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Municipal Waste Combustion Multipollutant Study

Emission Test Report

Wheelabrator Millbury, Inc.
Millbury, Massachusetts

EMISSION TEST REPORT

MUNICIPAL WASTE COMBUSTION STUDY

WHEELABRATOR MILLBURY, INC.
MILLBURY, MASSACHUSETTS

ESED Project No. 86/19a
EMB Report No. 88-MIN-07

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1.0 INTRODUCTION

During the week of February 8, 1988, Entropy Environmentalists, Inc. (Entropy), under contract to the U. S. Environmental Protection Agency (EPA), Emission Measurement Branch, conducted an emission testing program on one of two municipal waste combustor (MWC) units at Wheelabrator Environmental Systems' Resource Recovery Facility (Wheelabrator Millbury, Inc.) in Millbury, Massachusetts. This emission testing program was conducted in conjunction with an industry-funded compliance testing program sponsored by Wheelabrator Environmental Systems and Rust International. The compliance testing program was also conducted by Entropy.

Under contract to the EPA, Entropy conducted dioxin/furan testing at the inlet to the control equipment and ash and lime slurry sampling. Both were conducted concurrently with the dioxin/furan testing conducted at the outlet to the control equipment for the compliance testing program.

1.1 BACKGROUND

The U. S. Environmental Protection Agency published an advance notice of proposed rulemaking for municipal waste combustors in the Federal Register on July 7, 1987. The Agency will develop emission standards for new and modified municipal waste combustors (MWC) under Section 111(b) of the Clean Air Act and issue emission guidelines for existing MWC under Section 111(d) of the Act. The Federal Register notice was the culmination of 18 months of work which resulted in the development of the technical and health related documents which comprise EPA's Report to Congress on MWC. The Report to Congress was a joint effort involving the Offices of Air Quality Planning and Standards (OAQPS), Solid Waste (OSW), and Research and Development (ORD), and provided the technical basis behind the Agency decision to regulate MWC.

The Office of Air Quality Planning and Standards, through its Industrial Studies Branch (ISB) of the Emission Standards Division (ESD), and the Emission Measurement Branch (EMB) of the Technical Support Division (TSD), is responsible for reviewing the existing air emission data base on MWC and gathering additional data where necessary to support regulations development for MWC, particularly regarding emerging air pollution control technologies. As a result, several MWC emission tests have been performed and several more are in the planning stages to support the current standards development work.

The emissions being studied in this overall assessment of MWC are the criteria pollutants -- particulate matter (PM), sulfur dioxides (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and total hydrocarbons (THC); acid gases, such as hydrogen chloride (HCl); chlorinated organics, including chlorinated dibenzo-p-dioxins (CDD), chlorinated dibenzofurans (CDF), and dioxin and furan precursors; and specific metals, including arsenic (As), cadmium (Cd), total chromium (Cr), mercury (Hg), nickel (Ni), and lead (Pb). For this test program, dioxins/furans were the pollutants of interest.

1.2 PURPOSE AND OBJECTIVES OF TEST PROGRAM

Wheelabrator Environmental Systems, Inc. (WES) is one of the principal suppliers of mass burn combustor technology in the United States. The Millbury facility employs typical WES combustor technology consisting of a Von Roll grate system and Babcock & Wilcox boiler. The flue gas emissions are controlled by a spray dryer/electrostatic precipitator (SD/ESP) system, which is the first such application of this control device on an MWC in North America.

On June 26, 1987, the OAQPS issued operational guidance to the EPA Regions stating that good combustion and a spray dryer followed by an efficient particulate collector shall be considered BACT for new and modified MWC during PSD/NSR permitting activities. The EPA currently has no data to characterize the performance of an SD/ESP on MWC emissions and sponsored this test program to gather data to support the development of Federal emission standards for MWC.

The specific objectives of the Millbury test program were:

1. To determine the control efficiency of a spray dryer/electrostatic precipitator (SD/ESP) on mass-burn MWC dioxin/furan (CDD/CDF) emissions under normal facility operating conditions.

2. To obtain plant operating and plant continuous emission monitoring (CEM) data for CO, O_2, SO_2, and NO_x for the periods of emission testing conducted to meet Objective No. 1.

To accomplish these objectives, Entropy performed manual sampling for CDD/CDF using modified Method 5 (MM5) and Method 3 (Orsat) measurements at the inlet to the spray dryer, while the Wheelabrator contractor (also Entropy) conducted simultaneous CDD/CDF at the outlet to the ESP for compliance testing purposes. Entropy collected ash samples from various collection points during the CDD/CDF testing which were analyzed for CDD/CDF, percent

carbon, and percent combustibles. Lime slurry samples were also collected and analyzed for CDD/CDF, percent solids, and specific gravity.

Throughout the test period, Radian Corporation monitored and compiled the process and control system operating parameters plus the continuous emission monitoring data from all the plant monitors, which included CO, SO_2, O_2 at the SD inlet and SO_2, NO_x, O_2, and opacity at the ESP outlet (see Chapter 2.0).

1.3 TEST PROGRAM ORGANIZATION

The overall organizational scheme for the test program is shown in Figure 1.1. Mr. Dan Bivins of EPA's Emission Measurement Branch served as EPA Task Manager for Entropy's part in the EPA test program. Mr. Chuck Masser was the on-site representative for EPA's Air and Energy Engineering Research Laboratory.

Entropy's Task Manager for the EPA-sponsored work, Mr. Bill DeWees, was responsible for management of the inlet test crew, in addition to direct communication and liason with the EPA. Dr. Scott Steinsberger, Entropy's Quality Assurance Coordinator, was responsible for monitoring the day-to-day QA/QC problems.

Mr. Bob Tekach of Wheelabrator Millbury, Inc. and Mr. Timothy Porter of Wheelabrator Environmental Systems served as the facility contacts.

1.4 REPORTING OBJECTIVES AND FORMAT

This report presents the results of the inlet CDD/CDF testing and process sample collection conducted by Entropy under contract to the U. S. EPA. A companion summary report compares these inlet data to the outlet CDD/CDF data generated for the compliance test program to assess the control efficiency of the SD/ESP system for these pollutants.

This report is organized into several sections that address the various aspects of the testing program. Following the introduction is the "Facility Description and Operation During Testing Program" section prepared by Radian Corporation that describes the combustion and add-on pollution control equipment and presents the operating and CEM data recorded during the emissions testing program. Following this section is the "Summary of Results" section that includes tables summarizing the test conditions, the calculated CDD/CDF emission rates, the process sample CDD/CDF contents, and the analytical results. The next section, "Sampling Locations and Sampling

CONTRACTOR EFFORT

Contractor	Scope of Work	Funding Source
Entropy (CEM / Eng. Div)	Conduct EPA field test program at spray dryer inlet	EPA / OAQPS
Radian	Perform process monitoring	EPA / OAQPS
Entropy (Source Test Div.)	Compliance field testing at ESP outlet	Rust International Corp.
RTI	EPA test program QA	EPA / AEERL

GOVERNMENT PERSONNEL AT TEST SITE

EPA / AEERL	Chuck Masser
EPA / OAQPS	Dan Bivins Mike Johnston
Massachusetts DEQE	Craig Dunlop Paul Duiggins

MANAGEMENT PROTOCOL

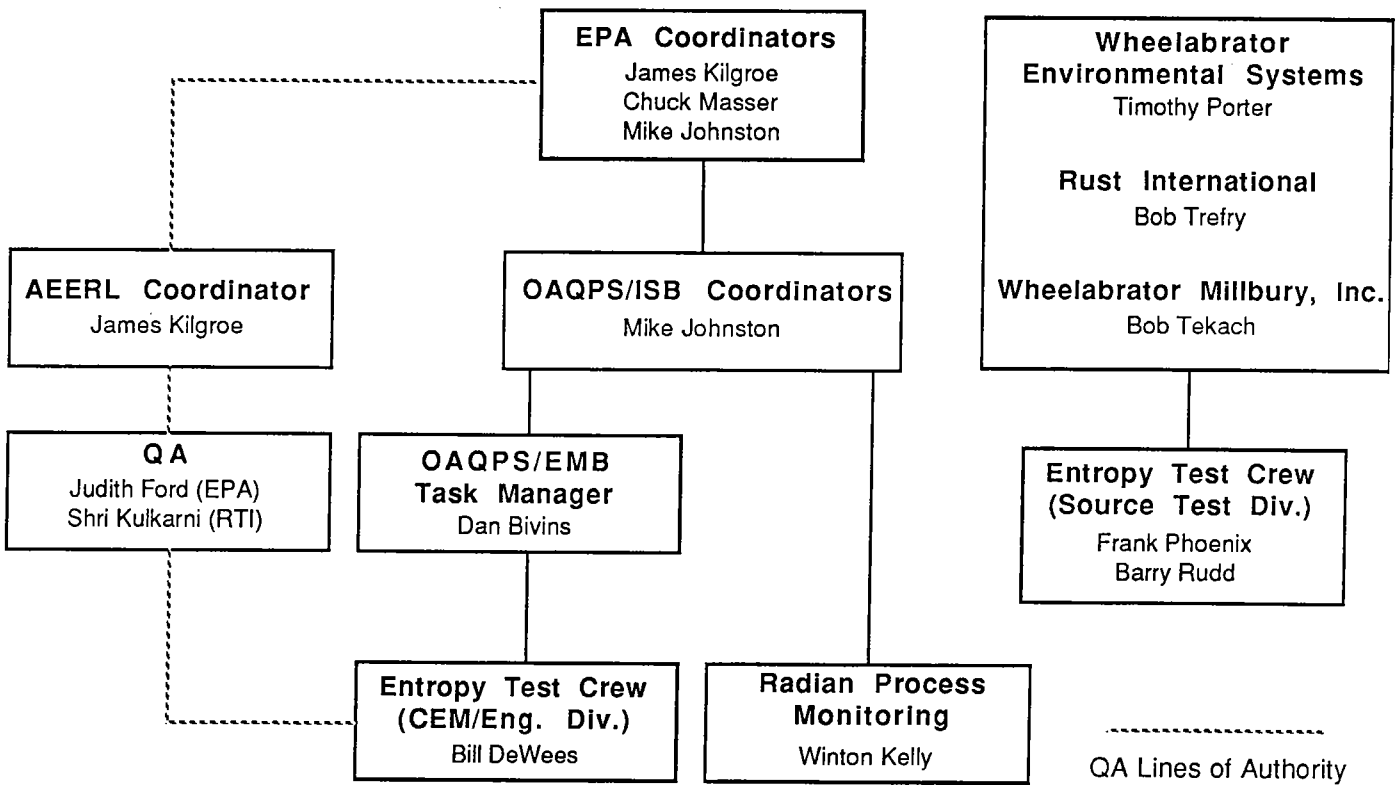

Figure 1-1. Organizational scheme for Wheelabrator Millbury testing program.

and Analytical Procedures" describes and illustrates the sampling locations for the emissions testing program and explains the sampling and analysis strategies used. The final section, "Quality Assurance/Quality Control," describes the procedures used to ensure the integrity of the sampling and analytical data. The Appendices to this report present the Test Results and Example Calculations (Appendix A); Field and Analytical Data(Appendix B); Sampling and Analytical Procedures (Appendix C); Calibration and Quality Assurance (Appendix D); Radian Process Data (Appendix E); and Test Participants and Observers (Appendix F); and Draft Final Audit Report prepared by Research Triangle Institute (Appendix G).

2.0 FACILITY DESCRIPTION AND OPERATION DURING TEST PROGRAM

This section contains a description of the Millbury Resource Recovery Facility located in Millbury, Massachusetts. A discussion of the facility operation and a summary of the values of key operating parameters and emissions monitored during testing are also included in this section.

2.1 FACILITY DESCRIPTION

The Millbury facility was designed, constructed, and is operated by Wheelabrator Environmental Systems, Inc. The Millbury facility is a mass burn municipal waste combustion facility consisting of two identical combustor, boiler, and flue gas treatment systems that exhaust into one common stack. The process schematic is shown in Figure 2-1.

Municipal solid waste (MSW) is charged to a Babcock and Wilcox waterwall combustor and boiler unit that is equipped with a Von Roll reciprocating, inclined grate. Each combustor is designed to process 750 tons/day of MSW. The combustor flue gases pass up through the waterwall section of the combustor and then into superheater, generator, and economizer heat transfer passes. Each boiler is rated to produce 190,000 lb/hr of superheated steam at 825°F and 850 psia. The combined steam from the two units is supplied to a turbine/generator set which is rated at 40 megawatts. The electricity is sold to a utility grid.

Each combustor is equipped with a spray dryer and electrostatic precipitator (ESP) emission control system to control acid gas and particulate emissions. The flue gas then exhausts to the atmosphere through a 365-foot reinforced concrete stack which is common to both units.

2.1.1 Waste Separation

The only waste preparation involves the removal of large pieces of metal prior to incineration. Hospital and radioactive wastes are not accepted at the facility.

2.1.2 Combustion Air

The forced-draft combustion air fans draw air from the tipping floor and enclosed receiving pit area. The slight negative pressure created in the

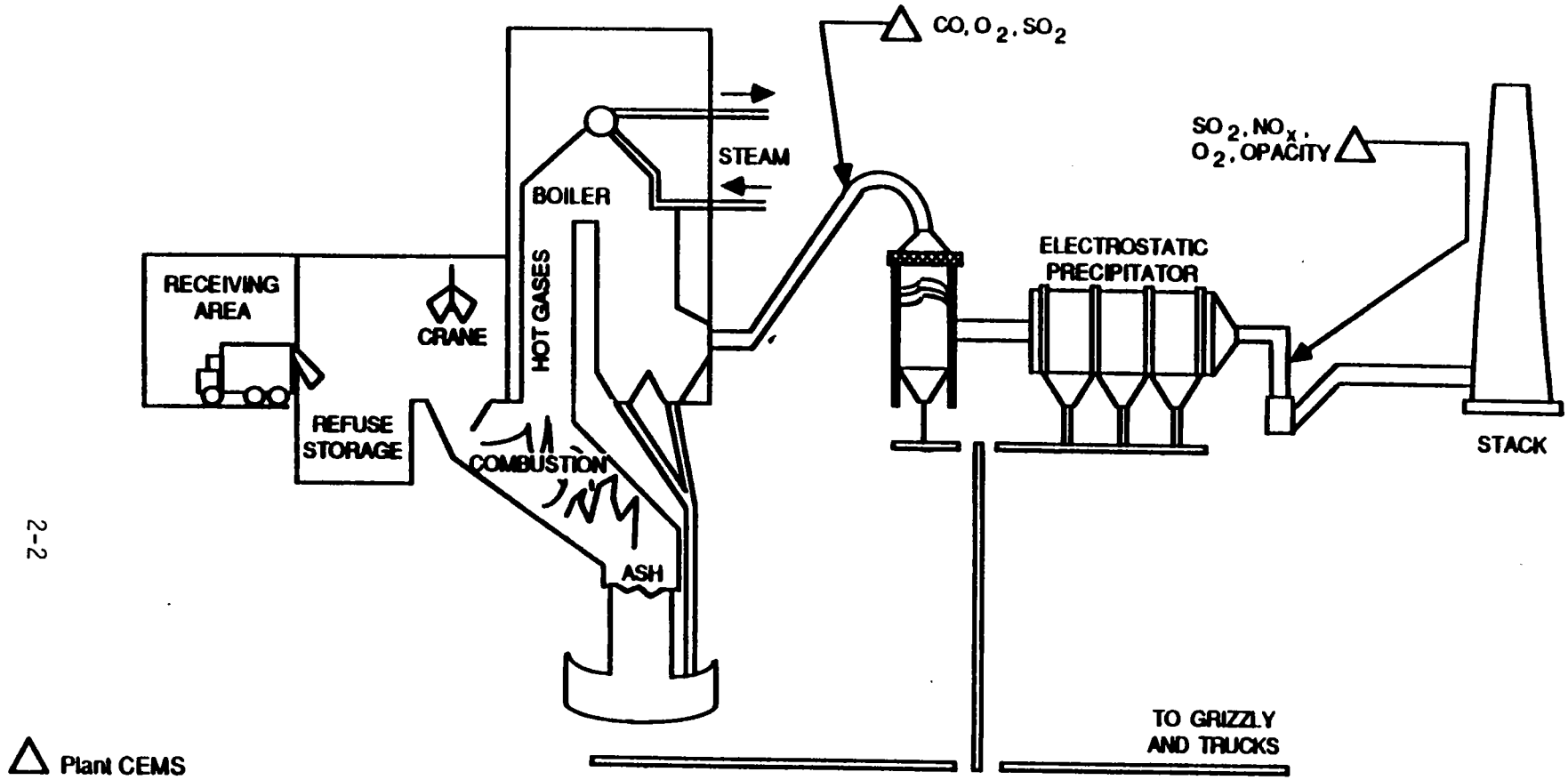

Figure 2-1. Process Schematic, Millbury Resource Recovery Facility

tipping floor area prevents the release of dust and odors. The primary air passes through a steam air heater prior to being directed to the undergrate air plenums. The secondary air is not heated and passes through a separate secondary air fan prior to entering the overfire air nozzle headers.

2.1.3 Combustor and Boiler

Each combustor/boiler unit was manufactured by Babcock and Wilcox. The combustor grate is a Von Roll reciprocating, inclined grate. The fuel from the feed chute is pushed onto the upper end of the grate by hydraulically operated ram feeders. The combustor/boiler unit is designed to ensure that the refuse is exposed to temperatures greater than 1,800^{o}F for a residence time of at least 1 second. Auxiliary fuel (natural gas) is available at 34 to 45 percent of combustor thermal capacity but is generally used only during startup and shutdown and is normally not needed to maintain steam load or minimum flue gas temperatures.

The heat recovery system, in addition to the waterwalls in the combustion zone, includes superheater, generator, and economizer sections. The boiler is rated at 190,000 lb/hr of superheated steam at 825°F and 850 psia (323 million Btu/hr maximum Btu output). At the exit of the economizer, the flue gas temperature is approximately 440°F. Each combustor is maintained under a negative draft by an induced-draft fan located just before the stack.

2.1.4 Spray Dryer and ESP

The combustion gases exiting the combustor enter a spray dryer/ESP emission control system designed by Wheelabrator Air Pollution Control Systems. Slaked lime, along with metered dilution water for temperature control, is injected into the spray dryer vessel. The slurry water is evaporated by the hot flue gas and the acid gases react with the lime. In addition, particulate and excess lime serve as nucleation points for the adsorption and agglomeration of volatile organic compounds (VOC) and metals.

The lime slurry feedrate is varied according to the outlet SO_2 concentration. Dilution water is added to the lime slurry to reduce the flue gas temperature. The spray dryer outlet temperature is typically maintained

at about 255°F. The simplified spray dryer process control system is illustrated in Figure 2-2. The system is designed for automatic control of the lime feed rate and the dilution water. The lime feed control loop is operated automatically to maintain the required SO_2 outlet concentration. Manual adjustments of the set point are made to control SO_2 excursions.

The dry solids and flyash are then collected in a three-field ESP designed by Wheelabrator Air Pollution Control Systems. The ESP is cleaned according to various rapping cycle programs. The ESP rapping program used during this testing program was:

1. The inlet gas distribution plates are rapped. Each of the three plates is rapped sequentially.
2. The inlet field discharge electrodes for Fields 1, 2, and 3 are rapped sequentially.
3. There is then a 3-minute pause in the cycle.
4. The inlet field collection plates (Fields 1, 2, and 3) are rapped sequentially.
5. There is then a 5-minute pause.

The complete cycle requires 11 to 13 minutes and repeats continuously.

2.1.5 Ash Handling

The ash handling system removes ash from the grate discharges, superheater, generator and economizer tube banks, spray dryer, and ESP. The water-quenched bottom ash from the grates and the superheater, generator, and economizer ash are removed by vibrating conveyors to an enclosed ash handling area. ESP and spray dryer ash are drag-conveyed and mixed with the bottom ash mixture in the enclosed ash handling area. The combined ash is then screened to remove large materials and landfilled. Any oversize materials are separated and are landfilled. Ferrous materials are reclaimed and sold.

2.2 SUMMARY OF OPERATION

Five test runs were conducted on Unit 2 between February 8-10, 1988. During each test run, only municipal solid waste was fired. No plant operational problems were experienced during any of the test runs. Soot blowing did not occur during any of the test runs.

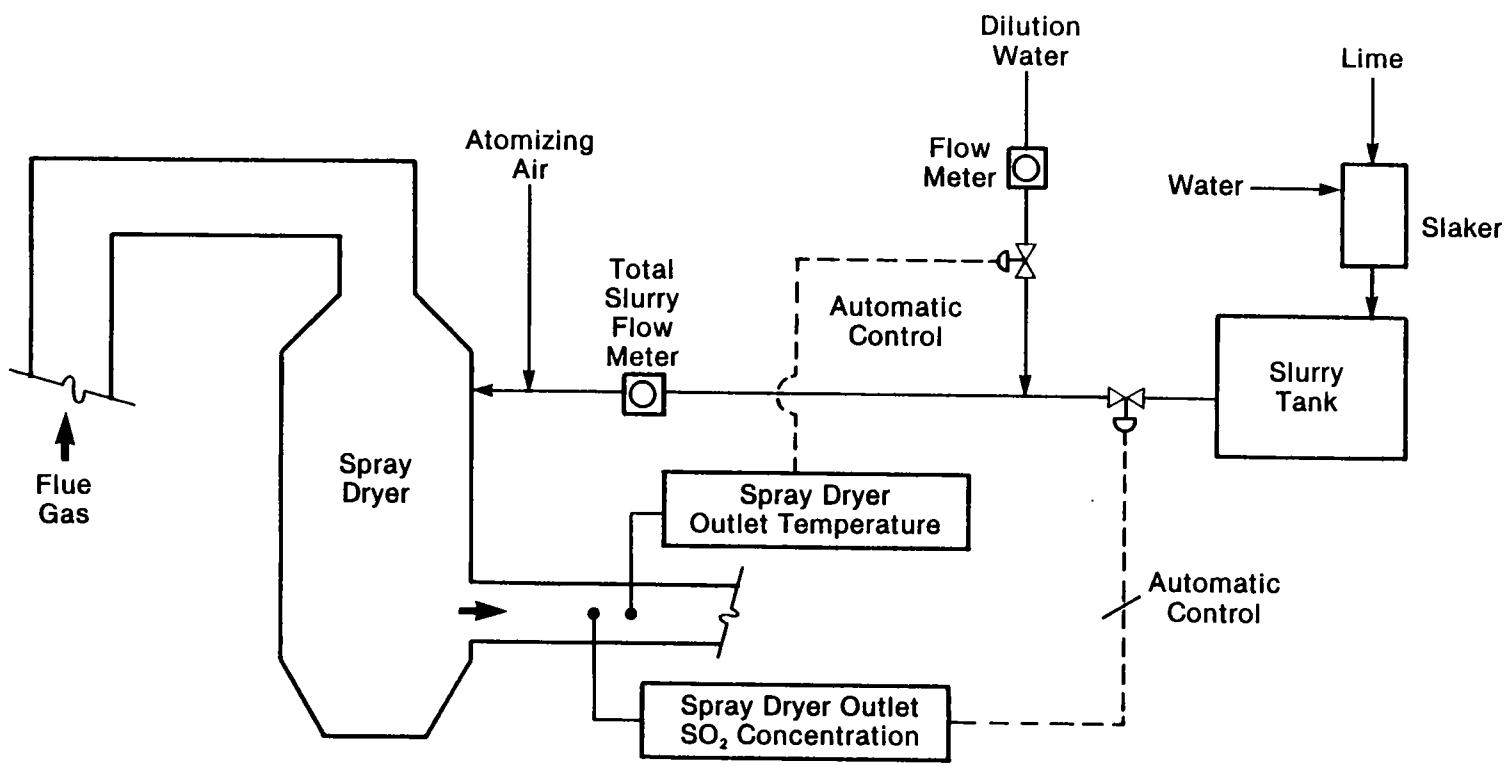

Figure 2-2. Spray Dryer Process Control Schematic

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2.3 SUMMARY OF OPERATING PARAMETERS DURING THE TEST PROGRAM

This section summarizes the values of key operating parameters and emissions that were monitored during the test program. The purpose of evaluating these operating parameters is to determine if the combustor and control system were operating under similar conditions during each of the five test runs.

The process operating parameters that were recorded at the Millbury facility are listed in Table 2-1. The locations of the various temperature, pressure, and flow sensors are presented in Figures 2-3 through 2-5. The digital data were recorded every ten minutes and the manual data were recorded every 30 minutes. Only 22 of the 40 digitally-recorded operating parameters could be automatically recorded due to the plant's computer configuration. The remaining parameters were keyed in manually from computer screen printouts and lag the digital data by one to three minutes. Opacity data were initially recorded manually until it was determined that the opacity meter reading was inaccurate. No further data were recorded and the data are not presented. The plant separately recorded concentration values for O_2 at the economizer outlet and ESP outlet and for NO_x at the ESP outlet based on 6-minute averages. The complete set of operating data recorded during the test program is included in Appendix G.

The continuous emission monitors (CEM's) for SO_2, NO_x, CO, and O_2 were not certified by EPA at the time of the test program. Quality assurance measures (calibrations, bias checks, etc.) were not performed with the test program. Concentration data reported for these species are indicative of trends in operation, but are not necessarily the true concentrations.

The average values for the operating parameters over the actual testing intervals are summarized in Table 2-2. The average values over the testing intervals for the 6-minute average data for O_2 and NO_x are presented in Table 2-3. On an average basis, the combustor operating conditions appear to have remained consistent for all five test runs. The only variation of interest would be the higher inlet SO_2 and CO concentrations for Run 3. Consequently, the lime slurry controller setting was the highest and the dilution water flow rate was the lowest for this run. Since the combustor

TABLE 2-1. PROCESS DATA RECORDED DIGITALLY AND MANUALLY DURING THE MILLBURY RESOURCE RECOVERY FACILITY TEST PROGRAM

Digital Data:

Trend Log 1

1. Steam Flow (total steam to turbine)[a]
2. Superheater Steam Temperature[b]
3. Steam Pressure[b]
4. Natural Gas Flow
5. Primary Air Flow[c]
6. Primary Air Temperature[b]
7. Primary Air Pressure
8. Secondary Air Flow[c]
9. Secondary Air Pressure
10. Oxygen

Trend Log 2

1. Combustor Draft
2. Steam to Atmosphere
3. Boiler Feedwater Temperature
4. Combustor Temperature
5. Combustor Pressure
6. Superheater Outlet Gas Temperature
7. Superheater Outlet Gas Pressure[b]
8. Economizer Inlet Gas Temperature
9. Economizer Outlet Pressure[b]
10. ID Fan Pressure

Trend Log 3

1. Spray Dryer Inlet Temperature
2. Spray Dryer Outlet Temperature
3. Lime Slurry Rate (% of controller)[b]
4. Dilution Water Flow[b]
5. Total Slurry Flow
6. Inlet SO_2 Concentration[b]
7. Outlet SO_2 Concentration
8. Percent SO_2 Removal
9. CO Concentration

Trend Log 4

1. ESP Outlet Temperature[b]
2. Field 1 Secondary Voltage
3. Field 2 Secondary Voltage[b]
4. Field 3 Secondary Voltage[b]

Continued

TABLE 2-1 (CONCLUDED). PROCESS DATA RECORDED DIGITALLY AND MANUALLY DURING THE MILLBURY RESOURCE RECOVERY FACILITY TEST PROGRAM

Manual Data:

1. Opacity (6-minute intervals)[d]
2. Soot blowing cycles (intermittent as required)[e]
3. ESP rapping cycles (intermittent as required)
4. ESP Primary Voltages/Amperages per field (30-min intervals) (AC)
5. ESP Secondary Amperages per field (30-min intervals) (DC)
6. ESP Spark Rate per field (30-min intervals)

[a]Changed during the first run to total steam from Unit #2 only.

[b]Data manually entered from screen printouts.

[c]Reported as total air flow.

[d]Data not recorded.

[e]Soot blowing did not occur during any of the tests.

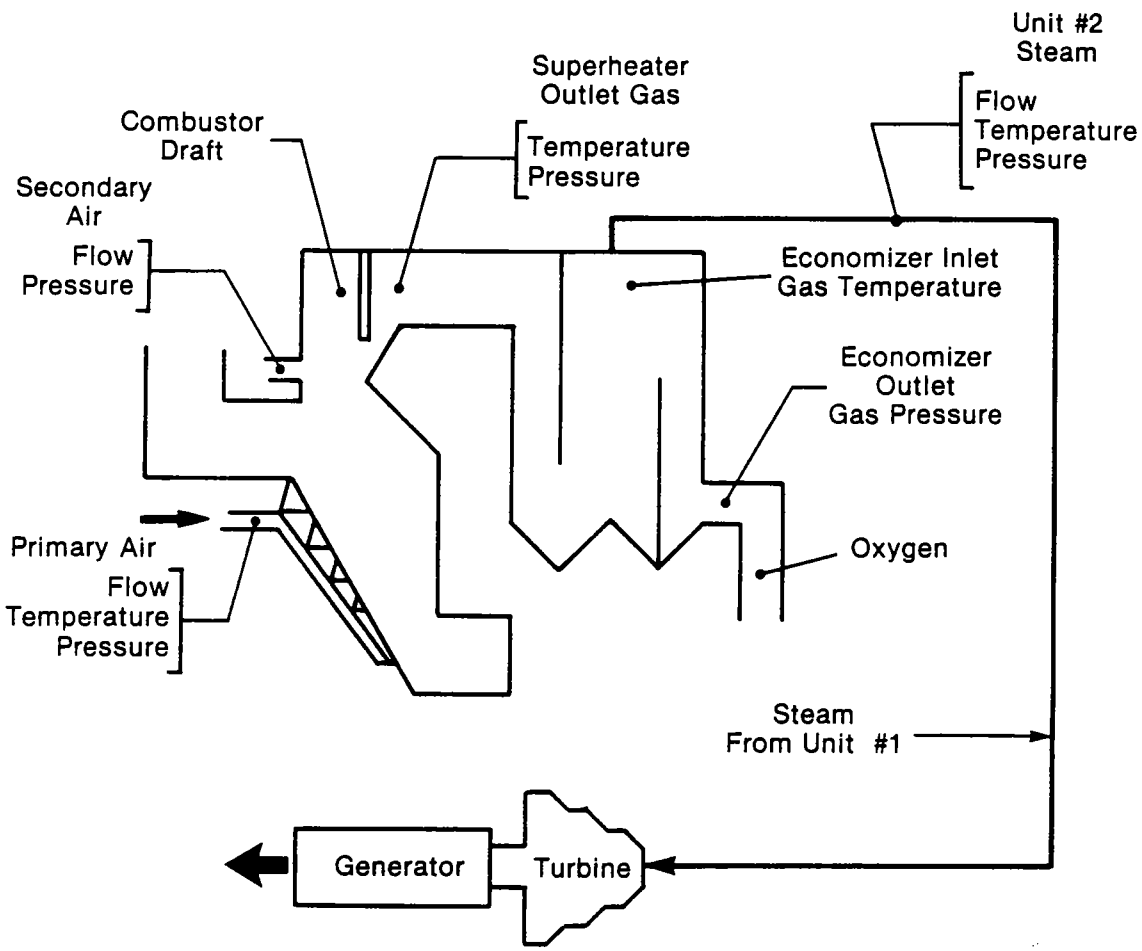

Figure 2-3. Process Data Sensor Locations for the Combustor System

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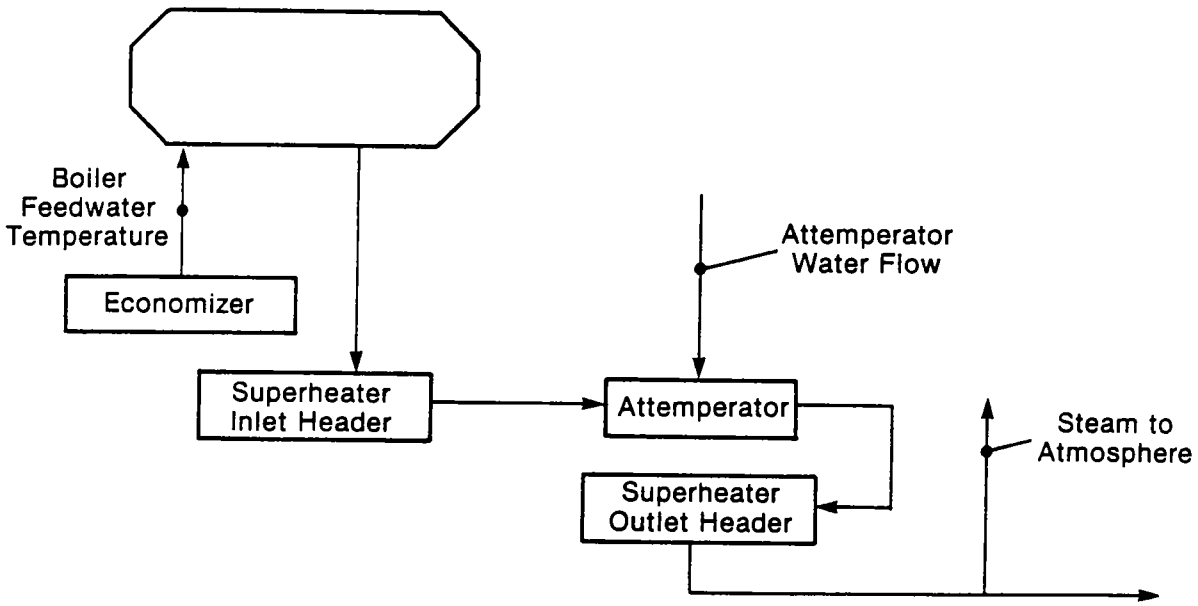

Figure 2-4. Process Data Sensor Locations for the Steam Generator System

3881166R

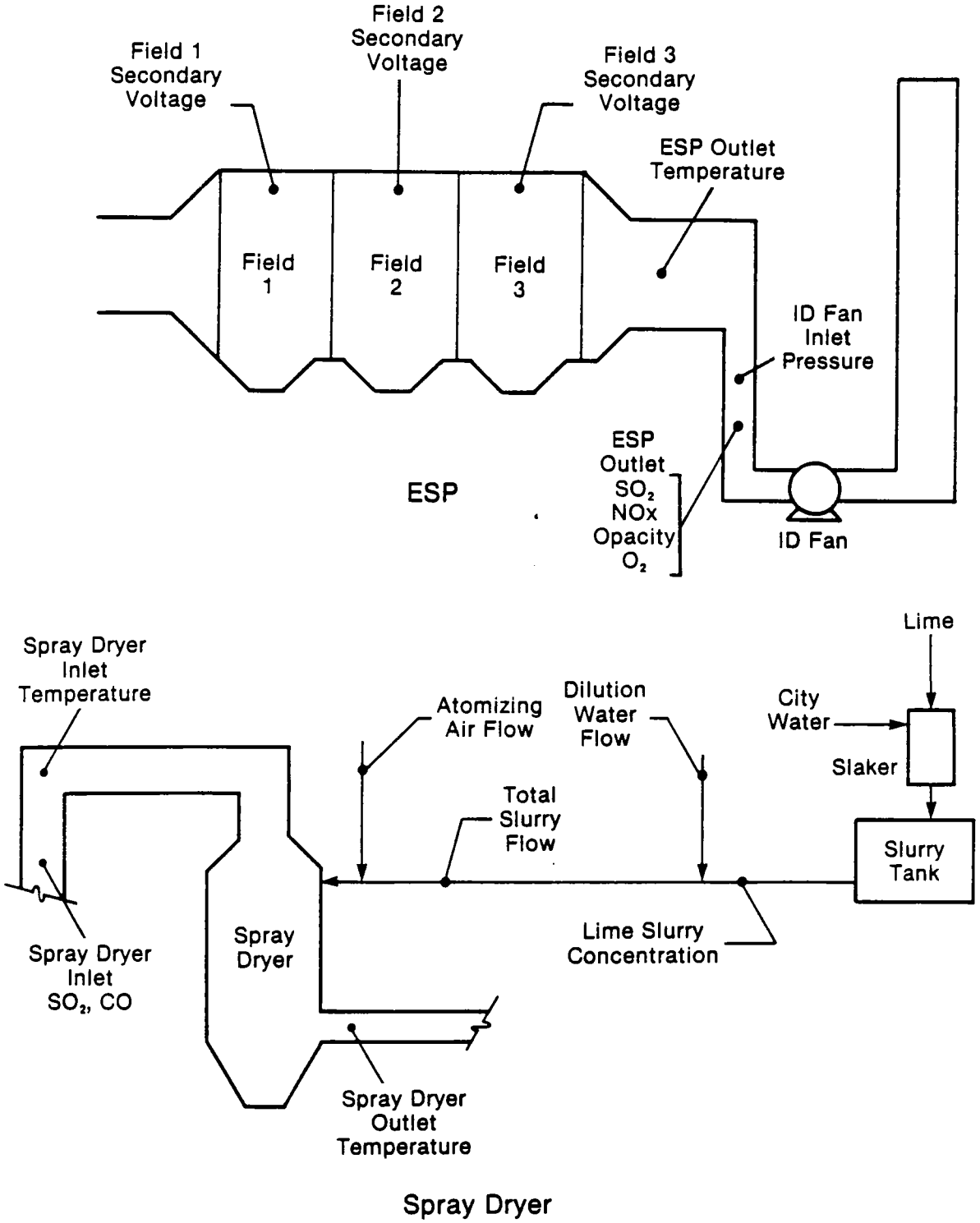

Figure 2-5. Process Data Sensor Locations for the ESP and Spray Dryer System

0781165R

TABLE 2-2. SUMMARY OF RESULTS, AVERAGE PROCESS DATA

Parameter	Units	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Std. Dev.
Digital:								
Steam Flow	(K lb/hr)	188.1	188.0	187.7	187.6	187.7	187.8	0.2
Superheater Steam Temperature	(^{o}F)	825	825	824	825	824	825	0.6
Steam Pressure	(psig)	858	858	858	858	858	858	0
Natural Gas Flow	(Kscfh)	0	0	0	0	0	0	0
Total Air Flow	(Kacfm)	87.00	91.25	83.63	84.39	80.39	85.33	4.06
Undergrate Air Temperature	(^{o}F)	149	142	148	149	153	148	4
Primary Air Pressure	(in. H_2O)	11.99	12.19	12.08	12.11	12.12	12.10	0.07
Secondary Air Pressure	(in. H_2O)	25.87	25.98	26.02	25.94	26.10	25.98	0.09
Oxygen	(%)	11.98	12.40	11.52	12.69	10.76	11.80	0.68
Combustor Draft	(in. H_2O)	-0.26	-0.24	-0.28	-0.18	-0.20	-0.23	0.04
Steam to Atmosphere	(K lb/hr)	0	0	0	0	0	0	0
Superheater Outlet Gas Temperature	(^{o}F)	966	959	975	972	984	971	9
Superheater Outlet Gas Pressure	(in. H_2O)	-0.92	-0.93	-0.95	-0.84	-0.84	-0.90	0.05
Economizer Inlet Gas Temperature	(^{o}F)	688	697	682	690	677	689	8
Spray Dryer Inlet Pressure	(in. H_2O)	-2.19	-2.20	-2.03	-2.09	-1.96	-2.09	0.10
Precipitator Outlet Pressure	(in. H_2O)	-4.00	-4.13	-3.66	-3.74	-3.42	-3.79	0.28
Spray Dryer Inlet Temperature	(^{o}F)	438	441	432	438	430	436	5
Spray Dryer Outlet Temperature	(^{o}F)	255	255	255	253	250	254	2
Lime Slurry Rate	(% controller scale)	49.6	51.2	61.4	59.9	50.6	54.5	5.6
Dilution Water Flow	(GPM)	20.9	21.2	14.4	16.7	18.8	18.4	2.9
Total Slurry Flow	(GPM)	41.3	43.0	38.8	41.0	38.9	40.6	1.8
Inlet SO_2 Concentration	(PPM)	107.8	94.8	235.8	214.9	216.4	173.9	(6)
Outlet SO_2 Concentration	(PPM)	17.1	17.8	44.6	47.6	42.0	33.9	14.9
SO_2 Removal	(%)	86.0	84.8	83.2	78.7	81.0	82.7	2.9
CO Concentration	(PPM)	14.2	14.6	43.0	26.0	26.6	24.9	11.8
ESP Outlet Temperature	(^{o}F)	254	254	253	252	249	252	2
Field 1 Secondary Voltage[a]	(KV)	54.2	53.7	57.1	57.5	55.0	55.5	1.7
Field 2 Secondary Voltage[a]	(KV)	53.9	54.0	56.4	55.0	54.2	54.7	1.0
Field 3 Secondary Voltage[a]	(KV)	59.0	58.8	59.1	59.8	59.4	59.2	0.4

Continued

pmw/048
88-3b.tbl

TABLE 2-2 (CONCLUDED). SUMMARY OF RESULTS, AVERAGE PROCESS DATA

Parameter	Units	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Std. Dev.
Manual:								
Field 1 Primary Voltage-AC	(V)	307	305	329	322	322	317	11
Field 2 Primary Voltage-AC	(V)	333	325	339	326	330	331	6
Field 3 Primary Voltage-AC	(V)	370	373	370	374	373	372	2
Field 1 Primary Current-AC	(Amps)	110	117	99	101	115	108	8
Field 2 Primary Current-AC	(Amps)	171	175	163	173	175	171	5
Field 3 Primary Current-AC	(Amps)	167	170	164	166	170	167	3
Field 1 Secondary Voltage[a]	(KV)	44	44	49	47	44	46	2
Field 2 Secondary Voltage[a]	(KV)	44	44	46	44	45	45	0.9
Field 3 Secondary Voltage[a]	(KV)	49	50	49	49	49	49	0.4
Field 1 Secondary Current-DC	(Amps)	0.62	0.63	0.54	0.56	0.59	0.59	0.04
Field 2 Secondary Current-DC	(Amps)	1.03	1.06	0.98	1.04	1.07	1.04	0.04
Field 3 Secondary Current-DC	(Amps)	1.04	1.07	1.02	1.04	1.06	1.05	0.02
Field 1 Spark Rate	(Sparks/Min x 10)	0	0	1.00	0	0	0.2	0.5
Field 2 Spark Rate	(Sparks/Min x 10)	0	0	0	0	0	0	0
Field 3 Spark Rate	(Sparks/Min x 10)	0	0	0	0	0	0	0

[a]Parameter measured at different time intervals on different readouts.

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88-3b.tbl

TABLE 2-3. SUMMARY OF DATA FOR O_2 AND NO_x[a]

Parameter	Units	Run 1	Run 2	Run 3	Run 4	Run 5	Average	Std. Dev.
Oxygen (Economizer Outlet)	(%)	11.1	11.3	11.0	11.4	10.7	11.1	0.3
Oxygen (ESP Outlet)	(%)	11.7	11.9	11.3	11.7	11.2	11.6	0.3
NO_x (ESP Outlet)	(ppm)	150.9	142.1	166.2	149.3	133.8	148.5	12.0

[a]Data recorded as 6-minute averages.

pmw/048
88-3c.tbl

operating conditions were consistent for all five runs, the higher SO_2 and CO concentrations are attributable to the variation in composition of the refuse fed to the combustor during the testing period.

Plots of the 10-minute and 6-minute average data versus run time are presented in this section. The plots have been reduced in size in order to illustrate the relative values between the five runs. Full-size plots for each run are included in Appendix G if more detail is required by the reader. Each of the trend plots is discussed separately in the following sections.

2.3.1 Steam Load, Oxygen, and Nitrogen Oxides

Figure 2-6 presents steam flow, temperature, and pressure vs. run time for each of the five test runs. As is shown in the figure, these parameters were consistent for all five test runs. The standard deviation of the steam load between runs was an average of 0.2 percent.

The 6-minute average values for oxygen at the economizer outlet and ESP outlet and NO_x at the ESP outlet for each run are plotted against run time in Figure 2-7. The oxygen levels at both locations were fairly consistent across the test runs. The oxygen concentrations were similar across the air pollution control system, indicating that little dilution air entered the system. The NO_x concentration generally ranged from 150 to 180 ppm. During Run 5, the NO_x concentration was consistently below 150 ppm.

2.3.2 Combustion Air Parameters

The total combustion air flow and undergrate air temperature are presented in Figure 2-8 vs. run time. As can be seen in the figure, the undergrate air temperature did not vary significantly between test runs. However, the total air flow varied for all test runs and was inconsistent for Runs 2 and 4. In addition, the figure shows that the total air flow for Run 1 increased slightly throughout the test run. This is expected since the oxygen level for this run increased throughout the test.

Primary and secondary air pressure are plotted against run time in Figure 2-9. These combustion air parameters did not vary significantly between test runs.

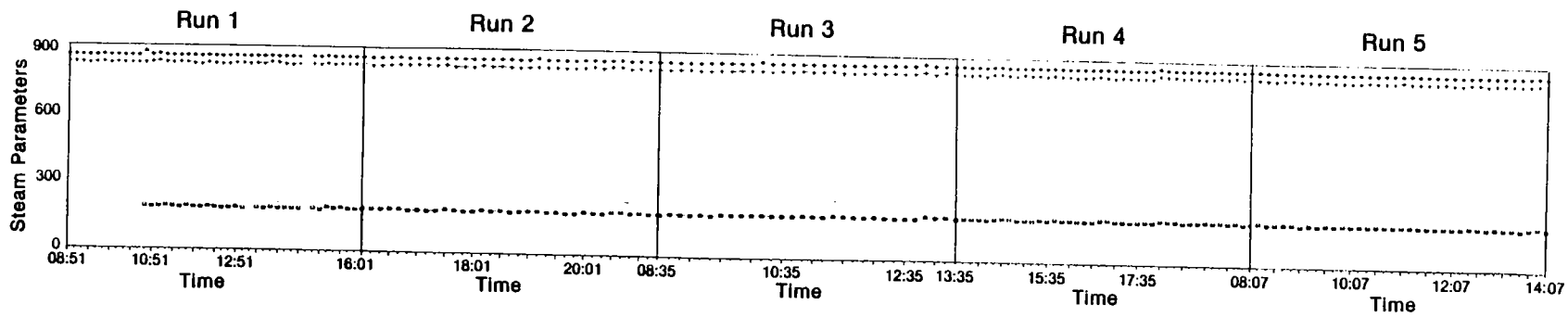
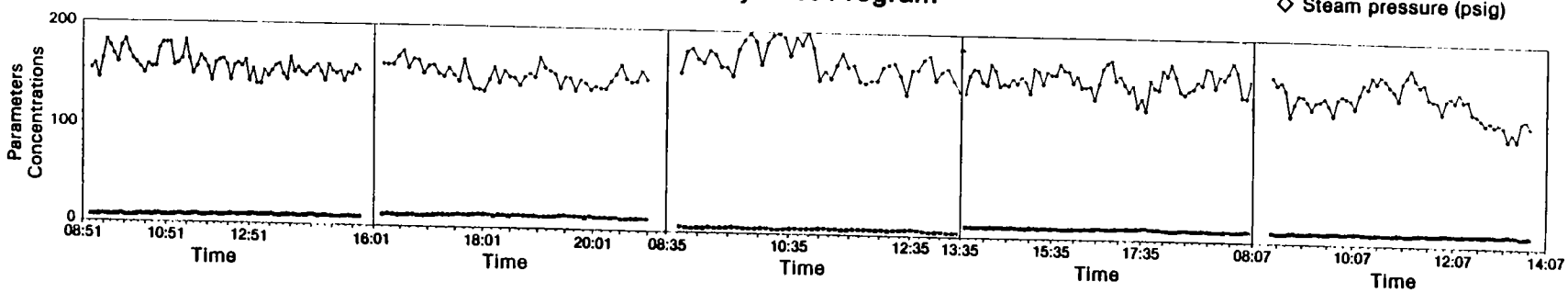


Figure 2-6. Steam Flow, Temperature, and Pressure as a Function of Time During the Millbury Test Program

KEY
□ Total steam flow (1000 lb/hr)
+ Steam temperature (°F)
◇ Steam pressure (psig)



KEY
□ Oxygen concentration at economizer outlet (%)
+ Oxygen concentration at ESP outlet (%)
◇ NOx concentration at ESP outlet (ppm)

Figure 2-7. Oxygen and NOx Concentration as a Function of Time During the Millbury Test Program

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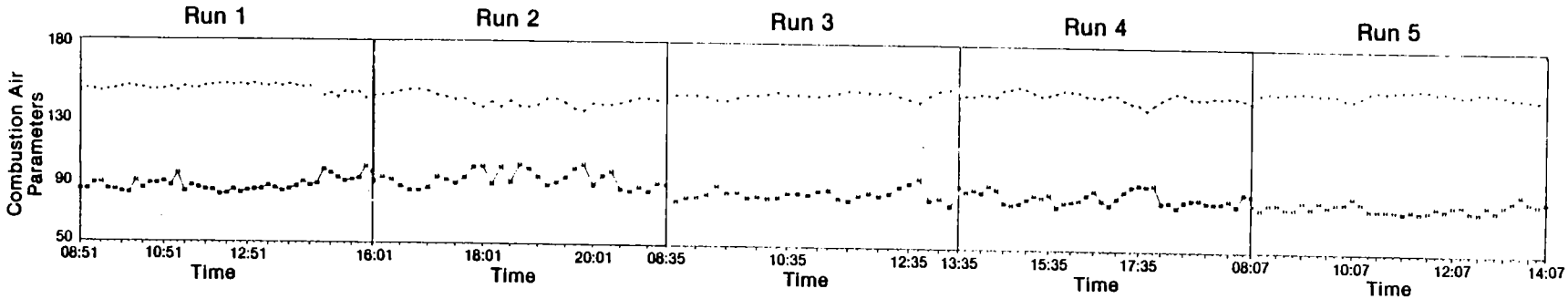
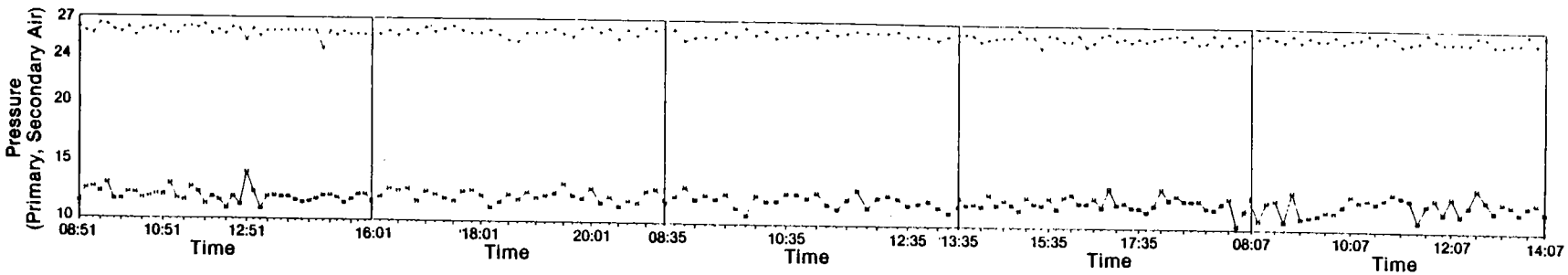


Figure 2-8. Combustion Air Parameters as a Function of Time During the Millbury Test Program

KEY
□ Total air flow (1000 acfm)
+ Undergrate air temperature (°F)



KEY
□ Primary air pressure (in. H_2O)
+ Secondary air pressure (in. H_2O)

Figure 2-9. Primary and Secondary Air Pressure as a Function of Time During the Millbury Test Program

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2.3.3 CO Concentrations and Furnace Temperature Profile

CO concentrations vs. run time are plotted in Figure 2-10. Except for Run 3, the CO concentration was generally below 30 ppm indicating good combustion in the combustor. The average CO concentration for Run 3 was 43.0 ppm.

Figure 2-11 presents the superheater outlet gas and economizer inlet gas temperatures. These temperatures were fairly consistent across the test runs. The highest mean superheater exit gas temperature (984°F) occurred during Run 3. This test run also has the lowest economizer inlet gas temperature (677°F). This suggests better heat transfer with the hotter flue gas due to the larger temperature differential between the hot flue gas and the boiler water.

2.3.4 Pressure Profile

The furnace draft, superheater outlet, spray dryer inlet, and ESP outlet pressures are plotted vs. run time in Figure 2-12. As can be seen from the figure, all of the pressures were fairly consistent across the test runs. The combustor draft went positive several times during each test run.

2.3.5 Control System Temperature Profile

Figure 2-13 presents a plot of spray dryer inlet, spray dryer outlet, and ESP outlet temperatures vs. run time for all five test runs. The spray dryer inlet temperature was fairly consistent across all test runs, ranging from 430 to 450°F. Test Runs 1 and 5 show an upward trend in the spray dryer inlet temperature as each test progressed. The spray dryer outlet and ESP outlet temperatures were also fairly consistent across the test runs, ranging from 250 to 260°F.

2.3.6 Spray Dryer Operating Variables

Inlet and outlet SO_2 concentration, total slurry flow, and dilution water flow are plotted against run time in Figures 2-14 and 2-15. The total slurry flow, dilution water flow, and the lime slurry rate are highly variable within each test run and change as necessary to keep the spray dryer inlet temperature and outlet SO_2 concentration within control set points.

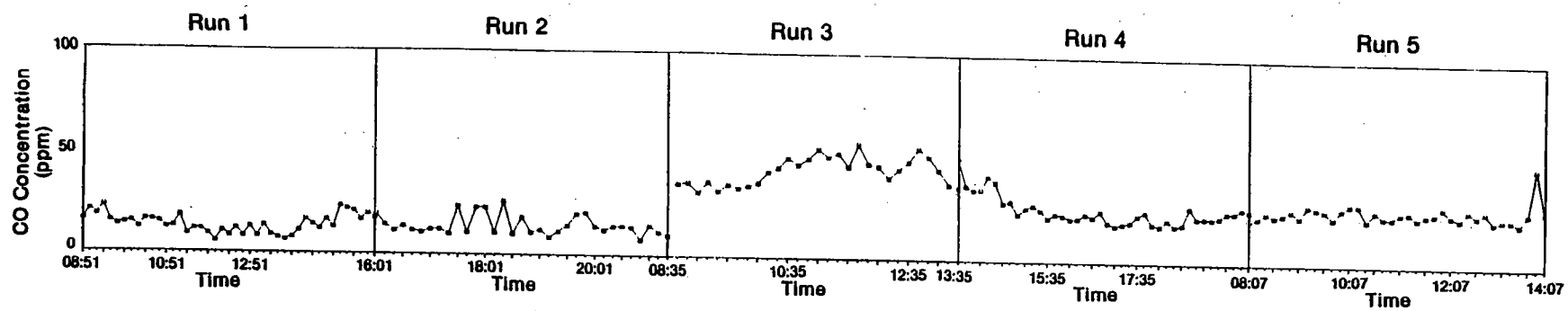

Figure 2-10. CO Concentration as a Function of Time During the Millbury Test Program

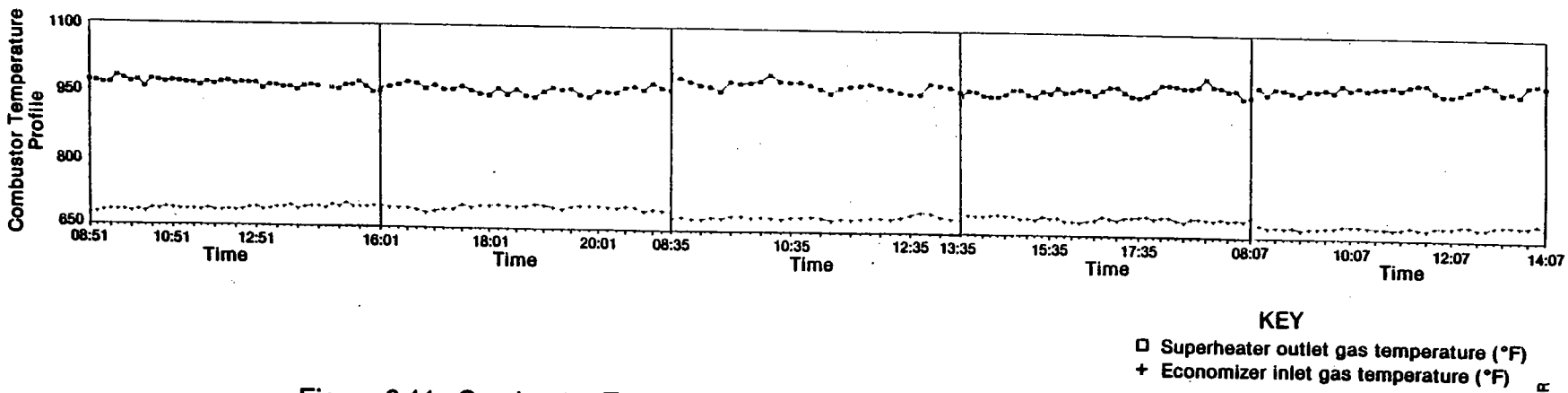

Figure 2-11. Combustor Temperatures as a Function of Time During the Millbury Test Program

0781159R

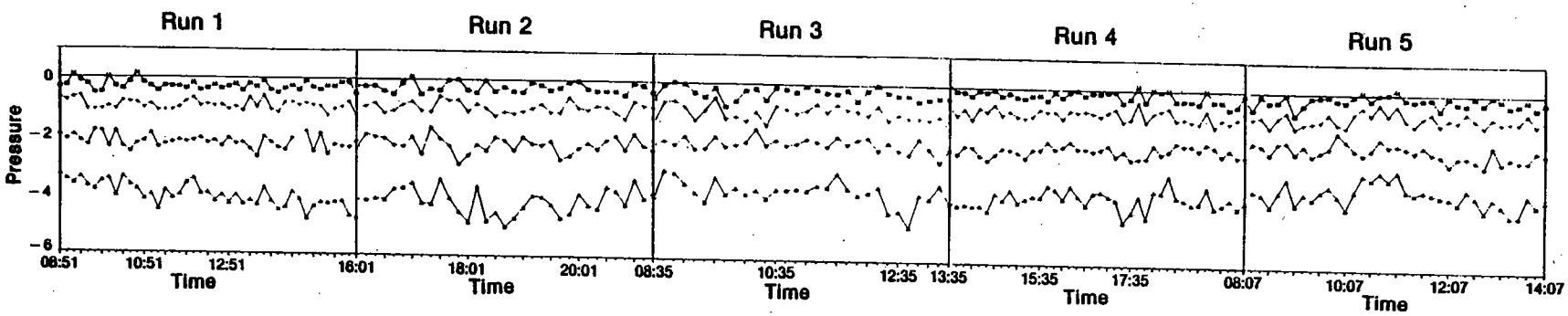

Figure 2-12. Pressure Profile as a Function of Time During the Millbury Test Program

KEY
- □ Furnace draft (in. H_2O)
- + Superheater outlet pressure (in. H_2O)
- ◇ Spray dryer inlet pressure (in. H_2O)
- △ ESP outlet pressure (in. H_2O)

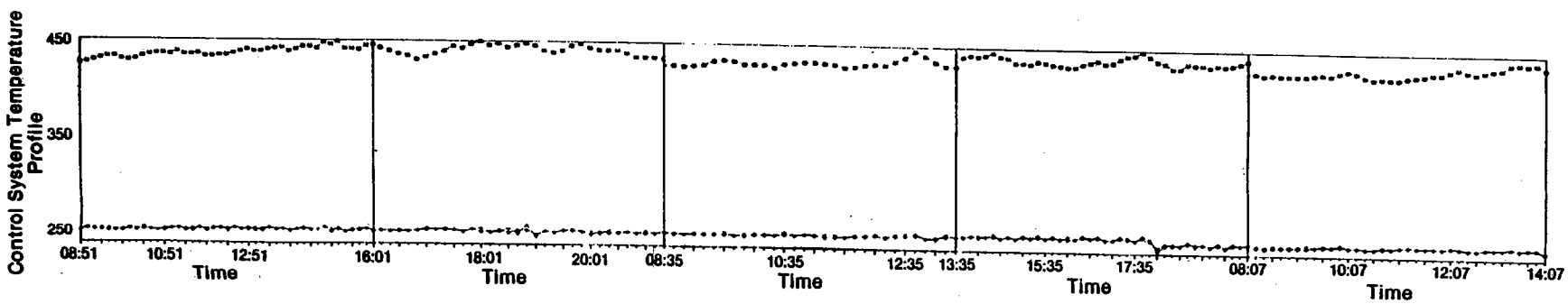

Figure 2-13. Control System Temperature as a Function of Time During the Millbury Test Program

KEY
- □ Spray dryer inlet temperature (°F)
- + Spray dryer outlet temperature (°F)
- ◇ ESP outlet temperature (°F)

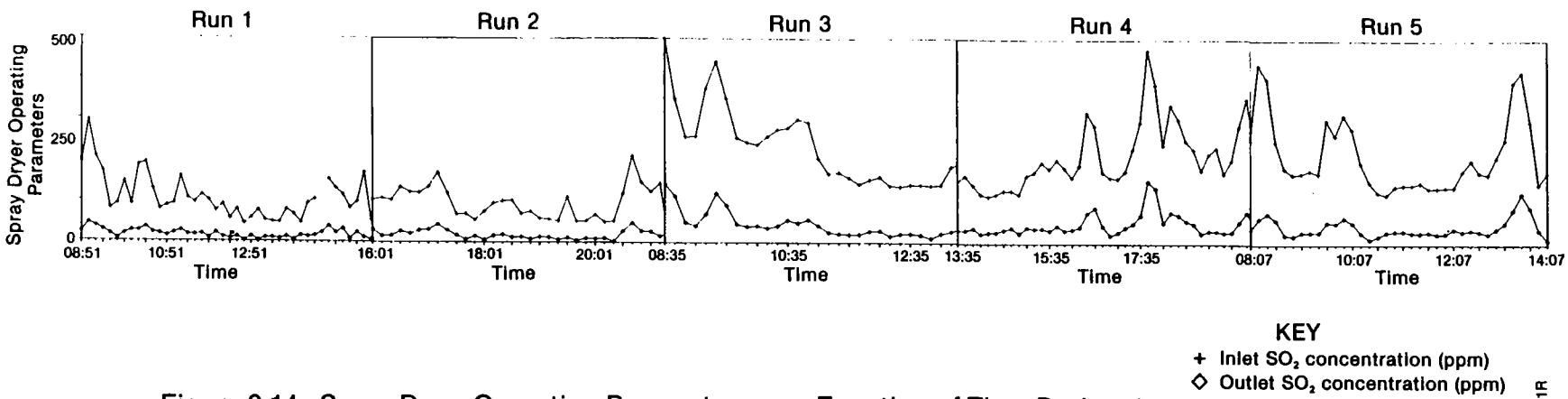

Figure 2-14. Spray Dryer Operating Parameters as a Function of Time During the Millbury Test Program

0781161R

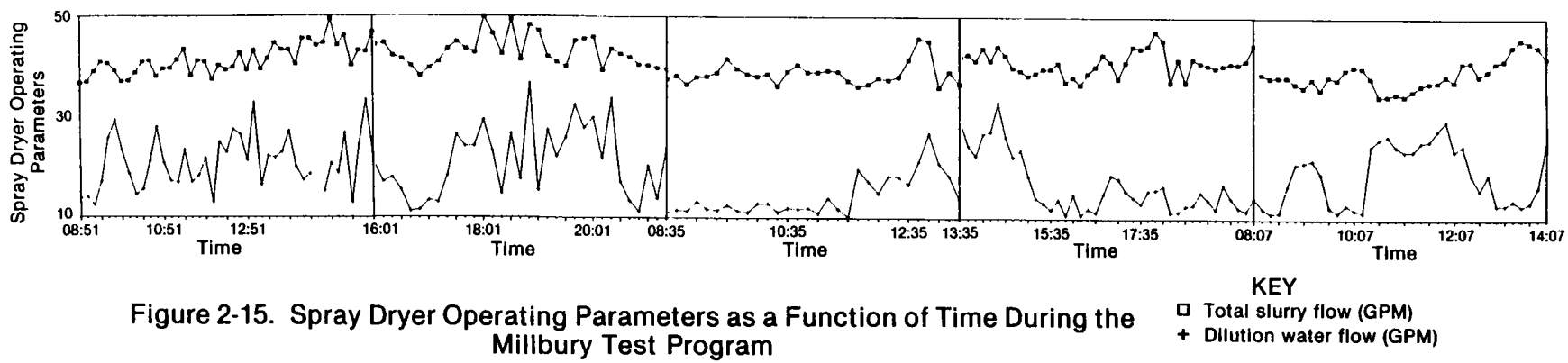

Figure 2-15. Spray Dryer Operating Parameters as a Function of Time During the Millbury Test Program

The inlet and outlet SO_2 concentrations also vary significantly within each test run. This shows the nonuniformity of the municipal waste fed during the test runs.

2.3.7 SO_2 Removal Efficiency and Lime Feed Rate

The SO_2 removal efficiency across the emission control system and lime feed rate are plotted against run time in Figure 2-16. The SO_2 removal efficiency was calculated based on the measured SO_2 concentrations at the spray dryer inlet and outlet. These concentrations were not normalized in calculating removal efficiency because O_2 data at the outlet were 6-minute averages and the SO_2 data were point values recorded every 10 minutes. The lime feed rate was calculated based on the total slurry flow and the solids concentration and specific gravity of the total slurry flow for each test run (Table 3-7). The total slurry specific gravity and solids content were assumed constant throughout each test run, although these values varied because of changes in the dilution water rate. The fraction of the solids which is CaO was assumed constant at 0.55 based on data taken at another test site that used the same type of lime slurry system. The lime feed rate was calculated by the equation:

Lime feed rate (lb/min) = Total slurry feed rate (gal/min) x Solids content (%) x CaO in Solids (0.55) x Specific gravity of slurry x Density H_2O (8.342 lb/gal)

The efficiency fluctuates due to the variability in inlet SO_2 concentrations and automatic adjustment of the spray dryer operating variables. During the five test runs, the SO_2 removal efficiency ranged from 70 to 98 percent. The lime feed rate ranged from 10 to 20 lb/min across the test runs.

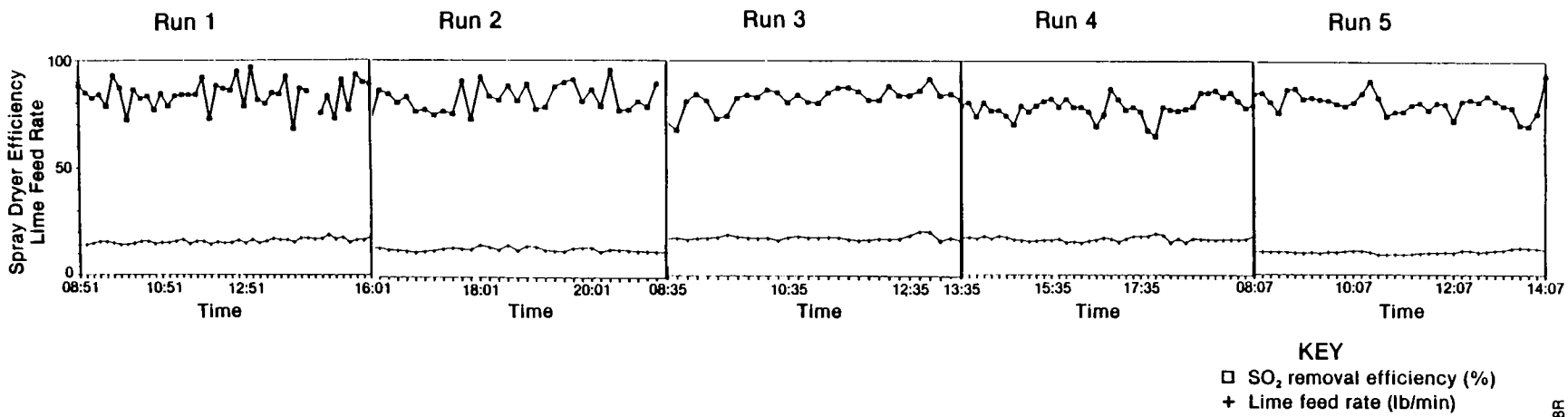

Figure 2-16. Spray Dryer Efficiency and Lime Feed Rate as a Function of Time During the Millbury Test Program

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3.0 SUMMARY OF RESULTS

Sampling for CDD/CDF, using the ASME/EPA/DOE protocol and a modified Method 5 (MM5) train, and simultaneous Method 3 testing were conducted at the inlet to the spray dryer of Unit 2 at the Wheelabrator Millbury municipal waste combustor facility. Representative ash samples from various discharge points and lime slurry samples were also collected during the period of emission testing. Table 3.1 summarizes the test schedule for this sampling.

In brief, the average CDD concentration (uncontrolled) for Runs 1-5 at the inlet to the spray dryer was 50.6 nanograms per dry standard cubic meter (ng/dscm), corrected to 12 percent CO_2. The average CDF concentration (uncontrolled) was 228 ng/dscm, corrected to 12 percent CO_2, and the total average CDD/CDF concentration (uncontrolled) was 279 ng/dscm, corrected to 12 percent CO_2. In terms of 2,3,7,8-TCDD toxic equivalents, the average uncontrolled CDD concentration was 0.87 ng/dscm, corrected. The average uncontrolled CDF concentration was 0.84 ng/dscm, corrected, and the average uncontrolled total CDD/CDF concentration was 1.71 ng/dscm, corrected. For the ash samples, total CDD/CDF concentrations ranged from 0.04 ng/g (0.00 ng/g 2,3,7,8-TCDD toxic equivalents) in the bottom ash to 84.8 ng/g (0.51 ng/g 2,3,7,8-TCDD toxic equivalents) in the ESP ash from the third field. The single lime slurry sample analyzed for CDD/CDF showed a total CDD/CDF concentration of 0.51 ng/g (0.00 ng/g 2,3,7,8-TCDD toxic equivalents). The CO_2 and O_2 concentrations in the flue gas during Runs 1 through 5 ranged from 9.2 to 9.9% and 10.0 to 10.7%, respectively.

Discussions detailing all the results obtained are presented in the following sections. Computer printouts of the sample calculations are presented in Appendix A. Original field data sheets and the analytical data are located in Appendix B.

3.1 RESULTS OF EMISSION TESTING AT SPRAY DRYER INLET

The emission results from the testing conducted at the spray dryer inlet represent the uncontrolled emissions from the Unit 2 municipal waste combustor at the Resource Recovery Facility in Millbury, Massachusetts. This report presents emission results from this inlet location only. A subsequent report will summarize these results and will compare them with the results from emission testing conducted concurrently at the outlet to the control equipment for compliance purposes which was funded under an industrial contract to Entropy.

TABLE 3.1. TESTING SCHEDULE FOR WHEELABRATOR MILLBURY

Date	Sample Type	Spray Dryer Inlet		ESP Outlet*		Various Ash/Lime Locations**	
		Run No.	Time 24 hr Clock	Run No.	Time 24 hr Clock	Sample No.	Time 24 hr Clock
2/8/88	MM5 (CDD/CDF)	MM5-IN-1	0858-1538	MM5-O-1	0855-1545		
	M3 (O_2, CO_2)	M3-IN-1	0858-1538	M3-O-1	0855-1545		
	Bottom Ash					ASH-BOTTOM-1	0940-1605
	Economizer/Generator Ash					ASH-ECON/GEN-1	0910-1605
	Spray Dryer Ash					ASH-SPRAYDR-1	0914-1609
	ESP Ash-All Fields					ASH-ESPALL-1	0912-1607
	ESP Ash-Fields 2,3					ASH-ESP 2,3-1	0911-1606
	ESP Ash-Field 3					ASH-ESP 3-1	0910-1605
	Lime Slurry					LIME-1	0930
	MM5 (CDD/CDF)	MM5-IN-2	1630-2111	MM5-O-2	1630-2115		
	M3 (O_2, CO_2)	M3-IN-2	1630-2111	M3-O-2	1630-2115		
	Bottom Ash					ASH-BOTTOM-2	1730-2130
	Economizer/Generator Ash					ASH-ECON/GEN-2	1700-2130
	Spray Dryer Ash					ASH-SPRAYDR-2	1704-2134
	ESP Ash-All Fields					ASH-ESPALL-2	1702-2132
	ESP Ash-Fields 2,3					ASH-ESP 2,3-2	1701-2131
	ESP Ash-Field 3					ASH-ESP 3-2	1700-2130
	Lime Slurry					LIME-2	1800

(continued)

TABLE 3.1. (continued)

Date	Sample Type	Spray Dryer Inlet		ESP Outlet*		Various Ash/Lime Locations**	
		Run No.	Time 24 hr Clock	Run No.	Time 24 hr Clock	Sample No.	Time 24 hr Clock
2/9/88	MM5 (CDD/CDF)	MM5-IN-3	0830-1315	MM5-0-3	0830-1325		
	M3 (O_2, CO_2)	M3-IN-3	0830-1315	M3-0-3	0830-1325		
	Bottom Ash					ASH-BOTTOM-3	0915-1330
	Economizer/Generator Ash					ASH-ECON/GEN-3	0845-1330
	Spray Dryer Ash					ASH-SPRAYDR-3	0849-1334
	ESP Ash-All Fields					ASH-ESPALL-3	0847-1332
	ESP Ash-Fields 2,3					ASH-ESP 2,3-3	0846-1331
	ESP Ash-Field 3					ASH-ESP 3-3	0845-1330
	Lime Slurry					LIME-3	1100
	MM5 (CDD/CDF)	MM5-IN-4	1430-1954	MM5-0-4	1430-1957		
	M3 (O_2, CO_2)	M3-IN-4	1430-1954	M3-0-4	1430-1957		
	Bottom Ash					ASH-BOTTOM-4	1515-2000
	Economizer/Generator Ash					ASH-ECON/GEN-4	1445-2000
	Spray Dryer Ash					ASH-SPRAYDR-4	1449-2004
	ESP Ash-All Fields					ASH-ESPALL-4	1447-2002
	ESP Ash-Fields 2,3					ASH-ESP 2,3-4	1446-2001
	ESP Ash-Field 3					ASH-ESP 3-4	1445-2000
	Lime Slurry					LIME-4	1830

(continued)

TABLE 3.1. (continued)

Date	Sample Type	Spray Dryer Inlet		ESP Outlet*		Various Ash/Lime Locations**	
		Run No.	Time 24 hr Clock	Run No.	Time 24 hr Clock	Sample No.	Time 24 hr Clock
2/10/88	MM5 (CDD/CDF)	MM5-IN-5	0845-1343	MM5-0-5	0845-1349		
	M3 (O_2, CO_2)	M3-IN-5	0845-1343	M3-0-5	0845-1349		
	Bottom Ash					ASH-BOTTOM-5	0920-1355
	Economizer/Generator Ash					ASH-ECON/GEN-5	0855-1355
	Spray Dryer Ash					ASH-SPRAYDR-5	0859-1359
	ESP Ash-All Fields					ASH-ESPALL-5	0857-1357
	ESP Ash-Fields 2,3					ASH-ESP 2,3-5	0856-1356
	ESP Ash-Field 3					ASH-ESP 3-5	0855-1355
	Lime Slurry					LIME-5	1200

*Sample collection and analysis for compliance purposes funded under an industrial contract to Entropy; data not presented in this report.

**See sample type column for location sampled.

CDD/CDF samples were collected at the inlet to the spray dryer using a modified Method 5 (MM5) train fitted with a condensor and an XAD-2 sorbent module following the filter following the ASME/EPA/DOE protocol for CDD/CDF sampling (see Appendix C). Samples were recovered in seven components. They were analyzed for CDD/CDF in separate front half samples (prior to and including the filter) and back half samples (back half of the filter holder up to and including the impingers) using high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). Multipoint, integrated Method 3 sampling was conducted simultaneously with the CDD/CDF sampling. The volumetric flow rate and moisture of the flue gas was measured using the MM5 train. Complete descriptions of the inlet sampling location and the sampling and analytical procedures are presented in Section 4.0 and Appendix C.

3.1.1 Flue Gas Conditions and Isokinetic Sampling Rate

A summary of the flue gas conditions at the spray dryer inlet during the five test runs is presented in Table 3.2. The volumetric flow rates were consistent from run to run and averaged 310,000 actual cubic meters per hour (11,000,000 actual cubic feet per hour). The flue gas temperature averaged 224°C (435°F), with an average moisture content of 12.4 percent. The oxygen and carbon dioxide concentrations averaged 10.2 percent and 9.5 percent, respectively. The volumetric flow rate at standard conditions averaged 158,000 dry standard cubic meters per hour (5,590,000 dry standard cubic feet per hour). Standard conditions are 20°C (68°F) and 760 mm Hg (29.92 in. Hg). The isokinetic sampling rates were well within the allowable range for all five runs.

3.1.2 CDD/CDF Emissions

A summary of CDD/CDF emission concentrations and 2,3,7,8-TCDD toxic equivalent concentrations measured at the spray dryer inlet sampling location are presented in Table 3.3. This table includes concentrations and 2,3,7,8-TCDD toxic equivalencies for individual isomers and isomer groups as well as for total CDD, total CDF, and total CDD/CDF. All concentrations have been corrected to 12% CO_2 using the CO_2 value for the appropriate run. The factors used to generate the 2,3,7,8-toxic equivalent concentrations are the factors routinely used in EPA studies.*

*"Interim procedures for estimating risks associated with exposure to mixtures of chlorinated dioxins and dibenzofurans other than 2,3,7,8-TCDD," by J. Bellin and D. Barnes, U. S. EPA, Washington, DC, November 21, 1985.

TABLE 3.2. SUMMARY OF FLUE GAS CONDITIONS AT SPRAY DRYER INLET

Run No.	Date (1988)	Volumetric Flow Rate				Stack Temp		Moisture %	O_2 %	CO_2 %	Isokinetic %
		Actual[a]		Standard[b]							
		acmh x 10^3	acfh x 10^3	dscmh x 10^3	dscfh x 10^3	°C	°F				
2-MM5-IN-1	2/8	326	11,500	166	5,850	226	440	12.4	10.3	9.4	108.1
2-MM5-IN-2	2/8	325	11,500	165	5,810	228	442	12.3	10.7	9.2	105.6
2-MM5-IN-3	2/9	298	10,500	151	5,340	221	430	13.4	10.0	9.9	104.9
2-MM5-IN-4	2/9	309	10,900	160	5,650	224	435	11.3	10.2	9.7	102.6
2-MM5-IN-5	2/10	294	10,400	150	5,310	221	429	12.6	10.0	9.3	103.3
Average		310	11,000	158	5,590	224	435	12.4	10.2	9.5	

[a]Volumetric flow rate in actual cubic meters per hour (acmh) and actual cubic feet per hour (acfh) at stack conditions.
[b]Volumetric flow rate in dry standard cubic meters per hour (dscmh) and dry standard cubic feet per hour (dscfh); standard conditions are 68°F and 29.92 inches Hg.

TABLE 3.3. CDD/CDF EMISSION RESULTS AND 2,3,7,8-TCDD TOXIC EQUIVALENTS FOR SPRAY DRYER INLET AT WHEELABRATOR MILLBURY

Isomer	Concentration (ng/dscm corrected to 12% CO_2)						2378-TCDD Toxic Equiv Factor	2378-TCDD Toxic Equivalents (ng/dscm, corrected to 12% CO_2)					
	Run 1	Run 2	Run 3	Run 4	Run 5	Ave		Run 1	Run 2	Run 3	Run 4	Run 5	Ave
Dioxins													
TOTAL MCDD	ND*	ND	ND	ND	ND	0.000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL DCDD	0.905	0.936	2.03	1.81	1.85	1.51	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL TriCDD	3.00	2.55	3.76	7.35	7.35	4.80	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
2378-TCDD	0.480	0.405	0.283	0.311	0.315	0.359	1.0000	0.480	0.405	0.283	0.311	0.315	0.359
OTHER TCDD	5.86	5.55	3.80	4.10	4.94	4.85	0.0100	0.059	0.056	0.038	0.041	0.049	0.049
12378-PCDD	0.857	0.721	0.380	0.444	0.573	0.595	0.5000	0.429	0.361	0.190	0.222	0.287	0.298
OTHER PCDD	6.01	5.40	3.75	3.90	4.01	4.61	0.0050	0.030	0.027	0.019	0.020	0.020	0.023
123478-HxCDD	0.781	0.640	0.420	0.529	0.672	0.608	0.0400	0.031	0.026	0.017	0.021	0.027	0.024
123678-HxCDD	1.24	1.05	0.637	0.809	0.797	0.907	0.0400	0.050	0.042	0.025	0.032	0.032	0.036
123789-HxCDD	2.55	2.08	1.07	1.67	2.02	1.88	0.0400	0.102	0.083	0.043	0.067	0.081	0.075
OTHER HxCDD	9.77	6.34	7.12	8.64	7.38	7.85	0.0004	0.004	0.003	0.003	0.003	0.003	0.003
1234678-HpCDD	5.77	5.45	3.61	5.18	3.82	4.77	0.0010	0.006	0.005	0.004	0.005	0.004	0.005
OTHER HpCDD	4.99	5.51	3.75	5.01	3.52	4.56	0.00001	0.000	0.000	0.000	0.000	0.000	0.000
OCDD	13.5	14.4	7.80	21.6	9.30	13.3	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL CDD	55.7	51.0	38.4	61.4	46.5	50.6		1.19	1.01	0.622	0.722	0.818	0.872
Furans													
TOTAL MCDF	ND	0.13	1.18	0.483	0.710	0.501	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL DCDF	19.9	7.85	46.2	21.9	24.2	24.0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL TriCDF	45.4	60.7	82.3	123	107	83.6	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
2378-TCDF	2.95	2.73	1.78	1.92	1.87	2.25	0.1000	0.295	0.273	0.178	0.192	0.187	0.225
OTHER TCDF	64.4	61.8	39.8	42.0	45.3	50.7	0.0010	0.064	0.062	0.040	0.042	0.045	0.051
12378-PCDF	2.47	2.56	2.12	1.56	1.68	2.08	0.1000	0.247	0.256	0.212	0.156	0.168	0.208
23478-PCDF	3.08	2.52	1.80	1.81	1.77	2.20	0.1000	0.308	0.252	0.180	0.181	0.177	0.220
OTHER PCDF	32.603	27.3	23.0	20.2	20.1	24.6	0.0010	0.033	0.027	0.023	0.020	0.020	0.025
123478-HxCDF	6.56	5.92	4.09	4.93	5.29	5.36	0.0100	0.066	0.059	0.041	0.049	0.053	0.054
123678-HxCDF	3.78	3.54	2.06	2.21	2.45	2.81	0.0100	0.038	0.035	0.021	0.022	0.025	0.028
234678-HxCDF	3.45	3.11	1.86	2.34	2.42	2.64	0.0100	0.034	0.031	0.019	0.023	0.024	0.026
123789-HxCDF	0.290	0.252	ND	0.114	0.006	0.132	0.0100	0.003	0.003	0.000	0.001	0.000	0.001
OTHER HxCDF	18.1	20.3	11.9	13.2	14.9	15.7	0.0001	0.002	0.002	0.001	0.001	0.001	0.001
1234678-HpCDF	7.80	7.49	4.65	5.14	4.88	5.99	0.0001	0.001	0.001	0.000	0.001	0.000	0.001
1234789-HpCDF	0.654	0.880	0.316	0.383	0.362	0.519	0.0001	0.000	0.000	0.000	0.000	0.000	0.000
OTHER HpCDF	3.76	3.96	2.25	2.25	2.13	2.87	0.00001	0.000	0.000	0.000	0.000	0.000	0.000
OCDF	3.05	3.88	1.30	1.76	1.62	2.32	0.0000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL CDF	218	215	226	245	237	228		1.09	1.00	0.715	0.688	0.700	0.839
TOTAL CDD/CDF	274	266	264	306	284	279		2.28	2.01	1.34	1.41	1.52	1.71

*ND - isomer not detected or did not meet all qualitative identification criteria. Detection limits and estimated maximum possible concentrations for separate back half and front half samples are found in Table 3.5.

As is evident from Table 3.3, the total CDD/CDF emissions (and individual isomer concentrations) were quite consistent from run to run. Corrected to 12% CO_2, the total CDD concentration averaged 50.6 ng/dscm (standard deviation 8.8), the total CDF concentration averaged 228 ng/dscm (standard deviation 12.6), and the total CDD/CDF concentration averaged 279 ng/dscm (standard deviation 17.3). The total CDD/CDF concentration in terms of 2,3,7,8-TCDD toxic equivalents, which account for the toxicity of each isomer or isomer group, averaged 1.71 ng/dscm, corrected to 12% CO_2.

3.2 PROCESS SAMPLE CDD/CDF CONCENTRATIONS

Tables 3.4A and 3.4B present the CDD/CDF concentrations and 2,3,7,8-TCDD toxic equivalent concentrations, respectively, in the process samples collected during this test program. Samples were taken of the bottom ash, economizer/generator ash, spray dryer ash, and the ESP ash from all fields, fields 2 and 3, and field 3. Samples were also taken of the lime slurry feed to the spray dryer. Values reported for all ash samples are the CDD/CDF concentrations in a composite of samples collected during the five test runs. Values reported for the lime slurry are the CDD/CDF concentrations in the sample from Run No. 1.

As shown in Table 3.4A, the concentration of CDD/CDF in the ash increases significantly from the beginning to the end of the MWC system. The increase is approximately three orders of magnitude, from a total CDD/CDF concentration in the bottom ash of 0.04 nanograms per gram (ng/g) to a total CDD/CDF concentration in the ash from the third and final field of the ESP of 85 ng/g. The same trend was observed in the 2,3,7,8-TCDD toxic equivalents for these samples (Table 3.4B). The lime slurry sample showed small concentrations of several isomers, but these were not significant in terms of 2,3,7,8-TCDD toxic equivalents.

3.3 ANALYSIS OF CDD/CDF IN EMISSION AND PROCESS SAMPLES

Table 3.5 presents the results, in nanograms of analyte per sample, for the CDD/CDF analysis on the spray dryer inlet flue gas emission samples collected at Millbury. As previously stated, the emissions collected by each train were analyzed separately in a front half sample (sample recovered from portion of the train prior to and including the filter) and a back half sample (sample recovered from the back half of the filter holder up to and including the impingers). Separate front half/back half analyses were performed for two

TABLE 3.4A. CDD/CDF RESULTS FOR PROCESS SAMPLES

Isomers	Concentration (ng/g)						
	Bottom Ash	Econ/ Gen Ash	Spray Dryer Ash	ESP Ash All Fields	ESP Ash Fields 2,3	ESP Ash Field 3	Lime Slurry
Dioxins							
TOTAL MCDD	ND(0.001)*	ND(0.001)	ND(0.003)	ND(0.001)	ND(0.003)	ND(0.008)	ND(0.033)
TOTAL DCDD	ND(0.001)	ND[0.016]	ND(0.005)	0.066	ND(0.005)	ND[0.245]	ND(0.062)
TOTAL TriCDD	ND(0.003)	ND[0.009]	ND(0.010)	0.134	0.111	0.387	ND(0.118)
2378-TCDD	ND[0.001]	0.005	0.010	0.030	0.040	0.090	ND[0.010]
OTHER TCDD	ND[0.001]	0.026	0.010	0.270	0.388	1.15	0.017
12378-PCDD	ND(0.001)	0.006	ND(0.008)	0.040	0.063	0.125	ND(0.110)
OTHER PCDD	ND(0.001)	0.004	0.012	0.259	0.280	1.41	ND(0.110)
123478-HxCDD	ND(0.001)	ND(0.003)	ND(0.013)	0.041	0.060	0.176	ND(0.098)
123678-HxCDD	ND(0.001)	ND(0.003)	ND(0.010)	0.065	0.108	0.419	ND(0.090)
123789-HxCDD	ND(0.001)	ND[0.006]	0.026	0.127	0.192	0.589	ND(0.110)
OTHER HxCDD	ND[0.035]	0.019	0.042	0.298	0.501	3.63	ND[0.347]
1234678-HpCDD	0.003	0.044	0.049	0.370	0.533	2.19	0.049
OTHER HpCDD	ND	0.034	0.065	0.344	0.550	2.21	0.039
OCDD	0.016	0.115	0.094	0.941	1.08	4.44	0.249
TOTAL CDD	0.019	0.253	0.308	2.99	3.91	16.8	0.354
Furans							
TOTAL MCDF	ND(0.001)	ND[0.015]	ND(0.003)	0.036	ND(0.003)	0.237	ND(0.022)
TOTAL DCDF	ND(0.001)	ND[0.095]	ND(0.008)	1.49	ND(0.008)	5.79	ND(0.095)
TOTAL TriCDF	0.009	0.605	0.124	3.15	3.28	15.3	0.027
2378-TCDF	0.0004	0.030	0.030	0.150	0.250	0.620	0.003
OTHER TCDF	0.004	0.722	0.478	3.86	6.26	19.9	ND[0.213]
12378-PCDF	ND(0.001)	ND[0.022]	0.031	0.164	0.275	0.710	ND(0.073)
23478-PCDF	ND[0.001]	0.025	0.032	0.205	0.326	0.826	ND(0.075)
OTHER PCDF	0.003	0.234	0.312	2.10	3.16	9.42	ND[0.380]
123478-HxCDF	ND(0.001)	0.042	0.089	0.428	0.642	2.12	ND(0.055)
123678-HxCDF	ND(0.001)	0.019	ND[0.045]	0.228	0.352	1.18	ND(0.048)
234678-HxCDF	ND(0.001)	0.021	ND[0.029]	0.225	0.335	1.25	ND(0.065)
123789-HxCDF	ND(0.001)	ND(0.003)	ND(0.010)	ND[0.014]	ND[0.024]	ND[0.081]	ND(0.083)
OTHER HxCDF	ND(0.001)	0.085	0.155	1.13	1.88	5.58	0.027
1234678-HpCDF	0.004	0.061	0.108	0.581	0.870	3.00	0.049
1234789-HpCDF	ND(0.001)	0.007	ND(0.013)	ND[0.045]	0.065	0.253	ND(0.065)
OTHER HpCDF	ND	0.037	0.016	0.179	0.352	0.953	0.007
OCDF	ND[0.005]	0.048	ND(0.030)	0.174	0.214	0.788	0.041
TOTAL CDF	0.020	1.94	1.38	14.1	18.3	68.0	0.154
TOTAL CDD/CDF	0.039	2.19	1.69	17.1	22.2	84.8	0.508

*ND - not detected. Detection limits are shown in parentheses ( ); estimated maximum possible concentrations for analytes found above the detection limit, but not meeting all the qualitative identification criteria, are shown in brackets [ ].

TABLE 3.4B. 2,3,7,8-TCDD TOXIC EQUIVALENTS FOR PROCESS SAMPLES

Isomers	2378-TCDD Toxic Equiv Factor	2378-TCDD Toxic Equivalents (ng/g)						
		Bottom Ash	Econ/ Gen Ash	Spray Dryer Ash	ESP Ash All Fields	ESP Ash Fields 2,3	ESP Ash Field 3	Lime Slurry
Dioxins								
TOTAL MCDD	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL DCDD	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL TriCDD	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2378-TCDD	1.0000	0.000	0.005	0.010	0.030	0.040	0.090	0.000
OTHER TCDD	0.0100	0.000	0.000	0.000	0.003	0.004	0.012	0.000
12378-PCDD	0.5000	0.000	0.003	0.000	0.020	0.032	0.063	0.000
OTHER PCDD	0.0050	0.000	0.000	0.000	0.001	0.001	0.007	0.000
123478-HxCDD	0.0400	0.000	0.000	0.000	0.002	0.002	0.007	0.000
123678-HxCDD	0.0400	0.000	0.000	0.000	0.003	0.004	0.017	0.000
123789-HxCDD	0.0400	0.000	0.000	0.001	0.005	0.008	0.024	0.000
OTHER HxCDD	0.0004	0.000	0.000	0.000	0.000	0.000	0.001	0.000
1234678-HpCDD	0.0010	0.000	0.000	0.000	0.000	0.001	0.002	0.000
OTHER HpCDD	0.00001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OCDD	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL CDD		0.000	0.008	0.011	0.064	0.092	0.223	0.000
Furans								
TOTAL MCDF	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL DCDF	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL TriCDF	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2378-TCDF	0.1000	0.000	0.003	0.003	0.015	0.025	0.062	0.000
OTHER TCDF	0.0010	0.000	0.001	0.000	0.004	0.006	0.020	0.000
12378-PCDF	0.1000	0.000	0.000	0.003	0.016	0.028	0.071	0.000
23478-PCDF	0.1000	0.000	0.003	0.003	0.021	0.033	0.083	0.000
OTHER PCDF	0.0010	0.000	0.000	0.000	0.002	0.003	0.009	0.000
123478-HxCDF	0.0100	0.000	0.000	0.001	0.004	0.006	0.021	0.000
123678-HxCDF	0.0100	0.000	0.000	0.000	0.002	0.004	0.012	0.000
234678-HxCDF	0.0100	0.000	0.000	0.000	0.002	0.003	0.013	0.000
123789-HxCDF	0.0100	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OTHER HxCDF	0.0001	0.000	0.000	0.000	0.000	0.000	0.001	0.000
1234678-HpCDF	0.0001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1234789-HpCDF	0.0001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OTHER HpCDF	0.00001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OCDF	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL CDF		0.000	0.007	0.010	0.067	0.108	0.292	0.000
TOTAL CDD/CDF		0.000	0.015	0.021	0.131	0.200	0.515	0.000

TABLE 3.5. FRONT HALF/BACK HALF CDD/CDF RESULTS FOR INLET EMISSION SAMPLES

Isomer	Results in Total ng per Sample*'**									
	Run 1		Run 2		Run 3		Run 4		Run 5	
	FH	BH	FH	BH	FH	BH	FH	BH	FH	BH
Dioxins										
TOTAL MCDD	ND (0.005)	ND (0.008)	ND (0.008)	ND (0.005)	ND (0.018)	ND (0.040)	ND (0.013)	ND [0.226]	ND (0.008)	ND (0.003)
TOTAL DCDD	1.508	ND (0.018)	1.481	ND (0.010)	3.158	ND (0.080)	2.238	0.606	2.336	0.313
TOTAL TriCDD	5.002	ND (0.045)	4.034	ND (0.028)	5.838	ND (0.215)	9.646	1.938	9.605	0.905
2378-TCDD	0.800	ND [0.020]	0.640	ND [0.020]	0.440	ND (0.010)	0.430	0.060	0.450	ND [0.030]
OTHER TCDD	9.765	ND [0.029]	8.777	ND [0.057]	5.907	ND (0.065)	5.547	0.919	6.709	0.359
12378-PCDD	1.429	ND (0.018)	1.141	ND (0.013)	0.590	ND (0.068)	0.622	0.077	0.800	0.020
OTHER PCDD	10.020	ND [0.033]	8.540	ND (0.013)	5.824	ND (0.068)	5.550	0.595	5.595	0.136
123478-HxCDD	1.302	ND (0.025)	1.013	ND (0.015)	0.653	ND (0.100)	0.765	0.069	0.948	0.014
123678-HxCDD	2.071	ND (0.025)	1.654	ND (0.015)	0.990	ND (0.100)	1.174	0.101	1.120	0.020
123789-HxCDD	4.251	ND (0.030)	3.291	ND (0.018)	1.665	ND (0.118)	2.441	0.191	2.855	0.039
OTHER HxCDD	16.293	ND [0.537]	10.027	ND [0.456]	11.062	ND [0.588]	12.967	0.640	10.402	0.159
TOTAL HpCDD	17.836	0.101	17.286	0.050	11.435	ND (0.075)	14.907	1.145	10.247	0.253
OCDD	21.610	0.899	21.374	1.364	10.911	1.200	32.454	1.636	12.728	0.578
TOTAL CDD	91.9	1.00	79.3	1.41	58.5	1.20	88.7	8.00	63.8	2.80
Furans										
TOTAL MCDF	ND [0.346]	ND (0.008)	0.197	ND (0.005)	1.826	ND (0.037)	0.628	0.133	0.539	0.477
TOTAL DCDF	33.207	ND (0.022)	12.417	ND (0.015)	71.747	ND (0.015)	27.125	7.362	32.369	2.319
TOTAL TriCDF	73.761	1.929	95.004	1.056	127.883	ND (0.018)	150.490	43.533	137.351	16.391
2378-TCDF	4.780	0.130	4.220	0.100	2.750	0.020	2.510	0.520	2.500	0.170
OTHER TCDF	105.753	1.618	96.963	0.770	61.890	ND (0.048)	53.544	12.646	60.228	4.529
12378-PCDF	4.045	0.070	4.014	0.032	3.294	ND (0.043)	2.098	0.358	2.306	0.101
23478-PCDF	5.057	0.078	3.991	ND [0.025]	2.793	ND (0.048)	2.445	0.409	2.424	0.103
OTHER PCDF	53.540	0.811	42.942	0.198	35.800	ND (0.045)	26.440	5.435	27.381	1.310
123478-HxCDF	10.930	ND [0.197]	9.361	ND (0.010)	6.350	ND (0.058)	6.714	1.054	7.302	0.271
123678-HxCDF	6.333	ND (0.015)	5.603	ND (0.008)	3.201	ND (0.055)	3.051	0.435	3.393	0.118
234678-HxCDF	5.751	ND (0.018)	4.912	ND (0.010)	2.885	ND (0.073)	3.272	0.419	3.369	0.099
123789-HxCDF	0.484	ND (0.025)	0.399	ND (0.015)	ND (0.073)	ND (0.095)	0.180	ND (0.018)	ND [0.225]	0.009
OTHER HxCDF	29.817	0.283	32.168	ND (0.010)	18.480	ND (0.068)	18.218	2.634	20.519	0.797
TOTAL HpCDF	20.049	0.323	19.428	0.082	11.068	0.139	10.860	1.385	10.047	0.502
OCDF	4.695	0.392	6.130	ND [0.102]	2.017	ND [0.242]	2.434	0.342	2.000	0.320
TOTAL CDF	358	5.63	338	2.24	352	0.159	310	76.7	312	27.5
TOTAL CDD/CDF	450	6.63	417	3.65	411	1.36	399	84.7	376	30.3

*ND - not detected. Detection limits are shown in parentheses ( ); estimated maximum possible concentrations for analytes found above the detection limit, but not meeting all the qualitative identification criteria, are shown in brackets [ ].

**FH - front half; BH - back half.

reasons: (1) to be consistent with the compliance test protocol for the CDD/CDF sampling to be performed at the outlet which called for separate front half/back half analysis, and (2) to assess differences in recovery of the internal standards potentially caused by the different matrices of the fractions (see Chapter 5.0). The analytical results for the spray dryer inlet emission samples indicate that the total CDD/CDF catch found in the back half sample ranged from 1 to 17 percent.

As shown in Tables 3.4A and 3.5, ND or "not detected" is designated for a number of CDD/CDF isomers. ND listed as a sample result indicates one of two conditions. Under the first condition, the sample yielded an analyte response that was less than 2.5 times the background noise level. In these cases, ND was listed and the detection limit was reported in parentheses. Under the second condition, the GC/MS signals for an analyte eluted within the specified retention time windows for those analytes with a signal-to-noise ratio in excess of 2.5 to 1, but they did not meet all of the established qualitative identification criteria (see Table 5.2). In these cases, ND was listed with an "estimated maximum possible concentration" (EMPC) for the analyte in brackets. For the purposes of calculating sample catches and emission concentrations, all NDs were treated as zeros.

In addition to the analysis for CDD/CDF, all the composited ash samples were analyzed for carbon content and ash content. These results are presented in Table 3.6. The lime slurry samples from each run were analyzed for solids content and specific gravity. These results are presented in Table 3.7.

3.4 CDD/CDF HOMOLOGUE DISTRIBUTIONS

The CDD/CDF homologue distributions are presented in Figures 3-1a through 3-1c for the flue gas emission samples and in Figures 3-2a and 3-2b for the process samples. The homologue distributions in the emission samples for both CDD and CDF were very consistent in the front halves and in the total sample from run to run. Because such small quantities of any of the homologues were found in the back halves, the data are less consistent. For the CDD homologues, the hexa-, hepta-, and octa-CDD comprised about 60 mole percent of the samples. For the CDF homologues, the mono- through the penta- CDF were the most prevalent species.

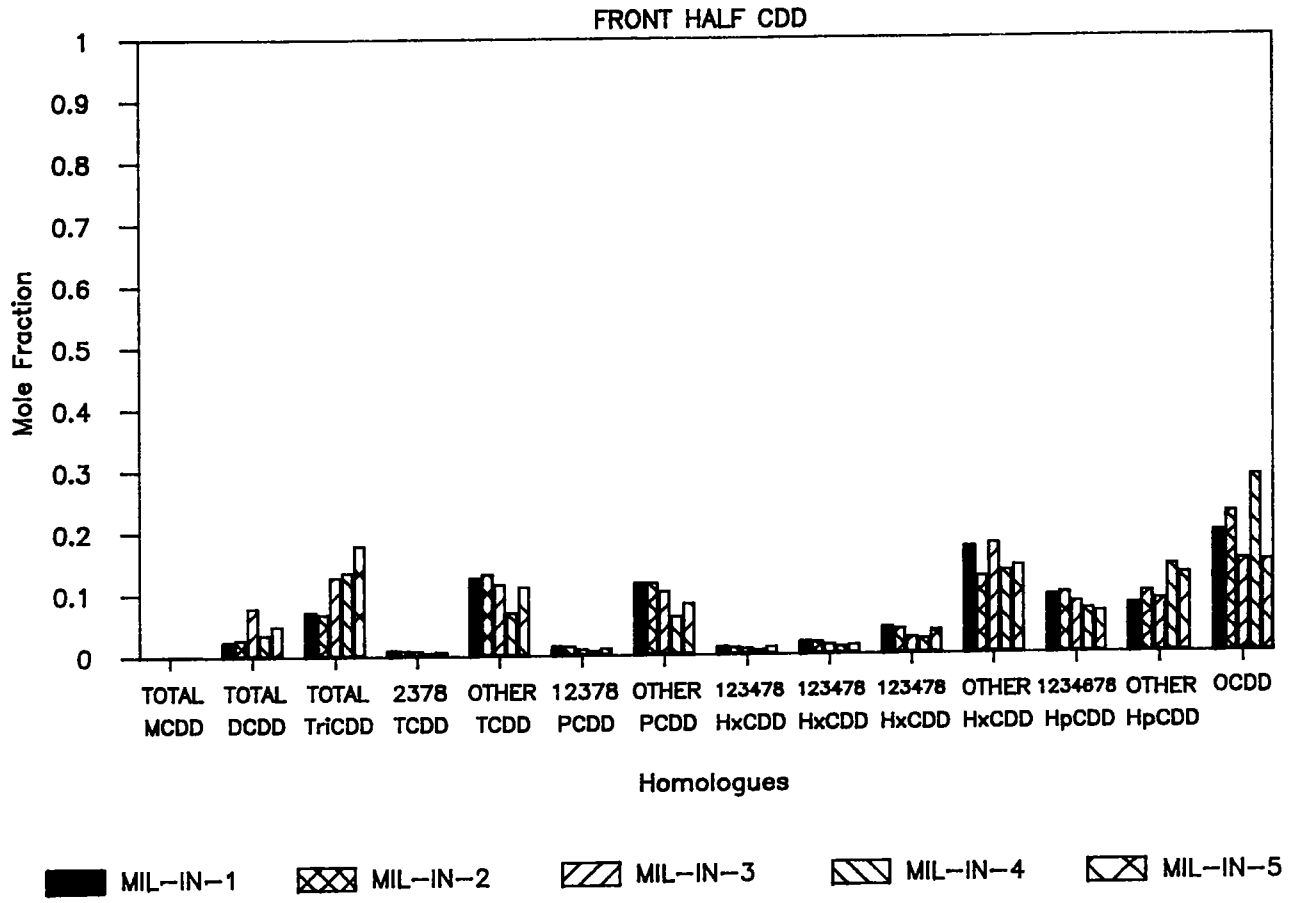
TABLE 3.6. ANALYTICAL RESULTS FOR CARBON AND ASH CONTENT OF ASH SAMPLES

Sample	Carbon Content (%)	Ash Content (%)
Bottom Ash	2.81	81.62
Economizer/Generating Bank Ash	3.99	90.01
Spray Dryer Ash	2.46	90.27
ESP Ash - All Fields	1.08	87.12
ESP Ash - Fields 2 & 3	2.40	88.15
ESP Ash - Field 3	1.83	91.46

TABLE 3.7. ANALYTICAL RESULTS FOR SPECIFIC GRAVITY AND SOLIDS CONTENT OF LIME SLURRY SAMPLES

Sample	Specific Gravity* (Unitless)	Solids Content* (%)
Lime Slurry - Run 1	1.032	8.06
Lime Slurry - Run 2	1.027	6.40
Lime Slurry - Run 3	1.029	9.74
Lime Slurry - Run 4	1.035	8.76
Lime Slurry - Run 5	1.027	5.96

*Average of three measurements.



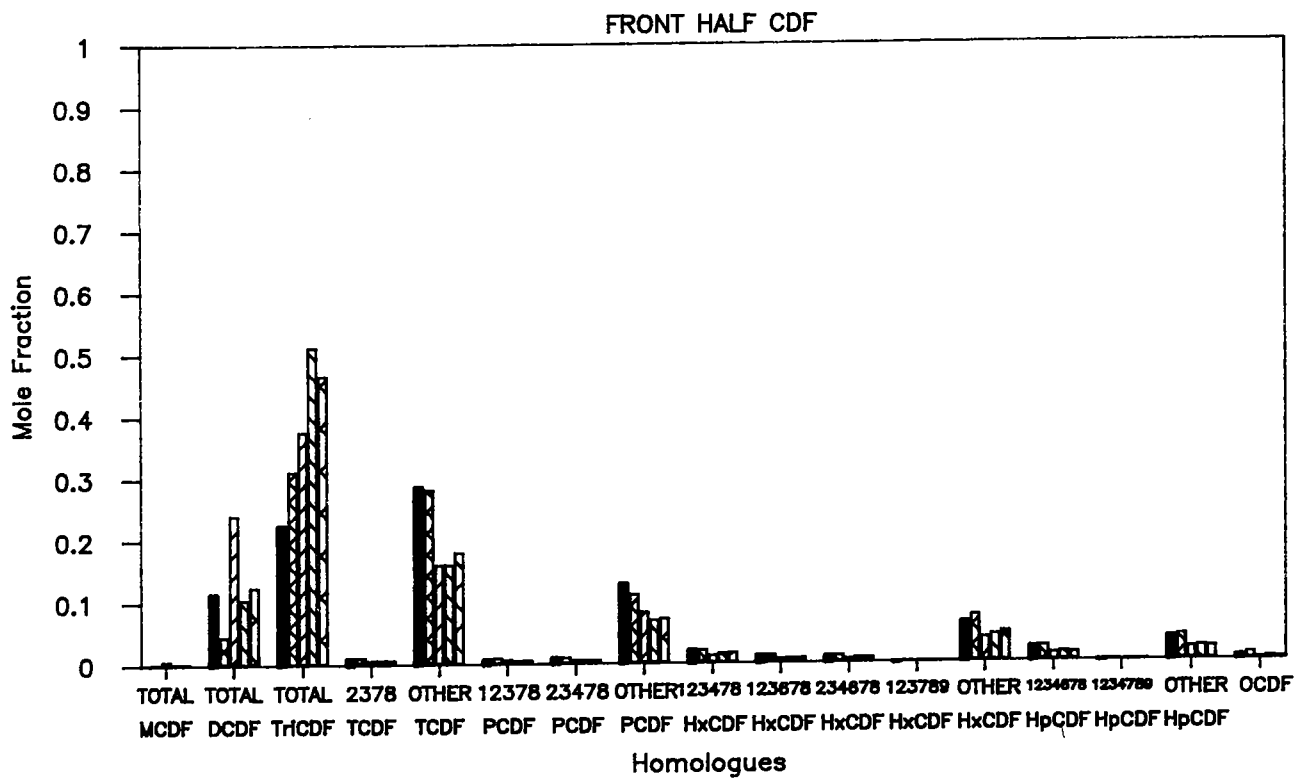


Figure 3-1a. CDD and CDF homologue distributions for front half flue gas emission samples.

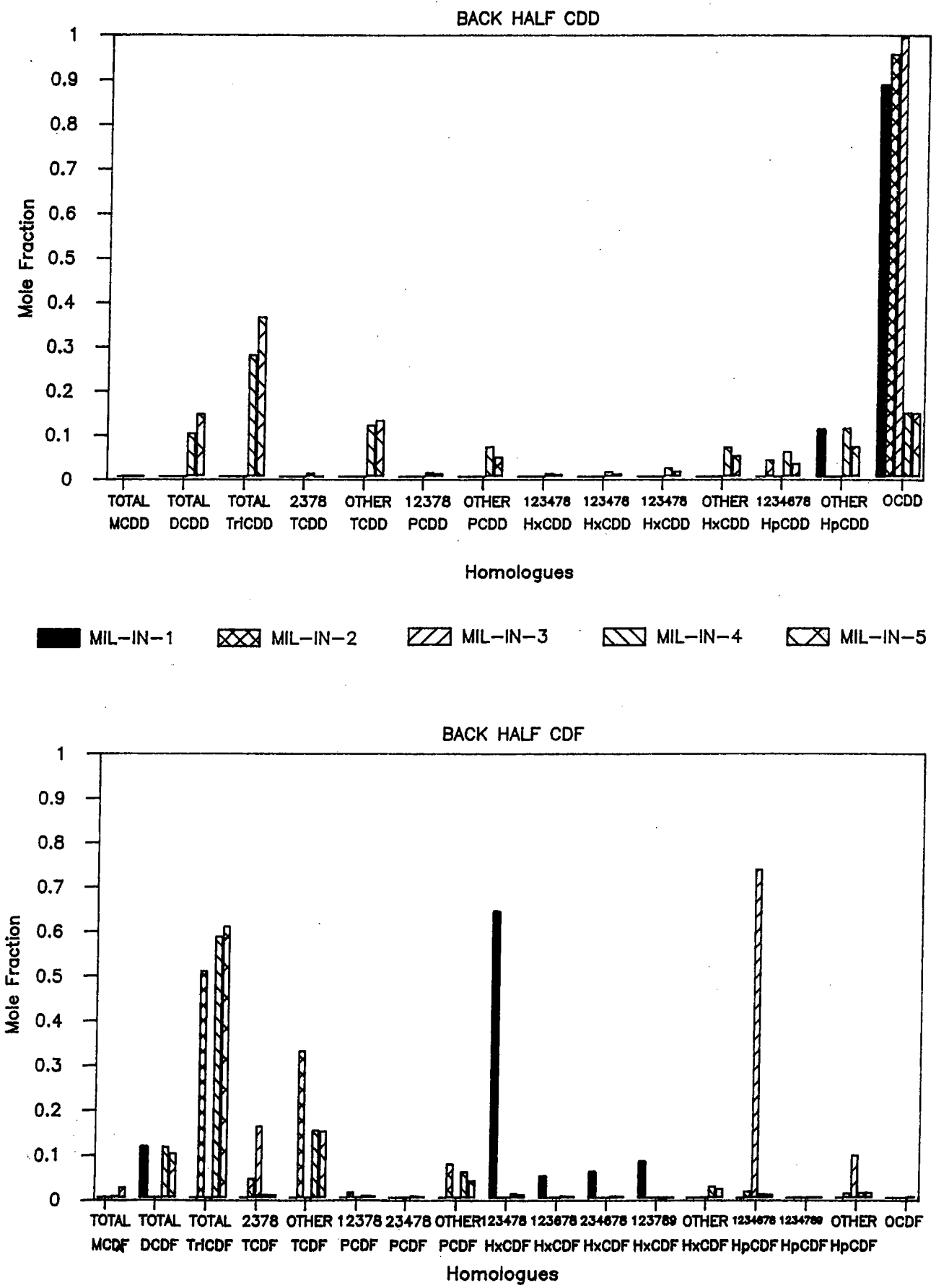


Figure 3-1b. CDD and CDF homologue distributions for back half flue gas emission samples.

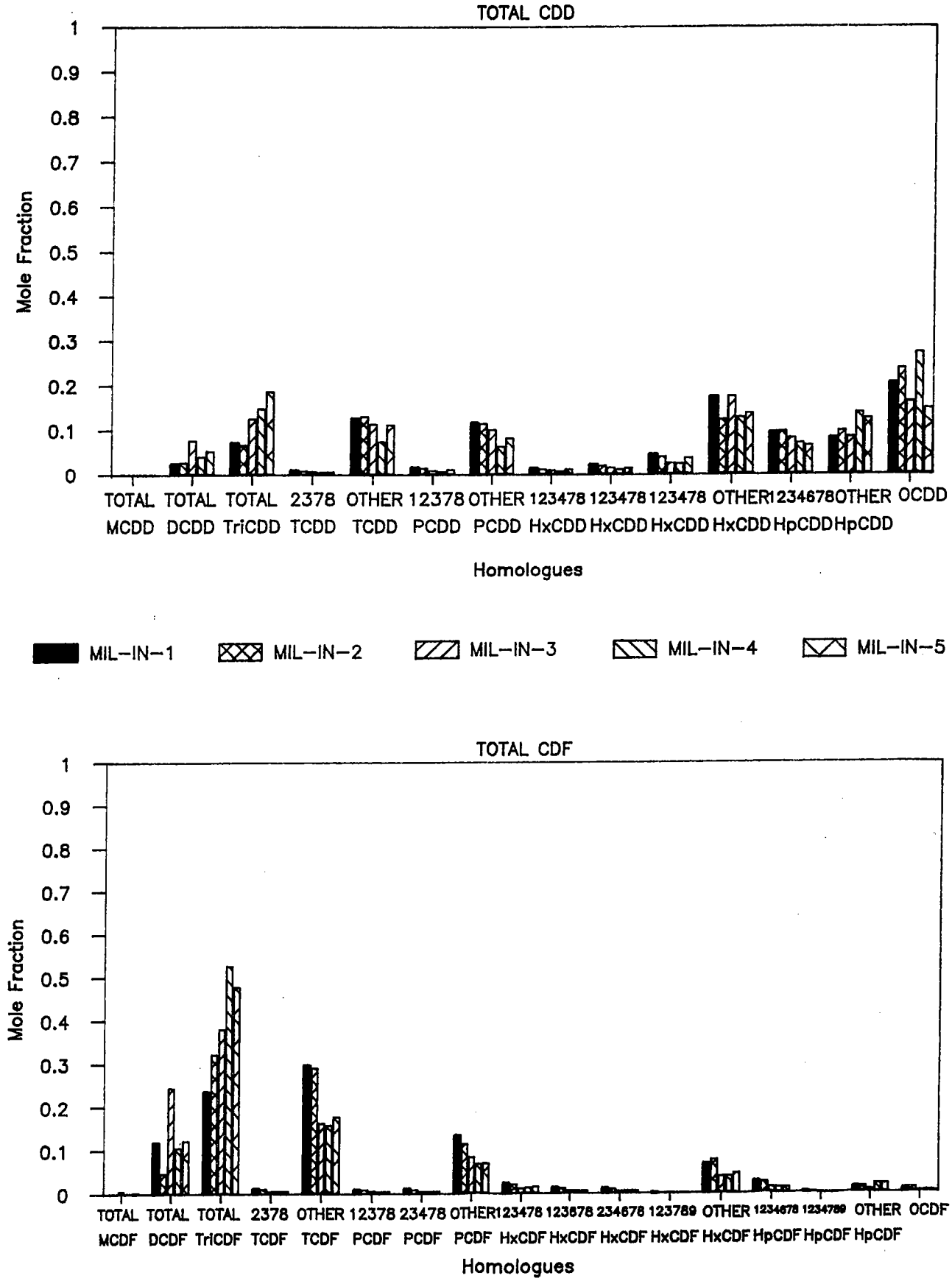
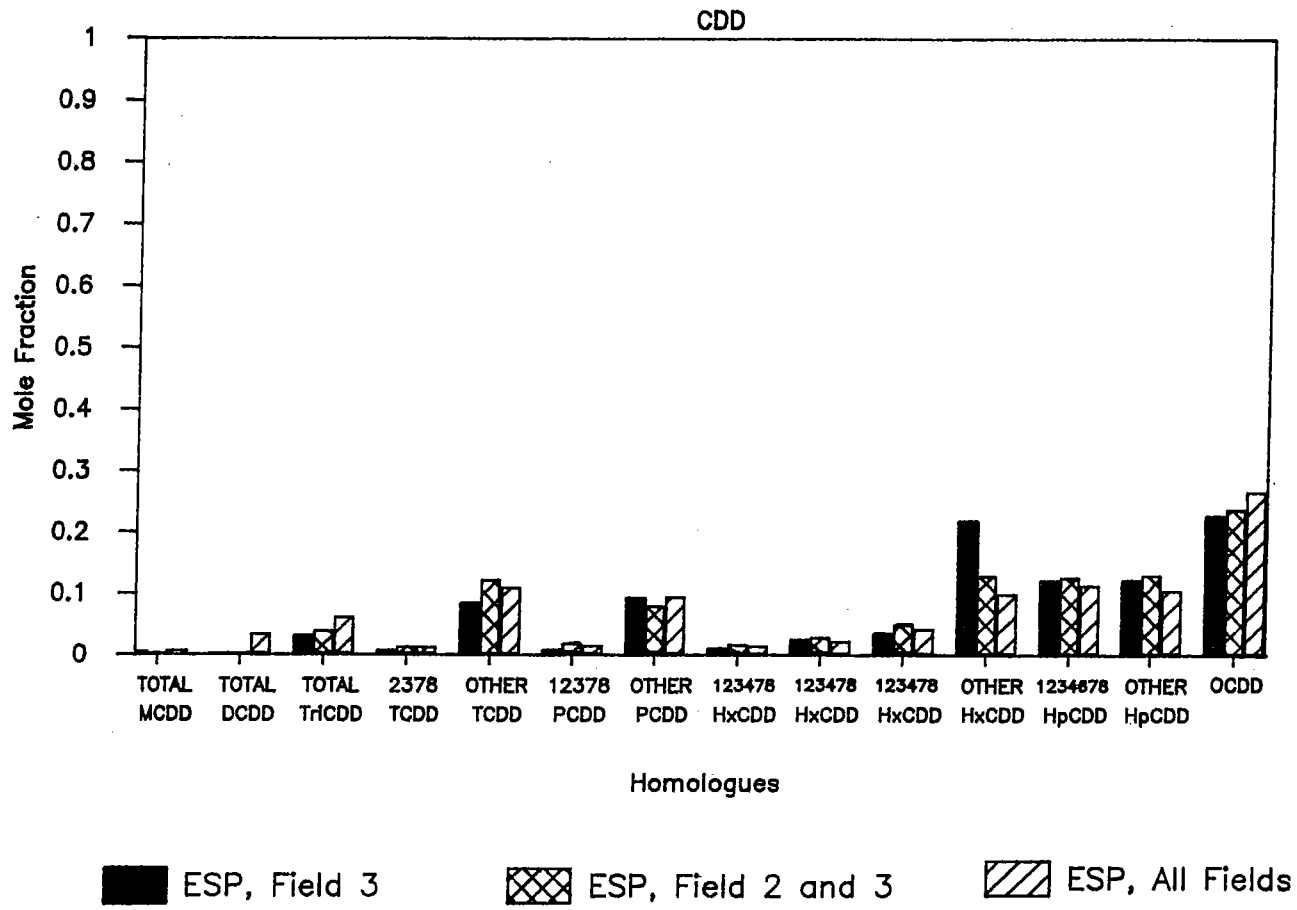


Figure 3-1c. CDD and CDF homologue distribution in combined front and back half flue gas emission samples.



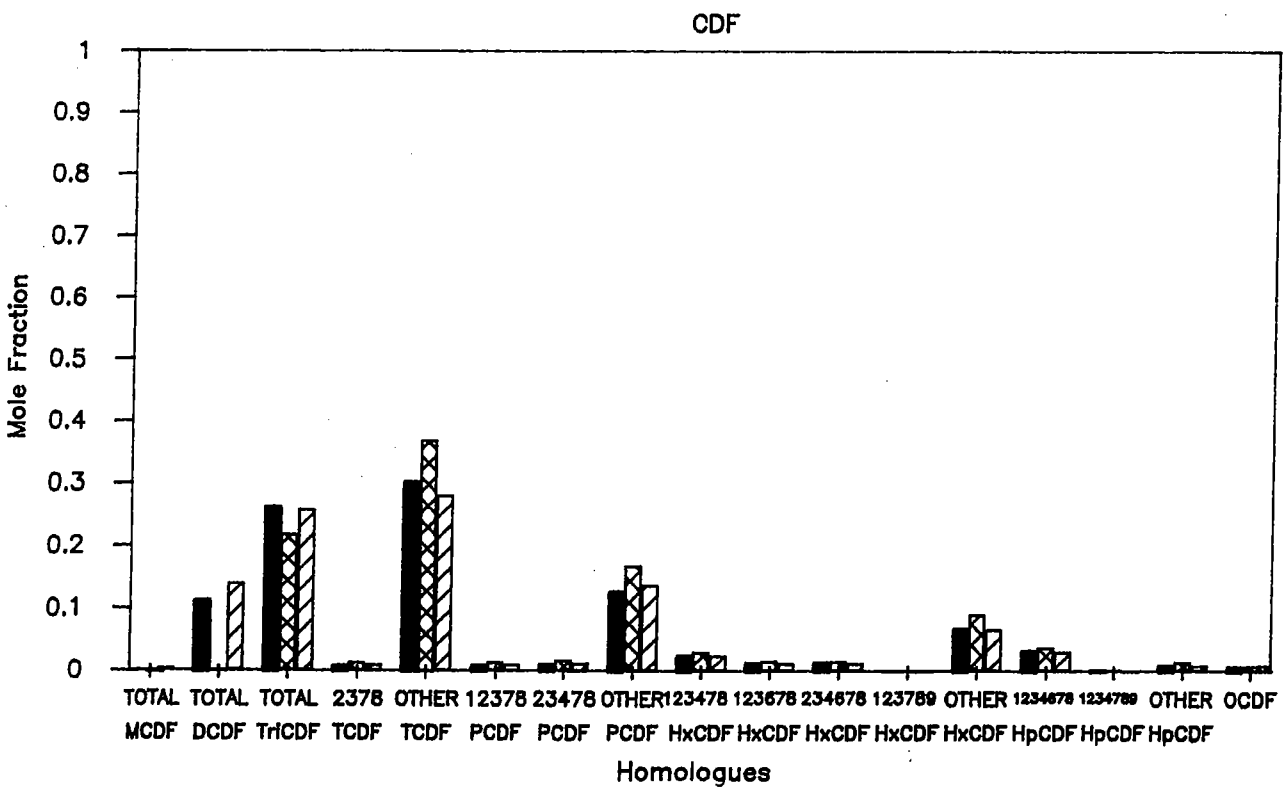
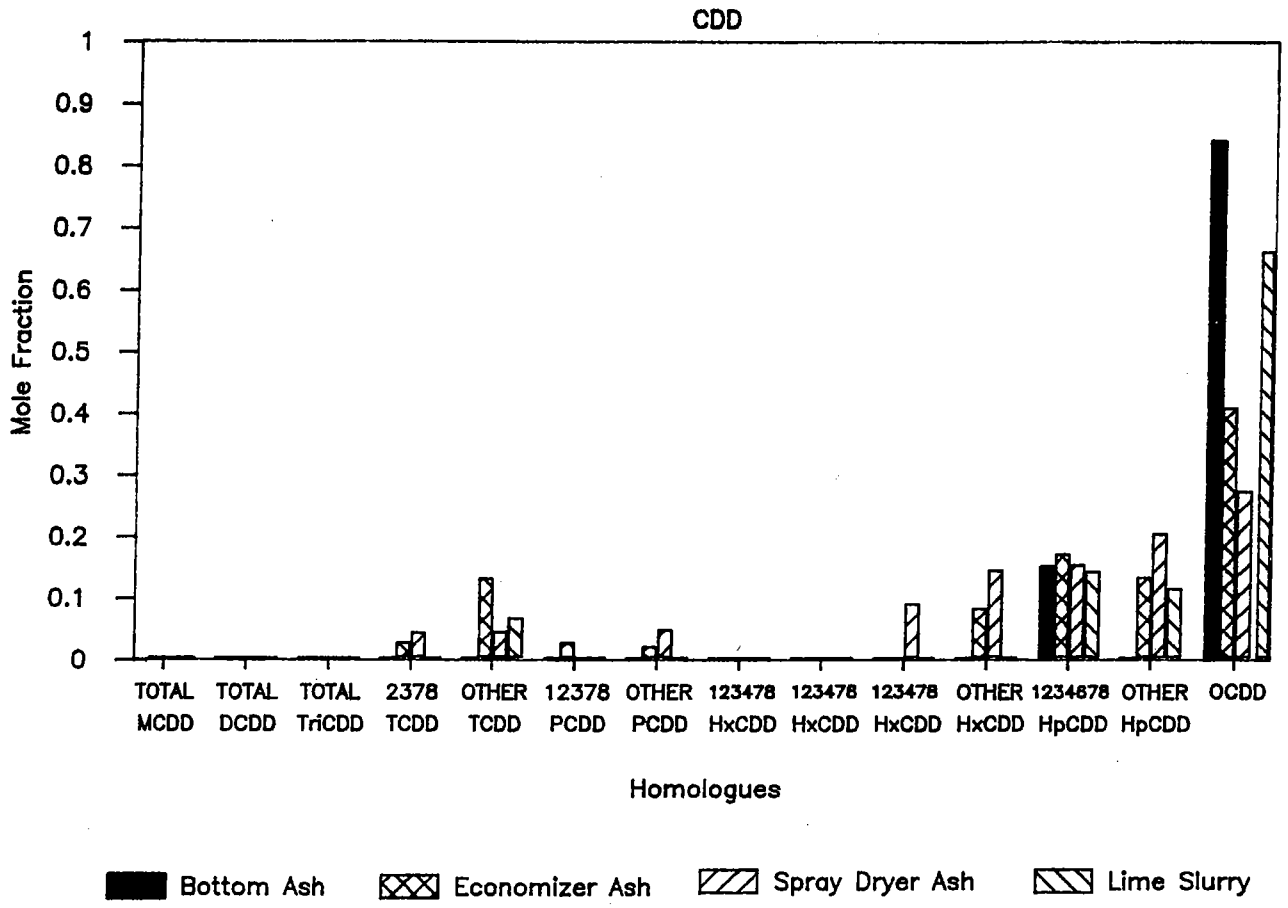


Figure 3-2a. CDD and CDF homologue distributions for ESP ash samples.



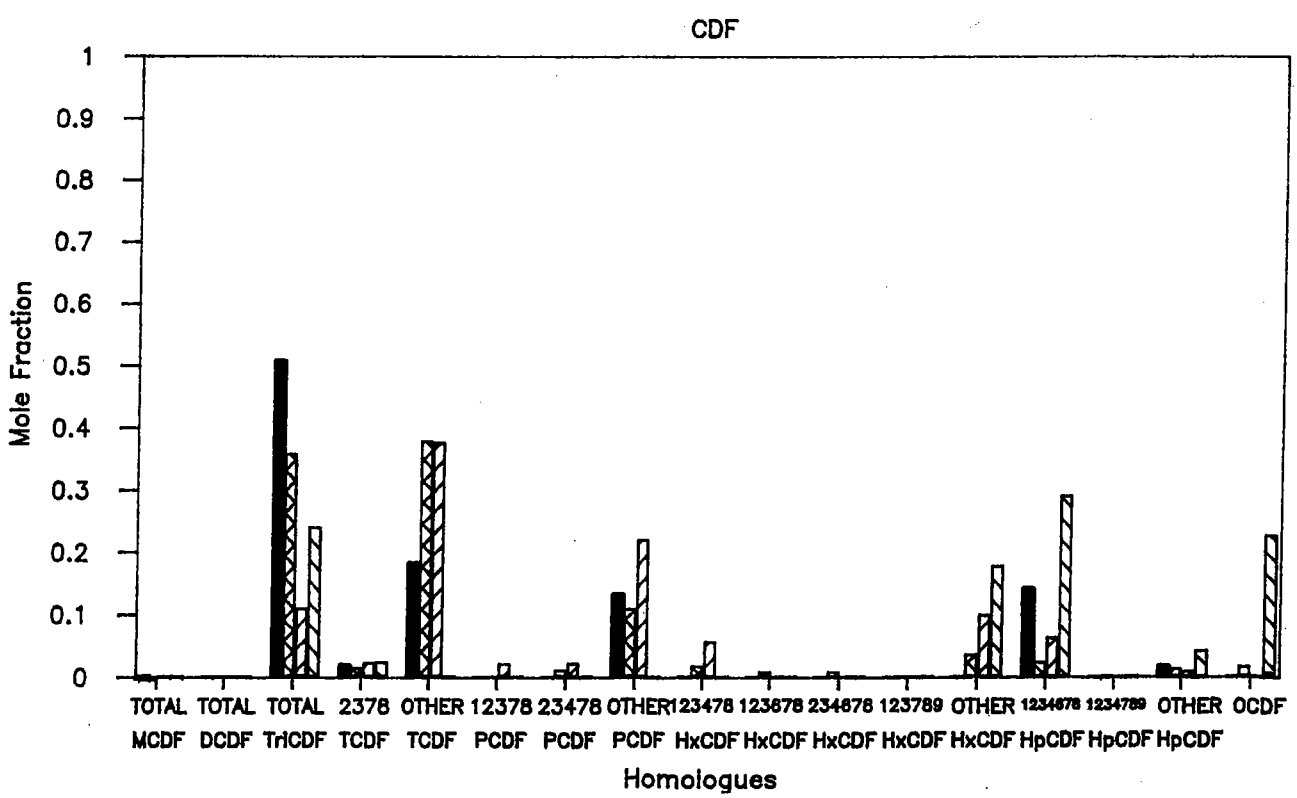


Figure 3-2b. CDD and CDF homologue distributions for bottom ash, economizer/ generator ash, spray dryer ash, and lime slurry samples.

Except for the bottom ash and lime slurry samples, the homologue distributions in the process samples were also very consistent. The bottom ash and the lime slurry, both of which had low total CDD/CDF concentrations, showed a very high proportion of octa-CDD. Like the flue gas emission samples, the process samples contained proportionally more of (1) the more chlorinated CDD homologues and (2) the less chlorinated CDF homologues.

4.0 SAMPLING LOCATIONS AND SAMPLING AND ANALYTICAL PROCEDURES

This section describes the sampling locations and the sampling and analytical procedures used to characterize the emissions from Unit 2 at Wheelabrator Millbury. A schematic of one of the two identical MWC units and the relative sampling locations are shown in Figure 4.1. Emissions at the inlet to the spray dryer were sampled for CDD/CDF emissions, exhaust gas velocity, and molecular weight. In addition, samples of ash were taken at a number of locations in the ash handling system and samples of lime slurry were taken from the spray dryer penthouse during each test run. The test matrix for the EPA-sponsored test program is presented in Table 4.1. The subsections that follow further describe each sampling location and the applicable sampling and analytical procedures.

4.1 SPRAY DRYER INLET

EPA Method 3 and CDD/CDF sampling were performed at the spray dryer inlet. The round vertical duct at the spray dryer inlet is 8 feet, 9 inches in diameter. The two installed emission sampling ports are 90° apart, 4 inches in diameter, and have 12-inch flanges. There was a clearance problem associated wtih sampling through one of these ports, so the plant installed a third 4-inch port 85° from one of the existing ports to alleviate this problem. All the ports are located approximately 35 feet downstream (4 duct diameters) and approximately 19 feet upstream (2.17 duct diameters) from the nearest flow distrubances. A schematic of the sampling location is shown in Figure 4.2.

For the CDD/CDF and Method 3 sampling, a total of 24 points, per Method 1, were sampled in the duct. For the CDD/CDF sampling, each point was sampled for 10 minutes for a total run time of 240 minutes (4 hours); this sampling time was based on the time established for the outlet sampling runs, which were performed concurrently. Gas meter, velocity head, orifice meter, vacuum, and temperature readings were taken at 10-minute intervals.

4.2 BOTTOM ASH SAMPLING LOCATION

The bottom ash was sampled following quenching with water as it extruded from the boiler onto a vibrating conveyor. There is a stairway next to the extrusion area which made it possible to sample the bottom ash using a long-handled scoop as it fell onto the conveyor. A diagram of the sampling location is shown in Figure 4.3.

