C7-C17 (dry)	> C17 (dry)	
1055-1435	R4SS1	1053	24.8	36.2	0.9	1.3		
	R4SS2	1112	34.0	49.6	1.0	1.5		
	R4SS3	1130	13.2	19.3	173.9	253.9		
	R4SS4	1148	31.3	45.7	16.7	24.4		
	R4SS5	1207	23.0	33.6	26.8	39.1		
	R4SS7	1232	30.1	43.9	3.3	4.8		
	R4SS8	1251	42.1	61.5	1.7	2.5		
	R4SS9	1309	29.6	43.2	0.7	1.0		
	R4SS10	1327	24.3	35.5	52.4	76.5		
	R4SS12	1346	27.0	39.4	5.4	7.9		
	R4SS13	1404	44.3	64.7	3.1	4.5		
	R4SS14	1422	46.8	68.3	2.2	3.2		
	Run Average =			45.1		35.0	5.62	85.7

Note: Off-scale peak in C7-C17 region during 1130 sample, due to ESP shutdown.

Note: R4SS6 was taken during calibration and there was no R4SS11.

File: TOMS By: PSM Date: 10/29/90

TABLE B-4-5. ORGANIC MASS DATA FOR RUN 5

Run Time (24-h)	Sample No.	Carbon fractions (ppm propane)						Total mass (TOM) (dry)
		Time	C1-C7 (wet)	C1-C7 (dry)	C7-C17 (wet)	C7-C17 (dry)	> C17 (dry)	
1047-1535	R5SS1	1046	38.1	59.8	2.5	3.9		
	R5SS2	1105	84.3	132.3	11.4	17.9		
	R5SS3	1123	29.5	46.3	3.1	4.9		
	R5SS4	1220	61.6	96.7	4.0	6.3		
	R5SS5	1245	47.2	74.1	1.9	3.0		
	R5SS6	1303	36.9	57.9	2.1	3.3		
	R5SS7	1322	66.6	104.6	3.5	5.5		
	R5SS8	1341	48.1	75.5	2.9	4.6		
	R5SS9	1359	41.5	65.1	2.7	4.2		
	R5SS10	1418	17.9	28.1	0.5	0.8		
	R5SS11	1436	37.9	59.5	2.0	3.1		
	R5SS12	1457	41.1	64.5	2.1	3.3		
	R5SS13	1515	48.4	76.0	2.5	3.9		
	Run Average =			72.3		5.0	8.22	85.5

Note: Off-scale peak in C1-C7 region during 1105 sample.

TABLE B-4-6. ORGANIC MASS DATA FOR RUN 6

Run Time (24-h)	Sample No.	Carbon fractions (ppm propane)						Total mass (TOM) (dry)
		Time	C1-C7 (wet)	C1-C7 (dry)	C7-C17 (wet)	C7-C17 (dry)	> C17 (dry)	
1900-2152	R6SS1	1900	79.8	125.3	5.9	9.3		
	R6SS2	1918	26.7	41.9	2.3	3.6		
	R6SS3	1937	40.8	64.1	1.4	2.2		
	R6SS4	2003	49.7	78.0	1.6	2.5		
	R6SS5	2022	46.3	72.7	1.8	2.8		
	R6SS6	2040	46.4	72.8	2.4	3.8		
	R6SS7	2059	45.8	71.9	2.6	4.1		
	R6SS8	2118	18.7	29.4	1.1	1.7		
	R6SS9	2136	34.7	54.5	1.2	1.9		
	Run Average =			67.8		3.5	9.56	80.9

File: TOMS By: PSM Date: 10/29/90

Filename:RUN1
Name:RUN1
Date:06-20-1990
Location:HANNIBAL,MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

Time	O2 (%, dry)	CO2 (%, dry)	CO (ppm, dry)	THCH (ppm, wet)	THCH (ppm dry)	THCC (ppm dry)	CO @ 7% O2 (ppm, dry)	THCH @ 7% O2 (ppm, dry)	THCC @ 7% O (ppm, dry)
1118	3.9	23.7	203.1	18.6	27.5	9.5	165.8	22.5	7.8
1119	4.1	23.1	208.3	15.9	23.5	10.2	172.8	19.5	8.5
1120	4.6	22.6	213.0	13.3	19.7	10.8	181.4	16.8	9.2
1121	4.3	22.6	214.6	13.0	19.2	11.4	179.7	16.1	9.5
1122	4.0	22.9	215.0	14.3	21.2	11.4	176.5	17.4	9.4
1123	3.9	23.0	215.3	15.2	22.5	10.8	176.2	18.4	8.8
1124	3.7	23.1	213.8	18.3	27.1	10.5	172.7	21.9	8.5
1125	3.8	23.0	212.2	17.5	25.9	10.8	172.3	21.0	8.8
1126	4.2	22.6	211.5	19.7	29.1	11.2	176.1	24.3	9.3
1127	4.6	22.3	210.4	10.6	15.7	11.8	179.2	13.4	10.0
1128	4.6	22.2	209.3	16.7	24.7	12.2	178.9	21.1	10.4
1129	4.3	22.5	208.4	17.7	26.2	11.8	175.0	22.0	9.9
1130	4.2	22.6	208.4	16.7	24.7	11.3	174.1	20.6	9.4
1131	4.6	22.3	209.2	16.2	24.0	10.9	178.2	20.4	9.3
1132	4.5	22.4	208.4	19.0	28.1	10.6	177.1	23.9	9.0
1133	4.4	22.5	207.1	19.9	29.4	10.5	174.8	24.8	8.9
1134	4.3	22.6	205.6	19.1	28.3	10.2	172.8	23.7	8.6
1135	4.5	22.4	204.8	15.5	22.9	9.9	173.2	19.4	8.4
1136	4.6	22.3	204.2	11.4	16.9	9.7	174.1	14.4	8.3
1137	4.5	22.4	203.4	15.0	22.2	9.6	172.4	18.8	8.1
1138	4.6	22.3	202.5	15.0	22.2	9.5	173.3	19.0	8.1
1139	5.5	21.4	204.4	13.5	20.0	9.4	184.7	18.0	8.5
1140	6.4	20.6	205.6	12.6	18.6	9.3	197.3	17.9	8.9
1141	6.4	20.6	204.9	12.3	18.2	9.3	195.9	17.4	8.9
1142	6.3	20.6	204.6	11.9	17.6	9.0	195.0	16.8	8.6
1143	6.5	20.6	204.5	11.6	17.2	8.7	196.9	16.5	8.4
1144	6.3	20.9	203.0	11.5	17.0	8.2	193.6	16.2	7.8
1145	5.9	21.6	200.0	11.8	17.5	7.9	185.6	16.2	7.3
1146	5.7	21.8	197.4	11.9	17.6	7.5	180.9	16.1	6.9
1147	5.4	22.2	193.5	12.6	18.6	7.3	173.5	16.7	6.5
1148	5.0	22.4	188.4	13.1	19.4	7.2	164.9	17.0	6.3

Port change									
1214	4.1	22.4	202.9	16.3	24.1	11.0	167.9	20.0	9.1
1215	4.1	22.4	204.4	15.0	22.2	11.0	169.3	18.4	9.1
1216	4.0	22.7	204.8	15.9	23.5	11.0	168.5	19.3	9.0
1217	3.9	23.1	205.7	17.1	25.3	11.0	168.0	20.7	9.0
1218	4.0	23.0	207.0	16.6	24.6	11.0	170.6	20.2	9.1
1219	4.1	22.6	209.4	14.4	21.3	11.1	173.8	17.7	9.2
1220	4.2	22.7	209.7	13.7	20.3	11.5	174.2	16.8	9.6
1221	4.3	22.6	211.4	13.3	19.7	11.7	176.9	16.5	9.8
1222	4.2	22.7	212.5	13.2	19.5	11.8	177.1	16.3	9.8
1223	4.1	23.0	212.5	14.2	21.0	11.8	176.2	17.4	9.8
1224	4.0	23.1	213.1	14.8	21.9	11.6	175.8	18.1	9.6
1225	4.2	22.7	214.5	13.9	20.6	11.5	178.9	17.1	9.6
1226	4.1	22.9	214.9	12.9	19.1	11.5	178.4	15.8	9.5
1227	4.3	22.8	215.5	11.8	17.5	11.6	180.2	14.6	9.7
1228	4.3	22.8	215.7	12.6	18.6	11.5	181.0	15.6	9.7
1229	4.2	23.1	215.2	13.4	19.8	11.5	179.5	16.5	9.6
1230	4.2	23.1	215.6	13.2	19.5	11.4	180.0	16.3	9.5
1231	4.2	23.2	215.7	13.4	19.8	11.3	179.9	16.5	9.4
1232	4.7	22.7	216.9	12.3	18.2	11.3	185.8	15.6	9.7
1233	4.8	22.5	217.6	12.5	18.5	11.3	187.5	15.9	9.7
1234	4.8	22.5	217.4	13.1	19.4	11.3	187.8	16.7	9.8
1235	4.8	22.5	217.2	13.1	19.4	11.0	187.1	16.7	9.5
1236	4.8	22.5	217.0	13.1	19.4	10.6	187.0	16.7	9.1
1237	4.9	22.3	217.4	12.9	19.1	10.3	188.5	16.5	8.9
1238	5.3	21.8	218.7	11.3	16.7	9.9	195.3	14.9	8.8
1239	5.4	21.7	218.3	10.5	15.5	9.6	195.9	13.9	8.6
1240	5.3	22.0	217.1	10.7	15.8	9.4	193.8	14.1	8.4
1241	5.2	22.1	216.6	10.8	16.0	9.1	192.2	14.2	8.1
1242	5.2	21.9	217.0	10.6	15.7	8.8	192.3	13.9	7.8
1243	5.7	21.5	217.6	10.4	15.4	8.7	198.9	14.1	8.0
1244	5.3	21.8	216.3	11.2	16.6	8.6	192.8	14.8	7.7
Port change									
1308	4.6	21.8	195.2	12.9	19.1	7.7	166.1	16.2	6.6
1309	4.6	21.8	195.3	13.3	19.7	7.8	166.3	16.8	6.6
1310	4.4	22.1	194.5	14.2	21.0	7.9	164.2	17.7	6.7
1311	4.4	22.2	194.5	14.6	21.6	8.0	164.2	18.2	6.8
1312	4.8	21.7	196.4	12.8	18.9	8.1	169.8	16.4	7.0
1313	4.8	21.8	196.7	13.0	19.2	8.2	170.1	16.6	7.1
1314	4.9	21.7	197.9	12.8	18.9	8.4	171.8	16.4	7.3
1315	4.8	21.8	198.1	12.6	18.6	8.5	171.1	16.1	7.3
1316	4.9	21.7	199.3	9.8	14.5	8.5	172.8	12.6	7.4
1317	4.9	21.7	200.1	9.7	14.3	8.4	174.2	12.5	7.3

1318	4.8	21.9	200.8	10.1	14.9	8.2	174.0	12.9	7.1
1319	4.8	22.0	201.2	10.4	15.4	8.1	173.3	13.3	7.0
1320	4.8	22.0	202.4	11.0	16.3	8.0	174.7	14.0	6.9
1321	4.6	22.3	202.8	12.2	18.0	7.9	173.1	15.4	6.7
1322	4.7	22.4	204.3	12.1	17.9	7.9	175.4	15.4	6.8
1323	4.6	22.6	205.6	13.0	19.2	7.9	175.9	16.5	6.8
1324	4.7	22.2	207.3	13.1	19.4	8.0	178.3	16.7	6.9
1325	4.8	22.2	208.9	12.9	19.1	8.1	180.4	16.5	7.0
1326	4.8	22.1	210.1	13.1	19.4	8.1	181.1	16.7	7.0
1327	4.8	22.1	211.3	13.1	19.4	8.1	182.2	16.7	7.0
1328	5.0	22.3	211.6	13.4	19.8	8.0	184.9	17.3	7.0
1329	5.0	22.1	213.2	12.6	18.6	8.0	187.0	16.4	7.0
1330	5.5	21.4	215.5	10.8	16.0	8.0	195.0	14.5	7.2
1331	6.6	20.4	218.6	9.7	14.3	7.9	212.8	14.0	7.7
1332	7.0	20.3	219.6	9.1	13.5	7.9	219.0	13.4	7.9
1333	7.0	20.3	220.1	8.7	12.9	7.8	220.4	12.9	7.8
1334	6.6	20.7	219.4	9.1	13.5	7.6	213.2	13.1	7.4
1335	6.7	20.6	219.7	9.3	13.8	7.2	215.4	13.5	7.1
1336	7.0	20.1	221.1	9.1	13.5	7.0	220.3	13.4	7.0
1337	7.2	19.9	221.1	9.2	13.6	6.7	223.7	13.8	6.8
1338	7.4	19.5	222.0	9.2	13.6	6.5	228.2	14.0	6.7
Port change									
1418	11.1	15.1	213.5	7.9	11.7	4.9	302.8	16.6	7.0
1419	11.1	15.4	212.5	8.0	11.8	4.8	300.5	16.7	6.8
1420	11.0	15.3	212.2	8.1	12.0	4.8	296.2	16.7	6.7
1421	10.9	15.1	210.8	7.7	11.4	4.7	293.1	15.8	6.5
1422	10.9	14.9	209.1	8.4	12.4	4.7	290.4	17.3	6.5
1423	11.1	14.6	206.7	7.6	11.2	4.7	293.2	15.9	6.7
1424	11.4	14.3	204.0	7.9	11.7	4.7	298.7	17.1	6.9
1425	11.3	14.5	199.8	8.2	12.1	4.7	289.6	17.6	6.8
1426	10.3	15.7	192.6	8.4	12.4	4.7	251.1	16.2	6.1
1427	9.4	16.2	187.5	7.4	10.9	4.7	225.9	13.2	5.7
1428	8.9	16.6	182.9	7.5	11.1	4.7	210.9	12.8	5.4
1429	8.4	16.9	178.2	7.5	11.1	4.7	198.3	12.3	5.2
1430	8.3	16.9	174.4	7.7	11.4	4.7	191.6	12.5	5.2
1431	8.1	17.1	170.4	7.1	10.5	4.7	185.2	11.4	5.1
1432	8.1	17.1	167.4	6.5	9.6	4.7	181.4	10.4	5.1
1433	8.1	17.4	163.1	6.7	9.9	4.7	176.5	10.7	5.1
1434	8.2	17.3	160.0	6.9	10.2	4.7	174.7	11.1	5.1
1435	8.4	17.1	157.0	7.1	10.5	4.7	174.4	11.7	5.2
1436	8.7	16.6	154.3	7.2	10.7	4.7	175.6	12.1	5.3
1437	8.7	16.6	150.9	7.7	11.4	4.7	171.9	13.0	5.4
1438	8.8	16.5	148.2	7.6	11.2	4.7	169.9	12.9	5.4

1439	8.9	16.2	145.5	7.3	10.8	4.7	168.8	12.5	5.5
1440	8.6	16.3	142.1	6.5	9.6	4.6	161.0	10.9	5.2
1441	8.9	16.4	139.1	6.2	9.2	4.6	160.7	10.6	5.3
1442	8.8	17.0	135.1	6.3	9.3	4.5	154.8	10.7	5.2
1443	8.5	17.0	132.7	6.4	9.5	4.5	148.6	10.6	5.0
1444	7.8	17.3	129.2	6.5	9.6	4.4	137.1	10.2	4.7
1445	7.1	18.7	124.7	6.9	10.2	4.4	125.6	10.3	4.4
1446	6.8	19.1	121.5	7.2	10.7	4.4	119.6	10.5	4.3
1447	7.0	18.9	119.4	7.3	10.8	4.3	119.1	10.8	4.3
1448	7.1	18.7	117.6	7.2	10.7	4.2	118.4	10.7	4.2
AVG =	5.9	20.7	198.4	11.7	17.3	8.3	187.3	15.9	7.6
MIN =	3.7	14.3	117.6	6.2	9.2	4.2	118.4	10.2	4.2
MAX =	11.4	23.7	222.0	19.9	29.4	12.2	302.8	24.8	10.4

O2 = Oxygen
CO2 = Carbon Dioxide
CO = Carbon Monoxide
THCH = Hydrocarbons-Hot line
THCC = Hydrocarbons-Cold line

Filename:RUN2
Name:RUN2
Date:06-21-1990
Location:HANNIBAL,MO
Project 9102-63-13
Operator:BG
VERSION=05/07/90

TIME	O2 (%, dry)	CO2 (%, dry)	CO (ppm, dry)	THCH (ppm, wet)	THCH (ppm, dry)	THCC (ppm, dry)	CO @ 7% O2 (ppm, dry)	THCH @ 7% O (ppm, dry)	THCC @ 7% O (ppm, dry)
1230	4.3	22.8	293.8	37.2	59.7	40.4	246.9	50.2	33.9
1231	4.3	22.7	294.8	33.2	53.3	41.6	246.8	44.6	34.8
1232	3.9	23.4	293.1	35.9	57.6	41.8	240.2	47.2	34.3
1233	4.1	23.2	295.0	37.7	60.5	42.0	243.8	50.0	34.7
1234	3.6	23.6	294.9	45.6	73.2	41.8	237.5	59.0	33.7
1235	3.5	23.7	295.8	48.4	77.7	41.8	237.2	62.3	33.5
1236	3.7	23.4	298.5	45.8	73.5	42.1	242.1	59.6	34.1
1237	3.9	23.3	299.7	40.3	64.7	42.0	245.8	53.1	34.4
1238	4.1	23.0	302.1	39.4	63.2	42.2	250.6	52.5	35.0
1239	3.7	23.4	301.0	44.9	72.1	42.4	244.1	58.5	34.4
1240	4.3	22.8	304.4	35.0	56.2	42.8	254.7	47.0	35.8
1241	4.3	23.0	304.2	38.7	62.1	43.2	254.7	52.0	36.2
1242	4.5	22.6	306.2	32.5	52.2	43.5	259.8	44.3	36.9
1243	4.1	23.2	303.9	37.2	59.7	44.1	252.3	49.6	36.6
1244	4.2	23.0	305.3	39.2	62.9	45.9	254.4	52.4	38.3
1245	3.7	24.1	301.6	51.1	82.0	45.3	244.1	66.4	36.7
1246	3.5	24.6	300.0	58.4	93.7	44.5	239.5	74.8	35.5
1247	4.1	23.1	305.7	43.3	69.5	44.9	252.8	57.5	37.1
1248	3.9	23.2	306.1	42.4	68.1	46.4	250.2	55.6	37.9
1249	3.9	23.2	305.1	40.2	64.5	48.7	249.8	52.8	39.9
1250	3.8	23.3	304.8	43.2	69.3	46.7	248.4	56.5	38.1
1251	4.3	23.1	305.8	38.1	61.2	49.5	256.1	51.2	41.4
1252	4.0	23.0	305.8	37.3	59.9	49.2	252.0	49.3	40.5
1253	4.0	23.0	305.5	36.7	58.9	49.0	251.6	48.5	40.4
1254	4.0	22.9	305.5	34.7	55.7	48.4	251.3	45.8	39.8
1255	3.9	22.9	304.7	37.9	60.8	47.6	249.5	49.8	39.0
1256	3.6	23.3	303.5	41.6	66.8	47.0	244.8	53.8	37.9
1257	3.6	23.5	302.8	43.1	69.2	46.2	243.6	55.7	37.2
1258	3.7	24.0	300.4	53.5	85.9	46.0	243.1	69.5	37.2
1259	3.5	23.9	299.9	57.1	91.7	46.4	239.9	73.3	37.1
1300	3.8	23.5	300.8	52.9	84.9	47.5	245.3	69.2	38.7

Port change									
1319	3.8	23.7	289.1	53.0	85.1	56.5	235.9	69.4	46.1
1320	3.5	23.9	286.9	56.8	91.2	56.6	229.7	73.0	45.3
1321	3.8	23.9	285.4	43.6	70.0	56.3	231.8	56.8	45.7
1322	3.5	24.0	283.7	53.1	85.2	56.8	227.5	68.3	45.5
1323	4.0	23.2	285.2	47.4	76.1	57.7	235.4	62.8	47.6
1324	3.8	23.4	282.9	49.2	79.0	58.7	230.7	64.4	47.9
1325	3.9	23.3	281.9	49.9	80.1	59.3	230.5	65.5	48.5
1326	4.3	22.9	281.7	45.5	73.0	59.4	236.6	61.3	49.9
1327	3.8	23.5	278.4	41.0	65.8	58.9	226.5	53.5	47.9
1328	3.8	23.4	277.5	24.4	39.2	58.7	225.9	31.9	47.8
1329	3.8	23.4	276.7	19.9	31.9	58.0	225.0	26.0	47.2
1330	4.1	23.0	277.5	21.4	34.3	57.8	229.9	28.5	47.9
1331	3.8	23.5	275.4	40.0	64.2	58.2	224.4	52.3	47.4
1332	3.9	23.3	275.1	41.9	67.3	58.8	224.7	54.9	48.0
1333	3.9	23.3	275.1	47.2	75.8	58.8	225.1	62.0	48.1
1334	3.8	23.4	274.6	56.8	91.2	58.4	222.9	74.0	47.4
1335	3.7	23.5	273.8	57.0	91.5	58.3	221.7	74.1	47.2
1336	3.5	23.8	272.5	55.1	88.4	57.8	218.2	70.8	46.3
1337	3.7	23.6	273.5	58.2	93.4	57.3	221.2	75.6	46.3
1338	3.8	23.4	273.7	52.5	84.3	57.4	222.8	68.6	46.7
1339	3.9	23.3	274.0	53.4	85.7	58.1	223.9	70.1	47.5
1340	4.7	22.3	277.1	44.8	71.9	58.6	237.7	61.7	50.3
1341	4.0	23.2	273.4	45.1	72.4	58.5	224.8	59.5	48.1
1342	4.1	23.0	274.0	44.9	72.1	58.2	227.5	59.8	48.3
1343	4.5	22.5	275.7	40.3	64.7	57.4	233.5	54.8	48.6
1344	4.1	22.8	274.3	43.5	69.8	56.5	226.6	57.7	46.7
1345	4.2	22.6	274.8	42.8	68.7	55.9	228.5	57.1	46.5
1346	4.2	22.5	275.1	42.9	68.9	54.9	229.3	57.4	45.8
1347	4.9	21.6	277.5	34.1	54.7	53.9	240.7	47.5	46.8
1348	4.7	22.0	275.2	35.4	56.8	53.2	236.2	48.8	45.7
1349	4.6	22.1	273.3	35.0	56.2	52.4	233.2	47.9	44.7
Port change									
1410	3.4	24.2	278.6	59.6	95.7	56.7	221.4	76.0	45.1
1411	3.3	24.1	280.5	60.6	97.3	59.2	221.5	76.8	46.7
1412	3.3	24.1	283.8	57.4	92.1	60.2	224.5	72.9	47.6
1413	3.5	23.8	286.8	52.6	84.4	60.9	228.8	67.4	48.6
1414	3.7	23.6	285.3	46.8	75.1	61.4	230.6	60.7	49.6
1415	3.7	24.0	282.7	52.0	83.5	61.5	228.1	67.4	49.6
1416	3.7	24.1	283.0	52.1	83.6	60.9	228.5	67.5	49.2
1417	3.6	24.0	283.7	49.8	79.9	60.0	227.6	64.1	48.1
1418	3.5	24.0	283.3	53.8	86.4	59.7	226.8	69.1	47.8
1419	3.7	23.9	284.2	50.5	81.1	59.6	229.7	65.5	48.2

1420	3.7	23.9	282.9	49.7	79.8	59.3	228.7	64.5	47.9
1421	3.8	23.8	281.5	47.7	76.6	59.1	229.7	62.5	48.2
1422	3.8	24.1	279.3	46.8	75.1	58.7	226.8	61.0	47.7
1423	4.1	23.6	280.1	42.3	67.9	58.1	232.2	56.3	48.2
1424	3.8	24.0	276.6	46.3	74.3	57.5	225.7	60.6	46.9
1425	3.8	24.0	275.0	46.5	74.6	56.9	223.8	60.8	46.3
1426	3.6	24.1	273.1	49.0	78.7	56.2	220.2	63.4	45.3
1427	3.8	23.8	272.5	47.6	76.4	55.4	221.5	62.1	45.0
1428	3.4	24.5	268.3	54.5	87.5	54.9	212.8	69.4	43.5
1429	3.3	24.4	267.7	57.1	91.7	54.9	212.1	72.6	43.5
1430	3.5	24.2	267.2	54.7	87.8	55.0	214.0	70.3	44.1
1431	3.5	24.1	266.6	54.8	88.0	55.6	213.5	70.4	44.5
1432	3.7	24.4	264.7	52.9	84.9	56.8	214.0	68.6	45.9
1433	3.9	23.9	266.0	48.2	77.4	57.5	217.7	63.3	47.0
1434	4.0	23.7	266.0	46.7	75.0	58.1	219.4	61.8	47.9
1435	3.9	23.9	265.2	49.8	79.9	58.4	216.6	65.3	47.7
1436	3.9	23.8	265.3	48.8	78.3	58.1	216.8	64.0	47.5
1437	3.4	24.2	263.7	56.2	90.2	57.6	209.9	71.8	45.8
1438	3.4	24.0	264.6	50.6	81.2	57.3	209.9	64.4	45.5
1439	3.4	23.9	265.2	53.5	85.9	57.1	211.2	68.4	45.5
1440	3.9	23.6	266.8	50.6	81.2	57.6	218.1	66.4	47.1
Port change									
1510	4.1	22.9	259.3	45.5	73.0	54.0	214.8	60.5	44.7
1511	4.3	22.6	260.3	38.3	61.5	54.1	217.7	51.4	45.2
1512	4.1	22.8	260.0	43.6	70.0	54.1	215.8	58.1	44.9
1513	3.9	22.8	259.8	45.4	72.9	53.5	213.0	59.7	43.9
1514	3.8	23.0	259.5	43.8	70.3	52.7	211.5	57.3	42.9
1515	3.3	23.5	258.4	50.7	81.4	52.0	204.8	64.5	41.2
1516	4.3	22.3	262.4	40.9	65.7	51.7	220.1	55.1	43.4
1517	4.1	22.7	260.7	37.4	60.0	51.7	215.5	49.6	42.7
1518	3.6	23.2	259.7	46.4	74.5	52.5	208.7	59.9	42.2
1519	5.0	21.5	265.2	33.0	53.0	52.8	231.8	46.3	46.1
1520	4.6	22.1	263.2	34.4	55.2	51.8	224.0	47.0	44.1
1521	4.8	21.7	264.3	30.0	48.2	51.9	229.1	41.7	44.9
1522	4.0	22.6	262.0	38.3	61.5	51.5	216.1	50.7	42.5
1523	4.3	22.3	263.9	36.2	58.1	50.1	221.6	48.8	42.1
1524	4.3	22.5	263.0	35.1	56.3	48.8	220.9	47.3	41.0
1525	4.0	22.7	262.5	38.8	62.3	48.0	215.8	51.2	39.5
1526	4.2	22.4	264.2	42.7	68.5	47.9	220.7	57.3	40.0
1527	4.1	22.7	263.5	41.2	66.1	47.3	218.0	54.7	39.1
1528	4.0	22.7	264.3	43.9	70.5	46.9	217.7	58.0	38.6
1529	3.9	23.0	263.5	44.0	70.6	46.8	215.4	57.7	38.2
1530	3.7	23.1	263.6	45.3	72.7	46.5	212.9	58.7	37.6

1531	3.5	23.3	263.6	46.1	74.0	46.5	211.1	59.3	37.2
1532	3.7	22.9	265.3	48.2	77.4	47.0	215.2	62.8	38.1
1533	3.9	22.8	266.0	41.2	66.1	47.5	217.4	54.0	38.8
1534	3.9	22.7	266.9	48.6	78.0	48.7	219.0	64.0	40.0
1535	4.2	22.3	269.0	46.1	74.0	49.7	224.2	61.7	41.4
1536	4.4	22.1	270.0	42.2	67.7	50.1	227.0	57.0	42.1
1537	4.0	22.6	269.2	42.0	67.4	50.4	222.0	55.6	41.6
1538	3.9	22.6	269.5	45.2	72.6	50.1	220.5	59.4	41.0
1539	4.2	22.1	272.3	35.8	57.5	49.0	227.2	47.9	40.9
1540	4.1	22.1	272.8	35.5	57.0	48.3	226.4	47.3	40.1
AVG =	3.9	23.3	279.5	44.8	71.9	52.6	229.0	58.8	43.1
MIN =	3.3	21.5	258.4	19.9	31.9	40.4	204.8	26.0	33.5
MAX =	5.0	24.6	306.2	60.6	97.3	61.5	259.8	76.8	50.3

O2 = Oxygen
CO2 = Carbon Dioxide
CO = Carbon Monoxide
THCH = Hydrocarbon Hot-line
THCC = Hydrocarbon Cold-line

Filename:RUN3
Name:RUN3
Date:06-22-1990
Location: HANNIBAL,MO
Project :9102-63-13
Operator:BG
VERSION=05/07/90

TIME	O2 (%, dry)	CO2 (%, dry)	CO (ppm, dry)	THCH (ppm, dry)	THCH (ppm, dry)	THCC (ppm, dry)	CO @ 7% O2 (ppm, dry)	THCH @ 7% O2 (ppm, dry)	THCC @ 7% O2 (ppm, dry)
1135	3.7	23.7	244.0	69.5	108.1	50.1	196.9	87.2	40.4
1136	3.9	23.2	298.4	56.7	88.2	50.7	243.9	72.1	41.4
1137	4.2	23.0	307.8	55.3	86.0	52.5	255.9	71.5	43.6
1138	4.2	22.9	298.8	54.9	85.4	55.0	248.9	71.1	45.8
1139	4.1	22.9	302.9	54.3	84.4	56.1	250.5	69.8	46.4
1140	4.0	23.1	291.8	61.0	94.9	56.3	240.2	78.1	46.3
1141	4.2	22.5	323.3	44.1	68.6	56.1	268.8	57.0	46.6
1142	4.5	22.6	320.5	45.4	70.6	55.9	271.6	59.8	47.4
1143	4.4	22.9	302.8	49.6	77.1	55.9	254.9	64.9	47.1
1144	4.5	22.4	331.7	42.4	65.9	55.0	281.1	55.9	46.6
1145	4.6	22.6	315.4	57.0	88.6	54.2	268.6	75.5	46.2
1146	4.5	22.7	310.6	60.5	94.1	54.5	263.7	79.9	46.3
1147	4.4	22.9	298.7	62.3	96.9	53.7	251.8	81.7	45.3
1148	4.0	23.1	273.3	61.0	94.9	53.1	224.8	78.0	43.7
1149	3.8	23.1	269.5	61.4	95.5	52.7	218.9	77.5	42.8
1150	4.0	22.5	285.9	44.9	69.8	52.7	234.8	57.3	43.3
1151	4.2	22.7	304.8	45.1	70.1	53.7	253.4	58.3	44.6
1152	4.1	22.7	309.0	47.2	73.4	54.7	256.6	61.0	45.4
1153	4.2	22.3	309.9	44.2	68.7	54.7	258.7	57.4	45.7
1154	4.2	22.3	320.5	47.1	73.3	54.1	267.2	61.1	45.1
1155	4.2	22.8	317.1	55.9	86.9	53.4	264.4	72.5	44.5
1156	4.1	22.8	303.7	55.3	86.0	52.1	251.4	71.2	43.1
1157	3.7	23.1	296.6	67.7	105.3	50.7	239.9	85.2	41.0
1158	3.7	22.9	277.6	62.3	96.9	50.3	224.8	78.5	40.7
1159	4.0	22.6	283.3	41.0	63.8	50.3	233.2	52.5	41.4
1200	4.2	22.4	306.7	44.4	69.1	51.3	255.0	57.4	42.6
1201	4.3	22.3	322.5	48.7	75.7	52.5	270.0	63.4	44.0
1202	4.2	22.5	326.2	50.6	78.7	52.9	271.7	65.5	44.1
1203	4.3	22.4	315.6	51.2	79.6	52.6	264.3	66.7	44.0
1204	4.1	22.7	322.9	61.8	96.1	52.2	267.6	79.7	43.3
1205	4.2	22.3	314.6	56.2	87.4	51.5	262.6	73.0	43.0

Port change									
1223	4.1	22.5	318.2	57.4	89.3	40.4	263.0	73.8	33.4
1224	4.1	22.2	323.5	56.9	88.5	40.5	268.3	73.4	33.6
1225	4.5	21.8	331.1	51.8	80.6	41.2	280.9	68.4	35.0
1226	4.3	22.1	335.2	39.0	60.7	41.9	280.3	50.7	35.0
1227	4.3	21.9	334.1	35.1	54.6	42.7	280.3	45.8	35.8
1228	4.1	22.6	342.3	44.2	68.7	42.9	283.9	57.0	35.6
1229	4.2	22.5	338.7	48.0	74.7	42.4	281.6	62.1	35.2
1230	4.1	22.6	320.1	41.1	63.9	41.7	265.5	53.0	34.6
1231	4.1	22.4	330.2	38.8	60.3	41.1	274.2	50.1	34.1
1232	4.4	22.0	336.9	34.7	54.0	40.5	284.8	45.6	34.2
1233	4.3	22.3	343.4	43.9	68.3	42.8	287.7	57.2	35.9
1234	4.2	22.4	343.8	47.5	73.9	43.5	286.5	61.6	36.3
1235	4.3	22.3	337.1	45.7	71.1	43.2	283.1	59.7	36.3
1236	4.5	22.0	336.6	38.6	60.0	43.0	285.4	50.9	36.5
1237	4.3	22.5	338.1	41.8	65.0	43.3	283.3	54.5	36.3
1238	4.2	22.6	338.1	47.4	73.7	43.6	282.3	61.5	36.4
1239	4.2	22.6	332.0	54.2	84.3	43.3	276.7	70.2	36.1
1240	4.3	22.4	334.3	48.5	75.4	43.4	280.4	63.3	36.4
1241	4.5	22.2	333.1	41.9	65.2	43.9	282.3	55.2	37.2
1242	4.3	22.3	338.9	39.5	61.4	44.9	284.4	51.6	37.7
1243	4.4	22.3	334.6	37.6	58.5	45.3	281.7	49.2	38.1
1244	4.3	22.3	341.4	41.7	64.9	45.3	286.5	54.4	38.0
1245	4.3	22.4	338.1	44.2	68.7	45.3	283.8	57.7	38.0
1246	4.6	22.0	337.9	41.3	64.2	45.2	287.7	54.7	38.5
1247	4.3	22.5	345.2	45.8	71.2	45.3	288.7	59.6	37.9
1248	4.3	22.4	344.8	44.2	68.7	45.1	288.7	57.6	37.8
1249	4.4	22.1	332.9	35.3	54.9	44.3	281.4	46.4	37.5
1250	4.6	21.9	345.8	A	A	43.9	294.5	A	37.4
1251	4.5	22.1	352.1	A	A	44.0	298.6	A	37.3
1252	4.6	22.1	350.9	A	A	43.5	298.6	A	37.0
1253	4.6	22.2	344.7	A	A	42.6	293.7	A	36.3
Port change									
1314	4.2	22.2	347.2	49.1	76.4	42.6	289.7	63.7	35.5
1315	4.3	22.0	344.0	50.3	78.2	42.7	288.4	65.6	35.8
1316	4.2	21.9	345.2	46.6	72.5	43.3	288.4	60.5	36.2
1317	4.5	21.5	346.7	38.5	59.9	43.8	293.8	50.7	37.1
1318	4.7	21.4	348.0	35.7	55.5	43.8	298.5	47.6	37.6
1319	4.6	21.5	355.0	34.5	53.7	43.3	302.1	45.7	36.9
1320	4.7	21.3	365.0	33.7	52.4	42.2	313.1	45.0	36.2
1321	4.6	21.5	365.4	36.7	57.1	40.7	312.1	48.8	34.8
1322	4.5	21.5	360.7	37.8	58.8	39.6	305.9	49.8	33.6
1323	4.7	21.2	351.6	34.3	53.3	38.0	302.5	45.9	32.7

1324	5.0	20.8	362.1	30.5	47.4	37.0	317.4	41.6	32.4
1325	5.0	21.0	357.5	30.6	47.6	36.4	312.2	41.6	31.8
1326	4.8	21.7	350.0	35.1	54.6	35.6	302.8	47.2	30.8
1327	4.8	21.3	349.2	34.7	54.0	34.3	302.2	46.7	29.7
1328	5.1	20.9	353.4	31.4	48.8	33.2	310.8	42.9	29.2
1329	5.1	20.8	349.8	22.5	35.0	33.0	307.0	30.7	29.0
1330	4.9	21.2	349.7	25.5	39.7	33.2	304.1	34.5	28.9
1331	5.5	20.6	358.8	23.4	36.4	32.5	324.3	32.9	29.4
1332	4.8	21.4	356.0	26.2	40.7	31.6	306.7	35.1	27.2
1333	4.6	21.6	353.7	23.6	36.7	31.2	301.4	31.3	26.6
Plant changing feed tanks									
1540	3.4	22.8	326.1	53.2	82.7	51.6	259.4	65.8	41.0
1541	3.4	22.6	322.4	55.9	86.9	51.2	256.3	69.1	40.7
1542	3.5	22.6	319.5	62.0	96.4	50.9	255.2	77.0	40.7
1543	3.5	22.5	317.7	55.1	85.7	51.3	254.2	68.6	41.0
1544	3.6	22.4	317.3	52.8	82.1	51.9	255.0	66.0	41.7
1545	3.6	22.4	317.2	49.6	77.1	52.1	255.4	62.1	41.9
1546	3.7	22.4	318.3	51.4	79.9	52.2	257.7	64.7	42.3
1547	3.9	22.2	319.5	43.0	66.9	52.4	261.6	54.8	42.9
1548	4.0	22.0	320.7	39.5	61.4	52.5	264.7	50.7	43.3
1549	3.7	22.4	319.2	50.2	78.1	52.0	258.0	63.1	42.0
1550	3.7	22.4	319.1	47.4	73.7	51.6	258.2	59.7	41.8
Port change									
1615	3.7	22.5	309.1	48.6	75.6	48.2	250.6	61.3	39.1
1616	3.7	22.5	308.9	44.3	68.9	47.9	250.0	55.8	38.8
1617	3.7	22.6	302.7	48.8	75.9	47.9	244.5	61.3	38.7
1618	3.8	22.5	311.7	57.2	89.0	48.5	253.4	72.3	39.4
1619	3.9	22.1	322.8	57.8	89.9	49.4	264.0	73.5	40.4
1620	3.8	22.4	314.8	56.3	87.6	50.0	256.8	71.4	40.8
1621	3.6	23.0	289.6	60.2	93.6	50.4	233.5	75.5	40.6
1622	3.7	22.5	301.5	53.2	82.7	50.0	244.4	67.1	40.5
1623	3.8	22.5	312.1	50.1	77.9	50.1	254.0	63.4	40.8
1624	3.8	22.4	321.8	54.3	84.4	51.0	261.6	68.7	41.5
1625	3.8	22.4	330.3	48.1	74.8	51.7	268.4	60.8	42.0
1626	3.8	22.5	320.5	49.4	76.8	52.0	261.2	62.6	42.4
1627	3.9	22.2	325.3	45.9	71.4	52.1	265.6	58.3	42.5
1628	3.9	22.1	329.8	46.5	72.3	51.7	269.9	59.2	42.3
1629	3.9	22.2	342.4	36.2	56.3	51.6	281.0	46.2	42.3
1630	4.0	22.1	341.0	37.0	57.5	51.4	281.2	47.4	42.4
1631	4.0	22.3	323.8	51.2	79.6	50.6	266.0	65.4	41.6
1632	3.9	22.3	312.6	49.8	77.4	50.0	256.1	63.4	41.0
1633	3.8	22.7	304.2	52.6	81.8	49.2	247.5	66.5	40.0
1634	3.7	22.4	312.7	47.7	74.2	49.4	253.5	60.1	40.0

1635	3.9	22.3	319.6	53.0	82.4	50.2	261.2	67.4	41.0
1636	3.9	22.4	302.8	54.2	84.3	51.2	247.2	68.8	41.8
1637	3.8	22.8	300.0	56.7	88.2	51.3	243.6	71.6	41.7
1638	3.8	22.8	330.4	35.5	55.2	51.4	268.6	44.9	41.8
1639	3.8	23.0	329.4	45.5	70.8	52.1	268.3	57.6	42.4
1640	3.9	23.0	337.0	42.3	65.8	52.8	275.1	53.7	43.1
1641	4.1	22.7	352.3	41.5	64.5	52.5	291.5	53.4	43.4
1642	4.2	22.3	344.9	48.1	74.8	52.1	288.1	62.5	43.5
1643	4.3	22.6	347.6	50.6	78.7	51.2	290.5	65.8	42.8
1644	4.3	22.4	359.3	41.8	65.0	49.6	301.2	54.5	41.6
1645	4.3	22.5	353.0	42.0	65.3	48.3	295.9	54.8	40.5
AVG =	4.2	22.3	326.3	45.1	70.1	47.5	271.8	60.1	39.4
MIN =	3.4	20.6	244.0	14.3	35.0	31.2	196.9	30.7	26.6
MAX =	5.5	23.7	365.4	69.5	108.1	56.3	324.3	87.2	47.4

O2 = Oxygen
CO2 = Carbon Dioxide
CO = Carbon Monoxide
THCH = Hydrocarbon Hot-line
THCC = Hydrocarbon Cold-line

Filename:RUN4
Name:RUN4
Date:06-23-1990
Location:HANNIBAL,MO
Project: 9102-63-13
Operator:BG
VERSION=05/07/90

TIME	O2 (%, dry)	CO2 (%, dry)	C0 (ppm, dry)	THCH (ppm, wet)	THCH (ppm, dry)	THCC (ppm, dry)	CO @ 7% O2 (ppm, dry)	THCH @ 7% O2 (ppm, dry)	THCC @ 7% O2 (ppm, dry)
1055	4.5	22.5	271.0	32.3	47.2	24.7	229.2	39.9	20.9
1056	4.4	22.6	274.3	31.6	46.1	24.8	230.9	38.8	20.9
1057	4.2	22.6	267.5	29.3	42.8	24.8	223.4	35.7	20.7
1058	4.4	22.5	264.3	29.1	42.5	24.7	222.8	35.8	20.8
1059	4.3	22.5	273.6	28.6	41.8	24.7	229.8	35.1	20.7
1100	4.2	22.9	265.3	33.6	49.1	25.1	221.2	40.9	20.9
1101	4.2	22.6	274.5	30.8	45.0	24.9	228.9	37.5	20.8
1102	4.2	22.6	269.7	30.1	43.9	24.8	224.5	36.6	20.6
1103	4.2	22.7	268.9	31.3	45.7	25.5	223.8	38.0	21.2
1104	4.4	22.3	270.9	28.9	42.2	26.3	228.5	35.6	22.2
1105	4.6	22.2	273.0	27.3	39.9	26.8	233.0	34.0	22.9
1106	4.3	22.7	275.7	31.0	45.3	27.3	231.5	38.0	22.9
1107	4.4	22.4	271.2	27.1	39.6	27.1	228.2	33.3	22.8
1108	4.4	22.6	268.0	30.2	44.1	26.2	226.4	37.2	22.1
1109	3.9	23.9	240.9	41.7	60.9	25.7	197.1	49.8	21.0
1110	4.0	23.0	251.9	33.5	48.9	25.3	206.8	40.2	20.8
1111	4.0	22.7	264.0	30.4	44.4	25.3	217.8	36.6	20.9
1112	4.2	22.6	266.2	29.1	42.5	27.6	222.0	35.4	23.0
1113	4.2	22.6	263.0	28.9	42.2	29.2	218.9	35.1	24.3
1114	4.3	22.4	264.3	30.1	43.9	29.3	221.7	36.9	24.6
1115	4.3	22.6	264.4	31.7	46.3	28.9	221.0	38.7	24.2
1116	4.2	22.5	266.8	30.1	43.9	28.4	222.9	36.7	23.7
1117	4.1	22.8	263.7	33.5	48.9	27.7	219.0	40.6	23.0
1118	4.1	22.6	267.3	27.9	40.7	27.5	222.0	33.8	22.8
1119	4.1	22.6	267.0	26.0	38.0	26.9	221.6	31.5	22.3
1120	4.2	22.4	265.8	25.6	37.4	26.9	221.8	31.2	22.4
1121	4.3	22.5	261.6	27.2	39.7	27.0	219.4	33.3	22.6
1122	4.3	23.1	272.9	32.1	46.9	26.6	228.1	39.2	22.2
1123	4.2	22.6	269.7	27.7	40.4	26.1	224.6	33.7	21.7
1124	4.3	22.4	263.7	24.8	36.2	25.5	221.5	30.4	21.4
1125	4.4	22.6	270.2	25.0	36.5	25.5	227.5	30.7	21.5

Port change									
1140	4.2	22.7	256.0	27.9	40.7	26.5	213.1	33.9	22.1
1141	4.2	22.5	256.0	25.4	37.1	25.7	213.2	30.9	21.4
1142	4.1	22.6	255.7	25.7	37.5	25.2	212.3	31.2	20.9
1143	4.1	22.5	250.3	22.3	32.6	25.2	207.8	27.0	20.9
1144	4.2	22.6	250.2	23.8	34.7	25.1	208.1	28.9	20.9
1145	4.2	22.6	251.5	25.1	36.6	24.5	209.3	30.5	20.4
1146	4.2	22.6	256.2	24.5	35.8	24.1	213.2	29.8	20.1
1147	4.2	22.4	254.7	23.6	34.5	23.7	212.1	28.7	19.7
1148	4.3	22.6	252.7	25.4	37.1	23.8	211.2	31.0	19.9
1149	4.3	22.7	251.6	26.2	38.2	23.8	210.9	32.1	20.0
1150	4.3	22.5	252.4	24.0	35.0	23.4	211.6	29.4	19.6
1151	4.5	22.2	248.9	21.0	30.7	23.1	210.9	26.0	19.6
1152	4.4	22.3	249.6	21.6	31.5	23.0	210.5	26.6	19.4
1153	4.2	22.7	250.2	23.9	34.9	23.0	208.0	29.0	19.1
1154	4.3	22.4	250.9	20.3	29.6	22.6	210.5	24.9	19.0
1155	4.6	22.0	251.8	18.8	27.4	22.0	215.0	23.4	18.8
1156	4.1	22.5	253.7	23.9	34.9	21.8	210.7	29.0	18.1
1157	4.1	22.7	249.7	26.9	39.3	22.0	207.1	32.6	18.2
1158	4.2	22.5	254.8	28.8	42.0	21.8	211.8	35.0	18.1
1159	4.1	22.5	254.4	26.0	38.0	21.9	211.0	31.5	18.2
1200	4.2	22.3	254.9	25.6	37.4	22.4	212.4	31.1	18.7
1201	4.2	22.2	259.9	25.9	37.8	23.1	216.7	31.5	19.3
1202	4.1	22.5	261.4	25.6	37.4	23.6	215.9	30.9	19.5
1203	4.0	22.3	256.4	25.1	36.6	23.7	211.5	30.2	19.6
1204	4.1	22.3	258.2	26.2	38.2	23.6	213.4	31.6	19.5
1205	4.2	22.3	261.2	24.6	35.9	23.8	217.9	30.0	19.9
1206	4.0	22.5	260.1	23.5	34.3	24.1	214.6	28.3	19.9
1207	4.0	22.3	258.2	24.5	35.8	24.3	212.5	29.4	20.0
1208	4.2	22.1	256.6	25.8	37.7	24.4	214.3	31.5	20.4
1209	4.2	22.1	256.4	25.1	36.6	24.5	213.7	30.5	20.4
1210	4.1	22.4	259.1	27.5	40.1	24.5	214.9	33.3	20.3
Port change Conducted zero and span of THC units									
1224	4.4	22.2	254.2	A	A	A	214.0	A	84.6*
1225	4.4	22.2	254.0	A	A	A	214.6	A	84.9*
1226	4.3	22.7	248.0	A	A	A	207.9	A	84.3*
1227	4.3	22.8	244.9	A	A	A	205.6	A	84.4*
1228	4.0	22.9	246.3	A	A	A	202.2	A	82.5*
1229	4.2	22.4	253.0	A	A	A	210.3	A	60.4*
1230	4.2	22.7	256.4	28.7	41.9	20.3	213.3	34.9	16.9
1231	4.4	22.2	257.4	20.8	30.4	20.7	216.6	25.5	17.4
1232	4.3	22.5	259.4	26.1	38.1	22.0	217.9	32.0	18.5
1233	4.1	22.9	253.7	32.1	46.9	22.2	209.8	38.8	18.4

1234	3.9	23.1	241.7	37.1	54.2	22.5	198.0	44.4	18.4
1235	3.9	23.1	240.8	35.1	51.2	22.5	197.3	42.0	18.4
1236	4.1	22.9	254.3	28.9	42.2	22.7	210.2	34.9	18.8
1237	3.9	23.2	251.2	31.3	45.7	23.6	205.8	37.4	19.3
1238	3.9	23.1	252.2	26.0	38.0	25.0	206.5	31.1	20.5
1239	3.9	23.0	250.5	25.7	37.5	26.2	204.8	30.7	21.4
1240	3.8	23.3	242.2	32.7	47.7	26.8	196.6	38.7	21.8
1241	3.8	22.8	247.9	33.1	48.3	27.5	201.7	39.3	22.4
1242	3.8	22.9	246.5	33.0	48.2	27.9	200.6	39.2	22.7
1243	4.0	22.6	251.5	29.5	43.1	28.3	206.6	35.4	23.3
1244	4.0	22.5	249.2	26.7	39.0	29.0	205.3	32.1	23.9
1245	4.1	22.5	251.0	21.1	30.8	29.5	207.7	25.5	24.4
1246	4.0	22.8	251.7	25.5	37.2	29.4	207.3	30.7	24.2
1247	3.9	23.3	249.0	29.8	43.5	28.8	203.6	35.6	23.6
1248	4.0	22.6	256.7	28.5	41.6	28.1	211.5	34.3	23.2
1249	4.0	22.5	258.9	27.0	39.4	27.7	213.7	32.5	22.9
1250	3.9	23.1	245.1	35.0	51.1	27.8	200.5	41.8	22.7
1251	3.9	23.0	245.5	33.6	49.1	28.2	200.5	40.1	23.0
1252	3.9	22.7	245.5	33.6	49.1	28.1	200.6	40.1	23.0
1253	3.9	22.6	249.2	29.9	43.6	28.0	203.8	35.7	22.9
1254	4.0	22.5	247.8	32.2	47.0	28.7	204.4	38.8	23.7
Port change									
1405	4.0	23.0	295.1	32.8	47.9	28.0	242.6	39.4	23.0
1406	4.0	23.1	288.3	32.1	46.9	29.8	237.6	38.6	24.6
1407	4.2	22.5	301.4	26.1	38.1	30.9	251.6	31.8	25.8
1408	4.0	23.7	281.5	32.2	47.0	31.2	231.6	38.7	25.7
1409	3.8	23.0	290.6	27.1	39.6	31.8	236.8	32.2	25.9
1410	4.0	22.5	297.5	24.0	35.0	31.1	245.4	28.9	25.7
1411	4.2	22.7	298.8	26.1	38.1	31.8	248.3	31.7	26.4
1412	4.2	22.4	294.2	24.9	36.4	31.9	245.2	30.3	26.6
1413	4.3	22.8	292.1	31.1	45.4	31.1	244.7	38.0	26.1
1414	4.0	23.0	293.3	33.9	49.5	29.9	241.7	40.8	24.6
1415	4.1	22.9	294.6	31.3	45.7	29.0	243.8	37.8	24.0
1416	4.1	23.0	277.1	42.3	61.8	28.3	229.0	51.0	23.4
1417	3.8	23.3	265.9	46.3	67.6	28.3	216.4	55.0	23.0
1418	3.7	23.5	281.5	39.1	57.1	28.3	228.1	46.2	22.9
1419	3.8	23.2	287.0	28.7	41.9	28.8	234.0	34.2	23.5
1420	4.0	22.7	296.2	24.8	36.2	30.7	243.8	29.8	25.3
1421	4.1	22.8	286.3	27.3	39.9	31.9	237.0	33.0	26.4
1422	3.9	23.1	277.4	32.1	46.9	32.1	227.2	38.4	26.3
1423	3.7	23.7	252.0	42.6	62.2	31.5	203.3	50.2	25.4
1424	3.4	23.7	254.0	43.3	63.2	31.0	202.4	50.4	24.7
1425	3.4	23.5	258.8	43.1	62.9	30.9	205.9	50.0	24.6

1426	3.7	23.3	280.5	38.7	56.5	32.3	226.3	45.6	26.1
1427	3.9	23.0	291.2	32.6	47.6	34.3	237.9	38.9	28.0
1428	3.9	23.1	295.6	30.3	44.2	36.0	242.6	36.3	29.5
1429	3.9	23.1	293.8	31.0	45.3	36.9	240.0	37.0	30.1
1430	3.8	23.3	278.7	35.1	51.2	36.8	227.2	41.8	30.0
1431	3.9	22.9	289.8	29.6	43.2	36.1	236.6	35.3	29.5
1432	4.0	22.9	292.5	29.8	43.5	35.3	240.3	35.7	29.0
1433	4.1	22.9	299.9	31.1	45.4	34.9	247.7	37.5	28.8
1434	4.0	22.9	299.7	29.2	42.6	34.6	247.1	35.1	28.5
1435	4.1	22.8	298.1	30.5	44.5	33.6	246.8	36.9	27.8
1436	4.1	22.7	294.2	25.4	37.1	32.6	243.3	30.7	27.0
AVG=	4.1	22.7	264.8	29.1	42.6	27.1	219.4	35.2	21.3
MIN=	3.4	22.02	240.8	18.8	27.4	20.3	196.6	23.4	16.9
MAX=	4.6	23.87	301.4	46.3	67.6	36.9	251.6	55.0	30.1

O2 = Oxygen
CO2 = Carbon Dioxide
CO = Carbon Monoxide
THCH = Hydrocarbon Hot-line
THCC = Hydrocarbon Cold-line

A Span gas in line. Invalid data. Turned back to stack gas at 12:29.

Filename:RUN5
Name:RUN5
Date:07-05-1990
Location:HANNIBAL, MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

TIME	O2 (%, dry)	CO2 (%, dry)	CO (ppm, dry)	THCH (ppm, wet)	THCH (ppm, dry)	THCC (ppm, dry)	CO @ 7% O2 (ppm, dry)	THCH @ 7% O (ppm, dry)	THCC @ 7% O (ppm, dry)
1220	4.2	22.8	A	64.6	101.4	48.1	A	84.5	40.1
1221	3.8	23.5	A	79.0	124.0	49.6	A	100.8	40.3
1222	3.9	23.4	A	67.1	105.3	50.3	A	86.0	41.1
1223	4.1	22.9	A	B	B	50.9	A	B	42.2
1224	4.3	22.8	A	B	B	52.5	A	B	44.1
1225	4.2	23.1	A	B	B	54.4	A	B	45.3
1226	3.8	23.4	A	69.3	108.8	54.1	A	88.6	44.1
1227	3.7	23.8	175.5	82.5	129.5	52.7	142.4	105.1	42.7
1228	3.9	23.2	234.7	65.1	102.2	53.0	192.2	83.7	43.4
1229	4.4	23.0	265.6	58.6	92.0	55.9	223.9	77.5	47.1
1230	4.5	22.9	263.3	60.2	94.5	58.7	222.9	80.0	49.7
1231	4.4	23.0	251.5	B	B	59.2	212.1	B	49.9
1232	4.2	23.2	253.4	B	B	57.0	211.5	B	47.6
1233	4.3	23.0	268.6	B	B	54.8	225.2	B	45.9
1234	4.6	22.8	269.9	B	B	53.9	230.3	B	46.0
1235	C	C	C	C	C	C	C	C	C
1248	4.4	22.8	255.3	52.1	81.8	42.1	215.4	69.0	35.5
1249	4.3	22.7	252.1	47.6	74.7	42.4	211.0	62.5	35.5
1250	4.6	22.6	274.1	61.7	96.9	43.5	233.8	82.6	37.1
1251	4.5	22.6	264.6	46.5	73.0	43.5	224.6	62.0	36.9
1252	4.6	22.7	283.7	37.1	58.2	44.6	242.0	49.7	38.0
1253	3.7	23.6	217.3	77.6	121.8	43.8	175.6	98.5	35.4
1254	3.2	23.9	153.4	92.3	144.9	43.8	120.8	114.1	34.5
1255	3.9	23.3	201.0	67.4	105.8	43.5	164.7	86.7	35.6
1256	4.8	22.4	275.9	46.4	72.8	46.2	237.7	62.8	39.8
1257	4.8	22.3	287.4	50.2	78.8	50.6	248.8	68.2	43.8
1258	4.5	22.5	282.4	38.4	60.3	52.4	240.2	51.3	44.6
1259	5.0	21.9	266.3	31.2	49.0	50.8	233.3	42.9	44.5
1300	5.0	22.0	264.6	31.1	48.8	48.7	230.9	42.6	42.5
1301	4.9	22.0	280.8	38.1	59.8	47.6	243.7	51.9	41.3

1302	4.7	22.1	283.8	46.4	72.8	45.7	243.9	62.6	39.3
1303	4.7	22.1	282.4	35.9	56.4	43.7	242.3	48.3	37.5
Port change									
1319	3.4	23.1	253.8	85.6	134.4	50.8	201.9	106.9	40.4
1320	5.8	20.1	228.6	32.4	50.9	49.6	210.7	46.9	45.7
1321	5.1	21.4	221.6	35.3	55.4	50.2	195.1	48.8	44.2
1322	4.7	21.9	248.6	53.3	83.7	53.1	212.9	71.6	45.5
1323	4.5	21.9	259.7	55.9	87.8	52.0	220.1	74.4	44.1
1324	4.4	22.0	257.9	54.9	86.2	50.1	217.4	72.6	42.2
1325	4.5	22.0	259.1	41.1	64.5	48.9	219.7	54.7	41.5
1326	4.6	21.7	261.9	40.2	63.1	48.3	224.0	54.0	41.3
1327	4.7	21.5	265.7	37.1	58.2	47.5	227.5	49.9	40.7
1328	4.7	21.6	269.8	40.6	63.7	46.8	231.9	54.8	40.2
1329	4.9	21.6	276.0	38.6	60.6	45.8	239.9	52.7	39.8
1330	4.8	21.3	282.1	44.0	69.1	44.5	243.6	59.7	38.4
1331	4.8	21.4	285.5	37.8	59.3	43.2	247.0	51.3	37.4
1332	4.4	22.1	283.7	49.8	78.2	42.2	239.1	65.9	35.6
1333	4.2	21.9	281.3	52.2	81.9	41.5	234.4	68.3	34.6
1334	4.4	21.8	278.5	47.7	74.9	40.2	235.4	63.3	34.0
1335	4.5	21.8	278.8	48.7	76.5	40.6	236.6	64.9	34.4
1336	4.3	21.9	272.3	53.1	83.4	41.9	227.6	69.7	35.0
1337	3.9	22.4	262.6	63.1	99.1	41.8	215.1	81.1	34.2
1338	3.8	22.4	259.6	57.4	90.1	41.5	210.9	73.2	33.7
1339	4.3	21.9	263.5	41.9	65.8	41.7	221.0	55.2	35.0
1340	4.5	21.7	266.4	43.1	67.7	42.6	225.6	57.3	36.1
1341	4.5	21.8	268.5	48.3	75.8	44.6	227.4	64.2	37.8
1342	4.8	21.5	267.1	42.8	67.2	45.1	230.8	58.1	39.0
1343	4.6	21.5	263.6	42.8	67.2	44.3	225.6	57.5	37.9
1344	4.5	21.8	260.0	45.4	71.3	43.9	220.2	60.4	37.2
1345	5.4	20.6	264.2	32.8	51.5	42.7	237.1	46.2	38.3
1346	5.3	21.0	264.2	33.6	52.7	41.7	235.0	46.9	37.1
1347	4.3	21.9	264.1	44.2	69.4	41.0	221.0	58.1	34.3
1348	4.8	21.3	270.1	37.5	58.9	39.8	233.4	50.9	34.4
Port change									
1408	5.1	21.0	280.7	33.1	52.0	34.2	246.5	45.6	30.0
1409	5.4	20.9	282.6	27.0	42.4	34.8	253.0	37.9	31.2
1410	5.4	20.9	283.1	31.2	49.0	35.1	253.7	43.9	31.5
1411	4.8	21.6	282.2	41.3	64.8	35.2	243.6	56.0	30.4
1412	4.7	21.4	282.0	43.3	68.0	34.5	242.7	58.5	29.7
1413	4.7	21.3	283.0	44.1	69.2	33.5	243.7	59.6	28.8
1414	4.9	21.4	284.8	47.7	74.9	33.6	247.0	65.0	29.1
1415	5.3	20.9	286.8	23.0	36.1	33.5	255.1	32.1	29.8
1416	5.1	21.1	285.9	35.9	56.4	34.0	251.4	49.6	29.9

1417	5.1	21.0	285.8	33.3	52.3	35.9	251.0	45.9	31.5
1418	4.7	21.5	283.1	41.0	64.4	36.6	243.3	55.3	31.5
1419	4.7	21.6	282.4	41.5	65.1	34.7	242.7	56.0	29.8
1420	4.7	21.5	282.2	40.1	63.0	33.9	242.7	54.1	29.2
1421	4.6	21.6	282.1	39.3	61.7	33.2	241.0	52.7	28.4
1422	4.7	21.4	283.5	40.3	63.3	33.2	242.9	54.2	28.4
1423	4.8	21.4	284.3	40.4	63.4	33.3	245.4	54.7	28.7
1424	5.0	21.2	285.3	40.4	63.4	33.6	250.1	55.6	29.5
1425	5.2	21.1	285.5	39.5	62.0	33.8	252.7	54.9	29.9
1426	5.0	21.2	284.2	35.3	55.4	33.9	248.8	48.5	29.7
1427	5.3	20.9	285.3	33.3	52.3	33.6	253.8	46.5	29.9
1428	5.0	21.1	283.8	36.4	57.1	33.0	248.6	50.1	28.9
1429	5.2	21.0	285.0	38.8	60.9	32.8	252.5	54.0	29.1
1430	4.9	21.3	284.2	37.7	59.2	32.4	247.0	51.4	28.2
1431	4.7	21.4	284.2	42.1	66.1	32.0	244.2	56.8	27.5
1432	4.7	21.6	284.1	47.6	74.7	31.7	243.9	64.1	27.2
1433	4.5	21.8	284.3	50.4	79.1	31.5	241.5	67.2	26.8
1434	4.6	21.6	285.1	47.4	74.4	31.7	242.9	63.4	27.0
1435	4.6	22.0	283.4	51.3	80.5	32.3	241.2	68.5	27.5
1436	4.5	21.8	282.6	52.4	82.3	33.0	239.9	69.8	28.0
1437	4.7	21.6	282.5	53.2	83.5	34.0	242.6	71.7	29.2
1438	4.7	21.6	282.9	34.2	53.7	34.7	243.4	46.2	29.9
Port change									
1455	C	C	C	C	C	C	C	C	C
1456	C	C	C	C	C	C	C	C	C
1457	4.6	22.1	249.3	47.3	74.3	17.4	212.4	63.3	14.8
1458	4.7	21.8	281.9	43.2	67.8	22.0	242.7	58.4	18.9
1459	4.6	22.3	284.2	50.2	78.8	28.0	242.2	67.2	23.9
1500	4.5	22.4	277.5	48.6	76.3	32.0	235.3	64.7	27.1
1501	4.3	22.6	278.2	57.0	89.5	33.2	232.7	74.8	27.8
1502	4.4	22.5	268.5	58.2	91.4	33.9	225.8	76.8	28.5
1503	4.6	22.0	277.9	50.5	79.3	34.7	236.9	67.6	29.6
1504	4.2	22.6	278.1	51.6	81.0	35.6	231.9	67.5	29.7
1505	4.5	22.1	283.7	37.9	59.5	36.7	240.9	50.5	31.2
1506	4.5	22.1	283.9	37.2	58.4	36.9	241.0	49.6	31.3
1507	4.5	22.4	287.2	40.3	63.3	37.4	243.1	53.5	31.7
1508	4.4	22.4	278.5	46.0	72.2	37.9	234.5	60.8	31.9
1509	4.7	22.0	280.1	41.0	64.4	37.9	240.9	55.4	32.6
1510	4.5	22.2	281.7	46.0	72.2	38.0	238.6	61.2	32.2
1511	4.3	22.6	282.0	54.7	85.9	38.2	236.8	72.1	32.1
1512	4.1	22.8	275.5	57.4	90.1	38.0	228.4	74.7	31.5
1513	4.1	22.7	273.1	50.6	79.4	37.3	226.8	66.0	31.0
1514	4.0	22.9	270.7	51.0	80.1	37.2	222.9	65.9	30.6

1515	4.1	22.6	268.0	51.9	81.5	37.9	221.9	67.5	31.4
1516	4.4	22.4	274.9	47.5	74.6	39.5	232.0	62.9	33.3
1517	4.5	22.4	280.1	48.4	76.0	40.9	237.5	64.4	34.7
1518	4.4	22.4	283.9	54.5	85.6	42.2	239.4	72.2	35.6
1519	4.3	22.5	286.7	39.9	62.6	42.6	240.9	52.6	35.8
1520	4.3	22.4	287.7	38.0	59.7	42.5	240.9	50.0	35.6
1521	4.3	22.6	284.0	37.9	59.5	42.1	237.4	49.7	35.2
1522	4.2	22.7	285.3	42.3	66.4	41.6	237.2	55.2	34.6
1523	4.0	22.9	283.6	49.3	77.4	41.5	233.7	63.8	34.2
1524	4.1	22.5	272.6	53.6	84.1	41.3	225.8	69.7	34.2
1525	3.9	22.9	281.8	64.3	100.9	41.6	231.3	82.8	34.1
AVG	4.4	22.1	271.1	47.2	74.1	41.3	231.1	62.7	35.1
MIN	3.2	20.1	153.4	23.0	36.1	17.4	120.8	32.1	14.8
MAX	5.8	23.9	287.7	92.3	144.9	59.2	255.1	114.1	49.9

O2 = Oxygen
CO2 = Carbon Dioxide
CO = Carbon Monoxide
THCH = Hydrocarbon Hot-line
THCC = Hydrocarbon Cold-line

A Replacing ascarite filter. Invalid data.
B Lost THCH flow. Invalid data.
C Blowback of system. Invalid data.

Filename:RUN6
Name:RUN6
Date:07-05-1990
Location:HANNIBAL, MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

TIME	O2 (%, dry)	CO2 (%, dry)	CO (ppm, dry)	THCH (ppm, wet)	THCH (ppm, dry)	THCC (ppm, dry)	CO @ 7% O2 (ppm, dry)	THCH @ 7% O2 (ppm, dry)	THCC @ 7% O2 (ppm, dry)
1900	3.7	23.8	213.7	83.6	131.2	60.1	173.1	106.3	48.7
1901	3.7	23.8	194.1	86.2	135.3	59.8	156.9	109.4	48.3
1902	3.7	23.8	190.5	74.1	116.3	60.5	154.2	94.1	49.0
1903	4.0	23.4	189.5	59.2	92.9	62.3	156.0	76.5	51.3
1904	4.3	23.0	210.1	53.6	84.1	64.1	176.4	70.7	53.8
1905	4.2	23.2	224.7	60.6	95.1	65.4	187.3	79.3	54.5
1906	4.6	22.9	227.0	47.5	74.6	65.4	193.2	63.5	55.7
1907	4.8	22.4	236.3	42.2	66.2	64.1	203.8	57.1	55.3
1908	4.8	22.5	246.6	43.1	67.7	62.4	212.8	58.4	53.9
1909	4.5	22.6	250.8	53.0	83.2	59.8	213.2	70.7	50.8
1910	4.0	23.4	249.3	74.0	116.2	56.9	205.2	95.6	46.8
1911	3.7	23.7	235.0	74.9	117.6	53.4	190.3	95.2	43.2
1912	4.4	22.9	204.3	57.2	89.8	51.2	171.9	75.5	43.1
1913	4.2	23.1	201.9	52.6	82.6	51.6	167.9	68.6	42.9
1914	4.0	23.4	226.1	57.0	89.5	54.4	186.2	73.7	44.8
1915	4.2	23.1	225.1	61.9	97.2	55.2	187.5	80.9	46.0
1916	4.6	22.6	219.0	54.9	86.2	54.5	186.4	73.3	46.4
1917	4.9	22.2	232.9	45.5	71.4	55.1	202.9	62.2	48.0
1918	5.3	21.7	245.6	37.0	58.1	55.8	219.4	51.9	49.9
1919	5.2	21.8	252.7	43.1	67.7	55.1	223.8	59.9	48.8
1920	5.1	22.0	254.4	44.4	69.7	52.8	223.3	61.2	46.3
1921	5.1	22.0	251.8	46.0	72.2	49.5	221.2	63.4	43.5
1922	4.7	22.4	250.0	55.6	87.3	46.4	214.6	74.9	39.8
1923	4.2	22.8	247.1	66.7	104.7	44.9	206.4	87.5	37.5
1924	4.2	22.6	242.2	74.7	117.3	43.6	201.8	97.7	36.3
1925	4.8	22.0	241.2	A	A	43.1	208.7	A	37.3
1926	4.4	22.6	241.2	A	A	43.9	203.8	A	37.1
1927	4.3	22.6	250.2	A	A	45.1	209.9	A	37.8
1928	4.4	22.6	242.6	A	A	45.3	204.1	A	38.1
1929	4.6	22.3	241.3	A	A	45.7	205.4	A	38.9

1930	5.1	21.8	242.4	A	A	46.8	214.0	A	41.3
Port change									
1940	4.8	22.1	244.4	58.8	92.3	38.7	210.8	79.6	33.4
1941	A	A	A	A	A	38.6	A	A	25.7
1942	A	A	A	A	A	39.2	A	A	26.1
1943	3.8	23.4	236.1	B	B	40.5	191.6	B	32.9
1944	4.1	23.0	214.7	54.6	85.7	38.9	177.9	71.0	32.2
1945	4.1	22.8	184.1	56.0	87.9	37.2	152.5	72.8	30.8
1946	4.3	22.5	207.5	52.1	81.8	40.6	174.3	68.7	34.1
1947	4.3	22.9	222.4	59.7	93.7	42.9	186.7	78.7	36.0
1948	4.3	22.8	231.5	59.2	92.9	44.0	194.5	78.1	37.0
1949	4.3	22.9	235.4	56.9	89.3	44.2	197.1	74.8	37.0
1950	4.2	23.1	237.1	53.3	83.7	44.5	197.8	69.8	37.1
1951	4.8	22.7	240.3	51.0	80.1	44.7	207.0	69.0	38.5
1952	4.7	22.5	242.5	52.3	82.1	45.3	208.7	70.6	39.0
1953	4.3	23.2	254.4	63.1	99.1	46.0	213.7	83.2	38.6
1954	4.3	23.0	252.7	67.3	105.7	45.3	211.8	88.6	38.0
1955	4.2	23.1	243.2	68.0	106.8	44.5	203.0	89.1	37.1
1956	C	C	C	C	C	45.0	C	C	30.0
1957	C	C	C	C	C	45.8	C	C	30.5
1958	C	C	C	C	C	46.4	C	C	30.9
1959	C	C	C	C	C	45.1	C	C	30.1
2000	C	C	C	C	C	39.2	C	C	26.1
2001	C	C	C	C	C	34.3	C	C	22.9
2002	C	C	C	C	C	30.1	C	C	20.1
2003	C	C	C	C	C	27.9	C	C	18.6
2004	4.2	23.4	234.9	57.8	90.7	29.3	195.6	75.6	24.4
2005	4.2	23.3	232.6	57.7	90.6	31.6	193.8	75.5	26.3
2006	4.6	22.8	232.5	51.0	80.1	34.2	198.0	68.2	29.1
2007	4.7	22.7	234.8	45.1	70.8	36.7	201.9	60.9	31.6
2008	3.7	23.9	242.5	91.6	143.8	38.8	196.1	116.3	31.4
2009	4.2	23.3	208.8	66.4	104.2	39.5	173.7	86.7	32.9
2010	4.3	23.2	209.1	53.2	83.5	39.3	175.5	70.1	33.0
Port change									
2019	4.8	22.6	246.6	38.8	60.9	39.8	213.2	52.7	34.4
2020	4.9	22.5	250.1	39.0	61.2	39.6	217.3	53.2	34.4
2021	4.6	22.9	252.2	49.7	78.0	39.0	215.3	66.6	33.3
2022	4.4	23.0	250.4	57.8	90.7	38.3	211.1	76.5	32.3
2023	4.7	22.5	250.0	54.3	85.2	38.0	215.3	73.4	32.7
2024	4.7	22.6	244.2	30.6	48.0	38.3	209.9	41.3	32.9
2025	4.7	22.6	247.2	37.9	59.5	39.6	212.8	51.2	34.1
2026	4.5	22.6	253.0	47.9	75.2	40.3	215.1	63.9	34.3
2027	4.7	22.5	251.0	45.2	71.0	40.2	215.8	61.0	34.6

2028	4.0	23.1	248.4	70.1	110.0	39.8	204.9	90.8	32.8
2029	4.1	23.2	239.6	66.1	103.8	39.8	198.1	85.8	32.9
2030	4.1	23.1	231.0	66.0	103.6	39.6	191.4	85.8	32.8
2031	4.1	23.2	233.7	60.7	95.3	41.4	193.1	78.8	34.2
2032	4.5	22.8	230.3	38.6	60.6	43.8	195.1	51.3	37.1
2033	4.8	22.4	234.4	42.2	66.2	45.6	202.3	57.2	39.4
2034	5.0	22.0	248.0	41.5	65.1	47.1	217.4	57.1	41.3
2035	5.0	22.2	256.2	44.7	70.2	47.3	224.3	61.4	41.4
2036	4.5	22.6	253.1	55.9	87.8	46.0	214.8	74.5	39.0
2037	4.4	22.8	249.0	52.5	82.4	44.2	209.4	69.3	37.2
2038	4.4	22.7	243.2	48.9	76.8	42.2	204.7	64.6	35.5
2039	4.4	22.7	242.8	45.2	71.0	42.0	204.5	59.8	35.4
2040	4.4	22.9	243.0	43.8	68.8	42.1	204.8	58.0	35.5
2041	4.5	22.8	243.3	43.2	67.8	42.3	205.9	57.4	35.8
2042	4.5	22.7	244.5	42.6	66.9	42.7	207.3	56.7	36.2
2043	5.0	22.0	249.5	41.4	65.0	43.3	217.8	56.7	37.8
2044	5.3	21.7	251.4	38.5	60.4	43.7	223.9	53.8	38.9
2045	5.1	22.1	260.9	42.9	67.3	43.5	229.6	59.3	38.3
2046	4.2	23.0	259.8	48.1	75.5	42.2	216.0	62.8	35.1
2047	4.2	23.0	247.6	49.4	77.6	40.3	206.3	64.6	33.6
2048	4.9	22.1	238.0	37.6	59.0	39.0	206.3	51.2	33.8
2049	5.2	21.8	249.4	36.5	57.3	40.5	221.0	50.8	35.9
Port change									
2122	4.7	22.3	256.3	41.4	65.0	36.8	220.0	55.8	31.6
2123	4.6	22.2	255.5	29.1	45.7	35.8	218.2	39.0	30.6
2124	4.9	22.0	258.7	31.6	49.6	35.0	224.4	43.0	30.4
2125	4.9	22.3	258.1	37.9	59.5	34.2	224.7	51.8	29.8
2126	5.5	21.4	260.7	29.1	45.7	33.6	235.6	41.3	30.4
2127	5.0	22.2	257.6	35.5	55.7	32.7	225.8	48.9	28.7
2128	4.7	22.8	253.6	46.5	73.0	32.0	217.3	62.5	27.4
2129	4.6	22.9	253.9	30.0	47.1	30.9	216.3	40.1	26.3
2130	4.8	22.6	254.4	29.0	45.5	30.0	220.0	39.4	25.9
2131	4.8	22.6	255.3	37.7	59.2	30.1	221.2	51.3	26.1
2132	4.7	22.8	255.0	41.7	65.5	30.8	219.0	56.2	26.5
2133	5.0	22.4	256.9	39.1	61.4	31.0	224.1	53.5	27.0
2134	4.5	22.9	254.2	46.8	73.5	30.8	215.4	62.3	26.1
2135	4.5	22.8	251.1	45.6	71.6	30.9	213.6	60.9	26.3
2136	4.6	22.8	253.5	47.6	74.7	31.1	216.4	63.8	26.5
2137	4.7	22.6	255.5	27.1	42.5	31.5	219.2	36.5	27.0
2138	4.7	22.5	257.9	34.3	53.8	32.1	221.0	46.1	27.5
2139	4.6	22.6	256.0	32.5	51.0	32.6	218.1	43.5	27.8
2140	4.6	22.6	258.4	37.0	58.1	32.8	221.1	49.7	28.1
2141	4.6	22.6	258.8	44.1	69.2	32.9	220.9	59.1	28.1

2142	4.6	22.7	258.6	43.5	68.3	33.3	220.5	58.2	28.4
2143	4.7	22.6	260.5	42.7	67.0	33.3	223.7	57.6	28.6
2144	4.5	22.8	263.0	47.1	73.9	33.5	223.4	62.8	28.5
2145	4.7	22.6	261.6	46.3	72.7	33.8	224.1	62.3	29.0
2146	4.7	22.4	259.6	52.5	82.4	33.9	223.1	70.8	29.1
2147	4.7	22.4	261.5	31.6	49.6	34.2	225.0	42.7	29.4
2148	4.7	22.5	264.0	33.6	52.7	34.6	226.2	45.2	29.6
2149	4.8	22.5	263.8	32.5	51.0	34.5	227.8	44.1	29.8
2150	4.7	22.6	260.4	40.9	64.2	34.3	223.7	55.1	29.5
2151	4.6	22.7	258.1	44.8	70.3	34.4	220.5	60.1	29.4
AVG	4.5	22.5	243.1	49.4	77.5	42.2	206.6	65.5	35.3
MIN	1.9	4.4	184.1	27.1	42.5	27.9	157.5	36.5	18.6
MAX	5.5	23.9	318.2	91.6	143.8	65.4	235.6	116.3	55.7

O2 = Oxygen
CO2 = Carbon Dioxide
CO = Carbon Monoxide
THCH = Hydrocarbon Hot-line
THCC = Hydrocarbon Cold-line

A = Lost sampling flow. Invalid data.
B = Lost THCH flow. Invalid data.
C = Backflow of system. Invalid data.