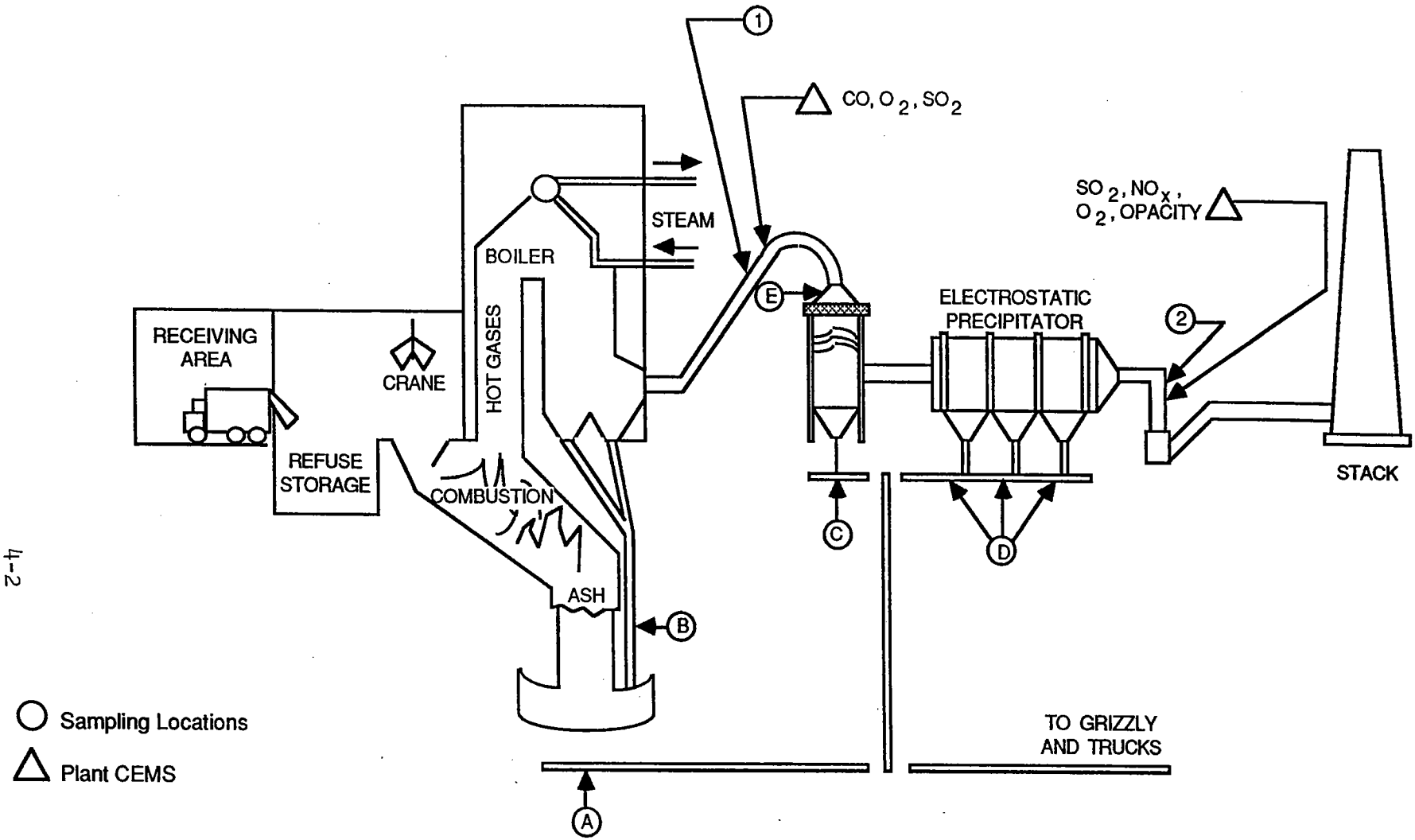
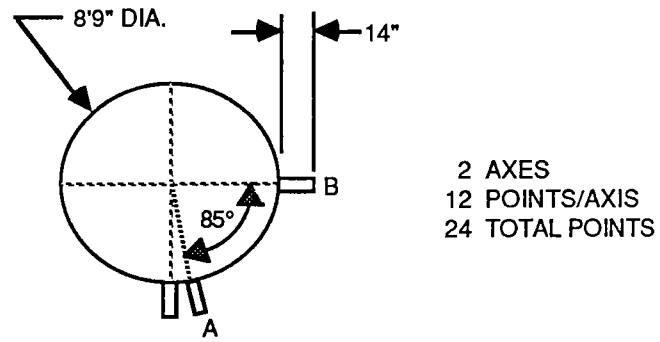


Figure 4.1. Process schematic showing sampling locations for MWC Unit 2 at Wheelabrator Millbury; locations are keyed to Table 4.1.

TABLE 4.1. TEST MATRIX FOR WHEELABRATOR MILLBURY

Location[a]	Sample Type	Sampling Method	Analysis Parameter	Analysis Method
1-Spray dryer inlet	Combustion gas	MM5 (5 runs)[b,c]	CDD/CDF	HRGC/HRMS
		M3	O_2, CO_2	Orsat
		CEMS[d]	O_2 CO SO_2	Electrocatalytic cell NDIR NDUV
2-ESP outlet	Combustion gas	CEMS[d]	O_2 SO_2 NO_x	Electrocatalytic cell NDUV Chemiluminescence
A-Bottom ash discharge	Bottom ash	Integrated grab[e]	Percent combustibles Percent carbon CDD/CDF	ASTM E830 ASTM E777 HRGC/HRMS
B-Economizer and generating bank discharge	Economizer and generating bank ash	Integrated grab[e]	Percent combustibles Percent carbon CDD/CDF	ASTM E830 ASTM E777 HRGC/HRMS
C-Spray dryer discharge	Spray dryer ash	Integrated grab[e]	Percent combustibles Percent carbon CDD/CDF	ASTM E830 ASTM E777 HRGC/HRMS
D-ESP discharge (three locations)	Fly ash	Integrated grab[e]	Percent combustibles Percent carbon CDD/CDF	ASTM E830 ASTM E777 HRGC/HRMS
E-Spray dryer penthouse	Lime slurry	Grab[f]	CDD/CDF Percent solids Specific gravity	HRGC/HRMS

[a]Numbers and letters refer to Figure 4.1.
[b]Five simultaneous MM5 runs were conducted by Wheelabrator on ESP outlet; Wheelabrator also conducted one additional MM5 run at the outlet for a total of six runs.
[c]Separate analyses of front and back half samples.
[d]Plant monitors; data compiled by Radian Corporation.
[e]Five-run composite made from half of sample from each run; this was analyzed for CDD/CDF, % C, and % combustibles. Remaining half samples were archived.
[f]One grab sample per run; portions of all these samples were analyzed for percent solids and specific gravity; one of the five samples was analyzed for CDD/CDF; the remaining portions were archived.



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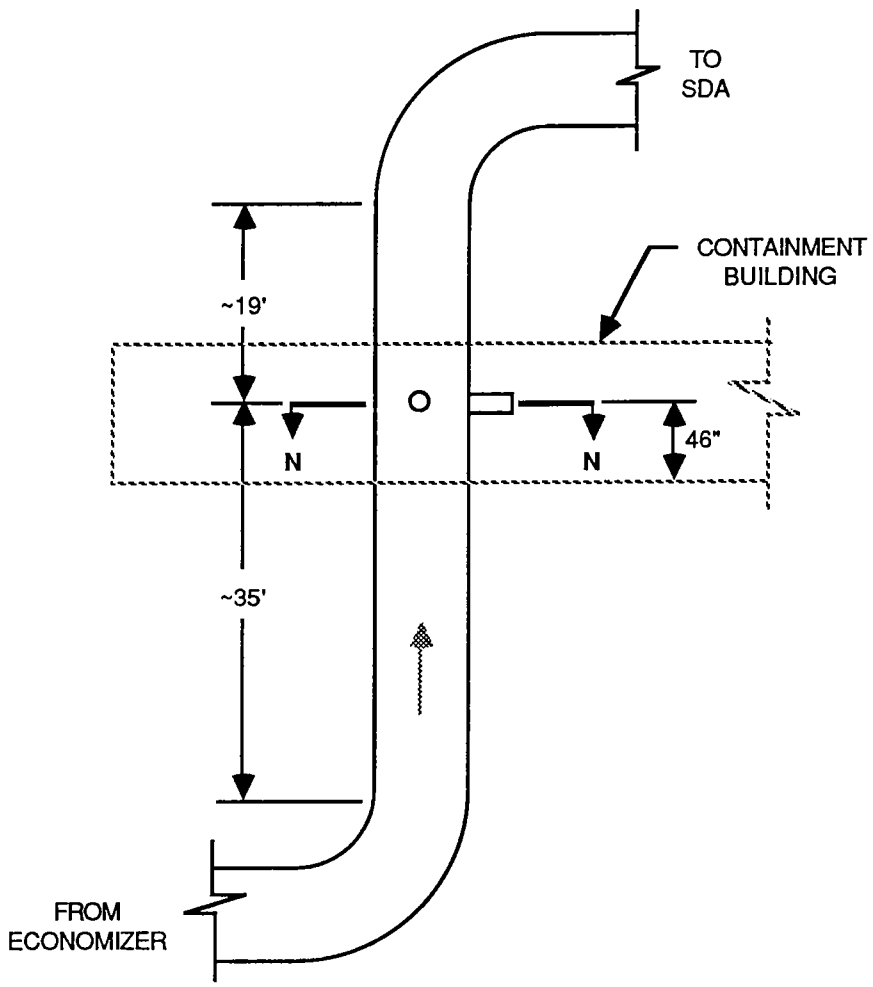

Figure 4.2. Spray dryer inlet sampling location.

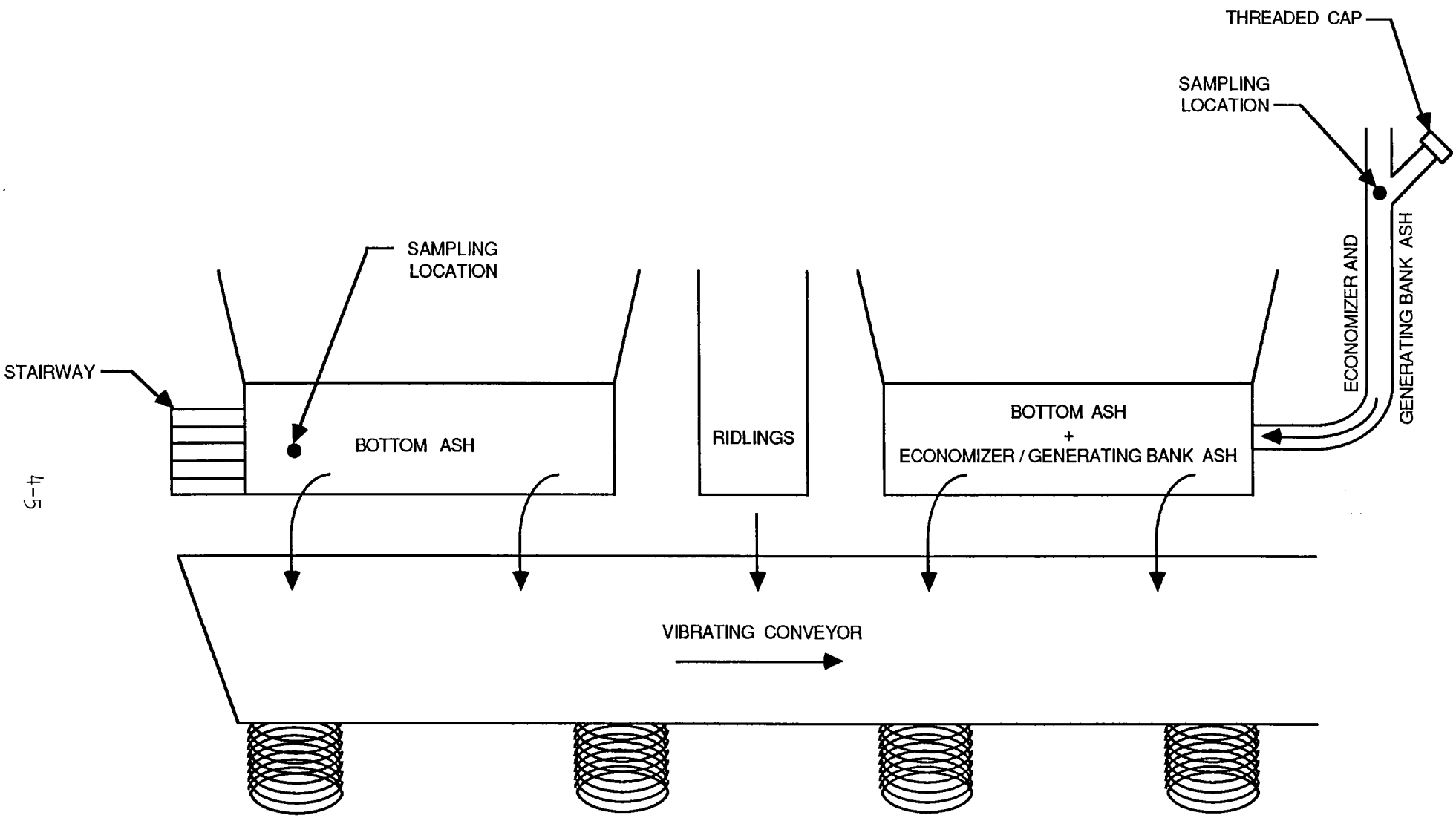

Figure 4.3. Bottom ash and economizer ash/generating bank ash sampling locations.

4.3 ECONOMIZER/GENERATING BANK ASH SAMPLING LOCATION

Ash from the economizer and the generating bank is conducted downward in a pipe and is combined with the bottom ash in the quench tank opposite the bottom ash sampling location before it is extruded onto the vibrating conveyor. This ash was sampled with a scoop through a tap in the pipe. The sampling location is shown in Figure 4.3.

4.4 SPRAY DRYER ASH SAMPLING LOCATION

The spray dryer ash was collected using a scoop from a drag conveyor that serves the spray dryer hopper alone. The conveyor was easily accessed through an existing hatch. This sampling location is diagrammed in Figure 4.4.

4.5 ESP ASH SAMPLING LOCATIONS

ESP ash was collected using a scoop at three points along the drag conveyor serving this control device. These locations represented (1) the ash from Field 3, (2) the ash from Fields 2 and 3, and (3) the ash from all three fields. All locations were easily accessed through existing hatches. A diagram of the sampling locations is shown in Figure 4.5.

4.6 LIME SLURRY SAMPLING LOCATION

The lime slurry samples were collected from the lime slurry feed line in the spray dryer absorber penthouse from an easily accessed spigot.

4.7 VELOCITY AND GAS TEMPERATURE

A Type-S pitot tube and an inclined draft gauge manometer, or two differential pressure gauges in-parallel, were used to measure the flue gas velocity pressure (delta P). Velocity pressures were measured at each sampling point across the duct to determine an average value according to the procedures in Method 2.* The temperature at each sampling point was measured using a thermocouple with a digital readout.

4.8 METHOD 3 - MOLECULAR WEIGHT

4.8.1 Sampling Operations

The O_2, CO_2, and N_2 contents and the molecular weight of the flue gas were determined using EPA Method 3.* During the CDD/CDF sampling, an integrated bag sample was extracted at the traverse points at the inlet sampling location

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*40 CFR 60, July 1, 1987.

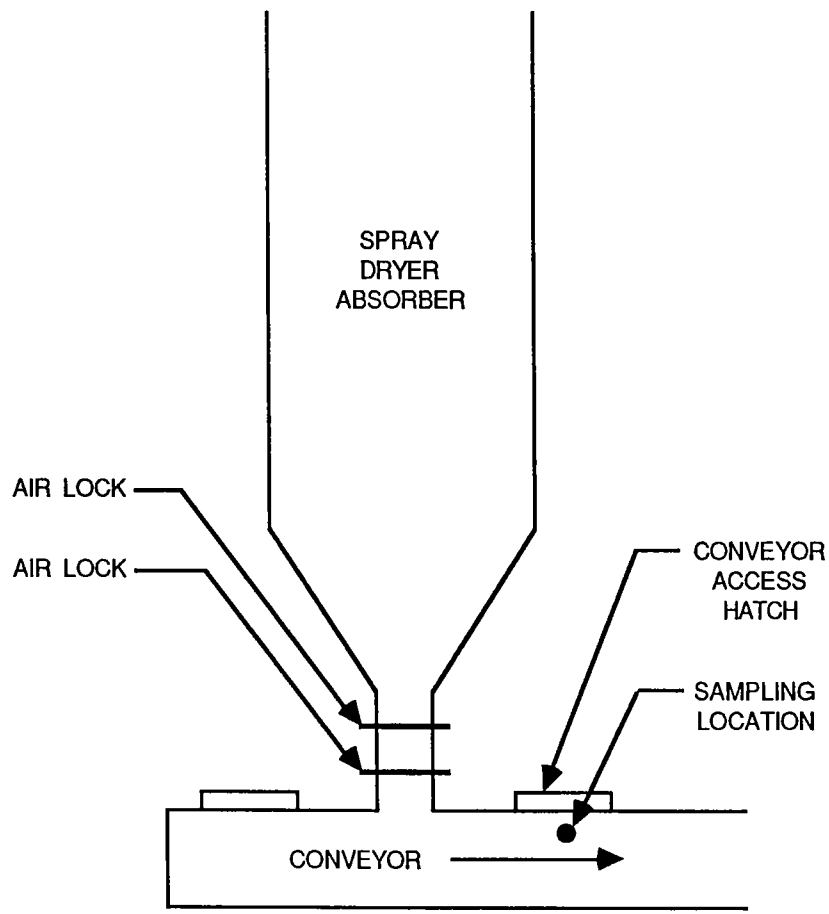

Figure 4.4. Spray dryer ash sampling location.

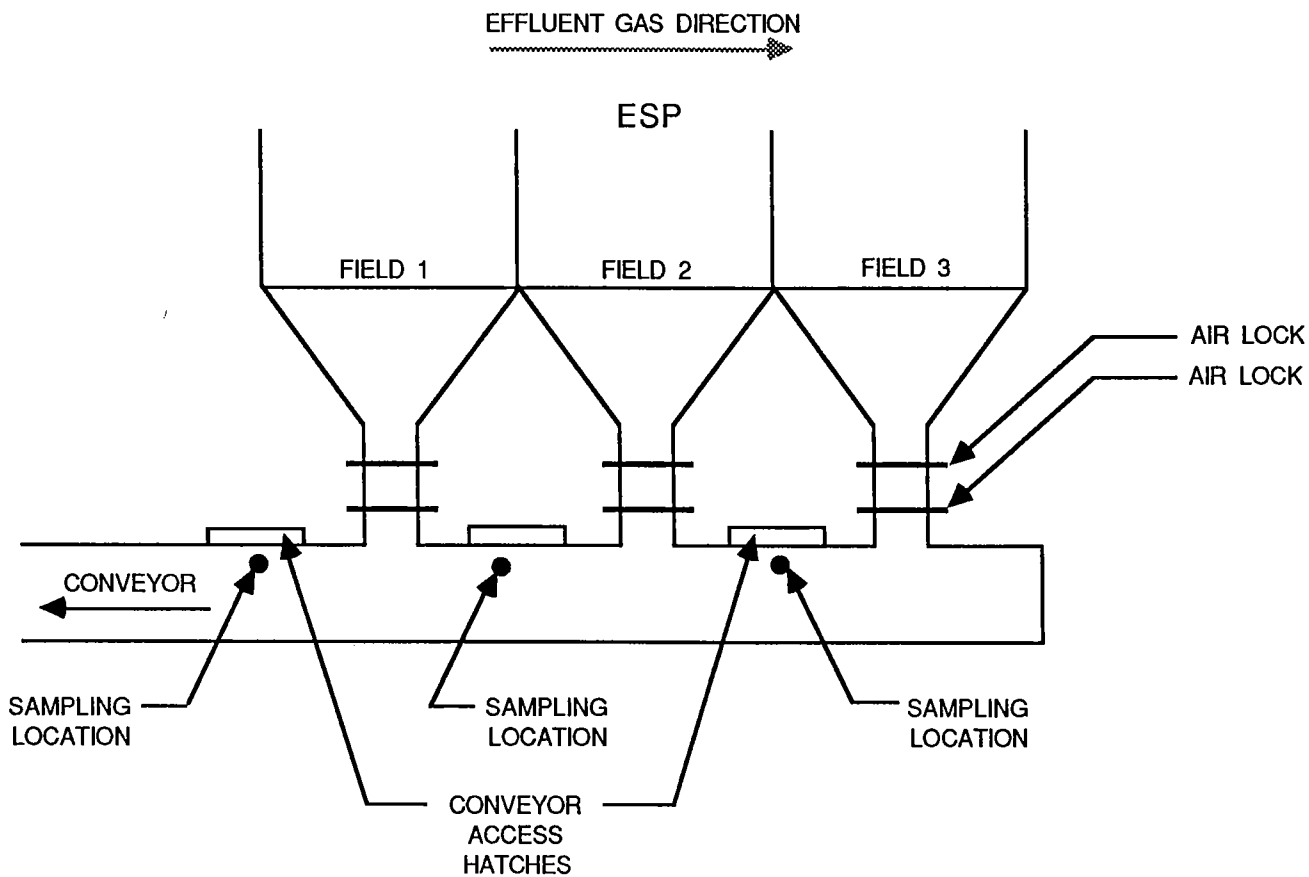

Figure 4.5. ESP ash sampling locations.

at a rate of approximately 0.5 L/min using a non-contaminating pump. The sampling train used is shown in Figure 4.6. A moisture knockout trap allowed the analysis to be performed on a dry basis. Total sample volume was approximately 4 to 5 cubic feet.

4.8.2 Analysis

The integrated bag samples were analyzed with an Orsat™ analyzer for CO_2 and O_2. Nitrogen was determined by difference. The analysis was repeated a minimum of three times on each bag until three results were within the limits specified by the method, and an average of these three results was used. The absorbing solutions used in the analyzer were potassium hydroxide (45% by volume) for carbon dioxide and pyrogallate (pyrogallol in potassium hydroxide) for oxygen.

4.9 CDD/CDF SAMPLING AND ANALYSIS

The emissions sampling and analysis for CDD/CDF was conducted according to the ASME/EPA Environmental Standards Workshop draft protocols: (1) "Sampling for the Determination of Chlorinated Organic Compounds in Stack Emissions," and (2) "Analytical Procedures to Assay Stack Effluent Samples and Residual Combustion Products for Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans" (December 1984) (see Appendix C). The protocols were modified slightly to use methylene chloride to replace hexane during all aspects of sampling equipment preparation and sample recovery. Methylene chloride was shown to recover the higher chlorinated CDD/CDF more efficiently than hexane during the EPA National Dioxin Strategy Tier 4 program.

4.9.1 Sampling Equipment and Preparation

The CDD/CDF sampling train is shown in Figure 4.7. At sampling locations with a high particulate loading, such as the spray dryer inlet, the cyclone shown in Figure 4.7 is necessary.

All glass components of the sampling train, sample containers, and glassware used for sample recovery were precleaned according to the following procedures prior to sampling:

1. Soak in hot, soapy water (Alconox®) at 50°C or higher.
2. Triple-rinse with H_2O.

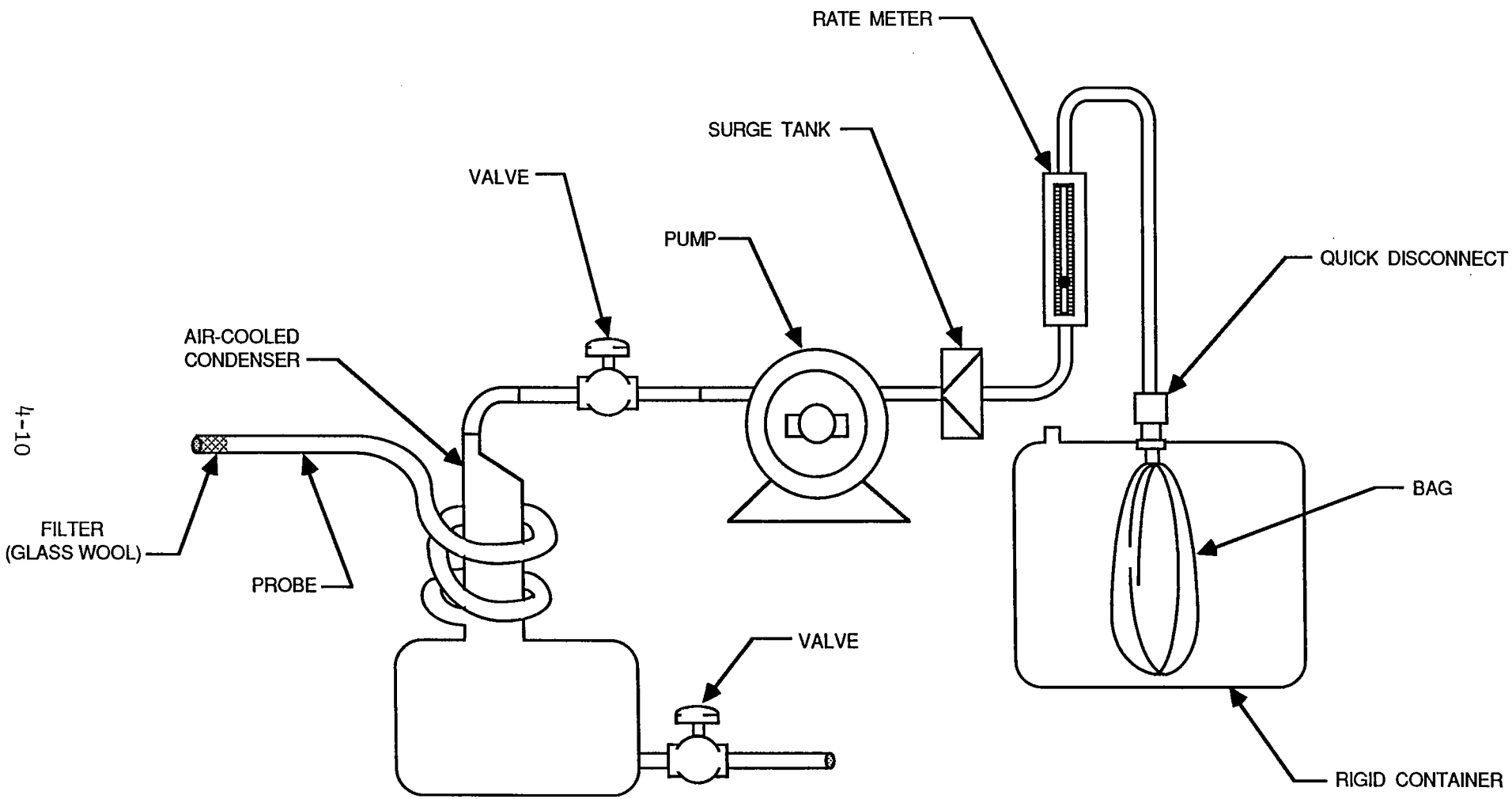

Figure 4.6. Integrated gas sampling train for Method 3.

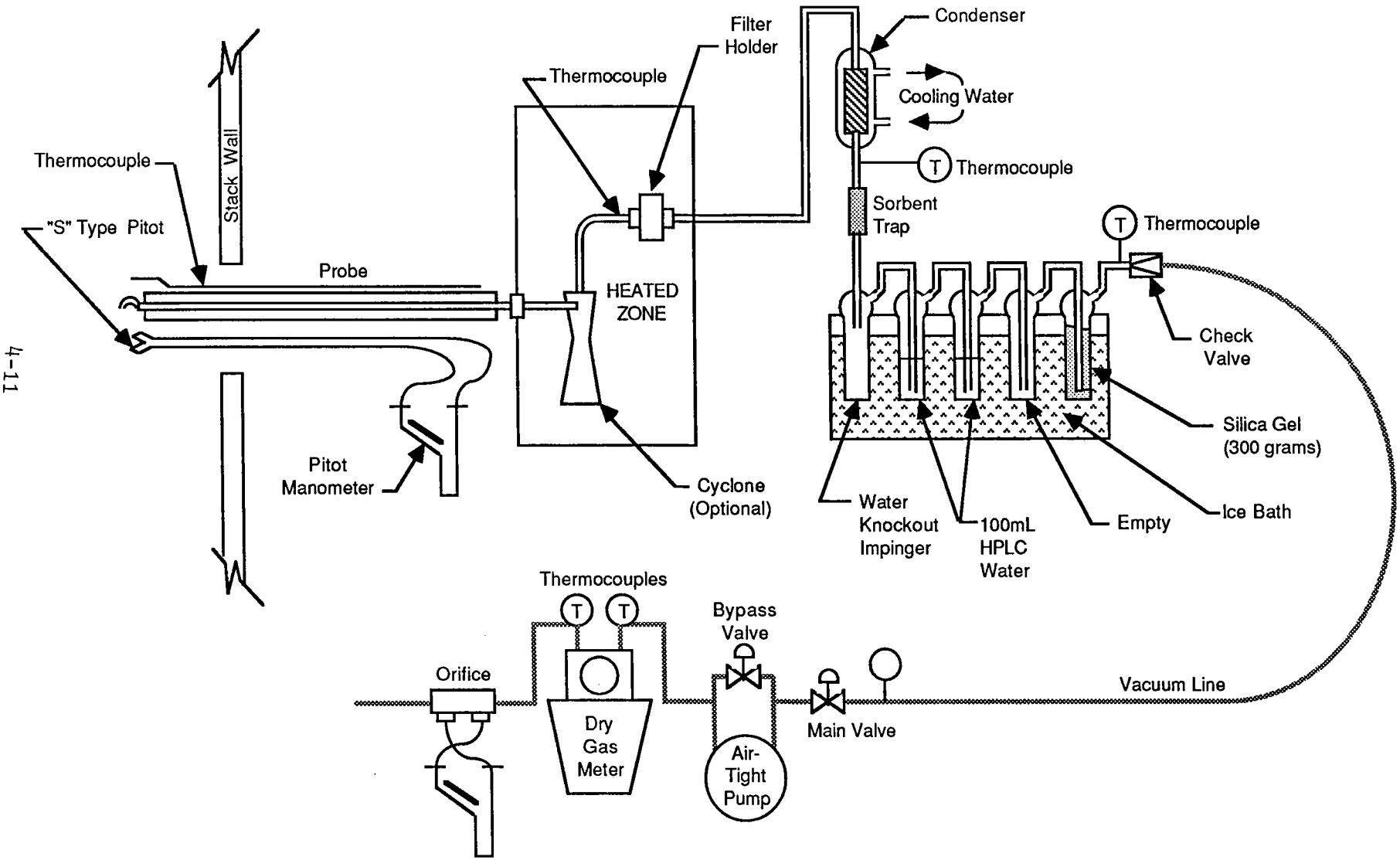

Figure 4.7. CDD/CDF sampling train configuration.

3. Triple-rinse with deionized/distilled H_2O.
4. Bake at 450°F for 2 hours.
5. Triple-rinse with acetone (pesticide grade).
6. Triple-rinse with methylene chloride (pesticide grade).
7. Cap all openings with cleaned glass plugs or methylene chloride rinsed aluminum foil.

Non-glass components (e.g., nozzles, teflon filter frits, tweezers, teflon squeeze bottles, and nylon probe brushes) were cleaned following the same procedure, except the baking step was eliminated.

To prevent field contamination, the glass-fiber filters for CDD/CDF testing were placed in a pre-cleaned petri dish sealed with Teflon tape. Twenty (20) filters from the same sample lot were extracted simultaneously using methylene chloride in a Soxhlet extractor for a period of 24 hours. Contamination of the filters was checked with the proof rinse blank sample.

Precleaned XAD-2 resin (Supelpak-2®) was purchased from Supelco. This resin meets EPA-recommended criteria for purity as outlined in EPA's "Level 1 Environmental Assessment Procedures Manual."

The remaining preparation involved calibration and leak checking of all the sampling equipment, including meter boxes, temperature sensors, nozzles, pitot tubes, and umbilicals. These procedures were performed according to the requirements specified in EPA's "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III" (600/4-77-027b). The results were documented and retained (see Appendix D).

4.9.2 Sampling Train Assembly

Sampling trains were assembled in both the recovery area and at the sampling location. The empty, clean impingers were first laid out in order. The first impinger was a knockout impinger with a short tip to collect condensate forming in the coil and XAD trap; the short tip ensured that the gas was not bubbled through the condensate preventing carryover to the next impinger. The next two impingers were filled with 100 ml each of high performance liquid chromatography (HPCL) quality water. The fourth impinger was empty, and the fifth impinger was charged with 300 grams of indicating silica gel. The impingers were connected together using U-tube connectors with Singer® screw caps. The screw threads and the O-rings in the caps were wound with Teflon tape to ensure leak-free connections. The impingers were arranged in the train box. The XAD trap was attached to the condensor and this assembly was attached to the knockout impinger.

Next, the filter was loaded into the filter holder, and together with the cyclone was attached between the probe and condensor assembly. The entire train underwent a preliminary leak check before leaving the recovery area. For transport to the sampling location, the probe assembly had to be removed from the train. All openings on the probe and nozzle assembly and the impinger train were capped with methylene chloride rinsed foil.

4.9.3 Sampling Operations

The sampling train was operated according to the ASME/EPA protocol, which is based on EPA Method 5 procedures.* Special attention was given to the following QC checks:

1. Prior to and following each run, the entire sampling train was leak-checked to ensure that leakage did not exceed the lesser of (a) 4 percent of the average sampling rate, or (b) 0.02 actual cubic feet per minute (acfm).
2. The filter compartment was maintained at 248 $\pm$ 25°F during sampling.
3. Flue gas entering the sorbent module was maintained at or below 68°F.
4. Isokinetic sampling was maintained within 10 percent.
5. Stored resin was kept below 120°F at all times.

4.9.4 Sample Recovery

Prior to transfer to the recovery area, the openings of the sampling train were capped with methylene chloride rinsed foil. Once in the recovery area, the sampling trains were recovered following the scheme shown in Figure 4.8. Liquid samples were placed in precleaned amber glass bottles to prevent light degradation. Filters were placed in precleaned glass petri dishes sealed with Teflon tape. Both the petri dishes and the capped XAD traps were covered wtih aluminum foil to prevent light degradation. The sample containers from each CDD/CDF test run included those shown in Table 4.2 The XAD-2 resin was kept refrigerated. The other CDD/CDF samples were stored in coolers at 80°F or less.

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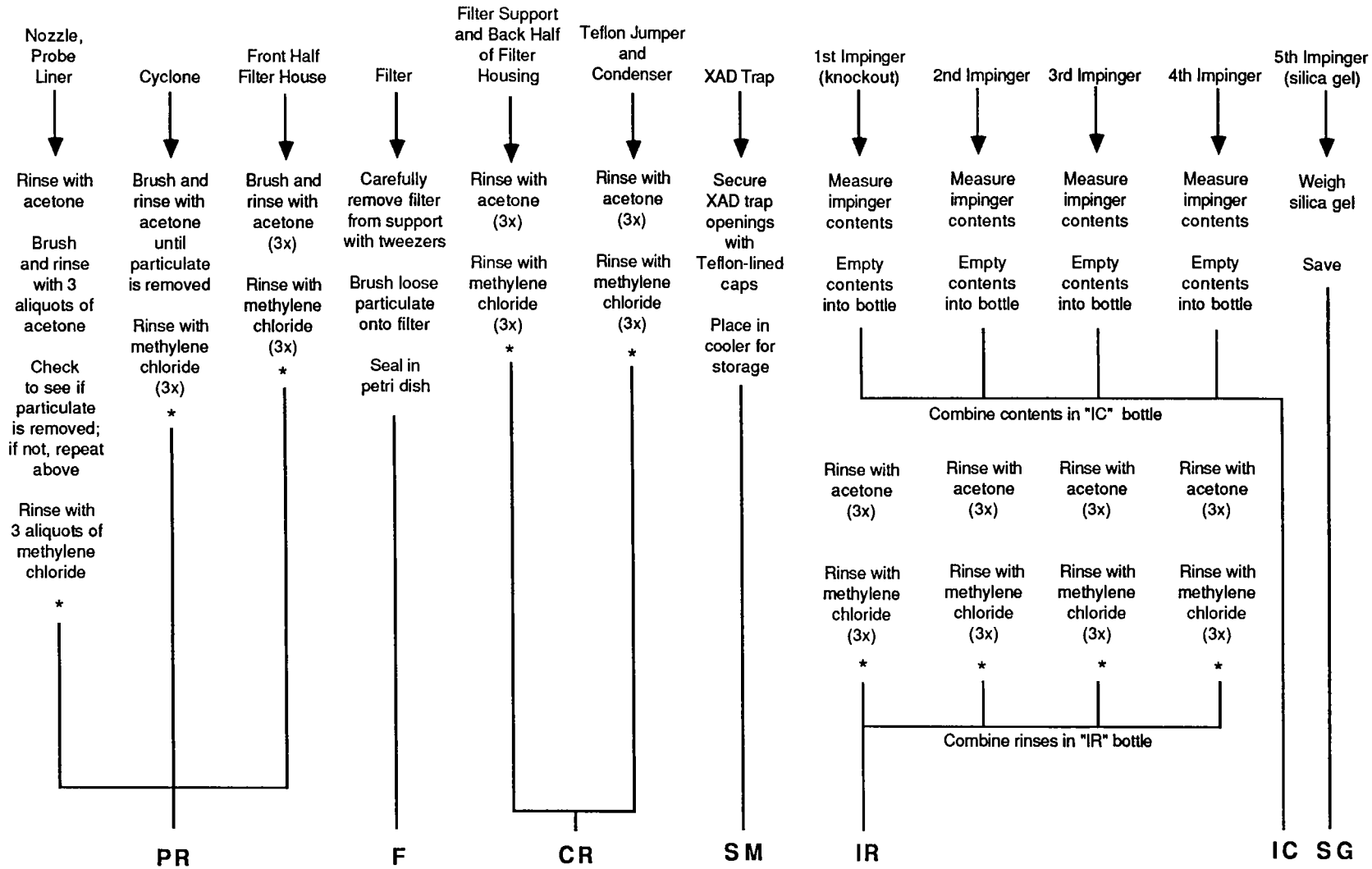
*40 CFR 60, July 1, 1987.



* A final rinse with toluene of each of these components will be combined into a separate sample fraction.

Figure 4.8. CDD/CDF sample recovery scheme.

TABLE 4.2. CDD/CDF SAMPLING TRAIN COMPONENTS

1.	Component 1 (F)	Filter(s)
2.	Component 2 (PR)	Rinses of nozzle, probe, cyclone, transfer line, and front half of filter holder*
3.	Component 3 (CR)	Rinses of back half of filter holder, Teflon jumper, and condenser*
4.	Component 4 (IC)	First, second, third, and fourth impinger contents
5.	Component 5 (IR)	First, second, third, and fourth impinger rinses*
6.	Component 6 (SM)	XAD-2® resin
7.	Component 7 (SG)	Silica gel

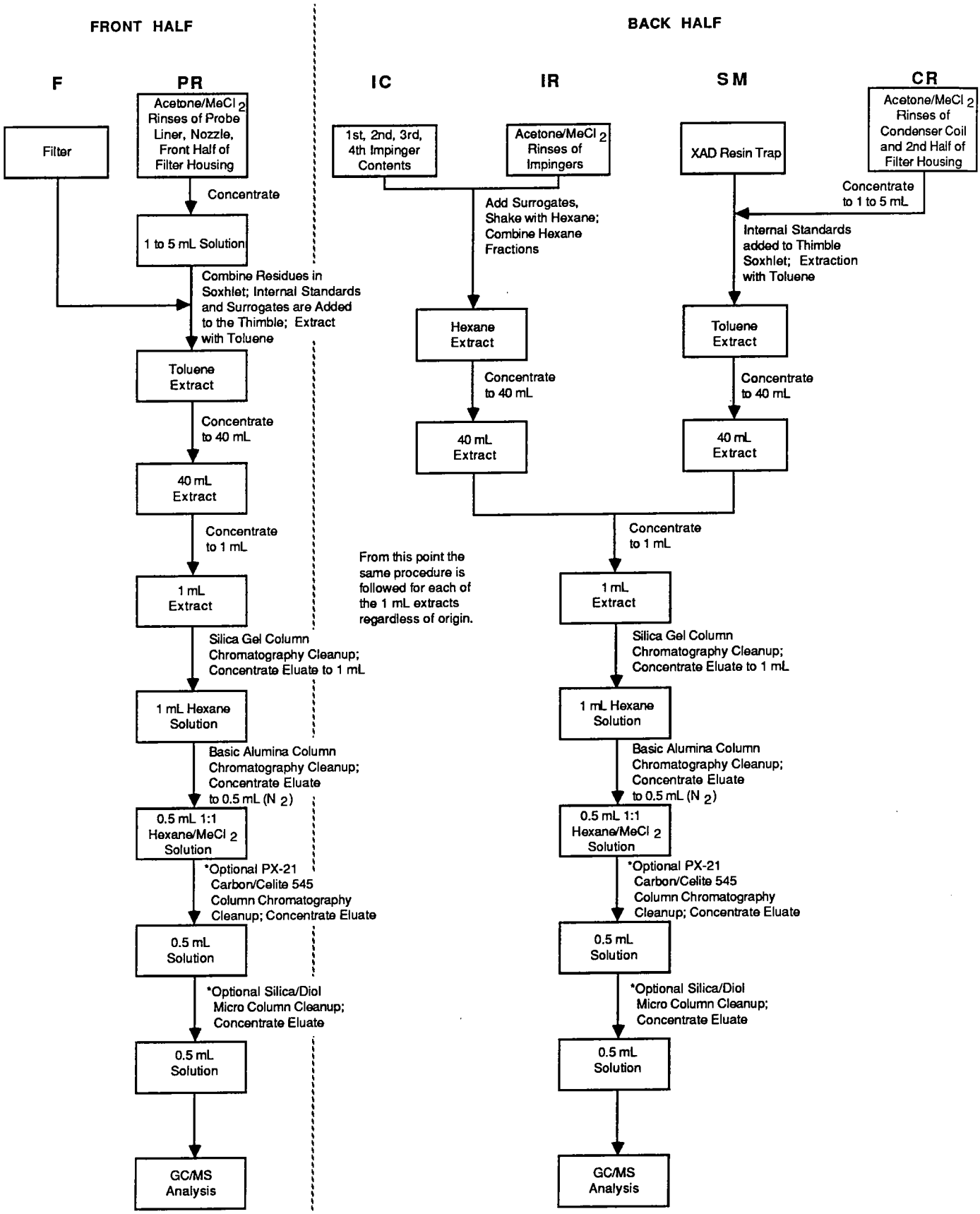
*Rinses include acetone and methylene chloride in same container.

4.9.5 Sample Analysis

The CDD/CDF analysis was conducted by Triangle Laboratories in Research Triangle Park, North Carolina according to the ASME/EPA protocol (see Figure 4.9). Samples collected in the front half (prior to and including the filter) and the back half (back half of the filter holder up to and including the impingers) of the sampling train were analyzed separately for QC purposes to ensure that the internal standards were not being lost in the front half portion. Extractions were completed within 30 days of sampling. The analyses included a high resolution gas chromatographic/high resolution mass spectrometric (HRGC/HRMS) screening for the mono- through octa-CDDs and CDFs. A confirmational analysis for the 2,3,7,8- substituted isomers was also conducted. Table 4.3 lists the specific compounds for which the analysis was performed. Details of the analysis are contained in Appendix C.

4.9.6 Sample Train Blanks

One field blank and a proof rinse blank for each sampling train were recovered. The field blank and one of the proof rinse blanks were analyzed as part of the test program. (Results for these samples are presented in Section 5.0.)



* For large volumes, organic solutions are concentrated using a rotary evaporator apparatus. For small volumes, samples are concentrated under nitrogen.

Figure 4.9. Scheme for analyzing CDD/CDF emission samples.

TABLE 4.3. CDD/CDF ISOMERS FOR WHICH ANALYTICAL RESULTS WERE REPORTED

1. Total Monochlorinated dibenzo-p-dioxin (MCDD)
2. Total Dichlorinated dibenzo-p-dioxins (DCDD)
3. Total Trichlorinated dibenzo-p-dioxins (TrCDD)
4. 2,3,7,8 Tetrachloro dibenzo-p-dioxin (2,3,7,8-TCDD)
5. Total Tetrachlorinated dibenzo-p-dioxins (TCDD)
6. 1,2,3,7,8 Pentachloro dibenzo-p-dioxin (1,2,3,7,8-PeCDD)
7. Total Pentachlorinated dibenzo-p-dioxins (PeCDD)
8. 1,2,3,4,7,8 Hexachloro dibenzo-p-dioxin (1,2,3,4,7,8-HxCDD)
9. 1,2,3,6,7,8 Hexachloro dibenzo-p-dioxin (1,2,3,6,7,8-HxCDD)
10. 1,2,3,7,8,9 Hexachloro dibenzo-p-dioxin (1,2,3,7,8,9-HxCDD)
11. Total Hexachlorinated dibenzo-p-dioxins (HxCDD)
12. 1,2,3,4,6,7,8 Heptachlorinated dibenzo-p-dioxin (1,2,3,4,6,7,8-HpCDD)
13. Total Heptachlorinated dibenzo-p-dioxins (HpCDD)
14. Total Octachlorinated dibenzo-p-dioxins (OCDD)
15. Total Monochlorinated dibenzofurans (MCDF)
16. Total Dichlorinated dibenzofurans (DCDF)
17. Total Trichlorinated dibenzofurans (TrCDF)
18. 2,3,7,8 Tetrachloro dibenzofurans (2,3,7,8-TCDF)
19. Total Tetrachlorinated dibenzofurans (TCDF)
20. 1,2,3,7,8 Pentachloro dibenzofuran (1,2,3,7,8-PeCDF)
21. 2,3,4,7,8 Pentachloro dibenzofuran (2,3,4,7,8-PeCDF)
22. Total Pentachlorinated dibenzofurans (PeCDF)
23. 1,2,3,4,7,8 Hexachloro dibenzofuran (1,2,3,4,7,8-HxCDF)
24. 1,2,3,6,7,8 Hexachloro dibenzofuran (1,2,3,6,7,8-HxCDF)
25. 1,2,3,7,8,9 Hexachloro dibenzofuran (1,2,3,7,8,9-HxCDF)
26. 2,3,4,6,7,8 Hexachloro dibenzofuran (2,3,4,6,7,8-HxCDF)
27. Total Hexachlorinated dibenzofurans (HxCDF)
28. 1,2,3,4,6,7,8 Heptachlorinated dibenzofurans (1,2,3,4,6,7,8-HpCDF)
29. 1,2,3,4,7,8,9 Heptachlorinated dibenzofurans (1,2,3,4,7,8,9-HpCDF)
30. Total Heptachlorinated dibenzofurans (HpCDF)
31. Total Octachlorinated dibenzofurans (OCDF)

4.10 ASH SAMPLING AND ANALYSIS

Ash samples were collected from six different locations during each CDD/CDF sampling run. For the bottom, economizer/generating bank, spray dryer, and ESP ash, equal volume grab samples were collected every 15 minutes over the flue gas sampling period beginning 15 minutes after flue gas sampling began and continuing for 15 minutes following the termination of sampling. This ash sampling procedure was designed to account for the processing time of the ash handling systems, so that the ash sampling was as simultaneous as possible with the flue gas sampling.

At the end of each run, the composited grab samples from each location were mixed together. Following mixing, the ash was coned and quartered according to ASTM D 346-78 (see Appendix C). A 1-liter aliquot was saved in two 500 ml amber glass bottles. Upon completion of all the CDD/CDF sampling runs, half (one 500 ml jar) of each of the five integrated aliquots from each location was loaded into a cleaned mixing container. This ash was mixed, coned, and quartered. One 500 ml aliquot was saved in an amber glass bottle and one 40 ml aliquot in an amber glass vial. The 500 ml aliquot of this combined aliquot was analyzed for CDD/CDF, percent carbon (ASTM E 777), and percent combustibles (ASTM E 830). The 40 ml vial, along with 40 ml vials containing integrated samples for each separate run were archived.

A flow chart of the ash sampling protocol is presented in Figure 4.10.

4.11 LIME SLURRY SAMPLING AND ANALYSIS

A lime slurry was collected from the spray dryer penthouse once near the middle of each CDD/CDF sampling run. Each sample was analyzed for percent solids and specific gravity. One of the samples collected over the course of the test program was analyzed for CDD/CDF. The remaining portions of the samples were archived.

Prior to Sampling:

1. Rinse metal buckets and scoops with distilled water.
2. Rinse out mixing container with distilled water.
3. Allow equipment to dry.
4. Clear out any overnight ash buildup from sampling ports.

↓

Ash Collection:

1. Collect subsample once every 15 minutes beginning 15 minutes after flue gas sampling begins.

↓

Following Each Sampling Run:

1. Mix composited ash sample from each location separately.
2. Cone and quarter to 1 liter (two 500 mL jars) using ASTM D346-78.
3. Using a scoop, place sample in precleaned amber glass bottles.
4. Clean mixing equipment with distilled water.

↓

Following All Sampling Runs:

1. Load half (500 mL) of integrated ash from each of five sampling runs for a single ash sampling location
2. Mix.
3. Allow ash dust to settle.
4. Cone and quarter to 500 mL.
5. Place sample in new precleaned amber glass bottle.
6. Clean mixing equipment with distilled water.
7. Send this sample (combined runs) for analysis.
8. Archive 40 mL portion of remaining half of sample (single run) in amber glass vial.

Figure 4.10. Ash sampling protocol.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

Important to any emission testing program are procedures to ensure the quality of the data obtained during the program. These procedures, referrred to as quality assurance/quality control (QA/QC), serve to document the quality of the data in terms of accuracy, precision, representativeness, completeness, and comparability; maintain the data quality within predetermined control limits; and provide guidelines for corrective actions if a particular procedure is out of control.

This section presents the results of internal QA/QC activities performed by Entropy throughout the course of the test program along with results of audit samples supplied by EPA. External QA activities performed by EPA's Office of Research and Development and its contractor, Research Triangle Institute, are presented in a separate report which is reproduced in Appendix G.

5.1 OVERVIEW OF QA/QC ACTIVITIES

The detailed description of the QA/QC activities associated with this emission testing program was presented in the "QA/QC Project Plan, Municipal Waste Combustor Test Program, Millbury Resource Recovery Facility," dated Feburary 4, 1988, which was prepared prior to the test. In brief, the following QA/QC activities were conducted for this test program:

- Established QC control criteria (see Table 5.1);
- Established acceptance criteria and limits with appropriate corrective actions (see Table 5.2);
- Internal QC including standard procedures for equipment and reagent preparation and QC checks in performance of standard methods for sample collection and analysis (see Section 4.0 of this report and the QA/QC Project Plan for details);
- Specific sample custody procedures (see QA/QC Project Plan);
- Calibration of sampling equipment and analytical instrumentation (see Appendix D);
- On-site audits of sampling equipment;
- Performance evaluation audits of analytical systems; and
- External technical systems audits (see independent report by RTI in Appendix G).

The results of these QA/QC activities are presented in the following sections.

TABLE 5.1. PROGRAM QUALITY CONTROL CRITERIA

Measurement Parameter (Method)	Reference	Precision[a,h]	Accuracy	Completeness[b]
CDD/CDF	ASME/EPA Protocols[c] SW-846 Method 0010[d]	50%[f]	50%[g]	75%
EPA Method 3	ES&T Article[e]	6%[f]	10%[g]	75%

[a]Analytical only, for manual sampling methods.

[b]Valid data percentage of total runs conducted.

[c]"Sampling for the Determination of Chlorinated Organic Compounds in Stack Emissions" and "Analytical Procedures to Assay Stack Effluent Samples and Residual Combustion Products for Polychlorinated Dibenzo-p-dioxins and Dibenzofurans," prepared by Group C - Environmental Standards Workshop, sponsored by ASME/DOE/EPA, Draft December 31, 1984.

[d]Method 0010: Modified Method 5 Sampling Train in Test Methods for Evaluating Solid Waste, Third Edition, Volume Two, U.S. Environmental Protection Agency Publication No. SW-846, November 1986.

[e]Midgett, M.R. "How EPA Validates NSPS Methodology." Environmental Science and Technology., Vol. 11, No. 7, July 1977, pp. 655-659.

[f]Percent difference for duplicate analyses, where:

$$\%D = \frac{\text{First Value} - \text{Second Value}}{0.5\ (\text{First} + \text{Second Values})} \times 100\%$$

[g]Relative error (%) for audit analyses and spiked compounds, where:

$$\%E = \frac{\text{Measured Value} - \text{Actual (Spiked) Value}}{\text{Actual (Spiked) Value}} \times 100\%$$

[h]Precision and accuracy based on EPA collaborative tests.

TABLE 5.2. SUMMARY OF ACCEPTANCE CRITERIA, CONTROL LIMITS, AND CORRECTIVE ACTIONS

Criteria	Control Limits[a,b]	Corrective Action
Method 3		
Flexible bag leaks	None	Replace bag
Train leaks	None; 10 in. Hg vacuum stable for $\geq$ 30 sec	Replace items as necessary
Analyzer leaks	$\leq$ 0.2 ml for 4 minutes	Check connections
Triplicate analysis for CO_2	Any three analyses differ by by $\leq$ 0.3% absolute (CO_2 >4%) or $\leq$ 0.2% absolute (CO_2 $\leq$4%)	Continue to repeat analysis until control limit is met
Triplicate analysis for O_2	Any three analyses differ by by $\leq$ 0.2% (O_2 $\geq$15%) or $\leq$ 0.3% (O_2 <15%)	Continue to repeat analysis until control limit is met
Manual Sampling		
Flow Alignment	Avg. resultant angle within 20°	Adjust flow data to correct for misalignment based on misalignment angles
Isokinetics	100 $\pm$ 10%	Qualify data
Final Leakrate (after each port)	$\leq$ 0.02 acfm or 4% of sampling rate, whichever is less	Adjust sample volume for port
Dry gas meter calibration	Post average factor (Y) agree $\pm$ 5% of pre-factor	Adjust sample volumes using the Y that gives smallest volume
Individual Correction Factor (Y_i)	Agree within 2% of average factor	Redo correction factor
Intermediate Dry Gas Meter	Calibrated every six months against EPA standard	Recalibrate against EPA standard
CDD/CDF Analytical Results		
Internal Standard Recoveries	100 $\pm$ 50%	Re-extract and reanalyze
Surrogate Recoveries	100 $\pm$ 50%	No action
Verfication of Identification		
1) Ratio of M+ to M+2 or M+2 to M+4	Within 20% of theoretical value, except for TCDD/TCDF which are taken within 13%	Reconsider peak identification
2) Retention Time	Within 3 seconds of the corresponding or nearest ^{13}C internal standard or surrogate standard (with reference to continuing calibration)	Reconsider peak identification
3) Signal to Noise Ratio	Greater than 2.5	Reconsider peak identification

(continued)

TABLE 5.2. (continued)

Criteria	Control Limits[a,b]	Corrective Action
Lab Proof Blank	Less than target limits of detection	Determine source of contamination; change reagents and/or reclean glassware
Reagent Blank (if analyzed)	Less than target limits of detection	Change reagents
Field Blank	Less than target limits of detection	Determine source of contamination; change reagents and/or reclean glassware
Audit Sample	Relative error $\leq$ 50%	Reanalyze
Duplicates	Percent difference $\leq$ 50%	Reanalyze

[a]Relative error (%) derived from audit analyses, where:

$$\text{Percent Error} = \frac{\text{Measured Value} - \text{Actual Value}}{\text{Actual Value}} \times 100\%$$

[b]Percent difference (%) for duplicate analyses, where:

$$\text{Percent Difference} = \frac{\text{First Value} - \text{Second Value}}{0.5\ (\text{First} + \text{Second Values})} \times 100\%$$

5.2 ON-SITE AUDIT OF SAMPLING EQUIPMENT

An on-site audit was performed on the meter box used for the CDD/CDF sampling using a critical orifice supplied by EPA's Quality Assurance Division. The data are summarized in Table 5.3. Entropy used the procedures described in Part 40 of the Code of Federal Regulations, Title 60, Appendix A, Method 5, Section 7.2.3 to perform the audit.

TABLE 5.3. METER BOX AUDIT

Meter Box No.	Dry Gas Meter $V_{m(std)}$, ft^3	Critical Orifice $V_{m(std)}$, ft^3	Percent Difference	Within Allowable Limits
N-16	3.895	3.860	-0.91	✓

5.3 CDD/CDF SAMPLING AND ANALYSIS

As detailed in the "QA/QC Project Plan" for the test program and in Triangle Laboratories "Case Narrative" for sample analysis, all CDD/CDF samples were spiked with known amounts of internal standards and surrogate standards prior to extraction and analysis. The recoveries for the internal standards were used to adjust the reported values for the native CDD/CDF isomers. The surrogate recoveries were used to provide additional information on the extraction efficiency, but were not used to adjust the results.

Table 5.4 summarizes the internal standard recoveries for both the general analysis for all CDD/CDF isomers and the confirmational analysis for the 2,3,7,8-substituted isomers. The QC objectives for this test program indicated a range for both internal standard and surrogate recoveries of 50 to 150%. As found in previous studies, the internal standard recoveries for the front half of the flue gas emission samples were generally less than those for the corresponding back half samples, but all were well within the acceptable range. The internal standard recoveries were low for some of the labeled isomer spikes in some of the ash samples. The internal standard recoveries were low for all labeled isomers in the lime slurry sample and in one method blank sample. However, these samples showed no evidence of significant CDD/CDF content and were not reanalyzed.

TABLE 5.4. INTERNAL STANDARD RECOVERIES FOR CDD/CDF ANALYSES

Sample*	Recovery (%)						
	General Analysis					Confirmational Analysis	
	2378-$^{13}C_{12}$-TCDD	$^{13}C_{12}$-PCDD	$^{13}C_{12}$-HxCDD	$^{13}C_{12}$-HpCDD	$^{13}C_{12}$-OCDD	2378-$^{13}C_{12}$-TCDD	$^{13}C_{12}$-TCDF
Flue Gas							
MM5-IN-1 (FH) #1	97	112		97	80	98	95
MM5-IN-1 (BH) #2	96	108	58	109	125	95	94
MM5-IN-2 (FH) #3	100	137	81	110	92	82	82
MM5-IN-2 (BH) #4	91	79	72	105	93	95	93
MM5-IN-3 (FH) #5	76	73	84	96	64	85	99
MM5-IN-3 (BH) #6	95	131	87	154	140	111	93
MM5-IN-4 (FH) #7	78	115	74	102	84	88	96
MM4-IN-4 (BH) #8	82	116	71	114	114	94	78
MM5-IN-5 (FH) #10	91	150	76	132	135	81	82
MM5-IN-5 (BH) #11	124	218	112	136**	142**	84	77
MM5-IN-4 (TR) #9	75	68	54	93	97	88	73
Process							
ASH-BOTTOM #13	90	77	61	89	80	106	92
ASH-ECON/GEN #14	60	49	39	40	36	56	52
ASH-SPRAYDR #15	65	54	44	37	29	65	59
ASH-ESPALL #18	88	61	55	62	57	94	91
ASH-ESP 2,3 #16	71	71	45	53	38	68	60
ASH-ESP 3 #17	72	57	50	63	62	78	72
LIME #19	48	33	34	41	45	47	44
Blanks, Audit Samples							
MM5-IN-FB #12	96	128	106	125	84	83	73
MM5-IN-LABPB #20	95	165	90	134	136	83	68
TLI METH BL 1	74	89	57	93	109	--	--
TLI METH BL 2	75	80	96	86	55	--	-
TLI METH BL 3	85	81	63	95	105	31	23
TLI METH BL 4	32	37	21	29	13	--	--
FLYASH AUD #21	67	51	37	44	39	68	52
XAD AUD F-130 #22	75	62	43	100	70	84	74
XAD AUD F-145 #23	86	77	55	90	62	91	83
XAD AUD F-176 #24	70	85	46	82	85	--	--

*FH - front half sample; BH - back half sample; TR - toluene rinse sample.

corresponds to number on Entropy sample inventory and Triangle Laboratories' analytical printouts.

**Quantitative interference.

Surrogate standards were added to the samples at two different times for this sampling program. A known amount of the surrogate mixture was used as a field sampling spike in all XAD-2 resin trap fractions and was added to each trap prior to shipment to the field. The surrogate recovery results presented in Table 5.5 for the front half samples thus account for losses during sampling and analysis. The recovery of these field spikes was very good, ranging from 94 to 160 percent. Surrogate standards were added to the back half fractions during sample preparation prior to extraction. Recovery of these standards was also very good, ranging from 81 to 141 percent (see Table 5.5). Surrogate recoveries for all the process and quality assurance samples were also very good, with the exception that the recovery of $^{13}C_{12}$-HxCDF was slightly above the 150 percent limit of the QA/QC range for several of the samples.

Table 5.6 presents the CDD/CDF results for the three different types of blanks collected and analyzed during the Millbury test program. Proof rinse blanks were collected from all trains used for CDD/CDF sampling at the inlet. One of these proof rinse blank samples was selected and analyzed for CDD/CDF. The remaining proof rinse blank samples were archived. The proof rinse blank is used to quantify the background levels of CDD/CDF from the glassware and recovery equipment. Each train used was charged and then recovered as it would be for a test run. The majority of CDD/CDF isomers were not detected or were detected in very small quantities in the proof blank analyzed. The OCDD level in the proof rinse blank was, however, in the range of that in the inlet emission samples. In terms of 2,3,7,8-TCDD toxic equivalents, this would have no impact, since the 2,3,7,8-TCDD toxic equivalent factor for OCDD is 0.000.

Triangle Laboratories analyzed two method blanks with each of the two analyses conducted on the Millbury samples. These blanks are used to verify that the reagents and equipment used in the analysis are free of contamination. The results for one method blank from each analysis are presented in Table 5.6. Only OCDD in trace quantities was detected in all of the method blanks. All these values were close to the detection limit and are therefore considered insignificant.

A field blank was collected from one sampling train that had been previously used for CDD/CDF sampling at the inlet. This train was charged with reagents and placed at the inlet sampling location during an entire test run and it was later recovered. Field blanks are used to assess the level of sample

TABLE 5.5. SURROGATE STANDARD RECOVERIES FOR CDD/CDF ANALYSES

Sample*		Recovery (%)			
		General Analysis			Confirmational Analysis
		$^{13}C_{12}$-TCDF	^{37}Cl-TCDD	$^{13}C_{12}$-HxCDF	^{37}Cl-TCDD
MM5-IN-1 (FH)	#1	94	107	139	105
MM5-IN-1 (BH)	#2	81	86	141	95
MM5-IN-2 (FH)	#3	108	90	144	105
MM5-IN-2 (BH)	#4	85	85	130	96
MM5-IN-3 (FH)	#5	108	96	160	105
MM5-IN-3 (BH)	#6	99	85	135	98
MM5-IN-4 (FH)	#7	98	99	136	113
MM5-IN-4 (BH)	#8	89	94	125	97
MM5-IN-5 (FH)	#10	98	99	135	109
MM5-IN-5 (BH)	#11	94	93	130	100
MM5-IN-4 (TR)	#9	90	92	159	110
Process					
ASH-BOTTOM	#13	88	91	143	104
ASH-ECON/GEN	#14	96	97	142	111
ASH-SPRAYDR	#15	97	96	172	108
ASH-ESPALL	#18	93	94	149	107
ASH-ESP2,3	#16	94	96	143	107
ASH-ESP3	#17	104	102	179	105
LIME	#19	96	93	138	106
Blanks, Audit Samples					
MM5-IN-FB	#12	95	94	135	98
MM5-IN-LABPB	#20	95	95	125	98
TLI METH BL 1		80	94	138	--
TLI METH BL 2		87	86	143	--
TLI METH BL 3		86	93	134	108
TLI METH BL 4		91	84	127	--
FLYASH AUD	#21	112	102	168	108
XAD AUD	#22	110	97	196	109
XAD AUD	#23	118	101	179	106
XAD AUD	#24	86	96	126	--

*FH - front half sample; BH - back half sample; TR - toluene rinse sample.
corresponds to number on Entropy sample inventory and Triangle Laboratories' analytical printouts.

TABLE 5.6. SAMPLE BLANK AND TOLUENE RINSE RESULTS FOR CDD/CDF ANALYSES

Analyte	Results in Total ng per Sample*				
	Laboratory Proof Blank	Analytical Method Blank #1**	Analytical Method Blank #4**	Field Blank	Toluene Rinse
Dioxins					
Total MCDD	ND (0.008)	ND (0.010)	ND (0.005)	ND (0.015)	ND (0.015)
Total DCDD	ND (0.020)	ND (0.018)	ND (0.013)	ND (0.035)	ND (0.030)
Total TriCDD	ND (0.050)	ND (0.050)	ND (0.022)	ND (0.085)	ND (0.080)
2378-TCDD	ND [0.010]	ND (0.015)	ND (0.010)	ND [0.010]	ND [0.010]
Total TCDD	ND [0.158]	ND (0.015)	ND (0.010)	ND [0.086]	ND (0.025)
12378-PCDD	ND (0.010)	ND (0.018)	ND (0.015)	ND (0.020)	ND (0.037)
Total PCDD	ND (0.010)	ND (0.018)	ND (0.015)	ND [0.021]	ND (0.037)
123478-HxCDD	ND [0.019]	ND (0.028)	ND (0.008)	ND (0.043)	ND (0.048)
123678-HxCDD	0.030	ND (0.028)	ND (0.005)	ND (0.033)	ND (0.048)
123789-HxCDD	0.044	ND (0.033)	ND (0.010)	ND (0.048)	ND (0.055)
Total HxCDD	0.158	ND [0.552]	ND [0.009]	ND [0.501]	ND [0.545]
1234678-HpCDD	0.977	ND (0.022)	ND [0.011]	0.151	0.069
Total HpCDD	1.824	ND (0.022)	ND [0.011]	0.312	0.149
OCDD	13.016	0.134	0.146	0.841	0.335
Furans					
Total MCDF	ND (0.005)	ND (0.008)	ND (0.005)	ND (0.010)	ND (0.015)
Total DCDF	ND (0.035)	ND (0.025)	ND (0.018)	ND (0.060)	ND (0.043)
Total TriCDF	0.623	ND (0.028)	ND (0.015)	0.352	ND (0.045)
2378-TCDF	ND (0.010)	ND (0.010)	ND (0.005)	0.030	0.010
Total TCDF	0.017	ND (0.010)	ND (0.005)	0.128	ND (0.018)
12378-PCDF	ND [0.009]	ND (0.013)	ND (0.008)	0.034	ND (0.025)
23478-HxCDF	0.010	ND (0.013)	ND (0.010)	0.064	ND (0.028)
Total PCDF	0.051	ND (0.013)	ND (0.008)	0.241	0.089
123478-HxCDF	0.053	ND (0.018)	ND (0.005)	0.204	ND (0.028)
123678-HxCDF	0.015	ND (0.015)	ND (0.003)	ND [0.042]	ND (0.025)
234678-HxCDF	ND (0.013)	ND (0.020)	ND (0.005)	ND [0.043]	ND (0.033)
123789-HxCDF	ND (0.018)	ND (0.028)	ND (0.008)	ND (0.040)	ND (0.045)
Total HxCDF	0.192	ND (0.018)	ND (0.005)	0.430	ND (0.030)
1234678-HpCDF	0.220	ND (0.013)	ND (0.003)	0.301	0.060
1234789-HpCDF	ND (0.010)	ND (0.015)	ND (0.005)	ND (0.030)	ND (0.025)
Total HpCDF	0.420	ND (0.015)	ND (0.005)	0.398	0.068
OCDF	0.491	ND (0.025)	ND (0.020)	0.402	ND (0.043)

*ND - not detected. Detection limits are shown in parentheses ( ); estimated maximum possible concentrations for analytes found above the detection limit, but not meeting all the qualitative identification criteria, are shown in brackets [ ].

**Highest of two method blanks reported for each analysis.

contamination introduced by charging, handling, recovering, and transporting the trains. The field blank results (see Table 5.6) were relatively low in relation to the values obtained for the inlet samples.

Results of another sample taken for QC purposes are also presented in Table 5.6. Preliminary data from a previous study had indicated that toluene might serve as a better recovery solvent for CDD/CDF emission sampling. In light of this, a final rinse of each sampling train was made using toluene. One of these rinses was analyzed for CCD/CDF. The remaining toluene rinse samples were archived. As seen in Table 5.6, there was no indication of significant CDD/CDF residue left in the train which was caught by the toluene rinse. Therefore, the remaining toluene samples were not analyzed.

Four audit samples were submitted to Triangle Laboratories for analysis along with the emission and process samples. These included three spiked XAD-2 sorbent modules supplied by the Quality Assurance Division of EPA's Environmental Monitoring Systems Laboratory and one fly ash audit sample obtained from EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada. Figures 5-1, 5-2, and 5-3 present the results for the spiked XAD audit samples. The fly ash audit sample contained 1.75 ng/g of 2,3,7,8-TCDD and the value reported by the laboratory was 1.68 ng/g of 2,3,7,8-TCDD; this is a percent error of 4.0%.

5.4 SUMMARY OF ACHIEVED DATA QUALITY OBJECTIVES

A summary of the achieved precision, accuracy, and completeness objectives is presented in Table 5.7. All measured objectives were achieved. It was not possible to quantify the accuracy of the Method 3 sampling and analysis because no audit sample was available. Also, it was not possible to quantify the precision of the CDD/CDF analysis because, as a cost savings, no samples were analyzed in duplicate.

U.S. EPA QUALITY ASSURANCE DIVISION DIOXIN/FURAN AUDIT FORM

AUDITEE Triangle Lab ADDRESS RTP, NC
AUDIT SAMPLE NO. 130 DATE OF AUDIT 3/24/88

Compound	Auditee Result (ng/sample)	Compound	Auditee Result (ng/sample)
2378-TCDD	0.6	2378-TCDF	1.55
Other TCDD	8.595	Other TCDF	74.307
12378-PCDD	2.608	12378-PCDF	3.084
Other PCDD	23.098	23478-PCDF	4.471
123478-HxCDD	7.033	Other PCDF	47.871
123678-HxCDD	9.398	123478-HxCDF	29.336
123789-HxCDD	22.483	123678-HxCDF	14.916
Other HxCDD	56.553	123789-HxCDF	(1.557)
1234678-HpCDD	28.571	234678-HxCDF	13.988
Other HpCDD	24.858	Other HxCDF	59.016
OCDD	33.677	1234678-HpCDF	29.847
		1234789-HpCDF	1.776
		Other HpCDF	14.292
		OCDF	5.783

The results of the above performance audit sample are as follows:

RESULTS OF THE POLYCHLORINATED DIBENZODIOXINS (CDD)

1) 2 of the 11 different CDD are not within the 90% confidence intervals.
2) 1 of the 11 different CDD are not within 50% of the 90% confidence intervals.

RESULTS OF THE POLYCHLORINATED DIBENZOFURANS (CDF)

3) 2 of the 14 different CDF are not within the 90% confidence intervals.
4) 1 of the 14 different CDF are not within 50% of the 90% confidence intervals.

RESULTS BASED ON A 2,3,7,8-TCDD TOXIC EQUIVALENCY FACTORS

5) Based on the 2,3,7.8-TCDD toxic equivalency factors, the average percent error outside the 90% confidence limits was 1.9% with an average bias of +1.9%.

Note: For those CDD and CDF reported as not detected by the Auditee, three times the reported detection limit (in parantheses) was used for the calculations. The identical procedure was used for calculating the confidence intervals.

Figure 5-1. Audit sample results for CDD/CDF audit sample 130.

U.S. EPA QUALITY ASSURANCE DIVISION DIOXIN/FURAN AUDIT FORM

AUDITEE Triangle Lab ADDRESS RTP, NC
AUDIT SAMPLE NO. 145 DATE OF AUDIT 3/24/88

Compound	Auditee Result (ng/sample)	Compound	Auditee Result (ng/sample)
2378-TCDD	0.96	2378-TCDF	1.36
Other TCDD	6.237	Other TCDF	38.183
12378-PCDD	1.595	12378-PCDF	2.015
Other PCDD	14.134	23478-PCDF	2.593
123478-HxCDD	5.110	Other PCDF	31.99
123678-HxCDD	4.118	123478-HxCDF	15.545
123789-HxCDD	11.616	123678-HxCDF	7.350
Other HxCDD	32.424	123789-HxCDF	0.585
1234678-HpCDD	20.805	234678-HxCDF	7.922
Other HpCDD	20.033	Other HxCDF	34.325
OCDD	28.671	1234678-HpCDF	19.960
		1234789-HpCDF	1.620
		Other HpCDF	10.918
		OCDF	13.105

The results of the above performance audit sample are as follows:

RESULTS OF THE POLYCHLORINATED DIBENZODIOXINS (CDD)

1) 1 of the 11 different CDD are not within the 90% confidence intervals.
2) 1 of the 11 different CDD are not within 50% of the 90% confidence intervals.

RESULTS OF THE POLYCHLORINATED DIBENZOFURANS (CDF)

3) 2 of the 14 different CDF are not within the 90% confidence intervals.
4) 2 of the 14 different CDF are not within 50% of the 90% confidence intervals.

RESULTS BASED ON A 2,3,7,8-TCDD TOXIC EQUIVALENCY FACTORS

5) Based on the 2,3,7.8-TCDD toxic equivalency factors, the average percent error outside the 90% confidence limits was 8.6% with an average bias of +8.6%.

Note: For those CDD and CDF reported as not detected by the Auditee, three times the reported detection limit (in parantheses) was used for the calculations. The identical procedure was used for calculating the confidence intervals.

Figure 5-2. Audit sample results for CDD/CDF audit sample 145.

U.S. EPA QUALITY ASSURANCE DIVISION DIOXIN/FURAN AUDIT FORM

AUDITEE Triangle Lab ADDRESS RTP, NC
AUDIT SAMPLE NO. 176 DATE OF AUDIT 3/24/88

Compound	Auditee Result (ng/sample)	Compound	Auditee Result (ng/sample)
2378-TCDD	(0.135)	2378-TCDF	(0.099)
Other TCDD	(0.135)	Other TCDF	(0.099)
12378-PCDD	(0.204)	12378-PCDF	(0.120)
Other PCDD	(0.204)	23478-PCDF	(0.129)
123478-HxCDD	(0.321)	Other PCDF	(0.120)
123678-HxCDD	(0.249)	123478-HxCDF	(0.165)
123789-HxCDD	(0.375)	123678-HxCDF	(0.129)
Other HxCDD	(0.309)	123789-HxCDF	(0.294)
1234678-HpCDD	0.337	234678-HxCDF	(0.204)
Other HpCDD	0.771	Other HxCDF	(0.180)
OCDD	4.818	1234678-HpCDF	0.091
		1234789-HpCDF	(0.150)
		Other HpCDF	0.107
		OCDF	0.200

The results of the above performance audit sample are as follows:

RESULTS OF THE POLYCHLORINATED DIBENZODIOXINS (CDD)

1) 1 of the 11 different CDD are not within the 90% confidence intervals.
2) 1 of the 11 different CDD are not within 50% of the 90% confidence intervals.

RESULTS OF THE POLYCHLORINATED DIBENZOFURANS (CDF)

3) 0 of the 14 different CDF are not within the 90% confidence intervals.
4) 0 of the 14 different CDF are not within 50% of the 90% confidence intervals.

RESULTS BASED ON A 2,3,7,8-TCDD TOXIC EQUIVALENCY FACTORS

5) Based on the 2,3,7.8-TCDD toxic equivalency factors, the average percent error outside the 90% confidence limits was 0.00% with an average bias of 0.00%.

Note: For those CDD and CDF reported as not detected by the Auditee, three times the reported detection limit (in parantheses) was used for the calculations. The identical procedure was used for calculating the confidence intervals.

Figure 5-3. Audit sample results for CDD/CDF audit sample 176.

TABLE 5.7. SUMMARY OF ACHIEVED DATA QUALITY OBJECTIVES

Measurement Parameter (Method)	Reference	Precision[a,h,f]	Accuracy[g]	Completeness[b]
CDD/CDF	ASME/EPA Protocols[c]			
	SW-846 Method 0010[d]	NA	i	100%
EPA Method 3	ES&T Article[e]	<1.1%	NA	100%

[a]Analytical only, for manual sampling methods.

[b]Valid data percentage of total runs conducted.

[c]"Sampling for the Determination of Chlorinated Organic Compounds in Stack Emissions" and "Analytical Procedures to Assay Stack Effluent Samples and Residual Combustion Products for Polychlorinated Dibenzo-p-dioxins and Dibenzofurans," prepared by Group C - Environmental Standards Workshop, sponsored by ASME/DOE/EPA, Draft December 31, 1984.

[d]Method 0010: Modified Method 5 Sampling Train in Test Methods for Evaluating Solid Waste, Third Edition, Volume Two, U.S. Environmental Protection Agency Publication No. SW-846, November 1986.

[e]Midgett, M.R. "How EPA Validates NSPS Methodology." Environmental Science and Technology., Vol. 11, No. 7, July 1977, pp. 655-659.

[f]Percent difference for duplicate analyses, where:

$$\%D = \frac{\text{First Value} - \text{Second Value}}{0.5\ (\text{First} + \text{Second Values})} \times 100\%$$

[g]Relative error (%) for audit analyses and spiked compounds, where:

$$\%E = \frac{\text{Measured Value} - \text{Actual (Spiked) Value}}{\text{Actual (Spiked) Value}} \times 100\%$$

[h]Precision and accuracy based on EPA collaborative tests.

[i]See Figures 5-1, 5-2, and 5-3.

APPENDIX A

TEST RESULTS AND EXAMPLE CALCULATIONS

- Flue Gas Sampling Field Data, Emission Results, CDD/CDF Isomer Calculations
- Process Sample CDD/CDF Isomer Calculations
- Example Calculations

FIELD DATA

PLANT	Wheelabrator Environmental Systems	DATE	2/8/88
SAMPLING LOCATION	Unit 2 Inlet	RUN NUMBER	2-MM5-I-1
OPERATOR	Tom McDonald	NOZZLE #	905
BAR.PRESS.,in Hg	29.7000	NOZZLE DIAMETER,inches	0.181
STATIC PRESS.in H2O	-2.2500	METER BOX NUMBER	Nutech 10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.75
LEAK RATE,CFM	0.0080	ASSUMED MOISTURE, %	12.0

ANALYTICAL RESULTS DATA

RUN START TIME	08:58	TOT VOL. H2O COLL.(ml)	226.0
RUN STOP TIME	15:38	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	Total CDD	92.887 ng
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.006	Total CDF	363.836 ng
EST. DRY MOL. WT.(Lb/Lb-Mole)	29.92	TOTAL CATCH -	
STACK/DUCT AREA (in2)	8,659.0	Total CDD/CDF	456.723 ng

Sample Point No.	Sample Time (min)	Dry Gas Met. (Cu.Ft)	Pit.Vel Head (inH2O)	Orif. (inH2O) Ideal	^H (inH2O) Actual	Gas Met Temp. oF	Filter Temp oF	Conden. Temp. oF	Imp.Ex. Temp. oF	Stack Temp oF	Leak Chec (u40,4
1	0	651.343	0.34	0.00	0.21	74	260.0	28	59	430	
2	10	653.850	0.34	0.00	0.20	76	261.0	30	52	431	
3	20	656.500	0.53	0.00	0.21	78	247.0	29	49	435	
4	30	659.640	0.51	0.00	0.24	80	246.0	30	48	436	
5	40	661.150	0.59	0.00	0.33	81	249.0	30	49	434	
6	50	665.870	0.56	0.00	0.34	84	250.0	31	48	430	
7	60	668.910	0.54	0.00	0.32	86	257.0	31	50	434	
8	70	672.070	0.51	0.00	0.33	87	251.0	33	51	437	
9	80	677.181	0.53	0.00	0.35	84	230.0	31	52	436	
10	90	680.720	0.56	0.00	0.30	86	249.0	32	53	438	
11	100	684.130	0.48	0.00	0.27	86	253.0	32	55	443	
12	110	687.760	0.44	0.00	0.27	87	251.0	33	54	438	
13	120	691.650	0.43	0.00	0.31	87	251.0	33	52	435	729.0
14	130	693.100	0.49	0.00	0.35	87	250.0	33	55	437	729.0
15	140	696.130	0.56	0.00	0.38	87	251.0	34	53	442	
16	150	699.370	0.61	0.00	0.32	87	251.0	34	56	446	
17	160	702.810	0.52	0.00	0.31	88	249.0	35	59	442	
18	170	706.030	0.50	0.00	0.32	88	249.0	35	61	443	
19	180	709.195	0.51	0.00	0.34	88	250.0	34	57	449	
20	190	712.300	0.54	0.00	0.39	88	251.0	34	58	447	
21	200	715.510	0.63	0.00	0.36	88	251.0	34	59	452	
22	210	719.000	0.57	0.00	0.37	89	251.0	35	55	444	
23	220	722.440	0.59	0.00	0.32	89	252.0	34	52	446	
24	230	725.840	0.52	0.00	0.35	89	251.0	35	51	445	
	240	729.085									
FINAL DIFF/AVGS.		77.733	0.51		0.31	85				440	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS

2/8/88	Wheelabrator Environmental Systems	2-MM5-I-1
	Run Start Time Run Finish Time	08:58 15:38
Theta	Net Run Time, Minutes	240
	Net Sampling Points	24
Dia	Nozzle Diameter, Inches	0.181
Cp	Pitot Tube Coefficient	0.840
Y	Dry Gas Meter Calibration Factor	1.006
Pbar	Barometric Pressure, Inches Hg	29.700
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.312
Vm	Volume of Metered Gas Sample, Dry ACF	77.733
tm	Dry Gas Meter Temperature, Degrees F	85.2
Vm(std)	Volume of Metered Gas Sample, Dry SCF	75.208
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	226.0
Vw(std)	Volume of Water Vapor, SCF	10.638
%H2O	Moisture Content, % by Volume	12.39
Mfd	Dry Mole Fraction	0.876
%CO2	Percent CO2 by Volume, Dry	9.4
%O2	Percent O2 by Volume, Dry	10.3
Fo	Orsat Validation Value	1.128
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	29.92
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.44
Pg	Flue Gas Static Pressure, in. Hg	-2.250
Ps	Absolute Flue Gas Press., in Hg	29.535
ts	Flue Gas Temperature, Degrees F	440
Delta p	Average Velocity Head, in. H2O	0.5140
vs	Flue Gas Velocity, Ft/Sec	53.28
A	Stack/Duct Area, Sq. Inches	8,659
Qsd	Volumetric Air Flow Rate, Dry SCFM	97,568.0
Qaw	Volumetric Air Flow Rate, Wet ACFM	192,221.1
%I	Isokinetic Sampling Rate, %	108.1

*Standard conditions: 68°F and 29.92 inches of Hg.

EMISSIONS RESULTS

2/8/88 Wheelabrator Environmental Systems 2-MM5-I-1

FLUE GAS TEMPERATURE

Degrees Fahrenheit	439.6
Degrees Centigrade	226.4

AIR FLOW RATES x million

Actual Cubic Meters/hr	0.3266
Actual Cubic Feet/hr	11.5333
Dry Std. Cubic Meters/hr	0.1658
Dry Std. Cubic Feet/hr	5.8541

CONCENTRATIONS AND EMISSION RATES - PMRc

Total CDD

ng	Catch	92.887 ng
mg/dscm	Concentration, mg/dscm	0.044 x 10E-3
gr/dscf	Concentration, grains per dscf	0.019 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.016 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.007 x 10E-3

Total CDF

ng	Catch	363.836 ng
mg/dscm	Concentration, mg/dscm	0.171 x 10E-3
gr/dscf	Concentration, grains per dscf	0.075 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.062 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.028 x 10E-3

Total CDD/CDF

ng	Catch	456.723 ng
mg/dscm	Concentration, mg/dscm	0.214 x 10E-3
gr/dscf	Concentration, grains per dscf	0.094 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.078 x 10E-3

Note: Concentrations and emission rates <u>not</u> corrected to 12% CO_2.

Job Name: Millbury
EEI Ref#: 3516
Run IDs: 2-MM5-IN-1

NAME	Front Half Amount (ng)	NUMB	DL	Back Half Amount (ng)	NUMB	DL	Front Half Conc Corr 12% CO2 (ng/dscm)	Back Half Conc Corr 12% CO2 (ng/dscm)	BH+FH Conc Corr 12% CO2 (ng/dscm)	2378-TCDD Toxic Equiv Factor	2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	0	0.005	0.000	0	0.008	0.000	0.000	0.000	0.0000	0.000
TOTAL DCDD	1.508	1	0.000	0.000	0	0.018	0.905	0.000	0.905	0.0000	0.000
TOTAL TriCDD	5.002	6	0.000	0.000	0	0.045	3.001	0.000	3.001	0.0000	0.000
2378-TCDD	0.800	1	0.000	0.000	-1	0.020	0.480	0.000	0.480	1.0000	0.480
OTHER TCDD	9.765	14	0.000	0.000	-1	0.029	5.858	0.000	5.858	0.0100	0.059
12378-PCDD	1.429	1	0.000	0.000	0	0.018	0.857	0.000	0.857	0.5000	0.429
OTHER PCDD	10.020	12	0.000	0.000	-1	0.033	6.011	0.000	6.011	0.0050	0.030
123478-HxCDD	1.302	1	0.000	0.000	0	0.025	0.781	0.000	0.781	0.0400	0.031
123678-HxCDD	2.071	1	0.000	0.000	0	0.025	1.242	0.000	1.242	0.0400	0.050
123789-HxCDD	4.251	1	0.000	0.000	0	0.030	2.550	0.000	2.550	0.0400	0.102
OTHER HxCDD	16.293	7	0.000	0.000	-1	0.537	9.774	0.000	9.774	0.0004	0.004
1234678-HpCDD	9.624	1	0.000	0.000	-1	0.106	5.773	0.000	5.773	0.0010	0.006
OTHER HpCDD	8.212	2	0.000	0.101	1	0.000	4.926	0.061	4.987	0.00001	0.000
OCDD	21.610	1	0.000	0.899	1	0.000	12.963	0.539	13.502	0.0000	0.000
TOTAL MCDF	0.000	-3	0.346	0.000	0	0.008	0.000	0.000	0.000	0.0000	0.000
TOTAL DCDF	33.207	7	0.000	0.000	0	0.022	19.920	0.000	19.920	0.0000	0.000
TOTAL TriCDF	73.761	11	0.000	1.929	7	0.000	44.247	1.157	45.404	0.0000	0.000
2378-TCDF	4.780	1	0.000	0.130	1	0.000	2.867	0.078	2.945	0.1000	0.295
OTHER TCDF	105.753	16	0.000	1.618	10	0.000	63.438	0.971	64.408	0.0010	0.064
12378-PCDF	4.045	1	0.000	0.070	1	0.000	2.426	0.042	2.468	0.1000	0.247
23478-PCDF	5.057	1	0.000	0.078	1	0.000	3.034	0.047	3.080	0.1000	0.308
OTHER PCDF	53.540	16	0.000	0.811	9	0.000	32.117	0.486	32.603	0.0010	0.033
123478-HxCDF	10.930	1	0.000	0.000	-1	0.197	6.557	0.000	6.557	0.0100	0.066
123678-HxCDF	6.333	1	0.000	0.000	0	0.015	3.799	0.000	3.799	0.0100	0.038
234678-HxCDF	5.751	1	0.000	0.000	0	0.018	3.450	0.000	3.450	0.0100	0.034
123789-HxCDF	0.484	1	0.000	0.000	0	0.025	0.290	0.000	0.290	0.0100	0.003
OTHER HxCDF	29.817	12	0.000	0.283	1	0.000	17.886	0.170	18.056	0.0001	0.002
1234678-HpCDF	12.825	1	0.000	0.183	1	0.000	7.693	0.110	7.803	0.0001	0.001
1234789-HpCDF	1.038	1	0.000	0.052	1	0.000	0.623	0.031	0.654	0.0001	0.000
OTHER HpCDF	6.186	4	0.000	0.088	3	0.000	3.711	0.053	3.764	0.00001	0.000
OCDF	4.695	1	0.000	0.392	1	0.000	2.816	0.235	3.052	0.0000	0.000
TOTAL CDD	91.887			1.000			55.120	0.600	55.720		1.190
TOTAL CDF	358.202			5.634			214.874	3.380	218.254		1.090
TOTAL CDD/CDF	450.089			6.634			269.994	3.980	273.974		2.280

Note: Number in column labelled "NUMB" indicates the following:

0 - Isomer not detected at detection limit listed in "DL" column.
>1 - Isomer detected at level in results column to left.
<1 - Isomer detected, but did not meet all qualitative identification criteria; number listed in "DL" column is estimated maximum possible concentration (EMPC). See Appendix C for further explanation.

FIELD DATA

PLANT	Wheelabrator Environmental Systems	DATE	2/8/88
SAMPLING LOCATION	Unit 2 Inlet	RUN NUMBER	2-MM5-I-2
OPERATOR	Tom McDonald	NOZZLE #	905
BAR.PRESS.,in Hg	29.7000	NOZZLE DIAMETER,inches	0.181
STATIC PRESS.in H2O	-2.1500	METER BOX NUMBER	Nutech 10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.75
LEAK RATE,CFM	0.0000	ASSUMED MOISTURE, %	12.0

ANALYTICAL RESULTS DATA

RUN START TIME	16:30	TOT VOL. H2O COLL.(ml)	218.0
RUN STOP TIME	21:11	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	Total CDD	80.672 ng
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.006	Total CDF	339.987 ng
EST. DRY MOL. WT.(Lb/Lb-Mole)	29.9	TOTAL CATCH -	
STACK/DUCT AREA (in2)	8,659.0	Total CDD/CDF	420.659 ng

Sample Point No.	Sample Time (min)	Dry Gas Met. (Cu.Ft)	Pit.Vel Head (inH2O)	Orif. (inH2O) Ideal	^H (inH2O) Actual	Gas Met Temp. oF	Filter Temp oF	Conden. Temp. oF	Imp.Ex. Temp. oF	Stack Temp oF	Leak Chec (u40,4
1	0	730.146	0.40	0.00	0.25	79	255.0	31	47	435	
2	10	732.910	0.45	0.00	0.28	82	253.0	32	47	439	
3	20	735.860	0.47	0.00	0.29	84	254.0	32	48	444	
4	30	738.930	0.47	0.00	0.29	85	253.0	33	48	447	
5	40	741.230	0.52	0.00	0.32	86	251.0	32	47	440	
6	50	745.040	0.48	0.00	0.30	87	253.0	33	48	445	
7	60	748.200	0.48	0.00	0.30	87	255.0	35	49	451	
8	70	751.390	0.62	0.00	0.39	87	254.0	32	48	448	
9	80	754.690	0.66	0.00	0.41	86	253.0	33	49	449	
10	90	758.200	0.65	0.00	0.41	86	258.0	34	49	451	
11	100	761.690	0.52	0.00	0.32	86	253.0	35	53	446	
12	110	764.910	0.63	0.00	0.39	86	258.0	35	55	443	
13	120	769.830	0.42	0.00	0.26	86	257.0	36	54	433	805.5
14	130	771.240	0.55	0.00	0.33	86	258.0	38	55	441	805.5
15	140	774.860	0.52	0.00	0.32	86	257.0	31	55	440	
16	150	777.710	0.60	0.00	0.37	86	255.0	32	54	442	
17	160	781.170	0.63	0.00	0.39	86	255.0	32	54	442	
18	170	784.680	0.61	0.00	0.38	85	248.0	32	54	449	
19	180	788.050	0.44	0.00	0.27	85	247.0	36	47	442	
20	190	791.050	0.46	0.00	0.27	85	247.0	38	48	444	
21	200	793.990	0.44	0.00	0.27	86	248.0	40	49	439	
22	210	797.180	0.40	0.00	0.25	85	249.0	40	48	436	
23	220	799.870	0.45	0.00	0.26	86	249.0	41	49	435	
24	230	802.770	0.38	0.00	0.25	85	248.0	39	50	436	
	240	805.542									
FINAL DIFF/AVGS.		75.396	0.51		0.32	85				442	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS

2/8/88	Wheelabrator Environmental Systems	2-MM5-I-2
	Run Start Time Run Finish Time	16:30 21:11
Theta	Net Run Time, Minutes	240
	Net Sampling Points	24
Dia	Nozzle Diameter, Inches	0.181
Cp	Pitot Tube Coefficient	0.840
Y	Dry Gas Meter Calibration Factor	1.006
Pbar	Barometric Pressure, Inches Hg	29.700
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.316
Vm	Volume of Metered Gas Sample, Dry ACF	75.396
tm	Dry Gas Meter Temperature, Degrees F	85.3
Vm(std)	Volume of Metered Gas Sample, Dry SCF	72.925
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	218.0
Vw(std)	Volume of Water Vapor, SCF	10.261
%H2O	Moisture Content, % by Volume	12.34
Mfd	Dry Mole Fraction	0.877
%CO2	Percent CO2 by Volume, Dry	9.2
%O2	Percent O2 by Volume, Dry	10.7
Fo	Orsat Validation Value	1.109
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	29.9
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.43
Pg	Flue Gas Static Pressure, in. Hg	-2.150
Ps	Absolute Flue Gas Press., in Hg	29.542
ts	Flue Gas Temperature, Degrees F	442
Delta p	Average Velocity Head, in. H2O	0.5069
vs	Flue Gas Velocity, Ft/Sec	52.99
A	Stack/Duct Area, Sq. Inches	8,659
Qsd	Volumetric Air Flow Rate, Dry SCFM	96,831.9
Qaw	Volumetric Air Flow Rate, Wet ACFM	191,192.0
%I	Isokinetic Sampling Rate, %	105.6

*Standard conditions: 68°F and 29.92 inches of Hg.

EMISSIONS RESULTS

2/8/88 Wheelabrator Environmental Systems 2-MM5-I-2

FLUE GAS TEMPERATURE

Degrees Fahrenheit	442.4
Degrees Centigrade	228.0

AIR FLOW RATES x million

Actual Cubic Meters/hr	0.3248
Actual Cubic Feet/hr	11.4715
Dry Std. Cubic Meters/hr	0.1645
Dry Std. Cubic Feet/hr	5.8099

CONCENTRATIONS AND EMISSION RATES - PMRc

Total CDD

ng	Catch	80.672 ng
mg/dscm	Concentration, mg/dscm	0.039 x 10E-3
gr/dscf	Concentration, grains per dscf	0.017 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.014 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.006 x 10E-3

Total CDF

ng	Catch	339.987 ng
mg/dscm	Concentration, mg/dscm	0.165 x 10E-3
gr/dscf	Concentration, grains per dscf	0.072 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.060 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.027 x 10E-3

Total CDD/CDF

ng	Catch	420.659 ng
mg/dscm	Concentration, mg/dscm	0.204 x 10E-3
gr/dscf	Concentration, grains per dscf	0.089 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.074 x 10E-3

Note: Concentrations and emission rates <u>not</u> corrected to 12% CO_2.

Job Name: Millbury
EEI Ref#: 3516
Run IDs: 2-MM5-IN-2

NAME	Front Half Amount (ng)	NUMB	DL	Back Half Amount (ng)	NUMB	DL	Front Half Conc Corr 12% CO2 (ng/dscm)	Back Half Conc Corr 12% CO2 (ng/dscm)	BH+FH Conc Corr 12% CO2 (ng/dscm)	2378-TCDD Toxic Equiv Factor	2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	0	0.008	0.000	0	0.005	0.000	0.000	0.000	0.0000	0.000
TOTAL DCDD	1.481	1	0.000	0.000	0	0.010	0.936	0.000	0.936	0.0000	0.000
TOTAL TriCDD	4.034	5	0.000	0.000	0	0.028	2.550	0.000	2.550	0.0000	0.000
2378-TCDD	0.640	1	0.000	0.000	-1	0.020	0.405	0.000	0.405	1.0000	0.405
OTHER TCDD	8.777	13	0.000	0.000	-1	0.057	5.548	0.000	5.548	0.0100	0.055
12378-PCDD	1.141	1	0.000	0.000	0	0.013	0.721	0.000	0.721	0.5000	0.361
OTHER PCDD	8.540	12	0.000	0.000	0	0.013	5.398	0.000	5.398	0.0050	0.027
123478-HxCDD	1.013	1	0.000	0.000	0	0.015	0.640	0.000	0.640	0.0400	0.026
123678-HxCDD	1.654	1	0.000	0.000	0	0.015	1.045	0.000	1.045	0.0400	0.042
123789-HxCDD	3.291	1	0.000	0.000	0	0.018	2.080	0.000	2.080	0.0400	0.083
OTHER HxCDD	10.027	6	0.000	0.000	-1	0.456	6.338	0.000	6.338	0.0004	0.003
1234678-HpCDD	8.572	1	0.000	0.050	1	0.000	5.418	0.032	5.450	0.0010	0.005
OTHER HpCDD	8.714	2	0.000	0.000	1	0.000	5.508	0.000	5.508	0.00001	0.000
OCDD	21.374	1	0.000	1.364	1	0.000	13.510	0.862	14.373	0.0000	0.000
TOTAL MCDF	0.197	1	0.000	0.000	0	0.005	0.125	0.000	0.125	0.0000	0.000
TOTAL DCDF	12.417	6	0.000	0.000	0	0.015	7.849	0.000	7.849	0.0000	0.000
TOTAL TriCDF	95.004	11	0.000	1.056	6	0.000	60.052	0.667	60.719	0.0000	0.000
2378-TCDF	4.220	1	0.000	0.100	1	0.000	2.667	0.063	2.731	0.1000	0.273
OTHER TCDF	96.963	15	0.000	0.770	8	0.000	61.290	0.487	61.777	0.0010	0.062
12378-PCDF	4.014	1	0.000	0.032	1	0.000	2.537	0.020	2.557	0.1000	0.256
23478-PCDF	3.991	1	0.000	0.000	-1	0.025	2.523	0.000	2.523	0.1000	0.252
OTHER PCDF	42.942	13	0.000	0.198	3	0.000	27.143	0.125	27.269	0.0010	0.027
123478-HxCDF	9.361	1	0.000	0.000	0	0.010	5.917	0.000	5.917	0.0100	0.059
123678-HxCDF	5.603	1	0.000	0.000	0	0.008	3.542	0.000	3.542	0.0100	0.035
234678-HxCDF	4.912	1	0.000	0.000	0	0.010	3.105	0.000	3.105	0.0100	0.031
123789-HxCDF	0.399	1	0.000	0.000	0	0.015	0.252	0.000	0.252	0.0100	0.003
OTHER HxCDF	32.168	12	0.000	0.000	0	0.010	20.333	0.000	20.333	0.0001	0.002
1234678-HpCDF	11.809	1	0.000	0.047	1	0.000	7.464	0.030	7.494	0.0001	0.001
1234789-HpCDF	1.392	1	0.000	0.000	0	0.010	0.880	0.000	0.880	0.0001	0.000
OTHER HpCDF	6.227	4	0.000	0.035	2	0.000	3.936	0.022	3.958	0.00001	0.000
OCDF	6.130	1	0.000	0.000	-1	0.102	3.875	0.000	3.875	0.0000	0.000
TOTAL CDD	79.258			1.414			50.099	0.894	50.993		1.006
TOTAL CDF	337.749			2.238			213.490	1.415	214.905		1.001
TOTAL CDD/CDF	417.007			3.652			263.589	2.308	265.897		2.007

Note: Number in column labelled "NUMB" indicates the following:

0 - Isomer not detected at detection limit listed in "DL" column.
>1 - Isomer detected at level in results column to left.
<1 - Isomer detected, but did not meet all qualitative identification criteria; number listed in "DL" column is estimated maximum possible concentration (EMPC). See Appendix C for further explanation.

FIELD DATA

PLANT	Wheelabrator Environmental Systems	DATE	2/9/88
SAMPLING LOCATION	Unit 2 Inlet	RUN NUMBER	2-MM5-I-3
OPERATOR	Tom McDonald	NOZZLE #	905
BAR.PRESS.,in Hg	29.7000	NOZZLE DIAMETER,inches	0.181
STATIC PRESS.in H2O	-2.1500	METER BOX NUMBER	Nutech 10
LEAK TEST VACUUM,in.Hg	5.0000	METER BOX ^H@	1.75
LEAK RATE,CFM	0.0000	ASSUMED MOISTURE, %	12.0

ANALYTICAL RESULTS DATA

RUN START TIME	08:30	TOT VOL. H2O COLL.(ml)	218.0
RUN STOP TIME	13:15	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	Total CDD	59.673 ng
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.006	Total CDF	352.143 ng
EST. DRY MOL. WT.(Lb/Lb-Mole)	29.98	TOTAL CATCH -	
STACK/DUCT AREA (in2)	8,659.0	Total CDD/CDF	411.816 ng

Sample Point No.	Sample Time (min)	Dry Gas Met. (Cu.Ft)	Pit.Vel Head (inH2O)	Orif. (inH2O) Ideal	^H (inH2O) Actual	Gas Met Temp. oF	Filter Temp oF	Conden. Temp. oF	Imp.Ex. Temp. oF	Stack Temp oF	Leak Chec (u40,4
1	0	846.015	0.31	0.00	0.19	73	250.0	31	48	419	
2	10	848.370	0.47	0.00	0.28	74	248.0	31	45	420	
3	20	851.510	0.50	0.00	0.30	77	249.0	30	44	425	
4	30	854.550	0.54	0.00	0.32	78	248.0	31	45	428	
5	40	857.730	0.58	0.00	0.34	79	247.0	30	46	433	
6	50	860.890	0.50	0.00	0.30	79	248.0	29	49	433	
7	60	863.900	0.40	0.00	0.24	80	249.0	30	52	432	
8	70	866.620	0.40	0.00	0.23	81	255.0	29	58	431	
9	80	869.270	0.23	0.00	0.24	81	254.0	30	58	433	
10	90	871.880	0.37	0.00	0.20	81	251.0	31	58	428	
11	100	874.520	0.40	0.00	0.22	82	252.0	31	57	425	
12	110	877.220	0.33	0.00	0.24	82	252.0	31	56	427	
13	120	880.720	0.28	0.00	0.20	83	250.0	30	61	430	914.4
14	130	881.820	0.43	0.00	0.26	82	250.0	29	62	423	914.4
15	140	884.630	0.45	0.00	0.27	83	248.0	29	57	427	
16	150	887.510	0.46	0.00	0.26	84	248.0	30	56	427	
17	160	890.510	0.46	0.00	0.27	84	249.0	30	56	427	
18	170	893.390	0.42	0.00	0.25	85	249.0	29	56	429	
19	180	896.240	0.41	0.00	0.24	86	250.0	30	57	432	
20	190	899.020	0.48	0.00	0.28	87	251.0	31	56	431	
21	200	901.960	0.54	0.00	0.32	88	254.0	28	56	436	
22	210	905.200	0.66	0.00	0.39	89	253.0	29	48	442	
23	220	908.550	0.40	0.00	0.24	89	251.0	30	49	449	
24	230	911.520	0.47	0.00	0.28	89	252.0	30	55	437	
	240	914.496									
FINAL DIFF/AVGS.		68.481	0.43		0.27	82				430	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS

2/9/88	Wheelabrator Environmental Systems	2-MM5-I-3
	Run Start Time Run Finish Time	08:30 13:15
Theta	Net Run Time, Minutes	240
	Net Sampling Points	24
Dia	Nozzle Diameter, Inches	0.181
Cp	Pitot Tube Coefficient	0.840
Y	Dry Gas Meter Calibration Factor	1.006
Pbar	Barometric Pressure, Inches Hg	29.700
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.265
Vm	Volume of Metered Gas Sample, Dry ACF	68.481
tm	Dry Gas Meter Temperature, Degrees F	82.3
Vm(std)	Volume of Metered Gas Sample, Dry SCF	66.595
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	218.0
Vw(std)	Volume of Water Vapor, SCF	10.261
%H2O	Moisture Content, % by Volume	13.35
Mfd	Dry Mole Fraction	0.866
%CO2	Percent CO2 by Volume, Dry	9.9
%O2	Percent O2 by Volume, Dry	10.0
Fo	Orsat Validation Value	1.101
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	29.98
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.38
Pg	Flue Gas Static Pressure, in. Hg	-2.150
Ps	Absolute Flue Gas Press., in Hg	29.542
ts	Flue Gas Temperature, Degrees F	430
Delta p	Average Velocity Head, in. H2O	0.4321
vs	Flue Gas Velocity, Ft/Sec	48.64
A	Stack/Duct Area, Sq. Inches	8,659
Qsd	Volumetric Air Flow Rate, Dry SCFM	89,049.3
Qaw	Volumetric Air Flow Rate, Wet ACFM	175,480.3
%I	Isokinetic Sampling Rate, %	104.9

*Standard conditions: 68°F and 29.92 inches of Hg.

EMISSIONS RESULTS

2/9/88 Wheelabrator Environmental Systems 2-MM5-I-3

	FLUE GAS TEMPERATURE	
	Degrees Fahrenheit	430.2
	Degrees Centigrade	221.2
	AIR FLOW RATES x million	
	Actual Cubic Meters/hr	0.2981
	Actual Cubic Feet/hr	10.5288
	Dry Std. Cubic Meters/hr	0.1513
	Dry Std. Cubic Feet/hr	5.3430
	CONCENTRATIONS AND EMISSION RATES - PMRc	
	Total CDD	
ng	Catch	59.673 ng
mg/dscm	Concentration, mg/dscm	0.032 x 10E-3
gr/dscf	Concentration, grains per dscf	0.014 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.011 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.005 x 10E-3
	Total CDF	
ng	Catch	352.143 ng
mg/dscm	Concentration, mg/dscm	0.187 x 10E-3
gr/dscf	Concentration, grains per dscf	0.082 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.062 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.028 x 10E-3
	Total CDD/CDF	
ng	Catch	411.816 ng
mg/dscm	Concentration, mg/dscm	0.218 x 10E-3
gr/dscf	Concentration, grains per dscf	0.095 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.073 x 10E-3

Note: Concentrations and emission rates <u>not</u> corrected to 12% CO_2.

Job Name: Millbury
EEI Ref#: 3516
Run IDs: 2-MM5-IN-3

NAME	Front Half Amount (ng)	NUMB	DL	Back Half Amount (ng)	NUMB	DL	Front Half Conc Corr 12% CO2 (ng/dscm)	Back Half Conc Corr 12% CO2 (ng/dscm)	BH+FH Conc Corr 12% CO2 (ng/dscm)	2378-TCDD Toxic Equiv Factor	2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	0	0.018	0.000	0	0.040	0.000	0.000	0.000	0.0000	0.000
TOTAL DCDD	3.158	1	0.000	0.000	0	0.080	2.031	0.000	2.031	0.0000	0.000
TOTAL TriCDD	5.838	3	0.000	0.000	0	0.215	3.755	0.000	3.755	0.0000	0.000
2378-TCDD	0.440	1	0.000	0.000	0	0.010	0.283	0.000	0.283	1.0000	0.283
OTHER TCDD	5.907	13	0.000	0.000	0	0.065	3.800	0.000	3.800	0.0100	0.038
12378-PCDD	0.590	1	0.000	0.000	0	0.068	0.380	0.000	0.380	0.5000	0.190
OTHER PCDD	5.824	9	0.000	0.000	0	0.068	3.746	0.000	3.746	0.0050	0.019
123478-HxCDD	0.653	1	0.000	0.000	0	0.100	0.420	0.000	0.420	0.0400	0.017
123678-HxCDD	0.990	1	0.000	0.000	0	0.100	0.637	0.000	0.637	0.0400	0.025
123789-HxCDD	1.665	1	0.000	0.000	0	0.118	1.071	0.000	1.071	0.0400	0.043
OTHER HxCDD	11.062	7	0.000	0.000	-1	0.588	7.115	0.000	7.115	0.0004	0.003
1234678-HpCDD	5.610	1	0.000	0.000	0	0.075	3.609	0.000	3.609	0.0010	0.004
OTHER HpCDD	5.825	2	0.000	0.000	0	0.075	3.747	0.000	3.747	0.00001	0.000
OCDD	10.911	1	0.000	1.200	1	0.000	7.018	0.772	7.790	0.0000	0.000
TOTAL MCDF	1.826	3	0.000	0.000	0	0.037	1.175	0.000	1.175	0.0000	0.000
TOTAL DCDF	71.747	7	0.000	0.000	0	0.115	46.150	0.000	46.150	0.0000	0.000
TOTAL TriCDF	127.883	11	0.000	0.000	0	0.118	82.259	0.000	82.259	0.0000	0.000
2378-TCDF	2.750	1	0.000	0.020	1	0.000	1.769	0.013	1.782	0.1000	0.178
OTHER TCDF	61.890	13	0.000	0.000	0	0.048	39.810	0.000	39.810	0.0010	0.040
12378-PCDF	3.294	1	0.000	0.000	0	0.043	2.119	0.000	2.119	0.1000	0.212
23478-PCDF	2.793	1	0.000	0.000	0	0.048	1.797	0.000	1.797	0.1000	0.180
OTHER PCDF	35.800	12	0.000	0.000	0	0.045	23.028	0.000	23.028	0.0010	0.023
123478-HxCDF	6.350	1	0.000	0.000	0	0.058	4.085	0.000	4.085	0.0100	0.041
123678-HxCDF	3.201	1	0.000	0.000	0	0.055	2.059	0.000	2.059	0.0100	0.021
234678-HxCDF	2.885	1	0.000	0.000	0	0.073	1.856	0.000	1.856	0.0100	0.019
123789-HxCDF	0.000	0	0.073	0.000	0	0.095	0.000	0.000	0.000	0.0100	0.000
OTHER HxCDF	18.480	7	0.000	0.000	0	0.068	11.887	0.000	11.887	0.0001	0.001
1234678-HpCDF	7.099	1	0.000	0.123	1	0.000	4.566	0.079	4.645	0.0001	0.000
1234789-HpCDF	0.492	1	0.000	0.000	0	0.053	0.316	0.000	0.316	0.0001	0.000
OTHER HpCDF	3.477	4	0.000	0.016	1	0.000	2.237	0.010	2.247	0.00001	0.000
OCDF	2.017	1	0.000	0.000	-1	0.242	1.297	0.000	1.297	0.0000	0.000
TOTAL CDD	58.473			1.200			37.612	0.772	38.384		0.621
TOTAL CDF	351.984			0.159			226.409	0.102	226.511		0.714
TOTAL CDD/CDF	410.457			1.359			264.021	0.874	264.895		1.335

Note: Number in column labelled "NUMB" indicates the following:

0 - Isomer not detected at detection limit listed in "DL" column.
>1 - Isomer detected at level in results column to left.
<1 - Isomer detected, but did not meet all qualitative identification criteria; number listed in "DL" column is estimated maximum possible concentration (EMPC). See Appendix C for further explanation.

FIELD DATA

PLANT	Wheelabrator Environmental Systems	DATE	2/9/88
SAMPLING LOCATION	Unit 2 Inlet	RUN NUMBER	2-MM5-I-4
OPERATOR	Tom McDonald	NOZZLE #	905
BAR.PRESS.,in Hg	29.7000	NOZZLE DIAMETER,inches	0.181
STATIC PRESS.in H2O	-2.1000	METER BOX NUMBER	Nutech 10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.75
LEAK RATE,CFM	0.0090	ASSUMED MOISTURE, %	12.0

ANALYTICAL RESULTS DATA

RUN START TIME	14:30	TOT VOL. H2O COLL.(ml)	186.0
RUN STOP TIME	19:54	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	Total CDD	96.718 ng
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.006	Total CDF	386.674 ng
EST. DRY MOL. WT.(Lb/Lb-Mole)	29.7	TOTAL CATCH -	
STACK/DUCT AREA (in2)	8,659.0	Total CDD/CDF	483.390 ng

Sample Point No.	Sample Time (min)	Dry Gas Met. (Cu.Ft)	Pit.Vel Head (inH2O)	Orif. (inH2O) Ideal	^H (inH2O) Actual	Gas Met Temp. oF	Filter Temp oF	Conden. Temp. oF	Imp.Ex. Temp. oF	Stack Temp oF	Leak Chec (u40,4
1	0	916.114	0.38	0.00	0.23	75	263.0	31	51	428	
2	10	918.710	0.50	0.00	0.30	75	264.0	29	50	435	
3	20	921.780	0.47	0.00	0.28	77	253.0	29	51	432	
4	30	924.730	0.50	0.00	0.30	80	252.0	29	50	432	
5	40	927.780	0.45	0.00	0.27	82	251.0	29	48	433	
6	50	930.690	0.45	0.00	0.27	81	252.0	30	49	435	
7	60	933.600	0.49	0.00	0.29	82	255.0	30	49	438	
8	70	936.310	0.47	0.00	0.28	82	254.0	39	49	434	
9	80	939.080	0.44	0.00	0.26	83	257.0	32	49	434	
10	90	942.198	0.48	0.00	0.28	83	253.0	33	48	440	
11	100	945.480	0.48	0.00	0.28	84	252.0	31	48	439	
12	110	948.540	0.52	0.00	0.31	85	250.0	33	49	439	
13	120	953.150	0.43	0.00	0.26	84	268.0	28	48	426	986.7
14	130	954.610	0.58	0.00	0.34	84	265.0	29	49	439	986.7
15	140	957.960	0.66	0.00	0.39	83	260.0	31	51	444	
16	150	961.360	0.55	0.00	0.33	83	255.0	30	49	435	
17	160	964.371	0.43	0.00	0.26	80	245.0	32	49	429	
18	170	967.340	0.47	0.00	0.28	80	252.0	33	51	433	
19	180	970.370	0.38	0.00	0.23	81	251.0	30	50	436	
20	190	973.060	0.41	0.00	0.24	81	250.0	30	51	438	
21	200	975.780	0.38	0.00	0.23	80	251.0	32	54	432	
22	210	978.530	0.42	0.00	0.25	80	264.0	29	53	434	
23	220	981.360	0.44	0.00	0.26	80	261.0	29	52	433	
24	230	984.170	0.38	0.00	0.23	81	255.0	28	56	436	
	240	986.780									
FINAL DIFF/AVGS.		70.664	0.46		0.28	81				435	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS

2/9/88	Wheelabrator Environmental Systems	2-MM5-I-4
	Run Start Time Run Finish Time	14:30 19:54
Theta	Net Run Time, Minutes	240
	Net Sampling Points	24
Dia	Nozzle Diameter, Inches	0.181
Cp	Pitot Tube Coefficient	0.840
Y	Dry Gas Meter Calibration Factor	1.006
Pbar	Barometric Pressure, Inches Hg	29.700
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.277
Vm	Volume of Metered Gas Sample, Dry ACF	70.664
tm	Dry Gas Meter Temperature, Degrees F	81.1
Vm(std)	Volume of Metered Gas Sample, Dry SCF	68.879
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	186.0
Vw(std)	Volume of Water Vapor, SCF	8.755
%H2O	Moisture Content, % by Volume	11.28
Mfd	Dry Mole Fraction	0.887
%CO2	Percent CO2 by Volume, Dry	9.7
%O2	Percent O2 by Volume, Dry	10.2
Fo	Orsat Validation Value	1.103
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	29.7
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.38
Pg	Flue Gas Static Pressure, in. Hg	-2.100
Ps	Absolute Flue Gas Press., in Hg	29.546
ts	Flue Gas Temperature, Degrees F	435
Delta p	Average Velocity Head, in. H2O	0.4628
vs	Flue Gas Velocity, Ft/Sec	50.46
A	Stack/Duct Area, Sq. Inches	8,659
Qsd	Volumetric Air Flow Rate, Dry SCFM	94,133.3
Qaw	Volumetric Air Flow Rate, Wet ACFM	182,073.0
%I	Isokinetic Sampling Rate, %	102.6

*Standard conditions: 68°F and 29.92 inches of Hg.

EMISSIONS RESULTS

2/9/88 Wheelabrator Environmental Systems 2-MM5-I-4

FLUE GAS TEMPERATURE

Degrees Fahrenheit	434.8
Degrees Centigrade	223.8

AIR FLOW RATES x million

Actual Cubic Meters/hr	0.3093
Actual Cubic Feet/hr	10.9244
Dry Std. Cubic Meters/hr	0.1599
Dry Std. Cubic Feet/hr	5.6480

CONCENTRATIONS AND EMISSION RATES - PMRc

Total CDD

ng	Catch	96.718 ng
mg/dscm	Concentration, mg/dscm	0.050 x 10E-3
gr/dscf	Concentration, grains per dscf	0.022 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.017 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.008 x 10E-3

Total CDF

ng	Catch	386.674 ng
mg/dscm	Concentration, mg/dscm	0.198 x 10E-3
gr/dscf	Concentration, grains per dscf	0.087 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.070 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.032 x 10E-3

Total CDD/CDF

ng	Catch	483.390 ng
mg/dscm	Concentration, mg/dscm	0.248 x 10E-3
gr/dscf	Concentration, grains per dscf	0.108 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.087 x 10E-3

Note: Concentrations and emission rates <u>not</u> corrected to 12% CO_2.

Job Name: Millbury
EEI Ref#: 3516
Run IDs: 2-MM5-IN-4

NAME	Front Half Amount (ng)	NUMB	DL	Back Half Amount (ng)	NUMB	DL	Front Half Conc Corr 12% CO2 (ng/dscm)	Back Half Conc Corr 12% CO2 (ng/dscm)	BH+FH Conc Corr 12% CO2 (ng/dscm)	2378-TCDD Toxic Equiv Factor	2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	0	0.013	0.000	-2	0.226	0.000	0.000	0.000	0.0000	0.000
TOTAL DCDD	2.238	1	0.000	0.606	1	0.000	1.421	0.385	1.805	0.0000	0.000
TOTAL TriCDD	9.646	5	0.000	1.938	3	0.000	6.123	1.230	7.353	0.0000	0.000
2378-TCDD	0.430	1	0.000	0.060	1	0.000	0.273	0.038	0.311	1.0000	0.311
OTHER TCDD	5.547	12	0.000	0.919	9	0.000	3.521	0.583	4.104	0.0100	0.041
12378-PCDD	0.622	1	0.000	0.077	1	0.000	0.395	0.049	0.444	0.5000	0.222
OTHER PCDD	5.550	10	0.000	0.595	8	0.000	3.523	0.378	3.900	0.0050	0.020
123478-HxCDD	0.765	1	0.000	0.069	1	0.000	0.486	0.044	0.529	0.0400	0.021
123678-HxCDD	1.174	1	0.000	0.101	1	0.000	0.745	0.064	0.809	0.0400	0.032
123789-HxCDD	2.441	1	0.000	0.191	1	0.000	1.549	0.121	1.671	0.0400	0.067
OTHER HxCDD	12.967	7	0.000	0.640	5	0.000	8.231	0.406	8.637	0.0004	0.003
1234678-HpCDD	7.581	1	0.000	0.583	1	0.000	4.812	0.370	5.182	0.0010	0.005
OTHER HpCDD	7.326	2	0.000	0.562	2	0.000	4.650	0.357	5.007	0.00001	0.000
OCDD	32.454	1	0.000	1.636	1	0.000	20.600	1.038	21.638	0.0000	0.000
TOTAL MCDF	0.628	3	0.000	0.133	3	0.000	0.399	0.084	0.483	0.0000	0.000
TOTAL DCDF	27.125	4	0.000	7.362	6	0.000	17.217	4.673	21.890	0.0000	0.000
TOTAL TriCDF	150.490	12	0.000	43.533	11	0.000	95.521	27.632	123.152	0.0000	0.000
2378-TCDF	2.510	1	0.000	0.520	1	0.000	1.593	0.330	1.923	0.1000	0.192
OTHER TCDF	53.544	14	0.000	12.646	14	0.000	33.986	8.027	42.013	0.0010	0.042
12378-PCDF	2.098	1	0.000	0.358	1	0.000	1.332	0.227	1.559	0.1000	0.156
23478-PCDF	2.445	1	0.000	0.409	1	0.000	1.552	0.260	1.812	0.1000	0.181
OTHER PCDF	26.440	13	0.000	5.435	15	0.000	16.782	3.450	20.232	0.0010	0.020
123478-HxCDF	6.714	1	0.000	1.054	1	0.000	4.262	0.669	4.931	0.0100	0.049
123678-HxCDF	3.051	1	0.000	0.435	1	0.000	1.937	0.276	2.213	0.0100	0.022
234678-HxCDF	3.272	1	0.000	0.419	1	0.000	2.077	0.266	2.343	0.0100	0.023
123789-HxCDF	0.180	1	0.000	0.000	0	0.018	0.114	0.000	0.114	0.0100	0.001
OTHER HxCDF	18.218	11	0.000	2.634	8	0.000	11.564	1.672	13.235	0.0001	0.001
1234678-HpCDF	7.132	1	0.000	0.967	1	0.000	4.527	0.614	5.141	0.0001	0.001
1234789-HpCDF	0.557	1	0.000	0.046	1	0.000	0.354	0.029	0.383	0.0001	0.000
OTHER HpCDF	3.171	4	0.000	0.372	4	0.000	2.013	0.236	2.249	0.00001	0.000
OCDF	2.434	1	0.000	0.342	1	0.000	1.545	0.217	1.762	0.0000	0.000
TOTAL CDD	88.741			7.977			56.327	5.063	61.390		0.722
TOTAL CDF	310.009			76.665			196.772	48.662	245.434		0.690
TOTAL CDD/CDF	398.750			84.642			253.099	53.725	306.824		1.412

Note: Number in column labelled "NUMB" indicates the following:

0 - Isomer not detected at detection limit listed in "DL" column.
>1 - Isomer detected at level in results column to left.
<1 - Isomer detected, but did not meet all qualitative identification criteria; number listed in "DL" column is estimated maximum possible concentration (EMPC). See Appendix C for further explanation.

FIELD DATA

PLANT	Wheelabrator Environmental Systems	DATE	2/10/88
SAMPLING LOCATION	Unit 2 Inlet	RUN NUMBER	2-MM5-I-5
OPERATOR	Tom McDonald	NOZZLE #	905
BAR.PRESS.,in Hg	29.7000	NOZZLE DIAMETER,inches	0.181
STATIC PRESS.in H2O	-2.2500	METER BOX NUMBER	Nutech 10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.75
LEAK RATE,CFM	0.0030	ASSUMED MOISTURE, %	12.0

ANALYTICAL RESULTS DATA

RUN START TIME	08:45	TOT VOL. H2O COLL.(ml)	200.0
RUN STOP TIME	13:43	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	Total CDD	66.591 ng
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.006	Total CDF	339.244 ng
EST. DRY MOL. WT.(Lb/Lb-Mole)	29.89	TOTAL CATCH -	
STACK/DUCT AREA (in2)	8,659.0	Total CDD/CDF	405.835 ng

Sample Point No.	Sample Time (min)	Dry Gas Met. (Cu.Ft)	Pit.Vel Head (inH2O)	Orif. (inH2O) Ideal	^H (inH2O) Actual	Gas Met Temp. oF	Filter Temp oF	Conden. Temp. oF	Imp.Ex. Temp. oF	Stack Temp oF	Leak Chec (u40,4
1	0	997.796	0.34	0.00	0.20	71	251.0	30	43	421	
2	10	1000.320	0.42	0.00	0.25	72	256.0	29	49	423	
3	20	1003.160	0.44	0.00	0.26	75	250.0	29	49	421	
4	30	1006.180	0.46	0.00	0.27	77	252.0	28	48	427	
5	40	1009.180	0.49	0.00	0.29	80	251.0	29	49	424	
6	50	1012.040	0.43	0.00	0.26	80	252.0	30	48	427	
7	60	1014.980	0.40	0.00	0.24	80	252.0	30	49	430	
8	70	1017.760	0.43	0.00	0.26	82	255.0	31	53	433	
9	80	1020.540	0.37	0.00	0.22	84	253.0	28	52	429	
10	90	1023.190	0.41	0.00	0.24	85	252.0	28	53	427	
11	100	1025.800	0.36	0.00	0.21	86	253.0	29	53	425	
12	110	1028.500	0.32	0.00	0.20	80	252.0	28	55	423	
13	120	1032.900	0.32	0.00	0.19	82	254.0	29	43	421	64.8
14	130	1033.230	0.41	0.00	0.24	82	253.0	29	44	424	64.8
15	140	1035.940	0.45	0.00	0.26	83	255.0	29	46	426	
16	150	1038.640	0.40	0.00	0.27	84	255.0	30	48	428	
17	160	1041.410	0.39	0.00	0.23	83	255.0	29	51	432	
18	170	1044.000	0.42	0.00	0.25	85	253.0	27	50	434	
19	180	1046.720	0.37	0.00	0.22	88	261.0	28	51	434	
20	190	1049.250	0.41	0.00	0.24	89	260.0	29	47	431	
21	200	1052.180	0.47	0.00	0.28	86	255.0	29	48	438	
22	210	1055.240	0.55	0.00	0.33	87	257.0	30	49	438	
23	220	1058.520	0.52	0.00	0.31	88	250.0	30	51	443	
24	230	1061.790	0.54	0.00	0.32	88	251.0	29	49	445	
	240	1064.886									
FINAL DIFF/AVGS.		67.087	0.42		0.25	82				429	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS

2/10/88	Wheelabrator Environmental Systems	2-MM5-I-5
	Run Start Time Run Finish Time	08:45 13:43
Theta	Net Run Time, Minutes	240
	Net Sampling Points	24
Dia	Nozzle Diameter, Inches	0.181
Cp	Pitot Tube Coefficient	0.840
Y	Dry Gas Meter Calibration Factor	1.006
Pbar	Barometric Pressure, Inches Hg	29.700
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.252
Vm	Volume of Metered Gas Sample, Dry ACF	67.087
tm	Dry Gas Meter Temperature, Degrees F	82.4
Vm(std)	Volume of Metered Gas Sample, Dry SCF	65.232
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	200.0
Vw(std)	Volume of Water Vapor, SCF	9.414
%H2O	Moisture Content, % by Volume	12.61
Mfd	Dry Mole Fraction	0.874
%CO2	Percent CO2 by Volume, Dry	9.3
%O2	Percent O2 by Volume, Dry	10.0
Fo	Orsat Validation Value	1.172
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	29.89
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.39
Pg	Flue Gas Static Pressure, in. Hg	-2.250
Ps	Absolute Flue Gas Press., in Hg	29.535
ts	Flue Gas Temperature, Degrees F	429
Delta p	Average Velocity Head, in. H2O	0.4195
vs	Flue Gas Velocity, Ft/Sec	47.90
A	Stack/Duct Area, Sq. Inches	8,659
Qsd	Volumetric Air Flow Rate, Dry SCFM	88,509.6
Qaw	Volumetric Air Flow Rate, Wet ACFM	172,821.5
%I	Isokinetic Sampling Rate, %	103.3

*Standard conditions: 68°F and 29.92 inches of Hg.

EMISSIONS RESULTS

2/10/88 Wheelabrator Environmental Systems 2-MM5-I-5

FLUE GAS TEMPERATURE

Degrees Fahrenheit	429.3
Degrees Centigrade	220.7

AIR FLOW RATES x million

Actual Cubic Meters/hr	0.2936
Actual Cubic Feet/hr	10.3693
Dry Std. Cubic Meters/hr	0.1504
Dry Std. Cubic Feet/hr	5.3106

CONCENTRATIONS AND EMISSION RATES - PMRc

Total CDD

ng	Catch	66.591 ng
mg/dscm	Concentration, mg/dscm	0.036 x 10E-3
gr/dscf	Concentration, grains per dscf	0.016 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.012 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.005 x 10E-3

Total CDF

ng	Catch	339.244 ng
mg/dscm	Concentration, mg/dscm	0.184 x 10E-3
gr/dscf	Concentration, grains per dscf	0.080 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.061 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.028 x 10E-3

Total CDD/CDF

ng	Catch	405.835 ng
mg/dscm	Concentration, mg/dscm	0.220 x 10E-3
gr/dscf	Concentration, grains per dscf	0.096 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	0.073 x 10E-3

Note: Concentrations and emission rates <u>not</u> corrected to 12% CO_2.

Job Name: Millbury
EEI Ref#: 3516
Run IDs: 2-MM5-IN-5

NAME	Front Half Amount (ng)	NUMB	DL	Back Half Amount (ng)	NUMB	DL	Front Half Conc Corr 12% CO2 (ng/dscm)	Back Half Conc Corr 12% CO2 (ng/dscm)	BH+FH Conc Corr 12% CO2 (ng/dscm)	2378-TCDD Toxic Equiv Factor	2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	0	0.008	0.000	0	0.003	0.000	0.000	0.000	0.0000	0.000
TOTAL DCDD	2.336	1	0.000	0.313	1	0.000	1.633	0.219	1.852	0.0000	0.000
TOTAL TriCDD	9.605	6	0.000	0.905	5	0.000	6.714	0.633	7.347	0.0000	0.000
2378-TCDD	0.450	1	0.000	0.000	-1	0.030	0.315	0.000	0.315	1.0000	0.315
OTHER TCDD	6.709	13	0.000	0.359	12	0.000	4.690	0.251	4.941	0.0100	0.049
12378-PCDD	0.800	1	0.000	0.020	1	0.000	0.559	0.014	0.573	0.5000	0.287
OTHER PCDD	5.595	11	0.000	0.136	9	0.000	3.911	0.095	4.006	0.0050	0.020
123478-HxCDD	0.948	1	0.000	0.014	1	0.000	0.663	0.010	0.672	0.0400	0.027
123678-HxCDD	1.120	1	0.000	0.020	1	0.000	0.783	0.014	0.797	0.0400	0.032
123789-HxCDD	2.855	1	0.000	0.039	1	0.000	1.996	0.027	2.023	0.0400	0.081
OTHER HxCDD	10.402	7	0.000	0.159	5	0.000	7.271	0.111	7.383	0.0004	0.003
1234678-HpCDD	5.360	1	0.000	0.109	1	0.000	3.747	0.076	3.823	0.0010	0.004
OTHER HpCDD	4.887	2	0.000	0.144	2	0.000	3.416	0.101	3.517	0.00001	0.000
OCDD	12.728	1	0.000	0.578	1	0.000	8.897	0.404	9.301	0.0000	0.000
TOTAL MCDF	0.539	2	0.000	0.477	3	0.000	0.377	0.333	0.710	0.0000	0.000
TOTAL DCDF	32.369	7	0.000	2.319	3	0.000	22.627	1.621	24.248	0.0000	0.000
TOTAL TriCDF	137.351	12	0.000	16.391	10	0.000	96.014	11.458	107.472	0.0000	0.000
2378-TCDF	2.500	1	0.000	0.170	1	0.000	1.748	0.119	1.866	0.1000	0.187
OTHER TCDF	60.228	15	0.000	4.529	13	0.000	42.102	3.166	45.268	0.0010	0.045
12378-PCDF	2.306	1	0.000	0.101	1	0.000	1.612	0.071	1.683	0.1000	0.168
23478-PCDF	2.424	1	0.000	0.103	1	0.000	1.694	0.072	1.766	0.1000	0.177
OTHER PCDF	27.381	14	0.000	1.310	12	0.000	19.141	0.916	20.056	0.0010	0.020
123478-HxCDF	7.302	1	0.000	0.271	1	0.000	5.104	0.189	5.294	0.0100	0.053
123678-HxCDF	3.393	1	0.000	0.118	1	0.000	2.372	0.082	2.454	0.0100	0.025
234678-HxCDF	3.369	1	0.000	0.099	1	0.000	2.355	0.069	2.424	0.0100	0.024
123789-HxCDF	0.000	-1	0.225	0.009	1	0.000	0.000	0.006	0.006	0.0100	0.000
OTHER HxCDF	20.519	11	0.000	0.797	11	0.000	14.344	0.557	14.901	0.0001	0.001
1234678-HpCDF	6.683	1	0.000	0.300	1	0.000	4.672	0.210	4.881	0.0001	0.000
1234789-HpCDF	0.477	1	0.000	0.041	1	0.000	0.333	0.029	0.362	0.0001	0.000
OTHER HpCDF	2.887	4	0.000	0.161	4	0.000	2.018	0.113	2.131	0.00001	0.000
OCDF	2.000	1	0.000	0.320	1	0.000	1.398	0.224	1.622	0.0000	0.000
TOTAL CDD	63.795			2.796			44.595	1.955	46.550		0.817
TOTAL CDF	311.728			27.516			217.911	19.235	237.146		0.701
TOTAL CDD/CDF	375.523			30.312			262.507	21.189	283.696		1.518

Note: Number in column labelled "NUMB" indicates the following:

0 - Isomer not detected at detection limit listed in "DL" column.
>1 - Isomer detected at level in results column to left.
<1 - Isomer detected, but did not meet all qualitative identification criteria; number listed in "DL" column is estimated maximum possible concentration (EMPC). See Appendix C for further explanation.

Job Name: Millbury
EEI Ref#: 3516
Run IDs: Bottom Ash, Economizer/Generator Ash

NAME	(ng/samp)	(g)	Bottom Ash (ng/g)	NUMB	DL	(ng/samp)	(g)	Econ/Gen Ash (ng/g)	NUMB	DL	2378-TCDD Toxic Equiv Factor	Bottom Ash 2378-TCDD Toxic Equiv	Econ/Gen Ash 2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	0	0.001	0.0000	0.000	0.000
TOTAL DCDD	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	-1	0.016	0.0000	0.000	0.000
TOTAL TriCDD	0.000	10.19	0.000	0	0.003	0.000	10.09	0.000	-1	0.009	0.0000	0.000	0.000
2378-TCDD		10.19	0.000	-1	0.001		10.09	0.005	1	0.000	1.0000	0.000	0.005
OTHER TCDD	0.000	10.19	0.000	-1	0.001	0.259	10.09	0.026	4	0.000	0.0100	0.000	0.000
12378-PCDD	0.000	10.19	0.000	0	0.001	0.056	10.09	0.006	1	0.000	0.5000	0.000	0.003
OTHER PCDD	0.000	10.19	0.000	0	0.001	0.042	10.09	0.004	2	0.000	0.0050	0.000	0.000
123478-HxCDD	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	0	0.003	0.0400	0.000	0.000
123678-HxCDD	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	0	0.003	0.0400	0.000	0.000
123789-HxCDD	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	-1	0.006	0.0400	0.000	0.000
OTHER HxCDD	0.000	10.19	0.000	-2	0.035	0.195	10.09	0.019	1	0.000	0.0004	0.000	0.000
1234678-HpCDD	0.027	10.19	0.003	1	0.000	0.447	10.09	0.044	1	0.000	0.0010	0.000	0.000
OTHER HpCDD	0.000	10.19	0.000	1	0.000	0.347	10.09	0.034	2	0.000	0.00001	0.000	0.000
OCDD	0.164	10.19	0.016	1	0.000	1.162	10.09	0.115	1	0.000	0.0000	0.000	0.000
TOTAL MCDF	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	-4	0.015	0.0000	0.000	0.000
TOTAL DCDF	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	-2	0.095	0.0000	0.000	0.000
TOTAL TriCDF	0.091	10.19	0.009	1	0.000	6.102	10.09	0.605	8	0.000	0.0000	0.000	0.000
2378-TCDF		10.19	0.0004	1	0.000		10.09	0.030	1	0.000	0.1000	0.000	0.003
OTHER TCDF	0.037	10.19	0.004	2	0.000	7.284	10.09	0.722	13	0.000	0.0010	0.000	0.001
12378-PCDF	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	-1	0.022	0.1000	0.000	0.000
23478-PCDF	0.000	10.19	0.000	-1	0.001	0.256	10.09	0.025	1	0.000	0.1000	0.000	0.003
OTHER PCDF	0.030	10.19	0.003	2	0.000	2.359	10.09	0.234	8	0.000	0.0010	0.000	0.000
123478-HxCDF	0.000	10.19	0.000	0	0.001	0.419	10.09	0.042	1	0.000	0.0100	0.000	0.000
123678-HxCDF	0.000	10.19	0.000	0	0.001	0.193	10.09	0.019	1	0.000	0.0100	0.000	0.000
234678-HxCDF	0.000	10.19	0.000	0	0.001	0.214	10.09	0.021	1	0.000	0.0100	0.000	0.000
123789-HxCDF	0.000	10.19	0.000	0	0.001	0.000	10.09	0.000	0	0.003	0.0100	0.000	0.000
OTHER HxCDF	0.000	10.19	0.000	0	0.001	0.861	10.09	0.085	6	0.000	0.0001	0.000	0.000
1234678-HpCDF	0.038	10.19	0.004	1	0.000	0.619	10.09	0.061	1	0.000	0.0001	0.000	0.000
1234789-HpCDF	0.000	10.19	0.000	0	0.001	0.067	10.09	0.007	1	0.000	0.0001	0.000	0.000
OTHER HpCDF	0.005	10.19	0.000	1	0.000	0.371	10.09	0.037	4	0.000	0.00001	0.000	0.000
OCDF	0.000	10.19	0.000	-1	0.005	0.488	10.09	0.048	1	0.000	0.0000	0.000	0.000
TOTAL CDD			0.019					0.254				0.000	0.008
TOTAL CDF			0.020					1.936				0.000	0.007
TOTAL CDD/CDF			0.039					2.190				0.000	0.015

Note: Number in column labelled "NUMB" indicates the following:

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Job Name: Millbury
EEI Ref#: 3516
Run IDs: Spray Dryer Ash, ESP Ash All Fields

NAME	(ng/samp)	(g)	Spray Dryer Ash (ng/g)	NUMB	DL	(ng/samp)	(g)	ESP All Ash (ng/g)	NUMB	DL	2378-TCDD Toxic Equiv Factor	Spray Dr Ash 2378-TCDD Toxic Equiv	ESP All Ash 2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	10.15	0.000	0	0.003	0.000	10.13	0.000	0	0.001	0.0000	0.000	0.000
TOTAL DCDD	0.000	10.15	0.000	0	0.005	0.671	10.13	0.066	1	0.000	0.0000	0.000	0.000
TOTAL TriCDD	0.000	10.15	0.000	0	0.010	1.359	10.13	0.134	3	0.000	0.0000	0.000	0.000
2378-TCDD		10.15	0.010	1	0.000		10.13	0.030	1	0.000	1.0000	0.010	0.030
OTHER TCDD	0.105	10.15	0.010	1	0.000	2.736	10.13	0.270	13	0.000	0.0100	0.000	0.003
12378-PCDD	0.000	10.15	0.000	0	0.008	0.402	10.13	0.040	1	0.000	0.5000	0.000	0.020
OTHER PCDD	0.125	10.15	0.012	1	0.000	2.620	10.13	0.259	9	0.000	0.0050	0.000	0.001
123478-HxCDD	0.000	10.15	0.000	0	0.013	0.420	10.13	0.041	1	0.000	0.0400	0.000	0.002
123678-HxCDD	0.000	10.15	0.000	0	0.010	0.654	10.13	0.065	1	0.000	0.0400	0.000	0.003
123789-HxCDD	0.262	10.15	0.026	1	0.000	1.286	10.13	0.127	1	0.000	0.0400	0.001	0.005
OTHER HxCDD	0.425	10.15	0.042	2	0.000	3.014	10.13	0.298	5	0.000	0.0004	0.000	0.000
1234678-HpCDD	0.493	10.15	0.049	1	0.000	3.745	10.13	0.370	1	0.000	0.0010	0.000	0.000
OTHER HpCDD	0.657	10.15	0.065	2	0.000	3.484	10.13	0.344	2	0.000	0.00001	0.000	0.000
OCDD	0.953	10.15	0.094	1	0.000	9.534	10.13	0.941	1	0.000	0.0000	0.000	0.000
TOTAL MCDF	0.000	10.15	0.000	0	0.003	0.369	10.13	0.036	2	0.000	0.0000	0.000	0.000
TOTAL DCDF	0.000	10.15	0.000	0	0.008	15.072	10.13	1.488	7	0.000	0.0000	0.000	0.000
TOTAL TriCDF	1.257	10.15	0.124	3	0.000	31.874	10.13	3.146	11	0.000	0.0000	0.000	0.000
2378-TCDF		10.15	0.030	1	0.000		10.13	0.150	1	0.000	0.1000	0.003	0.015
OTHER TCDF	4.856	10.15	0.478	8	0.000	39.114	10.13	3.861	14	0.000	0.0010	0.000	0.004
12378-PCDF	0.312	10.15	0.031	1	0.000	1.666	10.13	0.164	1	0.000	0.1000	0.003	0.016
23478-PCDF	0.325	10.15	0.032	1	0.000	2.081	10.13	0.205	1	0.000	0.1000	0.003	0.021
OTHER PCDF	3.170	10.15	0.312	9	0.000	21.289	10.13	2.102	13	0.000	0.0010	0.000	0.002
123478-HxCDF	0.902	10.15	0.089	1	0.000	4.336	10.13	0.428	1	0.000	0.0100	0.001	0.004
123678-HxCDF	0.000	10.15	0.000	-1	0.045	2.311	10.13	0.228	1	0.000	0.0100	0.000	0.002
234678-HxCDF	0.000	10.15	0.000	-1	0.029	2.278	10.13	0.225	1	0.000	0.0100	0.000	0.002
123789-HxCDF	0.000	10.15	0.000	0	0.010	0.000	10.13	0.000	-1	0.014	0.0100	0.000	0.000
OTHER HxCDF	1.576	10.15	0.155	2	0.000	11.476	10.13	1.133	11	0.000	0.0001	0.000	0.000
1234678-HpCDF	1.099	10.15	0.108	1	0.000	5.890	10.13	0.581	1	0.000	0.0001	0.000	0.000
1234789-HpCDF	0.000	10.15	0.000	0	0.013	0.000	10.13	0.000	-1	0.045	0.0001	0.000	0.000
OTHER HpCDF	0.163	10.15	0.016	1	0.000	1.813	10.13	0.179	2	0.000	0.00001	0.000	0.000
OCDF	0.000	10.15	0.000	0	0.030	1.766	10.13	0.174	1	0.000	0.0000	0.000	0.000
TOTAL CDD			0.308					2.984				0.011	0.064
TOTAL CDF			1.376					14.102				0.011	0.067
TOTAL CDD/CDF			1.683					17.086				0.022	0.131

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Job Name: Millbury
EEI Ref#: 3516
Run IDs: ESP Ash Fields 2 & 3, ESP Ash Field 3

NAME	(ng/samp)	(g)	ESP 2,3 Ash (ng/g)	NUMB	DL	(ng/samp)	(g)	ESP 3 Ash (ng/g)	NUMB	DL	2378-TCDD Toxic Equiv Factor	ESP 2,3 Ash 2378-TCDD Toxic Equiv	ESP 3 Ash 2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	9.59	0.000	0	0.003	0.000	10.02	0.000	0	0.008	0.0000	0.000	0.000
TOTAL DCDD	0.000	9.59	0.000	0	0.005	0.000	10.02	0.000	-1	0.245	0.0000	0.000	0.000
TOTAL TriCDD	1.060	9.59	0.111	2	0.000	3.877	10.02	0.387	2	0.000	0.0000	0.000	0.000
2378-TCDD		9.59	0.040	1	0.000		10.02	0.090	1	0.000	1.0000	0.040	0.090
OTHER TCDD	3.721	9.59	0.388	11	0.000	11.546	10.02	1.152	8	0.000	0.0100	0.004	0.012
12378-PCDD	0.603	9.59	0.063	1	0.000	1.252	10.02	0.125	1	0.000	0.5000	0.031	0.062
OTHER PCDD	2.687	9.59	0.280	6	0.000	14.150	10.02	1.412	7	0.000	0.0050	0.001	0.007
123478-HxCDD	0.579	9.59	0.060	1	0.000	1.759	10.02	0.176	1	0.000	0.0400	0.002	0.007
123678-HxCDD	1.034	9.59	0.108	1	0.000	4.194	10.02	0.419	1	0.000	0.0400	0.004	0.017
123789-HxCDD	1.838	9.59	0.192	1	0.000	5.897	10.02	0.589	1	0.000	0.0400	0.008	0.024
OTHER HxCDD	4.804	9.59	0.501	5	0.000	36.337	10.02	3.626	6	0.000	0.0004	0.000	0.001
1234678-HpCDD	5.115	9.59	0.533	1	0.000	21.943	10.02	2.190	1	0.000	0.0010	0.001	0.002
OTHER HpCDD	5.273	9.59	0.550	2	0.000	22.157	10.02	2.211	2	0.000	0.00001	0.000	0.000
OCDD	10.395	9.59	1.084	1	0.000	44.474	10.02	4.439	1	0.000	0.0000	0.000	0.000
TOTAL MCDF	0.000	9.59	0.000	0	0.003	2.379	10.02	0.237	1	0.000	0.0000	0.000	0.000
TOTAL DCDF	0.000	9.59	0.000	0	0.008	57.988	10.02	5.787	5	0.000	0.0000	0.000	0.000
TOTAL TriCDF	31.422	9.59	3.277	10	0.000	153.416	10.02	15.311	11	0.000	0.0000	0.000	0.000
2378-TCDF		9.59	0.250	1	0.000		10.02	0.620	1	0.000	0.1000	0.025	0.062
OTHER TCDF	60.028	9.59	6.259	14	0.000	199.722	10.02	19.932	13	0.000	0.0010	0.006	0.020
12378-PCDF	2.641	9.59	0.275	1	0.000	7.110	10.02	0.710	1	0.000	0.1000	0.028	0.071
23478-PCDF	3.124	9.59	0.326	1	0.000	8.272	10.02	0.826	1	0.000	0.1000	0.033	0.083
OTHER PCDF	30.342	9.59	3.164	12	0.000	94.405	10.02	9.422	13	0.000	0.0010	0.003	0.009
123478-HxCDF	6.154	9.59	0.642	1	0.000	21.279	10.02	2.124	1	0.000	0.0100	0.006	0.021
123678-HxCDF	3.380	9.59	0.352	1	0.000	11.778	10.02	1.175	1	0.000	0.0100	0.004	0.012
234678-HxCDF	3.212	9.59	0.335	1	0.000	12.492	10.02	1.247	1	0.000	0.0100	0.003	0.012
123789-HxCDF	0.000	9.59	0.000	-1	0.024	0.000	10.02	0.000	-1	0.081	0.0100	0.000	0.000
OTHER HxCDF	18.043	9.59	1.881	11	0.000	55.925	10.02	5.581	9	0.000	0.0001	0.000	0.001
1234678-HpCDF	8.345	9.59	0.870	1	0.000	30.074	10.02	3.001	1	0.000	0.0001	0.000	0.000
1234789-HpCDF	0.620	9.59	0.065	1	0.000	2.536	10.02	0.253	1	0.000	0.0001	0.000	0.000
OTHER HpCDF	3.374	9.59	0.352	4	0.000	9.551	10.02	0.953	3	0.000	0.00001	0.000	0.000
OCDF	2.049	9.59	0.214	1	0.000	7.893	10.02	0.788	1	0.000	0.0000	0.000	0.000
TOTAL CDD			3.910					16.815				0.092	0.222
TOTAL CDF			18.262					67.967				0.108	0.291
TOTAL CDD/CDF			22.171					84.782				0.200	0.513

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Job Name: Millbury
EEI Ref#: 3516
Run IDs: Lime

NAME	(ng/sample)	(g)	Lime (ng/g)	NUMB	DL	2378-TCDD Toxic Equiv Factor	Lime 2378-TCDD Toxic Equiv
TOTAL MCDD	0.000	6.39	0.000	0	0.033	0.0000	0.000
TOTAL DCDD	0.000	6.39	0.000	0	0.062	0.0000	0.000
TOTAL TriCDD	0.000	6.39	0.000	0	0.118	0.0000	0.000
2378-TCDD	0.000	6.39	0.000	-1	0.010	1.0000	0.000
OTHER TCDD	0.108	6.39	0.017	1	0.000	0.0100	0.000
12378-PCDD	0.000	6.39	0.000	0	0.110	0.5000	0.000
OTHER PCDD	0.000	6.39	0.000	0	0.110	0.0050	0.000
123478-HxCDD	0.000	6.39	0.000	0	0.098	0.0400	0.000
123678-HxCDD	0.000	6.39	0.000	0	0.090	0.0400	0.000
123789-HxCDD	0.000	6.39	0.000	0	0.110	0.0400	0.000
OTHER HxCDD	0.000	6.39	0.000	-1	0.347	0.0004	0.000
1234678-HpCDD	0.311	6.39	0.049	1	0.000	0.0010	0.000
OTHER HpCDD	0.250	6.39	0.039	2	0.000	0.00001	0.000
OCDD	1.591	6.39	0.249	1	0.000	0.0000	0.000
TOTAL MCDF	0.000	6.39	0.000	0	0.022	0.0000	0.000
TOTAL DCDF	0.000	6.39	0.000	0	0.095	0.0000	0.000
TOTAL TriCDF	0.171	6.39	0.027	1	0.000	0.0000	0.000
2378-TCDF	0.020	6.39	0.003	1	0.000	0.1000	0.000
OTHER TCDF	0.000	6.39	0.000	-2	0.213	0.0010	0.000
12378-PCDF	0.000	6.39	0.000	0	0.073	0.1000	0.000
23478-PCDF	0.000	6.39	0.000	0	0.075	0.1000	0.000
OTHER PCDF	0.000	6.39	0.000	-2	0.380	0.0010	0.000
123478-HxCDF	0.000	6.39	0.000	0	0.055	0.0100	0.000
123678-HxCDF	0.000	6.39	0.000	0	0.048	0.0100	0.000
234678-HxCDF	0.000	6.39	0.000	0	0.065	0.0100	0.000
123789-HxCDF	0.000	6.39	0.000	0	0.083	0.0100	0.000
OTHER HxCDF	0.175	6.39	0.027	1	0.000	0.0001	0.000
1234678-HpCDF	0.311	6.39	0.049	1	0.000	0.0001	0.000
1234789-HpCDF	0.000	6.39	0.000	0	0.065	0.0001	0.000
OTHER HpCDF	0.046	6.39	0.007	1	0.000	0.00001	0.000
OCDF	0.263	6.39	0.041	1	0.000	0.0000	0.000
TOTAL CDD			0.354				0.000
TOTAL CDF			0.154				0.000
TOTAL CDD/CDF			0.508				0.001

Note: Number in column labelled "NUMB" indicates the following:

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EXAMPLE CALCULATIONS

Wheelabrator Resource Recovery Facility
Millbury, Massachusetts

Run No. 2-MM5-I-1

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

$$Vm(std) = 17.64 * Y * Vm * \frac{(Pbar + Delta\ H/13.6)}{(460 + tm)}$$

$$Vm(std) = 17.64 * 1.0060 * 77.733 * \frac{(29.700 + 0.312/13.6)}{(460 + 85.2)}$$

$$Vm(std) = 75.203$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

$$Vw(std) = 0.04707 * Vlc$$

$$Vw(std) = 0.04707 * 226.00 = 10.638 \text{ SCF}$$

PERCENT MOISTURE, BY VOLUME, AS MEASURED IN FLUE GAS

$$\%H2O = 100 * Vw(std) / (Vw(std) + Vm(std))$$

$$\%H2O = 100 * \frac{10.638}{10.638 + 75.203} = 12.4\%$$

DRY MOLE FRACTION OF FLUE GAS

$$Mfd = 1 - \%H2O/100$$

$$Mfd = 1 - 12.4\% = 0.876$$

WET MOLECULAR WEIGHT OF FLUE GAS

$$Ms = (Md * Mfd) + (0.18 * \%H2O)$$

$$Ms = (29.92 * 0.876) + (0.18 * 12.4) = 28.44 \text{ LB/LB-MOLE}$$

*Standard conditions: 68°F and 29.92 inches of Hg.

EXAMPLE CALCULATIONS Page 2

Run No. 2-MM5-I-1

ABSOLUTE FLUE GAS PRESSURE

$$Ps = Pbar + Pg / 13.6$$

$$Ps = 29.700 + (-2.250 / 13.6) = 29.53$$

AVERAGE FLUE GAS VELOCITY e: (Delta p)avg is square of avg sq. root]

$$vs = 85.49 * Cp * SQRT\left[\frac{(Delta\ p)avg * (460 + ts)}{Ps * Ms}\right]$$

$$vs = 85.49 * 0.840 * SQRT\left[\frac{0.5140 * (460 + 440.0)}{29.53 * 28.44}\right]$$

$$vs = 53.29 \text{ FT/SEC}$$

DRY VOLUMETRIC FLUE GAS FLOW RATE @ STANDARD CONDITIONS

$$Qsd = \frac{60}{144} * Mfd * vs * A * \frac{Tstd}{ts + 460} * \frac{Ps}{Pstd}$$

$$Qsd = \frac{60}{144} * 0.876 * 53.29 * 8659 * \frac{528}{440.0 + 460} * \frac{29.53}{29.92}$$

$$Qsd = 97,545 \text{ SCFM}$$

WET VOLUMETRIC STACK GAS FLOW RATE @ FLUE GAS CONDITIONS

$$Qaw = 60/144 * vs * A$$

$$Qaw = 60/144 * 53.29 * 8659 = 192,266 \text{ ACFM}$$

PERCENT ISOKINETIC OF SAMPLING RATE

$$\%I = \frac{Pstd}{Tstd} * \frac{100}{60} * \frac{(ts + 460) * Vm(stsd)}{Ps * vs * Mfd * Theta * Area\text{-}Nozzle,\ sq.ft.}$$

$$\%I = \frac{29.92}{528} * \frac{100}{60} * \frac{(440.0 + 460) * 75.203}{29.53 * 53.29 * 0.876 * 240.0 * 0.000178}$$

$$\%I = 108.1\ \%$$

Run No. 2-MM5-I-1

GRAINS PER DRY STANDARD CUBIC FOOT : Total CDD/CDF

$$gr/DSCF = \frac{7000 \text{ grains}}{453{,}592{,}000{,}000 \text{ ng}} * \frac{ngs}{Vm(std)}$$

$$gr/DSCF = \frac{7000}{453{,}592{,}000{,}000} * \frac{456.723}{75.203} = 9.372E-08$$

NANOGRAMS PER DRY STANDARD CUBIC METER: Total CDD/CDF

$$ng/dscm = \frac{35.43 \text{ ft3}}{1 \text{ m3}} * \frac{ngs}{Vm(std)}$$

ng/dscm = 35.34 * 456.723 / 75.203 = 214.6

POUNDS PER HOUR - PMRc: Total CDD/CDF

$$lb/hr = \frac{1 \text{ lb}}{7000 \text{ grains}} * \frac{60 \text{ min}}{1 \text{ hr}} * \frac{grains}{dscf} * \frac{dscf}{min}$$

lb/hr = 60 / 7000 * 9.37E-08 * 97545 = 7.836E-05

NANOGRAMS PER DRY STANDARD CUBIC METER CORRECTED TO 12% CO2: Total CDD/

$$ng/dscm\ (corr) = \frac{ng}{dscm} * \frac{12}{\%CO2}$$

ng/dscm (corr) = 214.625 * 12/ 9.4 = 273.99

Run No. 2-MM5-I-1

2378 - TOXIC EQUIVALENTS: 12378-PCDD

$$\text{2378-TCDD Toxic Equiv (ng/dscm)} = \frac{35.34\ ft3}{1\ m3} * \frac{ngs}{Vm(std)} * \frac{12}{\%CO2} * \text{Toxic Equiv Factor}$$

$$\text{2378-TCDD Toxic Equiv (ng/dscm)} = 35.34 * \frac{1.429}{75.203} * \frac{12}{9.4} * 0.5000$$

$$= 0.429$$

PROCESS SAMPLES - NANOGRAMS PER GRAM: ESP Ash, All Fields - OCDD

$$ng/g = \frac{\text{ng in sample}}{\text{sample wt. (g)}}$$

$$ng/g = \frac{9.534}{10.13} = 0.941$$

APPENDIX B

FIELD AND ANALYTICAL DATA

- MM5 Field Data
- Orsat Field Data
- Process Sample Collection Forms
- Sample Recovery and Integrity Data Form (Moisture Data)
- Sample Inventory
- Triangle Laboratories Sample Tracking Form
- Triangle Laboratories CDD/CDF Analytical Data
- Triangle Laboratories Confirmational Analytical Data
- Percent Carbon, Percent Ash for Ash Samples
- Percent Solids, Specific Gravity for Lime Slurry Samples

Preliminary Field Data

PLANT NAME Wheelabrator

LOCATION Millbury, Mass.

SAMPLING LOCATION Nos. 1 & 2 SDA Inlets

DUCT DEPTH
FROM INSIDE FAR WALL TO OUTSIDE OF PORT 119"

NIPPLE LENGTH 14"

DEPTH OF DUCT 105"

WIDTH (RECTANGULAR DUCT) NA

EQUIVALENT DIAMETER:

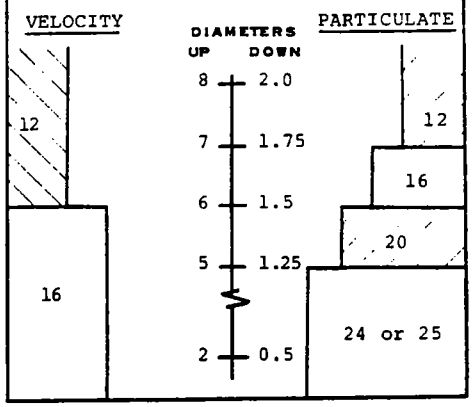
$D_E = \frac{2 \times \text{DEPTH} \times \text{WIDTH}}{\text{DEPTH} + \text{WIDTH}} = \frac{2(\quad)(\quad)}{(\quad + \quad)} = \_\_\_\_$

DISTANCE FROM PORTS TO NEAREST FLOW DISTURBANCE	UPSTREAM	DOWNSTREAM
	~35'	~19'
DIAMETERS	~4	~2.2

STACK AREA= $(105/2)^2 \pi$ = 86.9 IN^2

DRAW HORIZONTAL LINE THROUGH DIAMETERS

If more than 8 and 2 diameters and if duct dia. is less than 24", use 8 or 9 points.



Point	% OF DUCT DEPTH	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
1	2.1	2 1/4	16 1/4
2	6.7	7	21
3	11.8	12 3/8	26 3/8
4	17.7	18 5/8	32 5/8
5	25	26 1/4	40 1/4
6	35.6	37 3/8	51 3/8
7	64.4	67 5/8	81 5/8
8	75	78 3/4	92 3/4
9	82.3	86 3/4	100 3/8
10	88.2	92 5/8	106 5/8
11	93.3	98	112
12	97.9	102 3/4	116 3/4
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF TRAVERSE POINTS IN RECTANGULAR STACKS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

MODIFIED METHOD 5 FIELD DATA

COMPANY NAME Wheelabrator
ADDRESS Millbury, MASS
SAMPLING LOCATION #2 SDA Inlet
DATE 2-8-88
TEAM LEADER [illegible]
BAROMETRIC PRESSURE, IN. HG 29.7
STATIC PRESSURE, IN. H_2O -2.25
RUN NUMBER 2MM5-IN-1
TIME START 0858
TIME FINISH 1538
TECHNICIANS —

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15 15 3 6 5
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.008 0.012 0.010 0.000 0.000 0.009

LK. READ	ES NG
677.51	
675	18
690	21
690.20	
709.95	
709.	1

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- ✓ PITOTS, POST-TEST
- ✓ ORSAT SAMPLING SYSTEM
- ✓ TEDLAR BAG
- ✓ THERMOCOUPLE @ 450 °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE 905 DIAMETER .181
METER BOX N16 T/C READOUT F6
UMBILICAL U2 T/C PROBE 11-51
SAMPLE BOX 22 ORSAT PUMP 11
PROBE 11- TEDLAR BAG 17

FILTER #	TARE

NOMOGRAPH SET-UP NOMOGRAPH # [illegible]

$\Delta H_@$ 1.75 C FACTOR 0.88
METER TEMP 90 STACK TEMP 240
% MOISTURE 12 REF. ΔP 2.95

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP. °F FILTER BOX	GAS TEMP. °F CONDEN. EXIT	GAS TEMP. °F IMPIN. EXIT	STACK TEMP	*
A-1	0/0	651.343	0.34	0.21	0.21	74	1	260	28	59	430	
	5	652.63	0.32	0.20	0.20	75	1	263	28	51	431	
2	10	653.85	0.34	0.21	0.21	76	2	261	30	52	431	
	15	655.15	0.39	0.24	0.24	77	2	255	28	51	430	
3	20	656.50	0.53	0.33	0.33	78	2	247	29	49	435	
	25	658.08	0.55	0.34	0.34	79	2	245	29	49	434	
4	30	659.64	0.51	0.32	0.32	80	3	246	30	48	436	
	35	661.15	0.50	0.31	0.31	81	3	247	30	49	435	
5	40	662.63	0.59	0.37	0.37	81	7	249	30	49	434	
	45	664.25	0.56	0.35	0.35	82	10	250	31	49	434	
6	50	665.87	0.56	0.35	0.35	84	11	250	31	48	430	
	55	667.48	0.42	0.26	0.26	85	12	249	30	49	432	
7	60	668.91	0.54	0.34	0.34	86	12	257	31	50	434	
	65	670.49	0.53	0.33	0.33	87	13	255	31	50	436	
8	70	672.07	0.51	0.32	0.32	87	13	251	33	51	437	
	75	673.71	0.53	0.33	0.33	88	14	249	32	54	437	
9	80	677.181	0.53	0.33	0.33	84	1	230	31	52	436	
	85	679.12	0.52	0.32	0.32	85	2	248	31	52	437	
10	90	680.72	0.56	0.35	0.35	86	2	249	32	53	438	
	95	682.37	0.58	0.36	0.36	86	2	251	32	53	440	
11	100	684.13	0.48	0.30	0.30	86	2	253	32	55	443	
	105	685.63	0.51	0.32	0.32	87	2	253	32	54	440	
12	110	687.26	0.44	0.27	0.27	87	2	251	33	54	438	
	115	688.71	0.46	0.29	0.29	88	2	250	33	54	439	
	120/0	690.215	0.41	0.26	0.26	87	2	251	34	55	435	

Fyrite 9.5%

new filter →

V_M $\overline{(\sqrt{\Delta P})^2}$ ~~0.322~~ $\overline{\Delta H}$ $\overline{T_M}$ $\overline{T_S}$

ENTROPY

MODIFIED METHOD 5 FIELD DATA

Page 2 Run Number 2MM5-IN-1

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP. °F FILTER BOX	GAS TEMP. °F CONDEN. EXIT	GAS TEMP. °F IMPIN. EXIT	STACK TEMP.	*
B 1	5	691.65	0.43	0.27	0.27	87	2	251	33	52	435	
2	10	693.10	0.49	0.31	0.31	87	2	250	33	55	437	
	15	694.61	0.47	0.29	0.29	87	3	251	34	55	440	
3	20	696.13	0.56	0.35	0.35	87	3	251	34	53	442	
	25	297.72	0.56	0.35	0.35	87	3	250	33	54	441	
4	30	699.37	0.61	0.38	0.38	87	3	251	34	56	446	
	35	701.13	0.60	0.37	0.37	88	3	249	34	59	446	
5	40	702.81	0.52	0.32	0.32	88	3.5	249	35	59	442	
	45	704.42	0.55	0.34	0.34	88	3.5	249	35	62	442	
6	50	706.03	0.50	0.31	0.31	88	3.5	249	35	61	443	
	55	707.58	0.51	0.32	0.32	88	3.5	250	34	59	443	
7	60	709.195	0.51	0.32	0.32	88	3.5	250	34	57	449	
	65	710.78	0.48	0.30	0.30	88	4	250	34	57	448	
8	70	712.33	0.54	0.34	0.34	88	4	251	34	58	447	
	75	713.92	0.51	0.32	0.32	88	4	252	34	58	447	
9	80	715.51	0.63	0.39	0.39	88	4	251	34	59	452	
	85	717.24	0.64	0.40	0.40	89	4.5	252	34	56	450	
10	90	719.00	0.57	0.36	0.36	89	4.5	251	35	55	444	
	95	720.71	0.61	0.38	0.38	89	4.5	251	34	53	446	
11	100	722.44	0.59	0.37	0.37	89	5	252	34	52	446	
	105	724.15	0.59	0.37	0.37	89	5	252	35	51	445	
12	110	725.84	0.52	0.32	0.32	89	5	251	35	51	443	
	115	727.44	0.56	0.35	0.35	89	5	251	34	50	444	
	04/off	729.085										

709.195
709.151

75.354 77.368 0.5131 0.322 85 440

V_M $(\sqrt{\Delta P})^2$ ΔH T_M T_S

ENTROPY

MODIFIED METHOD 5 FIELD DATA

COMPANY NAME Wheelabrator
ADDRESS Millbury, Mass.
SAMPLING LOCATION #2 SDA Inlet
DATE 2-8-88
TEAM LEADER TMS
TECHNICIANS —
RUN NUMBER 2 mm5-IN-2
TIME START 1630
TIME FINISH 2111
BAROMETRIC PRESSURE, IN. HG 29.7
STATIC PRESSURE, IN. H_2O -2.15
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 7 6
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.000 0.000 0.000

LK. TEST READINGS
768.360
768.399

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- ✓ PITOTS, POST-TEST
- ✓ ORSAT SAMPLING SYSTEM
- — TEDLAR BAG
- ✓ THERMOCOUPLE @ 440 °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE 905 DIAMETER .181
METER BOX N16 T/C READOUT F6
UMBILICAL U2 T/C PROBE 11-
SAMPLE BOX 24 ORSAT PUMP 9
PROBE 11- TEDLAR BAG 20

FILTER #	TARE

NOMOGRAPH SET-UP NOMOGRAPH # TMS

$\Delta H_@$ 1.75 C FACTOR 0.88
METER TEMP 90 STACK TEMP 440
% MOISTURE 12 REF. ΔP 2.95

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP. °F FILTER BOX	GAS TEMP. °F CONDEN. EXIT	GAS TEMP. °F IMPIN. EXIT	STACK TEMP.	*
B 1	0/0	730.146	0.40	0.25	0.25	79	0	255	31	47	435	
	5	731.55	0.38	0.24	0.24	81	1	253	31	47	436	
2	10	732.91	0.45	0.28	0.28	82	2	253	32	48	439	
	15	734.39	0.44	0.27	0.27	83	2	255	32	48	440	
3	20	735.86	0.47	0.29	0.29	84	2	254	32	48	444	
	25	737.35	0.53	0.33	0.33	84	3	254	33	48	443	
4	30	738.93	0.47	0.29	0.29	85	3	253	33	49	447	
	35	740.42	0.48	0.30	0.30	85	3	253	32	49	446	
5	40	741.23	0.52	0.32	0.32	86	3	251	32	47	440	
	45	743.50	0.52	0.32	0.32	86	3	252	33	48	443	
6	50	745.04	0.48	0.30	0.30	86	3	253	33	48	445	
	55	746.59	0.57	0.36	0.36	87	3	253	35	49	448	
7	60	748.20	0.48	0.30	0.30	87	4	255	35	49	451	
	65	749.77	0.48	0.30	0.30	87	4	254	32	47	450	
8	70	751.39	0.62	0.39	0.39	87	4	254	32	48	448	
	75	752.97	0.61	0.38	0.38	87	4	255	33	49	447	
9	80	754.69	0.66	0.41	0.41	87	4	255	33	49	449	
	85	756.47	0.56	0.35	0.35	86	4	254	33	48	447	
10	90	758.20	0.65	0.41	0.41	86	5	258	34	49	451	
	95	759.94	0.55	0.34	0.34	86	5	259	34	49	448	
11	100	761.69	0.52	0.32	0.32	86	4	268	35	53	446	
	105	763.26	0.61	0.38	0.38	86	4	265	36	55	447	
12	110	764.91	0.63	0.39	0.39	86	5	258	35	55	443	
	115	766.65	0.60	0.37	0.37	86	5	255	35	54	441	
A 1	120/0	768.399	0.44	0.27	0.27	86	4	256	36	56	440	

768.360
768.399

V_M ~~0.5063~~ $(\sqrt{\Delta P})^2$ ~~0.316~~ ΔH ~~85~~ T_M ~~442~~ T_S

ENTROPY

MODIFIED METHOD 5 FIELD DATA

Page 2 Run Number 2. mm5-IV-2

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP. °F FILTER BOX	GAS TEMP. °F CONDEN. EXIT	GAS TEMP. °F IMPIN. EXIT	STACK TEMP.	*
1	5	769.83	0.42	0.26	0.26	86	5	257	36	54	433	
2	10	771.24	0.55	0.34	0.34	86	5	258	38	55	441	
	15	772.86	0.54	0.34	0.34	86	5	257	38	55	442	
3	20	774.48	0.52	0.32	0.32	86	5	257	37	55	440	
	25	776.08	0.56	0.35	0.35	86	5	255	32	53	441	
4	30	777.71	0.60	0.37	0.37	86	5	255	31	54	442	
	35	779.42	0.63	0.39	0.39	86	5	256	32	54	439	
5	40	781.17	0.63	0.39	0.39	86	5	255	32	54	442	
	45	782.91	0.65	0.41	0.41	86	6	249	32	53	441	
6	50	784.68	0.61	0.38	0.38	86	6	248	32	54	439	
	55	786.42	0.51	0.32	0.32	86	5.5	248	33	48	441	
7	60	788.05	0.44	0.27	0.27	86	5	247	32	47	442	
	65	789.61	0.46	0.29	0.29	86	5	247	32	48	441	
8	70	791.05	0.44	0.27	0.27	86	5	247	33	48	444	
	75	792.51	0.44	0.27	0.27	85	5	248	33	49	443	
9	80	793.99	0.40	0.25	0.25	85	5	248	36	49	439	
	85	795.47	0.45	0.28	0.28	85	5	248	37	48	443	
10	90	797.18	0.42	0.26	0.26	85	5	249	38	48	436	
	95	798.42	0.42	0.26	0.26	85	5	248	40	49	437	
11	100	799.87	0.40	0.25	0.25	85	5	249	40	51	435	
	105	801.29	0.43	0.27	0.27	85	5	249	40	50	436	
12	110	802.77	0.35	0.24	0.24	86	5	248	39	50	435	
	115	804.16	0.38	0.24	0.24	86	5	247	41	52	437	
	240/off	805.542										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
75.357	0.5063 (0.5049)	0.316	85	442

ENTROPY

MODIFIED METHOD 5 FIELD DATA

COMPANY NAME wheelabrator
ADDRESS Millbury, Mass
SAMPLING LOCATION #2 SDA Inlet
DATE 2-9-88
TEAM LEADER (TMS)
TECHNICIANS —
RUN NUMBER 2MM5-III-3
TIME START 0830
TIME FINISH 1315
BAROMETRIC PRESSURE, IN. HG 29.7
STATIC PRESSURE, IN. H_2O -2.15
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15 5 5
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.009 0.009 0.000 0.000

LK. TEST READINGS
846.911
846.678
879.770
879.726

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- ✓ PITOTS, POST-TEST
- ✓ ORSAT SAMPLING SYSTEM
- ✓ TEDLAR BAG
- ✓ THERMOCOUPLE @ 440 °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE 905 DIAMETER .181
METER BOX N16 T/C READOUT E6
UMBILICAL U2 T/C PROBE 11-
SAMPLE BOX 22 ORSAT PUMP 9
PROBE 11- TEDLAR BAG 17

FILTER # **TARE**

NOMOGRAPH SET-UP NOMOGRAPH # (TMS)

$\Delta H_@$ 1.75 C FACTOR 0.87 - .05 = 0.82
METER TEMP 80 STACK TEMP 440
% MOISTURE 12 REF. ΔP ~~2.95~~ 3.10

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP. °F FILTER BOX	GAS TEMP. °F CONDEN. EXIT	GAS TEMP. °F IMPIN. EXIT	STACK TEMP.	*
A 1	0/0	846.015	0.31	0.19	0.19	73	0	250	31	48	419	
	5	847.37	0.29	0.17	0.17	73	0	249	31	45	420	
2	10	848.56	0.47	0.28	0.28	74	1	248	31	45	422	
	15	850.03	0.47	0.28	0.28	75	1	250	30	45	422	
3	20	851.51	0.50	0.30	0.30	77	2	249	30	44	425	
	25	853.05	0.49	0.29	0.29	78	2	249	31	45	425	
4	30	854.55	0.54	0.32	0.32	78	2	248	31	45	428	
	35	856.13	0.52	0.31	0.31	78	2	247	30	45	429	
5	40	857.73	0.58	0.34	0.34	79	3	247	30	46	430	
	45	859.29	0.56	0.33	0.33	79	3	248	29	46	432	
6	50	860.89	0.50	0.30	0.30	79	3	247	29	49	433	
	55	862.48	0.48	0.28	0.28	80	3	248	30	51	435	
7	60	863.90	0.40	0.24	0.24	80	3	248	30	52	432	
	65	865.27	0.39	0.23	0.23	81	3	248	29	52	431	
8	70	866.62	0.40	0.24	0.24	81	3	249	30	58	431	
	75	867.95	0.40	0.24	0.24	81	3	253	30	59	433	
9	80	869.27	0.34	0.20	0.20	81	3	255	31	58	428	
	85	870.55	0.40	0.24	0.24	81	3	254	31	59	431	
10	90	871.88	0.37	0.22	0.22	81	3	254	30	58	425	
	95	873.21	0.39	0.23	0.23	81	3	255	30	59	427	
11	100	874.52	0.40	0.24	0.24	82	4	251	31	57	431	
	105	875.86	0.38	0.23	0.23	82	4	251	31	57	432	
12	110	877.22	0.33	0.20	0.20	82	4	252	30	56	430	
	115	878.47	0.33	0.20	0.20	83	4	251	31	57	431	
B 1	120/0	879.770	0.27	0.16	0.16	82	2	249	32	58	424	

V_M $\overline{(\sqrt{\Delta P})^2}$ $\overline{\Delta H}$ $\overline{T_M}$ $\overline{T_S}$

ENTROPY

MODIFIED METHOD 5 FIELD DATA Page 2 Run Number MM5-IU-3

Wheelabrator

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP., °F FILTER BOX	GAS TEMP., °F CONDEN. EXIT	GAS TEMP., °F IMPIN. EXIT	STACK TEMP.	*
B 1	5	880.72	0.28	0.17	0.17	83	2	250	30	61	423	
2	10	881.82	0.43	0.26	0.26	83	4	250	29	62	427	
	15	883.25	0.43	0.26	0.26	83	4	249	29	58	429	
3	20	884.63	0.45	0.27	0.27	83	4	248	29	57	427	
	25	886.08	0.44	0.26	0.26	83	4	249	30	55	426	
4	30	887.51	0.46	0.27	0.27	84	4	248	30	56	427	
	35	888.97	0.45	0.27	0.27	84	4	248	30	55	427	
5	40	890.51	0.46	0.27	0.27	84	4	249	30	56	429	
Pyrite ⇒ 5%	45	891.95	0.47	0.28	0.28	84	4	249	29	56	430	
6	50	893.39	0.42	0.25	0.25	85	4	249	29	57	432	
	55	894.82	0.42	0.25	0.25	85	4	250	29	57	430	
7	60	896.24	0.41	0.24	0.24	86	4	250	30	57	431	
	65	897.59	0.44	0.26	0.26	86	4	251	30	56	431	
8	70	899.02	0.48	0.28	0.28	86	5	251	31	56	436	
	75	900.50	0.48	0.28	0.28	86	5	252	30	56	436	
9	80	901.96	0.54	0.32	0.32	87	5	254	28	55	442	
	85	903.51	0.60	0.36	0.36	87	5	253	29	55	447	
10	90	905.20	0.66	0.39	0.39	88	5	253	29	56	449	
	95	906.96	0.54	0.32	0.32	89	5	254	30	55	444	
11	100	908.55	0.40	0.24	0.24	89	5	251	30	55	437	
	105	909.93	0.54	0.32	0.32	89	5	251	30	56	436	
12	110	911.52	0.47	0.28	0.28	89	5	252	30	56	436	
	115	912.97	0.50	0.30	0.30	89	5	252	31	55	436	
	240/off	914.496										

V_M	$\frac{}{(\sqrt{\Delta P})^2}$	$\frac{}{\Delta H}$	$\frac{}{T_M}$	$\frac{}{T_S}$
68.204	0.4394	0.264	82	431

ENTROPY

MODIFIED METHOD 5 FIELD DATA

COMPANY NAME Wheelabrator
ADDRESS Millbury, Mass
SAMPLING LOCATION #2 SDA Inlet
DATE 2-9-88
TEAM LEADER TMG
TECHNICIANS
RUN NUMBER 2MAS-II-4
TIME START 1430
TIME FINISH 1954

BAROMETRIC PRESSURE, IN. HG 29.7
STATIC PRESSURE, IN. H_2O -2.10

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 14 14 14 15 2
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.015 0.018 0.018 0.017 0.009 0.000

LK. TEST READINGS
~~942.198~~ 941.848
943.806
942.863
951.755
951.730
964.371
964.207

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- ___ PITOTS, POST-TEST
- ✓ ORSAT SAMPLING SYSTEM
- ✓ TEDLAR BAG
- ___ THERMOCOUPLE @ 440 °F

IDENTIFICATION NUMBERS

REAGENT BOX ___ NOZZLE 905 DIAMETER .181
METER BOX N16 T/C READOUT F6
UMBILICAL U2 T/C PROBE 11-
SAMPLE BOX 22 ORSAT PUMP 9
PROBE 11- TEDLAR BAG 17

FILTER # **TARE**

NOMOGRAPH SET-UP NOMOGRAPH # TMG

$\Delta H_@$ 1.75 C FACTOR 0.87-0.05 = 0.82
METER TEMP 80 STACK TEMP 440
% MOISTURE 12 REF. ΔP 3.10

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP., °F FILTER BOX	GAS TEMP., °F CONDEN. EXIT	GAS TEMP., °F IMPIN. EXIT	STACK TEMP.	*
1	0/0	916.114	0.38	0.23	0.23	75	0	273	31	51	428	
	5	917.51	0.37	0.22	0.22	75	0	273	29	50	423	
2	10	918.71	0.50	0.30	0.30	76	1	264	29	50	435	
	15	920.28	0.47	0.28	0.28	76	1	258	29	50	434	
3	20	921.78	0.48	0.28	0.28	77	1	253	29	51	432	
	25	923.26	0.48	0.28	0.28	79	1	252	28	50	432	
4	30	924.73	0.50	0.30	0.30	80	1	252	29	50	432	
	35	926.26	0.51	0.30	0.30	81	2	254	29	50	432	
5	40	927.78	0.45	0.27	0.27	82	2	251	29	48	433	
	45	929.24	0.46	0.27	0.27	82	2	251	30	48	433	
6	50	930.69	0.45	0.27	0.27	81	2	250	30	49	435	
	55	932.15	0.43	0.26	0.26	81	2	252	29	49	434	
7	60	933.60	0.49	0.29	0.29	82	2	252	30	49	438	
	65	935.03	0.45	0.27	0.27	82	3	255	41	49	436	
8	70	936.31	0.47	0.28	0.28	82	7	254	39	48	454	
	75	937.62	0.42	0.25	0.25	83	10	254	36	49	435	
9	80	939.08	0.44	0.26	0.26	83	10	255	32	48	434	
	85	940.47	0.42	0.25	0.25	83	11	257	32	49	453	
10	90	942.198	0.48	0.28	0.28	82	1	253	33	48	440	
	95	943.94	0.51	0.30	0.30	84	2	253	32	48	441	
11	100	945.48	0.48	0.28	0.28	84	2	252	31	49	439	
	105	946.99	0.50	0.30	0.30	85	2	252	31	48	438	
12	110	948.54	0.52	0.31	0.31	85	2	250	33	48	439	
	115	950.10	0.55	0.33	0.33	85	2	250	35	49	440	
1	120/0	951.755	0.41	0.24	0.24	84	2	253	38	50	426	

new filter ⇒

V_M $\overline{(\sqrt{\Delta P})^2}$ $\overline{\Delta H}$ $\overline{T_M}$ $\overline{T_S}$

ENTROPY

MODIFIED METHOD 5- FIELD DATA Page 2 Run Number 2MMS-II-4

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP. °F FILTER BOX	GAS TEMP. °F CONDEN. EXIT	GAS TEMP. °F IMPIN. EXIT	STACK TEMP.	*
1	5	953.15	0.43	0.26	0.26	84	2	268	28	49	426	
2	10	954.61	0.58	0.34	0.34	84	2	265	29	48	439	
	15	956.22	0.64	0.38	0.38	84	2	263	32	49	441	
3	20	957.96	0.66	0.39	0.39	83	2	260	31	49	444	
	25	959.71	0.64	0.38	0.38	83	3	260	30	49	441	
4	30	961.36	0.55	0.33	0.33	83	3	255	30	51	435	
	35	962.81	0.47	0.28	0.28	83	5	256	32	51	432	
5	40	964.371	0.43	0.26	0.26	80	1	245	32	49	429	
	45	965.88	0.46	0.27	0.27	80	2	249	33	48	429	
6	50	967.34	0.47	0.28	0.28	80	2	252	33	49	433	
	55	968.86	0.48	0.28	0.28	81	2	251	32	49	435	
7	60	970.37	0.38	0.23	0.23	81	2	251	30	51	436	
	65	971.74	0.41	0.24	0.24	81	2	250	31	50	438	
8	70	973.06	0.41	0.24	0.24	81	2	250	30	50	435	
	75	974.46	0.37	0.22	0.22	80	2	252	30	51	432	
9	80	975.78	0.38	0.23	0.23	80	2	251	32	51	433	
	85	977.10	0.44	0.26	0.26	80	2	261	29	53	434	
10	90	978.53	0.42	0.25	0.25	80	2	264	29	54	433	
	95	979.97	0.40	0.24	0.24	80	2	265	30	54	433	
11	100	981.36	0.44	0.26	0.26	81	3	261	29	53	433	
	105	982.79	0.42	0.25	0.25	81	3	258	29	52	436	
12	110	984.17	0.38	0.23	0.23	81	3	255	28	56	434	
	115	985.53	0.41	0.24	0.24	81	3	253	29	52	433	
	240/off	986.780										

new filter ↳

Hybrite ~5%

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
69.789	0.4621	0.276	81	434 ~~433~~

Final 3 leak checks on Test log

ENTROPY

MODIFIED METHOD 5 FIELD DATA

COMPANY NAME Wheelabrator
ADDRESS Millbury, Mass.
SAMPLING LOCATION #2 SDA Inlet
DATE 2-10-88 TEAM LEADER TMS TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 29.7 STATIC PRESSURE, IN. H_2O -2.10
RUN NUMBER MAS-I-5 (2-)
TIME START 0845
TIME FINISH 1343

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 3 15 15 1
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.003 0.000 0.004 0.000 0.000

LK. TEST READINGS: 1030.972, 1030.936, 1050.703, 1050.474

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- ✓ PITOTS, POST-TEST
- ✓ ORSAT SAMPLING SYSTEM
- ✓ TEDLAR BAG
- ✓ THERMOCOUPLE @ 440 °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE 905 DIAMETER .181
METER BOX N16 T/C READOUT F6
UMBILICAL U2 T/C PROBE 11-
SAMPLE BOX 22 ORSAT PUMP 9
PROBE 11- TEDLAR BAG 17

FILTER # / **TARE**

NOMOGRAPH SET-UP NOMOGRAPH # (TMS)

ΔH@ 1.75 C FACTOR 0.87 - 0.05 = 0.82
METER TEMP 80 STACK TEMP 440
% MOISTURE 12 REF. ΔP 3.10

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP., °F FILTER BOX	GAS TEMP., °F CONDEN. EXIT	GAS TEMP., °F IMPIN. EXIT	STACK TEMP.	*
A 1	0/0	997.796	0.34	0.20	0.20	71	0	251	30	43	421	
	5	999.01	0.36	0.21	0.21	71	0	255	29	48	419	
2	10	1000.32	0.42	0.25	0.25	72	1	256	29	49	423	
	15	1.75	0.42	0.25	0.25	73	1	251	29	48	421	
3	20	3.16	0.44	0.26	0.26	75	1	250	29	49	421	
	25	4.61	0.55	0.33	0.33	76	1	250	30	49	427	
4	30	6.18	0.46	0.27	0.27	77	1	252	28	48	423	
	35	7.68	0.48	0.28	0.28	78	1	252	29	48	424	
5	40	9.18	0.49	0.29	0.29	80	2	251	29	49	424	
	45	10.65	0.48	0.28	0.28	80	2	253	30	49	422	
6	50	12.04	0.43	0.26	0.26	80	2	252	30	48	427	
	55	13.49	0.48	0.28	0.28	80	2	253	32	49	429	
7	60	14.98	0.40	0.24	0.24	80	2	252	31	49	430	
	65	16.35	0.42	0.25	0.25	81	2	253	29	52	431	
8	70	17.76	0.43	0.26	0.26	82	2	255	28	53	433	
	75	19.16	0.38	0.23	0.23	83	2	254	28	53	429	
9	80	20.54	0.37	0.22	0.22	84	2	253	28	52	429	
	85	21.85	0.35	0.23	0.23	84	2	257	28	52	428	
10	90	23.19	0.41	0.24	0.24	85	2	252	28	53	427	
	95	24.54	0.34	0.20	0.20	85	2	253	29	52	423	
11	100	25.80	0.36	0.21	0.21	86	2	253	29	53	425	
	105	27.15	0.36	0.21	0.21	80	2	252	28	52	423	
12	110	28.50	0.33	0.20	0.20	81	2	252	28	55	423	
	115	29.70	0.32	0.19	0.19	82	3	254	29	55	421	
B 1	120/0	1030.972	0.32	0.19	0.19	82	1	252	29	55	422	

V_M $\overline{(\sqrt{\Delta P})^2}$ $\overline{\Delta H}$ $\overline{T_M}$ $\overline{T_S}$

ENTROPY

MODIFIED METHOD 5 FIELD DATA Page 2 Run Number 2-mms2-I-5

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	GAS TEMP. °F FILTER BOX	GAS TEMP. °F CONDEN. EXIT	GAS TEMP. °F IMPIN. EXIT	STACK TEMP.	*
1	5	32.09	0.32	0.19	0.19	82	2	254	29	43	421	
2	10	33.23	0.41	0.24	0.24	82	3	253	29	44	424	
	15	34.55	0.43	0.26	0.26	82	4	253	28	44	423	
3	20	35.94	0.45	0.27	0.27	83	4	255	29	46	426	
	25	37.33	0.42	0.25	0.25	83	6	254	29	47	427	
4	30	38.64	0.40	0.24	0.24	84	7	255	30	48	428	
	35	40.04	0.41	0.24	0.24	83	9	255	30	48	428	
5	40	41.41	0.39	0.23	0.23	83	10	253	29	51	432	
	45	42.69	0.40	0.24	0.24	84	11	259	29	52	433	
6	50	44.00	0.42	0.25	0.25	85	11	261	27	50	434	
	55	45.35	0.39	0.23	0.23	87	12	260	28	51	433	
7	60	46.72	0.37	0.22	0.22	88	12	260	28	51	434	
	65	47.95	0.41	0.24	0.24	88	12	263	29	50	434	
8	70	49.25	0.41	0.24	0.24	89	12	255	29	47	431	
new filter →	75	1050.703	0.49	0.29	0.29	86	0	231	29	49	436	
9	80	52.18	0.47	0.28	0.28	86	1	257	29	48	438	
	85	53.72	0.49	0.29	0.29	86	1	253	30	48	438	
10	90	55.24	0.55	0.33	0.33	87	1	250	30	49	442	
	95	56.88	0.58	0.34	0.34	87	1	250	31	51	443	
11	100	58.52	0.52	0.31	0.31	88	1	249	30	51	442	
	105	60.09	0.61	0.36	0.36	88	1	249	30	50	445	
12	110	61.79	0.54	0.32	0.32	88	1	251	29	49	444	
Ignite 8 %	115	63.36	0.49	0.29	0.29	88	1	250	30	49	441	
	240/off	1064.886										

V_M	$(\sqrt{\Delta P})^2$	$\overline{\Delta H}$	$\overline{T_M}$	$\overline{T_S}$
66.825	0.4252 ~~0.4246~~	0.254 ~~0.276~~	82 ~~81~~	429 ~~434~~

ENTROPY

ORSAT FIELD DATA

Plant Name WHEELABRATOR MILLBURY, INC.

Sampling Location UNIT # 2 - SDA INLET Fuel Type REFUSE

Run and/or Sample No. 2-MM5-I-1 Leak Test? ✓ Date 02.08.88 Operator BDR

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
0858	1625	9.3	19.6	—	10.3	—	
To	1635	9.4	19.7		10.3		
1538	1640	9.4	19.7		10.3		
	Avg.	9.4		Avg.	10.3	—	80.3

Run and/or Sample No. 2-MM5-I-2 Leak Test? ✓ Date 02.08.88 Operator ATM

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
1630	2125	9.2	19.9	—	10.7	—	
To	2130	9.2	19.8		10.6		
2111	2135	9.2	19.9		10.7		
	Avg.	9.2		Avg.	10.7	—	80.1

Run and/or Sample No. 2-MM5-I-3 Leak Test? ✓ Date 02.09.88 Operator BDR

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
0830	1330	9.9	19.9	—	10.0	—	
To	1340	9.9	19.9		10.0		
1315	1350	9.9	19.9		10.0		
	Avg.	9.9		Avg.	10.0	—	80.1

ENTROPY ENVIRONMENTALISTS, INC.
SPECIALISTS IN SOURCE SAMPLING

ORSAT FIELD DATA

Plant Name WHEELABRATOR MILLBURY, INC.

Sampling Location UNIT # 2-SDA INLET Fuel Type REFUSE

Run and/or Sample No. 2-MMS-I-4 Leak Test? ✓ Date 02-09-88 Operator ATM

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
1430	2010	9.6	19.9	—	10.3	—	
To	2015	9.7	19.9		10.2		
1954	2020	9.7	19.8		10.2		
	Avg.	9.7		Avg.	10.2	—	80.1

Run and/or Sample No. 2-MMS-I-5 Leak Test? ✓ Date 02-10-88 Operator _____

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
	Avg.			Avg.			

Run and/or Sample No. _____ Leak Test? _____ Date _____ Operator _____

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
	Avg.			Avg.			

F-1009
8/86

ENTROPY ENVIRONMENTALISTS, INC. SPECIALISTS IN SOURCE SAMPLING

ORSAT FIELD DATA

Plant Name Wheelabrator, Millbury

Sampling Location #2 SDA Inlet Fuel Type GARBAGE

Run and/or Sample No. 2-MMS-I-5 Leak Test? ✓ Date 2-10-88 Operator TAS

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
0845	1400	9.3	19.3	—	10.0		
		9.3	19.3	—	10.0		
1343	1435	9.3	19.3	—	10.0		
	Avg.	9.3		Avg.	10.0		80.7

Run and/or Sample No. _____ Leak Test? _____ Date _____ Operator _____

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
	Avg.			Avg.			

Run and/or Sample No. _____ Leak Test? _____ Date _____ Operator _____

Time of Sample Collection	Time of Analysis	CO_2 Reading A	O_2 Reading B	CO Reading C	$\%O_2$ B-A	%CO C-B	$\%N_2$ 100-C
	Avg.			Avg.			

F-1009
8/86

ENTROPY ENVIRONMENTALISTS, INC. SPECIALISTS IN SOURCE SAMPLING

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelabrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE Bottom Ash

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) One scoop was taken every 15 minutes. The combined sample was coned and quartered. The sample was placed in two jars - A+B

SAMPLING LOG				
SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
2/8/88-Mill Ash-Bottom-1-a	2/8/88	940-1605	DGB	Bottom Ash
2/8/88-Mill Ash-Bottom-1-b	2/8/88	940-1605	DGB	Bottom Ash
2/8/88-Mill Ash-Bottom-2a	2/8/88	1730-2130	DGB	Bottom Ash
2/8/88-Mill Ash-Bottom-2-b	2/8/88	1730-2130	DGB	Bottom Ash
2/9/88-Mill Ash-Bottom-3a	2/9/88	915-1330	DGB	Bottom Ash
2/9/88-Mill Ash-Bottom-3b	2/9/88	915-1330	DGB	Bottom Ash
2/9/88-Mill Ash-Bottom-4-a	2/9/88	1515-2000	DGB	Bottom Ash
2/9/88-Mill Ash-Bottom-4-b	2/9/89	1515-2000	DGP	Bottom Ash

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

ENTROPY

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelabrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE Bottom Ash
Lime Slurry

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) One scoop of bottom ash was taken every 15 minutes. The combined sample was coned and quartered and then placed in two jars - ~~A+B~~ The Lime Slurry was taken once per each run.

SAMPLING LOG				
SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
2/10/88-MILL Ash-Bottom-5-a	2/10/88	920-1355	DGB	Bottom Ash
2/10/88-MILL Ash-Bottom-5-b	2/10/88	920-1355	DGB	Bottom Ash
2/8/88-MILL Lime-1	2/8/88	930	BFR	Lime Slurry
2/8/88-MILL Lime-2	2/8/88	1800	BFR	Lime Slurry
2/9/88-MILL Lime-3	2/9/88	1100	SCS	Lime Slurry
2/9/88-MILL Lime-4	2/9/88	1830	SCS	Lime Slurry
2/10/88-MILL Lim-5	2/10/88	1200	SCS	Lime Slurry

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

ENTROPY

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelabrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE Economizer Hopper Ash

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) A bottle was placed in the ash line from the economizer. The bottle was emptied every 15 minutes. The combined sample was coned and quartered. The sample was placed in two jars - A & B

SAMPLING LOG

SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
2/8/88-Mill ASH-ECON/GEN-1-a	2/8/88	910-1605	MGJ	Economizer ash line
2/8/88-Mill ASH-ECON/GEN-1-b	2/8/88	910-1605	MGJ	Econ ash line
2/8/88-Mill ASH-ECON/GEN-2-a	2/8/88	1700-2130	MGJ	Econ Ash Line
2/8/88-Mill ASH-ECON/GEN-2-b	2/8/88	1700-2130	MGJ	Econ Ash Line
2/9/88-Mill ASH-ECON/GEN-3-a	2/9/88	845-1330	MGJ	Econ Ash Line
2/9/88-Mill ASH-ECON/GEN-3-b	2/9/88	845-1330	MGJ	Econ Ash Line
2/9/88-Mill ASH-ECON/GEN-4-a	2/9/88	1445-2000	MGJ	Econ Ash Line
2/9/88-Mill ASH-ECON/GEN-4-b	2/9/88	1445-2000	MGJ	Econ Ash Line

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelabrator

PLANT LOCATION Millury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE Economizer Hopper Ash

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) A bottle was placed in the ash line from the economizer. The bottle was emptied every 15 minutes. The combined sample was coned and quartered. The sample was placed in two jars - A & B

SAMPLING LOG

SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
ASH-2/10/88-MILL ECON/GEN-5-a	2/10/88	855-1355	MGJ	Econ Ash Line
ASH-2/10/88-MILL ECON/GEN-5-b	2/10/88	855-1355	MGJ	Econ Ash Line

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

ENTROPY

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelabrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE SPRAY DRYER ASH

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) Sample taken with scoop. Three scoops taken every 15 minutes. Combined sample coned and quartered. The sample was placed in two jars - A & B

SAMPLING LOG

SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
ASH-2/8/88-MILL SPRAY DR-2-a	2/8/88	1704-2134-	WGD	SPRAY DRYER Hopper
ASH-2/8/88-MILL SPRAY DR-2-b	2/8/88	1704-2134	WGD	SPRAY DRYER Hopper
ASH-2/9/88-MILL SPRAY DR-3-a	2/9/88	849-1334	WGD	SPRAY DRYER Hopper
ASH-2/9/88-MILL SPRAY DR-3-b	2/9/88	849-1334	WGD	SPRAY DRYER Hopper
ASH-2/9/88-MILL SPRAY DR-4-a	2/9/88	1449-2004	WGD	SPRAY DRYER Hopper
ASH-2/9/88-MILL SPRAY DR-4-b	2/9/88	1449-2004	WGD	SPRAY DRYER Hopper
ASH-2/10/88-MILL SPRAY DR-5-a	2/10/88	859-1359	WGD	SPRAY DRYER Hopper
ASH-2/10/88-MILL SPRAY DR-5-b	2/10/88	859-1359	WGD	SPRAY DRYER Hopper

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelabrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE ESP Hopper Ash from Fields 1, 2 & 3
~~ESP~~ SPRAY DRYER ASH

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) Sample taken with scoop. One scoop for ESP Hopper ash and 3 scoops for spray dryer ash. Combined sample for each s: Coned and quartered. The sample was placed in two jars - A+B

SAMPLING LOG

SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
ASH-2/9/88-MILL ESP-ALL-4a	2/9/88	1447-2002	WGD	ESP Hopper All fields
ASH-2/9/88-MILL ESP-ALL-4-b	2/9/88	1447-2002	WGD	ESP Hopper All fields
ASH-2/10/88-MILL ESP-ALL-5-a	2/10/88	857-1357	WGD	ESP Hopper All fields
ASH-2/10/88-MILL ESP-ALL-5b	2/10/88	857-1357	WGD	ESP Hopper All fields
ASH-2/10/88-MILL ESP-ALL-6-a	2/10/88	1600-	WGD	ESP Hopper All fields
ASH-2/10/88-MILL ESP-ALL-6-b	2/10/88	1606-	WGD	ESP Hopper All fields
ASH-2/8/88-MILL SPRAY DR-1-a	2/8/88	914-1609	WGD	SPRAY DRYER Hopper
ASH-2/8/88-MILL SPRAY DR-1-b	2/8/88	914-1609	WGD	SPRAY DRYER Hopper

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

F-0002
8/86

ENTROPY

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelabrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE ESP Hopper ash from Fields 2+3 And ESP Hopper ash from Fields 1, 2 & 3

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) Sample taken with scoop. One scoop every 15 minutes. Combined sample coned and quartered and then placed in two jars - A+B

SAMPLING LOG

SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
ASH-ESP-23-5-a 2/10/88-MILL	2/10/88	856-1356	WGD	ESP Hopper fields 2+3
ASH-ESP-23-5b 2/10/88-MILL	2/10/88	856-1356	WGD	ESP Hopper fields 2+3
ASH-ESP-ALL-1-a 2/8/88-MILL	2/8/88	912-1607	WGD	ESP Hopper All fields
ASH-ESP-ALL-1-b 2/8/88-MILL	2/8/88	912-1607	WGD	ESP Hopper All fields
ASH-ESP-ALL-2a 2/8/88-MILL	2/8/88	1702-2132	WGD	ESP Hopper All fields
ASH-ESP-ALL-2-b 2/8/88-MILL	2/8/88	1702-2132	WGD	ESP Hopper All fields
ASH-ESP-ALL-3-a 2/9/88-MILL	2/9/88	847-1332	WGD	ESP Hopper All fields
ASH-ESP-ALL-3-b 2/9/88-MILL	2/9/88	847-1332	WGD	ESP Hopper All fields

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

F-0002
8/86

ENTROPY

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME ~~MIL~~ Wheelabrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS MWC

DESCRIBE SAMPLE ESP Hopper ash from Field 2&3

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) Sample taken with scoop. One scoop every 15 minutes. Combined sample coned and quartered and then placed in two jars - A&B

SAMPLING LOG				
SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
2/8/88-MILL ash-ESP-23-1-a	~~[illegible]~~ 2/8/88	911-1606	WGD	ESP Hopper field 2&3
2/8/88-MILL ash-ESP-23-1-b	2/8/88	911-1606	WGD	ESP Hopper fields 2&3
2/8/88-MILL ash-ESP-23-2-a	2/8/88	1701-2131	WGD	ESP Hopper fields 2&3
2/8/88-MILL ash-ESP-23-2-b	2/8/88	~~[illegible]~~ 1701-2131	WGD	ESP Hopper fields 2&3
2/9/88-MILL ash-ESP-23-3-a	2/9/88	846-1331	WGD	ESP Hopper fields 2&3
2/9/88-MILL ash-ESP-23-3-b	2/9/88	846-1331	WGD	ESP Hopper fields 2&3
2/9/88-MILL ash-ESP-23-4-a	2/9/88	1446-2001	WGD	ESP Hopper fields 2&3
2/9/88-MILL ash-ESP-23-4-b	2/9/88	1446-2001	WGD	ESP Hopper fields 2&3

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

F-0002
8/86

ENTROPY

PROCESS SAMPLE CHAIN OF CUSTODY

PLANT NAME Wheelerbrator

PLANT LOCATION Millbury Mass

DESCRIBE PROCESS ESP Hopper Ash from Field #3 - MWC

DESCRIBE SAMPLE ESP Hopper Ash from Field #3

DESCRIBE SAMPLING PROCEDURES (i.e. Grab or Intergrated sample; single or composite, etc.) Sample pulled through stainless steel probe teflon line and collected in stainless steel impinger Three drag lines collected every 15 minutes. Entire sample was placed in a single jar.

SAMPLING LOG

SAMPLE ID	DATE	TIME	TAKEN BY	SAMPLING LOCATION
2/8/88-mill ash-ESP-3-1	2/8/88	910-1605	WGD	ESP Field 3
2/8/88-mill ash-ESP-3-2-a	2/8/88	1700-2130	WGD	ESP Field 3
2/9/88-mill ash-ESP-3-3a	2/9/88	845-1330	WGD	ESP Field 3
2/9/88-mill ash-ESP-3-4-a	2/9/88	1445-2000	WGD	ESP Field 3
2/10/88-mill ash-ESP-3-5-a	2/10/88	855-1355	WGD	ESP Field 3

SAMPLES RECEIVED FROM THE PLANT BY _____ ON _____

SAMPLES RECEIVED IN THE LAB BY _____ ON _____

F-0002
8/86

ENTROPY

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant Wheelabrator, Millbury Mass Sample date 2/8/88
Sample location SDA Inlet Unit 2 Run number 1
Sample recovery person ACC/SCS Recovery date 2/8/88
Filter(s) number N/A

MOISTURE

Impingers 198+120+78 Silica gel 2 bottles!

Final volume (wt)	398 ml (g)	Final wt	____ g	____ g
Initial volume (wt)	200 ml (g)	Initial wt	____ g	____ g
Net volume (wt)	196 ml (g)	Net wt	____ g	____ g

Total moisture ____ g
Color of silica gel 25% spent of 400g
Description of impinger water Clear

RECOVERED SAMPLE

Blank filter container number Mil-MM5-Filter-RB Sealed ✓
Filter container number Mil-MM5-In-1-F Sealed ✓
Description of particulate on filter Fine gray / larger part. in cyclone

Acetone rinse container number ~~NA~~ NA Liquid level marked? ____
Acetone blank container number ~~NA~~ NA Liquid level marked? ____
Samples stored and locked ✓
Remarks

Date of laboratory custody
Laboratory personnel taking custody
Remarks Box 22

ENTROPY

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant Wheelabrator, Millbury Mass. Sample date 2/08/88
Sample location Inlet Unit 2 SDA Run number 2
Sample recovery person ACC / SCS Recovery date 2/08/88
Filter(s) number NA

MOISTURE

Impingers 186 + 202 Silica gel 2 bottles!

Final volume (wt)	388 ml (g)	Final wt	g	g
Initial volume (wt)	200 ml (g)	Initial wt	g	g
Net volume (wt)	188 ml (g)	Net wt	g	g

Total moisture g

Color of silica gel 25% spent (2 bottles)
Description of impinger water clear

RECOVERED SAMPLE

Blank filter container number Mil-MM5-Filter-RB Sealed ✓
Filter container number Mil-MM5-In-2-F Sealed ✓
Description of particulate on filter light gray / large ash + carbon in cyclone

Acetone rinse container number NA Liquid level marked?
Acetone blank container number NA Liquid level marked?
Samples stored and locked ✓
Remarks

Date of laboratory custody
Laboratory personnel taking custody
Remarks Box 24

ENTROPY

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant Wheelabrator, Millbury Sample date 2/09/88
Sample location Inlet Unit 2 SDA Run number 3
Sample recovery person ACC/SCS Recovery date 2/09/88
Filter(s) number NA

MOISTURE

Impingers	180 + 198		Silica gel	2 bottles!	
Final volume (wt)	378 ml (g)		Final wt	g	g
Initial volume (wt)	200 ml (g)		Initial wt	g	g
Net volume (wt)	178 ml (g)		Net wt	g	g

Total moisture _____ g
Color of silica gel 50% spent
Description of impinger water clear

RECOVERED SAMPLE

Blank filter container number Mi-MM5-Filter-RB Sealed ✓
Filter container number Mi-MM5-In-3-F Sealed ✓
Description of particulate on filter small gray / large ash and carbon in cyclone

Acetone rinse container number NA Liquid level marked? _____
Acetone blank container number NA Liquid level marked? _____
Samples stored and locked ✓
Remarks _____

Date of laboratory custody _____
Laboratory personnel taking custody _____
Remarks Box 22

ENTROPY

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant Wheelabrator, Millburg Sample date 2/09/88
Sample location Inlet Unit 2 SDA Run number 4
Sample recovery person ACC/SCS Recovery date 2/09/88
Filter(s) number NA

MOISTURE

Impingers 168 + 198 Silica gel 2 bottles!

Final volume (wt)	366 ml (g)	Final wt	____ g	____ g
Initial volume (wt)	200 ml (g)	Initial wt	____ g	____ g
Net volume (wt)	166 ml (g)	Net wt	____ g	____ g

Total moisture ____ g

Color of silica gel 25% Spent

Description of impinger water clear

RECOVERED SAMPLE

Blank filter container number Mil-MM5-Filter-RB Sealed ✓

Filter container number Mil-MM5-In-4-F Sealed ✓

Description of particulate on filter Small grey / large ash and carbon in cyclone

Acetone rinse container number NA Liquid level marked? ____

Acetone blank container number NA Liquid level marked? ____

Samples stored and locked ✓

Remarks ____

Date of laboratory custody ____

Laboratory personnel taking custody ____

Remarks Box 24

ENTROPY

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant Wheelabrator Millbury Mass Sample date 2/10/88
Sample location Inlet Unit 2 SDA Run number #5
Sample recovery person ACC/SCS Recovery date 2/10/88
Filter(s) number NA

MOISTURE

Impingers 178+ 202 Silica gel 2 bottles

Final volume (wt)	____ ml (g)	Final wt	____ g	____ g
Initial volume (wt)	____ ml (g)	Initial wt	____ g	____ g
Net volume (wt)	____ ml (g)	Net wt	____ g	____ g

Total moisture ____ g
Color of silica gel 25% Spent
Description of impinger water clear

RECOVERED SAMPLE

Blank filter container number MM5-Filter-RB Sealed ✓
Filter container number Mil-MM5-In-5-F Sealed ____
Description of particulate on filter Small gray / large ash + carbon in cyclone

Acetone rinse container number NA Liquid level marked? ____
Acetone blank container number NA Liquid level marked? ____
Samples stored and locked ✓
Remarks ____

Date of laboratory custody ____
Laboratory personnel taking custody ____
Remarks Box 22

ENTROPY

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant _____ Sample date 2/10/88

Sample location Fulet Unit 2 SDA Run number Field Blank

Sample recovery person _____ Recovery date 2/10/88

Filter(s) number _____

MOISTURE

Impingers			Silica gel		
Final volume (wt)	200 ml (g)		Final wt	_____ g	_____ g
Initial volume (wt)	200 ml (g)		Initial wt	_____ g	_____ g
Net volume (wt)	0 ml (g)		Net wt	_____ g	_____ g