APPENDIX B-5

TOTAL HYDROCARBON AND TOTAL ORGANIC MASS DATA

This appendix contains minute-by-minute readings of both the hot and cold hydrocarbon analyzers. Also included are plots of each run's HC readings, hot and cold, along with each organic mass measurement determined by field GC. Note that the HC monitors were taken off line about once every hour for calibration purposes.

Filename:RUN1
Name:RUN1
Date:06-20-1990
Location:HANNIBAL,MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

Time	Decimal Time	Decimal Time x 100	THCH (ppm dry)	THCC (ppm dry)	TOM (ppm dry)
1114	11.23	1123			22.6
1118	11.30	1130	27.5	9.5	
1119	11.32	1132	23.5	10.2	
1120	11.33	1133	19.7	10.8	
1121	11.35	1135	19.2	11.4	
1122	11.37	1137	21.2	11.4	
1123	11.38	1138	22.5	10.8	
1124	11.40	1140	27.1	10.5	
1125	11.42	1142	25.9	10.8	
1126	11.43	1143	29.1	11.2	
1127	11.45	1145	15.7	11.8	
1128	11.47	1147	24.7	12.2	
1129	11.48	1148	26.2	11.8	
1130	11.50	1150	24.7	11.3	
1131	11.52	1152	24.0	10.9	
1132	11.53	1153	28.1	10.6	29.5
1133	11.55	1155	29.4	10.5	
1134	11.57	1157	28.3	10.2	
1135	11.58	1158	22.9	9.9	
1136	11.60	1160	16.9	9.7	
1137	11.62	1162	22.2	9.6	
1138	11.63	1163	22.2	9.5	
1139	11.65	1165	20.0	9.4	
1140	11.67	1167	18.6	9.3	
1141	11.68	1168	18.2	9.3	
1142	11.70	1170	17.6	9.0	
1143	11.72	1172	17.2	8.7	
1144	11.73	1173	17.0	8.2	
1145	11.75	1175	17.5	7.9	
1146	11.77	1177	17.6	7.5	
1147	11.78	1178	18.6	7.3	
1148	11.80	1180	19.4	7.2	
1149	11.82	1182			
1151	11.85	1185			20.1
1209	12.15	1215			22.9
1213	12.22	1222			
1214	12.23	1223	24.1	11.0	
1215	12.25	1225	22.2	11.0	
1216	12.27	1227	23.5	11.0	
1217	12.28	1228	25.3	11.0	
1218	12.30	1230	24.6	11.0	
1219	12.32	1232	21.3	11.1	

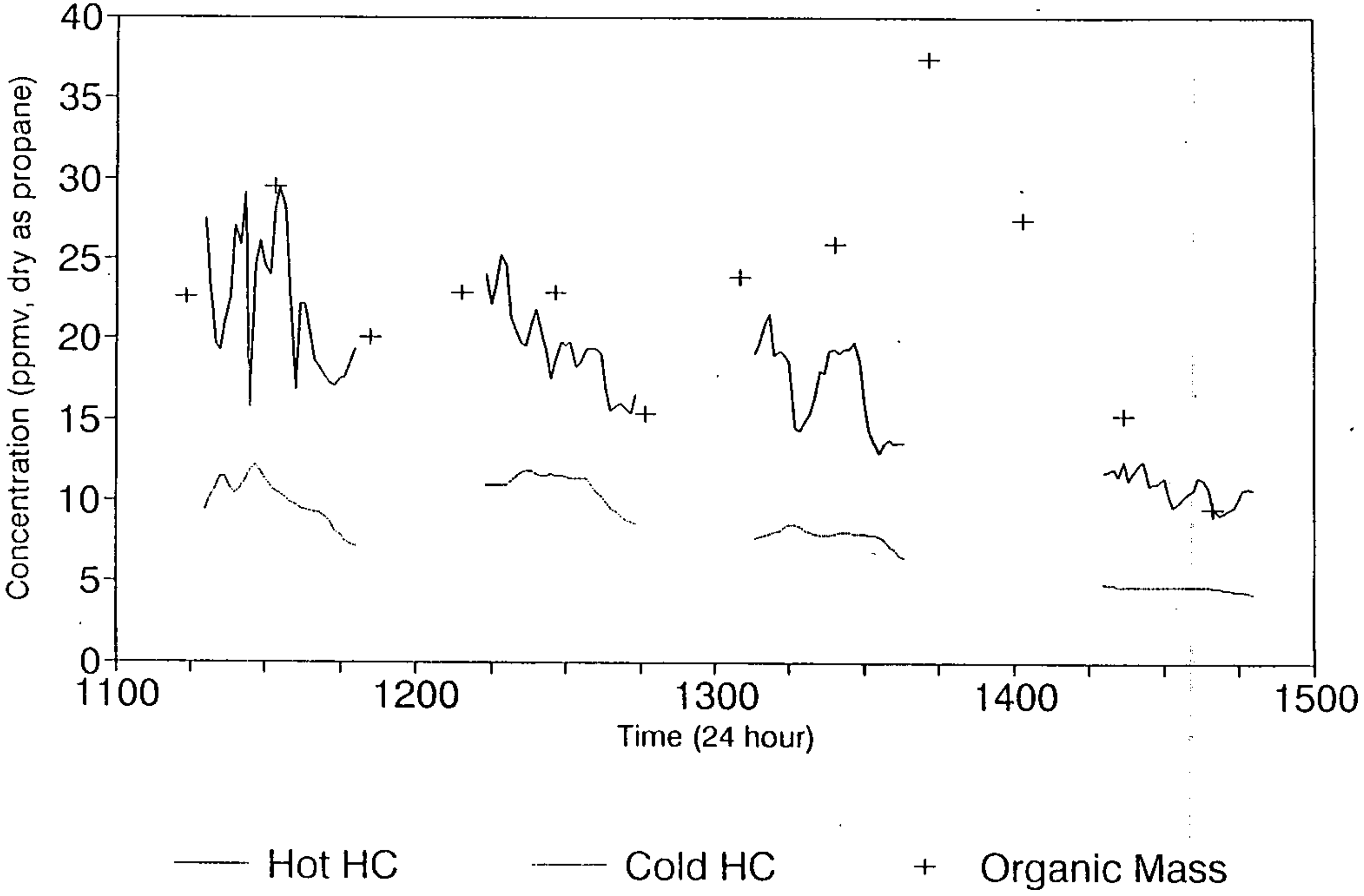
Run 1, continued

Time	Decimal Time	Decimal Time x 100	THCH (ppm dry)	THCC (ppm dry)	TOM (ppm dry)
1220	12.33	1233	20.3	11.5	
1221	12.35	1235	19.7	11.7	
1222	12.37	1237	19.5	11.8	
1223	12.38	1238	21.0	11.8	
1224	12.40	1240	21.9	11.6	
1225	12.42	1242	20.6	11.5	
1226	12.43	1243	19.1	11.5	
1227	12.45	1245	17.5	11.6	
1228	12.47	1247	18.6	11.5	22.9
1229	12.48	1248	19.8	11.5	
1230	12.50	1250	19.5	11.4	
1231	12.52	1252	19.8	11.3	
1232	12.53	1253	18.2	11.3	
1233	12.55	1255	18.5	11.3	
1234	12.57	1257	19.4	11.3	
1235	12.58	1258	19.4	11.0	
1236	12.60	1260	19.4	10.6	
1237	12.62	1262	19.1	10.3	
1238	12.63	1263	16.7	9.9	
1239	12.65	1265	15.5	9.6	
1240	12.67	1267	15.8	9.4	
1241	12.68	1268	16.0	9.1	
1242	12.70	1270	15.7	8.8	
1243	12.72	1272	15.4	8.7	
1244	12.73	1273	16.6	8.6	
1245	12.75	1275			
1246	12.77	1277			15.3
1305	13.08	1308			23.9
1307	13.12	1312			
1308	13.13	1313	19.1	7.7	
1309	13.15	1315	19.7	7.8	
1310	13.17	1317	21.0	7.9	
1311	13.18	1318	21.6	8.0	
1312	13.20	1320	18.9	8.1	
1313	13.22	1322	19.2	8.2	
1314	13.23	1323	18.9	8.4	
1315	13.25	1325	18.6	8.5	
1316	13.27	1327	14.5	8.5	
1317	13.28	1328	14.3	8.4	
1318	13.30	1330	14.9	8.2	
1319	13.32	1332	15.4	8.1	
1320	13.33	1333	16.3	8.0	
1321	13.35	1335	18.0	7.9	
1322	13.37	1337	17.9	7.9	
1323	13.38	1338	19.2	7.9	
1324	13.40	1340	19.4	8.0	26.0
1325	13.42	1342	19.1	8.1	
1326	13.43	1343	19.4	8.1	
1327	13.45	1345	19.4	8.1	
1328	13.47	1347	19.8	8.0	

Run 1, continued

Time	Decimal Time	Decimal Time x 100	THCH (ppm dry)	THCC (ppm dry)	TOM (ppm dry)
1329	13.48	1348	18.6	8.0	
1330	13.50	1350	16.0	8.0	
1331	13.52	1352	14.3	7.9	
1332	13.53	1353	13.5	7.9	
1333	13.55	1355	12.9	7.8	
1334	13.57	1357	13.5	7.6	
1335	13.58	1358	13.8	7.2	
1336	13.60	1360	13.5	7.0	
1337	13.62	1362	13.6	6.7	
1338	13.63	1363	13.6	6.5	
1337	13.62	1362			
1343	13.72	1372			37.4
1402	14.03	1403			27.5
1417	14.28	1428			
1418	14.30	1430	11.7	4.9	
1419	14.32	1432	11.8	4.8	
1420	14.33	1433	12.0	4.8	
1421	14.35	1435	11.4	4.7	
1422	14.37	1437	12.4	4.7	15.2
1423	14.38	1438	11.2	4.7	
1424	14.40	1440	11.7	4.7	
1425	14.42	1442	12.1	4.7	
1426	14.43	1443	12.4	4.7	
1427	14.45	1445	10.9	4.7	
1428	14.47	1447	11.1	4.7	
1429	14.48	1448	11.1	4.7	
1430	14.50	1450	11.4	4.7	
1431	14.52	1452	10.5	4.7	
1432	14.53	1453	9.6	4.7	
1433	14.55	1455	9.9	4.7	
1434	14.57	1457	10.2	4.7	
1435	14.58	1458	10.5	4.7	
1436	14.60	1460	10.7	4.7	
1437	14.62	1462	11.4	4.7	
1438	14.63	1463	11.2	4.7	
1439	14.65	1465	10.8	4.7	
1440	14.67	1467	9.6	4.6	9.6
1441	14.68	1468	9.2	4.6	
1442	14.70	1470	9.3	4.5	
1443	14.72	1472	9.5	4.5	
1444	14.73	1473	9.6	4.4	
1445	14.75	1475	10.2	4.4	
1446	14.77	1477	10.7	4.4	
1447	14.78	1478	10.8	4.3	
1448	14.80	1480	10.7	4.2	

RUN 1 - HOT AND COLD HC CONCENTRATIONS AND TOTAL ORGANIC MASS



Filename:RUN2
Name:RUN2
Date:06-21-1990
Location:HANNIBAL,MO
Project
Operator:BG
VERSION=05/07/90

Time	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1228	12.47	1247			70.2
1230	12.50	1250	59.7	40.4	
1231	12.52	1252	53.3	41.6	
1232	12.53	1253	57.6	41.8	
1233	12.55	1255	60.5	42.0	
1234	12.57	1257	73.2	41.8	
1235	12.58	1258	77.7	41.8	
1236	12.60	1260	73.5	42.1	
1237	12.62	1262	64.7	42.0	
1238	12.63	1263	63.2	42.2	
1239	12.65	1265	72.1	42.4	
1240	12.67	1267	56.2	42.8	
1241	12.68	1268	62.1	43.2	
1242	12.70	1270	52.2	43.5	
1243	12.72	1272	59.7	44.1	
1244	12.73	1273	62.9	45.9	
1245	12.75	1275	82.0	45.3	
1246	12.77	1277	93.7	44.5	84.8
1247	12.78	1278	69.5	44.9	
1248	12.80	1280	68.1	46.4	
1249	12.82	1282	64.5	48.7	
1250	12.83	1283	69.3	46.7	
1251	12.85	1285	61.2	49.5	
1252	12.87	1287	59.9	49.2	
1253	12.88	1288	58.9	49.0	
1254	12.90	1290	55.7	48.4	
1255	12.92	1292	60.8	47.6	
1256	12.93	1293	66.8	47.0	
1257	12.95	1295	69.2	46.2	
1258	12.97	1297	85.9	46.0	
1259	12.98	1298	91.7	46.4	
1300	13.00	1300	84.9	47.5	
1305	13.08	1308			106.8
1319	13.32	1332	85.1	56.5	
1320	13.33	1333	91.2	56.6	
1321	13.35	1335	70.0	56.3	
1322	13.37	1337	85.2	56.8	
1323	13.38	1338	76.1	57.7	
1324	13.40	1340	79.0	58.7	164.5
1325	13.42	1342	80.1	59.3	
1326	13.43	1343	73.0	59.4	
1327	13.45	1345	65.8	58.9	

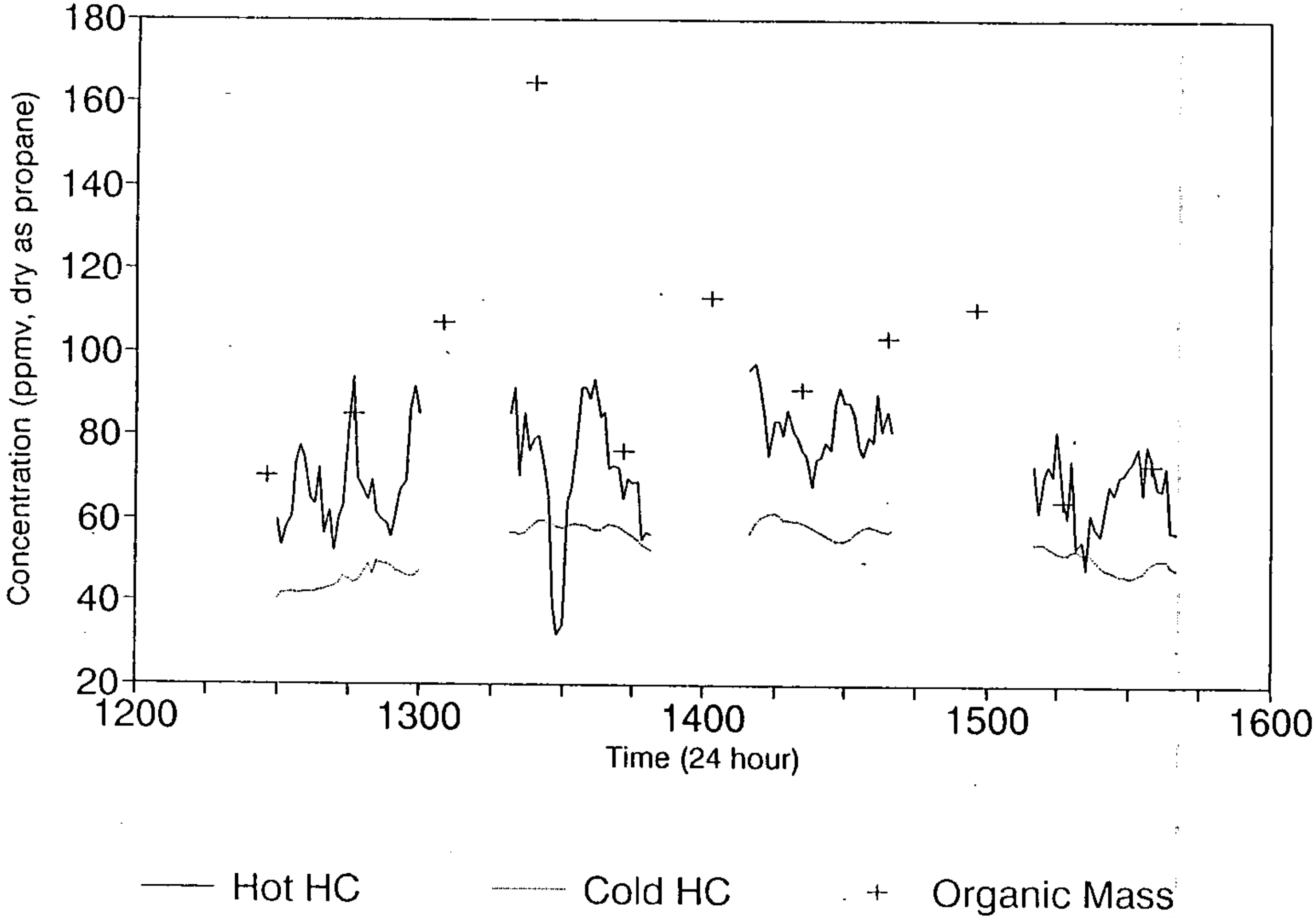
Run 2, continued

Time	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1328	13.47	1347	39.2	58.7	
1329	13.48	1348	31.9	58.0	
1330	13.50	1350	34.3	57.8	
1331	13.52	1352	64.2	58.2	
1332	13.53	1353	67.3	58.8	
1333	13.55	1355	75.8	58.8	
1334	13.57	1357	91.2	58.4	
1335	13.58	1358	91.5	58.3	
1336	13.60	1360	88.4	57.8	
1337	13.62	1362	93.4	57.3	
1338	13.63	1363	84.3	57.4	
1339	13.65	1365	85.7	58.1	
1340	13.67	1367	71.9	58.6	
1341	13.68	1368	72.4	58.5	
1342	13.70	1370	72.1	58.2	
1343	13.72	1372	64.7	57.4	76.1
1344	13.73	1373	69.8	56.5	
1345	13.75	1375	68.7	55.9	
1346	13.77	1377	68.9	54.9	
1347	13.78	1378	54.7	53.9	
1348	13.80	1380	56.8	53.2	
1349	13.82	1382	56.2	52.4	
1402	14.03	1403			112.8
1410	14.17	1417	95.7	56.7	
1411	14.18	1418	97.3	59.2	
1412	14.20	1420	92.1	60.2	
1413	14.22	1422	84.4	60.9	
1414	14.23	1423	75.1	61.4	
1415	14.25	1425	83.5	61.5	
1416	14.27	1427	83.6	60.9	
1417	14.28	1428	79.9	60.0	
1418	14.30	1430	86.4	59.7	
1419	14.32	1432	81.1	59.6	
1420	14.33	1433	79.8	59.3	
1421	14.35	1435	76.6	59.1	90.9
1422	14.37	1437	75.1	58.7	
1423	14.38	1438	67.9	58.1	
1424	14.40	1440	74.3	57.5	
1425	14.42	1442	74.6	56.9	
1426	14.43	1443	78.7	56.2	
1427	14.45	1445	76.4	55.4	
1428	14.47	1447	87.5	54.9	
1429	14.48	1448	91.7	54.9	
1430	14.50	1450	87.8	55.0	
1431	14.52	1452	88.0	55.6	
1432	14.53	1453	84.9	56.8	
1433	14.55	1455	77.4	57.5	
1434	14.57	1457	75.0	58.1	
1435	14.58	1458	79.9	58.4	
1436	14.60	1460	78.3	58.1	

Run 2, continued

Time	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1437	14.62	1462	90.2	57.6	
1438	14.63	1463	81.2	57.3	
1439	14.65	1465	85.9	57.1	103.2
1440	14.67	1467	81.2	57.6	
1458	14.97	1497			110.4
1510	15.17	1517	73.0	54.0	
1511	15.18	1518	61.5	54.1	
1512	15.20	1520	70.0	54.1	
1513	15.22	1522	72.9	53.5	
1514	15.23	1523	70.3	52.7	
1515	15.25	1525	81.4	52.0	
1516	15.27	1527	65.7	51.7	64.5
1517	15.28	1528	60.0	51.7	
1518	15.30	1530	74.5	52.5	
1519	15.32	1532	53.0	52.8	
1520	15.33	1533	55.2	51.8	
1521	15.35	1535	48.2	51.9	
1522	15.37	1537	61.5	51.5	
1523	15.38	1538	58.1	50.1	
1524	15.40	1540	56.3	48.8	
1525	15.42	1542	62.3	48.0	
1526	15.43	1543	68.5	47.9	
1527	15.45	1545	66.1	47.3	
1528	15.47	1547	70.5	46.9	
1529	15.48	1548	70.6	46.8	
1530	15.50	1550	72.7	46.5	
1531	15.52	1552	74.0	46.5	
1532	15.53	1553	77.4	47.0	
1533	15.55	1555	66.1	47.5	
1534	15.57	1557	78.0	48.7	
1535	15.58	1558	74.0	49.7	73.0
1536	15.60	1560	67.7	50.1	
1537	15.62	1562	67.4	50.4	
1538	15.63	1563	72.6	50.1	
1539	15.65	1565	57.5	49.0	
1540	15.67	1567	57.0	48.3	

RUN 2 - HOT AND COLD HC CONCENTRATIONS AND TOTAL ORGANIC MASS



Filename:RUN3
Name:RUN3
Date:06-22-1990
Location: HANNIBAL,MO
Project
Operator:BG
VERSION=05/07/90

TIME	DECIMAL TIME	DECIMAL TIME X 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1133	11.55	1155			106.9
1135	11.58	1158	108.1	50.1	
1136	11.60	1160	88.2	50.7	
1137	11.62	1162	86.0	52.5	
1138	11.63	1163	85.4	55.0	
1139	11.65	1165	84.4	56.1	
1140	11.67	1167	94.9	56.3	
1141	11.68	1168	68.6	56.1	
1142	11.70	1170	70.6	55.9	
1143	11.72	1172	77.1	55.9	
1144	11.73	1173	65.9	55.0	
1145	11.75	1175	88.6	54.2	
1146	11.77	1177	94.1	54.5	
1147	11.78	1178	96.9	53.7	
1148	11.80	1180	94.9	53.1	
1149	11.82	1182	95.5	52.7	
1150	11.83	1183	69.8	52.7	
1151	11.85	1185	70.1	53.7	100
1152	11.87	1187	73.4	54.7	
1153	11.88	1188	68.7	54.7	
1154	11.90	1190	73.3	54.1	
1155	11.92	1192	86.9	53.4	
1156	11.93	1193	86.0	52.1	
1157	11.95	1195	105.3	50.7	
1158	11.97	1197	96.9	50.3	
1159	11.98	1198	63.8	50.3	
1200	12.00	1200	69.1	51.3	
1201	12.02	1202	75.7	52.5	
1202	12.03	1203	78.7	52.9	
1203	12.05	1205	79.6	52.6	
1204	12.07	1207	96.1	52.2	
1205	12.08	1208	87.4	51.5	
1209	12.15	1215			62.5
1223	12.38	1238	89.3	40.4	
1224	12.40	1240	88.5	40.5	
1225	12.42	1242	80.6	41.2	
1226	12.43	1243	60.7	41.9	
1227	12.45	1245	54.6	42.7	59.3
1228	12.47	1247	68.7	42.9	
1229	12.48	1248	74.7	42.4	
1230	12.50	1250	63.9	41.7	
1231	12.52	1252	60.3	41.1	

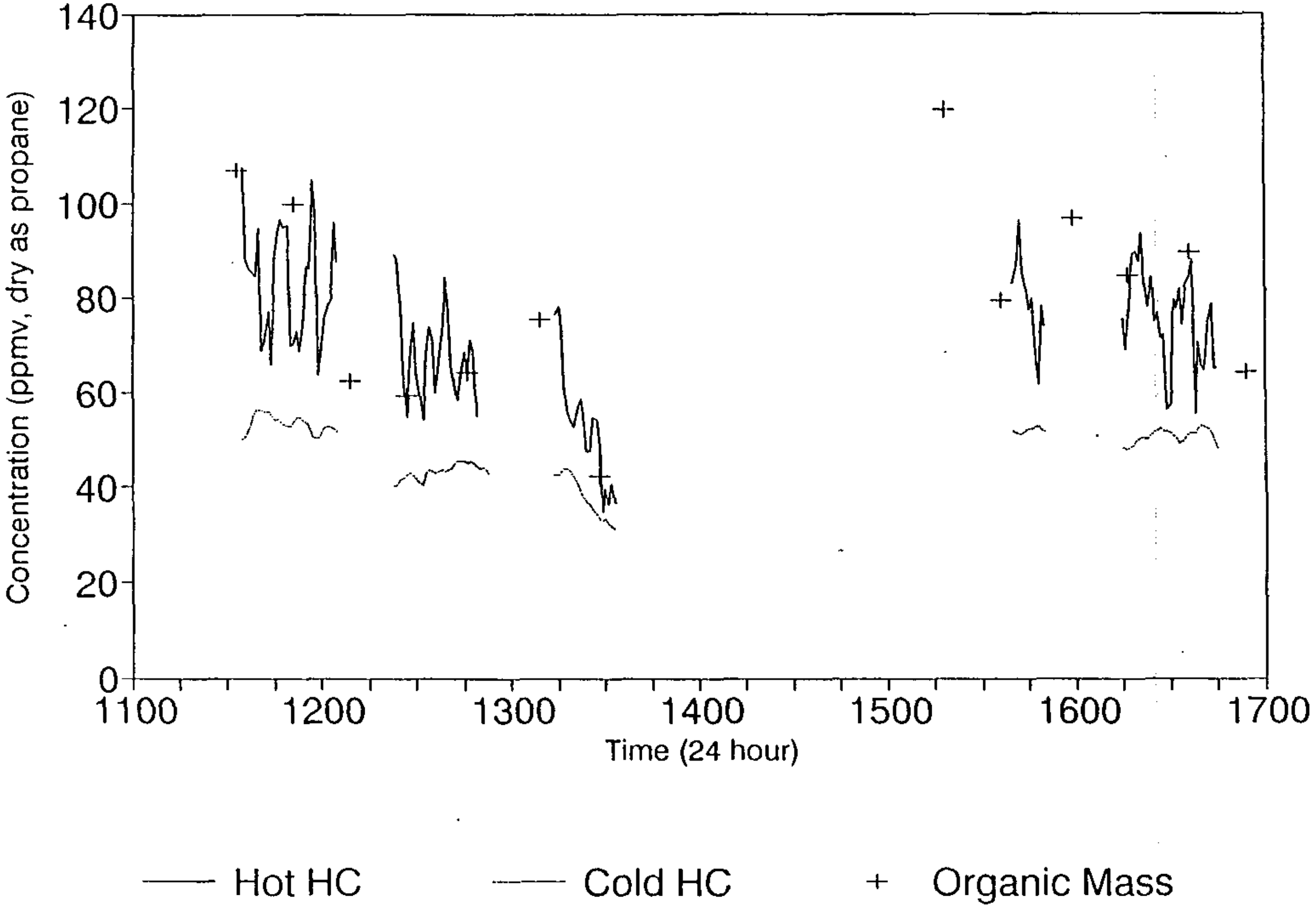
Run 3, continued

TIME	DECIMAL TIME	DECIMAL TIME X 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1232	12.53	1253	54.0	40.5	
1233	12.55	1255	68.3	42.8	
1234	12.57	1257	73.9	43.5	
1235	12.58	1258	71.1	43.2	
1236	12.60	1260	60.0	43.0	
1237	12.62	1262	65.0	43.3	
1238	12.63	1263	73.7	43.6	
1239	12.65	1265	84.3	43.3	
1240	12.67	1267	75.4	43.4	
1241	12.68	1268	65.2	43.9	
1242	12.70	1270	61.4	44.9	
1243	12.72	1272	58.5	45.3	
1244	12.73	1273	64.9	45.3	
1245	12.75	1275	68.7	45.3	
1246	12.77	1277	64.2	45.2	64.3
1247	12.78	1278	71.2	45.3	
1248	12.80	1280	68.7	45.1	
1249	12.82	1282	54.9	44.3	
1250	12.83	1283		43.9	
1251	12.85	1285		44.0	
1252	12.87	1287		43.5	
1253	12.88	1288		42.6	
1309	13.15	1315			75.3
1314	13.23	1323	76.4	42.6	
1315	13.25	1325	78.2	42.7	
1316	13.27	1327	72.5	43.3	
1317	13.28	1328	59.9	43.8	
1318	13.30	1330	55.5	43.8	
1319	13.32	1332	53.7	43.3	
1320	13.33	1333	52.4	42.2	
1321	13.35	1335	57.1	40.7	
1322	13.37	1337	58.8	39.6	
1323	13.38	1338	53.3	38.0	
1324	13.40	1340	47.4	37.0	
1325	13.42	1342	47.6	36.4	
1326	13.43	1343	54.6	35.6	
1327	13.45	1345	54.0	34.3	
1328	13.47	1347	48.8	33.2	42.3
1329	13.48	1348	35.0	33.0	
1330	13.50	1350	39.7	33.2	
1331	13.52	1352	36.4	32.5	
1332	13.53	1353	40.7	31.6	
1333	13.55	1355	36.7	31.2	
1518	15.30	1530			119.6
1536	15.60	1560			79.5
1540	15.67	1567	82.7	51.6	
1541	15.68	1568	86.9	51.2	
1542	15.70	1570	96.4	50.9	
1543	15.72	1572	85.7	51.3	
1544	15.73	1573	82.1	51.9	

Run 3, continued

TIME	DECIMAL TIME	DECIMAL TIME X 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1545	15.75	1575	77.1	52.1	
1546	15.77	1577	79.9	52.2	
1547	15.78	1578	66.9	52.4	
1548	15.80	1580	61.4	52.5	
1549	15.82	1582	78.1	52.0	
1550	15.83	1583	73.7	51.6	
1559	15.98	1598			96.8
1615	16.25	1625	75.6	48.2	
1616	16.27	1627	68.9	47.9	
1617	16.28	1628	75.9	47.9	84.8
1618	16.30	1630	89.0	48.5	
1619	16.32	1632	89.9	49.4	
1620	16.33	1633	87.6	50.0	
1621	16.35	1635	93.6	50.4	
1622	16.37	1637	82.7	50.0	
1623	16.38	1638	77.9	50.1	
1624	16.40	1640	84.4	51.0	
1625	16.42	1642	74.8	51.7	
1626	16.43	1643	76.8	52.0	
1627	16.45	1645	71.4	52.1	
1628	16.47	1647	72.3	51.7	
1629	16.48	1648	56.3	51.6	
1630	16.50	1650	57.5	51.4	
1631	16.52	1652	79.6	50.6	
1632	16.53	1653	77.4	50.0	
1633	16.55	1655	81.8	49.2	
1634	16.57	1657	74.2	49.4	
1635	16.58	1658	82.4	50.2	
1636	16.60	1660	84.3	51.2	89.6
1637	16.62	1662	88.2	51.3	
1638	16.63	1663	55.2	51.4	
1639	16.65	1665	70.8	52.1	
1640	16.67	1667	65.8	52.8	
1641	16.68	1668	64.5	52.5	
1642	16.70	1670	74.8	52.1	
1643	16.72	1672	78.7	51.2	
1644	16.73	1673	65.0	49.6	
1645	16.75	1675	65.3	48.3	
1654	16.90	1690			64.4

RUN 3 - HOT AND COLD HC CONCENTRATIONS
AND TOTAL ORGANIC MASS



Filename:RUN4
Name:RUN4
Date:06-23-1990
Location:HANNIBAL,MO
Project :
Operator:BG
VERSION=05/07/90

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1053	10.88	1088			43.1
1055	10.92	1092	47.2	24.7	
1056	10.93	1093	46.1	24.8	
1057	10.95	1095	42.8	24.8	
1058	10.97	1097	42.5	24.7	
1059	10.98	1098	41.8	24.7	
1100	11.00	1100	49.1	25.1	
1101	11.02	1102	45.0	24.9	
1102	11.03	1103	43.9	24.8	
1103	11.05	1105	45.7	25.5	
1104	11.07	1107	42.2	26.3	
1105	11.08	1108	39.9	26.8	
1106	11.10	1110	45.3	27.3	
1107	11.12	1112	39.6	27.1	
1108	11.13	1113	44.1	26.2	
1109	11.15	1115	60.9	25.7	
1110	11.17	1117	48.9	25.3	
1111	11.18	1118	44.4	25.3	
1112	11.20	1120	42.5	27.6	56.7
1113	11.22	1122	42.2	29.2	
1114	11.23	1123	43.9	29.3	
1115	11.25	1125	46.3	28.9	
1116	11.27	1127	43.9	28.4	
1117	11.28	1128	48.9	27.7	
1118	11.30	1130	40.7	27.5	
1119	11.32	1132	38.0	26.9	
1120	11.33	1133	37.4	26.9	
1121	11.35	1135	39.7	27.0	
1122	11.37	1137	46.9	26.6	
1123	11.38	1138	40.4	26.1	
1124	11.40	1140	36.2	25.5	
1125	11.42	1142	36.5	25.5	
1130	11.50	1150			278.8
1140	11.67	1167	40.7	26.5	
1141	11.68	1168	37.1	25.7	
1142	11.70	1170	37.5	25.2	
1143	11.72	1172	32.6	25.2	
1144	11.73	1173	34.7	25.1	
1145	11.75	1175	36.6	24.5	
1146	11.77	1177	35.8	24.1	
1147	11.78	1178	34.5	23.7	
1148	11.80	1180	37.1	23.8	75.7

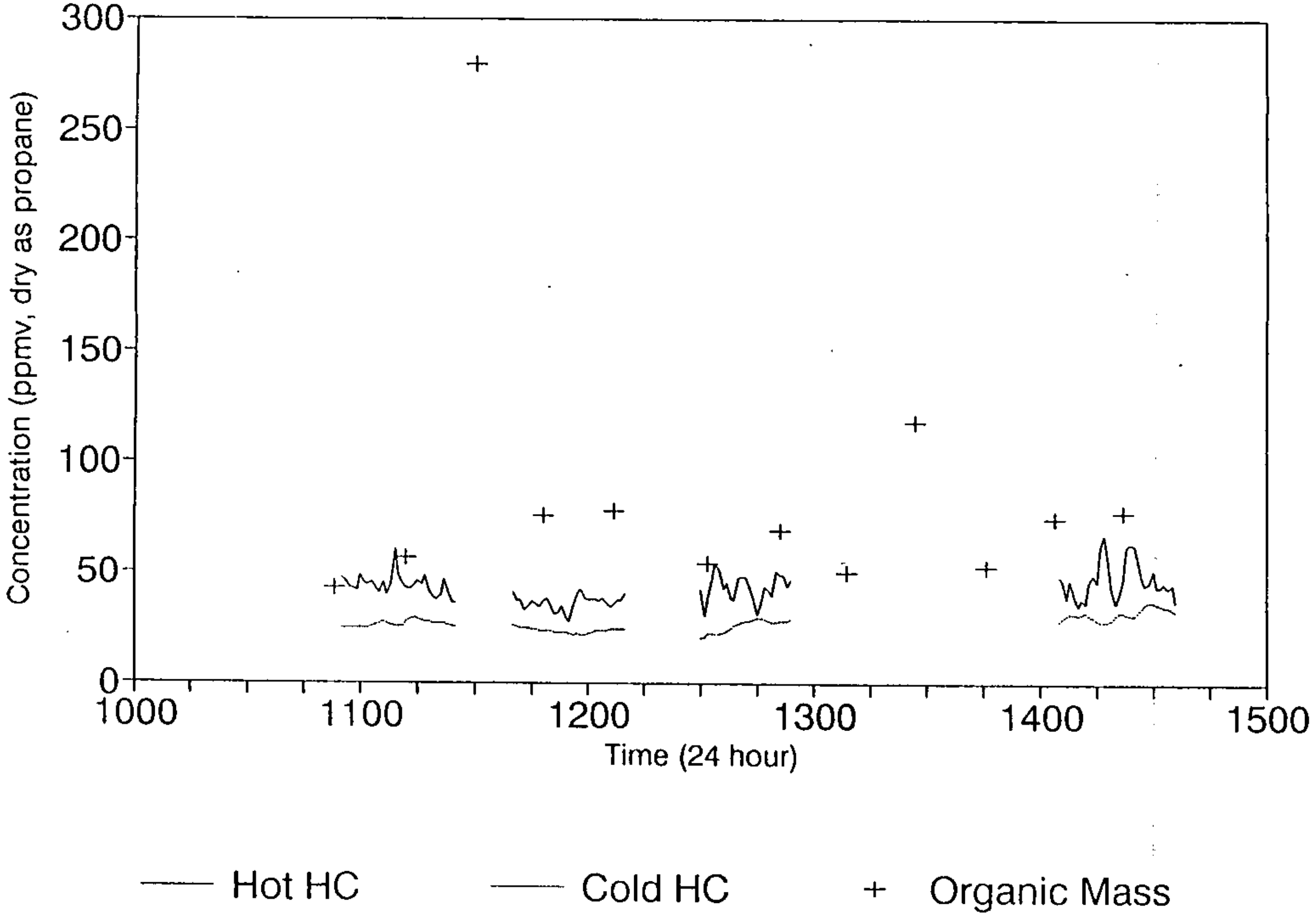
Run 4, continued

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1149	11.82	1182	38.2	23.8	
1150	11.83	1183	35.0	23.4	
1151	11.85	1185	30.7	23.1	
1152	11.87	1187	31.5	23.0	
1153	11.88	1188	34.9	23.0	
1154	11.90	1190	29.6	22.6	
1155	11.92	1192	27.4	22.0	
1156	11.93	1193	34.9	21.8	
1157	11.95	1195	39.3	22.0	
1158	11.97	1197	42.0	21.8	
1159	11.98	1198	38.0	21.9	
1200	12.00	1200	37.4	22.4	
1201	12.02	1202	37.8	23.1	
1202	12.03	1203	37.4	23.6	
1203	12.05	1205	36.6	23.7	
1204	12.07	1207	38.2	23.6	
1205	12.08	1208	35.9	23.8	
1206	12.10	1210	34.3	24.1	
1207	12.12	1212	35.8	24.3	78.3
1208	12.13	1213	37.7	24.4	
1209	12.15	1215	36.6	24.5	
1210	12.17	1217	40.1	24.5	
1211	12.18	1218			
1224	12.40	1240			
1225	12.42	1242			
1226	12.43	1243			
1227	12.45	1245			
1228	12.47	1247			
1229	12.48	1248			
1230	12.50	1250	41.9	20.3	
1231	12.52	1252	30.4	20.7	
1232	12.53	1253	38.1	22.0	54.4
1233	12.55	1255	46.9	22.2	
1234	12.57	1257	54.2	22.5	
1235	12.58	1258	51.2	22.5	
1236	12.60	1260	42.2	22.7	
1237	12.62	1262	45.7	23.6	
1238	12.63	1263	38.0	25.0	
1239	12.65	1265	37.5	26.2	
1240	12.67	1267	47.7	26.8	
1241	12.68	1268	48.3	27.5	
1242	12.70	1270	48.2	27.9	
1243	12.72	1272	43.1	28.3	
1244	12.73	1273	39.0	29.0	
1245	12.75	1275	30.8	29.5	
1246	12.77	1277	37.2	29.4	
1247	12.78	1278	43.5	28.8	
1248	12.80	1280	41.6	28.1	
1249	12.82	1282	39.4	27.7	
1250	12.83	1283	51.1	27.8	

Run 4, continued

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1251	12.85	1285	49.1	28.2	69.6
1252	12.87	1287	49.1	28.1	
1253	12.88	1288	43.6	28.0	
1254	12.90	1290	47.0	28.7	
1309	13.15	1315			49.9
1327	13.45	1345			117.6
1346	13.77	1377			52.9
1404	14.07	1407			74.8
1405	14.08	1408	47.9	28.0	
1406	14.10	1410	46.9	29.8	
1407	14.12	1412	38.1	30.9	
1408	14.13	1413	47.0	31.2	
1409	14.15	1415	39.6	31.8	
1410	14.17	1417	35.0	31.1	
1411	14.18	1418	38.1	31.8	
1412	14.20	1420	36.4	31.9	
1413	14.22	1422	45.4	31.1	
1414	14.23	1423	49.5	29.9	
1415	14.25	1425	45.7	29.0	
1416	14.27	1427	61.8	28.3	
1417	14.28	1428	67.6	28.3	
1418	14.30	1430	57.1	28.3	
1419	14.32	1432	41.9	28.8	
1420	14.33	1433	36.2	30.7	
1421	14.35	1435	39.9	31.9	
1422	14.37	1437	46.9	32.1	77.2
1423	14.38	1438	62.2	31.5	
1424	14.40	1440	63.2	31.0	
1425	14.42	1442	62.9	30.9	
1426	14.43	1443	56.5	32.3	
1427	14.45	1445	47.6	34.3	
1428	14.47	1447	44.2	36.0	
1429	14.48	1448	45.3	36.9	
1430	14.50	1450	51.2	36.8	
1431	14.52	1452	43.2	36.1	
1432	14.53	1453	43.5	35.3	
1433	14.55	1455	45.4	34.9	
1434	14.57	1457	42.6	34.6	
1435	14.58	1458	44.5	33.6	
1436	14.60	1460	37.1	32.6	

RUN 4 - HOT AND COLD HC CONCENTRATIONS AND TOTAL ORGANIC MASS



Filename:RUN5
Name:RUN5
Date:07-05-1990
Location:HANNIBAL, MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1046	10.77	1077			72
1105	11.08	1108			158.5
1123	11.38	1138			59.4
1220	12.33	1233	101.4	48.1	111.2
1221	12.35	1235	124.0	49.6	
1222	12.37	1237	105.3	50.3	
1223	12.38	1238		50.9	
1224	12.40	1240		52.5	
1225	12.42	1242		54.4	
1226	12.43	1243	108.8	54.1	
1227	12.45	1245	129.5	52.7	
1228	12.47	1247	102.2	53.0	
1229	12.48	1248	92.0	55.9	
1230	12.50	1250	94.5	58.7	
1231	12.52	1252		59.2	
1232	12.53	1253		57.0	
1233	12.55	1255		54.8	
1234	12.57	1257		53.9	
1235	12.58	1258			
1245	12.75	1275			85.3
1248	12.80	1280	81.8	42.1	
1249	12.82	1282	74.7	42.4	
1250	12.83	1283	96.9	43.5	
1251	12.85	1285	73.0	43.5	
1252	12.87	1287	58.2	44.6	
1253	12.88	1288	121.8	43.8	
1254	12.90	1290	144.9	43.8	
1255	12.92	1292	105.8	43.5	
1256	12.93	1293	72.8	46.2	
1257	12.95	1295	78.8	50.6	
1258	12.97	1297	60.3	52.4	
1259	12.98	1298	49.0	50.8	
1300	13.00	1300	48.8	48.7	
1301	13.02	1302	59.8	47.6	
1302	13.03	1303	72.8	45.7	
1303	13.05	1305	56.4	43.7	69.4
1304	13.07	1307			
1319	13.32	1332	134.4	50.8	
1320	13.33	1333	50.9	49.6	
1321	13.35	1335	55.4	50.2	
1322	13.37	1337	83.7	53.1	118.3

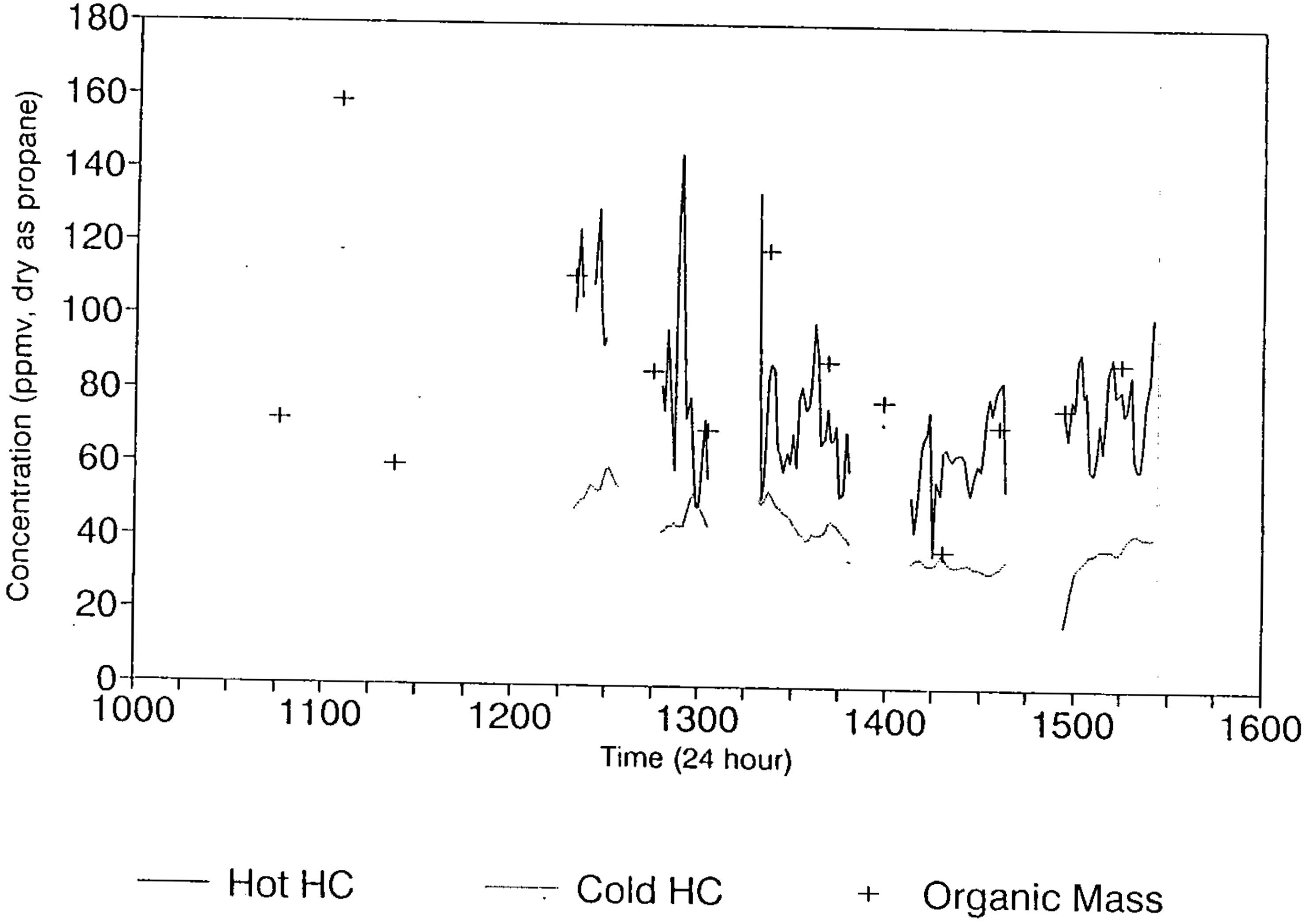
Run 5, continued

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1323	13.38	1338	87.8	52.0	
1324	13.40	1340	86.2	50.1	
1325	13.42	1342	64.5	48.9	
1326	13.43	1343	63.1	48.3	
1327	13.45	1345	58.2	47.5	
1328	13.47	1347	63.7	46.8	
1329	13.48	1348	60.6	45.8	
1330	13.50	1350	69.1	44.5	
1331	13.52	1352	59.3	43.2	
1332	13.53	1353	78.2	42.2	
1333	13.55	1355	81.9	41.5	
1334	13.57	1357	74.9	40.2	
1335	13.58	1358	76.5	40.6	
1336	13.60	1360	83.4	41.9	
1337	13.62	1362	99.1	41.8	
1338	13.63	1363	90.1	41.5	
1339	13.65	1365	65.8	41.7	
1340	13.67	1367	67.7	42.6	
1341	13.68	1368	75.8	44.6	88.3
1342	13.70	1370	67.2	45.1	
1343	13.72	1372	67.2	44.3	
1344	13.73	1373	71.3	43.9	
1345	13.75	1375	51.5	42.7	
1346	13.77	1377	52.7	41.7	
1347	13.78	1378	69.4	41.0	
1348	13.80	1380	58.9	39.8	
1359	13.98	1398			77.6
1408	14.13	1413	52.0	34.2	
1409	14.15	1415	42.4	34.8	
1410	14.17	1417	49.0	35.1	
1411	14.18	1418	64.8	35.2	
1412	14.20	1420	68.0	34.5	
1413	14.22	1422	69.2	33.5	
1414	14.23	1423	74.9	33.6	
1415	14.25	1425	36.1	33.5	
1416	14.27	1427	56.4	34.0	
1417	14.28	1428	52.3	35.9	
1418	14.30	1430	64.4	36.6	37.1
1419	14.32	1432	65.1	34.7	
1420	14.33	1433	63.0	33.9	
1421	14.35	1435	61.7	33.2	
1422	14.37	1437	63.3	33.2	
1423	14.38	1438	63.4	33.3	
1424	14.40	1440	63.4	33.6	
1425	14.42	1442	62.0	33.8	
1426	14.43	1443	55.4	33.9	
1427	14.45	1445	52.3	33.6	
1428	14.47	1447	57.1	33.0	
1429	14.48	1448	60.9	32.8	
1430	14.50	1450	59.2	32.4	

Run 5, continued

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1431	14.52	1452	66.1	32.0	
1432	14.53	1453	74.7	31.7	
1433	14.55	1455	79.1	31.5	
1434	14.57	1457	74.4	31.7	
1435	14.58	1458	80.5	32.3	
1436	14.60	1460	82.3	33.0	70.9
1437	14.62	1462	83.5	34.0	
1438	14.63	1463	53.7	34.7	
1439	14.65	1465			
1455	14.92	1492			
1456	14.93	1493			
1457	14.95	1495	74.3	17.4	76
1458	14.97	1497	67.8	22.0	
1459	14.98	1498	78.8	28.0	
1500	15.00	1500	76.3	32.0	
1501	15.02	1502	89.5	33.2	
1502	15.03	1503	91.4	33.9	
1503	15.05	1505	79.3	34.7	
1504	15.07	1507	81.0	35.6	
1505	15.08	1508	59.5	36.7	
1506	15.10	1510	58.4	36.9	
1507	15.12	1512	63.3	37.4	
1508	15.13	1513	72.2	37.9	
1509	15.15	1515	64.4	37.9	
1510	15.17	1517	72.2	38.0	
1511	15.18	1518	85.9	38.2	
1512	15.20	1520	90.1	38.0	
1513	15.22	1522	79.4	37.3	
1514	15.23	1523	80.1	37.2	
1515	15.25	1525	81.5	37.9	88.1
1516	15.27	1527	74.6	39.5	
1517	15.28	1528	76.0	40.9	
1518	15.30	1530	85.6	42.2	
1519	15.32	1532	62.6	42.6	
1520	15.33	1533	59.7	42.5	
1521	15.35	1535	59.5	42.1	
1522	15.37	1537	66.4	41.6	
1523	15.38	1538	77.4	41.5	
1524	15.40	1540	84.1	41.3	
1525	15.42	1542	100.9	41.6	

RUN 5 - HOT AND COLD HC CONCENTRATIONS AND TOTAL ORGANIC MASS



Filename:RUN6
Name:RUN6
Date:07-05-1990
Location:HANNIBAL, MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1900	19.00	1900	131.2	60.1	144.1
1901	19.02	1902	135.3	59.8	
1902	19.03	1903	116.3	60.5	
1903	19.05	1905	92.9	62.3	
1904	19.07	1907	84.1	64.1	
1905	19.08	1908	95.1	65.4	
1906	19.10	1910	74.6	65.4	
1907	19.12	1912	66.2	64.1	
1908	19.13	1913	67.7	62.4	
1909	19.15	1915	83.2	59.8	
1910	19.17	1917	116.2	56.9	
1911	19.18	1918	117.6	53.4	
1912	19.20	1920	89.8	51.2	
1913	19.22	1922	82.6	51.6	
1914	19.23	1923	89.5	54.4	
1915	19.25	1925	97.2	55.2	
1916	19.27	1927	86.2	54.5	
1917	19.28	1928	71.4	55.1	
1918	19.30	1930	58.1	55.8	55.1
1919	19.32	1932	67.7	55.1	
1920	19.33	1933	69.7	52.8	
1921	19.35	1935	72.2	49.5	
1922	19.37	1937	87.3	46.4	
1923	19.38	1938	104.7	44.9	
1924	19.40	1940	117.3	43.6	
1925	19.42	1942		43.1	
1926	19.43	1943		43.9	
1927	19.45	1945		45.1	
1928	19.47	1947		45.3	
1929	19.48	1948		45.7	
1930	19.50	1950		46.8	
1937	19.62	1962			75.8
1940	19.67	1967	92.3	38.7	
1941	19.68	1968		38.6	
1942	19.70	1970		39.2	
1943	19.72	1972		40.5	
1944	19.73	1973	85.7	38.9	
1945	19.75	1975	87.9	37.2	
1946	19.77	1977	81.8	40.6	
1947	19.78	1978	93.7	42.9	
1948	19.80	1980	92.9	44.0	

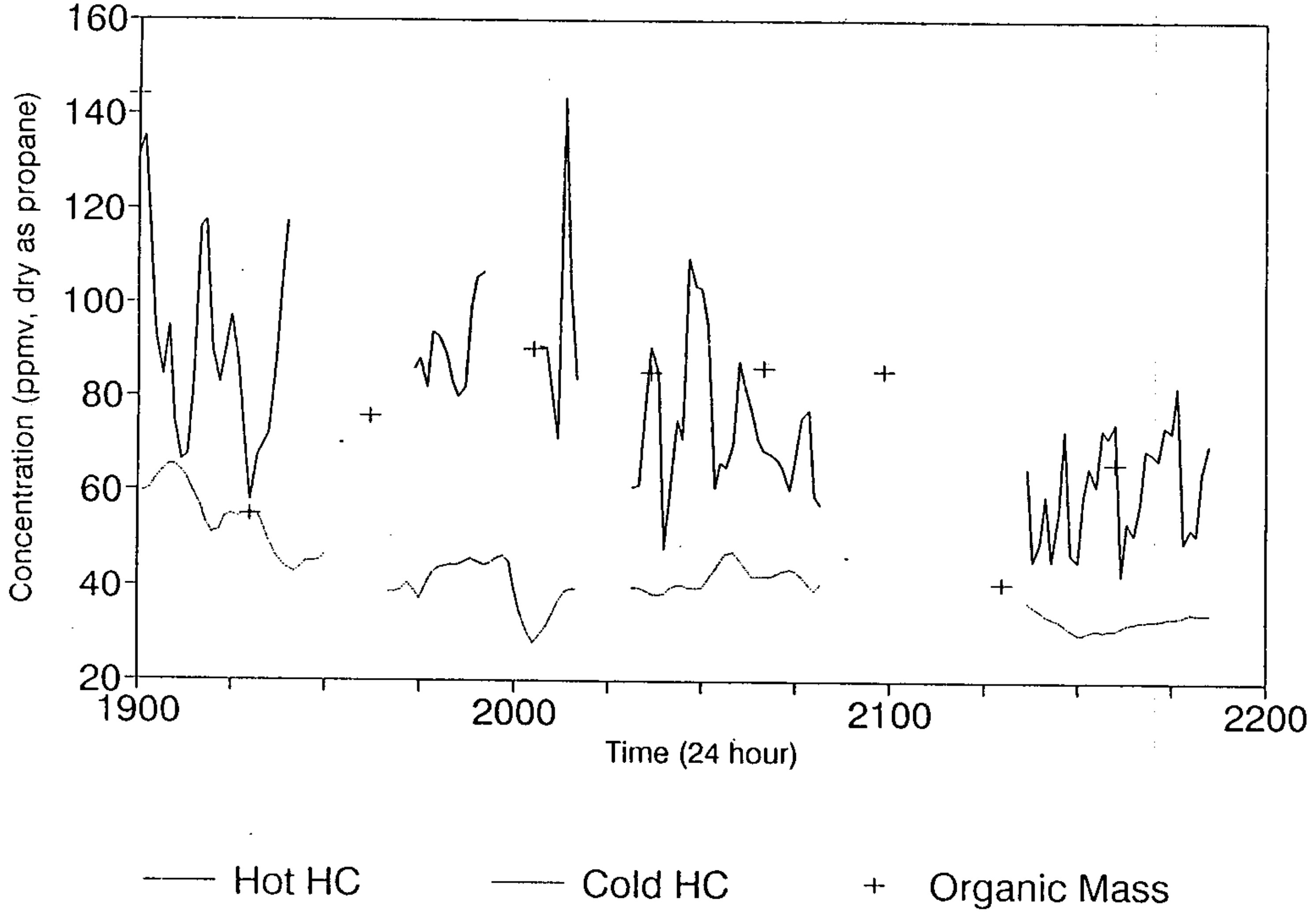
Run 6, continued

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
1949	19.82	1982	89.3	44.2	
1950	19.83	1983	83.7	44.5	
1951	19.85	1985	80.1	44.7	
1952	19.87	1987	82.1	45.3	
1953	19.88	1988	99.1	46.0	
1954	19.90	1990	105.7	45.3	
1955	19.92	1992	106.8	44.5	
1956	19.93	1993		45.0	
1957	19.95	1995		45.8	
1958	19.97	1997		46.4	
1959	19.98	1998		45.1	
2000	20.00	2000		39.2	
2001	20.02	2002		34.3	
2002	20.03	2003		30.1	
2003	20.05	2005		27.9	90.1
2004	20.07	2007	90.7	29.3	
2005	20.08	2008	90.6	31.6	
2006	20.10	2010	80.1	34.2	
2007	20.12	2012	70.8	36.7	
2008	20.13	2013	143.8	38.8	
2009	20.15	2015	104.2	39.5	
2010	20.17	2017	83.5	39.3	
2011	20.18	2018			
2019	20.32	2032	60.9	39.8	
2020	20.33	2033	61.2	39.6	
2021	20.35	2035	78.0	39.0	
2022	20.37	2037	90.7	38.3	85.1
2023	20.38	2038	85.2	38.0	
2024	20.40	2040	48.0	38.3	
2025	20.42	2042	59.5	39.6	
2026	20.43	2043	75.2	40.3	
2027	20.45	2045	71.0	40.2	
2028	20.47	2047	110.0	39.8	
2029	20.48	2048	103.8	39.8	
2030	20.50	2050	103.6	39.6	
2031	20.52	2052	95.3	41.4	
2032	20.53	2053	60.6	43.8	
2033	20.55	2055	66.2	45.6	
2034	20.57	2057	65.1	47.1	
2035	20.58	2058	70.2	47.3	
2036	20.60	2060	87.8	46.0	
2037	20.62	2062	82.4	44.2	
2038	20.63	2063	76.8	42.2	
2039	20.65	2065	71.0	42.0	
2040	20.67	2067	68.8	42.1	86.2
2041	20.68	2068	67.8	42.3	
2042	20.70	2070	66.9	42.7	
2043	20.72	2072	65.0	43.3	
2044	20.73	2073	60.4	43.7	
2045	20.75	2075	67.3	43.5	

Run 6, continued

TIME	Decimal Time	Decimal Time x 100	THCH (ppm, dry)	THCC (ppm, dry)	TOM (ppm, dry)
2046	20.77	2077	75.5	42.2	
2047	20.78	2078	77.6	40.3	
2048	20.80	2080	59.0	39.0	
2049	20.82	2082	57.3	40.5	
2059	20.98	2098			85.5
2118	21.30	2130			40.6
2122	21.37	2137	65.0	36.8	
2123	21.38	2138	45.7	35.8	
2124	21.40	2140	49.6	35.0	
2125	21.42	2142	59.5	34.2	
2126	21.43	2143	45.7	33.6	
2127	21.45	2145	55.7	32.7	
2128	21.47	2147	73.0	32.0	
2129	21.48	2148	47.1	30.9	
2130	21.50	2150	45.5	30.0	
2131	21.52	2152	59.2	30.1	
2132	21.53	2153	65.5	30.8	
2133	21.55	2155	61.4	31.0	
2134	21.57	2157	73.5	30.8	
2135	21.58	2158	71.6	30.9	
2136	21.60	2160	74.7	31.1	65.9
2137	21.62	2162	42.5	31.5	
2138	21.63	2163	53.8	32.1	
2139	21.65	2165	51.0	32.6	
2140	21.67	2167	58.1	32.8	
2141	21.68	2168	69.2	32.9	
2142	21.70	2170	68.3	33.3	
2143	21.72	2172	67.0	33.3	
2144	21.73	2173	73.9	33.5	
2145	21.75	2175	72.7	33.8	
2146	21.77	2177	82.4	33.9	
2147	21.78	2178	49.6	34.2	
2148	21.80	2180	52.7	34.6	
2149	21.82	2182	51.0	34.5	
2150	21.83	2183	64.2	34.3	
2151	21.85	2185	70.3	34.4	

RUN 6 - HOT AND COLD HC CONCENTRATIONS
AND TOTAL ORGANIC MASS



APPENDIX B-6

VOLATILE ORGANICS DATA

This appendix presents a summary of VOST data, laboratory techniques and QA/QC checks performed.

ADJUSTED VOST VOLUMES

Run #	Trap pair	Volume sampled (L)	Meter temp. (C)	BP ("Hg)	Meter coef.	Adjusted volume (L)
1	1	9.69	34.0	29.16	1.013	9.13
1	2	9.82	36.0	29.16	1.013	9.19
1	3	10.15	36.0	29.16	1.013	9.50
2	1	10.12	44.0	29.34	1.013	9.29
2	2	9.76	46.0	29.34	1.013	8.92
2	3	9.85	48.0	29.34	1.013	8.93
3	1	10.57	37.0	29.18	1.013	9.87
3	2	10.63	39.0	29.18	1.013	9.86
3	3	9.58	40.0	29.18	1.013	8.86
4	1	10.16	34.0	29.24	1.013	9.60
4	2	10.09	36.0	29.24	1.013	9.47
4	3	10.00	37.0	29.24	1.013	9.36
5	1	9.36	39.0	29.42	1.013	8.76
5	2	9.48	41.0	29.42	1.013	8.81
5	3	9.75	44.0	29.42	1.013	8.98
5	4	9.69	46.0	29.42	1.013	8.86
6	1	9.24	39.0	29.42	1.013	8.64
6	2	9.50	40.0	29.42	1.013	8.86
6	3	9.37	40.0	29.42	1.013	8.73

VOLATILE ORGANICS ANALYSIS DATA SUMMARY

This Data Summary describes the analysis of volatiles samples collected from the Continental Cement Wet Kiln in Hannibal, MO. Two sample types were analyzed: VOST (Tenax and Tenax/Charcoal cartridges) and VOST condensates. Analysis of reportable data began on June 22, 1990 and proceeded until July 16. Procedures used for the analysis of the volatiles samples are described in "Draft Test and QA Plan--Continental Wet Kiln, Hannibal, MO" (June 8, 1990). The analysis procedures described in the test plan were derived from SW-846 Methods 8240 and 5040; however, a number of modifications to these methods were employed by MRI for this study. These modifications are listed in Sections 11.1 and 11.2 of the test plan. Two modifications were made to the purge-and-trap apparatus which were not listed in the test plan. These modifications are described in a later section of this memo.

1.0 SAMPLE ANALYSIS

Twenty-seven volatile "Products of Incomplete Combustion" (PIC) compounds were selected for analysis in this study. The list of compounds actually used is slightly different than that provided in the test plan because three compounds were not included in the composite standard mixture purchased from Supelco. The three compounds not included in the analysis are cis-1,3-dichloropropene, 2-chloroethylvinyl ether and trichlorofluoromethane. In addition, two compounds were analyzed in this study that were not included in the original list (chlorobenzene and p-dioxane).

Two internal standards (d_6-benzene and 1,4-difluorobenzene) and four surrogates (d_4-1,2-dichloroethane, d_5-chlorobenzene, d_8-toluene and bromofluorobenzene) were added to the samples immediately prior to analysis. Surrogate and target analyte concentrations were determined by the internal standard method using 1,4-difluorobenzene as the reference internal standard. The second internal standard compound, d6-benzene, was not used as a reference due to problems associated with the sample matrix (this problem is described in a later section of this appendix). Separate calibration curves were generated for the VOST samples and VOST condensate samples.

2.0 DATA ORGANIZATION

Results of this analysis are available in two forms: summary report and the "raw" GC/MS data. The summary reports are contained in this appendix and the raw data has been appropriately stored for possible future reference. The contents of each of these data forms are outlined below:

A. Summary Reports

1. Calibration Curve Summary
2. MRI QA Performance Sample Analysis Summary
3. Daily Blanks Analysis Summary
4. Daily Standards Analysis Summary
5. VOST Sample Analysis Summary
6. VOST Condensate Analysis Summary

B. Raw Data

1. Tentatively Identified Compounds (TIC) Summaries
2. Total characterization of unidentified peaks in a VOST sample pair (Tenax and Tenax/Charcoal)
3. Reconstructed ion chromatograms (RICs) of VOST samples
4. PFK spectrum and mass listing
5. BFB spectrum, mass listing, and BFB QA summary
6. PARA printouts
7. QUAN quantitation report printouts
8. RIC and ion plots
9. Photocopies of all pertinent laboratory notebook pages
10. Calibration curve printouts, including RESP curves, EDRL listings, and average relative response factors
11. Sample Traceability forms

3.0 ADDITIONAL NOTES REGARDING THIS ANALYSIS

3.1 All the samples were analyzed within the 14 day holding time specified in the test plan (holding times for VOST condensates were not specifically mentioned in the test plan.)

3.2 Although not formally required for this study as per the test plan, calibration curves were generated for all of the PIC compounds and appropriate quality assurance procedures were followed. It was felt that a true calibration curve would provide more accurate quantitative information than the procedure recommended in the test plan (using either response factors of 1.0 or "historical" response factors for quantitation of PIC's). Three calibration curves were generated during the course of the study: two calibration curves for the analysis of VOST samples and a separate calibration curve for the analysis of the VOST condensates.

3.3 Relative standard deviations (RSD's) for the PIC response factors (Rfs) in the three calibration curves were generally within ±30%, with the exception of some early eluting (i.e. very volatile) compounds in the VOST calibration curves, which was attributable to the method in which the standards were introduced into the GC/MS. A single standard solution containing 50 ng/ul of each PIC compound was used. In order to generate a multi-point calibration, increasing volumes of the standard solution were spiked onto a clean VOST trap and thermally desorbed onto the analytical trap. As a result, the high point of the calibration curve required injecting a relatively large volume (20µl) of PIC standard onto the VOST trap. It is believed that the large amount of solvent (methanol) injected onto the trap "flushed" the more volatile compounds through the trap without being absorbed onto the Tenax. By contrast, the effect was not observed in the waters analysis, where the PIC standard was injected directly into 5ml of water which was then purged onto the analytical trap. The flushing effect is not relevant to the analysis of the VOST samples themselves, since no large volumes of solvent were spiked onto the sample traps. Response factors for the high levels of affected compounds were discarded when cali curve average RFs were computed.

3.4 Two modifications to Method 8240 were employed for the purge-and-trap portion of the analysis apparatus. The first modification involved heating the purge tower water to ca. 40°C using a heating jacket around the purge tower for the VOST condensate analysis. This was done to improve the purging efficiency of the system for the more water soluble PIC compounds (notably methyl ethyl ketone and *p*-dioxane). The second modification involved removing the water from the purge tower altogether for the analysis of the VOST samples. In this configuration, the purge tower simply acted as a dry water trap in case large amounts of water were collected in the VOST cartridges during sampling. As can be seen in the attached Calibration Curve and Daily Standards Analysis Summaries, the dry-purge tower setup was effective in providing good reproducibility for all PIC compounds in the VOST analysis, including those which were water-soluble. In the VOST condensate analysis however, the purging efficiency of p-dioxane from the purge water was poor, even though the purge water was heated.

3.5 Although not specifically required by either the test or QA plan, a QA Performance Sample was analyzed for both the VOST and VOST condensate analyses. Results of the QAP sample are attached. PIC recoveries for the VOST condensate analysis were all within ±25% with the exception of chloroform (36% recovery), which had an actual concentration approximately ten times the highest point of the calibration curve. Recoveries of PIC's in the VOST QAP sample analysis were not as good, although it is suspected that this was due to the fact that the sample was analyzed immediately following the high level calibration standard and some carry-over may have occurred (all the reported recoveries had a high bias). The problem was noted by the QA officer on the attached QA Performance Sample Request and Reporting Form and no further action was taken.

3.6 As expected, the VOST samples contained very high levels of some PIC's, notably benzene, toluene, acetone, acrylonitrile and ethylbenzene. In some cases, PIC levels were so high that the primary quantitation ion was saturated. In such cases, quantitation was performed using an alternate quantitation ion of lower intensity. Unfortunately, the range of the calibration curve was usually exceeded in such cases but the reported values should still provide a reasonable estimate of the PIC concentration. Previous analyses of this type have indicated that compounds may be accurately quantitated outside a calibration curve range as long as the quantitation ions used are not saturated, although the calculated amounts should still only be regarded as semi-quantitative.

3.7 Limits of detection and limits of quantitation were not determined for this study. Therefore, no amounts were "filtered out". As a precaution, PIC amounts which fall below the lowest level of their respective calibration curve should only be regarded as semi-quantitative.

3.8 As stated previously, six reference compounds (two internal standards and four surrogates) were added to the sample immediately prior to analysis. A relatively large number of reference compounds were used in this study to provide redundancy in case interferences prevented accurate quantitation of one or more of them. The problem of sample matrix interference was described in a previous report ("Applicability of the VOST Method for Measuring Cement Kiln

Emissions During Firing of Hazardous Wastes", prepared for U.S. E.P.A. by Radian Corp., May 16, 1988). As was seen in that study, the high levels of native benzene observed in the VOST samples severely interfered with the quantitation of the d_6-benzene internal standard, and as a result d_6-benzene was not used as a reference compound in quantitative determinations. Similarly, d_4-1,2-dichloroethane was also severely affected by matrix interference, as can be seen in the attached VOST Sample Analysis Summary. Relative standard deviations for the recovery of df-benzene and d_4-1,2-dichloroethane in the VOST samples were determined to be 59% and 51%, respectively. In contrast, recovery RSD's for the same compounds in the daily standards was determined to be 102% and 97%, respectively. No major interferences were observed in the VOST samples for the remaining four reference compounds; recovery RSD's for the surrogates d_8-toluene, bromofluorobenzene and d_5-chlorobenzene were 4%, 15% and 6%, respectively (recovery is not applicable to the fourth compound, 1,4-difluorobenzene, which served as the internal standard). No interferences were observed in the VOST condensate samples.

3.9 In addition to the PIC compounds, a number of other compounds were observed in the VOST samples, including large numbers of alkanes, alkenes, cyclic hydrocarbons, benzaldehyde, benzofuran, benzonitrile and methyl styrene, to name a few. Two sets of data relating to these other compounds are available for possible future reference. The first set includes tentative identifications and quantitations of the ten largest peaks in each of the VOST sample runs. The test plan originally specified that only five peaks were to be identified, however due to the large number of observed peaks, it was felt that an additional effort in this area might be appropriate. The second set of data extends that concern to include a complete characterization of all major peaks in a single VOST sample (Tenax and Tenax/charcoal traps). This complete characterization may be considered an example of the types of compounds that were present in the other VOST samples. Identification of unknown peaks were performed using a computerized mass spectral library search program (LIBR, Finnigan/MAT Corp.) which compared the unknown spectra to 42222 reference mass spectra contained in the NBS/EPA mass spectral database. The library results were then reviewed and corrected by a mass spectrometrist experienced in mass spectral interpretation.