Total moisture _____ g

Color of silica gel 0%

Description of impinger water Clear

RECOVERED SAMPLE

Blank filter container number _____ Sealed _____

Filter container number _____ Sealed _____

Description of particulate on filter _____

Acetone rinse container number _____ Liquid level marked? _____

Acetone blank container number _____ Liquid level marked? _____

Samples stored and locked _____

Remarks _____

Date of laboratory custody _____

Laboratory personnel taking custody _____

Remarks started 15:00

ENTROPY

SAMPLE INVENTORY FOR MILLBURY, MA. RESCO

Label Format

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-----------------------------------
Plant: Millbury      Date:  2/   /88|
Run No.:  MM5        Method:        |
Location: IN         Portion:       |
Sample #:  2/08/88-MIL-MM5-IN-1-PR  |
-----------------------------------|
```

LEGEND:
- PR = Probe Rinse
- F = Filter
- CR = Condenser Rinse
- SM = Sorbent Module
- IC = Impinger Contents
- IR = Impinger Rinse
- SG = Silica Gel
- T = Toluene Rinse

Combined Sample	DATE	Plant	Sample Type	Sampling Location	Run No.	Portion		Sample #
1	2/08/88	Millbury	MM5	IN	1	PR	1 of 2	2/08/88-MIL-MM5-IN-1-PR
	2/08/88	Millbury	MM5	IN	1	PR	2 of 2	2/08/88-MIL-MM5-IN-1-PR
	2/08/88	Millbury	MM5	IN	1	F		2/08/88-MIL-MM5-IN-1-F
2	2/08/88	Millbury	MM5	IN	1	CR		2/08/88-MIL-MM5-IN-1-CR
	2/08/88	Millbury	MM5	IN	1	SM		2/08/88-MIL-MM5-IN-1-SM
	2/08/88	Millbury	MM5	IN	1	IC		2/08/88-MIL-MM5-IN-1-IC
	2/08/88	Millbury	MM5	IN	1	IR		2/08/88-MIL-MM5-IN-1-IR
3	2/08/88	Millbury	MM5	IN	2	PR	1 of 2	2/08/88-MIL-MM5-IN-2-PR
	2/08/88	Millbury	MM5	IN	2	PR	2 of 2	2/08/88-MIL-MM5-IN-2-PR
	2/08/88	Millbury	MM5	IN	2	F		2/08/88-MIL-MM5-IN-2-F
4	2/08/88	Millbury	MM5	IN	2	CR		2/08/88-MIL-MM5-IN-2-CR
	2/08/88	Millbury	MM5	IN	2	SM		2/08/88-MIL-MM5-IN-2-SM
	2/08/88	Millbury	MM5	IN	2	IC		2/08/88-MIL-MM5-IN-2-IC
	2/08/88	Millbury	MM5	IN	2	IR		2/08/88-MIL-MM5-IN-2-IR
5	2/09/88	Millbury	MM5	IN	3	PR	1 of 2	2/09/88-MIL-MM5-IN-3-PR
	2/09/88	Millbury	MM5	IN	3	PR	2 of 2	2/09/88-MIL-MM5-IN-3-PR
	2/09/88	Millbury	MM5	IN	3	F		2/09/88-MIL-MM5-IN-3-F
6	2/09/88	Millbury	MM5	IN	3	CR		2/09/88-MIL-MM5-IN-3-CR
	2/09/88	Millbury	MM5	IN	3	SM		2/09/88-MIL-MM5-IN-3-SM
	2/09/88	Millbury	MM5	IN	3	IC		2/09/88-MIL-MM5-IN-3-IC
	2/09/88	Millbury	MM5	IN	3	IR		2/09/88-MIL-MM5-IN-3-IR
7	2/09/88	Millbury	MM5	IN	4	PR	1 of 3	2/09/88-MIL-MM5-IN-4-PR
	2/09/88	Millbury	MM5	IN	4	PR	2 of 3	2/09/88-MIL-MM5-IN-4-PR
	2/09/88	Millbury	MM5	IN	4	PR	3 of 3	2/09/88-MIL-MM5-IN-4-PR
	2/09/88	Millbury	MM5	IN	4	F		2/09/88-MIL-MM5-IN-4-F

Transmitted by: _____ Date: 2/24/88

Received by: _____ Date: 2-24-88

Combined Sample	DATE	Plant	Sample Type	Sampling Location	Run No.	Portion		Sample #
8	2/09/88	Millbury	MM5	IN	4	CR	1 of 2	2/09/88-MIL-MM5-IN-4-CR
	2/09/88	Millbury	MM5	IN	4	CR	2 of 2	2/09/88-MIL-MM5-IN-4-CR
	2/09/88	Millbury	MM5	IN	4	SM		2/09/88-MIL-MM5-IN-4-SM
	2/09/88	Millbury	MM5	IN	4	IC		2/09/88-MIL-MM5-IN-4-IC
	2/09/88	Millbury	MM5	IN	4	IR	1 of 2	2/09/88-MIL-MM5-IN-4-IR
	2/09/88	Millbury	MM5	IN	4	IR	2 of 2	2/09/88-MIL-MM5-IN-4-IR
9	2/09/88	Millbury	MM5	IN	4	T	1 of 2	2/09/88-MIL-MM5-IN-4-T
	2/09/88	Millbury	MM5	IN	4	T	2 of 2	2/09/88-MIL-MM5-IN-4-T
10	2/10/88	Millbury	MM5	IN	5	PR	1 of 2	2/10/88-MIL-MM5-IN-5-PR
	2/10/88	Millbury	MM5	IN	5	PR	2 of 2	2/10/88-MIL-MM5-IN-5-PR
	2/10/88	Millbury	MM5	IN	5	F		2/10/88-MIL-MM5-IN-5-F
11	2/10/88	Millbury	MM5	IN	5	CR		2/10/88-MIL-MM5-IN-5-CR
	2/10/88	Millbury	MM5	IN	5	SM		2/10/88-MIL-MM5-IN-5-SM
	2/10/88	Millbury	MM5	IN	5	IC		2/10/88-MIL-MM5-IN-5-IC
	2/10/88	Millbury	MM5	IN	5	IR		2/10/88-MIL-MM5-IN-5-IR
12	2/10/88	Millbury	MM5	IN	FB	PR	Train 2	2/10/88-MIL-MM5-IN-FB-PR
	2/10/88	Millbury	MM5	IN	FB	F	Train 2	2/10/88-MIL-MM5-IN-FB-F
	2/10/88	Millbury	MM5	IN	FB	CR	Train 2	2/10/88-MIL-MM5-IN-FB-CR
	2/10/88	Millbury	MM5	IN	FB	SM	Train 2	2/10/88-MIL-MM5-IN-FB-SM
	2/10/88	Millbury	MM5	IN	FB	IC	Train 2	2/10/88-MIL-MM5-IN-FB-IC
	2/10/88	Millbury	MM5	IN	FB	IR	Train 2	2/10/88-MIL-MM5-IN-FB-IR
13	2/23/88	Millbury	ASH	BOTTOM	COMB	a		2/23/88-MIL-ASH-BOTTOM-a
14	2/23/88	Millbury	ASH	ECON/GEN	COMB	a		2/23/88-MIL-ASH-ECON/GEN-a
15	2/23/88	Millbury	ASH	SPRAY DR.	COMB	a		2/23/88-MIL-ASH-SPRAY DR.-
16	2/23/88	Millbury	ASH	ESP 2+3	COMB	a		2/23/88-MIL-ASH-ESP 2+3-a
17	2/23/88	Millbury	ASH	ESP 3	COMB	a		2/23/88-MIL-ASH-ESP 3-a
18	2/23/88	Millbury	ASH	ESP ALL	COMB	a		2/23/88-MIL-ASH-ESP ALL-a
19	2/08/88	Millbury	LIME		1			2/08/88-MIL-LIME- -1-
20	2/07/88	Millbury	MM5-PB	LAB	4	PR	Train 2	2/07/88-MIL-MM5-PB-LAB-4-PI
	2/07/88	Millbury	MM5-PB	LAB	4	F	Train 2	2/07/88-MIL-MM5-PB-LAB-4-F
	2/07/88	Millbury	MM5-PB	LAB	4	CR	Train 2	2/07/88-MIL-MM5-PB-LAB-4-CI
	2/07/88	Millbury	MM5-PB	LAB	4	SM	Train 2	2/07/88-MIL-MM5-PB-LAB-4-SI
	2/07/88	Millbury	MM5-PB	LAB	4	IC	Train 2	2/07/88-MIL-MM5-PB-LAB-4-II
	2/07/88	Millbury	MM5-PB	LAB	4	IR	Train 2	2/07/88-MIL-MM5-PB-LAB-4-II
21	2/23/88	Millbury	FLYASH	AUD				2/23/88-MIL-FLYASH-AUD- -
22	2/23/88	Millbury	XAD	AUD	F-130			2/23/88-MIL-XAD-AUD-F-130-
23	2/23/88	Millbury	XAD	AUD	F-145			2/23/88-MIL-XAD-AUD-F-145-
24	2/23/88	Millbury	XAD	AUD	F-176			2/23/88-MIL-XAD-AUD-F-176-

Transmitted by: _____ Date: 2-24-88

Received by: _____ Date: 2-24-88

FH1BH SEPARATE EXCEPT FOR FB and LAB

ASME 1A

TRIANGLE LABORATORIES, INC.

PCDD/PCDF SAMPLE TRACKING & MANAGEMENT FORM

HIGH/LOW 70H/70S

XAD PRE-SPIKED → cl 2138 (10ng)

TLI PROJECT NUMBER: 2131 DUE DATE: 23 MAR 88

CUSTOMER ID. : ENTROPY RECEIVING DATE : 25 Feb 88

NUMBER OF SAMPLES: 2 TURN AROUND TIME : 30d

EXTRACTION DATE : 2/27/88 SPLE FORT. SLN ID.: MM5

METHOD BLANK: no [] yes [X] DUPL.: no yes ID (N/A)

SAMPLE EXTRACTION: Soxhlet Sep.Fun. Jar D.Stark Other M. 5

SAMPLE CLEANUP: 8280 A540 Reg.V ASME Other

MASS SPECTROMETER: 8280 ASME ~~8290~~ SYSTEM: M-O TR-O T-O TETR

CONFIRM : no tetra T-Hp RTW TEF RS(250)

DATA REDUCTION: 8280 8280III ASME/8290

MS: no yes MSD ID(N/A) MS SLN: µL ID(N/A)

ENTRY No.	TLI. No	CLIENT SPLE ID	SPLE TYPE	SAMPLE SIZE	IS	DRY WT Y/N	IS/SS VOL 100µL	C/MS FILE NAME	CONFIRM NAME	UNITS pg/ng ppt/ppb	COMMENTS Place client sple ID HERE	Q C
01	TLI	BLANK			*		* 100µl	~~M880953~~ M880974			*	
1	6-28-1→2	Sample #1					100µl	M880954	S880934		2-08-88 MIL-MM5-IN-1	
2	** 3→6	#2			100µl			M880979 ~~M880955~~	S880935		1	
3	7→8	#3					100µl	M880956	S880936		2	
4	** 9→12	#4			100µl			M880978 ~~M880958~~	S880937		2	
5	13,14	#5					100µl	M880961			2-09-88 MIL-MM5-IN-3	
6	** 15→18	#6			100µl			M880977	S880949		3	
7	6-27-1,2	#7					100µl	M880968 ~~M880966~~	S880939		4	
8	** 3→6	#8			100µl			M880965	S880944		4	
02	TLI Blank						100µl	M880975				
10	6-27-7-8	#10					100µl	M880964	S880945		2-10-88 MIL-MM5-IN-5	
11	** 9→12	#11			100µl			M880963	S880946		5	
12	** 13-18	#12			100µl			M880962	S880947		FB	
20	** 6-28-1→6	#20			100µl			M880967	S880948		2-07-88- MIL-MM5-PB-LAB-4	
15												
16	** XAD's (SM) were				IS (S1-94-6)		SFS combined (S1-94-7)					
17	prespiked c̄ 10 ng Surr. (2137/2138)											
18												
19												
20	* These samples were split into two equal halves - One arch ed and the other cleaned up											

RRF (FS) ical concal

ICAL (FS) ASME 3/13/88

CONCAL (FS) M880949 FOR ENTRIES 953 TO 958

M880960 FOR ENTRIES 961 TO 968

M880971 974 to 979

RRT (conf.) ical concal

ICAL (conf.) U.S. 3/3/88

CONCAL (conf.) S880941 FOR ENTRIES 944 TO 949

S880929 FOR ENTRIES 934 TO 939

COL. PER. S880928

COL. PER. S880940

B-34

REV 5 2/20/88

Retck - M880948

Retck - M880959

RTcheck - M880970

Invalid Data

ASME ⚠

TRIANGLE LABORATORIES, INC.

PCDD/PCDF SAMPLE TRACKING & MANAGEMENT FORM

HIGH/LOW 70N/70S

TLI PROJECT NUMBER: 2192 DUE DATE: 23 MAR 88

SAMPLE EXTRACTION: Soxhlet Sep.Fun. Jar D.Stark Other
SAMPLE CLEANUP: 8280 A540 Reg.V ASME Other
MASS SPECTROMETER: 8280 ASME ~~8290~~ SYSTEM: M-O TR-O T-O TETR
CONFIRM : no tetra T-Hp RTW TEF RS(500/250)(***)
DATA REDUCTION: 8280 8280III ASME/8290
MS: no yes MSD ID(N/A) MS SLN: µL ID(N/A)

CUSTOMER ID. : ENTROPY
NUMBER OF SAMPLES: 2
EXTRACTION DATE : 3-[illegible]
METHOD BLANK: no [ ] yes [X]

RECEIVING DATE : 25 FEB 88
TURN AROUND TIME : 3 wk
SPLE FORT. SLN ID.: 01 SFS
DUPL.: no yes ID (N/A)

ENTRY No.	TLI. No	CLIENT SPLE ID	SPLE TYPE	SAMPLE SIZE	% MOIST. LIPID	DRY WT Y/N	IS/SS VOL 100µL	GC/MS FILE NAME	CONFIRM NAME	UNITS pg/ng ppt/ppb	COMMENTS	Q C	
03	TLI	BLANK					100µl	M880980	S880974				PPB
9	6-29-1A,B	Sample #9						M880981	S880969		2-09-88 MIL-MM5-IN-4-T		ng
13	6-29-2	2-23-88-MIL-ASH Bottom @ #13		10.19g				M880982	S880970		2-23-88-MIL-ASH Bottom @		PPB
14	3	#14		10.09g				M880987	S880973		Econ/Gen @		
15	4	#15		10.15g				M880988	S880972		Spray Dr @		
16	5	#16		9.59g				M880989	S880971		ESP 2+3 @		
17	6	#17		10.02g				M880992	S880977		ESP 3 @		
18	7	#18		10.13g				M880995	S880975		ESP All-@		
19	8	2-08-88-MIL-LIME-1- #19		6.39g 25ml			100µl IS (SI-85-3A) 100µl Surr (SI-94-4)	M880994	S880976		used 1.0g to calculate an absolute amount		ng
B													
21	9	#21		10.11g			100µl	M881002	S880980		2-23-88-MIL FlyAsh-AUD		PPB
22	10	#22		1.0 DH ~~40.09g~~				M881003	S880979		XAD-AUD-F-130		ng
23	11	#23		1.0 DH ~~40.12g~~				M881004	S880978		-145		ng
24	12	#24		1.0 DH ~~39.87g~~				M881005			176		ng
25	TLI Blank							M881001					PPB
16							SFS Combined SI-94-7						
17													
18													
19													
20													

RRF (FS) ical concal
ICAL (FS) FS ASME 3/13/88
CONCAL (FS) M880971 FOR ENTRIES 980 TO 982
M880986 987 TO 995
M880996 FOR ENTRIES 1001 TO 1006

RRT (conf.) ical concal
ICAL (conf.) U.S. 3/2/88
CONCAL (conf.) S880964 FOR ENTRIES 969 TO 980
FOR ENTRIES TO

REV 5 2/20/88 SPLIT XAD ONLY

B-35

Ret-Chk = S880963

RETCK M880974 ~~M880975~~ DH (***) Use 500 for ASH
Use 250 for XAD.

MOLECULAR WEIGHTS OF CDD/CDF ISOMERS

NAME	Mol. Wt.
TOTAL MCDD	218.35
TOTAL DCDD	252.90
TOTAL TriCDD	287.45
2378-TCDD	322.00
TOTAL TCDD	322.00
12378-PCDD	356.44
TOTAL PCDD	356.44
123478-HxCDD	390.88
123678-HxCDD	390.88
123789-HxCDD	390.88
TOTAL HxCDD	390.88
1234678-HpCDD	425.32
TOTAL HpCDD	425.32
OCDD	459.76
TOTAL MCDF	202.35
TOTAL DCDF	236.90
TOTAL TriCDF	271.45
2378-TCDF	306.00
TOTAL TCDF	306.00
12378-PCDF	340.44
23478-PCDF	340.44
TOTAL PCDF	340.44
123478-HxCDF	374.88
123678-HxCDF	374.88
234678-HxCDF	374.88
123789-HxCDF	374.88
TOTAL HxCDF	374.88
1234678-HpCDF	409.32
1234789-HpCDF	409.32
TOTAL HpCDF	409.32
OCDF	443.76

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: JJ
DATE: 03/16/88

FILE NAME: M880954
SAMPLE ID: SAMPLE #1
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880949

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.005			
TOTAL DCDD	1.508	1			1.69	
TOTAL TRICDD	5.002	6			1.02	
2378-TCDD	0.900				0.76	29.10
TOTAL TCDD	10.565	14			0.80	
12378-PCDD	1.429				0.61	34.31
TOTAL PCDD	11.449	12			0.63	
123478-HxCDD	1.302				1.26	39.16
123678-HxCDD	2.071				1.32	39.24
123789-HxCDD	4.251				1.26	39.52
TOTAL HxCDD	23.917	7			1.28	
1234678-HpCDD	9.624				1.06	44.12
TOTAL HpCDD	17.836	2			1.06	
OCDD	21.610				0.89	49.16
TOTAL MCDF	ND			0.346	2.49	
TOTAL DCDF	33.207	7			6.21	
TOTAL TRICDF	73.761	11			1.04	
2378-TCDF	14.850				0.79	28.25
TOTAL TCDF	110.533	16			0.77	
12378-PCDF	4.045				0.62	33.05
23478-PCDF	5.057				0.63	34.02
TOTAL PCDF	62.642	16			0.62	
123478-HxCDF	10.930				1.17	38.07
123678-HxCDF	6.333				1.18	38.17
234678-HxCDF	5.751				1.20	39.05
123789-HxCDF	0.484				1.24	40.13
TOTAL HxCDF	53.315	12			1.21	
1234678-HpCDF	12.825				1.01	42.42
1234789-HpCDF	1.038				0.96	44.50
TOTAL HpCDF	20.049	4			1.02	
OCDF	4.695				0.86	49.29

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.39	93.90	0.80	28.22
37CL-TCDD	10.74	107.40		29.10
13C12-HxCDF	13.94	139.40	1.27	38.07

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	9.68	96.80	0.80	29.09
13C12-PCDD	11.19	111.90	0.63	34.31
13C12-HxCDD	6.88	68.80	1.27	39.23
13C12-HpCDD	9.72	97.20	1.07	44.12
13C12-OCDD	16.08	80.40	0.89	49.15

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/18/88

FILE NAME: M880979
SAMPLE ID: SAMPLE #2
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880971

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.008			
TOTAL DCDD	ND		0.018			
TOTAL TRICDD	ND		0.045			
2378-TCDD	ND		0.013			
TOTAL TCDD	ND			0.029	1.06	
12378-PCDD	ND		0.018			
TOTAL PCDD	ND			0.033	0.73	
123478-HxCDD	ND		0.025			
123678-HxCDD	ND		0.025			
123789-HxCDD	ND		0.030			
TOTAL HxCDD	ND			0.537	4.09	
1234678-HpCDD	ND			0.106	1.30	
TOTAL HpCDD	0.101	1			1.12	
OCDD	0.899				0.80	49.24
TOTAL MCDF	ND		0.008			
TOTAL DCDF	ND		0.022			
TOTAL TRICDF	1.929	7			1.02	
2378-TCDF	0.222				0.70	28.31
TOTAL TCDF	1.748	10			0.73	
12378-PCDF	0.070				0.69	33.12
23478-PCDF	0.078				0.64	34.10
TOTAL PCDF	0.959	9			0.61	
123478-HxCDF	ND			0.197	1.89	
123678-HxCDF	ND		0.015			
234678-HxCDF	ND		0.018			
123789-HxCDF	ND		0.025			
TOTAL HxCDF	0.283	1			1.19	
1234678-HpCDF	0.183				1.15	42.49
1234789-HpCDF	0.052				0.96	44.58
TOTAL HpCDF	0.323	3			1.06	
OCDF	0.392				0.92	49.37

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	8.07	80.70	0.78	28.28
37CL-TCDD	8.60	86.00		29.17
13C12-HxCDF	14.05	140.50	1.24	38.14

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	9.56	95.60	0.80	29.16
13C12-PCDD	10.79	107.90	0.62	34.37
13C12-HxCDD	5.79	57.90	1.25	39.31
13C12-HpCDD	10.90	109.00	1.07	44.19
13C12-OCDD	24.98	124.90	0.92	49.23

M880979B
MATCHED GC PEAKS /RATIO/ RET TIME

M_Z	RATIO	RT.	AREA	MATCH_RAT	MATCH_RT	REL_RT
270	1.33	20.37	579.17	.F.	.F.	0.000
270	0.89	20.57	561.90	.T.	.F.	0.000
270	1.13	21.21	543.02	.T.	.F.	0.000
270	1.30	21.45	944.13	.F.	.F.	0.000
270	1.06	22.06	674.92	.T.	.F.	0.000
270	1.06	22.29	561.42	.T.	.F.	0.000
270	1.01	22.39	775.07	.T.	.F.	0.000
270	0.87	22.56	179.62	.T.	.F.	0.000
270	1.10	23.08	700.85	.T.	.F.	0.000
304	0.68	25.51	246.52	.T.	.F.	0.883
304	0.69	26.06	171.60	.T.	.F.	0.892
304	0.74	26.26	2410.37	.T.	.F.	0.903
304	0.72	26.42	1347.63	.T.	.F.	0.912
304	0.73	27.07	1318.48	.T.	.F.	0.927
304	0.65	27.25	913.30	.T.	.F.	0.937
304	0.54	27.41	1004.19	.F.	.F.	0.946
304	0.81	28.03	586.60	.T.	.F.	0.958
304	0.70	28.31	1121.67	.T.	.T.	0.974
304	0.76	28.58	449.01	.T.	.F.	0.990
304	0.83	29.12	259.91	.T.	.F.	0.998
316	0.68	28.01	403.75	.T.	.F.	0.957
316	0.78	28.28	43029.66	.T.	.T.	0.973
316	0.72	30.23	707.02	.T.	.F.	1.038
320	1.06	28.01	109.64	.F.	.F.	0.957
328	0.00	29.17	31249.63	.T.	.T.	1.001
332	0.81	29.02	24689.12	.T.	.T.	0.992
332	0.80	29.16	35050.26	.T.	.T.	1.000
338	0.75	30.42	282.75	.F.	.F.	0.887
338	0.54	31.56	345.06	.T.	.F.	0.922
338	0.62	32.05	1770.03	.T.	.F.	0.927
338	0.59	32.17	340.77	.T.	.F.	0.933
338	0.68	32.49	361.29	.T.	.F.	0.948
338	0.69	33.12	320.29	.T.	.T.	0.959
338	0.58	33.24	184.53	.T.	.F.	0.965
338	0.52	33.34	276.29	.T.	.F.	0.970
338	0.64	34.10	328.01	.T.	.T.	0.987
338	0.67	34.21	274.38	.T.	.F.	0.992
354	0.73	32.13	99.11	.F.	.F.	0.931
366	0.62	34.37	13902.78	.T.	.T.	1.000
374	1.19	36.59	835.68	.T.	.F.	0.936
374	1.89	38.13	661.30	.F.	.T.	0.967
386	1.24	38.14	36328.22	.T.	.T.	0.968
390	4.09	38.14	1003.53	.F.	.F.	0.968
402	1.25	39.31	14690.84	.T.	.T.	1.000
402	1.26	39.59	27030.84	.T.	.T.	1.012
408	1.15	42.49	947.50	.T.	.T.	0.966
408	0.83	43.11	248.39	.F.	.F.	0.974
408	1.08	43.24	315.76	.T.	.F.	0.979
408	0.96	44.58	206.15	.T.	.T.	1.015
424	1.12	43.15	279.11	.T.	.F.	0.976

M880979B
MATCHED GC PEAKS /RATIO/ RET TIME

M_Z	RATIO	RT.	AREA	MATCH_RAT	MATCH_RT	REL_RT
424	1.30	44.20	291.87	.F.	.T.	1.000
436	1.07	44.19	19892.36	.T.	.T.	1.000
442	0.92	49.37	1015.24	.T.	.T.	1.005
458	0.80	49.24	1789.82	.T.	.T.	1.000
470	0.92	49.23	39097.05	.T.	.T.	1.000
*** Total ***						
***	51.15	1773.8	313707.41			44.425

M880979B
MATCHED GC PEAKS /RATIO/ RET TIME

M_Z	RATIO	RT.	AREA	MATCH_RAT	MATCH_RT	REL_RT	
202	4.92	8.52	323.44	.F.	.F.	0.000	Delete noise H.N
202	3.43	9.00	416.83	.T.	.F.	0.000	
218	0.14	7.49	2721.94	.F.	.F.	0.000	
218	0.11	7.58	4430.48	.F.	.F.	0.000	
218	0.09	8.52	4429.96	.F.	.F.	0.000	
218	0.22	9.06	1751.06	.F.	.F.	0.000	
218	0.51	9.25	1219.57	.F.	.F.	0.000	Delete noise H.N
218	0.22	9.32	1572.20	.F.	.F.	0.000	
218	0.29	9.55	4704.31	.F.	.F.	0.000	
218	0.29	10.14	2902.12	.F.	.F.	0.000	
218	0.30	10.40	1957.72	.F.	.F.	0.000	
218	0.22	10.52	2769.00	.F.	.F.	0.000	
218	0.15	11.07	3364.27	.F.	.F.	0.000	
218	0.13	11.30	3437.20	.F.	.F.	0.000	
218	0.19	12.01	2862.46	.F.	.F.	0.000	
218	0.20	13.13	2005.47	.F.	.F.	0.000	
238	0.25	11.49	367.68	.F.	.F.	0.000	Delete noise H.N
238	8.18	14.06	605.56	.F.	.F.	0.000	
238	0.76	14.20	263.22	.F.	.F.	0.000	
238	4.01	15.56	327.32	.F.	.F.	0.000	
238	3.83	16.45	273.96	.F.	.F.	0.000	
252	10.25	12.09	852.16	.F.	.F.	0.000	
270	1.33	20.37	579.17	.F.	.F.	0.000	
270	~~0.86~~ 0.89	20.57	~~523.32~~	~~.F.~~ T 561.9	.F.	0.000	Ch H.N
270	1.13	21.21	543.02	.T.	.F.	0.000	
270	1.30	21.45	944.13	.F.	.F.	0.000	
270	1.06	22.06	674.92	.T.	.F.	0.000	
270	1.06	22.29	561.42	.T.	.F.	0.000	
270	1.01	22.39	775.07	.T.	.F.	0.000	
270	0.87	22.56	179.62	.T.	.F.	0.000	
270	1.10	23.08	700.85	.T.	.F.	0.000	
304	0.68	25.51	246.52	.T.	.F.	0.883	
304	0.69	26.06	171.60	.T.	.F.	0.892	
304	0.74	26.26	2410.37	.T.	.F.	0.903	
304	0.72	26.42	1347.63	.T.	.F.	0.912	
304	0.73	27.07	1318.48	.T.	.F.	0.927	
304	~~0.64~~ 0.65	27.25	~~915.83~~	~~.F.~~ T 919.3	.F.	0.937	Ch H.N
304	0.54	27.41	1004.19	.F.	.F.	0.946	d well Ch RO
304	~~0.62~~ 0.58	28.03	~~588.42~~	~~.F.~~ T 586.6	.F.	0.958	Ch H.N
304	0.70	28.31	1121.67	.T.	.T.	0.974	
304	0.76	28.58	449.01	.T.	.F.	0.990	
304	0.83	29.12	259.91	.T.	.F.	0.998	
316	0.68	28.01	403.75	.T.	.F.	0.957	
316	0.78	28.28	43029.66	.T.	.T.	0.973	
316	0.72	30.23	707.02	.T.	.F.	1.038	
320	1.06	28.01	109.64	.F.	.F.	0.957	
328	0.00	29.17	31249.63	.T.	.T.	1.001	
332	0.81	29.02	24689.12	.T.	.T.	0.992	
332	0.80	29.16	35050.26	.T.	.T.	1.000	
338	0.75	30.42	282.75	.F.	.F.	0.887	

M880979B
MATCHED GC PEAKS /RATIO/ RET TIME

	M_Z	RATIO	RT.	AREA	MATCH_RAT	MATCH_RT	REL_RT	
	338	0.54	31.56	345.06	.T.	.F.	0.922	
	338	0.62	32.05	1770.03	.T.	.F.	0.927	
	338	0.59	32.17	340.77	.T.	.F.	0.933	
Ck doubled	338	0.68	32.49	361.29	.T.	.F.	0.948	OK. TV
Ck	338	0.~~41~~ 69	33.12 320.29	~~369.52~~	~~.F.~~ T	.T.	0.959	
	338	0.58	33.24	184.53	.T.	.F.	0.965	
	338	0.52	33.34	276.29	.T.	.F.	0.970	
	338	0.64	34.10	328.01	.T.	.T.	0.987	
	338	0.67	34.21	274.38	.T.	.F.	0.992	
	354	0.73	32.13	99.11	.F.	.F.	0.931	
	366	0.62	34.37	13902.78	.T.	.T.	1.000	
DELETE NOISE TV	374	1.92	36.44	143.16	.F.	.F.	0.930	
	374	2.16	36.48	69.89	.F.	.F.	0.931	
	374	1.19	36.59	835.68	.T.	.F.	0.936	
	374	1.89	38.13	661.30	.F.	.T.	0.967	
Delete noise H.R.	374	1.83	38.23	369.15	.F.	.T.	0.971	
	374	2.28	39.14	230.79	.F.	.T.	0.993	
	386	1.24	38.14	36328.22	.T.	.T.	0.968	
	390	4.09	38.14	1003.53	.F.	.F.	0.968	
	402	1.25	39.31	14690.84	.T.	.T.	1.000	
	402	1.26	39.59	27030.84	.T.	.T.	1.012	
	408	1.15	42.49	947.50	.T.	.T.	0.966	
Ck	408	0.83	43.11	248.39	.F.	.F.	0.974	RO
	408	1.08	43.24	315.76	.T.	.F.	0.979	
Ck	408	~~1.19~~ .96	44.58 206.15	~~166.14~~	~~.F.~~ T	.T.	1.015	
	424	1.12	43.15	279.11	.T.	.F.	0.976	
Ck	424	1.30	44.20	291.87	.F.	.T.	1.000	RO
	436	1.07	44.19	19892.36	.T.	.T.	1.000	
	442	0.92	49.37	1015.24	.T.	.T.	1.005	
	458	0.80	49.24	1789.82	.T.	.T.	1.000	
	470	0.92	49.23	39097.05	.T.	.T.	1.000	
	*** Total ***							
	***	97.75	2164.8	358053.32			48.250	

M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
202	104.84	7.21
202	54.75	7.36
202	174.01	7.43
202	90.19	8.08
202	268.82	8.52
202	322.68	9.00
202	281.87	9.06
202	52.90	9.16
202	237.28	9.28
202	160.90	9.34
202	301.43	9.41
202	511.73	9.53
202	414.96	10.05
202	85.27	10.28
202	203.20	10.54
202	228.41	11.07
202	164.57	11.23
202	99.39	11.31
202	57.22	11.45
202	100.23	12.03
202	190.23	12.10
202	174.63	12.25
202	132.06	12.34
202	159.58	12.50
202	104.09	13.02
202	122.18	13.31
202	334.60	13.55
204	97.06	7.26
204	54.62	8.52
204	94.15	9.00
204	48.24	19.40
204	64.99	19.56
204	129.27	20.28
204	126.28	20.38
204	117.29	20.49
204	483.83	22.54
218	336.70	7.49
218	443.36	7.58
218	354.83	8.52
218	319.62	9.06
218	412.44	9.25
218	283.85	9.32
218	1058.92	9.55
218	651.04	10.14
218	455.09	10.40
218	497.56	10.52
218	436.10	11.07
218	391.41	11.30
218	461.63	12.01
218	322.00	12.32

M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
218	852.63	12.45
218	494.30	13.03
218	335.05	13.13
218	699.82	13.35
220	551.22	7.18
220	2385.24	7.48
220	3987.12	7.59
220	3072.03	8.17
220	3999.27	8.34
220	4075.13	8.53
220	1431.44	9.06
220	807.13	9.25
220	1288.35	9.32
220	1170.07	9.43
220	3645.39	9.55
220	2251.08	10.14
220	704.17	10.31
220	1502.63	10.40
220	2271.44	10.52
220	2928.17	11.07
220	3045.79	11.28
220	2463.20	11.45
220	2400.83	12.00
220	2496.39	12.16
220	2907.05	12.50
220	3229.39	12.59
220	1670.42	13.14
220	4521.15	13.30
220	3163.12	13.53
220	1287.05	14.17
220	2429.03	14.25
220	3229.43	14.34
220	2875.52	15.16
220	1929.87	15.23
220	3249.70	15.35
220	1958.64	16.06
220	2120.27	16.39
220	1525.47	16.54
220	2067.90	17.09
220	1429.50	17.15
220	4595.76	17.41
220	887.18	17.52
220	1717.15	18.24
220	2429.05	18.35
220	1295.53	18.53
220	2504.91	19.14
220	3620.12	19.25
220	4359.95	19.44
220	6080.08	19.59
220	4619.62	20.09

M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
220	4681.65	20.53
220	8708.86	21.33
220	5179.85	21.45
220	5305.68	21.56
220	4422.58	22.04
220	5461.04	22.15
220	4540.18	22.26
220	3551.24	22.41
220	4286.71	22.58
220	4011.81	23.14
220	5618.28	23.32
220	4238.61	23.48
220	1712.57	24.09
220	2416.29	24.23
220	1880.05	24.47
220	2650.11	24.56
220	2498.07	25.11
238	44.66	11.11
238	291.93	11.37
238	74.67	11.49
238	94.92	11.57
238	378.34	12.08
238	130.54	12.20
238	95.15	12.28
238	234.10	12.41
238	210.80	12.54
238	324.55	13.11
238	339.46	13.20
238	76.02	13.36
238	291.74	13.44
238	539.58	14.06
238	113.33	14.20
238	99.67	14.29
238	116.01	14.39
238	153.54	14.45
238	69.08	14.58
238	183.40	15.19
238	148.77	15.28
238	616.39	15.45
238	262.05	15.56
238	320.61	16.23
238	46.07	16.35
238	217.20	16.45
238	287.95	16.59
240	65.00	7.09
240	59.57	7.19
240	102.95	7.32
240	218.76	7.50
240	48.02	8.19
240	127.51	8.43

M8809791
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
240	81.14	9.10
240	67.34	9.21
240	84.09	9.37
240	112.66	9.56
240	99.12	10.02
240	56.40	10.13
240	153.47	10.24
240	55.95	10.37
240	102.53	10.47
240	122.39	10.56
240	87.43	11.05
240	268.05	11.23
240	190.30	11.33
240	293.01	11.49
240	117.84	12.05
240	58.70	13.49
240	51.28	13.56
240	65.98	14.07
240	149.89	14.22
240	111.99	15.08
240	122.83	15.25
240	80.79	15.38
240	65.27	15.57
240	187.06	16.19
240	56.76	16.44
240	174.91	16.56
240	126.64	17.20
240	163.18	17.30
240	170.33	17.50
240	99.81	17.59
240	81.51	18.41
240	141.75	19.00
240	89.55	19.07
240	85.13	19.15
240	54.51	19.24
240	91.50	19.47
240	68.14	20.30
240	202.66	20.36
240	77.66	20.51
240	80.39	21.03
240	260.43	21.12
240	126.42	21.24
240	100.07	21.39
240	229.25	21.55
240	77.87	22.11
240	77.22	22.19
240	97.63	22.27
240	316.41	23.00
240	119.18	23.11
240	50.19	23.39

M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
240	81.54	23.53
240	45.12	24.13
240	158.75	24.28
240	72.53	24.40
240	107.97	25.00
240	98.90	25.16
252	2640.81	7.22
252	2039.93	7.33
252	1037.97	7.45
252	1118.07	7.51
252	584.12	8.05
252	577.77	8.12
252	536.23	8.21
252	849.34	8.28
252	1024.86	8.43
252	265.94	8.56
252	259.25	9.02
252	913.47	9.17
252	359.48	9.28
252	587.76	9.39
252	1107.76	9.45
252	728.30	10.00
252	1107.11	10.13
252	1689.20	10.26
252	776.85	10.35
252	843.40	10.45
252	491.71	10.57
252	282.18	11.03
252	344.04	11.12
252	408.42	11.19
252	1089.63	11.37
252	265.54	11.49
252	274.12	11.56
252	776.38	12.09
252	128.07	12.27
252	118.15	12.35
252	135.49	12.42
252	296.46	12.53
252	403.92	13.10
252	594.88	13.20
252	287.50	13.37
252	594.17	13.45
252	744.54	14.05
252	697.65	14.13
252	418.48	14.21
252	288.48	14.29
252	1004.52	14.45
252	1919.20	14.57
252	321.70	15.19
252	563.09	15.27

M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
252	609.84	15.42
252	584.66	15.49
252	752.69	15.55
252	1386.80	16.18
252	656.24	16.34
252	1047.01	16.45
254	75.78	12.08
254	56.51	16.50
254	45.85	19.50
254	89.86	21.16
254	65.76	21.24
254	44.69	21.41
254	69.28	24.14
254	56.42	24.43
270	330.63	20.37
270	241.91	20.57
270	287.79	21.21
270	533.44	21.45
270	347.50	22.06
270	288.89	22.29
270	388.66	22.39
270	83.69	22.56
270	366.50	23.08
272	248.54	20.37
272	281.41	20.57
272	255.23	21.21
272	410.69	21.46
272	327.42	22.06
272	272.53	22.29
272	386.41	22.39
272	95.93	22.56
272	334.35	23.08
286	10.00	10.00
288	10.00	11.00
304	99.51	25.51
304	70.24	26.06
304	1023.85	26.26
304	564.69	26.42
304	558.18	27.07
304	356.81	27.25
304	352.10	27.41
304	224.85	28.03
304	462.36	28.31
304	194.57	28.58
304	117.57	29.12
304	23.59	30.18
306	147.01	25.51
306	101.36	26.06
306	1386.52	26.26
306	782.94	26.42

M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
306	760.30	27.07
306	559.02	27.26
306	652.09	27.43
306	363.57	28.03
306	191.56	28.18
306	659.31	28.31
306	254.44	28.57
306	142.34	29.11
306	39.83	29.26
306	328.30	34.38
316	163.96	28.01
316	18912.34	28.28
316	104.85	29.16
316	296.60	30.23
316	133.14	31.52
318	239.79	28.02
318	24117.32	28.28
318	192.77	28.55
318	410.42	30.23
320	56.44	28.01
320	51.21	28.28
320	31.51	29.10
322	29.54	26.39
322	53.20	28.01
328	31249.63	29.17
332	106.55	26.06
332	200.25	27.06
332	135.51	27.19
332	149.61	27.48
332	111.85	28.18
332	267.30	28.42
332	11036.93	29.02
332	15561.16	29.16
332	147.35	30.09
332	168.63	30.20
332	567.00	31.56
334	13652.19	29.02
334	19489.10	29.16
334	217.78	34.38
338	121.54	30.42
338	121.52	31.56
338	677.50	32.05
338	125.90	32.17
338	146.37	32.49
338	27.87	33.04
338	106.83	33.12
338	67.70	33.24
338	94.09	33.34
338	127.72	34.10
338	110.52	34.21

M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
340	161.21	30.41
340	223.54	31.56
340	1092.53	32.05
340	214.87	32.17
340	214.92	32.48
340	262.69	33.11
340	116.83	33.25
340	182.20	33.35
340	200.29	34.10
340	163.86	34.21
354	41.97	32.13
356	57.14	32.13
366	5304.49	34.37
368	8598.29	34.37
374	94.09	36.44
374	47.76	36.48
374	454.22	36.59
374	71.67	37.05
374	23.75	37.16
374	75.01	37.25
374	45.69	37.29
374	73.47	37.37
374	59.74	37.40
374	56.93	37.45
374	82.34	37.57
374	432.59	38.13
374	238.62	38.23
374	69.00	38.44
374	64.86	38.52
374	70.98	38.58
374	119.25	39.06
374	160.48	39.14
374	113.08	39.25
374	47.31	39.30
374	32.87	39.33
374	28.82	39.36
374	49.79	39.38
374	31.07	39.43
374	40.44	39.47
374	35.14	39.52
374	67.75	39.55
374	126.62	40.03
374	42.43	40.07
374	102.95	40.13
374	79.86	40.18
374	82.23	40.21
374	116.41	40.29
374	74.81	40.34
374	54.53	40.37
374	146.87	40.45

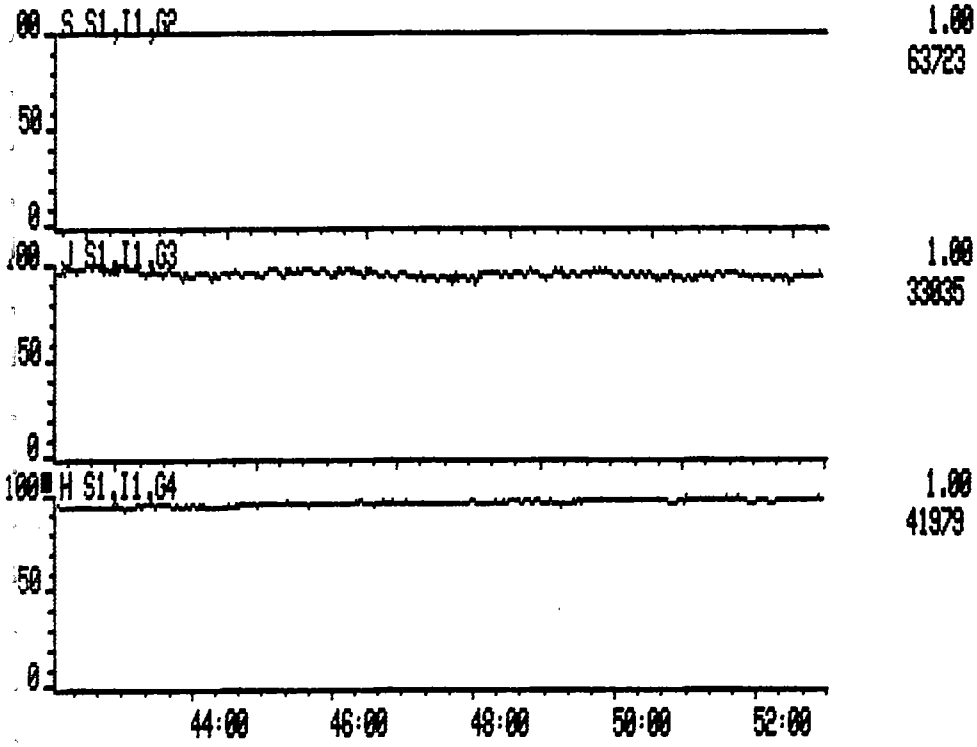
M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
374	99.42	40.54
374	26.40	40.58
374	59.74	41.01
374	93.08	41.04
374	42.17	41.08
374	162.42	41.15
374	41.02	41.22
374	39.34	41.30
374	24.47	41.41
374	22.91	41.43
374	28.72	41.48
376	49.07	36.45
376	22.13	36.48
376	381.46	36.58
376	228.71	38.14
376	130.53	38.25
376	70.31	39.12
386	20130.90	38.14
388	16197.32	38.14
390	806.21	38.14
390	28.56	38.35
392	197.32	38.14
392	41.88	38.32
402	8174.81	39.31
402	15050.90	39.59
404	6516.03	39.31
404	11979.94	39.59
408	507.36	42.49
408	112.41	43.11
408	163.84	43.24
408	90.31	44.58
410	440.14	42.49
410	135.98	43.12
410	151.92	43.24
410	75.83	44.57
410	1737.53	49.23
424	147.70	43.15
424	164.81	44.20
426	131.41	43.15
426	127.06	44.20
436	10290.77	44.19
438	27.46	43.14
438	9601.59	44.19
438	66.69	49.08
438	935.22	49.24
442	487.16	49.37
444	528.08	49.37
458	797.77	49.24
460	992.05	49.24
470	18721.29	49.23

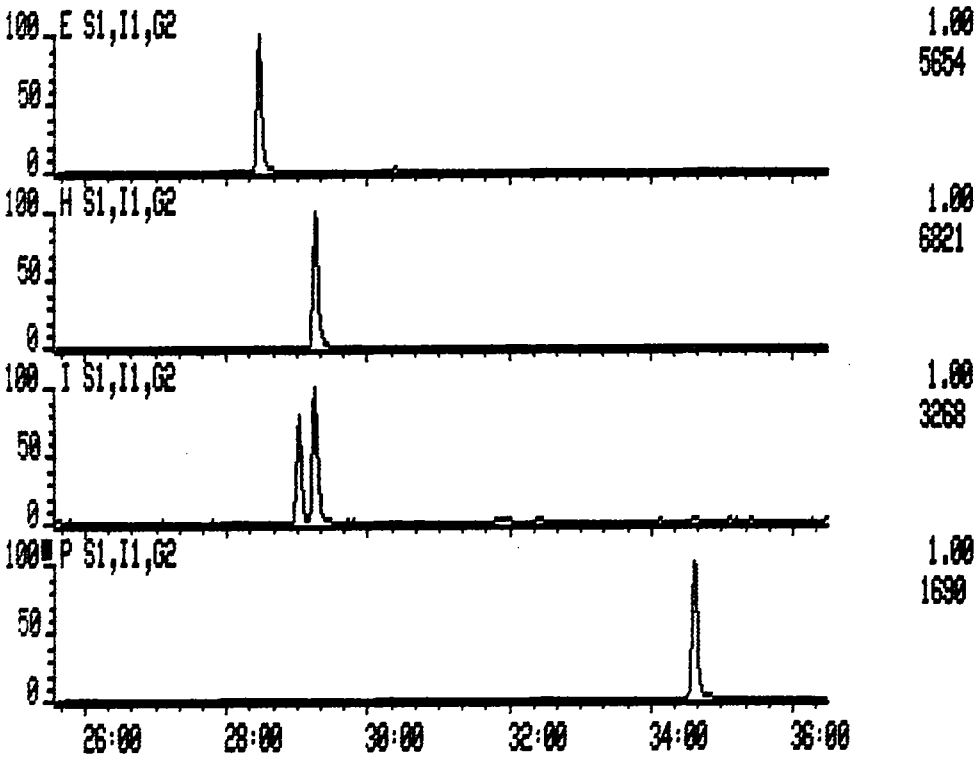
M880979I
RAW MASS AND AREA DATA

MASS	AREA	RET.TIME
472	20375.76	49.23
*** Total ***		
****	577789.81	10089.44

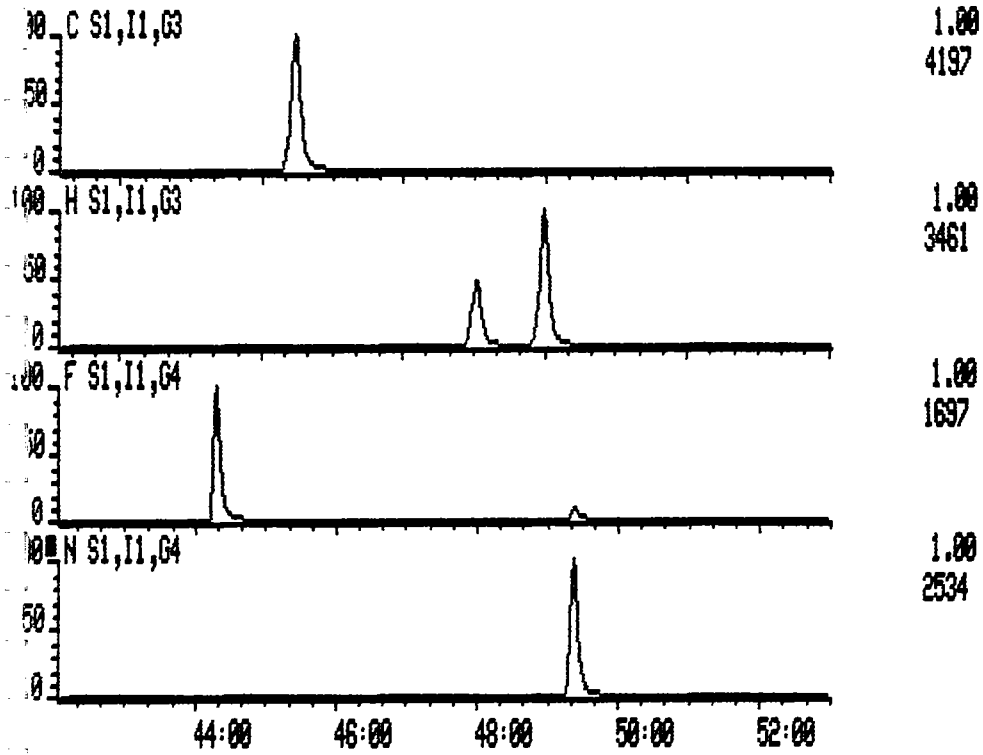
M888379 18-MAR-88 19:52 70E (EI+) Sus:D85
R 4 A: 440.9761 B: 407.7817 C: 409.7788 D: 423.7766 E: 425.7737
Text:SAMPLE #2 TLI#2191



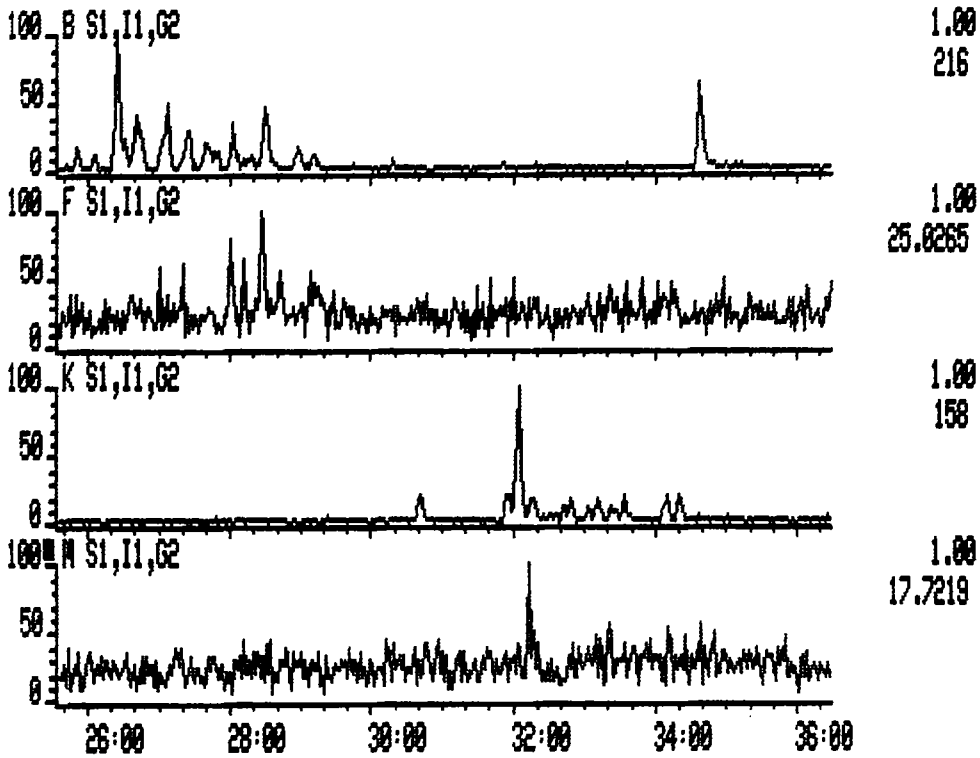
M888979 18-MAR-88 19:52 70E (EI+) Sus:D85
GR 2 A: 292.9825 B: 303.9016 C: 305.8987 D: 315.9419 E: 317.9389
Text:SAMPLE #2 TLI#2191



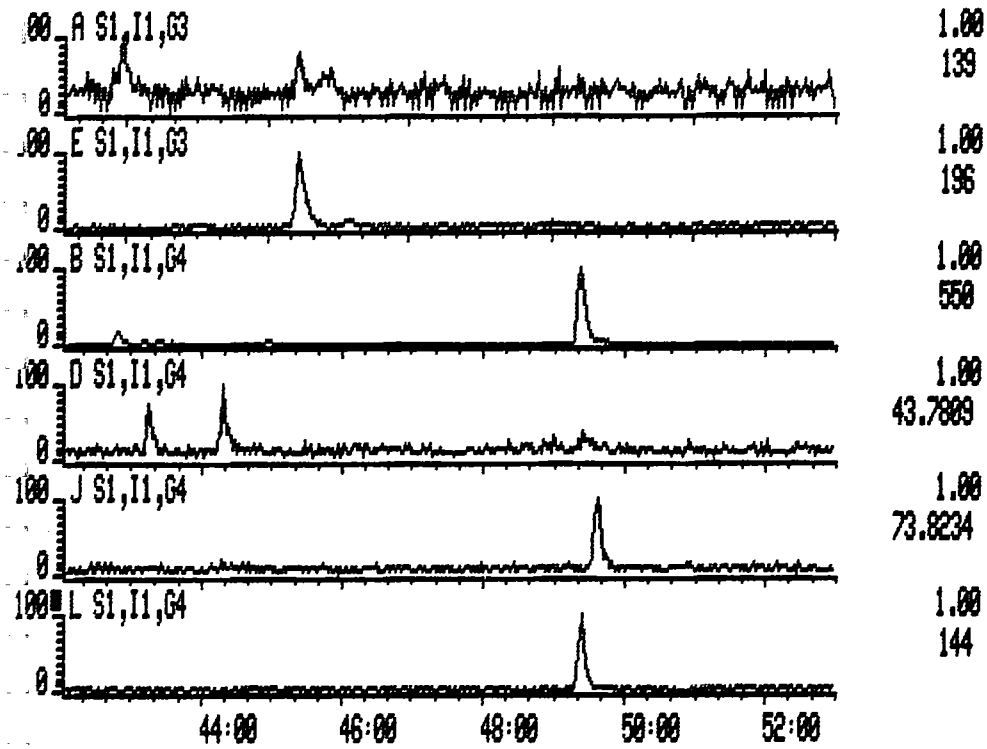
0888979 18-MAR-88 19:52 70E (EI+) Sys:D85
4 A: 440.9761 B: 407.7817 C: 409.7788 D: 423.7766 E: 425.7737
ext:SAMPLE #2 TLI#2191



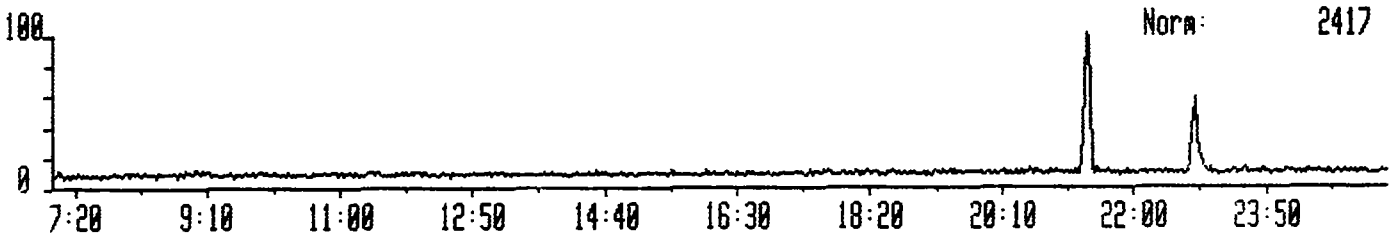
M880979 18-MAR-88 19:52 70E (EI+) Sys:D85
GR 2 A: 292.9825 B: 303.9016 C: 305.8987 D: 315.9419 E: 317.9389
Text:SAMPLE #2 TLI#2191



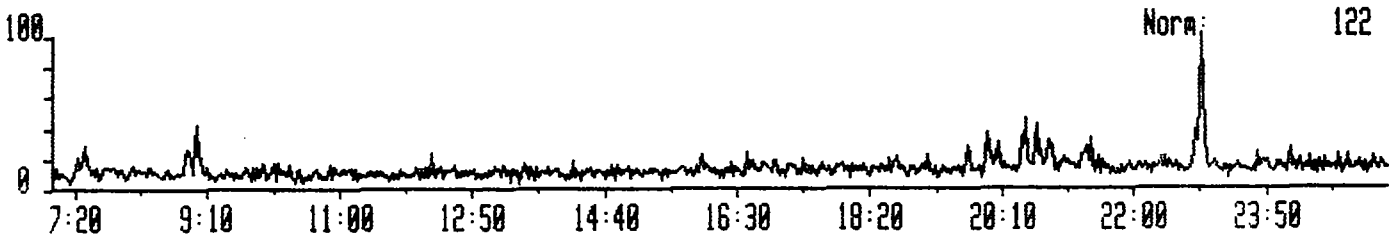
M880979 18-MAR-88 19:52 70E (EI+) Sus:085
4 A: 440.9761 B: 407.7817 C: 409.7788 D: 423.7766 E: 425.7737
ext:SAMPLE #2 TLI#2191



M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 202.0186
Text:SAMPLE #2 TLI#2191

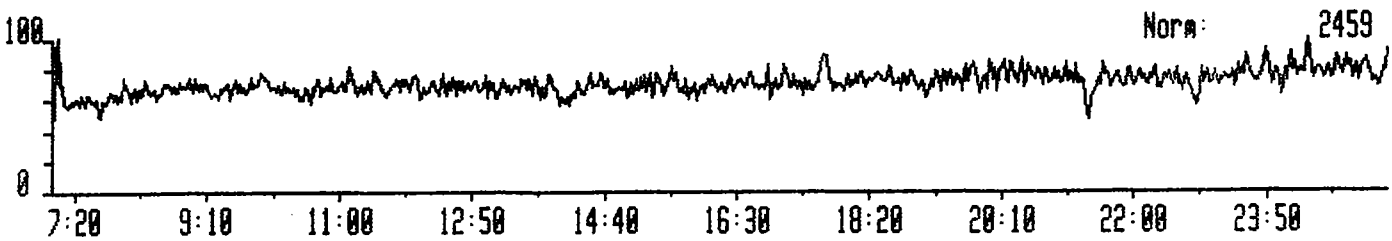


M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 204.0157
Text:SAMPLE #2 TLI#2191

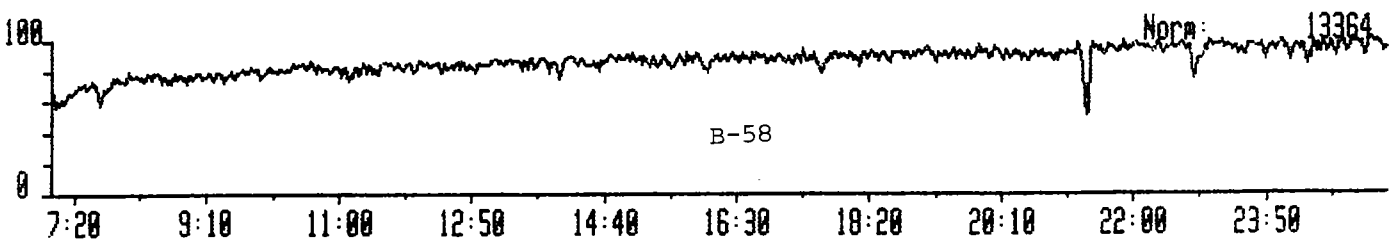


M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 218.0135
Text:SAMPLE #2 TLI#2191

M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 220.0106
Text:SAMPLE #2 TLI#2191



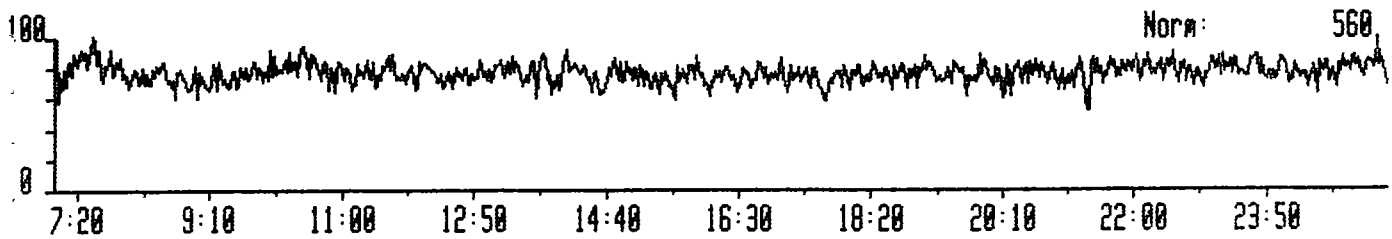
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 235.9796
Text:SAMPLE #2 TLI#2191



M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 237.9767
Text:SAMPLE #2 TLI#2191

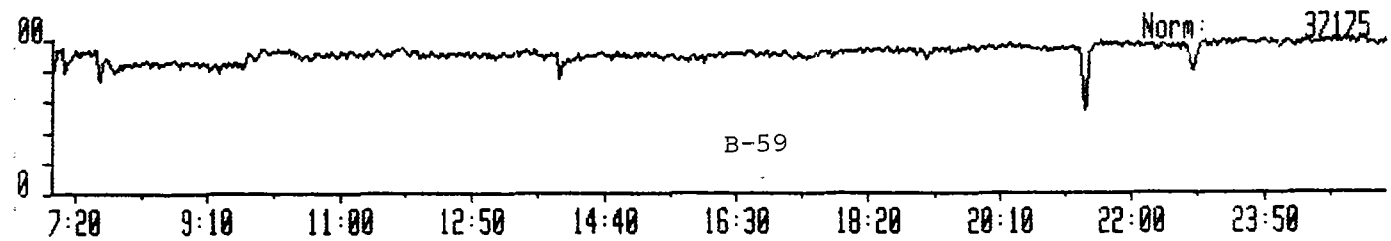
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 239.9738
Text:SAMPLE #2 TLI#2191

M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 251.9745
Text:SAMPLE #2 TLI#2191

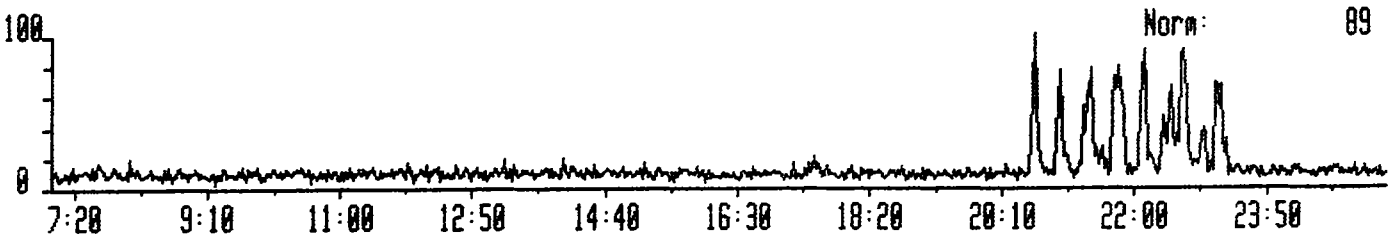


M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 253.9716
Text:SAMPLE #2 TLI#2191

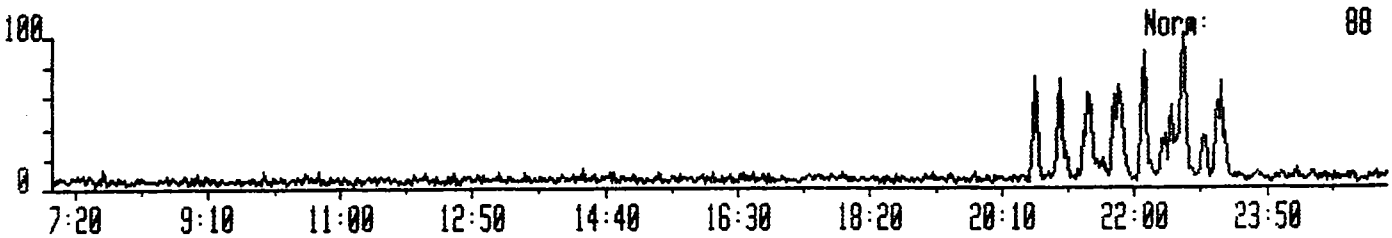
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 254.9856
Text:SAMPLE #2 TLI#2191



M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 269.9406
Text:SAMPLE #2 TLI#2191

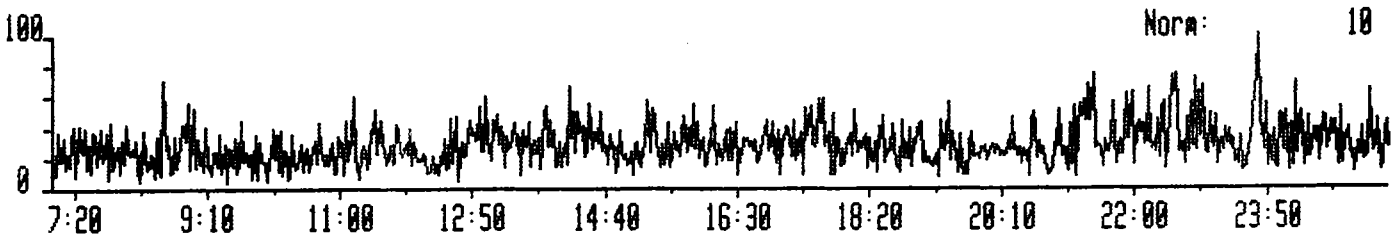


M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 271.9377
Text:SAMPLE #2 TLI#2191

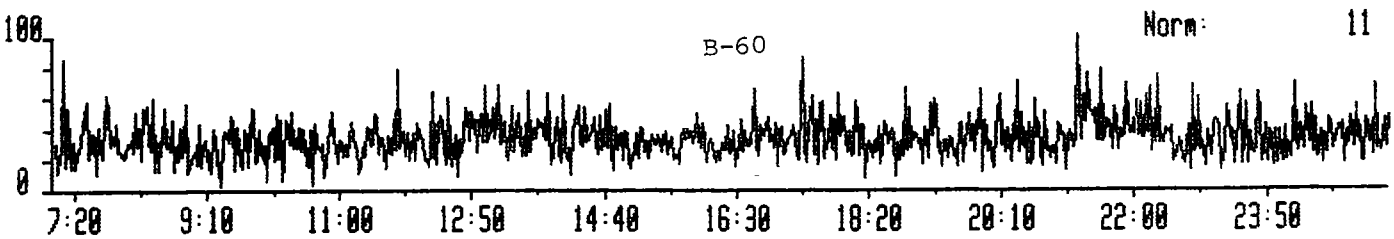


M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 285.9355
Text:SAMPLE #2 TLI#2191

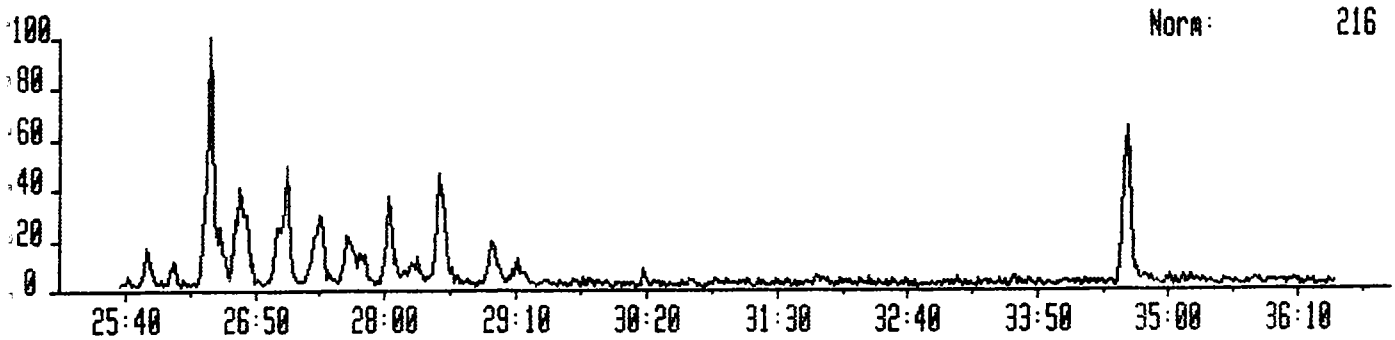
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 287.9326
Text:SAMPLE #2 TLI#2191



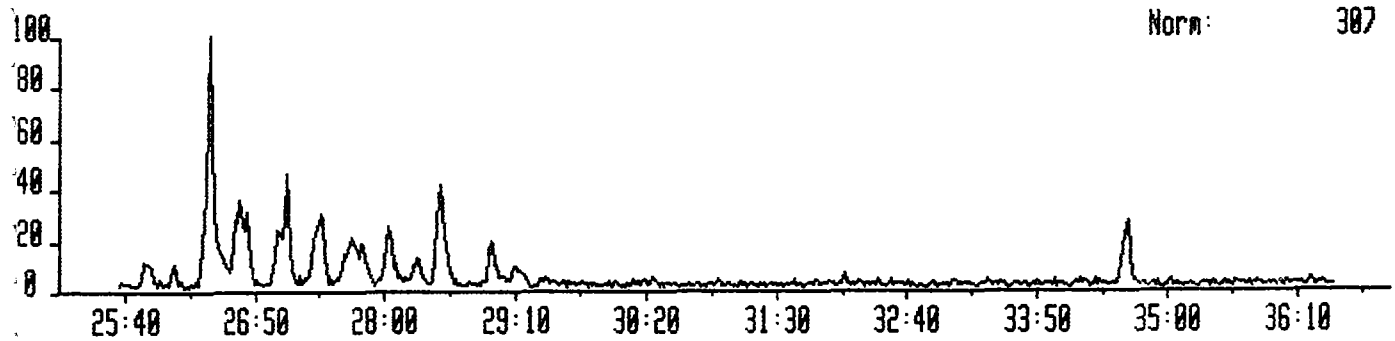
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 1 Mass 305.9280
Text:SAMPLE #2 TLI#2191



M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 303.9816
Text:SAMPLE #2 TLI#2191

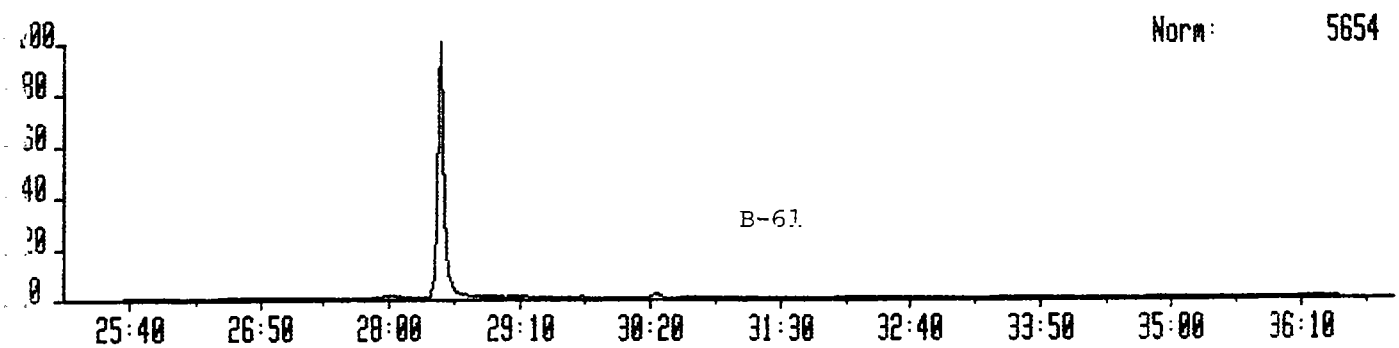


M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 305.8987
Text:SAMPLE #2 TLI#2191

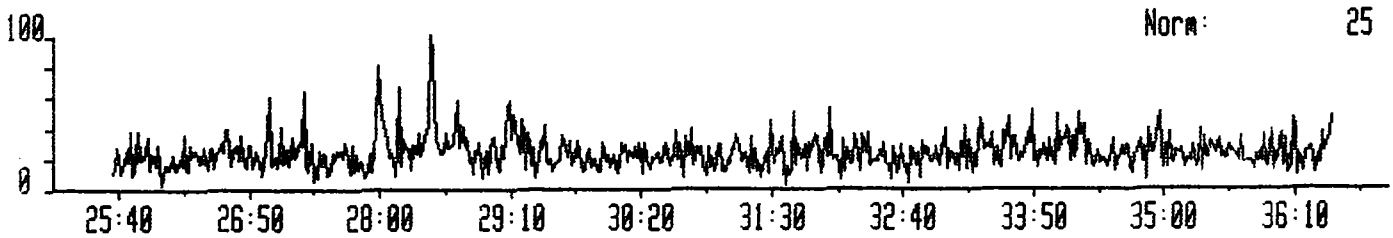


M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 315.9419
Text:SAMPLE #2 TLI#2191

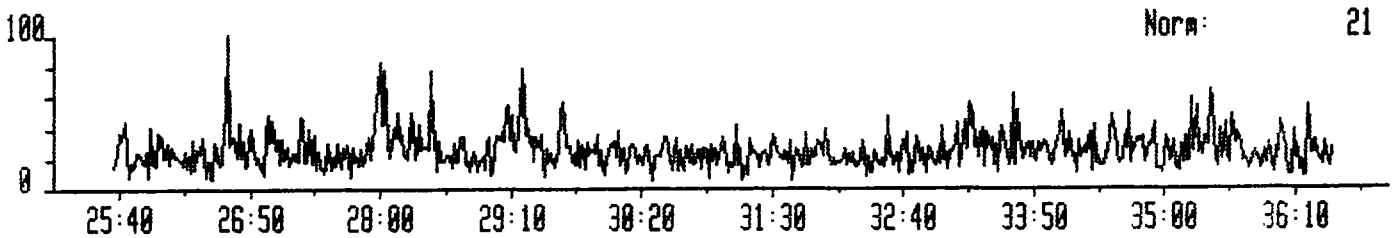
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 317.9389
Text:SAMPLE #2 TLI#2191



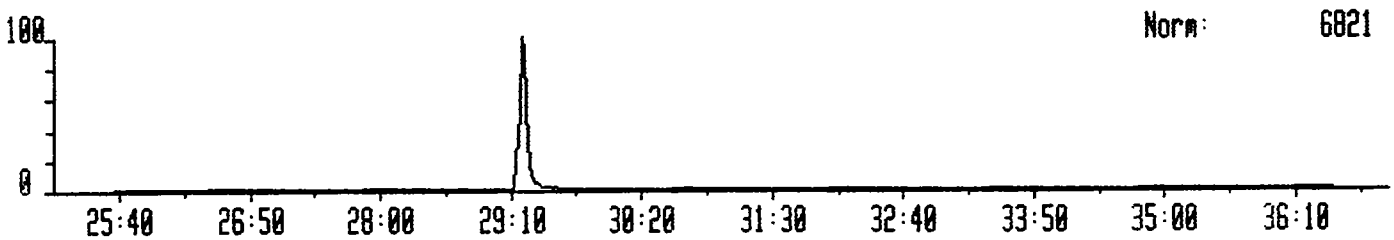
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 319.8965
Text:SAMPLE #2 TLI#2191



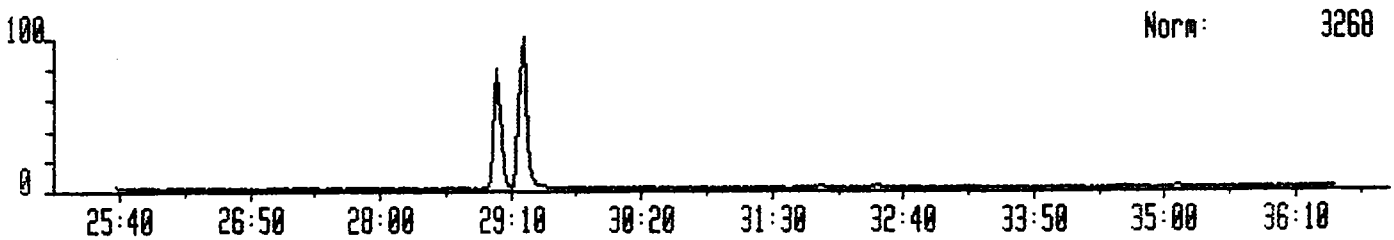
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 321.8936
Text:SAMPLE #2 TLI#2191



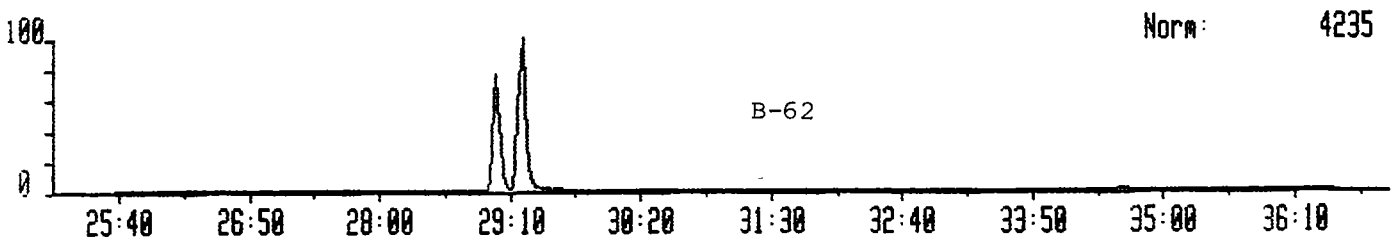
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 327.8847
Text:SAMPLE #2 TLI#2191



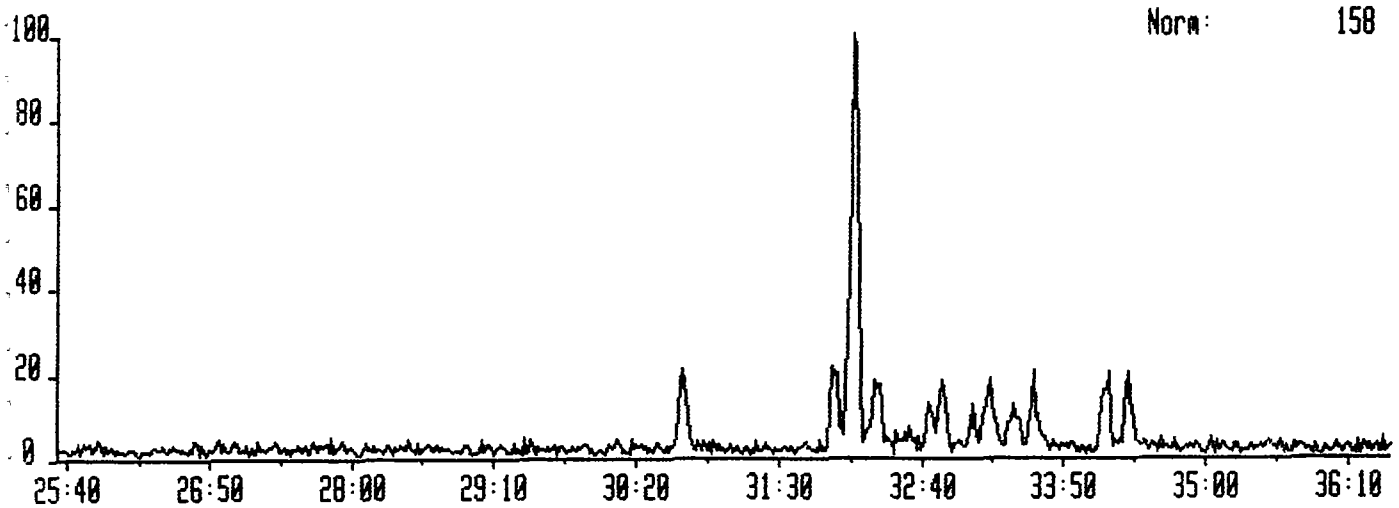
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 331.9368
Text:SAMPLE #2 TLI#2191



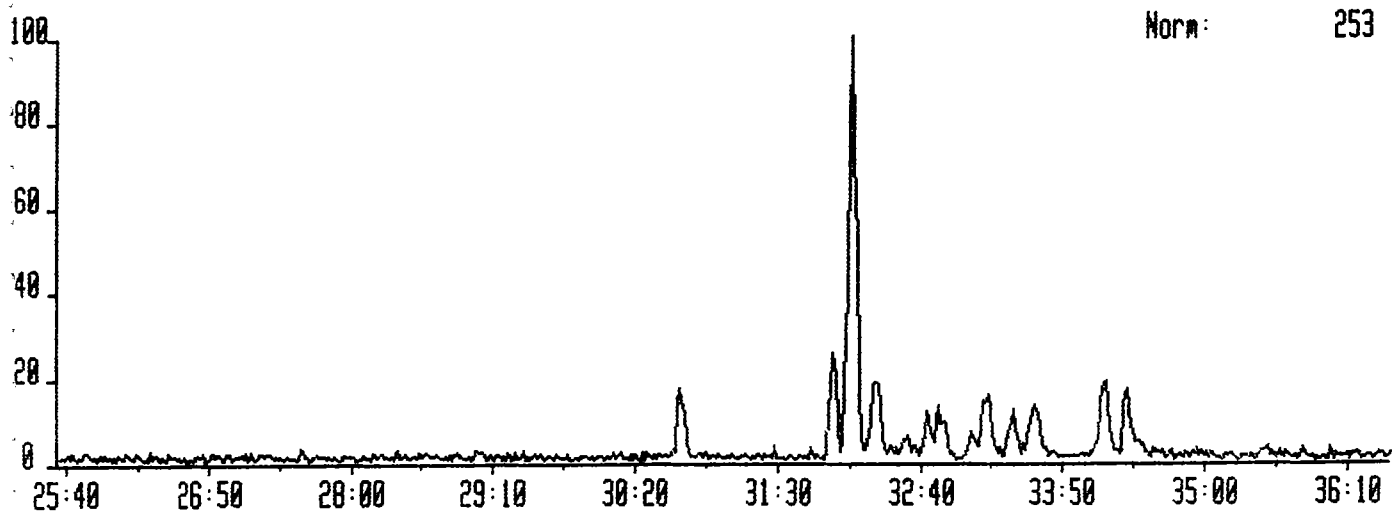
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 333.9338
Text:SAMPLE #2 TLI#2191



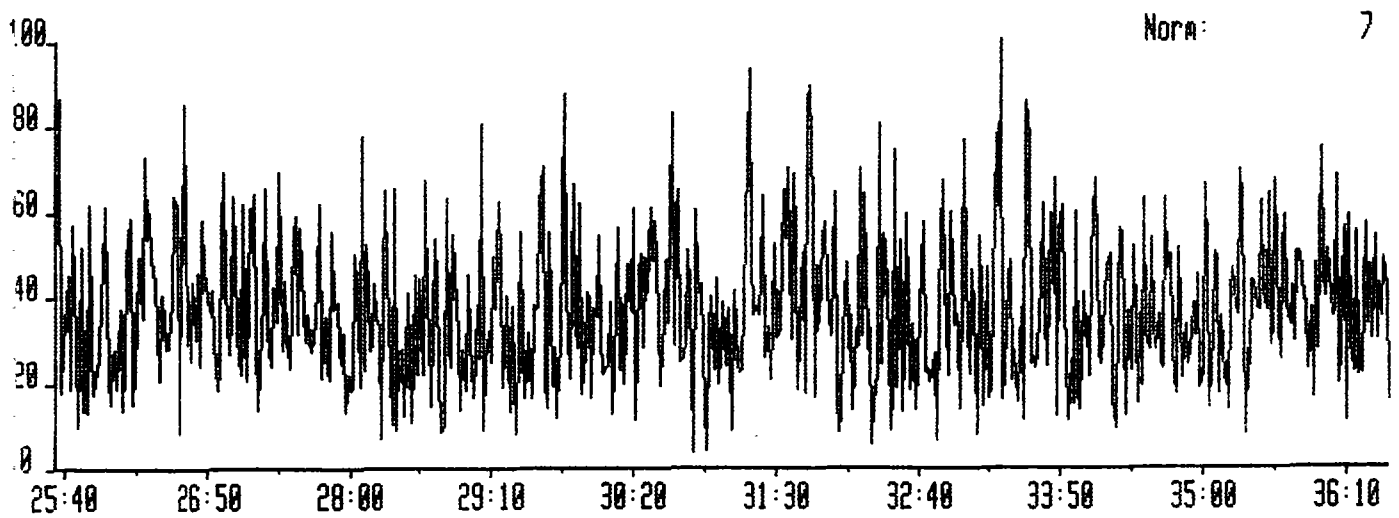
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 337.8626
Text:SAMPLE #2 TLI#2191



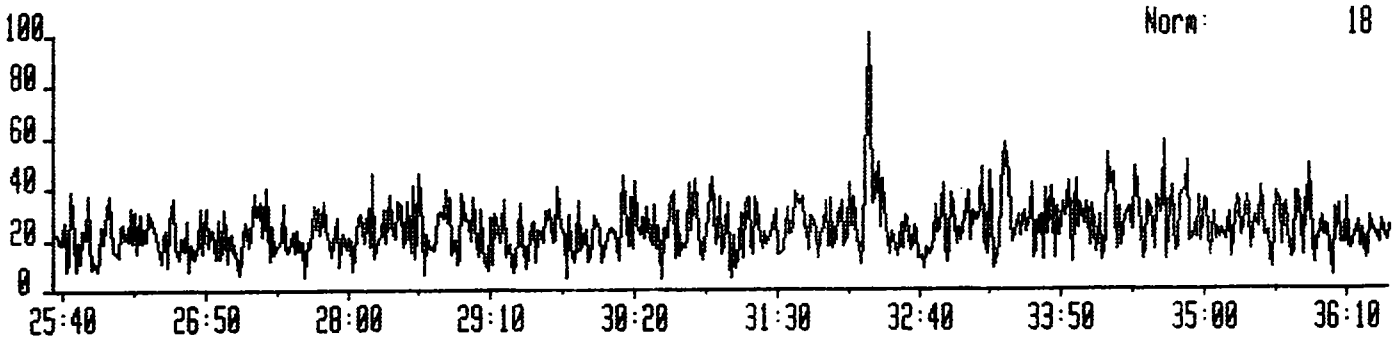
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 339.8597
Text:SAMPLE #2 TLI#2191



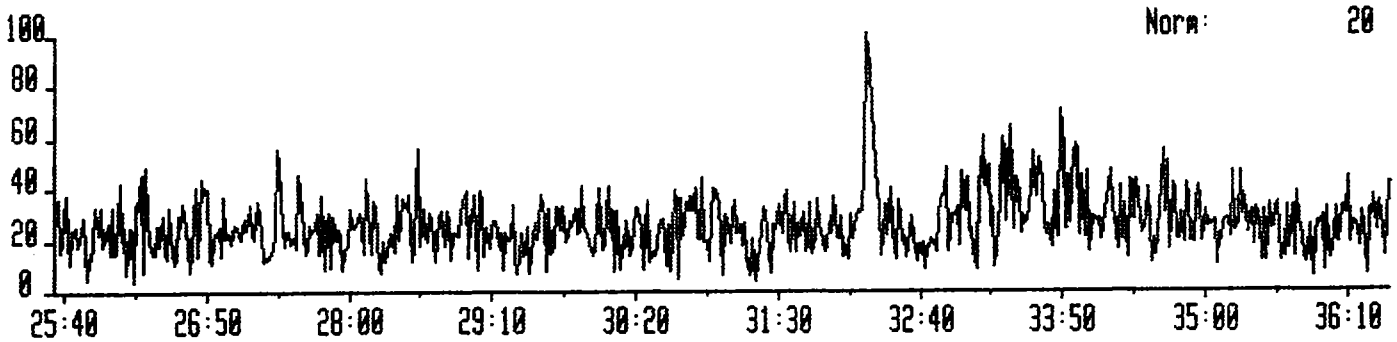
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 407.8003
Text:SAMPLE #2 TLI#2191



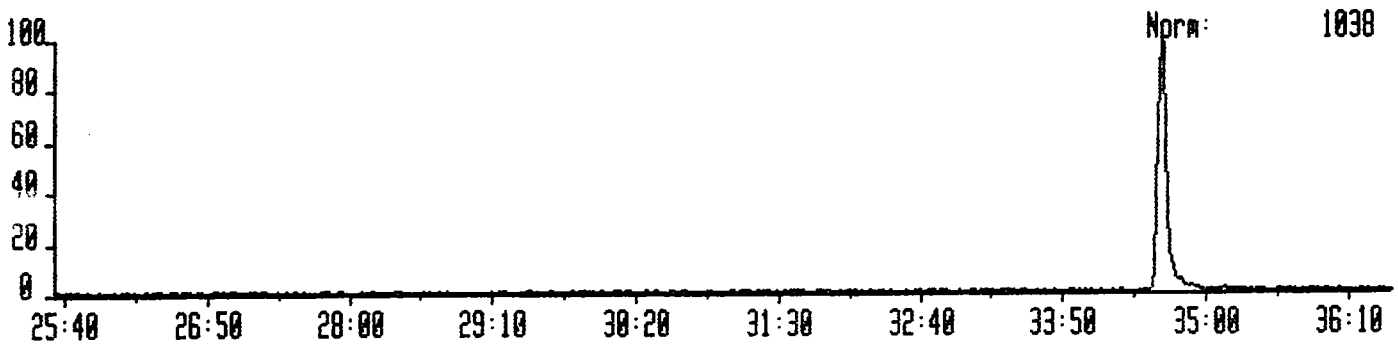
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 353.8575
Text:SAMPLE #2 TLI#2191



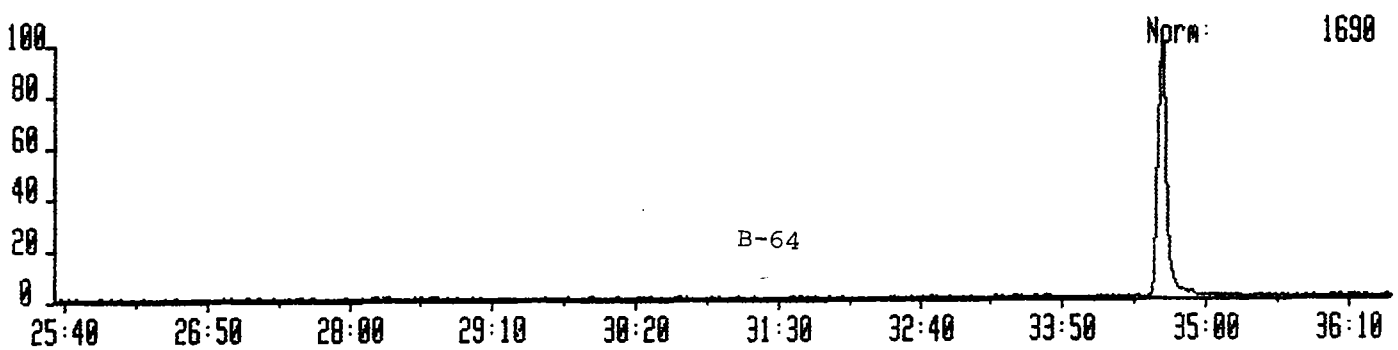
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 355.8546
Text:SAMPLE #2 TLI#2191



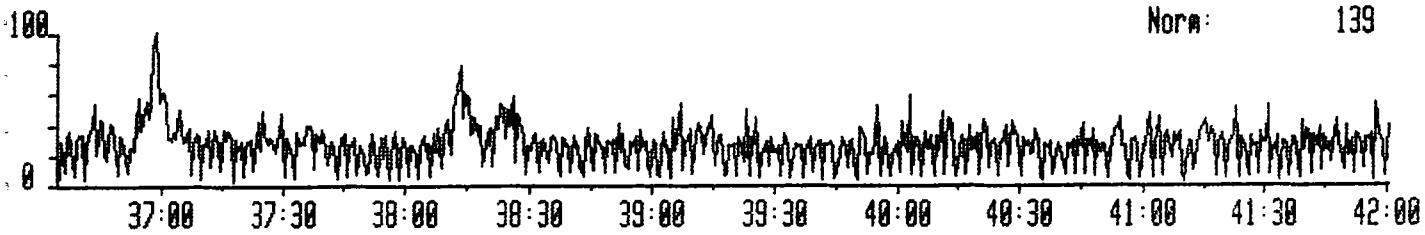
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 365.8977
Text:SAMPLE #2 TLI#2191



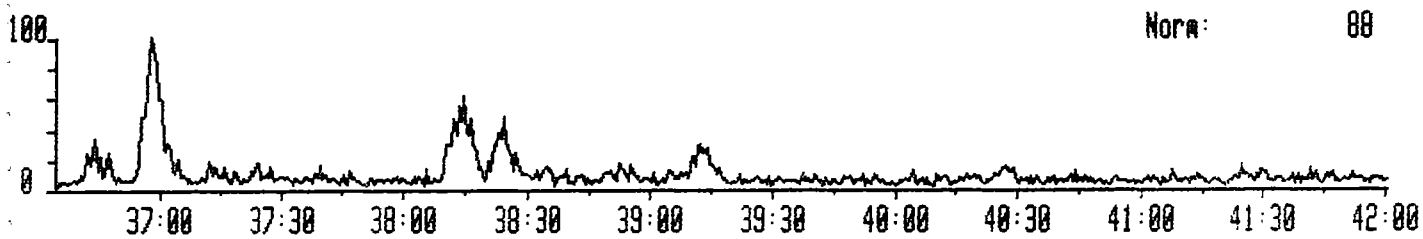
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 2 Mass 367.8948
Text:SAMPLE #2 TLI#2191



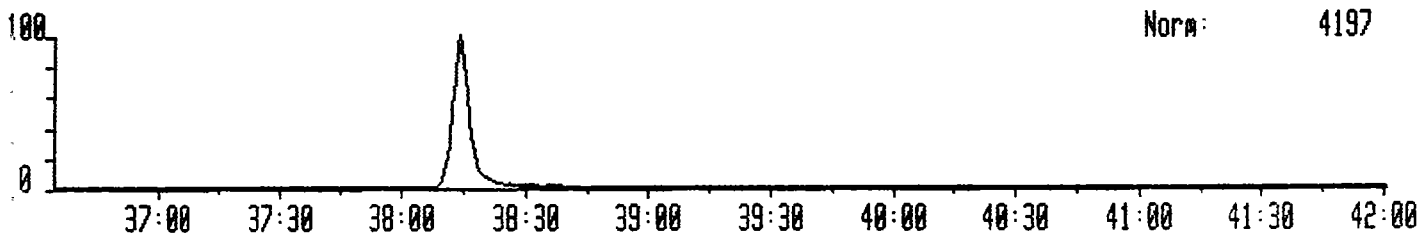
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 373.8207
Text:SAMPLE #2 TLI#2191



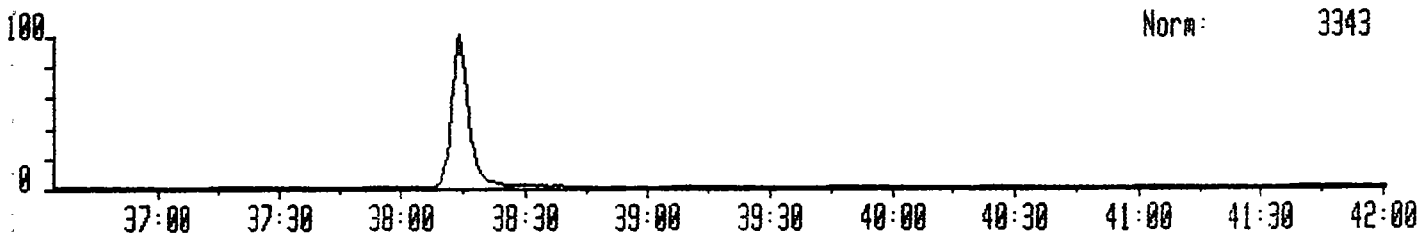
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 375.8178
Text:SAMPLE #2 TLI#2191



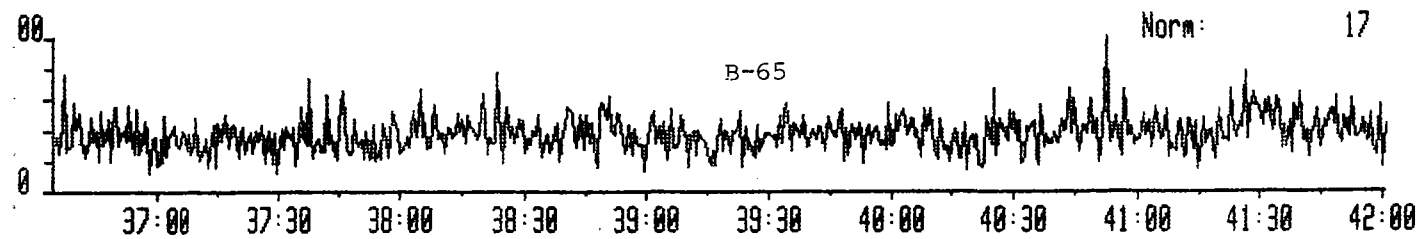
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 385.8609
Text:SAMPLE #2 TLI#2191



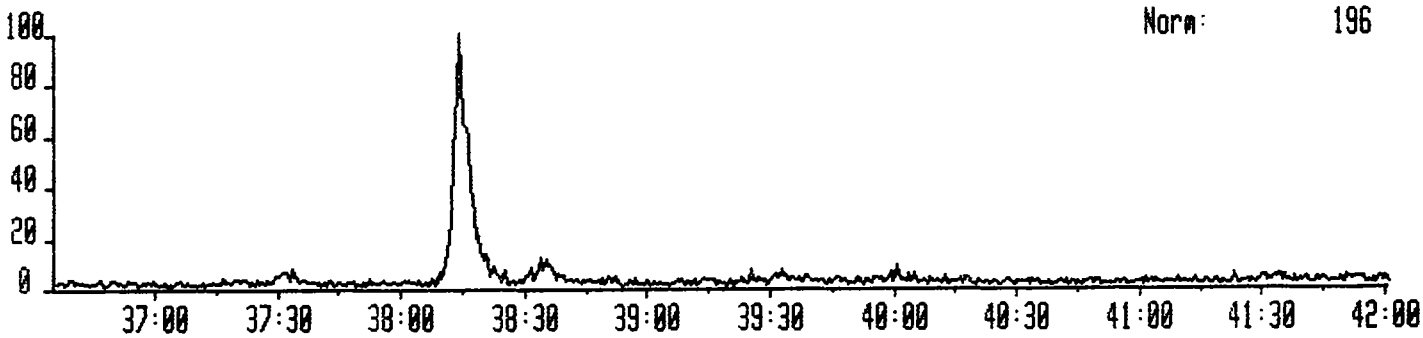
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 387.8580
Text:SAMPLE #2 TLI#2191



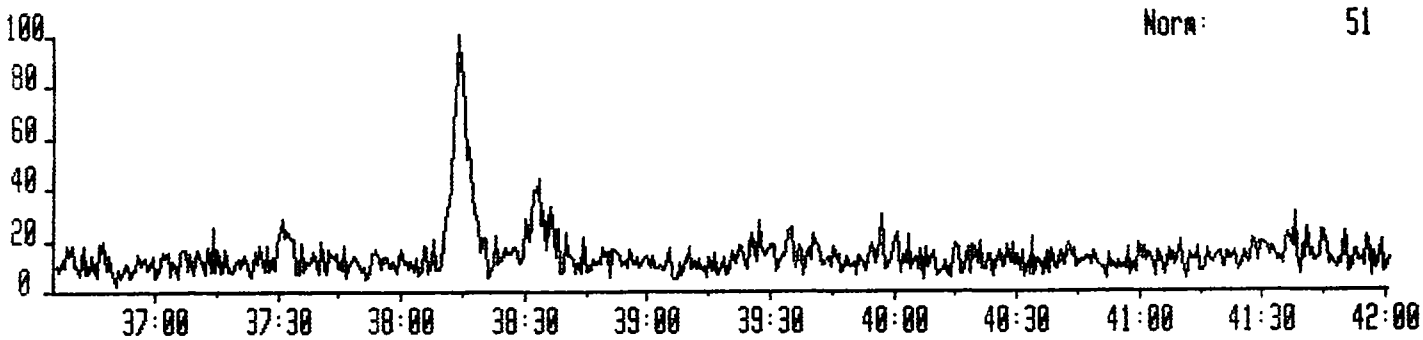
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 443.7584
Text:SAMPLE #2 TLI#2191



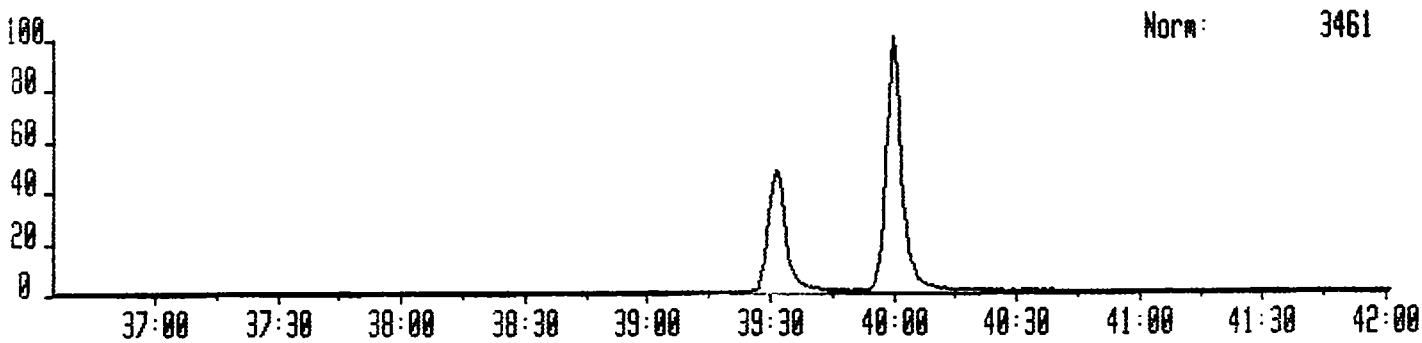
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 389.8156
Text:SAMPLE #2 TLI#2191



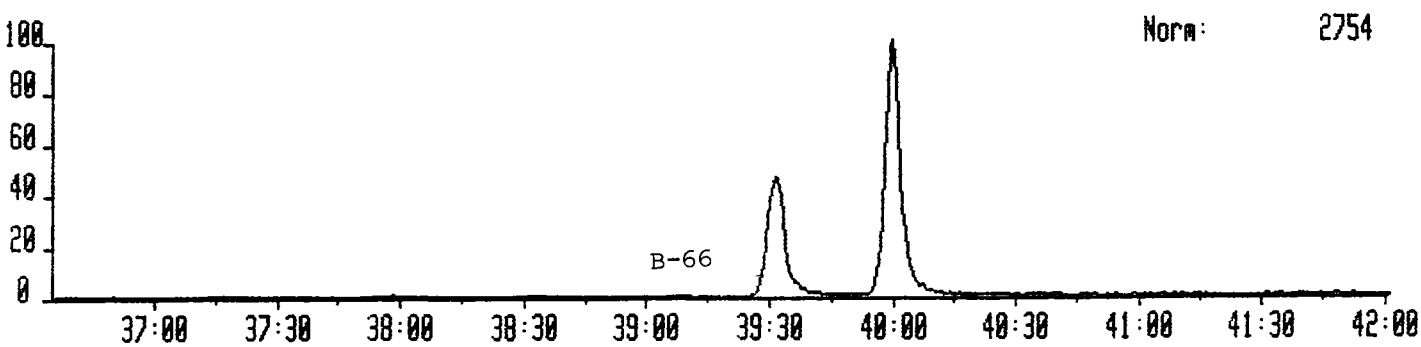
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 391.8127
Text:SAMPLE #2 TLI#2191



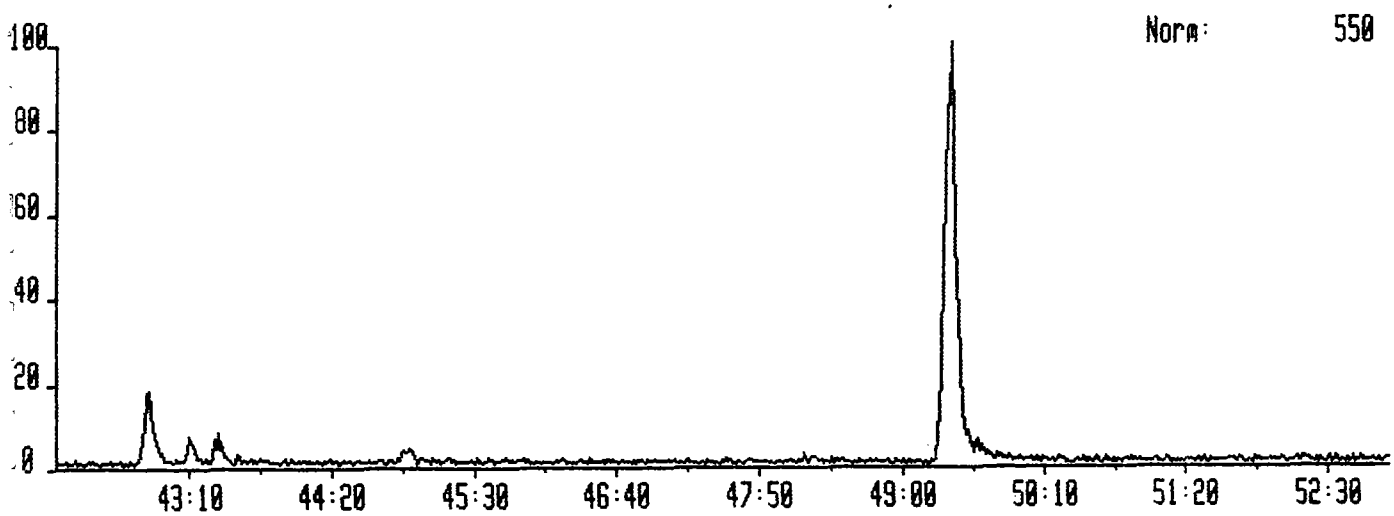
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 401.8558
Text:SAMPLE #2 TLI#2191



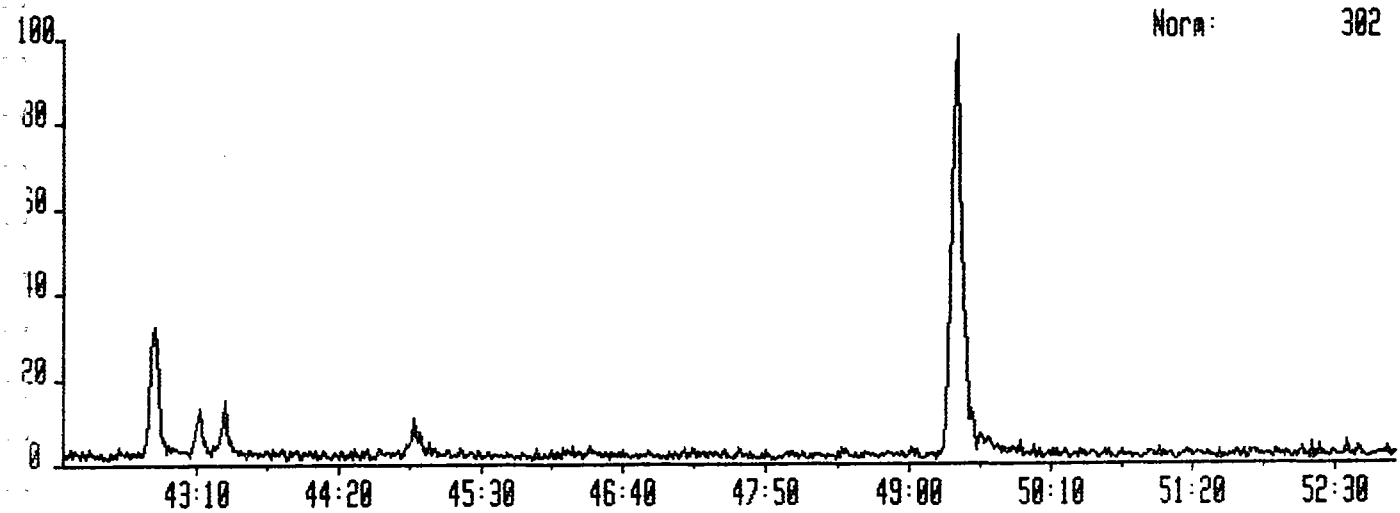
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 3 Mass 403.8529
Text:SAMPLE #2 TLI#2191



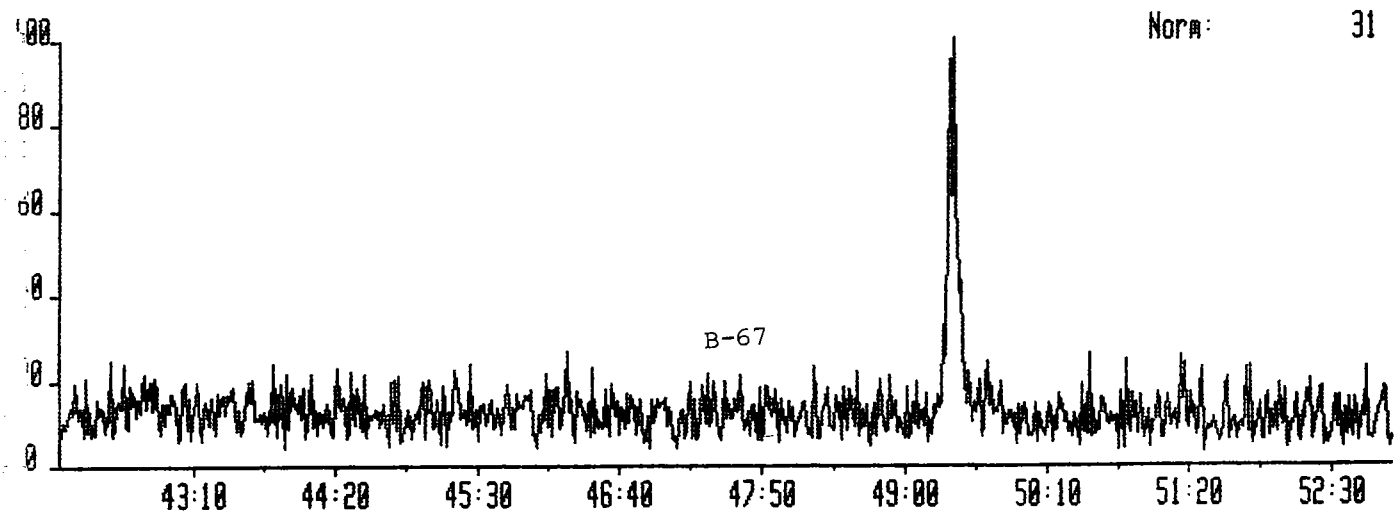
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 407.7817
Text:SAMPLE #2 TLI#2191



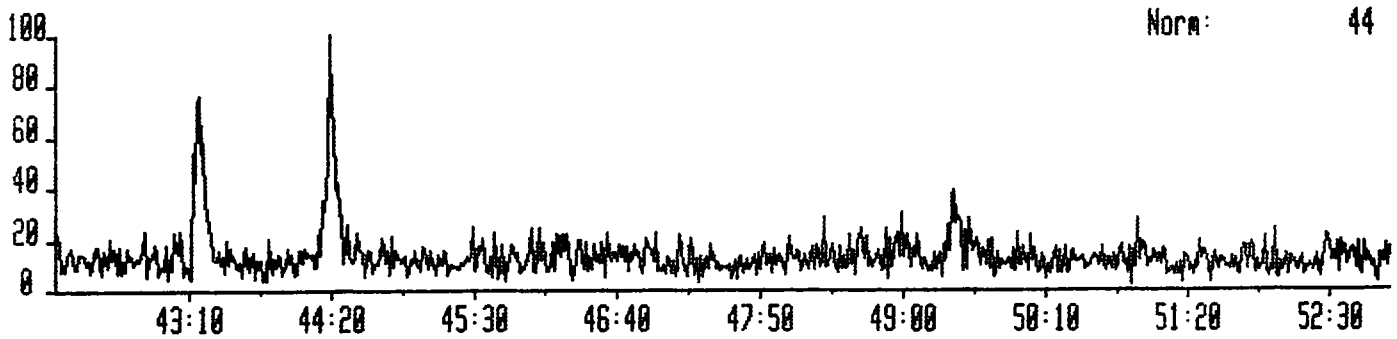
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 409.7788
Text:SAMPLE #2 TLI#2191



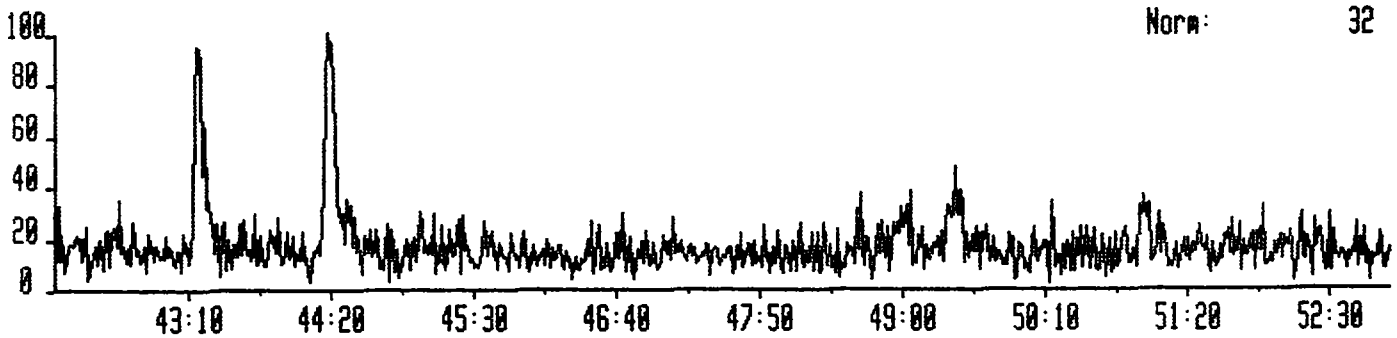
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 477.7200
Text:SAMPLE #2 TLI#2191



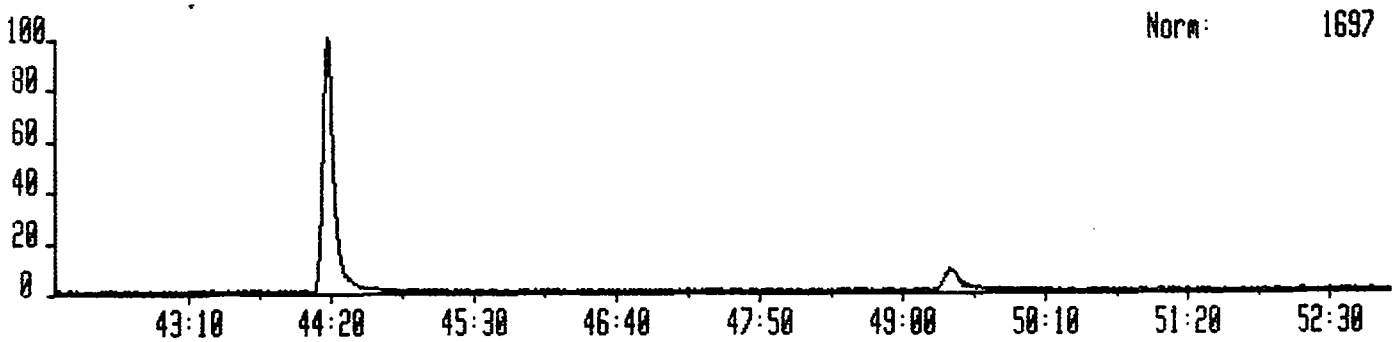
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 423.7766
Text:SAMPLE #2 TLI#2191



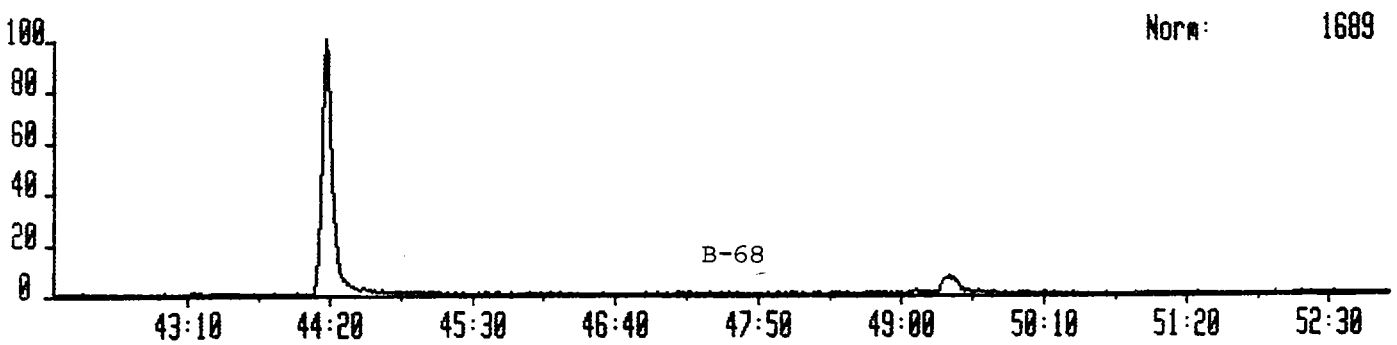
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 425.7737
Text:SAMPLE #2 TLI#2191



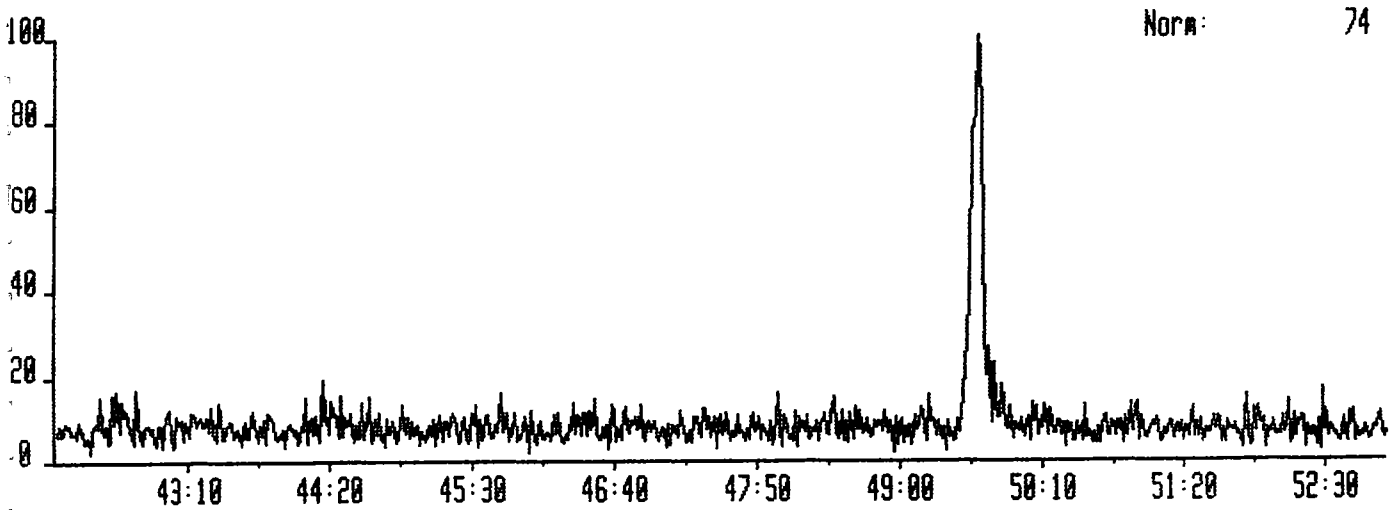
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 435.8169
Text:SAMPLE #2 TLI#2191



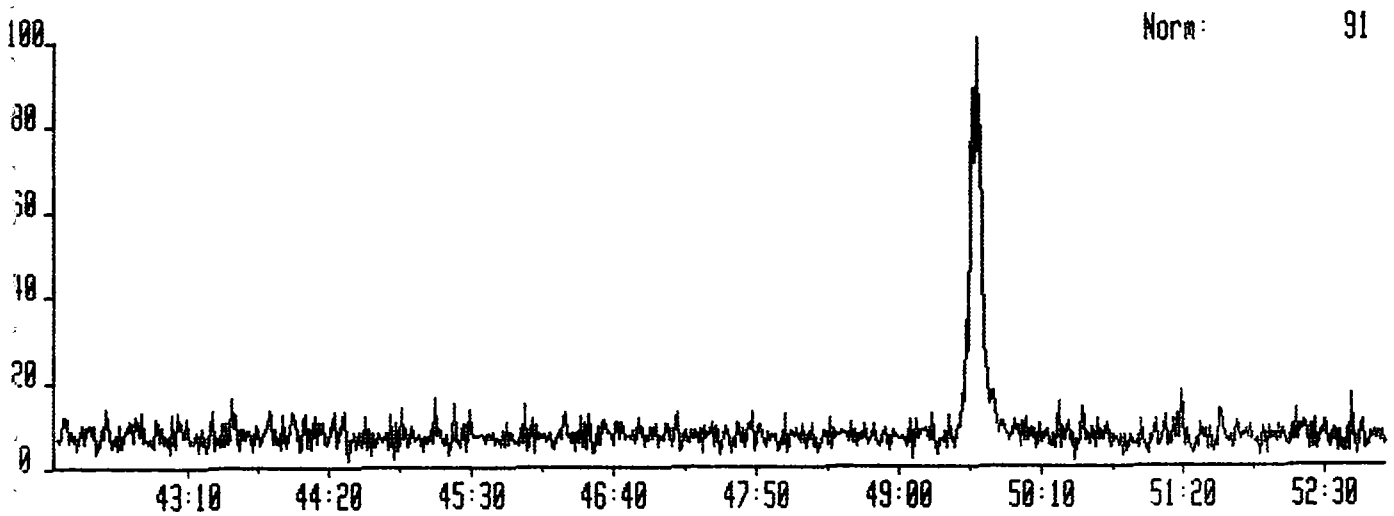
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 437.8139
Text:SAMPLE #2 TLI#2191



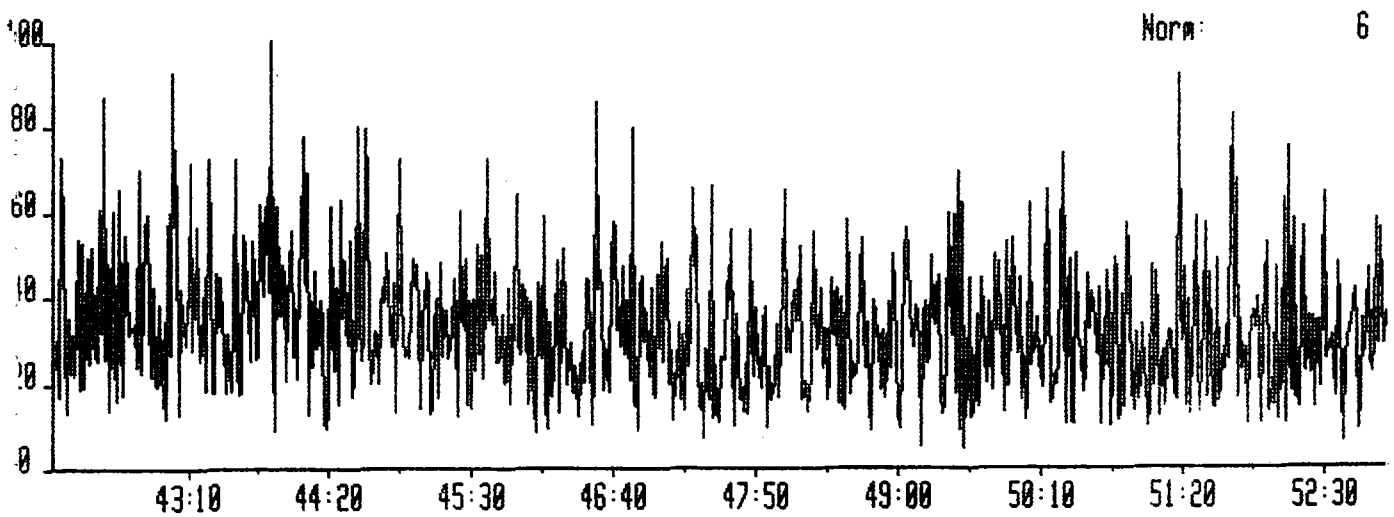
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 441.7428
Text:SAMPLE #2 TLI#2191



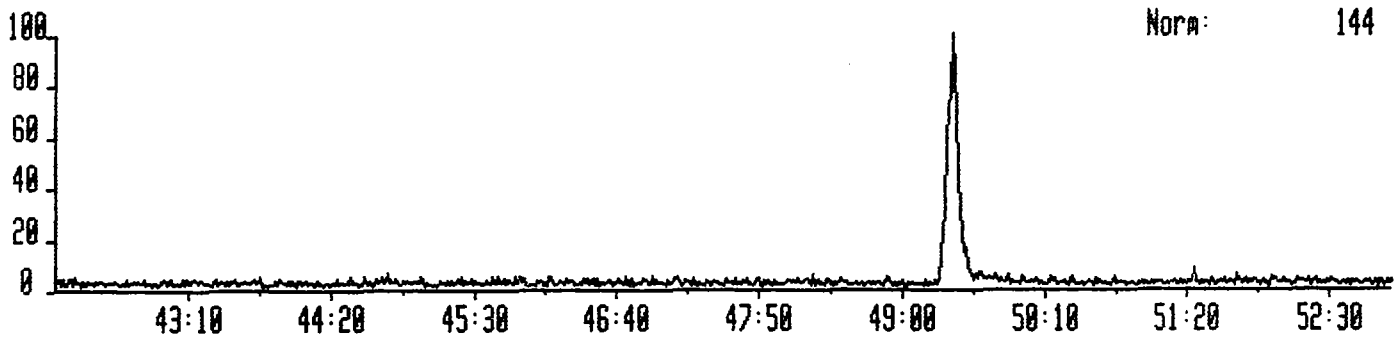
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 443.7399
Text:SAMPLE #2 TLI#2191



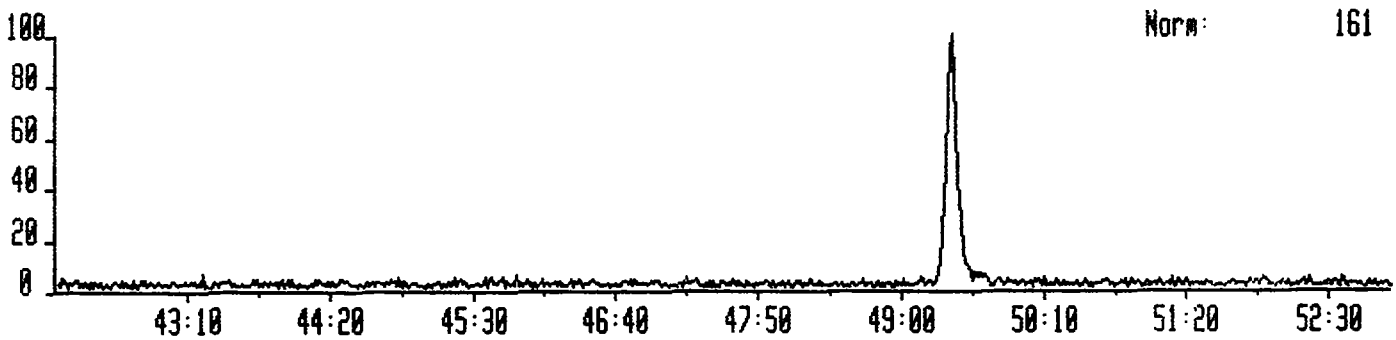
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 511.6810
Text:SAMPLE #2 TLI#2191



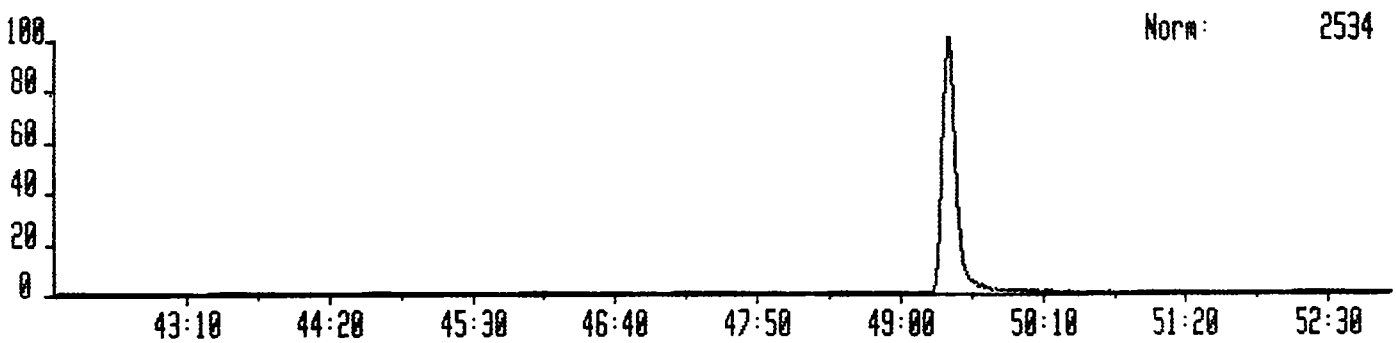
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 457.7377
Text:SAMPLE #2 TLI#2191



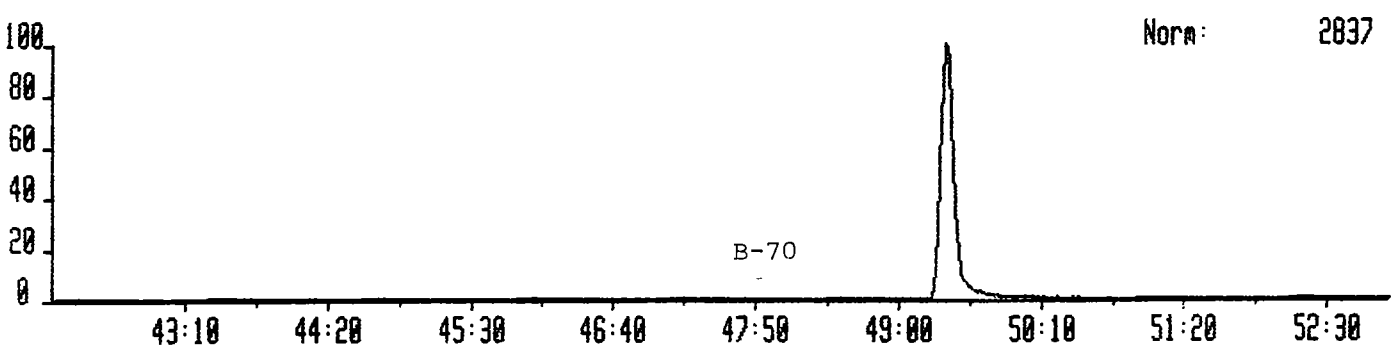
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 459.7347
Text:SAMPLE #2 TLI#2191



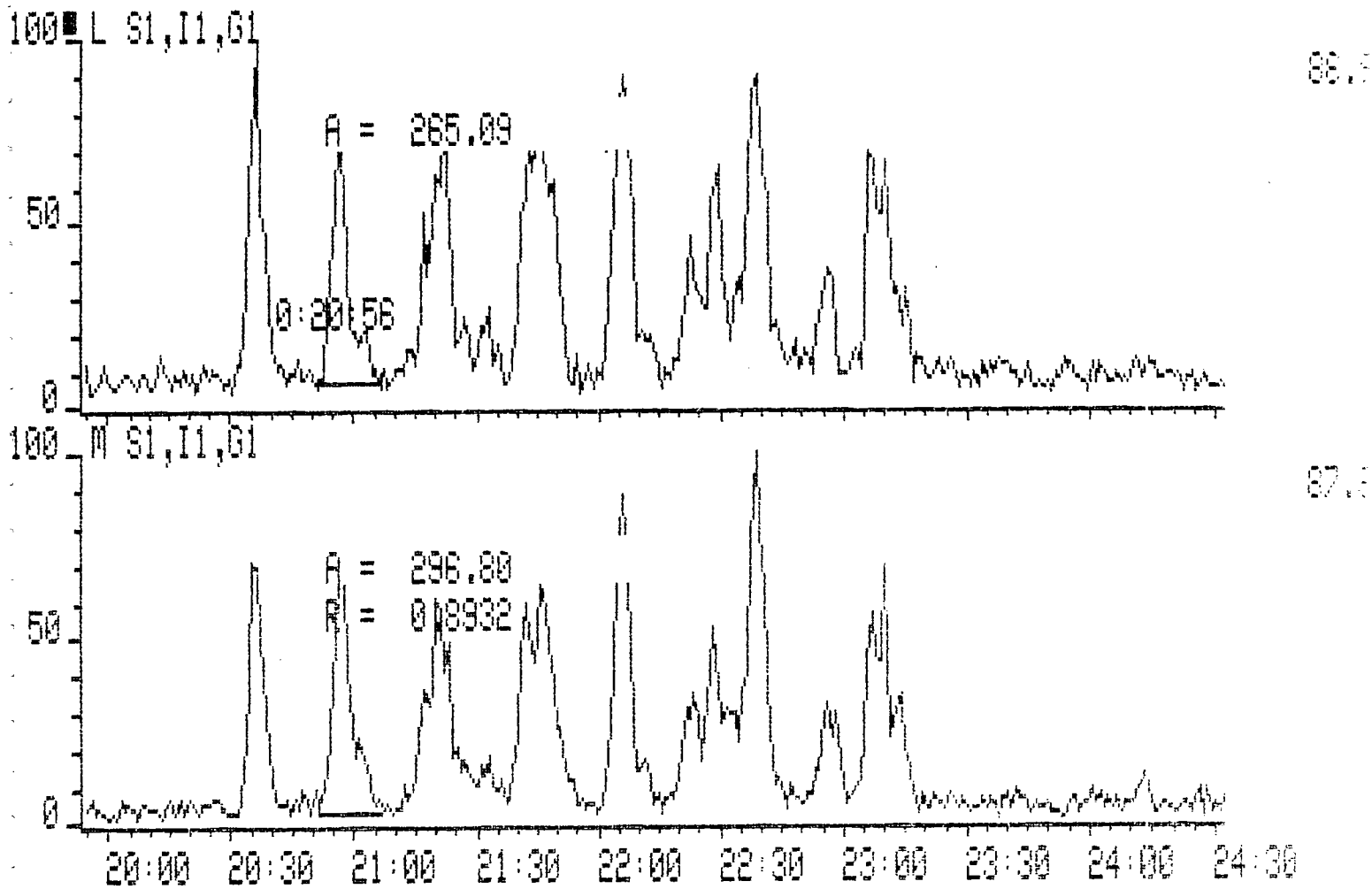
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 469.7779
Text:SAMPLE #2 TLI#2191



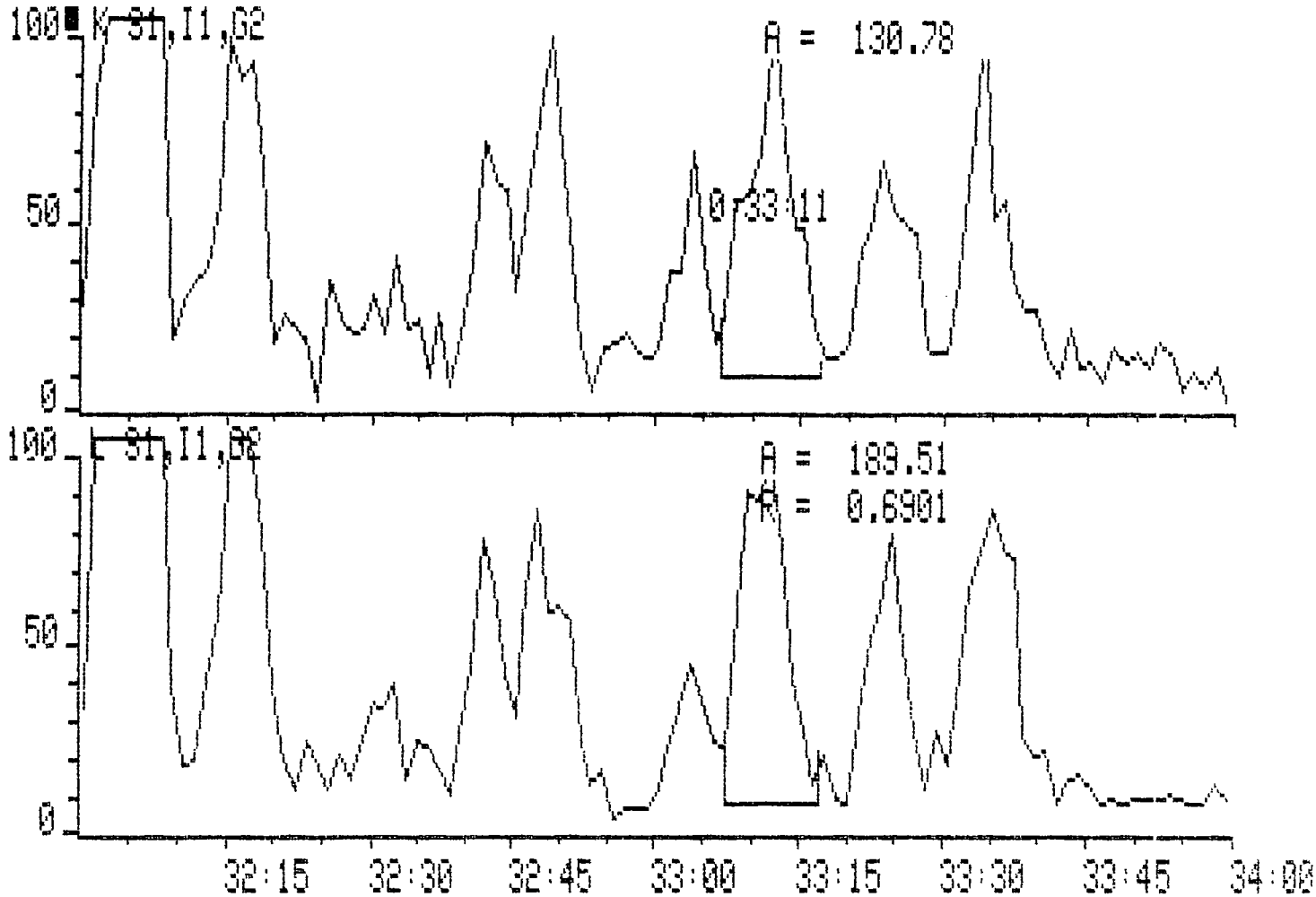
M880979 18-MAR-88 Sir:Voltage 70E Sys: DB5
Sample 1 Injection 1 Group 4 Mass 471.7750
Text:SAMPLE #2 TLI#2191

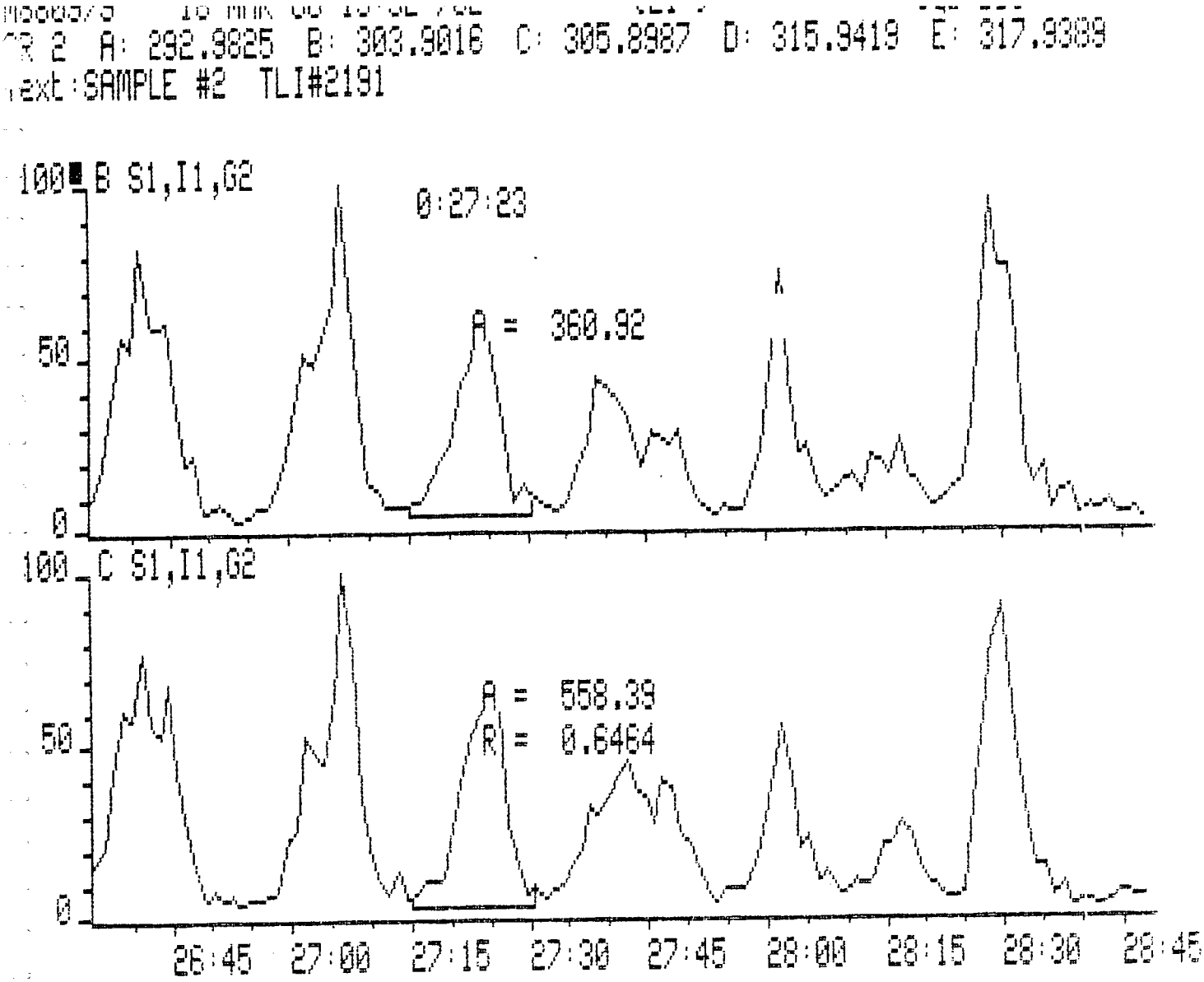


M880979 18-MAR-88 19:52 70L (Li+) Sys:UBD
R 1 I: 251.9745 J: 253.9716 K: 254.9856 L: 269.9406 M: 271.9377
Text:SAMPLE #2 TLI#2191



M880979 18-MAR-88 19:52 70E (EI+) Sys:DB5
GR 2 J: 333.9338 K: 337.8626 L: 339.8597 M: 353.8575 N: 355.8546
Text:SAMPLE #2 TLI#2191





CR 2 A: 292.9825 B: 303.9016 C: 305.8987 D: 315.9419 E: 317.9389
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100 C S1,I1,G2
A = 558.39
R = 0.6464
50
0
26:45
27:00
27:15
27:30
27:45
28:00
28:15
28:30
28:45

M880979 18-MAR-88 19:52 70E (EI+) Sys:DB5
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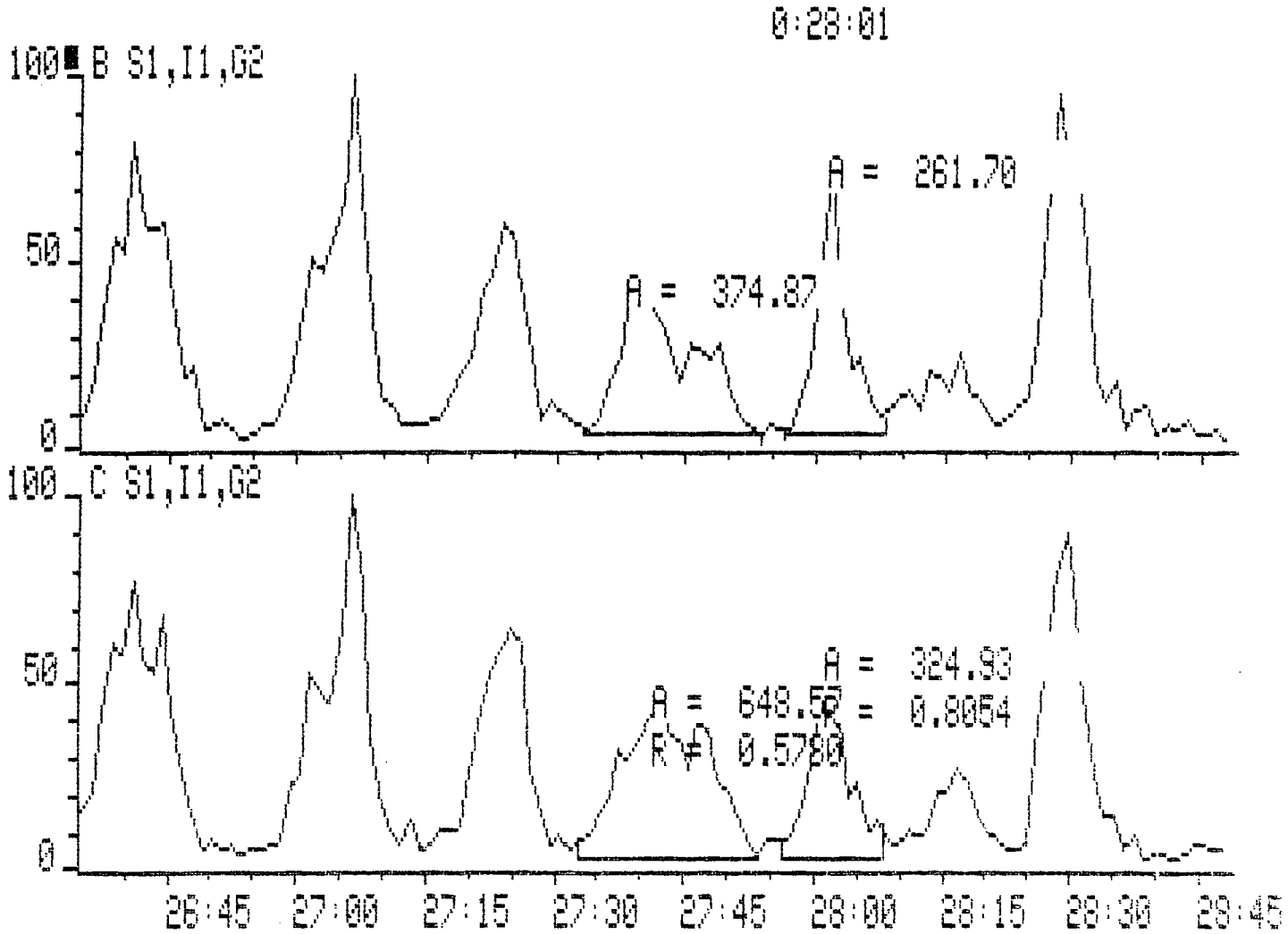

M880979 18-MAR-88 19:52 70E (EI+) Sys:DB5
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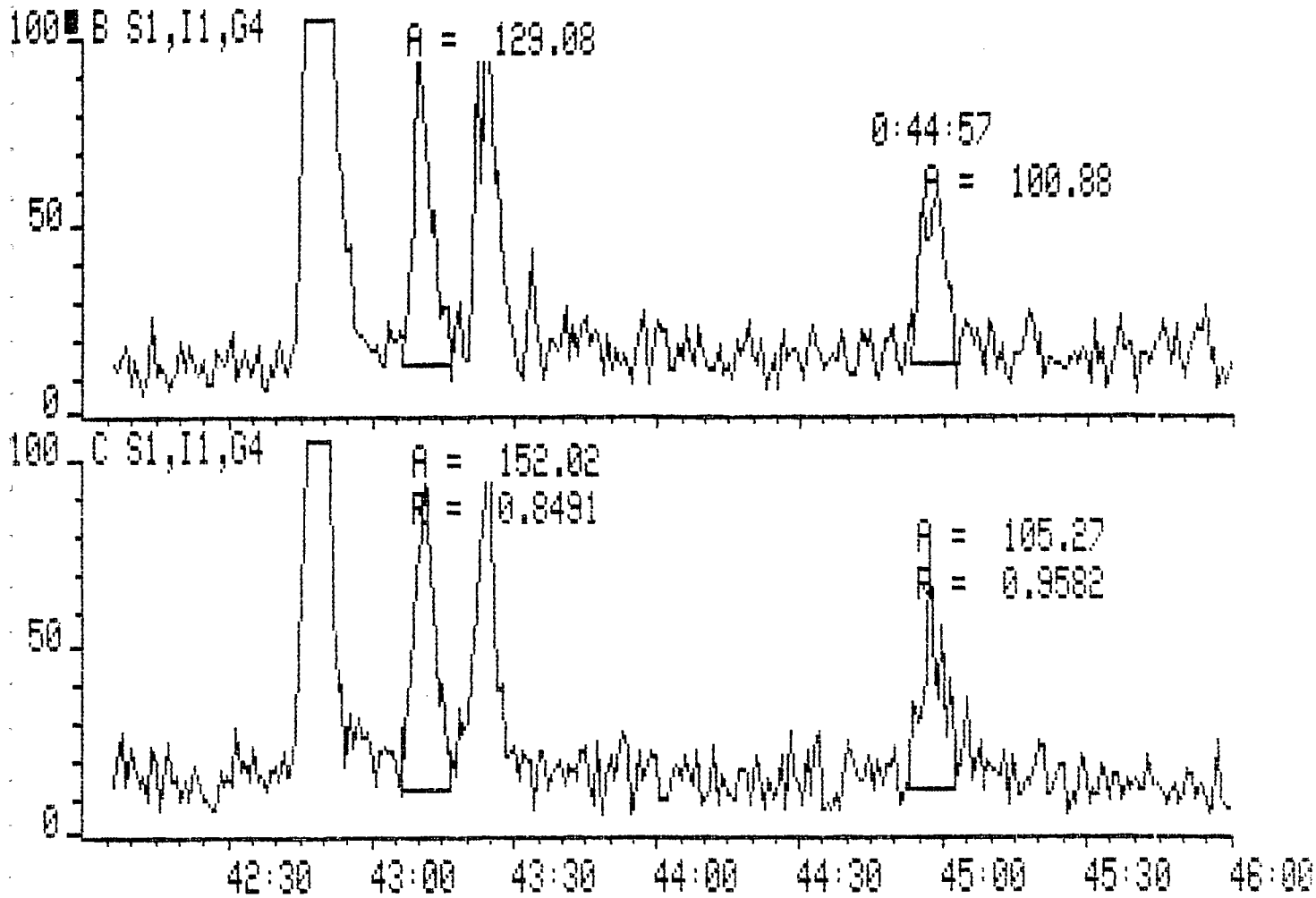

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: JJ
DATE: 03/16/88

FILE NAME: M880956
SAMPLE ID: SAMPLE #3
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880949

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.008			
TOTAL DCDD	1.481	1			1.61	
TOTAL TRICDD	4.034	5			1.05	
2378-TCDD	0.762				0.82	29.19
TOTAL TCDD	9.417	13			0.80	
12378-PCDD	1.141				0.68	34.40
TOTAL PCDD	9.681	12			0.66	
123478-HxCDD	1.013				1.34	39.26
123678-HxCDD	1.654				1.10	39.33
123789-HxCDD	3.291				1.19	40.01
TOTAL HxCDD	15.985	6			1.23	
1234678-HpCDD	8.572				1.09	44.22
TOTAL HpCDD	17.286	2			1.08	
OCDD	21.374				0.90	49.26
TOTAL MCDF	0.197	1			2.77	
TOTAL DCDF	12.417	6			6.15	
TOTAL TRICDF	95.004	11			1.04	
2378-TCDF	13.800				0.78	28.33
TOTAL TCDF	101.183	15			0.78	
12378-PCDF	4.014				0.61	33.15
23478-PCDF	3.991				0.60	34.11
TOTAL PCDF	50.947	13			0.60	
123478-HxCDF	9.361				1.13	38.17
123678-HxCDF	5.603				1.12	38.26
234678-HxCDF	4.912				1.19	39.14
123789-HxCDF	0.399				1.21	40.23
TOTAL HxCDF	52.443	12			1.17	
1234678-HpCDF	11.809				1.00	42.52
1234789-HpCDF	1.392				0.92	45.01
TOTAL HpCDF	19.428	4			0.96	
OCDF	6.130				0.85	49.38

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	10.84	108.40	0.83	28.31
37CL-TCDD	9.03	90.30		29.19
13C12-HxCDF	14.35	143.50	1.22	38.16

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	9.98	99.80	0.78	29.18
13C12-PCDD	13.66	136.60	0.61	34.40
13C12-HxCDD	8.08	80.80	1.35	39.33
13C12-HpCDD	10.97	109.70	1.06	44.21
13C12-OCDD	18.35	91.75	0.93	49.24

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/18/88
FILE NAME: M880978
SAMPLE ID: SAMPLE #4
CASE NO: ENTROPY
PROJ NO: 8802191
CONCAL: M880971

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.005			
TOTAL DCDD	ND		0.010			
TOTAL TRICDD	ND		0.028			
2378-TCDD	ND		0.008			
TOTAL TCDD	ND			0.057	3.98	
12378-PCDD	ND		0.013			
TOTAL PCDD	ND		0.013			
123478-HxCDD	ND		0.015			
123678-HxCDD	ND		0.015			
123789-HxCDD	ND		0.018			
TOTAL HxCDD	ND			0.456	5.20	
1234678-HpCDD	0.050				1.13	44.21
TOTAL HpCDD	0.050	1			1.13	
OCDD	1.364				0.79	49.24
TOTAL MCDF	ND		0.005			
TOTAL DCDF	ND		0.015			
TOTAL TRICDF	1.056	6			1.06	
2378-TCDF	0.134				0.84	28.32
TOTAL TCDF	0.870	8			0.75	
12378-PCDF	0.032				0.70	33.14
23478-PCDF	ND			0.025	0.96	
TOTAL PCDF	0.230	3			0.68	
123478-HxCDF	ND		0.010			
123678-HxCDF	ND		0.008			
234678-HxCDF	ND		0.010			
123789-HxCDF	ND		0.015			
TOTAL HxCDF	ND		0.010			
1234678-HpCDF	0.047				0.93	42.51
1234789-HpCDF	ND		0.010			
TOTAL HpCDF	0.082	2			0.90	
OCDF	ND			0.102	0.71	

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	8.49	84.90	0.78	28.29
37CL-TCDD	8.48	84.80		29.18
13C12-HxCDF	13.02	130.20	1.26	38.15

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	9.08	90.80	0.80	29.17
13C12-PCDD	7.87	78.70	0.62	34.38
13C12-HxCDD	7.15	71.50	1.26	39.32
13C12-HpCDD	10.48	104.80	1.04	44.20
13C12-OCDD	18.55	92.75	0.92	49.23

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: LD
DATE: 03/17/88

FILE NAME: M880961
SAMPLE ID: SAMPLE #5
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880960

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.018			
TOTAL DCDD	3.158	1			1.65	
TOTAL TRICDD	5.838	3			1.10	
2378-TCDD	0.429				0.80	29.18
TOTAL TCDD	6.347	13			0.80	
12378-PCDD	0.590				0.57	34.40
TOTAL PCDD	6.414	9			0.62	
123478-HxCDD	0.653				1.33	39.26
123678-HxCDD	0.990				1.28	39.33
123789-HxCDD	1.665				1.20	40.01
TOTAL HxCDD	14.370	7			1.30	
1234678-HpCDD	5.610				1.05	44.21
TOTAL HpCDD	11.435	2			1.04	
OCDD	10.911				0.90	49.25
TOTAL MCDF	1.826	3			3.15	
TOTAL DCDF	71.747	7			6.16	
TOTAL TRICDF	127.883	11			1.06	
2378-TCDF	7.899				0.71	28.33
TOTAL TCDF	64.648	13			0.74	
12378-PCDF	3.294				0.60	33.14
23478-PCDF	2.793				0.55	34.11
TOTAL PCDF	41.887	12			0.60	
123478-HxCDF	6.350				1.17	38.15
123678-HxCDF	3.201				1.16	38.26
234678-HxCDF	2.885				1.28	39.14
123789-HxCDF	ND		0.073			
TOTAL HxCDF	30.916	7			1.24	
1234678-HpCDF	7.099				1.02	42.51
1234789-HpCDF	0.492				0.95	45.00
TOTAL HpCDF	11.068	4			0.95	
OCDF	2.017				0.87	49.38

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	10.80	108.00	0.77	28.31
37CL-TCDD	9.60	96.00		29.18
13C12-HxCDF	15.99	159.90	1.23	38.15

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	7.55	75.50	0.80	29.17
13C12-PCDD	7.32	73.20	0.63	34.39
13C12-HxCDD	8.37	83.70	1.28	39.32
13C12-HpCDD	9.59	95.90	1.09	44.21
13C12-OCDD	12.83	64.15	0.88	49.24

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/18/88
FILE NAME: M880977
SAMPLE ID: SAMPLE #6
CASE NO: ENTROPY
PROJ NO: 8802191
CONCAL: M880971

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.040			
TOTAL DCDD	ND		0.080			
TOTAL TRICDD	ND		0.215			
2378-TCDD	ND		0.065			
TOTAL TCDD	ND		0.065			
12378-PCDD	ND		0.068			
TOTAL PCDD	ND		0.068			
123478-HxCDD	ND		0.100			
123678-HxCDD	ND		0.100			
123789-HxCDD	ND		0.118			
TOTAL HxCDD	ND			0.588	4.05	
1234678-HpCDD	ND		0.075			
TOTAL HpCDD	ND		0.075			
OCDD	1.200				0.95	49.25
TOTAL MCDF	ND		0.037			
TOTAL DCDF	ND		0.115			
TOTAL TRICDF	ND		0.118			
2378-TCDF	ND		0.048			
TOTAL TCDF	ND		0.048			
12378-PCDF	ND		0.043			
23478-PCDF	ND		0.048			
TOTAL PCDF	ND		0.045			
123478-HxCDF	ND		0.058			
123678-HxCDF	ND		0.055			
234678-HxCDF	ND		0.073			
123789-HxCDF	ND		0.095			
TOTAL HxCDF	ND		0.068			
1234678-HpCDF	0.123				0.89	42.52
1234789-HpCDF	ND		0.053			
TOTAL HpCDF	0.139	1			0.89	
OCDF	ND			0.242	0.62	

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.88	98.80	0.77	28.31
37CL-TCDD	8.45	84.50		29.18
13C12-HxCDF	13.52	135.20	1.32	38.16

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	9.46	94.60	0.88	29.17
13C12-PCDD	13.11	131.10	0.57	34.39
13C12-HxCDD	8.67	86.70	1.31	39.33
13C12-HpCDD	15.40	154.00	1.01	44.21
13C12-OCDD	28.09	140.45	0.87	49.24

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/17/88

FILE NAME: M880968
SAMPLE ID: SAMPLE #7
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880960

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.013			
TOTAL DCDD	2.238	1			1.65	
TOTAL TRICDD	9.646	5			1.01	
2378-TCDD	0.447				0.65	29.14
TOTAL TCDD	5.977	12			0.78	
12378-PCDD	0.622				0.62	34.37
TOTAL PCDD	6.172	10			0.59	
123478-HxCDD	0.765				1.24	39.23
123678-HxCDD	1.174				1.21	39.29
123789-HxCDD	2.441				1.21	39.58
TOTAL HxCDD	17.347	7			1.26	
1234678-HpCDD	7.581				1.00	44.18
TOTAL HpCDD	14.907	2			1.02	
OCDD	32.454				0.87	49.21
TOTAL MCDF	0.628	3			3.15	
TOTAL DCDF	27.125	4			6.59	
TOTAL TRICDF	150.490	12			1.04	
2378-TCDF	7.557				0.76	28.29
TOTAL TCDF	56.054	14			0.77	
12378-PCDF	2.098				0.60	33.10
23478-PCDF	2.445				0.61	34.08
TOTAL PCDF	30.983	13			0.61	
123478-HxCDF	6.714				1.18	38.12
123678-HxCDF	3.051				1.17	38.23
234678-HxCDF	3.272				1.21	39.10
123789-HxCDF	0.180				1.41	40.19
TOTAL HxCDF	31.435	11			1.18	
1234678-HpCDF	7.132				0.98	42.47
1234789-HpCDF	0.557				0.97	44.56
TOTAL HpCDF	10.860	4			1.00	
OCDF	2.434				0.84	49.35

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.79	97.90	0.77	28.27
37CL-TCDD	9.87	98.70		29.14
13C12-HxCDF	13.59	135.90	1.22	38.12

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	7.80	78.00	0.83	29.13
13C12-PCDD	11.45	114.50	0.63	34.36
13C12-HxCDD	7.37	73.70	1.25	39.29
13C12-HpCDD	10.18	101.80	1.01	44.17
13C12-OCDD	16.72	83.60	0.87	49.21

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/17/88

FILE NAME: M880965
SAMPLE ID: SAMPLE #8
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880960

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND			0.226	0.24	
TOTAL DCDD	0.606	1			1.55	
TOTAL TRICDD	1.938	3			1.06	
2378-TCDD	ND			0.072	0.48	
TOTAL TCDD	0.979	9			0.78	
12378-PCDD	0.077				0.62	34.36
TOTAL PCDD	0.672	8			0.59	
123478-HxCDD	0.069				1.21	39.20
123678-HxCDD	0.101				1.35	39.28
123789-HxCDD	0.191				1.09	39.55
TOTAL HxCDD	1.001	5			1.23	
1234678-HpCDD	0.583				1.03	44.16
TOTAL HpCDD	1.145	2			1.05	
OCDD	1.636				0.91	49.20
TOTAL MCDF	0.133	3			3.07	
TOTAL DCDF	7.362	6			6.21	
TOTAL TRICDF	43.533	11			1.03	
2378-TCDF	1.537				0.77	28.28
TOTAL TCDF	13.166	14			0.77	
12378-PCDF	0.358				0.53	33.09
23478-PCDF	0.409				0.63	34.07
TOTAL PCDF	6.202	15			0.60	
123478-HxCDF	1.054				1.19	38.10
123678-HxCDF	0.435				1.15	38.21
234678-HxCDF	0.419				1.22	39.09
123789-HxCDF	ND		0.018			
TOTAL HxCDF	4.542	8			1.25	
1234678-HpCDF	0.967				1.02	42.46
1234789-HpCDF	0.046				0.97	44.55
TOTAL HpCDF	1.385	4			1.07	
OCDF	0.342				0.89	49.33

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	8.85	88.50	0.78	28.26
37CL-TCDD	9.44	94.40		29.13
13C12-HxCDF	12.53	125.30	1.23	38.11

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	8.17	81.70	0.80	29.12
13C12-PCDD	11.63	116.30	0.64	34.33
13C12-HxCDD	7.12	71.20	1.23	39.27
13C12-HpCDD	11.38	113.80	1.03	44.15
13C12-OCDD	22.80	114.00	0.90	49.18

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/18/88

FILE NAME: M880981
SAMPLE ID: SAMPLE #9
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880971

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.015			
TOTAL DCDD	ND		0.030			
TOTAL TRICDD	ND		0.080			
2378-TCDD	ND		0.025			
TOTAL TCDD	ND		0.025			
12378-PCDD	ND		0.037			
TOTAL PCDD	ND		0.037			
123478-HxCDD	ND		0.048			
123678-HxCDD	ND		0.048			
123789-HxCDD	ND		0.055			
TOTAL HxCDD	ND			0.545	5.55	
1234678-HpCDD	0.069				0.92	44.22
TOTAL HpCDD	0.149	2			0.96	
OCDD	0.335				0.89	49.25
TOTAL MCDF	ND		0.015			
TOTAL DCDF	ND		0.043			
TOTAL TRICDF	ND		0.045			
2378-TCDF	ND		0.018			
TOTAL TCDF	ND		0.018			
12378-PCDF	ND		0.025			
23478-PCDF	ND		0.028			
TOTAL PCDF	0.089	1			0.61	
123478-HxCDF	ND		0.028			
123678-HxCDF	ND		0.025			
234678-HxCDF	ND		0.033			
123789-HxCDF	ND		0.045			
TOTAL HxCDF	ND		0.030			
1234678-HpCDF	0.060				1.14	42.53
1234789-HpCDF	ND		0.025			
TOTAL HpCDF	0.068	1			1.14	
OCDF	ND		0.043			

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	8.98	89.80	0.75	28.32
37CL-TCDD	9.20	92.00		29.19
13C12-HxCDF	15.86	158.60	1.28	38.17

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	7.51	75.10	0.77	29.18
13C12-PCDD	6.77	67.70	0.58	34.40
13C12-HxCDD	5.38	53.80	1.24	39.33
13C12-HpCDD	9.25	92.50	1.10	44.21
13C12-OCDD	19.30	96.50	0.87	49.25

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/17/88

FILE NAME: M880964
SAMPLE ID: SAMPLE #10
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880960

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.008			
TOTAL DCDD	2.336	1			1.52	
TOTAL TRICDD	9.605	6			1.06	
2378-TCDD	0.560				0.74	29.14
TOTAL TCDD	7.159	13			0.77	
12378-PCDD	0.800				0.59	34.37
TOTAL PCDD	6.395	11			0.60	
123478-HxCDD	0.948				1.19	39.22
123678-HxCDD	1.120				1.31	39.29
123789-HxCDD	2.855				1.22	39.57
TOTAL HxCDD	15.325	7			1.27	
1234678-HpCDD	5.360				1.00	44.18
TOTAL HpCDD	10.247	2			1.00	
OCDD	12.728				0.88	49.21
TOTAL MCDF	0.539	2			3.08	
TOTAL DCDF	32.369	7			5.92	
TOTAL TRICDF	137.351	12			1.03	
2378-TCDF	8.082				0.75	28.28
TOTAL TCDF	62.728	15			0.75	
12378-PCDF	2.306				0.62	33.10
23478-PCDF	2.424				0.64	34.08
TOTAL PCDF	32.111	14			0.63	
123478-HxCDF	7.302				1.21	38.12
123678-HxCDF	3.393				1.17	38.22
234678-HxCDF	3.369				1.19	39.10
123789-HxCDF	ND			0.225	1.49	
TOTAL HxCDF	34.583	11			1.18	
1234678-HpCDF	6.683				1.01	42.47
1234789-HpCDF	0.477				1.02	44.57
TOTAL HpCDF	10.047	4			1.00	
OCDF	2.000				0.84	49.34

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.80	98.00	0.77	28.26
37CL-TCDD	9.91	99.10		29.14
13C12-HxCDF	13.53	135.30	1.22	38.12

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)		% REC.	RATIO	RT
2378-13C12-TCDD	9.10		91.00	0.81	29.13
13C12-PCDD	15.03		150.30	0.62	34.36
13C12-HxCDD	7.61		76.10	1.24	39.28
13C12-HpCDD	13.22	B-83	132.20	1.03	44.17
13C12-OCDD	26.99		134.95	0.89	49.20

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/17/88

FILE NAME: M880963
SAMPLE ID: SAMPLE #11
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880960

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.003			
TOTAL DCDD	0.313	1			1.70	
TOTAL TRICDD	0.905	5			1.07	
2378-TCDD	ND			0.030	0.49	
TOTAL TCDD	0.359	12			0.79	
12378-PCDD	0.020				0.53	34.37
TOTAL PCDD	0.156	9			0.60	
123478-HxCDD	0.014				1.14	39.23
123678-HxCDD	0.020				1.35	39.30
123789-HxCDD	0.039				1.23	39.58
TOTAL HxCDD	0.232	5			1.29	
1234678-HpCDD	0.109				1.11	44.18
TOTAL HpCDD	0.253	2			1.06	
OCDD	0.578				0.83	49.22
TOTAL MCDF	0.477	3			2.91	
TOTAL DCDF	2.319	3			6.45	
TOTAL TRICDF	16.391	10			1.03	
2378-TCDF	0.503				0.76	28.29
TOTAL TCDF	4.699	13			0.74	
12378-PCDF	0.101				0.59	33.12
23478-PCDF	0.103				0.62	34.09
TOTAL PCDF	1.514	12			0.61	
123478-HxCDF	0.271				1.18	38.12
123678-HxCDF	0.118				1.22	38.23
234678-HxCDF	0.099				1.10	39.11
123789-HxCDF	0.009				1.21	40.19
TOTAL HxCDF	1.294	11			1.23	
1234678-HpCDF	0.300				1.01	42.48
1234789-HpCDF	0.041				0.97	44.57
TOTAL HpCDF	0.502	4			0.99	
OCDF	0.320				0.89	49.36

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.44	94.40	0.78	28.27
37CL-TCDD	9.31	93.10		29.16
13C12-HxCDF	12.97	129.70	1.25	38.12

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)		% REC.	RATIO	RT
2378-13C12-TCDD	12.43		124.30	0.80	29.14
13C12-PCDD	21.77		217.70	0.63	34.37
13C12-HxCDD	11.24		112.40	1.24	39.29
13C12-HpCDD *	13.62	B-84	136.20	1.04	44.18
13C12-OCDD *	28.37		141.85	0.90	49.21

QUANTITATIVE INTERFERENCE

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: LD
DATE: 03/17/88
FILE NAME: M880962
SAMPLE ID: SAMPLE #12
CASE NO: ENTROPY
PROJ NO: 8802191
CONCAL: M880960

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.015			
TOTAL DCDD	ND		0.035			
TOTAL TRICDD	ND		0.085			
2378-TCDD	ND		0.020			
TOTAL TCDD	ND			0.086	3.59	
12378-PCDD	ND		0.020			
TOTAL PCDD	ND			0.021	0.94	
123478-HxCDD	ND		0.043			
123678-HxCDD	ND		0.033			
123789-HxCDD	ND		0.048			
TOTAL HxCDD	ND			0.501	2.45	
1234678-HpCDD	0.151				1.10	44.23
TOTAL HpCDD	0.315	2			1.02	
OCDD	0.841				0.91	49.27
TOTAL MCDF	ND		0.010			
TOTAL DCDF	ND		0.060			
TOTAL TRICDF	0.352	3			1.13	
2378-TCDF	0.058				0.72	28.34
TOTAL TCDF	0.128	3			0.68	
12378-PCDF	0.034				0.62	33.14
23478-PCDF	0.064				0.60	34.13
TOTAL PCDF	0.241	3			0.61	
123478-HxCDF	0.204				1.38	38.17
123678-HxCDF	ND			0.042	1.49	
234678-HxCDF	ND			0.043	1.60	
123789-HxCDF	ND		0.040			
TOTAL HxCDF	0.430	2			1.33	
1234678-HpCDF	0.301				1.03	42.53
1234789-HpCDF	ND		0.030			
TOTAL HpCDF	0.398	2			1.06	
OCDF	0.402				0.86	49.40

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.48	94.80	0.79	28.32
37CL-TCDD	9.39	93.90		29.19
13C12-HxCDF	13.46	134.60	1.25	38.17

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	9.61	96.10	0.79	29.19
13C12-PCDD	12.78	127.80	0.60	34.40
13C12-HxCDD	10.57	105.70	1.29	39.33
13C12-HpCDD	12.52	125.20	0.99	44.22
13C12-OCDD	16.84	84.20	0.88	49.25

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/18/88
SAMPLEWT: 10.19

FILE NAME: M880982
SAMPLE ID: SAMPLE #13
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880971

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.001			
TOTAL DCDD	ND		0.001			
TOTAL TRICDD	ND		0.003			
2378-TCDD	ND		0.001			
TOTAL TCDD	ND			0.001	3.04	
12378-PCDD	ND		0.001			
TOTAL PCDD	ND		0.001			
123478-HxCDD	ND		0.001			
123678-HxCDD	ND		0.001			
123789-HxCDD	ND		0.001			
TOTAL HxCDD	ND			0.035	3.65	
1234678-HpCDD	0.003				0.99	44.33
TOTAL HpCDD	0.003	1			0.99	
OCDD	0.016				0.92	49.35
TOTAL MCDF	ND		0.001			
TOTAL DCDF	ND		0.001			
TOTAL TRICDF	0.009	1			0.94	
2378-TCDF	0.002				0.87	28.29
TOTAL TCDF	0.004	2			0.78	
12378-PCDF	ND		0.001			
23478-PCDF	ND			0.001	0.92	
TOTAL PCDF	0.003	2			0.60	
123478-HxCDF	ND		0.001			
123678-HxCDF	ND		0.001			
234678-HxCDF	ND		0.001			
123789-HxCDF	ND		0.001			
TOTAL HxCDF	ND		0.001			
1234678-HpCDF	0.004				1.09	43.02
1234789-HpCDF	ND		0.001			
TOTAL HpCDF	0.004	1			1.09	
OCDF	ND			0.005	0.42	

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	0.86	87.63	0.80	28.27
37CL-TCDD	0.89	90.69		29.16
13C12-HxCDF	1.40	142.66	1.24	38.25

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.88	89.67	0.80	29.14
13C12-PCDD	0.76	77.44	0.63	34.37
13C12-HxCDD	0.60	61.14	1.27	39.43
13C12-HpCDD	0.87	88.65	1.01	44.32
13C12-OCDD	1.57	79.99	0.91	49.34

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: AR
DATE: 03/19/88
SAMPLEWT: 10.09

FILE NAME: M880987
SAMPLE ID: SAMPLE #14
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880986

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.001			
TOTAL DCDD	ND			0.016	1.80	
TOTAL TRICDD	ND			0.009	1.87	
2378-TCDD	0.006				0.79	29.13
TOTAL TCDD	0.026	4			0.78	
12378-PCDD	0.006				0.67	34.35
TOTAL PCDD	0.010	2			0.63	
123478-HxCDD	ND		0.003			
123678-HxCDD	ND		0.003			
123789-HxCDD	ND			0.006	0.35	
TOTAL HxCDD	0.019	1			1.22	
1234678-HpCDD	0.044				1.02	44.18
TOTAL HpCDD	0.079	2			1.01	
OCDD	0.115				0.85	49.21
TOTAL MCDF	ND			0.015	1.71	
TOTAL DCDF	ND			0.095	4.30	
TOTAL TRICDF	0.605	8			1.00	
2378-TCDF	0.093				0.77	28.27
TOTAL TCDF	0.725	13			0.79	
12378-PCDF	ND			0.022	0.47	
23478-PCDF	0.025				0.67	34.08
TOTAL PCDF	0.259	8			0.59	
123478-HxCDF	0.042				1.19	38.12
123678-HxCDF	0.019				1.40	38.22
234678-HxCDF	0.021				1.35	39.10
123789-HxCDF	ND		0.003			
TOTAL HxCDF	0.167	6			1.30	
1234678-HpCDF	0.061				1.06	42.48
1234789-HpCDF	0.007				0.92	44.58
TOTAL HpCDF	0.105	4			0.96	
OCDF	0.048				0.83	49.35

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	0.95	95.85	0.79	28.25
37CL-TCDD	0.96	96.86		29.13
13C12-HxCDF	1.41	142.27	1.27	38.12

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.59	59.53	0.79	29.12
13C12-PCDD	0.49	49.44	0.64	34.34
13C12-HxCDD	0.39	39.35	1.29	39.27
13C12-HpCDD	0.40	40.36	1.07	44.17
13C12-OCDD	0.71	35.82	0.90	49.20

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: AR
DATE: 03/19/88
SAMPLEWT: 10.15

FILE NAME: M880988
SAMPLE ID: SAMPLE #15
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880986

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.003			
TOTAL DCDD	ND		0.005			
TOTAL TRICDD	ND		0.010			
2378-TCDD	ND		0.005			
TOTAL TCDD	0.011	1			0.79	
12378-PCDD	ND		0.008			
TOTAL PCDD	0.012	1			0.70	
123478-HxCDD	ND		0.013			
123678-HxCDD	ND		0.010			
123789-HxCDD	0.026				1.31	40.03
TOTAL HxCDD	0.068	2			1.28	
1234678-HpCDD	0.049				1.02	44.23
TOTAL HpCDD	0.113	2			0.97	
OCDD	0.094				0.76	49.26
TOTAL MCDF	ND		0.003			
TOTAL DCDF	ND		0.008			
TOTAL TRICDF	0.124	3			1.01	
2378-TCDF	0.089				0.67	28.34
TOTAL TCDF	0.481	8			0.75	
12378-PCDF	0.031				0.69	33.15
23478-PCDF	0.032				0.64	34.14
TOTAL PCDF	0.372	9			0.60	
123478-HxCDF	0.089				1.15	38.16
123678-HxCDF	ND			0.045	0.77	
234678-HxCDF	ND			0.029	1.90	
123789-HxCDF	ND		0.010			
TOTAL HxCDF	0.244	2			1.26	
1234678-HpCDF	0.108				0.95	42.53
1234789-HpCDF	ND		0.013			
TOTAL HpCDF	0.124	1			0.95	
OCDF	ND		0.030			

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	0.96	97.44	0.78	28.32
37CL-TCDD	0.95	96.42		29.19
13C12-HxCDF	1.69	171.53	1.30	38.17

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.64	64.96	0.80	29.18
13C12-PCDD	0.53	53.80	0.65	34.40
13C12-HxCDD	0.43	43.65	1.28	39.33
13C12-HpCDD	0.36	36.54	1.08	44.22
13C12-OCDD	0.57	28.93	0.88	49.25

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: AR
DATE: 03/19/88
SAMPLEWT: 9.59

FILE NAME: M880989
SAMPLE ID: SAMPLE #16
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880986

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.003			
TOTAL DCDD	ND		0.005			
TOTAL TRICDD	0.111	2			1.09	
2378-TCDD	0.041				0.81	29.32
TOTAL TCDD	0.392	11			0.79	
12378-PCDD	0.063				0.54	34.53
TOTAL PCDD	0.343	6			0.62	
123478-HxCDD	0.060				1.18	39.38
123678-HxCDD	0.108				1.35	39.46
123789-HxCDD	0.192				1.24	40.11
TOTAL HxCDD	0.861	5			1.28	
1234678-HpCDD	0.533				1.00	44.35
TOTAL HpCDD	1.083	2			1.02	
OCDD	1.084				0.90	49.37
TOTAL MCDF	ND		0.003			
TOTAL DCDF	ND		0.008			
TOTAL TRICDF	3.277	10			0.99	
2378-TCDF	0.864				0.75	28.46
TOTAL TCDF	6.286	14			0.75	
12378-PCDF	0.275				0.63	33.26
23478-PCDF	0.326				0.60	34.25
TOTAL PCDF	3.765	12			0.62	
123478-HxCDF	0.642				1.27	38.27
123678-HxCDF	0.352				1.27	38.39
234678-HxCDF	0.335				1.23	39.27
123789-HxCDF	ND			0.024	1.03	
TOTAL HxCDF	3.211	11			1.28	
1234678-HpCDF	0.870				1.02	43.04
1234789-HpCDF	0.065				1.06	45.13
TOTAL HpCDF	1.287	4			1.05	
OCDF	0.214				0.90	49.51

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	0.98	93.98	0.79	28.43
37CL-TCDD	1.00	95.90		29.31
13C12-HxCDF	1.49	142.89	1.22	38.29

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)		% REC.	RATIO	RT
2378-13C12-TCDD	0.74		70.97	0.83	29.31
13C12-PCDD	0.74		70.97	0.63	34.52
13C12-HxCDD	0.49		46.99	1.24	39.45
13C12-HpCDD	0.55		52.74	1.05	44.34
13C12-OCDD	0.80	B-89	38.36	0.90	49.36

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: MC
DATE: 03/19/88
SAMPLEWT: 10.02

FILE NAME: M880992
SAMPLE ID: SAMPLE #17
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880986

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.008			
TOTAL DCDD	ND			0.245	1.81	
TOTAL TRICDD	0.387	2			1.08	
2378-TCDD	0.082				0.73	29.14
TOTAL TCDD	1.161	8			0.77	
12378-PCDD	0.125				0.52	34.37
TOTAL PCDD	1.537	7			0.56	
123478-HxCDD	0.176				1.30	39.21
123678-HxCDD	0.419				1.21	39.29
123789-HxCDD	0.589				1.31	39.55
TOTAL HxCDD	4.809	6			1.32	
1234678-HpCDD	2.190				1.00	44.16
TOTAL HpCDD	4.401	2			1.02	
OCDD	4.439				0.84	49.18
TOTAL MCDF	0.237	1			2.87	
TOTAL DCDF	5.787	5			5.94	
TOTAL TRICDF	15.311	11			1.04	
2378-TCDF	2.766				0.77	28.28
TOTAL TCDF	19.994	13			0.77	
12378-PCDF	0.710				0.62	33.09
23478-PCDF	0.826				0.65	34.08
TOTAL PCDF	10.957	13			0.64	
123478-HxCDF	2.124				1.28	38.10
123678-HxCDF	1.175				1.29	38.21
234678-HxCDF	1.247				1.16	39.10
123789-HxCDF	ND			0.081	1.44	
TOTAL HxCDF	10.127	9			1.28	
1234678-HpCDF	3.001				1.02	42.45
1234789-HpCDF	0.253				0.87	44.55
TOTAL HpCDF	4.208	3			1.01	
OCDF	0.788				0.93	49.32

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	1.04	104.21	0.79	28.26
37CL-TCDD	1.02	102.20		29.14
13C12-HxCDF	1.79	179.36	1.12	38.11

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.72	72.14	0.76	29.13
13C12-PCDD	0.57	57.11	0.65	34.36
13C12-HxCDD	0.50	50.10	1.26	39.27
13C12-HpCDD	0.63	63.13	1.13	44.15
13C12-OCDD	1.24	62.12	0.93	49.17

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: MC
DATE: 03/19/88
SAMPLEWT: 10.13

FILE NAME: M880995
SAMPLE ID: SAMPLE #18
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880986

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.001			
TOTAL DCDD	0.066	1			1.55	
TOTAL TRICDD	0.134	3			1.10	
2378-TCDD	0.025				0.76	29.11
TOTAL TCDD	0.273	13			0.76	
12378-PCDD	0.040				0.61	34.33
TOTAL PCDD	0.298	9			0.57	
123478-HxCDD	0.041				1.07	39.18
123678-HxCDD	0.065				1.29	39.25
123789-HxCDD	0.127				1.26	39.51
TOTAL HxCDD	0.530	5			1.26	
1234678-HpCDD	0.370				0.98	44.13
TOTAL HpCDD	0.714	2			0.99	
OCDD	0.941				0.86	49.14
TOTAL MCDF	0.036	2			3.14	
TOTAL DCDF	1.488	7			6.44	
TOTAL TRICDF	3.147	11			1.00	
2378-TCDF	0.497				0.78	28.26
TOTAL TCDF	3.876	14			0.79	
12378-PCDF	0.165				0.60	33.07
23478-PCDF	0.205				0.60	34.04
TOTAL PCDF	2.471	13			0.62	
123478-HxCDF	0.428				1.24	38.08
123678-HxCDF	0.228				1.19	38.18
234678-HxCDF	0.225				1.24	39.06
123789-HxCDF	ND			0.014	1.53	
TOTAL HxCDF	2.014	11			1.25	
1234678-HpCDF	0.581				1.03	42.43
1234789-HpCDF	ND			0.045	1.20	
TOTAL HpCDF	0.760	2			1.07	
OCDF	0.174				0.83	49.28

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	0.92	93.20	0.82	28.24
37CL-TCDD	0.93	94.21		29.11
13C12-HxCDF	1.47	148.91	1.27	38.08

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.87	88.13	0.78	29.10
13C12-PCDD	0.60	60.78	0.64	34.32
13C12-HxCDD	0.54	54.70	1.25	39.24
13C12-HpCDD	0.61	61.79	1.07	44.13
13C12-OCDD	1.13	57.23	0.89	49.14

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: MC
DATE: 03/19/88

FILE NAME: M880994
SAMPLE ID: SAMPLE #19
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880986

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.033			
TOTAL DCDD	ND		0.062			
TOTAL TRICDD	ND		0.118			
2378-TCDD	ND		0.053			
TOTAL TCDD	0.108	1			0.82	
12378-PCDD	ND		0.110			
TOTAL PCDD	ND		0.110			
123478-HxCDD	ND		0.098			
123678-HxCDD	ND		0.090			
123789-HxCDD	ND		0.110			
TOTAL HxCDD	ND			0.347	3.20	
1234678-HpCDD	0.311				0.93	44.14
TOTAL HpCDD	0.561	2			0.98	
OCDD	1.591				1.00	49.16
TOTAL MCDF	ND		0.022			
TOTAL DCDF	ND		0.095			
TOTAL TRICDF	0.171	1			1.06	
2378-TCDF	ND		0.040			
TOTAL TCDF	ND			0.213	1.44	
12378-PCDF	ND		0.073			
23478-PCDF	ND		0.075			
TOTAL PCDF	ND			0.380	1.04	
123478-HxCDF	ND		0.055			
123678-HxCDF	ND		0.048			
234678-HxCDF	ND		0.065			
123789-HxCDF	ND		0.083			
TOTAL HxCDF	0.175	1			1.33	
1234678-HpCDF	0.311				0.99	42.45
1234789-HpCDF	ND		0.065			
TOTAL HpCDF	0.357	1			0.99	
OCDF	0.263				0.96	49.28

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.55	95.50	0.81	28.25
37CL-TCDD	9.31	93.10		29.12
13C12-HxCDF	13.76	137.60	1.35	38.09

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	4.83	48.30	0.85	29.11
13C12-PCDD	3.34	33.40	0.63	34.32
13C12-HxCDD	3.37	33.70	1.27	39.24
13C12-HpCDD	4.14	41.40	1.08	44.13
13C12-OCDD	8.95	44.75	0.87	49.15

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/17/88
FILE NAME: M880967
SAMPLE ID: SAMPLE #20
CASE NO: ENTROPY
PROJ NO: 8802191
CONCAL: M880960

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.008			
TOTAL DCDD	ND		0.020			
TOTAL TRICDD	ND		0.050			
2378-TCDD	ND		0.013			
TOTAL TCDD	ND			0.158	3.71	
12378-PCDD	ND		0.010			
TOTAL PCDD	ND		0.010			
123478-HxCDD	ND			0.019	1.47	
123678-HxCDD	0.030				1.10	39.30
123789-HxCDD	0.044				1.11	39.57
TOTAL HxCDD	0.158	3			1.11	
1234678-HpCDD	0.977				1.00	44.19
TOTAL HpCDD	1.824	2			0.99	
OCDD	13.016				0.87	49.21
TOTAL MCDF	ND		0.005			
TOTAL DCDF	ND		0.035			
TOTAL TRICDF	0.623	1			1.05	
2378-TCDF	0.017				0.72	28.28
TOTAL TCDF	0.017	1			0.72	
12378-PCDF	ND			0.009	0.75	
23478-PCDF	0.010				0.59	34.08
TOTAL PCDF	0.051	4			0.61	
123478-HxCDF	0.053				1.16	38.12
123678-HxCDF	0.015				1.34	38.22
234678-HxCDF	ND		0.013			
123789-HxCDF	ND		0.018			
TOTAL HxCDF	0.192	4			1.30	
1234678-HpCDF	0.220				0.96	42.48
1234789-HpCDF	ND		0.010			
TOTAL HpCDF	0.420	2			1.01	
OCDF	0.491				0.76	49.34

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	9.46	94.60	0.78	28.26
37CL-TCDD	9.49	94.90		29.14
13C12-HxCDF	12.47	124.70	1.26	38.12

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	9.46	94.60	0.80	29.13
13C12-PCDD	16.48	164.80	0.62	34.34
13C12-HxCDD	9.00	90.00	1.26	39.29
13C12-HpCDD	13.43	134.30	1.02	44.17
13C12-OCDD	27.11	135.55	0.89	49.20

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: AR
DATE: 03/20/88
SAMPLEWT: 10.11

FILE NAME: M881002
SAMPLE ID: SAMPLE #21
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880996

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.003			
TOTAL DCDD	ND		0.003			
TOTAL TRICDD	ND		0.005			
2378-TCDD	1.994				0.84	29.09
TOTAL TCDD	3.345	2			0.85	
12378-PCDD	ND			0.008	85.00	
TOTAL PCDD	ND			0.008	85.00	
123478-HxCDD	ND			0.014	4.05	
123678-HxCDD	ND			0.013	3.35	
123789-HxCDD	ND			0.020	2.23	
TOTAL HxCDD	ND			0.069	3.43	
1234678-HpCDD	0.028				0.87	44.13
TOTAL HpCDD	0.028	1			0.87	
OCDD	0.118				0.75	49.13
TOTAL MCDF	ND		0.001			
TOTAL DCDF	ND		0.005			
TOTAL TRICDF	ND		0.003			
2378-TCDF	ND			0.003	0.96	
TOTAL TCDF	ND			0.003	0.96	
12378-PCDF	ND		0.003			
23478-PCDF	0.009				0.55	34.03
TOTAL PCDF	0.009	1			0.55	
123478-HxCDF	0.029				1.22	38.08
123678-HxCDF	0.031				1.33	38.17
234678-HxCDF	0.030				1.36	39.06
123789-HxCDF	0.045				1.23	40.16
TOTAL HxCDF	0.130	4			1.29	
1234678-HpCDF	0.034				1.08	42.43
1234789-HpCDF	ND			0.031	1.42	
TOTAL HpCDF	0.040	1			1.08	
OCDF	ND			0.078	1.13	

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	1.11	112.22	0.84	28.21
37CL-TCDD	1.01	102.11		29.09
13C12-HxCDF	1.66	167.83	1.37	38.07

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.66	66.73	0.80	29.09
13C12-PCDD	0.50	50.55	0.64	34.31
13C12-HxCDD	0.37	37.41	1.31	39.23
13C12-HpCDD	0.44	44.48	1.10	44.11
13C12-OCDD	0.78	39.43	0.90	49.11

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/20/88
FILE NAME: M881003
SAMPLE ID: SAMPLE #22
CASE NO: ENTROPY
PROJ NO: 8802192
CONCAL: M880996

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.030			
TOTAL DCDD	0.607	1			1.66	
TOTAL TRICDD	0.907	1			0.92	
2378-TCDD	1.205				0.79	29.09
TOTAL TCDD	9.195	6			0.79	
12378-PCDD	2.608				0.69	34.31
TOTAL PCDD	25.706	9			0.58	
123478-HxCDD	7.033				1.31	39.16
123678-HxCDD	9.398				1.26	39.23
123789-HxCDD	22.483				1.32	39.52
TOTAL HxCDD	95.467	6			1.31	
1234678-HpCDD	28.571				1.06	44.12
TOTAL HpCDD	53.429	2			1.04	
OCDD	33.677				0.84	49.12
TOTAL MCDF	ND		0.025			
TOTAL DCDF	ND			3.172	8.59	
TOTAL TRICDF	8.194	4			1.03	
2378-TCDF	12.288				0.80	28.24
TOTAL TCDF	75.857	13			0.80	
12378-PCDF	3.084				0.55	33.04
23478-PCDF	4.471				0.63	34.02
TOTAL PCDF	55.426	11			0.62	
123478-HxCDF	29.336				1.33	38.05
123678-HxCDF	14.916				1.29	38.17
234678-HxCDF	13.988				1.32	39.04
123789-HxCDF	ND			0.519	1.98	
TOTAL HxCDF	117.256	7			1.32	
1234678-HpCDF	29.847				1.08	42.40
1234789-HpCDF	1.776				1.16	44.50
TOTAL HpCDF	45.915	4			1.10	
OCDF	5.783				0.96	49.25

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	11.03	110.30	0.81	28.21
37CL-TCDD	9.73	97.30		29.10
13C12-HxCDF	19.56	195.60	1.20	38.06

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	7.53	75.30	0.84	29.09
13C12-PCDD	6.16	61.60	0.58	34.30
13C12-HxCDD	4.34	43.40	1.33	39.23
13C12-HpCDD	10.02	100.20	1.13	44.11
13C12-OCDD	14.08	70.40	0.88	49.11

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/20/88
FILE NAME: M881004
SAMPLE ID: SAMPLE #23
CASE NO: ENTROPY
PROJ NO: 8802192
CONCAL: M880996

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.033			
TOTAL DCDD	0.200	1			1.76	
TOTAL TRICDD	1.169	2			1.00	
2378-TCDD	ND			1.236	1.00	
TOTAL TCDD	7.197	9			0.77	
12378-PCDD	1.595				0.53	34.32
TOTAL PCDD	15.729	9			0.60	
123478-HxCDD	5.110				1.33	39.18
123678-HxCDD	4.118				1.31	39.24
123789-HxCDD	11.616				1.30	39.50
TOTAL HxCDD	53.268	7			1.33	
1234678-HpCDD	20.805				1.03	44.13
TOTAL HpCDD	40.838	2			1.04	
OCDD	28.671				0.85	49.14
TOTAL MCDF	ND		0.028			
TOTAL DCDF	1.282	1			6.51	
TOTAL TRICDF	6.496	6			1.06	
2378-TCDF	8.044				0.84	28.25
TOTAL TCDF	39.543	13			0.81	
12378-PCDF	2.015				0.68	33.05
23478-PCDF	2.593				0.63	34.03
TOTAL PCDF	36.598	11			0.64	
123478-HxCDF	15.545				1.27	38.07
123678-HxCDF	7.350				1.40	38.18
234678-HxCDF	7.922				1.36	39.06
123789-HxCDF	0.585				1.09	40.12
TOTAL HxCDF	65.727	9			1.28	
1234678-HpCDF	19.960				1.06	42.42
1234789-HpCDF	1.620				1.02	44.51
TOTAL HpCDF	32.498	4			1.07	
OCDF	13.105				0.93	49.26

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	11.75	117.50	0.83	28.22
37CL-TCDD	10.06	100.60		29.11
13C12-HxCDF	17.89	178.90	1.28	38.08

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	8.60	86.00	0.83	29.10
13C12-PCDD	7.74	77.40	0.65	34.31
13C12-HxCDD	5.49	54.90	1.30	39.24
13C12-HpCDD	8.95	89.50	1.06	44.12
13C12-OCDD	12.12	60.60	0.98	49.13

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/20/88
FILE NAME: M881006
SAMPLE ID: SAMPLE #24
CASE NO: ENTROPY
PROJ NO: 8802192
CONCAL: M880996

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.028			
TOTAL DCDD	ND		0.060			
TOTAL TRICDD	ND		0.118			
2378-TCDD	ND		0.045			
TOTAL TCDD	ND		0.045			
12378-PCDD	ND		0.068			
TOTAL PCDD	ND		0.068			
123478-HxCDD	ND		0.107			
123678-HxCDD	ND		0.083			
123789-HxCDD	ND		0.125			
TOTAL HxCDD	ND		0.103			
1234678-HpCDD	0.337				0.95	44.14
TOTAL HpCDD	0.711	2			0.95	
OCDD	4.818				1.00	49.14
TOTAL MCDF	ND		0.022			
TOTAL DCDF	ND		0.092			
TOTAL TRICDF	ND		0.077			
2378-TCDF	ND		0.033			
TOTAL TCDF	ND		0.033			
12378-PCDF	ND		0.040			
23478-PCDF	ND		0.043			
TOTAL PCDF	ND		0.040			
123478-HxCDF	ND		0.055			
123678-HxCDF	ND		0.043			
234678-HxCDF	ND		0.068			
123789-HxCDF	ND		0.098			
TOTAL HxCDF	ND		0.060			
1234678-HpCDF	0.091				0.89	42.46
1234789-HpCDF	ND		0.050			
TOTAL HpCDF	0.107	1			0.89	
OCDF	0.200				0.96	49.29

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	8.60	86.00	0.77	28.24
37CL-TCDD	9.63	96.30		29.11
13C12-HxCDF	12.61	126.10	1.30	38.09

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	7.00	70.00	0.80	29.10
13C12-PCDD	8.52	85.20	0.61	34.33
13C12-HxCDD	4.60	46.00	1.27	39.25
13C12-HpCDD	8.18	81.80	0.96	44.13
13C12-OCDD	16.91	84.55	0.85	49.14

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: MC
DATE: 03/18/88

FILE NAME: M880974
SAMPLE ID: TLI BLANK #1
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880974 MR

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.010			
TOTAL DCDD	ND		0.018			
TOTAL TRICDD	ND		0.050			
2378-TCDD	ND		0.015			
TOTAL TCDD	ND		0.015			
12378-PCDD	ND		0.018			
TOTAL PCDD	ND		0.018			
123478-HxCDD	ND		0.028			
123678-HxCDD	ND		0.028			
123789-HxCDD	ND		0.033			
TOTAL HxCDD	ND			0.552	4.38	
1234678-HpCDD	ND		0.022			
TOTAL HpCDD	ND		0.022			
OCDD	0.134				0.79	49.22
TOTAL MCDF	ND		0.008			
TOTAL DCDF	ND		0.025			
TOTAL TRICDF	ND		0.028			
2378-TCDF	ND		0.010			
TOTAL TCDF	ND		0.010			
12378-PCDF	ND		0.013			
23478-PCDF	ND		0.013			
TOTAL PCDF	ND		0.013			
123478-HxCDF	ND		0.018			
123678-HxCDF	ND		0.015			
234678-HxCDF	ND		0.020			
123789-HxCDF	ND		0.028			
TOTAL HxCDF	ND		0.018			
1234678-HpCDF	ND		0.013			
1234789-HpCDF	ND		0.015			
TOTAL HpCDF	ND		0.015			
OCDF	ND		0.025			

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	7.89	78.90	0.77	28.27
37CL-TCDD	9.36	93.60		29.16
13C12-HxCDF	13.82	138.20	1.26	38.14

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	7.42	74.20	0.78	29.14
13C12-PCDD	8.92	89.20	0.60	34.37
13C12-HxCDD	5.74	57.40	1.24	39.30
13C12-HpCDD	9.34	93.40	1.09	44.19
13C12-OCDD	21.88	109.40	0.89	49.21

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: MC
DATE: 03/18/88

FILE NAME: M880975
SAMPLE ID: TLI BLANK #2
CASE NO: ENTROPY
PROJ NO: 8802191

CONCAL: M880971

NAME	AMT (ng)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.015			
TOTAL DCDD	ND		0.033			
TOTAL TRICDD	ND		0.085			
2378-TCDD	ND		0.025			
TOTAL TCDD	ND		0.025			
12378-PCDD	ND		0.033			
TOTAL PCDD	ND		0.033			
123478-HxCDD	ND		0.077			
123678-HxCDD	ND		0.077			
123789-HxCDD	ND		0.090			
TOTAL HxCDD	ND			0.415	10.42	
1234678-HpCDD	ND		0.118			
TOTAL HpCDD	ND		0.118			
OCDD	ND		0.288			
TOTAL MCDF	ND		0.015			
TOTAL DCDF	ND		0.045			
TOTAL TRICDF	ND		0.045			
2378-TCDF	ND		0.020			
TOTAL TCDF	ND		0.020			
12378-PCDF	ND		0.022			
23478-PCDF	ND		0.025			
TOTAL PCDF	ND		0.022			
123478-HxCDF	ND		0.045			
123678-HxCDF	ND		0.043			
234678-HxCDF	ND		0.055			
123789-HxCDF	ND		0.073			
TOTAL HxCDF	ND		0.053			
1234678-HpCDF	ND		0.062			
1234789-HpCDF	ND		0.083			
TOTAL HpCDF	ND		0.070			
OCDF	ND		0.220			

SURROGATE RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
13C12-TCDF	8.69	86.90	0.81	28.29
37CL-TCDD	8.57	85.70		29.17
13C12-HxCDF	14.27	142.70	1.29	38.14

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT
2378-13C12-TCDD	7.47	74.70	0.79	29.16
13C12-PCDD	8.03	80.30	0.58	34.38
13C12-HxCDD	9.59	95.90	1.38	39.31
13C12-HpCDD	8.62	86.20	1.04	44.21
13C12-OCDD	11.08	55.40	0.89	49.24

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: EW
DATE: 03/18/88
SAMPLEWT: 10.00

FILE NAME: M880980
SAMPLE ID: TLI BLANK #3
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880971

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.001			
TOTAL DCDD	ND		0.001			
TOTAL TRICDD	ND		0.003			
2378-TCDD	ND		0.001			
TOTAL TCDD	ND		0.001			
12378-PCDD	ND		0.001			
TOTAL PCDD	ND		0.001			
123478-HxCDD	ND		0.001			
123678-HxCDD	ND		0.001			
123789-HxCDD	ND		0.001			
TOTAL HxCDD	ND			0.046	5.10	
1234678-HpCDD	ND			0.002	0.74	
TOTAL HpCDD	ND			0.004	0.78	
OCDD	0.018				0.94	49.22
TOTAL MCDF	ND		0.001			
TOTAL DCDF	ND		0.001			
TOTAL TRICDF	ND			0.004	1.31	
2378-TCDF	ND		0.001			
TOTAL TCDF	ND			0.001	1.83	
12378-PCDF	ND		0.001			
23478-PCDF	ND		0.001			
TOTAL PCDF	ND		0.001			
123478-HxCDF	ND		0.001			
123678-HxCDF	ND		0.001			
234678-HxCDF	ND		0.001			
123789-HxCDF	ND		0.001			
TOTAL HxCDF	ND		0.001			
1234678-HpCDF	ND		0.001			
1234789-HpCDF	ND		0.001			
TOTAL HpCDF	ND		0.001			
OCDF	0.001				0.79	49.35

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	0.86	86.00	0.79	28.28
37CL-TCDD	0.93	93.00		29.17
13C12-HxCDF	1.34	134.00	1.26	38.14

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.85	85.00	0.78	29.16
13C12-PCDD	0.81	81.00	0.63	34.38
13C12-HxCDD	0.63	63.00	1.26	39.31
13C12-HpCDD	0.95	95.00	1.04	44.19
13C12-OCDD	2.10	105.00	0.89	49.21

TRIANGLE LABORATORIES, INC.
PCDD/PCDF ANALYSIS (D)

ANALYST: MC
DATE: 03/20/88
SAMPLEWT: 10.00

FILE NAME: M881001
SAMPLE ID: TLI BLANK #4
CASE NO: ENTROPY
PROJ NO: 8802192

CONCAL: M880996

NAME	CONC(ppb)	NUMBER	DL	EMPC	RATIO	RT
TOTAL MCDD	ND		0.005			
TOTAL DCDD	ND		0.013			
TOTAL TRICDD	ND		0.022			
2378-TCDD	ND		0.010			
TOTAL TCDD	ND		0.010			
12378-PCDD	ND		0.015			
TOTAL PCDD	ND		0.015			
123478-HxCDD	ND		0.008			
123678-HxCDD	ND		0.005			
123789-HxCDD	ND		0.010			
TOTAL HxCDD	ND			0.009	3.12	
1234678-HpCDD	ND			0.011	0.76	
TOTAL HpCDD	ND			0.011	0.76	
OCDD	0.146				0.80	49.12
TOTAL MCDF	ND		0.005			
TOTAL DCDF	ND		0.018			
TOTAL TRICDF	ND		0.015			
2378-TCDF	ND		0.005			
TOTAL TCDF	ND		0.005			
12378-PCDF	ND		0.008			
23478-PCDF	ND		0.010			
TOTAL PCDF	ND		0.008			
123478-HxCDF	ND		0.005			
123678-HxCDF	ND		0.003			
234678-HxCDF	ND		0.005			
123789-HxCDF	ND		0.008			
TOTAL HxCDF	ND		0.005			
1234678-HpCDF	ND		0.003			
1234789-HpCDF	ND		0.005			
TOTAL HpCDF	ND		0.005			
OCDF	ND		0.020			

SURROGATE RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
13C12-TCDF	0.91	91.00	0.88	28.21
37CL-TCDD	0.84	84.00		29.09
13C12-HxCDF	1.27	127.00	1.36	38.06

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	CONC (ppb)	% REC.	RATIO	RT
2378-13C12-TCDD	0.32	32.00	0.81	29.08
13C12-PCDD	0.37	37.00	0.55	34.32
13C12-HxCDD	0.21	21.00	1.27	39.22
13C12-HpCDD	0.29	29.00	1.10	44.12
13C12-OCDD	0.25	12.50	0.97	49.10