CALIBRATION CURVE SUMMARY

Calibration Curve Date: 6/22/90 Analysis Method: VOS
Instrument: 312

Index	Compound Name	Ref	m/z	Response Factor (vs total ng) 50	100	200	500	1000	Avg	RSD
IN001	d6-Benzene (I.S.)	IN002	84	1.076	1.079	1.058	1.039	.988	1.048	4
IN002	1,4-Difluorobenzene (I.S.)	IN002	114	1.000	1.000	1.000	1.000	1.000	1.000	100
IN003	d4-1,2-Dichloroethane (Surr.	IN002	65	.291	.293	.296	.304	.317	.300	4
IN004	d8-Toluene (Surr)	IN002	98	1.177	1.227	1.231	1.225	1.206	1.213	2
IN008	Bromofluorobenzene (Surr.)	IN002	174	.363	.387	.390	.390	.406	.387	4
IN009	d5-Chlorobenzene (Surr.)	IN002	117	.770	.810	.800	.781	.745	.781	3
IN026	Diethyl ether	IN002	74	.118	.120	.112	.048		.100	35
IN027	Acrolein	IN002	56	.085	.093	.094	.052		.081	25
IN028	1,1-Dichloroethene	IN002	61	.388	.400	.250	.114		.288	47
IN029	Acetone	IN002	58	.146	.159	.163	.129		.149	10
IN030	Methylene chloride	IN002	84	.229	.249	.272	.231		.245	8
IN031	Acrylonitrile	IN002	53	.259	.296	.322	.281	.227	.277	13
IN032	t-1,2-Dichloroethene	IN002	61	.464	.490	.529	.447		.483	7
IN033	1,1-Dichloroethane	IN002	63	.535	.581	.647	.550	.338	.530	22
IN034	Methyl ethyl ketone (MEK)	IN002	72	.152	.165	.173	.149	.138	.155	9
IN035	Chloroform	IN002	85	.289	.313	.346	.315	.321	.317	6
IN036	1,1,1-Trichloroethane	IN002	97	.315	.343	.357	.317	.254	.317	12
IN037	Carbon tetrachloride	IN002	117	.261	.288	.309	.269	.234	.272	10
IN038	Benzene	IN002	78	1.007	1.046	1.080	.991	.860	.997	8
IN039	1,2-Dichloroethane	IN002	62	.300	.312	.335	.303	.283	.307	6
IN040	Trichloroethene	IN002	95	.345	.380	.402	.466	.371	.393	12
IN041	1,2-Dichloropropane	IN002	63	.469	.507	.533	.499	.493	.500	5
IN042	p-Dioxane	IN002	88	.160	.158	.178	.151	.159	.161	6
IN043	Bromodichloromethane	IN002	83	.415	.451	.483	.456	.443	.450	5
IN044	Toluene	IN002	92	.635	.687	.702	.647	.572	.649	8
IN045	t-1,3-Dichloropropene	IN002	75	.293	.337	.365	.350	.355	.340	8
IN046	1,1,2-Trichloroethane	IN002	83	.308	.365	.381	.361	.347	.352	8
IN047	Tetrachloroethene (PERC)	IN002	164	.236	.260	.270	.252	.244	.252	5
IN048	Dibromochloromethane	IN002	129	.352	.391	.422	.404	.388	.391	7
IN049	Chlorobenzene (MCB)	IN002	112	.684	.729	.754	.718	.586	.694	9
IN050	Ethylbenzene	IN002	106	.325	.374	.391	.364	.348	.360	7
IN051	Bromoform	IN002	173	.296	.358	.382	.364	.345	.349	9
IN052	1,1,2,2-Tetrachloroethane	IN002	83	.712	.808	.841	.776	.615	.751	12
IN053	Benzene (m/z 51)	IN002	51	1.877	1.074	.669	.402	.310	.866	74
IN054	Benzene (m/z 79)	IN002	79	.048	.055	.062	.059	.059	.057	9
IN055	Toluene (m/z 65)	IN002	65	.189	.202	.206	.184	.170	.190	8
IN056	Acetone (m/z 42)	IN002	42	.032	.036	.042	.032		.035	14
IN057	Acrylonitrile (m/z 51)	IN002	51	.101	.108	.117	.102	.096	.105	8
IN058	Benzene (m/z 74)	IN002	74	.060	.053	.055	.049	.048	.053	9
IN059	Toluene (m/z 90)	IN002	90		.012	.015	.016	.016	.015	14
IN060	Ethylbenzene (m/z 92)	IN002	92	.077	.092	.101	.093	.088	.090	10

CALIBRATION CURVE SUMMARY

Calibration Curve Date: 7/5/90 Analysis Method: VOS
Instrument: 312

Index	Compound Name	Ref	m/z	Response Factor (vs total ng) 50	100	200	500	1000	Avg	RSD
IN001	d6-Benzene (I.S.)	IN002	84	1.043	1.036	1.032	.993	.935	1.008	4
IN002	1,4-Difluorobenzene (I.S.)	IN002	114	1.000	1.000	1.000	1.000	1.000	1.000	100
IN003	d4-1,2-Dichloroethane (Surr.	IN002	65	.310	.308	.317	.328	.336	.320	4
IN004	d8-Toluene (Surr)	IN002	98	1.187	1.187	1.201	1.183	1.170	1.186	1
IN008	Bromofluorobenzene (Surr.)	IN002	174	.403	.404	.412	.408	.409	.407	1
IN009	d5-Chlorobenzene (Surr.)	IN002	117	.791	.780	.789	.771	.745	.775	2
IN026	Diethyl ether	IN002	74	.128	.129	.122	.052		.108	35
IN027	Acrolein	IN002	56	.060	.065	.064	.035		.056	25
IN028	1,1-Dichloroethene	IN002	61	.433	.445	.365	.134		.344	42
IN029	Acetone	IN002	58	.165	.159	.149	.110		.146	17
IN030	Methylene chloride	IN002	84	.281	.275	.274	.129		.240	31
IN031	Acrylonitrile	IN002	53	.292	.299	.299	.284	.216	.278	13
IN032	t-1,2-Dichloroethene	IN002	61	.504	.519	.504	.464	.138	.426	38
IN033	1,1-Dichloroethane	IN002	63	.579	.600	.584	.556	.256	.515	28
IN034	Methyl ethyl ketone (MEK)	IN002	72	.169	.168	.164	.155	.137	.159	9
IN035	Chloroform	IN002	85	.337	.355	.354	.344	.332	.344	3
IN036	1,1,1-Trichloroethane	IN002	97	.376	.386	.398	.361	.267	.357	15
IN037	Carbon tetrachloride	IN002	117	.316	.342	.349	.312	.251	.314	12
IN038	Benzene	IN002	78	1.123	1.092	1.051	1.011	.881	1.032	9
IN039	1,2-Dichloroethane	IN002	62	.363	.367	.362	.353	.325	.354	5
IN040	Trichloroethene	IN002	95	.396	.406	.404	.401	.381	.397	3
IN041	1,2-Dichloropropane	IN002	63	.497	.515	.509	.499	.479	.500	3
IN042	p-Dioxane	IN002	88	.095	.131	.151	.176	.168	.144	23
IN043	Bromodichloromethane	IN002	83	.481	.492	.494	.488	.471	.485	2
IN044	Toluene	IN002	92	.762	.712	.691	.664	.585	.683	10
IN045	t-1,3-Dichloropropene	IN002	75	.347	.361	.364	.366	.361	.360	2
IN046	1,1,2-Trichloroethane	IN002	83	.352	.378	.371	.363	.343	.361	4
IN047	Tetrachloroethene (PERC)	IN002	164	.284	.289	.285	.276	.263	.279	4
IN048	Dibromochloromethane	IN002	129	.429	.449	.447	.446	.424	.439	3
N049	Chlorobenzene (MCB)	IN002	112	.766	.794	.781	.762	.618	.744	10
IN050	Ethylbenzene	IN002	106	.391	.400	.391	.380	.355	.383	5
IN051	Bromoform	IN002	173	.385	.413	.405	.403	.378	.397	4
N052	1,1,2,2-Tetrachloroethane	IN002	83	.857	.851	.822	.804	.640	.795	11
N053	Benzene (m/z 51)	IN002	51	1.806	1.022	.636	.394		.965	64
IN054	Benzene (m/z 79)	IN002	79	.055	.057	.057	.059	.057	.057	2
N055	Toluene (m/z 65)	IN002	65	.222	.209	.196	.184	.169	.196	11
N056	Acetone (m/z 42)	IN002	42	.036	.037	.041	.031		.037	12
IN057	Acrylonitrile (m/z 51)	IN002	51	.109	.118	.108	.105	.087	.106	11
N058	Benzene (m/z 74)	IN002	74	.064	.059	.056	.052	.050	.056	10
N059	Toluene (m/z 90)	IN002	90		.012	.016	.017	.016	.015	13
IN060	Ethylbenzene (m/z 92)	IN002	92	.096	.099	.102	.098	.091	.097	4

CALIBRATION CURVE SUMMARY

Calibration Curve Date: 7/2/90
Instrument: 312

Analysis Method: WAT

				Response Factor (vs total ng)						
Index	Compound Name	Ref	m/z	50	100	200	500	1000	Avg	RSD
IN001	d6-Benzene (I.S.)	IN002	84	1.049	1.045	1.041	1.017	.970	1.024	3
IN002	1,4-Difluorobenzene (I.S.)	IN002	114	1.000	1.000	1.000	1.000	1.000	1.000	100
IN003	d4-1,2-Dichloroethane (Surr.	IN002	65	.296	.297	.315	.311	.326	.309	4
IN004	d8-Toluene (Surr)	IN002	98	1.206	1.182	1.193	1.195	1.185	1.192	1
IN008	Bromofluorobenzene (Surr.)	IN002	174	.417	.412	.437	.422	.415	.421	2
IN009	d5-Chlorobenzene (Surr.)	IN002	117	.799	.790	.818	.779	.742	.786	4
IN026	Diethyl ether	IN002	74	.592	.604	.661	.483	.470	.562	15
IN027	Acrolein	IN002	56	.024	.029	.032	.027	.028	.028	9
IN028	1,1-Dichloroethene	IN002	61	.386	.408	.406	.361	.377	.388	5
IN029	Acetone	IN002	58	.025	.025	.027	.022	.022	.024	10
IN030	Methylene chloride	IN002	84	.235	.247	.264	.220	.240	.241	7
IN031	Acrylonitrile	IN002	53	.117	.124	.124	.101	.103	.114	10
IN032	t-1,2-Dichloroethene	IN002	61	.429	.454	.461	.394	.405	.428	7
IN033	1,1-Dichloroethane	IN002	63	.498	.527	.657	.468	.496	.529	14
IN034	Methyl ethyl ketone (MEK)	IN002	72	.053	.067	.056	.045	.047	.053	16
IN035	Chloroform	IN002	85	.347	.364	.384	.328	.361	.357	6
IN036	1,1,1-Trichloroethane	IN002	97	.383	.391	.390	.360	.389	.383	3
IN037	Carbon tetrachloride	IN002	117	.306	.334	.335	.298	.328	.320	5
IN038	Benzene	IN002	78	1.133	1.140	1.157	.985	.878	1.058	12
IN039	1,2-Dichloroethane	IN002	62	.356	.361	.389	.326	.335	.353	7
IN040	Trichloroethene	IN002	95	.418	.444	.449	.395	.408	.423	5
IN041	1,2-Dichloropropane	IN002	63	.543	.557	.580	.496	.522	.540	6
IN042	p-Dioxane	IN002	88	.000	.001	.000	.000	.000	.000	107
IN043	Bromodichloromethane	IN002	83	.488	.514	.545	.467	.503	.503	6
IN044	Toluene	IN002	92	.740	.735	.736	.635	.605	.690	9
IN045	t-1,3-Dichloropropene	IN002	75	.370	.378	.424	.354	.380	.381	7
IN046	1,1,2-Trichloroethane	IN002	83	.387	.402	.439	.356	.369	.390	8
IN047	Tetrachloroethene (PERC)	IN002	164	.286	.298	.293	.263	.265	.281	6
IN048	Dibromochloromethane	IN002	129	.445	.467	.518	.428	.439	.459	8
IN049	Chlorobenzene (MCB)	IN002	112	.832	.847	.869	.739	.639	.785	12
IN050	Ethylbenzene	IN002	106	.417	.425	.428	.371	.370	.402	7
IN051	Bromoform	IN002	173	.392	.426	.485	.393	.401	.419	9
IN052	1,1,2,2-Tetrachloroethane	IN002	83	.837	.865	.939	.753	.646	.808	14
IN053	Benzene (m/z 51)	IN002	51	1.821	1.051	.700	.392	.320	.857	71
IN054	Benzene (m/z 79)	IN002	79	.091	.091	.070	.063	.065	.076	18
IN055	Toluene (m/z 65)	IN002	65	.220	.216	.209	.177	.177	.200	10

To be completed by project personnel:
Project No.: 9102-6315
Requested by: Jon Onstot
Approved by:
Analysis Type: GC/MS Volatiles Full Scan

Request date: 6/22/90
Expected Analysis date: 7/1/90
Expected Reporting date:

To be completed by QA Unit:
QC Sample Prepared by: D Horton
Relinquished to: ONSTOT on 6/22/90
Storage Conditions:

QA Unit Sample Identification	Analyte	Solvent or Matrix	Found Compound ~~Concentration Range (units)~~	Analysis Results Found Concentration	QA Unit Report Actual Concentration	QA Unit Report % Found/Actual
04720		MeOH	chloroform	2236 ng/µl	6235	36% (10x ABOVE CURVE ON CONC)
*See VOST QAP Sample Request Form for list of possible analytes			carbon tetrachloride	193 ng/µl	157	123%
			trichloroethene	101 ng/µl	86	117%
			bromo-dichloro-methane	454 ng/µl	390	116%
			PERC	48 ng/µl	41	117%
			dibromochloro-methane	153 ng/µl	125	122%
			bromoform	101 ng/µl	87	116%

Comments:
Results of this analysis were not reported until after the analysis was completed. However, (a) analysis of a QAP sample was not required by the project test plan, and (b) the values were already known to the operator because of previous analysis of the same sample for VOST (see QAP Reporting Form dated 6/22/90) ~~and~~ Recoveries were ~~known~~ determined to be within appropriate QA guidelines JDW 9/21/90

Date analyzed: 7/3/90 11:18 AM
Reported by: Jon Onstot 9/20/90
Validated by:

Date reported: 9/21/90
QCC Reviewer:
QAU Approved:
Corrective Action?
☐ Yes [✓ No]
(See Comments)

Distribution:
(PROJECT LEADER)
TRANHOLM
ONSTOT
DUX

LKD 1866-24425

LISTING
EPA-OSW -
HANNIBAL
TEST BURN

To be completed by project personnel:
Project No.: 9102-6315
Requested by: Jon Onstot
Approved by:
Analysis Type: GC/MS - VOLATILES
Request date: 6/22/90
Expected Analysis date: 6/22/90
Expected Reporting date: 6/22/90

To be completed by QA Unit:
QC Sample Prepared by: DENNIS HOOTON
Relinquished to: JON ONSTOT on 6/22/90
Storage Conditions: AS STANDARD

QA Unit Sample Identification	Analyte	Solvent or Matrix	Concentration Range (units)	Analysis Results: Found Concentration	QA Unit Report: Actual Concentration	QA Unit Report: % Found/Actual
MRI SAMPLE 04720	see attached list	MeOH	calibration range = 20-1000 ng	acrolein - 51 26 acrylonitrile - 4t2, 2100	N/A N/A	} FALSE POSITIVES OR LAB CONTAMINANTS
			(10-500 ng/µl)	chloroform - 4200 carbon tet - 482	6235 211 157	34% (ABOVE CURVE) 134% OK
				p-dioxane - 185 206 trichloroethene - 20610 450	97.5 N/A 3 85.8	— FALSE POSITIVE OR LC 120% OK
				eBrCl2H - ~~400~~ toluene - 2142 CHBr2Cl - 933	~~125~~ 390 N/A 162 125	115% OK — FALSE POSITIVE OR LC 130%
				PERC - ~~58~~ 105 bromoform - ~~232~~ 116	40.6 86.5	131% 134% } OK
				tetrachloroethane, 1,1,2,2 - ~~59~~ 29.5	N/A	— - FALSE POSITIVE OR LAB CONTAM.

AUDIT SAMPLE WAS NBS SRM 1639 DH

SIGNIFICANT # OF FALSE HITS + SLIGHT HIGH BIAS ON SPIKED ANALYTES. DH

IN. 009 2-CHLOROETHYL VINYL ETHER
~~IN. 010 CHLOROMETHANE~~
~~IN. 011 BROMOMETHANE~~
~~IN. 012 VINYL CHLORIDE~~
~~IN. 013 CHLOROETHANE~~
IN. 014 METHYLENE CHLORIDE
IN. 015 ACETONE
IN. 016 ACROLEIN
B-122, 017 ACRYLONITRILE
018 1,1-DICHLOROETHENE
019 1,1-DICHLOROETHANE
IN. 020 T-1,2-DICHLOROETHENE
IN. 021 DIETHYL ETHER
IN. 022 CHLOROFORM
IN. 023 1,2-DICHLOROETHANE
IN. 024 METHYL ETHYL KETONE (MEK) ←
IN. 025 1,1,1-TRICHLOROETHANE
~~IN. 026 P-DIOXANE~~
IN. 027 CARBON TETRACHLORIDE
IN. 028 BROMO-DICHLOROMETHANE
IN. 029 1,2-DICHLOROPROPANE
IN. 030 T-1,3-DICHLOROPROPENE
IN. 031 TRICHLOROETHENE +
IN. 032 BENZENE
IN. 033 DIBROMO-CHLOROMETHANE
IN. 034 1,1,2-TRICHLOROETHANE
IN. 035 BROMOFORM
IN. 036 1,1,2,2-TETRACHLOROETHANE +
IN. 037 TETRACHLOROETHENE (PERC) +
IN. 038 TOLUENE
IN. 039 CHLOROBENZENE (MCB)
IN. 040 ETHYLBENZENE

STORE REMAINING STANDARD IN VIAL PROVIDED + RETURN FOR UNUSED PORTION. REANALYZE AFTER RECALIBRATIONS.

Date analyzed: JO 6/22/90
Reported by: Jon Ont
Validated by:

Date reported: 6/22/90
~~QCC Reviewed:~~ D Hooton
~~QAU Approved:~~

Corrective Action? ☑ Yes ☐ No
(See Comments)

Distribution:
TRANHOLM
GOING
DUX
C. GREEN
COATES
RADOZOVICH
HOLT
G. PODREBARAC
ONSTOT
KLAMM

INSTRUMENT ______

DATE OF INITIAL CALIBRATION 6/22/90

SUGGEST RUNNING LAB BLANK PRIOR TO SAMPLE ANALYSIS
[illegible]

Blank Analysis Summary - Hannibal 8912-3115

No.	Compound	Quan Ion (m/z)		Amount (ng) a/										
			Filename	F25YQ3	F25YQ4	F26YQ3	F26YQ4	F26YQ5	F26YQ6	F27YQ3	F27YQ4	F28YQ3	F28YQ4	F29YQ4
			Amt. (ng)	0	0	0	0	0	0	0	0	0	0	0
			Type c/	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK
1	d6-Benzene (Alt. I.S.)	84		105	105	107	108	106	102	106	100	108	105	108
2	1,4-Difluorobenzene (I.S.)	114		100	100	100	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. I.S.)	65		106	105	103	105	112	99	112	96	108	111	122
4	d8-Toluene (Surr.)	98		105	104	104	105	102	96	104	102	105	103	103
5	Bromofluorobenzene (Surr.)	174		109	107	106	106	108	104	101	107	102	105	104
6	d5-Chlorobenzene (Surr.)	117		109	107	109	108	107	100	108	106	107	106	107
7	Diethyl ether	74		< d/	<	<	<	<	<	<	<	<	<	<
8	Acrolein	56		<	<	<	<	<	<	<	<	<	<	<
9	1,1-Dichloroethene	61		<	<	<	<	<	<	<	<	<	<	<
10	Acetone	58		<	<	<	<	<	<	<	<	<	<	<
11	Methylene Chloride	84		<	<	<	<	<	<	<	<	<	<	<
12	Acrylonitrile	53		<	<	<	<	<	<	<	<	<	<	<
13	t-1,2-Dichloroethene	61		<	<	<	<	<	<	<	<	<	<	<
14	1,1-Dichloroethane	63		<	<	<	<	<	<	<	<	<	<	<
15	Methyl ethyl ketone (MEK)	72		<	<	<	<	<	<	<	<	<	<	<
16	Chloroform	85		<	<	<	<	<	<	<	<	<	<	<
17	1,1,1-Trichloroethane	97		<	<	<	<	<	<	<	<	<	<	<
18	Carbon Tetrachloride	117		<	<	<	<	<	<	<	<	<	<	<
19	Benzene	78		<	<	<	<	<	127	<	248	<	<	<
20	1,2-Dichloroethane	62		<	<	<	<	<	<	<	<	<	<	<
21	Trichloroethene	95		<	<	<	<	<	<	<	<	<	<	<
22	1,2-Dichloropropane	63		<	<	<	<	<	<	<	<	<	<	<
23	p-Dioxane	88		714	<	766	<	<	<	739	<	680	<	<
24	Bromodichloromethane	83		<	<	<	<	<	<	<	<	<	<	<
25	Toluene	92		<	<	<	<	<	<	<	74	<	<	<
26	t-1,3-Dichloropropene	75		<	<	<	<	<	<	<	<	<	<	<
27	1,1,2-Trichloroethane	83		<	<	<	<	<	<	<	<	<	<	<
28	Tetrachloroethene (PERC)	164		<	<	<	<	<	<	<	<	<	<	<
29	Dibromochloromethane	129		<	<	<	<	<	<	<	<	<	<	<
30	Chlorobenzene (MCB)	112		<	<	<	<	<	<	<	<	<	<	<
31	Ethylbenzene	106		<	<	<	<	<	<	<	<	<	<	<
32	Bromoform	173		<	<	<	<	<	<	<	<	<	<	<
33	1,1,2,2-Tetrachloroethane	83		<	<	<	<	<	<	<	<	<	<	<

a. Values for surrogates and alternate internal standards are percent recoveries.

b. Actual amt. = 5x nominal amt. - not applicable

c. VER = Daily initial verification std.
FIN = Daily final std.
BLK = Blank

d. < = Not detected at levels above the lowest calibration standard.

Blank Analysis Summary - Hannibal 8912-3115

				Amount (ng) a/										
		Quan Ion	Filename	G03YQ3	G03YQ5	G03YQ6	G05YQ7	G05YQ8	G06YQ3	G06YQ4	G10YQ3	G11YQ3	G11YQ4	G11YQ5
			Amt. (ng)	0	0	0	0	0	0	0	0	0	0	0
No.	Compound	(m/z)	Type c/	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK	BLK
1	d6-Benzene (Alt. I.S.)	84		102	104	104	104	100	99	104	102	103	103	101
2	1,4-Difluorobenzene (I.S.)	114		100	100	100	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. I.S.)	65		94	95	94	97	95	96	97	97	98	98	96
4	d8-Toluene (Surr.)	98		99	101	101	100	100	99	102	100	101	100	102
5	Bromofluorobenzene (Surr.)	174		98	101	100	96	0	0	103	96	99	97	103
6	d5-Chlorobenzene (Surr.)	117		101	103	103	103	103	102	105	103	105	103	105
7	Diethyl ether	74		< d/	<	<	<	<	<	<	<	<	<	<
8	Acrolein	56		<	<	<	<	<	<	<	<	<	<	<
9	1,1-Dichloroethene	61		<	<	<	<	<	<	<	<	<	<	<
10	Acetone	58		<	<	<	<	<	<	<	<	<	<	<
11	Methylene Chloride	84		<	<	<	<	<	<	<	<	<	<	<
12	Acrylonitrile	53		<	<	<	<	<	<	<	<	<	<	<
13	t-1,2-Dichloroethene	61		<	<	<	<	<	<	<	<	<	<	<
14	1,1-Dichloroethane	63		<	<	<	<	<	<	<	<	<	<	<
15	Methyl ethyl ketone (MEK)	72		<	<	<	<	<	<	<	<	<	<	<
16	Chloroform	85		<	<	<	<	<	<	<	<	<	<	<
17	1,1,1-Trichloroethane	97		<	<	<	<	<	<	<	<	<	<	<
18	Carbon Tetrachloride	117		<	<	<	<	<	<	<	<	<	<	<
19	Benzene	78		<	<	<	<	<	<	<	<	<	<	84
20	1,2-Dichloroethane	62		<	<	<	<	<	<	<	<	<	<	<
21	Trichloroethene	95		<	<	<	<	<	<	<	<	<	<	<
22	1,2-Dichloropropane	63		<	<	<	<	<	<	<	<	<	<	<
23	p-Dioxane	88		<	<	<	488	<	592	<	322	338	<	<
24	Bromodichloromethane	83		<	<	<	<	<	<	<	<	<	<	<
25	Toluene	92		<	<	<	<	<	<	<	<	<	<	<
26	t-1,3-Dichloropropene	75		<	<	<	<	<	<	<	<	<	<	<
27	1,1,2-Trichloroethane	83		<	<	<	<	<	<	<	<	<	<	<
28	Tetrachloroethene (PERC)	164		<	<	<	<	<	<	<	<	<	<	<
29	Dibromochloromethane	129		<	<	<	<	<	<	<	<	<	<	<
30	Chlorobenzene (MCB)	112		<	<	<	<	<	<	<	<	<	<	<
31	Ethylbenzene	106		<	<	<	<	<	<	<	<	<	<	<
32	Bromoform	173		<	<	<	<	<	<	<	<	<	<	<
33	1,1,2,2-Tetrachloroethane	83		<	<	<	<	<	<	<	<	<	<	<

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a. Values for surrogates and alternate internal

b. Actual amt. = 5x nominal amt.

c. VER = Daily initial verification std.
FIN = Daily final std.
BLK = Blank

d. < = Not detected at levels above the lowest

see footnote a 1st page of table.

B-124

Blank Analysis Summary - Hannibal 8912-3115

No.	Compound	Quan Ion (m/z)		Amount (ng)[a]							Avg Recovery (%)
			Filename	G12YQ4	G13YQ3	G13YQ4	G13YQ5	G13YQ6	G13YQ7	G16YQ3	
			Amt. (ng)	0	0	0	0	0	0	0	
			Type[c]	BLK	BLK	BLK	BLK	BLK	BLK	BLK	
1	d6-Benzene (Alt. I.S.)	84		104	100	99	99	99	99	101	103
2	1,4-Difluorobenzene (I.S.)	114		100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. I.S.)	65		92	93	94	92	92	92	99	100
4	d8-Toluene (Surr.)	98		104	97	100	100	99	101	99	101
5	Bromofluorobenzene (Surr.)	174		124	92	103	97	103	101	98	96
6	d5-Chlorobenzene (Surr.)	117		123	99	104	103	103	104	101	105
7	Diethyl ether	74		< [d]	<	<	<	<	<	<	
8	Acrolein	56		<	<	<	<	<	<	<	
9	1,1-Dichloroethene	61		<	<	<	<	<	<	<	
10	Acetone	58		<	<	<	<	<	<	<	
11	Methylene Chloride	84		<	<	<	<	<	<	<	
12	Acrylonitrile	53		<	<	<	<	<	<	<	
13	t-1,2-Dichloroethene	61		<	<	<	<	<	<	<	
14	1,1-Dichloroethane	63		<	<	<	<	<	<	<	
15	Methyl ethyl ketone (MEK)	72		<	<	<	<	<	<	<	
16	Chloroform	85		<	<	<	<	<	<	<	
17	1,1,1-Trichloroethane	97		<	<	<	<	<	<	<	
18	Carbon Tetrachloride	117		<	<	<	<	<	<	<	
19	Benzene	78		81	<	<	146	108	87	<	
20	1,2-Dichloroethane	62		<	<	<	<	<	<	<	
21	Trichloroethene	95		<	<	<	<	<	<	<	
22	1,2-Dichloropropane	63		<	<	<	<	<	<	<	
23	p-Dioxane	88		<	331	<	648	<	<	<	
24	Bromodichloromethane	83		<	<	<	<	<	<	<	
25	Toluene	92		<	<	<	<	<	<	<	
26	t-1,3-Dichloropropene	75		<	<	<	<	<	<	<	
27	1,1,2-Trichloroethane	83		<	<	<	<	<	<	<	
28	Tetrachloroethene (PERC)	164		<	<	<	<	<	<	<	
29	Dibromochloromethane	129		<	<	<	<	<	<	<	
30	Chlorobenzene (MCB)	112		<	<	<	<	<	<	<	
31	Ethylbenzene	106		<	<	<	<	<	<	<	
32	Bromoform	173		<	<	<	<	<	<	<	
33	1,1,2,2-Tetrachloroethane	83		<	<	<	<	<	<	<	

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a. Values for surrogates and alternate internal

b. Actual amt. = 5x nominal amt.

c. VER = Daily initial verification std.
FIN = Daily final std.
BLK = Blank

d. < = Not detected at levels above the lowest

Standards Analysis Summary - Hannibal 8912-3115

No.	Compound	Quan Ion (m/z)		Percent Recovery (%) [a]									
			Filename	F25YQ2	F25YQ5	F26YQ2	F26YQ7	F27YQ2	F27YQ5	F28YQ2	F28YQ5	F29YQ3	F29YQ5
			Amt. (ng)	200	200	200	200	200	200	200	200	200	200
			Type [b]	VER	FIN	VER	FIN	VER	FIN	VER	FIN	VER	FIN
1	d6-Benzene (Alt. I.S.)	84		102	104	103	78	105	74	109	106	105	102
2	1,4-Difluorobenzene (I.S.)	114		100	100	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. I.S.;	65		104	100	101	64	112	64	108	119	118	0
4	d8-Toluene (Surr.)	98		104	103	100	102	105	101	106	91	103	104
5	Bromofluorobenzene (Surr.)	174		103	107	100	106	102	108	98	59	104	0
6	d5-Chlorobenzene (Surr.)	117		105	105	103	103	107	104	108	78	105	0
7	Diethyl ether	74		126	128	132	111	134	35	130	133	120	114
8	Acrolein	56		101	109	111	70	112	52	110	80	95	0
9	1,1-Dichloroethene	61		132	132	138	137	148	59	144	165	151	143
10	Acetone	58		105	110	111	92	114	75	117	48	107	104
11	Methylene Chloride	84		108	116	116	96	118	89	123	118	112	99
12	Acrylonitrile	53		106	118	116	101	107	101	115	85	110	108
13	t-1,2-Dichloroethene	61		103	112	114	90	113	88	108	105	100	94
14	1,1-Dichloroethane	63		112	113	115	96	123	94	121	112	106	97
15	Methyl ethyl ketone (MEK)	72		104	111	113	88	109	89	125	69	92	115
16	Chloroform	85		105	112	110	78	112	76	113	128	121	110
17	1,1,1-Trichloroethane	97		108	115	115	86	126	72	128	132	133	120
18	Carbon Tetrachloride	117		110	117	113	83	128	79	123	132	133	120
19	Benzene	78		107	112	112	88	115	110	119	117	113	106
20	1,2-Dichloroethane	62		108	115	110	72	127	87	119	138	128	122
21	Trichloroethene	95		99	104	103	103	107	102	112	110	105	97
22	1,2-Dichloropropane	63		102	108	107	109	108	108	114	105	105	99
23	p-Dioxane	88		49	55	105	23	50	4	52	0	58	0
24	Bromodichloromethane	83		101	107	106	106	114	105	113	116	111	104
25	Toluene	92		106	111	109	111	115	120	114	105	110	104
26	t-1,3-Dichloropropene	75		102	107	104	109	116	111	116	104	114	108
27	1,1,2-Trichloroethane	83		102	108	106	108	109	108	108	93	102	95
28	Tetrachloroethene (PERC)	164		102	110	107	108	111	108	105	102	107	98
29	Dibromochloromethane	129		102	110	106	107	109	109	104	96	110	105
30	Chlorobenzene (MCB)	112		107	115	111	115	112	114	108	88	112	112
31	Ethylbenzene	106		106	110	109	111	114	112	116	77	110	105
32	Bromoform	173		103	113	107	110	113	116	112	71	114	109
33	1,1,2,2-Tetrachloroethane	83		108	114	113	116	108	119	108	58	108	0
34	Benzene (m/z 51)	51		80	82	80	54	83	59	83	85	84	82
35	Benzene (m/z 79)	79		120	109	114	160	179	223	119	170	184	144
36	Toluene (m/z 65)	65		108	113	112	111	117	124	120	104	108	106

a. Actual amt. = 5x nominal amt.
b. VER = Daily initial verification std.
FIN = Daily final std.
BLK = Blank

Standards Analysis Summary - Hannibal 8912-3115

				Percent Recovery (%) [a]									
		Quan Ion (m/z)	Filename	G03YQ2	G03YQ7	G05YQ9	G06YQ2	G06YQ6	G10YQ2	G10YQ4	G11YQ2	G11YQ6	G12YQ2
			Amt. (ng)	200	200	100	200	200	100	100	100	100	100
No.	Compound		Type [b]	VER	FIN	FIN	VER	FIN	VER	FIN	VER	FIN	VER
1	d6-Benzene (Alt. I.S.)	84		104	103	100	103	100	102	102	102	100	102
2	1,4-Difluorobenzene (I.S.)	114		100	100	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. I.S.)	65		97	96	95	97	98	97	101	98	98	96
4	d8-Toluene (Surr.)	98		100	102	100	103	103	99	101	99	101	99
5	Bromofluorobenzene (Surr.)	174		100	100	0	0	106	96	99	97	98	93
6	d5-Chlorobenzene (Surr.)	117		100	102	104	105	106	101	103	103	104	101
7	Diethyl ether	74		21	20	91	117	98	120	116	117	85	112
8	Acrolein	56		107	41	78	111	90	101	99	99	78	89
9	1,1-Dichloroethene	61		107	98	101	116	108	125	122	117	98	116
10	Acetone	58		109	79	81	98	83	105	108	98	87	94
11	Methylene Chloride	84		122	97	82	108	89	109	108	105	85	99
12	Acrylonitrile	53		127	83	83	102	88	97	105	97	86	92
13	t-1,2-Dichloroethene	61		126	99	90	116	96	121	121	116	95	110
14	1,1-Dichloroethane	63		120	116	87	110	92	115	116	112	89	107
15	Methyl ethyl ketone (MEK)	72		101	78	79	100	84	104	104	101	83	94
16	Chloroform	85		102	99	88	99	96	100	100	99	84	92
17	1,1,1-Trichloroethane	97		101	96	103	109	111	109	108	106	104	100
18	Carbon Tetrachloride	117		103	101	101	108	110	106	108	106	103	96
19	Benzene	78		104	102	128	100	132	102	104	100	114	94
20	1,2-Dichloroethane	62		101	98	98	97	103	101	102	98	100	93
21	Trichloroethene	95		100	98	97	96	101	100	100	98	99	92
22	1,2-Dichloropropane	63		100	98	96	96	101	99	101	98	100	91
23	p-Dioxane	88		477	196	30	65	4	51	65	93	59	53
24	Bromodichloromethane	83		99	97	95	100	101	98	100	97	96	91
25	Toluene	92		103	101	107	100	109	104	103	101	112	95
26	t-1,3-Dichloropropene	75		98	96	97	100	104	96	97	95	95	86
27	1,1,2-Trichloroethane	83		100	98	99	100	105	101	102	99	100	91
28	Tetrachloroethene (PERC)	164		105	101	98	100	103	102	100	99	99	91
29	Dibromochloromethane	129		100	97	94	98	104	96	97	96	95	86
30	Chlorobenzene (MCB)	112		105	102	103	103	108	104	103	103	103	94
31	Ethylbenzene	106		102	100	101	100	107	98	100	98	100	90
32	Bromoform	173		101	97	94	99	107	91	96	91	90	80
33	1,1,2,2-Tetrachloroethane	83		106	102	0	0	111	98	102	100	100	89
34	Benzene (m/z 51)	51		78	77	110	66	73	105	108	106	108	103
35	Benzene (m/z 79)	79		87	86	162	100	162	99	103	99	195	91
36	Toluene (m/z 65)	65		103	101	107	99	107	105	106	102	114	98

a. Actual amt. = 5x nominal amt.
b. VER = Daily initial verification std.
FIN = Daily final std.
BLK = Blank

Standards Analysis Summary - Hannibal 8912-3115

No.	Compound	Quan Ion (m/z)		Percent Recovery (%)[a]					Avg Recovery %
			Filename	G12YQ5	G13YQ2	G13YQ8	G16YQ2	G16YQ5	
			Amt. (ng)	100	100	100	200	200	
			Type[b]	FIN	VER	FIN	VER	FIN	
1	d6-Benzene (Alt. I.S.)	84		106	102	107	97	98	102
2	1,4-Difluorobenzene (I.S.)	114		100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. I.S.)	65		96	97	95	101	103	97
4	d8-Toluene (Surr.)	98		115	99	93	99	100	101
5	Bromofluorobenzene (Surr.)	174		125	92	135	101	100	93
6	d5-Chlorobenzene (Surr.)	117		122	100	126	103	102	103
7	Diethyl ether	74		125	127	103	21	22	98
8	Acrolein	56		86	105	75	73	65	85
9	1,1-Dichloroethene	61		134	131	113	101	108	122
10	Acetone	58		83	109	70	116	97	98
11	Methylene Chloride	84		115	116	104	109	103	106
12	Acrylonitrile	53		105	102	105	119	92	102
13	t-1,2-Dichloroethene	61		121	125	118	120	108	108
14	1,1-Dichloroethane	63		117	121	116	117	109	109
15	Methyl ethyl ketone (MEK)	72		101	105	101	99	85	97
16	Chloroform	85		99	104	96	103	105	101
17	1,1,1-Trichloroethane	97		111	113	102	103	105	109
18	Carbon Tetrachloride	117		106	111	104	102	105	108
19	Benzene	78		120	106	144	101	105	114
20	1,2-Dichloroethane	62		97	104	95	104	106	105
21	Trichloroethene	95		108	103	91	100	102	101
22	1,2-Dichloropropane	63		108	105	85	97	100	102
23	p-Dioxane	88		1	49	0	921	465	244
24	Bromodichloromethane	83		107	104	79	103	103	102
25	Toluene	92		124	108	110	102	105	106
26	t-1,3-Dichloropropene	75		109	98	107	101	102	103
27	1,1,2-Trichloroethane	83		115	106	115	100	101	103
28	Tetrachloroethene (PERC)	164		119	106	119	103	104	104
29	Dibromochloromethane	129		109	99	109	103	102	102
30	Chlorobenzene (MCB)	112		124	107	127	104	106	108
31	Ethylbenzene	106		120	102	127	99	103	105
32	Bromoform	173		102	94	115	105	101	101
33	1,1,2,2-Tetrachloroethane	83		131	101	135	104	102	93
34	Benzene (m/z 51)	51		108	107	113	75	77	91
35	Benzene (m/z 79)	79		143	103	188	86	84	135
36	Toluene (m/z 65)	65		117	110	100	100	106	107

a. *Actual amt. = 5x nominal amt.*

b. VER = Daily initial verification std.
FIN = Daily final std.
BLK = Blank

VOST Sample Analysis Summary - Hannibal 8912-3115

RUN 1 (total ng) [a]

No.	Compound	Quan Ion (m/z)	Pair 2		Pair 3		Pair 4		Field Blank		Trip Blank	
			Tenax 1082	T/C 1083	Tenax 1084	T/C 1085	Tenax 1086	T/C 1087	Tenax 1090	T/C 1091	Tenax 1092	T/C 1093
1	d6-Benzene (Alt. IS)	84	52	103	46	100	53	98	106	107	105	104
2	1,4-Difluorobenzene (IS)	114	100	100	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. IS	65	36	106	34	110	34	95	106	106	103	104
4	d8-Toluene (Surr.)	98	103	106	99	104	106	102	105	104	102	105
5	Bromofluorobenzene (Surr.)	174	99	111	101	111	102	98	113	108	94	108
6	d5-Chlorobenzene (Surr.)	117	97	112	95	110	97	103	110	108	104	111
7	Diethyl ether	74	0	0	0	0	0	0	0	0	0	0
8	Acrolein	56	1595	536	621	510	469	773	0	0	0	0
9	1,1-Dichloroethene	61	0	0	0	0	0	0	0	0	0	0
10	Acetone (b)	58	1378	442	1556	391	1545	593	55	0	22	0
11	Methylene Chloride	84	41	61	1799	26	45	25	27	0	3	0
12	Acrylonitrile (b)	53	2417	449	1843	294	2048	419	0	0	0	0
13	t-1,2-Dichloroethene	61	0	0	1	0	0	0	0	0	0	0
14	1,1-Dichloroethane	63	0	0	6	0	0	0	0	0	0	0
15	Methyl ethyl ketone (MEK)	72	644	29	0	25	456	46	15	10	7	10
16	Chloroform	85	72	0	75	0	62	41	0	0	0	0
17	1,1,1-Trichloroethane	97	118	19	74	2	5	0	0	0	0	0
18	Carbon Tetrachloride	117	5	0	8	0	0	0	0	0	0	0
19	Benzene (b)	78	3859	188	4982	103	4832	140	80	40	22	10
20	1,2-Dichloroethane	62	0	4	90	0	0	4	0	0	0	1
21	Trichloroethene	95	14	0	71	0	13	1	0	0	0	0
22	1,2-Dichloropropane	63	0	0	11	0	0	1	0	0	0	0
23	p-dioxane	88	32	91	233	36	131	220	70	22	0	54
24	Bromodichloromethane	83	43	9	38	0	40	12	0	0	0	0
25	Toluene (b)	92	1423	58	1552	13	1345	9	36	4	13	7
26	t-1,3-Dichloropropene	75	2	0	5	0	0	0	0	0	0	0
27	1,1,2-Trichloroethane	83	96	3	0	0	0	0	0	0	0	0
28	Tetrachloroethene (PERC)	164	3	0	46	0	2	0	0	0	0	0
29	Dibromochloromethane	129	10	0	7	0	0	0	0	0	0	0
30	Chlorobenzene (MCB)	112	300	0	317	0	309	3	0	0	0	0
31	*Ethylbenzene (b)*	106	262	4	230	2	215	2	0	0	0	0
32	Bromoform	173	7	0	5	0	5	13	0	0	0	0
33	1,1,2,2-Tetrachloroethane	83	144	0	127	0	0	15	0	0	0	0

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a. Amounts calculated using 1,4-Difluorobenzene as internal standard.
Values for surrogates and alternate internal standards are percent recoveries.

b. *Alternate quantitation ion may have been used in determining amount.*
Acetone: 0-2000 ng = m/z 58 ; >2000 ng = m/z 42
Acrylonitrile: 0-2000 ng = m/z 53; >2000 ng = m/z 51
Benzene: 0-1000 = m/z 78; 1000-2200 ng = m/z 79; > 2200 ng = m/z 74
Toluene: 0-1000 ng = m/z 92; 1000-2000 ng = m/z 65; >2000 ng = m/z 90
Ethylbenzene: 0-1000 = m/z 106; >1000 ng = m/z 92

VOST Sample Analysis Summary - Hannibal 8912-3115

RUN 2 (total ng) a/

No.	Compound	Quan Ion (m/z)	Pair 1 Tenax 2080	T/C 2081	Pair 2 Tenax 2082	T/C 2083	Pair 3 Tenax 2084	T/C 2085	Field Blank Tenax 2090	T/C 2091
1	d6-Benzene (Alt. IS)	84	125	103	0	101	0	104	104	103
2	1,4-Difluorobenzene (IS)	114	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. IS	65	10	97	12	105	8	108	115	113
4	d8-Toluene (Surr.)	98	95	103	88	104	92	106	105	104
5	Bromofluorobenzene (Surr.)	174	98	108	100	110	87	111	89	105
6	d5-Chlorobenzene (Surr.)	117	96	105	97	108	90	110	105	108
7	Diethyl ether	74	0	0	0	0	0	0	0	0
8	Acrolein	56	0	1621	0	772	0	4164	0	0
9	1,1-Dichloroethene	61	21	0	26	0	17	0	0	0
10	Acetone (b)	58	3216	887	3306	1053	3225	2079	28	5
11	Methylene Chloride	84	208	105	466	10	6306	51	39	0
12	Acrylonitrile (b)	53	2791	842	2204	1407	2777	1198	0	0
13	t-1,2-Dichloroethene	61	0	0	2	0	1	0	0	0
14	1,1-Dichloroethane	63	0	0	42	0	29	0	0	0
15	Methyl ethyl ketone (MEK)	72	858	479	834	0	748	0	0	6
16	Chloroform	85	61	0	38	0	41	0	0	0
17	1,1,1-Trichloroethane	97	134	257	0	0	0	0	0	0
18	Carbon Tetrachloride	117	0	46	0	0	18	0	0	0
19	Benzene (b)	78	14756	166	18572	70	14900	81	28	13
20	1,2-Dichloroethane	62	0	5	429	0	0	0	0	0
21	Trichloroethene	95	18	0	23	0	22	0	0	0
22	1,2-Dichloropropane	63	26	1	33	0	22	0	0	0
23	p-dioxane	88	0	0	0	0	0	0	2	115
24	Bromodichloromethane	83	0	10	37	9	0	12	0	0
25	Toluene (b)	92	4471	77	6186	7	4901	5	4	1
26	t-1,3-Dichloropropene	75	47	0	64	0	45	0	0	0
27	1,1,2-Trichloroethane	83	204	15	191	25	193	12	0	0
28	Tetrachloroethene (PERC)	164	5	0	3	0	10	0	0	0
29	Dibromochloromethane	129	4	0	4	0	3	0	0	0
30	Chlorobenzene (MCB)	112	392	2	509	0	455	0	0	0
31	Ethylbenzene (b)	106	1413	5	1682	0	1414	0	0	0
32	Bromoform	173	2	0	1	0	1	0	0	0
33	1,1,2,2-Tetrachloroethane	83	159	0	166	0	160	0	0	0

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a. Amounts calculated using 1,4-Difluoro
Values for surrogates and alternate ir

b. Alternate quantitation ion may have be
Acetone: 0-2000 ng = m/z 58 ; >2000
Acrylonitrile: 0-2000 ng = m/z 53; :
Benzene: 0-1000 = m/z 78; 1000-22
Toluene: 0-1000 ng = m/z 92; 1000
Ethylbenzene: 0-1000 = m/z 106; >

see footnote a 1st page of table

VOST Sample Analysis Summary - Hannibal 8912-3115

RUN 3 (total ng) a/

No.	Compound	Quan Ion (m/z)	Pair 1 Tenax 3080	Pair 1 T/C 3081	Pair 2 Tenax 3082	Pair 2 T/C 3083	Pair 3 Tenax 3084	Pair 3 T/C 3085	Field Blank Tenax 3090	Field Blank T/C 3091
1	d6-Benzene (Alt. IS)	84	0	105	0	103	0	101	101	109
2	1,4-Difluorobenzene (IS)	114	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. IS	65	16	102	18	97	40	96	121	124
4	d8-Toluene (Surr.)	98	100	99	100	103	80	102	102	106
5	Bromofluorobenzene (Surr.)	174	95	101	89	102	0	104	110	99
6	d5-Chlorobenzene (Surr.)	117	96	102	92	105	133	106	107	111
7	Diethyl ether	74	0	0	0	0	0	0	0	0
8	Acrolein	56	0	0	0	962	0	1532	0	0
9	1,1-Dichloroethene	61	0	0	17	0	0	0	0	0
10	Acetone (b)	58	6340	0	4770	890	0	1707	68	4
11	Methylene Chloride	84	173	0	123	32	0	18	0	0
12	Acrylonitrile (b)	53	6570	432	5726	422	1924	737	0	3
13	t-1,2-Dichloroethene	61	0	3	0	0	0	0	0	0
14	1,1-Dichloroethane	63	0	0	0	0	0	0	0	0
15	Methyl ethyl ketone (MEK)	72	1562	0	1485	0	1447	0	0	0
16	Chloroform	85	17	0	32	0	25	0	0	0
17	1,1,1-Trichloroethane	97	0	57	0	3	0	0	0	0
18	Carbon Tetrachloride	117	0	0	0	0	0	0	0	0
19	Benzene (b)	78	29586	39	26088	53	24163	45	19	9
20	1,2-Dichloroethane	62	595	0	0	0	476	0	0	0
21	Trichloroethene	95	25	0	20	2	14	0	0	0
22	1,2-Dichloropropane	63	32	0	25	2	0	0	0	0
23	p-dioxane	88	0	0	0	0	0	0	0	0
24	Bromodichloromethane	83	31	0	29	8	0	0	0	0
25	Toluene (b)	92	10828	32	7814	25	7207	8	1	1
26	t-1,3-Dichloropropene	75	40	1	100	1	24	0	0	0
27	1,1,2-Trichloroethane	83	197	3	0	8	24	0	0	0
28	Tetrachloroethene (PERC)	164	42	0	40	2	46	0	0	0
29	Dibromochloromethane	129	3	0	4	4	5	0	0	0
30	Chlorobenzene (MCB)	112	635	0	529	6	604	0	0	0
31	Ethylbenzene (b)	106	2233	1	1499	5	1755	0	0	0
32	Bromoform	173	2	0	2	11	0	0	0	0
33	1,1,2,2-Tetrachloroethane	83	165	0	158	27	0	0	0	0

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a. Amounts calculated using 1,4-Difluoro
Values for surrogates and alternate ir

b. Alternate quantitation ion may have be
Acetone: 0-2000 ng = m/z 58 ; >2000
Acrylonitrile: 0-2000 ng = m/z 53; :
Benzene: 0-1000 = m/z 78; 1000-22
Toluene: 0-1000 ng = m/z 92; 1000
Ethylbenzene: 0-1000 = m/z 106; >

VOST Sample Analysis Summary - Hannibal 8912-3115

RUN 4 (total ng) a/

No.	Compound	Quan Ion (m/z)	Pair 1 Tenax 4080	Pair 1 T/C 4081	Pair 2 Tenax 4082	Pair 2 T/C 4083	Pair 3 Tenax 4084	Pair 3 T/C 4085	Field Blank Tenax 4090	Field Blank T/C 4091	Trip Blank Tenax 4092	Trip Blank T/C 4093
1	d6-Benzene (Alt. IS)	84	0	99	0	97	0	98	102	102	102	103
2	1,4-Difluorobenzene (IS)	114	100	100	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. IS	65	17	96	32	96	12	97	96	96	97	96
4	d8-Toluene (Surr.)	98	101	100	101	101	100	101	101	100	100	101
5	Bromofluorobenzene (Surr.)	174	89	103	96	102	99	98	98	98	99	91
6	d5-Chlorobenzene (Surr.)	117	94	104	97	105	98	103	103	102	103	103
7	Diethyl ether	74	0	0	0	0	0	0	0	0	0	0
8	Acrolein	56	0	869	0	1190	0	1686	0	0	0	0
9	1,1-Dichloroethene	61	0	0	0	1	3	0	0	0	0	0
10	Acetone (b)	58	3348	201	3211	266	3218	752	55	0	49	0
11	Methylene Chloride	84	77	17	74	14	86	25	9	0	17	0
12	Acrylonitrile (b)	53	5600	570	4952	551	5442	592	0	0	0	0
13	t-1,2-Dichloroethene	61	3	0	3	0	2	0	0	0	0	0
14	1,1-Dichloroethane	63	20	0	16	0	20	0	0	0	0	0
15	Methyl ethyl ketone (MEK)	72	1056	0	985	0	985	0	9	0	0	8
16	Chloroform	85	52	0	64	0	60	0	0	0	0	0
17	1,1,1-Trichloroethane	97	8	12	0	0	0	0	0	0	0	0
18	Carbon Tetrachloride	117	0	0	0	0	0	0	0	0	0	0
19	Benzene (b)	78	13694	55	11757	48	14267	180	35	0	37	12
20	1,2-Dichloroethane	62	0	0	0	0	0	0	0	1	0	1
21	Trichloroethene	95	17	0	15	0	14	0	0	0	0	0
22	1,2-Dichloropropane	63	17	0	15	0	16	0	0	0	0	0
23	p-dioxane	88	16	0	0	0	0	0	2	105	5	11
24	Bromodichloromethane	83	28	4	25	6	0	5	0	0	0	0
25	Toluene (b)	92	5008	18	2902	6	4905	8	6	4	6	4
26	t-1,3-Dichloropropene	75	63	0	55	0	63	0	0	0	0	0
27	1,1,2-Trichloroethane	83	0	0	0	0	0	0	0	0	0	0
28	Tetrachloroethene (PERC)	164	23	0	22	0	21	1	0	0	0	0
29	Dibromochloromethane	129	1	0	0	0	0	0	0	0	0	0
30	Chlorobenzene (MCB)	112	427	0	368	0	401	0	0	0	0	0
31	Ethylbenzene (b)	106	756	2	591	0	781	2	0	0	0	0
32	Bromoform	173	0	0	0	0	0	0	0	0	0	0
33	1,1,2,2-Tetrachloroethane	83	138	0	128	0	126	0	0	0	0	0

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a. Amounts calculated using 1,4-Difluoro
Values for surrogates and alternate ir

b. Alternate quantitation ion may have be
Acetone: 0-2000 ng = m/z 58 ; >2000
Acrylonitrile: 0-2000 ng = m/z 53; :
Benzene: 0-1000 = m/z 78; 1000-22
Toluene: 0-1000 ng = m/z 92; 1000
Ethylbenzene: 0-1000 = m/z 106; >

VOST Sample Analysis Summary - Hannibal 8912-3115

			RUN 5 (total ng) a/					
No.	Compound	Quan Ion (m/z)	Pair 2 Tenax 5082	T/C 5083	Pair 3 Tenax 5084	T/C 5085	Pair 4 Tenax 5086	T/C 5087
1	d6-Benzene (Alt. IS)	84	0	102	0	102	0	101
2	1,4-Difluorobenzene (IS)	114	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. IS	65	15	96	9	96	14	96
4	d8-Toluene (Surr.)	98	95	102	95	101	92	101
5	Bromofluorobenzene (Surr.)	174	97	103	85	103	90	103
6	d5-Chlorobenzene (Surr.)	117	99	106	92	104	92	105
7	Diethyl ether	74	0	0	0	0	0	0
8	Acrolein	56	0	6818	0	5832	0	7326
9	1,1-Dichloroethene	61	0	0	0	0	0	2
10	Acetone (b)	58	6274	1552	4341	2526	6370	4601
11	Methylene Chloride	84	132	106	0	53	0	71
12	Acrylonitrile (b)	53	363	1022	2848	1096	3370	1393
13	t-1,2-Dichloroethene	61	0	0	3	0	0	0
14	1,1-Dichloroethane	63	0	0	28	0	0	0
15	Methyl ethyl ketone (MEK)	72	0	0	1535	0	2021	0
16	Chloroform	85	80	0	106	0	199	0
17	1,1,1-Trichloroethane	97	0	0	0	0	0	0
18	Carbon Tetrachloride	117	0	0	0	0	0	0
19	Benzene (b)	78	21477	38	15750	52	19729	52
20	1,2-Dichloroethane	62	0	2	0	0	0	0
21	*Trichloroethene*	95	30	0	26	0	41	0
22	1,2-Dichloropropane	63	24	0	18	0	24	1
23	p-dioxane	88	0	0	0	213	0	0
24	Bromodichloromethane	83	0	7	85	7	0	7
25	Toluene (b)	92	10355	23	6959	6	8049	7
26	t-1,3-Dichloropropene	75	128	0	87	0	99	0
27	1,1,2-Trichloroethane	83	0	7	0	16	14	19
28	Tetrachloroethene (PERC)	164	3	0	3	0	5	0
29	Dibromochloromethane	129	0	0	0	0	1	0
30	Chlorobenzene (MCB)	112	301	0	266	0	303	0
31	Ethylbenzene (b)	106	2096	2	1464	0	1774	0
32	Bromoform	173	0	0	0	0	0	0
33	1,1,2,2-Tetrachloroethane	83	125	0	119	1	127	0

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a. *Amounts calculated using 1,4-Difluoro*
Values for surrogates and alternate ir

b. Alternate quantitation ion may have be
Acetone: 0-2000 ng = m/z 58 ; >2000
Acrylonitrile: 0-2000 ng = m/z 53; :
Benzene: 0-1000 = m/z 78; 1000-22
Toluene: 0-1000 ng = m/z 92; 1000
Ethylbenzene: 0-1000 = m/z 106; >

VOST Sample Analysis Summary - Hannibal 8912-3115

RUN 5, cont. (total ng) a/

No.	Compound	Quan Ion (m/z)	Field Blank Tenax 5090	Field Blank T/C 5091	Trip Blank Tenax 5092	Trip Blank T/C 5093	Pr3 Field Blk Tenax 5094	Pr3 Field Blk T/C 5095	Pr4 Field Blk Tenax 5096	Pr4 Field Blk T/C 5097
1	d6-Benzene (Alt. IS)	84	103	103	101	103	103	102	103	104
2	1,4-Difluorobenzene (IS)	114	100	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. IS	65	98	99	97	98	98	99	99	99
4	d8-Toluene (Surr.)	98	101	100	98	99	100	101	100	100
5	Bromofluorobenzene (Surr.)	174	94	100	100	99	97	95	98	101
6	d5-Chlorobenzene (Surr.)	117	103	104	103	102	103	103	103	104
7	Diethyl ether	74	0	0	0	0	0	0	0	0
8	Acrolein	56	0	0	0	0	0	0	0	0
9	1,1-Dichloroethene	61	0	0	0	0	0	0	0	0
10	Acetone (b)	58	26	0	16	0	18	0	31	0
11	Methylene Chloride	84	8	3	6	0	0	0	41	0
12	Acrylonitrile (b)	53	0	0	0	0	0	0	0	0
13	t-1,2-Dichloroethene	61	0	0	0	0	0	0	0	0
14	1,1-Dichloroethane	63	0	0	0	0	0	0	0	0
15	Methyl ethyl ketone (MEK)	72	10	0	11	0	0	0	0	10
16	Chloroform	85	0	0	0	0	0	0	0	0
17	1,1,1-Trichloroethane	97	0	0	0	0	0	0	0	0
18	Carbon Tetrachloride	117	0	0	0	0	0	0	0	0
19	Benzene (b)	78	31	26	20	8	19	16	47	17
20	1,2-Dichloroethane	62	0	0	0	0	0	0	2	0
21	Trichloroethene	95	0	0	0	0	0	0	0	0
22	1,2-Dichloropropane	63	0	0	0	0	0	0	0	0
23	p-dioxane	88	5	0	35	14	0	11	0	33
24	Bromodichloromethane	83	0	0	0	0	0	0	0	0
25	Toluene (b)	92	5	6	4	3	4	4	8	3
26	t-1,3-Dichloropropene	75	0	0	0	0	0	0	0	0
27	1,1,2-Trichloroethane	83	0	0	0	0	0	0	0	0
28	Tetrachloroethene (PERC)	164	0	0	0	0	0	0	0	0
29	Dibromochloromethane	129	0	0	0	0	0	0	0	0
30	Chlorobenzene (MCB)	112	0	0	0	0	0	0	0	0
31	Ethylbenzene (b)	106	0	0	0	0	0	0	0	0
32	Bromoform	173	0	0	0	0	0	0	0	0
33	1,1,2,2-Tetrachloroethane	83	0	0	0	0	0	0	0	0

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a. Amounts calculated using 1,4-Difluoro
Values for surrogates and alternate ir
b. Alternate quantitation ion may have be
Acetone: 0-2000 ng = m/z 58 ; >2000
Acrylonitrile: 0-2000 ng = m/z 53; :
Benzene: 0-1000 = m/z 78; 1000-22
Toluene: 0-1000 ng = m/z 92; 1000
Ethylbenzene: 0-1000 = m/z 106; >

VOST Sample Analysis Summary - Hannibal 8912-3115

			RUN 6 (total ng) a/								Surrogate Recovery	
		Quan	Pair 1		Pair 2		Pair 3		Field Blank			
		Ion	Tenax	T/C	Tenax	T/C	Tenax	T/C	Tenax	T/C	Avg	RSD
No.	Compound	(m/z)	6080	6081	6082	6083	6084	6085	6090	6091	(ng)	(%)
1	d6-Benzene (Alt. IS)	84	0	102	0	102	0	102	104	103	75	59
2	1,4-Difluorobenzene (IS)	114	100	100	100	100	100	100	100	100	100	0
3	d4-1,2-Dichloroethane (Alt. IS	65	14	96	13	97	21	93	98	98	76	51
4	d8-Toluene (Surr.)	98	97	101	102	101	98	101	100	101	100	4
5	Bromofluorobenzene (Surr.)	174	100	99	95	94	93	100	100	102	98	15
6	d5-Chlorobenzene (Surr.)	117	98	103	97	100	95	105	102	105	103	6
7	Diethyl ether	74	0	0	0	0	0	0	0	0		
8	Acrolein	56	0	3967	0	5936	0	4928	0	0		
9	1,1-Dichloroethene	61	0	0	0	0	0	0	0	0		
10	Acetone (b)	58	6793	954	6702	0	5108	2107	43	4		
11	Methylene Chloride	84	0	33	0	36	0	39	21	4		
12	Acrylonitrile (b)	53	4102	454	4009	809	4043	678	0	0		
13	t-1,2-Dichloroethene	61	0	0	0	0	0	0	0	0		
14	1,1-Dichloroethane	63	41	0	30	0	0	0	0	0		
15	Methyl ethyl ketone (MEK)	72	1588	0	1526	0	1559	0	0	0		
16	Chloroform	85	98	0	83	0	99	0	0	0		
17	1,1,1-Trichloroethane	97	0	0	0	0	0	0	0	0		
18	Carbon Tetrachloride	117	0	0	0	0	0	0	0	0		
19	Benzene (b)	78	19649	56	18711	40	17619	42	90	30		
20	1,2-Dichloroethane	62	0	0	0	0	0	2	0	0		
21	Trichloroethene	95	26	0	31	0	27	0	0	0		
22	1,2-Dichloropropane	63	23	0	25	0	23	0	0	0		
23	p-dioxane	88	0	0	0	0	0	0	27	5		
24	Bromodichloromethane	83	0	6	0	6	0	4	0	0		
25	Toluene (b)	92	9012	9	8189	5	7912	5	7	5		
26	t-1,3-Dichloropropene	75	117	0	103	0	97	0	0	0		
27	1,1,2-Trichloroethane	83	0	1	141	4	0	5	0	0		
28	Tetrachloroethene (PERC)	164	3	0	2	0	2	0	0	0		
29	Dibromochloromethane	129	0	0	0	0	0	0	0	0		
30	Chlorobenzene (MCB)	112	305	0	278	0	272	0	0	0		
31	Ethylbenzene (b)	106	1930	1	1760	0	1676	0	0	0		
32	Bromoform	173	0	0	0	0	0	0	0	0		
33	1,1,2,2-Tetrachloroethane	83	132	0	126	0	118	0	0	0		

a. Amounts calculated using 1,4-Difluoro
Values for surrogates and alternate ir

b. Alternate quantitation ion may have be
Acetone: 0-2000 ng = m/z 58 ; >2000
Acrylonitrile: 0-2000 ng = m/z 53; :
Benzene: 0-1000 = m/z 78; 1000-22
Toluene: 0-1000 ng = m/z 92; 1000
Ethylbenzene: 0-1000 = m/z 106; >

VOST Condensate Sample Analysis Summary - Hannibal 8912-3115

No.	Compound	Quan Ion (m/z)	Amount (µg/L H_2O)[a]						
			G03Y1 1037	G03Y2 2037	G03Y3 3037	G03Y4 3055	G03Y5 4037	G16Y1 5037	G16Y2 6037
1	d6-Benzene (Alt. I.S.)	84	102	104	102	103	103	99	100
2	1,4-Difluorobenzene (I.S.)	114	100	100	100	100	100	100	100
3	d4-1,2-Dichloroethane (Alt. I.S.)	65	95	95	96	94	94	99	99
4	d8-Toluene (Surr.)	98	101	101	100	101	101	98	99
5	Bromofluorobenzene (Surr.)	174	98	99	98	100	100	99	100
6	d5-Chlorobenzene (Surr.)	117	103	102	102	103	103	103	103
7	Diethyl ether	74	0	0	0	0	0	0	0
8	Acrolein	56	0	23	45	0	0	30	117
9	1,1-Dichloroethene	61	0	0	0	0	0	0	0
10	Acetone	58	158	356	634	238	233	500	671
11	Methylene Chloride	84	0	97	1	289	2	1	0
12	Acrylonitrile	53	0	5	12	23	0	7	17
13	t-1,2-Dichloroethene	61	0	0	0	0	0	0	0
14	1,1-Dichloroethane	63	0	0	0	0	0	0	0
15	Methyl ethyl ketone (MEK)	72	0	0	0	0	0	0	0
16	Chloroform	85	0	0	0	0	0	0	0
17	1,1,1-Trichloroethane	97	62	0	0	0	0	0	0
18	Carbon Tetrachloride	117	11	0	0	0	0	0	0
19	Benzene	78	0	0	0	2	0	0	0
20	1,2-Dichloroethane	62	0	0	0	0	0	0	0
21	Trichloroethene	95	0	0	0	0	0	0	0
22	1,2-Dichloropropane	63	0	0	0	0	0	0	0
23	p-dioxane	88	0	0	0	0	0	0	0
24	Bromodichloromethane	83	0	0	0	0	0	0	0
25	Toluene	92	168	2	0	11	0	0	0
26	t-1,3-Dichloropropene	75	0	0	0	0	0	0	0
27	1,1,2-Trichloroethane	83	0	0	0	0	0	0	0
28	Tetrachloroethene (PERC)	164	0	0	0	0	0	0	0
29	Dibromochloromethane	129	0	0	0	0	0	0	0
30	Chlorobenzene (MCB)	112	0	0	0	0	0	0	0
31	Ethylbenzene	106	0	0	0	0	0	0	0
32	Bromoform	173	0	0	0	0	0	0	0
33	1,1,2,2-Tetrachloroethane	83	0	0	0	0	0	0	0

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a. Amounts calculated using 1,4-Difluorobenzene as internal standard.
Values for surrogates and alternate internal standards are percent recoveries.

VOST ANALYSIS RESULTS - RUN 1

	Pair No. 1		Pair No. 2		Pair No. 3		Field Blank		Trip Blank		Avg. Conc. (ng/L or ug/dscm)	Analyte Emission (mg/min)
	T (ng) 1082	T/C (ng) 1083	T (ng) 1084	T/C (ng) 1085	T (ng) 1086	T/C (ng) 1087	T (ng) 1090	T/C (ng) 1091	T (ng) 1092	T/C (ng) 1093		
Gas Sample Volume (L) =		9.13		9.19		9.50						
Diethyl ether												
Acrolein	1595	536	621	510	469	773					161.92	438.80
1,1-Dichloroethene												
Acetone (b)	1378	442	1556	391	1545	593	55		22		212.23	575.15
Methylene Chloride	41	61	1799	26	45	25	27		3		71.74	194.41
Acrylonitrile (b)	2417	449	1843	294	2048	419					268.47	727.56
t-1,2-Dichloroethene			1								0.04	0.11
1,1-Dichloroethane			6								0.22	0.60
Methyl ethyl ketone (MEK)	644	29		25	456	46	15	10	7	10	43.11	116.83
Chloroform	72		75		62	41					8.97	24.30
1,1,1-Trichloroethane	118	19	74	2	5						7.80	21.13
Carbon Tetrachloride	5		8								0.49	1.32
Benzene (b)	3859	188	4982	103	4832	140	80	40	22	10	506.98	1373.92
1,2-Dichloroethane		4	90			4				1	3.52	9.53
Trichloroethene	14		71		13	1					3.56	9.65
1,2-Dichloropropane			11			1					0.46	1.24
p-dioxane	32	91	233	36	131	220	70	22		54	26.71	72.39
Bromodichloromethane	43	9	38		40	12					5.10	13.81
Toluene (b)	1423	58	1552	13	1345	9	36	4	13	7	158.16	428.62
t-1,3-Dichloropropene	2		5								0.26	0.69
1,1,2-Trichloroethane	96	3									3.53	9.56
Tetrachloroethene (PERC)	3		46		2						1.82	4.92
Dibromochloromethane	10		7								0.63	1.70
Chlorobenzene (MCB)	300		317		309	3					33.39	90.48
Ethylbenzene (b)	262	4	230	2	215	2					25.70	69.64
Bromoform	7		5		5	13					1.08	2.92
1,1,2,2-Tetrachloroethane	144		127			15					10.26	27.81

File: VOST2 By: PSM Date: 10\22\90

VOST ANALYSIS RESULTS - RUN 2

	Pair No. 1		Pair No. 2		Pair No. 3		Field Blank		Avg. Conc. (ng/L or ug/dscm)	Analyte Emission (mg/min)
	T (ng) 2080	T/C (ng) 2081	T (ng) 2082	T/C (ng) 2083	T (ng) 2084	T/C (ng) 2085	T (ng) 2090	T/C (ng) 2091		
Gas Sample Volume (L) =		9.29		8.92		8.93				
Diethyl ether										
Acrolein		1621		772		4164			241.60	703.04
1,1-Dichloroethene	21		26		17				2.36	6.86
Acetone (b)	3216	887	3306	1053	3225	2079	28	5	507.23	1476.05
Methylene Chloride	208	105	466	10	6306	51	39		263.30	766.21
Acrylonitrile (b)	2791	842	2204	1407	2777	1198			413.39	1202.96
t-1,2-Dichloroethene			2		1				0.11	0.31
1,1-Dichloroethane			42		29				2.63	7.66
Methyl ethyl ketone (MEK)	858	479	834		748			6	107.55	312.96
Chloroform	61		38		41				5.17	15.04
1,1,1-Trichloroethane	134	257							14.40	41.91
Carbon Tetrachloride		46			18				2.34	6.80
Benzene (b)	14756	166	18572	70	14900	81	28	13	1788.68	5205.06
1,2-Dichloroethane		5	429						15.99	46.52
Trichloroethene	18		23		22				2.31	6.72
1,2-Dichloropropane	26	1	33		22				3.01	8.76
p-dioxane							2	115		
Bromodichloromethane		10	37	9		12			2.48	7.22
Toluene (b)	4471	77	6186	7	4901	5	4	1	576.53	1677.71
t-1,3-Dichloropropene	47		64		45				5.74	16.69
1,1,2-Trichloroethane	204	15	191	25	193	12			23.54	68.50
Tetrachloroethene (PERC)	5		3		10				0.67	1.95
Dibromochloromethane	4		4		3				0.42	1.22
Chlorobenzene (MCB)	392	2	509		455				50.01	145.54
Ethylbenzene (b)	1413	5	1682		1414				166.32	483.99
Bromoform	2		1		1				0.15	0.43
1,1,2,2-Tetrachloroethane	159		166		160				17.87	52.00

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VOST ANALYSIS RESULTS - RUN 3

	Pair No. 1		Pair No. 2		Pair No. 3		Field Blank		Avg. Conc. (ng/L or ug/dscm)	Analyte Emission (mg/min)
	T (ng) 3080	T/C (ng) 3081	T (ng) 3082	T/C (ng) 3083	T (ng) 3084	T/C (ng) 3085	T (ng) 3090	T/C (ng) 3091		
Gas Sample Volume (L) =		9.87		9.86		8.86				
Diethyl ether										
Acrolein				962		1532			87.24	261.72
1,1-Dichloroethene			17						0.59	1.77
Acetone (b)	6340		4770	890		1707	68	4	479.43	1438.29
Methylene Chloride	173		123	32		18			12.09	36.26
Acrylonitrile (b)	6570	432	5726	422	1924	737		3	553.01	1659.03
t-1,2-Dichloroethene		3							0.11	0.34
1,1-Dichloroethane										
Methyl ethyl ketone (MEK)	1562		1485		1447				157.16	471.47
Chloroform	17		32		25				2.59	7.76
1,1,1-Trichloroethane		57		3					2.09	6.27
Carbon Tetrachloride										
Benzene (b)	29586	39	26088	53	24163	45	19	9	2797.26	8391.79
1,2-Dichloroethane	595				476				37.47	112.42
Trichloroethene	25		20	2	14				2.11	6.34
1,2-Dichloropropane	32		25	2					2.06	6.19
p-dioxane										
Bromodichloromethane	31		29	8					2.40	7.19
Toluene (b)	10828	32	7814	25	7207	8	1	1	906.41	2719.23
t-1,3-Dichloropropene	40	1	100	1	24				5.80	17.40
1,1,2-Trichloroethane	197	3		8	24				8.09	24.26
Tetrachloroethene (PERC)	42		40	2	46				4.54	13.62
Dibromochloromethane	3		4	4	5				0.56	1.67
Chlorobenzene (MCB)	635		529	6	604				62.00	186.00
Ethylbenzene (b)	2233	1	1499	5	1755				192.12	576.35
Bromoform	2		2	11					0.50	1.51
1,1,2,2-Tetrachloroethane	165		158	27					12.24	36.71

File: VOST2 By: PSM Date: 10\22\90

VOST ANALYSIS RESULTS - RUN 4

	Pair No. 1		Pair No. 2		Pair No. 3		Field Blank		Trip Blank		Avg. Conc. (ng/L or ug/dscm)	Analyte Emission (mg/min)
	T (ng) 4080	T/C (ng) 4081	T (ng) 4082	T/C (ng) 4083	T (ng) 4084	T/C (ng) 4085	T (ng) 4090	T/C (ng) 4091	T (ng) 4092	T/C (ng) 4093		
Gas Sample Volume (L) =		9.60		9.47		9.36						
Diethyl ether												
Acrolein		869		1190		1686					131.71	459.15
1,1-Dichloroethene				1	3						0.13	0.44
Acetone (b)	3348	201	3211	266	3218	752	55		49		386.72	1348.11
Methylene Chloride	77	17	74	14	86	25	9		17		10.30	35.89
Acrylonitrile (b)	5600	570	4952	551	5442	592					622.82	2171.14
t-1,2-Dichloroethene	3		3		2						0.30	1.05
1,1-Dichloroethane	20		16		20						1.98	6.92
Methyl ethyl ketone (MEK)	1056		985		985		9			8	106.45	371.09
Chloroform	52		64		60						6.17	21.51
1,1,1-Trichloroethane	8	12									0.72	2.51
Carbon Tetrachloride												
Benzene (b)	13694	55	11757	48	14267	180	35		37	12	1406.95	4904.62
1,2-Dichloroethane								1		1		
Trichloroethene	17		15		14						1.59	5.53
1,2-Dichloropropane	17		15		16						1.69	5.90
p-dioxane	16						2	105	5	11	0.58	2.01
Bromodichloromethane	28	4	25	6		5					2.34	8.17
Toluene (b)	5008	18	2902	6	4905	8	6	4	6	4	451.89	1575.30
t-1,3-Dichloropropene	63		55		63						6.39	22.27
1,1,2-Trichloroethane												
Tetrachloroethene (PERC)	23		22		21	1					2.32	8.09
Dibromochloromethane	1										0.05	0.17
Chlorobenzene (MCB)	427		368		401						42.03	146.51
Ethylbenzene (b)	756	2	591		781	2					74.96	261.30
Bromoform												
1,1,2,2-Tetrachloroethane	138		128		126						13.77	47.99

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VOST ANALYSIS RESULTS – RUN 5

	Pair No. 2		Pair No. 3		Pair No. 4		Field Blank		Trip Blank		Avg. Conc. (ng/L or ug/dscm)	Analyte Emission (mg/min)
	T (ng) 5082	T/C (ng) 5083	T (ng) 5084	T/C (ng) 5085	T (ng) 5086	T/C (ng) 5087	T (ng) 5090	T/C (ng) 5091	T (ng) 5092	T/C (ng) 5093		
Gas Sample Volume (L) =		8.81		8.98		8.86						
Diethyl ether												
Acrolein		6818		5832		7326					749.56	2361.11
1,1-Dichloroethene						2					0.06	0.19
Acetone (b)	6274	1552	4341	2526	6370	4601	26		16		963.00	3033.46
Methylene Chloride	132	106		53		71	8	3	6		13.57	42.75
Acrylonitrile (b)	363	1022	2848	1096	3370	1393					378.68	1192.84
t-1,2-Dichloroethene			3								0.10	0.32
1,1-Dichloroethane			28								1.04	3.27
Methyl ethyl ketone (MEK)			1535		2021		10		11		133.45	420.36
Chloroform	80		106		199						14.44	45.47
1,1,1-Trichloroethane												
Carbon Tetrachloride												
Benzene (b)	21477	38	15750	52	19729	52	31	26	20	8	2142.50	6748.87
1,2-Dichloroethane		2									0.06	0.19
Trichloroethene	30		26		41						3.65	11.49
1,2-Dichloropropane	24		18		24	1					2.54	8.00
p-dioxane				213			5		35	14	7.99	25.16
Bromodichloromethane		7	85	7		7					4.01	12.62
Toluene (b)	10355	23	6959	6	8049	7	5	6	4	3	953.05	3002.11
t-1,3-Dichloropropene	128		87		99						11.80	37.19
1,1,2-Trichloroethane		7		16	14	19					2.12	6.67
Tetrachloroethene (PERC)	3		3		5						0.42	1.34
Dibromochloromethane					1						0.03	0.11
Chlorobenzene (MCB)	301		266		303						32.61	102.73
Ethylbenzene (b)	2096	2	1464		1774						200.18	630.56
Bromoform												
1,1,2,2-Tetrachloroethane	125		119	1	127						14.00	44.09

Note: Pair No. 1 was not analyzed, due to possible contamination from a concrete curing procedure occurring upwind of the sampling location.

File: VOST2 By: PSM Date: 10\22\90

VOST ANALYSIS RESULTS - RUN 6

	Pair No. 1		Pair No. 2		Pair No. 3		Field Blank		Avg. Conc. (ng/L or ug/dscm)	Analyte Emission (mg/min)
	T (ng) 6080	T/C (ng) 6081	T (ng) 6082	T/C (ng) 6083	T (ng) 6084	T/C (ng) 6085	T (ng) 6090	T/C (ng) 6091		
Gas Sample Volume (L) =		8.64		8.86		8.73				
Diethyl ether										
Acrolein		3967		5936		4928			565.42	1939.39
1,1-Dichloroethene										
Acetone (b)	6793	954	6702		5108	2107	43	4	825.95	2833.01
Methylene Chloride		33		36		39	21	4	4.09	14.04
Acrylonitrile (b)	4102	454	4009	809	4043	678			537.33	1843.03
t-1,2-Dichloroethene										
1,1-Dichloroethane	41		30						2.67	9.17
Methyl ethyl ketone (MEK)	1588		1526		1559				178.14	611.02
Chloroform	98		83		99				10.68	36.63
1,1,1-Trichloroethane										
Carbon Tetrachloride										
Benzene (b)	19649	56	18711	40	17619	42	90	30	2139.38	7338.08
1,2-Dichloroethane						2			0.06	0.20
Trichloroethene	26		31		27				3.19	10.96
1,2-Dichloropropane	23		25		23				2.70	9.25
p-dioxane							27	5		
Bromodichloromethane		6		6		4			0.61	2.09
Toluene (b)	9012	9	8189	5	7912	5	7	5	958.12	3286.34
t-1,3-Dichloropropene	117		103		97				12.07	41.41
1,1,2-Trichloroethane		1	141	4		5			5.73	19.65
Tetrachloroethene (PERC)	3		2		2				0.25	0.86
Dibromochloromethane										
Chlorobenzene (MCB)	305		278		272				32.58	111.74
Ethylbenzene (b)	1930	1	1760		1676				204.61	701.80
Bromoform										
1,1,2,2-Tetrachloroethane	132		126		118				14.33	49.17

File: VOST2 By: PSM Date: 10\22\90

APPENDIX B-7

SEMIVOLATILE ORGANICS DATA

Note: No significant problems were encountered with the Method 0010 trains. All test runs fell within the acceptable range for isokinetic performance, and all leak checks were passed.