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880934
DATE	3/19/88	CONCAL #	S880929
		TLI #	2191
SAMPLE ID	SAMPLE #1		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	4.78			0.748	24.58
2378-TCDD	0.80			0.772	22.22

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.51	105.12		22.22

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	9.82	98.15	0.801	22.21
13C12-TCDF	9.55	95.48	0.755	24.57

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880935
DATE	3/19/88	CONCAL #	S880929
		TLI #	2191
SAMPLE ID	SAMPLE #2		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.13			0.645	24.57
2378-TCDD	ND		0.02	0.614	22.21

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.12	101.21		22.21

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	9.51	95.12	0.793	22.19
13C12-TCDF	9.41	94.09	0.758	24.56

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880936
DATE	3/19/88	CONCAL #	S880929
		TLI #	2191
SAMPLE ID	SAMPLE #3		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	4.22			0.744	24.57
2378-TCDD	0.64			0.764	22.20

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.49	104.91		22.20

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.17	81.70	0.808	22.19
13C12-TCDF	8.24	82.44	0.757	24.56

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	s880937
DATE	3/19/88	CONCAL #	S880929
		TLI #	2191
SAMPLE ID	SAMPLE #4		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.10			0.801	24.55
2378-TCDD	ND		0.02	0.459	22.20

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	9.63	96.30		22.20

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	9.51	95.08	0.806	22.19
13C12-TCDF	9.30	93.00	0.750	24.55

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880938
DATE	3/19/88	CONCAL #	S880929
		TLI #	2191
SAMPLE ID	SAMPLE #5		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	2.75			0.742	24.55
2378-TCDD	0.44			0.739	22.18

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.49	104.85		22.18

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.51	85.08	0.811	22.17
13C12-TCDF	9.88	98.80	0.761	24.54

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880949
DATE	3/20/88	CONCAL #	S880941
		TLI #	2191
SAMPLE ID	SAMPLE #6		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.02			0.653	24.57
2378-TCDD	ND		0.01	0.348	22.21

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	9.83	98.33		22.21

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	11.07	110.69	0.812	22.20
13C12-TCDF	9.26	92.61	0.755	24.56

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880939
DATE	3/19/88	CONCAL #	S880929
		TLI #	2191
SAMPLE ID	SAMPLE #7		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	2.51			0.752	24.57
2378-TCDD	0.43			0.719	22.21

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	11.35	113.45		22.20

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.76	87.65	0.800	22.19
13C12-TCDF	9.61	96.07	0.750	24.56

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880944
DATE	3/20/88	CONCAL #	S880941
		TLI #	2191
SAMPLE ID	SAMPLE #8		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.52			0.752	24.57
2378-TCDD	0.06			0.671	22.20

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	9.75	97.45		22.20

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	9.39	93.92	0.807	22.19
13C12-TCDF	7.83	78.26	0.741	24.55

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880969
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #9		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.01			0.797	24.54
2378-TCDD	ND		0.01	0.314	22.17

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	11.05	110.47		22.18

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.77	87.66	0.812	22.17
13C12-TCDF	7.36	73.62	0.749	24.54

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TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880945
DATE	3/20/88	CONCAL #	S880941
		TLI #	2191
SAMPLE ID	SAMPLE #10		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	2.50			0.737	24.56
2378-TCDD	0.45			0.784	22.20

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.90	109.03		22.20

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
378-13C12-TCDD	8.12	81.25	0.818	22.19
13C12-TCDF	8.21	82.13	0.768	24.55

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880946
DATE	3/20/88	CONCAL #	S880941
		TLI #	2191
SAMPLE ID	SAMPLE #11		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.17			0.712	24.57
2378-TCDD	ND		0.03	0.592	22.20

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	9.99	99.86		22.20

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.40	84.04	0.808	22.19
13C12-TCDF	7.66	76.56	0.743	24.56

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880947
DATE	3/20/88	CONCAL #	S880941
		TLI #	2191
SAMPLE ID	SAMPLE #12		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.03			0.718	24.57
2378-TCDD	ND		0.01	0.364	22.20

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	9.80	98.04		22.21

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.31	83.07	0.827	22.20
13C12-TCDF	7.25	72.51	0.768	24.57

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880970
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #13		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	0.0004			0.877	24.54
2378-TCDD	ND		0.001	0.256	22.17

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.02	104.18		22.18

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	1.04	106.40	0.832	22.17
13C12-TCDF	0.90	92.09	0.760	24.53

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TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880973
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #14		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	0.03			0.741	24.54
2378-TCDD	0.005			0.689	22.17

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.10	111.12		22.17

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	0.55	55.68	0.830	22.16
13C12-TCDF	0.52	52.03	0.763	24.52

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880972
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #15		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	0.03			0.756	24.54
2378-TCDD	0.01			0.667	22.18

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.07	108.14		22.17

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	0.64	64.71	0.834	22.16
13C12-TCDF	0.58	58.99	0.755	24.54

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880971
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #16		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	0.25			0.774	24.53
2378-TCDD	0.04			0.756	22.17

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.12	106.95		22.17

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	0.71	67.76	0.832	22.16
13C12-TCDF	0.63	59.99	0.754	24.52

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TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880977
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #17		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	0.62			0.740	24.53
2378-TCDD	0.09			0.759	22.17

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.04	104.70		22.17

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	0.78	78.21	0.811	22.16
13C12-TCDF	0.72	71.96	0.749	24.52

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880975A
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #18		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	0.15			0.772	24.52
2378-TCDD	0.03			0.752	22.17

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.06	106.98		22.16

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	0.93	93.92	0.834	22.15
13C12-TCDF	0.89	90.57	0.761	24.51

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880976
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE 19		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	0.02			0.833	24.52
2378-TCDD	ND		0.01	0.271	22.15

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.56	105.58		22.16

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	4.74	47.40	0.827	22.15
13C12-TCDF	4.38	43.85	0.763	24.51

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	LKD	FILE #	S880948
DATE	3/20/88	CONCAL #	S880941
		TLI #	2191
SAMPLE ID	SAMPLE #20		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	ND	0.01		1.000	
2378-TCDD	ND		0.01	0.294	22.19

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	9.83	98.31		22.20

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.29	82.88	0.812	22.19
13C12-TCDF	6.81	68.05	0.762	24.56

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880980
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #21		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	0.0004			0.758	24.50
2378-TCDD	1.68			0.801	22.15

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.07	107.75		22.15

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	0.67	68.10	0.821	22.14
13C12-TCDF	0.51	52.05	0.762	24.50

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880979
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #22		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	1.55			0.762	24.52
2378-TCDD	0.60			0.722	22.17

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.89	108.92		22.17

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	8.35	83.52	0.827	22.16
13C12-TCDF	7.40	74.04	0.761	24.51

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880978
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	SAMPLE #23		

NAME	AMT (ng)	DL	EMPC	RATIO	RT
2378-TCDF	1.36			0.737	24.52
2378-TCDD	0.96			0.772	22.17

SURROGATE RESULTS SUMMARY

NAME	AMT (ng)	% RECOVERY	RATIO	RT
37Cl-TCDD	10.56	105.57		22.17

INTERNAL STANDARDS RECOVERY RESULTS

NAME	AMT (ng)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	9.12	91.21	0.813	22.16
13C12-TCDF	8.34	83.36	0.736	24.51

TRIANGLE LABORATORIES, INC
2,3,7,8-TCDD/TCDF ANALYSIS

ANALYST	JAJ	FILE #	S880974
DATE	3-22-88	CONCAL #	S880964
		TLI #	2192
SAMPLE ID	TLI BLANK #3		

NAME	CONC (ppb)	DL	EMPC	RATIO	RT
2378-TCDF	ND	0.0003		1.000	
2378-TCDD	ND		0.001	0.310	22.18

SURROGATE RESULTS SUMMARY

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
37Cl-TCDD	1.08	108.24		22.17

INTERNAL STANDARDS RECOVERY RESULTS

NAME	CONC (ppb)	% RECOVERY	RATIO	RT
2378-13C12-TCDD	0.31	31.06	0.831	22.16
13C12-TCDF	0.30	29.97	0.768	24.52

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Laboratories, Inc.

QUANTITATIVE MICROANALYSES
ORGANIC – INORGANIC

P.O. BOX 51610
KNOXVILLE, TN 37950-1610

615/546-1335

2323 SYCAMORE DR.
KNOXVILLE, TN 37921-1750

Ms. Anna C. Carver
Entropy Enviromentalests Inc.
Post Office Box 12291
Research Triangle Park, North Carolina 27709

March 15, 1988

Received: March 2nd
PO#: 3426ACC22688

Dear Ms. Carver:

Analysis of your compounds gave the following results:

Your #,	Our #,	% Carbon,	% Ash,
Ash Bottom Comb B	Z-772	2.81	81.62
Ash Econ/Gen Comb B	Z-773	3.99	90.01
Ash Spray Dryer Comb B	Z-774	2.46	90.27
Ash ESP 2&3 Comb B	Z-775	2.40	88.15
Ash 3 Comb 3	Z-776	1.83	91.46
Ash ESP All Comb B	Z-777	1.08	87.12

1.5 hours Carbon
3.0 hours Ash

The remainder of your samples are being returned as requested. There will be a charge of $1.00 per sample for postage and handling.

Sincerely yours,

GALBRAITH LABORATORIES, INC.

Gail R. Hutchens

Gail R. Hutchens
Exec. Vice-President

B-126

GRH:sc

WHEELABRATOR #5605

LIME SLURRY 3/8/88 MEQ SPECIFIC GRAVITY & % SOLIDS

SAMPLE I.D.	BEAKER# 1A	BEAKER# 1B	BEAKER# 1C
	23.8286		
(1) [2/08/88-MIL-LIME-1]		24.0096	23.6912
#2 INLET	✓23.8283	✓24.0093	✓23.6909
	23.8300	24.0100	23.6918
WT WITH 25 ML	47.5553	47.7308	47.3974
TARE	21.7500	21.9273	21.6152 (2.0757)
	25.8053 (2.0783)	25.8035 (2.0820)	25.7822
SG	1.032	1.032	1.031
% SOLIDS	8.05	8.07	8.05

(2) [2/08/88-MIL-LIME-2] #1 SDA INLET	BEAKER# 2A	BEAKER# 2B	BEAKER# 2C
	22.7800	✓22.8450	✓22.2274
	✓22.7795	22.8450	22.2277
	22.7802	22.8456	22.2286
WT. WITH 25 ML	46.8127	46.8705	46.2673
TARE	21.1476	21.2023	20.5767
	25.6651 (1.6319)	25.6682 (1.6427)	25.6906 (1.6507)
S.G.	1.027	1.027	1.028
% SOLIDS	6.36	6.4	6.43

(3) [2/09/88-MIL-LIME-3] #2 SDA INLET	BEAKER# 3A	BEAKER# 3B	BEAKER# 3C
	✓23.7527	✓24.1227	✓23.5162
	23.7529	24.1231	23.5162
WT WITH 25 ML	47.0863	47.4126	46.5197
TARE	21.23997	21.6099	21.~~0298~~ 0303
	25.8466 (2.5130)	25.8017 (2.5128)	25.4894 (2.4859)
S.G.	1.034	1.032	1.020
% SOLIDS	9.72	9.74	9.75

NOTE: SAMPLE #3 SO THICK PIPETTING WAS MOST DIFFICULT. POSSIBLY THE CAUSE FOR THE EXTREME DEVIATIONS IN WEIGHTS.

WHEELABRATOR #5605 % SOLIDS & SPECIFIC GRAVITY
3/11/88

(4) [2/09/88-MIL-LIME-4]

	BEAKER # 4A	BEAKER # 4B	BEAKER # 4C
#2 SDA INLET		✓23.7505	
	✓23.9131	23.7512	22.7405
	23.9131	23.7517	✓22.7403
WT WITH 25 ML	47.5139	47.3487	46.3533
TARE	21.6422	21.4847	20.4784
	25.8717 (2.2709)	25.8640 (2.2658)	25.8749 (2.619
SG.	1.035	1.035	1.035
% SOLIDS	8.78	8.76	8.74

(5) [2/10/88/MIL-LIME-5]

	BEAKER # 5A	BEAKER # 5B	BEAKER # 5C
CAP & JAR DID NOT AGREE	✓23.1637	✓22.6708	
ON LOC I.E. 1 OR 2 SDA	23.1643	22.6712	✓22.7837
INLET	23.1649	22.6717	22.7840
WT WITH 25 ML.	47.2789	46.8186	46.9155
TARE	21.6371	21.1425	21.2506
	25.6418 (1.5266)	25.6761 (1.5283)	25.6649 (1.55
S.G.	1.026	1.027	1.027
% SOLIDS	5.95	5.95	5.97

TO MAKE SAMPLES HOMOGENEOUS PRIOR TO ANALYSIS THE SAMPLE JAR WAS PLACED ON A STIRR PLATE AND CONTAINED A STIRR BAR. SAMPLES CONTINUED TO MIX WHILE A 25 ML PORTION WAS REMOVED FROM THE JAR USING A VOLUMETRIC PIPET. THE PIPETED ALIQUOT WAS PLACED IN A TARE WEIGHED BEAKER, THEN WEIGHED AGAIN. THE DIFFERENCE IN THE WEIGHTS WERE DIVIDED BY 25 TO DETERMINED THE SPECIFIC GRAVITY.

THE SAMPLES WERE THEN PLACED ON ~~THE~~ A STEAMBATH AND EVAPORATED TO DRYNESS, DESICCATED AND WEIGHED TO CONSTANT. THE DIFFERENCE BETWEEN THE ORIGINAL SAMPLE WEIGHT AND THE EVAPORATED WEIGHT WERE USED TO CALCULATE THE % SOLIDS.

APPENDIX C

SAMPLING AND ANALYTICAL PROCEDURES

- ASME/EPA/DOE Protocols for Sampling and Analysis of CDD/CDF
- Triangle Laboratories Case Narrative for Analysis of CDD/CDF
- ASTM Method E 777-81
- ASTM Method E 830-81

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SAMPLING FOR THE DETERMINATION OF CHLORINATED ORGANIC COMPOUNDS IN STACK EMISSIONS

1. PRINCIPLE AND APPLICABILITY

1.1 Principle: Stack gases that may contain chlorinated organic compounds are withdrawn from the stack using a sampling train. The analyte is collected in the sampling train. The compounds of interest are determined by solvent extraction followed by gas chromatography/mass spectroscopy (GC/MS).

1.2 Applicability: This method is applicable for the determination of chlorinated organic compounds in stack emissions. The sampling train is so designed that only the total amount of each chlorinated organic compound in the stack emissions may be determined. To date, no studies have been performed to demonstrate that the particulate and/or gaseous chlorinated organic compounds collected in separate parts of the sampling train accurately describes the actual partition of each in the stack emissions. If separate parts of the sampling train are analyzed separately, the data should be included and so noted as in Section 2 below. The sampling shall be conducted by competent personnel experienced with this test procedure and cognizant of intricacies of the operation of the prescribed sampling train and constraints of the analytical techniques for chlorinated organic compounds, especially PCDDs and PCDFs.

Note: This method assumes that all of the compounds of interest are collected either on the XAD-2 resin or in upstream sampling train components. Since the method at the present time has not been validated in the presence of all the other components present (HCl, high organic load) in the stack emission, it is recommended that appropriate quality control (QC) steps be employed until such validation has been completed. These QC steps may include the use of a backup resin trap or the addition of a representative labeled standard (distinguishable from the internal standard used for quantitation) to the filter and/or the XAD-2 in the field prior to the start of sampling. These steps will provide information on possible breakthrough of the compounds of interest.

2. REPORTABILITY

Recognizing that modification of the method may be required for specific applications, the final report of a test where changes are made shall include: (1) the exact modification; (2) the rationale for the modification; and (3) an estimate of the effect the modification will produce on the data.

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3. RANGE OF MINIMUM DETECTABLE STACK GAS CONCENTRATION

The range of the analytical method may be expanded considerably through concentration and/or dilution. The total method sensitivity is also highly dependent on the volume of stack gas sampled and the detection limit of the analytical finish. The user shall determine for their system the minimum detectable stack gas concentration for the chlorinated organic compounds of interest. The minimum detectable stack gas concentration should generally be in the ng/m^3 (nanogram/cubic meter) or lower range.

4. INTERFERENCES

Organic compounds other than the compounds of interest may interfere with the analysis. Appropriate sample clean-up steps shall be performed. Through all stages of sample handling and analysis, care should be taken to avoid contact of samples and extracts with synthetic organic materials other than polytetrafluorethylene (TFE®). Adhesives should not be used to hold TFE® liners on lids (but, if necessary, appropriate blanks must be run), and lubricating and sealing greases must not be used on the sampling train.

5. PRECISION AND ACCURACY

Precision and accuracy measurements have not yet been made on PCDD and PCDF using this method. These measurements are needed. However, recovery efficiencies for source samples spiked with compounds have ranged from 70 to 120%.[1,5]

6. SAMPLING RUNS, TIME, AND VOLUME

6.1 Sampling Runs: The number of sampling runs must be sufficient to provide minimal statistical data and in no case shall be less than three (3).

6.2 Sampling Time: The sampling time must be of sufficient length to provide coverage of the average operating conditions of the source. However, this shall not be less than three hours (3).

6.3 Sample Volume: The sampling volume must be sufficient to provide the required amount of analyte to meet both the MDL of the analytical finish and the allowable stack emissions. It may be calculated using the following formula:

$$\text{Sample Volume} = A \times \frac{100}{B} \times \frac{100}{C} \times \frac{1}{D}$$

A = The analytical MDL in ng
B = Percent (%) of the sample required per analytical finish run

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C = The sample recovery (%)
D = The allowable stack emissions (ng/m^3)

Example: A = 0.050 ng; B = 10%; C = 50%; and D = 1 ng/m^3

$$SV = 0.05 \times \frac{100}{10} \times \frac{100}{50} \times \frac{1}{1} = 1m^3$$

7. APPARATUS

Sampling Train: The train consists of nozzle, probe, heated particulate filter, and sorbent module followed by four impingers (Fig. 1). Provision is made for the addition of (1) a cyclone in the heated filter box when testing sources emitting high concentrations of particulate matter, (2) a large water trap between the heated filter and the sorbent module for stack gases with high moisture content, and (3) additional impingers following the sorbent module. If one of the options is utilized, the option used shall be detailed in the report. The train may be constructed by adaption of an EPA Method 5 train. Descriptions of the sampling train components are contained in the following sections.

7.1.1 Nozzle

The nozzle shall be made to the specifications of EPA Method 5. The nozzle may be made of nickel plated stainless steel, quartz, or borosilicate glass.

7.1.2 Probe

The probe shall be lined or made of TFE®, borosilicate, or quartz glass. The liner or probe extends past the retaining nut into the stack. A temperature controlled jacket provides protection of the liner or probe. The liner or probe shall be equipped with a connecting fitting that is capable of forming a leak-free, vacuum-tight connection without sealing greases.

7.1.3 Sample Transfer Lines (optional)

The sample transfer lines, if needed, shall be heat traced, heavy walled TFE® (1.3 cm [1/2 in.] O.D. x 0.3 cm [1/8 in.] wall) with connecting fittings that are capable of forming leak-free, vacuum-tight connections without using sealing greases. The line should be as short as possible and must be maintained at 120°C.

7.1.4 Filter Holder

Borosilicate glass, with a glass frit filter support and a glass-to-glass seal or TFE® gasket. A rubber gasket shall not be used. The holder design shall provide a positive seal against leakage from the outside or around the filter. The holder shall be attached immediately at the outlet of the probe (or cyclone, if used).

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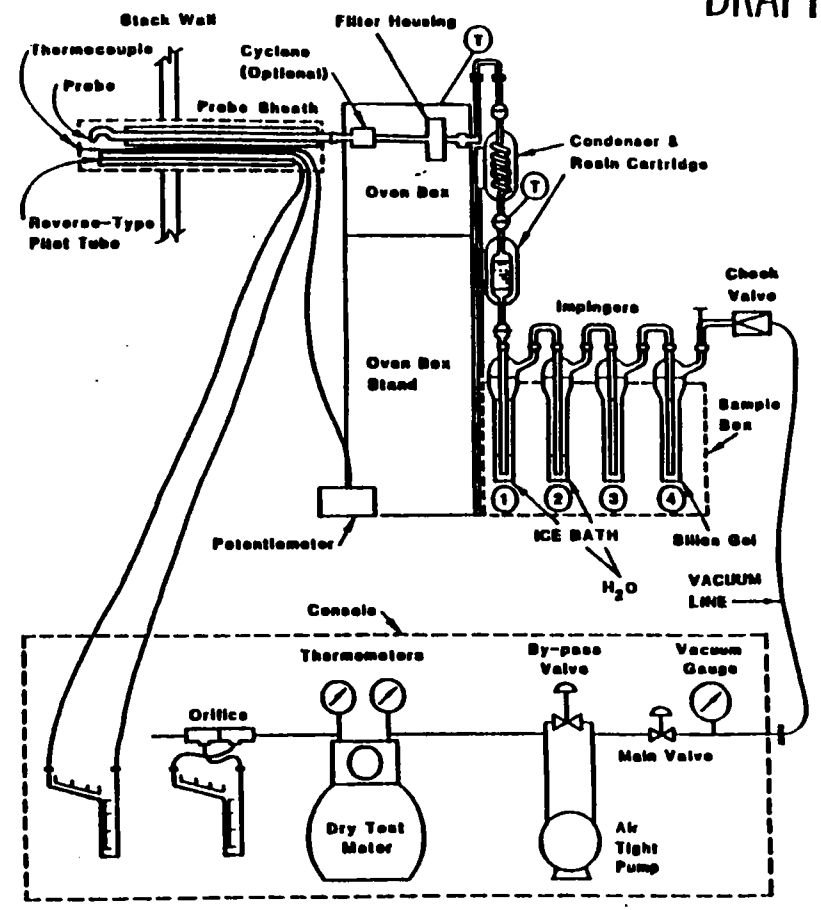

Impingers are of the Modified Greenberg-Smith Type
Impingers 1 and 2 Contain 100 ml Water
Impinger 3 Empty
Impinger 4 Contains 200-300 Grams Silica Gel
Impinger 1 is the Hexane-Rinsed Back-Up to the Resin Cartridge
(T) = Thermocouple location

Fig. 1. Modified EPA Method 5 Train for Organics Sampling

Source: Methods Manual Sampling and Analysis Procedures for Assessing Organics Emissions from Stationary Combustion Sources in Exposure Evaluation Division Studies, U.S. Environmental Protection Agency Report No. EPA-560-82-014 (January 1982)

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7.1.5 Cyclone in Filter Box (optional)

The cyclone shall be constructed of borosilicate glass with connecting fittings that are capable of forming leak-free, vacuum-tight connections without using sealing greases.

7.1.6 Filter Heating System

The heating system must be capable of maintaining a temperature around the filter holder (and cyclone, if used) during sampling of 120±14°C (248±25°F). A temperature gauge capable of measuring temperature to within 3°C (5.4°F) shall be installed so that the temperature around the filter holder can be regulated and monitored during sampling.

7.1.7 Solid Sorbent Module

Amberlite XAD-2® resin (XAD-2), confined in a trap, shall be used as the sorbent. The sorbent module shall be made of glass with connecting fittings that are able to form leak-free, vacuum-tight seals without use of sealant greases (Figs. 2 and 3). The XAD-2 trap must be in a vertical position. It is preceded by a coil-type condenser, also oriented vertically, with circulating cold water. Gas entering the sorbent module must be maintained at ≤20°C (68°F). Gas temperature shall be monitored by a thermocouple placed either at the inlet or exit of the sorbent trap. The sorbent bed must be firmly packed and secured in place to prevent settling or channeling during sample collection. Ground glass caps (or equivalent) must be provided to seal the sorbent-filled trap both prior to and following sampling. All sorbent modules must be maintained in the vertical position during sampling.

7.1.8 Impingers

Four or more impingers with connecting fittings able to form leak-free, vacuum-tight seals without sealant greases when connected together, shall be used. All impingers are of the Greenburg-Smith design modified by replacing the tip with 1.3 cm (1/2 in.) ID glass tube extending to 1.3 cm (1/2 in.) from the bottom of the flask.

7.1.9 Metering System

The metering system shall consist of a vacuum gauge, a leak-free pump, thermometers capable of measuring temperature to within 3°C (~5°F), a dry gas meter with 2 percent accuracy at the required sampling rate, and related equipment, or equivalent.

7.1.10 Barometer

Mercury, aneroid, or other barometers capable of measuring atmospheric pressure to within 2.5 Hg (0.1 in. Hg) shall be used.

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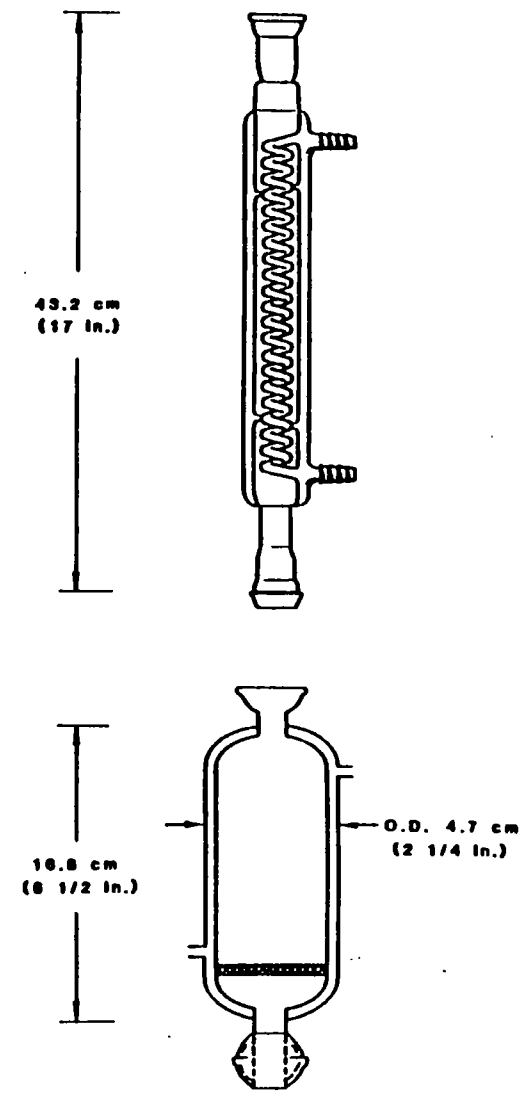

Fig. 2 Acceptable Sorbent Module Design #1

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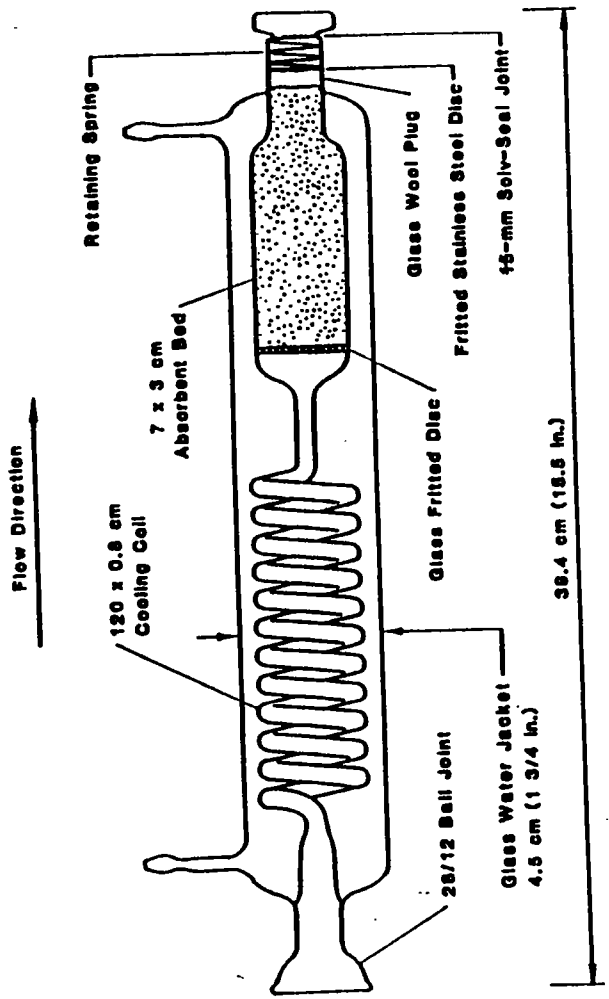

Fig. 3 Acceptable Sorbent Module Design #2

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7.2 Sample Recovery, Supplies, and Equipment

7.2.1 Ground Glass Caps or Hexane Rinsed Aluminum Foil

To cap off adsorbent tube and the other sample-exposed portions of the train. If TFE® screw connections are used, then TFE® screw caps shall be used.

7.2.2 Teflon FEP® Wash Bottle

Three 500 ml, Nalgene No. 0023A59, or equivalent.

7.2.3 Probe and Transfer Line Brush

Inert bristle brush with stainless steel rod-handle of sufficient length that is compatible with the liner or probe and transfer line.

7.2.4 Filter Storage Containers

Sealed filter holder or precleaned, wide-mouth amber glass containers with TFE®-lined screw caps or wrapped in hexane rinsed aluminum foil.

7.2.5 Balance

Triple beam, Ohaus model 7505, or equivalent.

7.2.6 Aluminum Foil

Heavy duty, hexane-rinsed.

7.2.7 Precleaned Metal Can

To recover used silica gel.

7.2.8 Precleaned Graduated Cylinder, e.g., 250 ml

250 ml, with 2 ml graduations, borosilicate glass.

7.2.9 Liquid Sample Storage Containers

Precleaned amber glass bottles or clear glass bottles wrapped in opaque material, 1 L, with TFE®-lined screw caps.

8. REAGENTS

8.1 Sampling

8.1.1 Filter -- Fiberglass Reeve-Angel 934 AH or Equivalent

Prior to use in the field, each lot of filters shall be subjected to precleaning and a quality control (QC) contamination check to confirm that there are no contaminants present that will

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interfere with the analysis of analyte at the target detection limits.

If performed, filter precleaning shall consist of Soxhlet extraction, in batches not to exceed 50 filters, with the solvent(s) to be applied to the field samples. As a QC check, the extracting solvent(s) shall be subjected to the same concentration, cleanup and analysis procedures to be used for the field samples. The background or blank value observed shall be converted to a per filter basis and shall be corrected for any differences in concentration factor between the QC check (CF_{QC}) and the actual sample analysis procedure (CF_s).

$$\text{Blank value per filter} = \frac{\text{Apparent } \mu g \text{ of analyte}}{\text{No. filters extracted}} \times \frac{CF_s}{CF_{QC}}$$

where:

$$CF = \frac{\text{Initial volume of extracting solvent}}{\text{Final Volume of concentrated extract}}$$

The quantitative criterion for acceptable filter quality will depend on the detection limit criteria established for the field sampling and analysis program. Filters that give a background or blank signal per filter greater than or equal to the target detection limit for the analyte(s) of concern shall be rejected for field use. Note that acceptance criteria for filter cleanliness depends not only on the inherent detection limit of the analysis method but also on the expected field sample volume and on the desired limit of detection in the sampled stream.

If the filters do not pass the QC check, they shall be re-extracted and the solvent extracts re-analyzed until an acceptably low background level is achieved.

8.1.2 Amberlite XAD-2 Resin

The cleanup procedure may be carried out in a giant Soxhlet extractor, which will contain enough Amberlite XAD-2® resin (XAD-2) for several sampling traps. An all glass thimble 55-90 mm OD x 150 mm deep (top to frit) containing an extra coarse frit is used for extraction of XAD-2. The frit is recessed 10-15 mm above a crenelated ring at the bottom of the thimble to facilitate drainage. The XAD-2 must be carefully retained in the extractor cup with a glass wool plug and stainless steel screen since it floats on methylene chloride. This process involves sequential extraction in the following order.

Solvent	Procedure
Water	Initial rinse with 1 L H_2O for 1 cycle, then discard H_2O
Water	Extract with H_2O for 8 hr
Methyl alcohol	Extract for 22 hr
Methylene chloride	Extract for 22 hr
Hexane	Extract for 22 hr

The XAD-2 must be dried by one of the following techniques.

(a) After evaluation of several methods of removing residual solvent, a fluidized-bed technique has proven to be the fastest and most reliable drying method.

A simple column with suitable retainers as shown in Fig. 4 will serve as a satisfactory column. A 10.2 cm (4 in.) diameter Pyrex pipe 0.6 m (2 ft. long) will hold all of the XAD-2 from the Soxhlet extractor, with sufficient space for fluidizing the bed while generating a minimum XAD-2 load at the exit of the column.

The gas used to remove the solvent is the key to preserving the cleanliness of the XAD-2. Liquid nitrogen from a regular commercial liquid nitrogen cylinder has routinely proven to be a reliable source of large volumes of gas free from organic contaminants. The liquid nitrogen cylinder is connected to the column by a length of precleaned 0.95 cm (3/8 in.) copper tubing, coiled to pass through a heat source. As nitrogen is bled from the cylinder, it is vaporized in the heat source and passes through the column. A convenient heat source is a water bath heated from a steam line. The final nitrogen temperature should only be warm to the touch and not over 40°C. Experience has shown that about 500 g of XAD-2 may be dried overnight consuming a full 160 L cylinder of liquid nitrogen.

As a second choice, high purity tank nitrogen may be used to dry the XAD-2. The high purity nitrogen must first be passed through a bed of activated charcoal approximately 150 mL in volume. With either type of drying method, the rate of flow should gently agitate the bed. Excessive fluidation may cause the particles to break up.

(b) As an alternate, if the nitrogen process is not available, the XAD-2 may be dried in a vacuum oven, if the temperature never exceeds 20°C.

The XAD-2, even if purchased clean, must be checked for both methylene chloride and hexane residues, plus normal blanks before use.

(c) Storage of Clean XAD-2: XAD-2 cleaned and dried as prescribed above is suitable for immediate use in the field, provided it passes the QC contamination check described in (d), below. However, precleaned dry XAD-2 may develop unacceptable levels of contamination if stored for periods exceeding a few weeks.

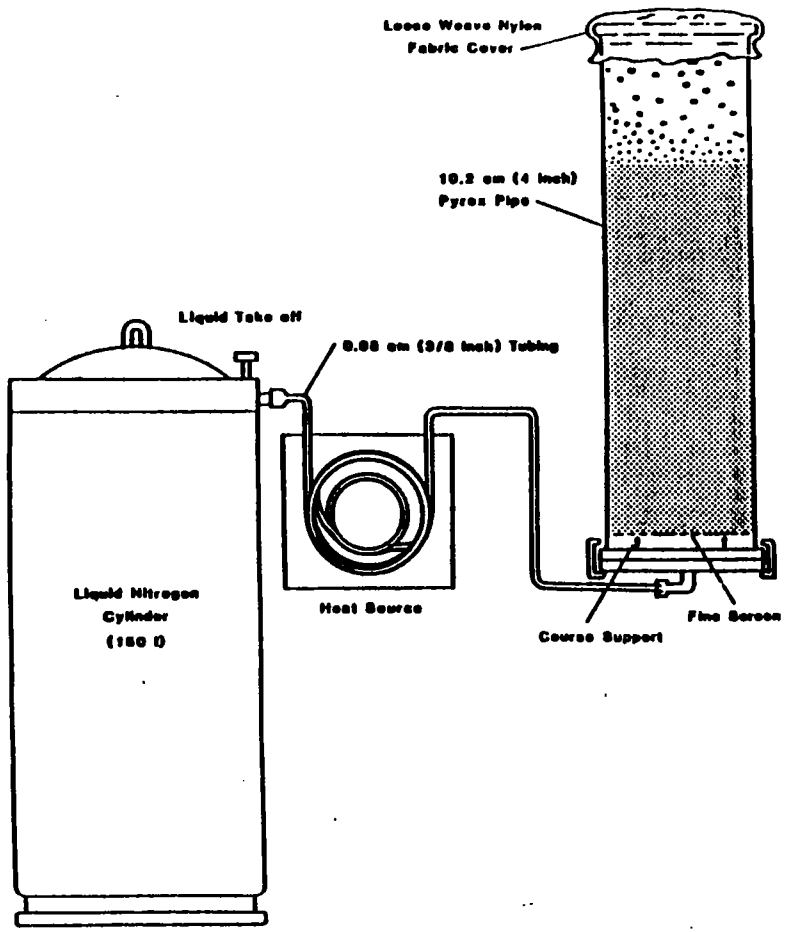

Fig. 4 XAD-2 Fluidized-Bed Drying Apparatus

If precleaned XAD-2 is not to be used immediately, it shall be stored under distilled-in-glass methanol. No more than two weeks prior to initiation of field sampling, the excess methanol shall be decanted; the XAD-2 shall be washed with a small volume of methylene chloride and dried with clean nitrogen as described in (b) above. An aliquot shall then be taken for the QC contamination check described in (d), below.

If the stored XAD-2 fails the QC check, it may be recleaned by repeating the final two steps of the extraction sequence above: sequential methylene chloride and hexane extraction. The QC contamination check shall be repeated after the XAD-2 is recleaned and dried.

(d) QC Contamination Check: The XAD-2, whether purchased, "precleaned", or cleaned as described above, shall be subjected to a QC check to confirm the absence of any contaminants that might cause interferences in the subsequent analysis of field samples. An aliquot of XAD-2, equivalent in size to one field sampling tube charge, shall be taken to characterize a single batch of XAD-2.

The XAD-2 aliquot shall be subjected to the same extraction, concentration, cleanup, and analytical procedure(s) as is (are) to be applied to the field samples. The quantitative criteria for acceptable XAD-2 quality will depend on the detection limit criteria established for the field sampling and analysis program. XAD-2 which yields a background or blank signal greater than or equal to that corresponding to one-half the MDL for the analyte(s) of concern shall be rejected for field use. Note that the acceptance limit for XAD-2 cleanliness depends not only on the inherent detection limit of the analytical method but also on the expected field sample volume and on the desired limit of detection in the sampled stream.

8.1.3 Glass Wool

Cleaned by thorough rinsing, i.e., sequential immersion in three aliquots of hexane, dried in a 110°C oven, and stored in a hexane-washed glass jar with TFE®-lined screw cap.

8.1.4 Water

Deionized, then glass-distilled, and stored in hexane-rinsed glass containers with TFE®-lined screw caps.

8.1.5 Silica Gel

Indicating type, 6-16 mesh. If previously used, dry at 175±5C for 2 hr. New silica gel may be used as received.

8.1.6 Crushed Ice

Place crushed ice in the water bath around the impingers during sampling.

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9. SAMPLE RECOVERY REAGENTS

9.1 Acetone

Pesticide quality, Burdick and Jackson "Distilled in Glass" or equivalent, stored in original containers. A blank must be screened by the analytical detection method.

9.2 Hexane

Pesticide quality, Burdick and Jackson "Distilled in Glass" or equivalent, stored in original containers. A blank must be screened by the analytical detection method.

10. PROCEDURE

Caution: Sections 10.1.1.2 and 10.1.1.3 shall be done in the laboratory.

10.1 Sampling

10.1.1 Pretest Preparation

All train components shall be maintained and calibrated according to the procedure described in APTD-0576 unless otherwise specified herein.

Weigh several 200 to 300 g portions of silica gel in air-tight containers to the nearest 0.5 g. Record the total weight of the silica gel plus container, on each container. As an alternative, the silica gel may be weighed directly in its impinger or sampling holder just prior to train assembly.

Check filters visually against light for irregularities and flaws or pinhole leaks. Pack the filters flat in a precleaned glass container or wrapped hexane-rinsed aluminum foil.

10.1.1.1 Preliminary Determinations

Select the sampling site and the minimum number of sampling points according to EPA Method 1. Determine the stack pressure, temperature, and the range of velocity heads using EPA Method 2; it is recommended that a leak-check of the pitot lines (see EPA Method 2, Sec. 3.1) be performed. Determine the moisture content using EPA Approximation Method 4 or its alternatives for the purpose of making isokinetic sampling rate-settings. Determine the stack gas dry molecular weight, as described in EPA Method 2, Sec. 3.6; if integrated EPA Method 3 sampling is used for molecular weight determination, the integrated bag sample shall be taken simultaneously with, and for the same total length of time as, the EPA Method 4 sampling.

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Select a nozzle size based on the range of velocity heads, such that it is not necessary to change the nozzle size in order to maintain isokinetic sampling rates. During the run, do not change the nozzle size. Ensure that the proper differential pressure gauge is chosen for the range of velocity heads encountered (see Section 2.2 of EPA Method 2).

Select a suitable probe length such that all traverse points can be sampled. For large stacks, consider sampling from opposite sides of the stack to reduce the length of probes.

Select a total sampling time greater than or equal to the minimum total sampling time specified in the test procedures for the specific industry such that (1) the sampling time per point is not less than 2 min., and (2) the sample volume taken (corrected to standard conditions) will exceed the required minimum total gas sample volume determined in Section 6.3. The latter is based on an approximate average sampling rate.

It is recommended that the number of minutes sampled at each point be an integer or an integer plus one-half minute, in order to avoid time-keeping errors.

10.1.1.2 Cleaning Glassware

All glass parts of the train upstream of and including the sorbent module and the first impinger should be cleaned as described in Section 3A of the 1980 issue of "Manual of Analytical Methods for the Analysis of Pesticides in Humans and Environmental Samples."[3] Special care should be devoted to the removal of residual silicone grease sealants on ground glass connections of used glassware. These grease residues should be removed by soaking several hours in a chromic acid cleaning solution prior to routine cleaning as described above.

10.1.1.3 Amberlite XAD-2 Resin Trap

Use a sufficient amount (at least 30 gms or 5 gms/m^3 of stack gas to be sampled) of cleaned XAD-2 to fill completely the glass sorbent trap which has been thoroughly cleaned as prescribed and rinsed with hexane. Follow the XAD-2 with hexane-rinsed glass wool and cap both ends. These caps should not be removed until the trap is fitted into the train. See Fig. 1 for details.

The dimensions and XAD-2 capacity of the sorbent trap, and the volume of gas to be sampled, should be varied as necessary to ensure efficient collection of the species of interest. Some illustrative data are presented in Table 1.

10.1.2 Preparation of Collection Train

During preparation and assembly of the sampling train, keep all train openings where contamination can enter covered until

TABLE 1

SAMPLE SIZE AND FLOW RATE COMPARISON FOR SEVERAL SORBENT TRAP DESIGNS

Trap	Dimensions (mm) Depth	Dimensions (mm) Diameter	Charge of XAD-2 Resin (g)	Flow Equivalent to 43 cm/sec[a]	Max. Sample Size (cm^3) for Efficient Capture of Following Compounds[b] Octane	Benzene	Phenol
SASS	70	90	130	165 Lpm (5.9 cfm)	150	3.0	240
ADL	70	45	40	40 Lpm (1.5 cfm)	45	0.9	74
Battelle	70	30	19	18 Lpm (0.65 cfm)	22	0.4	33

[a]Upper limit beyond which collection efficiency drops off.

[b]Calculated from V_g^T for 50% breakthrough. Specified value includes a safety factor of 2.

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just prior to assembly or until sampling is about to begin. Caution: Do not use sealant greases in assembling the train.

- Place approximately 100 gms of water in each of the first two impingers with a graduated cylinder, and leave the third impinger empty. Place approximately 200 to 300 g or more, if necessary, of silica gel in the last impinger. Weigh each impinger (stem included) and record the weights on the impingers and on the data sheet.

Assemble the train as shown in Fig. 1.

Place crushed ice in the water bath around the impingers.

10.1.3 Leak Check Procedures

10.1.3.1 Initial Leak Check

The train, including the probe, will be leak checked prior to being inserted into the stack after the sampling train has been assembled. Turn on and set (if applicable) the heating/cooling system(s) to cool the sample gas yet remain at a temperature sufficient to avoid condensation in the probe and connecting line to the first impinger (approximately 120°C). Allow time for the temperature to stabilize. Leak check the train at the sampling site by plugging the nozzle with a TFE® plug and pulling a 380 mm Hg (12 in. Hg) vacuum. A leakage rate in excess of 4% of the average sampling rate or 0.0057 m^3/min (0.02 cfm) whichever is less, is unacceptable. Sampling must cease if pressure during sampling exceeds the leak check pressure.

The following leak check instruction for the sampling train described in APTD-0576[2] and APTD-0581[4] may be helpful. Start the pump with bypass valve fully open and coarse adjust valve completely closed. Partially open the coarse adjust valve and slowly close the bypass valve until 380 mm Hg (12 in. Hg) vacuum is reached. Do not reverse the direction of the bypass valve. This will cause water to back up into the probe. If 380 mm Hg (12 in. Hg) is exceeded during the test, either leak check at this higher vacuum or end the leak check as described below and start the test over.

When the leak check is completed, first slowly remove the TFE® plug from the inlet to the probe then immediately turn off the vacuum pump. This prevents the water in the impingers from being forced backward into the probe.

10.1.3.2 Leak Checks During a Test

A leak check shall be performed before and after a change of port during a test. A leak check shall be performed before and after a component (e.g., filter or optional water knockout trap) is changed during a test.

Such leak checks shall be performed according to the procedure given in Section 10.1.3.1 of this method except that it shall be performed at a vacuum equal to or greater than the highest value recorded up to that point in the test. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 ft^3/min) or 4% of the average sampling rate (whichever is smaller) the results are acceptable. If, however, a higher leakage rate is observed, the tester shall either: (1) record the leakage rate and then correct the volume of gas sampled since the last leak check as shown in Section 10.1.3.4 of this method, or (2) void the test.

10.1.3.3 Post-Test Leak Check

A leak check is mandatory at the end of a test. This leak check shall be performed in accordance with the procedure given in Section 10.1.3.1 except that it shall be conducted at a vacuum equal to or greater than the highest value recorded during the test. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 ft^3/min) or 4% of the average sampling rate (whichever is smaller), the results are acceptable. If, however, a higher leakage rate is observed, the tester shall either: (1) record the leakage rate and correct the volume as gas sampled since the last leak check as shown in Section 10.1.3.4 of this method, or (2) void the test.

10.1.3.4 Correcting for Excessive Leakage Rates

The equation given in Section 11.3 of this method for calculating V_m(std), the corrected volume of gas sampled, can be used as written unless the leakage rate observed during any leak check after the start of a test exceeded L_a, the maximum acceptable leakage rate (see definitions below). If an observed leakage rate exceeds L_a, then replace V_m in the equation in Section 11.3 with the following expression:

$$[V_m - \sum_{i=1}^{n} (L_i - L_a)\,\theta_i - L_p - L_a)\,\theta_p]$$

where:

V_m = Volume of gas sampled as measured by the dry gas meter (dscf).

L_a = Maximum acceptable leakage rate equal to 0.00057 m^3/min. (0.02 ft^3/min) or 4% of the average sampling rate, whichever is smaller.

L_p = Leakage rate observed during the post-test leak check, m^3/min (ft^3/min).

L_i = Leakage rate observed during the leak check performed prior to the "i th" leak check (i = 1,2,3...n), m^3/min (ft^3/min).

θ_i = Sampling time interval between two successive leak checks beginning with the interval between the first and second leak checks, min.

θ_p = Sampling time interval between the last (n th) leak check and the end of the test, min.

Substitute only for those leakages (L_i or L_p) which exceeded L_a.

10.1.3.5 Train Operation

During the sampling run, a sampling rate within 10% of the selected sampling rate shall be maintained. Data will be considered acceptable if readings are recorded at least every 5 min. and not more than 10% of the point readings are in excess of ±10% and the average of the point readings is within ±10%. During the run, if it becomes necessary to change any system component in any part of the train, a leak check must be performed prior to restarting.

For each run, record the data required on the data sheets. An example is shown in Fig. 4. Be sure to record the initial dry gas meter reading. Record the dry gas meter readings at the beginning and end of each sampling time increment and when sampling is halted.

To begin sampling, remove the nozzle cap, verify (if applicable) that the probe and sorbent module temperature control systems are working and at temperature and that the probe is properly positioned. Position the probe at the sampling point. Immediately start the pump and adjust the flow rate.

If the stack is under significant sub-ambient pressure (height of impinger stem), take care to close the coarse adjust valve before inserting the probe into the stack to avoid water backing into the probe. If necessary, the pump may be turned on with the coarse adjust valve closed.

During the test run, make periodic adjustments to keep the probe temperature at the proper value. Add more ice and, if necessary, salt to the ice bath. Also, periodically check the level and zero of the manometer and maintain the temperature of sorbent module at or less than 20°C but above 0°C.

If the pressure drop across the train becomes high enough to make the sampling rate difficult to maintain, the test run shall be terminated unless the replacing of the filter corrects the problem. If the filter is replaced, a leak check shall be performed.

At the end of the sample run, turn off the pump, remove the probe and nozzle from the stack, and record the final dry gas meter reading. Perform the post test leak check.*

*With acceptability of the test run to be based on the same criterion as in 10.1.3.1.

FIELD DATA

PLANT _____
DATE _____
SAMPLING LOCATION _____
SAMPLE TYPE _____
RUN NUMBER _____
OPERATOR _____
BAROMETRIC PRESSURE _____
SITE TO BARO. ELEVATION (ft.) _____
CORRECTED B.P. _____
STATIC PRESSURE (P_s) _____
FILTER NUMBER(s) _____

LEAK CHECK: Initial at ≥ 15" Hg CFM _____
Final at _____ "Hg CFM _____
Pitot at ≥ 3" H_2O _____

PROBE LENGTH AND TYPE _____
NOZZLE I.D. _____
ASSUMED MOISTURE, % _____
SAMPLE BOX NUMBER _____
METER BOX NUMBER _____
TEMPERATURE METER NO _____
THERMOCOUPLE I.D. NO _____
METER ΔH _____
METER CORRECTION _____
C FACTOR _____
REFERENCE Δp _____
UMBILICAL CORD I.D. NO _____

SCHEMATIC OF TRAVERSE POINT LAYOUT

Read and Record All Data

Every _____ Minutes

$$Vm_i = \_\_\_\_\_ (Tm + 460)\sqrt{\frac{\Delta Ps}{Ts + 460}}$$

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3		VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F XAD-2	IMPINGER TEMPERATURE, °F
		DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F			

10.2 Sample Recovery

Proper cleanup procedure begins as soon as the probe is removed from the stack at the end of the sampling period.

When the probe can be safety handled, wipe off all external particulate matter near the tip of the probe. Remove the probe from the train and close off both ends with hexane-rinsed aluminum foil. Seal off the inlet to the train with a ground glass cap or hexane-rinsed aluminum foil.

Transfer the probe and impinger assembly to the cleanup area. This area should be clean and enclosed so that the chances of contaminating or losing the sample will be minimized. No smoking shall be allowed.

Inspect the train prior to and during disassembly and note any abnormal conditions, e.g., broken filters, color of the impinger liquid, etc. Treat the samples as follows:

10.2.1 Container No. 1

Either seal the ends of the filter holder or carefully remove the filter from the filter holder and place it in its identified container. Use a pair of precleaned tweezers to handle the filter. If it is necessary to fold the filter, do so such that the particulate cake is inside the fold. Carefully transfer to the container any particulate matter and/or filter fibers which adhere to the filter holder gasket, by using a dry inert bristle brush and/or a sharp-edged blade. Seal the container.

10.2.2 Sorbent Modules

Remove the sorbent module from the train and cap it off.

10.2.3 Cyclone Catch

If the optional cyclone is used, quantitatively recover the particulate into a sample container and cap.

10.2.4 Sample Container No. 2

Quantitatively recover material deposited in the nozzle, probe, transfer line, the front half of the filter holder, and the cyclone, if used, first by brushing and then by sequentially rinsing with acetone and then hexane three times each and add all these rinses to Container No. 2. Mark level of liquid on container.

10.2.5 Sample Container No. 3

Rinse the back half of the filter holder, the connecting line between the filter and the condenser and the condenser (if using the separate condenser-sorbent trap) three times each with acetone

and hexane collecting all rinses in Container 3. If using the combined condenser-sorbent trap, the rinse of the condenser shall be performed in the laboratory after removal of the XAD-2. If the optional water knockout trap has been employed, it shall be weighed and recorded and its contents placed in Container 3 along with the rinses of it. Rinse it three times each with acetone, and hexane. Mark level of liquid on container.

10.2.6 Sample Container No. 4

Remove the first impinger. Wipe off the outside of the impinger to remove excessive water and other material, weigh (stem included), and record the weight on data sheet. Pour the contents and rinses directly into Container No. 4. Rinse the impinger sequentially three times with acetone, and hexane. Mark level of liquid on container.

10.2.7 Sample Container No. 5

Remove the second and third impingers, wipe the outside to remove excessive water and other debris, weigh (stem included) and record weight on data sheet. Empty the contents and rinses into Container No. 5. Rinse each with distilled DI water three times. Mark level of liquid on container.

10.2.8 Silica Gel Container

Remove the last impinger, wipe the outside to remove excessive water and other debris, weigh (stem included), and record weight on data sheet. Place the silica gel into its marked container.

11. CALCULATIONS

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculations.

11.1 Nomenclature

G_a - Total weight of chlorinated organic compounds in stack gas sample, ng.

C_a - Concentration of chlorinated organic compounds in stack gas, $\mu g/m^3$, corrected to standard conditions of 20°C, 760 mm Hg (68°F, 29.92 in. Hg) on dry basis.

A_n - Cross-sectional area of nozzle, m^2 (ft^2).

B_{ws} - Water vapor in the gas stream, proportion by volume.

I - Percent of isokinetic sampling.

M_w - Molecular weight of water, 18 g/g-mole (18 lb/lb-mole)

P_{bar} - Barometric pressure at the sampling site, mm Hg (in. Hg).

P_s - Absolute stack gas pressure, mm Hg (in. Hg).

P_{std} - Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R - Ideal gas constant, 0.06236 mm Hg-m^3/°K-g-mole (21.83 in. Hg-ft^3/°R-lb-mole).

T_m - Absolute average dry gas meter temperature °K (°R).

T_s - Absolute average stack gas temperature °K (°R).

T_{std} - Standard absolute temperature, 293°K (68°F).

m_{lc} - Total mass of liquid collected in impingers and silica gel.

V_m - Volume of gas sample as measured by dry gas meter, dcm (dcf).

$V_m(std)$ - Volume of gas sample measured by the dry gas meter corrected to standard conditions, dscm (dscf).

$V_w(std)$ - Volume of water vapor in the gas sample corrected to standard conditions, scm (scf).

v_s - Stack gas velocity, calculated by combustion calculation, m/sec (ft/sec).

Y - Meter box correction factor.

ΔH - Average pressure differential across the orifice meter, mm H_2O (in. H_2O).

θ - Total sampling time, min.

13.6 - Specific gravity of mercury.

60 - Sec/min.

100 - Conversion to percent.

11.2 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop

See data sheet (Fig. 5).

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11.3 Dry Gas Volume

Correct the sample volume measured by the dry gas meter to standard conditions [20°C, 760 mm Hg (68°F, 29.92 in. HG)] by using Equation 1.

$$V_m(std) = Y\, V_m \frac{T_{std}}{T_m} \frac{P_{bar} + \frac{\Delta H}{13.6}}{P_{std}} = K_1 V_m \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \qquad (1)$$

where:

K_1 = 0.3855 °K/mm Hg for metric units

= 17.65 °R/in. Hg for English units

11.4 Volume of Water Vapor

$$V_w(std) = m_{lc} \frac{RT_{std}}{M_w \times P_{std}} = K_2 m_{lc} \qquad (2)$$

where:

K_2 = 0.00134 m^3/ml for metric units

= 0.0472 ft^3/ml for English units

11.5 Moisture Content

$$B_{ws} = \frac{V_w(std)}{V_m(std) + V_w(std)} \qquad (3)$$

If liquid droplets are present in the gas stream assume the stream to be saturated and use a psychrometric chart to obtain an approximation of the moisture percentage.

11.6 Percent Isokinetic Sampling

$$I = \frac{100\, T_s\, [K_4\, m_{lc} + (V_m K_m)\, (P_{bar} + \Delta H/13.6)]}{60\, \theta_{vs}\, P_s\, A_n} \qquad (4)$$

where:

K_4 = 0.003454 mm Hg - m^3/ml - °K for metric units

= 0.002669 in Hg - ft^3/ml - °R for English units

11.7 Concentration of Chlorinated Organic Compounds in Stack Gas

Determine the concentration of chlorinated organic compounds in the stack gas according to Equation 5.

$$C_s = K_5 \frac{\quad}{V_m(std)} \qquad (5)$$

where:

K_5 = 35.31 ft^3/m^3

12. QUALITY ASSURANCE (QA) PROCEDURES

The positive identification and quantification of specific compounds in this assessment of stationary conventional combustion sources is highly dependent on the integrity of the samples received and the precision and accuracy of all analytical procedures employed. The QA procedures described in this section were designed to monitor the performance of the sampling methods and to provide information to take corrective actions if problems are observed.

Field Blanks

The field blanks should be submitted as part of the samples collected at each particular testing site. These blanks should consist of materials that are used for sample collection and storage and are expected to be handled with exactly the same procedure as each sample medium.

Blank Train

For each series of test runs, set up a blank train in a manner identical to that described above, but with the probe inlet capped with hexane-rinsed aluminum foil and the exit end of the last impinger capped with a ground glass cap. Allow the train to remain assembled for a period equivalent to one test run. Recover the blank sample as described in Sec. 7.2.

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ANALYTICAL PROCEDURES TO ASSAY STACK EFFLUENT SAMPLES AND RESIDUAL COMBUSTION PRODUCTS FOR POLYCHLORINATED DIBENZO-p-DIOXINS (PCDD) AND POLYCHLORINATED DIBENZOFURANS (PCDF)

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. Scope and Applicability of Method

The analytical procedures described here are applicable for the :termination of polychlorinated dibenzo-p-dioxins (PCDD) and dibenzo-ırans (PCDF) in stack effluents from combustion processes. These methods ·e also applicable to residual combustion products such as bottom and ·ecipitator ash. The methods presented entail addition of isotopically-ıbeled internal standards to all samples in known quantities, extraction f the sample with appropriate organic solvents, preliminary fractionation ıd cleanup of the extracts using a sequence of liquid chromatography ›lumns, and analysis of the processed extract for PCDD and PCDF using ›upled gas chromatography - mass spectrometry (GC-MS). Various :rformance criteria are specified herein which the analytical data ıst satisfy for quality assurance purposes. These represent minimum ·iteria which must be incorporated into any program in which PCDD ıd PCDF are determined in combustion product samples.

The method presented here does not yield definitive information on ıe concentration of individual PCDD/PCDF isomers, except for 2,3,7,8-:trachlorodibenzo-p-dioxin (TCDD) and 2,3,7,8-Tetrachlorodibenzofuran (TCDF). Rather, it is designed to indicate the total concentration of ıe isomers of several chlorinated classes of PCDD/PCDF (that is, total :tra-, penta-, hexa-, hepta-, and octachlorinated dibenzo-p-dioxins and ibenzofurans). Of the 75 separate PCDD and 135 PCDF isomers, there ·e 22 TCDD, 38 TCDF, 14 PeCDD, 28 PeCDF, 10 HxCDD, 16 HxCDF, 2 HpCDD, HpCDF, 1 OCDD and 1 OCDF.[a]

The analytical method presented herein is intended to be applicable ›r determining PCDD/PCDF present in combustion products at the ppt to ›m level, but the sensitivity which can ultimately be achieved for a iven sample will depend upon the types and concentrations of other chemical ›mpounds in the sample.

The method described here must be implemented by or under the ›pervision of chemists with experience in handling supertoxic materials ıd analyses should only be performed in rigorously controlled, limited :cess laboratories. The quantitation of PCDD/PCDF should be accomplished nly by analysts experienced in utilizing capillary-column gas chromatography-ıss spectrometry to accomplish quantitation of chlorocarbons and similar ›mpounds at very low concentration.

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The toxicological data which are available for the PCDD and PCDF are far from complete. That is, the toxicological properties of all of the isomers comprising the 75 possible PCDD and 135 possible PCDF are not presently known. However, a considerable body of toxicological data exists for 2,3,7,8-TCDD which indicates that, in certain animal species, this compound is lethal at extraordinarily low does and causes a wide range of systemic affects, including hepatic disorders, carcinoma and birth defects. While much less data is available regarding the toxicology of 2,3,7,8-TCDF, sufficient data is available to form the basis for the belief that 2,3,7,8-TCDF is similar in its toxicological properties to 2,3,7,8-TCDD. Relatively little is known about the toxicology of the higher chlorinated PCDD and PCDF (that is, penta through octachlorinated PCDD/PCDF), although there is some data to suggest that certain penta-, hexa-, and hepta- PCDD/PCDF isomers are hazardous. In view of the extraordinary toxicity of 2,3,7,8-TCDD and in view of the exceptional biological activity of this compound (on the basis of enzyme induction assays) and of compounds having similar molecular structures, extensive precautions are required to preclude exposure to personnel during handling and analysis of materials containing these compounds and to prevent contamination of the laboratory. Specific safety and handling procedures which are recommended are given in the Appendix to this protocol.

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a. The abbreviations which are used to designate chlorinated dibenzo-p-dioxins and dibenzofurans throughout this document are as follows:

PCDD - Any or all of the 75 possible chlorinated dibenzo-p-dioxin isomers

PCDF - Any or all of the 135 possible chlorinated dibenzofuran isomers

TCDD - Any or all of the 22 possible tetrachlorinated dibenzo-p-dioxin isomers

TCDF - Any or all of the 138 possible tetrachlorinated dibenzofuran isomers

PeCDD - Any or all of the 14 possible pentachlorinated dibenzo-p-dioxin isomers

PeCDF - Any or all of the 28 possible pentachlorinated dibenzofuran isomers

HxCDD - Any or all of the 10 possible hexachlorinated dibenzo-p-dioxin isomers

HXCDF - Any or all of the 16 possible hexachlorinated dibensofuran isomers

HpCDD - Any or all of the 2 possible heptachlorinated dibenzo-p-dioxin isomers

HpCDF - Any or all of the 4 possible heptachlorinated dibenzofuran isomers

OCDD - Octachlorodibenzo-p-dioxin

OCDF - Octachlorodibenzofuran

Specific Isomers. - Any of the abbreviations cited above may be converted to designate a specific isomer by indicating the exact positions (carbon atoms) where chlorines are located within the molecule. For example, 2,3,7,8-TCDD refers to only one of the 22 possible TCDD isomers - that isomer which is chlorinated in the 2,3,7,8 positions of the dibenzo-p-dioxin ring structure.

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2. Reagents and Chemicals

The following reagents and chemicals are appropriate for use in these procedures. In all cases, equivalent materials from other suppliers may also be used.

2.1 Potassium Hydroxide, Anhydrous, Granular Sodium Sulfate and Sulfuric Acid (all Reagent Grade): J. T. Baker Chemical Co. or Fisher Scientific Co. The granular sodium sulfate is purified prior to use by placing a beaker containing the sodium sulfate in a 400°C oven for four hours, then removing the beaker and allowing it to cool in a desiccator. Store the purified sodium sulfate in a bottle equipped with a Teflon-lined screw cap.

2.2 Hexane, Methylene Chloride, Benzene, Methanol, Toluene, Isooctane: "Distilled in Glass" Burdick and Jackson.

2.3 Tridecane (Reagent Grade): Sigma Chemical Co.

2.4 Basic Alumina (Activity Grade 1, 100 - 200 mesh): ICN Pharmaceuticals. Immediately prior to use, the alumina is activated by heating for at least 16 hours at 600°C in a muffle furnace and then allowed to cool in a desiccator for at least 30 minutes prior to use. Store pre-conditioned alumina in a desiccator.

2.5 Silica (Bio-Sil A.100/200 mesh): Bio-Rad. The following procedure is recommended for conditioning the Bio-Sil A prior to use. Place an appropriate quantity of Bio-Sil A in a 30 mm x 300 mm long glass tube (the silica gel is held in place by glass wool plugs) which is placed in a tube furnace. The glass tube is connected to a pre-purified nitrogen cylinder, through a series of four traps (stainless steel tubes, 1.0 cm O.D. x 10 cm long)[6]: 1) Trap No. 1 - Mixture comprised of Chromosorb W/AW (60/80 mesh coated with 5% Apiezon L), Graphite (UCP-1-100), Activated Carbon (50 to 200 mesh) in a 7:1.5:1.5 ratio (Chromosorb W/AW, Apiezon L obtained from Supelco, Inc., Graphite obtained from Ultracarbon Corporation, 100 mesh, 1-M-USP; Activated Carbon obtained from Fisher Scientific Co.); 2) Trap No. 2 - Molecular Sieve 13 X (60/80 mesh), Supelco, Inc.; 3) Trap No. 3 - Carbosieve S (80/100 mesh), obtained from Supelco, Inc.; 4) The Bio-Sil A is heated in the tube for 30 minutes at 180°C while purging with nitrogen (flow rate 50-100 mL/minute), and the tube is then removed from the furnace and allowed to cool to room temperature. Methanol (175 mL) is then passed through the tube, followed by 175 mL methylene chloride. The tube containing the silica is then returned to the furnace, the nitrogen purge is again established (50-100 mL flow) and the tube is heated at 50°C for 10 minutes, then the temperature is gradually increased to 180°C over 25 minutes and maintained at 180°C for 90 minutes. Heating is then discontinued but the nitrogen purge is continued until the tube

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cools to room temperature. Finally, the silica is transferred to a clean, dry, glass bottle and capped with a Teflon-lined screw cap for storage.

2.6 Silica Gel Impregnated With Sulfuric Acid: Concentrated sulfuric acid (44 g) is combined with 100 g Bio-Sil A (conditioned as described above) in a screw capped bottle and agitated to mix thoroughly. Aggregates are dispersed with a stirring rod until a uniform mixture is obtained. The H_2SO_4-silica gel is stored in a screw-capped bottle (Teflon-lined cap).

2.7 Silica Gel Impregnated with Sodium Hydroxide: 1N Sodium hydroxide (39 g) is combined with 100 g Bio-Sil A (conditioned as described above) in a screw capped bottle and agitated to mix throughly. Aggregates are dispersed with a stirring rod until a uniform mixture is obtained. The NaOH-silica gel is stored in a screw-capped bottle (Teflon-lined cap).

2.8 Carbon/Celite:
Carbon: AX-21 Carbon, Anderson Development Co., Adrian, Mich. 49221
Celite 545: Fisher Scientific Co

Combine AX-21 Carbon (10.7 g) with Celite 545 (124 g) in a 250 mL glass bottle fitted with a Teflon-lined cap. Agitate the mixture to combine thoroughly. Store in the screw-capped bottle.

2.9 Sepralyte Diol (40μ): Analytichem International

2.10 Nitrogen and Hydrogen (Ultra High Purity): Matheson Scientific

3. Apparatus and Materials

The following apparatus and materials are appropriate for use in these procedures. In all cases, equivalent items from other suppliers may also be used.

3.1 Glassware used in the analytical procedures (including the Soxhlet apparatus and disposable bottles) is cleaned by rinsing successively three times with methanol and then three times with methylene chloride, and finally drying it in a 100°C oven. Bottles cleaned in this manner are allowed to cool to room temperature and are then capped using Teflon-lined lids. Teflon cap liners are rinsed as just described but are allowed to air-dry. More rigorous cleaning of some glassware with detergent may be required prior to the solvent rinses, for example, the glassware employed for Soxhlet extraction of samples.

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3.1.1 Sample Vessels: 125 mL and 250 mL flint glass bottles fitted with screw caps and teflon cap liners, and glass test tubes, VWR-Scientific.

3.1.2 Teflon Cap Liners: Scientific Specialities Service, Inc.

3.1.3 Soxhlet Apparatus: Extraction apparatus, Allihn condenser, Kimax Brand, American Scientific Products Cat. No. E6252-2A.

3.1.4 Gravity Flow Liquid Chromatographic Columns: Custom Fabricated (Details of the columns are provided in later sections).

3.1.5 Micro-vials (3.0 mL): Reliance Glass.

3.2 Capillary Gas Chromatographic Columns: Two different columns are required if data on both 2,3,7,8-TCDD and 2,3,7,8-TCDF, as well as on the total PCDD/PCDF by chlorinated class, are desired. The appropriate columns are: 1) A fused silica column (60 M x 0.25 mm I.D.) coated with DB-5 (0.25 μ film thickness), J & W Scientific, Inc., Rancho Cordova, Calif., is utilized to separate each of the several tetra-through octachlorinated CDDs and CDFs, as a group, from all of the other groups. While this column does not resolve all of the isomers within each chlorinated group, it effectively resolves each of the chlorinated groups from all of the other chlorinated groups and therefore provides data on the total concentration of each group (that is, total tetra-, penta-, hexa-, hepta- and octa CDDs and CDFs). This column also resolves 2,3,7,8-TCDD from all of the other 21 TCDD isomers and this isomer can therefore be determined quantitatively if proper calibration procedures are applied as described further in a later section. This column does not completely resolve 2,3,7,8-TCDF from the other TCDF isomers, and if a peak corresponding in retention time to 2,3,7,8-TCDF is observed in the analysis using this column, then a portion of the sample extract must be reanalyzed using the second GC column described below if isomer - specific data on 2,3,7,8-TCDF is desired. 2) A fused silica column (30 M x 0.25 mm I.D.) coated with DB-225 (0.25 μ film thickness), J & W Scientific, Inc., Rancho Cordova, Calif., must be utilized to obtain quantitative data on the concentration of 2,3,7,8-TCDF, since this column adequately resolves 2,3,7,8-TCDF from the other TCDF isomers.

3.3 Balance: Analytical Balance, readibility, 0.0001 g.

3.4 Nitrogen Blowdown Concentration Apparatus: N-Evap Analytical Evaporator Model III, Organomation Associates Inc.

3.5 Tube Furnace: Lindberg Type 59344.

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4. Instrumentation

Gas Chromatograph-Mass Spectrometer-Data System (GC/MS/DS): The instrument system used to analyze sample extracts for PCDD/PCDF comprises a gas chromatograph (fitted for capillary columns) coupled directly or through an enrichment device to a mass spectrometer which is equipped with a computer-based data system. The individual components of the GC/MS/DS are described below.

4.1 Gas Chromatograph (GC): The chromatograph must be equipped with an appropriate injector and pneumatic system to permit use of the specified glass or fused silica capillary columns. It must also incorporate an oven which can be heated in a reproducible, programmed temperature cycle. The injector should be configured for splitless/split injections. The GC column performance should be verified at the beginning of each 8 hour work period or at the beginning of each series of analyses if more than one set of samples is analyzed during an 8 hour shift. Extracts of complex combustion products and effluents may contain numerous organic residues even after application of the extensive prefractionation/cleanup procedures specified in this method. These residues may result in serious deviation of GC column performance and therefore, frequent performance checks are desirable. Using appropriate calibration mixtures, as described below, the retention time windows for each chlorinated class of CDDs/CDFs must be verified. In addition, the GC column utilized must be demonstrated to effectively separate 2,3,7,8-TCDD from all other TCDD isomers if data on 2,3,7,8-TCDD alone is desired with at least 20% valley definition between the 2,3,7,8- isomer and the other adjacent-eluting TCDD isomers. Typically, capillary column peak widths (at half-maximum peak height) on the order of 5-10 seconds are obtained in the course of these analyses. An appropriate GC temperature program for the analyses described herein is discussed in a later section (see Table 1).

4.2 Gas Chromatograph-Mass Spectrometer Interface: The GC-MS interface can include enrichment devices, such as a glass jet separator or a silicone membrane separator, or the gas chromatograph can be directly coupled to the mass spectrometer source, if the system has adequate pumping of the source region. The interface may include a diverter valve for shunting the column effluent and isolating the mass spectrometer source. All components of the interface should be glass or glass-lined stainless steel. The interface components must be compatible with temperatures in the neighborhood of 250°C, which is the temperature at which the interface is typically maintained throughout analyses for PCDD/PCDF. The GC/MS interface must be appropriately configured so that the separation of 2,3,7,8-TCDD from the other TCDD isomers which is achieved in the gas chromatographic column is not appreciably degraded. Cold spots and/or active surfaces (adsorption sites) in the GC/MS interface can cause peak tailing and peak broadening. If the latter are observed, thorough cleaning of the injection port, interface and connecting lines should be accomplished prior to proceeding.

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4.3 Mass Spectrometer (MS): The mass spectrometer used for the analyses described here is typically a double-focusing sector or quadrupole instrument equipped with an electron impact source (70 ev), maintained at 250°C, and a standard electron multiplier detector. If possible, it is desirable to have both low and high resolution capability with the mass spectrometer used, since confirmation of data obtained by low resolution MS using high resolution MS is sometimes desirable. Alternatively, a combination of mass spectrometers can be used for this purpose. The static resolution of the instrument must be maintained at a minimum of 1:500 (with a 10% valley between adjacent masses) if operating in the low resolution MS mode, and a minimum resolution of 1:10,000 is desirable for operation in the high resolution mode. The mass spectrometer must also be configured for rapid computer-controlled selected-ion monitoring in both high and low resolution operating modes. At a minimum, two ion-masses characteristic of each class of chlorinated dioxins should be monitored, and these are two ions in the molecular ion isotopic cluster. It is desirable for increased confidence in the data to also monitor the fragment ions arising from the loss of COCl from the molecular ion. In order to accomplish the requisite rapid multiple ion monitoring sequence during the time period defined by a typically capillary chromatographic peak (the base of the chromatographic peak is typically 15-20 seconds in width), the following MS performance parameters are typically required (assuming a 4-ion monitoring sequence for each class of PCDD/PCDF): dwell time/ion-mass, ≈100 msec.; minimum number of data points/chromatographic peak, 7 . The mass scale of the mass spectrometer is calibrated using high boiling perfluorokerosene and/or some other suitable mass standard depending upon the requirements of the GC-MS-DS system utilized. The actual procedures utilized for calibration of the mass scale will be unique to the particular mass spectrometer being employed. A list of the appropriate ions to be monitored in the PCDD/PCDF analyses described herein is presented in a later section (see Table 1).

4.4 Data System: A dedicated computer-based data system, capable of providing the data described above, is employed to control the rapid selected-ion monitoring sequence and to acquire the data. Both digital data (peak areas or peak heights) as well as peak profiles (displays of intensities of ion-masses monitored as a function of time) should be acquired during the analyses, and displayed by the data system. This raw data (mass chromatograms) should be provided in the report of the data.

5. Calibration Standards

A recommended set of calibration standards to be used in the analyses described herein is presented below. Stock standard solutions of the various PCDD and PCDF isomers and mixtures thereof are prepared in a glovebox, using weighed quantities of the authentic isomers.[b] These stock solutions are contained in appropriate volumetric flasks and are stored tightly stoppered, in a refrigerator. Aliquots of the stock standards are removed for direct use or for subsequent serial dilutions to prepare working standards. These standards must be checked regularly (by comparing instrument response factors for them over a period of

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time) to ensure that solvent evaporation or other losses have not occurred which would alter the standard concentration. The several recommended standard solutions are as follows.