SUMMARY OF MM5 DATA

Run	Sample time (min)	Sample vol. (dscm)	Isokinetic (%)	O_2(%)[a]	CO_2(%)[a]	H_2O(%)	Stack flowrate (dscm/min)
1	120	1.447	96.9	6.3	19.1	32.4	2700
2	120	1.682	104.9	3.9	23.3	37.7	2900
3	120	1.714	103.7	4.2	22.3	35.7	3000
4	120	1.805	94.3	4.1	22.7	31.5	3500
5	120	1.788	99.2	4.5	22.0	36.3	3200
6	120	1.969	100.3	4.8	21.9	36.3	3400

[a] Analysis by Orsat.

```
FILE NAME - 9102RUN1                                          PROG.=VER 06/09/89
RUN # - RUN 1                                                 07-11-1990  15:26:58
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-20-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Feet)=             838.300
Final Meter Volume (Cubic Feet)=               888.218
Meter Factor=                                    1.096
Final Leak Rate (cu ft/min)=                     0.003
Net Meter Volume (Cubic Feet)=                  54.710
Gas Volume (Dry Standard Cubic Feet)=           51.091

Barometric Pressure (in Hg)=                     29.09
Static Pressure (Inches H20)=                    -0.50

Percent Oxygen=                                    6.3
Percent Carbon Dioxide=                           19.1
Moisture Collected (ml)=                         520.1
Percent Water=                                    32.4

Average Meter Temperature (F)=                      91
Average Delta H (in H20)=                         0.72
Average Delta P (in H20)=                        0.256
Average Stack Temperature (F)=                     448

Dry Molecular Weight=                            31.31
Wet Molecular Weight=                            27.00

Average Square Root of Delta P (in H20)=        0.5028
% Isokinetic=                                     96.9

Pitot Coefficient=                                0.83
Sampling Time (Minutes)=                         120.0
Nozzle Diameter (Inches)=                        0.302
Stack Axis #1 (Inches)=                          141.0
Stack Axis #2 (Inches)=                          141.0
Circular Stack
Stack Area (Square Feet)=                       108.43

Stack Velocity  (Actual, Feet/min)=              2,314
Flow Rate (Actual, Cubic ft/min)=              250,886
Flow rate (Standard, Wet, Cubic ft/min)=       141,722
Flow Rate (Standard, Dry, Cubic ft/min)=        95,792

Particulate Loading - Front Half

Particulate Weight (g)=                         0.0000    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=         0.0000        0.0000      0.0000
Particulate Loading, Actual (gr/cu ft)=         0.0000
Emission Rate (lb/hr)=                            0.00

No Back Half Analysis
```

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                        * * METRIC UNITS * *
FILE NAME - 9102RUN1                                          PROG.=VER 06/09/89
RUN # - RUN 1                                                 07-11-1990  15:27:00
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-20-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Meters)=              23.737
Final Meter Volume (Cubic Meters)=                25.151
Meter Factor=                                      1.096
Final Leak Rate (cu m/min)=                       0.0001
Net Meter Volume (Cubic Meters)=                   1.549
Gas Volume (Dry Standard Cubic Meters)=            1.447

Barometric Pressure (mm Hg)=                         739
Static Pressure (mm H2O)=                            -13

Percent Oxygen=                                      6.3
Percent Carbon Dioxide=                             19.1
Moisture Collected (ml)=                           520.1
Percent Water=                                      32.4

Average Meter Temperature (C)=                        33
Average Delta H (mm H2O)=                           18.4
Average Delta P (mm H2O)=                            6.5
Average Stack Temperature (C)=                       231

Dry Molecular Weight=                              31.31
Wet Molecular Weight=                              27.00

Average Square Root of Delta P (mm H2O)=          2.5341
% Isokinetic=                                       96.9

Pitot Coefficient=                                  0.83
Sampling Time (Minutes)=                           120.0
Nozzle Diameter (mm)=                               7.67
Stack Axis #1 (Meters)=                            3.581
Stack Axis #2 (Meters)=                            3.581
Circular Stack
Stack Area (Square Meters)=                       10.074

Stack Velocity  (Actual, m/min)=                     705
Flow rate (Actual, Cubic m/min)=                   7,104
Flow rate (Standard, Wet, Cubic m/min)=            4,013
Flow rate (Standard, Dry, Cubic m/min)=            2,713

Particulate Loading - Front Half

Particulate Weight (g)=                           0.0000    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=             0.0              0.0         0.0
Particulate Loading, Actual (mg/cu m)=               0.0
Emission Rate (kg/hr)=                              0.00

No Back Half Analysis
```

```
FILE NAME - 9102RUN1                                   PROG.=VER 06/09/89
RUN # - RUN 1                                          07-11-1990  15:27:02
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-20-90
PROJECT # - 9102-63-13

Point #      Delta P    Delta H     Stack T      Meter T
            (in. H20) (in. H20)      (F)     In(F)  Out(F)
  1          0.210       0.57        470        77      77
  2          0.200       0.56        461        76      76
  3          0.260       0.70        460        81      77
  4          0.250       0.70        455        85      81
  5          0.240       0.69        454        87      82
  6          0.250       0.70        452        89      84
  7          0.230       0.65        440        87      87
  8          0.230       0.66        440        88      88
  9          0.300       0.85        445        90      89
 10          0.330       0.90        449        92      89
 11          0.340       0.95        450        95      90
 12          0.290       0.80        453        96      91
 13          0.230       0.67        439        90      90
 14          0.240       0.67        473        90      91
 15          0.310       0.85        480        93      91
 16          0.320       0.88        485        97      92
 17          0.320       0.90        484       100      94
 18          0.300       0.85        483       100      94
 19          0.140       0.40        428        93      92
 20          0.130       0.40        379        94      93
 21          0.260       0.75        416        99      95
 22          0.250       0.75        415       102      96
 23          0.270       0.80        415       104      97
 24          0.240       0.75        417       105      98


Fraction                 Final Wt. Tare Wt. Blank Wt. Net Wt.
                           (g)       (g)       (g)      (g)
DRY CATCH                0.0000    0.0000    0.0000   0.0000
FILTER                   0.0000    0.0000    0.0000   0.0000

Fraction                 Final Wt. Tare Wt.   Vol.    Net Wt.
                           (g)       (g)      (ml)      (g)
PROBE RINSE              0.0000    0.0000     0.0   0.0000
IMPINGERS                0.0000    0.0000     0.0   0.0000
Probe Rinse Blank (mg/ml)=  0.0000
Impinger Blank (mg/ml)=  0.0000
```

```
FILE NAME - 9102RUN2                                   PROG.=VER 06/09/89
RUN # - RUN2                                           07-11-1990  15:30:34
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-21-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Feet)=             890.328
Final Meter Volume (Cubic Feet)=               949.323
Meter Factor=                                    1.096
Final Leak Rate (cu ft/min)=                     0.003
Net Meter Volume (Cubic Feet)=                  64.659
Gas Volume (Dry Standard Cubic Feet)=           59.397

Barometric Pressure (in Hg)=                     29.27
Static Pressure (Inches H20)=                    -0.50

Percent Oxygen=                                    3.9
Percent Carbon Dioxide=                           23.3
Moisture Collected (ml)=                         763.2
Percent Water=                                    37.7

Average Meter Temperature (F)=                     104
Average Delta H (in H20)=                         1.02
Average Delta P (in H20)=                        0.379
Average Stack Temperature (F)=                     527

Dry Molecular Weight=                            31.88
Wet Molecular Weight=                            26.65

Average Square Root of Delta P (in H20)=        0.6052
% Isokinetic=                                    104.9

Pitot Coefficient=                                0.83
Sampling Time (Minutes)=                         120.0
Nozzle Diameter (Inches)=                        0.302
Stack Axis #1 (Inches)=                          141.0
Stack Axis #2 (Inches)=                          141.0
Circular Stack
Stack Area (Square Feet)=                       108.43

Stack Velocity  (Actual, Feet/min)=              2,914
Flow Rate (Actual, Cubic ft/min)=              315,943
Flow rate (Standard, Wet, Cubic ft/min)=       165,122
Flow Rate (Standard, Dry, Cubic ft/min)=       102,867

Particulate Loading - Front Half

Particulate Weight (g)=                         0.0000   Corr. to 7% 02 & 12% C02
Particulate Loading, Dry Std. (gr/scf)=         0.0000       0.0000       0.0000
Particulate Loading, Actual (gr/cu ft)=         0.0000
Emission Rate (lb/hr)=                            0.00

No Back Half Analysis
```

```
                    * * METRIC UNITS * *
FILE NAME - 9102RUN2                                   PROG.=VER 06/09/89
RUN # - RUN2                                           07-11-1990  15:30:36
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-21-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Meters)=            25.211
Final Meter Volume (Cubic Meters)=              26.881
Meter Factor=                                    1.096
Final Leak Rate (cu m/min)=                     0.0001
Net Meter Volume (Cubic Meters)=                 1.831
Gas Volume (Dry Standard Cubic Meters)=          1.682

Barometric Pressure (mm Hg)=                       743
Static Pressure (mm H20)=                          -13

Percent Oxygen=                                    3.9
Percent Carbon Dioxide=                           23.3
Moisture Collected (ml)=                         763.2
Percent Water=                                    37.7

Average Meter Temperature (C)=                      40
Average Delta H (mm H20)=                         26.0
Average Delta P (mm H20)=                          9.6
Average Stack Temperature (C)=                     275

Dry Molecular Weight=                            31.88
Wet Molecular Weight=                            26.65

Average Square Root of Delta P (mm H20)=        3.0499
% Isokinetic=                                    104.9

Pitot Coefficient=                                0.83
Sampling Time (Minutes)=                         120.0
Nozzle Diameter (mm)=                             7.67
Stack Axis #1 (Meters)=                          3.581
Stack Axis #2 (Meters)=                          3.581
Circular Stack
Stack Area (Square Meters)=                     10.074

Stack Velocity  (Actual, m/min)=                   888
Flow rate (Actual, Cubic m/min)=                 8,947
Flow rate (Standard, Wet, Cubic m/min)=          4,676
Flow rate (Standard, Dry, Cubic m/min)=          2,913

Particulate Loading - Front Half

Particulate Weight (g)=                         0.0000    Corr. to 7% 02 & 12% C02
Particulate Loading, Dry Std. (mg/cu m)=           0.0           0.0          0.0
Particulate Loading, Actual (mg/cu m)=             0.0
Emission Rate (kg/hr)=                            0.00

No Back Half Analysis
```

```
FILE NAME - 9102RUN2                                    PROG.=VER 06/09/89
RUN # - RUN2                                            07-11-1990  15:30:37
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-21-90
PROJECT # - 9102-63-13

Point #       Delta P   Delta H    Stack T      Meter T
             (in. H20) (in. H20)    (F)     In(F)   Out(F)
 1            0.230      0.63       508        94      94
 2            0.240      0.65       509        94      93
 3            0.250      0.65       530        96      93
 4            0.250      0.66       534        99      94
 5            0.250      0.66       532       100      95
 6            0.250      0.67       533       101      96
 7            0.230      0.65       498        99      98
 8            0.240      0.66       503       100      99
 9            0.520      1.40       527       103     100
 10           0.560      1.50       530       105     101
 11           0.570      1.50       528       109     103
 12           0.540      1.50       529       115     105
 13           0.250      0.69       504       104     103
 14           0.250      0.70       511       106     104
 15           0.480      1.30       533       108     105
 16           0.560      1.50       536       112     106
 17           0.570      1.55       539       113     106
 18           0.580      1.59       542       116     107
 19           0.260      0.71       530       104     103
 20           0.240      0.68       500       103     103
 21           0.420      1.10       547       106     104
 22           0.460      1.20       549       114     106
 23           0.450      1.20       549       116     108
 24           0.450      1.20       549       116     109


Fraction                 Final Wt. Tare Wt. Blank Wt. Net Wt.
                           (g)       (g)      (g)       (g)
DRY CATCH                0.0000    0.0000   0.0000    0.0000
FILTER                   0.0000    0.0000   0.0000    0.0000

Fraction                 Final Wt. Tare Wt.   Vol.    Net Wt.
                           (g)       (g)      (ml)      (g)
PROBE RINSE              0.0000    0.0000    0.0    0.0000
IMPINGERS                0.0000    0.0000    0.0    0.0000
Probe Rinse Blank (mg/ml)=  0.0000
Impinger Blank (mg/ml)=  0.0000
```

```
FILE NAME - 9102RUN3                                            PROG.=VER 06/09/89
RUN # - RUN3                                                    07-11-1990  15:32:38
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-22-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Feet)=                  950.558
Final Meter Volume (Cubic Feet)=                   1009.020
Meter Factor=                                         1.096
Final Leak Rate (cu ft/min)=                          0.004
Net Meter Volume (Cubic Feet)=                       64.074
Gas Volume (Dry Standard Cubic Feet)=                60.531

Barometric Pressure (in Hg)=                          29.11
Static Pressure (Inches H20)=                         -0.50

Percent Oxygen=                                         4.2
Percent Carbon Dioxide=                                22.3
Moisture Collected (ml)=                              712.3
Percent Water=                                         35.7

Average Meter Temperature (F)=                           85
Average Delta H (in H20)=                              0.98
Average Delta P (in H20)=                             0.387
Average Stack Temperature (F)=                          557

Dry Molecular Weight=                                 31.74
Wet Molecular Weight=                                 26.84

Average Square Root of Delta P (in H20)=             0.6171
% Isokinetic=                                         103.7

Pitot Coefficient=                                     0.83
Sampling Time (Minutes)=                              120.0
Nozzle Diameter (Inches)=                             0.302
Stack Axis #1 (Inches)=                               141.0
Stack Axis #2 (Inches)=                               141.0
Circular Stack
Stack Area (Square Feet)=                            108.43

Stack Velocity  (Actual, Feet/min)=                   3,013
Flow Rate (Actual, Cubic ft/min)=                   326,714
Flow rate (Standard, Wet, Cubic ft/min)=            164,868
Flow Rate (Standard, Dry, Cubic ft/min)=            106,076

Particulate Loading - Front Half

Particulate Weight (g)=                              0.0000    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=              0.0000        0.0000      0.0000
Particulate Loading, Actual (gr/cu ft)=              0.0000
Emission Rate (lb/hr)=                                 0.00

No Back Half Analysis
```

```
                        * * METRIC UNITS * *
FILE NAME - 9102RUN3                                         PROG.=VER 06/09/89
RUN # - RUN3                                                 07-11-1990  15:32:39
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-22-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Meters)=               26.916
Final Meter Volume (Cubic Meters)=                 28.571
Meter Factor=                                       1.096
Final Leak Rate (cu m/min)=                        0.0001
Net Meter Volume (Cubic Meters)=                    1.814
Gas Volume (Dry Standard Cubic Meters)=             1.714

Barometric Pressure (mm Hg)=                          739
Static Pressure (mm H20)=                             -13

Percent Oxygen=                                       4.2
Percent Carbon Dioxide=                              22.3
Moisture Collected (ml)=                            712.3
Percent Water=                                       35.7

Average Meter Temperature (C)=                         29
Average Delta H (mm H20)=                            24.8
Average Delta P (mm H20)=                             9.8
Average Stack Temperature (C)=                        292

Dry Molecular Weight=                               31.74
Wet Molecular Weight=                               26.84

Average Square Root of Delta P (mm H20)=           3.1100
% Isokinetic=                                       103.7

Pitot Coefficient=                                   0.83
Sampling Time (Minutes)=                            120.0
Nozzle Diameter (mm)=                                7.67
Stack Axis #1 (Meters)=                             3.581
Stack Axis #2 (Meters)=                             3.581
Circular Stack
Stack Area (Square Meters)=                        10.074

Stack Velocity  (Actual, m/min)=                      918
Flow rate (Actual, Cubic m/min)=                    9,252
Flow rate (Standard, Wet, Cubic m/min)=             4,669
Flow rate (Standard, Dry, Cubic m/min)=             3,004

Particulate Loading - Front Half

Particulate Weight (g)=                            0.0000    Corr. to 7% 02 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=              0.0           0.0        0.0
Particulate Loading, Actual (mg/cu m)=                0.0
Emission Rate (kg/hr)=                               0.00

No Back Half Analysis
```

```
FILE NAME - 9102RUN3                                 PROG.=VER 06/09/89
RUN # - RUN3                                         07-11-1990  15:32:41
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-22-90
PROJECT # - 9102-63-13

Point #      Delta P    Delta H    Stack T      Meter T
            (in. H20) (in. H20)    (F)      In(F)  Out(F)
  1          0.370      0.90       549        76      76
  2          0.350      0.75       553        77      76
  3          0.360      0.90       559        80      76
  4          0.370      0.93       560        83      77
  5          0.400      1.00       560        85      79
  6          0.400      1.00       560        88      81
  7          0.370      0.95       546        81      81
  8          0.410      1.10       545        81      82
  9          0.580      1.50       553        84      82
 10          0.430      1.10       556        89      83
 11          0.410      1.00       558        91      85
 12          0.420      1.10       559        92      86
 13          0.300      0.77       547        84      84
 14          0.240      0.61       550        86      86
 15          0.240      0.60       559        88      86
 16          0.250      0.65       561        90      87
 17          0.270      0.70       560        91      88
 18          0.570      1.40       565        84      85
 19          0.280      0.71       550        84      83
 20          0.290      0.74       553        85      85
 21          0.440      1.10       563        88      85
 22          0.510      1.30       565        94      87
 23          0.510      1.30       565        96      88
 24          0.520      1.30       565       100      90


Fraction                 Final Wt.  Tare Wt.  Blank Wt.  Net Wt.
                            (g)        (g)       (g)       (g)
DRY CATCH                 0.0000     0.0000    0.0000    0.0000
FILTER                    0.0000     0.0000    0.0000    0.0000

Fraction                 Final Wt.  Tare Wt.    Vol.     Net Wt.
                            (g)        (g)      (ml)       (g)
PROBE RINSE               0.0000     0.0000     0.0    0.0000
IMPINGERS                 0.0000     0.0000     0.0    0.0000
Probe Rinse Blank (mg/ml)=   0.0000
Impinger Blank (mg/ml)=   0.0000
```

```
FILE NAME - 9102RUN4                                      PROG.=VER 06/09/89
RUN # - RUN4                                              07-11-1990  15:35:22
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-23-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Feet)=              10.261
Final Meter Volume (Cubic Feet)=                71.940
Meter Factor=                                    1.096
Final Leak Rate (cu ft/min)=                     0.006
Net Meter Volume (Cubic Feet)=                  67.600
Gas Volume (Dry Standard Cubic Feet)=           63.745

Barometric Pressure (in Hg)=                     29.17
Static Pressure (Inches H2O)=                    -0.50

Percent Oxygen=                                    4.1
Percent Carbon Dioxide=                           22.7
Moisture Collected (ml)=                         623.1
Percent Water=                                    31.5

Average Meter Temperature (F)=                      87
Average Delta H (in H2O)=                         1.11
Average Delta P (in H2O)=                        0.465
Average Stack Temperature (F)=                     551

Dry Molecular Weight=                            31.80
Wet Molecular Weight=                            27.45

Average Square Root of Delta P (in H2O)=        0.6764
% Isokinetic=                                     94.3

Pitot Coefficient=                                0.83
Sampling Time (Minutes)=                         120.0
Nozzle Diameter (Inches)=                        0.302
Stack Axis #1 (Inches)=                          141.0
Stack Axis #2 (Inches)=                          141.0
Circular Stack
Stack Area (Square Feet)=                       108.43

Stack Velocity  (Actual, Feet/min)=              3,254
Flow Rate (Actual, Cubic ft/min)=              352,840
Flow rate (Standard, Wet, Cubic ft/min)=       179,368
Flow Rate (Standard, Dry, Cubic ft/min)=       122,821

Particulate Loading - Front Half

Particulate Weight (g)=                         0.0000    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=         0.0000         0.0000      0.0000
Particulate Loading, Actual (gr/cu ft)=         0.0000
Emission Rate (lb/hr)=                            0.00

No Back Half Analysis
```

```
                    * * METRIC UNITS * *
FILE NAME - 9102RUN4                                    PROG.=VER 06/09/89
RUN # - RUN4                                            07-11-1990  15:35:24
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-23-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Meters)=             0.291
Final Meter Volume (Cubic Meters)=               2.037
Meter Factor=                                    1.096
Final Leak Rate (cu m/min)=                     0.0002
Net Meter Volume (Cubic Meters)=                 1.914
Gas Volume (Dry Standard Cubic Meters)=          1.805

Barometric Pressure (mm Hg)=                       741
Static Pressure (mm H2O)=                          -13

Percent Oxygen=                                    4.1
Percent Carbon Dioxide=                           22.7
Moisture Collected (ml)=                         623.1
Percent Water=                                    31.5

Average Meter Temperature (C)=                      31
Average Delta H (mm H2O)=                         28.3
Average Delta P (mm H2O)=                         11.8
Average Stack Temperature (C)=                     289

Dry Molecular Weight=                            31.80
Wet Molecular Weight=                            27.45

Average Square Root of Delta P (mm H2O)=        3.4091
% Isokinetic=                                     94.3

Pitot Coefficient=                                0.83
Sampling Time (Minutes)=                         120.0
Nozzle Diameter (mm)=                             7.67
Stack Axis #1 (Meters)=                          3.581
Stack Axis #2 (Meters)=                          3.581
Circular Stack
Stack Area (Square Meters)=                     10.074

Stack Velocity  (Actual, m/min)=                   992
Flow rate (Actual, Cubic m/min)=                 9,991
Flow rate (Standard, Wet, Cubic m/min)=          5,079
Flow rate (Standard, Dry, Cubic m/min)=          3,478

Particulate Loading - Front Half

Particulate Weight (g)=                         0.0000   Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=           0.0           0.0         0.0
Particulate Loading, Actual (mg/cu m)=             0.0
Emission Rate (kg/hr)=                            0.00

No Back Half Analysis
```

```
FILE NAME - 9102RUN4                                              PROG.=VER 06/09/89
RUN # - RUN4                                                      07-11-1990  15:35:25
LOCATION - CONTINENTAL CEMENT STACK
DATE - 6-23-90
PROJECT # - 9102-63-13

Point #      Delta P    Delta H    Stack T       Meter T
            (in. H20) (in. H20)    (F)      In(F)   Out(F)
  1          0.330      0.78       553       75       75
  2          0.320      0.77       544       76       75
  3          0.470      1.10       551       79       75
  4          0.520      1.20       553       84       77
  5          0.510      1.20       554       88       80
  6          0.510      1.20       554       90       81
  7          0.400      0.98       545       85       83
  8          0.410      1.00       549       88       85
  9          0.560      1.30       556       92       87
  10         0.600      1.40       557       92       87
  11         0.600      1.40       558       96       89
  12         0.570      1.40       556       97       90
  13         0.360      0.90       540       90       89
  14         0.370      0.90       545       91       90
  15         0.540      1.30       556       93       91
  16         0.610      1.50       559       96       91
  17         0.620      1.50       561       98       92
  18         0.620      1.50       561      100       93
  19         0.260      0.64       537       83       83
  20         0.230      0.57       526       83       83
  21         0.420      1.00       553       86       84
  22         0.430      1.00       554       91       86
  23         0.450      1.10       555       94       87
  24         0.450      1.10       555       97       89


Fraction                   Final Wt. Tare Wt. Blank Wt. Net Wt.
                             (g)       (g)       (g)      (g)
DRY CATCH                  0.0000    0.0000    0.0000    0.0000
FILTER                     0.0000    0.0000    0.0000    0.0000

Fraction                   Final Wt. Tare Wt.   Vol.     Net Wt.
                             (g)       (g)      (ml)      (g)
PROBE RINSE                0.0000    0.0000     0.0     0.0000
IMPINGERS                  0.0000    0.0000     0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0000
Impinger Blank (mg/ml)=  0.0000
```

```
FILE NAME - 9102RUN5                                        PROG.=VER 06/09/89
RUN # - RUN5                                                07-12-1990  10:42:17
LOCATION - CONTINENTAL CEMENT STACK
DATE - 7-5-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Feet)=                  94.040
Final Meter Volume (Cubic Feet)=                   157.590
Meter Factor=                                        1.096
Final Leak Rate (cu ft/min)=                         0.005
Net Meter Volume (Cubic Feet)=                      69.651
Gas Volume (Dry Standard Cubic Feet)=               63.143

Barometric Pressure (in Hg)=                         29.34
Static Pressure (Inches H20)=                        -0.50

Percent Oxygen=                                        4.5
Percent Carbon Dioxide=                               22.0
Moisture Collected (ml)=                             763.3
Percent Water=                                        36.3

Average Meter Temperature (F)=                         113
Average Delta H (in H20)=                             1.17
Average Delta P (in H20)=                            0.408
Average Stack Temperature (F)=                         505

Dry Molecular Weight=                                31.70
Wet Molecular Weight=                                26.73

Average Square Root of Delta P (in H20)=            0.6323
% Isokinetic=                                         99.2

Pitot Coefficient=                                    0.83
Sampling Time (Minutes)=                             120.0
Nozzle Diameter (Inches)=                            0.308
Stack Axis #1 (Inches)=                              141.0
Stack Axis #2 (Inches)=                              141.0
Circular Stack
Stack Area (Square Feet)=                           108.43

Stack Velocity  (Actual, Feet/min)=                  3,003
Flow Rate (Actual, Cubic ft/min)=                  325,577
Flow rate (Standard, Wet, Cubic ft/min)=           174,415
Flow Rate (Standard, Dry, Cubic ft/min)=           111,137

Particulate Loading - Front Half

Particulate Weight (g)=                             0.0000    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=             0.0000         0.0000     0.0000
Particulate Loading, Actual (gr/cu ft)=             0.0000
Emission Rate (lb/hr)=                                0.00

No Back Half Analysis
```

```
                       * * METRIC UNITS * *
FILE NAME - 9102RUN5                                          PROG.=VER 06/09/89
RUN # - RUN5                                                  07-12-1990  10:42:19
LOCATION - CONTINENTAL CEMENT STACK
DATE - 7-5-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Meters)=             2.663
Final Meter Volume (Cubic Meters)=               4.462
Meter Factor=                                    1.096
Final Leak Rate (cu m/min)=                     0.0001
Net Meter Volume (Cubic Meters)=                 1.972
Gas Volume (Dry Standard Cubic Meters)=          1.788

Barometric Pressure (mm Hg)=                       745
Static Pressure (mm H20)=                          -13

Percent Oxygen=                                    4.5
Percent Carbon Dioxide=                           22.0
Moisture Collected (ml)=                         763.3
Percent Water=                                    36.3

Average Meter Temperature (C)=                      45
Average Delta H (mm H20)=                         29.6
Average Delta P (mm H20)=                         10.4
Average Stack Temperature (C)=                     263

Dry Molecular Weight=                            31.70
Wet Molecular Weight=                            26.73

Average Square Root of Delta P (mm H20)=        3.1867
% Isokinetic=                                     99.2

Pitot Coefficient=                                0.83
Sampling Time (Minutes)=                         120.0
Nozzle Diameter (mm)=                             7.82
Stack Axis #1 (Meters)=                          3.581
Stack Axis #2 (Meters)=                          3.581
Circular Stack
Stack Area (Square Meters)=                     10.074

Stack Velocity  (Actual, m/min)=                   915
Flow rate (Actual, Cubic m/min)=                 9,219
Flow rate (Standard, Wet, Cubic m/min)=          4,939
Flow rate (Standard, Dry, Cubic m/min)=          3,147

Particulate Loading - Front Half

Particulate Weight (g)=                         0.0000    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=           0.0              0.0         0.0
Particulate Loading, Actual (mg/cu m)=             0.0
Emission Rate (kg/hr)=                            0.00

No Back Half Analysis
```

```
FILE NAME - 9102RUN5                                           PROG.=VER 06/09/89
RUN # - RUN5                                                   07-12-1990  10:42:20
LOCATION - CONTINENTAL CEMENT STACK
DATE - 7-5-90
PROJECT # - 9102-63-13

Point #        Delta P    Delta H    Stack T      Meter T
              (in. H2O) (in. H2O)    (F)      In(F)  Out(F)
  1            0.280      0.81       501      103     101
  2            0.280      0.80       504      104     102
  3            0.460      1.30       516      108     104
  4            0.490      1.40       518      113     105
  5            0.510      1.40       516      106     106
  6            0.480      1.30       516      114     107
  7            0.300      0.86       504      109     106
  8            0.330      0.94       504      110     108
  9            0.470      1.30       510      115     109
  10           0.500      1.40       512      120     111
  11           0.530      1.50       510      123     114
  12           0.510      1.50       512      125     115
  13           0.290      0.85       495      112     110
  14           0.300      0.88       493      111     111
  15           0.520      1.50       509      116     112
  16           0.560      1.60       511      121     114
  17           0.560      1.60       512      124     115
  18           0.530      1.50       511      126     116
  19           0.220      0.65       495      112     109
  20           0.210      0.61       491      112     109
  21           0.330      0.96       497      115     112
  22           0.370      1.10       497      119     114
  23           0.380      1.10       497      122     115
  24           0.380      1.10       496      123     115


Fraction                 Final Wt. Tare Wt. Blank Wt. Net Wt.
                           (g)       (g)       (g)      (g)
DRY CATCH                0.0000    0.0000    0.0000    0.0000
FILTER                   0.0000    0.0000    0.0000    0.0000

Fraction                 Final Wt. Tare Wt.   Vol.     Net Wt.
                           (g)       (g)      (ml)      (g)
PROBE RINSE              0.0000    0.0000    0.0     0.0000
IMPINGERS                0.0000    0.0000    0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0000
Impinger Blank (mg/ml)=  0.0000
```

```
FILE NAME - 9102RUN6                                              PROG.=VER 06/09/89
RUN # - RUN6                                                      07-12-1990  10:44:21
LOCATION - CONTINENTAL CEMENT STACK
DATE - 7-5-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Feet)=              158.750
Final Meter Volume (Cubic Feet)=                227.840
Meter Factor=                                     1.096
Final Leak Rate (cu ft/min)=                      0.002
Net Meter Volume (Cubic Feet)=                   75.723
Gas Volume (Dry Standard Cubic Feet)=            69.552

Barometric Pressure (in Hg)=                      29.34
Static Pressure (Inches H20)=                     -0.50

Percent Oxygen=                                     4.8
Percent Carbon Dioxide=                            21.9
Moisture Collected (ml)=                          840.3
Percent Water=                                     36.3

Average Meter Temperature (F)=                      105
Average Delta H (in H20)=                          1.36
Average Delta P (in H20)=                         0.484
Average Stack Temperature (F)=                      517

Dry Molecular Weight=                             31.70
Wet Molecular Weight=                             26.73

Average Square Root of Delta P (in H20)=         0.6934
% Isokinetic=                                     100.3

Pitot Coefficient=                                 0.83
Sampling Time (Minutes)=                          120.0
Nozzle Diameter (Inches)=                         0.308
Stack Axis #1 (Inches)=                           141.0
Stack Axis #2 (Inches)=                           141.0
Circular Stack
Stack Area (Square Feet)=                        108.43

Stack Velocity  (Actual, Feet/min)=               3,313
Flow Rate (Actual, Cubic ft/min)=               359,228
Flow rate (Standard, Wet, Cubic ft/min)=        190,087
Flow Rate (Standard, Dry, Cubic ft/min)=        121,148

Particulate Loading - Front Half

Particulate Weight (g)=                          0.0000     Corr. to 7% 02 & 12% C02
Particulate Loading, Dry Std. (gr/scf)=          0.0000          0.0000     0.0000
Particulate Loading, Actual (gr/cu ft)=          0.0000
Emission Rate (lb/hr)=                             0.00

No Back Half Analysis
```

```
                        * * METRIC UNITS * *
FILE NAME - 9102RUN6                                        PROG.=VER 06/09/89
RUN # - RUN6                                                07-12-1990  10:44:22
LOCATION - CONTINENTAL CEMENT STACK
DATE - 7-5-90
PROJECT # - 9102-63-13

Initial Meter Volume (Cubic Meters)=          4.495
Final Meter Volume (Cubic Meters)=            6.452
Meter Factor=                                 1.096
Final Leak Rate (cu m/min)=                  0.0001
Net Meter Volume (Cubic Meters)=              2.144
Gas Volume (Dry Standard Cubic Meters)=       1.969

Barometric Pressure (mm Hg)=                    745
Static Pressure (mm H2O)=                       -13

Percent Oxygen=                                 4.8
Percent Carbon Dioxide=                        21.9
Moisture Collected (ml)=                      840.3
Percent Water=                                 36.3

Average Meter Temperature (C)=                   41
Average Delta H (mm H2O)=                      34.5
Average Delta P (mm H2O)=                      12.3
Average Stack Temperature (C)=                  270

Dry Molecular Weight=                         31.70
Wet Molecular Weight=                         26.73

Average Square Root of Delta P (mm H2O)=     3.4945
% Isokinetic=                                 100.3

Pitot Coefficient=                             0.83
Sampling Time (Minutes)=                      120.0
Nozzle Diameter (mm)=                          7.82
Stack Axis #1 (Meters)=                       3.581
Stack Axis #2 (Meters)=                       3.581
Circular Stack
Stack Area (Square Meters)=                  10.074

Stack Velocity  (Actual, m/min)=              1,010
Flow rate (Actual, Cubic m/min)=             10,172
Flow rate (Standard, Wet, Cubic m/min)=       5,383
Flow rate (Standard, Dry, Cubic m/min)=       3,431

Particulate Loading - Front Half

Particulate Weight (g)=                      0.0000    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=        0.0          0.0         0.0
Particulate Loading, Actual (mg/cu m)=          0.0
Emission Rate (kg/hr)=                         0.00

No Back Half Analysis
```

```
FILE NAME - 9102RUN6                                          PROG.=VER 06/09/89
RUN # - RUN6                                                  07-12-1990  10:44:24
LOCATION - CONTINENTAL CEMENT STACK
DATE - 7-5-90
PROJECT # - 9102-63-13

Point #       Delta P    Delta H    Stack T      Meter T
            (in. H2O) (in. H2O)    (F)      In(F)   Out(F)
  1           0.440      1.20      532        94      93
  2           0.440      1.20      521        92      91
  3           0.460      1.20      521        97      92
  4           0.520      1.40      521       101      93
  5           0.540      1.50      520       105      95
  6           0.500      1.40      519       109      97
  7           0.450      1.20      518       104     101
  8           0.540      1.50      521       107     103
  9           0.580      1.60      519       112     104
 10           0.610      1.70      519       115     106
 11           0.620      1.80      517       117     108
 12           0.560      1.60      515       117     108
 13           0.420      1.20      515       109     107
 14           0.520      1.50      516       110     108
 15           0.540      1.50      517       114     108
 16           0.580      1.60      517       117     110
 17           0.590      1.70      516       118     110
 18           0.400      1.20      515       119     111
 19           0.390      1.10      515       100     100
 20           0.390      1.10      515       102     102
 21           0.380      1.10      513       106     103
 22           0.390      1.10      512       109     103
 23           0.380      1.10      510       111     104
 24           0.380      1.10      510       112     105


Fraction                 Final Wt. Tare Wt. Blank Wt. Net Wt.
                            (g)       (g)      (g)      (g)
DRY CATCH                 0.0000    0.0000    0.0000   0.0000
FILTER                    0.0000    0.0000    0.0000   0.0000

Fraction                 Final Wt. Tare Wt.   Vol.     Net Wt.
                            (g)       (g)     (ml)      (g)
PROBE RINSE               0.0000    0.0000    0.0     0.0000
IMPINGERS                 0.0000    0.0000    0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0000
Impinger Blank (mg/ml)=  0.0000
```

METHODS

The MM5 samples for semi-volatiles, PCDD/PCDFs, and gravimetric analysis were prepared according to EPA SW-846 methods with modifications described previously in this appendix. The five components of the sampling train (front-half rinse, filter, back-half rinse, XAD, and condensate) were each extracted separately. All samples were treated similarly. Prior to extraction of the filter, the front-half rinse was filtered to remove any particulates. This filter and solids catch were combined with the MM5 filter and extracted.

Individual sampling train components were spiked with surrogate compounds before solvent extraction as described below:

Component spiked with surrogate mixture:	Run No.	
	Semi-vol.	D/F
Filter	1, 5	1, 4, 5
Front half rinse	2	No
XAD	3	3
Back half rinse	4	No
Condensate	6	No

The filter/solids catch and XAD samples were extracted initially with dichloromethane for 16 - 22 hrs. The solvent was removed, and the sample was extracted for an additional 16 - 22 hrs with toluene. A third solvent, methyl-t-butyl ether was used to extract the samples for a final 16 - 22 hrs. The three solvent extracts were combined and saved.

A similar three solvent extraction scheme was used for the front-half, back-half and condensate components of the MM5 train. The pH of each of these components was initially adjusted to 7-8, using 1 N NaOH or 1:1 H2SO4:H2O. Each sample was extracted three times with dichloromethane in a separatory funnel. The sample pH was adjusted to 11 using 1 N NaOH and the sample was extracted three more times with dichloromethane. The pH of the sample was adjusted back to 7-8 and the samples was extracted with toluene and methyl-t-butyl ether, respectively. The dichloromethane, toluene and methyl-t-butyl ether extracts were combined and saved.

The five component extracts from each train were combined, concentrated to 10ml and split for semi-volatile, PCDD/PCDF and gravimetric analysis as shown below. The semi-volatile portion was concentrated to 1ml prior to analysis. The PCDD/PCDF portion was cleaned up according to EPA SW-846 Method 8280 prior to analysis.

<u>Sample:</u>	Blank Train	Method Blank	Method Blank	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Analysis <u>Fraction</u>	(ml in fraction)								
Semi-vol.	2.5ml	5.0	5.0	2.5	5.0	2.5	2.5	2.5	5.0
PCDD/PCDF	2.5ml	0	0	2.5	0	2.5	2.5	2.5	0
Gravimetric	5.0ml	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

The following laboratory QC samples were generated for PCDD/PCDF analysis to monitor the precision and accuracy of the analytical results. These nine samples were prepared and analyzed as described previously. The blank samples were also analyzed for semi-volatiles.

	XAD	Filter	Water
Matrix Spike	X	X	X
Matrix Spike Duplicate	X	X	X
Blank	X	X	X

Deviations from sample preparation protocol:

The sample analysis holding times were not met for all samples.

Six MM5 trains were collected between June 20 and July 6, 1990. Solvent extraction of the samples was done in two separate sets on June 26 and July 9. Therefore, extraction of all samples was started within 6 days after sampling, and all extraction holding times were met.

Sample analysis for the semi-volatile screen was started on August 16, 1990, which is 51 days after preparation of the first set of samples, and 38 days after preparation of the second set of samples. Therefore, analysis holding times of 40 days after sample preparation were not met for samples collected during Runs 1 through 4. The reasons for this have been investigated and corrective action will be taken.

Analysis holding times for PCDD/PCDF analysis (6 months after sample preparation) were met.

The solvent reservoir went dry during the methyl-t-butyl ether extraction of Sample 4030 (Run 4 XAD). This was due to uncontrolled water temperature in the soxhlet condensers. Corrective action taken to prevent this in the future involved moving solvent extraction operations to the routine sample preparation lab, which has chilled water for the condensers.

The syringe used to add the surrogate mixture to the blank train samples apparently did not retain the volume sampled. The sample preparation supervisor has discarded such syringes.

Sample 5030 (Run 5 XAD) had some resin break through past the Soxhlet sample reservoir into the boiling flask. In addition, a small loss of solvent was observed. The resin was filtered out of the solvent reservoir and recombined with the bulk of the XAD in the sample reservoir before extraction with methyl-t-butyl ether.

RESULTS

Table 1 summarizes the PCDD/PCDF analytical results in the Hannibal Cement Kiln samples. Tables 2 through 5 present the results of analysis of the quality assurance samples (method blanks, matrix spikes and matrix spike duplicates). Surrogate recoveries for PCDDs and PCDFs are also included on these tables.

Positive identification of the PCDD and PCDF congeners was based on retention time and theoretical ratios of areas measured for each of the two ions monitored (15%). All calibration criteria were met during analysis of these samples as specified in SW-846 Method 8290, including the modifications described previously.

The limits of detection given in Table 1 are based on Estimated Detection Limits (EDL). The EDL is calculated from the amount of noise detected at the expected retention time of a target compound. The EDL was also applied to non-2,3,7,8 PCDD and PCDF isomers in determining which isomers to include in the calculations of total PCDD/PCDF homologs.

Comments on PCDD/PCDF Results

PCDD/PCDF results reported for Run 4 and the Blank Train are suspect because of low surrogate recoveries for all labeled compounds spiked into the sample before extraction (see Table 1). Similarly low surrogate recoveries were also detected in one of the water matrix spikes (Table 3), and may be related to the syringe used for spiking (see item above in method deviations).

The overall PCDD/PCDF surrogate recovery average was 72.4% (n=126 determinations, 14 samples analyzed, 35.2% RSD), but if the three samples which had low surrogate recoveries are discounted (i.e., reported as suspect), the overall average surrogate recovery increases to 82.8% (n=99 determinations, 11 samples analyzed, 21.1% RSD). In both cases, the precision quality control objective of 35% was met.

Overall, 25 PCDD/PCDF surrogate determinations, out of a total of 126 determinations, were outside accuracy criteria of 40-120%. This indicates that 81.2% of the determinations were within acceptance criteria, which is within the required completeness quality control objectives (QCOs). Discounting the three samples with low surrogate recoveries, 95 out of 99 (96%) determinations were within QCOs.

Overall, 102 matrix spike recovery determinations were made, of which 70.6% were within quality control objectives of 40-120% recovery. This included one matrix spike whose surrogate recovery suggest suspect data. Excluding this suspect sample, 94.7% of the 38 remaining matrix spike recovery determinations were within the objectives.

Matrix spike recovery determinations were made in duplicate for each of the three matrices used (filter, XAD, water). Including the water matrix spike with suspect results, 93.7% of the determinations (n=32) were within precision objectives. If the suspect sample is excluded, 100% (n=30) of the determinations were within criteria.

Method blanks were not analyzed concurrently with all the samples. The method blanks that were extracted were prepared under representative laboratory conditions, using the same set of reagents as were used for the field samples. In this context, the blanks analyzed should be considered to be method blanks for samples that were co-extracted, reagent blanks for all others, and blanks representative of typical laboratory conditions.

Table 6 summarizes the semi-volatile screening results in the Hannibal Cement Kiln samples. This table includes the results of analysis of the method blanks and blank train. Surrogate recoveries for D10-pyrene and 2,4,6-tribromophenol are also included on this table. Table 7 presents the identification and estimated concentration for tentatively identified compounds detected in these samples.

All mass calibration criteria related to DFTPP tuning were verified prior to analysis of samples. Prior to the GC/MS semi-volatile screening of these samples, a calibration curve containing all of the USEPA-CLP target analytes was prepared. These responses were used to confirm that the instrument response was still valid and to quantify the concentration of the CLP analytes in the samples.

Comments on Semi-volatile screening results:

Each sample was spiked with 20 g/mL of the internal standards rather than the originally specified 40 g/mL. The 20 g/mL spike was consistent with the requirements for EPAs Contract Laboratory Program (CLP). This modification was approved because the samples were analyzed for semi-volatile organic compounds using the CLP calibration curve.

The GC conditions were somewhat different from those originally specified in the method. The GC conditions appropriate for the CLP samples were used in order to minimize the impact on retention time data.

Two semi-volatile surrogate compounds were used, D10-pyrene and 2,4,6-tribromophenol. The recovery for D10-pyrene was within the data quality objective range of 70-130% for all samples. The recovery for 2,4,6-tribromophenol was above the 130% objective for several of the analyses, however the average recovery was within the objectives at 128% 38.

SEMIVOLATILE ANALYSIS RESULTS

	Blank	Run 1			Run 2			Run 3		
	Weight Found (ug)	Weight Found (ug)	Conc. (ug/dscm or ng/L)	Analyte Emission (mg/min)	Weight Found (ug)	Conc. (ug/dscm or ng/L)	Analyte Emission (mg/min)	Weight Found (ug)	Conc. (ug/dscm or ng/L)	Analyte Emission (mg/min)
Gas Sample Volume =		1.447			1.682			1.714		
Stack Gas Flowrate (dscm/min) =		2710			2910			3000		
PQL (total ug) =	40	40			20			40		
Benzyl alcohol	140	1000[a]	700	2000	1000[a]	600	2000	800[a]	500	2000
Benzoic acid		2000[a]	1000	3000	1000[a]	600	2000	2000[a]	1000	3000
Phenol					130	77	225	290	169	508
2-Chlorophenol										
2-Methyl phenol										
4-Methyl phenol					87	52	151	90	53	158
Naphthalene		210	145	393	1000[a]	600	2000	1000[a]	600	2000
2-Methyl naphthalene		75	52	140	170	101	294	260	152	455
2,4,6-Trichlorophenol					44	26	76			
Acenaphthylene					160	95	277	200	117	350
Dibenzofuran					170	101	294	250	146	438
Diethyl phthalate										
Fluorene					44	26	76	50	29	88
Phenanthrene		30	21	56	200[a]	100[a]	300	270	158	473
Anthracene					22	13	38	25	15	44
Fluoranthene					77	46	133	80	47	140
Pyrene					49	29	85	48	28	84
Benz[a]anthracene										
Chrysene					38	23	66	38	22	67
Bis(2-ethylhexyl)phthalate										

File: SVOL By: PSM Date: 11/29/90

SEMIVOLATILE ANALYSIS RESULTS (con't)

	Run 4			Run 5			Run 6		
	Weight Found (ug)	Conc. (ug/dscm or ng/L)	Analyte Emission (mg/min)	Weight Found (ug)	Conc. (ug/dscm or ng/L)	Analyte Emission (mg/min)	Weight Found (ug)	Conc. (ug/dscm or ng/L)	Analyte Emission (mg/min)
Gas Sample Volume =	1.805			1.788			1.969		
Stack Gas Flowrate (dscm/min) =	3486			3150			3430		
PQL (total ug) =	40			40			20		
Benzyl alcohol	800[a]	400	1000	1000[a]	600	2000	700[a]	400	1000
Benzoic acid	2000[a]	1000	3000	1000[a]	600	2000	300[a]	200	700
Phenol	98	54	189	120	67	211	270	137	470
2-Chlorophenol	16	9	31						
2-Methyl phenol							30	15	52
4-Methyl phenol	110	61	212	110	62	194	110	56	192
Naphthalene	1000[a]	600	2000	1000[a]	600	2000	1000[a]	500	2000
2-Methyl naphthalene	160	89	309	260	145	458	200	100	300
2,4,6-Trichlorophenol	58	32	112						
Acenaphthylene	130	72	251	190	106	335	170	86	296
Dibenzofuran	170	94	328	230	129	405	180	91	314
Diethyl phthalate	47	26	91						
Fluorene				75	42	132	75	38	131
Phenanthrene	150	83	290	290	162	511	200[a]	100	300
Anthracene				41	23	72	49	25	85
Fluoranthene				110	62	194	100	51	174
Pyrene				87	49	153	88	45	153
Benz[a]anthracene							20	10	35
Chrysene				57	32	100	63	32	110
Bis(2-ethylhexyl)phthalate				94	53	166	53	27	92

[a] Response was higher then the highest calibration point, therefore the value is an estimate only.

File: SVOL By: PSM Date: 11

The following compounds represent the semivolatile analytes that were not detected above the PQL in any of the MM5 sampling train samples.

ANILINE
AZOBENZENE
BIS(2-CHLOROETHYL)ETHER
1,3-DICHLOROBENZENE
1,4-DICHLOROBENZENE
1,2-DICHLOROBENZENE
2-METHYL PHENOL
2,2'-OXYBIS(1-CHLOROPROPANE)
N-NITROSO-DI-N-PROPYLAMINE
HEXACHLOROETHANE
NITROBENZENE
ISOPHRONE
2-NITROPHENOL
2,4-DIMETHYL PHENOL
BIS(2-CHLOROETHOXY)METHANE
2,4-DICHLOROPHENOL
1,2,4-TRICHLOROBENZENE
4-CHLOROANILINE
HEXACHLORO-1,3-BUTADIENE
4-CHLORO-3-METHYL PHENOL
HEXACHLOROCYCLOPENTADIENE
2,4,5-TRICHLOROPHENOL
2-CHLORONAPHTHALENE
2-NITROANILINE
DIMETHYL PHTHALATE
2,6-DINITROTOLUENE
3-NITROANILINE
ACENAPHTHENE
2,4-DINITROPHENOL
4-NITROPHENOL
2,4-DINITROTOLUENE
4-CHLOROPHENYL-PHENYL ETHER
4-NITROANILINE
4,6-DINITRO-2-METHYL PHENOL
N-NITROSO-DIPHENYLAMINE
4-BROMOPHENYL-PHENYL ETHER
HEXACHLOROBENZENE
PENTACHLOROPHENOL
CARBAZOLE
BENZYL BUTYL PHTHALATE
3,3'-DICHLOROBENZIDINE
BENZ[A]ANTHRACENE
DI-N-OCTYL PHTHALATE
BENZO[B]FLUORANTHENE
BENZO[K]FLUORANTHENE
BENZO[A]PYRENE
INDENO[1,2,3-C,D]PYRENE
DIBENZ[A,H]ANTHRACENE
BENZO[G,H,I]PERYLENE

File: SVNOHITS By: PSM Date: 11/29/90

QUALITY CONTROL DATA FOR PCDD/PCDF ANALYSES

SAMPLE DESCRIPTION: WATER
DATA FILE NAME: 8P10WTQC DATA DISK ID: __________

	<----------DUPLICATES----------				<--------MATRIX SPK 1		-------->	<--------MATRIX SPK 2			-------->
GC/MS filename:					H09V5			H08V5			
QA type (dup,MS,MSdup):					MS	Matrix spk	Matrix spk	MS DUP	Matrix spk	Matrix spk	MATRIX SPK
Reporting units:			Avg.	RPD(a)	FG	level	%recovery(b)	FG	level	% recovery	RPD
========ANALYTES========											
2,3,7,8-TCDF	NA	NA	NA	NA	15100	5998	251.8%	6960	5998	116.0%	73.3%
2,3,7,8-TCDD	NA	NA	NA	NA	15000	5978	250.9%	6830	5978	114.3%	74.9%
1,2,3,7,8-PeCDF	NA	NA	NA	NA	22100	6028	366.5%	11400	6028	189.1%	63.9%
2,3,4,7,8-PeCDF	NA	NA	NA	NA	11900	5978	199.1%	6480	5978	108.4%	59.0%
1,2,3,7,8-PeCDD	NA	NA	NA	NA	10700	6098	175.7%	5130	6098	84.1%	72.0%
1,2,3,4,7,8-HxCDF	NA	NA	NA	NA	42300	14868	284.5%	20200	14868	135.9%	70.7%
1,2,3,6,7,8-HxCDF	NA	NA	NA	NA	39400	14856	265.2%	19000	14856	127.9%	69.9%
2,3,4,6,7,8-HxCDF	NA	NA	NA	NA	43100	15130	284.9%	20600	15130	136.2%	70.6%
1,2,3,7,8,9-HxCDF	NA	NA	NA	NA	39400	14914	256.0%	19000	14914	128.3%	66.5%
1,2,3,4,7,8-HxCDD	NA	NA	NA	NA	36400	14880	246.0%	16600	14880	113.1%	74.7%
1,2,3,6,7,8-HxCDD	NA	NA	NA	NA	32600	15256	213.5%	14900	15256	97.6%	74.5%
1,2,3,7,8,9-HxCDD	NA	NA	NA	NA	36500	15266	239.1%	16900	15266	110.7%	73.4%
1,2,3,4,6,7,8-HpCDF	NA	NA	NA	NA	43300	15002	288.6%	17700	15002	118.0%	83.9%
1,2,3,4,7,8,9-HpCDF	NA	NA	NA	NA	43200	15050	287.0%	18400	15050	122.3%	80.5%
1,2,3,4,6,7,8-HpCDD	NA	NA	NA	NA	35900	14988	239.5%	16000	14988	106.8%	76.7%
OCDF	NA	NA	NA	NA	84200	30318	277.7%	36600	30318	120.7%	78.8%
OCDD	NA	NA	NA	NA	74100	29412	251.9%	30900	29412	105.1%	82.2%
PERCENT SURROGATE RECOVERIES----------											
13C-TCDF	ND	ND	-	-	33.5	-	-	78.2	-	-	-
13C-TCDD	ND	ND	-	-	33.7	-	-	74.8	-	-	-
13C-PeCDF	ND	ND	-	-	40.7	-	-	97.5	-	-	-
13C-PeCDD	ND	ND	-	-	37.1	-	-	88.5	-	-	-
13C-HxCDF	ND	ND	-	-	23.9	-	-	65.5	-	-	-
13C-HxCDD	ND	ND	-	-	26.5	-	-	71.3	-	-	-
13C-HpCDF	ND	ND	-	-	29.0	-	-	91.5	-	-	-
13C-HpCDD	ND	ND	-	-	32.5	-	-	104.0	-	-	-
13C-OCDD	ND	ND	-	-	28.1	-	-	86.5	-	-	-

a RPD (relative percent difference) = ((REP 1- REP 2)/AVE OF REP 1 AND REP 2) * 100
b % RECOVERY = ((AMOUNT FOUND IN SPIKE - NATIVE LEVEL AVG)/AMOUNT SPIKED) * 100

NS=not spiked; NA=not analyzed or not detected; ND=not detected; TR=detected, but a level lower than the quantitation limit

25-Nov-90

QUALITY CONTROL DATA FOR PCDD/PCDF ANALYSES

SAMPLE DESCRIPTION: FILTER
DATA FILE NAME: 5912FL3D DATA DISK ID: ____________

	<----------DUPLICATES-----				<--------MATRIX SPK 1--------->			<--------MATRIX SPK 2--------->			
GC/MS filename:					H09V4			H09V7			
QA type (dup,MS,MSdup):					MS	Matrix spk	Matrix spk	MS DUP	Matrix spk	Matrix spk	MATRIX SPK
Reporting units:			Avg.	RPD(a)	PG	level	%recovery(b)	PG	level	% recovery	RPD
========ANALYTES											
2,3,7,8-TCDF	NA	NA	NA	NA	6480	5998	108.0%	5390	5998	89.9%	18.4%
2,3,7,8-TCDD	NA	NA	NA	NA	6600	5978	110.4%	5950	5978	99.5%	10.4%
1,2,3,7,8-PeCDF	NA	NA	NA	NA	10700	6028	177.5%	9670	6028	160.4%	10.1%
2,3,4,7,8-PeCDF	NA	NA	NA	NA	5390	5978	90.2%	5130	5978	85.8%	4.9%
1,2,3,7,8-PeCDD	NA	NA	NA	NA	4650	6098	76.3%	4370	6098	71.7%	6.2%
1,2,3,4,7,8-HxCDF	NA	NA	NA	NA	17600	14868	118.4%	15400	14868	103.6%	13.3%
1,2,3,6,7,8-HxCDF	NA	NA	NA	NA	17900	14856	120.5%	15400	14856	103.7%	15.0%
2,3,4,6,7,8-HxCDF	NA	NA	NA	NA	17300	15130	114.3%	15100	15130	99.8%	13.6%
1,2,3,7,8,9-HxCDF	NA	NA	NA	NA	14300	14814	96.5%	13400	14814	90.5%	6.5%
1,2,3,4,7,8-HxCDD	NA	NA	NA	NA	15200	14680	103.5%	13400	14680	91.3%	12.6%
1,2,3,6,7,8-HxCDD	NA	NA	NA	NA	13700	15266	89.7%	12000	15266	78.6%	13.2%
1,2,3,7,8,9-HxCDD	NA	NA	NA	NA	13400	15266	87.8%	13000	15266	85.2%	3.0%
1,2,3,4,6,7,8-HpCDF	NA	NA	NA	NA	18600	15002	124.0%	14500	15002	96.7%	24.8%
1,2,3,4,7,8,9-HpCDF	NA	NA	NA	NA	15800	15050	105.0%	12900	15050	85.7%	20.2%
1,2,3,4,6,7,8-HpCDD	NA	NA	NA	NA	15600	14988	104.1%	13800	14988	92.1%	12.2%
OCDF	NA	NA	NA	NA	34800	15002	232.0%	27600	15002	184.0%	23.1%
OCDD	NA	NA	NA	NA	15700	14986	104.8%	13900	14988	92.7%	12.2%
PERCENT SURROGATE RECOVERIES											
13C-TCDF	ND	ND	-	-	81.6	-	-	82.1	-	-	-
13C-TCDD	ND	ND	-	-	78.2	-	-	73.9	-	-	-
13C-PeCDF	ND	ND	-	-	91.9	-	-	96.5	-	-	-
13C-PeCDD	ND	ND	-	-	86.1	-	-	89.4	-	-	-
13C-HxCDF	ND	ND	-	-	75.6	-	-	64.9	-	-	-
13C-HxCDD	ND	ND	-	-	91.0	-	-	75.2	-	-	-
13C-HpCDF	ND	ND	-	-	85.0	-	-	82.4	-	-	-
13C-HpCDD	ND	ND	-	-	70.5	-	-	72.7	-	-	-
13C-OCDD	ND	ND	-	-	86.9	-	-	83.9	-	-	-

a RPD (relative percent difference) = ((REP 1- REP 2)/AVG OF REP 1 AND REP 2) * 100
b % RECOVERY = ((AMOUNT FOUND IN SPIKE - NATIVE LEVEL AVG)/AMOUNT SPIKED) * 100

NS=not spiked; NA=not analyzed or not detected; ND=not detected; TR=detected, but a level lower than the quantitation limit

5-Nov-90

SUMMARY TABLE OF BLANKS FOR PCDD/PCDF ANALYSES

	FILTER BLANK		XAD BLANK		WATER BLANK	
	ORIGINAL	REVISED	ORIGINAL	REVISED	ORIGINAL	REVISED
ANALYTES						
2,3,7,8-TCDF	<49.6	12.6	<74.77	15.8	<38.1	15.5
2,3,7,8-TCDD	<52.1	11.5	<77.3	<16	<35.6	<17.6
1,2,3,7,8-PeCDF	<34.8	<15.7	<56.6	<18	<29.5	19.5
2,3,4,7,8-PeCDF	<34.8	<6.65	<56.6	<7.43	<29.5	<8.35
1,2,3,7,8-PeCDD	<47.2	6.48	<74.1	<5.15	<33.6	7.92
1,2,3,4,7,8-HxCDF	<161	13.5	<230	<19.5	<115	20
1,2,3,6,7,8-HxCDF	<153	10.3	<232	12	<115	15.2
2,3,4,6,7,8-HxCDF	<165	8.79	<236	<8.29	<112	14.4
1,2,3,7,8,9-HxCDF	<161	6.53	<229	8.35	<115	<13.7
1,2,3,4,7,8-HxCDD	<158	<7.25	<226	<3.65	<107	<11.2
1,2,3,6,7,8-HxCDD	<164	7.81	<235	<6.63	<111	11.4
1,2,3,7,8,9-HxCDD	<164	<7.68	<235	<4.93	<111	13.3
1,2,3,4,6,7,8-HpCDF	<121	<9.5	<174	21.4	<82.6	14.5
1,2,3,4,7,8,9-HpCDF	<122	4.19	<176	<7.29	<83.7	10.5
1,2,3,4,6,7,8-HpCDD	<114	19.3	<158	70.9	<74.7	27.1
OCDF	<257	<11.1	<418	47.5	<178	23.8
OCDD	<255	110	<415	330	<177	151
PERCENT SURROGATE RECOVERIES						
13C-TCDF	66		99		64.7	
13C-TCDD	62.9		93.2		66.4	
13C-PeCDF	56.7		141		83.3	
13C-PeCDD	66.9		105		73.7	
13C-HxCDF	52.7		75		52.6	
13C-HxCDD	52.8		75.8		56	
13C-HpCDF	70.3		101		73.9	
13C-HpCDD	77.3		107		81.5	
13C-OCDD	57.6		90.1		67.6	

Table 6. GC/MS screen data summary for Cement Kilns 2 (Hannibal)

GC/MS FILE No.:	HI6A1	HI6A2	HI6A3	HI6A4	HI6A5	HI6A6	HI6A7	HI6A8	HI6A9
Sample name:	BLANK TRAIN	METH. BLANK	METH. BLANK	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
No. of splits:	4	2	2	4	2	4	4	4	2
Detection limit (total ug):	40	20	20	40	20	40	40	40	20
Compound									
SURROGATES									
D10-PYRENE	94.0%	110.0%	95.0%	110.0%	93.0%	100.0%	95.0%	100.0%	98.0%
2,4,6-TRIBROMOPHENOL	140.0%	120.0%	75.0%	150.0%	160.0%	150.0%	150.0%	87.0%	73.0%
TARGET COMPOUNDS									
Total amount in ug									
ANILINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
BENZYL ALCOHOL	140	76	140	1000*	1000*	800*	800*	1000*	700*
BENZOIC ACID	< 40	< 20	< 20	2000*	1000*	2000*	2000*	1000*	300*
AZOBENZENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
PHENOL	< 40	< 20	< 20	< 40	130	290	98	120	270
BIS(2-CHLOROETHYL)ETHER	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2-CHLOROPHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
1,3-DICHLOROBENZENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
1,4-DICHLOROBENZENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
1,2-DICHLOROBENZENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2-METHYL PHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	30
2,2'-OXYBIS(1-CHLOROPROPANE)	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
4-METHYL PHENOL	< 40	< 20	< 20	< 40	87	90	110	110	110
N-NITROSO-DI-N-PROPYLAMINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
HEXACHLOROETHANE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
NITROBENZENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
ISOPHRONE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2-NITROPHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2,4-DIMETHYL PHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
BIS(2-CHLOROETHOXY)METHANE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2,4-DICHLOROPHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
1,2,4-TRICHLOROBENZENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
NAPHTHALENE	< 40	< 20	< 20	210	1000*	1000*	1000*	1000*	1000*
4-CHLOROANILINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
HEXACHLORO-1,3-BUTADIENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
4-CHLORO-3-METHYL PHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2-METHYL NAPHTHALENE	< 40	< 20	< 20	75	170	260	160	260	250
HEXACHLOROCYCLOPENTADIENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2,4,6-TRICHLOROPHENOL	< 40	< 20	< 20	< 40	44	< 40	58	< 40	< 20
2,4,5-TRICHLOROPHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2-CHLORONAPHTHALENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2-NITROANILINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
DIMETHYL PHTHALATE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
ACENAPHTHYLENE	< 40	< 20	< 20	< 40	160	200	130	190	170
2,6-DINITROTOLUENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
3-NITROANILINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
ACENAPHTHENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
2,4-DINITROPHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
4-NITROPHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
DIBENZOFURAN	< 40	< 20	< 20	< 40	170	250	170	230	180
2,4-DINITROTOLUENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
DIETHYL PHTHALATE	< 40	< 20	< 20	< 40	< 20	< 40	47	< 40	< 20
4-CHLOROPHENYL-PHENYL ETHER	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
FLUORENE	< 40	< 20	< 20	< 40	44	50	< 40	75	75

Table 6. GC/MS screen data summary for Cement Kilns 2 (Hannibal)

GC/MS FILE No.:	H16A1	H16A2	H16A3	H16A4	H16A5	H16A6	H16A7	H16A8	H16A9
Sample name:	BLANK TRAIN	METH. BLANK	METH. BLANK	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
No. of splits:	4	2	2	4	2	4	4	4	2
Detection limit (total ug):	40	20	20	40	20	40	40	40	20
Compound									
4-NITROANILINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
4,6-DINITRO-2-METHYL PHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
N-NITROSO-DIPHENYLAMINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
4-BROMOPHENYL-PHENYL ETHER	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
HEXACHLOROBENZENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
PENTACHLOROPHENOL	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
PHENANTHRENE	< 40	< 20	< 20	< 40	200*	270	150	290	200*
ANTHRACENE	< 40	< 20	< 20	< 40	22	< 40	< 40	41	49
CARBAZOLE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
DI-N-BUTYL PHTHALATE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
FLUORANTHENE	< 40	< 20	< 20	< 40	77	80	< 40	110	100
PYRENE	< 40	< 20	< 20	< 40	49	48	< 40	87	86
BENZYL BUTYL PHTHALATE	< 40	< 20	< 20	< 40	ND	< 40	< 40	< 40	< 20
3,3'-DICHLOROBENZIDINE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
BENZ[A]ANTHRACENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	20
CHRYSENE	< 40	< 20	< 20	< 40	38	< 40	< 40	57	63
BIS(2-ETHYLHEXYL)PHTHALATE	< 40	37	46	<100*	<100*	<100*	<100*	<100*	<100*
DI-N-OCTYL PHTHALATE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
BENZO[B]FLUORANTHENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
BENZO[K]FLUORANTHENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
BENZO[A]PYRENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
INDENO[1,2,3-C,D]PYRENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
DIBENZ[A,H]ANTHRACENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20
BENZO[G,H,I]PERYLENE	< 40	< 20	< 20	< 40	< 20	< 40	< 40	< 40	< 20

* Response greater than calibration curve. Value is estimate only.

Table 7. Tentatively Identified Compounds in Hannibal Cement Kiln Emissions

GC/MS FILE No.:			H16A1	H16A2	H16A3	H16A4	H16A5	H16A6	H16A7	H16A8	H16A9
Sample name:			BLANK TRAIN	METH. BLANK	METH. BLANK	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
No. of splits:			4	2	2	4	2	4	4	4	2
Detection limit (total ug):			1	1	1	1	1	1	1	1	1
NON-TARGET MAJORS	Total amount in ug										
Name	Scan Range										
Isocyanobenzene	194								186		
Subst. benzene	369		252	157		548					
C4 benzene	388						26				132
Subst. benzene	395					56					
Alkane	417					122	44	476	226		258
Subst. benzene	424					188					
Unknown	508										87
Unknown	524										94
Phthalic anhydride	553							112			
C1 naphthalene	561										83
Alkane	586										91
C2 naphthalene	615						55				
C2 naphthalene	642						60				
Subst. benzene	650						64				
C2 naphthalene + Alkane	657	661				140	100	138		160	90
Subst. benzene	678	681				164	73	180	160	152	95
Alkane	688					106					
C3 naphthalene	726									156	
Naphthalenecarboxaldehyde	733	737					104	180		138	119
Subst. benzene	739									102	
Bromochlorinated unknown	763						53				
C3 naphthalene + 2nd compd	768	771						132		152	74
Unknown	826						54				
Alkane	848	849				64		168		176	
Alkane	914								120		
Phenanthrenedione	922	923					127	238	220	184	
Phenalenone + Alkane	1046							162			
Alkane	1228										18
Alkane	1367										33
Alkane	1672										18

APPENDIX B-8

GALBRAITH LAB ANALYSIS RESULTS

HARRY W. GALBRAITH, PH.D
CHAIRMAN OF THE BOARD

KENNETH S. WOODS
PRESIDENT

GAIL R. HUTCHENS
EXECUTIVE VICE-PRESIDENT

VELMA M. RUSSELL
SECRETARY/TREASURER

GALBRAITH
Laboratories, Inc.

QUANTITATIVE MICROANALYSES
ORGANIC – INORGANIC
615/546-1335

P.O. BOX 51610
KNOXVILLE, TN 37950-1610

2323 SYCAMORE DR.
KNOXVILLE, TN 37921-1750

Mr. Dan March
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

August 1, 1990

Received: July 20th
PO#114195

Dear Mr.March:

Analysis of your compounds gave the following results:

	Your #,	Our #,	mg/liter TOC,
Run 1	1006	M-6687	6
2	2006	M-6688	3
3	3006	M-6689	6
4	4006	M-6690	6 6
5	5006	M-6691	8
6	6006	M-6692	8

WATER FRACTION
of Lime Slurry

ETTER AND SHIPMENTS BY U.S. MAIL · P.O. BOX 51610, KNOXVILLE, TN 37950-1610. OTHER CARRIERS · 2323 SYCAMORE DR. KNOXVILLE, TN 37921-1750
ESTABLISHED 1950

	Your #,	Our #,	% Cl,	BTU/pound,	
Run 2	2004	M-6693	1.83	10498	LIQUID WASTE
3	3004	M-6694	1.57	9837	
2	2008	M-6696	1.01	7828	Powdered waste
3	3008	M-6697	1.35	8158	
4	4008	M-6698	1.69 1.51	8709 8932	
HCl Test	5045	M-6699	1.72	12630	LIQUID WASTE

Sample # 4004 will be ready later.

Sincerely yours,

GALBRAITH LABORATORIES, INC.

Gail R. Hutchens

Gail R.Hutchens
Exec.Vice-President

GRH:np

HCl Sample Summary

		HCl Train	Dilution Train
Run 1			
	Caustic	1032	1020
	Acidic	1033	1021
	Rinse	1035	1024
	Filter	No filter	1025
Run 2			
	Caustic	2032	2020
	Acidic	2033	2021
	Rinse	No rinse	No rinse
	Filter	No filter	2025
Run 3			
	Caustic	3032	3020
	Acidic	3033	3021
	Rinse	3034	No rinse
	Filter	3035	3025
Run 4			
	Caustic	4032	4020
	Acidic	4033	4021
	Rinse	4052	4024
	Filter	4035	4025
Run 5			
	Caustic	5032	5020
	Acidic	5033	5021
	Rinse	5034	5024
	Filter	5035	5025
Run 6			
	Caustic	6032	6020
	Acidic	6033	6021
	Rinse	6034	6024
	Filter	6035	6025
HCl Test			
	Caustic	5045	5049
	Acidic	5046	5050
	Rinse	5047	5051
	Filter	5048	5052

HARRY W. GALBRAITH, PH.D
CHAIRMAN OF THE BOARD

KENNETH S. WOODS
PRESIDENT

GAIL R. HUTCHENS
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SECRETARY/TREASURER

GALBRAITH
Laboratories, Inc.

QUANTITATIVE MICROANALYSES
ORGANIC – INORGANIC
615/546-1335

P.O. BOX 51610
KNOXVILLE, TN 37950-1610

2323 SYCAMORE DR.
KNOXVILLE, TN 37921-1750

Mr. Dan March
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

August 3, 1990

Received: July 17th
PO#114195

Dear Mr.March:

Analysis of your compounds gave the following results:

Your #,	Our #,	NH_3 as N, mg/liter	K, ppm	Cl^- mg/liter
1020	M-6000	0.3	0.9	145
1021	M-6001	0.3	2.9	10
1024	M-6002	1.3	<0.6	101
1032	M-6004	9.0	32.6	613
1033	M-6005	6.3	31.3	378
5049	M-6003	0.3	<0.6	29
1035	M-6006	1.9	6.2	38
1050	M-6007	0.5	0.7	405
1051	M-6008	1.7	<0.6	248
1052	M-6009	1285	1.0	1034
1048	M-6010	1.3	11.2	<0.4
1049	M-6011	0.4	110	<0.4
2020	M-6012	0.3	<0.6	9
2021	M-6013	0.3	0.6	159
5050	M-6014	0.4	1.4	4
2032	M-6015	15.1	<0.6	152

LETTER AND SHIPMENTS BY U.S. MAIL · P.O. BOX 51610, KNOXVILLE, TN 37950-1610. OTHER CARRIERS · 2323 SYCAMORE DR. KNOXVILLE, TN 37921-1750
ESTABLISHED 1950

Your #,	Our #,	NH_3 as N, mg/liter	K, ppm	Cl^- mg/liter
2033	M-6016	0.3	1.9	1
3020	M-6017	1.2	<0.6	230
3021	M-6018	0.6	2.5	54
5051	M-6019	0.3	<0.6	<0.4
3032	M-6020	22.2	0.6	837
3033	M-6021	15.2	1.0	297
3034	M-6022	2.6	31.0	14
5045	M-6023	1.3	<0.5	164
4020	M-6024	0.9	<0.5	408
		0.8	<0.6	424
4021	M-6025	0.6	<0.6	75
		0.8	<0.6	71
4024	M-6026	0.4	2.1	2
		0.4	2.1	2
5046	M-6027	28.1	0.8	9
4032	M-6028	17.6	<0.6	842
		17.5	<0.6	861
4033	M-6029	9.9	<0.6	315
		9.4	<0.6	358
4052	M-6030	4.1	39.6	5.9
		3.2	40.2	5.8
5047	M-6031	0.2	302	2.4
5020	M-6032	<0.1	0.2	15.3
5021	M-6033	0.3	0.7	2.5
5024	M-6034	2.8	<0.6	<0.4
6034	M-6035	1.0	15.5	7.7
5032	M-6036	42.1	<0.6	168
5034	M-6037	0.5	17.8	10.6

Your #,	Our #,	NH_3 as N,	Potassium,	Chloride,
6033	M-6038	14.8 mg/liter	14.6 mg/liter	126 mg/liter
6020	M-6039	<0.1 mg/liter	<0.6 ppm	7.0 mg/liter
6021	M-6040	84.3 mg/liter	<0.6 ppm	1.8 mg/liter
6024	M-6041	7.6 mg/liter	<0.6 ppm	<0.4 mg/liter
6032	M-6042	23.0 mg/liter	14.1 ppm	133.6 mg/liter
6025	M-6043	26.1 µg/filter	1860 µg/filter	1343 µg/filter
5035	M-6044	1248 µg/filter	30050 µg/filter	17201 µg/filter
5025	M-6045	43.2 µg/filter	1575 µg/filter	1239 µg/filter
6035	M-6046	2410 µg/filter	14775 µg/filter	5250 µg/filter
1025	M-6047	40.5 µg/filter	1525 µg/filter	1253 µg/filter
2025	M-6048	87.2 µg/filter	3610 µg/filter	1805 µg/filter
3025	M-6049	8.7 µg/filter	4515 µg/filter	1574 µg/filter
5052	M-6050	52.3 µg/filter	1005 µg/filter	1185 µg/filter
3035	M-6051	32.6 µg/filter	37950 µg/filter	543 µg/filter
4025	M-6052	64.8 µg/filter 73.8 µg/filter	6100 µg/filter 6060 µg/filter	1835 µg/filter 1855 µg/filter
4035	M-6053	29.6 µg/filter 26.8 µg/filter	62000 µg/filter 62500 µg/filter	13276 µg/filter 13436 µg/filter
5048	M-6054	31.4 µg/filter	24500 µg/filter	729 µg/filter

Sincerely yours,

GALBRAITH LABORATORIES, INC.

Gail R. Hutchens/ke

Gail R. Hutchens
Exec.Vice-President

GRH:np

HARRY W. GALBRAITH, PH.D
CHAIRMAN OF THE BOARD

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GALBRAITH
Laboratories, Inc.

QUANTITATIVE MICROANALYSES
ORGANIC – INORGANIC
615/546-1335

P.O. BOX 51610
KNOXVILLE, TN 37950-1610

2323 SYCAMORE DR.
KNOXVILLE, TN 37921-1750

Mr. Dan March
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

August 2, 1990

Received: July 20th

Dear Mr.March:

Analysis of your compound gave the following results:

Your #,	Our #,	% Cl,	BTU/pound,
4004	M-6695	1.69	10713
		1.62	10396

RUN 4 LIQUID WASTE

Sincerely yours,

GALBRAITH LABORATORIES,INC.

Gail R. Hutchens/Bn

Gail R.Hutchens
Exec.Vice-President

GRH:np

ETTER AND SHIPMENTS BY U.S. MAIL · P.O. BOX 51610, KNOXVILLE, TN 37950-1610. OTHER CARRIERS · 2323 SYCAMORE DR. KNOXVILLE, TN 37921-1750
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APPENDIX B-9

HCl DATA

Tables 1-7 of this appendix summarize the data from the HCl and HCl dilution trains for each ion. A QA/QC data table is also included. The appendix also contains raw data on the HCl CEM, HCl dilution train and HCl train. Note that the HCl train used a VOST console and dry gas meter for run 1, but was switched to a standard M5-style meter box and dry gas meter for the remaining runs.

TABLE 1. CHLORIDE ANALYSIS RESULTS FOR STACK MM5-HCl SAMPLING TRAIN

Run	Train Component		CL- conc. (mg/L)	Impinger volume (L)	CL- Quantity found (mg)	Total CL- (mg)	Stack gas sample volume (dscm)	CL- (g/dscm)	Stack flow (dscm/m)	CL- emission (g/min)	CL- emission (mol/min)
1	Front half	Rinse	38	0.0644	2.45		0.258		2,710		
		Filter (a)	(a)	(a)	(a)						
	Back half	Acidic	613	0.1054	64.61						
		Caustic	756	0.0947	71.59						
	Total (b)					102.86		0.3987		1080.43	30.475
2	Front half	Rinse (c)	(c)	(c)	(c)		0.204		2,910		
		Filter (a)	(a)	(a)	(a)						
	Back half	Acidic	152	0.1778	27.03						
		Caustic	2	0.1041	0.21						
	Total (b)					27.13		0.1330		387.00	10.916
3	Front half	Rinse (d)	14	0.092	1.29	1.833	1.474	0.0012	3,000	3.73	0.105
		Filter	NA	NA	0.543						
	Back half	Acidic	837	0.4210	352.38	352.4		0.2391		717.19	20.229
		Caustic	594	0.3490	207.31	207.3		0.1406		421.93	11.901
4	Front half	Rinse (d)	5.9	0.086	0.51	13.87	1.495	0.0093	3,480	32.28	0.910
		Filter	NA	NA	13.356						
	Back half	Acidic	852	0.5070	431.96	432.0		0.2889		1005.50	28.361
		Caustic	674	0.2556	172.27	172.27		0.1152		401.00	11.311
5	Front half	Rinse	10.6	0.1400	1.48	18.68	1.503	0.0124	3,150	39.15	1.104
		Filter	NA	NA	17.201						
	Back half	Acidic	168	0.4611	77.46	77.46		0.0515		162.34	4.579
		Caustic (e)	(e)	(e)	(e)	(e)					
6	Front half	Rinse (d)	7.7	0.0610	0.47	5.72	1.502	0.0038	3,430	13.06	0.368
		Filter	NA	NA	5.25						
	Back half	Acidic	133.6	0.4955	66.20	66.20		0.0441		151.18	4.264
		Caustic	252	0.2921	73.61	73.61		0.0490		168.10	4.741
HCl (f)	Front half	Rinse	2.4	0.0566	0.14	0.869	1.442	0.0006	3,200	1.93	0.054
		Filter	NA	NA	0.729						
	Back half	Acidic	164.0	0.5353	87.79	87.79		0.0609		194.82	5.495
		Caustic	18	0.1367	2.46	2.46		0.0017		5.46	0.154

NA = Not Applicable.

a Sampling train was assembled without a filter.

b Because the train was assembled without a filter, result can only be reported for the train as one component.

c Sample was not collected during lab recovery of the sampling train.

d Rinse volume is estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

e Sample container was broken during shipment.

f The stack flowrate of 3200 dscm/m is an estimate. Measurement not performed during sampling.

TABLE 2. POTASSIUM ANALYSIS RESULTS FOR STACK MM5-HCl SAMPLING TRAIN

Run	Train Component		K+ conc. (mg/L)	Impinger volume (L)	K+ Quantity found (mg)	Total K+ (mg)	Stack gas sample volume (dscm)	K+ (g/dscm)	Stack flow (dscm/m)	K+ emission (g/min)	K+ emission (mol/min)
1	Front half	Rinse	6.2	0.0644	0.40		0.258		2,710		
		Filter (a)	(a)	(a)	(a)						
	Back half	Acidic	32.6	0.1054	3.44						
		Caustic	31.3	0.0947	2.96						
	Total (b)					6.8		0.0264		71.43	1.827
2	Front half	Rinse (c)	(c)	(c)	(c)		0.204		2,910		
		Filter (a)	(a)	(a)	(a)						
	Back half	Acidic	0.6	0.1778	0.11						
		Caustic	1.9	0.1041	0.20						
	Total (b)					0.31		0.0015		4.42	0.113
3	Front half	Rinse (d)	31.0	0.092	2.85	40.8	1.474	0.0277	3,000	83.04	2.124
		Filter	NA	NA	37.95						
	Back half	Acidic	0.6	0.4210	0.25	0.6		0.0004		1.22	0.031
		Caustic	1.0	0.3490	0.35						
4	Front half	Rinse (d)	39.9	0.086	3.43	65.68	1.495	0.0439	3,480	152.89	3.910
		Filter	NA	NA	62.25						
	Back half	Acidic	0.6	0.5070	0.30	0.45		0.0003		1.05	0.027
		Caustic	0.6	0.2556	0.15						
5	Front half	Rinse	17.80	0.1400	2.49	32.54	1.503	0.0217	3,150	68.20	1.744
		Filter	NA	NA	30.05						
	Back half	Acidic	0.6	0.4611	0.28	0.28		0.0002		0.59	0.015
		Caustic (e)	(e)	(e)	(e)	(e)					
6	Front half	Rinse (d)	15.50	0.0610	0.95	15.725	1.502	0.0105	3,430	35.91	0.918
		Filter	NA	NA	14.775						
	Back half	Acidic	14.1	0.4955	6.99	11.25		0.0075		25.69	0.657
		Caustic	14.6	0.2921	4.26						
HCl (f)	Front half	Rinse	302	0.0566	17.09	41.59	1.442	0.0288	3,200	92.29	2.360
		Filter	NA	NA	24.5						
	Back half	Acidic	0.5	0.5353	0.27	0.38		0.0003		0.84	0.022
		Caustic	0.8	0.1367	0.11						

NA = Not Applicable.

a Sampling train was assembled without a filter.

b Because the train was assembled without a filter, result can only be reported for the train as one component.

c Sample was not collected during lab recovery of the sampling train.

d Rinse volume is estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

e Sample container was broken during shipment.

f The stack flowrate of 3200 dscm/m is an estimate. Measurement not performed during sampling.

TABLE 3. AMMONIUM ANALYSIS RESULTS FOR STACK MM5-HCl SAMPLING TRAIN

Run	Train Component		NH3 conc. (mg/L)	Impinger volume (L)	NH3 Quantity found (mg)	Total NH3 (mg)	Stack gas sample volume (dscm)	NH3 (g/dscm)	Stack flow (dscm/m)	NH3 emission (g/min)	NH4+ emission (mol/min)
1	Front half	Rinse	1.9	0.0644	0.12		0.258		2,710		
		Filter (a)	(a)	(a)	(a)						
	Back half	Acidic	9	0.1054	0.95						
		Caustic	6.3	0.0947	0.60						
	Total (b)					1.67		0.0065		17.54	1.030
2	Front half	Rinse (c)	(c)	(c)	(c)		0.204		2,910		
		Filter (a)	(a)	(a)	(a)						
	Back half	Acidic	15.1	0.1778	2.68						
		Caustic	0.3	0.1041	0.03						
	Total (b)					2.71		0.0133		38.66	2.270
3	Front half	Rinse (d)	2.6	0.092	0.24	0.2726	1.474	0.0002	3,000	0.55	0.033
		Filter	NA	NA	0.0326						
	Back half	Acidic	22.2	0.4210	9.35	14.65		0.0099		29.82	1.751
		Caustic	15.2	0.3490	5.30						
4	Front half	Rinse (d)	3.7	0.086	0.32	0.3482	1.495	0.0002	3,480	0.81	0.048
		Filter	NA	NA	0.0282						
	Back half	Acidic	17.6	0.5070	8.92	11.4		0.0076		26.54	1.558
		Caustic	9.7	0.2556	2.48						
5	Front half	Rinse	0.50	0.1400	0.07	1.318	1.503	0.0009	3,150	2.76	0.162
		Filter	NA	NA	1.248						
	Back half	Acidic	42.1	0.4611	19.41	19.41		0.0129		40.68	2.389
		Caustic (e)	(c)	0.3367	(c)						
6	Front half	Rinse (d)	1.00	0.0610	0.06	2.47	1.502	0.0016	3,430	5.64	0.331
		Filter	NA	NA	2.41						
	Back half	Acidic	23	0.4955	11.40	15.72		0.0105		35.90	2.108
		Caustic	14.8	0.2921	4.32						
HCl (f)	Front half	Rinse	0.20	0.0566	0.01	0.0414	1.442	0.00003	3,200	0.09	0.005
		Filter	NA	NA	0.0314						
	Back half	Acidic	1.3	0.5353	0.6959	4.536		0.0031		10.07	0.591
		Caustic	28.1	0.1367	3.84						

NA = Not Applicable.

a Sampling train was assembled without a filter.

b Because the train was assembled without a filter, result can only be reported for the train as one component.

c Sample was not collected during lab recovery of the sampling train.

d Rinse volume is estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

e Sample container was broken during shipment.

f The stack flowrate of 3200 dscm/m is an estimate. Measurement not performed during sampling.

TABLE 4. CHLORIDE ANALYSIS RESULTS FOR DILUTION SAMPLING TRAIN

Run	Train Component		CL- conc. (mg/L)	Impinger volume (L)	CL- Quantity found (mg)	Total CL- (mg)	Stack gas sample volume (dscm)	CL- (g/dscm)	Stack flow (dscm/m)	CL- emission (g/min)	CL- emission (mol/min)
1	Front half	Rinse (b)	101	0.0410	4.14	5.39	0.199	0.0271	2,710	73.44	2.072
		Filter	NA	NA	1.253						
	Back half	Acidic (a)	145	0.1630	23.64	23.64		0.1188		321.93	9.081
		Caustic (a)	20	0.1360	2.72	2.72		0.0137		37.04	1.045
2	Front half	Rinse (c)	(c)	(c)		1.81	0.187	0.0097	2,910	28.09	0.792
		Filter	NA	NA	1.805						
	Back half	Acidic	9	0.1199	1.08	1.08		0.0058		16.81	0.474
		Caustic	318	0.1101	35.01	35.01		0.1872		544.81	15.367
3	Front half	Rinse (c)	(c)	(c)		1.57	0.183	0.0086	3,000	25.80	0.728
		Filter	NA	NA	1.574						
	Back half	Acidic	230	0.0789	18.15	18.15		0.0992		297.54	8.393
		Caustic	108	0.0939	10.14	10.14		0.0554		166.23	4.689
4	Front half	Rinse (b)	2	0.039	0.08	1.93	0.211	0.0091	3,480	31.75	0.896
		Filter	NA	NA	1.845						
	Back half	Acidic	416	0.1237	51.46	51.46		0.2439		848.72	23.939
		Caustic	146	0.1174	17.14	17.14		0.0812		282.69	7.974
5	Front half	Rinse (b)	0.4	0.043	0.02	1.26	0.117	0.0108	3,150	33.90	0.956
		Filter	NA	NA	1.239						
	Back half	Acidic	15.3	0.1269	1.94	1.94		0.0166		52.23	1.473
		Caustic	5.0	0.1084	0.54	0.54		0.0046		14.54	0.410
6	Front half	Rinse	0.4	0.0250	0.01	1.35	0.238	0.0057	3,430	19.50	0.550
		Filter	NA	NA	1.343						
	Back half	Acidic	7.0	0.1095	0.77	0.77		0.0032		11.10	0.313
		Caustic	3.6	0.1044	0.38	0.38		0.0016		5.48	0.154
HCl (d)	Front half	Rinse (b)	0.4	0.0400	0.02	1.21	0.164	0.0073	3,200	23.51	0.663
		Filter	NA	NA	1.185						
	Back half	Acidic	29.0	0.1350	3.92	3.92		0.0239		76.49	2.157
		Caustic	8.0	0.1111	0.89	0.89		0.0054		17.37	0.490

NA = Not Applicable

a Impinger volumes were estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

b Rinse volume is estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

c Sample was not collected during lab recovery of the sampling train.

d The stack flowrate of 3200 dscm/m is an estimate. Measurement not performed during sampling.

TABLE 5. POTASSIUM ANALYSIS RESULTS FOR DILUTION SAMPLING TRAIN

Run	Train Component		K+ conc. (mg/L)	Impinger volume (L)	K+ Quantity found (mg)	Total K+ (mg)	Stack gas sample volume (dscm)	K+ (g/dscm)	Stack flow (dscm/m)	K+ emission (g/min)	K+ emission (mol/min)
1	Front half	Rinse (b)	0.6	0.0410	0.02	1.55	0.199	0.0078	2,710	21.04	0.538
		Filter	NA	NA	1.525						
	Back half	Acidic (a)	0.9	0.1630	0.15	0.54		0.0027		7.35	0.188
		Caustic (a)	2.9	0.1360	0.39						
2	Front half	Rinse (c)	(c)	(c)	(c)	3.61	0.187	0.0193	2,910	56.18	1.437
		Filter	NA	NA	3.61						
	Back half	Acidic	0.6	0.1199	0.07	0.14		0.0007		2.18	0.056
		Caustic	0.6	0.1101	0.07						
3	Front half	Rinse (c)	(c)	(c)	(c)	4.52	0.183	0.0247	3,000	74.02	1.893
		Filter	NA	NA	4.515						
	Back half	Acidic	0.6	0.0789	0.05	0.28		0.0015		4.59	0.117
		Caustic	2.5	0.0939	0.23						
4	Front half	Rinse (b)	2.1	0.039	0.08	6.16	0.211	0.0292	3,480	101.60	2.598
		Filter	NA	NA	6.08						
	Back half	Acidic	0.6	0.1237	0.07	0.14		0.0007		2.31	0.059
		Caustic	0.6	0.1174	0.07						
5	Front half	Rinse (b)	0.60	0.043	0.03	1.61	0.117	0.0137	3,150	43.21	1.105
		Filter	NA	NA	1.575						
	Back half	Acidic	0.2	0.1269	0.03	0.11		0.0009		2.96	0.076
		Caustic	0.70	0.1084	0.08						
6	Front half	Rinse	0.60	0.0250	0.02	1.88	0.238	0.0079	3,430	27.09	0.693
		Filter	NA	NA	1.86						
	Back half	Acidic	0.60	0.1095	0.07	0.13		0.0005		1.87	0.048
		Caustic	0.60	0.1044	0.06						
HCl (d)	Front half	Rinse (b)	0.60	0.0400	0.02	1.03	0.164	0.0063	3,200	20.00	0.511
		Filter	NA	NA	1.005						
	Back half	Acidic	0.6	0.1350	0.08	0.24		0.0015		4.68	0.120
		Caustic	1.4	0.1111	0.16						

NA = Not Applicable

a Impinger volumes were estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

b Rinse volume is estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

c Sample was not collected during lab recovery of the sampling train.

d The stack flowrate of 3200 dscm/m is an estimate. Measurement not performed during sampling.

TABLE 6. AMMONIUM ANALYSIS RESULTS FOR DILUTION SAMPLING TRAIN

Run	Train Component		NH3 conc. (mg/L)	Impinger volume (L)	NH3 Quantity found (mg)	Total NH3 (mg)	Stack gas sample volume (dscm)	NH3 (g/dscm)	Stack flow (dscm/m)	NH3 emission (g/min)	NH4+ emission (mol/min)
1	Front half	Rinse (b)	1.3	0.0410	0.05	0.09	0.199	0.0005	2,710	1.23	0.072
		Filter	NA	NA	0.0405						
	Back half	Acidic (a)	0.3	0.1630	0.05	0.09		0.0005		1.23	0.072
		Caustic (a)	0.3	0.1360	0.04						
2	Front half	Rinse (c)	(c)	(c)	(c)	0.09	0.187	0.0005	2,910	1.36	0.080
		Filter	NA	NA	0.0872						
	Back half	Acidic	0.3	0.1199	0.04	0.07		0.0004		1.09	0.064
		Caustic	0.3	0.1101	0.03						
3	Front half	Rinse (c)	(c)	(c)	(c)	0.01	0.183	0.00005	3,000	0.14	0.008
		Filter	NA	NA	0.0087						
	Back half	Acidic	1.2	0.0789	0.09	0.15		0.0008		2.46	0.144
		Caustic	0.6	0.0939	0.06						
4	Front half	Rinse (b)	0.4	0.039	0.02	0.09	0.211	0.0004	3,480	1.47	0.086
		Filter	NA	NA	0.0693						
	Back half	Acidic	0.9	0.1237	0.11	0.19		0.0009		3.13	0.184
		Caustic	0.7	0.1174	0.08						
5	Front half	Rinse (b)	2.80	0.043	0.12	0.16	0.117	0.0014	3,150	4.39	0.258
		Filter	NA	NA	0.0432						
	Back half	Acidic	0.1	0.1269	0.01	0.04		0.0003		1.08	0.063
		Caustic	0.30	0.1084	0.03						
6	Front half	Rinse	7.60	0.0250	0.19	0.22	0.238	0.0009	3,430	3.11	0.183
		Filter	NA	NA	0.0261						
	Back half	Acidic	0.10	0.1095	0.01	8.81		0.0370		126.97	7.455
		Caustic	84.30	0.1044	8.80						
HCl (d)	Front half	Rinse (b)	0.30	0.0400	0.01	0.06	0.164	0.0004	3,200	1.22	0.071
		Filter	NA	NA	0.0523						
	Back half	Acidic	0.3	0.1350	0.04050	0.08		0.0005		1.57	0.092
		Caustic	0.4	0.1111	0.04						

NA = Not Applicable

a Impinger volumes were estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

b Rinse volume is estimated as the sample volume remaining after analyses plus the estimated volumes removed by Galbraith for these analyses.

c Sample was not collected during lab recovery of the sampling train.

d The stack flowrate of 3200 dscm/m is an estimate. Measurement not performed during sampling.

TABLE 7. ION PERCENTAGES FOUND IN SAMPLING TRAINS
(Shading indicates a complete data set.)

			Dilution Train						Stack HCl Train					
			CL- emission (g/min)		K+ emission (g/min)		NH3 emission (g/min)		CL- emission (g/min)		K+ emission (g/min)		NH3 emission (g/min)	
Run 1	Front Half		73.44	17.0%	21.04	74.1%	1.23	50.0%	NA	NA	NA	NA	NA	NA
	Back Half	Acidic	321.93	74.4%	7.35	25.9%	1.23	50.0%	NA	NA	NA	NA	NA	NA
		Caustic	37.04	8.6%					NA	NA				
	Total		432.41		28.39		2.46		1080.43		71.43		17.54	
Run 2	Front Half		28.09	4.8%	56.18	96.3%	1.36	55.5%	NA	NA	NA	NA	NA	NA
	Back Half	Acidic	16.81	2.9%	2.18	3.7%	1.09	44.5%	NA	NA	NA	NA	NA	NA
		Caustic	544.81	92.4%					NA	NA				
	Total		589.71		58.36		2.45		387.00		4.42		38.66	
Run 3	Front Half		25.80	5.3%	74.02	94.2%	0.14	5.5%	3.73	0.3%	83.04	98.6%	0.55	1.8%
	Back Half	Acidic	297.54	60.8%	4.59	5.8%	2.46	94.5%	717.19	62.8%	1.22	1.4%	29.82	98.2%
		Caustic	166.23	34.0%					421.93	36.9%				
	Total		489.57		78.61		2.60		1142.85		84.26		30.37	
Run 4	Front Half		31.75	2.7%	101.60	97.8%	1.47	32.0%	32.28	2.2%	152.89	99.3%	0.81	3.0%
	Back Half	Acidic	848.72	73.0%	2.31	2.2%	3.13	68.0%	1005.50	69.9%	1.05	0.7%	26.54	97.0%
		Caustic	282.69	24.3%					401.00	27.9%				
	Total		1163.16		103.91		4.60		1438.78		153.94		27.35	
Run 5	Front Half		33.90	33.7%	43.21	93.6%	4.39	80.3%	39.15	NA	68.20	NA	2.76	NA
	Back Half	Acidic	52.23	51.9%	2.96	6.4%	1.08	19.7%	162.34	NA	0.59	NA	40.68	NA
		Caustic	14.54	14.4%					NA	NA				
	Total		100.67		46.17		5.47		NA		NA		NA	
Run 6	Front Half		19.50	54.0%	27.09	93.5%	3.11	2.4%	13.06	3.9%	35.91	58.3%	5.64	13.6%
	Back Half	Acidic	11.10	30.8%	1.87	6.5%	126.97	97.6%	151.18	45.5%	25.69	41.7%	35.90	86.4%
		Caustic	5.48	15.2%					168.10	50.6%				
	Total		36.08		28.96		130.08		332.34		61.60		41.54	
HCL Run	Front Half		23.51	20.0%	20.00	81.0%	0.20	11.1%	1.93	1.0%	92.29	99.1%	0.09	0.9%
	Back Half	Acidic	76.49	65.2%	4.68	19.0%	1.57	88.9%	194.82	96.3%	0.84	0.9%	10.07	99.1%
		Caustic	17.37	14.8%					5.46	2.7%				
	Total		117.37		24.68		1.77		202.21		93.13		10.16	

NA = Not Available. (See Tables 1 through 6); Front half/back half comparisons not possible without filter; or broken sample bottle prohibits comparison.

SUMMARY OF HCl QA/QC SAMPLES

QA/QC Samples

Sample No.	Ion	Prepared Value	Measured Value	Percent Error
1048	K+	100 ppm	110	10.0
1049	K+	10 ppm	11.2	12.0
1050	Cl-	400 mg/L	405	1.3
1051	Cl-	200 mg/L	248	24.0
1052	Cl-	1000 mg/L	1034	3.4

Replicate Samples(a)

Sample No.	NH3(mg/L)	K(ppm)	Cl(mg/L)
4020	0.9	<0.5	408
(acid)	0.8	<0.6	424
4021	0.6	<0.6	75
(caustic)	0.8	<0.6	71
4024	0.4	2.1	2
(rinse)	0.4	2.1	2
4025	64.8	6100	1835
(filter)	73.8	6060	1855
4032	17.6	<0.6	842
(acid)	17.5	<0.6	861
4033	9.9	<0.6	315
(caustic)	9.4	<0.6	358
4052	4.1	39.6	5.9
(rinse)	3.2	40.2	5.8
4035	29.6	62000	13276
(filter)	26.8	62500	13436

(a) - All samples are from Run 4; 4020-4025 HCl Dilution;
4032-4052 HCl train.

Note - All filters are in total ug/filter, not mg/L or ppm.

Volume Corrections [illegible] Train

Run	Sample Vol.(ft3)	Temp. deg.F	Press. (in.Hg)	Meter Factor	Corr. Vol.(dscf)	Corr. Vol.(dscm)
1	[illegible]	[illegible]	29.09	1.029	9.110	0.258
2	[illegible]	102.4	29.27	1.064	7.204	0.204
3	53.134	97.8	29.11	1.064	52.060	1.474
4	52.905	88.6	29.17	1.064	52.800	1.495
5	54.066	101.4	29.34	1.064	53.055	1.503
6	53.300	94.3	29.37	1.064	53.027	1.502
HCl Test	52.826	111.0	29.31	1.064	50.914	1.442

Volume Corrections for Dilution HCl Train

Run	Sample Vol.(ft3)	Temp. deg.F	Press. (in.Hg)	Meter Factor	Corr. Vol.(dscf)	Corr. Vol.(dscm)
1	7.320	100	29.16	1.044	7.022	0.199
2	6.840	100	29.34	1.044	6.602	0.187
3	6.718	100	29.18	1.044	6.459	0.183
4	7.750	100	29.24	1.044	7.455	0.211
5	4.235	100	29.42	1.044	4.118	0.117
6	8.680	100	29.44	1.044	8.407	0.238
HCl Test	6.000	100	29.39	1.044	5.799	0.164

HCl DILUTION TRAIN RATIOS

Run	Dilution ratio
1	31.4
2	35.1
3	42.1
4	33.2
5	32.5
6	24.9
HCl	42.4

HCl Continuous Monitor

Filename:RUN5
Name:RUN5
Date:07-05-1990
Location:HANNIBAL, MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

TIME	HCl (ppm,dry)	HCl @ 7% O2 (ppm,dry)
1220	18.9	15.7
1221	15.8	12.8
1222	15.1	12.3
1223	15.6	12.9
1224	16.1	13.5
1225	14.4	12.0
1226	12.5	10.2
1227	12.6	10.2
1228	12.5	10.2
1229	21.0	17.7
1230	27.5	23.3
1231	21.6	18.2
1232	16.1	13.4
1233	18.4	15.4
1234	25.4	21.7
1235	30.5	20.3
1236	25.1	16.7
1237	15.4	10.3
1238	16.5	11.0
1239	14.4	9.6
1240	12.6	8.4
1241	11.2	7.5
1242	10.3	6.9
1243	13.2	8.8
1244	16.7	11.1
1245	13.7	9.1
1246	16.3	10.9
1247	24.2	20.2
1248	21.6	18.2
1249	29.8	24.9

1250	21.6	18.4
1251	13.0	11.0
1252	12.6	10.7
1253	11.4	9.2
1254	15.6	12.3
1255	13.2	10.8
1256	12.5	10.8
1257	10.3	8.9
1258	11.9	10.1
1259	15.8	13.8
1300	13.3	11.6
1301	13.9	12.1
1302	14.2	12.2
1303	13.3	11.4
Port change		
1319	12.8	10.2
1320	13.2	12.2
1321	12.1	10.7
1322	12.5	10.7
1323	11.4	9.7
1324	14.4	12.1
1325	12.5	10.6
1326	11.6	9.9
1327	11.4	9.8
1328	14.4	12.4
1329	19.5	16.9
1330	14.2	12.3
1331	10.9	9.4
1332	12.5	10.5
1333	12.5	10.4
1334	16.3	13.8
1335	15.6	13.2
1336	14.0	11.7
1337	11.9	9.7
1338	15.4	12.5
1339	21.7	18.2
1340	14.4	12.2
1341	11.9	10.1
1342	13.2	11.4
1343	11.1	9.5
1344	10.5	8.9
1345	11.8	10.6
1346	14.7	13.1

1347	13.9	11.6
1348	13.2	11.4
Port change		
1408	8.9	7.8
1409	9.1	8.1
1410	9.3	8.3
1411	8.2	7.1
1412	8.1	7.0

AVG = 12.2

MIN = 6.9

MAX = 24.9

HCl = Hydrochloric acid

Filename:RUN5A
Name:RUN5A
Date:07-02-1990
Location:HANNIBAL, MO
Project:9102-63-13
Operator:BG
VERSION=05/07/90

TIME	HCl (ppm, dry)	HCl @ 7% O2 (ppm, dry
1647	57.0	54.3
1648	51.2	48.8
1649	61.2	58.3
1650	76.3	72.7
1651	47.7	45.4
1652	61.9	59.0
1653	49.8	47.4
1654	51.9	49.4
1655	48.4	46.1
1656	53.5	51.0
1657	57.9	55.1
1658	65.6	62.5
1659	61.4	58.5
1700	51.9	49.4
1701	48.1	45.8
1702	61.9	59.0
1703	63.0	60.0
1704	55.6	53.0
1705	46.5	44.3
1706	43.3	41.2
1707	41.2	39.2
1708	44.2	42.1
1709	57.4	54.7
1710	62.6	59.6
1711	57.2	54.5
1712	45.8	43.6
1713	44.4	42.3
1714	52.6	50.1
1715	42.1	40.1
1716	39.8	37.9

1717	35.8	34.1
1718	33.0	31.4
1719	37.4	35.6
1720	30.2	28.8
1721	30.0	28.6
1722	36.7	35.0
1723	47.7	45.4
1724	41.9	39.9
1725	34.2	32.6
1726	30.9	29.4
1727	30.5	29.0
1728	32.3	30.8
1729	29.3	27.9
1730	28.6	27.2
1731	26.0	24.8
1732	28.1	26.8
1733	56.1	53.4
1734	41.6	39.6
1735	45.4	43.2
1736	38.4	36.6
1737	34.4	32.8
1738	27.9	26.6
1739	24.7	23.5
1740	33.3	31.7
1741	36.7	35.0
1742	30.5	29.0
1743	30.9	29.4
1744	26.5	25.2
1745	26.0	24.8
1746	23.7	22.6
1747	46.7	44.5
1748	47.0	44.8
1749	38.6	36.8
1750	37.7	35.9
1751	28.4	27.0
1752	26.7	25.4
1753	27.2	25.9
1754	30.9	29.4
1755	30.0	28.6
1756	24.7	23.5
1757	25.1	23.9
1758	27.4	26.1
1759	27.9	26.6

1800	21.9	20.9
1801	29.3	27.9
1802	22.8	21.7
1803	21.9	20.9
1804	18.4	17.5
1805	20.9	19.9
1806	39.3	37.4
1807	30.7	29.2
1808	27.4	26.1
1809	25.4	24.2
1810	17.4	16.6
1811	21.9	20.9
1812	25.6	24.4
1813	22.6	21.5
1814	29.1	27.7
1815	24.0	22.9
1816	24.2	23.0
1817	24.2	23.0
1818	26.3	25.0
1819	20.9	19.9
1820	16.3	15.5
1821	19.1	18.2
1822	16.7	15.9
1823	20.7	19.7
1824	18.8	17.9
1825	18.6	17.7
1826	17.9	17.0
1827	16.5	15.7
1828	20.2	19.2
1829	14.2	13.5
1830	15.1	14.4
1831	21.4	20.4
1832	17.7	16.9
1833	15.6	14.9
1834	12.8	12.2
1835	12.1	11.5
1836	9.5	9.0
1837	9.5	9.0
1838	9.5	9.0
1839	14.9	14.2
1840	28.6	27.2
1841	21.2	20.2
1842	24.2	23.0

1843	16.0	15.2
1844	11.4	10.9
1845	17.9	17.0
1846	12.8	12.2
1847	14.4	13.7

AVERAGE = 31.4

MINIMUM = 9.0

MAXIMUM = 72.7

AVERAGE O2 = 6.3

HCl Dilution Probe Raw Data

HCl Dilution Probe

RUN 1 6-20-90 D. Mac.

Preliminary

STACK GAS ONLY

ΔH = 1.8

TIME = 2.0 min

Initial Meter = 885.750

FINAL Meter = 885.871

DIFF = 0.121 Rate = .061 cfm

DILUTION AIR

ΔH = 1.8

TIME = 2.0 min

Initial Meter = 888.200

FINAL Meter = 892.150

DIFF = 3.950 Rate = 1.975

Dilution RATIO = 31.4 (1.975 - .061) / .061

TIME	Pump VAC	ΔH	Dry Gas Meter	Temperatures									
				ELBOW	1	2	3	4	5	6	7	EXIT	AMB
1145			899.887										
~~1145~~1150	7	1.8	909.6	606	97	94	91	90	88	86	85	72	74
1155	10	1.8	917.43	590	169	113	93	90	86	85	84.8	77	76
1200	11	1.8	—	608	213	121	96	91	87	86	84	82	82
1205	11	1.8	—	602	227	125	98	—	88	86	85	82	79
1220	12	1.8	965.02	604	248	146	104	95	89	87	85	82	76
1225	13	1.8	974.86	605	280	153	107	96	90	88	86	82	74
1230	12	1.8	985.00	601	271	156	107	97	91	88	86	82	78
1245	13	1.8	1015.10	607	275	261	111	100	93	90	88	84	74
1250	13	1.8	—	606	278	165	113	102	95	92	89	85	77
1255	13	1.8	1035.60	604	240	165	113	102	95	92	90	84	74
1300	13	1.8	1045.90	606	248	168	116	102	95	91	90	83	74
1305													
310	13	1.8	1066.55	603	240	169	114	102	94	91	90	83	76
1315	12	1.8	1076.82	602	242	168	114	102	95	—	91	83	75
1320	12	1.8	1087.21	600	235	168	114	102	95	92	91	83	75
1325	12	1.8	1097.90	598	234	167	113	103	95	92	90	84	74
1330	12	1.8	1107.1	607	249	169	115	103	96	92	91	84	78
1335	12	1.8	1117.1	610	254	170	115	104	96	92	91	84	76
1340	12	1.8	1127.4	611	257	170	114	104	96	92	91	85	78
1345	12	1.8	1137.755										

HCl Dilution Probe

RUN 2 6-21-90

Preliminary
STACK GAS ONLY
ΔH = 1.8
TIME = 2.0 min
Initial Meter = 138.250
FINAL Meter = 138.372
DIFF = 0.122
Rate = .061 cf

DILUTION AIR
ΔH = 1.8
TIME = 2.0 min
Initial Meter = 142.000
FINAL Meter = 146.400
DIFF = 4.400
Rate = 2.200

Dilution Ratio = (2.200 - .061)/.061 = 35.1

TIME	Pump VAC	ΔH	Dry GAS Meter	ELBOW	1	2	3	4	5	6	7	EXIT	AMB.
1251	13	1.5	233.333	550	257	161	122	115	110	107	105	107.8	93
1256	13	1.4	244.0	552	266	164	122	116	110	107	106	102	9
1301	13	1.4	252.9	552	265	164	123	116	109	107	105	102	9
1306	13	1.5	—	549	272	167	125	116	110	107	105	101	9
1311	13	1.6	273.7	552	273	169	124	115	110	106	105	102	9
1316	13	1.6	284.2	550	259	170	125	116	110	107	105	101	9
1321													
1331	13	1.7	315.6	557	260	170	128	117	111	108	107	104	95
1336	13	1.6	326.0	549	258	175	128	119	112	109	107	103	9
1341	13	1.6	336.6	553	256	175	128	118	112	109	108	105	9
1346	13	1.6	347.2	550	255	177	128	119	112	109	108	104	96
01 ~~1356~~	13	1.5	378.7	551	249	168	124	119	112	108	106	102	9
1406	13	1.6											
1411	13	1.7	399.9	543	248	164	126	118	111	109	107	103	9
1416	13	1.7	410.5	551	235	168	124	117	110	108	106	102	93
1431	13	1.6	442.4	548	224	174	127	118	111	108	107	103	9
1436	13	1.7	453.1	551	230	175	128	118	111	109	108	103	94
1446	13	1.7	474.4	558	256	176	129	120	113	110	108	105	95
1451	13	1.7	485.07	549	255	174	128	121	110	109	108	105	93

Final
ΔH = 1.6
Time = 2.0 min
Final meter = 485.920
Initial meter = 485.750
0.170
Rate = 0.05 cfm

HCl Dilution Probe

RUN 3 6-22-90

Preliminary
STACK GAS ONLY

ΔH = 1.8
TIME = 3.0 min

Initial Meter = 486.130
Final Meter = 486.289
DIFF = .159
Rate = .053

DILUTION AIR

ΔH = 1.8
TIME = 2.0 min

Initial Meter = 488.800
Final Meter = 493.370
DIFF = 4.57
Rate = 2.285

(2.285 - .053)/.053 = 42.1

TIME	Pump VAC	ΔH	Dry Gas Meter	Temperatures ELBOW	1	2	3	4	5	6	7	EXIT	AMB.
1135	13	1.0	533.054	505	223	127	103	97	91	87	87	86	83
1140	13	1.1	—	530	233	125	103	97	92	90	89	87	77
1155	13	1.3	573.5	531	257	128	107	96	92	89	88	86	82
1200	13	1.6	583.7	580	281	136	107	99	93	90	90	86	81
1205	13	1.6	594.0	590	281	137	107	99	95	89	89	86	80
1210	13	1.3	604.3	645	281	138	107	100	94	91	90	88	79
1215	13	1.1	614.4	647	285	133	109	100	96	91	90	87	77
1220	13	1.3	—	649	290	135	112	100	95	91	90	88	79
1225	13	1.2	—	649	290	135	109	100	95	91	90	88	80
1235	13	1.2	—	623	285	136	109	102	96	93	93	89	81
1240	13	1.1	665.9										
1250	13	1.4	686.2	624	287	137	110	101	98	95	92	88	80
1255	13	1.5	696.855										
	Shut down to fix THC sample line.												
1320	13	1.3	696.855	626	220	119	107	100	97	94	94	89	82
1325	13	1.1	707.0	624	242	120	105	100	96	93	93	89	81
	~~Stop to deal with~~												
			760.093	627	282	133	110	102	96	94	93	84	
	Stop to deal with stack HCl train												
1540	13	1.2	760.093	548	190	115	107	98	97	96	96	92	82
1545	13	1.2	769.9	634	237	113	103	98	95	93	93	91	81
1555	13	1.1	790.3	636	264	119	105	97	94	94	94	90	87
1600	13	1.1	800.4	635	268	123	107	97	95	92	91	90	84
1605	13	1.1	810.5	635	274	126	110	98	95	93	92	91	8.3
1610	13	1.1	820.698	630	240	118	102	97	95	94	94	91	83

Unable to maintain original ΔH setting — valves wide open.

6-23-90 DM/SWK

Final	154.637			155.265
Initial	154.500	~~154.660~~	154.790	155.150
Diff	.137			.115

2 MIN @ 1.25 "H_2O

Final	155.415	155.546	155.720	
Initial	155.300	155.430	155.680	
	.115	.116	.120	
1.25	÷2 = .0575 cfm	.058	.060	Avg = .0585 cfm @ 1.25 ΔH

Final	155.910	156.041	156.186	
Initial	155.800	155.930	155.070	
1.10	.110	.111	.116	
	÷2 .055 cfm	.0555 cfm	.058 cfm	Avg = .0562 cfm @ 1.10 ΔH

Final	156.455	156.777	156.966	
Initial	156.330	156.640	156.830	
	.125	.137	.136	
1.5	÷2 .0625 cfm	.0685	.068	Avg = .0663 cfm @ 1.5 ΔH

6-23-90
by SNK.

HCl Dilution Probe Calibration

AH	Time (min)	Initial	FINAL	DIFF	FLOW (cfm)	Avg.
1.2	2.0 min	820.800	820.885	.085	.0425	.044
1.2	2.0	820.900	820.991	.091	.0455	
1.1	2.0	821.020	821.116	.096	.0480	.052
1.1	2.0	821.160	821.271	.111	.0555	
1.35	2.0	821.400	821.524	.124	.062	.062
1.35	2.0	821.540	821.664	.124	.062	
1.60	2.0	821.700	821.836	.136	.068	.067
1.60	2.0	821.850	821.983	.133	.0665	

HCl Dilution Probe - Run 4

Dan March
6-23-90

Preliminary
STACK GAS ONLY
ΔH = 1.6
TIME = 2.0
Initial Meter = 822.200
FINAL Meter = 822.322
DIFF = 0.122
Rate = .061

DILUTION AIR
ΔH = 1.6
TIME = 2.0
Initial Meter = 824.000
FINAL Meter = 828.175
DIFF = 4.175
Rate = 2.087
(2.0875 - .061)/.061 = 33.2

TIME	Pump VAC	ΔH	Dry Gas Meter	Temperatures										
				ELBOW	1	2	3	4	5	6	7	EXIT	AMB
1057	14	1.4	840.000	534	176	107	99	93	90	88	89	80	7
1102	14	1.3	849.0	531	238	117	102	92	89	89	88	81	8.
1107	14	1.2	859.7	543	239	120	105	93	89	88	87	82	7
1112	14	1.3	—	531	237	124	106	93	90	88	87	83	—
1122	14	1.2	889.7	527	242	127	108	94	91	89	89	85	79
1132	14	1.3	909.8	528	252	134	110	96	92	91	90	87	8.
1142	13	1.3	930.1	531	257	137	114	97	94	93	91	88	77
52	13	1.3	950.5	526	256	137	113	97	94	92	91	89	8
1202	13	1.4	970.9	—	—	137	110	97	94	93	92	88	7
1212	13	1.3	991.5	530	257	137	111	97	94	93	91	89	8
1222	14	1.2	1002.0	531	260	135	DM ~~9~~ 113	97	94	93	92	88	7
1232	14	1.3	1032.7	530	256	140	113	97	95	93	92	89	80
1242	14	1.3	1053.3	527	272	143	114	98	95	93	92	88	7
1252	13	1.3	1074.1	528	262	143	114	98	95	94	92	87	80
1302	13	1.2	1094.8	532	269	146	116	99	96	95	92	88	7

HCl Dilution Probe

HCl Test
7-2-90

Preliminary
STACK GAS ONLY
ΔH = 1.15
TIME = 2.0 min.

Initial Meter = 189.900
FINAL Meter = 190.022
DIFF = ~~.878~~ .122
Rate = 0.061

DILUTION AIR
ΔH = 1.15
TIME = 2.0

Initial Meter = 263.500
FINAL Meter = 268.800
DIFF = 5.300
(5.3 - .122) / .122 = 42.4
Rate = 2.65 cfm

TIME	Pump VAC	ΔH	Dry GAS Meter	Temperatures ELBOW	1	2	3	4	5	6	7	EXIT	AMB
1547	6	1.2	269.864	558	227	127	118	109	108	107	106	100	93
1652	5	1.1	277.9	556	220	128	116	109	108	106	105	99	96
1657	6	1.2	285.0	544	240	127	115	108	107	104	103	99	91
1702	5	1.2	292.2	541	257	131	117	108	106	104	103	99	92
1707	6	1.1	299.4	542	268	134	118	106	106	104	103	98	96
1717	6	1.1	313.9	545	281	137	121	107	106	104	102	98	96
1732	5	1.2	336.0	546	293	149	126	109	106	104	102	98	92
1742	6	1.2	350.6	546	299	156	129	110	108	105	103	97	95
1752	5	1.1	366.0	542	300	157	131	110	110	105	104	99	98
1802	6	1.1	380.4	538	296	156	131	111	110	106	104	99	97
1812	5	1.2	395.1	543	265	157	136	112	110	107	105	100	85
1827	5	1.1	—	545	284	157	132	116	111	109	104	98	90
1847	—	—	448.035	—	—	—	—	—	—	—	—	—	—

FINAL Calibration:
ΔH = 1.2
Init: 448.050
FIN.: 448.150
.100/2 min = .050 cfm

HCl Dilution Probe

Run 5

25-90
Dm

Preliminary
STACK GAS ONLY
ΔH = ~~13~~ 1.3
TIME = 2.0 min

Initial Meter = ~~448.250~~ 450.680
FINAL Meter = ~~[illegible]~~ 450.754
DIFF = 0.074
Rate = .037

DILUTION AIR
ΔH = 1.3
TIME = 2.0 min

Initial Meter = 452.500
FINAL Meter = 454.980
DIFF = 2.48
Rate = 1.24

(1.24 - .037)/~~.034~~ .037 = 32.5 dilution rate

TIME	Pump VAC	ΔH	Dry GAS Meter	Temperatures ELBOW	1	2	3	4	5	6	7	EXIT	AMB
1050	13	1.3	456.123	507	185	120	111	99	99	98	98	94	96
1100	15	1.3	468.4	528	243	121	113	101	100	98	98	95	9
1110	15	1.3	480.7	528	261	132	117	102	102	99	99	96	9
1120	15	1.3	493.8	534	255	143	119	102	103	101	100	96	9
			500.564										
	MM5 train failed 1st port leak check												
1226	13	1.3	500.564	534	167	120	111	98	99	99	98	-	9
1236	13	1.3	512.43	536	224	127	113	100	100	99	98	-	96
	THC-Hot Flame went out. Blew out lines												
1252	13	-	512.43										93
1302	13	1.2	525.0	536	233	129	113	99	101	100	99	96	94
1315	13	1.3	540.4	531	233	136	116	100	102	100	97	96	94
1338	13	1.2	568.7	533	238	148	121	105	102	101	98	96	
1353	14	1.3	587.2	533	246	151	121	105	103	102	99	97	94
1403	14	1.3	599.8	531	247	151	123	105	103	102	99	97	91
1407		1.3	604.754										

Final Calibration

ΔH
Time

Final 605.177
Initial 605.800
Diff

Rate

HCl Dilution Probe

Run 6 7-5-90
DJM

Preliminary

STACK GAS ONLY
ΔH = 1.3 605.738 Initial Meter = 605.420
605.600 FINAL Meter = 605.560
TIME = ~~2.0~~ 3.0 .138 DIFF = .140 Rate = .046

DILUTION AIR
ΔH = 1.3 Initial Meter = 608.300
FINAL Meter = 610.680
TIME = 2.0 DIFF = 2.380 Rate = 1.19

TIME	Pump VAC	ΔH	Dry GAS Meter	Temperatures ELBOW	1	2	3	4	5	6	7	EXIT	AME
~~1800~~ 1903	15	1.3	611.600	550	187	119	108	94	96	96	93	86	9
1913	14	1.3	623.40	553	236	128	113	96	97	96	95	87	9
1923	14	1.3	635.2	553	245	127	114	97	98	97	96	92	9
1933	14	1.3	647.1	553	243	139	116	99	99	97	96	89	92
1949	14	1.3	—	552	242	146	119	100	101	99	98	90	93
2003	15	1.3	682.0	549	244	148	120	101	102	100	99	93	89
2033	17	1.3	718.3	549	274	157	120	101	102	100	98	92	89
2043	18	1.2	730.9	552	270	158	124	102	100	100	98	92	9
2123	18	1.2	781.190	553	261	160	127	103	104	102	100	94	9

Final Calibration

781.470
781.285
.185

ΔH 1.3
Time 3.0 min

RATE = 0.062

HCl Train Raw Data Sheets

HCl TRAIN

~~INTEGRATED GAS SAMPLING DATA FORM~~

ant Continental Cement
Date 6-20-90
ampling Location Stack
Operator P. McElhany
ample Container Type Impingers
Test No. 1 - Base Line
Sample Bag I.D. No.
~~Barometric~~ Pressure 29.09 (corrected)

Vost Console #5

Flow Meter: Type
I.D. —
~~Pump:~~ Type
I.D. —

Flow Control Device (Microvalve? Critical Orifice?) —
Desired Flow Rate (cc/min) —

Total Sampling Time 84 min.
Average Flow Meter Reading Off-Scale
Average Flow Rate (cc/min, l/min) 3.18 l/min
Estimated Actual Volume (liters) 266.78

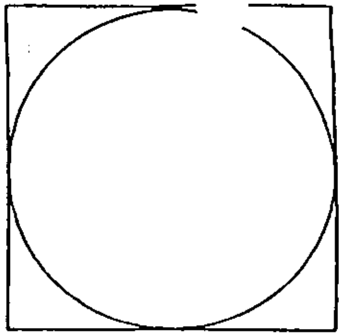
Time 24 Hr Clock	Flow Meter Reading	(liters) DGM	(in Hg) Vacuum Gauge Comments	(°F) Meter Temp
12:13	Off Scale	0.00	5	85.4
12:18	|	15.9	5	85.4
12:23	|	33.8	5	85.4
12:28	|	51.9	5	85.6
12:33	|	69.7	5	85.6
12:40	|	94.5	5	86.9
12:47 ~~1:47~~ PM	|	119.3	5	88.3
13:01	|	168.4	5	89.6
13:06	|	186.0	5	88.8
13:11	|	203.1	5.6	87.2
13:16	|	217.7	5.3	86.5
13:21	|	232.4	5.3	85.6
13:26	|	244.0	6.5	84.6
13:32	|	256.9	7.0	84.3
13:37	|	266.78	7.3	84.3

FIELD DATA

RUN NO. 2
PROJECT NO. 9102-63-13
PLANT Continental Cement
DATE 6-21-90
SAMPLING LOCATION STACK
SAMPLE TYPE HCL
OPERATOR McClhaney
FILTER NO. —
RECORD DATA EVERY — MIN.
UMBILICAL/SAMPLER HOOKUP —

PROBE NO. —
PROBE LENGTH AND TYPE 6'
SAMPLE BOX NO. —
METER BOX NO. —
TEMP. CONTROLLER NO. —
TEMP. METER NO. —
THERMOCOUPLE I.D. NO. —
UMBILICAL CORD I.D. NO. —
UMBILICAL CORD I.D. NO. —
NOZZLE NO. —

NOZZLE DIA. —
ASSUMED MOISTURE % —
METER ΔH@ —
METER CORRECTION —
PITOT NO. —
PITOT COEFFICIENT —
BAROMETRIC PRESSURE —
SITE TO BARO. ELEVATION (ft.) —
CORRECTED B.P. (0.1 in./100 ft.) —
STATIC PRESSURE —



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK $\geq 3'' H_2O$

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	1315	1439				
PASS/FAIL	Pass	Pass				

PITOT LEAK CHECK $\geq 3'' H_2O$

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	12:30				
VACUUM, In. Hg	≥15"		≥15"		≥15"
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, In. Hg		≥15"		≥15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME 236.903
FINAL VOLUME
LEAK CHECK VOLUME
ADJUSTED FINAL VOLUME 244.225

COMMENTS Filled out after MM5 Console #4

Revision 11/18/86

HCl

RUN NO. 2
DATE 6-21-90

SAMPLING LOCATION stack
PROJECT NO. 9201-63-13

p. 1 of 1
OPERATOR P. McElhaney

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft³ INITIAL ____ DESIRED	GAS METER READING (V_m), ft³ ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
	13:19		236.903		Below	Scale		98.8	99.6	0						
	13:24		237.375					99.8	99.8	3.5						
	13:29		237.745					100.0	100.2	3.5						
	13:34		238.200					101.2	101.6	3.3						
	13:39		238.672					101.6	101.4	3.5						
	13:46		239.320					102.4	102.6	3.3						
	13:52		239.890					102.4	102.6	3.0						
	14:03		241.000					102.8	103.2	2.5						
	14:09		241.550					103.8	104.2	2.5						
	14:14		242.040					103.2	103.6	*						
pmc	~~14:21~~		~~242.533~~					~~102.0~~	~~105.2~~	~~*~~						
	14:21		242.825													
	14:26		243.213					103.4	105.2	*						
	14:31		243.698					104.0	105.6	*						
	14:37		244.275					104.0	106.4	*						

COMMENTS * off scale

MIDWEST RESEARCH INSTITUTE

Run Number 3

Project Number 9102-63-13

Date 6-22-90

Plant Continental Cement

Sampling Location Stack

HCl

FIELD CREW

Crew Chief Dan Marsh

Testing Engineer

Assistant Testing Engineer

Process Engineer

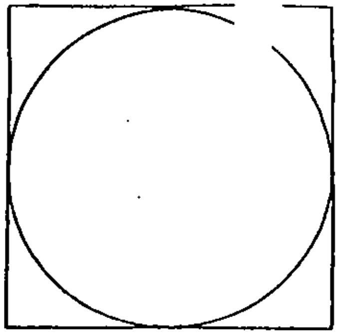
Other

FIELD [illegible] A

RUN NO. 3
PROJECT NO. 9102-63-13
PLANT Centennial Cement
DATE 6-22-90
SAMPLING LOCATION —
SAMPLE TYPE HCL
OPERATOR P. McElbany
FILTER NO. —
RECORD DATA EVERY 5 MIN.
UMBILICAL/SAMPLER HOOKUP 4H-5

PROBE NO. #2L-5
PROBE LENGTH AND TYPE 6' - Gls
SAMPLE BOX NO. 01187
METER BOX NO. 4
TEMP. CONTROLLER NO. N/A
TEMP. METER NO. —
THERMOCOUPLE I.D. NO. —
UMBILICAL CORD I.D. NO. —
UMBILICAL CORD I.D. NO. —
NOZZLE NO. —

NOZZLE DIA. —
ASSUMED MOISTURE % —
METER ΔH@ —
METER CORRECTION —
PITOT NO. —
PITOT COEFFICIENT —
BAROMETRIC PRESSURE 29.18
SITE TO BARO. ELEVATION (ft.) 25
CORRECTED B.P. (0.1 in./100 ft.) 29.11
STATIC PRESSURE -.5



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK ≥3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	~~10:10~~					
PASS/FAIL	Aborted pmc					

PITOT LEAK CHECK ≥3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	15:00	17:25				
PASS/FAIL		Pass				

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)					
VACUUM, in. Hg	≥15"		≥15"		≥15"
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, in. Hg		≥15"		≥15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME ~~347.5~~ 294.396
FINAL VOLUME 347.530
LEAK CHECK VOLUME
ADJUSTED FINAL VOLUME

COMMENTS

Revised 11/18/86

HCl

RUN NO. 3
DATE 6-22-90

SAMPLING LOCATION Stack
PROJECT NO. 9102-63-13

p. 1 of 1
OPERATOR P. McElhaney

GAS METER READING (V_m), ft³ INITIAL 294.396

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr.)	GAS METER READING (V_m), ft³ DESIRED	GAS METER READING (V_m), ft³ ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
	15:19		294.396					88	87	3.5		228	230	227		
	15:24		295.970					93	89	3		241	241	260		
	15:29		298.150				560	95	91	3		229	235	271		
	15:34		300.370				557	96	92			231	231	286		
	15:39		302.570				561	95	92	3		228	231	288		
	15:44		304.700				567	96	93			233	232	290		
	15:49		306.880				562	98	93	3.3		230	234	295		
	15:54		309.090				556	99	94	3.2		232	230	295		
	16:00		311.715				568	99	95	3.5		233	228	295		
	16:10		316.120				559	100	96	3.5		239	236	300		
	16:15		318.330				570	102	98	3.5		237	234	298		
	16:20		320.550				560	101	97	3.6		236	240	304		
	16:25		322.775				570	101	98	3.9		239	244	301		
	16:30		325.020				567	101	98	4.0		240	243	301		
	16:35		327.260				561	101	99	4.2		236	239	302		
	16:40		329.515				559	101	99	4.3		231	236	300		
	16:45		331.760				557	102	98	4.5		234	235	296		
	16:50		334.000				552	102	99	4.7		230	234	298		
	16:55		336.240				568	103	99	4.6		233	231	291		
	17:00		338.490				567	103	99	4.8		236	233	299		
	17:05		340.750				558	103	99	4.9		236	237	299		
	17:10		343.030				557	104	100	4.8		232	236	291		
	17:15		345.280				567	103	99	4.8		232	238	293		
	17:20		347.530				559	102	100	4.8		233	233	296		

COMMENTS

MIDWEST RESEARCH INSTITUTE

Run Number 4

Project Number 9102-63-13

Date 6-23-90

Plant Continental Cement

Sampling Location Stack

HCl

FIELD CREW

Crew Chief Dan March

Testing Engineer

Assistant Testing Engineer

Process Engineer

Other

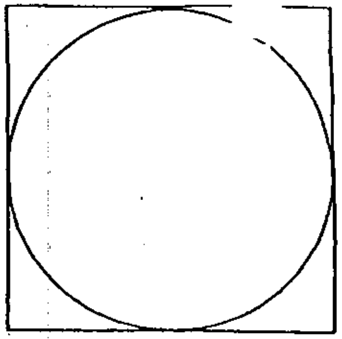
(HCl)

FIELD D A

RUN NO. 1
PROJECT NO. 9102-63-13
PLANT Continental Cement
DATE 6-24-90
SAMPLING LOCATION Stack
SAMPLE TYPE Impingers
OPERATOR P. McElhany
FILTER NO.
RECORD DATA EVERY 5 MIN.
UMBILICAL/SAMPLER HOOKUP

PROBE NO.
PROBE LENGTH AND TYPE 6'
SAMPLE BOX NO.
METER BOX NO. 4
TEMP. CONTROLLER NO.
TEMP. METER NO.
THERMOCOUPLE I.D. NO. TC-72-5
UMBILICAL CORD I.D. NO. V-50-2
UMBILICAL CORD I.D. NO.
NOZZLE NO.

NOZZLE DIA.
ASSUMED MOISTURE %
METER ΔH @
METER CORRECTION
PITOT NO.
PITOT COEFFICIENT
BAROMETRIC PRESSURE
SITE TO BARO. ELEVATION (ft.) 25'
CORRECTED B.P. (0.1 in./100 ft.)
STATIC PRESSURE



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK ≥3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	9:00					
PASS/FAIL						

PITOT LEAK CHECK ≥3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	9:00	1345			
VACUUM, In. Hg	≥15"	6"	≥15"		≥15"
CFM		.000			
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, In. Hg		≥15"		≥15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME
FINAL VOLUME
LEAK CHECK VOLUME
ADJUSTED FINAL VOLUME

COMMENTS

Revision 11/18/86

RUN NO. 4
DATE 6-23-90

SAMPLING LOCATION Stack
PROJECT NO. 9107-63-13

P. 1 of 1
OPERATOR P McElheny

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr.)	GAS METER READING (V_m), ft³ INITIAL 348.445		VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
		DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F							
	10:57		348.448				557	76	76	3.3		247	238	262		
	11:02		350.640				558	77	75	3.1		247	247	267		
	11:07		352.820				557	81	77	3.5		248	247	266		
	11:12		354.990				558	83	77			240	250	272		
	11:17		357.140				557	85	79	3.5		248	250	273		
	11:22		359.320				557	87	81	3.6		250	249	275		
	11:28		361.950				558	89	83	3.7		252	244	277		
	11:38		366.350				560	92	85	3.6		251	249	274		
	11:42		368.110				561	94	88	3.8		243	257	276		
	11:48		370.755				561	95	90	3.8		249	250	276		
	11:52		372.515				561	93	89	3.4		249	252	267		
	11:58		375.230				559	94	90	3.6		247	247	273		
	12:02		377.030				559	93	89	3.4		250	250	273		
	12:07		379.240				558	93	89	3.5		244	249	271		
	12:12		381.455			PM	~~558~~									
	12:23		386.290				558	95	91	3.6		248	249	270		
	12:28		388.500				560	96	91	3.6		252	248	274		
	12:32		390.280				562	95	92	3.7		246	247	278		
	12:37		392.480				562	96	92	3.9		242	246	274		
	12:42		394.685				564	97	93			243	249	271		
	12:47		396.990				562	97	93	4.3		244	248	273		
	12:52		399.135				558	96	93			243	250	273		
	12:57		401.350				562	96	93			246	244	276		

COMMENTS

MIDWEST RESEARCH INSTITUTE

Run Number 5A

Project Number 9102-63-13

Date 7-2-90 (HCl Test)

Plant Continental Cement

Sampling Location Stack

FIELD CREW

Crew Chief Dan Hagan

Testing Engineer [illegible] Baker

Assistant Testing Engineer

Process Engineer

Other

RUN NO. NOT A RUN (HCl TEST)
DATE 7-2-90

SAMPLING LOCATION STACK
PROJECT NO. 9102-6313

p.
OPERATOR J. Baker

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr.)	GAS METER READING INITIAL (V_m) ft³ 428.714 DESIRED	GAS METER READING ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET $(T_{m_{in}})$, °F	DRY GAS METER TEMPERATURE OUTLET $(T_{m_{out}})$, °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
	0	1647															
	5	1652	—	431.06	—	—	.64	535	103.2	100.	3"	—	—	261	270		
	10	1657	—	433.21	—	—	.61	521	104	104	3"	—	—	256	275		
	15	1702	—	435.37	—	—	.59	531	107	106	3"	—	—	256	274		
	20	1707	—	437.55	—	—	.60	529	109	106	3"	—	—	258	275		
	25	1712	—	439.75	—	—	.59	527	111	107	3"	—	—	258	270		
	30	1717	—	441.96	—	—	.60	526	112	108	3"	—	—	258	270		
	35	1722	—	444.12	—	—	.61	522	113	110	3"	—	—	258	276		
	40	1727	—	446.34	—	—	.59	531	114	111	3"	—	—	257	273		
	45	1732	—	448.57	—	—	.60	532	115	112	3"	—	—	258	269		
	50	1737	—	450.81	—	—	.59	531	116	114	3"	—	—	257	270		
	55	1742	—	453.01	—	—	.60	530	116	114	3"	—	—	258	271		
	60	1747	—	455.23	—	—	.60	528	116	115	3"	—	—	258	270		
	65	1752	—	457.46	—	—	.60	527	117	115	3"	—	—	259	272		
	70	1757	—	459.71	—	—	.60	525	118	116	3"	—	—	258	270		
	75	1802	—	461.95	—	—	.59	524	118	116	3"	—	—	258	271		
	80	1807	—	464.09	—	—	.59	523	117	116	3"	—	—	259	270		
	85	1812	—	466.27	—	—	.59	523	112	112	3"	—	—	259	269		
	90	1817	—	468.47	—	—	.59	520	110	110	3"	—	—	257	268		
	95	1822	—	470.69	—	—	.60	520	110	110	3"	—	—	261	269		
	100	1827	—	472.86	—	—	.59	518	109	109	3"	—	—	259	270		
	105	1832	—	475.02	—	—	.61	518	109	109	3"	—	—	259	270		
	110	1837	—	477.21	—	—	.60	518	108	108	3"	—	—	260	270		
	115	1842	—	479.43	—	—	.60	518	109	109	3"	—	—	260	269		
	120	1847	—	481.54	—	—	.59	512	108	108	3"	—	—	260	263		

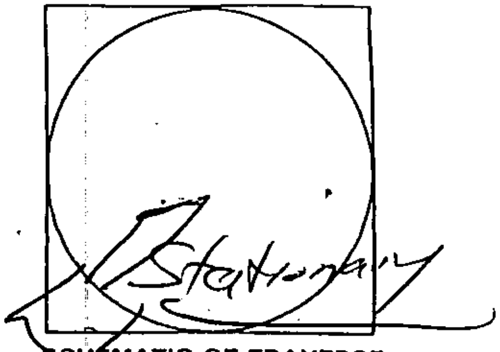
COMMENTS

FIELD DATA

RUN NO. A@T ARUN (HCl Test)
PROJECT NO. 902-637-3
PLANT Continental Cement
DATE 2-2-90
SAMPLING LOCATION STACK
SAMPLE TYPE HCl
OPERATOR Baker
FILTER NO.
RECORD DATA EVERY 5 MIN.
UMBILICAL/SAMPLER HOOKUP U-5

PROBE NO.
PROBE LENGTH AND TYPE 6'
SAMPLE BOX NO. OH-GD [illegible]
METER BOX NO. N-9 [illegible]
TEMP. CONTROLLER NO. [illegible]
TEMP. METER NO. N-9
THERMOCOUPLE I.D. NO. TG-28-5
UMBILICAL CORD I.D. NO. U-38-8
UMBILICAL CORD I.D. NO. U-38-8
NOZZLE NO.

NOZZLE DIA.
ASSUMED MOISTURE % .39
METER ΔH @ 1.59
METER CORRECTION
PITOT NO. P-9
PITOT COEFFICIENT .832
BAROMETRIC PRESSURE 29.38
SITE TO BARO. ELEVATION (ft.) 3
CORRECTED B.P. (0.1 in./100 ft.) 29.37
STATIC PRESSURE -.3



SCHEMATIC OF TRAVERSE POINT LAYOUT

29.380
- .075
29.305

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	Pass	Pass				
PASS/FAIL	1201	1647				

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)					
VACUUM, In. Hg	≥ 15"		≥ 15"		≥ 15"
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, In. Hg		≥ 15"		≥ 15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME
FINAL VOLUME
LEAK CHECK VOLUME
ADJUSTED FINAL VOLUME

COMMENTS

Revision 1/86

MIDWEST RESEARCH INSTITUTE

Run Number 5

Project Number 9102-63-13

Date

Plant Continental Cement

Sampling Location Stack

FIELD CREW

Crew Chief Dan March

Testing Engineer Frank Grammer

Assistant Testing Engineer

Process Engineer Scott Klamm

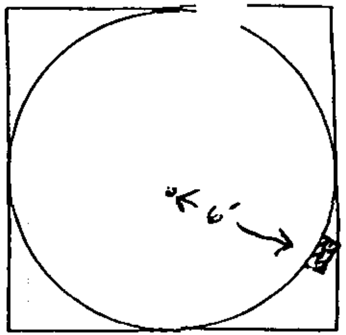
Other

FIELD DATA

RUN NO. 5
PROJECT NO. 9102-63-13
PLANT Continental Cement
DATE 7-5-90
SAMPLING LOCATION Stack outlet
SAMPLE TYPE HCL
OPERATOR Frank Gramner
FILTER NO. NA
RECORD DATA EVERY 5 MIN.
UMBILICAL/SAMPLER HOOKUP UH-5

PROBE NO. NA
PROBE LENGTH AND TYPE 22" Glass
SAMPLE BOX NO. 11187
METER BOX NO. 4
TEMP. CONTROLLER NO. NA
TEMP. METER NO. Y-1335
THERMOCOUPLE I.D. NO. 72-5
UMBILICAL CORD I.D. NO. U-50-2
UMBILICAL CORD I.D. NO. U-50-6
NOZZLE NO. 22

NOZZLE DIA. NA
ASSUMED MOISTURE % 37
METER ΔH @ 1.89
METER CORRECTION 1.064
PITOT NO. S-11
PITOT COEFFICIENT NA
BAROMETRIC PRESSURE 29.42
SITE TO BARO. ELEVATION (ft.) 80
CORRECTED B.P. (0.1 in./100 ft.) 29.34
STATIC PRESSURE -.5



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK, ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	NA	NA				
PASS/FAIL		NA				

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

B-244

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	0904	1422			
VACUUM, In. Hg	FG ~~≥15"~~ 10"	10"	≥15"		≥15"
CFM	.00~~2~~	.004			
VOLUMES	30 sec.				
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, In. Hg		≥15"		≥15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME 483.181
FINAL VOLUME 537.247
LEAK CHECK VOLUME NA
ADJUSTED FINAL VOLUME 537.247

COMMENTS

Revision 11/18/86

RUN NO. 05
DATE 7-5-90

SAMPLING LOCATION Stack outlet
PROJECT NO. 9162-63-13

p. 1 of 1
OPERATOR Frank Grammer

Down
1127
e- ur 1225
DOWN
1238
1254
Start

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr.)	GAS METER READING (V_m), ft³ INITIAL 483.181 DESIRED	GAS METER READING ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
	0	1050															
NO	5	1055	NA	485.48	NA	NA	.6	500.8	99	99	N/A	N/A	227	255	241		
traverse	10	1100		487.8			.6	499	100	98			228	265	249		
	15	1105		491.04			.6	496	102	99			227	255	254		
	20	1110		492.24			.6	491	104	100			226	239	257		
	25	1115		494.38			.6	490	103	100			224	236	258		
	30	1120		496.6			.6	490	104	101			225	226	260		
	35	1125		498.8			.6	487	104	101			221	234	258		
	40	1208		501.2			.6	498	102	101			222	234	257		
	45	1233		503.2			.6	511	97	97			220	234	248		
	50	1238		505.4			.6	510	100	99			220	238	251		
	55	1259		507.5			.6	507	99	99			221	229	250		
	60	1304		509.3			.6	508	99	99			221	234	251		
	0							507	100	98			221	235	255		
	65	1309															
	70	1314		BUSY - PORT Change													
	75	1319		516.0			.6	506	101	99			222	234	258		
	80	1324		518.1			.6	506	102	102			221	236	257		
	85	1329		Busy			.6	503	106	101			224	245	261		
	90	1334		522.5			.6	502	106	102			225	237	263		
	95	1339		524.7			.6	Busy	107	103			Busy		261		
	100	1444		Busy			.6	503	107	106			223	234	261		
	105	1449		529.3			.6	503	105	105			221	234	261		
	110	1454															
	115	1459															
	120	1504		537.247													

COMMENTS My watch is appoximately 3 minutes ahead of Karl Bakers

MIDWEST RESEARCH INSTITUTE

Run Number 6

Project Number 9102-63-13

Date

Plant Continental Cement

Sampling Location Stack

FIELD CREW

Crew Chief Don March

Testing Engineer Frank Grammer

Assistant Testing Engineer

Process Engineer Scott Klamm

Other

RUN NO. 06
DATE 7-5-90

SAMPLING LOCATION Stack outlet
PROJECT NO. 9102-63-13

p. 1 of 1
OPERATOR Frank Grammer

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr.)	GAS METER READING (V_m), ft³ INITIAL 538.355 DESIRED	GAS METER READING ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F
	0	1903													
NO	5	1908	NA	541.8	NA	NA	~~541.8~~ 1.6	514	90	90	6.8	57	240	246	253
traverse	10	1913		544.2			.6	514	92	92	3.1	53	180	249	259
	15	1918		546.2			.6	514	92	91	3.2	53	179	244	254
	20	1923		548.3			.6	514	94	91	3.2	54	181	250	253
	25	1928		550.5			.6	514	94	91	3.5	54	180	250	253
	30	1933		BUSY	Port Change		.6	514	95	92	3.5	56	180	251	255
	35	1938								Busy					
	40	1943		556.9			.6	501	98	94	4.0	57	181	253	254
	45	1948		Busy			.6	512	99	94	4.0	58	180	253	256
	50	1953		561.4			.6	510	98	95	3.4	53	179	252	258
	55	1958		563.6			.6	510	97	~~FG 97~~ 95	3.8	50	178	250	256
	60	2003		565.7			.6	509	97	95	3.8	51	176	251	254
	65	2008		567.9			.6	508	96	95	3.8	54	177	249	254
	70	2013		BUSY	PORT Change		.6	509	95	94	3.8	55	176	247	253
	75	2018						~~508~~		Busy					~~253~~ FG
	80	2023		574.3			.6	508	96	93	4.0	56	174	246	252
	85	2028		576.4			.6	508	96	93	4.0	56	174	246	250
	90	2033		~~5~~	BUSY			507			~~4.0~~	~~51~~	~~174~~	~~245~~	~~254~~ FG
	95	2038		580.9			Busy				4.0	51	174	245	254
	100	2043		583.0			.6	508	96	95	4.0	52	174	250	253
	105	2048		585.2			.6	509	95	94	4.0	53	175	248	254
	110	2053		Busy			.6	508	96	93	4.0	54	172	249	252
	115	2058		589.5			.6	508	95	93	4.2	55	172	246	249
	120	2103		591.055			.6	508	96	93	4.2	56	173	248	251

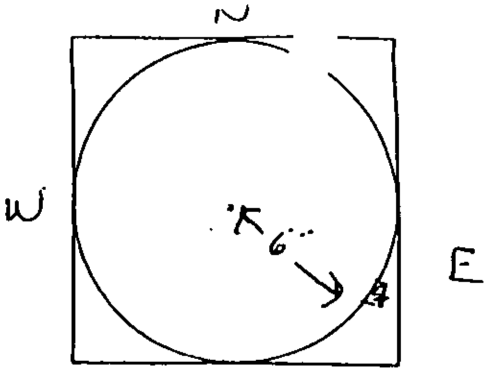
COMMENTS

FIELD DATA

RUN NO. 06
PROJECT NO. 9102-63-13