5.1 Standard Mixture A: Prepare a stock solution containing the following isotopically-labelled PCDD and PCDF in isooctane at the indicated concentrations: 2.5ng./μl $^{13}C_{12}$-2,3,7,8-TCDD, 2.5ng/μl $^{37}Cl_4$-2,3,7,8-TCDF, 25ng/μL $^{13}C_{12}$-1,2,3,4,7,8-HxCDD, 25ng/μL $^{13}C_{12}$-1,2,3,4,7,8-HxCDF, 25ng/μL $^{13}C_{12}$-OCDD, and 25ng/μL $^{13}C_{12}$-OCDF. Portions of this isomer mixture are added to all samples prior to analyses and serve as internal standards for use in quantitation. Recovery of these standards is also used to guage the overall efficacy of the analytical procedures.

5.2 Standard B: Prepare a stock solution containing 1.0 ng of $^{37}Cl_4$-2,3,7,8-TCDD/μL of isooctane. This standard can be coinjected if desired, along with aliquots of the final sample extract to reliably estimate the recovery of the $^{13}C_{12}$-2,3,7,8-TCDD surrogate standard.

5.3 Standard Mixture C: Prepare a stock solution containing 100 ng/μL of isooctane of each of the following PCDD and PCDF: 2,3,7,8-TCDF; 2,3,7,8-TCDD; 1,3,4,6,8-PeCDF, 2,3,4,6,7-PeCDF; 1,2,4,7,9-PeCDD; 1,2,3,8,9-PeCDD; 1,2,3,4,6,8-HxCDF; 2,3,4,6,7,8-HxCDF; 1,2,3,4,6,8-HxCDD, 1,2,3,4,6,7-HxCDD; 1,2,3,4,6,7,8-HpCDF; 1,2,3,4,7,8,9-HpCDF; 1,2,3,4,6,7,8-HpCDD; 1,2,3,4,6,7,9-HpCDD; OCDF: and OCDD. This isomer mixture is used to define the gas chromatographic retention time intervals or windows for each of the penta-, hexa-, hepta-, and octachlorinated groups of PCDD and PCDF. Each pair of isomers of a given chlorinated class which is listed here corresponds to the first and last eluting isomers of that class on the DB-5 capillary GC column (except for TCDD and TCDF). In addition, this isomer mixture is used to determine GC-MS response factors for representative isomers of each of the penta-, hexa-, hepta-, and octachlorinated groups of PCDD and PCDF. The later data are used in quantitating the analytes in unknown samples.

5.4 Standard Mixture D: Prepare a stock solution containing 50 pg/μL of isooctane of each of the following TCDD isomers: 1,3,6,8-TCDD; 1,2,3,7-TCDD; 1,2,3,9-TCDD; 2,3,7,8-TCDD; and 1,2,8,9-TCDD. Two of the isomers in this mixture are used to define the gas chromatographic retention time window for TCDDs (1,3,6,8-TCDD is the first eluting TCDD

b. Some of the PCDD/PCDF isomer standards recommended for this method are available from Cambridge Isotope Laboratories, Cambridge, Massachusetts. Other PCDD/PCDF standards are available from the Brehm Laboratory, Wright State University, Dayton, Ohio, from the U.S. EPA Standard Repository at Research Triangle Park, North Carolina and possibly from other laboratories Not all of the indicated isotopically-labelled PCDD/PCDF internal standards recommended here are presently available in quantities sufficient for widespread distribution, but these are expected to be available in the near future.

isomer and 1,2,8,9-TCDD is the last eluting TCDD isomer on the DB-5 GC column). The remaining isomers serve to demonstrate that the 2,3,7,8-TCDD isomer is resolved from the other nearest eluting TCDD isomers, and that the column therefore yields quantitative data for the 2,3,7,8-TCDD isomer alone.

5.5 Standard Mixture E: Prepare a stock solution containing 50 pg/µl of isooctane of each of the following TCDF isomers: 1,3,6,8-TCDF; 2,3,4,8-TCDF; 2,3,7,8-TCDF, 2,3,4,7-TCDF; and 1,2,8,9-TCDF. This isomer mixture is used to define the TCDF gas chromatographic retention time window (1,3,6,8- and 1,2,8,9-TCDF are the first and last eluting TCDFs on the DB-5 capillary column) and to demonstrate that 2,3,7,8-TCDF is uniquely resolved from the adjacent-eluting TCDF isomers.

6. Procedures for Addition of Internal Standards and Extraction of Samples

Both liquid and solid samples will be obtained for PCDD/PCDF analyses as a result of the application of an appropriate stack sampling procedure. Samples resulting from the sampling train will include the following (these will be provided to the analytical laboratory as separate samples in the form indicated): 1) particulate filter and particulates thereon; 2) particulates from the cyclone (if used); 3) combined aqueous solutions from the impingers; 4) the intact XAD-resin cartridge and the resin therein; 5) combined aqueous rinse (if used) solutions from rinses of the nozzle, probe, filter holder, cyclone (if used), impingers, and all connecting lines; 6) combined acetone rinse solutions from rinses of the nozzle, probe, filter holder, cyclone (if used), impingers, and all connecting lines; 7) combined hexane rinse solutions from rinses of the nozzle, probe, filter, cyclone (if used), impingers, and all connecting lines. In addition, samples of bottom ash, precipitator ash, incinerator feed materials or fuel, quench liquids, and materials from effluent control devices may also be provided for analyses.

In general, the volumes of all liquid samples received for analyses are measured and recorded, and where appropriate, solid samples or aliquots thereof are weighed. Any samples which are homogeneous (as for example, a single liquid phase sample or a solid which can be thoroughly mixed) can be split prior to analyses, if desired, provided that this will still permit the attainment of the desired detection limits for the analytes of interest. Samples such as particulates from the sampling train which are generally collected in relatively small quantity, are preferably analyzed in total.

6.1 Organic Liquid Samples (Acetone and Hexane Solutions). Combine the acetone and hexane rinse solution and concentrate to a volume of about 1-5 ml using the nitrogen blowdown apparatus (a stream of dry nitrogen)

while heating the sample gently on a water bath. Rinse the vessels which contained the original solutions three times with small portions of hexane and add these to the concentrated solutions and concentrate further to near dryness. This residue will likely contain particulates which were removed in the rinses of the train probe and nozzle. Combine the residue (along with three rinses of the final sample vessel) in the Soxhlet apparatus with the filter and particulates, and proceed as described under Solid Sample below.

6.2 Aqueous Liquids
Add an appropriate quantity of the isotopically-labeled internal standard mixture (Standard Mixture A described earlier) to the aqueous liquid sample (or an aliquot thereof) in a screw-capped bottle fitted with a Teflon-lined cap. Add approximately 25% by volume of hexane to the spiked aqueous sample, seal the bottle and agitate on a shaker for a period of three hours. Allow the vessel to stand until the aqueous and organic layers separate, then transfer the organic layer to a separate sample bottle. Repeat the hexane extraction sequence two additional times and combine the organic fractions with that from the first extraction. Proceed with the sample fractionation and cleanup procedures described below.

6.3 Solid Samples
Place a glass extraction thimble and 1 g of silica gel and a plug of glass wool into the Soxhlet apparatus, charge the apparatus with toluene and reflux for a period of one hour. Remove the toluene and discard it, retaining the silica gel, or if desired, retain a portion of the toluene to check for background contamination. For extraction of particulates, place the entire sample in the thimble onto the bed of precleaned silica gel (1 cm. thick), and top with the precleaned glass wool retained from the initial Soxhlet cleaning procedure. Add the appropriate quantity of the isotopically-labelled internal standard mixture (Standard Mixture A described earlier) to the sample in the Soxhlet thimble. Charge the Soxhlet with toluene and reflux for a period of 16 hours. After extraction, allow the Soxhlet to cool, remove the toluene extract, and transfer it to another sample vessel. Concentrate the extract to a volume of approximately 40 ml by using the nitrogen blowdown apparatus described earlier. Proceed with the sample fractionation and cleanup procedures described below.

7. Procedures for Cleanup and Fractionation of Sample Extracts

The following column chromatographic sample clean-up procedures are used in the order given, although not all may be required. In general, the silica and alumina column procedures are considered to be a minimum requirement. Acceptable alternative cleanup procedures may be used provided that they are demonstrated to effectively transmit a

8.3.2 Static Resolution: 1:600 (10% valley) or 1:10,000 depending upon requirements. Usually the sample extracts are initially analyzed using low resolution MS, then if PCDD/PCDF are detected, it is desirable to analyze a second portion of the sample extract using high resolution MS.

8.3.3 Source Temperature: 250°C

8.3.4 Ions Monitored: Computer-Controlled Selected-Ion Monitoring. See Table 1 for list of ion masses monitored and time intervals during which ions characteristic of each class of CDDs and CDFs are monitored.

8.4 Calibration Procedures:

8.4.1 Calibrating the MS Mass Scale: Perfluoro Kerosene, decafluorotriphenyl phosphine, or any other accepted mass marker compound must be introduced into the MS, in order to calibrate the mass scale through at least m/z 500. The procedures specified by the manufacturer for the particular MS instrument used are to be employed for this purpose. The mass calibration should be rechecked at least at 8 hr. operating intervals.

8.4.2 Table 1 shows the GC temperature program typically used to resolve each chlorinated class of PCDD and PCDF from the other chlorinated classes, and indicates the corresponding time intervals during which ions indicative of each chlorinated class are monitored by the MS. This temperature program and ion monitoring time cycle must be established by each analyst for the particular instrumentation used by injecting aliquots of Standard Mixtures C, D, and E (See earlier section of this protocol for description of these mixtures). It may be necessary to adjust the temperature program and ion monitoring cycles slightly based on the observations from analysis of these mixtures.

8.4.3 Checking GC Column Resolution for 2,3,7,8-TCDD and 2,3,7,8-TCDF: Utilize the column-resolution TCDD and TCDF isomer mixtures (Standard Mixtures D and E, containing 50 pg/µl, respectively of the appropriate TCDD and TCDF isomers) to verify that 2,3,7,8-TCDD and 2,3,7,8-TCDF are separated from the other TCDD and TCDF isomers, respectively. A 20% valley or less must be obtained between the mass chromatographic peak observed for 2,3,7,8-TCDD and adjacent peaks arising from other TCDD isomers, and similar separation of 2,3,7,8-TCDF from other neighboring TCDFs, is required. Standard Mixture D is utilized with the DB5 column and Standard Mixture E with the DB-225 column. Analyze the column performance standards using the instrumental parameters specified in Sections 8.2 and 8.3, and in Table 1. The column performance evaluation must be performed each time a new column is installed in the gas chromatograph, and at least once during each 8 hour operating period. Providing that the same column is employed for a

period of time, its performance can also be gauged by noting the peak width (at 1/2 peak height) for 2,3,7,8-TCDD or for 2,3,7,8-TCDF. If this peak width is observed to broaden by 20% or more as compared to the usual width for satisfactory operation, then the column resolution is suspect and must be checked. If the column resolution is found to be insufficient to resolve 2,3,7,8-TCDD and 2,3,7,8-TCDF from their neighboring TCDD and TCDF isomers, respectively, (as measured on the two different columns used for resolving these two isomers), then a new DB-5 and/or DB-225 GC column must be installed.

8.4.4 Calibration of the GC-MS-DS system to accomplish quantitative analysis of 2,3,7,8-TCDD and 2,3,7,8-TCDF, and of the total tetra- through octa-CDDs and CDFs contained in the sample extract, is accomplished by analyzing a series of at least three working calibration standards. Each of these standards is prepared to contain the same concentration of each of the stable-isotopically labelled internal standards used here (Standard Mixture A) but a different concentration of native PCDD/PCDF (Standard Mixture C). Typically, mixtures will be prepared so that the ratio of native PCDD and PCDF to isotopically-labelled PCDD and PCDF will be on the order of 0.1, 0.5 and 1.0 in the three working calibration mixtures. The actual concentrations of both native and isotopically-labelled PCDD and PCDF in the working calibration standards will be selected by the analyst on the basis of the concentrations to be measured in the actual sample extracts. At the time when aliquots of each of the standards are injected (and also when injecting aliquots of actual sample extracts), if desired, an aliquot of a standard containing typically 1 ng of $^{37}Cl_4$-2,3,7,8-TCDD (Standard B) can be drawn into the micro syringe containing the calibration solution described above (or the sample extract) and this is then co-injected along with the sample extract in order to obtain data permitting calculation of the percent recovery of the $^{13}C_{12}$-2,3,7,8-TCDD internal standard. Equations for calculating relative response factors from the calibration data derived from the calibration standard analyses, and for calculating the recovery of the $^{13}C_{12}$-2,3,7,8-TCDD and the other isotopically-labelled PCDD and PCDF, and the concentration of native PCDD and PCDF in the sample (from the extract analysis), are summarized below. In these calculations, as can be seen, 2,3,7,8-TCDD is employed as the illustrative model. However, the calculations for each of the other native dioxins and furans in the sample analyzed are accomplished in an analgous manner. It should be noted that in view of the fact that stable-isotopically labelled internal standards corresponding to each tetra- through octachlorinated class are not used here (owing to limited availability at this time) the following approach is adopted: For quantitation of tetrachlorinated dibenzofurans $^{13}C_{12}$-2,3,7,8-TCDF is used as the internal standard. For quantitation of tetrachlorodibenzo-p-dioxins, $^{13}C_{12}$-2,3,7,8-TCDD is used as the internal standard. For quantitation of PeCDD, HxCDD, PeCDF, and HxCDF, the corresponding stable-isotopically labelled HxCDD and HxCDF internal standards are used. For quantitation of HpCDD, OCDD, and HpCDF, OCDF, the isotopically-labelled OCDD and OCDF, respectively, are used. Inherent in this approach is the assumption that the response factors for each of the isomers

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representative set of the analytes of interest. The column chromatographic procedures listed here have been demonstrated to be effective for a mixture consisting of 1,2,3,4-TCDD, 2,3,7,8-TCDD, 2,3,6,8-TCDF, 1,2,4,8-TCDF, 2,3,7,8-TCDF, 1,2,3,7,8-PeCDD, 1,2,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDD, 1,2,4,6,7,9-HxCDF, 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,8,9-HpCDF, OCDD and OCDF

An extract obtained as described in the foregoing sections is concentrated to a volume of about 1 mL using the nitrogen blowdown apparatus, and this is transferred quantitatively (with rinsings) to the combination silica gel column described below.

7.1 Combination Silica Gel Column: Pack one end of a glass column (20 mm. O.D. x 230 mm in length) with glass wool (precleaned) and add, in sequence, 1 g silica gel, 2 g base-modified silica gel, 1 g silica gel, 4 g acid-modified silica gel, and 1 g silica gel. (Silica gel and modified silica gel are prepared as described in the Reagents sections of this protocol.) Preelute the column with 30 mL hexane and discard the eluate. Add the sample extract in 5 mL of hexane to the column along with two additional 5 ml rinses. Elute the column with an additional 90 mL of hexane and retain the entire eluate. Concentrate this solution to a volume of about 1 ml.

7.2 Basic Alumina Column: Cut off a 10 mL disposable Pasteur glass pipette at the 4 mL graduation mark and pack the lower section with glass wool (precleaned) and 3 g of Woelm basic alumina (prepared as described in the Reagent section of this protocol). Transfer the concentrated extract from the combination silica column to the top of the column and elute the column sequentially with 15 mL of hexane, 10 mL of 8% methylene chloride-in-hexane and 15 mL of 50% methylene chloride-in-hexane, discarding the first two eluate fractions and retaining the third eluate fraction. Concentrate the latter fraction to about 0.5 mL using the nitrogen blowdown apparatus described earlier.

7.3 PX-21 Carbon/Celite 545 Column: Take a 9 inch disposable Pasteur pipette and cut off a 0.5 inch section from the constricted tip. Insert a filter paper disk at the top of the tube, 2.5 cm. from the constriction. Add a sufficient quantity of PX-21 Carbon/Celite 545 (Prepared as described in the reagent section of this protocol) to the tube to form a 2 cm. length of the Carbon-Celite. Insert a glass wool plug. Preelute the column in sequence with 2 mL of 50% benzene-in-ethyl acetate, 1 mL of 50% methylene chloride-in-cyclohexane and 2 mL of hexane, and discard these eluates. Load the extract (in 1 mL of hexane) from the alumina column onto the top of the column, along with 1 mL hexane rinse. Elute the column with 2 mL of 50% methylene chloride-in-hexane and 2 mL of 50% benzene-in-ethyl acetate and discard these eluates. Invert the column and reverse elute it with 4 mL of toluene, retaining this eluate. Concentrate the eluate and transfer it to a Reacti-Vial for storage. Store extracts in a freezer, shielded from light, prior

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to GC-MS analysis. If desired, still another column chromatographic clean-up step can be employed prior to concentration of the extract, as described below.

7.4 Silica/Diol Micro Column Cleanup: After the above clean-up steps small amounts of highly colored polar compounds may be present in complex samples. These are removed, if necessary, by the following column: Push a small plug of glass wool into a disposable 6 mm i.d. glass Pasteur pipette, followed by 3 mm of Sepralyte (Analytichem International), 6 mm of silica gel and finally 3 mm of sodium sulfate. The column is pre-wet with hexane, the sample is applied in 100 µL of 100% hexane and eluted with hexane, collecting 1.5 ml.

8. Procedure for Analysis of Sample Extracts for PCDD/PCDF Using Gas Chromatography-Mass Spectrometry (GC-MS).

8.1 Sample extracts prepared by the procedures described in the foregoing are analyzed by GC-MS utilizing the following instrumental parameters. Typically, 1 to 5 µL portions of the extract are injected into the GC. Sample extracts are first analyzed using the DB-5 capillary GC column to obtain data on the concentrations of total tetra-through octa-CDDs and CDFs, and on 2,3,7,8-TCDD. If tetra-CDFs are detected in this analysis, then another aliquot of the sample is analyzed in a separate run, using the DB-225 column to obtain data on the concentration of 2,3,7,8-TCDF.

8.2 Gas Chromatograph

8.2.1 Injector: Configured for capillary column, splitless/split injection (split flow on 60 seconds following injection), injector temperature, 250°C.

8.2.2 Carrier gas: Hydrogen, 30 lb head pressure.

8.2.3 Capillary Column 1: For total tetra- through octa - CDDs/CDFs and 2,3,7,8-TCDD, 60 M x 0.25 mm I.D. fused silica DB-5; temperature programmed (see Table 1 for temperature program). Capillary Column 2: for 2,3,7,8-TCDF only, 60 M x 0.25 mm I.D. fused silica DB-225, temperature programmed (180°C for 1 min., then increase from 180°C to 240°C @ 5°C/min., hold at 240°C for 1 min.)

8.2.4 Interface Temperature: 250°C

8.3 Mass Spectrometer

8.3.1 Ionization Mode: Electron impact (70 eV)

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of each chlorinated class are the same, and in the case of the penta- and hepta-CDDs and CDFs, the assumption is made that the responses for these two classes are equivalent to those for the tetra-isomers and the octa-isomers, respectively.

8.4.5 Equations for Calculating Response Factors, Concentration of 2,3,7,8-TCDD In An Unknown Sample, and Recoveries of Internal Standards.

Equation 1: Response Factor (RRF) for native 2,3,7,8-TCDD using $^{13}C_{12}$-2,3,7,8-TCDD as an internal standard.

$$RRF_d = (A_s C_{is} / A_{is} C_s)$$

where: A_s = SIM response for 2,3,7,8-TCDD ion at m/z 320 + 322

A_{is} = SIM response for $^{13}C_{12}$-2,3,7,8-TCDD internal standard ion at m/z 332

C_{is} = Concentration of the internal standard (pg./µL.)

C_s = Concentration of the 2,3,7,8-TCDD (pg./µL.)

Equation 2: Response Factor (RRF) for $^{37}Cl_4$-2,3,7,8-TCDD, the co-injected external standard

$$RRF_f = (A_{is} C_{es}) / (A_{es} C_{is})$$

where: A_{is} = SIM response for $^{13}C_{12}$-2,3,7,8-TCDD internal standard ion at m/z 332

A_{es} = SIM response for co-injected $^{37}Cl_4$-2,3,7,8-TCDD external standard at m/z 328 - 0.009 (SIM response for native 2,3,7,8-TCDD at m/z 322)

C_{is} = Concentration of the internal standard (pg./µL.)

C_{es} = Concentration of the external standard (pg./µL.)

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Equation 3: Calculation of concentration of native 2,3,7,8-TCDD using $^{13}C_{12}$-2,3,7,8-TCDD as internal standard

$$\text{Concentration, pg./g.} = (A_s)(I_s) / (A_{is})(RRF_d)(W)$$

where: A_s = SIM response for 2,3,7,8-TCDD ion at m/z 320 + 322

A_{is} = SIM response for the $^{13}C_{12}$-2,3,7,8-TCDD internal standard ion at m/z 332

I_s = Amount of internal standard added to each sample (pg.)

W = Weight of soil or waste in grams

RRF_d = Relative response factor from Equation 1

Equation 4: Calculation of % recovery of $^{13}C_{12}$-2,3,7,8-TCDD internal standard

$$\% \text{ Recovery} = 100(A_{is})(E_s) / (A_{es})(I_i)(RRF_f)$$

A_{is} = SIM response for $^{13}C_{12}$-2,3,7,8-TCDD internal standard ion at m/z 332

A_{es} = SIM response for $^{37}Cl_4$-2,3,7,8-TCDD external standard ion at m/z 328 - 0.009 (SIM Response for native 2,3,7,8-TCDD at m/z 322)

E_s = Amount of $^{37}Cl_4$-2,3,7,8-TCDD external standard co-injected with sample extract (ng.)

I_i = Theoretical amount of $^{13}C_{12}$-2,3,7,8-TCDD internal standard in injection

RRF_f = Relative response factor from Equation 2

As noted above, procedures similar to these are applied to calculate analytical results for all of the other PCDD/PCDF determined in this method.

8.5 Criteria Which GC-MS Data Must Satisfy for Identification of PCDD/PCDF in Samples Analyzed and Additional Details of Calculation Procedures.

In order to identify specific PCDD/PCDF in samples analyzed, the GC-MS data obtained must satisfy the following criteria:

8.5.1 Mass spectral responses must be observed at both the molecular and fragment ion masses corresponding to the ions indicative of each chlorinated class of PCDD/PCDF identified (see Table 1) and intensities of these ions must maximize essentially simultaneously (within ± 1 second). In addition, the chromatographic retention times observed for each PCDD/PCDF signal must be correct relative to the appropriate

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stable-isotopically labelled internal standard and must be consistent with the retention time windows established for the chlorinated group to which the particular PCDD/PCDF is assigned.

8.5.2 The ratio of the intensity of the molecular ion $(M)^+$ signal to that of the $(M+2)^+$ signal must be within ± 10% of the theoretically expected ratio (for example, 0.77 in the case of TCDD; therefore the acceptable range for this ratio is 0.69 to 0.85).

8.5.3 The intensities of the ion signals are considered to be detectable if each exceeds the baseline noise by a factor of at least 3:1. The ion intensities are considered to be quantitatively measurable if each ion intensity exceeds the baseline noise by a factor of at least 5:1[c].

8.5.4 For reliable detection and quantitation of PCDF it is also desirable to monitor signals arising from chlorinated diphenyl ethers which, if present could give rise to fragment ions yielding ion masses identical to those monitored as indicators of the PCDF. Accordingly, in Table 1, appropriate chlorinated diphenyl ether masses are specified which must be monitored simultaneously with the PCDF ion-masses. Only when the response for the diphenyl ether ion mass is not detected at the same time as the PCDF ion mass can the signal obtained for an apparent PCDF be considered unique.

8.5.5 Measurement of the concentration of the congeners in a chlorinated class using the methods described herein is based on the assumption that all of the congeners are identical to the calibration standards employed in terms of their respective chemical and separation properties and in terms of their respective gas chromatographic and mass spectrometric responses. Using these assumptions, for example, the $^{13}C_{12}$-2,3,7,8-TCDD internal standard is utilized as the internal calibration standard for all of the 22 TCDD isomers or congeners. Furthermore, the concentration of the total TCDD present in a sample extract is determined by calculating, on the basis of the standard procedure outlined above, the concentration of each TCDD isomer peak (or peaks for multiple TCDD isomers, where these coelute) and these individual concentrations are subsequently summed to obtain the concentration of "total" TCDD.

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[c] In practice, the analyst can estimate the baseline noise by measuring the extension of the baseline immediately prior to each of the two mass chromatographic peaks attributed to a given PCDD or PCDF. Spurious signals may arise either from electronic noise or from other organic compounds in the extract. Since it may be desirable to evaluate the judgement of the analyst in this respect, copies of original mass chromatograms must be included in the report of analytical results.

8.6 Frequently, during the analysis of actual sample extracts, extraneous compounds which are present in the extract (those organic compounds not completely removed during the clean-up phase of the analysis) can cause changes in the liquid and gas chromatographic elution characteristics of the PCDD/PCDF (typically retention times for the PCDD/PCDF are prolonged). Such extraneous organic compounds, when introduced into the mass spectrometer source may also result in a decrease in the sensitivity of the MS because of suppression of ionization, and other affects such as charge transfer phenomena. The shifts in chromatographic retention times are usually general shifts, that is, the relative retention times for the PCDD/PCDF are not changed, although the entire elution time scale is prolonged. The analyst's intervention in the GC-MS operating sequence can correct for the lengthened GC retention times which are sometimes observed due to the presence of extraneous organics in the sample extract. For example, using the program outlined in Table 1, if the retention time observed for 2,3,7,8-TCDD (which normally is 19.5 minutes) is lengthened by 30 seconds or more, appropriate adjustments in the programming sequence outlined in Table 1 can be made, that is, each selected ion-monitoring program is delayed by a length of time proportionate to the lengthening of the retention time for the 2,3,7,8-TCDD isomer. In the case of ionization suppression, this phenomenon is inherently counteracted by the internal standard approach. However, if loss of sensitivity due to ionization suppression is severe, additional clean-up of the sample extract may be required in order to achieve the desired detection limits.

9. Quality Assurance/Quality Control

9.1 Quality assurance and quality control are ensured by the following provisions:

9.1.1 Each sample analyzed is spiked with stable isotopically labelled internal standards, prior to extraction and analysis. Recoveries obtained for each of these standards should typically be in the range from 60-90%. Since these compounds are used as true internal standards however, lower recoveries do not necessarily invalidate the analytical results for native PCDD/PCDF, but may result in higher detection limits than are desired.

9.1.2 Processing and analysis of at least one method blank sample is accomplished for each set of samples (a set being defined as 20 samples or less).

9.1.3 It is desirable to analyze at least one sample spiked with representative native PCDD/PCDF for each set of 20 or fewer samples. The result of this analysis provides an indication of the efficacy of the entire analytical procedure. The results of this analysis will be considered acceptable if the detected concentration of each of the native

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PCDD/PCDF added to the sample is within ±50% of the known concentration. (An appropriate set of native isomers to be added here is a set such as that indicated for Standard Mixture C.)

9.1.4 At least one of the samples analyzed out of each set (of 20 samples or less) is analyzed in duplicate and the results of the duplicate analysis are included in the report of data.

9.1.5 Performance evaluation samples prepared by EPA, or other laboratories, which contain representative PCDD/PCDF in concentrations approximating those present in typical field samples being analyzed (but unknown to the analyzing lab) should be periodically distributed to laboratories accomplishing these analyses.

9.1.6 Sources of all calibration and performance standards used in the analyses and the purity of these materials must be specified in the data report.

10. Data Reporting

10.1 Each report of analyses accomplished using the protocol described herein will typically include tables of results which include the following:

10.1.1 Complete identification of the samples analyzed (sample numbers and source).

10.1.2 The dates and times at which all analyses were accomplished. This information should also appear on each mass chromatogram included with the report.

10.1.3 Raw mass chromatographic data which consists of the absolute intensities (based on either peak height or peak area) of the signals observed for the ion-masses monitored (See Table 1).

10.1.4 The calculated ratios of the intensities of the molecular ions for all PCDD/PCDF detected.

10.1.5 The calculated concentrations of native 2,3,7,8-TCDD and 2,3,7,8-TCDF, and the total concentrations of the congeners of each class of PCDD/PCDF for each sample analyzed, expressed in nanograms TCDD per gram of sample (that is, parts-per-billion) as determined from the raw data. If no PCDD/PCDF are detected, the notation "Not Detected" or "N.D." is used, and the minimum detectable concentrations (or detection limits) are reported.

10.1.6 The same raw and calculated data which are provided for the actual samples will also be reported for the duplicate analyses, the method blank analyses, the spiked sample analyses and any other QA or performance samples analyzed in conjunction with the actual sample set(s).

10.1.7 The recoveries of the internal standards in percent.

10.1.8 The recoveries of the native PCDD/PCDF from spiked samples in percent.

10.1.9 The calibration data, including response factors calculated from the three point calibration procedure described elsewhere in this protocol. Data showing that these factors have been verified at least once during each 8 hour period of operation or with each separate set of samples analyzed must be included.

10.1.10 The weight or quantity of the original sample analyzed.

10.1.11 Documentation of the source of all PCDD/PCDF standards used and available specifications on purity.

10.1.12 In addition to the tables described above, each report of analyses will include all mass chromatograms obtained for all samples analyzed, as well as for all calibration, GC column performance, and GC "window" definition runs and results of column performance checks.

10.1.13 Any deviations from the procedures described in this protocal which are applied in the analyses of samples will be documented in detail in the analytical report.

11. Typical Data Indicative of Method Performance - Precision and Accuracy.

11.1 The method described herein has typically been employed to quantitatively determine 2,3,7,8-TCDD in combustion product samples at concentrations as low as 10 picograms/gram and as high at 100 μg/g. Concentrations of the other PCDD/PCDF which can be detected typically fall within the range of 20 picograms/isomer/gram of sample, to 100 picograms/g of sample. Of course, the limits of detection which can be practically achieved are dependent on the quantity of sample available

and the amount and kind of other interferring organic residues which are present in the sample. With respect to precision, the average deviation of data obtained from the analyses of a number of aliquots of the same sample containing the 2,3,7,8-TCDD isomer in the 250-300 ppb range is estimated to be ±10% or better. Data on the precision of quantitation of multiple PCDD/PCDF in a single sample are not as yet available. As yet, there is inadequate interlaboratory and performance evaluation data available to specify the accuracy which can be expected of the analytical procedures described herein.

TABLE 1. Sequence of Operations in GC-MS-DS Quantitation of CDDs/CDFs in Extracts of Environmental Samples

Elapsed Time (min)	Event	GC Column Temperature* (°C)	Temperature Program Rate (°C/min)	Ions Monitored by Mass Spectrometer (m/z)	Identity of Fragment Ion	Compounds Monitored	Approximate Theoretical Ratio of [M]+/[M+2]
0.00	Injection, splitless	190					
1.00	Turn on split valve	190					
1.00	Begin temp. program to 220°C	190	5				
6.00	Open column flow to mass spectrometer	215	5				
7.00	Column temperature hold	220					
14.00	Start Tetra Program; sweep = 350 ppm; time/mass = 0.08 sec.			240.938	$[M-COCl]^+$	TCDF	
				258.930	$[M-COCl]^+$	TCDD	
				303.902	$[M]^+$	TCDF	0.77
				305.899	$[M+2]^+$	TCDF	
				315.942	$[M]^+$	$^{13}C_{12}$-TCDF	
				319.897	$[M]^+$	TCDD	0.77
				321.894	$[M+2]^+$	TCDD	
				327.885	$[M]^+$	$^{13}Cl_4$-TCDD	
				331.937	$[M]^+$	$^{13}C_{12}$-TCDD	
				373.840	$[M]^+$	HxDPE[a]	
22.00	Stop Tetra Program	220					
22.50	Start Penta Program; sweep = 350 ppm; time/mass = 0.12 sec.			274.899	$[M-COCl]^+$	PeCDF	
				290.894	$[M-COCl]^+$	PeCDD	
				337.863	$[M]^+$	PeCDF	0.61
23.00	Begin temp. program to 235°	220	5	339.860	$[M+2]^+$	PeCDF	
26.00	Column temperature hold	235		353.858	$[M]^+$	PeCDD	0.61
				355.855	$[M+2]^+$	PeCDD	
				407.801	$[M]^+$	HpDPE[a]	
32.00	Stop Penta Program						
32.50	Start Hexa Program; sweep = 350 ppm; time/mass = 0.20 sec.	235		310.857	$[M-COCl]^+$	HxCDF	
				326.852	$[M-COCl]^+$	HxCDD	
				373.821	$[M]^+$	HxCDF	1.23
				375.821	$[M+2]^+$	HxCDF	
				385.861	$[M]^+$	$^{13}C_{12}$-HxCDF	
				389.816	$[M]^+$	HxCDD	1.23
				391.813	$[M+2]^+$	HxCDD	
				411.856	$[M]^+$	$^{13}C_{12}$-HxCDD	
				443.759	$[M]^+$	ODPE[a]	

TABLE 1. Sequence of Operations in GC-MS-DS Quantitation of PCDD/PCDF* in Extracts of Environmental Samples (Cont.)

Elapsed Time (min)	Event	GC Column Temperature (°C)	Temperature Program Rate (°C/min)	Ions Monitored by Mass Spectrometer (m/z)	Identity of Fragment Ion	Compounds Monitored	Approximate Theoretical Ratio of $[M]^+:[M+2]^+$
33.00	Begin temp. program to 250°C	235	5				
36.00	Column temperature hold	250					
42.50	Stop Hexa Program						
43.00	Start Hepta Program; sweep = 350 ppm; time/mass = 0.30 sec.	250		344.818	$[M-COCl]^+$	HpCDF	
				360.813	$[M-COCl]^+$	HpCDD	
				407.782	$[M]^+$	HpCDF	1.03
				409.779	$[M+2]^+$	HpCDF	1.03
				423.777	$[M]^+$	HpCDD	
				425.774	$[M+2]^+$	HpCDD	
				477.720	$[M^+]$	HDPE[a].	
53.00	Stop Hepta Program	250					
53.50	Start Octa Program; sweep = 350 ppm; time/mass = 0.30 sec.	250		378.768	$[M-COCl]^+$	OCDF	
				394.774	$[M-COCl]^+$	OCDD	
				441.732	$[M]^+$	OCDF	0.88
54.00	Begin temp. program to 270°	250°	5	443.740	$[M+2]^+$	OCDF	
58.00	Column temperature hold	270°		453.772	$[M]^+$	$^{13}C_{12}$-OCDF	
				457.738	$[M]^+$	OCDD	0.88
				459.735	$[M+2]^+$	OCDD	
				469.779	$[M]^+$	$^{13}C_{12}$-OCDD	
				471.776	$[M+2]^+$	$^{13}C_{12}$-OCDD	
				511.681	$[M]^+$	DDPE[a].	
65.00	Stop Octa Program						
65.00	Begin temp. program to 300°	270°	5				
71.00	Column temperature hold	300°					
75.00	Cool Column to 190°						

[a] HxDPE, HpDPE, DDPE, HDPE, DDPE are abbreviations which designate (respectively) hexachloro-, heptachloro-, octachloro-, nonachloro-, and decachlorodiphenyl ethers.

*The parameters given here are applicable for a 60-meter fused silica capillary GC column coated with DB-5.

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APPENDIX

RECOMMENDED SAFETY AND HANDLING PROCEDURES FOR LABORATORIES CONDUCTING PCDD/PCDF ANALYSES

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Recommended Safety and Handling Procedures in Connection with Implementing The Analytical Protocal for Determination of PCDD/PCDF in Combustion Products

1. The human toxicology of PCDD/PCDF is not well defined at present, lthough the 2,3,7,8-TCDD isomer has been found to be acnegenic, arcinogenic, and teratogenic in the course of laboratory animal .tudies. The 2,3,7,8-TCDD is a solid at room temperature, and has a elatively low vapor pressure. The solubility of this compound in ater is only about 200 parts-per-trillion, but the solubility in arious organic solvents ranges from about 0.001% to 0.14%. The physical roperties of the 135 other tetra-through octachlorinaed PCDD/PCDF have not een well established, although it is presumed that the physical roperties of these congeners are generally similar to those of the ,3,7,8-TCDD isomer. On the basis of the available toxicological nd physical property data for TCDD, this compound, as well as the other CDD and PCDF, should be handled only by highly trained personnel ho are thoroughly versed in the appropriate procedures, and who nderstand the associated risks.

2. PCDD/PCDF and samples containing these are handled using essentially the same techniques as those employed in handling radioactive or infectious materials. Well-ventilated, controlled-access laboratories are required, and laboratory personnel entering these laboratories should wear appropriate safety clothing, including disposable coveralls, shoe covers, gloves, and face and head masks. During analytical operations which may give rise to aerosols or dusts, personnel should wear respirators equipped with activated carbon filters. Eye protection equipment (preferably full face shields) must be worn at all times while working in the analytical laboratory with PCDD/PCDF. Various types of gloves can be used by personnel, depending upon the analytical operation being accomplished. Latex gloves are generally utilized, and when handling samples thought to be particularly hazardous, an additional set of gloves is also worn beneath the latex gloves (for example, Playtex gloves supplied by American Scientific Products, Cat. No. 67216). Bench-tops and other work surfaces in the laboratory should be covered with plastic-backed absorbent paper during all analytical processing. When finely divided samples (dusts, soils, dry chemicals) are being processed, removal of these from sample containers, as well as other operations, including weighing, transferring, and mixing with solvents, should all be accomplished within a glove box. Glove boxes, hoods and the effluents from mechanical vacuum pumps and gas chromatographs on the mass spectrometers should be vented to the atmosphere preferably only after passing through HEPA particulate filters and vapor-sorbing charcoal.

3. All laboratory ware, safety clothing and other items potentially contaminated with PCDD/PCDF in the course of analyses must be carefully secured and subjected to proper disposal. When feasible, liquid wastes

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are concentrated, and the residues are placed in approved steel hazardous waste drums fitted with heavy gauge polyethylene liners. Glass and combustible items are compacted using a dedicated trash compactor used only for hazardous waste materials and then placed in the same type of disposal drum. Disposal of accumulated wastes is periodically accomplished by high temperature incineration at EPA-approved facilities.

4. Surfaces of laboratory benches, apparatus and other appropriate areas should be periodically subjected to surface wipe tests using solvent-wetted filter paper which is then analyzed to check for PCDD/PCDF contamination in the laboratory. Typically, if the detectable level of TCDD or TCDF from such a test is greater than 50ng/m^2, this indicates the need for decontamination of the laboratory. A typical action limit in terms of surface contamination of the other PCDD/PCDF (summed) is 500ng/m^2. In the event of a spill within the laboratory, absorbent paper is used to wipe up the spilled material and this is then placed into a hazardous waste drum. The contaminated surface is subsequently cleaned thoroughly by washing with appropriate solvents (methylene chloride followed by methanol) and laboratory detergents. This is repeated until wipe tests indicate that the levels of surface contamination are below the limits cited.

5. In the unlikely event that analytical personnel experience skin contact with PCDD/PCDF or samples containing these, the contaminated skin area should immediately be thoroughly scrubbed using mild soap and water. Personnel involved in any such accident should subsequently be taken to the nearest medical facility, preferably a facility whose staff is knowledgable in the toxicology of chlorinated hydrocarbons. Again, disposal of contaminated clothing is accomplished by placing it in hazardous waste drums.

6. It is desirable that personnel working in laboratories where PCDD/PCDF are handled be given periodic physical examinations (at least yearly). Such examinations should include specialized tests, such as those for urinary porphyrins and for certain blood parameters which, based upon published clinical observations, are appropriate for persons who may be exposed to PCDD/PCDF. Periodic facial photographs to document the onset of dermatologic problems are also advisable.

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CASE NARRATIVE
70H MODEL

DATE: 25 MARCH 1988
CLIENT ID: ENTROPY ENVIRONMENTALISTS
TLI NO.: 12191 & 12192
OBJECTIVE: ANALYSIS OF MM5, ASH, LIME AND TOLUENE RINSE SAMPLES FOR THE PRESENCE OF MONO- THROUGH OCTACHLORO-DIBENZODIOXINS AND DIBENZOFURANS BY HIGH-RESOLUTION GAS CHROMATOGRAPHY/HIGH-RESOLUTION MASS SPECTROMETRY

Sample Management

The samples received on February 25 were divided into two groups of samples, each being assigned a different TLI project number (12191 and 12192). The MM5 samples were combined and processed under TLI Project 12191 while the ash and XAD modules samples were processed under TLI Project 12192. This data package reports the results from the analysis of five front-half MM5s, five back-half MM5s, one field blank MM5, one lab blank MM5, seven ashes, one lime, one toluene rinse and three XAD modules.

Sample Preparation

The samples were prepared by using the methods described in the ASME analytical protocol. The solid samples are extracted by using toluene in a Soxhlet extractor for 16 hours and the aqueous samples are extracted with hexane in a jar. The sample extracts are then subjected to a series of chromatographic (Biosil, alumina and carbon columns) cleanups as described in the ASME protocol.

All the samples (including the quality control and method blank samples) were fortified with 10 ng of the tetra- through heptachlorinated internal and surrogate standards and 20 ng of the octachlorinated dibenzodioxin internal standard. This was accomplished by using the sample fortification solution described in Table 1. Note that the XAD resin from the MM5 samples, which were pre-spiked with 10 ng of the surrogate compounds before the sampling session, were not fortified with the surrogate compounds before the extraction procedure.

The solution contains eight carbon-labeled PCDD/PCDF standards. The $^{13}C_{12}$-2,3,7,8-TCDD internal standard is used to quantify TCDDs and TCDFs, $^{13}C_{12}$-1,2,3,7,8-PeCDD is used to quantify PeCDDs and PeCDFs, $^{13}C_{12}$-1,2,3,6,7,8-HxCDD is used to quantify HxCDDs

and HxCDFs, $^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD is used to quantify HpCDDs and HpCDFs, and $^{13}C_{12}$-OCDD is used to quantify OCDD and OCDF.

The sample processing and fortification schemes used for the front-half and back-half MM5 components are shown in respectively Figures 1 and 2. Figure 3 summarizes the sample processing and fortification schemes for the combined MM5 samples (field and laboratory blanks).

Document Control

The Document Control package contains all laboratory records received or generated during the sample handling by Triangle Laboratories.

Data Package

On the enclosed sample data sheets, the concentrations are given in parts per billion (ppb) for the ashe samples and ng per sample for the MM5 samples. "**RT**" is the gas chromatographic retention time in minutes and seconds, "**number**" is the number of GC peaks identified as PCDD/PCDF isomers in the totals reported for each homologous series, and "**ratio**" is the integrated ion abundance ratio observed for the M to M+2 ions of the tetra- through pentachlorinated isomers and M+2 to M+4 for the hexa- through octachlorinated isomers. "**DL**" is the detection limit for samples presenting an analyte response that is less than 2.5 times the background level. "**EMPC**", representing the estimated maximum possible concentration, is reported for GC/MS signals eluting within the PCDD/PCDF retention time windows established with the daily GC performance analysis, and which are characterized by a signal-to-noise ratio in excess of 2.5:1 but do not meet all of the qualitative identification criteria listed below. The "EMPC" is calculated by using the same expression used for reporting the identified analyte concentrations. The "DL" and "EMPC" are both reported in the units described above.

For quantifications, the sum of the peak areas for the two ions monitored is used. When no peak is detected, an area of 10 counts for each ion (total 20 counts) is used to calculate the detection limit. The results of the ash samples are given on a wet weight basis.

High-Resolution Gas Chromatography / High-Resolution Mass Spectrometry

For GC/MS analysis, the final residue was dissolved in 20 uL of a toluene solution containing the recovery standards shown in Table 1. The recoveries of the carbon-labeled tetra- and penta-chlorinated dibenzodioxins internal standards were calculated by using $^{13}C_{12}$-1,2,3,4-TCDD as the recovery standard. The recoveries of higher homologues (hexa- through octachlorinated

congeners) were determined relative to $^{13}C_{12}$-1,2,3,7,8,9-HxCDD.

The concentrations of $^{37}Cl_4$-2,3,7,8-TCDD and $^{13}C_{12}$-2,3,7,8-TCDF in the final extract are calculated relative to $^{13}C_{12}$-2,3,7,8-TCDD. The concentration of the third surrogate standard (i.e., $^{13}C_{12}$-1,2,3,4,7,8-HxCDF) is measured against $^{13}C_{12}$-1,2,3,6,7,8-HxCDD.

The samples were analyzed by using a VG 7070H mass spectrometer operated in the selected ion recording mode, at a resolving power of 8,000. A VG 11/250 data system was used to acquire the data. A Varian 3700 GC , equipped with a fused-silica capillary column, was employed. One uL of the 20-uL final sample volume was analyzed by using the GC conditions summarized in Table 3.

Initial Calibration

The mass spectrometer response was calibrated with the help of the set of six initial calibration solutions shown in Table 2.

An acceptable calibration must meet the following criteria:

1) The percent relative standard deviations for the mean response factors from each of the unlabeled analytes (Table 2) and of the internal standards (Table 2) must be less than 20 percent.

2) The signal-to-noise ratio (S/N) for the GC signals present in every selected ion current profile must be $\geq$ 2.5.

3) The ion abundance ratios must be within the specified control limits (see identification criteria).

Continuing Calibration

A continuing calibration was demonstrated every 12 hours by injecting one uL of solution number 4 from Table 2. The response factors (RFs) used for the calculation of the analyte concentrations were obtained from the daily continuing calibration check (*vide infra*). For the total homologous PCDD/PCDF concentrations (e.g., total HxCDDs), the RFs were taken, when applicable, as the average of the RFs for the individual congeners listed in the continuing calibration reporting form. Note that when only one isomer is present, a discrepancy may appear between the reported concentration for the individual isomer and the total, as a result of using a different RF.

The continuing calibration delta RF (on the data sheets) corresponds to the relative percent difference between the daily RF and the initial calibration RF.

An acceptable continuing calibration run must meet the following criteria:

1) The measured RFs (for the unlabeled as well as labeled compounds) obtained during the continuing calibration run must be within 20 percent for tetra- through heptachlorinated compounds and 25 percent for octachlorinated compounds of the mean values established during the initial calibration.
2) The ion-abundance ratios must be within the allowed control limits listed below.

Confirmation Analyses

For confirmation of 2,3,7,8-TCDD and 2,3,7,8-TCDF, the samples were analyzed on a second high-resolution GC column (SP-2331/DB-17) also under high-resolution mass spectrometric conditions.

Identification Criteria

The positive identification criteria used for the characterization of polychlorinated dibenzodioxins and dibenzofurans are as follows:

1) The integrated ion abundance ratio (M+/M+2 or M+2/M+4) must be within 15 percent of the theoretical value. The acceptable ion abundance ratio ranges for the identification of chlorine-containing compounds are:

M/M+2
- tetra 0.65-0.89
- penta 0.52-0.70

M+2/M+4
- hexa 1.05-1.41
- hepta 0.87-1.17
- octa 0.75-1.01

2) The retention time for the analytes must be within 3 s of the corresponding ^{13}C-labeled internal standard or surrogate standard.

3) The monitored ions for an analyte must maximize within 3 s.

4) The identification of specific isomers that do not have a corresponding ^{13}C-labeled standards is done by comparison of the relative retention time (RRT) of the analyte to the nearest internal standard retention time with reference (i.e., within 0.005 RRT units) to the comparable RRTs found in the continuing calibration.

5) The (S/N) for all monitored ions must be greater than 2.5.

6) The confirmation of 2,3,7,8-TCDD and 2,3,7,8-TCDF must satisfy all of the above identification criteria.

For Triangle Laboratories,

Analyst	QA Project Officer	Program Manager
Linda Duncan for Michael Chu	Hani Karam	
Michael D. Chu	Hani S. Karam	Yves Tondeur

TABLE 1: COMPOSITION OF THE SAMPLE FORTIFICATION AND RECOVERY STANDARDS SOLUTIONS
(concentrations in pg/uL)

Analyte	Sample Fortification Solution	Recovery Standards Solution*
$^{13}C_{12}$-2,3,7,8-TCDD (IS)	100	-
$^{13}C_{12}$-1,2,3,4-TCDD (RS)	-	500
$^{37}Cl_4$-2,3,7,8-TCDD (SS)	100	-
$^{13}C_{12}$-2,3,7,8-TCDF (SS)	100	-
$^{13}C_{12}$-1,2,3,7,8-PeCDD (IS)	100	-
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD (IS)	100	-
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD (RS)	-	500
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF (SS)	100	-
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD (IS)	100	-
$^{13}C_{12}$-OCDD (IS)	200	-

IS = Internal Standard; SS = Surrogate Standard; RS = Recovery Standard

* = The concentration of the recovery standards used for the MM5 samples is 250 pg/uL.

Note: The volume of the recovery standards solution added to the final extract before GC/MS analysis is 20 uL.

TABLE 2: COMPOSITION OF THE INITIAL CALIBRATION SOLUTIONS

Compound	Concentrations (pg/uL)					
Sol. Number	1	2	3	4	5	6
Unlabeled Analytes						
2-MoCDD	5	10	50	100	500	1000
3-MoCDF	5	10	50	100	500	1000
2,3-DiCDD	5	10	50	100	500	1000
2,3-DiCDF	5	10	50	100	500	1000
1,2,4-TrCDD	5	10	50	100	500	1000
2,3,8-TrCDF	5	10	50	100	500	1000
2,3,7,8-TCDD	5	10	50	100	500	1000
2,3,7,8-TCDF	5	10	50	100	500	1000
1,2,3,7,8-PeCDD	25	50	250	500	2500	5000
1,2,3,7,8-PeCDF	25	50	250	500	2500	5000
2,3,4,7,8-PeCDF	25	50	250	500	2500	5000
1,2,3,4,7,8-HxCDD	25	50	250	500	2500	5000
1,2,3,6,7,8-HxCDD	25	50	250	500	2500	5000
1,2,3,7,8,9-HxCDD	25	50	250	500	2500	5000
1,2,3,4,7,8-HxCDF	25	50	250	500	2500	5000
1,2,3,6,7,8-HxCDF	25	50	250	500	2500	5000
1,2,3,7,8,9-HxCDF	25	50	250	500	2500	5000
2,3,4,6,7,8-HxCDF	25	50	250	500	2500	5000
1,2,3,4,6,7,8-HpCDD	25	50	250	500	2500	5000
1,2,3,4,6,7,8-HpCDF	25	50	250	500	2500	5000
1,2,3,4,7,8,9-HpCDF	25	50	250	500	2500	5000
OCDD	50	100	500	1000	5000	10000
OCDF	50	100	500	1000	5000	10000
Internal Standards						
$^{13}C_{12}$-2,3,7,8-TCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8-PeCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	100	100	100	100	100	100
$^{13}C_{12}$-OCDD	200	200	200	200	200	200
Surrogate Standards						
$^{37}Cl_4$-2,3,7,8-TCDD	5	10	50	100	500	1000
$^{13}C_{12}$-2,3,7,8-TCDF	5	10	50	100	500	1000
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	5	10	50	100	500	1000
Recovery Standard						
$^{13}C_{12}$-1,2,3,4-TCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD	100	100	100	100	100	100

TABLE 3: GAS CHROMATOGRAPHY CONDITIONS

Column type	DB-5
Length (m)	60
i.d. (mm)	0.25
Film Thickness (um)	0.25
Carrier Gas	Helium
Carrier Gas Flow (mL/min)	1-2
Injection Mode	splitless
Valve Time (s)	30
Initial Temperature (° C)	150
Program Temperature	150° C to 190° C ballistically then 3° C/min up to 300° C.

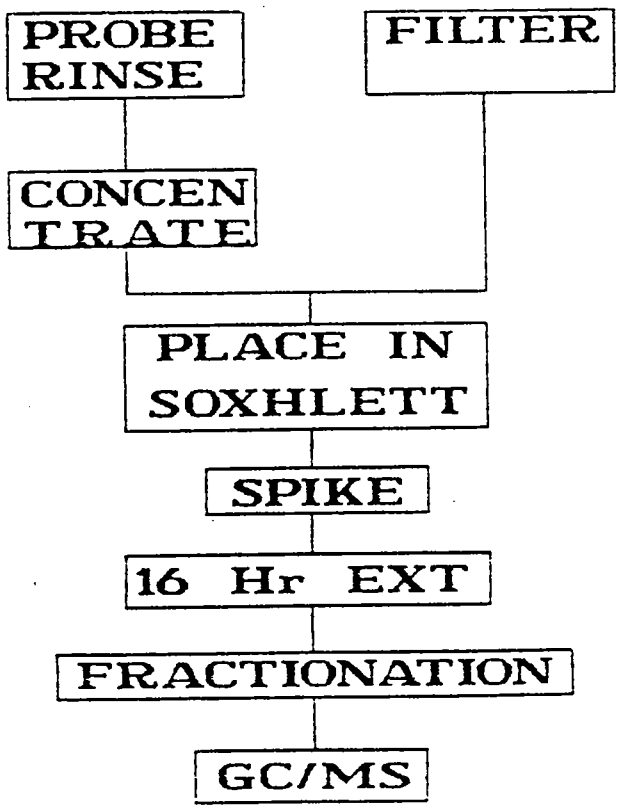
PROBE RINSE
FILTER
CONCEN TRATE
PLACE IN SOXHLETT
SPIKE
16 Hr EXT
FRACTIONATION
GC/MS

Fig 1.

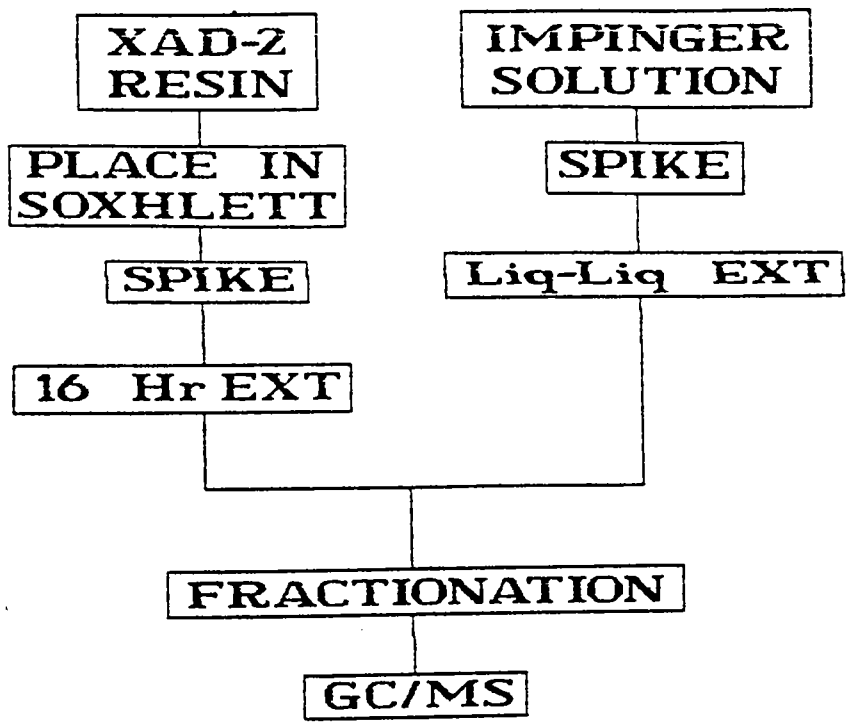
XAD-2 RESIN
IMPINGER SOLUTION
PLACE IN SOXHLETT
SPIKE
SPIKE
Liq-Liq EXT
16 Hr EXT
FRACTIONATION
GC/MS

Fig. 2

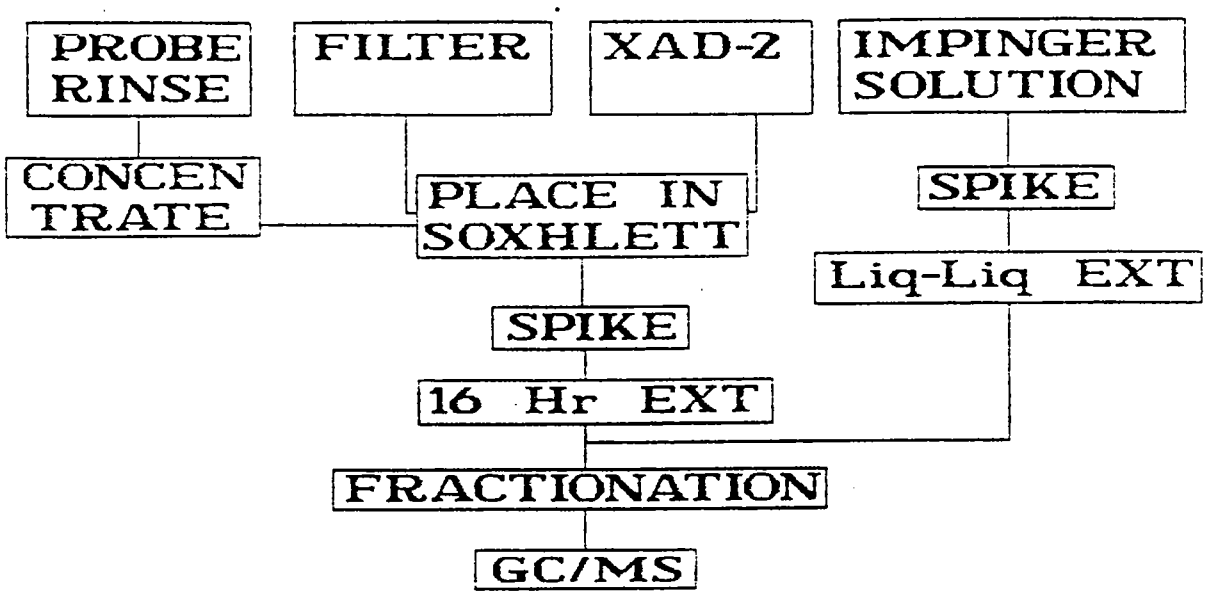
PROBE RINSE
FILTER
XAD-2
IMPINGER SOLUTION
CONCEN TRATE
PLACE IN SOXHLETT
SPIKE
Liq-Liq EXT
SPIKE
16 Hr EXT
FRACTIONATION
GC/MS

Fig. 3

Standard Test Method for
CARBON AND HYDROGEN IN THE ANALYSIS SAMPLE OF REFUSE-DERIVED FUEL[1]

This standard is issued under the fixed designation E 777; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method covers the determination of total carbon and hydrogen in a sample of refuse-derived fuel (RDF-3). Both carbon and hydrogen are determined in one operation. This method yields the total percentages of carbon and hydrogen in RDF-3 as analyzed and the results include not only the carbon and hydrogen in the organic matter, but also the carbon present in mineral carbonates and the hydrogen present in the free moisture accompanying the analysis sample as well as hydrogen present as water of hydration.

NOTE 1—It is recognized that certain technical applications of the data derived from this test procedure may justify additional corrections. These corrections could involve compensation for the carbon present as carbonates, the hydrogen of free moisture accompanying the analysis sample, and the calculated hydrogen present as water of hydration.

1.2 This method may be applicable to any waste material from which a laboratory analysis sample can be prepared.

1.3 Refuse-derived fuel-3 (RDF-3) is defined as a shredded fuel derived from muncipal solid waste (MSW) which has been processed to remove metal, glass, and other inorganics. This material has a particle size such that 95 weight % passes through a 2-in. square-mesh screen.

NOTE 2—Other refuse-derived fuel may be classified as follows:

RDF-1— Wastes used as a fuel in a discarded form.

RDF-2— Wastes processed to coarse particle size with or without ferrous metal separation.

RDF-4— Combustible waste processed into powder form, 95 weight % passing 10-mesh screening.

RDF-5— Combustible waste densified (compressed) into the form of pellets, slugs, cubettes, or briquettes.

RDF-6— Combustible waste processed into liquid fuel

RDF-7— Combustible waste processed into gaseous fuel.

2. Applicable Documents

2.1 *ASTM Standards:*

D 1193 Specification for Reagent Water[2]

E 790 Test Method for Residual Moisture in Refuse-Derived Fuel Analysis Sample[3]

E 791 Test Method for Calculating Refuse-Derived Fuel Analysis Data From As-Determined to Different Bases[3]

3. Summary of Method

3.1 The determination is made by burning the sample to convert all of the carbon to carbon dioxide and all of the hydrogen to water. The combustion is carried out by high purity oxygen that has been passed through a purifying train. The carbon dioxide and water are recovered in an absorption train. The combustion tube packing is used to remove any interfering substances. This method gives the total percentages of carbon and hydrogen in the RDF-3 as analyzed, including the carbon in carbonates and the hydrogen in any form of water.

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[1] This method is under the jurisdiction of ASTM Committee E-38 on Resource Recovery and is the direct responsibility of Subcommittee E38.01 on Energy.

Current edition approved Jan. 30, 1981. Published March 1981.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 11.04.

4. Significance and Use

4.1 The standard sample is available to producers and users of RDF-3 as a method of determining the weight percent of carbon and hydrogen in the analysis sample.

4.2 Carbon and hydrogen are part of the ultimate analysis of a fuel and can be used for calculations of combustion parameters.

5. Apparatus

5.1 *Oxygen-Purifying Train*—The high-purity oxygen is passed through water and carbon dioxide absorbers prior to use for combustion. The oxygen-purifying train consists of the following three units in order of passage of oxygen (see Fig. 1):

5.1.1 *First Water Absorber*—A container constructed so that the oxygen must pass through a column of reagent. The container shall have a capacity for at least 45 cm^3 of solid reagent, and the minimum gas travel through the reagent shall be at least 80 mm. A container of large volume and long path of oxygen travel through the reagent will be found to be advantageous where many carbon and hydrogen determinations are made.

5.1.2 *Carbon Dioxide Absorber*—If solid reagents are used for carbon dioxide absorption, the container shall be as described in 5.1.1. If a solution is used, the container shall be a Varnier bulb. It shall provide a column of reagent adequate to remove the carbon dioxide completely.

5.1.3 *Second Water Absorber*—Same as specified in 5.1.1.

5.2 *Flowmeter*, used to permit volumetric measurement of the rate of flow of oxygen during the determination. It shall be suitable for measuring flow rates within the range from 50 to 100 mL/min (standard temperature and pressure). The use of a double-stage pressure-reducing regulator with gage and needle valve is recommended to permit easy and accurate adjustment to the rate of flow.

5.3 *Combustion Unit*, consisting of three electrically heated furnace sections, individually controlled, which may be mounted on rails for easy movement. The upper part of each furnace may be hinged so that it can be opened for inspection of the combustion tube. The three furnace sections shall be as follows (see Fig. 1):

5.3.1 *Furnace Section 1*—Furnace section 1 is nearest the oxygen inlet end of the combustion tube, approximately 130 mm long and used to heat the inlet end of the combustion tube and the sample. It shall be capable of rapidly attaining an operating temperature of 875 ± 25°C.

NOTE 3—Combustion tube temperature shall be measured by means of a thermocouple placed immediately adjacent to the tube near the center of the appropriate tube section.

5.3.2 *Furnace Section 2*—Furnace section 2 shall be approximately 330 mm in length and used to heat that portion of the tube filled with cupric oxide. The operating temperature shall be 850 ± 20°C (see Note 3).

5.3.3 *Furnace Section 3*—Furnace section 3 shall be approximately 230 mm long, and used to heat that portion of the tube filled with lead chromate or silver. The operating temperature shall be 500 ± 50°C.

5.3.4 *Combustion Tube*, made of fused quartz, or high-silica glass and having a nominal inside diameter which may vary within the limits of 19 to 22 mm and a minimum total length of 970 mm. The exit end shall be tapered down to provide a tubulated section for connection to the absorption train. The tubulated section shall have a length of 20 to 25 mm, an internal diameter of not less than 3 mm, and an external diameter of approximately 7 mm. The total length of the reduced end shall not exceed 60 mm. If a translucent fused quartz tube is used, a transparent section 190 mm long, located 250 mm from the oxygen inlet end of the tube, will be found convenient (see Fig. 2).

5.3.5 *Combustion Boat*, made of glazed porcelain, fused silica, or platinum. Boats with internal dimensions of approximately 70 by 8 by 8 mm have been found convenient.

5.4 *Absorption Train*, identical to the oxygen absorption train indicated in 5.1 to obtain system equilibrium. Therefore, the absorption train shall consist of the following units arranged as listed in the order of passage of oxygen (see Fig. 1):

5.4.1 *First Water Absorber*, as described in 5.1.1.

5.4.2 *Carbon Dioxide Absorber*, as described in 5.1.2.

5.4.3 *Second Water Absorber*, as described in 5.1.3. The second water absorber is also known as a guard tube.

6. Reagents

6.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the American Chemical Society, where such specifications are available.[4] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water, Type III, conforming to Specification D 1193.

6.3 *Oxygen*, with minimum acceptable purity 99.5 %.

NOTE 4—If the blank tests for flow (see 8.3.2) indicate interfering impurities in the oxygen supply by consistent weight-gain in the absorbers, eliminate these impurities by using a preheater furnace and tube, filled with cupric oxide. Operate this preheater at 850 ± 20°C and insert in series between the supply tank of oxygen and the purification train.

6.4 *Combustion Tube Reagents:*

6.4.1 *Cupric Oxide* (CuO), wire form, dust-free.

6.4.2 *Fused Lead Chromate* ($PbCrO_4$), approximately 2.38 to 0.84 mm in size.

6.4.3 *Silver Gauze*, 99.9 % silver minimum purity, 0.84 mm, made from approximately No. 27 B&S gage wire.

6.4.4 *Copper Gauze*, 99.0 % copper minimum purity, 0.84 mm, made from approximately No. 26 B&S gage wire.

6.5 *Purification and Absorption Train Reagents:*

6.5.1 *Water Absorbent*—Anhydrous magnesium perchlorate ($Mg(ClO_4)_2$) approximately 2.38 to 0.35 mm in size.[5]

6.5.2 *Carbon Dioxide Absorbent*—If a solid reagent is used, it shall be sodium or potassium hydroxide (NaOH or KOH) impregnated in an inert carrier approximately 2.38 to 0.84 mm in size. Use of soda lime in place of the above or in admixture with them is permissible (Note 5). If a solution is used, it shall be 30 weight % potassium hydroxide (KOH).

NOTE 5—Acceptable carbon dioxide absorbing reagents using sodium or potassium hydroxide are sold under the tradenames: Ascarite, Caroxite, and Mikohbite. If soda lime is used in admixture with any of the foregoing, it should not exceed 30 weight % of the total reagent. In using Ascarite it may be necessary to add a few drops of water to this reagent to assure complete absorption of carbon dioxide.

7. Precautions

7.1 Due to the origins of RDF in municipal waste, common sense dictates that some precautions should be observed when conducting tests on the samples. Recommended hygienic practices include use of gloves when handling RDF; wearing dust masks (NIOSH-approved type), especially while milling RDF samples; conducting tests under a negative pressure hood when possible; and washing hands before eating or smoking.

8. Preparation of Apparatus

8.1 *Combustion Tube Packing*—To ensure complete oxidation of combustion products and complete removal of interfering substances such as oxides of sulfur, the combustion tube shall be packed with cupric oxide and lead chromate or silver gauze. The arrangement and lengths of the tube fillings and separating plugs shall be as shown in Fig. 2 (see Note 6). It is recommended that the tube be placed in a vertical position (constricted end downward) for packing. When filling the tube with lead chromate, any residual reagent adhering to the walls of the empty portion of the tube must be removed. When silver gauze is used as a tube filling, the required length of filling may be prepared conveniently from three or four strips 150 to 200 mm in length, by rolling each strip into a cylindrical plug and inserting the strips end-to-end in the tube.

NOTE 6—Longer furnaces with appropriate lengths of tube packing will be satisfactory.

8.2 *Purification and Absorption Trains:*

8.2.1 *Water Absorbers*—Fill a container, described in 5.1.1, with a permissible solid desiccant, as described in 6.5.1, by adding the required amount in small portions and settling each portion by gently tapping between additions. Place a glass wool plug between the reagent and absorber outlet to prevent loss of reagent dust.

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[4] "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, D.C. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Reagent Chemicals and Standards* (1967 revised edition), by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N.Y., and the *United States Pharmacopeia*.

[5] Tradenames of this reagent are Anhydrone or Dehydrite

8.2.2 *Carbon Dioxide Absorbers*—If a solid reagent is used for the retention of carbon dioxide, 6.5.2, fill the absorber, 5.1.2, as described in 8.2.1. Place a layer or cap of desiccant in the outlet section of the container; it shall be the same as that used in the water absorber. This layer shall have a bulk volume not less than one fourth nor more than one third of the combined volume of both reagents.

8.2.2.1 If a liquid absorbent is used, fill the inner tube of the Vanier bulb with the same desiccant used in the water absorber. If a solid absorbent is used, place a glass wool plug in the outlet section of the container to prevent loss of reagent dust.

8.2.3 *Guard Tube*—Pack a container, as described in 5.1.1, with equal volumes of the water absorbent and a solid carbon dioxide absorbent.

8.2.4 *Connections*—To ensure a closed system from the supply tank of oxygen to the guard tube at the end of the absorption train, it is recommended that all connections be glass-to-glass or glass-to-quartz butt joints with short lengths of flexible tubing as seals. The connection between the purification train and the combustion tube may be made by means of a rubber stopper or other suitable device. All connections shall be gas tight. No lubricant shall be used for making tubing connections in the absorption train.

8.3 *Conditioning of Apparatus.*

8.3.1 *Newly Packed Combustion Tube*—Burn a sample of RDF-3 as described in 10.4 except that the products of combustion need not be fixed in a weighed absorption train.

8.3.2 *Used Combustion Tube*—After any extended shut down (one day or more) test the combustion train under procedure conditions, but without burning a sample, for 40 min with weighed absorbers connected. A variation of not more than 0.5 mg of both water and carbon dioxide absorbers shall be considered satisfactory (see Note 4).

8.3.3 *Absorption Train*—Condition freshly packed absorbers and guard tubes by burning a sample of RDF-3, as described in 10.4, except that the absorber weights need not be determined.

8.3.4 Make standard checks frequently, particularly when intermittent use of the combustion train is common or when any changes have been made in the system. Burn a standard substance of certified analysis, such as benzoic acid or sucrose as furnished by the National Bureau of Standards, as described in Section 10. A variation from the theoretical of not more than 0.07 % for hydrogen nor more than 0.30 % for carbon shall be considered satisfactory.

9. Sampling

9.1 RDF-3 products are frequently nonhomogeneous. For this reason significant care should be exercised to obtain a representative laboratory sample from the RDF-3 lot to be characterized.

9.2 The sampling method for this procedure should be based on agreement between the involved parties.

9.3 The laboratory sample must be air-dried and particle size reduced to pass a 0.5 mm-screen for analysis. This procedure must be performed carefully to preserve the sample's representative characteristics (other than particle size) while preparing the analysis sample to be used in the procedures.[6]

10. Procedure

10.1 After the combustion tube and absorbers have been conditioned as prescribed in Section 8, conduct the test as follows:

10.2 *Absorption Train*—Bring the water and carbon dioxide absorbers to room temperature near the balance for 15 to 20 min, vent momentarily to the atmosphere, wipe with a chamois or lint-free cloth in the areas where handled, and weigh the water and carbon dioxide absorbers to the nearest 0.1 mg.

10.3 *Sample*—After thoroughly mixing the RDF-3 analysis sample to provide the best possible mix of heavy fines with milled fluff, weigh approximately 0.2 g to the nearest 0.1 mg of sample into a combustion boat.

NOTE 7—The final milling stage may produce a suitably mixed analysis sample without further mixing. It is important that no unwanted segregation of particle sizes take place. True representation of the analysis sample must be contained in the 200 mg used for the analysis.

10.4 *Sample Analysis*—With furnace sections 2 and 3 at specified temperatures and positioned as shown in Fig. 2, perform the following operations in rapid succession in the order listed:

10.4.1 If a conventional type of sample heating furnace is used for heating furnace section 1, place it so that its left-hand edge is about 100 mm from the oxygen inlet end of the combustion tube.

10.4.2 Attach the weighed absorption train to the combustion tube.

10.4.3 Push the sample boat containing the weighed sample into the combustion tube to a point within approximately 20 mm from plug P_1 (see Fig. 2).

10.4.4 Close the tube and adjust the oxygen flow to a rate of 50 to 100 mL/min (standard temperature and pressure), being the same as used in blanking (see 8.3.2).

10.4.5 Apply full heat to heating section 1 to bring it to an operating temperature of 850 to 900°C as rapidly as possible. Move the heater slowly toward the boat so that it completely covers the boat and is brought into contact with furnace section 2 over a period of 10 to 20 min (Note 8). Allow it to remain in this position for an additional 5 to 10 min, and then shut off the heat and return the sample heater to its original position. Continue the flow of oxygen through the system for 10 min (Note 9), close the absorbers under a positive pressure of oxygen and detach them from the train. Remove the absorbers to the vicinity of the balance, allow them to cool to room temperature for 15 to 20 min, vent momentarily to the atmosphere, wipe them with a chamois or lint-free cloth in the areas handled, and finally weigh them to the nearest 0.1 mg. While the absorbers are cooling, it is recommended that the ash remaining in the combustion boat be examined for tracers of unburned carbon which, if present, will nullify the determination.

NOTE 8—Some variation in operating technique and heater manipulation may be permitted at the discretion of the analyst, provided that it is conducive to a gradual and controlled release of volatile matter. Conditions that lead to visible burning (flame combustion) of the sample shall be avoided.

NOTE 9—Since water may condense in the cooler outlet end of the combustion tube or in the inlet arm of the water absorber, the use of an external or internal heat-conducting device (a metal heat bridge) is recommended to prevent such condensation or promote reevaporation during this flushing period.

11. Calculations

11.1 Calculate the percentage of carbon in the analysis sample as follows:

$$\text{Carbon, \%} = \frac{A}{B} \times 27.289$$

where:

A = increase in weight of CO_2 absorber, g.
B = grams of sample used, and
27.289 = percentage of carbon in CO_2.

11.2 Calculate the percentage of hydrogen in the analysis sample as follows (see Note 8).

$$\text{Hydrogen, \%} = \frac{C}{B} \times 11.19$$

where:

C = increase in weight of water absorber, g.
B = grams of sample used, and
11.19 = percentage of hydrogen in water.

NOTE 10—The water absorbed in the water absorber includes not only water formed as a product of combustion, but also free water (moisture) in the sample and water of hydration of materials that may be contained in RDF-3.

12. Report

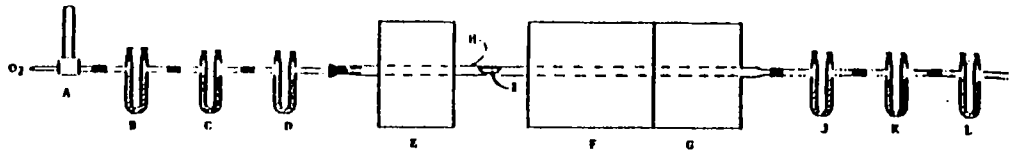
12.1 The results of the carbon and hydrogen analysis may be reported on any of a number of bases, differing from each other in the manner by which moisture is treated.

12.2 The numerical moisture value established by Method E 790 shall be used for converting carbon and hydrogen data on the as-determined basis to the dry basis as in Method E 791.

13. Precision

13.1 Repeatability and reproducibility will be determined.

[6] ASTM Subcommittee E38.01 is currently in the process of developing procedures for sampling RDF-3 and the preparation of an analysis sample.



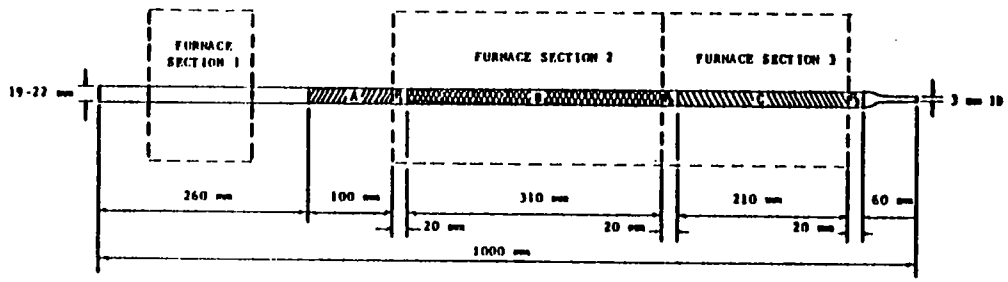
A = flowmeter (5.2)
B, C, D = oxygen purifying train (5.1)
B = first water absorber (5.1.1)
C = carbon dioxide absorber (5.1.2)
D = second water absorber (5.1.3)

E, F, G, H, I = combustion unit (5.3)
E = furnace section 1 (5.3.1)
F = furnace section 2 (5.3.2)
G = furnace section 3 (5.3.3)
H = combustion tube (5.3.4)
I = combustion boat (5.3.5)

J, K, L = absorption train (5.4)
J = first water absorber (5.4.1)
K = carbon dioxide absorber (5.4.2)
L = guard tube (5.4.3)

NOTE—*C* and *K* can substitute a Vanier bulb if liquid absorbent is used.

FIG. 1 Set-Up of Apparatus



A = clear fused quartz section (optional when a translucent quartz tube is used)
B = cupric oxide filling
C = lead chromate or silver gauze filling
P_1, P_2, P_3 = oxidized copper gauze plugs

NOTE—When furnace sections longer than those specified in 5.3 are to be used, changes in the above dimensions shall be in accordance with provisions of Note 6.

FIG. 2 Arrangement of Tube Filling for Combustion Tube

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

Standard Test Method for ASH IN THE ANALYSIS SAMPLE OF REFUSE-DERIVED FUEL[1]

This standard is issued under the fixed designation E 830; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method covers determination of the ash content in the analysis sample of refuse-derived fuel (RDF-3). The results obtained can be applied as the weight percent ash in the proximate analysis and in the ultimate analysis.

1.2 Refuse-derived fuel (RDF-3) is defined as a shredded fuel derived from municipal solid waste (MSW) that has been processed to remove metal, glass, and other inorganics. This material has a particle size such that 95 weight % passes through a 2-in. square mesh screen.

NOTE 1—Other refuse-derived fuel may be classified as follows:

- RDF-1—Wastes used as a fuel in as-discarded form.
- RDF-2—Wastes processed to coarse particle size with or without ferrous metal separation.
- RDF-4—Combustible waste processed into powder form, 95 weight % passing 10-mesh screening.
- RDF-5—Combustible waste densified (compressed) into the form of pellets, slugs, cubettes, or briquettes.
- RDF-6—Combustible waste processed into liquid fuel.
- RDF-7—Combustible waste processed into gaseous fuel.

2. Applicable Documents

2.1 *ASTM Standard:*

D 3173 Test Method for Moisture in the Analysis Sample of Coal and Coke[2]

3. Summary of Method

3.1 Ash is determined by weighing the residue remaining after burning the RDF-3 under rigidly controlled conditions of sample weight, temperature, and furnace atmosphere.

4. Significance and Use

4.1 This method is available to producers and users of RDF-3 as a method of determining the weight percent of ash in the analysis sample.

5. Apparatus

5.1 *Electric Furnace*—For determination of the ash content of RDF-3, the furnace shall have adequate air ventilation and shall be capable of temperature regulation up to at least 750 ± 25°C. An air change rate of 1 to 4 furnace volumes of air per minute has been found adequate.

NOTE 2—It may be possible to reduce the rate of air flow below the suggested minimum without adversely affecting results of the ash determination.

5.2 *Porcelain Capsules*, about 22 mm (⅞ in.) in depth, and 44 mm (1¾ in.) in diameter, or similar containers.

NOTE 3—Weighing bottles of borosilicate glass may be safely used without deformation or softening at temperatures of 600°C or less.

6. Precautions

6.1 Due to the origins of RDF in municipal waste, common sense dictates that some precautions should be observed when conducting tests on the samples. Recommended hygienic practices include use of gloves when handling RDF; wearing dust masks (NIOSH-approved type), especially while milling RDF samples; conducting tests under a negative pressure hood when possible; and washing hands before eating or smoking.

7. Sampling

7.1 The laboratory sample shall be obtained in accordance with sampling methods developed for materials of similar physical form.

7.2 The laboratory sample shall be prepared in accordance with sampling methods developed for materials of similar physical forms.

8. Procedure

8.1 After thoroughly mixing the RDF-3 analysis sample to provide the best possible mix of heavy fines with the milled fluff, transfer approximately 1 g of the sample to a tared, previously fired container (weighed to the nearest 0.1 mg) with a scoop or spatula. Quickly weigh sample and container to the nearest 0.1 mg. As an alternate method use the dried RDF-3 from the residual moisture determination. See Test Method D 3173.

8.2 Place the uncovered container containing the sample in the furnace at low temperature and gradually heat to ignition at such a rate as to avoid mechanical loss from too rapid expulsion of volatile matter.

8.3 Finish the ignition to constant weight (±0.001 g/h) at 575 ± 25°C. It may be determined that a constant weight can be routinely established by allowing a sample to ash within the prescribed temperature range for a set period of time.

NOTE 4—Experience has shown that particles of glass and sand tend to sinter to each other and also to porcelain crucibles at temperatures close to 675°C. If laboratory conditions necessitate maintaining consistency in the maximum furnace temperature used for ash tests of other fuels, the ignition may be finished to constant weight (±0.001 g/h) at a temperature of 725 ± 25°C. If this option is invoked, it should be also noted that prolonged exposure to high temperatures may actually result in changes in weight due to possible chemical reactions.

8.4 Cool in a desiccator over desiccant and weigh as soon as possible after the container and ash reach the temperature of the area in which weighing is performed.

9. Calculations

9.1 Calculate the ash percent in the analysis sample as follows:

$$\text{Ash as-determined, \%} = [(A - B)/C] \times 100$$

where:

A = weight of container and ash residue, g,
B = weight of empty container, g, and
C = weight of ash analysis sample, g (includes residual moisture).

9.2 Use the numerical moisture value established by Method D 3173 for converting ash data on the as-determined basis to the dry basis.

10. Report

10.1 Difficulty may be experienced in securing satisfactory check determinations of ash in the same or different laboratories for RDF-3 rich in heavy fines. This is caused by siliceous matter such as glass and sand as well as a wide variety of other particles of different densities entrained in the milled RDF-3 in nonuniform strata. When such a condition is anticipated or encountered, a paired set of determinations should be made, and the results reported as an average. If one determination of a paired set is accidentally ruined, another pair must be run. An off or unusual value does not constitute a ruined determination. In such cases, an additional set of duplicate determinations should be run and all values reported as an average of the two sets.

11. Precision and Accuracy

11.1 A repeatability and reproducibility section will be drafted by Subcommittee E38.0 after the conclusion of round-robin testing.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

[1] This method is under the jurisdiction of ASTM Committee E-38 on Resource Recovery and is the direct responsibility of Subcommittee E38.01 on Energy.

Current edition approved August 31, 1981. Published October 1981.

[2] *Annual Book of ASTM Standards*, Vol 05.05.

APPENDIX D

CALIBRATION AND QUALITY ASSURANCE DATA

- Quality Assurance Procedures
- Calibration Data
- Meter Box Audit
- Triangle Laboratories Continuing Calibration Data
- Reagent Box Custody Sheets

QUALITY ASSURANCE PROCEDURES

General. Each item of field test equipment purchased or constructed by Entropy is assigned a unique, permanent identification number. New items for which calibration is required are calibrated before initial field use. Equipment whose calibration status may change with use or with time is inspected in the field before testing begins, and again upon return from each field use. When an item of equipment is found to be out of calibration, it is adjusted and recalibrated or retired from service. All equipment is periodically recalibrated in full, regardless of the outcome of these regular inspections.

Calibrations are conducted in a manner and at a frequency which meet or exceed U. S. EPA specifications. Entropy follows the calibration procedures outlined the EPA Reference Methods, and those recommended within the Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III (EPA-600/4-77-027b, August, 1977). When the Reference Methods are inapplicable, Entropy uses methods such as those prescribed by the American Society for Testing and Materials (ASTM).

Data obtained during calibrations are recorded on standardized forms, which are checked for completeness and accuracy by the Quality Assurance Manager or the Quality Assurance Director. Data reduction and subsequent calculations are performed using Entropy's in-house computer facilities. Calculations are generally performed at least twice as a check for accuracy. Copies of calibration data are included in the test or project reports.

Inspection and Maintenance. An effective preventive maintenance program is necessary to ensure data quality. Each item of equipment returning from the field is inspected before it is returned to storage. During the course of these inspections, items are cleaned, repaired, reconditioned, and recalibrated where necessary.

Each item of equipment transported to the field for this test program was inspected again before being packed. Entropy performs these quality assurance activities prior to departure for the job site to detect equipment problems which may originate during periods of storage. This minimizes lost time on site due to equipment failure.

Occasional equipment failure in the field is unavoidable despite the most rigorous inspection and maintenance procedures. For this reason, Entropy routinely transports sufficient backup equipment to the job site to have complete redundancy of all critical sampling train components.

Calibration. Emissions sampling equipment that requires calibration includes the nozzle, pitot tube, pressure gauges, thermometers, flow meters, dry gas meters, and barometers. The following sections elaborate on the calibration procedures followed by Entropy for these items of equipment. Calibration data for the specific items of equipment used for this test program follow the text.

Nozzles. Each probe nozzle is uniquely and permanently identified at the time of purchase, and calibrated before initial field use. The inside diameter of the nozzle is measured to the nearest 0.001 in. using a micrometer. Five measurements are made using different diameters each time. If the difference between the high and the low numbers does not exceed 0.004 inch, the average of the five measurements is used. If the difference exceeds this amount, or when the nozzle becomes nicked, dented, or corroded, the nozzle is reshaped, sharpened, and recalibrated.

Pitot Tubes. All Type S pitot tubes used by Entropy, whether separate or attached to a sampling probe, are constructed in-house or by Nutech Corporation. Each pitot is calibrated when new in accordance with the geometry standards contained in EPA Reference Method 2. A Type S pitot tube, constructed and positioned according to these standards, will have a coefficient of 0.84 ± 0.02. This coefficient should not change as long as the pitot tube is not damaged.

Each pitot tube is inspected visually before it is transported to the field. If this inspection indicates damage or raises doubt that the pitot remains in accordance with the EPA geometry standards, the pitot tube is not used until it has been refurbished and recalibrated.

Differential Pressure Gauges. Some meter consoles used by Entropy are equipped with 10 in. W.C. inclined-vertical manometers. Fluid manometers do not require calibration other than leak checks. Manometers are leak-checked in the field prior to each test series, and again upon return from the field.

Most of Entropy's meter consoles are equipped with Magnehelic differential pressure gauges. Each set of gauges is calibrated initially over its full range, 0-10 inches W.C. After each field use, the calibration of the gauge set is checked against an inclined manometer at the average delta p encountered during the test. If the agreement is within $\pm$ 5 percent, the calibration is acceptable.

Thermometers.

Impinger Thermometer. On site, prior to the start of testing, the thermometer used to monitor the temperature of the gas leaving the last impinger is compared with a mercury-in-glass thermometer which meets ASTM E-1 specifications. The impinger thermometer is adjusted if necessary until it agrees within $2^{o}F$ of the reference thermometer. (If the thermometer is not adjustable, it is labeled with a correction factor).

Dry Gas Meter Thermometer. The thermometer used to measure the temperature of the metered gas sample is checked prior to each field trip against an ASTM mercury-in-glass thermometer. The dry gas meter thermometer is acceptable if the values agree with $5.4^{o}F$. Thermometers not meeting this requirement are adjusted or labeled with a correction factor.

Stack Temperature Sensor. All thermocouples employed by Entropy for the measurement of flue gas temperatures are calibrated upon receipt. Initial calibrations are performed at three points (ice bath, boiling water, and hot oil). An ASTM mercury-in-glass thermometer is used as a reference. The thermocouple is acceptable if the agreement is within 1.5 percent (absolute) at each of the three calibration points.

On site, prior to the start of testing, the reading from the stack gas thermocouple-potentiometer combination is compared with a mercury-in-glass reference thermometer. If the two agree within 1.5 percent (absolute), the thermocouple and potentiometer are considered to be in proper working order for the test series.

After each field use, the thermocouple-potentiometer system is compared with an ASTM mercury-in-glass reference thermometer at a temperature within 10 percent of the average absolute stack gas temperature. If the absolute

temperatures agree within 1.5 percent, the temperature data are considered valid.

Dry Gas Meter and Orifice Meter. The dry gas meter and orifice meter are calibrated simultaneously. There are two calibration procedures. The full calibration is a complete laboratory procedure used to obtain the calibration factor of the dry gas meter before its first use and periodically thereafter. Full calibrations are performed at three different orifice meter settings (flow rates). A simpler procedure, the post-test calibration, is designed to check whether the calibration factor has changed. Post-test calibrations are performed after each field test series at an intermediate orifice meter setting (based on the test data) and at the maximum vacuum reached during the test.

Entropy uses as a transfer standard a dry gas meter that is calibrated annually against a spirometer. During the annual calibration, triplicate calibration runs are performed at seven flow rates ranging from 0.25 to 1.40 cfm.

Dry Gas Meter. Each metering system receives a full calibration at the time of purchase, and a posttest calibration after each field use. If the calibration factor, Y, deviates by less than five percent from the initial value, the test data are acceptable. If Y deviates by more than five percent, the meter is recalibrated and the meter coefficient (initial or recalibrated) that yields the lowest sample volume for the test runs is used.

EPA Reference Method 5 calls for another full calibration anytime the posttest calibration check indicates that Y has changed by more than five percent. Standard practice at Entropy is to recalibrate the dry gas meter anytime Y is found to be outside the range $0.98 \leq Y \leq 1.02$.

Orifice Meter. An orifice meter calibration factor is calculated for each flow setting during a full calibration. If the range of values does not vary by more than 0.15 in. H_2O over the range of 0.4 to 4.0 in. H_2O, the arithmetic average of the values obtained during the calibration is used.

Barometer. Each field barometer is adjusted before each test series to agree within ± 0.1 inches of a reference aneroid barometer. The reference barometer is checked weekly against the station pressure value (corrected for elevation difference) reported by the National Weather Service station at the Raleigh-Durham airport, approximately 2.5 miles from Entropy's location.

NOZZLE NUMBER: 905

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
2/19/87	JE	.182	.179	.182	.180	.183	0.181

NOTE: All diameters measured in inches.

Meter Box Number: N16

Calibration by: T. McDonald

Standard Meter Number: 1017057

Standard Meter Gamma: 1.0020

Date: 12-29-87

Barometric Pressure (P_b): 29.51 in. Hg

*Date: _____

*Barometric Pressure (P_b): _____ in. Hg

METERBOX CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
3.946	58	10:00	0.50	4.101	78	1.0001	1.71
3.953	58	10:00	0.50	4.111	78	0.9994	1.71
7.990	58	10:00	2.10	8.262	80	1.0049	1.75
8.006	59	10:00	2.10	8.271	82	1.0076	1.74
11.948	60	10:00	4.50	12.177	83	1.0145	1.79
11.881	61	10:00	4.50	12.177	83	1.0069	1.82
					Average	1.0056	1.75

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}} \right]^2$$

F-1037
8/86

ENTROPY

Dry Gas Meter Identification: 1017057 Calibration by: M. Hendon

Date: 4-1-86 Barometric Pressure (P_b): 29.86 in. Hg

*Date: _____ *Barometric Pressure (P_b): _____ in. Hg

ENTROPY ENVIRONMENTALISTS, INC. PAGE 1 of 2

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft³	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft³	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (θ) min.	Flow Rate (Q) cfm	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
0.40	4.062	78.8	4.062	80	0.85	10.0	0.3971	1.0001	
	4.117	79.3	4.061	80	0.85	10.0	0.4021	1.0130	
	4.159	79.7	4.065	80	0.85	10.0	0.4088	1.0289	
0.60	6.084	79.7	6.035	80	1.3	10.0	0.5938	1.0055	
	6.166	79.7	6.016	80	1.275	10.0	0.6018	1.0223	
	6.102	79.7	6.015	80	1.25	10.0	0.5955	1.0119	
0.80	8.097	79.7	7.996	80	2.35	10.0	0.7902	1.0074	
	8.132	79.7	8.003	80	2.40	10.0	0.7937	1.0107	
	8.114	79.3	7.996	80	2.45	10.0	0.7925	1.0100	
1.0	10.128	78.8	10.119	80	3.875	10.0	0.9901	0.9936	
	10.164	78.8	10.081	80	3.80	10.0	0.9936	1.0011	
	10.173	78.8	10.092	80	3.80	10.0	0.9945	1.0009	
1.2	12.359	78.8	12.305	80	5.5	10.0	1.2092	0.9932	
	12.368	78.8	12.316	80	5.3	10.0	1.2091	0.9935	
	12.313	78.8	12.274	80	5.3	10.0	1.2037	0.9929	

$$Y_d = \frac{(V_s)(t_{ds} + 460)(P_b)}{(V_{ds})(t_s + 460)(P_b + (\Delta p / 13.6))}$$

$$Q = 0.64 \frac{(P_b)(V_s)}{(t_s + 460)(\theta)}$$

Dry Gas Meter Identification: 1017057 Calibration by: _____

Date: 4-1-86 Barometric Pressure (P_b): 29.86 in. Hg

ENTROPY ENVIRONMENTAL INC.

PAGE 2 of 2

*Date: _____ *Barometric Pressure (P_b): _____ in. Hg

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft^3	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft^3	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (θ) min.	Flow Rate (Q) cfm	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
1.4	14.454	77.7	14.462	81	7.625	10.0	1.4107	0.9834	
	14.444	78.8	14.446	80.5	7.55	10.0	1.4120	0.9847	
	14.399	78.8	14.406	80	7.575	10.0	1.4076	0.9834	
				$\bar{Y}_{ds}$ =		1.002			

$$Y_{ds} = \frac{(V_s)\ (t_{ds} + 460)\ (P_b)}{(V_{ds})\ (t_s + 460)\ (P_b + (\Delta p / 13.6))}$$

$$Q = (17.64)\ \frac{(P_b)\ (V_s)}{(t_s + 460)\ (\theta)}$$

Meter Box Number: N16

Calibration by: JG

Meter Box Vacuum: 14 in. Hg

Job 3520 Wheelabrator

Standard Meter Number: 1017057 Standard Meter Gamma: 1.002

Date: 2-19-88 Barometric Pressure (P_b): 29.82 in. Hg

POST TEST CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
3.059	68	10	0.30	3.121	73	0.991	1.77
3.088	68	10	0.30	3.184	77	0.988	1.73
3.010	68	10	0.30	3.072	80	1.003	1.81
					Average	0.994	1.77

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + \Delta H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

F-1038
8/86

ENTROPY

ON-SITE DRY GAS METER AUDIT

Date 2-9-88 Meter Box Identification Number N16

Time 0745 Pretest Gamma (Y) 1.0056 ΔH_a 1.75

Auditor (Vmg) - Barometric Pressure (P_{bar}) 29.7 in.Hg

Dry Gas Meter Readings, ft^3	Meter Temperatures, °F	Upper and Lower Limits for Audit Gamma
Initial 837.500	Initial 69 73	0.97 * Y = 0.9754
Final 845.162	Final 75	1.03 * Y = 1.0358

Dry Gas Volume Metered, ft^3	Average Meter Temperature, °F	Run Time, min.	Calculated Audit Gamma
Vm = 7.662	Tm = 74	10	Y_c = 0.9884

$$Y_c = \frac{10}{Vm} * \sqrt{\frac{0.0319\ (Tm + 460)}{P_{bar}}}$$

$$Y_c = \frac{10}{7.662} * \sqrt{\frac{0.0319\ (74 + 460)}{29.7}} = 0.9884$$

Audit Gamma Within Acceptable Limits? Yes ✓ No ___

F-1040
9/86

ENTRADY

0.49 ΔH

Date 2-9-88
Auditee ~~T. McDonald~~
Location Unit 2-Inlet
P_{bar} 29.7
$\Delta H_@$ 1.75
Audit Device No. 370

Time
Auditor T. McDonald
Meter Box No. N-16
Pretest Y 1.0056
K' 2.511×10^{-4} (#370)
ASTM Therm. °F
Filter Therm. °F
% Error

Stack Therm. °F
% Error
M_{inlet} Therm. °F
% Error
M_{outlet} Therm. °F
% Error °F
Condensor Therm. °F
% Error

Orifice gauge reading $\Delta H_@$ in. H_2O	Dry gas meter reading V_i/V_f ft^3	Meter temperatures T_i/T_f ~~inlet~~	~~outlet~~	Duration of run Θ min.
0.49	986.915	82		10
	990.917	82		

Dry Gas meter volume V_m, ft_3	Meter temperature average t_m, ft_3	$V_{m_{std}}$ a dry gas meter, ft^3	$V_{m_{std}}$ b orifice meter, ft^3	Percent difference, %	Acceptability
4.002	82	3.895	3.860	−0.91	✓

a)

Calculate $V_{m_{std}}$ from dry gas meter (English):

$$\frac{V_m Y \left(17.64 P_{bar} + \frac{\Delta H}{13.6}\right)}{(t_m + 460^oF)} = \frac{(4.002)(1.0056)\ 17.64\left(\frac{29.7 + 0.49}{13.6}\right)}{(542)} = 3.895\ ft^3$$

b)

Calculate $V_{m_{std}}$ from critical orifice (metric):

$$\frac{K' P_c \Theta}{\sqrt{T_o}} = \frac{(2.511 \times 10^{-4})(754.38)(10)}{\sqrt{300.778}} \frac{mm\ Hg \times min}{°K} = 0.109\ m^3 = 3.860\ ft^3$$

Figure 9.4. Dry gas meter and temperature sensor audit data.

TRIANGLE LABORATORIES, INC.
TCDD/TCDF CONTINUING CALIBRATION*

ANALYST AR FILE NAME S880729 ICAL DATE:3-MAR-88
DATE 3-19-88 STANDARD 50 AR 3-21-88

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
2378-TCDF	0.830	1	0.733	24.57	-0.172	-17.13%
2378-TCDD	0.998	1	0.784	22.20	-0.032	-3.09%

SUBROGATE RESPONSE FACTOR SUMMARY

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
37Cl-TCDD	2.177	2		22.20	0.091	1.38%

INTERNAL STANDARDS RESPONSE FACTOR SUMMARY

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
2378-13C12-TCDD	1.345	3	0.791	22.19	0.035	2.67%
13C12-TCDF	2.078	2	0.737	24.56	-0.111	-5.06%

*Supporting calibration data on file at Entropy Environmentalists, Inc.

001

TRIANGLE LABORATORIES, INC.
TCDD/TCDF CONTINUING CALIBRATION

ANALYST MDC FILE NAME S880941 ICAL DATE:3-MAR-88
DATE 3-20-88 STANDARD 50 AR 3-21-88

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
2378-TCDF	0.946	1	0.775	24.56	-0.056	-5.54%
2378-TCDD	1.090	1	0.798	22.20	0.060	5.83%

SURROGATE RESPONSE FACTOR SUMMARY

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
37Cl-TCDD	2.284	2		22.20	0.198	9.49%

INTERNAL STANDARDS RESPONSE FACTOR SUMMARY

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
2378-13C12-TCDD	1.316	3	0.811	22.19	0.007	0.50%
13C12-TCDF	2.391	2	0.757	24.55	0.203	9.28%

1

TRIANGLE LABORATORIES, INC.
TCDD/TCDF CONTINUING CALIBRATION

ANALYST LKD FILE NAME S880964 ICAL DATE:3-MAR-88
DATE 3/21/88 STANDARD 50 HR 3-21-88

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
2378-TCDF	0.978	1	0.767	24.54	-0.024	-2.39%
2378-TCDD	1.077	1	0.813	22.18	0.047	4.58%

SURROGATE RESPONSE FACTOR SUMMARY

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
37Cl-TCDD	2.207	2		22.18	0.121	5.79%

INTERNAL STANDARDS RESPONSE FACTOR SUMMARY

NAME	DAILY RF	CODE	RATIO	RT	DELTA RF	%DELTA RF
2378-13C12-TCDD	1.187	3	0.824	22.17	-0.123	-9.38%
13C12-TCDF	2.288	2	0.768	24.53	0.100	4.55%

CUSTODY SHEET FOR MM5 COOLER # DF 110

Date of Makeup 2/5 Initials SAW Sealed? ✓

Individual Tare of Reagent: 200 mls. of DI H_2O

Individual Silica Gel Tare Weight (2X) 200 gms.

Filter used? ✓ Knockout Impinger Catch? ✓ (✓ or X)

XAD Trap? ✓ Trap # and Tare wt., gms. ~~W95~~ MM5-IN-1-SM: W95 155.8

Rinse reagent identification 3X Acetone 3X $MeCl_2$ 3X Toluene Chipped

Lot #'s Acetone: 870833
$MeCl_2$: 3023 KBW
Toluene: 870840

Used as LPB

MM5IN-2-SM: W88 179.6

PLANT NAME Wheelabrator Millbury Mass

SAMPLING LOCATION Inlet Unit 2 SOA

Run I.D.	Date Used	Initials	Sealed?	Date Cleaned	% SilGel Spent	Initials	Sealed?	Box
MM5-IN-1	2/7/88	SCS	✓	2/08/88	25%	SCS	✓	2
~~SCS MM5-IN-2~~	~~2/7/88~~	~~SCS~~	~~✓~~					
MM5-IN-2	2/8/88	SCS	✓	2/08/88	25%	SCS	✓	2

	Date	Initials	Sealed?
Received in Lab	2/12	SAW	✓

Sampling Method

Remarks:

CUSTODY SHEET FOR MM5 COOLER # DF 108

Date of Makeup 2/5 Initials SAW Sealed? ✓

Individual Tare of Reagent: 200 mls. of DI H_2O

Individual Silica Gel Tare Weight 2X ~~285~~ 400 ~~200~~ gms.

Filter used? / Knockout Impinger Catch? / (✓ or X)

XAD Trap? / Trap # and Tare wt., gms. IN-3 W93 179.5g
~~IN-5 W81 168.8g~~

Rinse reagent identification 3X Acetone, 3X $MeCl_2$, 3X Toluene
Lot #'s 870833 3023 KBW 870840

PLANT NAME Wheelabrator, Millbury Mass.
SAMPLING LOCATION Inlet Unit 2

Run I.D.	Date Used	Initials	Sealed?	Date Cleaned	% SilGel Spent	Initials	Sealed?
MM5-IN-3	2/09/88	SCS	✓	~~2/09/88~~	50%	✓	✓
MM5-IN-5	2/09/88	SCS	✓	2/10/88	2-0%	✓	✓

	Date	Initials	Sealed?
Received in Lab	2/15	SAW	✓

Sampling Method MM5

Remarks:

CUSTODY SHEET FOR MM5 COOLER # DF 105

Date of Makeup 2-4-88 Initials CCM Sealed? ✓

Individual Tare of Reagent: 200 mls. of D.I. H_2O

Individual Silica Gel Tare Weight (2X) - 200 gms.

Filter used? N Knockout Impinger Catch? ✓ (✓ or X)

XAD Trap? ✓ Trap # and Tare wt., gms. IN-4 W86 168.7 g ~~IN-5 W81 168.8 g~~

Rinse reagent identification 3X Acetone, 3X $MeCl_2$, 3X Toluene

Lot # 870883 3023 KBW 870840

PLANT NAME Wheelabrator Millbury Mass.

SAMPLING LOCATION Inlet Unit #2 SDA

Run I.D.	Date Used	Initials	Sealed?	Date Cleaned	% SilGel Spent	Initials	Sealed?
MM5-IN-4	2/08/88	SCS	✓	2/09/88	25%	SCS	✓

	Date	Initials	Sealed?
Received in Lab	2/15	SAW	✓

Sampling Method

Remarks:

CUSTODY SHEET FOR MM5 COOLER # DF 140

Date of Makeup 2-5-88 Initials CMJ Sealed? —

Individual Tare of Reagent: 200 mls. of DI H_2O

Individual Silica Gel Tare Weight 200 gms. ✓

Filter used? ✓ Knockout Impinger Catch? ✓ (✓ or X)

XAD Trap? NO Trap # and Tare wt., gms. _____

Rinse reagent identification 3X Acetone 3X $MeCl_2$ 3X Toluene
Lot 370883 Lot 3023 KBW Lot 870840

PLANT NAME Wheelabrator, Millbury Mass

SAMPLING LOCATION Laboratory Proof Blanks

Run I.D.	Date Used	Initials	Sealed?	Date Cleaned	% SilGel Spent	Initials	Sealed?	Train #
MM5-LPB-1	2/07/88	SCS	✓	2/07/88	0	SCS	✓	#2 IN
MM5-LPB-2	2/07/88	SCS	✓	2/07/88	0	SCS	✓	#17 out

	Date	Initials	Sealed?
Received in Lab	2/15	SAW	✓

Sampling Method MM5

Remarks:

CUSTODY SHEET FOR MM5 COOLER # DF107

Date of Makeup 2-5-88 Initials CCW Sealed? ✓

Individual Tare of Reagent: 200 mls. of DI H_2O

Individual Silica Gel Tare Weight 200 gms.

Filter used? ✓ Knockout Impinger Catch? ✓ (✓ or X)

XAD Trap? _____ Trap # and Tare wt.,gms. _____

Rinse reagent identification 3X Acetone 3X $MeCl_2$ 3X Toluene

PLANT NAME Wheelabrator Millbury Mass.

SAMPLING LOCATION Laboratory Proof Blanks

Run I.D.	Date Used	Initials	Sealed?	Date Cleaned	% SilGel Spent	Initials	Sealed?
	2/07/88	SCS		2/07/88	NA	SCS	✓
	2/07/88	SCS		2/07/88	NA	SCS	✓

	Date	Initials	Sealed?
Received in Lab	2/15	SAW	✓

Sampling Method MM-5

Remarks: Toluene rinse in separate shipment

CUSTODY SHEET FOR MM5 COOLER # DP 130

Date of Makeup 2/4 Initials SAW Sealed? ✓

Individual Tare of Reagent: 200 mls. of DI H_2O

Individual Silica Gel Tare Weight 200 gms.

Filter used? ✓ Knockout Impinger Catch? ✓ (✓ or X)

XAD Trap? — Trap # and Tare wt., gms.

Rinse reagent identification 3X Acetone 3X $MeCl_2$ 3X Toluene

Acetone Lot # 870883
$MeCl_2$ lot # 874724
Toluene lot # 870480

PLANT NAME

SAMPLING LOCATION Laboratory Proof Blank-5 Train 23
Reagent Blanks

Run I.D.	Date Used	Initials	Sealed?	Date Cleaned	% SilGel Spent	Initials	Sealed?
~~MM5~~							
MM5-LPB-5	2/08/88	SCS	✓	2/08/88	0	SCS	✓
MM5-RB	~~2/10/88~~	SCS	✓	~~2/10~~	—	SCS	✓

23

	Date	Initials	Sealed?
Received in Lab	2/15	SAW	✓

Sampling Method Laboratory Proof Blanks and Reagent Blanks

Remarks:

APPENDIX E

PROCESS DATA

- Complete Operating Data Listing
- Trend Plots

(supplied by Radian Corporation)

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR FI2034	SHTR STM TEMP DEG F TI4062	EVG STM PRESS PSIG PIC0106B	BL MST OUTPUT % FIC2034	GRT MST OUTPUT % HIC2034C	NAT GAS FLOW KSCFH FI2153	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F TI2024	PRM AIR PRESS IN H20 PIC2028	SEC AIR PRESS IN H20 PIC2026	OXYGEN % AIC2064
08FEB88	08:51		826	857	33	45	0.0	84.00	148	11.44	26.13	10.66
08FEB88	09:01		826	858	31	43	0.0	83.88	149	12.56	25.75	10.09
08FEB88	09:11		825	857	36	48	0.0	88.00	148	12.66	25.56	10.78
08FEB88	09:21		821	856	40	50	0.0	88.50	147	12.25	26.44	10.84
08FEB88	09:31		825	857	37	49	0.0	84.00	148	13.03	26.31	10.81
08FEB88	09:41		827	860	31	42	0.0	83.63	149	11.63	25.88	10.88
08FEB88	09:51		822	857	32	43	0.0	82.25	150	11.66	25.69	10.72
08FEB88	10:01		826	858	31	42	0.0	81.75	151	12.25	26.13	10.88
08FEB88	10:11		824	856	45	56	0.0	89.63	150	12.22	25.44	12.25
08FEB88	10:21		824	857	37	48	0.0	84.63	149	11.75	25.94	11.91
08FEB88	10:31		823	856	40	52	0.0	88.00	148	11.91	26.13	11.84
08FEB88	10:41	190.0	825	875	39	50	0.0	87.96	148	12.10	25.87	11.19
08FEB88	10:51	187.8	828	859	37	48	0.0	89.13	149	12.03	26.19	11.34
08FEB88	11:01	190.1	833	864	35	46	0.0	86.50	150	13.03	25.63	10.63
08FEB88	11:11	193.6	827	858	33	43	0.0	94.38	147	11.72	25.63	12.25
08FEB88	11:21	190.6	825	857	33	44	0.0	82.75	150	11.56	26.19	11.69
08FEB88	11:31	186.4	828	857	39	51	0.0	86.75	149	12.78	26.25	11.75
08FEB88	11:41	193.7	827	858	29	41	0.0	85.25	149	12.31	26.13	10.84
08FEB88	11:51	188.2	821	857	34	45	0.0	84.00	151	11.25	26.44	11.75
08FEB88	12:01	187.2	819	856	34	45	0.0	83.63	151	11.91	25.63	11.69
08FEB88	12:11	192.3	827	858	25	37	0.0	81.00	152	11.63	25.94	11.56
08FEB88	12:21	188.0	823	857	30	41	0.0	81.38	152	10.91	25.63	11.88
08FEB88	12:31	184.3	820	856	37	48	0.0	84.13	151	11.94	26.19	12.97
08FEB88	12:41	186.4	821	857	33	45	0.0	82.00	152	11.25	26.06	12.47
08FEB88	12:51	189.6	826	859	31	42	0.0	83.63	151	14.00	25.13	12.06
08FEB88	13:01	184.4	826	857	37	47	0.0	84.13	153	12.38	26.13	12.94
08FEB88	13:11		822	857	34	46	0.0	84.50	151	10.91	25.50	12.63
08FEB88	13:21	188.1	825	857	34	45	0.0	86.50	151	12.00	25.94	13.03
08FEB88	13:31	184.7	823	857	38	49	0.0	85.00	152	12.06	25.94	12.78
08FEB88	13:41	190.8	832	859	31	42	0.0	83.13	151	11.94	25.94	12.06
08FEB88	13:51	186.7	829	857	35	46	0.0	84.50	152	11.97	26.00	12.91
08FEB88	14:01	187.8	823	857	35	47	0.0	86.13	151	11.69	25.94	12.44
08FEB88	14:11	186.9	820	857	38	49	0.0	89.38	150	11.50	26.00	13.53
08FEB88	14:21	185.9	824	856	40	51	0.0	86.88	151	11.63	26.00	12.41
08FEB88	14:31						0.0	88.13		11.84	26.00	12.78
08FEB88	14:41	189.5	824	857	42	54	0.0	97.38	145	12.13	24.44	13.16
08FEB88	14:51	181.5	821	856	53	64	0.0	95.00	146	12.16	25.94	13.78
08FEB88	15:01	193.9	827	860	38	48	0.0	92.00	144	11.97	25.63	11.72
08FEB88	15:11	188.0	822	857	43	54	0.0	89.75	147	11.50	25.94	12.66
08FEB88	15:21	191.9	825	857	37	48	0.0	90.75	147	11.81	25.69	11.69
08FEB88	15:31	184.9	824	857	46	57	0.0	91.75	147	12.25	25.75	12.56
08FEB88	15:41	184.4	825	857	52	63	0.0	99.63	143	12.28	25.69	13.38

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR	SHTR STM TEMP DEG F [a]	EVG STM PRESS PSIG [a]	BL MST OUTPUT % [a]	GRT MST OUTPUT % [a]	NAT GAS FLOW KSCFH	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F [a]	PRM AIR PRESS IN H20	SEC AIR PRESS IN H20	OXYGEN %
08FEB88	15:51	186.0	823	856	50	61	0.0	95.63	144	11.66	25.56	12.97
	AVERAGE	188.1	825	858	37	48	0.0	87.00	149	11.99	25.87	11.98

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H20 PIC2025	ATTPTR WTR FLOW KLB/HR FI2011	STM TO ATM KLB/HR FI2317	BL FDWR TEMP DEG F TI2010	BL FDWR FLOW KLB/HR FI2001 a	FURNACE TEMP DEG F TR2021	SPHTR OUT TEMP DEG F TI2021A	SPHTR OUT PRESS IN H20 PI2020 a	ECON OUT TEMP DEG F TI2038A	SDA IN PRESS IN H20 PI2039 a	PREC OUT PRESS IN H20 PI2375
08FEB88	08:51	-0.31	9.8	0	482	160.5	972	973	-0.67	676	-1.97	-3.31
08FEB88	09:01	-0.26	9.8	0	482	161.0	970	971	-0.77	678	-2.12	-3.48
08FEB88	09:11	0.12	9.8	0	483	158.5	966	967	-0.67	682	-1.97	-3.64
08FEB88	09:21	-0.10	10.0	0	486	159.0	966	967	-0.62	684	-2.17	-3.40
08FEB88	09:31	-0.21	11.3	0	489	160.0	990	983	-1.08	684	-2.32	-3.72
08FEB88	09:41	-0.51	10.5	0	490	162.0	976	977	-1.09	684	-1.80	-3.83
08FEB88	09:51	-0.49	9.8	0	487	162.0	972	969	-1.06	680	-1.83	-3.54
08FEB88	10:01	0.05	10.6	0	486	161.0	972	973	-0.97	684	-2.37	-3.45
08FEB88	10:11	-0.29	9.5	0	486	158.0	958	958	-1.07	680	-1.83	-4.05
08FEB88	10:21	-0.37	10.7	0	490	161.5	974	975	-0.78	688	-2.37	-3.38
08FEB88	10:31	-0.13	10.0	0	491	158.0	974	973	-0.82	686	-2.54	-3.66
08FEB88	10:41	0.17	10.0	0	493	162.9	977	969	-0.84	690	-2.25	-3.80
08FEB88	10:51	-0.16	10.0	0	492	160.0	968	972	-1.01	688	-2.16	-4.16
08FEB88	11:01	-0.28	10.0	0	492	162.0	970	970	-0.88	686	-1.89	-3.98
08FEB88	11:11	-0.43	8.0	0	494	157.5	952	968	-1.09	686	-2.38	-4.50
08FEB88	11:21	-0.26	10.2	0	492	164.5	968	967	-1.09	686	-2.26	-3.84
08FEB88	11:31	-0.28	9.5	0	490	162.0	964	962	-1.08	684	-2.20	-4.11
08FEB88	11:41	-0.28	10.0	0	492	161.5	966	969	-0.99	688	-2.13	-3.99
08FEB88	11:51	-0.35	9.0	0	489	163.0	962	965	-0.78	684	-2.18	-3.59
08FEB88	12:01	-0.16	8.7	0	488	161.5	970	970	-0.66	684	-2.14	-3.43
08FEB88	12:11	-0.40	9.8	0	489	161.5	966	972	-0.93	686	-2.05	-3.95
08FEB88	12:21	-0.34	8.8	0	488	160.0	964	966	-0.88	684	-2.22	-3.91
08FEB88	12:31	-0.23	8.7	0	490	158.5	970	969	-0.93	686	-2.14	-4.20
08FEB88	12:41	-0.34	9.0	0	493	161.5	966	968	-0.91	690	-2.33	-3.99
08FEB88	12:51	-0.28	8.7	0	495	159.5	966	968	-1.06	692	-2.05	-4.28
08FEB88	13:01	-0.20	8.3	0	495	160.0	956	956	-0.96	686	-2.24	-3.98
08FEB88	13:11	-0.42	8.3	0	493	160.5	962	964	-1.11	688	-2.20	-4.30
08FEB88	13:21	-0.17	7.9	0	494	159.5	960	963	-0.64	692	-2.42	-4.17
08FEB88	13:31	-0.29	7.9	0	496	162.5	960	959	-0.96	692	-2.68	-4.31
08FEB88	13:41	-0.08	8.7	0	498	160.5	958	960	-0.58	696	-1.99	-3.72
08FEB88	13:51	-0.38	8.4	0	495	164.5	954	953	-1.05	688	-2.19	-4.19
08FEB88	14:01	-0.48	8.0	0	494	161.5	960	962	-1.15	692	-2.37	-4.48
08FEB88	14:11	-0.32	7.5	0	497	160.5	962	964	-0.80	694	-2.45	-4.39
08FEB88	14:21	-0.24	8.5	0	499	159.5	964	961	-0.79	694	-2.04	-3.86
08FEB88	14:31	-0.39	8.1	0		165.0	958		-0.90	690		-4.11
08FEB88	14:41	-0.07	7.0	0	501	156.0	950	958	-0.83	698	-1.79	-4.78
08FEB88	14:51	-0.28	7.7	0	502	163.5	958	955	-0.90	694	-2.50	-4.34
08FEB88	15:01	-0.37	8.0	0	503	161.5	958	964	-0.92	702	-1.86	-4.20
08FEB88	15:11	-0.24	7.5	0	498	164.5	964	965	-1.24	694	-2.58	-4.23
08FEB88	15:21	-0.25	8.0	0	495	162.0	968	972	-1.00	694	-2.24	-4.19
08FEB88	15:31	-0.11	7.7	0	493	164.0	964	961	-0.93	694	-2.31	-4.16
08FEB88	15:41	-0.11	7.4	0	498	158.0	946	949	-0.76	696	-2.33	-4.66

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H20	ATTPTR WTR FLOW KLB/HR	STM TO ATM KLB/HR	BL FDWR TEMP DEG F	BL FDWR[a] FLOW KLB/HR	FURNACE TEMP DEG F	SPHTR OUT TEMP DEG F	SPHTR[a] OUT PRESS IN H20	ECON OUT TEMP DEG F	SDA IN[a] PRESS IN H20	PREC OUT PRESS IN H20
08FEB88	15:51	-0.49	8.0	0	501	163.0	952	951	-1.26	696	-2.12	-4.72
	AVERAGE	-0.26	9.0	0	492	161.0	964	966	-0.92	688	-2.19	-4.00

[a] THIS PARAMETER WAS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F TR2040	SPRY DRY OUT TEMP DEG F TIC2551	LIME SLRY CONC PERCENT HC2378	a DILUTION WATER GPM FIC2580	a TOT SLRY FLOW GPM FIC2552	IN SO2 CONC PPM AI2378	a IN SO2 FACTOR LB/MBTU AI2390	a OUT SO2 CONC PPM AIC2379A	OUT SO2 FACTOR LB/MBTU AI2386	a SO2 REMOVAL % AIC2378A	CO CONC PPM AI2379C
08FEB88	08:51	427	252	63.5	13.8	36.6	193.2	0.594	22.7	0.169	82.0	16.3
08FEB88	09:01	428	256	66.1	14.1	36.9	294.7	2.042	44.1	0.166	84.8	21.2
08FEB88	09:11	430	255	70.0	12.4	39.0	207.1	0.647	36.3	0.151	81.0	18.6
08FEB88	09:21	432	255	57.4	17.1	40.9	170.6	0.549	27.0	0.097	87.8	23.3
08FEB88	09:31	434	255	34.6	25.7	40.6	80.1	0.368	17.1	0.007	94.8	15.5
08FEB88	09:41	434	254	24.4	29.3	39.1	92.8	0.294	6.5	0.055	88.5	13.7
08FEB88	09:51	431	254	35.6	23.3	37.0	146.2	0.453	18.3	0.082	74.8	14.7
08FEB88	10:01	430	256	54.7	18.7	37.1	91.2	0.622	25.3	0.078	87.3	15.5
08FEB88	10:11	431	255	61.0	14.5	38.8	186.8	0.597	25.3	0.150	81.8	12.4
08FEB88	10:21	434	257	63.4	15.6	40.9	192.8	0.614	34.1	0.093	87.0	16.4
08FEB88	10:31	436	254	48.1	21.1	41.1	128.1	0.903	21.3	0.010	92.3	16.2
08FEB88	10:41	437	253	27.7	27.9	38.0	79.1	0.259	18.3	0.064	76.6	15.3
08FEB88	10:51	437	253	48.5	20.8	39.5	87.9	0.284	13.6	0.077	74.5	12.4
08FEB88	11:01	436	256	63.8	17.2	39.6	92.9	0.611	19.8	0.104	88.8	13.1
08FEB88	11:11	439	255	63.1	16.9	41.3	159.3	0.474	26.0	0.070	72.5	18.7
08FEB88	11:21	436	255	37.1	23.3	43.4	106.5	0.371	16.9	0.035	94.3	9.3
08FEB88	11:31	436	253	58.3	17.0	38.1	96.2	0.358	15.3	0.076	86.3	11.9
08FEB88	11:41	437	257	56.4	18.3	41.1	114.3	0.366	18.1	0.038	87.5	11.8
08FEB88	11:51	434	252	43.3	21.7	40.9	100.8	0.347	7.8	0.072	90.3	9.4
08FEB88	12:01	434	255	59.4	13.0	37.4	75.2	0.349	20.4	0.057	90.3	5.8
08FEB88	12:11	435	257	39.1	24.9	40.1	90.9	0.289	10.6	0.018	94.8	11.0
08FEB88	12:21	435	253	43.0	22.9	39.3	56.3	0.207	7.3	0.059	80.8	8.6
08FEB88	12:31	437	257	33.1	27.4	39.8	79.0	0.363	11.0	0.000	93.0	12.4
08FEB88	12:41	439	255	37.0	26.4	42.6	43.6	0.150	2.2	0.039	92.5	8.4
08FEB88	12:51	441	254	49.9	21.3	39.3	57.6	0.199	12.3	0.009	87.0	13.2
08FEB88	13:01	439	256	20.5	32.7	43.1	77.1	0.426	2.4	0.000	100.5	8.5
08FEB88	13:11	439	253	55.6	16.4	39.4	52.0	0.187	9.6	0.057	71.5	14.1
08FEB88	13:21	441	257	52.9	22.1	41.5	47.9	0.182	9.7	0.024	92.8	9.2
08FEB88	13:31	442	255	47.7	21.8	44.6	46.9	0.245	7.1	0.019	93.5	7.9
08FEB88	13:41	443	255	49.5	23.0	43.3	79.3	0.260	12.4	0.010	89.5	6.8
08FEB88	13:51	439	253	34.3	27.1	43.3	67.2	0.227	4.9	0.036	88.3	8.1
08FEB88	14:01	441	255	55.1	19.9	40.4	46.5	0.316	14.8	0.033	88.0	11.5
08FEB88	14:11	444	257	64.1	17.4	45.5	94.8	0.348	12.3	0.082	81.0	17.2
08FEB88	14:21	444	255	56.8	18.6	45.5	104.5	0.366	14.9	0.064	85.0	14.7
08FEB88	14:31	442	255			44.1			22.4		88.0	12.5
08FEB88	14:41	448	257	70.0	15.2	44.6	153.3	0.566	37.8	0.163	70.5	17.3
08FEB88	14:51	446	255	52.2	20.7	49.4	130.6	0.500	21.8	0.099	91.3	13.4
08FEB88	15:01	449	255	57.3	18.8	44.1	115.5	0.393	31.4	0.059	87.8	24.1
08FEB88	15:11	442	253	34.0	26.7	46.1	83.4	0.292	7.5	0.044	92.5	22.7
08FEB88	15:21	442	254	68.3	13.0	40.1	98.7	0.330	22.8	0.070	67.8	21.7
08FEB88	15:31	441	256	41.3	24.4	43.1	170.3	0.591	11.2	0.015	94.8	17.2
08FEB88	15:41	445	256	32.2	33.3	42.9	53.2	0.200	5.4	0.020	86.5	20.3
08FEB88	15:51	446	255	51.9	22.6	46.8	84.8	0.285	9.3	0.104	79.5	17.9

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F	SPRY DRY OUT TEMP DEG F	LIME SLRY CONC PERCENT	DILUTION[a] WATER GPM	TOT SLRY[a] FLOW GPM	IN SO2[a] CONC PPM	IN SO2[a] FACTOR LB/MBTU	OUT SO2 CONC PPM	OUT SO2[a] FACTOR LB/MBTU	SO2 REMOVAL %	CO CONC PPM
	AVERAGE	438	255	49.6	20.9	41.3	107.8	0.429	17.1	0.064	86.0	14.2

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F TI2376	FLD 1 SEC VOLT KV EI2586	FLD 2 SEC VOLT KV EI2587	FLD 3 SEC VOLT KV EI2588
		a		a	a
08FEB88	08:52	252	54.1	55.0	60.2
08FEB88	09:02	254	56.8	55.6	59.7
08FEB88	09:12	253	55.6	55.5	60.2
08FEB88	09:22	253	54.6	56.5	56.4
08FEB88	09:32	252	53.4	54.2	60.0
08FEB88	09:42	252	54.4	55.7	59.5
08FEB88	09:52	252	53.6	55.4	59.5
08FEB88	10:02	254	52.1	50.8	60.1
08FEB88	10:12	253	53.0	56.1	59.6
08FEB88	10:22	254	54.6	52.8	59.4
08FEB88	10:32	254	54.0	54.5	59.5
08FEB88	10:42	253	53.9	54.0	59.3
08FEB88	10:52	255	53.0	53.9	59.1
08FEB88	11:02	255	53.1	54.9	59.3
08FEB88	11:12	256	57.0	54.4	59.9
08FEB88	11:22	253	54.8	54.2	59.6
08FEB88	11:32	255	55.4	55.7	60.1
08FEB88	11:42	256	53.4	52.9	60.1
08FEB88	11:52	254	54.0	54.1	58.1
08FEB88	12:02	256	57.0	54.1	59.6
08FEB88	12:12	255	55.8	51.9	59.9
08FEB88	12:22	255	57.1	54.8	59.9
08FEB88	12:32	256	55.4	52.5	58.3
08FEB88	12:42	254	53.0	53.9	59.9
08FEB88	12:52	256	53.1	54.3	55.7
08FEB88	13:02	253	52.1	54.6	58.0
08FEB88	13:12	255	52.1	54.3	58.0
08FEB88	13:22	256	55.4	53.4	60.3
08FEB88	13:32	254	53.0	53.7	59.8
08FEB88	13:42	255	54.4	52.8	52.5
08FEB88	13:52	253	54.1	55.0	57.9
08FEB88	14:02	255	52.1	52.8	59.4
08FEB88	14:12	255	53.1	55.2	60.2
08FEB88	14:22	254	54.4	54.2	60.1
08FEB88	14:32		56.8		
08FEB88	14:42	257	57.6	48.5	60.0
08FEB88	14:52	252	53.4	50.8	55.7
08FEB88	15:02	256	55.1	53.8	60.3
08FEB88	15:12	252	53.1	53.2	59.0
08FEB88	15:22	255	54.4	53.5	59.5
08FEB88	15:32	254	53.8	53.7	53.3
08FEB88	15:42	256	52.6	54.1	59.6

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F [a]	FLD 1 SEC VOLT KV [a]	FLD 2 SEC VOLT KV [a]	FLD 3 SEC VOLT KV [a]
08FEB88	15:52	253	51.4	50.9	60.4
	AVERAGE	254	54.2	53.9	59.0

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 1C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 ESP OPERATING DATA

DATE	TIME	PRIMARY VOLTAGE VOLTS AC FIELD			PRIMARY CURRENT AMPS AC FIELD			SECONDARY VOLTAGE KVOLTS DC FIELD			SECONDARY CURRENT AMPS DC FIELD			SPARK RATE SPARKS/MIN X10 FIELD		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
08FEB88	08:59	330	330	380	112	172	167	38	45	50	0.66	1.07	1.06	0	0	0
08FEB88	09:29	280	330	380	120	175	171	44	44	49	0.69	1.09	1.07	0	0	0
08FEB88	09:59	310	340	360	109	180	161	42	44	49	0.62	1.05	1.03	0	0	0
08FEB88	10:29	290	330	370	110	178	171	46	44	49	0.66	1.05	1.08	0	0	0
08FEB88	11:00	300	330	370	122	177	170	45	45	49	0.65	1.08	1.07	0	0	0
08FEB88	11:29	330	340	370	84	176	169	50	46	49	0.69	1.03	1.06	0	0	0
08FEB88	12:00	330	340	380	105	173	169	47	46	49	0.51	1.08	0.99	1	0	0
08FEB88	12:30	320	340	350	112	178	155	43	45	48	0.46	1.08	0.97	1	0	0
08FEB88	13:00	280	330	370	101	176	170	42	44	50	0.62	1.05	1.07	0	0	0
08FEB88	13:30	310	330	370	118	180	168	44	44	49	0.68	1.10	1.04	0	0	0
08FEB88	14:00	310	330	370	119	175	167	42	41	50	0.57	0.78	1.07	0	0	0
08FEB88	14:30	300	330	380	94	121	171	48	43	50	0.66	0.88	1.04	0	0	0
08FEB88	15:00	310	320	360	116	162	162	46	44	49	0.59	0.98	1.02	0	0	0
08FEB88	15:30	300	340	370	111	174	165	45	46	49	0.68	1.04	1.04	0	0	0
	AVERAGE	307	333	370	110	171	167	44	44	49	0.62	1.03	1.04	0	0	0

TEST 2C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR FI2034	SHTR STM TEMP[a] DEG F TI4062	EVG STM PRESS[a] PSIG PIC0106B	BL MST OUTPUT[a] % FIC2034	GRT MST OUTPUT[a] % HIC2034C	NAT GAS FLOW KSCFH FI2153	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP[a] DEG F TI2024	PRM AIR PRESS IN H20 PIC2028	SEC AIR PRESS IN H20 PIC2026	OXYGEN % AIC2064
08FEB88	16:01	191.2	830	861	40	52	0.0	89.75	145	11.59	26.06	12.84
08FEB88	16:11	191.3	822	857	39	50	0.0	92.50	145	12.06	25.69	12.25
08FEB88	16:21	190.3	823	858	38	49	0.0	91.00	146	12.75	26.00	12.00
08FEB88	16:31	191.6	826	859	33	44	0.0	86.63	148	12.59	25.63	12.34
08FEB88	16:41	191.1	829	861	31	43	0.0	83.88	149	12.78	26.06	11.81
08FEB88	16:51	184.5	827	857	39	51	0.0	83.88	149	11.66	25.75	12.09
08FEB88	17:01	186.7	829	857	37	48	0.0	85.50	148	12.56	26.31	11.50
08FEB88	17:11	183.7	827	857	46	57	0.0	92.75	145	12.28	25.94	12.50
08FEB88	17:21	185.6	825	857	45	56	0.0	90.75	144	11.97	26.19	12.69
08FEB88	17:31	192.6	829	858	38	49	0.0	88.50	143	11.72	26.44	12.44
08FEB88	17:41	187.5	821	856	44	55	0.0	92.25	143	12.56	26.06	12.63
08FEB88	17:51	183.6	822	857	54	65	0.0	99.25	140	12.66	25.88	13.50
08FEB88	18:01	184.1	820	856	57	65	0.0	99.75	138	12.25	25.88	13.56
08FEB88	18:11	191.1	829	857	42	50	0.0	88.13	141	11.19	26.13	12.59
08FEB88	18:21	186.2	824	857	52	61	0.0	99.75	138	11.66	25.75	12.66
08FEB88	18:31	190.7	826	858	40	49	0.0	89.38	142	12.34	25.31	12.38
08FEB88	18:41	183.3	823	858	55	63	0.0	100.88	138	11.88	25.19	13.13
08FEB88	18:51	186.9	822	856	51	60	0.0	98.25	138	12.53	25.94	12.56
08FEB88	19:01	190.6	824	857	44	52	0.0	93.13	139	12.03	25.94	12.25
08FEB88	19:11	191.2	826	865	37	45	0.0	87.50	143	12.25	26.00	12.34
08FEB88	19:21	186.7	824	857	42	50	0.0	89.38	143	12.44	26.25	12.59
08FEB88	19:31	187.1	824	857	44	52	0.0	92.63	141	13.28	25.88	12.09
08FEB88	19:41	182.1	822	856	57	64	0.0	98.50	137	12.25	25.63	12.78
08FEB88	19:51	182.9	822	856	60	69	0.0	101.25	136	12.00	26.31	13.13
08FEB88	20:01	190.9	825	859	43	50	0.0	87.75	141	12.91	26.44	12.66
08FEB88	20:11	186.6	830	859	50	56	0.0	93.88	140	11.66	26.00	12.34
08FEB88	20:21	185.0	823	857	53	59	0.0	96.88	140	12.19	26.31	12.84
08FEB88	20:31	192.5	831	859	39	45	0.0	85.25	141	11.34	25.44	11.47
08FEB88	20:41	193.8	831	861	34	40	0.0	84.00	142	11.88	26.25	11.69
08FEB88	20:51	187.6	822	857	40	46	0.0	86.75	144	11.66	25.75	12.22
08FEB88	21:01	190.7	827	858	34	37	0.0	83.88	144	12.69	26.44	11.59
08FEB88	21:11	186.7	822	858	41	45	0.0	89.25	143	12.88	26.19	11.69
08FEB88	21:21	186.2	826	857	42	46	0.0	88.38	143	11.94	26.38	11.91
	AVERAGE	188.0	825	858	44	52	0.0	91.25	142	12.19	25.98	12.40

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 2C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H20 PIC2025	ATTPTR WTR FLOW KLB/HR FI2011	STM TO ATM KLB/HR FI2317 [a]	BL FDWR TEMP DEG F TI2010 [a]	BL FDWR FLOW KLB/HR FI2001	FURNACE TEMP DEG F TR2021	SPHTR OUT TEMP DEG F TI2021A [a]	SPHTR OUT PRESS IN H20 PI2020	ECON OUT TEMP DEG F TI2038A	SDA IN PRESS IN H20 PI2039 [a]	PREC OUT PRESS IN H20 PI2375
08FEB88	16:01	-0.21	9.5	0	503	163.5	960	960	-0.99	698	-2.31	-4.078
08FEB88	16:11	-0.22	7.8	0	498	164.5	956	963	-0.90	694	-1.87	-4.125
08FEB88	16:21	-0.21	8.1	0	493	164.5	964	967	-0.79	694	-1.96	-4.063
08FEB88	16:31	-0.38	9.3	0	490	163.0	968	974	-1.15	694	-2.01	-4.109
08FEB88	16:41	-0.49	9.8	0	489	164.5	970	971	-1.05	690	-2.25	-3.727
08FEB88	16:51	-0.12	8.8	0	485	162.5	964	959	-0.85	684	-2.29	-3.688
08FEB88	17:01	0.11	9.6	0	486	159.5	968	967	-0.73	688	-1.96	-3.531
08FEB88	17:11	-0.49	8.4	0	489	157.5	958	958	-1.05	692	-2.54	-4.219
08FEB88	17:21	-0.30	9.0	0	495	159.5	960	958	-1.09	692	-1.63	-4.25
08FEB88	17:31	-0.35	9.2	0	500	159.0	962	965	-0.55	702	-2.01	-3.391
08FEB88	17:41	-0.01	7.9	0	498	162.5	956	956	-0.69	696	-2.26	-4.047
08FEB88	17:51	0.03	6.8	0	501	158.5	948	949	-0.67	700	-2.88	-4.516
08FEB88	18:01	-0.34	7.0	0	505	158.5	950	946	-1.07	700	-2.58	-4.875
08FEB88	18:11	-0.42	9.2	0	504	168.5	962	961	-0.82	702	-2.22	-3.641
08FEB88	18:21	-0.01	6.3	0	500	160.5	946	948	-0.95	700	-2.42	-4.828
08FEB88	18:31	-0.38	8.3	0	499	167.5	958	959	-1.22	698	-1.96	-4.531
08FEB88	18:41	-0.23	6.5	0	498	158.5	946	946	-1.08	700	-2.07	-5.016
08FEB88	18:51	-0.38	7.1	0	503	163.5	942	942	-1.14	704	-2.41	-4.719
08FEB88	19:01	-0.40	7.7	0	502	165.0	954	955	-1.05	702	-1.95	-4.344
08FEB88	19:11	-0.07	8.3	0	498	165.5	964	964	-0.95	698	-2.18	-3.938
08FEB88	19:21	-0.15	7.7	0	492	164.0	960	960	-0.80	694	-2.22	-3.984
08FEB88	19:31	-0.34	7.6	0	493	162.5	962	962	-1.08	700	-2.08	-4.234
08FEB88	19:41	-0.25	6.8	0	498	155.0	948	949	-1.09	702	-2.70	-4.703
08FEB88	19:51	-0.06	6.2	0	504	160.0	944	944	-0.55	702	-2.57	-4.547
08FEB88	20:01	-0.01	8.3	0	503	167.5	962	958	-0.92	702	-2.31	-3.859
08FEB88	20:11	-0.26	7.6	0	497	163.5	956	956	-0.99	700	-2.14	-4.25
08FEB88	20:21	-0.34	6.3	0	495	162.0	954	955	-0.85	698	-2.34	-4.359
08FEB88	20:31	-0.33	8.7	0	497	164.5	968	966	-0.88	702	-2.03	-3.609
08FEB88	20:41	-0.34	9.1	0	494	164.5	970	969	-1.07	700	-1.87	-3.742
08FEB88	20:51	-0.47	7.2	0	489	163.5	960	961	-1.29	692	-2.35	-4.219
08FEB88	21:01	-0.07	8.5	0	488	165.0	974	976	-0.67	696	-1.80	-3.344
08FEB88	21:11	-0.13	7.0	0	497	159.5	964	966	-0.82	694	-2.21	-4
08FEB88	21:21	-0.35	7.5	0	488	161.5	962	962	-0.88	692	-2.36	-3.789
	AVERAGE	-0.24	8.0	0	496	162.4	959	959	-0.93	697	-2.20	-4.13

[a] THIS PARAMETER WAS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 2C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F TR2040	SPRY DRY OUT TEMP DEG F TIC2551	LIME SLRY CONC PERCENT HC2378	[a] DILUTION WATER GPM FIC2580	[a] TOT SLRY FLOW GPM FIC2552	[a] IN SO2 CONC PPM AI2378	[a] IN SO2 FACTOR LB/MBTU AI2390	OUT SO2 CONC PPM AIC2379A	[a] OUT SO2 FACTOR LB/MBTU AI2386	SO2 REMOVAL % AIC2378A	CO CONC PPM AI2379C
08FEB88	16:01	446	255	53.4	20.9	44.3	104.6	0.407	29.9	0.039	87.8	20.3
08FEB88	16:11	443	254	61.4	17.0	44.6	107.9	0.376	14.7	0.090	82.5	14.7
08FEB88	16:21	440	254	59.1	17.9	42.1	102.8	0.348	15.6	0.079	82.5	11.7
08FEB88	16:31	437	255	63.4	15.4	41.5	134.6	0.422	26.0	0.069	86.5	14.1
08FEB88	16:41	435	254	68.1	11.2	40.1	122.4	0.385	20.2	0.096	83.3	11.9
08FEB88	16:51	431	254	69.7	11.5	38.1	120.7	0.414	28.2	0.107	78.5	10.9
08FEB88	17:01	434	257	68.6	13.4	39.8	135.2	0.585	30.4	0.148	88.0	12.4
08FEB88	17:11	437	255	70.0	13.0	41.0	169.8	0.574	42.4		72.5	12.4
08FEB88	17:21	440	257	59.0	18.3	43.6	120.9	0.425	28.1	0.027	86.3	10.2
08FEB88	17:31	445	255	42.1	26.5	45.0	68.0	0.396	16.6	0.006	81.3	24.2
08FEB88	17:41	443	253	41.3	24.2	43.6	69.2	0.251	6.5	0.074	77.8	11.0
08FEB88	17:51	447	256	49.5	24.3	42.9	53.9	0.209	14.5	0.015	86.5	23.6
08FEB88	18:01	450	257	36.7	29.5	50.0	74.7	0.275	5.5	0.034	94.3	23.4
08FEB88	18:11	446	252	46.3	23.3	46.6	95.0	0.336	15.5	0.021	94.0	11.0
08FEB88	18:21	448	254	67.9	14.9	42.6	100.9	0.369	18.2	0.096	61.6	26.6
08FEB88	18:31	444	257	37.2	26.7	49.5	102.5	0.410	11.8	0.000	96.8	10.2
08FEB88	18:41	446	251	58.8	17.7	41.5	69.6	0.278	12.8	0.064	75.0	18.6
08FEB88	18:51	448	261	28.0	36.8	48.4	75.1	0.258	8.0	0.001	98.0	11.0
08FEB88	19:01	446	249	67.0	15.5	47.3	58.4	0.338	12.9	0.099	78.0	12.5
08FEB88	19:11	441	255	34.3	27.5	42.1	55.9	0.199	11.8	0.000	100.3	8.6
08FEB88	19:21	439	253	45.6	22.2	41.0	52.1	0.186	6.1	0.050	73.0	11.7
08FEB88	19:31	441	256	39.9	26.0	40.1	110.4	0.819	10.9	0.013	97.3	14.6
08FEB88	19:41	446	257	31.0	32.5	45.3	50.9	0.182	4.4	0.042	84.0	20.4
08FEB88	19:51	448	255	39.4	27.9	45.6	52.3	0.204	9.7	0.027	86.3	21.1
08FEB88	20:01	444	255	26.5	30.0	46.0	67.4	0.358	8.9	0.004	96.8	14.3
08FEB88	20:11	442	252	49.6	21.9	39.4	49.6	0.168	10.3	0.019	75.8	12.5
08FEB88	20:21	442	256	25.0	33.8	43.6	51.7	0.179	2.2	0.015	93.0	14.4
08FEB88	20:31	442	255	62.4	17.2	42.6	119.6	0.841	27.3	0.141	76.8	14.6
08FEB88	20:41	439	255	66.1	13.4	42.0	210.9	0.654	47.3	0.118	79.8	14.0
08FEB88	20:51	435	253	70.0	11.3	40.5	146.4	0.513	27.3	0.114	82.5	7.9
08FEB88	21:01	435	256	47.4	20.4	40.4	124.5	0.417	26.3	0.034	92.0	15.0
08FEB88	21:11	435	253	66.4	13.9	39.9	144.1	0.514	15.1	0.169	69.5	11.8
08FEB88	21:21	434	256	39.8	24.0	39.6	6.0	0.002	22.7	0.146	100.8	10.2
	AVERAGE	441	255	51.2	21.2	43.0	94.8	0.372	17.8	0.061	84.8	14.6

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 2C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F TI2376	FLD 1 SEC VOLT KV EI2586 [a]	FLD 2 SEC VOLT KV EI2587 [a]	FLD 3 SEC VOLT KV EI2588 [a]
08FEB88	16:02	254	51.1	53.5	57.8
08FEB88	16:12	254	52.8	52.5	60.4
08FEB88	16:22	253	52.8	54.9	59.8
08FEB88	16:32	253	54.0	53.9	60.2
08FEB88	16:42	253	54.8	53.8	60.1
08FEB88	16:52	254	54.4	55.8	57.1
08FEB88	17:02	255	54.6	55.1	60.3
08FEB88	17:12	255	57.0	53.8	53.0
08FEB88	17:22	255	55.1	56.0	59.9
08FEB88	17:32	255	55.4	55.5	57.2
08FEB88	17:42	253	52.8	52.3	57.9
08FEB88	17:52	256	54.4	53.4	55.4
08FEB88	18:02	253	52.1	54.9	59.9
08FEB88	18:12	253	52.8	53.4	56.4
08FEB88	18:22	255	54.0	55.1	59.3
08FEB88	18:32	252	51.1	53.7	60.2
08FEB88	18:42	255	55.8	54.8	59.9
08FEB88	18:52	255	54.8	54.1	60.1
08FEB88	19:02	250	53.4	53.1	60.1
08FEB88	19:12	254	54.6	54.5	59.5
08FEB88	19:22	253	53.4	54.2	60.1
08FEB88	19:32	255	53.8	53.6	59.8
08FEB88	19:42	255	52.8	53.2	58.7
08FEB88	19:52	254	53.0	50.6	59.4
08FEB88	20:02	251	51.8	55.1	56.9
08FEB88	20:12	254	53.8	51.4	58.3
08FEB88	20:22	253	52.0	53.7	56.6
08FEB88	20:32	253	51.1	54.6	59.0
08FEB88	20:42	254	53.0	53.5	59.7
08FEB88	20:52	253	53.6	55.2	59.7
08FEB88	21:02	253	54.1	53.4	59.3
08FEB88	21:12	253	55.1	55.0	58.5
08FEB88	21:22	254	56.4	53.2	58.4
	AVERAGE	254	53.7	54.0	58.8

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 2C
TEST DATE: 02/08/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 ESP OPERATING DATA

DATE	TIME	PRIMARY VOLTAGE VOLTS AC FIELD			PRIMARY CURRENT AMPS AC FIELD			SECONDARY VOLTAGE KVOLTS DC FIELD			SECONDARY CURRENT AMPS DC FIELD			SPARK RATE SPARKS/MIN X10 FIELD		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
08FEB88	16:31	310	330	370	116	175	170	43	45	50	0.55	1.06	1.08	0	0	0
08FEB88	17:00	320	330	380	114	173	170	48	45	50	0.70	1.02	1.07	0	0	0
08FEB88	17:30	310	330	380	121	173	170	44	44	50	0.62	1.03	1.08	0	0	0
08FEB88	18:00	300	320	370	121	178	161	44	44	50	0.68	1.08	1.04	0	0	0
08FEB88	18:30	300	320	370	120	177	170	43	43	49	0.66	1.07	1.07	0	0	0
08FEB88	19:00	300	310	370	119	169	166	44	44	49	0.68	1.03	1.05	0	0	0
08FEB88	19:30	320	330	380	122	177	170	45	45	50	0.69	1.11	1.08	0	0	0
08FEB88	20:00	290	320	370	110	179	172	43	43	49	0.59	1.02	1.08	0	0	0
08FEB88	20:30	300	330	370	119	175	174	42	44	49	0.62	1.08	1.09	0	0	0
08FEB88	21:00	300	330	370	109	178	174	42	45	50	0.53	1.11	1.07	0	0	0
	AVERAGE	305	325	373	117	175	170	44	44	50	0.63	1.06	1.07	0	0	0

TEST 3C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR FI2002B	SHTR STM TEMP DEG F TI4062	EVG STM PRESS PSIG PIC0106B	BL MST OUTPUT % FIC2034 [a]	GRT MST OUTPUT % HIC2034C [a]	NAT GAS FLOW KSCFH FI2153 [a]	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F TI2024 [a]	PRM AIR PRESS IN H20 PIC2028	SEC AIR PRESS IN H20 PIC2026	OXYGEN % AIC2064
09FEB88	08:35	185.5	824	857	35	32	0.0	82.75	145	11.72	25.25	11.84
09FEB88	08:45	190.5	824	858	29	26	0.0	78.00	146	12.28	26.31	10.63
09FEB88	08:55	188.0	826	857	32	28	0.0	80.63	147	13.09	25.38	10.66
09FEB88	09:05	186.5	827	857	34	31	0.0	81.13	147	12.03	25.69	11.06
09FEB88	09:15	188.0	822	856	34	31	0.0	82.75	145	12.44	25.75	11.03
09FEB88	09:25	184.0	822	857	42	39	0.0	88.50	144	12.09	25.63	11.75
09FEB88	09:35	190.0	824	858	35	32	0.0	83.75	143	12.56	26.19	11.47
09FEB88	09:45	188.0	824	857	37	34	0.0	84.38	145	11.38	25.81	11.34
09FEB88	09:55	188.5	826	857	35	31	0.0	81.00	147	10.75	26.50	11.31
09FEB88	10:05	188.5	826	857	33	30	0.0	81.88	147	12.47	25.94	10.91
09FEB88	10:15	189.5	826	865	28	27	0.0	80.75	148	11.97	26.31	9.97
09FEB88	10:25	187.0	822	857	33	30	0.0	81.38	149	12.00	25.69	11.03
09FEB88	10:35	187.0	826	858	37	33	0.0	84.00	147	12.66	25.88	10.88
09FEB88	10:45	187.0	824	857	37	35	0.0	84.13	148	12.59	26.00	11.59
09FEB88	10:55	189.0	828	857	36	33	0.0	83.25	147	12.25	26.31	11.25
09FEB88	11:05	187.5	824	857	38	36	0.0	85.75	147	12.75	25.88	11.59
09FEB88	11:15	185.5	826	857	40	37	0.0	86.50	148	11.75	26.50	12.06
09FEB88	11:25	191.0	828	858	32	29	0.0	81.13	149	11.38	26.06	10.88
09FEB88	11:35	189.5	822	857	31	28	0.0	79.88	151	12.19	26.19	11.78
09FEB88	11:45	187.0	822	856	34	31	0.0	83.25	150	13.00	26.38	12.06
09FEB88	11:55	186.0	822	857	40	36	0.0	85.00	150	11.47	26.25	11.91
09FEB88	12:05	188.5	824	857	34	32	0.0	83.13	149	12.34	26.25	11.59
09FEB88	12:15	185.0	822	857	38	35	0.0	84.75	150	12.56	26.25	12.25
09FEB88	12:25	183.5	824	858	44	40	0.0	89.13	148	12.31	26.38	12.66
09FEB88	12:35	183.5	822	857	50	47	0.0	91.38	146	11.75	25.94	12.41
09FEB88	12:45	184.0	822	857	50	47	0.0	94.88	144	11.91	26.06	12.59
09FEB88	12:55	195.0	830	865	32	29	0.0	80.88	148	12.13	25.94	11.38
09FEB88	13:05	190.0	820	858	36	33	0.0	82.25	151	11.59	25.69	11.22
09FEB88	13:15	191.5	830	857	33	30	0.0	77.50	152	11.13	26.00	11.63
09FEB88	13:25	185.0	824	857	44	41	0.0	85.13	151	11.72	26.19	12.78
	AVERAGE	187.7	824	858	36	33	0.0	83.63	148	12.08	26.02	11.52

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 3C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H20 PIC2025	ATTPTR WTR FLOW KLB/HR FI2011	STM TO ATM KLB/HR FI2317	BL FDWR TEMP DEG F TI2010	BL FDWR FLOW KLB/HR FI2001	FURNACE TEMP DEG F TR2021	SPHTR OUT TEMP DEG F TI2021A	SPHTR OUT PRESS IN H20 PI2020	ECON OUT TEMP DEG F TI2038A	SDA IN PRESS IN H20 PI2039 [a]	PREC OUT PRESS IN H20 PI2375
09FEB88	08:35	-0.53	9.8	0	480	158.5	982	982	-1.33	676	-2.12	-3.91
09FEB88	08:45	-0.08	10.9	0	482	163.0	992	989	-0.65	680	-1.98	-2.99
09FEB88	08:55	0.05	9.8	0	480	163.0	980	981	-0.60	676	-2.12	-3.08
09FEB88	09:05	-0.02	9.5	0	480	161.5	972	973	-0.80	676	-1.82	-3.45
09FEB88	09:15	-0.31	9.8	0	482	161.0	970	970	-1.26	680	-2.26	-3.73
09FEB88	09:25	-0.44	8.8	0	483	159.5	960	960	-0.90	678	-2.23	-4.06
09FEB88	09:35	-0.13	10.1	0	487	163.5	982	982	-0.47	684	-1.81	-3.21
09FEB88	09:45	-0.77	9.7	0	486	163.0	978	978	-1.18	684	-2.16	-3.78
09FEB88	09:55	-0.58	9.7	0	485	161.5	980	980	-1.11	680	-2.09	-3.56
09FEB88	10:05	-0.21	9.9	0	483	162.5	984	984	-1.26	682	-1.99	-3.76
09FEB88	10:15	-0.14	10.3	0	482	163.0	998	998	-0.93	680	-1.54	-3.61
09FEB88	10:25	-0.53	9.3	0	480	162.0	984	984	-1.41	678	-2.10	-3.91
09FEB88	10:35	-0.09	10.1	0	483	158.0	982	982	-0.72	682	-1.91	-3.58
09FEB88	10:45	-0.15	9.5	0	485	159.5	982	982	-0.84	682	-2.09	-3.59
09FEB88	10:55	-0.25	9.7	0	487	160.5	976	976	-0.98	684	-2.03	-3.55
09FEB88	11:05	-0.05	8.4	0	486	162.0	968	968	-0.87	682	-1.86	-3.60
09FEB88	11:15	-0.16	8.1	0	485	163.5	958	958	-0.64	676	-1.95	-3.43
09FEB88	11:25	-0.25	9.9	0	485	165.5	970	970	-0.93	680	-2.11	-3.48
09FEB88	11:35	-0.28	9.6	0	481	164.0	974	974	-0.66	678	-1.77	-3.00
09FEB88	11:45	-0.15	9.2	0	481	161.5	976	976	-0.83	680	-2.03	-3.52
09FEB88	11:55	-0.53	9.0	0	482	161.0	980	980	-0.89	682	-1.87	-3.73
09FEB88	12:05	-0.18	9.5	0	484	161.5	972	972	-1.02	682	-1.79	-3.64
09FEB88	12:15	0.02	8.4	0	482	163.0	968	968	-0.69	680	-2.22	-3.45
09FEB88	12:25	-0.23	8.4	0	484	159.0	962	962	-1.18	684	-1.96	-4.34
09FEB88	12:35	-0.32	7.7	0	489	157.5	958	958	-0.99	690	-2.21	-4.27
09FEB88	12:45	-0.32	8.1	0	497	160.5	958	958	-1.09	696	-2.33	-4.81
09FEB88	12:55	-0.51	10.3	0	498	167.0	982	982	-1.09	694	-1.80	-3.70
09FEB88	13:05	-0.43	8.6	0	490	163.0	978	978	-1.14	686	-2.14	-3.82
09FEB88	13:15	-0.38	10.1	0	486	164.5	974	974	-1.02	682	-2.58	-3.36
09FEB88	13:25	-0.38	8.5	0	483	160.5	964	964	-1.18	680	-2.14	-3.98
	AVERAGE	-0.28	9.4	0	485	161.8	975	975	-0.95	682	-2.03	-3.66

[a] THIS PARAMETER WAS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 3C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F TR2040	SPRY DRY OUT TEMP DEG F TIC2551	LIME SLRY CONC PERCENT HC2378	DILUTION[a] WATER GPM FIC2580	TOT SLRY[a] FLOW GPM FIC2552	IN SO2[a] CONC PPM AI2378	IN SO2[a] FACTOR LB/MBTU AI2390	OUT SO2 CONC PPM AIC2379A	OUT SO2[a] FACTOR LB/MBTU AI2386	SO2 REMOVAL % AIC2378A	CO CONC PPM AI2379C
09FEB88	08:36	428	255	70.0	11.0	37.5	500.1	1.675	143.0	0.728	68.8	35.1
09FEB88	08:46	428	255	70.0	11.5	38.3	351.7	1.094	113.3	0.208	83.3	35.9
09FEB88	08:56	427	254	70.0	11.3	36.5	258.4	0.807	48.4	0.164	82.5	36.6
09FEB88	09:06	428	255	68.2	13.2	38.0	259.7	0.819	40.0	0.180	83.3	31.9
09FEB88	09:16	429	255	70.0	11.7	38.1	377.3	1.238	69.5	0.404	72.3	37.0
09FEB88	09:26	433	255	70.0	11.5	38.9	443.6	1.586	120.0	0.567	72.3	32.6
09FEB88	09:36	434	256	70.0	12.5	41.6	353.0	1.169	90.8	0.211	84.0	35.9
09FEB88	09:46	433	253	70.0	11.4	39.6	255.9	0.858	43.8	0.162	83.5	34.3
09FEB88	09:56	430	255	70.0	11.1	38.6	244.8	0.837	38.4	0.127	86.5	35.5
09FEB88	10:06	430	255	66.2	12.9	38.1	238.8	0.773	40.1	0.140	84.8	36.9
09FEB88	10:16	430	255	70.0	12.9	38.6	258.7	0.800	34.5	0.149	83.0	42.4
09FEB88	10:26	427	254	70.0	11.2	36.3	275.8	0.860	40.0	0.173	83.3	44.5
09FEB88	10:36	431	257	69.9	12.0	39.1	279.8	0.909	54.1	0.215	82.3	49.4
09FEB88	10:46	432	254	69.9	11.8	40.5	301.0	0.971	47.1	0.218	82.3	46.0
09FEB88	10:56	433	255	69.9	12.0	39.0	293.2	0.966	55.8	0.220	82.5	49.1
09FEB88	11:06	433	255	66.5	11.0	39.0	205.6	0.704	40.5	0.145	83.8	53.9
09FEB88	11:16	432	255	61.3	14.0	39.4	168.2	0.596	24.7	0.094	87.3	50.1
09FEB88	11:26	431	255	53.4	11.8	39.1	171.3	0.543	21.3	0.074	88.5	52.0
09FEB88	11:36	428	253	46.1	10.3	37.3	158.7	0.510	19.6	0.066	88.0	45.5
09FEB88	11:46	429	255	44.7	19.7	36.1	143.1	0.474	20.2	0.096	85.5	56.6
09FEB88	11:56	431	255	53.5	17.3	36.6	153.7	0.551	27.8	0.106	81.5	47.0
09FEB88	12:06	432	256	62.0	15.0	37.9	160.8	0.515	29.3	0.086	85.5	46.0
09FEB88	12:16	431	254	48.7	18.4	37.5	139.4	0.475	16.3	0.063	87.3	40.1
09FEB88	12:26	435	256	53.8	18.2	38.1	137.3	0.513	21.8	0.095	84.0	44.6
09FEB88	12:36	439	257	60.5	16.8	41.5	141.5	0.511	22.5	0.105	84.8	48.3
09FEB88	12:46	446	257	53.1	21.3	45.8	141.4	0.520	19.4	0.054	89.8	54.9
09FEB88	12:56	441	252	34.3	26.9	45.3	139.5	0.451	11.6	0.040	91.0	50.9
09FEB88	13:06	435	251	44.8	21.0	36.0	141.5	0.466	22.6	0.128	75.0	44.6
09FEB88	13:16	431	257	50.3	18.5	39.1	185.6	0.569	28.1	0.095	88.3	37.5
09FEB88	13:26	431	254	64.1	13.9	36.8	195.7	0.688	35.1	0.167	81.0	36.0
	AVERAGE	432	255	61.4	14.4	38.8	235.8	0.782	44.6	0.176	83.2	43.0

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 3C
TEST DATE: 02/09/8

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F [a]	FLD 1 SEC VOLT KV	FLD 2 SEC VOLT KV [a]	FLD 3 SEC VOLT KV [a]
09FEB88	08:36	254	57.8	56.3	59.6
09FEB88	08:46	253	56.0	55.7	59.6
09FEB88	08:56	253	55.8	55.7	60.0
09FEB88	09:06	253	56.6	54.0	59.9
09FEB88	09:16	253	57.1	56.1	52.9
09FEB88	09:26	253	59.4	56.5	60.4
09FEB88	09:36	253	59.1	57.2	60.4
09FEB88	09:46	252	57.4	56.1	60.3
09FEB88	09:56	252	57.4	54.6	60.6
09FEB88	10:06	253	59.3	56.4	58.6
09FEB88	10:16	253	59.9	56.3	60.9
09FEB88	10:26	253	58.6	57.3	60.6
09FEB88	10:36	254	54.8	56.2	60.6
09FEB88	10:46	253	59.4	57.2	60.8
09FEB88	10:56	254	62.8	57.1	61.0
09FEB88	11:06	253	59.5	56.2	59.8
09FEB88	11:16	252	56.0	57.2	60.8
09FEB88	11:26	252	60.5	57.1	61.0
09FEB88	11:36	252	58.9	57.4	60.8
09FEB88	11:46	253	54.3	56.8	61.1
09FEB88	11:56	253	54.5	58.3	41.2
09FEB88	12:06	254	60.1	57.7	60.6
09FEB88	12:16	252	50.0	58.7	60.1
09FEB88	12:26	254	51.4	57.4	57.5
09FEB88	12:36	254	53.9	54.7	60.9
09FEB88	12:46	255	58.5	56.3	59.9
09FEB88	12:56	252	52.3	55.9	60.5
09FEB88	13:06	253	58.6	57.2	60.7
09FEB88	13:16	254	56.6	56.5	60.3
09FEB88	13:26	254	58.0	53.2	51.7
	AVERAGE	253	57.1	56.4	59.1

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

RADIAN CORPORATION

TEST 3C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F TR2040	SPRY DRY OUT TEMP DEG F TIC2551	LIME SLRY CONC PERCENT HC2378	DILUTION[a] WATER GPM FIC2580	TOT[a] SLRY FLOW GPM FIC2552	IN SO2[a] CONC PPM AI2378	IN SO2[a] FACTOR LB/MBTU AI2390	OUT SO2 CONC PPM AIC2379A	OUT SO2[a] FACTOR LB/MBTU AI2386	SO2 REMOVAL % AIC2378A	CO CONC PPM AI2379C
09FEB88	08:36	428	255	70.0	11.0	37.5	500.1	1.675	143.0	0.728	68.8	35.1
09FEB88	08:46	428	255	70.0	11.5	38.3	351.7	1.094	113.3	0.208	83.3	35.9
09FEB88	08:56	427	254	70.0	11.3	36.5	258.4	0.807	48.4	0.164	82.5	36.6
09FEB88	09:06	428	255	68.2	13.2	38.0	259.7	0.819	40.0	0.180	83.3	31.9
09FEB88	09:16	429	255	70.0	11.7	38.1	377.3	1.238	69.5	0.404	72.3	37.0
09FEB88	09:26	433	255	70.0	11.5	38.9	443.6	1.586	120.0	0.567	72.3	32.6
09FEB88	09:36	434	256	70.0	12.5	41.6	353.0	1.169	90.8	0.211	84.0	35.9
09FEB88	09:46	433	253	70.0	11.4	39.6	255.9	0.858	43.8	0.162	83.5	34.3
09FEB88	09:56	430	255	70.0	11.1	38.6	244.8	0.837	38.4	0.127	86.5	35.5
09FEB88	10:06	430	255	66.2	12.9	38.1	238.8	0.773	40.1	0.140	84.8	36.9
09FEB88	10:16	430	255	70.0	12.9	38.6	258.7	0.800	34.5	0.149	83.0	42.4
09FEB88	10:26	427	254	70.0	11.2	36.3	275.8	0.860	40.0	0.173	83.3	44.5
09FEB88	10:36	431	257	69.9	12.0	39.1	279.8	0.909	54.1	0.215	82.3	49.4
09FEB88	10:46	432	254	69.9	11.8	40.5	301.0	0.971	47.1	0.218	82.3	46.0
09FEB88	10:56	433	255	69.9	12.0	39.0	293.2	0.966	55.8	0.220	82.5	49.1
09FEB88	11:06	433	255	66.5	11.0	39.0	205.6	0.704	40.5	0.145	83.8	53.9
09FEB88	11:16	432	255	61.3	14.0	39.4	168.2	0.596	24.7	0.094	87.3	50.1
09FEB88	11:26	431	255	53.4	11.8	39.1	171.3	0.543	21.3	0.074	88.5	52.0
09FEB88	11:36	428	253	46.1	10.3	37.3	158.7	0.510	19.6	0.066	88.0	45.5
09FEB88	11:46	429	255	44.7	19.7	36.1	143.1	0.474	20.2	0.096	85.5	56.6
09FEB88	11:56	431	255	53.5	17.3	36.6	153.7	0.551	27.8	0.106	81.5	47.0
09FEB88	12:06	432	256	62.0	15.0	37.9	160.8	0.515	29.3	0.086	85.5	46.0
09FEB88	12:16	431	254	48.7	18.4	37.5	139.4	0.475	16.3	0.063	87.3	40.1
09FEB88	12:26	435	256	53.8	18.2	38.1	137.3	0.513	21.8	0.095	84.0	44.6
09FEB88	12:36	439	257	60.5	16.8	41.5	141.5	0.511	22.5	0.105	84.8	48.3
09FEB88	12:46	446	257	53.1	21.3	45.8	141.4	0.520	19.4	0.054	89.8	54.9
09FEB88	12:56	441	252	34.3	26.9	45.3	139.5	0.451	11.6	0.040	91.0	50.9
09FEB88	13:06	435	251	44.8	21.0	36.0	141.5	0.466	22.6	0.128	75.0	44.6
09FEB88	13:16	431	257	50.3	18.5	39.1	185.6	0.569	28.1	0.095	88.3	37.5
09FEB88	13:26	431	254	64.1	13.9	36.8	195.7	0.688	35.1	0.167	81.0	36.0
	AVERAGE	432	255	61.4	14.4	38.8	235.8	0.782	44.6	0.176	83.2	43.0

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 3C
TEST DATE: 02/09/8

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F [a]	FLD 1 SEC VOLT KV	FLD 2 SEC VOLT KV [a]	FLD 3 SEC VOLT KV [a]
09FEB88	08:36	254	57.8	56.3	59.6
09FEB88	08:46	253	56.0	55.7	59.6
09FEB88	08:56	253	55.8	55.7	60.0
09FEB88	09:06	253	56.6	54.0	59.9
09FEB88	09:16	253	57.1	56.1	52.9
09FEB88	09:26	253	59.4	56.5	60.4
09FEB88	09:36	253	59.1	57.2	60.4
09FEB88	09:46	252	57.4	56.1	60.3
09FEB88	09:56	252	57.4	54.6	60.6
09FEB88	10:06	253	59.3	56.4	58.6
09FEB88	10:16	253	59.9	56.3	60.9
09FEB88	10:26	253	58.6	57.3	60.6
09FEB88	10:36	254	54.8	56.2	60.6
09FEB88	10:46	253	59.4	57.2	60.8
09FEB88	10:56	254	62.8	57.1	61.0
09FEB88	11:06	253	59.5	56.2	59.8
09FEB88	11:16	252	56.0	57.2	60.8
09FEB88	11:26	252	60.5	57.1	61.0
09FEB88	11:36	252	58.9	57.4	60.8
09FEB88	11:46	253	54.3	56.8	61.1
09FEB88	11:56	253	54.5	58.3	41.2
09FEB88	12:06	254	60.1	57.7	60.6
09FEB88	12:16	252	50.0	58.7	60.1
09FEB88	12:26	254	51.4	57.4	57.5
09FEB88	12:36	254	53.9	54.7	60.9
09FEB88	12:46	255	58.5	56.3	59.9
09FEB88	12:56	252	52.3	55.9	60.5
09FEB88	13:06	253	58.6	57.2	60.7
09FEB88	13:16	254	56.6	56.5	60.3
09FEB88	13:26	254	58.0	53.2	51.7
	AVERAGE	253	57.1	56.4	59.1

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 3C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 ESP OPERATING DATA

DATE	TIME	PRIMARY VOLTAGE VOLTS AC FIELD			PRIMARY CURRENT AMPS AC FIELD			SECONDARY VOLTAGE KVOLTS DC FIELD			SECONDARY CURRENT AMPS DC FIELD			SPARK RATE SPARKS/MIN X10 FIELD		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
09FEB88	08:30	330	340	370	109	175	170	49	45	49	0.66	1.07	1.06	0	0	0
09FEB88	09:00	320	320	380	119	158	170	44	44	50	0.52	0.95	1.08	0	0	0
09FEB88	09:30	340	330	370	104	158	165	50	46	50	0.47	0.97	1.05	1	0	0
09FEB88	10:00	350	340	380	120	174	170	49	46	50	0.68	1.05	1.07	0	0	0
09FEB88	10:30	310	350	380	91	173	169	50	47	50	0.53	1.03	1.05	1	0	0
09FEB88	11:00	330	340	360	93	158	156	48	46	46	0.42	0.91	0.87	1	0	0
09FEB88	11:30	310	330	380	87	155	167	50	46	50	0.60	0.93	1.04	0	0	0
09FEB88	12:00	330	340	360	87	155	157	49	47	49	0.54	0.93	0.98	1	0	0
09FEB88	12:30	330	350	360	93	166	150	50	48	47	0.47	1.01	0.91	1	0	0
09FEB88	13:00	340	340	370	105	155	168	48	46	50	0.51	0.93	1.07	1	0	0
09FEB88	13:30	330	350	360	78	161	160	48	48	50	0.50	0.99	1.03	1	0	0
	AVERAGE	329	339	370	99	163	164	49	46	49	0.54	0.98	1.02	1	0	0

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR FI2002B	SHTR STM TEMP DEG F TI4062	EVG STM PRESS PSIG PIC0106B	BL MST OUTPUT % FIC2034	GRT MST OUTPUT % HIC2034C	NAT GAS FLOW KSCFH FI2153	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F TI2024	PRM AIR PRESS IN H20 PIC202B	SEC AIR PRESS IN H20 PIC2026	OXYGEN % AIC2064
09FEB88	13:35	185.5	822	857	42	39	0.0	89.88	147	12.41	25.63	12.31
09FEB88	13:45	188.5	822	858	41	38	0.0	86.38	148	11.81	26.19	12.81
09FEB88	13:55	188.0	822	857	43	41	0.0	87.88	148	11.91	26.06	12.50
09FEB88	14:05	188.5	824	858	40	37	0.0	86.13	150	11.72	25.56	12.50
09FEB88	14:15	185.0	818	856	47	44	0.0	91.00	149	12.75	25.75	12.72
09FEB88	14:25	188.5	828	859	44	41	0.0	88.63	148	11.81	25.88	12.41
09FEB88	14:35	192.5	828	860	34	30	0.0	80.00	152	12.25	25.94	12.84
09FEB88	14:45	191.0	824	857	31	29	0.0	78.88	153	11.88	25.94	12.34
09FEB88	14:55	185.0	822	857	39	34	0.0	79.88	154	11.38	26.56	12.91
09FEB88	15:05	185.5	828	857	37	34	0.0	82.25	153	12.53	26.00	12.09
09FEB88	15:15	184.5	824	857	41	39	0.0	85.13	151	12.00	26.00	12.25
09FEB88	15:25	190.0	826	858	37	33	0.0	83.75	149	11.88	25.06	11.50
09FEB88	15:35	186.0	822	857	41	38	0.0	86.00	150	12.50	26.19	12.44
09FEB88	15:45	192.5	828	859	29	26	0.0	77.63	151	11.53	26.06	11.41
09FEB88	15:55	187.5	824	858	34	32	0.0	80.75	153	12.59	25.69	12.19
09FEB88	16:05	187.5	824	857	34	31	0.0	81.38	152	12.81	25.69	11.34
09FEB88	16:15	185.5	820	857	38	35	0.0	82.25	152	12.06	26.25	12.63
09FEB88	16:25	185.0	822	857	41	38	0.0	85.63	149	12.03	25.25	12.03
09FEB88	16:35	183.5	824	857	45	42	0.0	88.50	149	12.50	25.63	13.03
09FEB88	16:45	191.5	828	858	35	32	0.0	82.25	148	11.72	26.19	12.28
09FEB88	16:55	192.5	824	859	31	28	0.0	79.38	150	13.38	26.38	12.66
09FEB88	17:05	186.0	820	857	40	36	0.0	83.75	150	11.97	25.81	12.78
09FEB88	17:15	185.0	824	857	44	41	0.0	88.13	147	12.13	26.00	13.13
09FEB88	17:25	184.5	822	856	48	45	0.0	91.25	145	11.75	25.69	13.19
09FEB88	17:35	184.5	822	857	51	48	0.0	92.50	144	11.69	26.00	13.31
09FEB88	17:45	187.0	822	857	50	46	0.0	91.88	141	11.38	25.75	12.97
09FEB88	17:55	185.0	820	857	50	46	0.0	92.63	144	11.91	25.94	13.75
09FEB88	18:05	194.0	834	865	34	30	0.0	81.13	147	13.34	26.13	11.28
09FEB88	18:15	191.5	830	860	33	29	0.0	81.75	150	12.41	26.19	10.75
09FEB88	18:25	190.0	830	858	31	27	0.0	78.38	152	12.78	26.31	11.56
09FEB88	18:35	185.0	826	857	39	35	0.0	82.13	151	12.34	25.88	12.38
09FEB88	18:45	187.5	828	858	38	34	0.0	83.38	149	12.34	26.31	11.53
09FEB88	18:55	187.5	824	858	39	35	0.0	83.75	148	12.38	25.56	11.91
09FEB88	19:05	190.0	822	858	34	31	0.0	81.75	148	11.75	25.69	11.34
09FEB88	19:15	187.0	826	857	35	31	0.0	81.25	149	11.63	26.38	12.03
09FEB88	19:25	189.5	828	859	34	30	0.0	81.63	149	12.13	25.56	11.31
09FEB88	19:35	186.0	826	857	38	34	0.0	83.38	150	12.59	26.31	12.09
09FEB88	19:45	189.0	830	857	35	31	0.0	79.75	149	10.28	25.63	19.69
09FEB88	19:55	183.0	824	856	44	40	0.0	87.50	148	11.53	26.00	20.13
09FEB88	20:05	187.0	826	859	41	38	0.0	86.38	146	12.75	26.50	13.47
	AVERAGE	187.6	825	858	39	36	0.0	84.39	149	12.11	25.94	12.69

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR	SHTR STM TEMP DEG F	EVG STM PRESS PSIG	BL MST OUTPUT % [a]	GRT MST OUTPUT % [a]	NAT GAS FLOW KSCFH [a]	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F	PRM AIR PRESS IN H2O [a]	SEC AIR PRESS IN H2O	OXYGEN %

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H20 PIC2025	ATTPTR WTR FLOW KLB/HR FI2011	STM TO ATM KLB/HR FI2317	BL FDWR TEMP DEG F TI2010	BL FDWR FLOW KLB/HR FI2001	FURNACE TEMP DEG F TR2021	SPHTR OUT TEMP DEG F TI2021A	SPHTR OUT PRESS IN H20 PI2020	ECON OUT TEMP DEG F TI2038A	SDA IN PRESS IN H20 PI2039	PREC OUT PRESS IN H20 PI2375
09FEB88	13:35	0.14	8.2	0	487	157.0	956	956	-0.65	690	-2.02	-3.90
09FEB88	13:45	-0.12	8.5	0	493	161.0	968	968	-0.95	692	-2.28	-4.03
09FEB88	13:55	-0.13	7.6	0	494	164.0	966	966	-0.72	690	-2.01	-3.98
09FEB88	14:05	-0.26	7.5	0	495	164.0	958	958	-1.08	690	-2.03	-4.03
09FEB88	14:15	-0.08	6.9	0	494	161.5	956	956	-0.68	692	-2.31	-4.02
09FEB88	14:25	-0.13	7.9	0	497	163.5	956	956	-0.80	694	-2.47	-4.20
09FEB88	14:35	-0.04	8.7	0	498	165.5	962	962	-0.55	692	-2.26	-3.58
09FEB88	14:45	-0.25	8.4	0	493	167.0	972	972	-0.91	692	-2.06	-3.81
09FEB88	14:55	-0.15	8.0	0	488	165.0	972	972	-0.78	686	-2.10	-3.45
09FEB88	15:05	-0.27	8.5	0	488	164.0	962	962	-0.94	688	-2.19	-3.89
09FEB88	15:15	-0.31	7.8	0	486	160.0	958	958	-0.99	684	-2.37	-3.76
09FEB88	15:25	-0.22	8.7	0	488	164.0	970	970	-0.92	692	-2.08	-3.66
09FEB88	15:35	-0.20	8.0	0	488	162.0	966	966	-0.69	688	-2.08	-3.68
09FEB88	15:45	-0.37	9.7	0	488	165.0	978	978	-0.76	690	-1.81	-3.29
09FEB88	15:55	-0.09	8.1	0	484	164.0	968	968	-0.75	682	-2.05	-3.40
09FEB88	16:05	-0.26	8.2	0	482	163.5	970	970	-1.00	682	-1.97	-3.73
09FEB88	16:15	-0.08	7.8	0	481	162.0	976	976	-0.71	680	-1.79	-3.29
09FEB88	16:25	-0.01	8.0	0	484	162.0	974	974	-0.77	684	-2.03	-3.63
09FEB88	16:35	-0.19	7.0	0	486	159.5	964	964	-0.72	686	-2.03	-3.94
09FEB88	16:45	-0.09	8.6	0	491	162.0	974	974	-0.79	694	-2.10	-3.51
09FEB88	16:55	-0.10	8.3	0	490	167.5	982	982	-0.90	690	-2.04	-3.46
09FEB88	17:05	-0.06	7.4	0	486	161.5	982	982	-0.76	686	-1.91	-3.62
09FEB88	17:15	-0.03	7.0	0	489	159.0	970	970	-0.64	692	-2.26	-3.75
09FEB88	17:25	-0.41	6.5	0	493	160.0	962	962	-1.07	692	-2.10	-4.52
09FEB88	17:35	-0.27	6.2	0	495	163.5	960	960	-0.97	694	-2.37	-4.17
09FEB88	17:45	0.18	6.0	0	498	160.0	964	964	-0.39	696	-2.32	-3.61
09FEB88	17:55	-0.38	5.9	0	495	167.5	974	974	-1.07	690	-2.31	-4.36
09FEB88	18:05	0.07	8.0	0	492	170.0	988	988	-0.77	694	-1.88	-3.42
09FEB88	18:15	-0.02	7.8	0	484	168.5	988	988	-0.67	694	-2.16	-3.46
09FEB88	18:25	0.04	8.3	0	482	166.0	986	986	-0.58	688	-2.07	-2.90
09FEB88	18:35	-0.33	7.6	0	480	164.0	982	982	-1.00	684	-1.79	-3.63
09FEB88	18:45	-0.32	8.0	0	484	159.5	982	982	-0.94	692	-1.88	-3.72
09FEB88	18:55	-0.32	8.1	0	486	164.0	986	986	-1.04	692	-1.88	-3.86
09FEB88	19:05	-0.41	8.4	0	487	162.5	1004	1004	-1.09	690	-2.03	-3.83
09FEB88	19:15	0.06	8.1	0	485	162.0	986	986	-0.66	688	-1.81	-3.28
09FEB88	19:25	-0.33	8.2	0	486	164.5	984	984	-1.22	692	-1.92	-3.98