PLANT Continental Cement
DATE 7-5-90
SAMPLING LOCATION Stack outlet
SAMPLE TYPE HCL
OPERATOR Frank Grammer
FILTER NO. NA
RECORD DATA EVERY 5 MIN.
UMBILICAL/SAMPLER HOOKUP

PROBE NO.
PROBE LENGTH AND TYPE 72'' glass
SAMPLE BOX NO.
METER BOX NO. 4
TEMP. CONTROLLER NO.
TEMP. METER NO.
THERMOCOUPLE I.D. NO.
UMBILICAL CORD I.D. NO. u-50-2
UMBILICAL CORD I.D. NO. u-50-6
NOZZLE NO.

NOZZLE DIA.
ASSUMED MOISTURE % 37
METER ΔH @ 1.89
METER CORRECTION 1.064
PITOT NO.
PITOT COEFFICIENT
BAROMETRIC PRESSURE
SITE TO BARO. ELEVATION (ft.) 80
CORRECTED B.P. (0.1 in./100 ft.)
STATIC PRESSURE -.5



SCHEMATIC OF TRAVERSE POINT LAYOUT

S

PITOT LEAK CHECK ≥ 3'' H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	NA	NA				
PASS/FAIL		NA				

PITOT LEAK CHECK ≥ 3'' H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	1245	2105			
VACUUM, In. Hg	FG ~~≥15''~~ 10''	10''	≥15''		≥15''
CFM	.001	.004			
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, In. Hg		≥15''		≥15''	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME
FINAL VOLUME
LEAK CHECK VOLUME
ADJUSTED FINAL VOLUME

COMMENTS

Revision 11/18/86

APPENDIX B-10

TOC ANALYSIS RESULTS

This appendix contains results of TOC analysis on the lime slurry samples and calculations of total TOC. A brief summary of the pyrolysis GC/MS analysis is also included.

Slurry density and % water were calculated by MRI's labs. Known aliquots of slurry were weighed to determine the density. Solid and liquid fractions were obtained by filtering the aliquot, drying the filter cake, and weighing to allow calculation of % solids.

Calculation of Overall TOC for Lime Slurrys

Run	Fraction	Lime Slurry Composition (% solid/liq.)	Measured TOC(%)	Measured TOC (mg/L)	TOC Quanti (mg)	Overall TOC (%)
1	Solid	61.0	0.12		0.0732	
	Liquid	39.0		6	0.0002	
	Total				0.0734	0.073
2	Solid	59.3	0.55(b)		0.3262	
	Liquid	40.7		3	0.0001	
	Total				0.3263	0.326
3	Solid	51.6	3.04(c)		1.5686	
	Liquid	48.4		6	0.0003	
	Total				1.5689	1.57
4	Solid	66.1	0.55		0.3636	
	Liquid	33.9		6(b)	0.0002	
	Total				0.3638	0.364
5	Solid	70.1	0.88		0.6169	
	Liquid	29.9		8	0.0002	
	Total				0.6171	0.617
6	Solid	68.6	0.33		0.2264	
	Liquid	31.4		8	0.0003	
	Total				0.2267	0.227

(a) - Basis of 100 g sample total, water density of 1 g/mL.
(b) - Average of two replicates.
(c) - Duplicate analysis performed to verify measured value.

GERG
Geochemical and Environmental Research Group
Ten South Graham Road
College Station, Texas 77840
TEXAS A&M UNIVERSITY
Telephone: (409) 690-0095
FAX: (409) 690-0059
TELEX: 910-380-8722

1 August 1990

Scott Klamm
Midwest Research Institute
425 Volker Blvd.
Kansas City, MO

Dear Scott:

Enclosed are TOC analysis results for the industrial cement kiln study (per GERG SOP-8907). These samples were particularly difficult to analyze and the following comments should be noted. A number of samples could not be dried even after several days of exposure in a recirculating oven at 50°C. This affected our ability to obtain an accurate sample weight and apparently the samples were moist with something other than water. The values on many samples approach the detection limit of the method (~0.05%). The samples were inhomogenous causing more than usual scatter in replicate analyses. Average TOC values are reported for each sample with replicates provided for the samples as requested. If you have any questions, please call.

Sincerely yours,

Mahlon C. Kennicutt

Mahlon C. Kennicutt II, Ph.D.
Associate Research Scientist

MCK/dep
enclosure

Table 1. Total organic carbon content of industrial cement kiln samples.

	Sample I.D.	TOC (%)
RUN 1	1006	0.12
2	2006	0.85, 0.25
3	3006	3.04
4	4006	0.55
5	5006	0.88
6	6006	0.33

SOLIDS FRACTION
of
Lime Slurry

GERG
Geochemical and Environmental Research Group
Ten South Graham Road
College Station, Texas 77845
TEXAS A&M UNIVERSITY
Telephone: (409) 690-0095
FAX: (409) 690-0059
TELEX: 910-380-8722

November 29, 1990

Scott Klamm
Associate Environmental Engineer
Midwest Research Institute
425 Volker
Kansas City, MO 64110

Dear Scott,

We have analysed the two samples which you sent to us earlier this month. The shale sample contained 1.8 % TOC while the limestone sample was below our level of detection. The anaysis was performed on a Leco furnace using the same procedure as we used on previous samples. If I can be of further assistance, please feel free to contact me.

Sincerely,

Stephen Sweet
Research Associate

HARRY W. GALBRAITH, PH.D
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Laboratories, Inc.
QUANTITATIVE MICROANALYSES
ORGANIC – INORGANIC
615/546-1335

P.O. BOX 51610
KNOXVILLE, TN 37950-1610

2323 SYCAMORE DR.
KNOXVILLE, TN 37921-1750

Mr. Dan March
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

August 1, 1990

Received: July 20th
PO#114195

Dear Mr.March:

Analysis of your compounds gave the following results:

	Your #,	Our #,	mg/liter TOC,
RUN 1	1006	M-6687	6
2	2006	M-6688	3
3	3006	M-6689	6
4	4006	M-6690	6 6
5	5006	M-6691	8
6	6006	M-6692	8

Continental Samples – WATER Fraction of LIME Slurrys

SUMMARY OF PYROLYSIS ANALYSIS OF SHALE AND LIMESTONE SAMPLES

Each of the two solid materials was analyzed by the technique of thermal desorption-GC/MS. Small aliquots (approximately 10 mg) of the material was placed in a quartz sample tube. For the limestone sample, the material appeared rather heterogeneous, so care was taken to include some of the sandy portion of the material as well as some chunks of the rocky portion.

Thermal desorption-GC/MS analysis of the samples was conducted using the conditions listed in Table 1. A typical experiment is begun by mounting the sample in the pyrolysis probe, inserting the probe into the interface to the GC and initiating the heating cycle. Once the thermal desorption event is concluded, the probe is removed and the GC/MS analysis is started. Analytical data is acquired in the conventional full-scan GC/MS mode.

The GC/MS instrumentation was calibrated daily for mass assignment. A blank, consisting of an empty sample tube, was analyzed prior to the analysis of the samples. Replicate analysis of the shale material was conducted.

For each material, the major GC/MS peaks were tabulated and tentatively identified based upon their mass spectral library search results. The abundance of each GC/MS peak relative to the other identified peaks was computed. In addition, specific mass chromatograms were plotted to determine the overall characteristics of the materials. Results are tabulated overleaf.

Table 1. Experimental parameters for thermal desorption-GC/MS analysis of shale, limestone, and raw meal composite.

Mass Spectrometry

Instrument:	Finnigan/MAT 4000
Ionization Mode:	70 eV electron ionization
Source ionizer temperature:	170°C
Resolution:	unit
Scan rate:	1.0 s/scan
Scan range:	40-500 amu
Data system:	Finnigan/MAT INCOS

Gas Chromatography

Instrument:	Hewlett-Packard 5890
Column:	DB-5 (J & W Scientific) 30 m x 0.25 mm i.d.
Injector Temperature:	270°C
GC/MS interface type:	Direct coupling
Interface temperature:	280°C
Carrier gas:	He at 7 psi
Temperature program:	40°C - 300°C at 10°C/min, initial hold for 4 minutes

Thermal Desorption

Instrument:	Chemical Data Systems Model 122 Extended Pyroprobe
Probe type:	Pt coil probe
Desorption temperatures:	500°C
Desorption time:	1 minute
Sample split:	30:1
TD-GC interface temp.:	250°C

Results from duplicate analyses of shale samples.

Tentative Identification[1]	Scan No.	% Total Peak Area[2] Run#1	% Total Peak Area[2] Run#2	%RD[3]
Air	18	-	-	-
Air	65	-	-	-
Cycloalkane	218	1.0	0.9	13
Alkane	246	2.6	1.4	59
Cycloalkane	295	6.0	3.5	52
Unknown	310	2.9	0.8	117
Xylene	340	3.4	4.5	27
Alkane	378	5.7	7.2	23
Alkane	430	4.6	5.4	17
Alkene	448	3.8	3.5	8
Alkane	468	2.8	3.5	22
Alkane	500	6.3	10.2	48
Alkane	526	6.9	6.2	10
Alkane	552	1.6	1.5	5
Alkane	565	2.9	2.6	12
Alkane	588	1.6	1.8	11
Alkane	610	7.0	8.3	17
C4-Alkylbenzene	665	3.1	6.1	65
Alkane	708	6.3	6.5	3
Alkane	721	3.8	3.3	13
Alkane	775	2.9	2.6	13
Alkane	799	7.7	6.5	16
Alkane	884	3.9	4.6	16
Alkane	934	1.6	0.1	181
Alkane	963	3.7	3.1	17
Alkane	1039	3.0	1.1	93
Alkane	1074	0.6	1.4	80
Alkane	1110	1.4	1.1	27
Alkane	1115	1.1	1.0	14
Alkane	1177	0.7	0.5	25
Alkane	1242	0.5	0.4	24
Alkane	1303	0.5	0.3	43

1. Tentative identification given to GC/MS peak.
2. Percent of the total area for the peaks in this table.
3. %RD=percent relative difference.

Results for thermal desorption-GC/MS of limestone.

Tentative Identification[1]	Scan No.	Peak Area	% Total Area[2]
Air	6	151680	-
Air	65	178352	-
Acetic acid	216	35472	14.7
Benzoic acid	673	124016	51.4
Unknown	887	8960	3.7
Phthalate ester	1034	28352	11.7
Alkane	1173	8776	3.6
Alkane	1518	17424	7.2
Alkane	1566	5408	2.2
Diphenylbutanone	2243	13088	5.4

1. Tentative identification given to GC/MS peak.
2. Percent of the total area for the peaks in this table.

APPENDIX C

QA/QC

APPENDIX C

SUMMARY OF QUALITY ASSURANCE AUDITS

This appendix describes the audits conducted during the course of the experimental activities associated with this demonstration test. Audits were conducted by T. Dux, the primary Quality Assurance Coordinator (QAC) for this project, and D. Hooton. All audits were reported to the project leader (D. Trenholm), the MRI Corporate Quality Assurance Unit (C. Green had oversight for this project) and appropriate line management and individual task leaders.

1.0 OVERALL AUDIT SUMMARY

A comprehensive auditing program was planned and conducted for this demonstration test. This program included an on-site technical systems audit and a comprehensive audit of data quality for measurement processes. During each audit the following general areas were addressed:

1. Adherence to test plan and referenced methods.
2. Implementation of all planned quality control (QC) procedures.
3. Satisfying the criteria for data quality indicators and calibration procedures.
4. Sufficient documentation to support test results.
5. Validation of all test results.
6. Verification of the accuracy of calculations.
7. Proper discussion in the final report of all data quality problems affecting test objectives.

The overall results of the audit indicate:

1. Test results were obtained as indicated in the test report.
2. All data quality problems were reviewed by project management and pertinent issues are discussed in the test report.
3. The majority of data quality indicators met the criteria of the test/QA plan or applicable reference method.
4. Data quality should be sufficient to meet the test objectives.

The remainder of the report documents the specific activities for each audit and any data quality problems noted by the auditor which could affect sample results. Where appropriate, the problems and its affect on data quality are discussed in the relevant sections of the final report.

2.0 AUDITS OF FIELD ACTIVITIES

There were five audits of activities directly associated with field sampling and field analyses. First, a technical systems audit of field operations was conducted. Second, an audit of data quality associated with the field operations was done by reviewing the supporting records. Third, fourth and fifth, similar audits were done for the continuous emission monitors, hydrogen chloride determinations and field GC sampling and analysis.

2.1 Technical Systems Audit of Field Operations

The audit was conducted on June 21, 1990, Run Number 2; the QAC was present from initial set up to final disposition of samples. During the audit, the QAC compared actual field operations to the specifications in the applicable procedures and the draft test/QA plan. Specific audit forms with applicable questions/observations were generated for this audit from the test plan and associated methods.

The following operations were observed:

- Sampling of lime slurry, liquid waste, process water, and coal.
- Delivery of waste feed both solid and liquid.
- VOST sampling by Method 0030.
- SVOST sampling by Method 0010.
- Sampling for hydrogen chloride (both trains).
- Sampling, calibration, and analysis by field GC.
- Operation and calibration of CEMS.
- Disassembly and storage of the MM5 train components.
- Disassembly and storage of VOST condensate and cartridges.

In general most field operations were conducted in accordance to the methodology and the draft test/QA plan. Personnel appeared to be well trained and competent. There was sufficient information recorded in most cases to completely support the data generated during this demonstration test. Most calibration, leak checks and associated QC procedures and information were well within criteria.

The following topics were noted during the audit:

1. This project was in a state of flux resulting numerous changes in conditions and specifications for the trial burn. The draft sampling plan does not completely reflect the work conducted during demonstration test. In addition, problems

developed during the run which required corrective action. Therefore, the activities in the test report in some cases do not exactly match what was indicated in the test plan. Major changes in the test plan and data quality problems were communicated to EPA personnel on a "real-time" basis to assure proper resolution.

The following minor difficulties and differences between the test plan and the actual conduct of the work were noted for Run 2:

- A different sampling port was required for VOST.
- A different sampling set up was used for the bag sampling.
- The nitrogen bias check of sampling lines for the CEMS and field GC was not done.
- A different filter was needed for the chloride train.
- A different sampling rate was used for chloride.
- A different sampling rate and sample volume was needed for VOST.
- Water was noted condensing in the unheated THC lines.

None of these items prevented achieving the project objectives.

2. Due to a change in the schedule for this test, the MRI HCl monitor was in use on another project and a monitor was borrowed from the EPA. The EPA monitor was received on-site and was not functioning.

3. Some process and waste feed sampling was conducted by facility personnel. The test plan indicated that MRI was to conduct all sampling, however, on some days facility personnel would not allow MRI samplers access to plant equipment (e.g., sampling ports and valves.) In these cases, an MRI technician observed all sampling except for powdered waste feed. Since powdered waste feed sampling was not done or observed by MRI personnel, the traceability and integrity of the sample cannot be MRI's responsibility.

2.2 Audit of the Data Quality of Field GC Sampling and Analysis

The QAC reviewed the conduct of the work as documented in the records and compared it to the test plan to assure that it met project requirements. The analyses and results for Run 4 were completely traced and selected results were verified.

The project records were complete and well organized. Results were traceable to raw data. All QC procedures were implemented, all QC results were calculated and met criteria. Two items noted during the audit are presented below and are discussed with the data in the final report.

1. The ethylene analysis was not possible in the field due to its coelution with ethane. This was done later in the laboratory, thus, the 24 h holding time by the plan for these samples could not be met. No ethylene was detected.

2. The field notebook indicated a flow rate problem with the Tedlar bag sample (C_1/C_2 determination) which may have resulted in a sample not representative of the entire Run 4.

2.3 Audit of the Data Quality of Field Sampling as Indicated by the Field Records

The QAC reviewed the field records (raw data, observations and calibration data) and traced the activities associated with Run 4. This was done to assure that the test plan and associated methods were conducted as planned, that valid field samples were obtained and that results for field sampling and calibration activities were traceable.

The audit indicated that most data was traceable and most QC checks met the appropriate criteria. The following topics were noted during the audit.

1. The MM5 train for run 4 failed the final leak check because the probe cracked while removing it from the port. The sample was judged to be valid.

2. A few final calibration records are incomplete for pyrometer, thermocouple, pitot tube, and VOST console data. This did not have significant impact on data quality.

2.4 Hydrogen Chloride Analyses

The QAC reviewed the raw data and final results for the HCl data associated with sampling trains. The results of the work were compared to the requirements of the test/QA plan. Selected samples were traced through the raw data and results were verified by the QAC.

The audit indicated that some work was not conducted according to the test plan and as a result some sample results are estimates and a few could not be reported. Evaluation of the data indicated that the estimated results, should be usable and that sufficient data were obtained to meet the overall needs of the project. The specific problems and impact are presented in the test report in the discussions of both sampling and final results.

2.5 Continuous Emission Monitors (CEMS)

The data were reviewed for general traceability, accurate representation, and compliance to the "Draft Test and QA Plan, Continental Cement Wet Kiln, Hannibal, Missouri." The following minor comment was noted.

Some loss of data was noted for Runs 5 and 6 due to technical problems during sampling, but these appear to be less than 10% of total sampling time.

3.0 AUDITS OF LABORATORY ACTIVITIES

There were three primary analyses conducted after the test; analysis of the Volatile Organic Sampling Train (VOST) for volatile organic compounds, analysis of the Modified Method 5 (MM5) sampling train for polychlorinated dibenzodioxins and dibenzofurans (PCDD/F) and analysis of the MM5 sampling train for semivolatile analytes.

3.1 Volatile Organic Sampling Train Analysis

The QAC reviewed the raw data, final results and summary memo. The results of the work were compared to the requirements of the test and QA plan. Selected samples were traced through the raw data and results were verified by the QAC.

The audit indicated that experimental work was conducted according to the test plan. The raw data package was organized and complete. Sample data were traceable and results were verifiable. The following topics were noted during the audit.

1. The 1,4-Dioxane results are suspect due to these two difficulties:
    a. At least one-third of the blanks had significant levels of the analyte with an average level of 560 ng. Many sample results are beneath the blank.
    b. The daily standard results were erratic. The recovery of the analyte in the daily standards ranged from the analyte not being detected to 920% of the actual concentration.
2. Two tubes (Run 1 Pair 3 Tenax and Run 2 Pair 3 Tenax) were received cracked and the contents were switched to another VOST tube for analysis. The samples have significantly higher levels of methylene chloride (10 to 20 times) than any of the other samples associated with those runs. There is a high probability that the methylene chloride is a result of laboratory contamination occurring during the switching of the packing material and methylene chloride levels for these two samples should not be used in engineering assessments.

3.2 PCDD/F Analysis of MM5 Samples

The QAC reviewed the raw data, final results and summary memo. The results of the work were compared to the requirements of the test and QA plan. Two samples (run 4 and blank train) were traced through the raw data and selected results were verified by the QAC. The following topics were noted during the audit.

1. There is a surrogate recovery objective of 40% to 120%. This was not met for the majority of the analytes in Run 4, the blank train and one water matrix spike. In these cases surrogates were all low, around 25% to 35%. PCDD/F results from Run 4 have been flagged in the final report.

   In addition, the matrix spike for Run 4 shows high recoveries for all the native PCDD/F, the other matrix spike gave generally acceptable surrogate and native recoveries. This indicates that the sample might have been incorrectly spiked with surrogates.

2. Elevated matrix spike recoveries occurred for the homolog data for HxCDD, HxCDF, HpCDF, and PeCDF. Appendix B-7 explains this more thoroughly.

3. The majority of the field samples (Runs 1, 2, 3, and 4) were processed without a method blank. Method blanks were run with the next batch of samples (Run 5 and spikes). This means that the majority of the samples are not directly associated with a blank. In addition, the blank train was extracted alone and appears to have consisted of only an XAD and filter. See Appendix B-7 for more information.

3.3 Semivolatile Analysis of MM5 Samples

The QAC reviewed the raw data, final results and summary memo. The results of the work were compared to the requirements of the test and QA plan. Two samples (Runs 4 and 6) were traced through the raw data and selected results were verified by the QAC. The audit of sample preparation activities are reported above with the audit on PCDD/F analyses.

In general sample results were traceable and generated according to the test and QA plan. Quality control procedures were implemented and most were within QC criteria. Following is a discussion of QA/QC topics from the audit.

1. Extraction holding times were met for all samples. Analysis holding times (40 days past extraction) were not met (exceeded by 11 days) for Runs 1, 2, 3, 4, and the blank train. Only Runs 5 and 6 met the analysis holding times.

2. There is a data quality objective of 70% to 130% recovery for the two surrogates. Each train had a different fraction spiked. The recoveries of d_{10}-pyrene were within the objectives and the average recovery for all six runs was 99% ± 6 (s). The surrogate 2,4,6-tribromophenol had some recoveries above the objectives, however, the average recovery was 128% ± 38 (s) which is within the objective.

3. The ether extraction for Run 4 evaporated to dryness during the night due to insufficient cooling capacity of the condensers. The impact upon sample results appears to be negligible since Run 4 data are comparable to other run's results.

4. Bis-2-ethylhexylphthalate was present in the blanks at levels between 20 to 50 µg, and present in samples at levels between 20 to 90 ng. This compound is a common laboratory contaminant and any result less than two times the blank level (e.g. < 100 ng) should be considered suspect.

APPENDIX D

RISK ASSESSMENT CALCULATIONS BY RADIAN

This appendix contains results of an independent risk assessment performed by RADIAN Corporation. These calculations were based on preliminary PCDD/PCDF data which is slightly different than the final data published in this report. Variations in the final data are less than 3%, however, minimizing any impact on these risk assessment calculations.

HEALTH RISK ASSESSMENT FOR
THE CONTINENTAL CEMENT KILN,
HANNIBAL, MISSOURI

prepared by;

RADIAN CORPORATION

Roger Christman, Project Manager
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Steven T. Cragg, Toxicologist
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November 1990

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EXECUTIVE SUMMARY

Radian Corporation was asked by the Office of Solid Waste of the Environmental Protection Agency (EPA) to conduct a risk assessment for dioxin emissions from the Continental Cement Kiln in Hannibal, Missouri. Results were based on dioxin stack analyses from four different incineration "runs," where different materials were burned in the kiln for each run. The first and fifth runs represented baselines where coal and coal/diesel fuel, respectively, were the only materials incinerated. In the third and fourth runs (a second run was apparently aborted), hazardous waste material was burned.

Ambient air concentrations of dioxins and furans resulting from measured kiln emissions at the stacktop were estimated within a 10,000 meter radius using SCREEN and ISCLT air dispersion models. TCDD-equivalent concentrations projected by the models at various "receptor" locations were converted to excess cancer risks using the EPA Cancer Potency Slope (a.k.a., the "unit risk" factor) for the dioxin isomer, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). In addition to a polar array of 360 receptors, the receptor network included 31 receptors to assess risks at specific locations, such as residences and public gathering places (e.g., schools, hospitals, government buildings, and recreational areas). The impact to the most exposed individual (MEI) location was also evaluated. The MEI location comprises that location on the ground where maximum annual average dioxin concentrations would occur.

Using conservative assumptions, cancer risks exceeded 1 chance in 1,000,000 only at the MEI and one of the elevated terrain locations for any of the runs. At present, no humans are located at either of these locations. MEI baseline cancer risks for a coal-only run (run #1) were 0.67 chance in 1,000,000 and were 2.3 in 1,000,000 for the coal and diesel fuel run (run #5). Risks to the MEI for the two kiln runs where hazardous waste was burned, produced risks of approximately 2 in 1,000,000 and 4 in 1,000,000 (runs #3 and #4, respectively). Risks at the elevated terrain location were approximately half that for the MEI for all runs. Results from the second hazardous waste run (run #4) are suspect due to low surrogate recoveries during chemical analysis.

1.0 INTRODUCTION

Radian conducts risk assessments for sites in accordance with procedures set forth in the US EPA Risk Assessment Guidance for Superfund, Volume 1. Human Health Evaluation Manual (Part A) (EPA, 1989a). Other guidance documents include, but are not limited to, The Risk Assessment Guidelines for 1986 (EPA, 1987a), and the Superfund Exposure Assessment Manual (EPA, 1988a).

The overall objectives of any risk assessment are listed below.

- o Identify contaminants of concern (i.e., indicator chemicals) from existing site data.
- o Characterize on-site exposure pathways by which chemicals might migrate through environmental media.
- o Identify locations where contact with humans or other receptors might occur.
- o Estimate contaminant concentrations at probable contact points.
- o Compare concentrations at contact points with appropriate guidelines and standards.
- o Define those receptors (human and environmental) who might be exposed at the contact points.
- o Calculate human and other receptor exposures at the contact points.
- o Evaluate the potential noncarcinogenic and carcinogenic health impacts associated with estimated receptor exposure levels.

For this risk assessment, the first two of these objectives are already defined. Specifically, dioxin is the sole chemical of concern and air is the pathway of concern.

2.0 Approach

The following is a generalized description of the approach used to evaluate potential public health and environmental impacts. There are four basic phases of a risk assessment that incorporate the objectives listed above.

Analytical Chemistry Evaluation and Selection of Chemicals of Concern: The quality of the risk assessment depends on the accuracy and completeness of the data upon which it is based. Chemical sampling and analysis of the site must be extensive enough to support the calculation of average concentrations representative of site contamination. This information must be of sufficient quality so that chemicals contributing the major risks may be identified along with their migration pathways, contact locations, and critically impacted receptors. Off-site concentrations must be characterized so that only chemicals that are specifically associated with the site influence risk calculations. Finally, analytical detection limits must allow sufficient sensitivity to quantify risks for the more potent chemicals.

Dioxins are the chemicals of concern for this assessment. The term "dioxins" comprises a class of polychlorinated dibenzo-p-dioxins and, often, the related class of chemicals, chlorinated dibenzofurans. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is considered the most toxic and carcinogenic isomer of either the dioxin or furan class. When "dioxins" are not speciated (i.e., when the individual isomers within each class are not quantified separately), it is the conservative practice to assign the toxicity of 2,3,7,8-TCDD to the entire class. This may markedly overestimate carcinogenic risks depending on the ratio of isomers actually present.

Exposure Assessment: The exposure assessment describes the on- and off-site movement of the chemicals and identifies and characterizes potentially exposed populations. Exposure pathways through which chemicals may contact human or environmental receptors are identified. The concentrations of indicator chemicals at receptor points are measured analytically or they are predicted by mathematical modeling. At this point, concentrations in the various media at contact points are compared to Applicable or Relevant and Appropriate Requirements (ARARs). Since no Federally mandated ARARs exist for dioxin in air, the uptake and absorption of this chemical by humans and critical environmental receptors is calculated to determine dosage or uptake..

In this assessment for the Continental facility, it is not necessary to calculate a dosage since EPA requested evaluation of only one contaminant migration pathway (air) and only one route of exposure (inhalation). Thus, it is sufficient to calculate exposure concentrations..

Toxicity Assessment: The intrinsic toxicity of the indicator chemicals is described in this phase. Major target organs are identified and other effects, such as possible reproductive hazards or cancer-causing potential, are described. Indicator chemical reference doses (RfDs) which represent acceptable daily intakes for non-carcinogenic effects are identified, as are cancer potency slopes (CPS's) if the chemical is capable of causing cancer. If RfDs or cancer potency slopes have not been derived by EPA or other appropriate scientific authorities, they may have to be derived from appropriate animal or human toxicity data. Relevant physical and chemical properties of the contaminants are also presented which might influence the likelihood of exposure.

Risk Characterization: In this phase, the exposure and toxicity assessments are integrated. The ground level concentrations estimated in the exposure assessment are compared with health-based concentrations described or developed in the toxicity assessment, in order to estimate the potential for non-cancer public health or environmental impacts. In addition, excess cancer risks are calculated by multiplying estimated exposure concentrations by the unit risk factor for dioxins and furans (as 2,3,7,8-TCDD equivalents), the chemicals of concern in this risk assessment. The risk characterization phase also includes a summary of the assumptions used in the assessments and explains the resulting uncertainties and limitations of the risk assessment.

3.0 CHEMICAL OF CONCERN SELECTION

The chemical of concern at this facility is dioxin, generated during the combustion of fuels and feed materials for the production of cement. The dioxin emissions have been speciated to characterize the various proportions of dioxin isomers. Thus, it is not necessary to assume that all of the dioxins were 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). This is important since other dioxin isomers closely related to 2,3,7,8-TCDD have relative cancer potencies ranging from one half to one thousandth that of 2,3,7,8-TCDD.

4.0 CHEMICAL MIGRATION PATHWAYS AND ROUTES OF EXPOSURE

Air is the primary medium through which dioxins migrate from their release point (the facility stack). Although indirect (i.e., non-inhalation) pathways would contribute to exposure, assessment of indirect pathways is beyond the scope of this assessment and is not evaluated.

5.0 POTENTIAL RECEPTORS

Human receptors are considered of primary importance in this risk assessment. The evaluation of receptors such as wildlife, while important, is beyond the scope of this risk assessment. Dioxin impacts are evaluated for the maximum exposed individual (MEI). The MEI is assumed to reside at the location of maximum ground-level dioxin concentration, determined by mathematical modeling (see Section 6). The mathematical modeling produces an estimate of ground-level dioxin concentrations for an array of receptors including discrete receptors. The MEI location is identified which may not correspond to an actual receptor. Discrete receptor locations include churches, schools, hospitals, and individual nearby residences identified from U.S. Geological Survey (USGS) topographical maps. Receptor locations are defined in the (following) Exposure Assessment section.

6.0 EXPOSURE ASSESSMENT

An exposure assessment for dioxin emissions from the Continental Cement facility was conducted using EPA-recommended dispersion models. These models were employed to estimate ambient dioxin concentrations given facility emission data, stack characteristics, and meteorological data. Predicted ground-level dioxin concentrations will be used to assess the potential health impacts in communities south and west of the facility, including the city of Hannibal to the north. Initial modeling results reflect the application of a unit emission rate. Actual dioxin emission rates are calculated and applied to these unit emission rate results later in this section.

Two models were chosen in conducting this analysis. The SCREEN model was used to locate "worst-case" maximum concentrations under a variety of meteorological conditions and terrain heights. Results from the SCREEN model were used primarily to help design a receptor network applied in the modeling analysis in which the ISCLT model was employed. The following sections discuss the assumptions and applications of the models chosen and the methodology employed including the results of the exposure assessment for dioxins.

6.1 Model Selection

The SCREEN model was selected to help design the receptor network used in the modeling analysis. This model was also used to determine stable plume heights for potential complex terrain assessments by which the potential for maximum impacts occurring in complex terrain is evaluated. The appropriate model was selected based on the averaging time pertaining to the exposure limit for dioxin. Given annual averaged meteorological conditions represented by a joint frequency distribution, the ISCLT model can be applied to predict annual average dioxin concentrations. The combination of averaging period, potential for building downwash, and terrain relief (comprised of elevations from below stack, up to intermediate heights throughout the modeling domain), make the ISCLT model appropriate for this analysis. The latest version of the EPA approved UNAMAP Version 6 Industrial Source Complex Long-Term (ISCLT) model was selected. The EPA guidelines (EPA, 1986b), recommend using ISC to model industrial sources located in urban or rural areas where the maximum terrain elevation does not exceed stack top elevation. The ISCLT model uses the generalized Briggs plume rise equations to calculate plume rise as a function of downwind distance, and adjusts the observed wind speed from the anemometer measurement height to the emission height.

The SCREEN model can be applied to assess terrain elevations greater than the stack top. Terrain elevations greater than stack top fall into two categories; intermediate and complex terrain. Based on initial SCREEN model runs, terrain heights greater than stack top fell into the intermediate category. The high stable plume height elevation, to which comparisons were made, was 1,100 feet. SCREEN was applied to determine if a more refined model was necessary to evaluate impacts on intermediate terrain receptors. As discussed in the following sections, a further analysis with a more refined model (e.g., VALLEY, using annualized meteorological data), was not necessary.

6.2 Land Use

Land use characteristics must be identified to determine the fraction of both urban and rural land use types that exist within a 3-kilometer radius of the facility under evaluation. The land use, based on the information for that particular area, is classified as urban or rural, and this enables the selection of appropriate dispersion coefficients for input to the ISCLT model. The land use typing scheme normally employed is that of Auer (Auer, 1978). A brief examination of the Hannibal East-Ill quadrangle map shows that the land use within 3 kilometers of the plant is classified as rural. Therefore, rural dispersion coefficients were chosen.

6.3 Meteorological Data

Meteorological data applied in the SCREEN model includes prescribed "worst-case" meteorological conditions. Each meteorological condition represents a particular plume description characteristic.

Five years of meteorological data were applied in the ISCLT modeling analysis. The meteorological data for each year was processed and converted into a joint frequency distribution. Because the facility is situated in a rural environment, the meteorological data were obtained from a National Weather Service (NWS) station located in a rural environment. The Springfield, Illinois NWS station was chosen for obtaining meteorological data because of the proximity to the Continental Cement Company along with similarities of the environment between the two sites.

Sequential hourly surface meteorological data collected at the Springfield, Illinois NWS station for the five-year period, 1984 to 1988, were selected for the analysis. Hourly meteorological data were compiled and processed, creating a STAR data file (joint frequency distribution of wind speed and direction by atmospheric stability class) for input to the ISCLT model.

Other meteorological data required as input to the ISCLT model include annual average mixing height and surface temperature for each stability class, and wind speed profile exponents. These data were based on annual average values for the Northeast portion of Missouri found in Holzworth (Holzworth, 1972).

6.4 Receptors

For the purpose of assessing potential maximum impacts on intermediate terrain receptors, using the SCREEN model, the five highest near-field terrain heights were selected as discrete receptors. They include the following:

MSL Height (ft)	Distance (m)	Direction
760	1,846	SW
780	1,942	SW
800	2,346	SW
820	2,615	SE
840	3,000	SE

A receptor network compatible for use in the ISCLT model was designed and consisted of a prescribed polar-type receptor network with discrete receptors positioned at arbitrary locations throughout the network. Receptor points on the reference network are identified by polar coordinates (radial distance and azimuth bearing). Discrete receptor points are identified by cartesian coordinates (UTM easting (X) and northing (Y) positions). The reference network consists of 360 receptors identified by 10 radial distances and 36 directions spaced at 10-degree intervals. Since no information was given defining property fence lines or boundaries, the closest receptor ring distance modeled, 100 meters, provides near-field estimated concentrations. The 50-meter ring distance was too close to be modeled. This distance is within the "$3H_b$" (i.e., 3 times the building height) limit, wherein ISCLT will not calculate concentrations. The area within this limit is where building downwash occurs within the cavity region and the ISCLT model is not applicable to cavity effects. No residents have been identified within 50 meters of the stack. The remaining ring distances include 200, 400, 800, 1500, 2200, 3000, 6000, and 9000 meters. Discrete receptor points are associated with locations accessible to the public, such as schools, hospitals, churches, and municipal buildings. Other discrete receptors included residential areas and potential maximum impact locations. Table 6-1 lists the discrete receptors evaluated in the analysis.

Receptor point elevations were identified by means of the USGS topographical map system. Mean sea level (MSL) elevations were determined for each receptor for the reference polar receptor network by locating the highest elevation within an area centered on each receptor point. The area is a sector that extends half the distance to neighboring radials and rings. MSL elevations for each discrete receptor were identified at each receptor location.

6.5 Emission Data

Source data was obtained from documentation provided from stack tests conducted by Midwest Research Institute (MRI) (see Appendix A). The Continental Cement plant source consists of one stack located near several electrostatic precipitators. The stack is cylindrical in shape and extends 150 feet above the base. Stack parameters are listed in Table 6-2.

TABLE 6-1: DISCRETE RECEPTORS INCLUDED IN MODELING ANALYSIS

DATE: 11/19/90

Receptor #	Receptor Description	USGS Receptor Locations (in kilometers) X	Y	Receptor Distance From Stack (km)	Receptor Elevation (ft)
	MEI LOCATION	644.32	4393.24	0.20	670
1	Monkey Run Residence I	645.60	4392.60	1.24	500
2	Monkey Run Residence II	645.58	4392.67	1.19	520
3	Ilasco Residence I	645.01	4392.56	0.81	470
4	Ilasco Residence II	645.98	4392.38	1.68	480
5	Local Residence I	644.57	4393.10	0.11	595
6	Local Residence II	645.62	4393.05	1.11	610
7	LeBaume Cave Residence	644.33	4393.95	0.77	500
8	Residence Near 607' Terrain Point	643.88	4392.61	0.87	600
9	Residence In South Direction	644.50	4392.20	1.00	510
10	Stacktop Height Location	644.25	4393.23	0.27	740
11	Elevated Terrain Location I	644.52	4393.07	0.13	620
12	Elevated Terrain Location II	644.51	4393.04	0.16	640
13	Elevated Terrain Location III	644.34	4393.03	0.25	700
14	Blessed Sacrament School	639.05	4395.87	6.09	570
15	St. Thomas Seminary	638.60	4396.13	6.61	640
16	Mark Twain School	638.52	4396.30	6.75	610
17	Court House	640.25	4396.25	5.25	510
18	City Hall	640.80	4396.54	5.00	490
19	Central School	640.23	4396.40	5.35	570
20	Pettibone School	640.35	4396.75	5.48	630
21	St. John School	639.80	4395.80	5.39	520
22	Field School	639.67	4395.70	5.46	520
23	Antioch Church	641.67	4390.83	3.71	800
24	Hospital Along Route 61	639.65	4395.82	5.53	540
25	Hospital Along Route 36	638.83	4395.93	6.31	540
26	School Near Oakwood	637.30	4393.95	7.26	550
27	Church Near Saverton	648.33	4390.30	4.79	480
28	High School Near Mason	638.00	4397.85	8.01	640
29	Turner School (Ely Road)	635.43	4396.50	9.67	740
30	School SE of Hannibal @ Terrace Av	641.50	4395.67	3.90	530
31	3 Church/1 School @ Rts 61/36	640.15	4396.10	5.24	510

TABLE 6-2 STACK PARAMETERS AND SOURCE DATA FOR THE CONTINENTAL CEMENT FACILITY

Parameters	Units Metric	English
Stack Height	45.72 m	150.00 ft
Stack Gas Exit Temperature	544.10 Deg K	520.00 Deg F
Stack Gas Exit Velocity	15.24 m/sec	50.00 ft/sec
Stack Inside Exit Diameter	3.58 m	11.74 ft

Source Emission Rate = 1 gm/sec

Stack Coordinates X = 644520 m Y = 4393200 m

Stack Base Elevation 590 ft

A unit emission rate of 1 gram per second was assumed in the modeling analysis. The resulting modeled concentrations reflect a concentration value "Chi/Q" where Chi represents a concentration in ug/m^3 and Q denotes an emission rate of 1 gm/sec. Thus, actual stacktop emissions in g/sec may be multiplied by Chi/Q to obtain modeled concentrations at various receptor locations.

6.6 GEP Analysis

A Good Engineering Practice (GEP) stack height analysis was performed to determine if building-induced wake effects on ground-level impacts should be included as part of the modeling analysis. The GEP analysis is required as part of an EPA rulemaking governing stack height regulations (see the July 8, 1985, Federal Register). The analysis includes a formula that defines the stack height necessary to ensure that emissions from the stack do not result in excessive concentrations in the immediate vicinity of the source as a result of aerodynamic effects created by nearby structures or terrain obstacles.

The formula consists of the height of the nearby structure plus 1.5 times the height or projected width of the structure, whichever is less. "Nearby" is defined as that distance within five times the lesser of the height or width dimensions of a structure but not greater than one-half mile. Both the height and width of the structure are determined from the frontal area of the structure projected onto a plane perpendicular to the wind.

For the Continental Cement plant, the GEP stack height was calculated based on estimates of the ESP structures and their proximity to the stack. The current stack height, 150 ft, is below the GEP formula height of 200 ft. as shown in Table 6-3. However, since the stack height is higher than the calculated cavity height - the structure height plus 0.5 times the lesser dimension - only Huber-Snyder wake effects were considered as part of the ISCLT modeling analysis.

TABLE 6-3. GEP ANALYSIS

GEP Formula: $H_G = H_B + 1.5L$

H_B = Height of nearby structure

L = Lesser dimension, height or projected width

5L = Nearby distance, or one-half a mile, whichever is less

Stack Height: 150 feet

H_B = 80 feet

L = 80 feet

H_G = 2.5(80) = 200 feet

5L = 5(80) = 400 feet

Distance from stack to nearby ESP structure = 30 feet
ESP structure is, therefore, within influence.

Cavity height below which Schulman/Scire downwash algorithm is employed:

$H_C = H_B + 0.5L$

H_C = 1.5(80) = 120 feet

<u>Summary</u>:

Stack height < GEP height

Stack height > Cavity height
Huber-Snyder wake effect algorithm will be applied in the ISCLT analysis.

6.7 Modeling Results

Both SCREEN model results for intermediate terrain and results from the ISCLT model were analyzed in order to verify that maximum predicted impacts occurred for terrain heights equal to or below stack height. The SCREEN model calculations included a "simple terrain" (terrain heights limited to stack height) analysis and a complex terrain (actual terrain heights) analysis. The maximum from each analysis was selected. The SCREEN model results using this approach represent 24-hour average concentrations. To obtain annual average concentrations, the 24-hour value was multiplied by a conversion factor of 0.4. For the SCREEN model, the maximum predicted annual average concentration was 0.287 ug/m^3 (based on a 1 gm/sec emission rate) and occurred 1,846 meters to the southwest of the facility. It should be noted that this conversion from a short-term to a long-term average is very conservative since it does not consider the annual fluctuations of wind speed, direction, and atmospheric stability.

A refined analysis using the VALLEY model for intermediate terrain was not required since the maximum predicted impact from the SCREEN model results, 0.287 ug/m^3 (based on a unit emission factor), is less than the maximum predicted impact, 0.38 ug/m^3, from the ISCLT model results. The latter, more health-protective modeling results were used in this report.

Annual averaged relative concentration estimates based on a unit emission rate are presented in Tables 6-4 through 6-6. Maximum predicted concentrations for the reference receptor network are presented in Table 5-4 for each year modeled. Using the ISCLT model, the maximum annual average impact, based on 1984 meteorological data, for the reference polar receptor network is 0.3804 μg/m^3 and is predicted to occur 200 meters west of the Continental Cement plant. Table 6-5 shows the maximum annual average impact based on an emission rate of 1 gm/sec for each discrete receptor along with the appropriate year of meteorological data. The maximum impact at the MEI location is 0.38 ug/m^3 per 1 gm/sec (a.k.a., "Chi/Q").

TABLE 6-4. MAXIMUM PREDICTED IMPACTS FOR REFERENCE POLAR RECEPTOR NETWORK

STAR Data Year	Annual Predicted Impact (Chi/Q)* (xE-02)	Ring Distance (m)	Direction (Deg)
1984	38.04	200	280
1985	23.04	200	260
1986	21.56	200	280
1987	31.84	200	260
1988	16.90	200	280

* "Chi" denotes concentration (ug/m^3); and "Q" denotes emission rate (gm/sec).

TABLE 6-5: MAXIMUM PREDICTED IMPACTS AT DISCRETE RECEPTORS

DATE: 11/19/90

Receptor #		Annual Impact (Chi/Q)* x E-02	STAR Data Year
1	Monkey Run Residence I	0.17	84
2	Monkey Run Residence II	0.19	84
3	Ilasco Residence I	0.05	84
4	Ilasco Residence II	0.21	84
5	Local Residence I	0.47	84
6	Local Residence II	0.30	84
7	LeBaume Cave Residence	0.07	84
8	Residence Near 607' Terrain Point	0.15	84
9	Residence In South Direction	0.17	84
10	Stacktop Height Location	22.50	84
11	Elevated Terrain Location I	2.87	84
12	Elevated Terrain Location II	4.92	84
13	Elevated Terrain Location III	7.54	87
14	Blessed Sacrament School	0.34	84
15	St. Thomas Seminary	0.49	84
16	Mark Twain School	0.42	84
17	Court House	0.29	88
18	City Hall	0.31	88
19	Central School	0.35	88
20	Pettibone School	0.48	84
21	St. John School	0.27	84
22	Field School	0.27	84
23	Antioch Church	0.82	87
24	Hospital Along Route 61	0.30	84
25	Hospital Along Route 36	0.30	84
26	School Near Oakwood	0.38	84
27	Church Near Saverton	0.34	88
28	High School Near Mason	0.46	84
29	Turner School (Ely Road)	0.69	84
30	School SE of Hannibal @ Terrace Av	0.35	88
31	3 Church/1 School @ Rts 61/36	0.28	88

* "Chi" denotes concentration (ug/m**3); and "Q" denotes emission rate (gm/sec).

Table 6-6 shows maximum impacts in terms of actual TCDD-equivalent emission rates and TCDD-equivalent ground level concentrations at the MEI and other receptor locations. Actual TCDD-equivalent emission rates for the four runs at the Continental facility are given in the MRI report in Appendix A. The maximum predicted annual average impact among discrete receptors having regular public access is predicted to occur at the Antioch Church 3.71 kilometers west of the facility.

TABLE 6-6: EMISSION RATES AND MAXIMUM PREDICTED CONCENTRATIONS IN TCDD-EQUIVALENTS

DATE: 11/19/90

			Run 1		Run 3		Run 4		Run 5	
RECEPTOR #	RECEPTOR DESCRIPTION	1 g/sec -based Annual Impact (Chi/Q)*	Actual TCDD-Equiv Emission Rate (g/sec)	TCDD-Equiv Modeled Ground-Level Concentration (ug/m3)	Actual TCDD-Equiv Emission Rate (g/sec)	TCDD-Equiv Modeled Ground-Level Concentration (ug/m3)	Actual TCDD-Equiv Emission Rate (g/sec)	TCDD-Equiv Modeled Ground-Level Concentration (ug/m3)	Actual TCDD-Equiv Emission Rate (g/sec)	TCDD-Equiv Modeled Ground-Level Concentration (ug/m3)
	MEI LOCATION	3.80E-01	5.50E-08	2.09E-08	1.67E-07	6.34E-08	3.50E-07	1.33E-07	1.81E-07	6.89E-08
1	Monkey Run Residence I	1.70E-03	5.50E-08	9.35E-11	1.67E-07	2.83E-10	3.50E-07	5.95E-10	1.81E-07	3.08E-10
2	Monkey Run Residence II	1.90E-03	5.50E-08	1.04E-10	1.67E-07	3.17E-10	3.50E-07	6.64E-10	1.81E-07	3.44E-10
3	Ilasco Residence I	5.00E-04	5.50E-08	2.75E-11	1.67E-07	8.33E-11	3.50E-07	1.75E-10	1.81E-07	9.06E-11
4	Ilasco Residence II	2.10E-03	5.50E-08	1.15E-10	1.67E-07	3.50E-10	3.50E-07	7.34E-10	1.81E-07	3.80E-10
5	Local Residence I	4.70E-03	5.50E-08	2.58E-10	1.67E-07	7.83E-10	3.50E-07	1.64E-09	1.81E-07	8.51E-10
6	Local Residence II	3.00E-03	5.50E-08	1.65E-10	1.67E-07	5.00E-10	3.50E-07	1.05E-09	1.81E-07	5.43E-10
7	LeBaume Cave Residence	7.00E-04	5.50E-08	3.85E-11	1.67E-07	1.17E-10	3.50E-07	2.45E-10	1.81E-07	1.27E-10
8	Residence near 607' Terrain Point	1.50E-03	5.50E-08	8.25E-11	1.67E-07	2.50E-10	3.50E-07	5.25E-10	1.81E-07	2.72E-10
9	Residence In South Direction	1.70E-03	5.50E-08	9.35E-11	1.67E-07	2.83E-10	3.50E-07	5.95E-10	1.81E-07	3.08E-10
10	Stacktop Height Location	2.25E-01	5.50E-08	1.24E-08	1.67E-07	3.75E-08	3.50E-07	7.87E-08	1.81E-07	4.07E-08
11	Elevated Terrain Location I	2.87E-02	5.50E-08	1.58E-09	1.67E-07	4.78E-09	3.50E-07	1.00E-08	1.81E-07	5.20E-09
12	Elevated Terrain Location II	4.92E-02	5.50E-08	2.70E-09	1.67E-07	8.20E-09	3.50E-07	1.72E-08	1.81E-07	8.91E-09
13	Elevated Terrain Location III	7.54E-02	5.50E-08	4.14E-09	1.67E-07	1.26E-08	3.50E-07	2.64E-08	1.81E-07	1.37E-08
14	Blessed Sacrament School	3.40E-03	5.50E-08	1.87E-10	1.67E-07	5.67E-10	3.50E-07	1.19E-09	1.81E-07	6.16E-10
15	St. Thomas Seminary	4.90E-03	5.50E-08	2.69E-10	1.67E-07	8.17E-10	3.50E-07	1.71E-09	1.81E-07	8.87E-10
16	Mark Twain School	4.20E-03	5.50E-08	2.31E-10	1.67E-07	7.00E-10	3.50E-07	1.47E-09	1.81E-07	7.61E-10
17	Court House	2.90E-03	5.50E-08	1.59E-10	1.67E-07	4.83E-10	3.50E-07	1.01E-09	1.81E-07	5.25E-10
18	City Hall	3.10E-03	5.50E-08	1.70E-10	1.67E-07	5.17E-10	3.50E-07	1.08E-09	1.81E-07	5.61E-10
19	Central School	3.50E-03	5.50E-08	1.92E-10	1.67E-07	5.83E-10	3.50E-07	1.22E-09	1.81E-07	6.34E-10
20	Pettibone School	4.80E-03	5.50E-08	2.64E-10	1.67E-07	8.00E-10	3.50E-07	1.68E-09	1.81E-07	8.69E-10
21	St. John School	2.70E-03	5.50E-08	1.48E-10	1.67E-07	4.50E-10	3.50E-07	9.44E-10	1.81E-07	4.89E-10
22	Field School	2.70E-03	5.50E-08	1.48E-10	1.67E-07	4.50E-10	3.50E-07	9.44E-10	1.81E-07	4.89E-10
23	Antioch Church	8.20E-03	5.50E-08	4.51E-10	1.67E-07	1.37E-09	3.50E-07	2.87E-09	1.81E-07	1.49E-09
24	Hospital Along Route 61	3.00E-03	5.50E-08	1.65E-10	1.67E-07	5.00E-10	3.50E-07	1.05E-09	1.81E-07	5.43E-10
25	Hospital Along Route 36	3.00E-03	5.50E-08	1.65E-10	1.67E-07	5.00E-10	3.50E-07	1.05E-09	1.81E-07	5.43E-10
26	School Near Oakwood	3.80E-03	5.50E-08	2.09E-10	1.67E-07	6.33E-10	3.50E-07	1.33E-09	1.81E-07	6.88E-10
27	Church Near Saverton	3.40E-03	5.50E-08	1.87E-10	1.67E-07	5.67E-10	3.50E-07	1.19E-09	1.81E-07	6.16E-10
28	High School Near Mason	4.60E-03	5.50E-08	2.53E-10	1.67E-07	7.67E-10	3.50E-07	1.61E-09	1.81E-07	8.33E-10
29	Turner School (Ely Road)	6.90E-03	5.50E-08	3.79E-10	1.67E-07	1.15E-09	3.50E-07	2.41E-09	1.81E-07	1.25E-09
30	School SE of Hannibal @ Terrace Av	3.50E-03	5.50E-08	1.92E-10	1.67E-07	5.83E-10	3.50E-07	1.22E-09	1.81E-07	6.34E-10
31	3 Church/1 School @ Rts 61/36	2.80E-03	5.50E-08	1.54E-10	1.67E-07	4.67E-10	3.50E-07	9.79E-10	1.81E-07	5.07E-10

* Chi/Q: Chi denotes concentration (ug/m3); and Q denotes emission rate (gm/sec).

Run 1; Baseline w/coal (only)
Run 3; Waste Fired
Run 4; Waste Fired
Run 5; Baseline w/coal and diesel fuel

7.0 TOXICITY AND FATE ASSESSMENT

Although much of the following information pertains specifically to 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD), this profile is intended to reflect the fate and toxicity of all dioxins and furans which are potentially being emitted from the Continental facility. Data on 2,3,7,8-TCDD is emphasized because this isomer is the most studied of the dioxins or furans. In this regard, the profile may tend to overstate the toxicity of dioxin/furan emissions, since 2,3,7,8-TCDD is easily the most toxic isomer of all the dioxins or furans. Data were taken from several references (Sax, 1989; RTECS, 1990; HSDB, 1990; IRIS, 1990; and several EPA documents, 1986, 1988, 1989).

7.1 Physicochemical and Other Characteristics of Dioxins

Where individual parameters are noted, such as boiling point, they refer to 2,3,7,8,-TCDD specifically.

Class Name: Dioxins, Polychlorinated Dibenzo-p-dioxins

Specific Isomer Name/Synonyms:

2,3,7,8-Tetrachlorodibenzo-p-dioxin,
2,3,7,8-Tetrachlorodibenzo(1,4)dioxin,
2,3,7,8-Tetrachlorodibenzo(b,d)(1,4)dioxin,
2,3,7,8-TCDD; TCDD; TCDBD, Dioxin, Dioxine, etc.

CAS RN: 1746-01-6

NIOSH N: HP 3500000

Chemical Family: Chlorinated Hydrocarbon

Chemical Formula: $C_{12}H_4Cl_4O_2$

Molecular Weight: 321.96

Boiling Point: 305°C

Specific Gravity: 1.326 @ 20°/4°

Vapor Pressure: ~1.0E-09 mmHg @ 25°C

Water Solubility: 8 to 19 ng/L @ ~25°C

Kow: 4E+06 to 15E+06 @~25°C

Henry's Law Constant: 3.60-03 atm-m^3/mol

Koc: 3.3E+06 ml/g

Fish Bioconcentration Factor: 5,000 L/kg

Half-Life: 3500-4500 days (soil); 350-700 days (surface water); Air - N/A

7.2 Environmental Fate of Dioxins

Sources: Dioxins are formed as pyrolysis products during the combustion of chlorine-containing organics. They are not known to occur naturally. Incineration processes constitute a major source of dioxin production, where dioxins may occur in emissions at concentrations generally in the parts per trillion range (HSDB, 1990). The concentration depends upon chlorine content of the feed material, combustion conditions, and pollution control. The exhaust of engines using leaded gasoline (containing ethylene dichloride as a lead scavenger) constitutes another major source of dioxins (ibid). Dioxins also may be formed as by-products during the synthesis of chlorine-containing chemicals including, particularly, chlorinated phenols. Dioxin has been widely recognized as a contaminant of the chlorinated phenoxy acetic acid defoliant, 2,4,5-T (the active ingredient in Agent Orange), and its precursor, trichlorophenol, although modern manufacturing practices have minimized the occurrence of dioxin contamination in the manufacture of these chemicals.

Air: Most major sources release dioxins directly into air (e.g., incinerators and car exhaust). When released from these sources, most of the dioxins are tightly bound to particulate, such as fly ash, but some are in the vapor phase. Most dioxins are associated with particulate emissions due to their very low vapor pressure and their strong tendency to adsorb to solid materials. In the bound form, dioxins may be rapidly removed from the atmosphere by rainfall or dry deposition, ultimately distributing in soils or sediments. Dioxins in the vapor phase are resistant to photochemical degradation with a half-life estimated at 8.3 days (HSDB, 1990). Dioxin concentrations near Superfund sites have been measured in the range of 1 picogram per cubic meter of air. Ambient air samples from Sweden showed dioxin levels ranging from 0.02 to 0.08 pg/m^3. The empirical evidence shows that the rate of migration of dioxins from other media into air is low. This is consistent with the very low vapor pressures and Henry's law constants of all the dioxin/furan congeners.

<u>Soil</u>: Dioxin levels in U.S. soil considered to be "uncontaminated" (i.e., rural) are usually below the analytical detection limit of 0.2 ng/kg (HSDB, 1990). However, urban soil concentrations, with no known source of dioxin contamination, have been found to range up to 9.4 ng/kg. Soils in the Times Beach area of Missouri, a site of dioxin contamination, were measured as high as 382 micrograms per kg soil (ibid). Dioxin binds strongly to organic carbon in soil. This characteristic, combined with its very low water solubility, reduces dioxin mobility. Thus, dioxins do not readily leach into ground water. Because of their strong soil-binding tendencies and very low vapor pressure, dioxins do not readily evaporate into the air. At the Seveso, Italy release site, dioxins in the upper 8 to 10 cm of soil slowly volatilized, showing a persistence half-life of 1 to 3 years while deeper soils exhibited half-lifes of 12 years. Dioxins persist in the soil for long periods of time not only due to their strong absorptive properties and low volatility, but also due to the stable nature of the dioxin molecular structure, resulting in chemical and biological half-life values in soil on the order of years to decades (ibid). Despite the slow removal of dioxins from soil by this mechanism, volatilization is, perhaps, the major mechanism of dioxin transfer from soil to air, and is appreciably faster in the warmer summer months than in winter (EPA, 1988).

<u>Water</u>: This medium may be contaminated directly via aqueous effluent discharges from plants whose manufacturing processes produce dioxins as byproducts. Indirectly, particulate deposition from incinerators and other combustion devices may transfer dioxins from air to surface waters. In addition, soil erosion may contribute to dioxin levels in the aqueous environment. Dioxins have not been detected in U.S. drinking waters but have been found in measurable concentrations in 0.2 percent of STORET data on surface waters (HSDB, 1990). In leachate samples from a contaminated dump-site, dioxins were detected at a concentration of 60 ug/L. In the aqueous environment, dioxins are predominantly associated with sediments and suspended particulate. In this bound form, dioxins may persist in sediments and the water column for long periods of time due to the very low rates of release

from particle surfaces into the aqueous phase as well as the low rates of biodegradation. Solubilized dioxins may be removed from the water column by evaporation and photolysis at a relatively rapid rate. The overall rate of removal is slow, however, because the predominant direction of the equilibrium is toward the bound phase. Removal is even slower in deeper water bodies. At the water's surface, solubilized dioxins may be removed by photolysis and evaporation at a half-life rate of 10's to 100's of hours. In an actual pond environment, half-lifes are on the order of years.

Biota: In earlier studies, TCDD was determined not to bioconcentrate in aquatic organisms to the same degree as other chlorinated hydrocarbons, such as DDT, Heptachlor, Chlordane, etc. (HSDB, 1990). Bioconcentration factors (BCFs), representing the ratio of water to organism dioxin concentrations (in L/kg), reported in the earlier literature, were: ~20,000 for snails and daphnia, ~5,000 for catfish, ~6,000 for fathead minnows, and 3-8,000 for rainbow trout (ibid). The 1986 Superfund Public Health Evaluation Manual lists a BCF for TCDD of 5,000 L/kg (EPA, 1986). However, more recent studies have indicated higher BCFs for TCDD: 66,000 for carp and 100-160,000 for fathead minnows (EPA, 1988).

More recently, sediment to organism concentration ratios, rather than water to organism BCFs, have been used to estimate dioxin concentrations in aquatic organisms (EPA, 1988). This is due to the difficulty of measuring low dioxin concentrations in water required for determination of a water/organism BCF. A ratio of 1 to 10 (sediment to organism) ratio has been used recently to estimate aquatic organism concentrations (ibid). TCDD has not been found to biomagnify up the food chain, and does not concentrate in the top predatory species such as rapiers (HSDB, 1990). Studies in cattle suggest a soil to milk fat concentration ratio of 5 or less (EPA, 1988).

7.3 Toxicity of Dioxins

TCDD is one of most toxic chemicals known, either from acute (single) or chronic (longterm/repeated) exposure. Single lethal doses are less than 1 mg/kg for most species tested. For the guinea pig, an oral LD-50 of 0.6 ug/kg has been reported. Even in the least sensitive species, hamsters, the oral LD-50 was approximately 1 mg/kg, still in the "Supertoxic" category as defined in Casarett & Doull (Klaassen, 1986). The 2,3,7,8-tetrachlorodibenzo-p-dioxin, to which the above toxicity information pertains, is the most toxic of the dioxin isomers. The more highly chlorinated dioxins are also supertoxic, having oral LD-50's less than 1 mg/kg (Sax, 1989). Symptoms observed in animals treated with dioxins include; loss of appetite, porphyria, and wasting/loss of body fat. The mechanism by which dioxins exert their toxic effects is unknown. Chronic effects in animals include; liver damage, thyroid atrophy (one of most sensitive indicators), fetotoxic/teratogenic and reproductive effects, immune suppression, tissue wasting/loss of body fat, liver enzyme induction, and cancer.

Toxic effects have been observed in humans overexposed to dioxins during industrial accidents. Findings observed in such workers are; chloracne, liver damage, polyneuropathy, and psychiatric disturbances. Members of the general population have been exposed when industrial accidents (e.g., Seveso, Italy) or inappropriate disposal methods (e.g., Times Beach, Missouri) have caused dioxins to be released into the environment. In addition, U.S. military personnel and civilians were exposed to the dioxin-contaminated defoliant, Agent Orange, in Viet Nam. Most epidemiological studies of such individuals have not shown a conclusive association between exposure and adverse health effects, although much controversy surrounds the studies. A Swedish/American study reported an increased incidence of soft tissue sarcomas in individuals exposed to phenoxy herbicides (Murphy, 1986). A study conducted in New Zealand found a statistical association between phenoxy herbicide exposure and congenital defects of the foot and urethral openings, but no increase in other congenital abnormalities (ibid).

No reference dose for noncarcinogenic effects has been established for any of the dioxin isomers. A cancer potency slope of 156,000 $(mg/kg\text{-}day)^{-1}$ has been generated by EPA for 2,3,7,8-TCDD (EPA, 1986, HEAST, 1990) as well as a slope of 6,200 $(mg/kg\text{-}day)^{-1}$ for hexachlorodibenzo-p-dioxin mixture (IRIS, 1990). No potency factor is reported currently for TCDD in IRIS. EPA has revised a procedure, the "toxicity equivalence" factor (TEF) approach, which assigns potency factors to non-TCDD dioxin and furan isomers which are some fraction of that for TCDD (EPA, 1989). This scheme assigns fractional potency factors only for isomers which have chlorine atoms in the 2,3,7,8- position (ibid). The higher chlorinated isomers without chlorines in these positions are assigned potency values of zero. Mono-, di-, and tri-chlorinated DDs/DFs also are not considered carcinogenic (ibid). Briefly, 2,3,7,8-PentachloroDDs are assigned TEFs of 0.5; 2,3,7,8-HexachloroDDs - 0.1; and 2,3,7,8-OctachloroDD is 0.1 (ibid). 2,3,7,8-TCDFs have TEFs of 0.1; 1,2,3,7,8-PeCDF - 0.05; 2,3,4,-7,8-PeCDF - 0.5; 2,3,7,8-HxCDFs - 0.1; 2,3,7,8-HepCDFs - 0.01; and OctaCDF is 0.001 (ibid).

Risk Specific Concentrations (RSCs), corresponding to various probabilities of contracting cancer, are derived from cancer potency slopes using the following formula;

$$\text{RSC (ug/m3)} = (1.0\text{E-}06/1.53\text{E+}05) \times 70 \text{ kg} \times 1{,}000 \text{ ug/mg} \times 1/20 \text{ m}^3\text{/day} \times 0.75$$

where 1.0E-06 is the risk level, 1.53E+05 $(mg/kg\text{-}day)^{-1}$ is the slope factor, 70 kg is average adult body weight, 20 m^3 is the inhalation rate for an average adult, and 0.75 is the fraction absorbed during each breath. The RSC corresponding to a 1 in 1,000,000 excess lifetime cancer risk, is 3.0E-08 ug/m^3. For a 1 in 100,000 risk, the concentration is 3.0E-07 ug/m^3; and for a 1 in 10,000 risk, is 3.0E-06 ug/m^3. The "unit risk" factor for 2,3,7,8-TCDD is 3.3E-05 $(pg/m^3)^{-1}$ or 33 $(ug/m^3)^{-1}$.

8.0 RISK CHARACTERIZATION

8.1 Results

Table 8-1 shows the excess lifetime cancer risk from the Continental Cement Kiln facility. The figures in the first four columns represent the concentrations in TCDD-equivalents for each receptor. A discussion of TCDD-equivalents is included in the Section 6.0 of this report. Multiplying these values by the cancer potency slope for 2,3,7,8-TCDD yields the cancer risk to the receptors. The last four columns correspond to cancer risks for the different sampling "runs," wherein different feed materials were burned in the incinerator. Run #1 reflects baseline conditions where only coal was burned. Runs #3 and #4 represent runs where hazardous wastes were fed into the incinerator, and run #5 represents another baseline where both coal and diesel fuel were burned. For the MEI, baseline risks for run #1 (coal only) and run #2 (coal and diesel fuel) were 0.7 and 2.3 chances in 1,000,000, respectively. Runs #3 and #4, where hazardous waste was burned, yielded risks to the MEI of 2.1 and 4.4 in 1,000,000, respectively.[1] In this analysis, no individuals resided or worked near the MEI location (i.e., the MEI location was unoccupied). The only other location where slightly lower cancer risks exceeded 1 chance in 1,000,000 was at a stacktop height location on a hillside approximately 2,700 meters downwind. This location is also unoccupied by any receptor at present. Cancer risks to other locations (such as the elevated locations) and risks to discrete, non-theoretical receptors (i.e., where humans are actually located) were all less than 1 in 1,000,000.

8.2 Assumptions and Uncertainty

Many assumptions were made in this risk assessment in the face of uncertainty which tend to overestimate exposures and health impacts in order to err on the side of protecting human health. The exposure estimates and resulting cancer risks assumed that all receptors are exposed continuously for a 70-year lifetime. This means that residents and occupants of any institutional or

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[1] It should be noted that surrogate recoveries during the chemical analysis for run 4 were low (approximately one-half that for the other runs). Thus, the results from run #4 are suspect.

TABLE 8-1 EXCESS LIFETIME CANCER RISK FROM THE CONTINENTAL CEMENT KILN FACILITY

DATE: 11/19/90

RECEPTOR #	RECEPTOR DESCRIPTION	TCDD-EQUIVALENT MODELED GROUND-LEVEL CONCENTRATION				TCDD Inhalation Cancer Potency Slope (ug/m3)-1	EXCESS LIFETIME CANCER RISK			
		RUN 1 (ug/m3)	RUN 3 (ug/m3)	RUN 4 (ug/m3)	RUN 5 (ug/m3)		RUN 1	RUN 3	RUN 4	RUN 5
	MEI LOCATION	2.09E-08	6.34E-08	1.3E-07	6.9E-08	33	6.9E-07	2.1E-06	4.4E-06	2.3E-06
10	Stacktop Height Location	1.24E-08	3.75E-08	7.9E-08	4.1E-08	33	4.1E-07	1.2E-06	2.6E-06	1.3E-06
13	Elevated Terrain Location III	4.14E-09	1.26E-08	2.6E-08	1.4E-08	33	1.4E-07	4.1E-07	8.7E-07	4.5E-07
12	Elevated Terrain Location II	2.70E-09	8.20E-09	1.7E-08	8.9E-09	33	8.9E-08	2.7E-07	5.7E-07	2.9E-07
11	Elevated Terrain Location I	1.58E-09	4.78E-09	1.0E-08	5.2E-09	33	5.2E-08	1.6E-07	3.3E-07	1.7E-07
23	Antioch Church	4.51E-10	1.37E-09	2.9E-09	1.5E-09	33	1.5E-08	4.5E-08	9.5E-08	4.9E-08
29	Turner School (Ely Road)	3.79E-10	1.15E-09	2.4E-09	1.2E-09	33	1.3E-08	3.8E-08	8.0E-08	4.1E-08
15	St. Thomas Seminary	2.69E-10	8.17E-10	1.7E-09	8.9E-10	33	8.9E-09	2.7E-08	5.7E-08	2.9E-08
20	Pettibone School	2.64E-10	8.00E-10	1.7E-09	8.7E-10	33	8.7E-09	2.6E-08	5.5E-08	2.9E-08
5	Local Residence I	2.58E-10	7.83E-10	1.6E-09	8.5E-10	33	8.5E-09	2.6E-08	5.4E-08	2.8E-08
28	High School Near Mason	2.53E-10	7.67E-10	1.6E-09	8.3E-10	33	8.3E-09	2.5E-08	5.3E-08	2.7E-08
16	Mark Twain School	2.31E-10	7.00E-10	1.5E-09	7.6E-10	33	7.6E-09	2.3E-08	4.8E-08	2.5E-08
26	School Near Oakwood	2.09E-10	6.33E-10	1.3E-09	6.9E-10	33	6.9E-09	2.1E-08	4.4E-08	2.3E-08
19	Central School	1.92E-10	5.83E-10	1.2E-09	6.3E-10	33	6.3E-09	1.9E-08	4.0E-08	2.1E-08
30	School SE of Hannibal @ Terrace Ave	1.92E-10	5.83E-10	1.2E-09	6.3E-10	33	6.3E-09	1.9E-08	4.0E-08	2.1E-08
14	Blessed Sacrament School	1.87E-10	5.67E-10	1.2E-09	6.2E-10	33	6.2E-09	1.9E-08	3.9E-08	2.0E-08
27	Church Near Saverton	1.87E-10	5.67E-10	1.2E-09	6.2E-10	33	6.2E-09	1.9E-08	3.9E-08	2.0E-08
18	City Hall	1.70E-10	5.17E-10	1.1E-09	5.6E-10	33	5.6E-09	1.7E-08	3.6E-08	1.9E-08
6	Local Residence II	1.65E-10	5.00E-10	1.0E-09	5.4E-10	33	5.4E-09	1.6E-08	3.5E-08	1.8E-08
24	Hospital Along Route 61	1.65E-10	5.00E-10	1.0E-09	5.4E-10	33	5.4E-09	1.6E-08	3.5E-08	1.8E-08
25	Hospital Along Route 36	1.65E-10	5.00E-10	1.0E-09	5.4E-10	33	5.4E-09	1.6E-08	3.5E-08	1.8E-08
17	Court House	1.59E-10	4.83E-10	1.0E-09	5.3E-10	33	5.3E-09	1.6E-08	3.3E-08	1.7E-08
31	3 Church/1 School @ Rts 61/36	1.54E-10	4.67E-10	9.8E-10	5.1E-10	33	5.1E-09	1.5E-08	3.2E-08	1.7E-08
22	Field School	1.48E-10	4.50E-10	9.4E-10	4.9E-10	33	4.9E-09	1.5E-08	3.1E-08	1.6E-08
21	St. John School	1.48E-10	4.50E-10	9.4E-10	4.9E-10	33	4.9E-09	1.5E-08	3.1E-08	1.6E-08
4	Ilasco Residence II	1.15E-10	3.50E-10	7.3E-10	3.8E-10	33	3.8E-09	1.2E-08	2.4E-08	1.3E-08
2	Monkey Run Residence II	1.04E-10	3.17E-10	6.6E-10	3.4E-10	33	3.4E-09	1.0E-08	2.2E-08	1.1E-08
9	Residence In South Direction	9.35E-11	2.83E-10	5.9E-10	3.1E-10	33	3.1E-09	9.3E-09	2.0E-08	1.0E-08
1	Monkey Run Residence I	9.35E-11	2.83E-10	5.9E-10	3.1E-10	33	3.1E-09	9.3E-09	2.0E-08	1.0E-08
8	Residence neat 607' Terrain Point	8.25E-11	2.50E-10	5.2E-10	2.7E-10	33	2.7E-09	8.2E-09	1.7E-08	9.0E-09
7	LeBaume Cave Residence	3.85E-11	1.17E-10	2.4E-10	1.3E-10	33	1.3E-09	3.8E-09	8.1E-09	4.2E-09
3	Ilasco Residence I	2.75E-11	8.33E-11	1.7E-10	9.1E-11	33	9.1E-10	2.7E-09	5.8E-09	3.0E-09

Run 1; Baseline w/coal (only)
Run 3; Waste Fired
Run 4; Waste Fired
Run 5; Baseline w/coal and diesel fuel

commercial structures were always at the receptor location for a seventy-year lifetime (never leaving), 24 hours per day. In reality, receptors, particularly in institutional or commercial facilities (e.g., churches, hospitals, offices), would not be exposed continuously for a 70-year lifetime. In addition, it was conservatively assumed that estimated concentrations inside such structures were equal to outdoor concentrations. The air dispersion model used to project downwind concentrations of dioxin did not use local meteorological data, but, instead, conservatively assumed that a receptor (wherever its location) was always directly downwind from the stack.

Finally, the cancer potency slope (CPS), from which the excess lifetime cancer risks were estimated, is a 95% upper-bound estimate of the slope of the dose-response curve for TCDD-induced cancer. In deriving the CPS, EPA uses data from high-dose animal studies to extrapolate the probability of contracting cancer at very low doses in humans (it is not practical to conduct experiments on the extremely large numbers of animals that would be necessary to detect an increased cancer incidence at much lower, more realistic dose levels; millions of animals per dose might be required). The linearized multistage model, which EPA generally uses to estimate the slope of the cancer dose-response curve at low doses, is not capable of accounting for bodily defense mechanisms which are overwhelmed at high doses but which might prevent cancer at lower doses, which the model tries to predict. Thus, the cancer-based, risk-specific acceptable concentrations are intentionally health-protective in that they tend to overestimate the cancer risk which would result from lifetime exposure. It is not possible at this time to estimate the degree of conservatism provided by the risk specific concentrations.

8.3 Summary

TCDD-equivalent dioxin concentrations were modeled for the most exposed individual (MEI) and several discrete downwind receptors using conservative modeling techniques. Only risks to the MEI and the "stacktop height" receptor exceeded the 1 in 1,000,000 risk level. No actual receptors are located at either of these locations at the present time. Baseline risks for a coal-only run was 0.67 chances in 1,000,000 for the MEI and 2.3 in 1,000,000 for a coal/diesel fuel run. Risks to the MEI for two incineration "runs," where hazardous waste was burned, produced risks of approximately 2 in 1,000,000 and 4 in 1,000,000. Risks for stacktop height location were approximately half those for the MEI location. For the second hazardous waste run (run #4), low surrogate recoveries render the results of this run questionable. Cancer risks from baseline (fuel only) runs, when compared to risks from hazardous waste runs, are roughly comparable (i.e., are within an order of magnitude of each other).

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APPENDIX A

TCDD-Equivalent Emission Rates for the Continental Facility
from a report by
Midwest Research Institute

Table 3. 2,3,7,8 TCDD EQUIVALENT EMISSIONS

		Run 1			Run 3			Run 4			Run 5		
		Sample volume (dscm) =		1.447	Sample volume (dscm) =		1.714	Sample volume (dscm) =		1.805	Sample volume (dscm) =		1.788
	EPA	Stack flow rate (dscm/m) =		2,713	Stack flow rate (dscm/m) =		3,004	Stack flow rate (dscm/m) =		3,478	Stack flow rate (dscm/m) =		3,147
	equiv.	Total		Equiv.	Total		Equiv.	Total		Equiv	Total		Equiv
Analyte	factor	(pg)	(ng/dscm)	(ng/dscm)	(pg)	(ng/dscm)	(ng/dscm)	(pg)	(ng/dscm)	(ng/dscm)	(pg)	(ng/dscm)	(ng/dscm)
Dioxins													
2,3,7,8-TCDD	1	131	0.0660	0.0660	106	0.0210	0.0210	219	0.121	0.121	121	0.0151	0.0151
1,2,3,7,8-PeCDD	0.5	255	0.0516	0.0258	3,240	0.942	0.471	4,520	1.31	0.655	5,220	1.45	0.727
1,2,3,4,7,8-HxCDD	0.1	550	0.0843	0.00840	4,580	0.0497	0.00497	7,170	2.08	0.208	9,280	2.59	0.259
1,2,3,6,7,8-HxCDD	0.1	647	0.447	0.0447	3,750	1.09	0.109	7,040	2.04	0.204	11,100	3.09	0.309
1,2,3,7,8,9-HxCDD	0.1	520	0.359	0.0359	4,980	1.45	0.145	7,880	2.28	0.228	9,150	2.55	0.255
1,2,3,4,6,7,8-HpCD	0.01	4,140	2.88	0.0286	12,400	3.60	0.0361	21,300	6.17	0.0617	36,000	10.0	0.100
OCDD	0.001	5,360	3.70	0.0037	16,900	4.91	0.00491	19,500	5.65	0.00565	15,800	4.40	0.00440
Furans													
2,3,7,8-TCDF	0.1	144	0.138	0.0138	210	0.1	0.01	338	0.10	0.010	472	0.13	0.013
1,2,3,7,8-PeCDF	0.05	149	0.103	0.00515	6,490	1.89	0.0943	10,400	3.01	0.151	3,720	1.04	0.0518
2,3,4,7,8-PeCDF	0.5	2,320	1.60	0.802	14,900	4.33	2.17	27,400	7.94	3.97	10,800	3.01	1.51
1,2,3,4,7,8-HxCDF	0.1	1,140	0.788	0.0788	4,970	1.44	0.145	7,440	2.16	0.216	3,720	1.04	0.104
1,2,3,6,7,8-HxCDF	0.1	571	0.395	0.0395	2,350	0.683	0.0683	3,960	1.15	0.115	2,000	0.557	0.0560
2,3,4,6,7,8-HxCDF	0.1	534	0.369	0.0369	884	0.257	0.0257	1,720	0.498	0.0498	1,250	0.35	0.035
1,2,3,7,8,9-HxCDF	0.1	387	0.0968	0.00968	565	0.164	0.0164	741	0.215	0.0215	303	0.0844	0.00840
1,2,3,4,6,7,8-HpCD	0.01	2,050	1.42	0.0142	4,750	1.38	0.0138	4,860	1.41	0.0141	1,400	0.390	0.00390
1,2,3,4,7,8,9-HpCD	0.01	356	0.246	0.00246	546	0.159	0.00159	643	0.186	0.00186	256	0.0713	0.000700
OCDF	0.001	1,660	1.15	0.00115	3,530	1.03	0.00103	3,040	0.881	0.000880	606	0.169	0.000170
Total 2,3,7,8-TCDD equivalent concentration (ng/dscm) =				1.218			3.329			6.033			3.45
Emission (ng/min) =				3,299			10,000			20,980			10,860
Emission (g/hr) =				0.0001979			0.0006000			0.001259			0.000652

Note In calculating 2,3,7,8-equivalents for isomers below detection limits, the detection limit was used

File: 2378EQUIV Date: 11/7/90 By: PSM

	RUN #1	RUN #2	RUN #3
DAY - FRIDAY - AUGUST 30, 1985			
TIME	8:45AM 10:03AM	10:49AM 12:07PM	12:53PM 2:15PM
TYPE OF FUEL	COAL	COAL	COAL
FUEL FEED RATE (TPH)	15.2	15.15	15.0
SULFUR CONTENT OF FUEL	1.82	1.77	1.76
KILN FEED RATE (TPH)	133	133	133
SULFUR CONTENT OF KILN FEED SO_3	0.14	0.15	0.18
OXYGEN CONTENT OF FLUE GASES	1.9	1.9	1.9
CLINKER PRODUCTION RATE (TPH)	86.7	86.7	86.7

Data used for calculations in Appendix E.

APPENDIX B

UNCONTROLLED TOTAL PARTICULATE EMISSION FACTOR CALCULATIONS

MRI-18

MIDWEST RESEARCH INSTITUTE

PROJECT DEVELOPMENT SKETCH

TITLE Emission Factor Calculations for Uncontrolled Sources (Refs. 21, 24, 26A/B, and 40)

PROJECT NO. 4892-L74/8481-L9 DRAWN JSK Orig. ~~APPR.~~ 6/8/83 Add. DATE 6/16/86

- Reference 21 - Rexnord Gravel Bed Filter Study

From p. 7, of Report EPA-600/2-76-164 - Uncontrolled

Table 2

Mass Emission Tests - Method 5

Inlet

Run #	~~1~~	2	3	4	5
Date	~~8-25-75~~	8-26-75	8-26-75	8-27-75	8-27-75
Time	~~1350~~	1015	1435	1050	1515
%, Moisture	~~2.33~~	1.65	2.60	1.54	1.80
Velocity, m/s (f/s)	~~10.44(34.24)~~	9.70(31.48)	7.42(24.35)	8.50(27.89)	7.97(26.15)
ACM/min (ACFM)	~~1467.3(51812)~~	1364.5(48140)	1043.5(36847)	1195.2(42203)	1120.6(39570)
SDCM/min (SDCFM)	~~937.1(33089)~~	1088.4(38431)	761.6(26891)	875.3(30906)	739.9(26128)
Grams/ACM (Grains/ACF)	~~2.039(0.891)~~	1.144(0.500)	1.602(0.700)	2.130(0.931)	2.078(0.908)
Grams/SDCM (Grains/SDCF)	~~3.192(1.395)~~	1.435(0.627)	2.197(0.960)	2.911(1.272)	3.146(1.375
Kg/hr. (Lbs/hr.)	~~179.46(395.65)~~	93.68(206.54)	100.37(221.27)	152.84(336.96)	139.68(307.94)

From p. 39, Appendix B, of Report EPA-600/2-76-164

APPENDIX B

PLANT PRODUCTION DATA

Date	8/25	8/26	8/27	2/28	8/29	11/4	11/5
Production Tons/Day	742	533*	961	1031	1064	1063	995

*Single kiln

Per Tele. Con. w/ Joe McCain @ SoRI - delete Run 1 since one of the kilns went down sometime during the day

Calculate Total Mass Emission Factor for each Run:

For Run #2: 8/26/75

$$93.68\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{533\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 4.648\ \text{kg/Mg}$$

For Run #3: 8/26/75

$$100.37\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{533\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 4.980\ \text{kg/Mg}$$

For Run #4: 8/27/75

$$152.84\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{961\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 4.206\ \text{kg/Mg}$$

For Run #5: 8/27/75

$$139.68\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{961\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 3.844\ \text{kg/Mg}$$

$$\overline{EF}_u = \frac{4.648 + 4.980 + 4.206 + 3.844}{4\ \text{tests}} = 4.42\ \text{kg/Mg}$$

From p. 8 of Report EPA-600/2-76-164 — Controlled

Table 3

Mass Emission Tests - Method 5

Outlet

Run #	~~1~~	2	3	4	5
Date	~~8-25-75~~	8-26-75	8-26-75	8-27-75	8-27-75
Time	~~1400~~	1015	1445	1100	1515
Velocity, m/s(f/s)	~~8.82(28.94)~~	8.76(28.73)	6.79(22.29)	7.98(26.18)	7.26(23.81)
%, Moisture	~~2.29~~	1.83	1.86	1.64	1.38
ACM/min(ACFM)	~~1631.7(57619)~~	1619.9(57201)	1256.8(44379)	1476.2(52124)	1342.5(47405)
SDCM/min(SCDFM)	~~1239.3(43759)~~	1326.4(46837)	1017.5(35927)	1174.2(41461)	1049.7(37067)
Grams/ACM(Grains/ACF)	~~0.094(0.041)~~	0.030(0.013)	0.064(0.028)	0.043(0.019)	0.034(0.015)
Grams/SDCM(Grains/SDCF)	~~0.121(0.053)~~	0.037(0.016)	0.080(0.035)	0.055(0.024)	0.043(0.019)
Kg/hr.(Lbs/hr.)	~~9.02(19.88)~~	2.91(6.42)	4.89(10.78)	3.87(8.53)	2.74(6.04)

For Run #2: 8/26/75

$$2.91\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{533\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.144\ \text{kg/Mg}$$

For Run #3: 8/26/75

$$4.89\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{533\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.243\ \text{kg/Mg}$$

For Run #4: 8/27/75

$$3.87\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{961\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.107\ \text{kg/Mg}$$

For Run #5: 8/27/75

$$2.74\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{961\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.075\ \text{kg/Mg}$$

$$\overline{EF}_c = \frac{0.144 + 0.243 + 0.107 + 0.075}{4\ \text{tests}} = 0.142\ \text{kg/Mg}$$

Table A-1

Inlet Mass Loading By Size Interval From Andersen Impactor Data

Mass Loading In Indicated Size Interval, mg/DNM^3

Date	Start	Duration (Minutes)	Dia., µm	ρ=1.0	>4.70	3.1-4.7	1.4-3.1	.87-1.4	.63-.87	<.63*	
8/27	1320	20			3459	28.6	20.7	4.84	2.42	13.5	*Filter c
8/27	1620	20			341[1]	20.9	13.8	3.59	1.00	4.99	dominated
8/27	1730	20			313[1]	14.5	11.4	2.43	1.42	2.23	particle
8/27	1800	20			581[1]	25.8	14.8	3.5	1.39	2.52	
8/28	0950	45			2737	9.2	5.20	1.11	0.48	4.65	[1]Nozzles
8/28	1105	120			4252	11.1	7.82	2.66	0.52	3.84	to avoid
8/28	1440	120			2098	9.3	6.44	3.26	2.64	13.5	stages.
8/29	1015	120			2711	12.2	7.44	2.31	2.04	6.89	
8/29	1400	120			2131	14.4	9.34	2.42	0.42	1.43	
					2896	16.22	10.77	2.90	1.37	5.94	Average
					3569	20.69	13.85	3.55	1.90	9.70	90% Uppe
					2223	11.74	7.69	2.25	0.84	3.09	90% Lowe
11/4	1100	65			2474	18.8	9.5	2.4	0.12	1.54	[2]Nozzle
11/4	1130	60			661[2]	19.3	12.2	0.51	1.03	4.60	directio
11/4	1430	135			1941	14.9	10.7	3.7	0.53	1.47	
11/4	1435	120			1791	12.4	8.53	2.53	0.67	1.52	
11/5	0935	120			2384	9.11	14.5	1.12	0.23	1.37	
11/5	0930	120			2453	14.6	7.51	1.32	0.03	0.69	
11/5	1415	120			4607	17.5	7.97	3.31	4.37	11.2	
11/5	1415	120			4232	19.7	10.6	4.02	3.42	14.4	
					2840	15.79	10.19	2.36	1.30	4.60	Average
					3650	18.31	11.72	3.23	2.41	1.05	90% Uppe
					2031	13.27	8.61	1.50	0.19	8.14	90% Lowe
			Dia., µm	ρ=2.7	>2.8	1.8-2.8	0.83-1.8	.48-0.83	.34-0.48	<0.34	

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Table A-2

Outlet Mass Loadings By Size Interval For August Test Series

Mass Loading* In Indicated Size Interval, mg/DNM[1]

Date	Start Time	Duration	Dilution Correct-ion Factor	Pres. Drop	Dia. ρ=1.0	>14.3	10.1-14.3	6.2-10.1	4.4-6.2	2.9-4.4	1.35-2.9	.82-1.35	.58-.82	<.58*
8/25	1440	120	1.32	16.5		2.89	2.77	2.57	2.90	4.83	4.41	2.13	0.96	1.49
8/25	1440	120	1.32	16.5		2.79	2.74	0.45	0.90	1.76	3.07	1.56	0.15	1.32
8/26	1119	84	1.22	17.0		2.39	1.57	2.19	3.55	5.97	4.21	3.36	0.94	0.21
8/26	1124	84	1.22	17.0		3.81	2.24	3.06	4.47	6.45	5.46	2.33	0.71	0.33
8/26[1]	1515	120	1.34	15.8		9.09	2.34	2.86	4.75	7.64	6.09	2.38	0.97	10.2
8/26[1]	1515	120	1.34	15.8		8.87	2.54	3.42	3.90	6.21	6.14	3.11	1.52	1.10
8/27	1100	120	1.34	15.8		12.0	3.31	3.14	4.37	7.80	7.16	3.48	1.54	0.93
8/27	1150	120	1.34	15.8		7.98	5.30	3.93	5.21	6.31	7.50	4.14	1.41	1.43
8/27	1515	120	1.42	12.9		7.40	2.83	2.89	4.02	5.56	7.43	4.36	1.77	1.54
8/27	1515	120	1.42	12.9		11.4	2.26	2.48	3.12	7.11	6.99	4.01	1.47	0.90
8/28	1045	120	1.31	17.3		7.16	2.22	2.20	3.17	6.23	5.17	2.71	1.15	1.61
8/28	1045	120	1.31	17.3		7.74	1.97	2.25	4.35	4.40	5.35	2.58	0.88	1.79
8/28	1415	120	1.47	12.8		7.72	2.14	2.60	3.25	5.26	5.57	3.00	1.92	5.73
8/28	1415	120	1.47	12.8		5.69	2.96	2.26	3.68	4.88	6.67	2.76	1.53	4.67
8/29	1000	120	1.27	17.6		10.2	2.13	3.11	4.14	5.77	5.13	2.53	1.70	3.98
8/29	1000	120	1.27	17.6		5.79	1.60	1.76	3.05	6.27	5.21	2.57	1.23	3.82
8/29	1400	120	1.41	11.6		2.69	1.51	1.17	1.15	1.55	3.93	2.30	1.28	1.27
8/29	1400	120	1.41	11.6		6.92	1.68	2.56	3.35	5.19	6.10	3.07	0.93	1.03
						8.85	3.31	3.24	4.58	7.15	7.55	3.77	1.66	2.74**
						10.71	3.87	3.73	5.23	8.13	8.43	4.34	1.95	3.76***
						6.99	2.74	2.76	3.93	6.17	6.67	3.19	1.37	1.73***
					Dia. ρ=2.7	>8.6	6.1-8.6	3.7-6.1	2.6-3.7	1.7-2.6	.78-1.7	.46-.78	.32-.46	<.32

Table A-3

Outlet Mass Loadings By Size Interval For November Test Series

Mass Loading* In Indicated Size Interval, mg/DNM³

Date	Start	Duration	Dilution Correction Factor	System Pres. Drop	Dia., µm ρ=1.0	>13.9	9.8-13.9	6.0-9.8	4.2-6.0	2.8-4.2	1.3-2.8	.79-1.3	.57-.79	<.57*
11/3	1545	120	1.35	NA		0.66	0.43	0.40	0.43	8.01²	9.45²	2.56	0.96	1.19
11/3	1545	120	1.35	NA		10.4¹	0.71	0.64	0.61	1.08	3.80	2.21	0.66	0.63
11/4	1130	240	1.39	9.6		0.23	0.13	0.19	0.18	0.64	2.63	2.58	1.02	0.57
11/4	1130	240	1.39	9.6		0.00	0.14	0.16	0.34	0.92	3.36	2.22	0.68	0.38
11/5	0945	240	1.32	14.0		0.99	0.49	0.51	0.61	1.16	3.78	2.51	0.86	0.97
11/5	0945	240	1.32	14.0		1.35	0.45	0.38	0.56	0.20	0.65	1.16	1.03	1.12
						.86	.53	0.51	.61	1.08	3.60	2.99	1.10	1.18**
						1.55	.77	0.71	.80	1.99	5.19	3.61	1.36	1.51***
						.17	.28	0.31	.43	.58	2.00	2.37	0.99	.85****
					Dia., µm ρ=2.7	>8.4	5.9-8.4	3.6-5.9	2.6-3.6	1.7-2.6	.76-1.7	.44-.76	.31-.44	<.31

* (Same as for Table A-2).

**Average after correcting for dilution.

***Upper 90% Confidence Level.

****Lower 90% Confidence Level.

[1] Nozzle scrapped port on entry

[2] Omitted from average

Table A-4

Inlet Mass Loading By Size Interval From Brink Impactor Data

Mass Loading In Indicated Size Interval, mg/DNM³

Date	Time	Duration	Dia., ρ=1	>17.8	12.6-17.8	7.2-12.6	4.3-7.2	3.0-4.3	1.6-3.0	1.14-1.6	0.67-1.14	<.67
8/26	1010	20		2020	36.6	28.1	22.1	13.6	14.5	7.66	20.4	5.96
8/26	1700	40		2160	38.9	15.2	17.2	6.1	3.0	3.5	8.6	12.6
8/27	1045	180		963	17.7	7.7	8.2	7.0	2.6	1.2	1.0	2.83
8/27	1605	180		824	65.9	22.4	29.3	9.4	2.6	1.8	2.2	4.00
8/28	0945	180		1720	50.8	17.8	11.4	4.3	1.9	1.1	0.8	2.8
8/28	1310	180		597	48.2	12.3	14.7	3.3	1.9	1.6	1.6	6.4
8/29	1000	180		3640	49.5	84.3	22.5	6.9	2.5	2.0	2.0	6.9
8/29	1400	180		1150	116	19.2	15.4	6.1	2.6	.6	.6	11.8
				1634	53.0	25.9	17.6	7.09	4.06	2.43	4.65	6.66*
				2301	72.5	42.3	22.2	9.24	6.92	3.97	9.28	9.19**
				967	33.4	9.4	13.0	4.93	1.20	0.90	0.02	4.13**
			Dia., ρ=2.7	>10.8	7.6-10.8	4.3-7.6	2.6-4.3	1.8-2.6	.92-1.8	.65-92	.36-.65	<.36

*Average
**Upper 90% Confidence Limit
***Lower 90% Confidence Limit

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- Reference 24 - Greencastle Stack Emissions Survey

(1) Coal-fired, wet process kiln

From Table II, page 5 of test report:

TABLE II

GREENCASTLE EMISSION SURVEY

PRECIPITATOR PERFORMANCE

Run No.	Insufflation Rate T/Hr	Exhaust Gas Precip. Input ACFM	Exhaust Gas Precip. Output ACFM	Dust Load Precip. Input T/Hr	Dust Load Precip. Output T/Hr		Dust Load Precip. Efficiency %
Normal Insufflation Rate:							
9, 10	6	238,300	216,800	4.90	.007		99.8
11, 12	6	234,300	222,200	5.01	.014		99.7
13, 14	6	228,800	219,900	5.17	.031		99.4
Ave.				5.03	.017	24	99.6
Elevated Insufflation Rate:							
15, 16	12	231,800	214,900	5.10	.007	14	99.8
17, 18	12	224,100	215,100	4.99	.021	22	99.6
19, 20	12	228,100	216,400	5.72	.025	50	99.5
Ave.				5.27	.018	36	99.6
Average for all 6 tests				5.15			

From Table III, page 6 of report

TABLE III

GREENCASTLE EMISSION SURVEY

PROCESS RATES, CONSUMPTION AND PRODUCTION

Run No.	Date (1977)	Type of Fuel	Fuel Rate T/Hr	Kiln Feed T/Hr	% Slurry Water	Clinker Produced T/Hr	Dust Disposed T/Hr
7	5 - 12	Coal	18.0	135	33.3	77	.146
9, 10	5 - 19	Coal	16.5	125	33.1	74	.146
11, 12	5 - 20	Coal	16.0	125	33.1	75	.146
13, 14	5 - 21	Coal	15.75	125	33.5	76	.146
15, 16	5 - 22	Coal	16.0	125	33.1	76	.146
17, 18	5 - 23	Coal	16.0	125	33.4	75	.146
19, 20	5 - 24	Coal	16.5	125	33.1	77	.146
Ave.			16.4	126	33.2	75.7	.146

$\therefore 5.15 \frac{\text{tons part.}}{\text{hr.}} \times \frac{1 \text{ hr.}}{75.7 \text{ ton clinker}} \times 908 \frac{\text{kg}}{\text{ton}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} = 68.1 \frac{\text{kg part.}}{\text{Mg clinker}}$

$68.1 \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 64.9 \frac{\text{kg part.}}{\text{Mg cement}}$

(Assumes 5% gypsum added)

- Reference 26A/B - KVB Combustion Modification Study

Test No. 3: Dry Process Kiln
Coke / Natural Gas-Fired (66/33%)
Measurements taken downstream of multiclone

Method 5 Data – taken during second test period (per Table 4-1 of EPA-600/7-79-015a)

- From p. 48 of EPA-600/7-79-015b:

$9.746 \frac{\text{gr}}{\text{dscf}} \times \frac{1 \text{ lb}}{7000 \text{ gr.}} \times 164228 \frac{\text{dscf}}{\text{min}} \times 60 \frac{\text{min}}{\text{hr.}} = 13719.14 \frac{\text{l}}{\text{h}}$ to baghouse

- From p. 43 of EPA-600/7-79-015b:

Clinker production rate $= 53 \frac{\text{short tons}}{\text{hr.}} \times \frac{1 \text{ Mg}}{1.102 \text{ tons}} = 48 \frac{\text{Mg}}{\text{hr.}}$

If ≈ 5% (weight) gypsum added: $48 \frac{\text{Mg}}{\text{hr.}} \times 1.05 = 50 \frac{\text{Mg cem}}{\text{hr.}}$

$\therefore 1379.14 \frac{\text{lbs}}{\text{hr.}} \times 0.454 \frac{\text{kg}}{\text{lb}} \times \frac{1 \text{ hr.}}{50 \text{ Mg}} = 124.57 \frac{\text{kg}}{\text{Mg}}$ Total Mass Emissions

Particle Size Analyses – Test Run #3

- From p. 50-53 of EPA-600/7-79-015b: Brink Impactor

Cyclone = 0.4328 gm = > 4.250 μmA Dp
Stage 1 = 0.1200 gm = 4.25 μmA Dp
" 2 = 0.0502 gm = 2.485 μmA Dp
" 3 = 0.0109 gm = 1.679 μmA Dp
" 4 = 0.0064 gm = 0.851 μmA Dp
" 5 = 0.0033 gm = 0.505 μmA Dp
Filter = 0.0028 gm = ≤ 170.3 μmA Dp

Particle Size Analysis: Test Run No. 3 (cont'd)

Total Catch = 0.4328 + 0.12 + 0.0502 + 0.0109 + 0.0064 + 0.0033 + 0.002

= 0.6264 gm

		% on Stage	Cumulative % < Size
> 4.25 μm =	$\frac{0.4328}{0.6264} \times 100 =$	69.1%	100%
4.25 μm =	$\frac{0.1200}{0.6264} \times 100 =$	19.2	30.9 %
2.485 μm =	$\frac{0.0502}{0.6264} \times 100 =$	8.01%	11.7 %
1.679 μm =	$\frac{0.0109}{0.6264} \times 100 =$	1.74%	3.73%
0.851 μm =	$\frac{0.0064}{0.6264} \times 100 =$	1.02%	1.99%
0.505 μm =	$\frac{0.0033}{0.6264} \times 100 =$	0.527%	0.974%
> 0.30 μm =	$\frac{0.0028}{0.6264} \times 100 =$	0.447%	0.447%

Basically the same as that shown on p. 53 of EPA-600/7-79-0156. ∴ Use KVB data!

Test No. 9 : Wet Process Kiln w/ ESP (30% H_2O Content)
Natural Gas-Fired
Measurements taken @ kiln outlet

Baseline Test #9-1 – Method 5 Data

- From p. 423 of EPA-600/7-79-015b:

$$12.941 \frac{\text{gr}}{\text{dscf}} \times 20918 \frac{\text{dscf}}{\text{min}} \times 2 \text{ ducts} \times 60 \frac{\text{min}}{\text{hr.}} \times \frac{1 \text{ lb.}}{7000 \text{ gr.}} = 4640.6 \frac{\text{lbs}}{\text{hr.}}$$

to ESP

- From Table 4-20, p. 84 of EPA-600/7-79-015a:

$$9.4 \frac{\text{kg clinker}}{\text{sec.}} \times 3600 \frac{\text{sec.}}{\text{hr.}} \times \frac{1 \text{ Mg}}{10^3 \text{ kg}} = 34 \frac{\text{Mg clinker}}{\text{hr}}$$

If 5% (weight) gypsum added: $34 \frac{\text{Mg}}{\text{hr.}} \times 1.05 = 36 \frac{\text{Mg cement}}{\text{hr.}}$

$$\therefore \; 4640.6 \frac{\text{lbs}}{\text{hr.}} \times 0.454 \frac{\text{kg}}{\text{lb}} \times \frac{1 \text{ hr.}}{36 \text{ Mg}} = 58.5 \frac{\text{kg}}{\text{Mg}}$$

Total Mass Emissions

Particle Size Analysis: Brink data (from p. 433 & 436 of EPA-600/7-79-015b)

Cyclone = 0.2850 gm = > 2.81 μmA = 49.7% of total catc
Stage 1 = 0.2035 gm = 2.81 μmA = 35.5% " " "
" 2 = 0.0471 gm = 1.66 μmA = 8.21% " " "
" 3 = 0.0191 gm = 1.13 μmA = 3.33% " " "
" 4 = 0.0103 gm = 0.59 μmA = 1.80% " " "
" 5 = 0.0087 gm = 0.37 μmA = 1.52% " " "
Filter = N.I

Total = 0.5737 gm

Kiln under upset condition during Brink run!

Low- NO_x Test #9-2: Method 5 Data

- From p. 426 of EPA-600/7-79-015b:

$$11.86\ \frac{gr}{dscf} \times 23864.6\ \frac{dscf}{min} \times 2 \text{ ducts} \times 60\ \frac{min}{hr.} \times \frac{1\ lb}{7000\ gr.} = 4852\ \frac{lbs}{hr.}$$

to ESP

- From Table 4-20, p. 84 of EPA-600/7-79-015a:

$$9.4\ \frac{kg\ clinker}{sec.} = 36\ \frac{Mg\ cement}{hr.}$$ (as in Test 9-1 above)

$$\therefore\ 4852.0\ \frac{lbs}{hr.} \times 0.454\ \frac{kg}{lb.} \times \frac{1\ hr.}{36\ Mg} = 61.19\ \frac{kg}{Mg}$$ Total Mass Emissions

Particle Size Analysis: Brink data (from p. 438 & 441 of EPA-600/7-79-015b)

Cyclone = 0.0658 gm = > 2.81 μmA = 47.3% of total
Stage 1 = 0.0416 gm = 2.81 μmA = 29.9% " "
" 2 = 0.0161 gm = 1.66 μmA = 11.6% " "
" 3 = 0.0082 gm = 1.13 μmA = 5.89% " "
" 4 = 0.0043 gm = 0.60 μmA = 3.09% " "
" 5 = 0.0025 gm = 0.38 μmA = 1.80% " "
Filter = 0.0007 gm = >0.3 μmA = 0.50% " "

Total = 0.1392 gm

Use cumulative % ≤ stated size shown on p. 436 and 441 for Runs 9-1 and 9-2 respectively!

SASS Train Data:

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From Table 4-21, page 92 of EPA-600/7-79-015a:
Calculate Total Mass Emission Factors from SASS Train Data

TABLE 4-21. TRACE SPECIES AND ORGANICS SAMPLING CONDITIONS
LOCATION 9 - ROTARY CEMENT KILN

TS & O Run No.	5	6	7	8
Test Number	9-3	9-4	9-5	9-6
Date (1976)	9/29	9/30	10/4	10/5
Port Location	ESP inlet	ESP inlet	ESP outlet	ESP outlet
Velocity, m/s (f/s)	5.17 (16.95)	5.06 (16.60)	17.48 (57.35)	17.41 (57.10)
Stack Flow, dNm³/s (10³ SCFM)	20.1 (42.6)	19.0 (40.3)	21.1 (44.7)	21.7 (46.0)
Stack Temp. K (°F)	415 (287)	425 (305)	411 (280)	408 (274)
Oxygen Content, %	4.5	2.3	6.8	6.6
Moisture, %	34.31	44.74	37.55	38.21
Sample Time, min.	75	75	300	300
Cyclone Flow, aecmm (acfm)	0.102 (3.591)	0.097 (3.415)	0.087 (3.067)	0.087 (3.078)
Isokinetic Ratio, %	96.8	119.2	105.5	104.5
Oven Temp., K (°F)	478 (400)	478 (400)	478 (400)	478 (400)
XAD2 Temp., K (°F)	303 (85)	297 (75)	299 (77)	294 (69)
Meter Temp., K (°F)	311 (00)	319 (115)	309 (97)	310 (99)
Nozzle Size, mm (in.)	19.05 (0.75)	19.05 (0.75)	9.53 (0.375)	9.53 (0.375)
No. of Filters Used	1	1	1	1
Sample flow, dry, scmm (scfm)	0.0342(1.382)	0.0386 (1.3631)	0.0351 (1.2384)	0.0345(1.2185)
Volume Collected, dry, scm (scf)	2.937 (103.64)	2.897 (102.23)	10.529 (371.53)	10.359 (365.55)
Particulate Catch, g	63.7780	54.17	0.6122	0.7939
Concentration, g/dNm³	21.7	18.88	0.0581	0.0766
Total Particulates, ng/J (lb/MMB)	7307 (17.0)	5548 (12.9)	22.7 (0.053)	29.47 (0.069)
Unit Conditions:				
Test Time, min	75	75	316.8	313.2
Nat. Gas, 10³ scm (10³ acf)	7.241 (255.5)	7.754 (273.6)	27.60 (973.7)	(28.44 (1004.1)
Dry Feed, 10⁶ g (10³ lb)	76.64 (168.6)	70.61 (155.4)	293.7 (646.0)	334.2 (735.2)
Slurry Feed, 10⁶ g (10³ lb)	119.0 (261.8)	108.6 (239.0)	462.5 (1017.4)	517.3 (1138.0)
Slurry Moisture, % weight	35.6	35.0	36.5	35.4
Clinker, 10⁶ g (10³ lb)	45.75 (100.7)	42.18 (92.69)	175.0 (385.1)	199.4 (438.6)
Precipitator Catch 10⁶g (10³lb)	2.131 (4.688)	2.131 (4.688)	9.375 (20.63)	9.375 (20.63)

- For Test 9-3 @ ESP Inlet - SASS Train Total Mass (Clink

$$21.7 \frac{\text{gm}}{\text{DNM}^3} \times 20.1 \frac{\text{DNM}^3}{\text{sec.}} \times \frac{4500 \text{ sec.}}{45.75 \text{ Mg clinker}} \times \frac{1 \text{ kg}}{10^3 \text{ gm}} = 42.9 \frac{\text{kg part.}}{\text{Mg clinker}}$$

- For Test 9-4 @ ESP Inlet - SASS Train Total Mass (Clinke

$$18.88 \frac{\text{gm}}{\text{DNM}^3} \times 19.0 \frac{\text{DNM}^3}{\text{sec}} \times \frac{4500 \text{ sec.}}{42.18 \text{ Mg clinker}} \times \frac{1 \text{ kg}}{10^3 \text{ gm}} = 38.27 \frac{\text{kg part.}}{\text{Mg clinke}}$$

- For Test 9-5 @ ESP Outlet – SASS Train Total Mass

$$0.0581\ \frac{\text{gm}}{\text{DNM}^3} \times 21.1\ \frac{\text{DNM}^3}{\text{sec.}} \times \frac{19008\ \text{sec.}}{175.0\ \text{Mg clinker}} \times \frac{1\ \text{kg}}{10^3\ \text{gm}} = 0.133\ \frac{\text{kg part.}}{\text{Mg clinker}}$$

- For Test 9-6 @ ESP Outlet – SASS Train Total Mass

$$0.0766\ \frac{\text{gm}}{\text{DNM}^3} \times 21.7\ \frac{\text{DNM}^3}{\text{sec.}} \times \frac{18792\ \text{sec}}{199.4\ \text{Mg clinker}} \times \frac{1\ \text{kg}}{10^3\ \text{gm}} = 0.157\ \frac{\text{kg part.}}{\text{Mg clinker}}$$

- For Test 9-3 @ ESP Inlet – SASS Train Total Mass (Cement) (assuming 5% (weight) gypsum added)

$$42.9\ \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 40.86\ \frac{\text{kg part.}}{\text{Mg cement}}$$

- For Test 9-4 @ ESP Inlet – SASS Train Total Mass (Cement)

$$38.27\ \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 36.45\ \frac{\text{kg part.}}{\text{Mg cement}}$$

- For Test 9-5 @ ESP Outlet – SASS Train Total Mass (Cement)

$$0.133\ \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.127\ \frac{\text{kg part.}}{\text{Mg cement}}$$

- For Test 9-6 @ ESP Outlet – SASS Train Total Mass (Cement)

$$0.157\ \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.150\ \frac{\text{kg part.}}{\text{Mg cement}}$$

Particle Size Distributions from SASS Data:

- For Test 9-3: From Table F-2, page 452 of EPA-600/7-79-015a

10 µm Cyclone, Probe, & Nozzle = 20.2357 gm
3 µm Cyclone = 23.5244 gm
1 µm Cyclone = 15.6894 gm
Backup Filter = 4.2785 gm
Total Catch 63.7730 gm

$\therefore$ > 10 μm = $\frac{20.2857}{63.7780} \times 100 =$ 31.807% of total catch

<10-3 μm = $\frac{23.5244}{63.7780} \times 100 =$ 36.885% of total catch

<3-1 μm = $\frac{15.6894}{63.7780} \times 100 =$ 24.600% of total catch

<1 - 0.3 μm = $\frac{4.2785}{63.7780} \times 100 =$ 6.7084 of total catch

- For Test 9-4 : From Table F-8, page 458 of EPA-600/7-79-015c

10 μm Cyclone, Probe & Nozzle = 17.6210 gm
3 μm Cyclone = 19.4157 gm
1 μm Cyclone = 12.6696 gm
Backup Filter = 4.4659 gm
Total Catch = 54.1722 gms

$\therefore$ >10 μm = $\frac{17.6210}{54.1722} \times 100 =$ 32.528% of total catch

<10 - 3 μm = $\frac{19.4157}{54.1722} \times 100 =$ 35.841% of total catch

<3 - 1 μm = $\frac{12.6696}{54.1722} \times 100 =$ 23.388% of total catch

<1 - 0.3 μm = $\frac{4.4659}{54.1722} \times 100 =$ 8.244% of total catch

- For Test 9-5 : From data sheet, page 469 of EPA-600/7-79-0

10 μm Cyclone, Probe, and Nozzle = 0.0214 gm
3 μm Cyclone = -0-
1 μm Cyclone = 0.4049 gm
Backup Filter = 0.1859 gm
Total Catch = 0.6122 gm

$\therefore \quad >10\ \mu m = \frac{0.0214}{0.6122} \times 100 = 3.50\%$ of total catch

$<10 - 3\ \mu m = -0- \qquad = 0\%$ of total catch

$<3 - 1\ \mu m = \frac{0.4049}{0.6122} \times 100 = 66.14\%$ of total catch

$<1 - 0.3\ \mu m = \frac{0.1859}{0.6122} \times 100 = 30.37\%$ of total catch

- For Test 9-6: From Table F-14, page 464 of EPA-600/7-79-01

10 μm Cyclone, Probe, and Nozzle = 0.0122 gm
3 μm Cyclone = No Sample
1 μm Cyclone = 0.5775 gm
Backup Filter = 0.2042 gm
Total Catch = 0.7939 gm

$\therefore \quad >10\ \mu m = \frac{0.0122}{0.7939} \times 100 = 1.54\%$ of total catch

$<10-3\ \mu m = -0- \qquad = N/A$ of total catch

$<3-1\ \mu m = \frac{0.5775}{0.7939} \times 100 = 72.74\%$ of total catch

$<1-0.3\ \mu m = \frac{0.2042}{0.7939} \times 100 = 25.72\%$ of total catch

⑰

- Reference 40 – Bonner Springs Stack Survey
Coal-fired wet process kiln – ASTM PTC-27
From Table T-1-A, page 16 of test report:

TABLE T-1-A

BONNER SPRINGS STACK EMISSION SURVEY

ELECTROSTATIC PRECIPITATOR EFFICIENCY DATA 1981

No. 4 KILN SYSTEM

Run Nos.	Date	Precipitator Input Lbs/Hr.	Stack Lbs/Hr.	Precipitator Efficiency $\frac{\text{Input - Output}}{\text{Input}}$
67,68	10-8	2613	32.2	98.7
73,74	10-9	2391	12.5	99.5
77,78	10-22	1864	5.5	99.7
83,84	10-23	1940	5.8	99.7
AVERAGE		2202	14.0	99.4

From Table T-4, page 20 of test report:

BONNER SPRINGS STACK EMISSION SURVEY

RATE PRODUCTION AND CONSUMPTION 1981

Date 1981	System Under Test	Fuel Used		Raw Mix Used			Clinker Produce Ton/Hr.
		Coal Lbs/Min.	Moisture %	Ton/Hr. Dry	Slurry Moist - %	$CaCO_3$ %	
10-8	No. 4 Stack & Pptr. Input	151	8.3	31.3	33.9	79.7	17.0
10-9	"	150	7.8	30.7	33.7	79.6	16.7
10-22	"	154	8.0	30.6	35.3	79.9	16.6
10-23	"	155	7.8	30.1	35.0	79.9	16.7

} Average clinker prod = 16.8 TPH

$$\therefore 2202 \frac{\text{lbs part.}}{\text{hr.}} \times \frac{1 \text{ hr.}}{16.8 \text{ tons clinker}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 62.42 \frac{\text{kg}}{\text{Mg cement}}$$

APPENDIX C

TOTAL PARTICULATE EMISSION FACTOR CALCULATIONS FOR CONTROLLED KILNS

MIDWEST RESEARCH INSTITUTE

PROJECT DEVELOPMENT SKETCH

MRI-18

TITLE Emission Factor Calculations for Controlled Cement Kilns

PROJECT NO. 4892-L74/8431-L9 DRAWN JSK Orig. ~~APPR.~~ 8/22/83 Add. DATE 6/17/86

- Report No. 71-MM-01: Wet Process Plant (Reference 10)

Gas-fired kiln equipped w/ electrostatic precipitator

From Table II, page 7 of test report:

Run #1 = 0.634 lbs/short ton feed
Run #2 = 1.019 " " " "
Run #3 = 1.799 "

Average = 1.151✓ lbs/short ton feed

$$1.151 \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.576 \frac{\text{kg part.}}{\text{Mg feed}}$$

Assuming: 2.45 Mg slurry/Mg cement (from EPA-600/2-77-023u p. 20)

$$0.576 \frac{\text{kg part.}}{\text{Mg slurry}} \times 2.45 \frac{\text{Mg slurry}}{\text{Mg cement}} = 1.41✓ \frac{\text{kg part.}}{\text{Mg cement}}$$

- Report No. 71-MM-03: Wet Process Plant (Reference 11)

Gas-fired kiln equipped w/ electrostatic precipitator

From Table 2, page viii of test report.

Run #1 = 0.844 lbs/short ton feed
Run #2 = 0.924 lbs/short ton feed

Average = 0.884✓ lbs/short ton feed

②

$$0.884\ \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.442\ \frac{\text{kg part.}}{\text{Mg feed}}$$

$$0.442\ \frac{\text{kg part.}}{\text{Mg feed}} \times 2.45\ \frac{\text{Mg slurry}}{\text{Mg cement}} = 1.08\ \frac{\text{kg part.}}{\text{Mg cement}}$$

- Report 71-MM-05: Dry Process Plant (Reference 13)

  (2) Coal-fired kilns equipped w/ multiclones + bhouses

  From Table 1, p. vii of ~~test~~ report:

  Run #1 = 0.0942 lbs/short ton feed
  Run #2 = 0.0553 " " " "
  Run #3 = 0.0606 " " " "

  Average = 0.0700 " " " "

  $$0.07\ \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.035\ \frac{\text{kg part}}{\text{Mg feed}}$$

  Assuming: 1.7 Mg raw meat / Mg cement (from EPA-600/2-77-023u p. 20)

  $$0.035\ \frac{\text{kg. part.}}{\text{Mg feed}} \times 1.7\ \frac{\text{Mg feed}}{\text{Mg cement}} = 0.0595\checkmark\ \frac{\text{kg part.}}{\text{Mg feed}}$$

- Report 71-MM-07: Wet Process Plant (Reference 15)

  No. 4 Kiln – Gas & Oil-Fired – equipped w/ bhouse

  From Table I, page 5 of test report: 6 stacks tested

  Combined Nat. Gas = 0.536 lbs/short ton feed
  " " No. 6 Oil = 0.513 lbs/short ton feed

$$\text{Nat. Gas} = 0.536\ \frac{\text{lbs part.}}{\text{short ton}} \times 1.102\ \frac{\text{short tons}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.268\ \frac{\text{kg}}{\text{Mg}}$$

$$0.268\ \frac{\text{kg part.}}{\text{Mg feed}} \times 2.45\ \frac{\text{Mg feed}}{\text{Mg cement}} = 0.657\ \frac{\text{kg part.}}{\text{Mg cement}}$$

$$\text{No. 6 Oil} = 0.513\ \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102\ \frac{\text{short tons}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.257\ \frac{\text{kg}}{\text{Mg}}$$

$$0.257\ \frac{\text{kg part.}}{\text{Mg feed}} \times 2.45\ \frac{\text{Mg feed}}{\text{Mg cement}} = 0.630\ \frac{\text{kg part.}}{\text{Mg cement}}$$

- Report 71-MM-15: Wet Process Plant (Reference 16)

  Gas-fired kiln equipped with bhouse

  From Table I, page 5 of test report:

  Run # 4 = 0.247 lbs/short ton feed
  Run # 5 = 0.309 lbs/short ton feed
  Run # 6 = 0.261 lbs/short ton feed

  Average = 0.272 lbs/short ton feed

$$0.272\ \frac{\text{lbs part.}}{\text{short ton feed}} \times 1.102\ \frac{\text{short tons}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.136\ \frac{\text{kg}}{\text{Mg}}$$

$$0.136\ \frac{\text{kg part.}}{\text{Mg feed}} \times 2.45\ \frac{\text{Mg feed}}{\text{Mg cement}} = 0.333\ \frac{\text{kg part.}}{\text{Mg cement}}$$

- Greencastle Stack Emissions Survey (Reference 24) ✓

  Coal-fired wet process kiln w/ESP – EPA Methods 1-5

  From Table 1, page 4 of report:

④

TABLE I

GREENCASTLE STACK EMISSIONS SURVEY

PARTICULATE EMISSION RATE

1977

Run No.	Date (1977)	Exhaust Gas Temp. °F.	Exhaust Gas Volume ACFM	Particulate Emission Rate Grains/ SCF Dry	Particulate Emission Rate Lbs/SCF Dry X10-6	Particulate Emission Rate Lbs/ Hr.	Particulate Emission Rate Tons/ Day
Normal Operation:							
1	5 - 8	332	239,200	.020	2.87	21.05	0.25
3	5 - 9	331	249,100	.055	8.29	56.24	0.68
5	5 - 10	334	240,700	.009	1.31	8.82	0.11
Ave.			243,000			28.70	0.35
Operation Following Precipitator Upgrading:							
21	6 - 20	310	232,900	.043	6.16	42.24	0.51
23	6 - 21	316	239,900	.032	4.65	30.98	0.37
25	6 - 22	307	236,700	.042	6.00	41.90	0.50
Ave.			236,500			38.37	0.46
			Average of all 6 runs			33.54✓	

From Table III, page 6 of report:

TABLE III

GREENCASTLE EMISSION SURVEY

PROCESS RATES, CONSUMPTION AND PRODUCTION

Run No.	Date (1977)	Type of Fuel	Fuel Rate T/Hr	Kiln Feed T/Hr	% Slurry Water	Clinker Produced T/Hr	Dust Disposed T/Hr
1	5 - 8	Coal	18.5	135	31.1	81	.146
3	5 - 9	Coal	18.0	135	33.3	79	.146
5	5 - 10	Coal	17.5	135	33.3	79	.146
Ave.			18.0	135	32.6	79.7	.146
21	6 - 20	Coal	18.75	138	33.2	88	.125
23	6 - 21	Coal	18.75	138	33.2	87	.125
25	6 - 22	Coal	19.50	138	33.3	88	.125
Ave.			19.00	138	33.2	87.7	.125

⑤

Average Clinker Production = $\frac{79.7 + 87.7}{2} \frac{\text{tons}}{\text{hr.}} = 83.7 \frac{\text{ton}}{\text{hr.}}$

$33.54 \frac{\text{lbs. part.}}{\text{hr}} \times \frac{1 \text{ hr.}}{83.7 \text{ tons clinker}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.20 \frac{\text{kg part}}{\text{Mg clinker}}$

If 5% gypsum is added to clinker:

$0.20 \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1.0 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 0.191 \frac{\text{kg}}{\text{Mg}}$ cement produced

- Nazareth Particulate Emission Test (Reference 25).

(4) Coal-fired, dry process kilns w/multiclone + ESP
No. 2 & 3 = North Stack; No. 4 & 5 = South Stack
Method 5 tests both w/ & w/o impinger catch

From summary table on page 3 of test report:

NAZARETH, PENNA PLANT

CONSOLIDATED SUMMARY - PARTICULATE EMISSIONS
PERIOD OF OCTOBER 6 thru OCTOBER 15, 1977

TEST LOCATION	PARTICULATE EMISSION RATE lbs/Hr. Probe Catch	Impinger Catch	Total Catch	gr/SCF Total Catch	KILN FEED RATE T/H	COAL RATE T/H	VOLUME ACFM	TEMP Deg.F.	ISOKINETIC %
NORTH STACK Total / Avg	16.6	29.7	46.3	0.045	61.8	8.3	213,400	365	89.5
No. 2 Kiln					29.8	4.1			
No. 3 Kiln					32.0	4.2			
SOUTH STACK Total / Avg	6.8	8.6	15.4	0.019	55.8	6.5	165,300	373	95.8
No. 4 Kiln					28.6	3.3			
No. 5 Kiln					27.2	3.2			
PLANT TOTAL	23.4	38.3	61.7	0.032	117.6	14.8	378,700	369	92.6

From Table 2, page 11 of test report:

⑥

TABLE 2

NAZARETH STACK EMISSION SURVEY

PROCESS RATES, CONSUMPTION AND PRODUCTION

1977

Run No.	Date	Kiln No.	Coal * Fuel Rate T/Hr	Kiln Feed T/Hr	Clinker Produced T/Hr	Clinker Dust T/Hr	Precip.& Multiclone Dust T/Hr
PA/6	10-6	4	3.1	27.6	16.0	—	—
		5	3.1	27.3	15.9	—	—
PA/7	10-7	4	3.3	29.9	17.3	0.2	0.2
		5	3.3	27.5	15.9	0.2	0.2
PA/15	10-15	4	3.4	28.3	16.4	—	—
		5	3.2	26.8	15.5	—	—
Ave. Kiln # 4			3.3	28.6	16.6		
Ave. Kiln # 5			3.2	27.2	15.8		
PA/10	10-10	2	4.2	30.0	17.4	0.1	—
		3	4.6	32.9	19.1	0.2	—
PA/11	10-11	2	4.1	29.3	17.0	0.1	2.0
		3	4.0	30.5	17.7	0.2	1.0
PA/12	10-12	2	4.0	30.1	17.5	0.1	2.2
		3	3.9	32.5	18.9	0.2	1.1
Ave. Kiln # 2			4.1	29.8	17.3		
Ave. Kiln # 3			4.2	32.0	18.6		

$$\text{Total Clinker Production} = 16.6 + 15.8 + 17.3 + 18.6 \ \frac{\text{tons clinker}}{\text{hr}}$$

$$= 68.3 \text{ tons/hr.}$$

$$\therefore 23.4 \ \frac{\cancel{\text{lbs}} \text{ part.}}{\cancel{\text{hr.}}} \times \frac{1 \ \cancel{\text{hr}}}{68.3 \ \cancel{\text{tons}} \text{ clinker}} \times 1.102 \ \frac{\cancel{\text{short ton}}}{\text{Mg}} \times 0.454 \ \frac{\text{kg}}{\cancel{\text{lb}}} = 0.171 \ \frac{\text{kg}}{\text{Mg}}$$

$$0.171 \ \frac{\text{kg part.}}{\cancel{\text{Mg}} \text{ clinker}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 0.163 \ \frac{\text{kg}}{\text{Mg}} \text{ cement produced}$$

- Report EPA-600/7-79-015a and 015b: 2 Plants Tested (Reference 26A/B)

Test No. 3: Dry Process Kiln
Coke / Natural Gas-Fired (66/33%)
Measurements taken downstream of multiclone

⑦

Method 5 Data – taken during second test period (per Table 4-18 of EPA-600/7-79-015a)

- From p. 48 of EPA-600/7-79-015b:

$$9.746\ \frac{gr}{dscf} \times \frac{1\ lb}{7000\ gr.} \times 164228\ \frac{dscf}{min} \times 60\ \frac{min}{hr.} = 13719.14\ \frac{lbs}{hr.}$$

to baghouse

- From p. 43 of EPA-600/7-79-015b:

$$\text{Clinker production rate} = 53\ \frac{\text{short tons}}{hr.} \times \frac{1\ Mg}{1.102\ tons} = 48\ \frac{Mg}{hr.}$$

If ~ 5% (weight) gypsum added: $48\ \frac{Mg}{hr.} \times 1.05 = 50\ \frac{Mg\ cem}{hr.}$

$$\therefore\ 13719.14\ \frac{lbs}{hr.} \times 0.454\ \frac{kg}{lb} \times \frac{1\ hr.}{50\ Mg} = 124.57\ \frac{kg}{Mg}$$ Total Mass Emissions

Test No. 9: Wet Process Kiln w/ ESP (30% H_2O Content)
Natural Gas-Fired

SASS Train Data:

From Table 4-21, page 92 of EPA-600/7-79-015a:
Calculate Total Mass Emission Factors from SASS Train Data

⑧

TABLE 4-21. TRACE SPECIES AND ORGANICS SAMPLING CONDITIONS LOCATION 9 - ROTARY CEMENT KILN

TS & O Run No.	~~5~~	~~6~~	7	8
Test Number	~~9-3~~	~~9-4~~	9-5	9-6
Date (1976)	~~9/29~~	~~9/30~~	10/4	10/5
Port Location	~~ESP inlet~~	~~ESP inlet~~	ESP outlet	ESP outlet
Velocity, m/s (f/s)	~~5.17 (16.95)~~	~~5.06 (16.60)~~	17.48 (57.35)	17.41 (57.10)
Stack Flow, dNm³/s (10³ SCFM)	~~20.1 (42.6)~~	~~19.0 (40.3)~~	21.1 (44.7)	21.7 (46.0)
Stack Temp. K (°F)	~~415 (287)~~	~~425 (305)~~	411 (280)	408 (274)
Oxygen Content, %	~~4.5~~	~~2.3~~	6.8	6.6
Moisture, %	~~34.31~~	~~44.74~~	37.55	38.21
Sample Time, min.	~~75~~	~~75~~	300	300
Cyclone Flow, acmm (acfm)	~~0.102 (3.591)~~	~~0.097 (3.435)~~	0.087 (3.067)	0.087 (3.076)
Isokinetic Ratio, %	~~96.8~~	~~12[illegible].2~~	105.5	104.5
Oven Temp., K (°F)	~~478 (400)~~	~~478 (400)~~	478 (400)	478 (400)
XAD2 Temp., K (°F)	~~303 (85)~~	~~297 (75)~~	299 (77)	294 (69)
Meter Temp., K (°F)	~~311 (00)~~	~~319 (115)~~	309 (97)	310 (99)
Nozzle Size, mm (in.)	~~19.05 (0.75)~~	~~19.05 (0.75)~~	9.53 (0.375)	9.53 (0.375)
No. of Filters Used	~~1~~	~~1~~	1	1
Sample Flow, dry, scmm (scfm)	~~0.0342 (1.382)~~	~~0.0386 (1.3631)~~	0.0351 (1.2384)	0.0345 (1.2185)
Volume Collected, dry, scm (scf)	~~2.937 (103.64)~~	~~2.897 (102.23)~~	10.529 (371.53)	10.359 (365.55)
Particulate Catch, g	~~63.7780~~	~~54.17~~	0.6122	0.7939
Concentration, g/dNm³	~~21.7~~	~~18.88~~	0.0581	0.0766
Total Particulates, ng/J (lb/MBtu)	~~7307 (17.0)~~	~~5548 (12.9)~~	22.7 (0.053)	29.47 (0.069)
Unit Conditions:				
Test Time, min	~~75~~	~~75~~	316.8	313.2
Nat. Gas, 10³ scm (10³ scf)	~~7.241 (255.5)~~	~~7.754 (273.6)~~	27.60 (973.7)	(26.46 (1004.1)
Dry Feed, 10⁶ g (10³ lb)	~~76.54 (168.6)~~	~~70.61 (155.6)~~	293.7 (646.0)	334.2 (735.2)
Slurry Feed, 10⁶ g (10³ lb)	~~118.0 (261.8)~~	~~108.6 (239.4)~~	462.5 (1017.4)	517.3 (1138.0)
Slurry Moisture, %, weight	~~35.6~~	~~35.0~~	36.5	35.4
Clinker, 10⁶ g (10³ lb)	~~45.75 (100.7)~~	~~42.18 (92.69)~~	175.0 (385.1)	199.4 (438.6)
Precipitator Catch 10⁶g (10³lb)	~~2.131 (4.688)~~	~~2.131 (4.688)~~	9.375 (20.63)	9.375 (20.63)

- For Test 9-5 @ ESP Outlet – SASS Train Total Mass

$$0.0581 \frac{gm}{DNM^3} \times 21.1 \frac{DNM^3}{sec} \times \frac{19008 \text{ sec.}}{175.0 \text{ Mg clinker}} \times \frac{1 \text{ kg}}{10^3 \text{ gm}} = 0.133 \frac{\text{kg part.}}{\text{Mg clinker}}$$

$$0.133 \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 0.127 \frac{\text{kg part.}}{\text{Mg cement}}$$

- For Test 9-6 @ ESP Outlet – SASS Train Total Mass

$$0.0766 \frac{gm}{DNM^3} \times 21.7 \frac{DNM^3}{sec.} \times \frac{18792 \text{ sec}}{199.4 \text{ Mg clinker}} \times \frac{1 \text{ kg}}{10^3 \text{ gm}} = 0.157 \frac{\text{kg part.}}{\text{Mg clinker}}$$

$$0.157 \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 0.150 \frac{\text{kg part.}}{\text{Mg cement}}$$

$$\text{Average} = \frac{0.127 + 0.150 \text{ kg/Mg}}{2 \text{ tests}} = 0.139 \text{ kg/Mg cement}$$

- Report KVB 5806-783: Dry Process Plant (Reference 27)

  2 Tests on Same Kiln equipped w/ bhouse

  From page 4-113 of test report:

  Gas-Fired Operation = 0.21 lbs/short ton cement

  Coal-Fired Operation = 0.43 lbs/short ton cement

  $$\text{Nat. Gas} = 0.21 \frac{\text{lbs}}{\text{short ton}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.11 \frac{\text{kg}}{\text{Mg}}$$

  $$\text{Coal} = 0.43 \frac{\text{lbs.}}{\text{short ton}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.22 \frac{\text{kg}}{\text{Mg}}$$

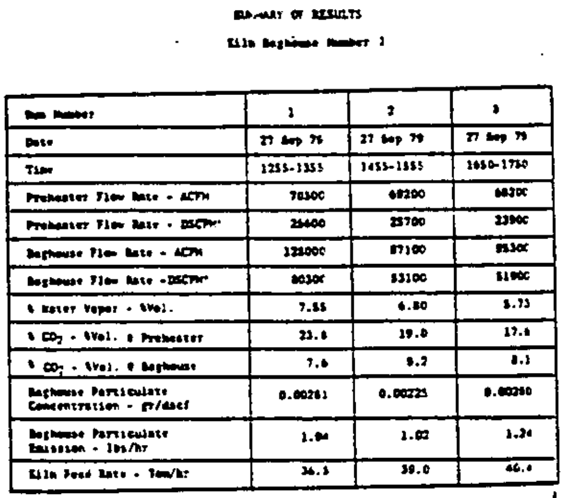
- Maryneal, TX Source Emissions Survey (Reference 30)

  (3) Coal-fired dry process kilns w/ suspension preheaters & baghouses

  Hi-vols in three sections of each bhouse (positive pressure)

  From page 6 of test report for Kiln No. 1 bhouse:

⑩



SUMMARY OF RESULTS

Kiln Baghouse Number 1

Run Number	1	2	3
Date	27 Sep 79	27 Sep 79	27 Sep 79
Time	1255-1355	1455-1555	1650-1750
Preheater Flow Rate - ACFM	70300	69200	68300
Preheater Flow Rate - DSCFM*	25400	25700	23900
Baghouse Flow Rate - ACFM	128000	87100	95300
Baghouse Flow Rate - DSCFM*	80300	53100	51900
% Water Vapor - %Vol.	7.55	6.80	5.73
% CO_2 - %Vol. @ Preheater	23.8	19.0	17.6
% CO_2 - %Vol. @ Baghouse	7.6	9.2	8.1
Baghouse Particulate Concentration - gr/dscf	0.00281	0.00225	0.00280
Baghouse Particulate Emission - lbs/hr	1.94	1.02	1.24
Kiln Feed Rate - Ton/hr	36.5	39.0	40.4

} Avg. emissions ≈ 1.40 lbs/hr.

Avg. feed = 38.6 TPH

Using conversion factor of feed to clinker of 0.54 as specified in Appendix E of test report:

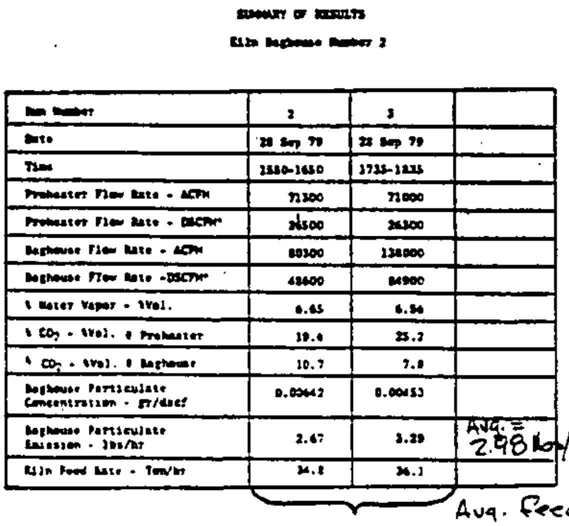
$$\text{Average clinker production} = 38.6 \ \frac{\text{tons feed}}{\text{hr.}} \times 0.54$$

$$= 20.8 \ \frac{\text{tons clinker}}{\text{hr}}$$

$$EF = 1.4 \ \frac{\text{lbs. part.}}{\text{hr.}} \times \frac{1 \text{ hr}}{20.8 \text{ tons clinker}} \times 1.102 \ \frac{\text{short ton}}{\text{Mg}} \times 0.454 \ \frac{\text{kg}}{\text{lb}} = 0.0337 \ \frac{\text{kg}}{\text{Mg}}$$

$$0.0337 \ \frac{\text{kg part}}{\text{Mg clinker}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 0.0321 \text{ kg/Mg cement}$$

From page 7 of test report for Kiln No. 2 bhouse:



SUMMARY OF RESULTS

Kiln Baghouse Number 2

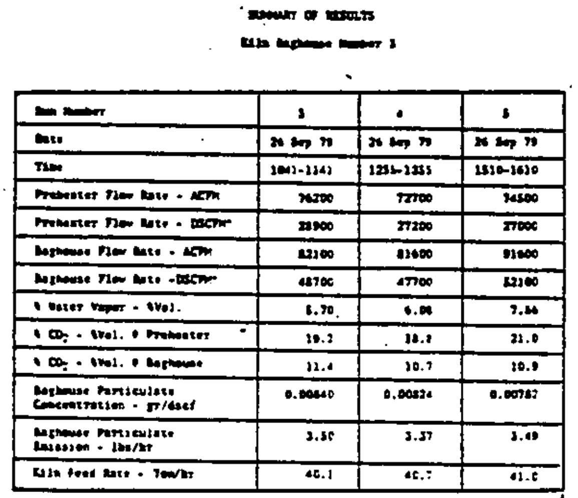
Run Number	2	3	
Date	28 Sep 79	28 Sep 79	
Time	1550-1650	1735-1835	
Preheater Flow Rate - ACFM	71300	71000	
Preheater Flow Rate - DSCFM*	26500	26300	
Baghouse Flow Rate - ACFM	80300	138000	
Baghouse Flow Rate - DSCFM*	48600	84900	
% Water Vapor - %Vol.	6.65	6.56	
% CO_2 - %Vol. @ Preheater	19.4	25.2	
% CO_2 - %Vol. @ Baghouse	10.7	7.8	
Baghouse Particulate Concentration - gr/dscf	0.00442	0.00453	
Baghouse Particulate Emission - lbs/hr	2.67	3.29	AVG. = 2.98 lbs/hr.
Kiln Feed Rate - Ton/hr	34.8	36.1	

Avg. feed = 35.5 TPH

Average clinker production = $35.5 \ \frac{\text{tons feed}}{\text{hr}} \times 0.54 = 19.2 \ \frac{\text{tons}}{\text{hr}}$

$$\overline{EF} = 2.98 \ \frac{\cancel{\text{lbs part.}}}{\cancel{\text{hr}}} \times \frac{1 \ \cancel{\text{hr}}}{19.2 \ \cancel{\text{tons clinker}}} \times 1.102 \ \frac{\cancel{\text{short ton}}}{\cancel{\text{Mg}}} \times 0.454 \ \frac{\text{kg}}{\cancel{\text{lb}}} \times \frac{1 \ \cancel{\text{Mg clinker}}}{1.05 \ \text{Mg cement}}$$
$$= 0.0739 \checkmark \ \frac{\text{kg part}}{\text{Mg cement}}$$

From page 8 of test report for Kiln No. 3 bhouse:



SUMMARY OF RESULTS

Kiln Baghouse Number 3

Run Number	3	4	5
Date	26 Sep 79	26 Sep 79	26 Sep 79
Time	1041-1141	1255-1355	1510-1610
Preheater Flow Rate - ACFM	76200	72700	74500
Preheater Flow Rate - DSCFM*	28900	27200	27000
Baghouse Flow Rate - ACFM	82100	81600	91600
Baghouse Flow Rate -DSCFM*	48700	47700	52100
% Water Vapor - %Vol.	5.70	6.06	7.56
% CO_2 - %Vol. @ Preheater	19.2	18.2	21.0
% CO_2 - %Vol. @ Baghouse	11.4	10.7	10.9
Baghouse Particulate Concentration - gr/dscf	0.00840	0.00824	0.00787
Baghouse Particulate Emission - lbs/hr	3.50	3.37	3.49
Kiln Feed Rate - Ton/hr	40.1	40.7	41.0

} Avg. emissions = $3.45 \ \frac{\text{lbs}}{\text{hr}}$

Avg. feed = 40.6 TPH

Average cement production = $40.6 \ \frac{\text{tons feed}}{\text{hr.}} \times 0.54 \times 1.05 \ \frac{\text{ton cement}}{\text{ton clinker}}$

$$= 23.0 \ \frac{\text{ton cement}}{\text{hr.}}$$

$$3.45 \ \frac{\text{lbs part.}}{\text{hr}} \times \frac{1 \ \text{hr}}{23.0 \ \text{tons cement}} \times 1.102 \ \frac{\text{short ton}}{\text{Mg}} \times 0.454 \ \frac{\text{kg}}{\text{lb}} = 0.075 \ \frac{\text{kg}}{\text{Mg cement}}$$

$$\therefore \text{Average for 3 Kilns} = \frac{0.0321 + 0.0739 + 0.0750}{3} = 0.0603 \ \frac{\text{kg part}}{\text{Mg cement}}$$

⑫

- Roanoke No. 5 Gas Process Survey (Reference 31)

(3) Coal-fired dry process kilns w/ multiclone + ESP

(1) Coal-fired dry process kiln w/ Lepol sys. & ESP

EPA Methods 1-5

From summary table on page 2 (?) of report:

Results showed average conditions for each Kiln System as follows:

Location Kiln Stack	Temp. °F	Volume ACFM	Emission Lbs/Hr	Opacity Lear Sieg.	Opacity OBS
1	401	65,700	28.4 ✓	34	
2			Postponed		
3	420	60,700	23.6 ✓	25	15.7
4	413	70,900	28.9 ✓	31	19.9
5 *	332	288,600	38.4 ✓	14	
5 **	326	192,000	20.3	14	
5 ***	296	86,650	12.2	11	

* No Gas Bypass
** Gas Bypass to one Raw Mill
*** Gas Bypass to two Raw Mills

From Table 3, page T-3:

TABLE 3 T-3

ROANOKE EMISSION SURVEY

PROCESS DATA, CONSUMPTION AND PRODUCTION

1979

Run No.	Date	Kiln No.	Fuel Rate T/H	% Water In Coal	Feed Rate T/H	% Water In Raw Mix	Clinker Production Rate T/H	Cooling Water Gal/Min
45-46	9-29	1	3.3	6.9	21.9	0.42	14.6	22
47-48	9-30	1	3.4	5.6	20.7	0.39	13.8	25
49-50	10-1	1	3.4	6.8	21.0	0.56	14.0	26
Average (Kiln #1)			3.4	7.1	21.2	0.46	14.1	24
		2	POSTPONED					
		2						
		2						
Average (Kiln #2)								
51-52	10-4	3	2.7	7.3	22.1	0.33	14.7	26
53-54	10-11	3	2.8	7.2	21.9	0.32	14.6	25
55-56	10-12	3	2.8	7.4	20.7	0.48	13.8	24
Average (Kiln #3)			2.8	7.3	21.6	0.38	14.4	25
39-40	9-19	4	3.0	5.4	26.0	0.45	17.3	26
41-42	9-20	4	2.9	6.3	25.6	0.38	18.4	25
43-44	9-27	4	3.0	6.6	32.1	0.38	21.4	29
Average (Kiln #4)			3.0	6.1	27.9	0.40	19.0	26
1-2	7-22	5	8.5	4.9	95	0.30	59	37
3-4	7-24	5	9.3	5.0	105	0.28	66	45
5-6	7-25	5	9.4	7.3	105	0.32	64	49
15-16	8-18	5	9.9	5.2	105	0.34	66	49
23-24	9-2	5	9.8	6.8	110	0.38	69	50
25-26	9-3	5	9.5	5.1	110	0.42	69	50
31-32	9-4	5	9.4	6.6	110	0.38	69	51
7-8	7-26	5	9.5	5.0	107	0.29	64	46
10	8-4	5	9.3	5.2	100	0.34	63	61
12	8-5	5	9.5	4.8	102	0.32	64	46
14	8-6	5	9.3	8.3	105	0.38	66	47
17-18	8-22	5	9.5	3.7	105	0.36	66	45
19-20	8-23	5	9.7	7.2	105	0.35	66	46
21-22	8-30	5	8.7	6.4	110	0.37	69	51
Average (Kiln #5)			9.4	5.7	105	0.34	66	48

By-pass to 1 mill (Avg = 66 TPH) { runs 1-2 through 31-32

(Avg. = 64 TPH) No by-pass { runs 7-8 through 14

By-pass to 2 mills (Avg. = 67 TPH) { runs 17-18 through 21-22

– Kiln No. 1 Stack:

$$28.4\ \frac{\text{lbs. part.}}{\text{hr.}} \times \frac{1\ \text{hr.}}{14.1\ \text{tons clinker}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 1.01\ \frac{\text{kg part.}}{\text{Mg clinker}}$$

$$1.01\ \frac{\text{kg part}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.962\ \text{kg part.}/\text{Mg cement}$$

– Kiln No 3 Stack:

$$23.6\ \frac{\text{lbs part}}{\text{hr.}} \times \frac{1\ \text{hr.}}{14.4\ \text{tons clinker}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.819\ \frac{\text{kg}}{\text{Mg}}$$

$$0.819\ \frac{\text{kg part.}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.780\ \text{kg part}/\text{Mg cement}$$

– Kiln No. 4 Stack:

$$28.9\ \frac{\text{lbs part}}{\text{hr}} \times \frac{1\ \text{hr}}{19.0\ \text{tons clinker}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.761\ \frac{\text{kg}}{\text{Mg}}$$

$$0.761\ \frac{\text{kg part}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.724\ \text{kg part}/\text{Mg cement}$$

– Kiln No. 5 Stack: Use no by-pass scenario

$$38.4\ \frac{\text{lbs part}}{\text{hr.}} \times \frac{1\ \text{hr}}{64\ \text{tons clinker}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.30\ \frac{\text{kg}}{\text{Mg}}$$

$$0.30\ \frac{\text{kg part}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.286\ \text{kg part}/\text{Mg cement}$$

$$\therefore \overline{EF} = \frac{0.962 + 0.780 + 0.724 + 0.286}{4} = 0.688\ \text{kg part}/\text{Mg cement}$$

- OK Cement Source Emission Study (Reference 33) ✓

① Coal-fired dry process kiln w/ cyclones + bhouse

EPA Method 5 tests on bhouse stack

From Summary of Results, page 3 of report:

⑭

SUMMARY OF RESULTS

Kiln Number 3 Stack

Run Number	2	3	4
Stack Flow Rate - ACFM	127,830	128,487	125,015
Stack Flow Rate - DSCFM*	70,239	70,405	70,003
% Water Vapor - % Vol.	6.7	7.0	6.0
% CO_2 - % Vol.	11.0	12.4	12.4
% O_2 - % Vol.	13.7	13.0	13.2
% Excess Air @ Sampling Point	219	192	203
Particulates Probe, Cyclone & Filter Catch grains/dscf*	0.0115	0.0109	0.0102
grains/cf @ Stack Conditions	0.0063	0.0059	0.0057
lbs/hr	6.9	6.6	6.1

$$\text{Average Emission Rate} = \frac{6.9 + 6.6 + 6.1}{3}\ \frac{\text{lbs}}{\text{hr.}} = 6.5\ \frac{\text{lbs part}}{\text{hr.}}$$

From page 10 of test report:

PRODUCTION DATA FACTORS

During Joy Baghouse Emission Test

Production Rates - For eight hours operation 11:00 a.m. - 7:00 p.m.
(3-28-80)

#3 Kiln

Raw Feeder Counts -
419.1 ÷ 8 = 52.5 tons raw per hour
= 52.5 tons/hr x 0.63 = 33.1 clinker tons/hr

$$\therefore EF = 6.5 \frac{\cancel{\text{lbs part}}}{\cancel{\text{hr.}}} \times \frac{1\ \cancel{\text{hr.}}}{33.1\ \cancel{\text{tons clinker}}} \times 1.102\ \frac{\cancel{\text{short ton}}}{\cancel{\text{Mg}}} \times 0.454\ \frac{\text{kg}}{\cancel{\text{lb}}} \times \frac{1\ \cancel{\text{Mg clinker}}}{1.05\ \text{Mg cement}}$$

$$= 0.094\ \text{kg part.}/\text{Mg cement}$$

- Lone Star, New Orleans Source Emission Survey (Reference 39)

(2) Coal-fired wet process kilns w/ESPs — Method 5 tests

From page 5 of test report:

SUMMARY OF EMISSION TESTS
New Orleans
November 9th - 13, 1981

	Kiln No. 1	Kiln No. 2
Stack Flow ACFM	252076	229817
Stack Flow DSCFM	125468	112262
% Water Vapor %Vol	23.2	22.8
Particulates Front Half		
Grains/Cf @Stack Conditions	0.0085	0.0088
Emissions lbs/hr.	18.33	17.4

Assuming identical kilns & control equipment:

$$\text{Average emission rate} = \frac{18.33+17.4}{2}\ \frac{\text{lbs}}{\text{hr}} = 17.9\ \frac{\text{lbs.}}{\text{hr.}}\ \text{for both kilns}$$

From page 16 of test report:

Assume dry feed!

PRODUCTION DATA DURING TESTING

	Raw Feed (tons/hr)	Coal Feed (tons/hr)	Total Feed (tons/hr)	Allowable Emissions (lbs/hr)
Kiln Number 1	83.0	11.0	94.0	Louisiana Regulation 50.66
Kiln Number 2	83.0	11.0	83.0	EPA Regulation 24.9

Average dry feed = 83 TPH

Kiln Number 1 Under State Regulations

Kiln Number 2 Installed after 1971 therefore, must abide by EPA Regulations.

81-107 -16-

Assuming: 1.7 Mg raw feed / Mg cement (per p. 20; EPA-600/2-77-023u)
(not including coal burned)

$$\therefore 17.9\ \frac{\text{lbs part}}{\text{hr.}} \times \frac{1\ \text{hr.}}{83.0\ \text{tons feed}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{Mg}} \times 1.7\ \frac{\text{Mg feed}}{\text{Mg cement}} = 0.183\ \frac{\text{kg}}{\text{Mg}}$$

- Bonner Springs Stack Emission Survey (Reference 40) ✓

(3) Coal-fired wet kilns w/ common ESP (No. 2 Stack)
(1) " " " kiln w/ ESP (No. 4 Stack)

EPA Method 5 Tests @ ESP Stacks

For No. 4 Kiln: from Table T-1, page 14 of test report:

TABLE T-1

BONNER SPRINGS STACK EMISSION SURVEY

PARTICULATE EMISSION RATE 1981

Run No.	Test Location	Date	Exhaust Gas Temp. °F.	Exhaust Gas Volume ACFM	Particulate Emission Rate Grains/SCF Dry	Lbs./SCF Dry x 10^{-6}	Lbs./Hr.	Tons/Day
2	No. 4 Stk.	9-8	—	—	—	—	—	—
3	"	"	777	75,900	0.1647	23.5	33.0	0.40
5	"	9-9	772	64,100	0.0741	10.4	19.7	0.24
6	"	"	769	72,900	0.0690	9.9	21.2	0.25
9	"	9-10	776	64,700	0.0623	8.9	18.0	0.22
10	"	"	768	67,200	0.0764	10.9	21.0	0.25
15	"	9-11	766	63,300	0.0955	13.6	25.9	0.31
16	"	"	768	55,300	0.0222	3.2	4.7	0.06
AVERAGE			771	64,300	0.0805	11.5	23.4	0.28

From Table T-4, page 19 of test report:

19

TABLE T-4

BONNER SPRINGS STACK EMISSION SURVEY

RATE PRODUCTION AND CONSUMPTION 1981

Date 1981	System Under Test	Fuel Used Coal Lbs/Min.	Fuel Used Moisture %	Raw Mix Used Tons/Hr. DRY	Raw Mix Used Slurry Moist - %	Raw Mix Used $CaCO_3$ %	Clinker Produc. Tons/Hr.
9-8	No. 4 Kiln Stk.	136	8.0	31.0	34.7	79.3	16.8
9-9	"	166	6.1	31.0	35.0	79.2	16.9
9-10	"	130	8.0	31.4	34.5	79.3	17.0
9-11	"	130	7.1	32.0	34.1	79.2	17.4

} Average clinker prod. rate = 17.0 TPH

$$\overline{EF} = 23.4 \frac{\text{lbs part}}{\text{hr}} \times \frac{1 \text{ hr}}{17.0 \text{ tons clinker}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 0.656 \frac{\text{kg}}{\text{Mg}}$$

For Kilns 1, 2, & 3: From Table T-1, page 14 of test report

Run No.	Test Location	Date	Exhaust Gas Temp. °F.	Exhaust Gas Volume ACFM	Grains/SCF Dry	Lbs./SCF Dry x 10^{-6}	Lbs./Hr.	Tons/Day
21	No. 3 Stk.	9-21	695	99,300	0.0306	4.4	16.3	0.20
22	"	9-21	697	105,400	0.0748	10.7	40.6	0.49
27	"	9-22	666	96,100	0.0206	2.9	11.6	0.14
28	"	9-22	666	100,900	0.0301	4.3	18.4	0.22
33	"	9-23	635	90,300	0.0177	2.5	10.0	0.12
34	"	9-23	635	85,200	0.0199	2.8	10.7	0.13
39	"	9-24	677	108,900	0.0340	4.9	20.4	0.25
40	"	9-24	676	110,600	0.0329	4.7	20.1	0.24
45	"	9-25	680	103,700	0.0602	8.6	34.4	0.41
46	"	9-25	679	111,400	0.0351	5.0	21.0	0.25
51	"	10-5	720	114,700	0.0240	3.4	13.1	0.16
52	"	10-5	724	118,400	0.1088	15.4	62.6	0.75
57	"	10-6	734	119,000	0.0788	11.3	44.8	0.54
58	"	10-6	734	127,200	0.0486	7.0	29.0	0.35
63	"	10-7	702	102,600	1.0470	147.0	~~551~~	6.6
64	"	10-7	703	93,400	0.6930	99.0	~~350~~	4.2
AVERAGE			688	103,700	0.1472	20.8	~~77.25~~	0.93
average not including Runs 63 & 64					0.062		25.2 lbs/hr.	

ESP upset during runs 63 & 64!

From Table T-4, page 19 of test report:

⑰

Date 1981	System Under Test	Fuel Used: Coal lbs/Min.	Fuel Used: Moisture %	Raw Mix Used: Ton/Hr. Dry	Raw Mix Used: Slurry Moist. - %	Raw Mix Used: $CaCO_3$ %	Clinker Produced Ton/Hr.	Totals
9-21	No. 2 Kiln Sch.							
	Kiln 1-24 Hr.	83	7.4	17.86	34.1	80.3	9.92	19.46
	Kiln 2-24 Hr.	88	7.4	17.27	34.1	80.3	9.54	
	Kiln 3-0 Hr.	—	—	—	—	—	—	
9-22	Kiln 1-0 Hr.	—	—	—	—	—	—	
	Kiln 2-24 Hr.	84	5.8	16.72	34.3	80.4	9.29	9.29
	Kiln 3-0 Hr.	—	—	—	—	—	—	
9-23	Kiln 1-0Hr.	—	—	—	—	—	—	
	Kiln 2-24 Hr.	85	6.5	16.80	34.0	80.3	9.38	18.05
	Kiln 3-12 Hr.	90	6.5	15.61	34.0	80.3	8.67	
9-24	Kiln 1-0 Hr.	—	—	—	—	—	—	
	Kiln 2-24 Hr.	86	8.0	17.17	34.1	80.3	9.54	18.92
	Kiln 3-24 Hr.	80	8.0	16.88	34.1	80.3	9.38	
9-25	Kiln 1-0 Hr.	—	—	—	—	—	—	
	Kiln 2-24 Hr.	84	7.8	17.41	34.0	80.3	9.67	19.09
	Kiln 3-24 Hr.	77	7.8	16.96	34.0	80.3	9.42	
10-3	Kiln 1-24 Hr.	87	7.2	18.23	33.8	79.9	10.13	29.71
	Kiln 2-24 Hr.	86	7.2	17.69	33.8	79.9	9.83	
	Kiln 3-20.5 Hr.	80	7.2	17.35	33.8	79.9	9.75	
10-6	Kiln 1-20 Hr.	89	7.5	18.18	34.3	79.8	10.10	29.25
	Kiln 2-24 Hr.	87	7.5	17.26	34.3	79.8	9.59	
	Kiln 3-23.75 Hr.	84	7.5	17.21	34.3	79.8	9.56	
10-7	Kiln 1-18 Hr.	89	7.0	16.31	34.1	79.7	9.06	Delete
	Kiln 2-23 Hr.	82	7.0	17.14	34.1	79.7	9.52	
	Kiln 3-24 Hr.	84	7.0	16.43	34.1	79.7	9.13	

Average clinker prod. = 20.54 TPH

$$\overline{EF} = 25.2\,\frac{\text{lbs part.}}{\text{hr.}} \times \frac{1\ \text{hr.}}{20.54\ \text{tons clinker}} \times 1.102\,\frac{\text{short tons}}{\text{Mg}} \times 0.454\,\frac{\text{kg}}{\text{lb}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.584\,\frac{\text{kg}}{\text{Mg}}$$

$$\text{Average of Two Kilns} = \frac{0.656 + 0.584}{2} = 0.620\ \text{kg/Mg cement}$$

- Mojave Annual Compliance Test (Reference 44)
  (1) Coal-fired, dry process kiln w/ suspension preheater, flash calciner, & bhouse (per Ref. 45)

From second page of test report: EPA Method 5 data

SUMMARY OF SOURCE TEST RESULTS

Company California Portland Cement . Test Date 5/23-5/24/83 APCD No. 1003026A Unit No. Kiln Baghouse

Pollutants	Emissions: Inlet: Concentration Wet: gr/scf	Inlet: Concentration Wet: @ 12% CO_2	Inlet: Concentration Wet: ppm_v	Inlet: Mass Flow Rate lb/hr	Outlet: Concentration Wet: gr/scf	Outlet: Concentration Wet: @ 12% CO_2	Outlet: Concentration Wet: ppm_v	Outlet: Concentration Wet: @ 3% O_2	Outlet: Mass Flow Rate lb/hr	Removal %	Emission Factor lb/ton: Inlet	Emission Factor lb/ton: Outlet
Particulate					0.0551* 0.0094 0.0077 0.0086	0.0409* 0.0063 0.0057 0.0060			100.57* 16.96 13.72 15.34			0.45* 0.08 0.06 0.07
Sulfate												
SO_2							52.79 [illegible] 50.09 53.29		111.45 112.76 102.29 108.83			
NO_x as NO_2 (dry)							296.37 282.85 258.96 279.39	495.8 468.8 421.4 462.0	423.42 404.11 369.98 399.17			
HC												

Scrubber Liquor Analysis: Chlorides -- Specific Gravity --

For Kern County Use Only:

Remarks: *Test 1 not included in average; probe/filter catch from test 1 agreed well with probe/filter catch from tests 2 & 3; however, impinger catch from test 1 was 9 times greater than tests 2 & 3, which agreed well; the cause of this large difference is unknown but obviously incorrect; therefore test 1 was eliminated; production rate for test 1 & 2 was 225 TPH; production rate for test 3 was 219 TPH (prorated).

→ Emission Factors w/ impinger catch

③

Assuming "Production Rate" is dry input to kiln and correcting for impinger catch:

Test No. 1 : Delete Data

Test No. 2: From weights on p. 3-6

$$\frac{0.08\ \text{lbs/ton}}{0.02949\ \text{gm}} = \frac{X\ \text{lbs/ton}}{0.00848\ \text{gm}}$$

$$X = 0.02\ \text{lbs/ton dry meal}$$

$$0.02\,\frac{\text{lbs part}}{\text{ton feed}} \times 1.7\,\frac{\text{tons feed}}{\text{ton cement}} \times 1.102\,\frac{\text{short ton}}{\text{Mg}} \times 0.454\,\frac{\text{kg}}{\text{lb}} = 0.02\,\frac{\text{kg part}}{\text{Mg cement}}$$

Test No. 3: From weights on p. 3-9

$$\frac{0.06\ \text{lbs/ton}}{0.02398\ \text{gm}} = \frac{X\ \text{lbs/ton}}{0.00691}$$

$$X = 0.02\ \text{lbs/ton dry meal}$$

$$0.02\,\frac{\text{lbs part}}{\text{ton feed}} \times 1.7\,\frac{\text{tons feed}}{\underset{\text{(per EPA-600/2-77-023u)}}{\text{ton cement}}} \times 1.102\,\frac{\text{short ton}}{\text{Mg}} \times 0.454\,\frac{\text{kg}}{\text{lb}} = 0.02\,\frac{\text{kg part}}{\text{Mg cement}}$$

Average of Test 2 & 3 = $\frac{0.02 + 0.02}{2} = 0.02$ kg/Mg

⑲

- Mojave Annual Compliance Test (Reference 50)

(1) Coal-fired dry process kiln w/ suspension preheater flash calciner, and bhouse

(3) EPA Method 5 Tests (including impinger catch)

From p. A-2 of test report: emission rate w/o impingers

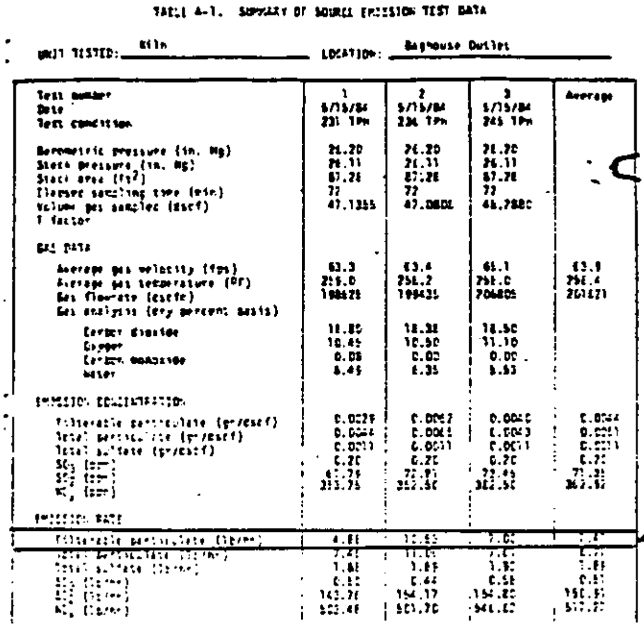


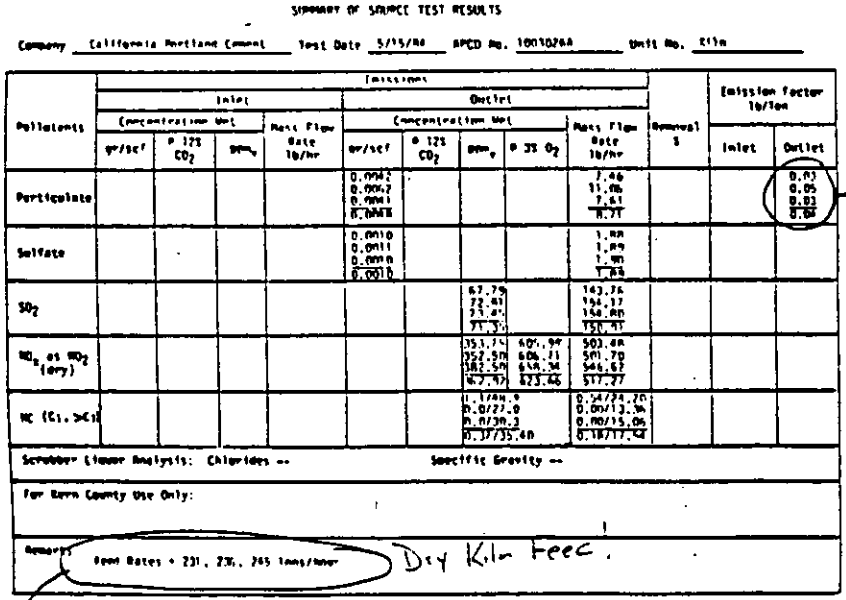
TABLE A-1. SUMMARY OF SOURCE EMISSION TEST DATA

UNIT TESTED: Kiln LOCATION: Baghouse Outlet

Test number	1	2	3	Average
Date	5/15/84	5/15/84	5/15/84	
Test condition	231 TPH	236 TPH	245 TPH	
Barometric pressure (in. Hg)	26.20	26.20	26.20	
Stack pressure (in. Hg)	26.11	26.11	26.11	
Stack area (ft^2)	67.28	67.28	67.28	
Elapsed sampling time (min)	72	72	72	
Volume gas sampled (dscf)	47.1355	47.0806	46.7880	
Y factor				
GAS DATA				
Average gas velocity (fps)	63.3	63.4	65.1	63.9
Average gas temperature (°F)	255.0	256.2	256.0	256.4
Gas flowrate (dscfm)	198628	199435	206805	201621
Gas analysis (dry percent basis)				
Carbon dioxide	18.80	18.38	18.50	
Oxygen	10.45	10.50	11.10	
Carbon monoxide	0.08	0.02	0.00	
Water	6.49	6.35	5.53	
EMISSION CONCENTRATION				
Filterable particulate (gr/dscf)	0.0029	0.0052	0.0040	0.0044
Total particulate (gr/dscf)	0.0044	0.0065	0.0043	0.0051
Total sulfate (gr/dscf)	0.0011	0.0011	0.0011	0.0011
SO$_3$ (ppm)	0.20	0.20	0.20	0.20
SO$_2$ (ppm)	67.79	72.91	72.45	71.38
NO$_x$ (ppm)	353.75	352.50	382.50	362.92
EMISSION RATE				
Filterable particulate (lb/hr)	4.88	10.53	7.02	[illegible]
Total particulate (lb/hr)	7.47	11.06	7.61	8.71
Total sulfate (lb/hr)	1.88	1.89	1.90	1.89
SO$_3$ (lb/hr)	0.52	0.44	0.58	0.51
SO$_2$ (lb/hr)	143.76	154.17	154.80	150.91
NO$_x$ (lb/hr)	503.48	501.70	546.62	517.27

Average emission rate w/o impingers

From Summary of Source Test Results: feedrates for tests



SUMMARY OF SOURCE TEST RESULTS

Company California Portland Cement Test Date 5/15/84 APCD No. 1003026A Unit No. Kiln

Pollutants	Emissions									Removal %	Emission factor lb/ton	
	Inlet				Outlet							
	Concentration Unit			Mass Flow Rate lb/hr	Concentration Unit				Mass Flow Rate lb/hr		Inlet	Outlet
	gr/scf	@ 12% CO$_2$	ppm$_v$		gr/scf	@ 12% CO$_2$	ppm$_v$	@ 3% O$_2$				
Particulate					0.0042 0.0067 0.0041 0.0048				7.46 11.06 7.61 8.71			0.03 0.05 0.03 0.04
Sulfate					0.0010 0.0011 0.0010 0.0010				1.88 1.89 1.90 1.89			
SO$_2$							67.79 72.91 72.45 71.38		143.76 154.17 154.80 150.91			
NO$_x$ as NO$_2$ (dry)							353.75 352.50 382.50 362.92	605.99 606.71 658.34 623.46	503.48 501.70 546.62 517.27			
HC (C$_1$, >C$_1$)							1.1/44.9 0.0/27.0 0.0/30.3 0.37/35.40		0.54/24.20 0.00/13.36 0.00/15.06 0.18/17.54			

Scrubber Liquor Analysis: Chlorides -- Specific Gravity --

For Kern County Use Only:

Remarks: Feed Rates = 231, 236, 245 tons/hour

Includes impinger catch

Dry Kiln Feed.

$$\text{Average feed} = \frac{231 + 236 + 245}{3}\ \frac{\text{tons}}{\text{hr.}} = 237 \text{ short tons/hr.}$$

(2D)

$$\therefore 7.47 \frac{\text{lbs part}}{\text{hr.}} \times \frac{1 \text{ hr.}}{237 \text{ tons dryfeed}} \times 1.7 \frac{\text{tons feed}}{\text{ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.0263 \text{ kg/Mg}$$

(average w/o impingers)

- Lehigh Particulate (Leeds) Compliance Test (Reference 51)

  (1) Coal-fired dry process kiln w/ ESP (Raw mill in series)

  EPA Method 5 test @ kiln stack - Loesche mill off

  From Calculation Sheets in Appendix B for Runs 2, 3, 4, & 5:

  $$\text{Average emission rate} = \frac{24.61 + 25.40 + 16.74 + 15.66}{4} \frac{\text{lbs}}{\text{hr.}}$$
  $$= 20.60 \text{ lbs part./hr.}$$

  From Process Records in Appendix D: Tests 2-5

  $$\text{Average feedrate} = \frac{140 + 133 + 135 + 134}{4} \frac{\text{short tons}}{\text{hr}} = 137 \frac{\text{tons}}{\text{hr.}}$$

  $$\therefore 20.60 \frac{\text{lbs part}}{\text{hr.}} \times \frac{1 \text{ hr.}}{137 \text{ tons feed}} \times 1.7 \frac{\text{tons feed}}{\text{ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} =$$
  $$0.1278 \frac{\text{kg part}}{\text{Mg cement}} =$$

- Lehigh Portland (Cementon) Compliance Test (Reference 52)

  (1) Coal-fired wet process kiln w/ ESP

  EPA Method 5 Tests @ Kiln Stack

  From p. 2-1 of test report:

TABLE 2-1. PARTICULATE EMISSIONS RESULTS

Date	Test No.	Time Period (hr)	Particulate Gr/DSCF*	Emissions lb/hr**
11/8/84	1C Comp 1	1525 - 1657	0.009	8.5
11/9/84	1C Comp 2	1316 - 1428	0.010	8.6
11/9/84	1C Comp 3	1610 - 1722	0.013	12.0
AVERAGE			0.011	9.7

*Standard conditions 68°F and 29.92 in Hg at stack oxygen level

**Based on stack velocity method of analysis

From p. 1-1 of test report:

1500 tons clinker/day ≅ 400 gpm slurry input

$$1500 \frac{\text{tons clinker}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hrs}} = 63 \frac{\text{tons clinker}}{\text{hr.}}$$

From p. A-2, A-5, & A-8 of test report:

$$\text{Average kiln feed} = \frac{400 + 400 + 405}{3} \frac{\text{gal}}{\text{min}}$$

$$= 402 \text{ gal/min slurry to kiln}$$

$$\therefore \frac{63 \text{ TPH clinker}}{400 \text{ gpm}} = \frac{X \text{ TPH clinker}}{402 \text{ gpm}}$$

$$X = 63 \text{ tons clinker/hr.}$$

Average emission factor for kiln:

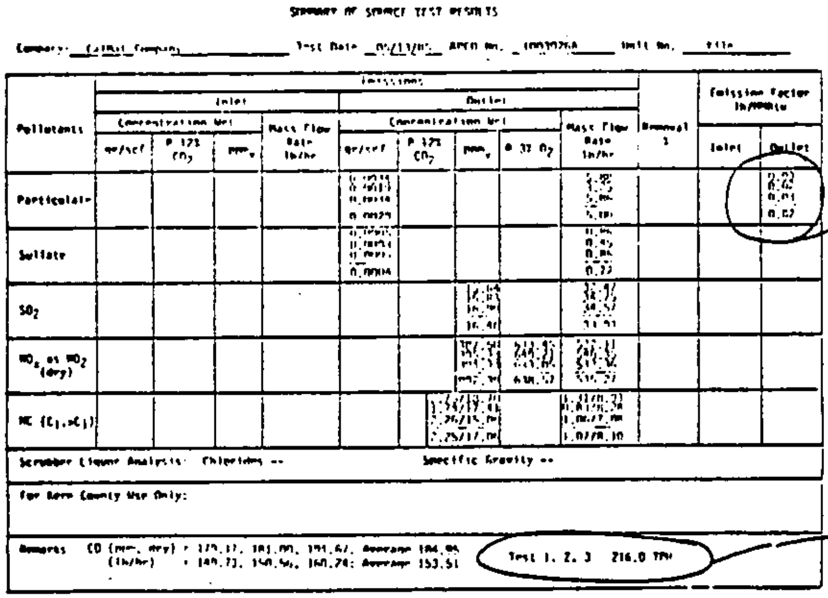
$$9.7 \frac{\text{lbs. part}}{\text{hr.}} \times \frac{1 \text{ hr.}}{63 \text{ tons clinker}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} = 0.073 \text{ kg/Mg cement}$$

- Mojave Annual Compliance Test – 1985 (Reference 53)

  (1) Coal-fired dry process kiln, w/ suspension preheater, flash calciner, & bhouse

  (2) EPA Method 5 Tests (includes impinger catch)

From Summary of Source Test Results:



SUMMARY OF SOURCE TEST RESULTS

Company: Calmat Company Test Date [illegible] APCD No. [illegible] Unit No. Kiln

Pollutants	Inlet: Concentration Wet gr/scf	Inlet: @ 12% CO2	Inlet: ppm	Inlet: Mass Flow Rate lb/hr	Outlet: Concentration Wet gr/scf	Outlet: @ 12% CO2	Outlet: ppm	Outlet: @ 3% O2	Outlet: Mass Flow Rate lb/hr	Removal %	Emission Factor lb/MMBtu Inlet	Emission Factor lb/MMBtu Outlet
Particulate					[illegible] [illegible] [illegible] 0.0029				[illegible]			[illegible] [illegible] 0.01 0.02
Sulfate					[illegible] [illegible] [illegible] 0.0004				[illegible] [illegible] [illegible] 0.72			
SO_2							[illegible]		[illegible]			
NO_x as NO_2 (dry)							[illegible]	[illegible]	[illegible]			
HC (C_1-C_3)						[illegible]			[illegible]			

Scrubber Liquor Analysis: Chlorides -- Specific Gravity --

For Kern County Use Only:

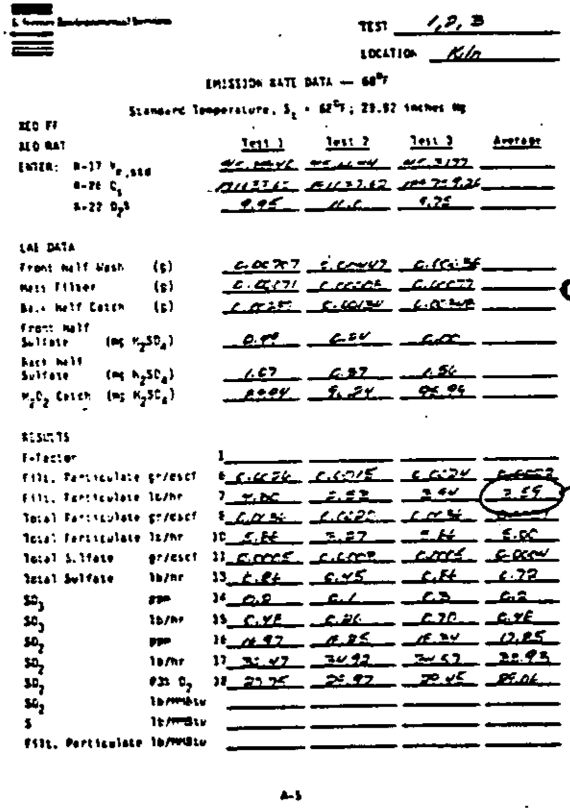
Remarks CO (ppm, dry) = 179.17, 181.00, 191.67, Average 184.95
(lb/hr) = 149.73, 150.56, 160.24; Average 153.51

Test 1, 2, 3 216.0 TPH

includes impinger catch

Assume: Average feed to kiln (dry)

From p. A-5 of test report: correct for impinger catch



TEST 1, 2, 3

LOCATION Kiln

EMISSION RATE DATA — 68°F

Standard Temperature, S_t = 68°F; 29.92 inches Hg

	Test 1	Test 2	Test 3	Average
ENTER: A-17 $V_{m,std}$	[illegible]	[illegible]	[illegible]	
A-26 C_s	[illegible]	[illegible]	[illegible]	
A-22 O_2	9.95	[illegible]	9.75	
LAB DATA				
Front Half Wash (g)	[illegible]	[illegible]	[illegible]	
Mass Filter (g)	[illegible]	[illegible]	[illegible]	
Back Half Catch (g)	[illegible]	[illegible]	[illegible]	
Front Half Sulfate (mg H_2SO_4)	[illegible]	[illegible]	[illegible]	
Back Half Sulfate (mg H_2SO_4)	1.67	[illegible]	1.56	
H_2O_2 Catch (mg H_2SO_4)	[illegible]	[illegible]	[illegible]	
RESULTS				
F-Factor 1				
Filt. Particulate gr/dscf 6	[illegible]	[illegible]	[illegible]	[illegible]
Filt. Particulate lb/hr 7	[illegible]	[illegible]	[illegible]	3.59
Total Particulate gr/dscf 8	[illegible]	[illegible]	[illegible]	[illegible]
Total Particulate lb/hr 10	[illegible]	[illegible]	[illegible]	[illegible]
Total Sulfate gr/dscf 11	[illegible]	[illegible]	[illegible]	[illegible]
Total Sulfate lb/hr 13	[illegible]	[illegible]	[illegible]	[illegible]
SO_3 ppm 14	[illegible]	[illegible]	[illegible]	[illegible]
SO_3 lb/hr 15	[illegible]	[illegible]	[illegible]	[illegible]
SO_2 ppm 16	[illegible]	[illegible]	[illegible]	12.85
SO_2 lb/hr 17	[illegible]	[illegible]	[illegible]	[illegible]
SO_2 @3% O_2 18	[illegible]	[illegible]	[illegible]	[illegible]
SO_2 lb/MMBtu				
S lb/MMBtu				
Filt. Particulate lb/MMBtu				

A-5

Average emission rate w/o impingers

$$3.59\ \frac{\text{lbs part}}{\text{hr.}} \times \frac{1\ \text{hr}}{216\ \text{tons feed}} \times 1.7\ \frac{\text{ton feed}}{\text{ton cement}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} = 0.0141\ \frac{\text{kg}}{\text{Mg cement}}$$

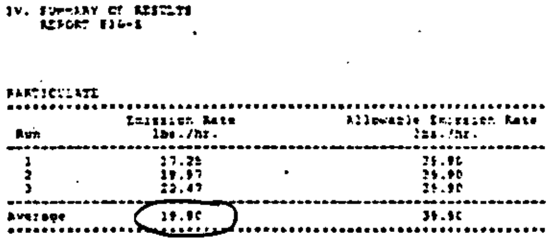
(23)

- Lonestar Florida Stack Test (Reference 54).

(1) Coal-fired wet process kiln w/ESP

(3) EPA Method 5 Tests on ESP Stack

From p. 4 of test report:

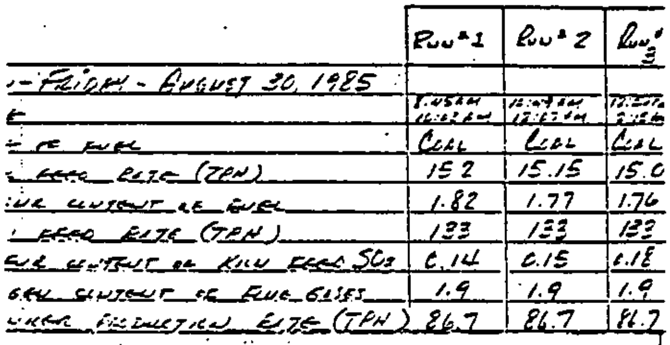


IV. SUMMARY OF RESULTS
REPORT [illegible]

PARTICULATE

Run	Emission Rate lbs./hr.	Allowable Emission Rate lbs./hr.
1	17.25	29.90
2	19.97	29.90
3	22.47	29.90
Average	19.90	29.90

From Appendix C, Process Data



	Run #1	Run #2	Run #3
–FRIDAY – AUGUST 30, 1985			
E	8:45AM 10:02AM	[illegible]	[illegible]
– OF FUEL	COAL	COAL	COAL
– FEED RATE (TPH)	15.2	15.15	15.0
UR CONTENT OF FUEL	1.82	1.77	1.76
FEED RATE (TPH)	133	133	133
UR CONTENT OF KILN FEED SO3	0.14	0.15	0.18
GEN CONTENT OF FLUE GASES	1.9	1.9	1.9
NKER PRODUCTION RATE (TPH)	86.7	86.7	86.7

86.7 TPH Average Clinker Prod

$$\therefore\ 19.90\,\frac{\text{lbs part}}{\text{hr.}} \times \frac{1\ \text{hr}}{86.7\ \text{tons clinker}} \times 1.102\,\frac{\text{short ton}}{\text{Mg}} \times 0.454\,\frac{\text{kg}}{\text{lb}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.109\,\frac{\text{kg}}{\text{Mg cement}}$$

APPENDIX D

TOTAL PARTICULATE EMISSION FACTOR CALCULATIONS FOR CONTROLLED COOLERS, MILLS, AND CRUSHING/SCREENING

MIDWEST RESEARCH INSTITUTE MRI-18

PROJECT DEVELOPMENT SKETCH

TITLE Emission Factor Calculations for Controlled Clinker Coolers, Mills, and Crushing / Screening

PROJECT NO. 4892-L74/8481-L9 DRAWN JSK Orig. 8/23/83 Rev. DATE 3/17/86

Clinker Coolers:

- Report 71-MM-01: Cooler w/ ESP on Wet Process Kiln (Reference No. 10)

From: Table I, page 6 of test report:

Run #1 = 0.106 lbs/short ton feed (clinker)
Run #2 = 0.102 " " " " "
Run #3 = 0.0798 " " " " "

Average = 0.0959 lbs/short ton feed "

$$0.0959 \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.048 \frac{\text{kg part.}}{\text{Mg feed}}$$

Assuming: 0.95 Mg clinker/Mg cement (from EPA-600/2-77-02 p. 20)

$$0.048 \frac{\text{kg part.}}{\text{Mg clinker}} \times 0.95 \frac{\text{Mg clinker}}{\text{Mg cement}} = 0.0456 \frac{\text{kg part.}}{\text{Mg cement}}$$

- Report 71-MM-03: Cooler w/ Baghouse on Wet Process Kiln (Reference No. 11)

From Table 1, page vii of test report:

Run #1 = 0.406 lbs/short ton clinker
Run #2 = 0.452 " " " "
Run #3 = 0.536 " " " "

Average = 0.465 " " " "

$$0.465 \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.233 \frac{\text{kg par}}{\text{Mg cl}}$$

$$0.233 \frac{\text{kg part.}}{\text{Mg clinker}} \times 0.95 \frac{\text{Mg clinker}}{\text{Mg cement}} = 0.221 \frac{\text{kg part.}}{\text{Mg cement}}$$

- Report 71-MM-06: Cooler w/ Baghouse on Wet Process Kiln (Reference No. 14)

From Table I, page 5 of test report

∴ Run #1 = 0.0253 lbs/short ton clinker
Run #2 = 0.0448 " " " "
Run #3 = 0.0305 " " " "

Average = 0.0335 " " " "

$$0.0335 \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb.}} = 0.0168 \frac{\text{kg}}{\text{Mg}}$$

$$0.0168 \frac{\text{kg part.}}{\text{Mg clinker}} \times 0.95 \frac{\text{Mg clinker}}{\text{Mg cement}} = 0.0160 \frac{\text{kg part.}}{\text{Mg cement}}$$

- Report EPA-600/2-76-164 – Evaluation of Rexnord Gravel Bed Filter (Reference No. 21)

From p. 39, Appendix B, of Report EPA-600/2-76-164

APPENDIX B

PLANT PRODUCTION DATA

Date	8/25	8/26	8/27	2/28	8/29	11/4	11/5
Production Tons/Day	742	533*	961	1031	1064	1063	995

*Single kiln

③

From p. 8 of Report EPA-600/2-76-164 — Controlled

Table 3

Mass Emission Tests - Method 5

Outlet

Run #	~~1~~	2	3	4	5
Date	~~8-25-75~~	8-26-75	8-26-75	8-27-75	8-27-75
Time	~~1400~~	1015	1445	1100	1515
Velocity, m/s(f/s)	~~8.82(28.94)~~	8.76(28.73)	6.79(22.29)	7.98(26.18)	7.26(23.81)
%, Moisture	~~2.29~~	1.83	1.86	1.64	1.38
ACM/min(ACFM)	~~1631.7(57619)~~	1619.9(57201)	1256.8(44379)	1476.2(52124)	1342.5(474
SDCM/min(SCDFM)	~~1239.3(43759)~~	1326.4(46837)	1017.5(35927)	1174.2(41461)	1049.7(370
Grams/ACM(Grains/ACF)	~~0.094(0.041)~~	0.030(0.013)	0.064(0.028)	0.043(0.019)	0.034(0.01
Grams/SDCM(Grains/SDCF)	~~0.121(0.053)~~	0.037(0.016)	0.080(0.035)	0.055(0.024)	0.043(0.01
Kg/hr.(Lbs/hr.)	~~9.02(19.88)~~	2.91(6.42)	4.89(10.78)	3.87(8.53)	2.74(6.04)

For Run #2: 8/26/75

$$2.91\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{533\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.144 ✓\ \text{kg/Mg}$$

For Run #3: 8/26/75

$$4.89\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{533\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.243 ✓\ \text{kg/Mg}$$

For Run #4: 8/27/75

$$3.87\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{961\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.107 ✓\ \text{kg/Mg}$$

For Run #5: 8/27/75

$$2.74\ \frac{\text{kg}}{\text{hr.}} \times \frac{1\ \text{day}}{961\ \text{tons cement}} \times 24\ \frac{\text{hrs}}{\text{day}} \times \frac{1.102\ \text{tons}}{\text{Mg}} = 0.075 ✓\ \text{kg/}$$

$$\overline{EF}_c = \frac{0.144 + 0.243 + 0.107 + 0.075}{4\ \text{tests}} = 0.142 ✓\ \text{kg/Mg cement}$$

②

- OK Cement Stack Analysis (Reference 32)

  (3) grate-type coolers w/ common gravel bed filter

  From page 3 of test report:

Haxuord
Pryor, Oklahoma

Particulate Emissions
Gravel Bed Filter
Page Three

EMISSIONS SUMMARY

	Run #1	Run #2	Run #3
Kiln Feed Rate, Tons/Hour	148.8	148.8	148.8
Clinker Feed Rate, Tons/Hour	83.8	83.8	83.8
Allowable Emission Rate, Lb./Hr. (EPA Regulations)	14.9	14.9	14.9
Allowable Emission Rate, Lb./Hr. (State of Oklahoma Regulation)	117.7	117.7	117.7
Actual Emission Rate, Lb./Hr. (Front Half of Train)	14.8	13.6	12.9

$$\overline{ER} = \frac{14.8 + 13.6 + 12.9}{3}\ \frac{\text{lbs}}{\text{hr.}} = 13.8\ \frac{\text{lbs part}}{\text{hr.}}$$

$$\therefore \overline{EF} = 13.8\ \frac{\text{lbs part}}{\text{hr}} \times \frac{1\ \text{hr}}{83.8\ \text{tons clinker}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}}$$

$$= 0.0824\ \frac{\text{kg part}}{\text{Mg clinker}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.0784\ \frac{\text{kg part}}{\text{Mg ceme}}$$

- Lone Star Florida Compliance Test (Reference 36)

  (1) unspecified cooler w/ bhouse

  From page 5 of test report:

SUMMARY OF RESULTS

	RUN 1	RUN 2	RUN 3	AVERAGE
DATE OF TEST	7-9-80	7-9-80	7-9-80	
EMISSION RATE (LBS./HR.)	11.68	20.81	18.46	16.98
ALLOWABLE EMISSION RATE (LBS./HR.)	17.03	17.03	17.03	17.03
EMISSION RATE (LBS./TON OF FEED)	.0686	.1222	.1084	.0997

Since NSPS is in ter
of dry feed to the
kiln – Assume:
Feed rate = dry
TPH to kiln
(no fuel)

⑤

Assuming: 1.7 Mg dry feed/Mg cement (per p. 20, EPA-600/2-77-023u)

$$\therefore \overline{EF} = 0.0997 \frac{\text{lbs part}}{\text{ton feed}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} \times 1.7 \frac{\text{Mg feed}}{\text{Mg cement}}$$

$$= 0.0848 \text{ kg part./Mg cement}$$

- Mason City NSPS Compliance Test (Reference 43)

(1) Unspecified cooler w/ bhouse

From Table 1, page 5 of test report:

Particulate Mass Flow from Kiln Cooler Stack (lb/hr)

Run I	2.7
Run II	1.0
Run III	1.0

$$\overline{ER} = \frac{2.7 + 1.0 + 1.0}{3} \frac{\text{lbs part}}{\text{hr.}} = 1.6 \text{ lbs part/hr.}$$

From Appendix E, pages E-1, E-3, & E-5:

Feed Rates to Kiln (dry) = 136.4, 139.2, & 138. tons/hr, respectivel

$$\text{Average feed rate} = \frac{136.4 + 139.2 + 138.1}{3} \frac{\text{tons}}{\text{hr}} = 137.9 \frac{\text{ton}}{\text{hr}}$$

⑥

$$\therefore \overline{EF} = 1.6 \frac{\text{lbs part}}{\text{hr}} \times \frac{1 \text{ hr}}{137.9 \text{ tons feed}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 5.8(10)^{-3} \frac{\text{kg}}{\text{M}}$$

kiln fee

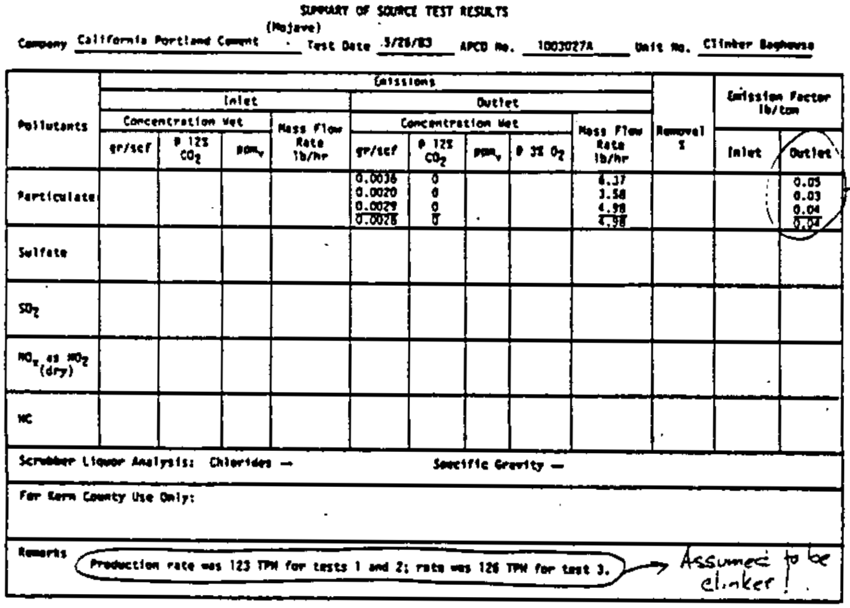
Assuming: 1.7 Mg dry feed/Mg cement (as above)

$$5.8(10)^{-3} \frac{\text{kg part}}{\text{Mg feed}} \times 1.7 \frac{\text{Mg feed}}{\text{Mg cement}} = 9.9(10)^{-3} \frac{\text{kg part}}{\text{Mg cement}}$$

- Mojave Annual Compliance Test (Reference 44)

(1) grate-type clinker cooler w/ bhouse

From page i of test report:



SUMMARY OF SOURCE TEST RESULTS

(Mojave)

Company California Portland Cement . Test Date 3/28/83 APCD No. 1003027A Unit No. Clinker Baghouse

Pollutants	Emissions									Removal %	Emission Factor lb/ton	
	Inlet				Outlet							
	Concentration Wet			Mass Flow Rate lb/hr	Concentration Wet				Mass Flow Rate lb/hr			
	gr/scf	@ 12% CO_2	ppm$_v$		gr/scf	@ 12% CO_2	ppm$_v$	@ 3% O_2			Inlet	Outlet
Particulate					0.0036 0.0020 0.0029 0.0028	0 0 0 0			6.37 3.58 4.98 4.98			0.05 0.03 0.04 0.04
Sulfate												
SO_2												
NO_x as NO_2 (dry)												
HC												

Scrubber Liquor Analysis: Chlorides — Specific Gravity —

For Kern County Use Only:

Remarks: Production rate was 123 TPH for tests 1 and 2; rate was 126 TPH for test 3. → Assumed to be clinker!

See below

Since above emission factors include impinger catch - a correction is necessary

∴ Subtracting impinger catch from total mass collected

Test No. 1: $\frac{0.05 \text{ lbs/ton}}{X \text{ lbs/ton}} = \frac{10.39 \text{ mg (w/impingers)}}{10.29 \text{ mg (wo/impingers)}}$ Impinger catch from p. 5-5

$X = 0.05 \text{ lbs/ton}$

Test No. 2: No correction req'd

⑦

Test No. 3: $\dfrac{0.04\ \text{lbs/ton}}{X\ \text{lbs/ton}} = \dfrac{7.79\ \text{mg}}{7.29\ \text{mg}}$ ← From p. 5-5 of report

$X = 0.04\ \text{lbs/ton}$

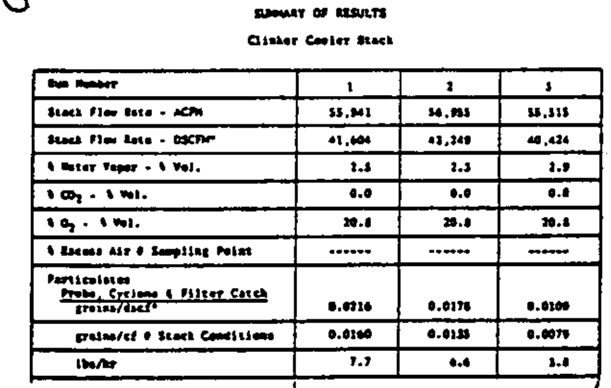
∴ Above average is still correct!

$$\overline{EF} = 0.04\ \frac{\text{lbs. part}}{\text{ton clinker}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}} = 0.02\ \frac{\text{kg}}{\text{Mg cement}}$$

- Lehigh Cement Source Emissions Survey (Reference 48)

(1) Unspecified clinker cooler w/ gravel bed filter

From page 6 of test report:



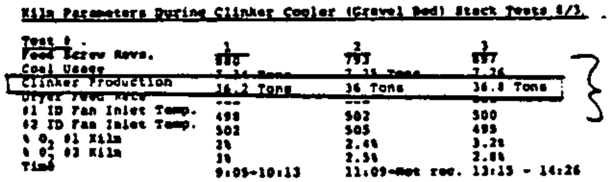
SUMMARY OF RESULTS

Clinker Cooler Stack

Run Number	1	2	3
Stack Flow Rate - ACFM	55,941	56,983	55,315
Stack Flow Rate - DSCFM*	41,604	43,249	40,424
% Water Vapor - % Vol.	2.1	2.3	2.9
% CO_2 - % Vol.	0.0	0.0	0.8
% O_2 - % Vol.	20.8	20.8	20.8
% Excess Air @ Sampling Point	------	------	------
Particulates Probe, Cyclone & Filter Catch grains/dscf*	0.0216	0.0176	0.0109
grains/cf @ Stack Conditions	0.0160	0.0133	0.0079
lbs/hr	7.7	6.6	3.8

Average = 6.0 lbs/hr.

From Appendix F of test report:



Kiln Parameters During Clinker Cooler (Gravel Bed) Stack Tests 1/3.

Test #	1	2	3
Feed Screw Revs.	880	793	897
Coal Usage	7.34 Tons	7.35 Tons	7.26
Clinker Production	36.2 Tons	36 Tons	36.8 Tons
Dryer Feed Rate	---	---	---
#1 ID Fan Inlet Temp.	498	502	500
#2 ID Fan Inlet Temp.	502	505	495
% O_2 #1 Kiln	2%	2.4%	3.2%
% O_2 #3 Kiln	3%	2.3%	2.8%
Time	9:05-10:13	11:09-Not rec.	13:15 - 14:26

Average = 36.3 TPH clinker

$$\overline{EF} = 6.0\ \frac{\text{lbs. part}}{\text{hr.}} \times \frac{1\ \text{hr.}}{36.3\ \text{tons clinker}} \times 1.102\ \frac{\text{short ton}}{\text{Mg}} \times 0.454\ \frac{\text{kg}}{\text{lb}} \times \frac{1\ \text{Mg clinker}}{1.05\ \text{Mg cement}}$$

$$= 0.079\ \text{kg part/Mg cement}$$

- Mojave Annual Compliance Test (Reference 50)

(1) Unspecified cooler w/ baghouse

From page A-16 of test report:

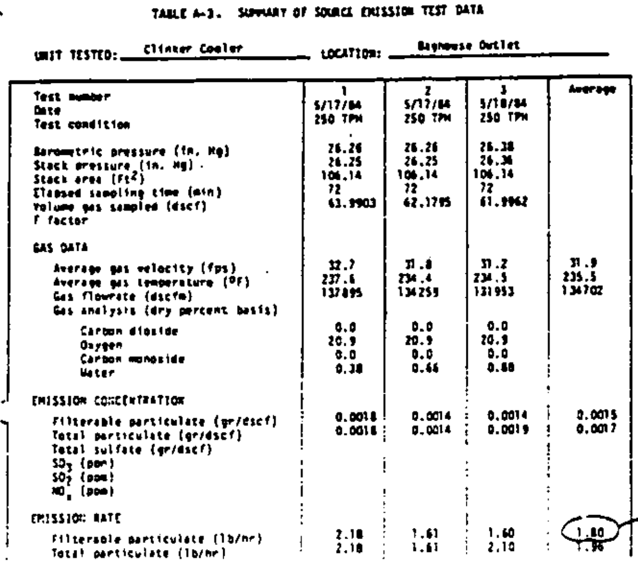


TABLE A-3. SUMMARY OF SOURCE EMISSION TEST DATA

UNIT TESTED: Clinker Cooler LOCATION: Baghouse Outlet

Test number	1	2	3	Average
Date	5/17/84	5/17/84	5/18/84	
Test condition	250 TPH	250 TPH	250 TPH	
Barometric pressure (in. Hg)	26.26	26.26	26.38	
Stack pressure (in. Hg)	26.25	26.25	26.36	
Stack area (Ft^2)	106.14	106.14	106.14	
Elapsed sampling time (min)	72	72	72	
Volume gas sampled (dscf)	63.9903	62.1795	61.9962	
F factor				
GAS DATA				
Average gas velocity (fps)	32.7	31.8	31.2	31.9
Average gas temperature (°F)	237.6	234.4	234.5	235.5
Gas flowrate (dscfm)	137895	134255	131953	134702
Gas analysis (dry percent basis)				
Carbon dioxide	0.0	0.0	0.0	
Oxygen	20.9	20.9	20.9	
Carbon monoxide	0.0	0.0	0.0	
Water	0.38	0.66	0.88	
EMISSION CONCENTRATION				
Filterable particulate (gr/dscf)	0.0018	0.0014	0.0014	0.0015
Total particulate (gr/dscf)	0.0018	0.0014	0.0019	0.0017
Total sulfate (gr/dscf)				
SO_3 (ppm)				
SO_2 (ppm)				
NO_x (ppm)				
EMISSION RATE				
Filterable particulate (lb/hr)	2.18	1.61	1.60	1.80
Total particulate (lb/hr)	2.18	1.61	2.10	1.96

Average w/o impinger catch

From summary on page i of test report:

Average feedrate = 250 TPH Clinker

$$\therefore \overline{EF} = 1.8 \frac{\text{lbs. part.}}{\text{hr.}} \times \frac{1 \text{ hr.}}{250 \cancel{\text{tons}} \text{ clinker}} \times 1.102 \frac{\text{short } \cancel{\text{ton}}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}}$$

$$= 3.4(10)^{-3} \text{ kg part./Mg cement}$$

- Lehigh Particulate Compliance Test (Reference 51)

(1) Grate-type cooler w/ cyclone + gravel bed filter

EPA Method 5 Tests @ gravel bed outlet

From Calculation Sheets in Appendix 3 for Runs 8, 9, & 10:

$$\text{Average emission rate} = \frac{73.35 + 38.92 + 49.90}{3} \frac{\text{lbs part}}{\text{hr}}$$

$$= 54.22 \text{ lbs/hr.}$$

From Process Records in Appendix D: Tests 8-10

$$\text{Average kiln feedrate} = \frac{154 + 163 + 155}{3} \ \frac{\text{short tons}}{\text{hr}}$$

$$= 157 \ \text{tons/hr. to kiln}$$

$$\therefore \ 54.22 \ \frac{\text{lbs part}}{\text{hr.}} \times \frac{1 \ \text{hr.}}{157 \ \text{tons feed}} \times 1.7 \ \frac{\text{tons feed}}{\text{ton cement}} \times 1.102 \ \frac{\text{short ton}}{\text{Mg}} \times 0.454 \ \frac{\text{kg}}{\text{lb}} = 0.293 \ \frac{\text{kg}}{\text{Mg cement}}$$

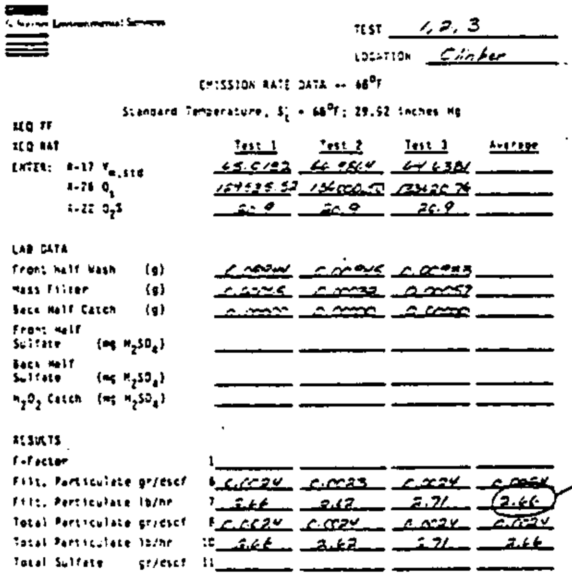
(assumes cooler prod. = kiln prod.)

- Mojave Annual Compliance Test - 1985 (Reference 53)

(1) Grate-type clinker cooler w/ baghouse

EPA Method 5 Tests (including impinger catch)

From p. A-13 of test report:



[illegible] Environmental Services

TEST 1, 2, 3

LOCATION Clinker

EMISSION RATE DATA -- 68°F

Standard Temperature, S_t = 68°F; 29.92 inches Hg

REQ FF

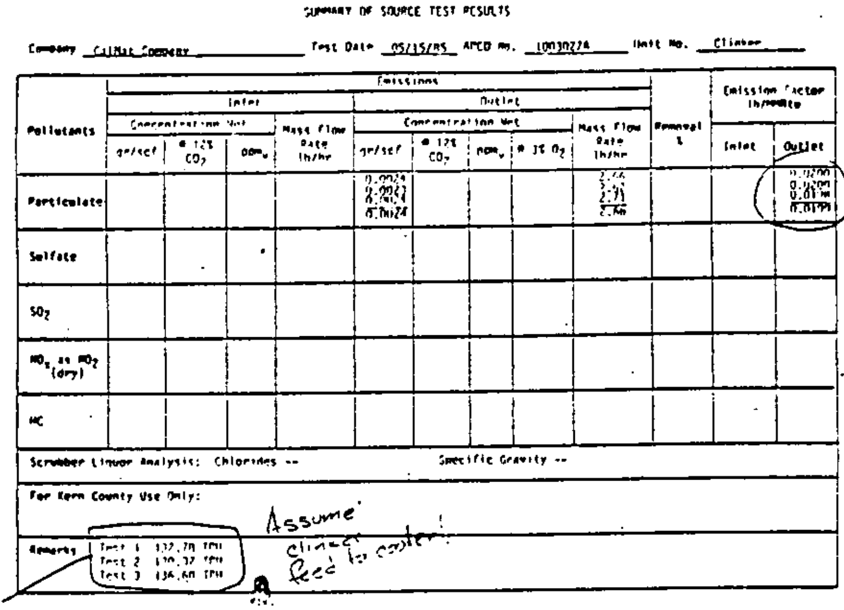
REQ RAT

	Test 1	Test 2	Test 3	Average
ENTER: A-17 $V_{m,std}$	65.0122	64.9864	64.6381	
A-26 Q_s	164525.52	[illegible]	[illegible]	
A-22 O_2%	20.9	20.9	20.9	
LAB DATA				
Front Half Wash (g)	[illegible]	[illegible]	[illegible]	
Mass Filter (g)	[illegible]	[illegible]	0.0057	
Back Half Catch (g)	0.0000	0.0000	0.0000	
Front Half Sulfate (mg H_2SO_4)				
Back Half Sulfate (mg H_2SO_4)				
H_2O_2 Catch (mg H_2SO_4)				
RESULTS				
F-Factor 1				
Filt. Particulate gr/dscf 6	0.0024	0.0023	0.0024	0.0024
Filt. Particulate lb/hr 7	2.66	2.62	2.71	2.66
Total Particulate gr/dscf 8	0.0024	0.0024	0.0024	0.0024
Total Particulate lb/hr 10	2.66	2.62	2.71	2.66
Total Sulfate gr/dscf 11				

Average emission rate (w/ impinger catch)

From Summary of Source Test Results:

10



SUMMARY OF SOURCE TEST RESULTS

Company CalMat Company Test Date 05/15/85 APCD No. 10030274 Unit No. Clinker

Pollutants	Emissions									Removal %	Emission Factor lb/ton	
	Inlet				Outlet							
	Concentration Wet			Mass Flow Rate lb/hr	Concentration Wet				Mass Flow Rate lb/hr			
	gr/scf	@ 12% CO2	ppm_v		gr/scf	@ 12% CO2	ppm_v	@ 3% O2			Inlet	Outlet
Particulate					0.0024 0.0027 0.0024 0.0024				2.66 [illegible] 2.71 2.66			0.0200 0.0200 0.01[illegible] 0.0199
Sulfate												
SO2												
NOx as NO2 (dry)												
HC												

Scrubber Liquor Analysis: Chlorides -- Specific Gravity --

For Kern County Use Only:

Remarks Test 1 132.70 TPH
Test 2 130.92 TPH
Test 3 136.60 TPH

Assume clinker feed to cooler!

[illegible] (lbs/ton)

Average feedrate = $\frac{132.73 + 130.92 + 136.63}{3}$ $\frac{\text{tons clinker}}{\text{hr}}$

= 133.46 tons/hr.

$\therefore 2.66 \frac{\text{lbs part}}{\text{hr}} \times \frac{1 \text{ hr}}{133.46 \text{ tons clinker}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{Mg}} \times \frac{1 \text{ Mg clinker}}{1.05 \text{ Mg cement}} =$

$0.00949 \frac{\text{kg part}}{\text{Mg cement}} =$

Finish Mill System (Includes Mill, Air Separators, Elevators & Weigh Feeders):

- Report 71-MM-04: Finish Mill on Wet Process (Reference 12)
  - No. 1 Mill Air Separator Baghouse A – From Table 1, page

Run # 1 = 0.0130 lbs/short ton cement
Run # 2 = 0.0255 " " " "
Run # 3 = 0.0245 " " " "

Average = 0.0210 " " " "

$$0.021 \frac{\text{lbs. part.}}{\text{short ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.0105 \frac{\text{kg}}{\text{M}}$$

  - No. 1 Mill Air Separator Baghouse B – From Table 2, page 6 of

Run # 1 = 0.0214 lbs/short ton cement
Run # 2 = 0.0163 " " " "
Run # 3 = 0.0164 " " " "

Average = 0.0181 " " " "

$$0.0181 \frac{\text{lbs. part.}}{\text{short ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.00906 \frac{\text{k}}{\text{M}}$$

  - No. 1 Mill (and Elevator) Baghouse – From Table 3, page 7 of report

Run # 1 = 0.0135 lbs/short ton cement
Run # 2 = 0.0133 " " " "
Run # 3 = 0.0134 " " " "

Average = 0.0134 " " " "

$$0.0134 \frac{\text{lbs. part}}{\text{short ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.0067 \frac{\text{k}}{\text{M}}$$

$$\text{Total System} = \underset{\text{(Bhouse A)}}{0.0105} + \underset{\text{(Bhouse B)}}{0.00906} + \underset{\text{(Mill + Elev.)}}{0.0067} = 0.0263 \frac{\text{kg part.}}{\text{Mg cemen}}$$

- Report 71-MM-06: No. 2 Finish Mill System w/ Baghouse (includes mill, air separators, and feeder) - Wet Process (Reference 14

From Table 2, page 6 of test report:

Run #1 = 0.0152 lbs/short ton cement
Run #2 = 0.0201 " " " "
Run #3 = 0.0120 " " " "

Average = 0.0158 " " " "

$$0.0158 \frac{\text{lbs. part.}}{\text{short ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.0079 \frac{\text{kg p}}{\text{Mg cem}}$$

- Report 71-MM-02 - Ball Mill w/ Baghouses on Wet Proce (Reference 17)
  - No. 2 Finish Mill BHouse - Per Table 4, page 5 of rep

Run # 2 = 0.00601 lbs/short ton cement
Run # 3 = 0.00601 " " " "

Average = 0.00601 " " " "

$$0.00601 \frac{\text{lbs part.}}{\text{short ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.00301 \frac{\text{k}}{\text{M}}$$

- No. 2 Mill Air Separator Baghouse - Per Table 5, page 6 of repo

Run #1 = 0.0173 lbs/short ton cement
Run #2 = 0.0164 " " " "

Average = 0.0169 " " " "

$$0.0169 \frac{\text{lbs. part.}}{\text{short ton cement}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.00846 \frac{\text{kg}}{\text{M}}$$

– No. 2 Mill Weigh Feeder Baghouse – Per Table 6, page 7 of rep

Run #1 = 0.00953 lbs/short ton cement
Run #2 = 0.00922 " " " "

Average = 0.00938 " " " "

$$0.00938 \ \frac{\text{lbs. part}}{\text{short ton cement}} \times 1.102 \ \frac{\text{short tons}}{\text{Mg}} \times 0.454 \ \frac{\text{kg}}{\text{lb}} = 0.00469 \ \frac{\text{k}}{\text{M}}$$

$$\therefore \text{Total System} = \underset{(\text{Mill})}{0.00301} + \underset{(\text{Air Sep})}{0.00846} + \underset{(\text{Feeder})}{0.00469} = 0.0162 \ \frac{\text{kg}}{\text{Mg}}$$

Raw Mill System:

- Report 71-MM-02: No. 2 Raw Ball Mill – Dry Process Pla
(Reference 17)

– No. 2 Raw Mill Baghouse – From Table 1, page 2 of repor

Run #1 = 0.0161 lbs/short ton raw material
Run #2 = 0.0183 " " " " "

Average = 0.0172 " " " " "

$$0.0172 \ \frac{\text{lbs. part}}{\text{short ton}} \times 1.102 \ \frac{\text{short ton}}{\text{Mg}} \times 0.454 \ \frac{\text{kg}}{\text{lb}} = 0.00861 \ \frac{\text{kg per}}{\text{Mg fee}}$$

Assuming: 1.7 Mg raw mat'l / Mg cement (per p.17 of EPA-600/2-77-023

$$\therefore 0.00861 \ \frac{\text{kg part}}{\text{Mg raw mat'l}} \times 1.7 \ \frac{\text{Mg raw mat'l}}{\text{Mg cement}} = 0.0146 \ \frac{\text{kg part}}{\text{Mg ceme}}$$

– No. 2 Mill Air Separator Baghouse – From Table 2, page 3 of re

Run #1 = 0.0376 lbs/short ton raw material
Run #2 = 0.0265 " " " " "

Average = 0.0321 " " " " "

$$0.0321 \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.0161 \frac{\text{kg par}}{\text{Mg fee}}$$

$$0.0161 \frac{\text{kg part.}}{\text{Mg raw mat'l}} \times 1.7 \frac{\text{Mg raw mat'l}}{\text{Mg cement}} = 0.0274 \frac{\text{kg part}}{\text{Mg cement}}$$

— No. 2 Mill Weigh Feed Baghouse – From Table 3, page 4

Run #1 = 0.0226 lbs / short ton raw material
Run #2 = 0.0153 " " " " "

Average = 0.019 " " " " "

$$0.019 \frac{\text{lbs. part.}}{\text{short ton}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.00951 \frac{\text{kg part}}{\text{Mg fee}}$$

$$0.00951 \frac{\text{kg part.}}{\text{Mg raw mat'l}} \times 1.7 \frac{\text{Mg raw mat'l}}{\text{Mg cement}} = 0.0162 \frac{\text{kg part}}{\text{Mg cement}}$$

$\therefore$ Total System $= 0.0146 + 0.0274 + 0.0162 = 0.0582 \frac{\text{kg. pa}}{\text{Mg cem}}$

$= 0.00861 + 0.0161 + 0.00951 = 0.0342$ kg/Mg raw m

Crushing and Screening:

- Report 74-STN-1 : From summary Table 1, page 5 of repo (Reference 18)
  - Primary Limestone Crusher Baghouse:

$$0.00101 \frac{\text{lbs. part.}}{\text{short ton stone}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.000505 \frac{\text{k}}{\text{M}}$$

— Primary Screen Baghouse:

$$0.00022 \frac{\text{lbs. part.}}{\text{short ton stone}} \times 1.102 \frac{\text{short ton}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.00011 \frac{\text{kg}}{\text{Mg}}$$

⑮

– Overland Conveyor Transfer Station Baghouse:

$$0.00003 \frac{\text{lbs. part.}}{\text{short ton stone}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.00002 \frac{\text{k}}{\text{M}}$$

– Secondary Screen & Crusher Baghouse:

$$0.00031 \frac{\text{lbs. part.}}{\text{short ton stone}} \times 1.102 \frac{\text{short tons}}{\text{Mg}} \times 0.454 \frac{\text{kg}}{\text{lb}} = 0.00016 \frac{\text{kg}}{\text{M}}$$

APPENDIX E

COMPUTER PRINTOUTS OF SPLINE ANALYSES FOR PARTICLE SIZE DISTRIBUTIONS

RESULTS OF SPLINE ANALYSES FOR REFERENCE 21 (SECTION 4.0)

McCain, J. D., Evaluation of Rexnord Gravel Bed Filter, EPA-600/2-76-164 (NTIS PB 255 095), U.S. Environmental Protection Agency, Research Triangle Park, NC, June 1976.

```
                 SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD  GRVL BED FLTR TEST  8/27 1320  CLINKER COOLER UNCONT

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
               RAW LOADING
CUT (um)         < CUT          CUM. % < CUT

 .63             13.5             .382538
 .87             2.42             .451112
 1.4             4.84             .588259
 3.1             20.7             1.17482
 4.7             28.6             1.98523
 200             3459             100

OUTPUT DATA:    TP EMISSION FACTOR =  8.84  LB/T  (   4.42  KG/MT)

                                      EMISSION FACTOR
CUT (umA)     CUM. % < CUT        (LB/T)         (KG/MT)

 .625            .381043          .0336842        .0168421
 1               .483183          .0427134        .0213567
 1.25            .547183          .0483709        .0241855
 2.5             .936927          .0828244        .0414122
 5               2.26136          .199904         .0999522
 10              10.0105          .88493          .442465
 15              22.069           1.9509          .97545
 20              33.9584          3.00192         1.50096

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST  8/28 0950 CLINKER COOLER UNCONT.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
               RAW LOADING
CUT (um)         < CUT          CUM. % < CUT

 .63             4.65              .168622
 .87             .48               .186029
 1.4             1.11              .22628
 3.1             5.2               .414848
 4.7             9.2               .748466
 200             2737              100

OUTPUT DATA:      TP EMISSION FACTOR =  8.84  LB/T  (   4.42  KG/MT)


                                     EMISSION FACTOR
CUT (umA)      CUM. % < CUT        (LB/T)          (KG/MT)

 .625             .168274          .0148754         7.4377E-03
 1                .194842          .017224          8.61202E-03
 1.25             .213681          .0188894         9.44469E-03
 2.5              .330523          .0292182         .0146091
 5                .902135          .0797488         .0398744
 10              6.87334           .607604          .303802
 15             19.1685           1.69449           .847246
 20             32.3749           2.86194          1.43097

END OF TEST SERIES
```

```
                     SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST  8/28 1105 CLINKER COOLER UNCONT.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
             RAW LOADING
CUT (um)       < CUT          CUM. % < CUT

 .63           3.84              .0897628
 .87           .52               .101918
 1.4           2.66              .164098
 3.1           7.82              .346896
 4.7           11.1              .606367
 200           4252              100

OUTPUT DATA:    TP EMISSION FACTOR =  8.84  LB/T  (   4.42  KG/MT)


                                    EMISSION FACTOR
CUT (umA)     CUM. % < CUT      (LB/T)         (KG/MT)

 .625           .0896615         7.92608E-03    3.96304E-03
 1              .116167          .0102692       5.13459E-03
 1.25           .146178          .0129221       6.46107E-03
 2.5            .273728          .0241976       .0120988
 5              .738515          .0652847       .0326424
 10             6.27328          .554558        .277279
 15             18.5191          1.63709        .818544
 20             32.0187          2.83045        1.41522

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST  8/28 1440 CLINKER COOLER UNCONT.

INPUT DATA:         PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                    TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                    PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
             RAW LOADING
CUT (um)       < CUT'         CUM. % < CUT

 .63           13.5             .63287
 .87           2.64             .756631
 1.4           3.26             .909457
 3.1           6.44             1.21136
 4.7           9.3              1.64734
 200           2098             100

OUTPUT DATA:     TP EMISSION FACTOR =  8.84  LB/T  (   4.42  KG/MT)


                                     EMISSION FACTOR
CUT (umA)     CUM. % < CUT        (LB/T)        (KG/MT)

 .625           .629739           .0556689       .0278345
 1              .801271           .0708324       .0354162
 1.25           .872015           .0770861       .038543
 2.5            1.08396           .0958217       .0479108
 5              1.86134           .164543        .0822714
 10             8.43077           .745281        .37264
 15             20.0571           1.77305        .886523
 20             32.1942           2.84597        1.42298

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/29 1015  CLINKER COOLER UNCONT.

INPUT DATA:         PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                    TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                    PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
               RAW LOADING
CUT (um)          < CUT          CUM. % < CUT

 .63             6.89              .251287
 .87             2.04              .325689
 1.4             2.31              .409938
 3.1             7.44              .681284
 4.7             12.2              1.12623
 200             2711              100

OUTPUT DATA:     TP EMISSION FACTOR =  8.84  LB/T  (   4.42  KG/MT)


                                      EMISSION FACTOR
CUT (umA)      CUM. % < CUT       (LB/T)          (KG/MT)

 .625            .24942            .0220488        .0110244
 1               .348808           .0308347        .0154173
 1.25            .387148           .0342239        .017112
 2.5             .563013           .0497703        .0248852
 5               1.3178            .116493         .0582467
 10              7.79999           .689519         .34476
 15              19.8807           1.75745         .878725
 20              32.5291           2.87557         1.43778

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST  8/29 1400 CLINKER COOLER UNCONT.

INPUT DATA:        PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                   TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                   PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
           RAW LOADING
CUT (um)     < CUT          CUM. % < CUT

 .63         1.43              .0662341
 .87         .42               .0856874
 1.4         2.42              .197776
 3.1         9.34              .630382
 4.7         14.4              1.29735
 200         2131              100


OUTPUT DATA:    TP EMISSION FACTOR =  8.84  LB/T  (   4.42  KG/MT)


                                   EMISSION FACTOR
CUT (umA)    CUM. % < CUT      (LB/T)          (KG/MT)

 .625          .0660233        5.83646E-03     2.91823E-03
 1.            .108576         9.59815E-03     4.79907E-03
 1.25          .162436         .0143593        7.17967E-03
 2.5           .451709         .039931         .0199655
 5             1.53142         .135378         .0676888
 10            8.99977         .795579         .39779
 15            21.502          1.90078         .950389
 20            33.9387         3.00018         1.50009

END OF TEST SERIES
```

```
                     SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST  11/4 1100 CLINKER COOLER UNCONT.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
              RAW LOADING
CUT (um)        < CUT          CUM. % < CUT

 .63            1.54                .0614437
 .87            .12                 .0662315
 1.4            2.4                 .161988
 3.1            9.5                 .541024
 4.7            18.8                1.29112
 109            2474                100

OUTPUT DATA:


CUT (umA)     CUM. % < CUT

 .625          .0613896
 1             .0844318
 1.25          .130475
 2.5           .373483
 5             1.58744
 10            12.828
 15            31.2133
 20            47.3594

END OF TEST SERIES
```

```
                SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 11/4 1430 CLINKER COOLER UNCONT.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
              RAW LOADING
CUT (um)        < CUT          CUM. % < CUT

 .63            1.47               .0745323
 .87            .53                .101404
 1.4            3.7                .289003
 3.1            10.7               .831517
 4.7            14.9               1.58698
 200            1941               100

OUTPUT DATA:


CUT (umA)     CUM. % < CUT

 .625          .0742731
 1             .13809
 1.25          .229001
 2.5           .620457
 5             1.84401
 10            9.52588
 15            21.8592
 20            34.034

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST  11/4 1435 CLINKER COOLER UNCONT.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
              RAW LOADING
CUT (um)        < CUT           CUM. % < CUT

 .63            1.52              .0836705
 .87            .67               .120552
 1.4            2.53              .259819
 3.1            8.53              .729365
 4.7            12.4              1.41194
 200            1791              100

OUTPUT DATA:


CUT (umA)    CUM. % < CUT

 .625          .0830518
 1             .15098
 1.25          .217659
 2.5           .540163
 5             1.65195
 10            9.10763
 15            21.4794
 20            33.8098

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST  11/5 0935 CLINKER COOLER UNCONT.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
           RAW LOADING
CUT (um)     < CUT         CUM. % < CUT

 .63         1.37              .0568387
 .87         .23               .066381
 1.4         1.12              .112848
 3.1         14.5              .714425
 4.7         9.11              1.09238
 200         2384              100

OUTPUT DATA:


CUT (umA)   CUM. % < CUT

 .625        .05674
 1           .0743156
 1.25        .0957273
 2.5         .479315
 5           1.27271
 10          7.41557
 15          19.3026
 20          31.9932

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD  GRVL BED FLTR TEST 11/5 0930  CLINKER COOLER UNCONT.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
              RAW LOADING
CUT (um)        < CUT          CUM. % < CUT

 .63            .69                .0278546
 .87            .03                .0290657
 1.4            1.32               .0823527
 3.1            7.51               .385524
 4.7            14.6               .974911
 200            2453               100

OUTPUT DATA:


                                    EMISSION FACTOR
CUT (umA)     CUM. % < CUT      (LB/T)          (KG/MT)

 .625           .0278407        2.0268E-03      1.0134E-03
 1              .0382794        2.78674E-03     1.39337E-03
 1.25           .0636172        4.63133E-03     2.31566E-03
 2.5            .248899         .0181198        9.05991E-03
 5              1.18597         .0863383        .0431692
 10             8.64826         .629593         .314797
 15             21.5816         1.57114         .78557
 20             34.3767         2.50263         1.25131

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 11/5 1415  CLINKER COOLER UNCONT.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
                RAW LOADING
CUT (um)          < CUT          CUM. % < CUT

 .63              11.2              .24079
 .87              4.37              .334742
 1.4              3.31              .405904
 3.1              7.97              .577252
 4.7              17.5              .953487
 200              4607              100

OUTPUT DATA:


CUT (umA)     CUM. % < CUT

 .625           .238355
 1              .35747
 1.25           .388784
 2.5            .524195
 5              1.12431
 10             7.30849
 15             19.4183
 20             32.297

END OF TEST SERIES
```

```
                 SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD  GRVL BED FLTR TEST 11/5 1415 CLINKER COOLER UNCONT.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
            RAW LOADING
CUT (um)       < CUT           CUM. % < CUT

 .63           14.4              .336123
 .87           3.42              .415953
 1.4           4.02              .509787
 3.1           10.6              .757212
 4.7           19.7              1.21705
 200           4232              100

OUTPUT DATA:


CUT (umA)    CUM. % < CUT

 .625          .334103
 1             .442371
 1.25          .485414
 2.5           .641642
 5             1.41512
 10            7.96363
 15            19.9808
 20            32.525

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/25 1440  CLINKER COOLER CONTR.

INPUT DATA:         PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                    TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                    PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
               RAW LOADING
CUT (um)         < CUT          CUM. % < CUT

 .58             1.49                5.97195
 .82             .96                 9.81964
 1.35            2.13                18.3567
 2.9             4.41                36.0321
 4.4             4.83                55.3908
 6.2             2.9                 67.014
 10.1            2.57                77.3146
 14.3            2.77                88.4168
 200             2.89                100

OUTPUT DATA:      TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                         EMISSION FACTOR
CUT (umA)       CUM. % < CUT        (LB/T)          (KG/MT)

 .625            6.6775            .0189641        9.48205E-03
 1               12.805            .0363661        .0181831
 1.25            16.8045           .0477249        .0238624
 2.5             31.4062           .0891936        .0445968
 5               60.0893           .170654         .0853268
 10              77.207            .219268         .109634
 15              89.6819           .254697         .127348
 20              96.1154           .272968         .136484

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/25 1440 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
                RAW LOADING
CUT (um)           < CUT            CUM. % < CUT

 .58               1.32                8.95522
 .82               .15                 9.97286
 1.35              1.56                20.5563
 2.9               3.07                41.384
 4.4               1.76                53.3243
 6.2               .9                  59.4301
 10.1              .45                 62.4831
 14.3              2.74                81.0719
 200               2.79                100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                     EMISSION FACTOR
CUT (umA)      CUM. % < CUT      (LB/T)          (KG/MT)

 .625            9.10535         .0258592         .0129296
 1               13.2698         .0376862         .0188431
 1.25            18.4785         .052479          .0262395
 2.5             37.1069         .105384          .0526918
 5               55.955          .158912          .0794561
 10              63.5517         .180487          .0902434
 15              83.2171         .236336          .118168
 20              94.8029         .26924           .13462

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/26 1119 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
                  RAW LOADING
CUT (um)            < CUT          CUM. % < CUT

 .58                .21                .861009
 .82                .94                4.71505
 1.35               3.36               18.4912
 2.9                4.21               35.7524
 4.4                5.97               60.2296
 6.2                3.55               74.7848
 10.1               2.19               83.7639
 14.3               1.57               90.2009
 200                2.39               100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (  .142  KG/MT)

                                      EMISSION FACTOR
CUT (umA)       CUM. % < CUT       (LB/T)           (KG/MT)

 .625             1.30917         3.71804E-03      1.85902E-03
 1                9.01402         .0255998         .0127999
 1.25             15.7058         .0446046         .0223023
 2.5              31.1306         .088411          .0442055
 5                66.2842         .188247          .0941236
 10               83.6507         .237568          .118784
 15               90.9626         .258334          .129167
 20               94.9789         .26974           .13487

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/26 1124 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
                RAW LOADING
CUT (um)          < CUT         CUM. % < CUT

 .58              .33               1.14345
 .82              .71               3.6036
 1.35             2.33              11.6771
 2.9              5.46              30.596
 4.4              6.45              52.9453
 6.2              4.47              68.4338
 10.1             3.06              79.0367
 14.3             2.24              86.7983
 200              3.81              100

OUTPUT DATA:    TP EMISSION FACTOR =  .284  LB/T  (  .142  KG/MT)


                                     EMISSION FACTOR
CUT (umA)     CUM. % < CUT       (LB/T)          (KG/MT)

 .625           1.4989           4.25689E-03    2.12844E-03
 1              6.08288          .0172754       8.63769E-03
 1.25           10.0044          .0284126       .0142063
 2.5            25.5287          .0725014       .0362507
 5              59.2083          .168152        .0840758
 10             78.8946          .224061        .11203
 15             87.7345          .249166        .124583
 20             92.7485          .263406        .131703

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/26 1515 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
               RAW LOADING
CUT (um)         < CUT          CUM. % < CUT

 .58             10.2              22.0207
 .82             .97               24.1149
 1.35            2.38              29.253
 2.9             6.09              42.4007
 4.4             7.64              58.8947
 6.2             4.75              69.1494
 10.1            2.86              75.3238
 14.3            2.34              80.3757
 200             9.09              100

OUTPUT DATA:    TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                         EMISSION FACTOR
CUT (umA)      CUM. % < CUT       (LB/T)          (KG/MT)

 .625            22.3893         .0635856        .0317928
 1               25.8958         .0735442        .0367721
 1.25            28.3023         .0803785        .0401893
 2.5             38.6325         .109716         .0548582
 5               63.1635         .179384         .0896922
 10              75.2504         .213711         .106856
 15              81.0395         .230152         .115076
 20              84.8653         .241017         .120509

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/26 1515 CLINKER COOLER CONTR.

INPUT DATA:        PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                   TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                   PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
                 RAW LOADING
CUT (um)           < CUT        CUM. % < CUT

 .58              1.1               2.98832
 .82              1.52              7.11763
 1.35             3.11              15.5664
 2.9              6.14              32.2467
 4.4              6.21              49.1171
 6.2              3.9               59.712
 10.1             3.42              69.003
 14.3             2.54              75.9033
 200              8.87              100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                     EMISSION FACTOR
CUT (umA)    CUM. % < CUT       (LB/T)         (KG/MT)

 .625          3.6858          .0104677        5.23383E-03
 1             10.0951         .0286702        .0143351
 1.25          14.0287         .0398415        .0199208
 2.5           28.0358         .0796217        .0398109
 5             53.3807         .151601         .0758006
 10            68.8504         .195535         .0977676
 15            76.8012         .218115         .109058
 20            81.9322         .232688         .116344

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/27 1100 CLINKER COOLER CONTR.

INPUT DATA:         PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                    TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                    PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

                RAW LOADING
CUT (um)          < CUT          CUM. % < CUT

 .58              .93               2.12669
 .82              1.54              5.6483
 1.35             3.48              13.6062
 2.9              7.16              29.9794
 4.4              7.8               47.8162
 6.2              4.37              57.8093
 10.1             3.14              64.9897
 14.3             3.31              72.5589
 200              12                100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                        EMISSION FACTOR
CUT (umA)       CUM. % < CUT          (LB/T)        (KG/MT)

 .625             2.69324           7.6488E-03    3.8244E-03
 1                8.37621           .0237884       .0118942
 1.25             12.1146           .0344056       .0172028
 2.5              25.7293           .0730711       .0365356
 5                51.9623           .147573        .0737865
 10               64.9145           .184357        .0921786
 15               73.5565           .208901        .10445
 20               79.3079           .225234        .112617

END OF TEST SERIES
```

```
                SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/27 1150 CLINKER COOLER CONTR.

INPUT DATA:        PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                   TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                   PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
                RAW LOADING
CUT (um)          < CUT           CUM. % < CUT

 .58              1.43                3.30942
 .82              1.41                6.57255
 1.35             4.14                16.1537
 2.9              7.5                 33.5108
 4.4              6.31                48.1139
 6.2              5.21                60.1713
 10.1             3.93                69.2664
 14.3             5.3                 81.5321
 200              7.98                100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)

                                     EMISSION FACTOR
CUT (umA)       CUM. % < CUT      (LB/T)          (KG/MT)

 .625             3.85397          .0109453        5.47264E-03
 1                9.72082          .0276071        .0138036
 1.25             14.3243          .0406809        .0203405
 2.5              29.4809          .0837257        .0418629
 5                52.8883          .150203         .0751013
 10               69.2193          .196583         .0982914
 15               83.0278          .235799         .1179
 20               91.0638          .258621         .129311

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/27 1515 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

                RAW LOADING
CUT (um)          < CUT          CUM. % < CUT

 .58             1.54               4.07407
 .82             1.77               8.75662
 1.35            4.36               20.291
 2.9             7.43               39.9471
 4.4             5.56               54.6561
 6.2             4.02               65.291
 10.1            2.89               72.9365
 14.3            2.83               80.4233
 200             7.4                100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)

                                      EMISSION FACTOR
CUT (umA)      CUM. % < CUT      (LB/T)          (KG/MT)

 .625            4.86637          .0138205        6.91024E-03
 1               12.703           .0360766        .0180383
 1.25            18.1678          .0515964        .0257982
 2.5             35.5927          .101083         .0505416
 5               58.9552          .167433         .0837164
 10              72.8557          .20691          .103455
 15              81.372           .231096         .115548
 20              86.6657          .24613          .123065

END OF TEST SERIES
```

```
                         SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/27 1515 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
              RAW LOADING
CUT (um)        < CUT          CUM. % < CUT

 .58            .9                2.26472
 .82            1.47              5.96377
 1.35           4.01              16.0544
 2.9            6.99              33.6437
 4.4            7.11              51.535
 6.2            3.12              59.386
 10.1           2.48              65.6266
 14.3           2.26              71.3136
 200            11.4              100

OUTPUT DATA:    TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)

                                       EMISSION FACTOR
CUT (umA)     CUM. % < CUT       (LB/T)            (KG/MT)

 .625           2.8458            8.08207E-03       4.04104E-03
 1              9.30074           .0264141          .0132071
 1.25           14.1216           .0401054          .0200527
 2.5            29.2995           .0832104          .0416052
 5              54.8729           .155839           .0779195
 10             65.5378           .186127           .0930637
 15             72.0945           .204748           .102374
 20             76.7437           .217952           .108976

END OF TEST SERIES
```

```
                     SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/28 1045 CLINKER COOLER CONTR.

INPUT DATA:        PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                   TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                   PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
             RAW LOADING
CUT (um)       < CUT          CUM. % < CUT

 .58           1.61             5.09171
 .82           1.15             8.72865
 1.35          2.71             17.2992
 2.9           5.17             33.6496
 4.4           6.23             53.3523
 6.2           3.17             63.3776
 10.1          2.2              70.3352
 14.3          2.22             77.3561
 200           7.16             100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                        EMISSION FACTOR
CUT (umA)     CUM. % < CUT        (LB/T)          (KG/MT)

 .625          5.74516           .0163162        8.15812E-03
 1             11.7048           .0332415        .0166208
 1.25          15.7337           .0446838        .0223419
 2.5           29.2474           .0830626        .0415313
 5             57.5773           .163519         .0817597
 10            70.2614           .199542         .0997711
 15            78.2653           .222274         .111137
 20            83.4329           .236949         .118475

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/28 1045 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
               RAW LOADING
CUT (um)         < CUT          CUM. % < CUT

 .58             1.79               5.71702
 .82             .88                8.52763
 1.35            2.58               16.7678
 2.9             5.35               33.855
 4.4             4.4                47.908
 6.2             4.35               61.8014
 10.1            2.25               68.9876
 14.3            1.97               75.2795
 200             7.74               100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                         EMISSION FACTOR
CUT (umA)       CUM. % < CUT        (LB/T)          (KG/MT)

 .625             6.20215          .0176141        8.80706E-03
 1                11.2987          .0320884        .0160442
 1.25             15.2334          .0432627        .0216314
 2.5              29.8337          .0847277        .0423639
 5                53.4467          .151789         .0758943
 10               68.926           .19575          .0978749
 15               76.1115          .216157         .108078
 20               80.9371          .229861         .114931

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/28 1415 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

                RAW LOADING
CUT (um)         < CUT          CUM. % < CUT

 .58             5.73               15.4074
 .82             1.92               20.57
 1.35            3                  28.6367
 2.9             5.57               43.6139
 4.4             5.26               57.7575
 6.2             3.25               66.4964
 10.1            2.6                73.4875
 14.3            2.14               79.2417
 200             7.72               100

OUTPUT DATA:      TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                        EMISSION FACTOR
CUT (umA)       CUM. % < CUT       (LB/T)           (KG/MT)

 .625            16.4663           .0467642          .0233821
 1               23.6295           .0671077          .0335538
 1.25            27.2883           .0774988          .0387494
 2.5             39.9041           .113328           .0566639
 5               61.3235           .174159           .0870793
 10              73.3873           .20842            .10421
 15              79.9919           .227177           .113588
 20              84.2833           .239365           .119682

END OF TEST SERIES
```

```
                         SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/28 1415 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

CUT (um)        RAW LOADING        CUM. % < CUT
                  < CUT

 .58              4.67                 13.3276
 .82              1.53                 17.6941
 1.35             2.7                  25.3995
 2.9              6.67                 44.4349
 4.4              4.88                 58.3619
 6.2              3.68                 68.8642
 10.1             2.26                 75.3139
 14.3             2.96                 83.7614
 200              5.69                 100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                        EMISSION FACTOR
CUT (umA)       CUM. % < CUT       (LB/T)          (KG/MT)

 .625             14.1999            .0403277        .0201638
 1                20.4602            .0581069        .0290535
 1.25             24.0315            .0682494        .0341247
 2.5              40.0748            .113813         .0569063
 5                62.6498            .177925         .0889627
 10               75.2909            .213826         .106913
 15               84.806             .240849         .120425
 20               90.5017            .257025         .128512

END OF TEST SERIES
```

```
                  SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/29 1000 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
               RAW LOADING
CUT (um)         < CUT           CUM. % < CUT

 .58              3.98                10.2869
 .82              1.7                 14.6808
 1.35             2.53                21.22
 2.9              5.13                34.4792
 4.4              5.77                49.3926
 6.2              4.14                60.0931
 10.1             3.11                68.1313
 14.3             2.13                73.6366
 200              10.2                100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                      EMISSION FACTOR
CUT (umA)      CUM. % < CUT       (LB/T)          (KG/MT)

 .625             11.1847          .0317644         .0158822
 1                17.1466          .0486963         .0243482
 1.25             20.1058          .0571006         .0285503
 2.5              30.9301          .0878414         .0439207
 5                53.6993          .152506          .0762531
 10               68.0011          .193123          .0965616
 15               74.3824          .211246          .105623
 20               78.7868          .223755          .111877

END OF TEST SERIES
```

```
                     SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/29 1000 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
                 RAW LOADING
CUT (um)          < CUT          CUM. % < CUT

 .58               3.82              12.2045
 .82               1.23              16.1342
 1.35              2.57              24.345
 2.9               5.21              40.9904
 4.4               6.27              61.0224
 6.2               3.05              70.7668
 10.1              1.76              76.3898
 14.3              1.6               81.5016
 200               5.79              100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                             EMISSION FACTOR
CUT (umA)       CUM. % < CUT        (LB/T)           (KG/MT)

 .625             12.9563           .0367958          .0183979
 1                19.0967           .0542347          .0271173
 1.25             22.9004           .065037           .0325185
 2.5              36.4326           .103469           .0517343
 5                65.2067           .185187           .0925936
 10               76.3313           .216781           .10839
 15               82.1678           .233357           .116678
 20               85.9804           .244184           .122092

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/29 1400 CLINKER COOLER CONTR.

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION
                 RAW LOADING
CUT (um)           < CUT        CUM. % < CUT

 .58               1.27             7.53709
 .82               1.28             15.1335
 1.35              2.3              28.7834
 2.9               3.93             52.1068
 4.4               1.55             61.3056
 6.2               1.15             68.1306
 10.1              1.17             75.0742
 14.3              1.51             84.0356
 200               2.69             100

OUTPUT DATA:     TP EMISSION FACTOR =  .284  LB/T  (   .142  KG/MT)


                                          EMISSION FACTOR
CUT (umA)       CUM. % < CUT        (LB/T)          (KG/MT)

 .625             8.91414          .0253162         .0126581
 1                20.1553          .0572411         .0286205
 1.25             26.4484          .0751136         .0375568
 2.5              47.8679          .135945          .0679725
 5                63.9865          .181722          .0908608
 10               75.0186          .213053          .106526
 15               85.136           .241786          .120893
 20               91.0908          .258698          .129349

END OF TEST SERIES
```

```
                 SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  REXNORD GRVL BED FLTR TEST 8/29 1400 CLINKER COOLER CONTR.

INPUT DATA:       PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                  TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                  PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

CUT (um)      RAW LOADING     CUM. % < CUT
                < CUT

 .58           1.03             3.3409
 .82           .93              6.35744
 1.35          3.07             16.3153
 2.9           6.1              36.1012
 4.4           5.19             52.9355
 6.2           3.35             63.8015
 10.1          2.56             72.1051
 14.3          1.68             77.5543
 200           6.92             100

OUTPUT DATA:    TP EMISSION FACTOR =  .284  LB/T  (  .142  KG/MT)


                                      EMISSION FACTOR
CUT (umA)     CUM. % < CUT        (LB/T)          (KG/MT)

 .625          3.8355             .0108928        5.44641E-03
 1             9.53263            .0270727        .0135363
 1.25          14.36              .0407823        .0203911
 2.5           31.4461            .0893069        .0446535
 5             57.3494            .162872         .0814361
 10            71.9675            .204388         .102194
 15            78.2745            .2223           .11115
 20            82.4492            .234156         .117078

END OF TEST SERIES
```

```
                SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:REXNORD GRVL BED FLTR TEST 11/3 1545 CLINKER COOLER CONTR.
INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
                 RAW LOADING
CUT (um)           < CUT        CUM. % < CUT

  .57              1.15              4.7817
  .79              .96               8.77339
  1.3              2.56              19.4179
  2.8              9.45              58.711
  4.2              8.01              92.0166
  6                .43               93.8046
  9.8              .4                95.4678
  13.9             .43               97.2557
  200              .66               100

OUTPUT DATA:


CUT (umA)     CUM. % < CUT

 .625           5.71449
 1              12.9081
 1.25           18.3125
 2.5            50.9708
 5              93.6688
 10             95.5874
 15             97.5884
 20             98.6438

END OF TEST SERIES
```

```
                     SPLIN2 PROGRAM - 02/22/82 V1

   TEST ID:REXNORD GRVL BED FLTR TEST 11/4 1130 CLINKER COOLER CONTR.

   INPUT DATA:


   MEASURED PARTICLE SIZE DISTRIBUTION
                         RAW LOADING
   CUT (um)                < CUT          CUM. % < CUT

     .57                   .57              6.97674
     .79                   1.02             19.4614
     1.3                   2.58             51.0404
     2.8                   2.63             83.2313
     4.2                   .64              91.0649
     6                     .18              93.2681
     9.8                   .19              95.5936
     13.9                  .13              97.1848
     200                   .23              100

   OUTPUT DATA:


   CUT (umA)       CUM. % < CUT


    .625              9.61859
    1                 32.9189
    1.25              47.9794
    2.5               79.9024
    5                 92.2836
    10                95.696
    15                97.4834
    20                98.4505

   END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:REXNORD GRVL BED FLTR TEST 11/4 1130 CLINKER COOLER CONTR.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
                 RAW LOADING
CUT (um)           < CUT         CUM. % < CUT

  .57               .38             4.6285
  .79               .68             12.9111
  1.3               2.22            39.9513
  2.8               3.36            80.877
  4.2               .92             92.0828
  6                 .34             96.2241
  9.8               .16             98.173
  13.9              .14             99.8782
  200               .01             100

OUTPUT DATA:


CUT (umA)     CUM. % < CUT

 .625          6.32592
 1             23.5358
 1.25          37.0932
 2.5           76.0017
 5             94.4541
 10            98.2987
 15            100.05
 20            100.425

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 01

  TEST ID:REXNORD GRVL BED FLTR TEST 11/5 0945 CLINKER COOLER CONTR.

  INPUT DATA:


  MEASURED PARTICLE SIZE DISTRIBUTION
                    RAW LOADING
  CUT (um)            < CUT          CUM. % < CUT

    .57                .97             8.16498
    .79                .86             15.404
    1.3                2.51            36.532
    2.8                3.78            68.3502
    4.2                1.16            78.1145
    6                  .61             83.2492
    9.8                .51             87.5421
    13.9               .49             91.6667
    200                .99             100

  OUTPUT DATA:


  CUT (umA)    CUM. % < CUT

   .625
   1
   1.25
   2.5
   5
   10
   15
   20

 END OF TEST SERIES
```

```
                  SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:REXNORD GRVL BED FLTR TEST 11/5 0945 CLINKER COOLER CONTR.

INPUT DATA:


MEASURED PARTICLE SIZE DISTRIBUTION
                 RAW LOADING
CUT (um)           < CUT         CUM. % < CUT

  .57              1.12           16.2319
  .79              1.03           31.1594
  1.3              1.16           47.971
  2.8              .65            57.3913
  4.2              .2             60.2899
  6                .56            68.4058
  9.8              .38            73.9131
  13.9             .45            80.4348
  200              1.35           100

OUTPUT DATA:


CUT (umA)      CUM. % < CUT

.625           20.0986
1              39.8803
1.25           46.7291
2.5            56.4482
5              64.386
10             74.3669
15             81.7644
20             86.3878

END OF TEST SERIES
```

RESULTS OF SPLINE ANALYSES FOR REFERENCE 26A AND 26B (SECTION 4.0)

Hunter, S. C., et al., Application of Combustion Modifications to Industrial Combustion Equipment, EPA-600/7-79-015a (NTIS PB 294 214), U.S. Environmental Protection Agency, Research Triangle Park, NC, January 1979; and

Hunter, S. C., et al., Application of Combustion Modifications to Industrial Combustion Equipment: Data Supplement A, EPA-600/7-79-015b (NTIS PB 293888), U. S. Environmental Protection Agency, Research Triangle Park, NC, February 1979.

```
                        SPLIN2 PROGRAM -  02/22/82 V1


TEST ID:  KVB/EPA   TEST RUN 3-2   MULTICLONE OUTLET

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD./HR
                     TOTAL PARTICULATE EMISSION RATE = 0  LB/HR
                     PARTICLE DENSITY = 1  G/CC

MEASURED SIZE DISTRIBUTION

CUT(um)           CUM. % < CUT

 .51                    .44
 .85                    .97
 1.68                   2
 2.49                   3.74
 4.25                   11.75
 15                     30.91
 200                    100


OUTPUT DATA:     TP EMISSION FACTOR =  249.2  LB/T  (   124.6  KG/MT)


                                            EMISSION FACTOR
CUT (umA)        CUM. % < CUT         (LB/T)           (KG/MT)

 .625              .618263           1.54071          .770355
 1                 1.13034           2.8168           1.4084
 1.25              1.40554           3.50261          1.7513
 2.5               3.82099           9.5219           4.76095
 5                 14.3113           35.6637          17.8318
 10                24.2585           60.4521          30.226
 15                31.204            77.7603          38.8802
 20                37.7452           94.0611          47.0305

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM -  02/22/82 V1


TEST ID:  KVB/EPA   TEST RUN 9-1   KILN OUTLET

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD./HR
                     TOTAL PARTICULATE EMISSION RATE = 0  LB/HR
                     PARTICLE DENSITY = 1  G/CC

MEASURED SIZE DISTRIBUTION

CUT(um)            CUM. % < CUT

 .37                  .01
 .59                  1.52
 1.13                 3.32
 1.66                 6.65
 2.81                 14.85
 15                   50.35
 200                  100


OUTPUT DATA:       TP EMISSION FACTOR =  117  LB/T  (   58.5  KG/MT)


                                         EMISSION FACTOR
CUT (umA)        CUM. % < CUT        (LB/T)          (KG/MT)

 .625              1.68966          1.9769           .988451
 1                 2.95593          3.45844          1.72922
 1.25              4.00466          4.68545          2.34272
 2.5               12.6416          14.7907          7.39536
 5                 25.6618          30.0243          15.0122
 10                40.3874          47.2533          23.6266
 15                50.4207          58.9922          29.4961
 20                58.021           67.8846          33.9423

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM -  02/22/82 V1


TEST ID:  KVB/EPA   TEST RUN 9-2   KILN OUTLET

INPUT DATA:         PROCESS WEIGHT RATE = 0  TONS PROD./HR
                    TOTAL PARTICULATE EMISSION RATE = 0  LB/HR
                    PARTICLE DENSITY = 1  G/CC

MEASURED SIZE DISTRIBUTION

CUT(um)           CUM. % < CUT

 .38                 .5
 .6                  2.3
 1.13                5.4
 1.66                11.3
 2.81                22.9
 15                  52.8
 200                 100


OUTPUT DATA:      TP EMISSION FACTOR =  122.4  LB/T  (   61.2  KG/MT)


                                           EMISSION FACTOR
CUT (umA)        CUM. % < CUT         (LB/T)        (KG/MT)

 .625             2.40487            2.94356         1.47178
 1                4.50161            5.50997         2.75498
 1.25             6.64121            8.12884         4.06442
 2.5              19.9713            24.4449         12.2225
 5                34.066             41.6968         20.8484
 10               45.5373            55.7376         27.8688
 15               53.0207            64.8974         32.4487
 20               58.9687            72.1777         36.0889

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  KVB/EPA   TEST 9-3   ESP INLET

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

CUT (um)     RAW % < CUT      CUM. % < CUT

 1              6.71             6.71
 3              24.6             31.31
 10             36.88            68.19
 200            31.81            100

OUTPUT DATA:    TP EMISSION FACTOR =  81.72  LB/T  (  40.86  KG/MT)


                                      EMISSION FACTOR
CUT (umA)     CUM. % < CUT        (LB/T)          (KG/MT)

 .625           2.72561           2.22737         1.11368
 1              6.71              5.48341         2.74171
 1.25           9.78224           7.99405         3.99702
 2.5            25.5771           20.9016         10.4508
 5              46.1931           37.749          18.8745
 10             68.0176           55.584          27.792
 15             79.6645           65.1018         32.5509
 20             86.3007           70.525          35.2625

END OF TEST SERIES
```

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  KVB/EPA   TEST 9-4   ESP INLET

INPUT DATA:        PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                   TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                   PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

CUT (um)     RAW % < CUT      CUM. % < CUT

 1              8.24              8.24
 3              23.39             31.63
 10             35.84             67.47
 200            32.53             100

OUTPUT DATA:     TP EMISSION FACTOR =  72.9  LB/T  (   36.45  KG/MT)


                                        EMISSION FACTOR
CUT (umA)     CUM. % < CUT        (LB/T)          (KG/MT)

 .625           3.83047            2.79242          1.39621
 1              8.24               6.00696          3.00348
 1.25           11.3896            8.30304          4.15152
 2.5            26.3925            19.2401          9.62006
 5              45.9572            33.5028          16.7514
 10             67.2939            49.0573          24.5286
 15             78.7318            57.3955          28.6978
 20             85.3165            62.1957          31.0979

END OF TEST SERIES
```

```
                        SPLIN2 PROGRAM -  02/22/82 V1

      TEST ID:  KVB/EPA  TEST 9-5   ESP OUTLET

      INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD./HR
                           TOTAL PARTICULATE EMISSION RATE = 0  LB/HR
                           PARTICLE DENSITY = 1  G/CC

      MEASURED SIZE DISTRIBUTION

      CUT(um)           CUM. % < CUT

       1                   30.3639
       3                   96.4907
       10                  96.5007
       200                 100

PROCESS DATA NOT AVAILABLE;EMISSION FACTOR DIRECTLY INPUT

      OUTPUT DATA:    TP EMISSION FACTOR =  .254  LB/T  (   .127  KG/MT)

                                                EMISSION FACTOR
      CUT (umA)        CUM. % < CUT          (LB/T)         (KG/MT)

       .625             28.564              .0725526        .0362763
       1                41.137              .104488         .052244
       1.25             47.545              .120764         .0603822
       2.5              67.111              .170462         .085231
       5                82.833              .210396         .105198
       10               92.677              .2354           .1177
       15               95.97               .243764         .121882
       20               97.481              .247602         .123801
THIS DATA SET WAS FIT TO A LOG-NORMAL SIZE DISTRIBUTION
```

```
                    SPLIN2 PROGRAM -  02/22/82 V1

      TEST ID:  KVB/EPA   TEST 9-6   ESP OUTLET

      INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD./HR
                           TOTAL PARTICULATE EMISSION RATE = 0  LB/HR
                           PARTICLE DENSITY = 1  G/CC

      MEASURED SIZE DISTRIBUTION

      CUT(um)           CUM. % < CUT

       1                   25.7174
       3                   98.4502
       10                  98.4602
       200                 100

 PROCESS DATA NOT AVAILABLE;EMISSION FACTOR DIRECTLY INPUT

      OUTPUT DATA:     TP EMISSION FACTOR =  .3  LB/T  (   .15  KG/MT)


                                              EMISSION FACTOR
      CUT (umA)        CUM. % < CUT        (LB/T)        (KG/MT)

       .625              16.736            .050208        .025104
       1                 29.91             .08973         .044865
       1.25              37.479            .112437        .0562185
       2.5               62.788            .188364        .094182
       5                 83.439            .250317        .125159
       10                94.707            .284121        .142061
       15                97.696            .293088        .146544
       20                98.817            .296451        .148226
 THIS DATA SET WAS FIT TO A LOG-NORMAL SIZE DISTRIBUTION
```

RESULTS OF SPLINE ANALYSES FOR REFERENCE 27 (SECTION 4.0)

Taback, H. J., *et al.*, *Fine Particle Emissions from Stationary and Miscellaneous Sources in the South Coast Air Basin*, KVB 5806-783 (NTIS PB 293 923), California State Air Resources Board, Sacramento, CA, February 1979.

```
                    SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  KVB/ARB  PULVERIZED COAL  TEST 18   BAGHOUSE OUTLET

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

CUT (um)     RAW % < CUT      CUM. % < CUT

 .99            34                 34
 3              34                 68
 10             24                 92
 200            8                  100

OUTPUT DATA:     TP EMISSION FACTOR =  .44  LB/T  (   .22  KG/MT)

                                          EMISSION FACTOR
CUT (umA)      CUM. % < CUT        (LB/T)          (KG/MT)

 .625            22.6933            .0998505        .0499253
 1               34.2755            .150812         .0754061
 1.25            40.6575            .178893         .0894466
 2.5             62.3054            .274144         .137072
 5               79.3977            .34935          .174675
 10              91.8575            .404173         .202087
 15              96.8591            .42618          .21309
 20              98.9845            .435532         .217766

END OF TEST SERIES
```

```
                  SPLIN2 PROGRAM - 02/22/82 V1

TEST ID:  KVB/ARB   NATURAL GAS   TEST 9   BAGHOUSE OUTLET

INPUT DATA:          PROCESS WEIGHT RATE = 0  TONS PROD. /HR
                     TOTAL PARTICULATE EMISSION RATE = 0 LB/HR
                     PARTICLE DENSITY = 1 G/CC

MEASURED PARTICLE SIZE DISTRIBUTION

CUT (um)      RAW % < CUT      CUM. % < CUT

 .99             20                 20
 3               40                 60
 10              32                 92
 200             8                  100

OUTPUT DATA:     TP EMISSION FACTOR =  .22  LB/T  (   .11  KG/MT)

                                         EMISSION FACTOR
CUT (umA)      CUM. % < CUT       (LB/T)           (KG/MT)

 .625            10.3974          .0228744         .0114372
 1               20.2616          .0445755         .0222878
 1.25            26.6543          .0586394         .0293197
 2.5             52.3879          .115253          .0576267
 5               75.0083          .165018          .0825091
 10              91.693           .201725          .100862
 15              97.8964          .215372          .107686
 20              100.057          .220126          .110063

END OF TEST SERIES
```

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/7-87-007	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Lime and Cement Industry Particulate Emissions: Source Category Report; Volume II. Cement Industry		5. REPORT DATE February 1987 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) John S. Kinsey		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Midwest Research Institute 425 Volker Boulevard Kansas City, Missouri 64110		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-02-3891, Task 9
12. SPONSORING AGENCY NAME AND ADDRESS **EPA, Office of Research and Development** **Air and Energy Engineering Research Laboratory** **Research Triangle Park, NC 27711**		13. TYPE OF REPORT AND PERIOD COVERED Task Final; 6/83 - 8/86 14. SPONSORING AGENCY CODE **EPA/600/13**

15. SUPPLEMENTARY NOTES AEERL project officer is Dale L. Harmon, Mail Drop 62B, 919/541-2429. Volume I (for the lime industry) is EPA-600/7-86-031 (NTIS PB87-103628), September 1986.

16. ABSTRACT
This volume of the report gives results of the development of particulate emission factors, based on cutoff size for inhalable particles for the cement industry. After a review of available information characterizing particulate emissions from cement plants, the data were summarized and rated in terms of reliability. Size specific emission factors were developed from these data for the major processes used in the manufacture of cement. A detailed process description is presented, with emphasis on factors affecting the generation of emissions. A replacement for Section 8.6 (Portland Cement Manufacturing) of EPA report AP-42, A Compilation of Air Pollutant Emissions Factors, was prepared, containing the size specific emission factors developed during this program.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Emission	Pollution Control	13B
Portland Cement		Stationary Sources	11B, 13C
Industrial Processes		Emission Factors	13H
Particles		Inhalable Particulate	14G
Dust			11G
Aerosols			07D

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