09FEB88	19:35	-0.33	7.5	0	486	163.0	976	976	-0.94	688	-2.20	-3.87
09FEB88	19:45	-0.59	8.3	0	487	164.0	978	978	-1.07	690	-2.01	-3.69
09FEB88	19:55	-0.50	6.2	0	488	162.0	960	960	-0.93	688	-2.23	-3.98
09FEB88	20:05	-0.11	7.3	0	491	162.0	964	964	-0.71	696	-2.22	-3.77
	AVERAGE	-0.18	7.8	0	489	163.2	972	972	-0.84	690	-2.09	-3.74

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H2O	ATTPTR WTR FLOW KLB/HR	STM TO ATM KLB/HR	BL FDWR TEMP DEG F	BL FDWR FLOW KLB/HR	FURNACE TEMP DEG F	SPHTR OUT TEMP DEG F	SPHTR OUT PRESS IN H2O	ECON OUT TEMP DEG F	SDA IN[a] PRESS IN H2O	PREC OUT PRESS IN H2O

[a] THIS PARAMETER WAS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F TR2040	SPRY DRY OUT TEMP DEG F TIC2551	LIME SLRY CONC PERCENT HC2378	a DILUTION WATER GPM FIC2580	a TOT SLRY FLOW GPM FIC2552	IN SO2 CONC PPM AI2378	a IN SO2 FACTOR LB/MBTU AI2390	OUT SO2 CONC PPM AIC2379A	a OUT SO2 FACTOR LB/MBTU AI2386	SO2 REMOVAL % AIC2378A	CO CONC PPM AI2379C
09FEB88	13:36	439	259	34.1	29.3	42.0	151.6	0.526	31.4	0.108	82.3	50.1
09FEB88	13:46	440	253	40.4	24.5	42.6	164.7	0.568	31.8	0.190	72.8	36.9
09FEB88	13:56	442	255	48.8	22.5	41.4	142.6	0.507	36.9	0.141	75.3	34.9
09FEB88	14:06	441	255	37.6	26.8	43.9	120.2	0.430	23.3	0.096	80.8	35.3
09FEB88	14:16	442	254	34.0	27.3	41.4	114.5	0.412	26.5	0.129	72.5	41.5
09FEB88	14:26	445	257	29.8	33.1	44.3	120.2	0.430	27.5	0.117	76.5	38.9
09FEB88	14:36	441	252	34.4	26.3	42.5	128.6	0.471	32.8	0.123	79.0	29.0
09FEB88	14:46	440	255	46.6	22.2	40.0	128.8	0.461	38.0	0.116	76.8	29.8
09FEB88	14:56	435	253	39.5	23.6	39.4	120.2	0.431	25.0	0.122	78.3	23.4
09FEB88	15:06	435	256	54.6	18.5	38.4	165.6	0.576	38.9	0.130	79.8	26.6
09FEB88	15:16	434	254	65.4	14.1	39.0	173.8	0.600	36.0	0.172	76.5	28.1
09FEB88	15:26	437	257	68.3	13.1	39.8	197.7	0.694	36.6	0.118	85.3	25.8
09FEB88	15:36	436	253	70.0	11.8	39.8	182.6	0.653	31.7	0.175	76.8	21.8
09FEB88	15:46	434	256	68.4	13.8	41.0	204.1	0.686	43.1	0.124	84.5	24.1
09FEB88	15:56	433	252	70.0	10.8	37.1	185.2	0.612	32.4	0.151	79.8	23.3
09FEB88	16:06	432	256	60.4	14.8	38.1	161.5	0.578	34.5	0.113	80.3	21.8
09FEB88	16:16	432	254	70.0	10.8	36.6	191.2	0.675	40.8	0.206	75.0	21.9
09FEB88	16:26	435	257	70.0	12.0	38.9	320.9	1.149	75.3	0.442	68.3	24.2
09FEB88	16:36	437	255	70.0	11.3	40.3	288.2	1.082	87.3	0.344	73.3	22.8
09FEB88	16:46	439	257	66.5	15.0	42.6	175.2	0.623	43.4	0.103	87.3	25.8
09FEB88	16:56	436	253	52.5	18.7	41.3	162.1	0.555	20.8	0.078	89.5	20.1
09FEB88	17:06	437	254	53.1	18.0	37.9	159.5	0.587	28.2	0.175	74.5	18.7
09FEB88	17:16	441	257	68.6	15.5	41.1	177.0	0.637	40.1	0.195	76.5	19.7
09FEB88	17:26	444	256	70.0	14.3	44.3	231.2	0.875	49.4	0.240	77.8	20.3
09FEB88	17:36	445	253	70.0	13.1	43.9	297.7	1.114	70.0	0.413	70.5	23.8
09FEB88	17:46	449	258	70.0	15.6	44.4	474.4	1.683	153.0	0.794	59.6	25.6
09FEB88	17:56	444	255	70.0	15.8	47.3	389.3	1.519	136.0	0.347	81.8	19.6
09FEB88	18:06	439	243	51.2	16.5	45.5	240.9	0.811	51.6	0.139	83.8	18.7
09FEB88	18:16	437	249	70.0	11.3	37.1	339.0	1.067	77.0	0.449	65.0	21.8
09FEB88	18:26	432	251	70.0	11.5	41.6	304.2	1.010	70.3	0.180	85.3	18.8
09FEB88	18:36	432	249	69.9	12.6	37.1	251.1	0.856	56.0	0.248	76.5	19.6
09FEB88	18:46	437	253	69.8	12.8	41.8	230.6	0.758	49.0	0.130	85.8	28.1
09FEB88	18:56	436	249	62.5	15.3	41.0	179.6	0.599	26.0	0.120	81.8	22.7
09FEB88	19:06	436	251	66.6	13.8	40.5	219.4	0.766	32.0	0.123	84.8	23.0
09FEB88	19:16	434	248	69.9	12.0	40.0	234.8	0.732	31.9	0.155	85.8	22.6
09FEB88	19:26	436	252	59.4	16.8	40.5	171.8	0.590	28.5	0.064	90.0	23.4
09FEB88	19:36	435	248	64.8	14.2	40.9	204.4	0.667	29.7	0.189	77.8	25.8
09FEB88	19:46	436	252	70.0	12.3	40.8	286.9	0.915	53.0	0.229	80.5	25.8
09FEB88	19:56	438	250	70.0	11.7	41.4	355.0	1.262	77.5	0.395	76.8	27.8
09FEB88	20:06	441	252	68.5	14.3	44.5	249.1	0.888	51.1	0.181	83.8	26.6
	AVERAGE	438	253	59.9	16.7	41.0	214.9	0.751	47.6	0.202	78.7	26.0

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F	SPRY DRY OUT TEMP DEG F	LIME SLRY CONC PERCENT	DILUTION[a] WATER GPM	TOT SLRY[a] FLOW GPM	IN SO2[a] CONC PPM	IN SO2[a] FACTOR LB/MBTU	OUT SO2 CONC PPM	OUT SO2[a] FACTOR LB/MBTU	SO2 REMOVAL %	CO CONC PPM

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F TI2376	FLD 1 SEC VOLT KV EI2586	FLD 2 SEC VOLT KV EI2587	FLD 3 SEC VOLT KV EI2588
		a		a	a
09FEB88	13:36	256	56.8	55.7	61.1
09FEB88	13:46	253	53.0	57.1	60.5
09FEB88	13:56	254	48.8	57.1	60.0
09FEB88	14:06	253	51.5	56.3	61.0
09FEB88	14:16	254	55.5	53.8	58.2
09FEB88	14:26	254	54.9	55.7	61.0
09FEB88	14:36	252	56.1	51.7	52.8
09FEB88	14:46	254	61.3	57.6	61.0
09FEB88	14:56	252	61.4	58.5	60.6
09FEB88	15:06	254	58.9	57.1	60.9
09FEB88	15:16	253	55.8	56.6	59.5
09FEB88	15:26	254	60.8	54.8	61.0
09FEB88	15:36	253	57.9	55.9	60.4
09FEB88	15:46	254	62.1	54.4	61.2
09FEB88	15:56	253	60.3	57.8	60.8
09FEB88	16:06	253	61.3	57.2	60.5
09FEB88	16:16	253	56.0	58.5	60.8
09FEB88	16:26	255	56.6	56.8	60.0
09FEB88	16:36	254	59.5	57.2	60.1
09FEB88	16:46	255	59.1	62.4	55.6
09FEB88	16:56	253	60.5	53.6	60.9
09FEB88	17:06	253	58.0	56.3	59.9
09FEB88	17:16	255	60.9	56.7	59.2
09FEB88	17:26	254	59.8	55.5	61.3
09FEB88	17:36	253	58.9	57.1	58.7
09FEB88	17:46	256	55.9	55.7	60.6
09FEB88	17:56	253	60.4	55.3	60.3
09FEB88	18:06	246	58.1	52.1	59.9
09FEB88	18:16	250	58.6	49.5	59.3
09FEB88	18:26	249	55.8	52.6	60.1
09FEB88	18:36	249	59.0	54.2	59.2
09FEB88	18:46	251	54.5	51.4	59.8
09FEB88	18:56	250	54.5	52.7	59.5
09FEB88	19:06	250	51.9	50.8	59.8
09FEB88	19:16	248	54.9	50.9	60.0
09FEB88	19:26	250	54.3	52.4	59.0
09FEB88	19:36	247	58.4	52.7	59.1
09FEB88	19:46	250	57.9	53.3	59.1
09FEB88	19:56	250	59.8	54.0	58.0
09FEB88	20:06	250	59.8	52.1	60.1
	AVERAGE	252	57.5	55.0	59.8

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT[a] TEMP DEG F	FLD 1[a] SEC VOLT KV	FLD 2[a] SEC VOLT KV	FLD 3[a] SEC VOLT KV

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 ESP OPERATING DATA

DATE	TIME	PRIMARY VOLTAGE VOLTS AC FIELD			PRIMARY CURRENT AMPS AC FIELD			SECONDARY VOLTAGE KVOLTS DC FIELD			SECONDARY CURRENT AMPS DC FIELD			SPARK RATE SPARKS/MIN X10 FIELD		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
09FEB88	15:10	350	340	380	106	175	170	40	45	50	0.47	0.98	1.04	1	0	0
09FEB88	15:30	300	340	380	79	177	166	48	45	50	0.51	1.08	1.01	1	0	0
09FEB88	16:00	350	340	380	94	171	137	52	46	50	0.47	1.05	1.02	1	0	0
09FEB88	16:30	340	340	370	82	172	162	51	45	50	0.63	0.98	1.02	0	0	0
09FEB88	17:00	320	340	380	94	177	162	51	46	50	0.57	1.07	1.03	1	0	0
09FEB88	17:30	290	340	360	75	151	161	50	47	44	0.40	1.02	0.92	1	0	0
09FEB88	18:00	340	310	380	120	176	174	48	43	50	0.63	1.07	1.07	0	0	0
09FEB88	18:30	310	310	370	106	180	175	48	43	49	0.66	1.04	1.09	0	0	0
09FEB88	19:00	300	310	370	119	172	175	32	42	49	0.47	1.04	1.09	0	0	0
09FEB88	19:30	310	310	370	119	176	175	46	42	49	0.67	1.02	1.09	0	0	0
09FEB88	20:00	330	310	370	115	173	172	49	44	49	0.65	1.08	1.08	0	0	0
	AVERAGE	322	326	374	101	173	166	47	44	49	0.56	1.04	1.04	0	0	0

TEST 5C
TEST DATE: 02/10/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR FI2002B	SHTR STM TEMP DEG F TI4062	EVG STM PRESS PSIG PIC0106B	BL MST OUTPUT % FIC2034 [a]	GRT MST OUTPUT % HIC2034C [a]	NAT GAS FLOW KSCFH FI2153 [a]	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F TI2024 [a]	PRM AIR PRESS IN H20 PIC2028	SEC AIR PRESS IN H20 PIC2026	OXYGEN % AIC2064
10FEB88	08:07	188.5	824	858	36	32	0.0	80.625	151	12.56	25.88	10.59
10FEB88	08:17	192.0	826	860	29	25	0.0	77.625	152	10.69	26.06	9.91
10FEB88	08:27	185.5	824	858	36	32	0.0	81.125	153	12.25	26.31	10.84
10FEB88	08:37	187.0	822	857	34	31	0.0	81.375	152	12.47	26.06	11.03
10FEB88	08:47	188.5	826	857	32	28	0.0	78.5	153	10.66	25.81	10.56
10FEB88	08:57	189.0	828	858	31	27	0.0	78.375	153	13.19	26.38	10.25
10FEB88	09:07	182.0	824	857	40	36	0.0	83.375	154	10.94	25.81	11.53
10FEB88	09:17	187.5	824	857	34	30	0.0	79	153	11.09	26.25	9.94
10FEB88	09:27	184.0	822	857	37	33	0.0	83.375	152	11.22	26.00	10.91
10FEB88	09:37	188.5	826	857	33	29	0.0	80.25	153	11.56	26.00	9.66
10FEB88	09:47	186.0	822	857	38	34	0.0	82.375	152	11.47	26.38	10.41
10FEB88	09:57	189.0	822	858	35	31	0.0	82.5	150	12.00	25.81	10.47
10FEB88	10:07	187.0	820	857	40	37	0.0	86.5	149	12.94	26.13	10.63
10FEB88	10:17	188.5	822	859	35	31	0.0	83	151	12.41	26.19	9.94
10FEB88	10:27	188.0	826	857	33	29	0.0	78.375	154	12.59	26.56	10.41
10FEB88	10:37	189.0	824	857	30	26	0.0	78.25	155	12.31	25.88	9.78
10FEB88	10:47	188.5	824	858	32	28	0.0	78.5	155	12.66	26.44	9.91
10FEB88	10:57	188.0	824	858	31	27	0.0	78.125	155	13.16	26.31	10.34
10FEB88	11:07	189.5	830	858	29	25	0.0	77.125	156	12.88	25.63	9.91
10FEB88	11:17	189.5	824	860	30	26	0.0	78.375	156	12.63	25.81	9.50
10FEB88	11:27	187.5	824	857	31	27	0.0	77.25	156	10.78	25.94	10.72
10FEB88	11:37	187.5	824	858	32	28	0.0	78	156	12.19	26.69	10.47
10FEB88	11:47	187.0	824	857	35	31	0.0	80.875	155	12.72	26.13	10.56
10FEB88	11:57	187.5	826	857	32	28	0.0	79	155	11.50	25.88	10.88
10FEB88	12:07	186.5	822	857	35	31	0.0	81.625	154	12.91	25.94	11.19
10FEB88	12:17	186.0	820	855	38	34	0.0	82.375	153	11.38	25.94	11.44
10FEB88	12:27	191.5	826	856	28	24	0.0	78.25	153	12.16	25.88	10.63
10FEB88	12:37	188.5	826	857	31	26	0.0	77.625	155	13.66	26.50	11.38
10FEB88	12:47	186.0	820	858	35	33	0.0	82.25	155	12.63	26.38	11.69
10FEB88	12:57	188.5	824	857	33	28	0.0	78.75	154	11.72	25.75	11.19
10FEB88	13:07	186.0	824	857	36	33	0.0	82.625	154	12.53	25.75	11.75
10FEB88	13:17	187.0	824	858	40	36	0.0	85.375	152	12.28	25.94	11.34
10FEB88	13:27	182.5	822	857	47	42	0.0	89.5	152	11.66	25.94	12.72
10FEB88	13:37	189.0	824	858	39	35	0.0	84.875	151	12.22	26.69	12.34
10FEB88	13:47	194.0	826	860	35	31	0.0	83.375	150	12.50	25.88	10.53
10FEB88	13:57	186.5	824	857	40	36	0.0	84.875	153	11.72	26.63	12.06
	AVERAGE	187.7	824	858	35	31	0.0	80.92708	153	12.12	26.10	10.76

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 3C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 ESP OPERATING DATA

DATE	TIME	PRIMARY VOLTAGE VOLTS AC FIELD			PRIMARY CURRENT AMPS AC FIELD			SECONDARY VOLTAGE KVOLTS DC FIELD			SECONDARY CURRENT AMPS DC FIELD			SPARK RATE SPARKS/MIN X10 FIELD		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
09FEB88	08:30	330	340	370	109	175	170	49	45	49	0.66	1.07	1.06	0	0	0
09FEB88	09:00	320	320	380	119	158	170	44	44	50	0.52	0.95	1.08	0	0	0
09FEB88	09:30	340	330	370	104	158	165	50	46	50	0.47	0.97	1.05	1	0	0
09FEB88	10:00	350	340	380	120	174	170	49	46	50	0.68	1.05	1.07	0	0	0
09FEB88	10:30	310	350	380	91	173	169	50	47	50	0.53	1.03	1.05	1	0	0
09FEB88	11:00	330	340	360	93	158	156	48	46	46	0.42	0.91	0.87	1	0	0
09FEB88	11:30	310	330	380	87	155	167	50	46	50	0.60	0.93	1.04	0	0	0
09FEB88	12:00	330	340	360	87	155	157	49	47	49	0.54	0.93	0.98	1	0	0
09FEB88	12:30	330	350	360	93	166	150	50	48	47	0.47	1.01	0.91	1	0	0
09FEB88	13:00	340	340	370	105	155	168	48	46	50	0.51	0.93	1.07	1	0	0
09FEB88	13:30	330	350	360	78	161	160	48	48	50	0.50	0.99	1.03	1	0	0
	AVERAGE	329	339	370	99	163	164	49	46	49	0.54	0.98	1.02	1	0	0

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR FI2002B	SHTR STM TEMP DEG F TI4062	EVG STM PRESS PSIG PIC0106B	a BL MST OUTPUT % FIC2034	a GRT MST OUTPUT % HIC2034C	a NAT GAS FLOW KSCFH FI2153	TOTAL AIR FLOW KACFM	a UNDERGRATE AIR TEMP DEG F TI2024	PRM AIR PRESS IN H20 PIC2028	SEC AIR PRESS IN H20 PIC2026	OXYGEN % AIC2064
09FEB88	13:35	185.5	822	857	42	39	0.0	89.88	147	12.41	25.63	12.31
09FEB88	13:45	188.5	822	858	41	38	0.0	86.38	148	11.81	26.19	12.81
09FEB88	13:55	188.0	822	857	43	41	0.0	87.88	148	11.91	26.06	12.50
09FEB88	14:05	188.5	824	858	40	37	0.0	86.13	150	11.72	25.56	12.50
09FEB88	14:15	185.0	818	856	47	44	0.0	91.00	149	12.75	25.75	12.72
09FEB88	14:25	188.5	828	859	44	41	0.0	88.63	148	11.81	25.88	12.41
09FEB88	14:35	192.5	828	860	34	30	0.0	80.00	152	12.25	25.94	12.84
09FEB88	14:45	191.0	824	857	31	29	0.0	78.88	153	11.88	25.94	12.34
09FEB88	14:55	185.0	822	857	39	34	0.0	79.88	154	11.38	26.56	12.91
09FEB88	15:05	185.5	828	857	37	34	0.0	82.25	153	12.53	26.00	12.09
09FEB88	15:15	184.5	824	857	41	39	0.0	85.13	151	12.00	26.00	12.25
09FEB88	15:25	190.0	826	858	37	33	0.0	83.75	149	11.88	25.06	11.50
09FEB88	15:35	186.0	822	857	41	38	0.0	86.00	150	12.50	26.19	12.44
09FEB88	15:45	192.5	828	859	29	26	0.0	77.63	151	11.53	26.06	11.41
09FEB88	15:55	187.5	824	858	34	32	0.0	80.75	153	12.59	25.69	12.19
09FEB88	16:05	187.5	824	857	34	31	0.0	81.38	152	12.81	25.69	11.34
09FEB88	16:15	185.5	820	857	38	35	0.0	82.25	152	12.06	26.25	12.63
09FEB88	16:25	185.0	822	857	41	38	0.0	85.63	149	12.03	25.25	12.03
09FEB88	16:35	183.5	824	857	45	42	0.0	88.50	149	12.50	25.63	13.03
09FEB88	16:45	191.5	828	858	35	32	0.0	82.25	148	11.72	26.19	12.28
09FEB88	16:55	192.5	824	859	31	28	0.0	79.38	150	13.38	26.38	12.66
09FEB88	17:05	186.0	820	857	40	36	0.0	83.75	150	11.97	25.81	12.78
09FEB88	17:15	185.0	824	857	44	41	0.0	88.13	147	12.13	26.00	13.13
09FEB88	17:25	184.5	822	856	48	45	0.0	91.25	145	11.75	25.69	13.19
09FEB88	17:35	184.5	822	857	51	48	0.0	92.50	144	11.69	26.00	13.31
09FEB88	17:45	187.0	822	857	50	46	0.0	91.88	141	11.38	25.75	12.97
09FEB88	17:55	185.0	820	857	50	46	0.0	92.63	144	11.91	25.94	13.75
09FEB88	18:05	194.0	834	865	34	30	0.0	81.13	147	13.34	26.13	11.28
09FEB88	18:15	191.5	830	860	33	29	0.0	81.75	150	12.41	26.19	10.75
09FEB88	18:25	190.0	830	858	31	27	0.0	78.38	152	12.78	26.31	11.56
09FEB88	18:35	185.0	826	857	39	35	0.0	82.13	151	12.34	25.88	12.38
09FEB88	18:45	187.5	828	858	38	34	0.0	83.38	149	12.34	26.31	11.53
09FEB88	18:55	187.5	824	858	39	35	0.0	83.75	148	12.38	25.56	11.91
09FEB88	19:05	190.0	822	858	34	31	0.0	81.75	148	11.75	25.69	11.34
09FEB88	19:15	187.0	826	857	35	31	0.0	81.25	149	11.63	26.38	12.03
09FEB88	19:25	189.5	828	859	34	30	0.0	81.63	149	12.13	25.56	11.31
09FEB88	19:35	186.0	826	857	38	34	0.0	83.38	150	12.59	26.31	12.09
09FEB88	19:45	189.0	830	857	35	31	0.0	79.75	149	10.28	25.63	19.69
09FEB88	19:55	183.0	824	856	44	40	0.0	87.50	148	11.53	26.00	20.13
09FEB88	20:05	187.0	826	859	41	38	0.0	86.38	146	12.75	26.50	13.47
	AVERAGE	187.6	825	858	39	36	0.0	84.39	149	12.11	25.94	12.69

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR	SHTR STM TEMP DEG F	EVG STM PRESS PSIG	BL MST OUTPUT[a] %	GRT MST OUTPUT[a] %	NAT GAS FLOW[a] KSCFH	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F	PRM AIR PRESS[a] IN H2O	SEC AIR PRESS IN H2O	OXYGEN %

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H20 PIC2025	ATTPTR WTR FLOW KLB/HR FI2011	STM TO ATM KLB/HR FI2317	BL FDWR TEMP DEG F TI2010	BL FDWR FLOW KLB/HR FI2001	FURNACE TEMP DEG F TR2021	SPHTR OUT TEMP DEG F TI2021A	SPHTR OUT PRESS IN H20 PI2020	ECON OUT TEMP DEG F TI2038A	SDA IN PRESS[a] IN H20 PI2039	PREC OUT PRESS IN H20 PI2375
09FEB88	13:35	0.14	8.2	0	487	157.0	956	956	-0.65	690	-2.02	-3.90
09FEB88	13:45	-0.12	8.5	0	493	161.0	968	968	-0.95	692	-2.28	-4.03
09FEB88	13:55	-0.13	7.6	0	494	164.0	966	966	-0.72	690	-2.01	-3.98
09FEB88	14:05	-0.26	7.5	0	495	164.0	958	958	-1.08	690	-2.03	-4.03
09FEB88	14:15	-0.08	6.9	0	494	161.5	956	956	-0.68	692	-2.31	-4.02
09FEB88	14:25	-0.13	7.9	0	497	163.5	956	956	-0.80	694	-2.47	-4.20
09FEB88	14:35	-0.04	8.7	0	498	165.5	962	962	-0.55	692	-2.26	-3.58
09FEB88	14:45	-0.25	8.4	0	493	167.0	972	972	-0.91	692	-2.06	-3.81
09FEB88	14:55	-0.15	8.0	0	488	165.0	972	972	-0.78	686	-2.10	-3.45
09FEB88	15:05	-0.27	8.5	0	488	164.0	962	962	-0.94	688	-2.19	-3.89
09FEB88	15:15	-0.31	7.8	0	486	160.0	958	958	-0.99	684	-2.37	-3.76
09FEB88	15:25	-0.22	8.7	0	488	164.0	970	970	-0.92	692	-2.08	-3.66
09FEB88	15:35	-0.20	8.0	0	488	162.0	966	966	-0.69	688	-2.08	-3.68
09FEB88	15:45	-0.37	9.7	0	488	165.0	978	978	-0.76	690	-1.81	-3.29
09FEB88	15:55	-0.09	8.1	0	484	164.0	968	968	-0.75	682	-2.05	-3.40
09FEB88	16:05	-0.26	8.2	0	482	163.5	970	970	-1.00	682	-1.97	-3.73
09FEB88	16:15	-0.08	7.8	0	481	162.0	976	976	-0.71	680	-1.79	-3.29
09FEB88	16:25	-0.01	8.0	0	484	162.0	974	974	-0.77	684	-2.03	-3.63
09FEB88	16:35	-0.19	7.0	0	486	159.5	964	964	-0.72	686	-2.03	-3.94
09FEB88	16:45	-0.09	8.6	0	491	162.0	974	974	-0.79	694	-2.10	-3.51
09FEB88	16:55	-0.10	8.3	0	490	167.5	982	982	-0.90	690	-2.04	-3.46
09FEB88	17:05	-0.06	7.4	0	486	161.5	982	982	-0.76	686	-1.91	-3.62
09FEB88	17:15	-0.03	7.0	0	489	159.0	970	970	-0.64	692	-2.26	-3.75
09FEB88	17:25	-0.41	6.5	0	493	160.0	962	962	-1.07	692	-2.10	-4.52
09FEB88	17:35	-0.27	6.2	0	495	163.5	960	960	-0.97	694	-2.37	-4.17
09FEB88	17:45	0.18	6.0	0	498	160.0	964	964	-0.39	696	-2.32	-3.61
09FEB88	17:55	-0.38	5.9	0	495	167.5	974	974	-1.07	690	-2.31	-4.36
09FEB88	18:05	0.07	8.0	0	492	170.0	988	988	-0.77	694	-1.88	-3.42
09FEB88	18:15	-0.02	7.8	0	484	168.5	988	988	-0.67	694	-2.16	-3.46
09FEB88	18:25	0.04	8.3	0	482	166.0	986	986	-0.58	688	-2.07	-2.90
09FEB88	18:35	-0.33	7.6	0	480	164.0	982	982	-1.00	684	-1.79	-3.63
09FEB88	18:45	-0.32	8.0	0	484	159.5	982	982	-0.94	692	-1.88	-3.72
09FEB88	18:55	-0.32	8.1	0	486	164.0	986	986	-1.04	692	-1.88	-3.86
09FEB88	19:05	-0.41	8.4	0	487	162.5	1004	1004	-1.09	690	-2.03	-3.83
09FEB88	19:15	0.06	8.1	0	485	162.0	986	986	-0.66	688	-1.81	-3.28
09FEB88	19:25	-0.33	8.2	0	486	164.5	984	984	-1.22	692	-1.92	-3.98
09FEB88	19:35	-0.33	7.5	0	486	163.0	976	976	-0.94	688	-2.20	-3.87
09FEB88	19:45	-0.59	8.3	0	487	164.0	978	978	-1.07	690	-2.01	-3.69
09FEB88	19:55	-0.50	6.2	0	488	162.0	960	960	-0.93	688	-2.23	-3.98
09FEB88	20:05	-0.11	7.3	0	491	162.0	964	964	-0.71	696	-2.22	-3.77
	AVERAGE	-0.18	7.8	0	489	163.2	972	972	-0.84	690	-2.09	-3.74

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H2O	ATTPTR WTR FLOW KLB/HR	STM TO ATM KLB/HR	BL FDWR TEMP DEG F	BL FDWR FLOW KLB/HR	FURNACE TEMP DEG F	SPHTR OUT TEMP DEG F	SPHTR OUT PRESS IN H2O	ECON OUT TEMP DEG F	SDA IN[a] PRESS IN H2O	PREC OUT PRESS IN H2O

[a] THIS PARAMETER WAS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

RADIAN CORPORATION

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F TR2040	SPRY DRY OUT TEMP DEG F TIC2551	LIME SLRY CONC PERCENT HC2378	a DILUTION WATER GPM FIC2580	a TOT SLRY FLOW GPM FIC2552	IN SO2 CONC PPM AI2378	a IN SO2 FACTOR LB/MBTU AI2390	OUT SO2 CONC PPM AIC2379A	OUT SO2 FACTOR LB/MBTU AI2386	a SO2 REMOVAL % AIC2378A	CO CONC PPM AI2379C
09FEB88	13:36	439	259	34.1	29.3	42.0	151.6	0.526	31.4	0.108	82.3	50.1
09FEB88	13:46	440	253	40.4	24.5	42.6	164.7	0.568	31.8	0.190	72.8	36.9
09FEB88	13:56	442	255	48.8	22.5	41.4	142.6	0.507	36.9	0.141	75.3	34.9
09FEB88	14:06	441	255	37.6	26.8	43.9	120.2	0.430	23.3	0.096	80.8	35.3
09FEB88	14:16	442	254	34.0	27.3	41.4	114.5	0.412	26.5	0.129	72.5	41.5
09FEB88	14:26	445	257	29.8	33.1	44.3	120.2	0.430	27.5	0.117	76.5	38.9
09FEB88	14:36	441	252	34.4	26.3	42.5	128.6	0.471	32.8	0.123	79.0	29.0
09FEB88	14:46	440	255	46.6	22.2	40.0	128.8	0.461	38.0	0.116	76.8	29.8
09FEB88	14:56	435	253	39.5	23.6	39.4	120.2	0.431	25.0	0.122	78.3	23.4
09FEB88	15:06	435	256	54.6	18.5	38.4	165.6	0.576	38.9	0.130	79.8	26.6
09FEB88	15:16	434	254	65.4	14.1	39.0	173.8	0.600	36.0	0.172	76.5	28.1
09FEB88	15:26	437	257	68.3	13.1	39.8	197.7	0.694	36.6	0.118	85.3	25.8
09FEB88	15:36	436	253	70.0	11.8	39.8	182.6	0.653	31.7	0.175	76.8	21.8
09FEB88	15:46	434	256	68.4	13.8	41.0	204.1	0.686	43.1	0.124	84.5	24.1
09FEB88	15:56	433	252	70.0	10.8	37.1	185.2	0.612	32.4	0.151	79.8	23.3
09FEB88	16:06	432	256	60.4	14.8	38.1	161.5	0.578	34.5	0.113	80.3	21.8
09FEB88	16:16	432	254	70.0	10.8	36.6	191.2	0.675	40.8	0.206	75.0	21.9
09FEB88	16:26	435	257	70.0	12.0	38.9	320.9	1.149	75.3	0.442	68.3	24.2
09FEB88	16:36	437	255	70.0	11.3	40.3	288.2	1.082	87.3	0.344	73.3	22.8
09FEB88	16:46	439	257	66.5	15.0	42.6	175.2	0.623	43.4	0.103	87.3	25.8
09FEB88	16:56	436	253	52.5	18.7	41.3	162.1	0.555	20.8	0.078	89.5	20.1
09FEB88	17:06	437	254	53.1	18.0	37.9	159.5	0.587	28.2	0.175	74.5	18.7
09FEB88	17:16	441	257	68.6	15.5	41.1	177.0	0.637	40.1	0.195	76.5	19.7
09FEB88	17:26	444	256	70.0	14.3	44.3	231.2	0.875	49.4	0.240	77.8	20.3
09FEB88	17:36	445	253	70.0	13.1	43.9	297.7	1.114	70.0	0.413	70.5	23.8
09FEB88	17:46	449	258	70.0	15.6	44.4	474.4	1.683	153.0	0.794	59.6	25.6
09FEB88	17:56	444	255	70.0	15.8	47.3	389.3	1.519	136.0	0.347	81.8	19.6
09FEB88	18:06	439	243	51.2	16.5	45.5	240.9	0.811	51.6	0.139	83.8	18.7
09FEB88	18:16	437	249	70.0	11.3	37.1	339.0	1.067	77.0	0.449	65.0	21.8
09FEB88	18:26	432	251	70.0	11.5	41.6	304.2	1.010	70.3	0.180	85.3	18.8
09FEB88	18:36	432	249	69.9	12.6	37.1	251.1	0.856	56.0	0.248	76.5	19.6
09FEB88	18:46	437	253	69.8	12.8	41.8	230.6	0.758	49.0	0.130	85.8	28.1
09FEB88	18:56	436	249	62.5	15.3	41.0	179.6	0.599	26.0	0.120	81.8	22.7
09FEB88	19:06	436	251	66.6	13.8	40.5	219.4	0.766	32.0	0.123	84.8	23.0
09FEB88	19:16	434	248	69.9	12.0	40.0	234.8	0.732	31.9	0.155	85.8	22.6
09FEB88	19:26	436	252	59.4	16.8	40.5	171.8	0.590	28.5	0.064	90.0	23.4
09FEB88	19:36	435	248	64.8	14.2	40.9	204.4	0.667	29.7	0.189	77.8	25.8
09FEB88	19:46	436	252	70.0	12.3	40.8	286.9	0.915	53.0	0.229	80.5	25.8
09FEB88	19:56	438	250	70.0	11.7	41.4	355.0	1.262	77.5	0.395	76.8	27.8
09FEB88	20:06	441	252	68.5	14.3	44.5	249.1	0.888	51.1	0.181	83.8	26.6
	AVERAGE	438	253	59.9	16.7	41.0	214.9	0.751	47.6	0.202	78.7	26.0

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F	SPRY DRY OUT TEMP DEG F	LIME SLRY CONC PERCENT	[a] DILUTION WATER GPM	[a] TOT SLRY FLOW GPM	[a] IN SO2 CONC PPM	[a] IN SO2 FACTOR LB/MBTU	OUT SO2 CONC PPM	[a] OUT SO2 FACTOR LB/MBTU	SO2 REMOVAL %	CO CONC PPM

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F TI2376	FLD 1 SEC VOLT KV EI2586	FLD 2 SEC VOLT KV EI2587	FLD 3 SEC VOLT KV EI2588
		a	a	a	a
09FEB88	13:36	256	56.8	55.7	61.1
09FEB88	13:46	253	53.0	57.1	60.5
09FEB88	13:56	254	48.8	57.1	60.0
09FEB88	14:06	253	51.5	56.3	61.0
09FEB88	14:16	254	55.5	53.8	58.2
09FEB88	14:26	254	54.9	55.7	61.0
09FEB88	14:36	252	56.1	51.7	52.8
09FEB88	14:46	254	61.3	57.6	61.0
09FEB88	14:56	252	61.4	58.5	60.6
09FEB88	15:06	254	58.9	57.1	60.9
09FEB88	15:16	253	55.8	56.6	59.5
09FEB88	15:26	254	60.8	54.8	61.0
09FEB88	15:36	253	57.9	55.9	60.4
09FEB88	15:46	254	62.1	54.4	61.2
09FEB88	15:56	253	60.3	57.8	60.8
09FEB88	16:06	253	61.3	57.2	60.5
09FEB88	16:16	253	56.0	58.5	60.8
09FEB88	16:26	255	56.6	56.8	60.0
09FEB88	16:36	254	59.5	57.2	60.1
09FEB88	16:46	255	59.1	62.4	55.6
09FEB88	16:56	253	60.5	53.6	60.9
09FEB88	17:06	253	58.0	56.3	59.9
09FEB88	17:16	255	60.9	56.7	59.2
09FEB88	17:26	254	59.8	55.5	61.3
09FEB88	17:36	253	58.9	57.1	58.7
09FEB88	17:46	256	55.9	55.7	60.6
09FEB88	17:56	253	60.4	55.3	60.3
09FEB88	18:06	246	58.1	52.1	59.9
09FEB88	18:16	250	58.6	49.5	59.3
09FEB88	18:26	249	55.8	52.6	60.1
09FEB88	18:36	249	59.0	54.2	59.2
09FEB88	18:46	251	54.5	51.4	59.8
09FEB88	18:56	250	54.5	52.7	59.5
09FEB88	19:06	250	51.9	50.8	59.8
09FEB88	19:16	248	54.9	50.9	60.0
09FEB88	19:26	250	54.3	52.4	59.0
09FEB88	19:36	247	58.4	52.7	59.1
09FEB88	19:46	250	57.9	53.3	59.1
09FEB88	19:56	250	59.8	54.0	58.0
09FEB88	20:06	250	59.8	52.1	60.1
	AVERAGE	252	57.5	55.0	59.8

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT[a] TEMP DEG F	FLD 1[a] SEC VOLT KV	FLD 2[a] SEC VOLT KV	FLD 3[a] SEC VOLT KV

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

RADIAN CORPORATION

TEST 4C
TEST DATE: 02/09/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 ESP OPERATING DATA

DATE	TIME	PRIMARY VOLTAGE VOLTS AC FIELD			PRIMARY CURRENT AMPS AC FIELD			SECONDARY VOLTAGE KVOLTS DC FIELD			SECONDARY CURRENT AMPS DC FIELD			SPARK RATE SPARKS/MIN X10 FIELD		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
09FEB88	15:10	350	340	380	106	175	170	40	45	50	0.47	0.98	1.04	1	0	0
09FEB88	15:30	300	340	380	79	177	166	48	45	50	0.51	1.08	1.01	1	0	0
09FEB88	16:00	350	340	380	94	171	137	52	46	50	0.47	1.05	1.02	1	0	0
09FEB88	16:30	340	340	370	82	172	162	51	45	50	0.63	0.98	1.02	0	0	0
09FEB88	17:00	320	340	380	94	177	162	51	46	50	0.57	1.07	1.03	1	0	0
09FEB88	17:30	290	340	360	75	151	161	50	47	44	0.40	1.02	0.92	1	0	0
09FEB88	18:00	340	310	380	120	176	174	48	43	50	0.63	1.07	1.07	0	0	0
09FEB88	18:30	310	310	370	106	180	175	48	43	49	0.66	1.04	1.09	0	0	0
09FEB88	19:00	300	310	370	119	172	175	32	42	49	0.47	1.04	1.09	0	0	0
09FEB88	19:30	310	310	370	119	176	175	46	42	49	0.67	1.02	1.09	0	0	0
09FEB88	20:00	330	310	370	115	173	172	49	44	49	0.65	1.08	1.08	0	0	0
	AVERAGE	322	326	374	101	173	166	47	44	49	0.56	1.04	1.04	0	0	0

RADIAN CORPORATION

TEST 5C
TEST DATE: 02/10/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 14

DATE	TIME	STM FLOW KLB/HR FI2002B	SHTR STM TEMP DEG F TI4062	EVG STM PRESS PSIG PIC0106B	BL MST OUTPUT % FIC2034	GRT MST OUTPUT % HIC2034C	NAT GAS FLOW KSCFH FI2153	TOTAL AIR FLOW KACFM	UNDERGRATE AIR TEMP DEG F TI2024	PRM AIR PRESS IN H20 PIC2028	SEC AIR PRESS IN H20 PIC2026	OXYGEN % AIC2064
				a	a	a			a			
10FEB88	08:07	188.5	824	858	36	32	0.0	80.625	151	12.56	25.88	10.59
10FEB88	08:17	192.0	826	860	29	25	0.0	77.625	152	10.69	26.06	9.91
10FEB88	08:27	185.5	824	858	36	32	0.0	81.125	153	12.25	26.31	10.84
10FEB88	08:37	187.0	822	857	34	31	0.0	81.375	152	12.47	26.06	11.03
10FEB88	08:47	188.5	826	857	32	28	0.0	78.5	153	10.66	25.81	10.56
10FEB88	08:57	189.0	828	858	31	27	0.0	78.375	153	13.19	26.38	10.25
10FEB88	09:07	182.0	824	857	40	36	0.0	83.375	154	10.94	25.81	11.53
10FEB88	09:17	187.5	824	857	34	30	0.0	79	153	11.09	26.25	9.94
10FEB88	09:27	184.0	822	857	37	33	0.0	83.375	152	11.22	26.00	10.91
10FEB88	09:37	188.5	826	857	33	29	0.0	80.25	153	11.56	26.00	9.66
10FEB88	09:47	186.0	822	857	38	34	0.0	82.375	152	11.47	26.38	10.41
10FEB88	09:57	189.0	822	858	35	31	0.0	82.5	150	12.00	25.81	10.47
10FEB88	10:07	187.0	820	857	40	37	0.0	86.5	149	12.94	26.13	10.63
10FEB88	10:17	188.5	822	859	35	31	0.0	83	151	12.41	26.19	9.94
10FEB88	10:27	188.0	826	857	33	29	0.0	78.375	154	12.59	26.56	10.41
10FEB88	10:37	189.0	824	857	30	26	0.0	78.25	155	12.31	25.88	9.78
10FEB88	10:47	188.5	824	858	32	28	0.0	78.5	155	12.66	26.44	9.91
10FEB88	10:57	188.0	824	858	31	27	0.0	78.125	155	13.16	26.31	10.34
10FEB88	11:07	189.5	830	858	29	25	0.0	77.125	156	12.88	25.63	9.91
10FEB88	11:17	189.5	824	860	30	26	0.0	78.375	156	12.63	25.81	9.50
10FEB88	11:27	187.5	824	857	31	27	0.0	77.25	156	10.78	25.94	10.72
10FEB88	11:37	187.5	824	858	32	28	0.0	78	156	12.19	26.69	10.47
10FEB88	11:47	187.0	824	857	35	31	0.0	80.875	155	12.72	26.13	10.56
10FEB88	11:57	187.5	826	857	32	28	0.0	79	155	11.50	25.88	10.88
10FEB88	12:07	186.5	822	857	35	31	0.0	81.625	154	12.91	25.94	11.19
10FEB88	12:17	186.0	820	855	38	34	0.0	82.375	153	11.38	25.94	11.44
10FEB88	12:27	191.5	826	856	28	24	0.0	78.25	153	12.16	25.88	10.63
10FEB88	12:37	188.5	826	857	31	26	0.0	77.625	155	13.66	26.50	11.38
10FEB88	12:47	186.0	820	858	35	33	0.0	82.25	155	12.63	26.38	11.69
10FEB88	12:57	188.5	824	857	33	28	0.0	78.75	154	11.72	25.75	11.19
10FEB88	13:07	186.0	824	857	36	33	0.0	82.625	154	12.53	25.75	11.75
10FEB88	13:17	187.0	824	858	40	36	0.0	85.375	152	12.28	25.94	11.34
10FEB88	13:27	182.5	822	857	47	42	0.0	89.5	152	11.66	25.94	12.72
10FEB88	13:37	189.0	824	858	39	35	0.0	84.875	151	12.22	26.69	12.34
10FEB88	13:47	194.0	826	860	35	31	0.0	83.375	150	12.50	25.88	10.53
10FEB88	13:57	186.5	824	857	40	36	0.0	84.875	153	11.72	26.63	12.06
	AVERAGE	187.7	824	858	35	31	0.0	80.92708	153	12.12	26.10	10.76

a
PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

TEST 5C
TEST DATE: 02/10/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 15

DATE	TIME	FURNACE DRAFT IN H20 PIC2025	ATTPTR WTR FLOW KLB/HR FI2011	STM TO ATM KLB/HR FI2317	BL FDWR TEMP DEG F TI2010	BL FDWR FLOW KLB/HR FI2001	FURNACE TEMP DEG F TR2021	SPHTR OUT TEMP DEG F TI2021A	SPHTR OUT PRESS IN H20 PI2020	ECON OUT TEMP DEG F TI2038A	SDA IN PRESS IN H20 PI2039 [a]	PREC OUT PRESS IN H20 PI2375
10FEB88	08:07	-0.18	11.4	0	482	160.0	982	982	-0.89	674	-2.00	-3.41
10FEB88	08:17	-0.57	11.9	0	481	161.0	984	984	-0.89	678	-1.75	-3.36
10FEB88	08:27	-0.11	10.7	0	479	161.0	968	968	-0.83	672	-1.83	-3.47
10FEB88	08:37	-0.33	10.7	0	479	161.5	982	982	-1.20	674	-2.11	-3.88
10FEB88	08:47	-0.30	11.1	0	479	159.0	980	980	-0.84	672	-1.74	-3.38
10FEB88	08:57	-0.04	10.9	0	479	161.0	974	974	-0.65	674	-1.70	-2.95
10FEB88	09:07	-0.75	10.2	0	477	158.5	968	968	-1.21	668	-2.08	-3.82
10FEB88	09:17	-0.40	10.8	0	478	159.5	980	980	-1.05	672	-1.82	-3.43
10FEB88	09:27	-0.14	9.8	0	478	159.0	978	978	-1.00	672	-2.14	-3.61
10FEB88	09:37	-0.11	11.0	0	480	161.0	982	982	-0.95	674	-2.01	-3.34
10FEB88	09:47	-0.07	10.3	0	479	162.5	976	976	-0.69	674	-1.88	-3.17
10FEB88	09:57	-0.21	11.3	0	482	158.0	992	992	-1.03	678	-1.34	-3.48
10FEB88	10:07	-0.27	10.7	0	484	158.0	982	982	-1.15	678	-1.62	-3.93
10FEB88	10:17	-0.06	10.5	0	483	163.5	988	988	-0.66	678	-1.92	-3.31
10FEB88	10:27	0.11	11.6	0	481	161.0	982	982	-0.44	676	-2.08	-2.75
10FEB88	10:37	-0.19	11.5	0	476	159.5	986	986	-0.70	674	-1.91	-2.91
10FEB88	10:47	0.02	11.5	0	475	160.0	986	986	-0.32	674	-1.54	-2.65
10FEB88	10:57	0.04	11.3	0	476	160.0	990	990	-0.70	672	-1.78	-2.92
10FEB88	11:07	0.18	11.8	0	477	160.0	984	984	-0.36	674	-1.75	-2.62
10FEB88	11:17	-0.15	11.6	0	477	160.0	992	992	-0.86	678	-1.84	-3.27
10FEB88	11:27	-0.21	11.1	0	479	159.0	996	996	-1.06	674	-1.96	-3.38
10FEB88	11:37	-0.15	11.0	0	480	159.0	996	996	-0.77	672	-1.79	-3.27
10FEB88	11:47	-0.12	10.2	0	482	158.5	980	980	-0.62	678	-2.00	-3.35
10FEB88	11:57	-0.50	10.2	0	483	162.0	972	972	-1.03	678	-2.07	-3.46
10FEB88	12:07	-0.06	10.3	0	484	159.0	972	972	-0.82	678	-2.39	-3.51
10FEB88	12:17	-0.27	9.9	0	487	158.0	976	976	-0.89	682	-2.13	-3.70
10FEB88	12:27	-0.31	10.9	0	488	162.5	984	984	-0.60	682	-2.11	-3.22
10FEB88	12:37	-0.06	10.4	0	486	162.5	992	992	-0.82	676	-2.23	-3.46
10FEB88	12:47	-0.29	9.1	0	484	159.5	1000	1000	-1.07	676	-2.44	-3.97
10FEB88	12:57	-0.03	10.1	0	486	159.0	994	994	-0.76	682	-1.75	-3.52
10FEB88	13:07	-0.14	9.7	0	487	160.5	978	978	-0.94	684	-2.30	-3.74
10FEB88	13:17	-0.37	9.6	0	491	159.0	982	982	-0.89	684	-2.13	-4.11
10FEB88	13:27	-0.30	8.4	0	493	159.0	974	974	-0.92	682	-2.22	-4.11
10FEB88	13:37	-0.15	9.3	0	495	163.0	996	996	-0.61	682	-2.23	-3.39
10FEB88	13:47	-0.43	10.3	0	495	163.5	1000	1000	-1.00	688	-1.89	-3.74
10FEB88	13:57	-0.25	9.5	0	490	162.0	994	994	-0.87	678	-2.00	-3.56
	AVERAGE	-0.20	10.6	0	483	160.3	984	984	-0.84	677	-1.96	-3.42

[a] THIS PARAMETER WAS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

RADIAN CORPORATION

TEST 5C
TEST DATE: 02/10/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 16

DATE	TIME	SPRY DRY IN TEMP DEG F TR2040 TR2040	SPRY DRY OUT TEMP DEG F TIC2551 TIC2551	LIME SLRY CONC PERCENT HC2378 HC2378	a DILUTION WATER GPM FIC2580 FIC2580	a TOT SLRY FLOW GPM FIC2552 FIC2552	IN SO2 CONC PPM AI2378 AI2378	a IN SO2 FACTOR LB/MBTU AI2390 AI2390	OUT SO2 CONC PPM AIC2379A AIC2379A	a OUT SO2 FACTOR LB/MBTU AI2386 AI2386	SO2 REMOVAL % AIC2378A AIC2378A	CO CONC PPM AI2379C AI2379C
10FEB88	08:08	428	251	64.6	14.4	39.1	254.8	0.782	38.3	0.183	84.3	21.9
10FEB88	08:18	428	250	70.0	12.2	38.9	439.4	1.224	63.8	0.277	78.0	23.3
10FEB88	08:28	426	249	69.7	11.2	38.1	405.0	1.260	76.0	0.287	82.8	25.8
10FEB88	08:38	427	251	70.0	11.4	38.3	251.3	0.822	60.0	0.147	84.3	24.0
10FEB88	08:48	426	250	54.7	16.6	38.3	186.3	0.565	24.1	0.059	91.3	25.1
10FEB88	08:58	426	250	43.0	21.0	37.0	171.5	0.523	21.4	0.104	83.5	27.3
10FEB88	09:08	426	250	42.6	21.3	36.1	174.1	0.575	30.2	0.097	86.8	23.9
10FEB88	09:18	426	251	43.1	21.8	37.9	181.5	0.584	30.3	0.090	87.5	29.7
10FEB88	09:28	427	249	48.8	19.1	35.8	174.0	0.585	30.5	0.165	80.8	28.5
10FEB88	09:38	428	251	70.0	12.4	38.4	304.7	0.955	54.8	0.251	79.3	27.4
10FEB88	09:48	427	250	70.0	11.4	37.8	266.2	0.908	52.4	0.231	76.0	23.6
10FEB88	09:58	430	252	69.7	12.9	39.8	316.3	0.980	65.3	0.259	79.3	28.1
10FEB88	10:08	432	249	70.0	11.9	40.4	282.3	0.930	53.1	0.212	82.0	30.5
10FEB88	10:18	430	250	57.0	11.4	40.1	199.4	0.628	29.2	0.073	89.3	30.4
10FEB88	10:28	426	249	30.1	24.6	38.1	152.6	0.501	13.5	0.019	96.0	22.8
10FEB88	10:38	424	248	21.5	26.0	34.4	127.8	0.390	21.2	0.097	79.0	27.4
10FEB88	10:48	425	251	23.0	26.6	34.5	121.8	0.363	30.9	0.127	70.5	24.5
10FEB88	10:58	424	250	28.7	24.5	35.0	141.9	0.409	33.1	0.130	76.3	24.3
10FEB88	11:08	424	251	34.0	23.5	34.5	145.6	0.440	33.8	0.115	77.0	26.6
10FEB88	11:18	426	251	33.4	23.6	35.5	145.4	0.425	29.5	0.121	73.8	27.1
10FEB88	11:28	427	251	31.6	25.3	36.6	151.0	0.472	28.8	0.112	79.0	24.1
10FEB88	11:38	428	251	32.7	25.6	37.1	137.5	0.448	31.0	0.079	82.0	25.8
10FEB88	11:48	430	251	28.6	27.7	37.3	138.1	0.469	26.5	0.114	75.3	26.4
10FEB88	11:58	430	250	23.6	29.6	38.5	139.8	0.443	27.6	0.090	78.3	29.8
10FEB88	12:08	433	251	39.9	23.6	37.4	139.9	0.471	38.6	0.165	74.0	25.8
10FEB88	12:18	436	251	43.4	24.6	41.1	179.6	0.620	32.9	0.140	79.0	24.1
10FEB88	12:28	433	250	52.1	18.8	41.3	205.4	0.665	36.1	0.126	84.0	28.4
10FEB88	12:38	431	249	57.0	15.8	38.5	175.8	0.547	33.0	0.103	88.8	25.8
10FEB88	12:48	433	251	52.7	18.9	39.5	170.8	0.575	27.1	0.158	77.8	28.0
10FEB88	12:58	435	251	68.3	12.9	41.1	212.6	0.699	38.9	0.175	81.5	22.9
10FEB88	13:08	436	251	70.0	12.9	41.6	256.3	0.864	52.8	0.252	77.0	24.1
10FEB88	13:18	441	252	70.0	13.8	44.4	395.9	1.426	85.3	0.491	71.0	24.1
10FEB88	13:28	442	250	70.0	12.7	45.8	422.1	1.555	124.8	0.531	72.5	22.0
10FEB88	13:38	441	251	70.0	13.4	45.1	300.4	1.022	90.5	0.278	79.5	27.4
10FEB88	13:48	442	251	63.0	16.5	44.4	146.9	0.518	35.6	0.067	90.0	49.4
10FEB88	13:58	437	247	34.9	25.9	42.1	175.2	0.558	11.5	0.076	89.0	28.3
	AVERAGE	430	250	50.6	18.8	38.9	216.4	0.700	42.0	0.167	81.0	26.6

TEST 5C
TEST DATE: 02/10/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 TREND LOG 17

DATE	TIME	ESP OUT TEMP DEG F TI2376	FLD 1 SEC VOLT KV EI2586 [a]	FLD 2 SEC VOLT KV EI2587 [a]	FLD 3 SEC VOLT KV EI2588 [a]
10FEB88	08:08	248	55.1	52.5	59.1
10FEB88	08:18	248	54.6	53.8	58.0
10FEB88	08:28	247	54.0	53.4	59.4
10FEB88	08:38	248	55.6	54.8	59.7
10FEB88	08:48	248	54.9	53.5	58.9
10FEB88	08:58	248	55.5	55.0	58.9
10FEB88	09:08	248	59.1	52.7	59.7
10FEB88	09:18	248	54.8	55.1	59.0
10FEB88	09:28	249	55.1	54.2	59.9
10FEB88	09:38	249	50.9	52.7	59.6
10FEB88	09:48	249	54.6	53.9	59.6
10FEB88	09:58	250	53.9	53.6	59.1
10FEB88	10:08	249	50.8	54.6	59.5
10FEB88	10:18	249	54.5	53.7	59.6
10FEB88	10:28	248	50.4	54.7	59.3
10FEB88	10:38	248	57.3	54.4	59.1
10FEB88	10:48	249	50.1	54.7	59.0
10FEB88	10:58	249	56.0	53.9	59.1
10FEB88	11:08	250	52.3	50.4	59.1
10FEB88	11:18	251	50.5	54.5	59.2
10FEB88	11:28	250	54.0	54.5	59.1
10FEB88	11:38	250	56.0	55.3	59.1
10FEB88	11:48	250	57.3	55.3	59.5
10FEB88	11:58	250	57.8	55.2	59.5
10FEB88	12:08	251	53.1	56.0	60.3
10FEB88	12:18	250	52.4	52.9	60.5
10FEB88	12:28	249	52.3	55.0	58.5
10FEB88	12:38	249	56.3	55.3	59.8
10FEB88	12:48	250	55.6	55.8	60.1
10FEB88	12:58	250	58.4	54.6	59.9
10FEB88	13:08	250	60.9	54.4	59.1
10FEB88	13:18	251	61.9	56.2	60.7
10FEB88	13:28	250	62.9	56.1	58.6
10FEB88	13:38	251	59.3	55.0	59.6
10FEB88	13:48	251	49.9	51.4	59.8
10FEB88	13:58	248	51.3	53.3	59.9
	AVERAGE	249.25	55.0	54.2	59.4

[a] PARAMETERS ENTERED MANUALLY FROM SCREEN PRINTOUTS.

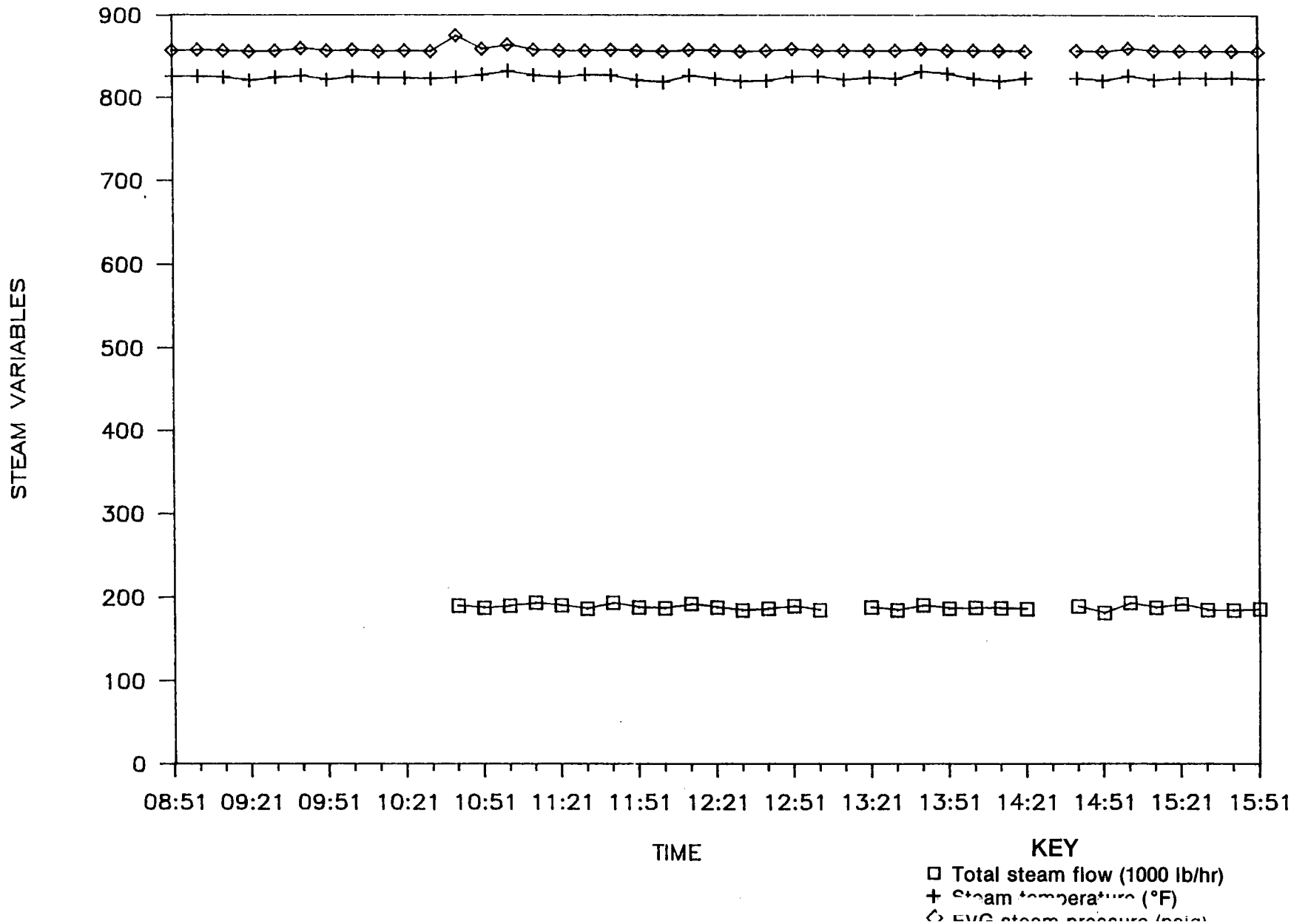
TEST 5C
TEST DATE: 02/10/88

PROCESS DATA SUMMARY
WHEELABRATOR MILLBURY, INC.
MILLBURY RESOURCE RECOVERY FACILITY
MILLBURY MASSACHUSETTS

UNIT 2 ESP OPERATING DATA

DATE	TIME	PRIMARY VOLTAGE VOLTS AC FIELD			PRIMARY CURRENT AMPS AC FIELD			SECONDARY VOLTAGE KVOLTS DC FIELD			SECONDARY CURRENT AMPS DC FIELD			SPARK RATE SPARKS/MIN X10 FIELD		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
10FEB88	08:45	320	340	370	123	178	173	45	45	49	0.61	1.08	1.09	0	0	0
10FEB88	09:15	310	310	370	121	181	172	42	44	49	0.59	1.11	1.07	0	0	0
10FEB88	09:45	310	330	370	103	178	172	45	44	49	0.50	1.08	1.07	1	0	0
10FEB88	10:15	330	330	370	121	175	164	47	44	48	0.60	1.06	1.04	0	0	0
10FEB88	10:45	320	330	370	116	169	172	44	45	49	0.52	1.03	1.07	0	0	0
10FEB88	11:15	310	330	370	118	178	174	44	45	49	0.63	1.09	1.09	0	0	0
10FEB88	11:45	320	340	370	107	174	167	46	45	49	0.63	1.03	1.09	0	0	0
10FEB88	12:15	320	320	370	121	176	170	42	44	50	0.52	1.05	1.08	0	0	0
10FEB88	12:45	330	340	380	109	178	171	48	46	50	0.67	1.02	1.05	0	0	0
10FEB88	13:15	360	330	380	117	169	170	41	45	50	0.60	1.06	1.02	1	0	0
10FEB88	13:45	310	330	380	106	172	170	45	45	50	0.64	1.11	1.03	0	0	0
	AVERAGE	322	330	373	115	175	170	44	45	49	0.59	1.07	1.06	0	0	0

RUN 1


900
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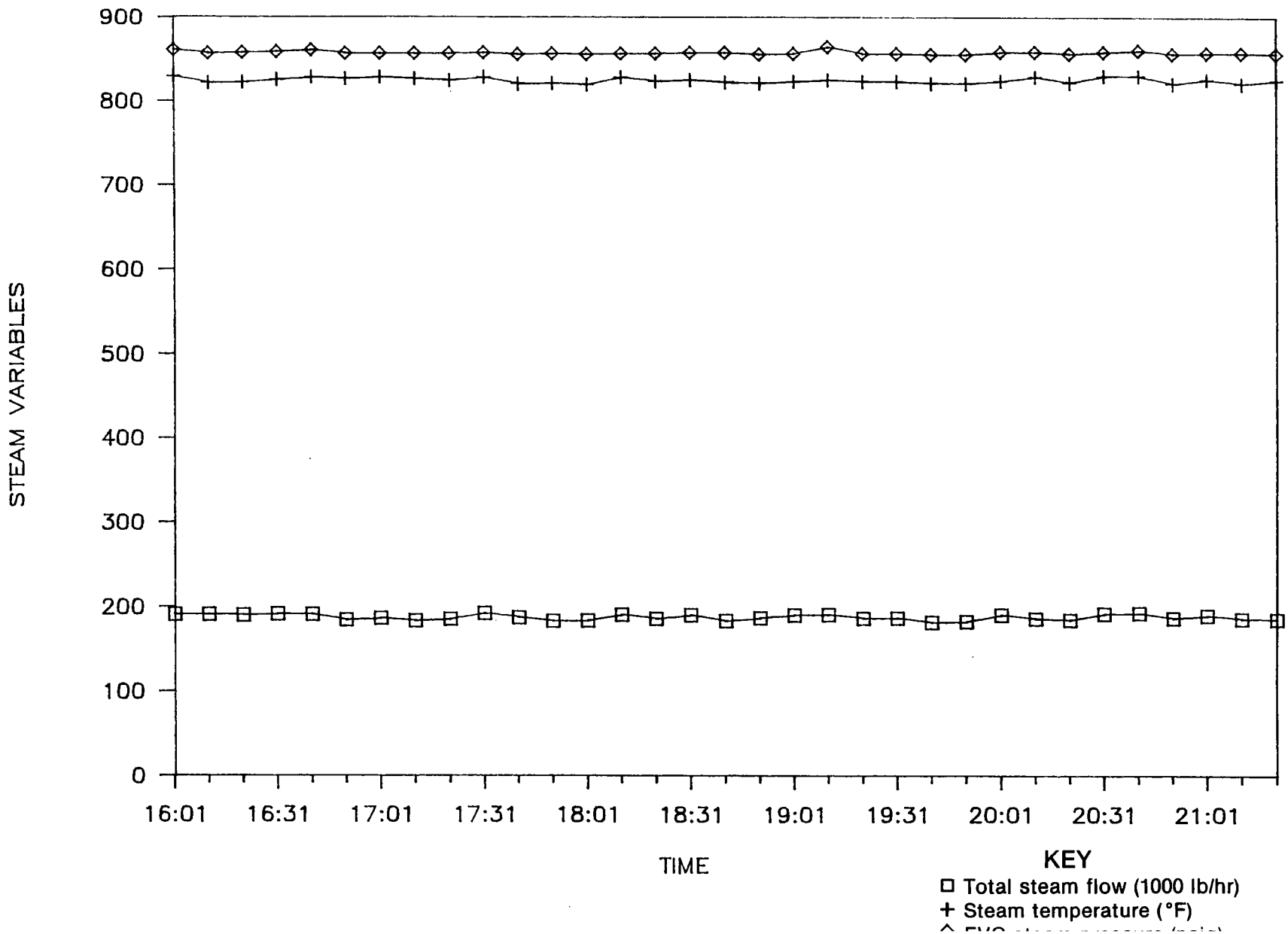
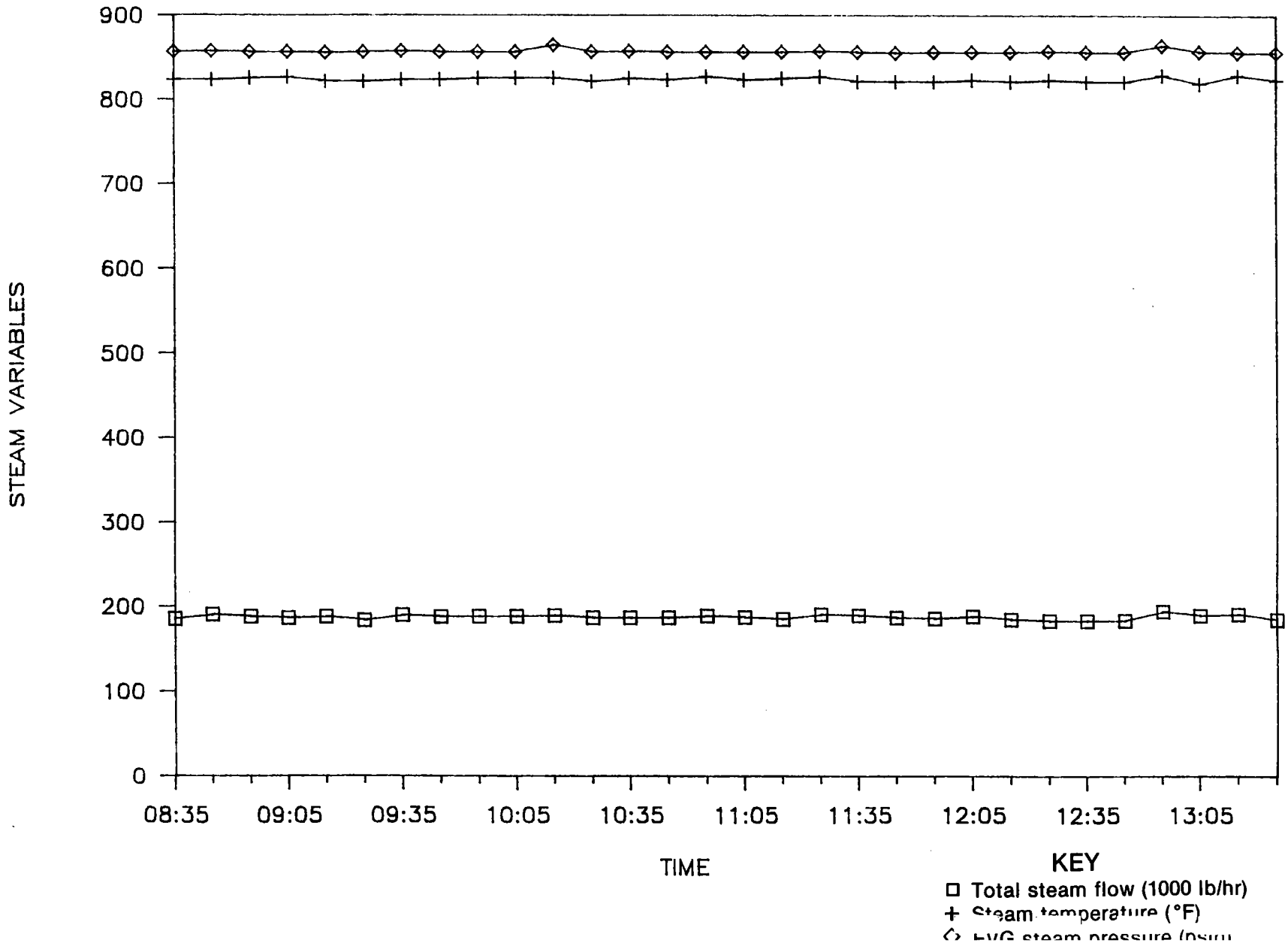
STEAM VARIABLES
08:51 09:21 09:51 10:21 10:51 11:21 11:51 12:21 12:51 13:21 13:51 14:21 14:51 15:21 15:51
TIME
KEY
Total steam flow (1000 lb/hr)
Steam temperature (°F)
EVG steam pressure (psig)

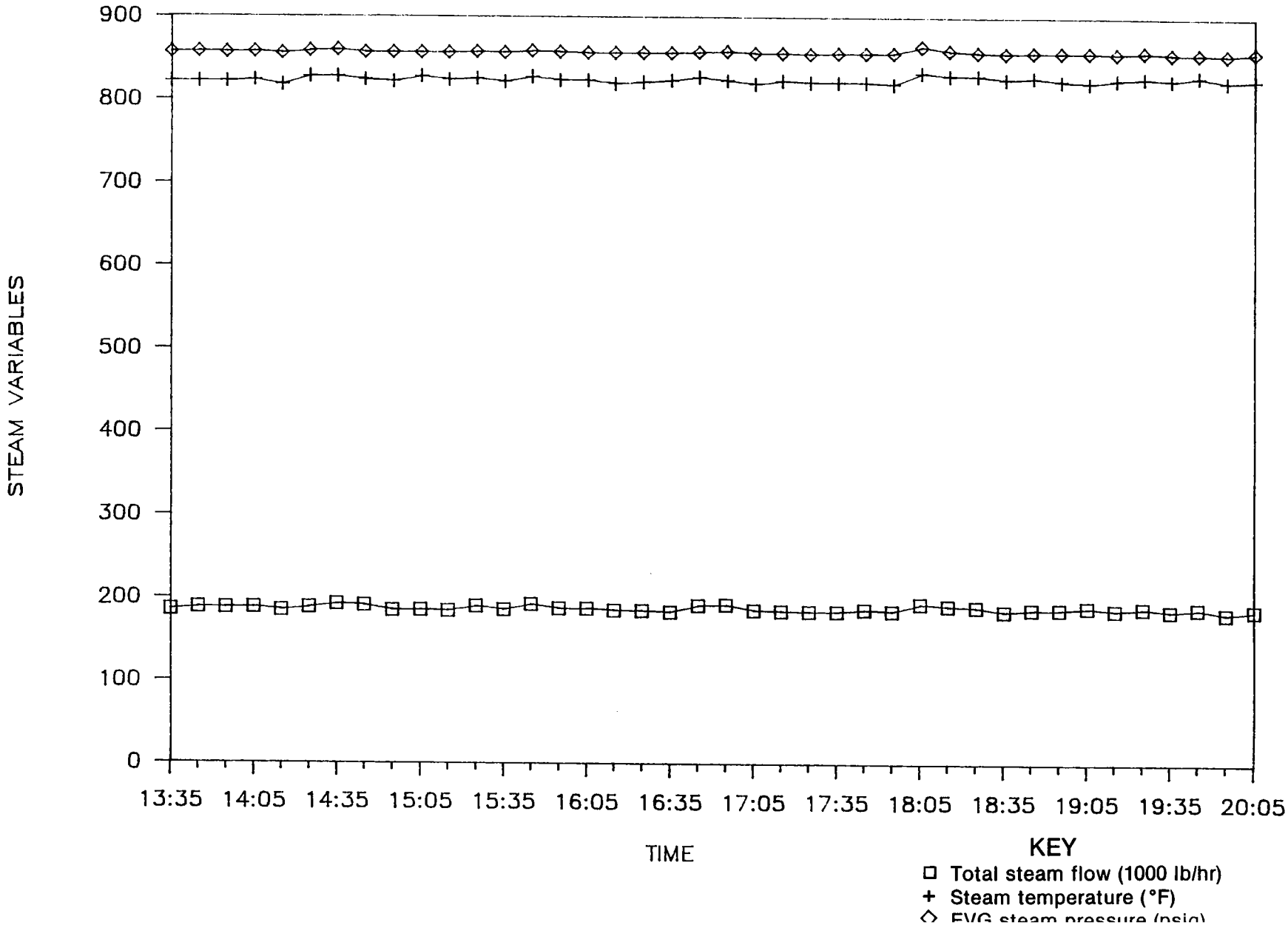
RUN 2


900
800
700
600
500
400
300
200
100
0
STEAM VARIABLES
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Total steam flow (1000 lb/hr)
Steam temperature (°F)

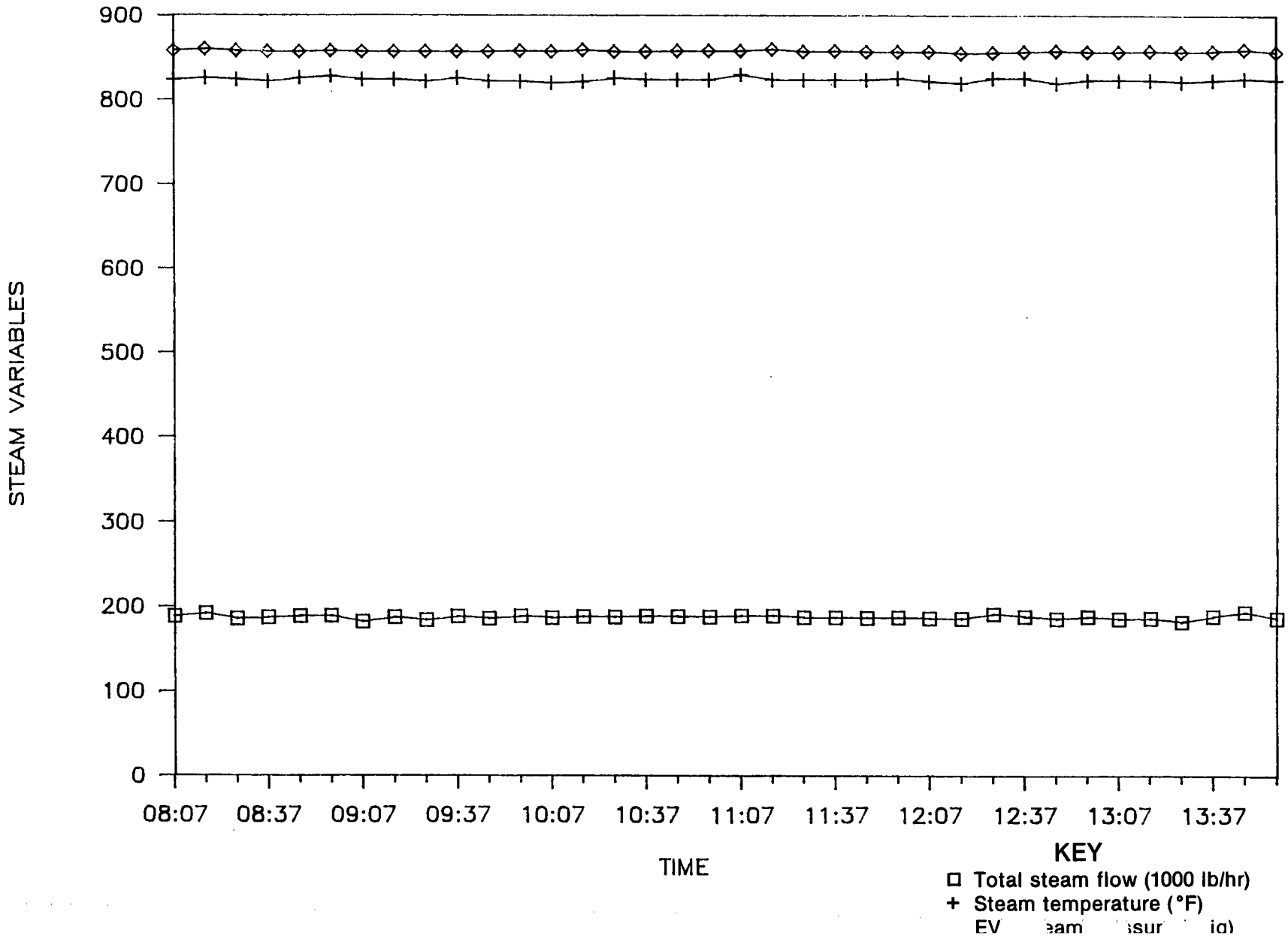
RUN 3


900
800
700
600
500
400
300
200
100
0
STEAM VARIABLES
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Total steam flow (1000 lb/hr)
Steam temperature (°F)

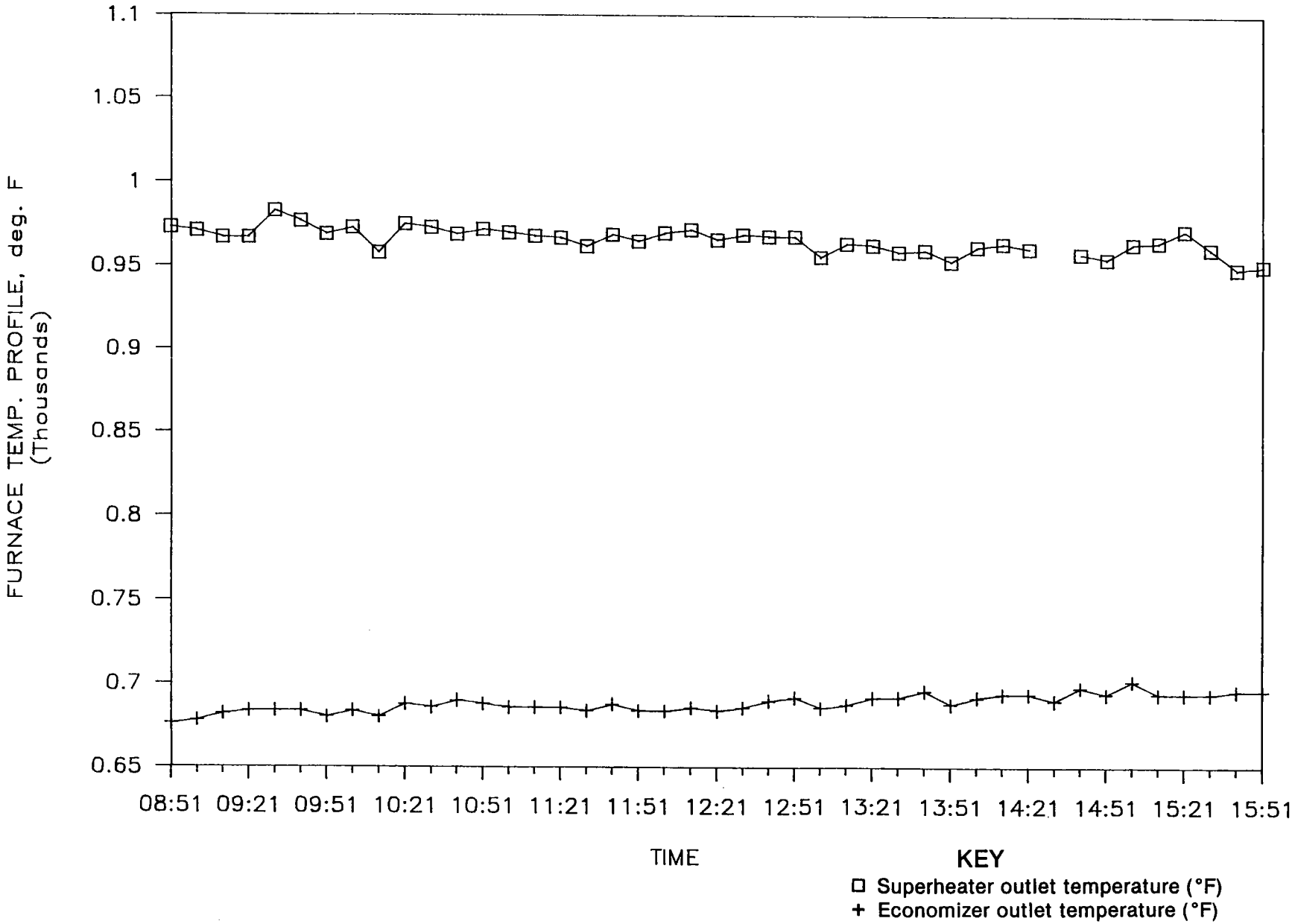
RUN 4


STEAM VARIABLES
900
800
700
600
500
400
300
200
100
0
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Total steam flow (1000 lb/hr)
Steam temperature (°F)
EVG steam pressure (psig)

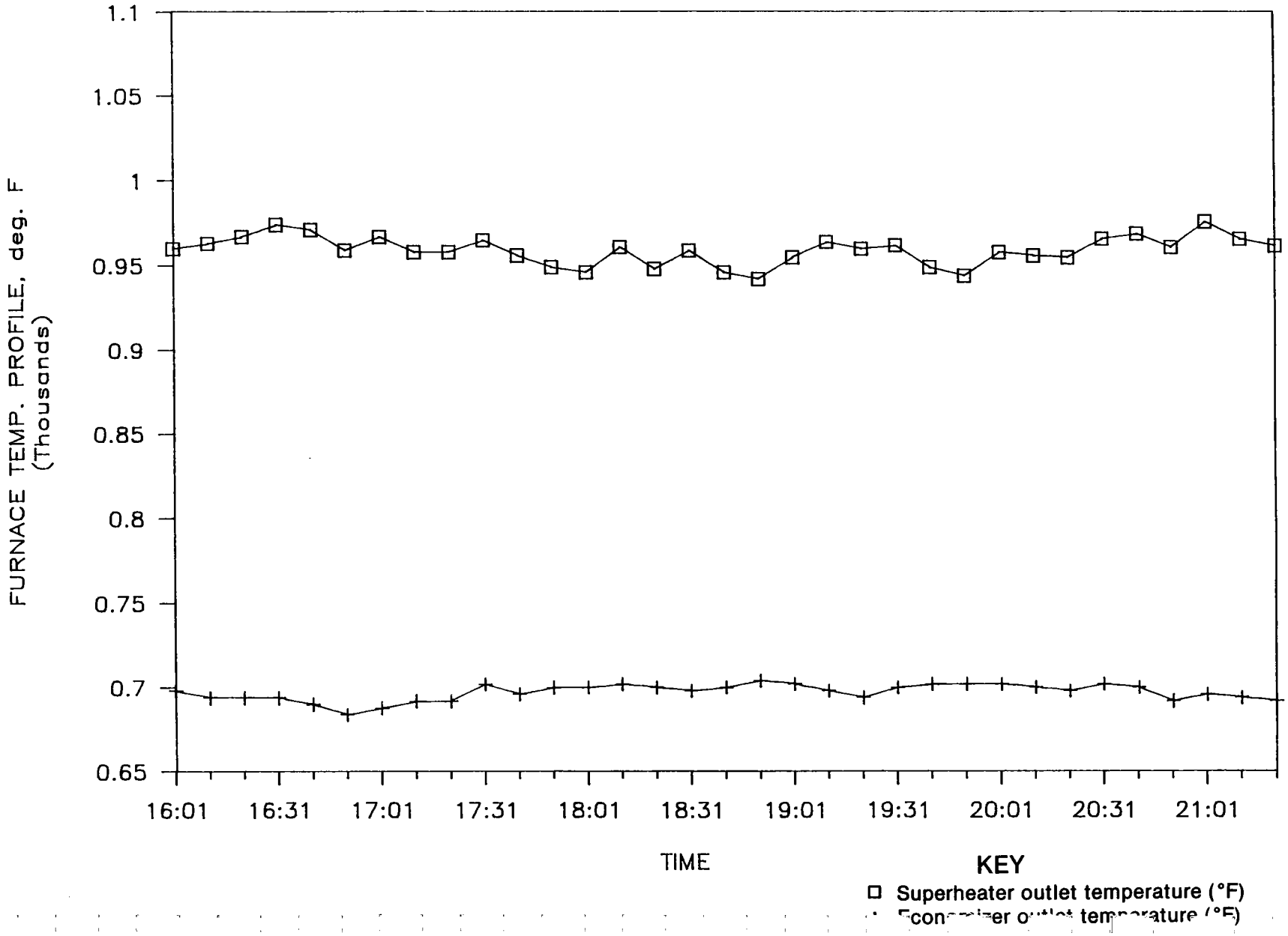
RUN 5

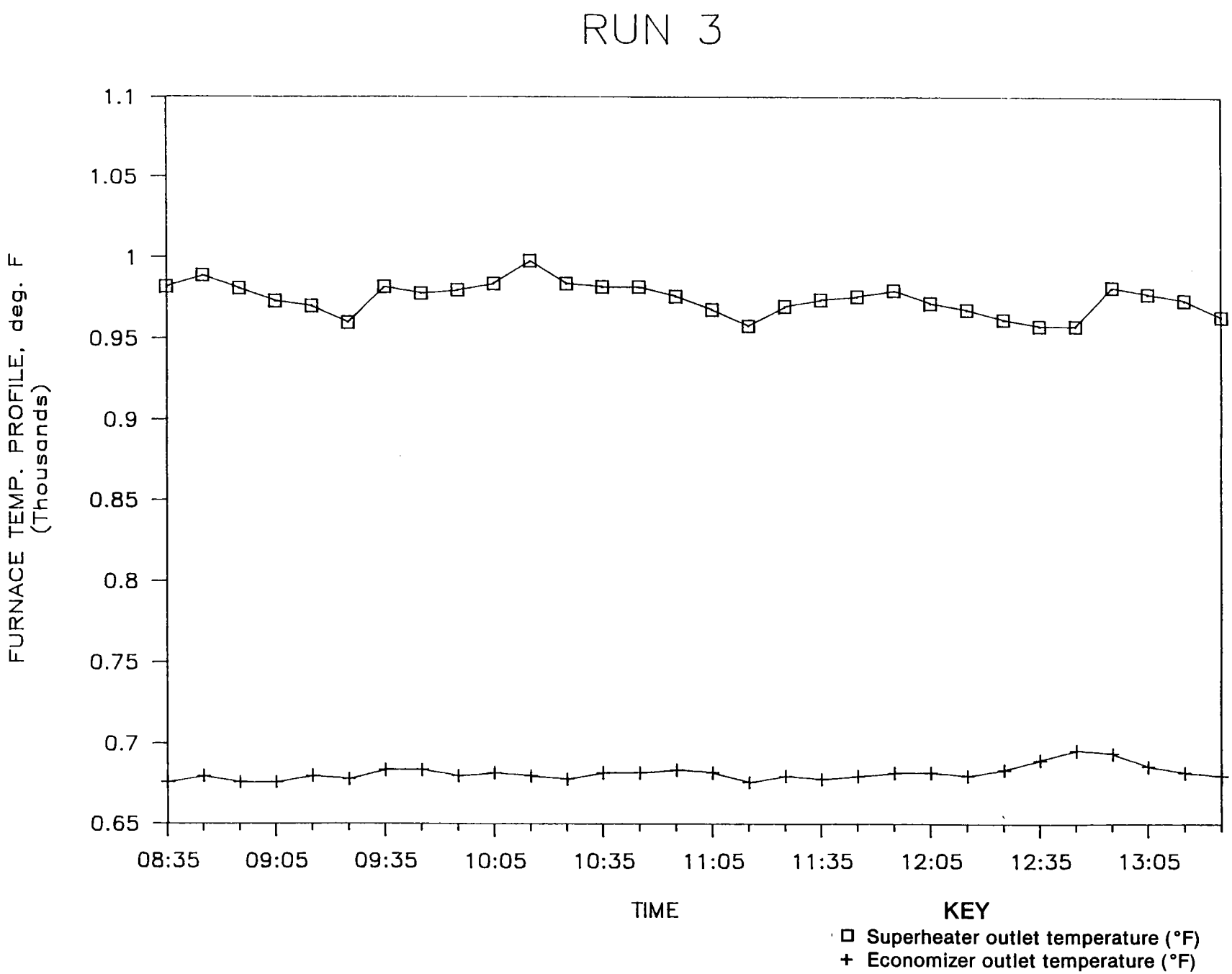

900
800
700
600
500
400
300
200
100
0
STEAM VARIABLES
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Total steam flow (1000 lb/hr)
Steam temperature (°F)

RUN 1

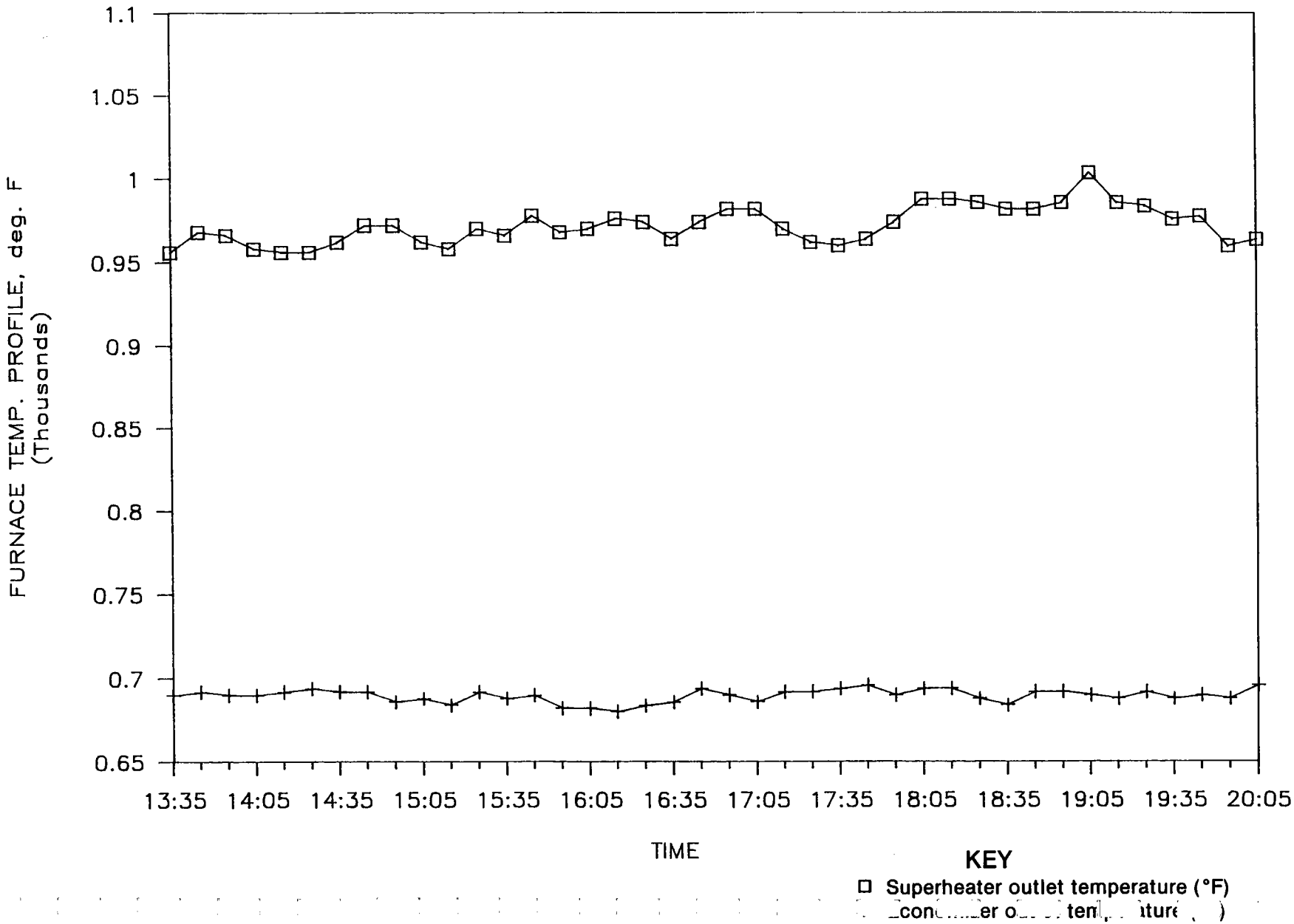

FURNACE TEMP. PROFILE, deg. F
(Thousands)
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Superheater outlet temperature (°F)
Economizer outlet temperature (°F)

RUN 2

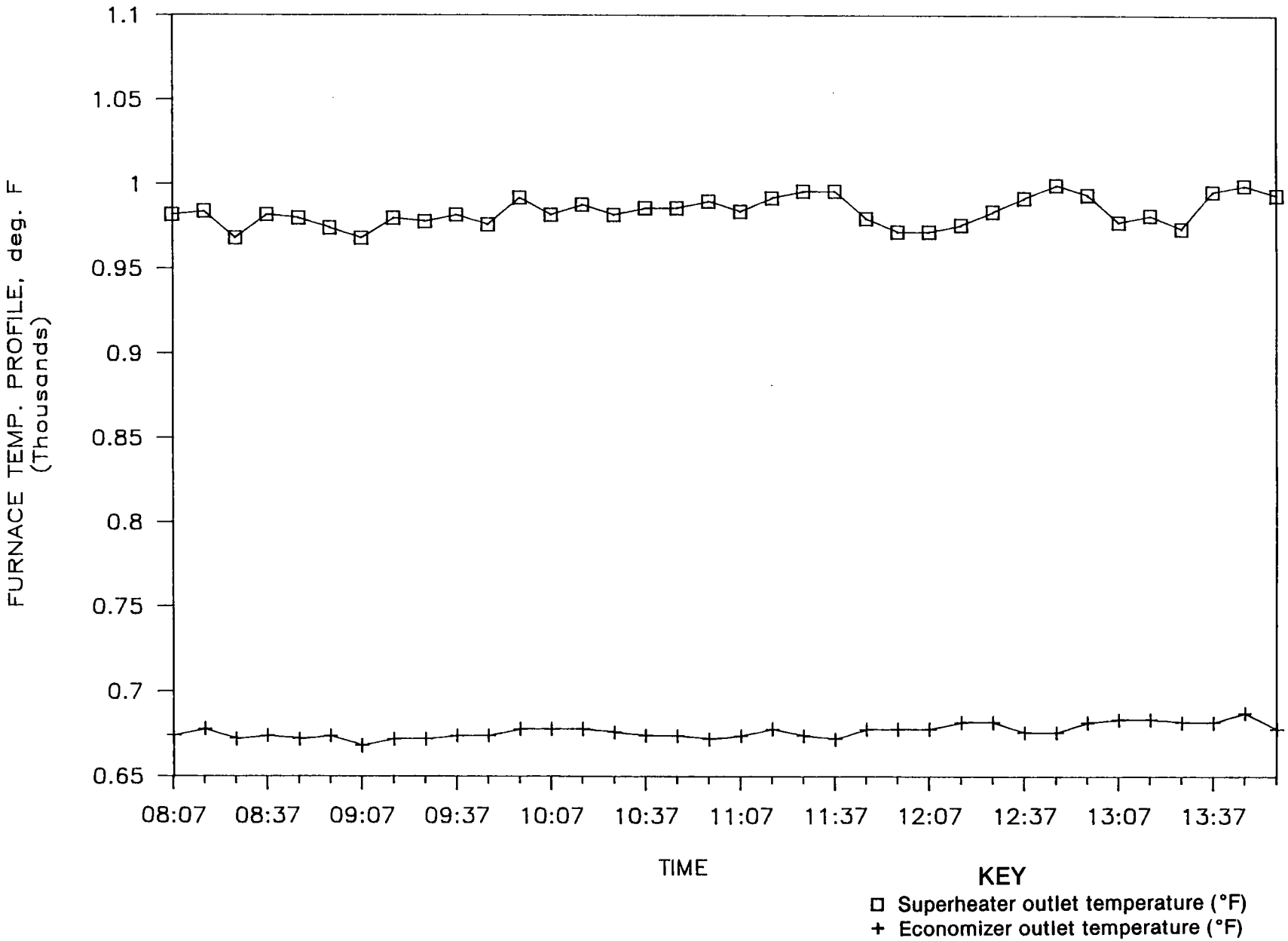

FURNACE TEMP. PROFILE, deg. F
(Thousands)
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Superheater outlet temperature (°F)


RUN 3
FURNACE TEMP. PROFILE, deg. F
(Thousands)
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Superheater outlet temperature (°F)
Economizer outlet temperature (°F)

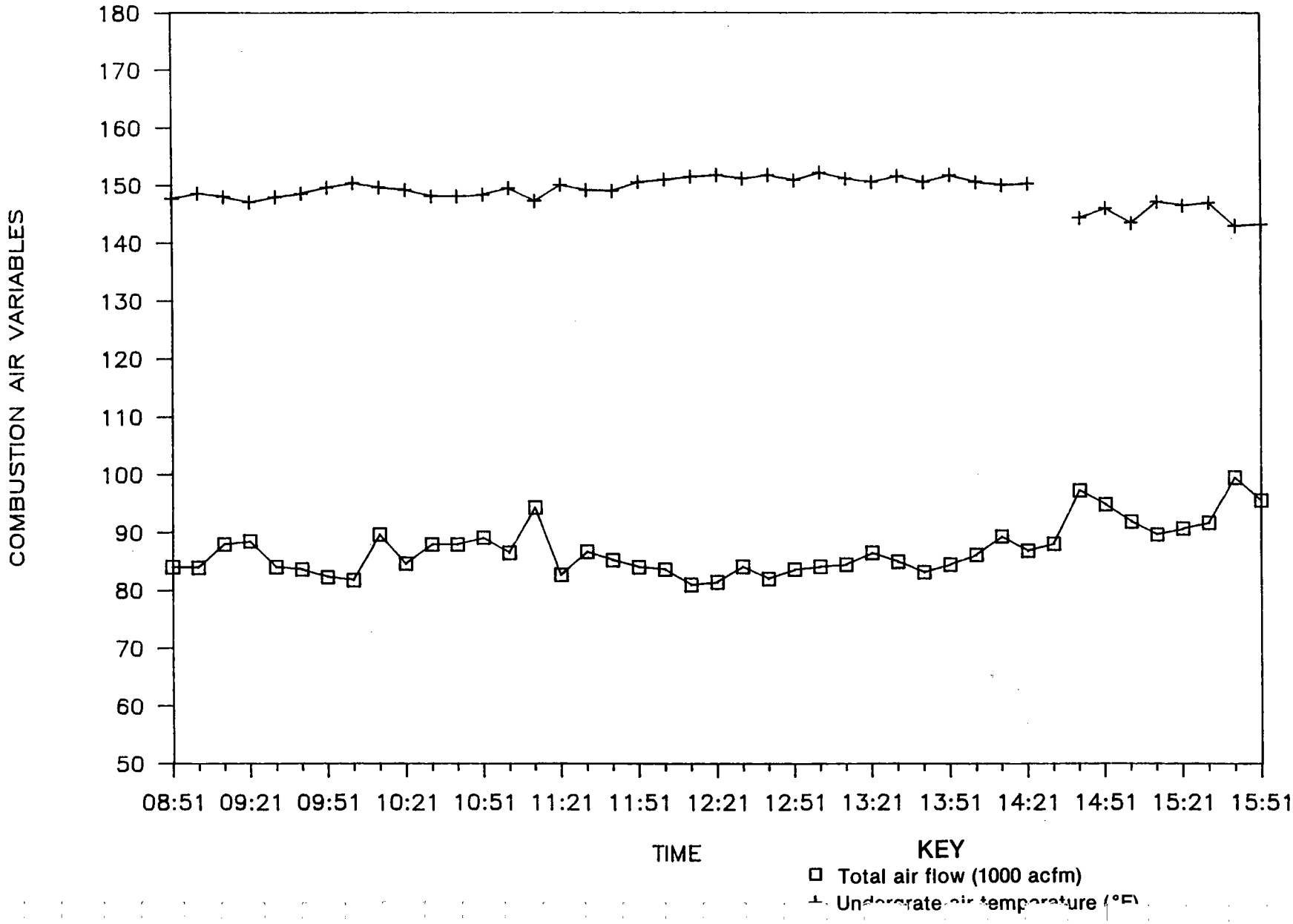
RUN 4

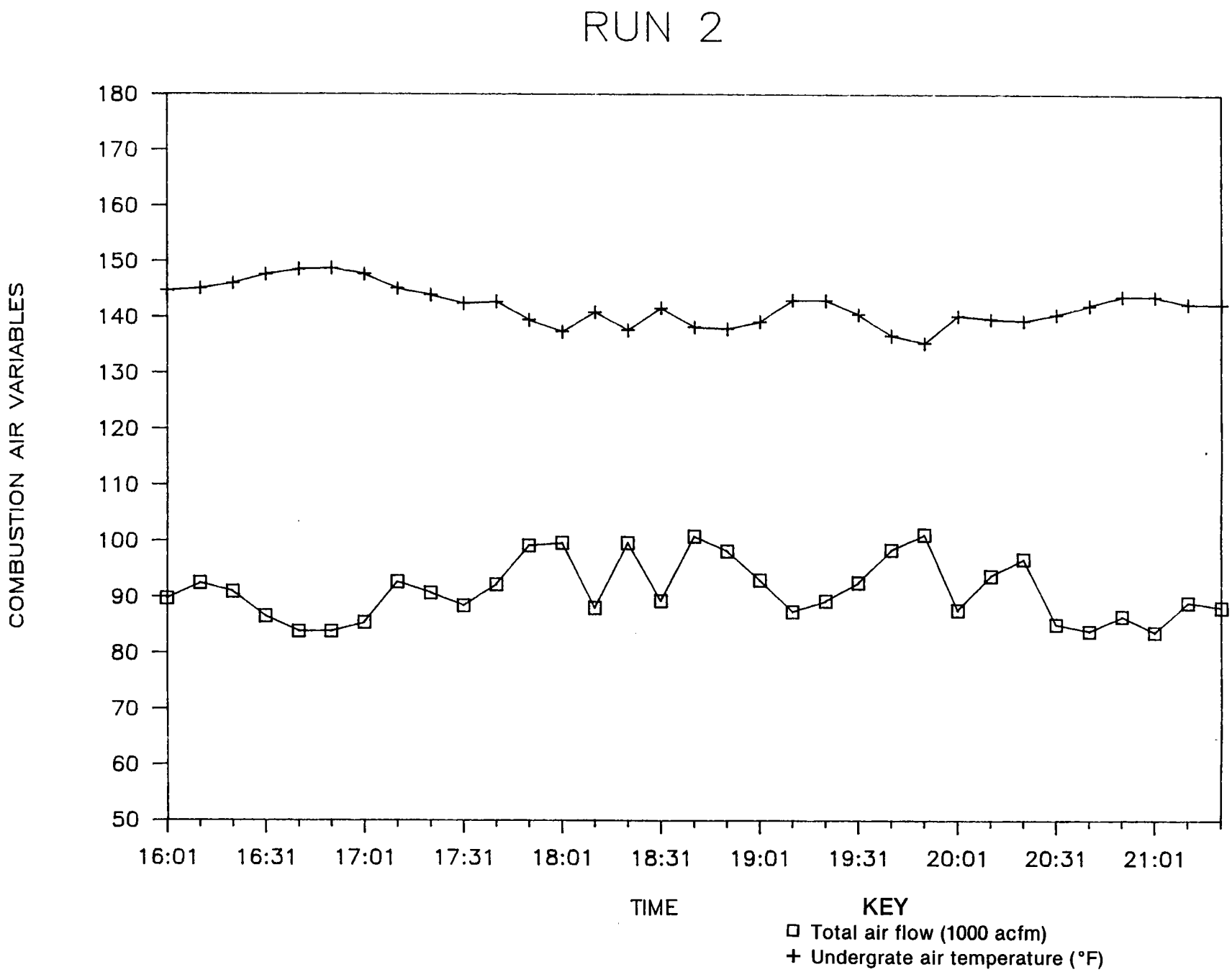

FURNACE TEMP. PROFILE, deg. F
(Thousands)
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Superheater outlet temperature (°F)

RUN 5

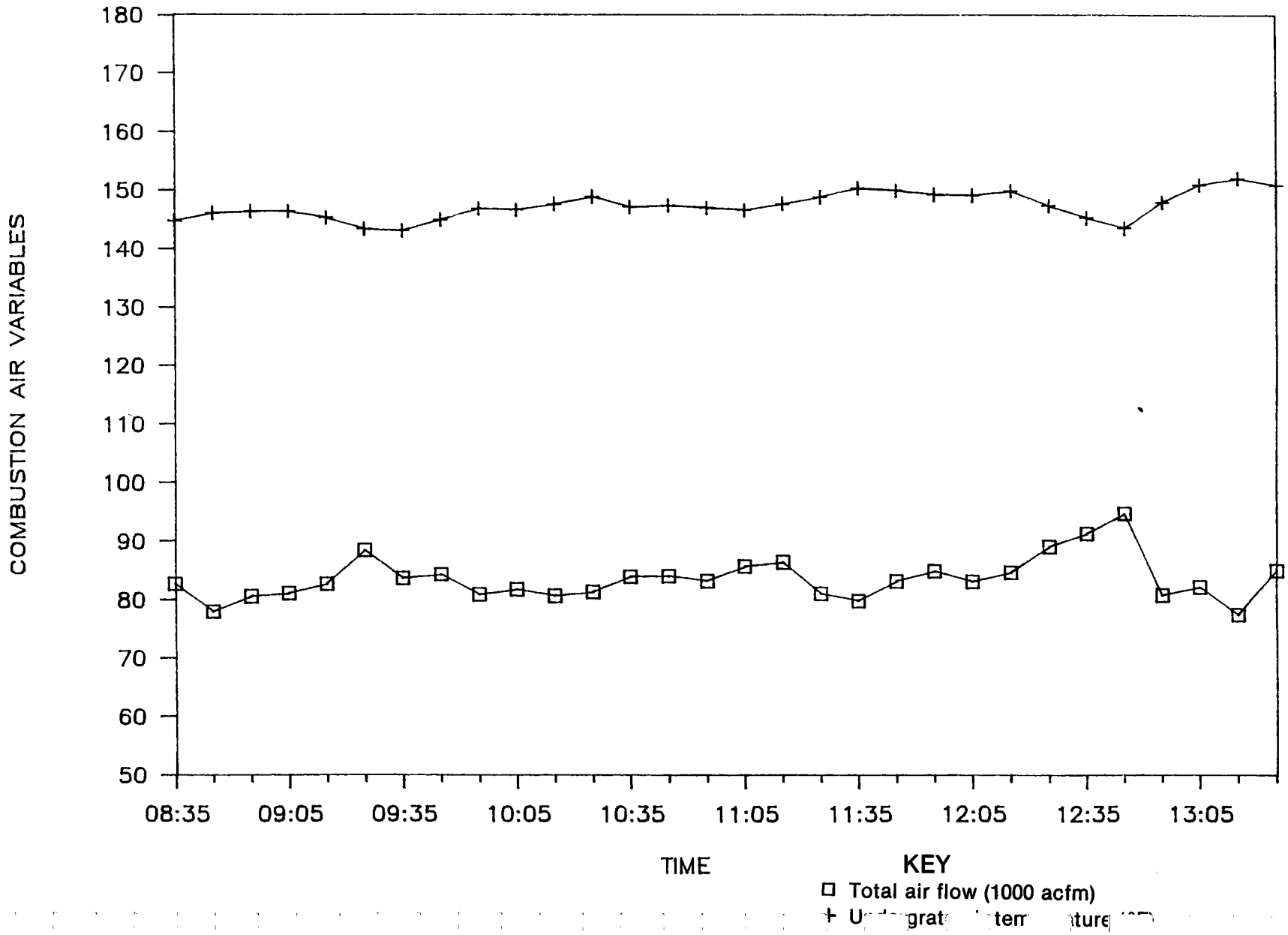

FURNACE TEMP. PROFILE, deg. F
(Thousands)
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Superheater outlet temperature (°F)
Economizer outlet temperature (°F)

RUN 1

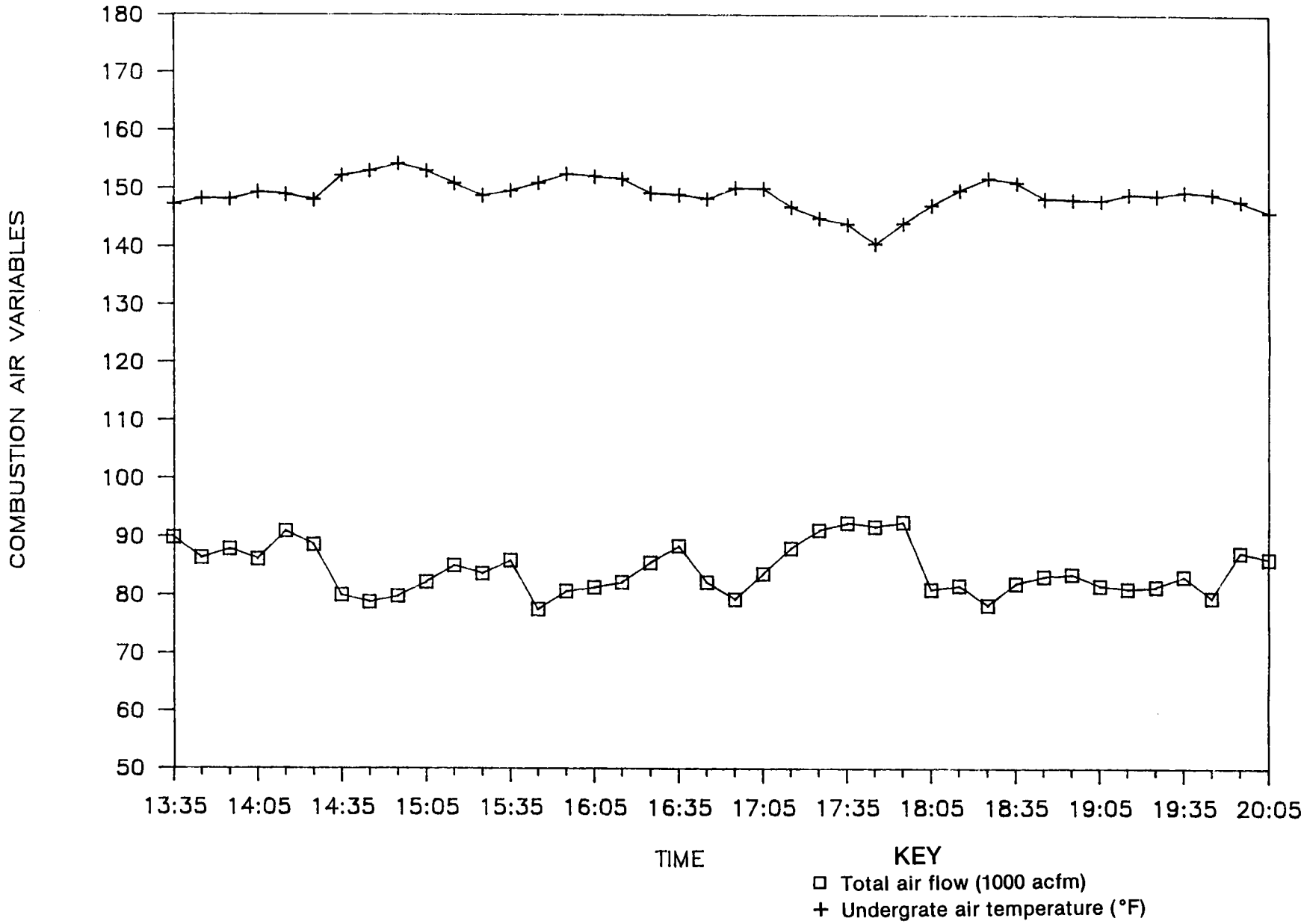

COMBUSTION AIR VARIABLES
180
170
160
150
140
130
120
110
100
90
80
70
60
50
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Total air flow (1000 acfm)
Undergrate air temperature (°F)


RUN 2
COMBUSTION AIR VARIABLES
180
170
160
150
140
130
120
110
100
90
80
70
60
50
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Total air flow (1000 acfm)
Undergrate air temperature (°F)

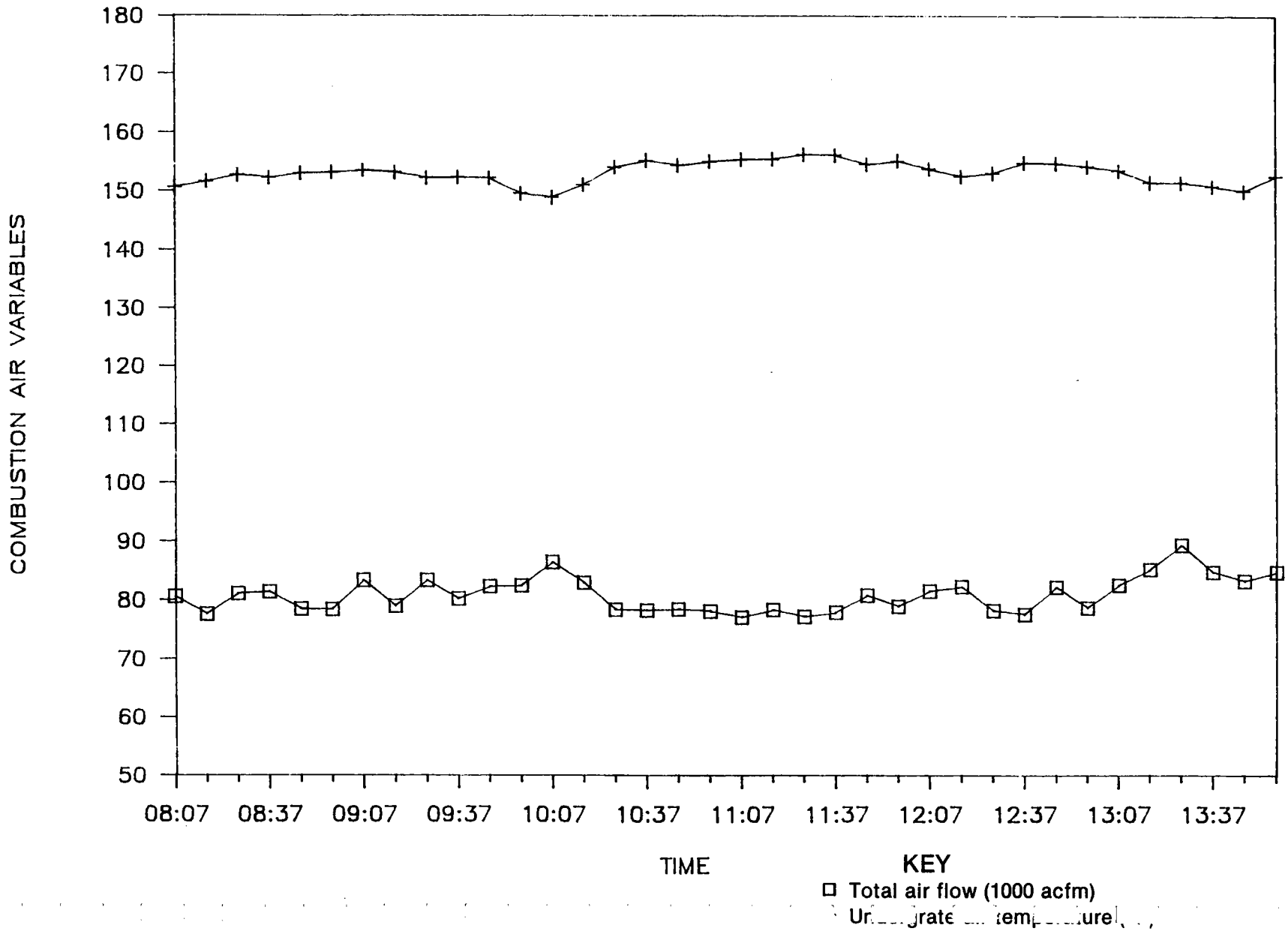
RUN 3

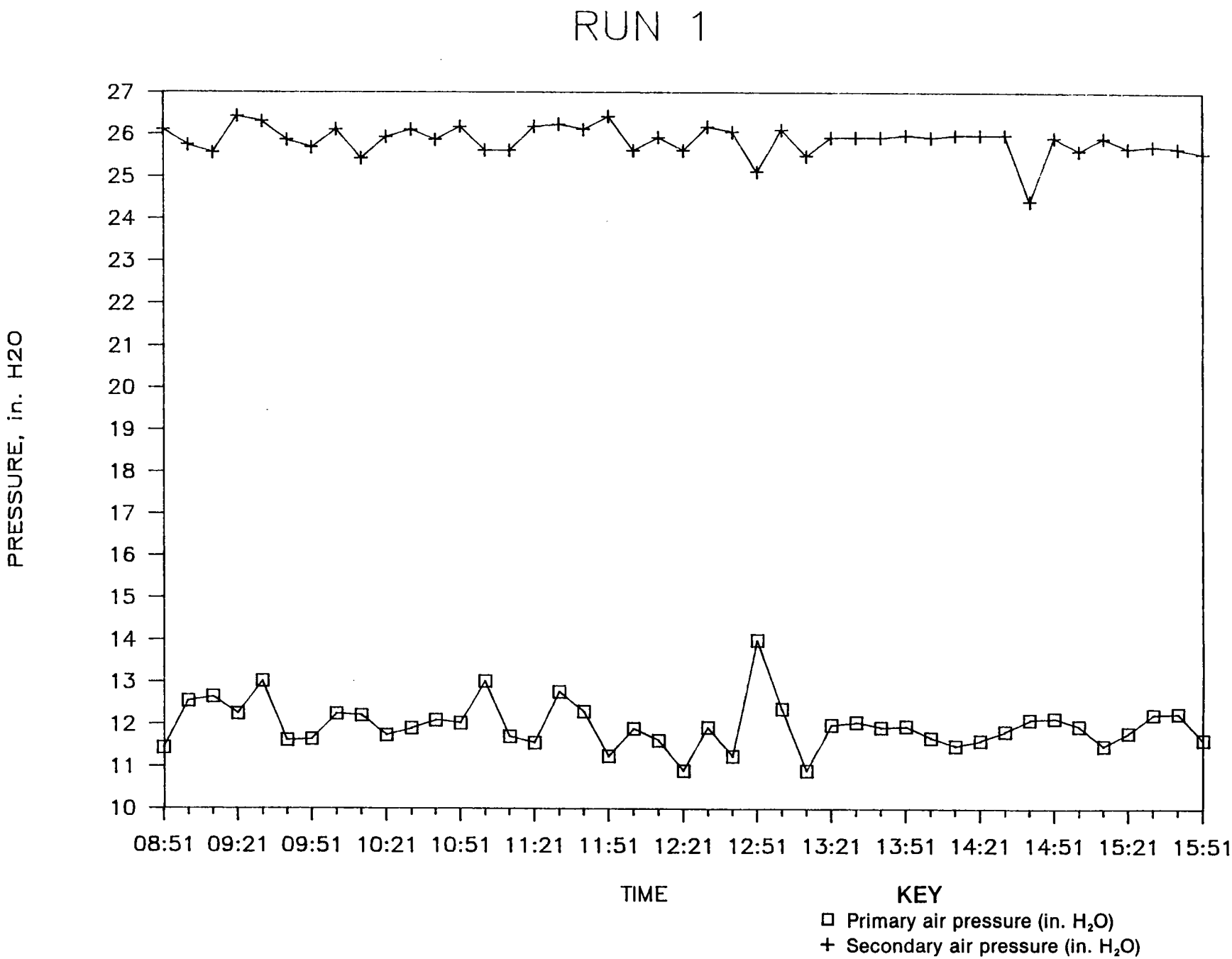

COMBUSTION AIR VARIABLES
180
170
160
150
140
130
120
110
100
90
80
70
60
50
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Total air flow (1000 acfm)

RUN 4

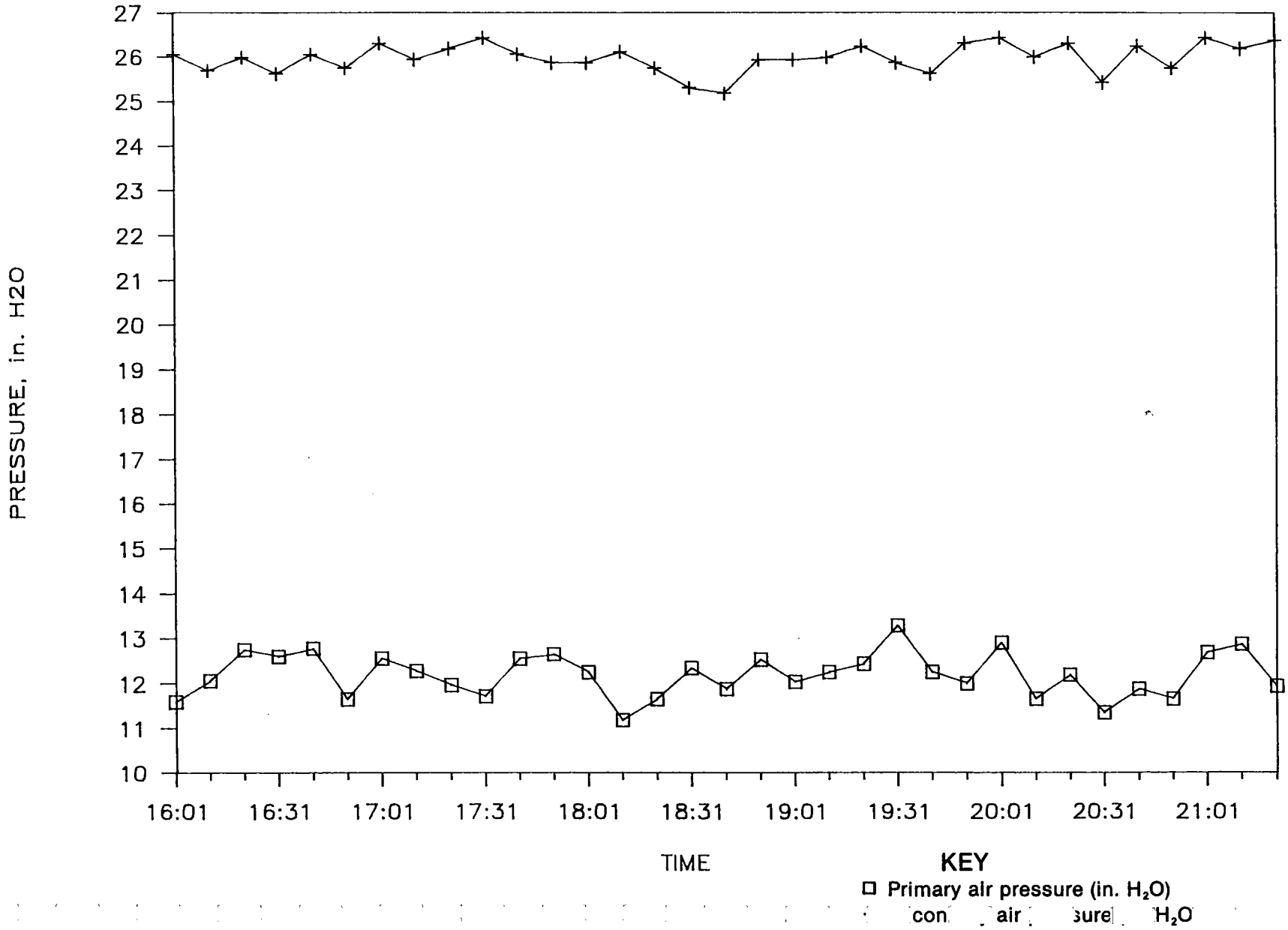

COMBUSTION AIR VARIABLES
180
170
160
150
140
130
120
110
100
90
80
70
60
50
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Total air flow (1000 acfm)
Undergrate air temperature (°F)

RUN 5

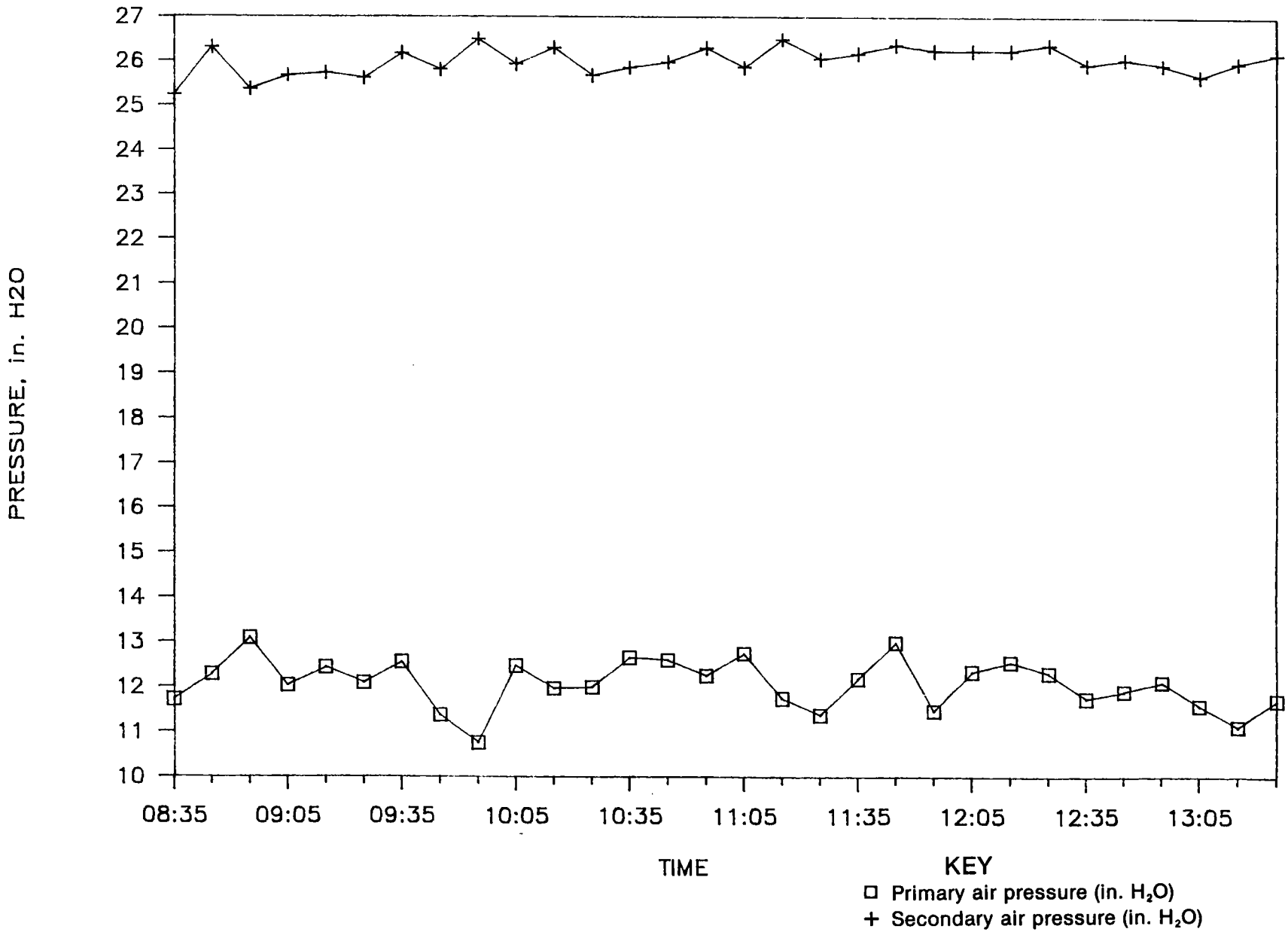

COMBUSTION AIR VARIABLES
180
170
160
150
140
130
120
110
100
90
80
70
60
50
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Total air flow (1000 acfm)


RUN 1
PRESSURE, in. H2O
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Primary air pressure (in. H_2O)
Secondary air pressure (in. H_2O)

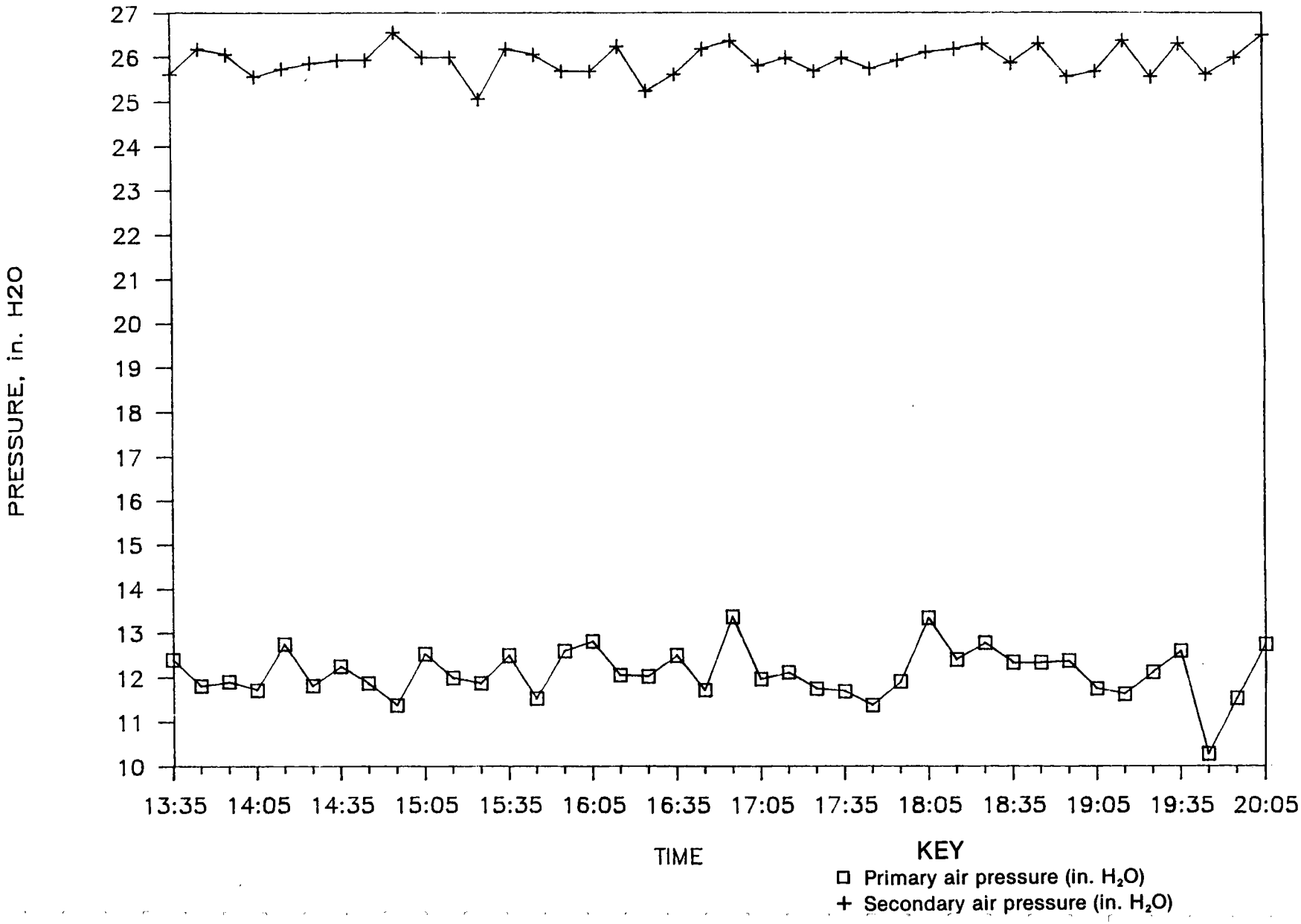
RUN 2

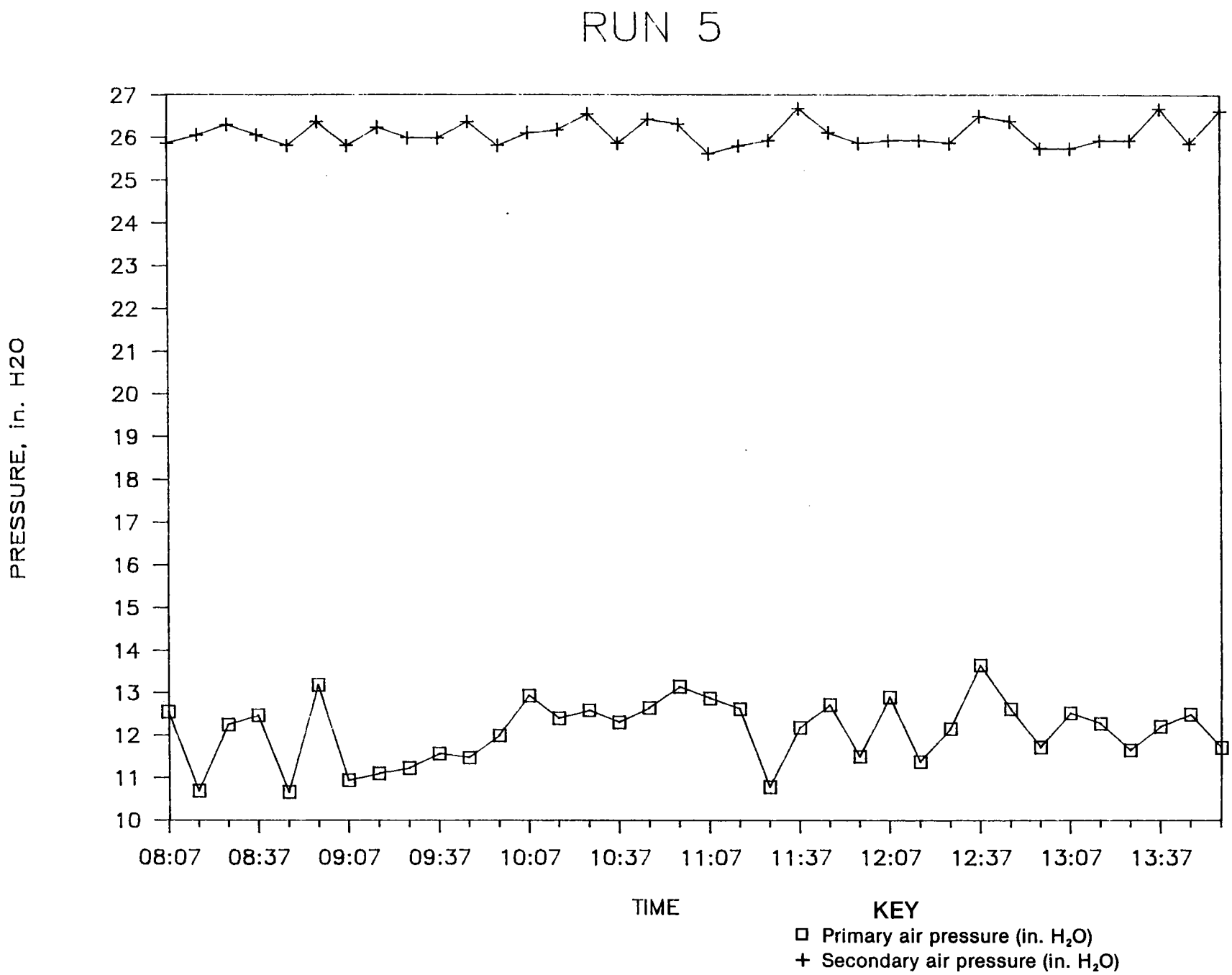

PRESSURE, in. H2O
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Primary air pressure (in. H_2O)
con air sure H_2O

RUN 3

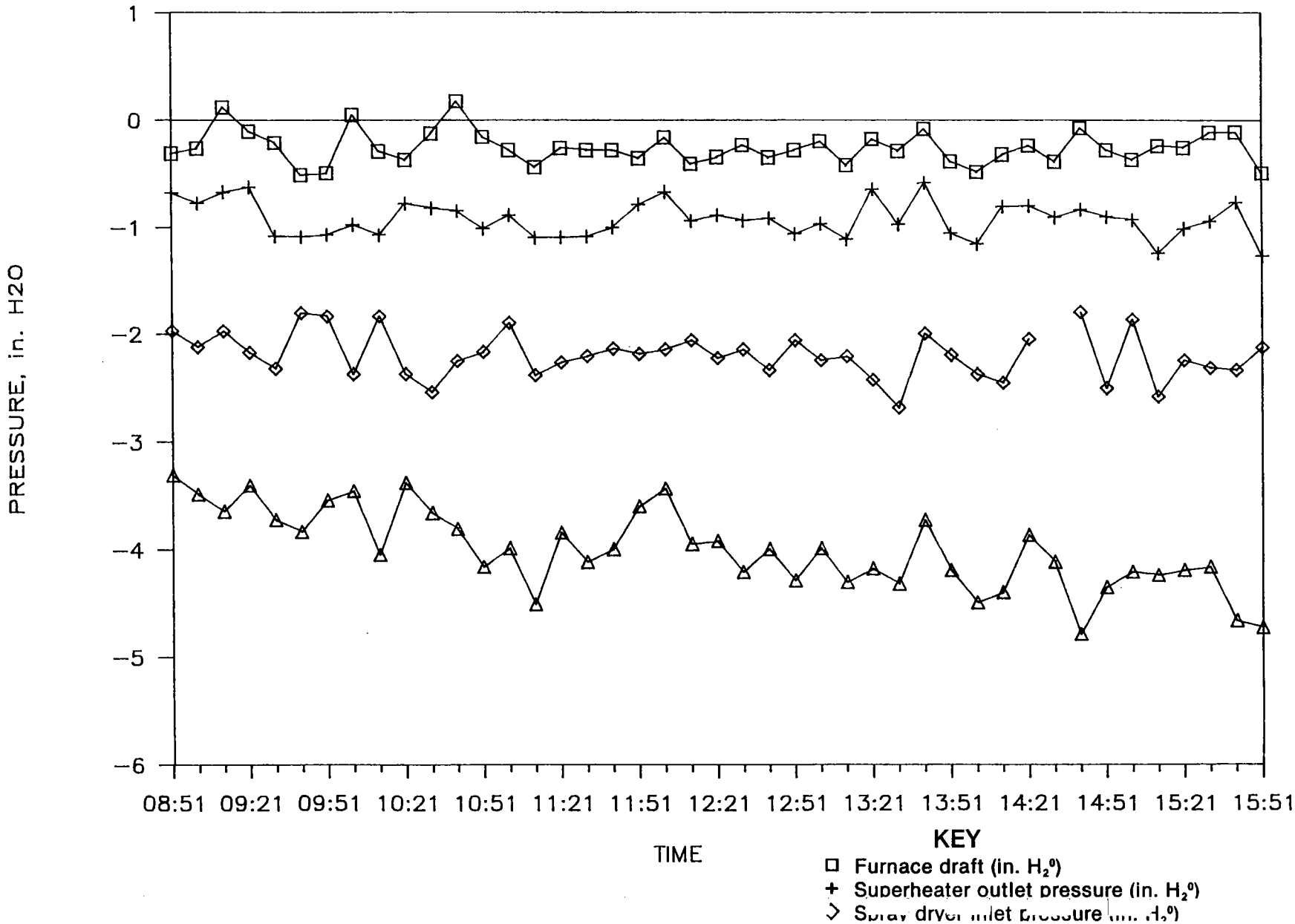

PRESSURE, in. H2O
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Primary air pressure (in. H_2O)
Secondary air pressure (in. H_2O)

RUN 4

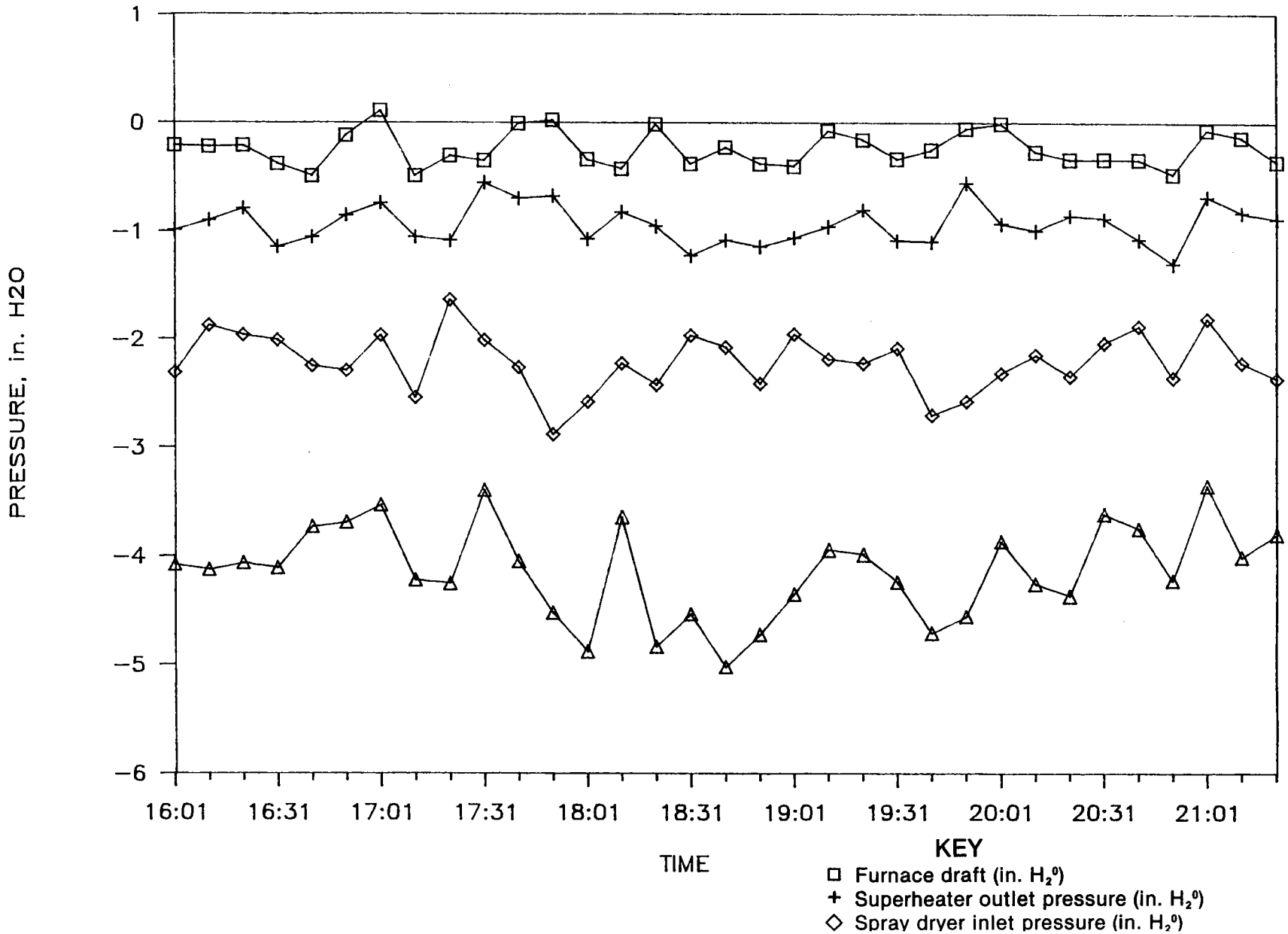

PRESSURE, in. H2O
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Primary air pressure (in. H_2O)
Secondary air pressure (in. H_2O)


RUN 5
PRESSURE, in. H2O
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Primary air pressure (in. H_2O)
Secondary air pressure (in. H_2O)

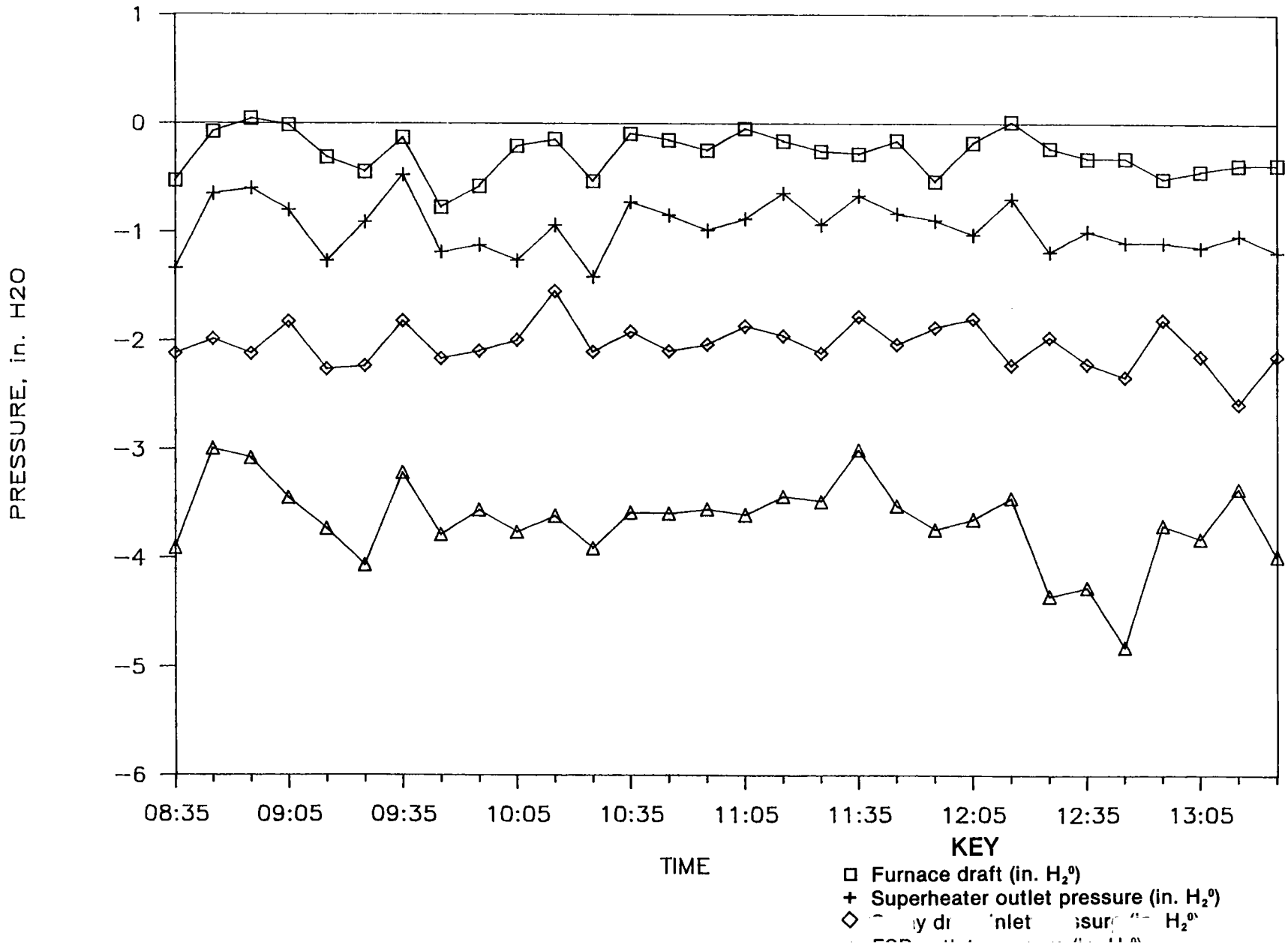
RUN 1


1
0
−1
−2
−3
−4
−5
−6
PRESSURE, in. H2O
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Furnace draft (in. H_2^0)
Superheater outlet pressure (in. H_2^0)
Spray dryer inlet pressure (in. H_2^0)

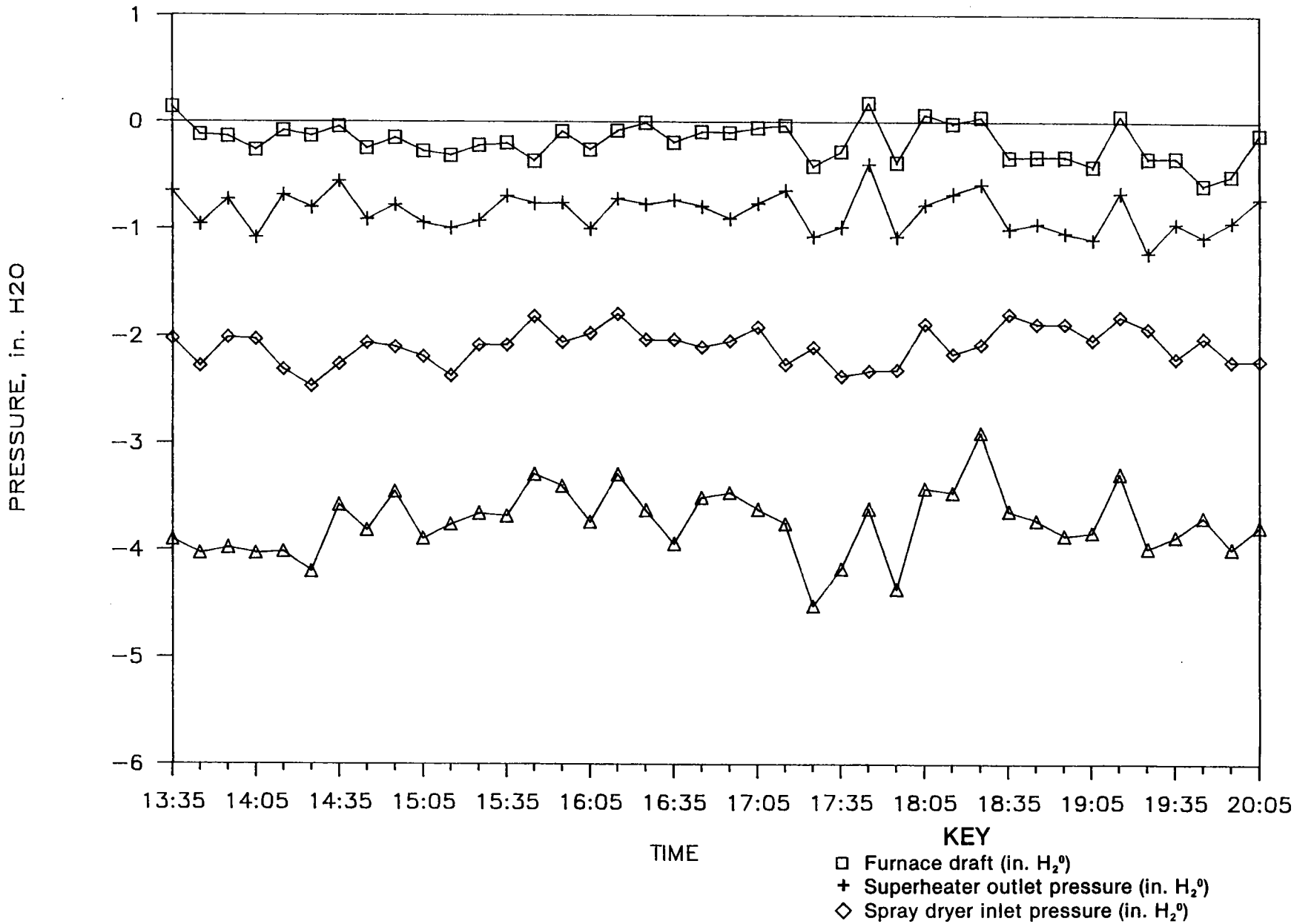
RUN 2


1
0
−1
−2
−3
−4
−5
−6
PRESSURE, in. H2O
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Furnace draft (in. H_2^0)
Superheater outlet pressure (in. H_2^0)
Spray dryer inlet pressure (in. H_2^0)

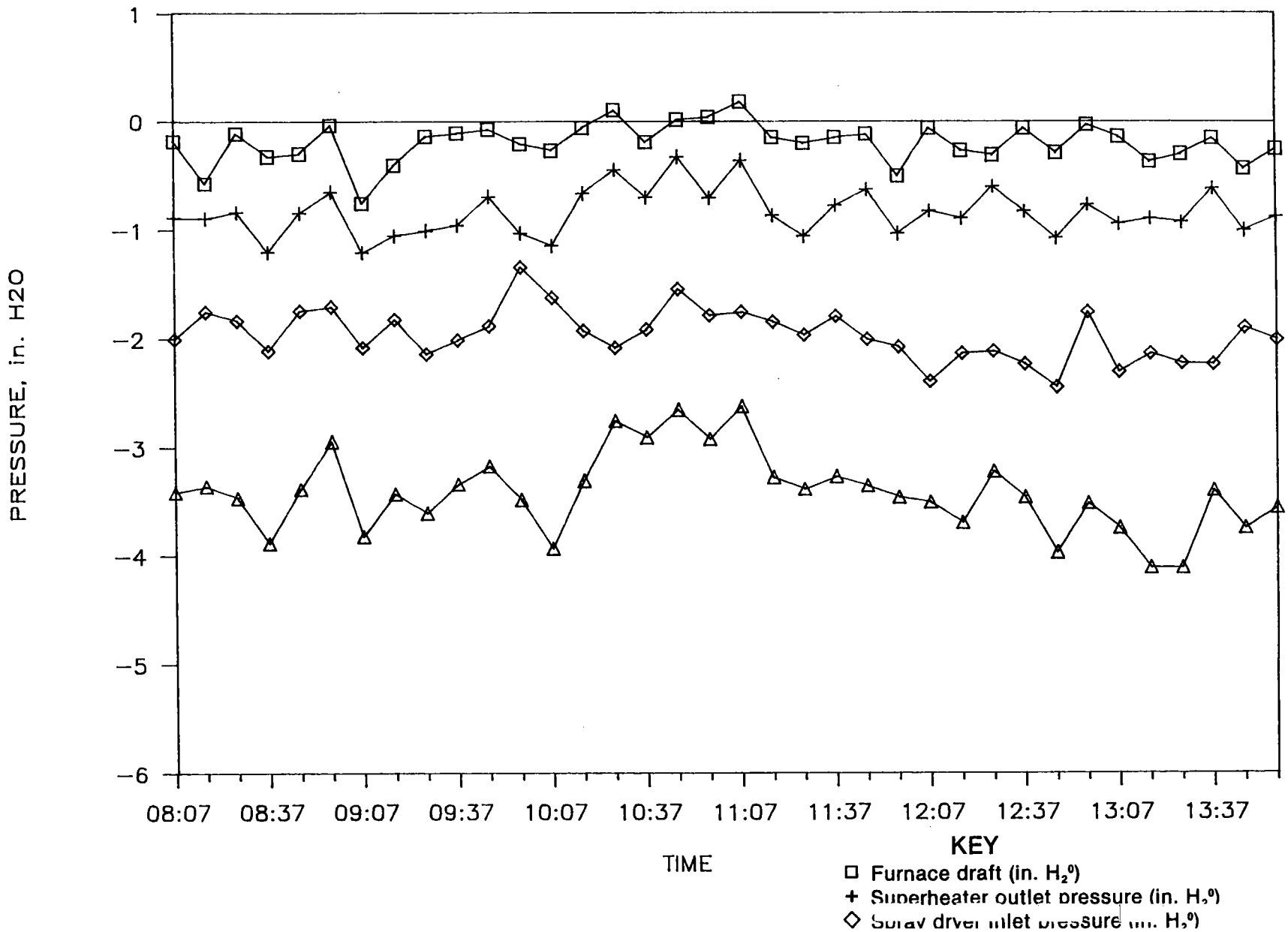
RUN 3


1
0
−1
−2
−3
−4
−5
−6
PRESSURE, in. H2O
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Furnace draft (in. H_2^0)
Superheater outlet pressure (in. H_2^0)

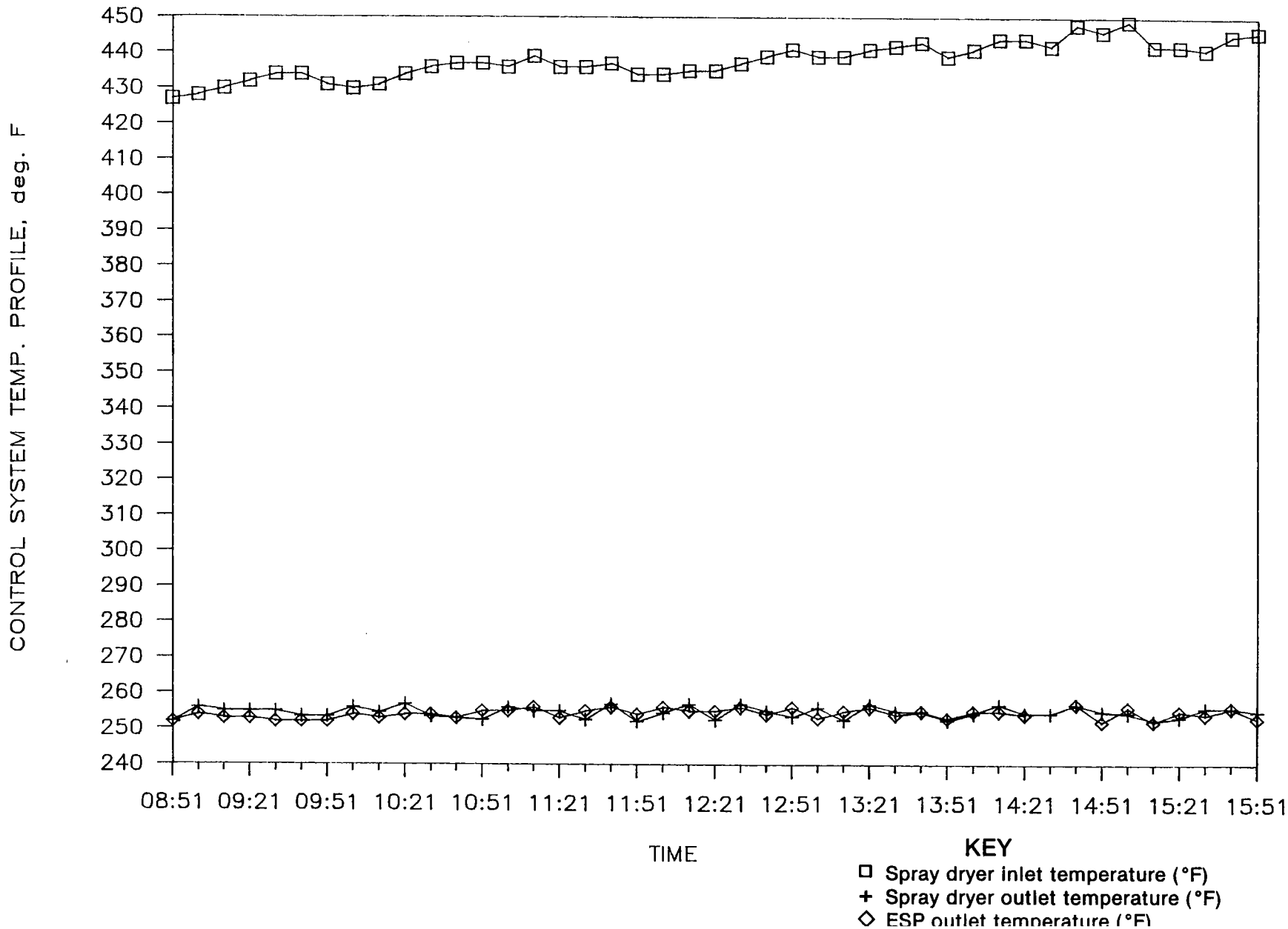
RUN 4


PRESSURE, in. H2O
1
0
−1
−2
−3
−4
−5
−6
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Furnace draft (in. H_2^0)
Superheater outlet pressure (in. H_2^0)
Spray dryer inlet pressure (in. H_2^0)

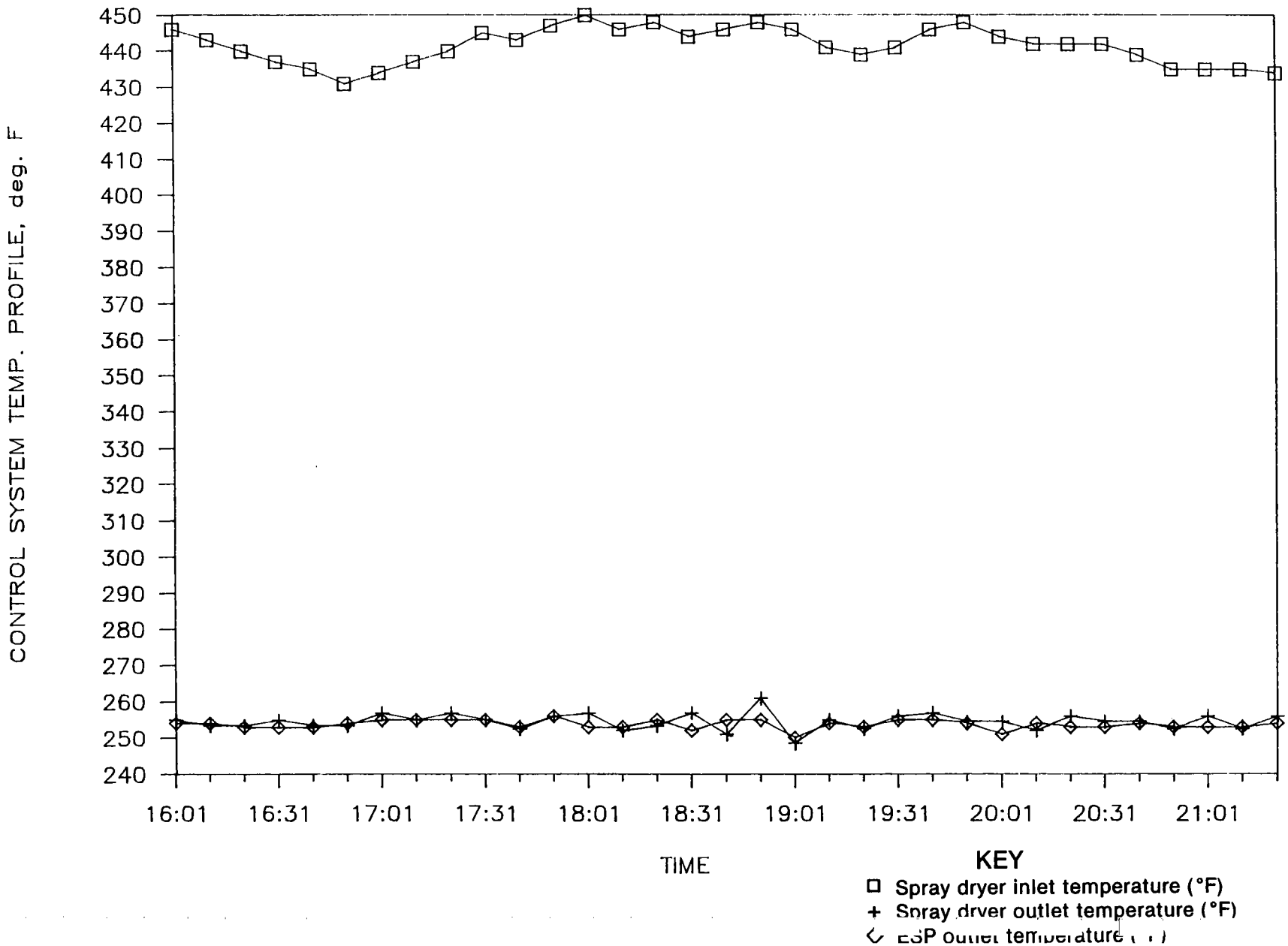
RUN 5


1
0
−1
−2
−3
−4
−5
−6
PRESSURE, in. H2O
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Furnace draft (in. H₂⁰)
Superheater outlet pressure (in. H₂⁰)
Spray dryer inlet pressure (in. H₂⁰)

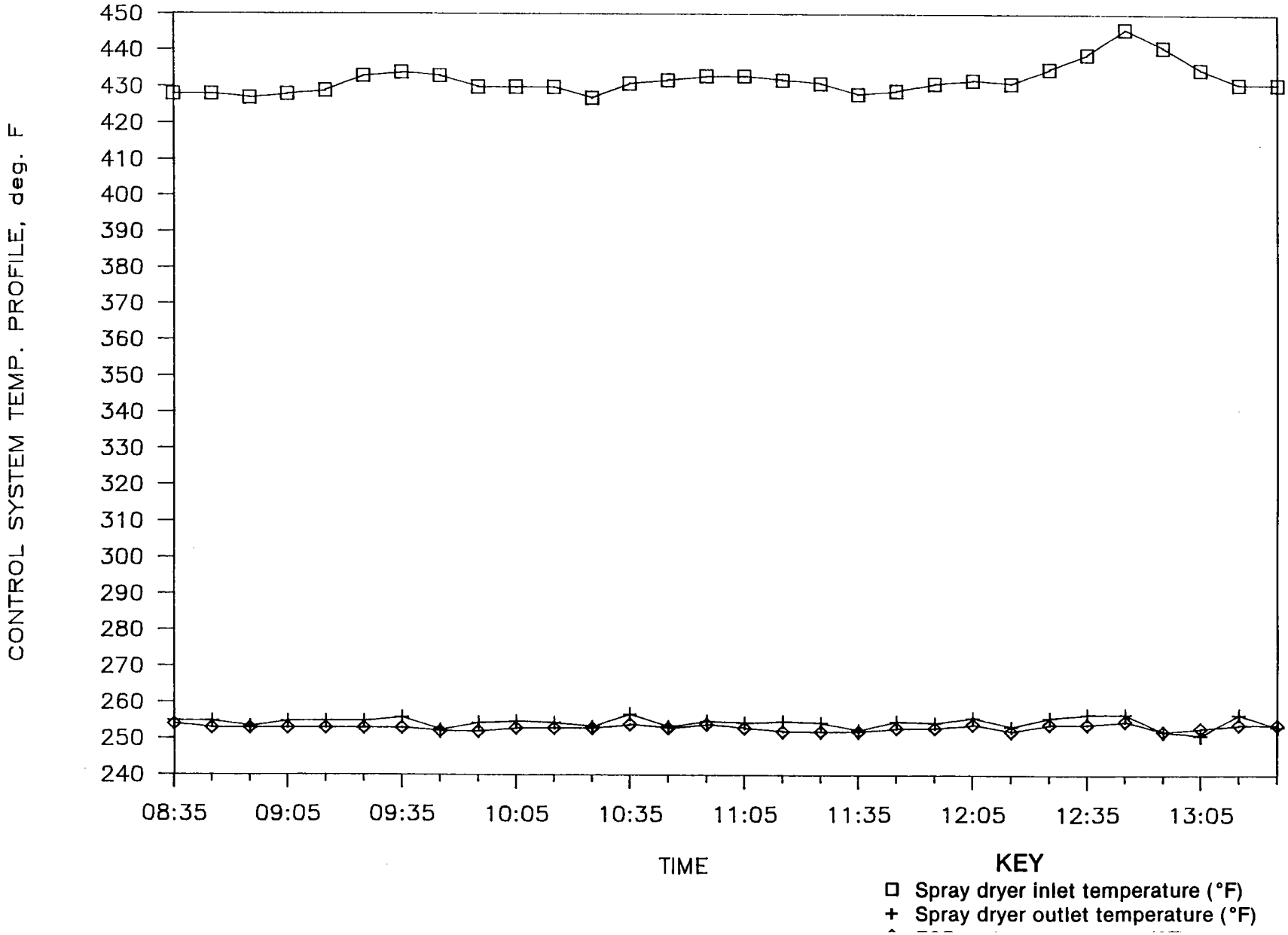
RUN 1


CONTROL SYSTEM TEMP. PROFILE, deg. F
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Spray dryer inlet temperature (°F)
Spray dryer outlet temperature (°F)
ESP outlet temperature (°F)

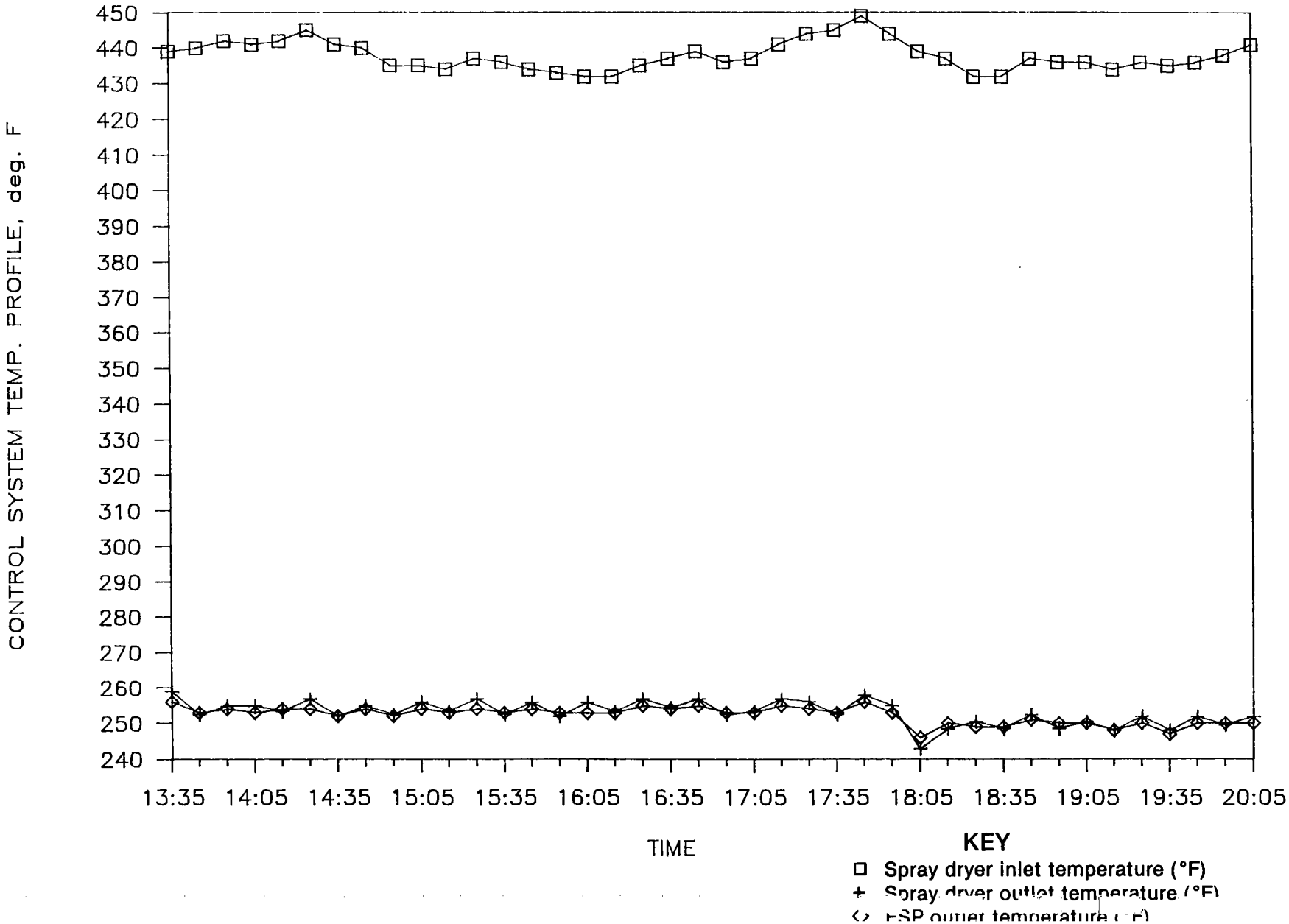
RUN 2


CONTROL SYSTEM TEMP. PROFILE, deg. F
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Spray dryer inlet temperature (°F)
Spray dryer outlet temperature (°F)
ESP outlet temperature

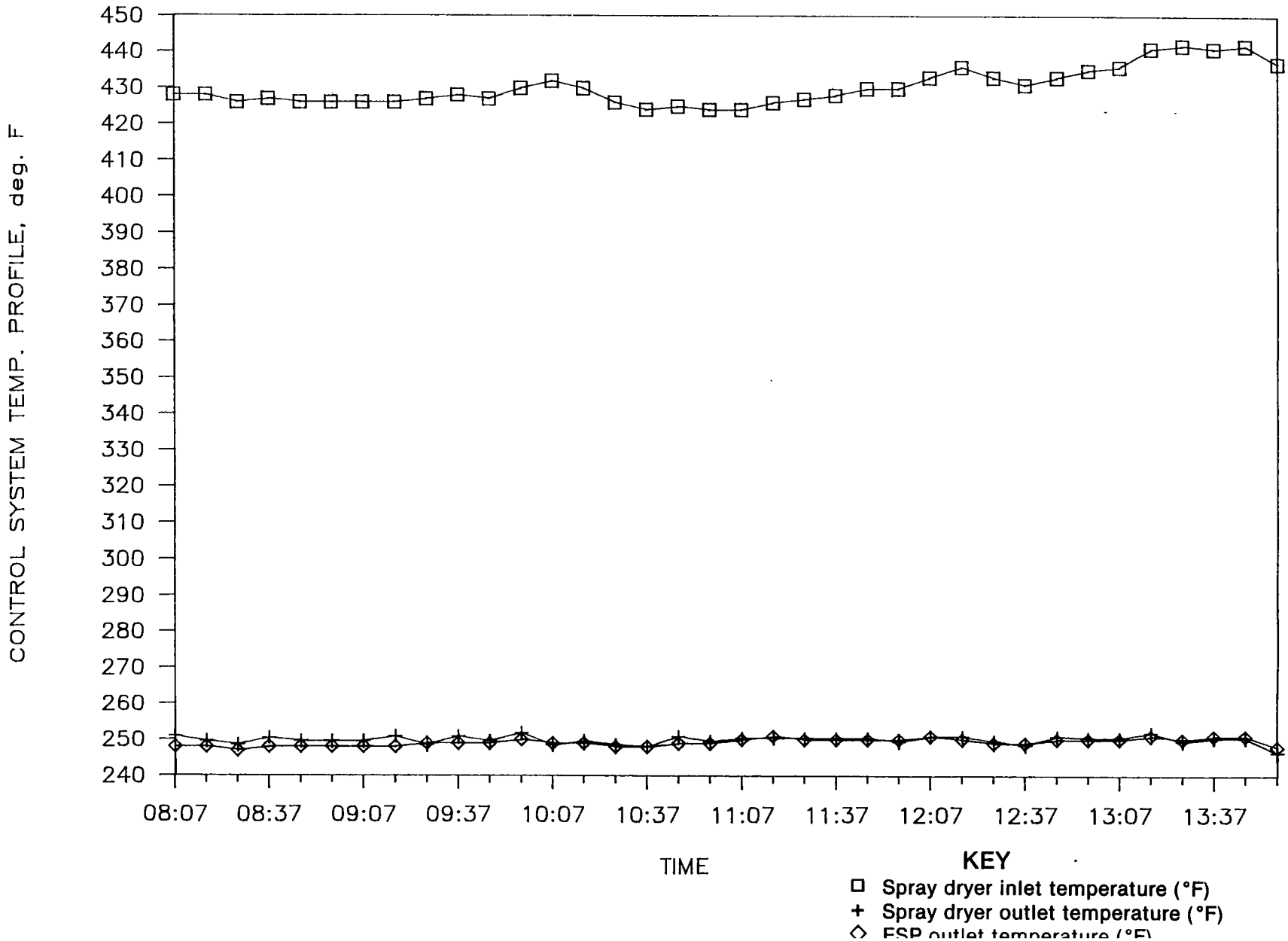
RUN 3


CONTROL SYSTEM TEMP. PROFILE, deg. F
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Spray dryer inlet temperature (°F)
Spray dryer outlet temperature (°F)

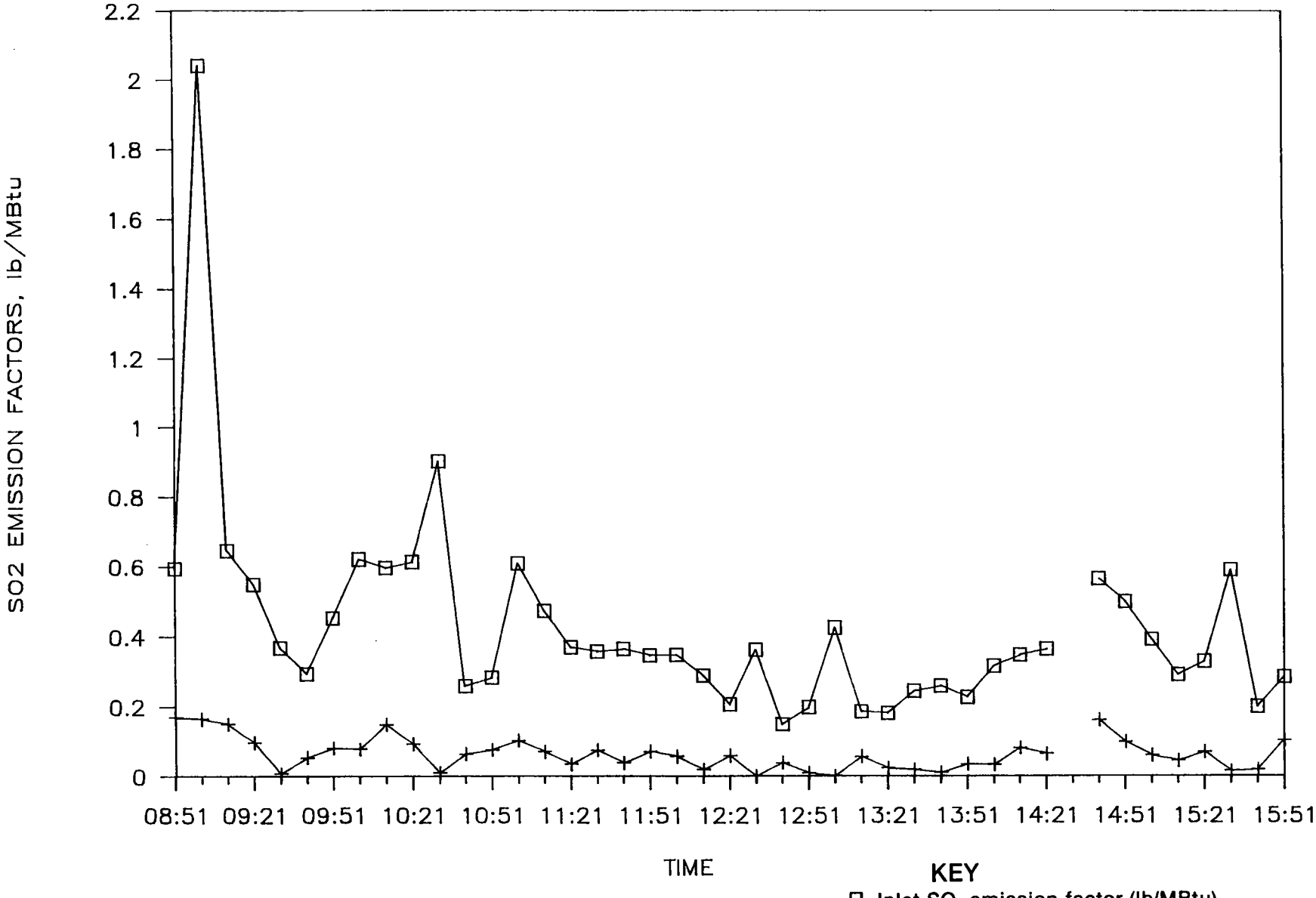
RUN 4


CONTROL SYSTEM TEMP. PROFILE, deg. F
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Spray dryer inlet temperature (°F)
Spray dryer outlet temperature (°F)
ESP outlet temperature (°F)

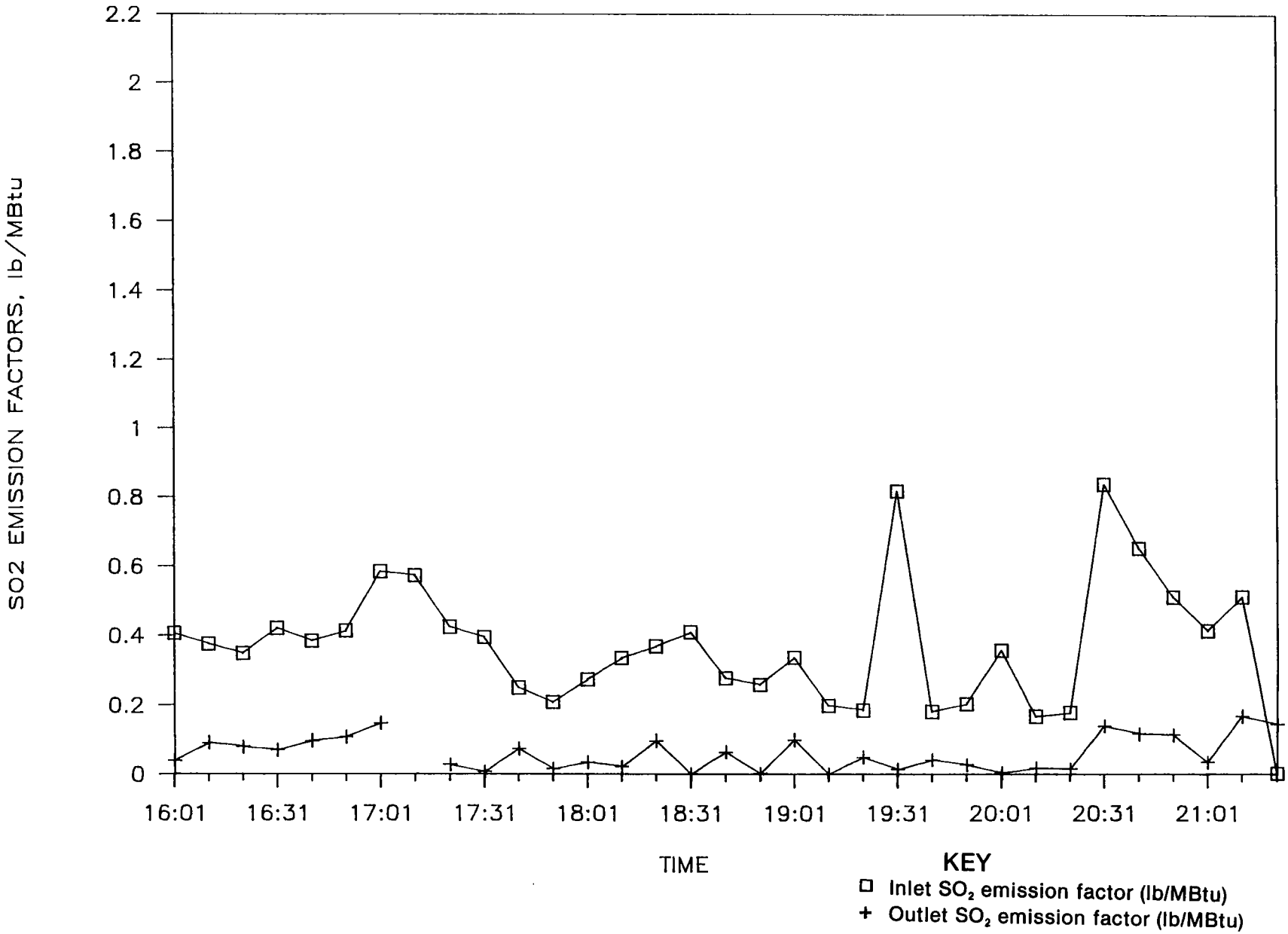
RUN 5


CONTROL SYSTEM TEMP. PROFILE, deg. F
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Spray dryer inlet temperature (°F)
Spray dryer outlet temperature (°F)
ESP outlet temperature (°F)

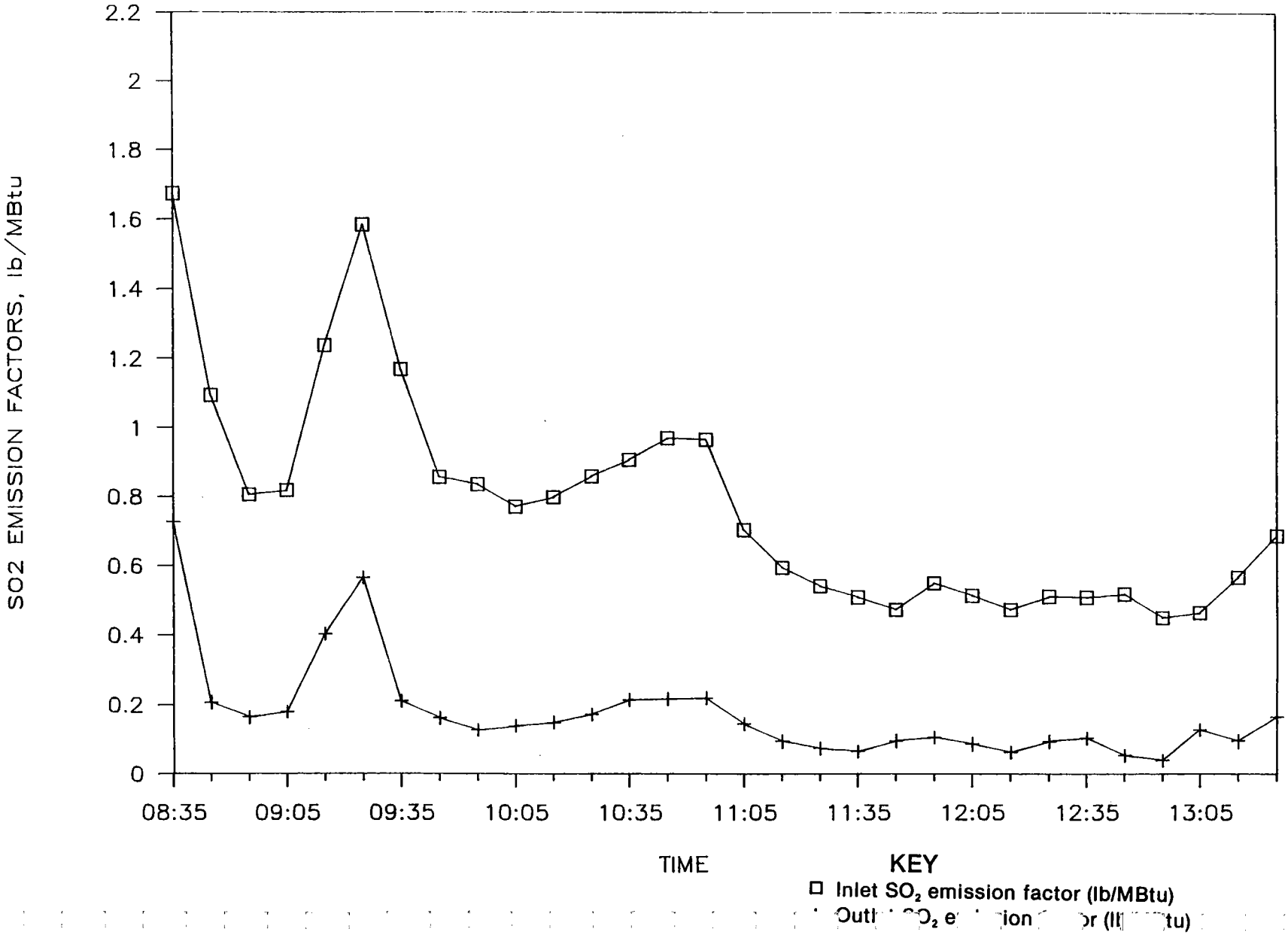
RUN 1

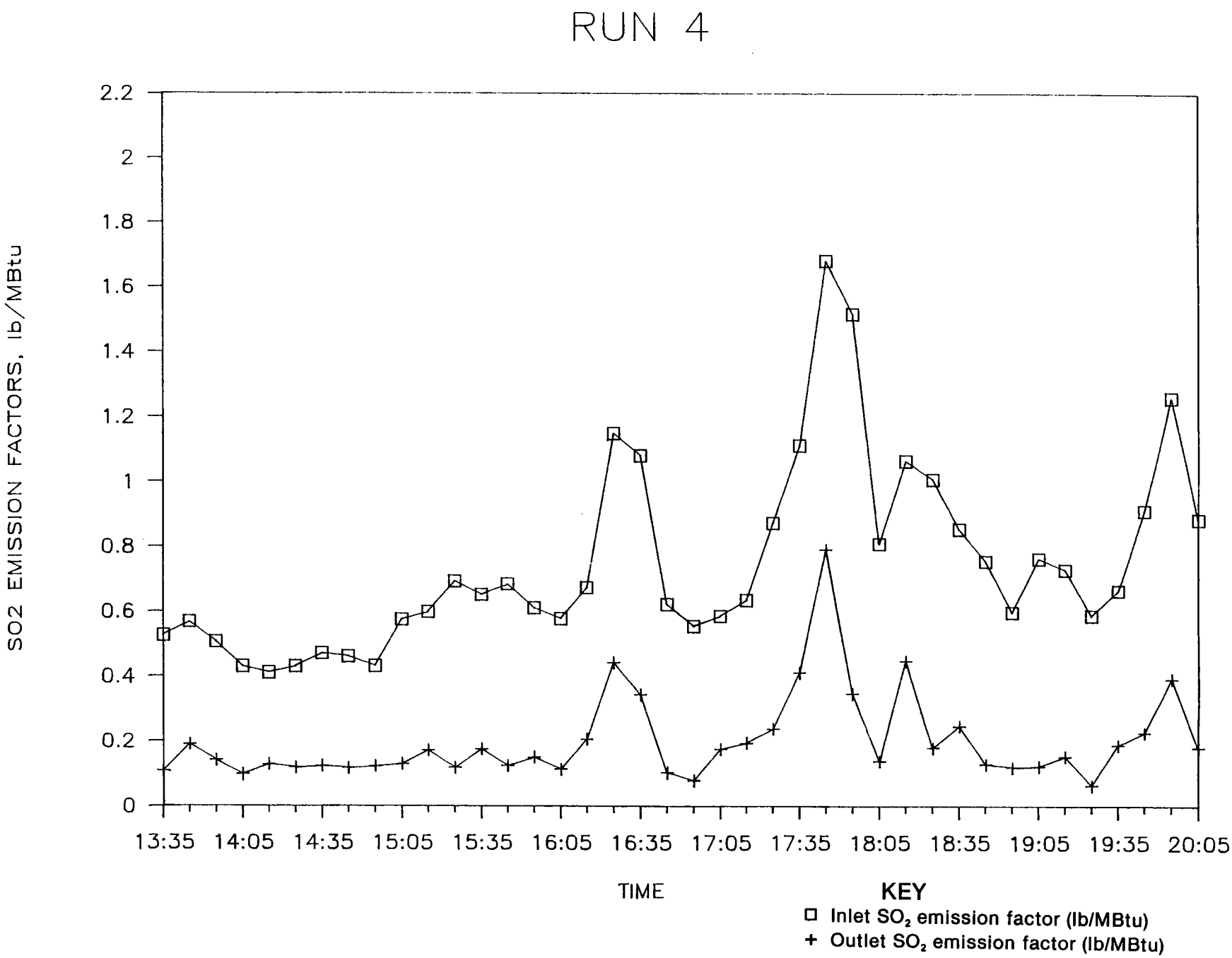

SO2 EMISSION FACTORS, lb/MBtu
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Inlet SO_2 emission factor (lb/MBtu)

RUN 2

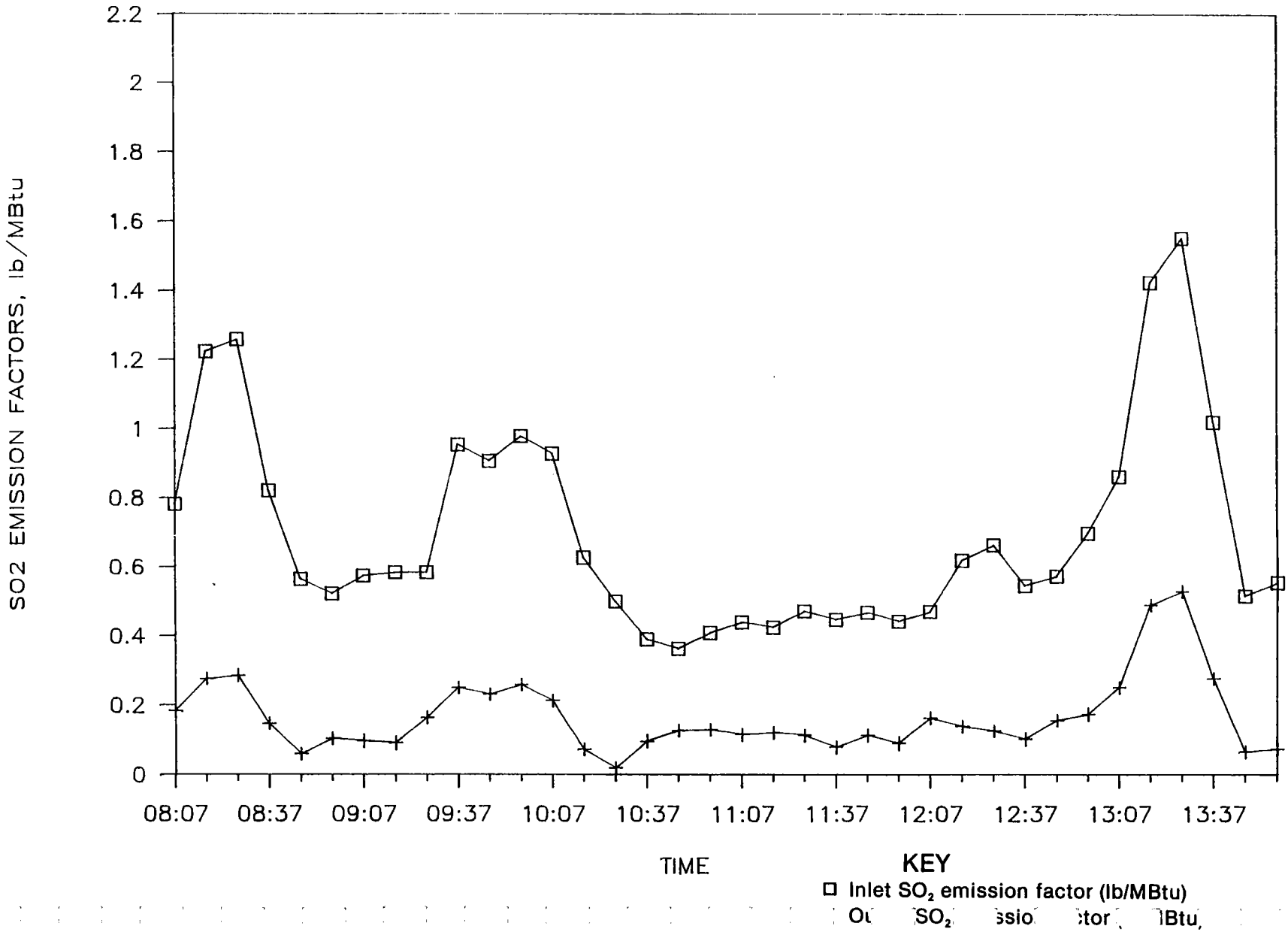

SO2 EMISSION FACTORS, lb/MBtu
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Inlet SO_2 emission factor (lb/MBtu)
Outlet SO_2 emission factor (lb/MBtu)

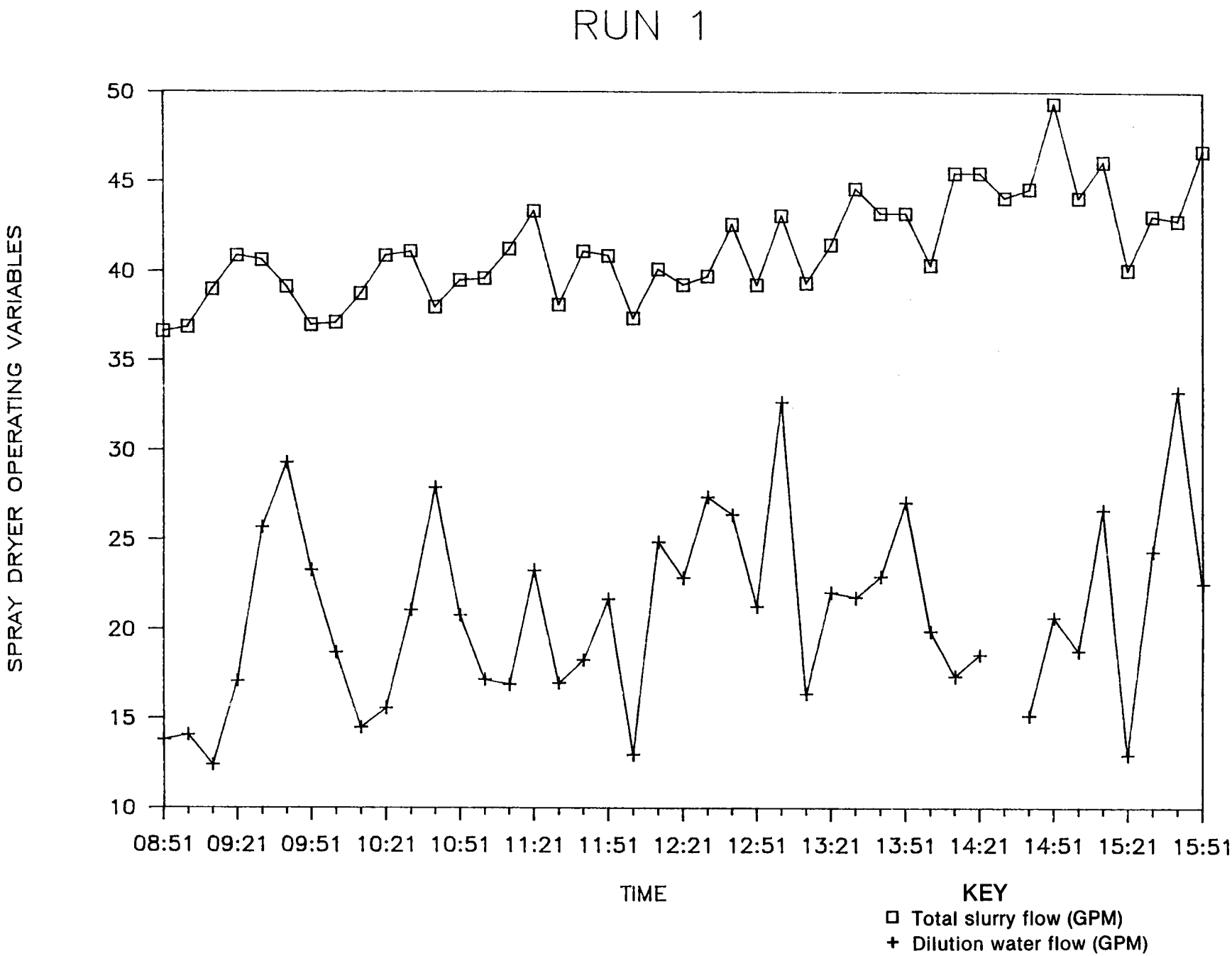
RUN 3

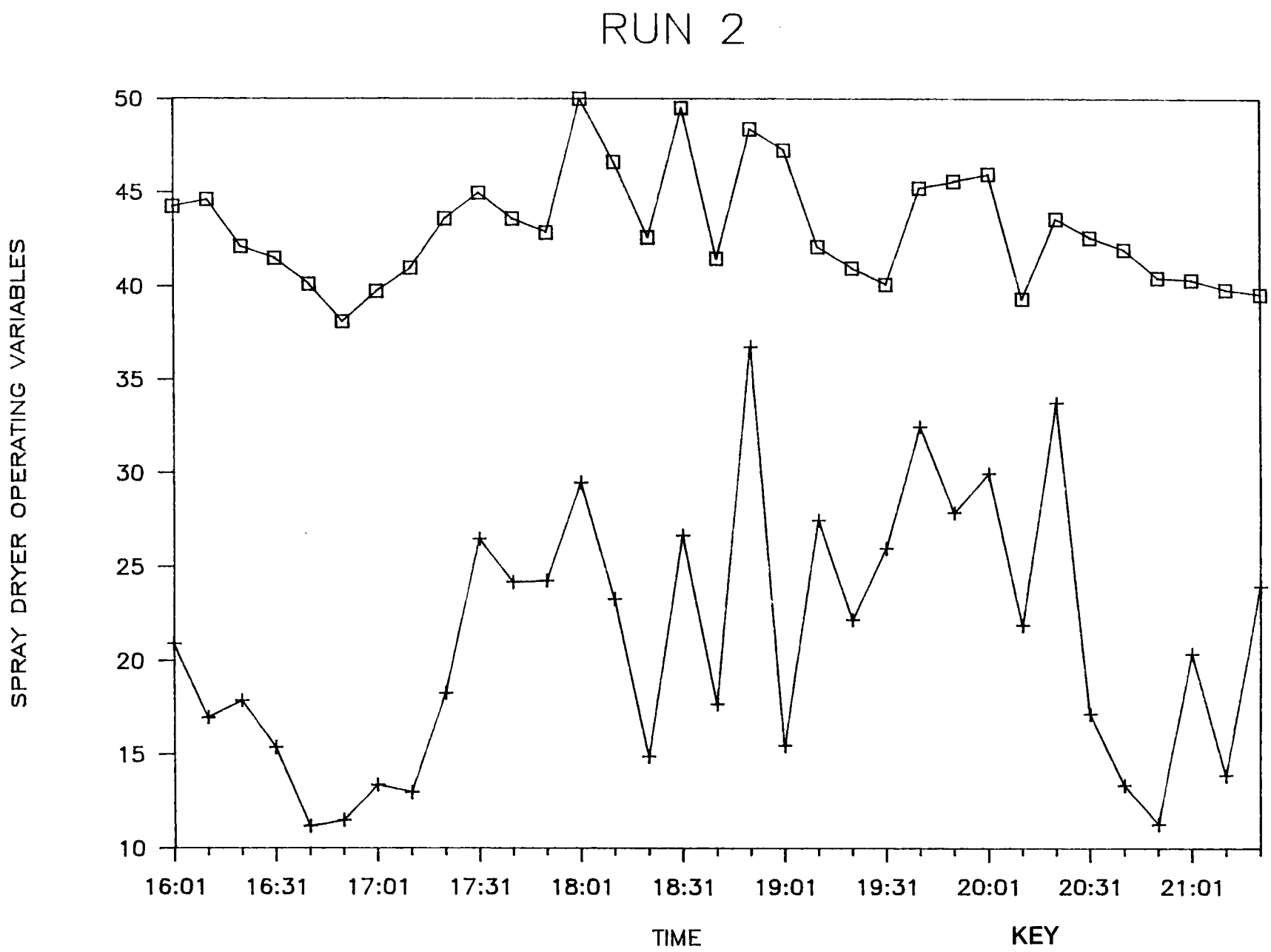

SO2 EMISSION FACTORS, lb/MBtu
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Inlet SO_2 emission factor (lb/MBtu)

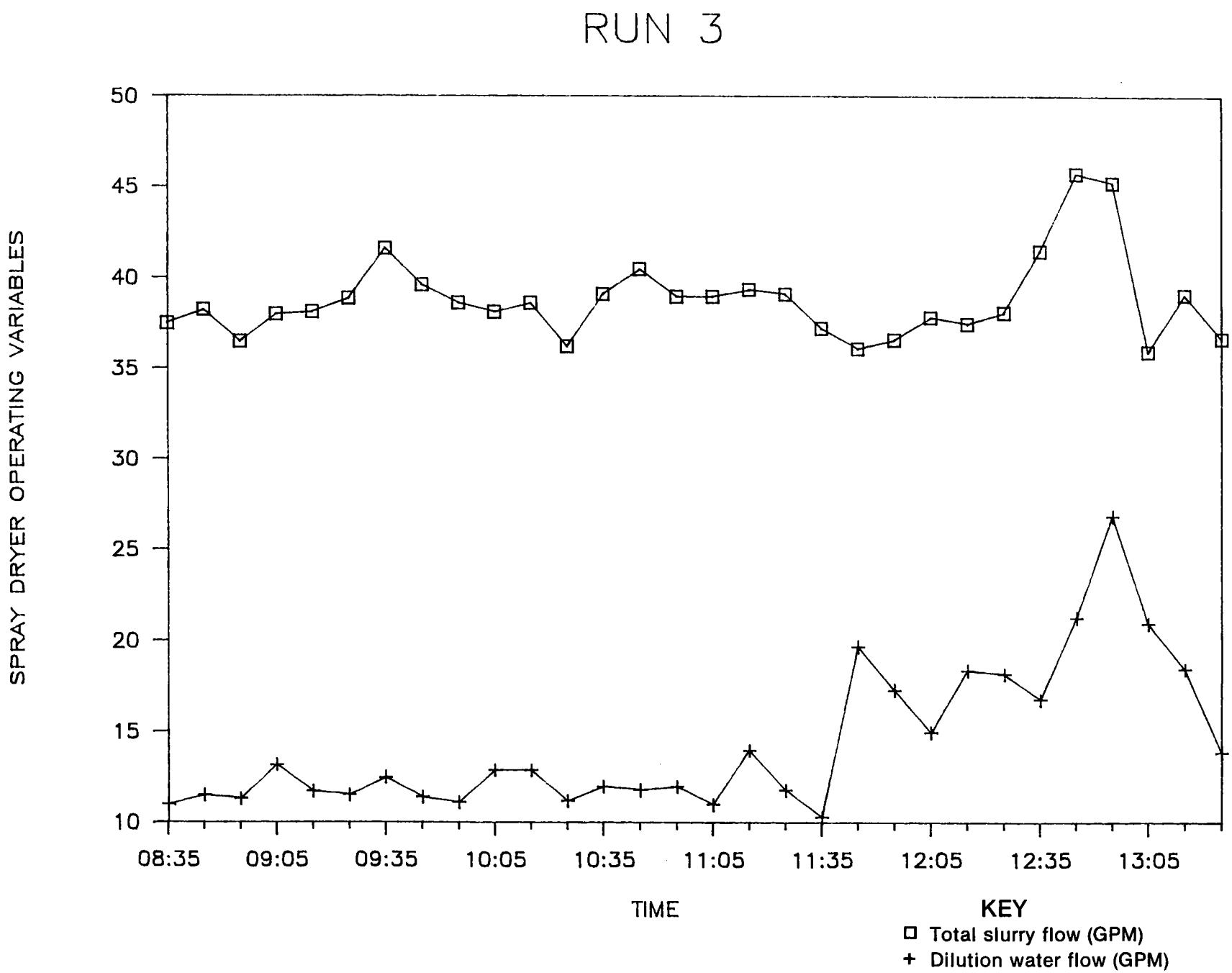

RUN 4
SO2 EMISSION FACTORS, lb/MBtu
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Inlet SO_2 emission factor (lb/MBtu)
Outlet SO_2 emission factor (lb/MBtu)

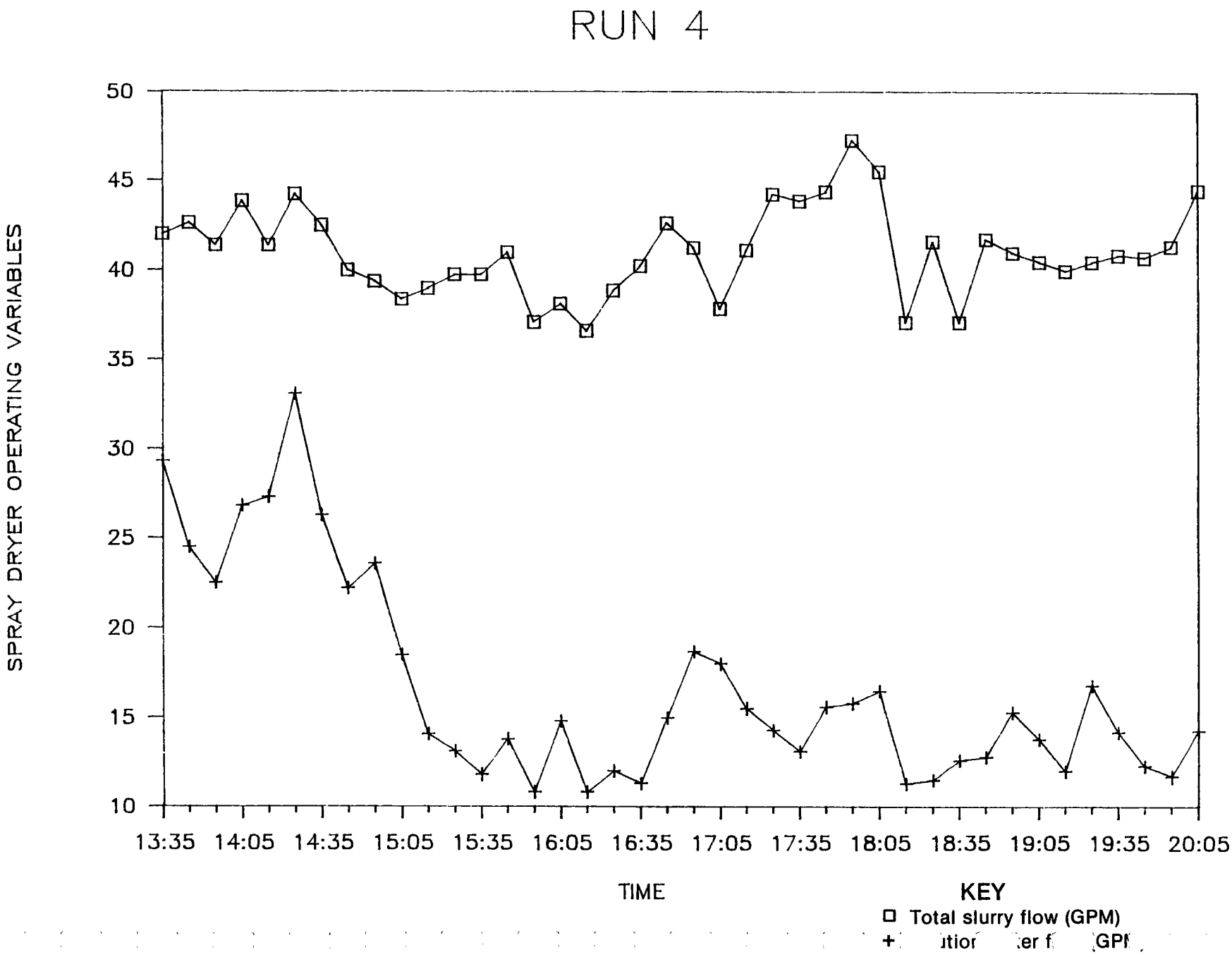
RUN 5

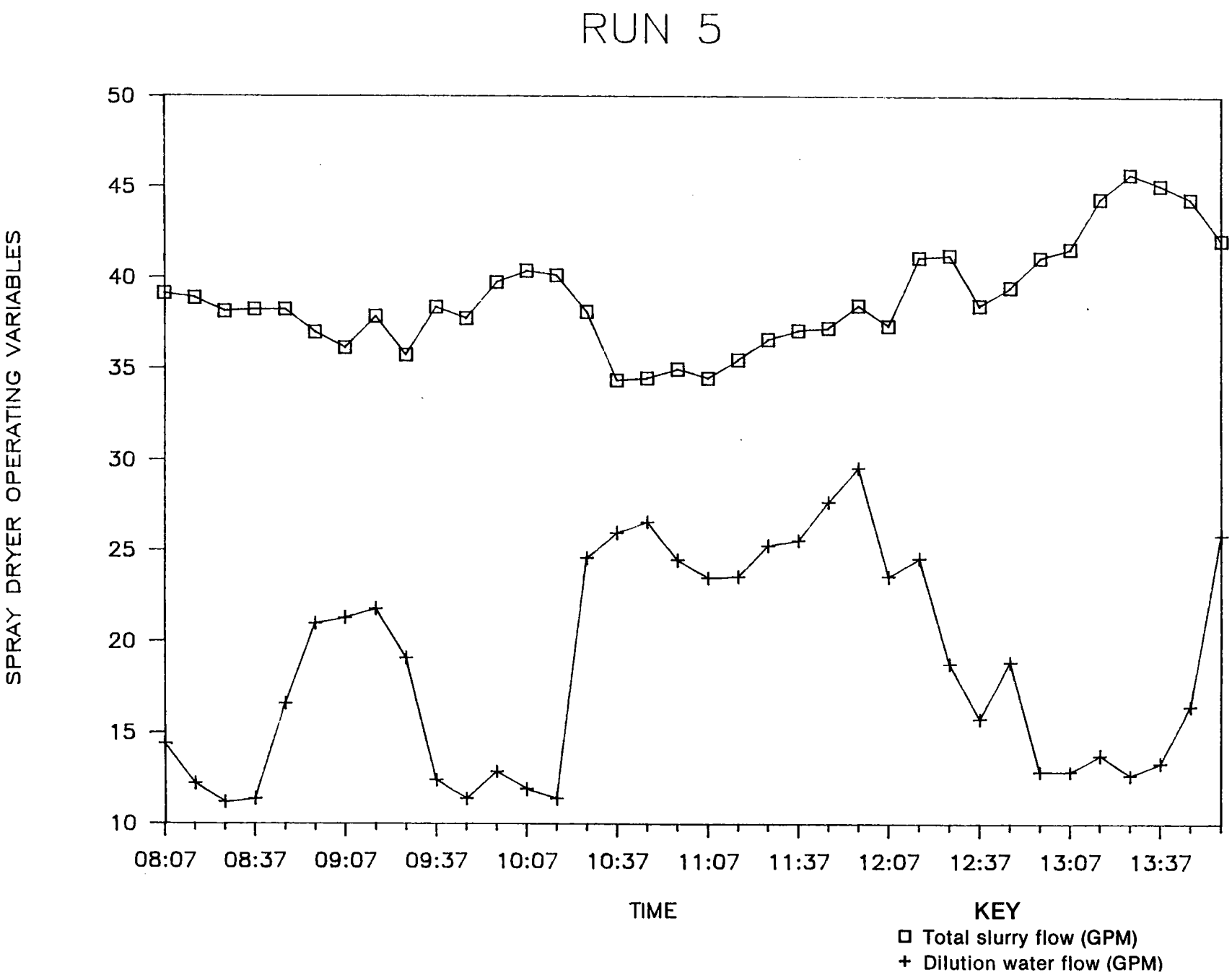

SO2 EMISSION FACTORS, lb/MBtu
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Inlet SO_2 emission factor (lb/MBtu)


RUN 1
SPRAY DRYER OPERATING VARIABLES
50
45
40
35
30
25
20
15
10
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Total slurry flow (GPM)
Dilution water flow (GPM)

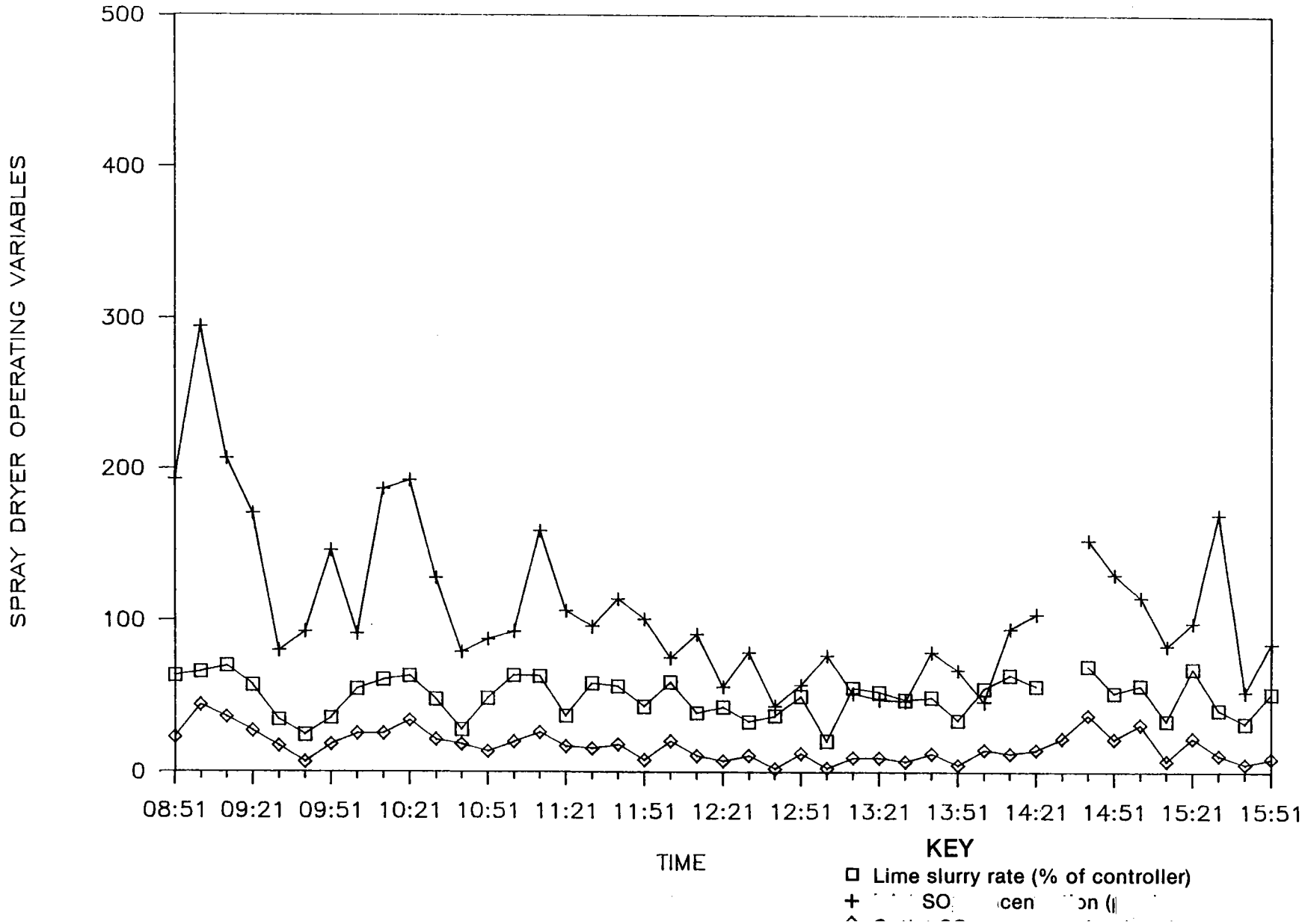

RUN 2
SPRAY DRYER OPERATING VARIABLES
50
45
40
35
30
25
20
15
10
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Total slurry flow (GPM)


RUN 3
SPRAY DRYER OPERATING VARIABLES
50
45
40
35
30
25
20
15
10
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Total slurry flow (GPM)
Dilution water flow (GPM)

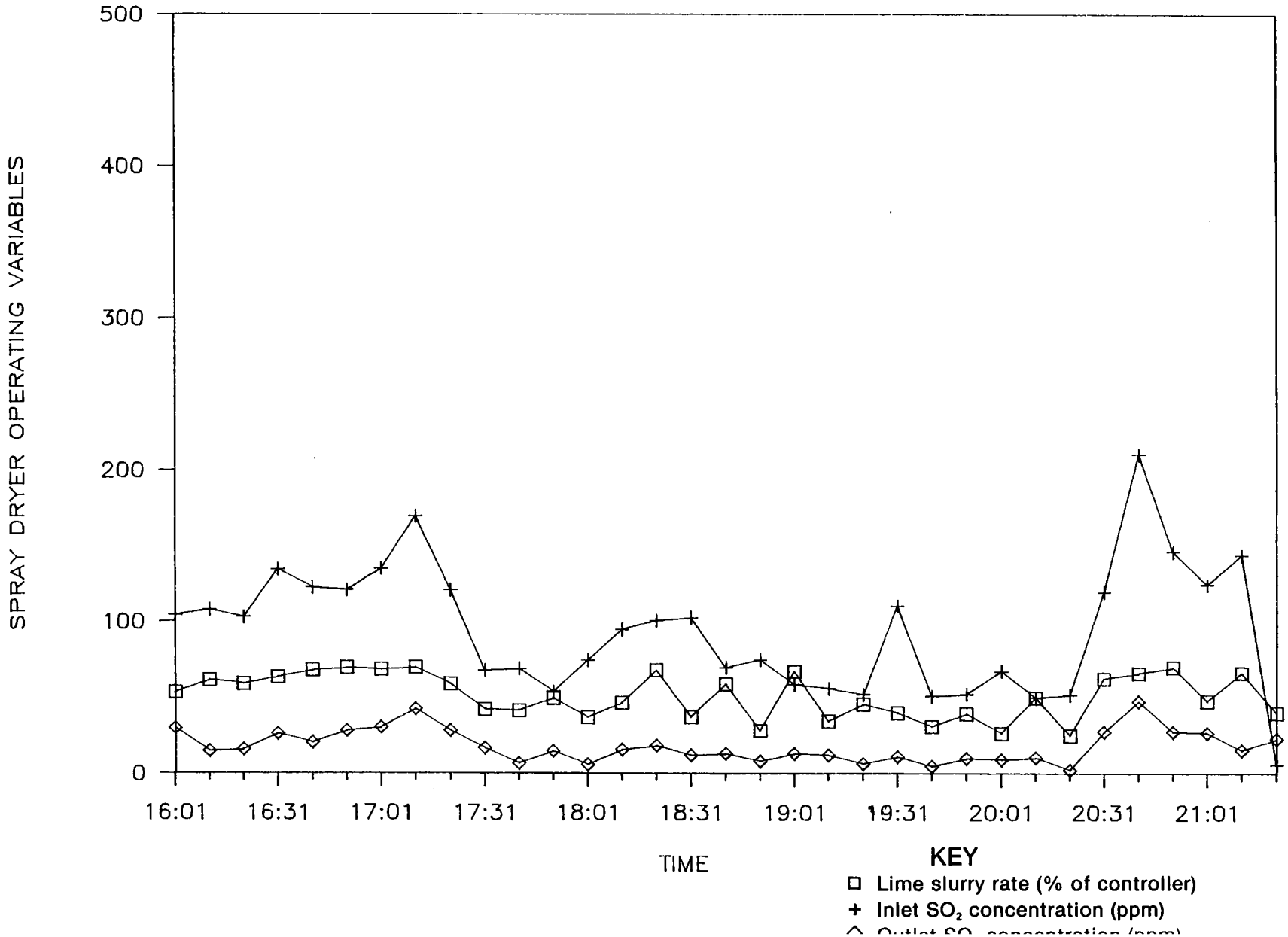

RUN 4
SPRAY DRYER OPERATING VARIABLES
50
45
40
35
30
25
20
15
10
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Total slurry flow (GPM)


RUN 5
SPRAY DRYER OPERATING VARIABLES
50
45
40
35
30
25
20
15
10
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Total slurry flow (GPM)
Dilution water flow (GPM)

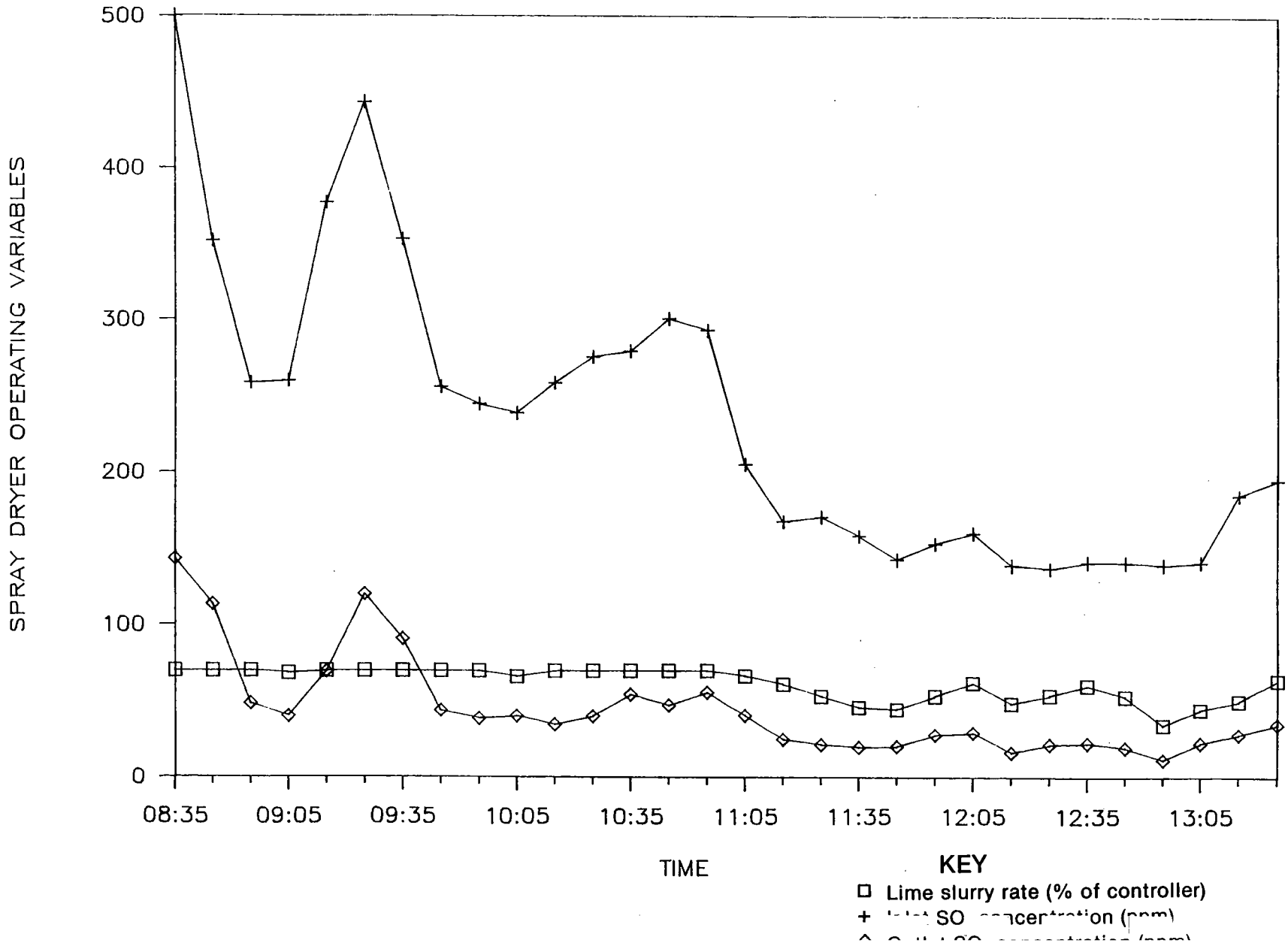
RUN 1


SPRAY DRYER OPERATING VARIABLES
500
400
300
200
100
0
08:51
09:21
09:51
10:21
10:51
11:21
11:51
12:21
12:51
13:21
13:51
14:21
14:51
15:21
15:51
TIME
KEY
Lime slurry rate (% of controller)

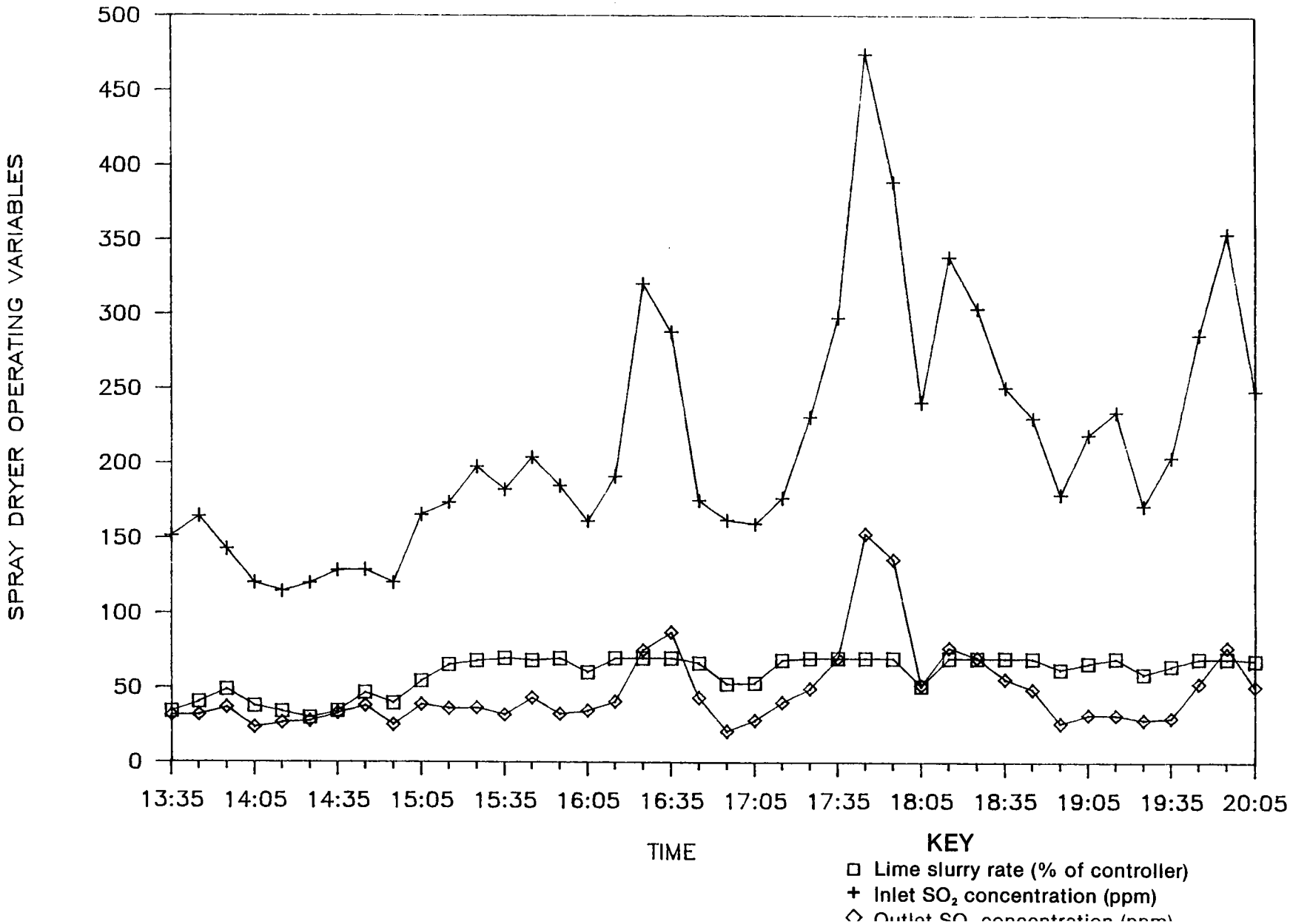
RUN 2


SPRAY DRYER OPERATING VARIABLES
500
400
300
200
100
0
16:01
16:31
17:01
17:31
18:01
18:31
19:01
19:31
20:01
20:31
21:01
TIME
KEY
Lime slurry rate (% of controller)
Inlet SO_2 concentration (ppm)

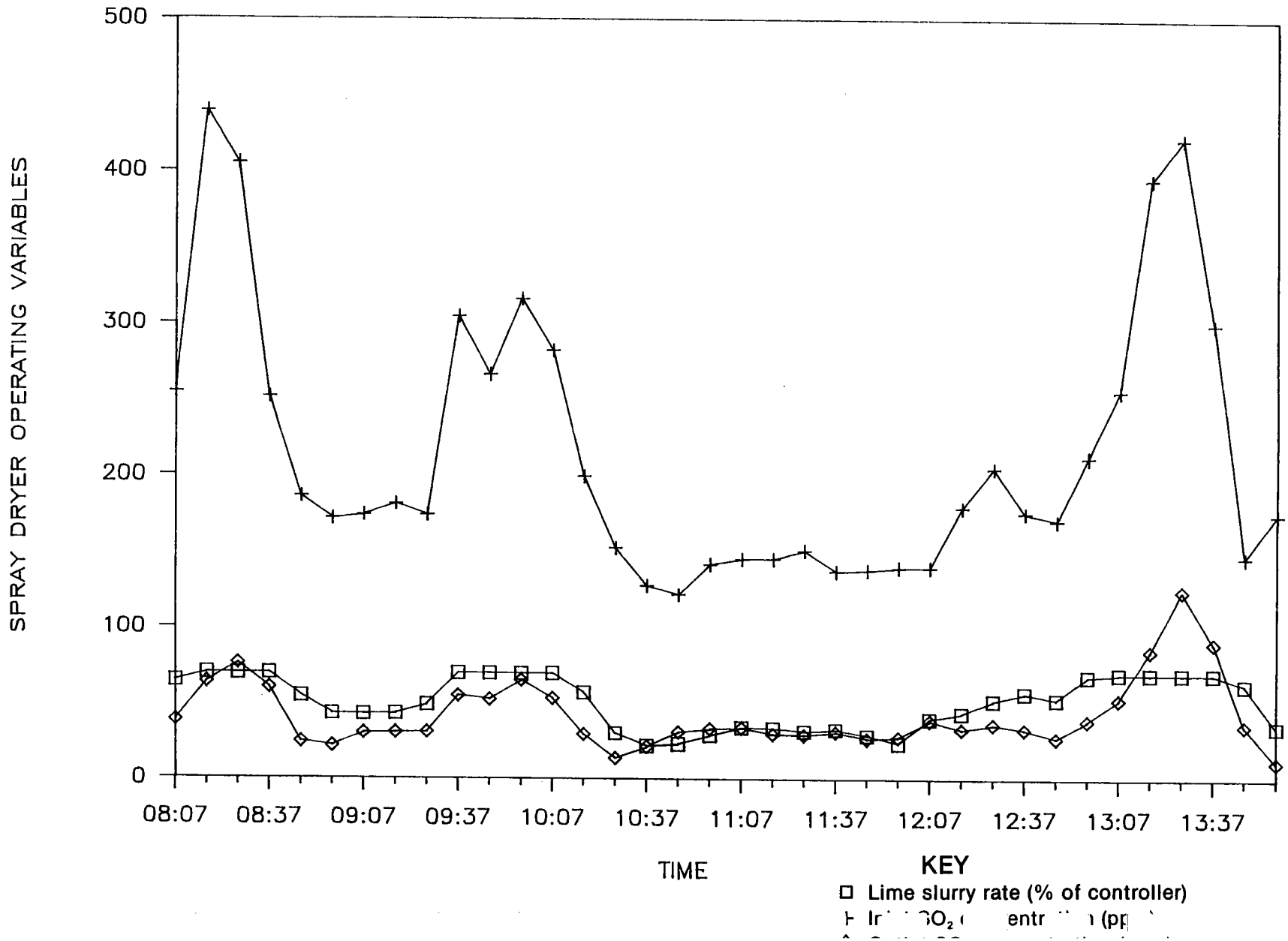
RUN 3


SPRAY DRYER OPERATING VARIABLES
500
400
300
200
100
0
08:35
09:05
09:35
10:05
10:35
11:05
11:35
12:05
12:35
13:05
TIME
KEY
Lime slurry rate (% of controller)

RUN 4


SPRAY DRYER OPERATING VARIABLES
500
450
400
350
300
250
200
150
100
50
0
13:35
14:05
14:35
15:05
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
TIME
KEY
Lime slurry rate (% of controller)
Inlet SO_2 concentration (ppm)
Outlet SO_2 concentration (ppm)

RUN 5


SPRAY DRYER OPERATING VARIABLES
500
400
300
200
100
0
08:07
08:37
09:07
09:37
10:07
10:37
11:07
11:37
12:07
12:37
13:07
13:37
TIME
KEY
Lime slurry rate (% of controller)

APPENDIX F

TEST PARTICIPANTS AND OBSERVERS

TEST PARTICIPANTS AND OBSERVERS

Name	Organization	Responsibility
Bill DeWees	Entropy Environmentalists, Inc.	Field Coordinator, Process Sampling
Tom McDonald	Entropy Environmentalists, Inc.	Sampling Team Leader
Scott Steinsberger	Entropy Environmentalists, Inc.	Sample Recovery
Anna Carver	Entropy Environmentalists, Inc.	Sampling Technician/ Sample Recovery
Dan Bivins	EPA, Emission Measurement Branch	EPA Task Manager/ Process Sampling
Mike Johnston	EPA, Industrial Studies Branch	EPA Task Manager/ Process Sampling
Chuck Masser	EPA, Air and Energy Engineering Research Laboratory	EPA Coordinator
Kathy Wertz	Radian Corporation	Collect Process and CEM Data

APPENDIX G

DRAFT FINAL AUDIT REPORT
PREPARED BY RESEARCH TRIANGLE INSTITUTE

RTI Project 433U-3967-07

DRAFT
FINAL
AUDIT REPORT

Prepared by

Joseph D. Evans
Keith A. Daum

Audit Description

Audit Type:	Technical Systems
Date Audit Performed:	February 8-10, 1988
OAQPS Project Officer:	Dan Bivins
AEERL Project Officer:	Charles Masser
Audit Location:	Wheelabrator Resource Recovery Facility Millbury, Massachusetts
Organizations Audited:	Entropy Environmentalists, Inc. Radian Corporation
Project Audited:	Municipal Waste Combustor Test Program Phase I Emission Testing Program
Project QTRAK ID:	87036/II

Judith S. Ford
Quality Assurance Officer
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Under EPA Contract No. 68-02-4291

June 14, 1988

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1.0 INTRODUCTION

1.1 PURPOSE OF AUDIT

A technical systems audit (TSA) is a qualitative on-site evaluation of a measurement system. The objective of a TSA is to assess all facilities and to document equipment operating procedures, equipment maintenance, recordkeeping, data validation, experimental procedures, calibration procedures, reporting requirements, and quality control procedures. Since the above items should be defined in the approved quality assurance project plan (QAPP) for the project, the QAPP provides the basis for the audit. Any undocumented or unauthorized deviations from the QAPP will be noted during the audit and included in this report.

The audit was performed at the Wheelabrator Resource Recovery Company in Millbury, Massachusetts. The purpose of this audit was to evaluate project activities during emission testing of the municipal waste combustor. RTI's responsibility was to develop a comprehensive checklist (included as Appendix A) to be used by OAQPS and AEERL technical personnel in order to perform a technical systems audit for on-site sampling and measurements. The completed checklist was returned to RTI after the test burn and has been used as the basis for this audit report. RTI personnel were not in Massachusetts for this audit.

1.2 AUDIT SUMMARY

The recommended rating is "acceptable with recommendations." Recommendations are based on answers to questions in the audit checklist. Potential problems concerning plant operating conditions are discussed in section 3.0.

1.3 DESCRIPTION OF THE PROCESS AUDITED

Wheelabrator Environmental Systems, Inc. (WES) is one of the principal suppliers of mass-burn combustor technology in the United States. The Millbury facility (Wheelabrator Millbury, Inc.) employs typical WES combustor technology consisting of a Von Roll grate system and Babcock & Wilcox boiler. The flue gas emissions are controlled by a spray dryer/electrostatic precipitator (SD/ESP) system, the first such application of this control device to municipal waste combustors (MWCs) in North America.

The EPA test program is being carried out in conjunction with the Massachusetts State-required compliance testing. The combined objectives of the Millbury test program are:

1. To determine the control efficiency of a spray dryer/electrostatic precipitator on mass-burn MWC emissions, including criteria pollutants, metals, acid gases, and dioxins/furans, under normal facility operating conditions.

2. To obtain continuous emission monitoring (CEM) data for CO, CO_2, O_2, SO_2, NO_x, and opacity.

Entropy will perform Method 3 (Orsat) measurements and manual sampling for chlorinated dibenzodioxins/chlorinated dibenzofurans (CDDs/CDFs) using Modified Method 5 (MM5) at the inlet to the spray dryer. Entropy is also conducting simultaneous CDD/CDF testing for Wheelabrator at the outlet to the ESP for compliance testing purposes. Thus, it will be possible to assess the control efficiency of the spray dryer/electrostatic precipitator (SD/ESP) system for CDDs/CDFs. Entropy will obtain ash samples from various collection points during the CDD/CDF testing which will be analyzed for dioxins/furans, percent carbon, and percent combustibles. Lime slurry samples will be collected and analyzed for dioxins/furans, percent solids, percent lime, and specific gravity.

Radian Corporation will monitor and record the process and control system parameters throughout the test period. The facility has agreed to provide continuous emission monitoring data from all available monitors (CO, SO_2, O_2 at the SD inlet; SO_2, NO_x, O_2, and opacity at the ESP outlet), which will also be reduced and reported by Radian.

1.4 SUPPORTING DOCUMENTATION

The checklist was designed to cover all sampling and analysis, as well as some of the process measurements which may have an impact on the final presentation of data, as presented in section 2.1. The technical basis for the checklist was developed from the following:

1. Quality Assurance Project Plan and Site Specific Work Plan: Municipal Waste Program, Phase I Emission Testing Program. February 1, 1988.

2. Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600/4-77-0276).

3. 40 CFR Part 60.

1.5 PRE-AUDIT ACTIVITIES

Previously, Dr. Shri Kulkarni (RTI) discussed with Mrs. Judith Ford (AEERL-EPA) and Mr. Gene Riley (OAQPS-EPA) RTI's QA responsibility for the municipal waste incineration emission measurements program. The first test of the MWC program at Biddeford, Maine, was completed in December; the Millbury, Massachusetts, facility represents the second system to be monitored. It was decided that like the Biddeford facility, RTI would prepare an audit checklist to be used by AEERL and OAQPS personnel, but would not attend the audit.

This checklist was prepared by Mr. Joseph Evans and Mr. Keith Daum and sent to Mr. Charles Masser (AEERL Project Officer). The checklist was completed by Mr. Masser and Mr. Dan Bivins (OAQPS) while they were on-site in Millbury, Massachusetts, on February 8, 9, and 10, 1988. Assessment of findings and preparation of this report were performed by RTI in collaboration with the on-site reviewers.

2.0 PRESENTATION OF CHECKLIST INFORMATION

2.1 OVERVIEW

There were six areas of importance covered by the audit checklist: operating conditions, process data collection, CDD/CDF sampling trains, solid sampling and analysis, Method 3 sampling and analysis, and general QA questions. The following sub-sections present information from the audit checklist which was completed by personnel on-site in Millbury, Massachusetts. The audit checklist is included as Appendix A.

2.2 OPERATING CONDITIONS

The intended purpose of the audit checklist was to obtain information on the agreed-upon operating conditions of the facility and emission control devices. For some parameters, this information was provided; in other cases, information on current operating conditions recorded during a test run was provided instead. In no case did responses in the audit checklist indicate that the facility or control device was operating outside of a normal range. The responses in the checklist did, however, indicate some places where there may be process measurement problems. In checklist section I.A.1, the agreed-upon value for the economizer outlet temperature was 400°F with an acceptable range from 375°F to 450°F. In checklist section I.B.1, data from dioxin run C-4 are presented, including a spray dryer inlet temperature of 438°F. The spray dryer inlet temperature should be lower than the economizer outlet temperature. It may be that during dioxin run C-4, the economizer was running near its upper acceptable limits of 450°F, and that 438°F is a reasonable temperature for the spray dryer inlet. If the economizer was not near its upper acceptable limit, however, then there may be a problem with temperature measurements.

The ESP secondary voltages recorded digitally and listed in checklist section I.B.1 are 61.8KV for Field 1, 57.1KV for Field 2, and 59.9KV for Field 3. The ESP secondary voltages recorded manually and listed in checklist section I.D.1 are 51KV for Field 1, 46KV for Field 2, and 50KV for Field 3. The average relative percent difference for Fields 1, 2, and 3 between the digitally recorded ESP voltages (section I.B.1) and the manually recorded ESP voltages (section I.D.1) is approximately 20%.

2.3 PROCESS DATA COLLECTION

Responses to questions in this section of the checklist indicate that plant instrument values will be reported for process data. All plant instruments were calibrated within the 6 months preceding the test and calibration factors are labelled on each instrument. The procedures for process data reduction were also available.

2.4 CDD/CDF SAMPLING TRAIN

Two separate Modified Method 5 (MM5) sampling trains were used for the collection of CDD/CDF samples in order to evaluate output differences. One was located at the spray dryer inlet; the other was downstream at the electrostatic precipitator (ESP) outlet. The QA Project Plan written by Entropy and reviewed by RTI included the MM5 train for the spray dryer inlet location, but not for the ESP outlet. The outlet sampling train was funded by Wheelabrator for compliance testing and sampling at the outlet was not included in EPA's QA Project Plan. Therefore, there may be a limited comparison of data between these two MM5 trains.

Standard QA/QC checks were performed prior to train operation including leak tests, gas meter calibration, and special cleaning of train components to prevent contamination as specified in Entropy's QA Project Plan (QAPP). Because of the nature of CDD/CDF analysis, additional precautions are taken during sample train set-up to prevent contamination. Entropy's QAPP had specified that glass fiber filters used in the sampling train were to be tested for contamination prior to train set-up. This was not performed for the sampling train at the inlet location, however, because funds were not available. All other precautions were performed in accordance with QAPP specifications.

Clean-up operations included methylene chloride and toluene for rinsing all train components. Train openings were loosely capped during removal of the sampling train. After removal, the XAD cartridge and all rinses were stored a maximum of 14 days before analysis.

2.5 SOLID SAMPLING AND ANALYSIS

Ash and lime slurry samples were obtained by Entropy for subsequent analysis. These are composite samples obtained as specified in Entropy's QAPP. Samples are properly stored and analyzed within 14 days. No unusual problems were noted on the checklist which would jeopardize the quality of data obtained from analysis of these samples.

2.6 METHOD 3 SAMPLING AND ANALYSIS

For the Orsat analyzer, the checklist indicates all appropriate calibration and QA were performed prior to and during testing. As with the CDD/CDF sampling trains, samples are taken at the inlet to the spray dryer and at the outlet of the electrostatic precipitator. As described in section 2.5, EPA funded testing at the spray dryer inlet and Wheelabrator provided funding for testing at the ESP outlet. It should be pointed out that different methods for CO detection were used at the outlet and inlet. If CO levels are above a certain concentration, then CO_2 and O_2 analysis corrections are necessary, and the use of different detection methods poses no problem in data quality.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

3.1.1 CDD/CDF Sampling Train

Analysis of CDDs/CDFs is a critical measurement and is directly related to one of the objectives of the study listed in section 1.3. For this reason, Entropy had proposed to test CDD/CDF contamination of glass fiber filters used in the CDD/CDF sampling train. This analysis was not performed for the sampling train at the spray dryer inlet location. Conclusion: Because the contamination measurement is probably more qualitative than quantitative, and since data on glass fiber filter contamination are available for the sampling train at the ESP outlet, it is probably acceptable to use data from the sampling train at the outlet location to determine if glass fiber filters contained significant amounts of contamination.

3.1.2 Temperature Measurement

Conclusion: There may be a temperature measurement problem in either the economizer outlet temperature or the spray dryer inlet. It is difficult to discern if there is a problem, however, because checklist section I.B.1 was completed with actual data from dioxin run C-4 while checklist section I.D.1 was completed with agreed-upon values and acceptable ranges. The spray dryer inlet temperature of 438°F recorded during the test (checklist section I.B.1) is a reasonable expectation considering the agreed-upon range of 375° to 450°F for the economizer outlet temperature (checklist section I.A.1), but only if the economizer is operating near the upper end of its range during the test.

3.1.3 ESP Voltages

Conclusion: The differences between the ESP secondary voltages listed in checklist section I.B.1 (digital data) and I.D.1 (manual data) indicate that there may be a measurement problem. There could be two reasons why the two sets of values are in disagreement by an average of 20%. The first is that there could be a measurement problem. Secondly, if these data were collected on two different sample runs, then there could be dust build-up on the ESP, indicating unrepresentative operating conditions.

3.2 RECOMMENDATIONS

3.2.1 Operating Conditions

- Determine if there is a temperature measurement problem in either the economizer outlet or the spray dryer inlet by reviewing process data collected for the project. If a problem exists, an explanation is needed.

- Investigate and explain the 20% difference between the digital and manually collected data for ESP secondary voltages.

3.2.2 CDD/CDF Sampling Train

- For upcoming projects, when two separate MM5 sampling trains are to be used for comparison, QA for both trains should be included in the QAPP.

4.0 AUDITORS' STATEMENT OF AUTHORIZATION/APPROVAL OF REPORT

Report Title: On-Site Technical Systems Audit of Entropy's Project Titled "Municipal Waste Combustor Test Program, Phase I Emission Testing Program" (QTRAK No. 87036, Category II)

Date of Report: June 14, 1988

Authors: Keith A. Daum and Joseph Evans, Research Triangle Institute

EPA Contract No.: 68-02-4291

RTI Project No.: 433U-3967-07

Auditors: Keith A. Daum and Joseph D. Evans of RTI
Dan Bivins (OAQPS) and Charles Masser (AEERL)

Date of Audit: February 8, 9, and 10, 1988

Authorization and Approval:

We hereby certify that the report described above is, to the best of our knowledge, complete and accurate.

Signatures of Lead Auditors

APPENDIX A

WHEELABRATOR RESOURCE RECOVERY FACILITY

AUDIT CHECKLIST FOR MILLBURY, MASSACHUSETTS

MILLBURY RESOURCE RECOVERY FACILITY AUDIT CHECKLIST

for Millbury, Massachusetts

I. OPERATING CONDITIONS for Unit I or II

A. Process Parameters

1. List the agreed upon values for plant process parameters, and the allowable ranges, that will be taken digitally during the test burn.

Process Data From Plant Instrumentation	Units	Expected Average Value	Allowable Range
Steam Flow (total steam to turbine)	10^3 lbs/hr	191	± 5
Superheater Steam Temperature °F	°F	835	750-850
EGV Steam Pressure ??	in. w.c.		
Boiler Master Output	%	60	30-60
Grate Master Output	%	60	40-70
Natural Gas Flow	10^3 lbs/hr	0	
Primary Air Flow	10^3 lbs/hr	35 KCFM	28-60 KCFM
Primary Air Temperature	°F	Amb - 300 →	
Primary Air Pressure	in. w.c.	15	12-17
Secondary Air Flow	10^3 lbs/hr	Same as prim	
Secondary Air Pressure	in. w.c.	25	22-28
Oxygen	% by vol.	8.5-10.5 →	
Furnace Draft	in. w.c.	-.1	-.001 ⇒ -.2
Attemperator Water Flow	10^3 lbs/hr	5	3-10
Steam to Atmosphere	10^3 lbs/hr	0	
Boiler Feedwater Temperature	°F	300	225-300
Boiler Feedwater Flow	10^3 lbs/hr	Same as steam flow	
Furnace Temperature	°F Superheater	1090	900-1200

A. Process Parameters (continued)

Process Data From Plant Instrumentation	Units	Expected Average Value	Allowable Range
Furnace Pressure	in. w.c.	Same as furnace draft	
Superheater Outlet Temperature (gas)	°F	Same as furnace Temp	
Superheater Outlet Pressure (gas)	in. w.c.	-.3 → -.4	
Economizer Outlet Temperature	°F	400	375 - 450
Economizer Outlet Pressure	10^3 lbs/hr	-3	-3 → -7 in of H_2O
ID Fan Pressure	in. w.c.	-7	

2. Are these normal operating conditions? yes If not, how will deviations affect the representativeness of the data?

3. What is the corrective action when plant process parameters are outside of the allowable range?

Master follows steam flow

5:10 PM 2/9/88
Taken during dioxin Run C-4
Note: for this and next two pages. GM

B. Emission Control System

1. List ~~the agreed-upon values for~~ of operating parameters for the emission control system ~~and the allowable ranges for data~~ that will be taken digitally during the test burn.

Process Data From Plant Instrumentation	Units	Expected Average Value	Allowable Range
Spray Dryer Inlet Temperature	°F	438	
Spray Dryer Outlet Temperature	°F	258	
Lime Slurry Concentration	%	60.3	
Atomizing Air Flow	10^3 lbs/hr	2666 SCFM	
Dilution Water Flow	gal/min	15.9	
Total Slurry flow	gal/min	42.0	
ESP Outlet Temperature	°F	254	
Field 1 Secondary Voltage	KVAC	61.8	
Field 2 Secondary Voltage	KVAC	57.1	
Field 3 Secondary Voltage	KAVC	59.9	

2. Are these normal operating conditions? If not, how will deviations affect the representativeness of the data?

3. What is the corrective action when emission control system parameters are outside of the allowable range?

C. Combustion Gas Data

1. List the ~~expected values for~~ of combustion gas data from plant instrumentation ~~and the allowable range for staying within conditions~~ during ~~specified for~~ the test burn.

Process Data From Plant Instrumentation	Units	Expected Average Value	Allowable Range
Inlet SO_2 Concentration	ppmv	159.4	
Inlet SO_2 Factor	$lb/10^6$ Btu	.605	
Outlet SO_2 Concentration	ppmv	36.1	
Outlet SO_2 Factor	$lb/10^6$ Btu	.162	
Percent SO_2 Removal	%	76.5	
CO Concentration	ppmv	17.93	
NO_x Concentration outlet	ppmv	153.9	
O_2	%	12.65	
Moisture	%	Not taken digitally	

D. Manually Recorded Data

1. List the ~~agreed-upon~~ values ~~and the allowable ranges~~ for manually recorded data during the test burn.

Manually Recorded Data	Units	Expected Average Value	Allowable Range
Opacity (6-min intervals)	%	3.8	Value digitally taken
Soot Blowing Cycles (intermittent as required)	minutes		Done only late at night. Not done during any of our tests
ESP Rapping Cycles (intermittent as required)	minutes 8-10 min cycle	Sequence – 1) 2) 3) 4) 5) 6)	Inlet gas distribution plates - 3; 1, 2, 3 Inlet field discharge electrodes; 3 min wait; 1, 2, 3 Inlet field collection plates; 5 min wait; recycle
ESP Primary Voltages/ Amperages per Field (^{3}0-min intervals)	1st 32/94, 2nd 34/177 v/Amps	3rd 38/162	
ESP Secondary Voltages & Amperages per Field (^{3}0-min intervals)	1st 51/.57, 2nd 46/1.07 kV/A	3rd 50/1.03	
ESP Spark Rate per Field (^{3}0-min intervals)	(Sparks/min.) x10	1st 2nd 3rd 1 0 0	

never exceeded 1 during testing

2. How often will these data be collected? As noted

3. How often will these values be checked, during the test burn? as noted

II. PROCESS DATA COLLECTION

Questions	Response Yes	Response No	Comments
Are plant instrument values used for process data?	✓		
Were plant instruments calibrated within the last 6 months? If not, list date of last calibration.	✓		
Are calibration factors labeled on the instrument?	✓		
Is a data logger used to collect process data?	✓		
Is the length of time between readings less than 30 minutes?	✓		
Are data checked and verified by someone other than the person operating the data logger?	✓		
How are data stored?			floppy disk
Is there a back-up system for data storage?	✓		
Are procedures for process data reduction available?	✓		

III. CDD/CDF SAMPLING TRAIN

5 9, 1988 Wheelabrator, Millbury Inlet Unit #2
Dan Brown Location

Questions	Response Yes	Response No	Comments
Have the dry gas meters been calibrated against a wet test meter standard?	✓		Against another meter calibrated by a wet test meter
Has the nozzle been calibrated to the nearest 0.025mm (0.001 in), and has the nozzle size been properly selected?	✓		
Have all train components been properly cleaned as described in ENTROPY's QAPP in order to prevent contamination?	✓		
Were openings capped after cleaning, with methylene chloride rinsed foil, in order to prevent contamination before installation?	✓		
Where the glass fiber filters for CDD/CDF testing checked for contamination prior to sampling train set up?		✓	Funds not available!
Are the trains correctly set up and leak-checked to less than 4% of the average sampling rate or 0.02 ft^3/min, whichever is less?	✓		
Is full-stack traversing being conducted?	✓		
Has a careful effort been made to assure that the nozzle and pitot tube are located parallel to the stack wall?	✓		

Box available on 2/9, Gamma O.K.

III. CDD/CDF SAMPLING TRAIN
(continued)

Questions	Response Yes	Response No	Comments
How has the sampling time been chosen to assure that the chance of "sample break-through" in the XAD cartridge is minimized?	✓		In previous study a XAD trap was put in series to show no breakthrough.
Are the resin cartridge and condenser mounted vertically on top of the first impinger?	✓		
Is the sample gas entering the resin cartridge cooled to less than 20°C (68°F)?	✓		
Are greaseless joints and seals used in the sampling train?	✓		
Is isokinetic sampling maintained within ±10% and checked every five minutes?	✓		
Is the sample site selection an appropriate distance downstream from any flow disturbance?	✓		
Are all impingers cooled in an ice bath at all times?	✓		
Do the equipment operators have access to test protocols and methods, are data sheets available, and is equipment in good repair?	✓		

III. CDD/CDF SAMPLING TRAIN (continued)

A. Sample Preparation, Storage, and Shipping

Questions	Response: Yes	Response: No	Comments
Are all openings loosely capped when the sampling train is removed from the stack in order to prevent contamination?	✓	✓	
Is the clean-up area clean and protected from the wind?	✓		
Is methylene chloride used in sample recovery and do sample recovery methods prevent contamination?	✓		Also toluene used for extra rinse + saved separately.
Do any visible particles remain inside the probe after rinsing?		✓	
Are sample containers labeled and sealed tight, and is the liquid level marked?	✓		
Is the XAD stored under refrigeration and is the XAD container carefully capped and stored to prevent loss of sample?	✓		
Are method and solvent blanks also included for analysis?	✓		
What percentage of the total samples are blanks?	—	—	50%
How long are the samples stored before extraction and analysis?	—	—	Less than 14 days.

IV. SOLID SAMPLING AND ANALYSIS

Questions	Response: Yes	Response: No	Comments
Are Lime Slurry and Ash samples obtained by ENTROPY?	✓		
Is the ash sample a composite, and are composites mixed thoroughly and saved for analysis as described in ENTROPY's QAPP?	✓		
How are samples stored and shipped in order to assure preservation before being analyzed?	—	—	Brown glass jars. Entropy van back to lab. Not on ice. Ambient < 30°F
What is the holding time before solid samples are extracted and analyzed?	—	—	Less than 14 days
Are Ash and Lime Slurry samples labeled appropriately for analysis?	✓		

V. METHOD 3 SAMPLING AND ANALYSIS

Questions	Response: Yes	Response: No	Comments
Is the rate meter capable of measuring flow to within ±2% of the selected flow rate?		✓	0 – 2 SCFM rate meter for indicating flow.
Has a leak check been performed on the flexible gas collection bag prior to sampling using a water manometer and are the results recorded?	✓		
Has a leak check been performed on the entire sampling train using a Hg manometer and are the results recorded?		✓	Bag was checked by pulling vacuum with sample train (M5) pump to 6" Hg; No leak detected. checked in shop w/ Hg manom
Is the sampling point within the duct chosen to be at the centroid of the cross section or at a point no closer to the walls than 1.0 meter?	✓		
Has a leak check been performed on the orsat analyzer and are results recorded?	✓		
Is sampling performed at a constant rate?	✓		Sampling begins 2 1/3 into duct. Negative pressure in duct prevents sampling on all points, because ambient air might enter system
Are sampling, analysis, and calculation procedures repeated until the dry molecular weights of any three grab samples differ from their mean by the following criteria?			
CO_2 $\leq 0.3\%$ absolute ($CO_2 > 4\%$) or $\leq 0.2\%$ absolute ($CO_2 \leq 4\%$)	✓		
O_2 $\leq 0.2\%$ absolute ($O_2 \geq 15\%$) or $\leq 0.3\%$ absolute ($O_2 < 15\%$)	✓		

V. METHOD 3 SAMPLING AND ANALYSIS (continued)

Questions	Response: Yes	Response: No	Comments
What type of correction is determined for CO in order that nitrogen can be determined by difference after analyzing for CO_2 and O_2?		✓	~~Assumption made~~ CO is measured by NDIR + less than 10 ppm.
Has calibration of the sampling apparatus and the orsat analyzer been checked within the last 3 months prior to this field test? Are calibration records available for inspection?	✓		

VI. GENERAL

Questions	Response: Yes	Response: No	Comments
Are all samples properly labeled and is adequate sample custody performed?	✓		
Do the sample labels include the time the sample was collected and who collected it?	✓		
Is there a designated sample custodian?	✓		
Have QA Officers from ENTROPY been on-site to inspect the operation?	✓		
What precautions are being taken to ensure comparability between the CDD/CDF data taken under OAQPS funding at the spray dryer inlet with CDD/CDF data taken at the outlet to the control equipment?	✓		Samples taken simultaneously. Audits for both. Same lab used for analysis. Same cleanup people for both

III. CDD/CDF SAMPLING TRAIN

Feb. 9, 1988 Wheelabrator, Millbury, MASS. Unit #2
Dan Bonin outlet location

Questions	Response Yes	Response No	Comments
Have the dry gas meters been calibrated against a wet test meter standard?	✓		
Has the nozzle been calibrated to the nearest 0.025mm (0.001 in), and has the nozzle size been properly selected?	✓		
Have all train components been properly cleaned as described in ENTROPY's QAPP in order to prevent contamination?	✓		
Were openings capped after cleaning, with methylene chloride rinsed foil, in order to prevent contamination before installation?	✓		
Where the glass fiber filters for CDD/CDF testing checked for contamination prior to sampling train set up?	✓		
Are the trains correctly set up and leak-checked to less than 4% of the average sampling rate or 0.02 ft^3/min, whichever is less?	✓		
Is full-stack traversing being conducted?	✓		
Has a careful effort been made to assure that the nozzle and pitot tube are located parallel to the stack wall?	✓		

III. CDD/CDF SAMPLING TRAIN
(continued)

Questions	Response: Yes	Response: No	Comments
How has the sampling time been chosen to assure that the chance of "sample break-through" in the XAD cartridge is minimized?		—	In a previous study, an XAD trap was put in series to show no breakthrough.
Are the resin cartridge and condenser mounted vertically on top of the first impinger?	✓		
Is the sample gas entering the resin cartridge cooled to less than 20°C (68°F)?	✓		
Are greaseless joints and seals used in the sampling train?	✓		
Is isokinetic sampling maintained within ±10% and checked every five minutes?	✓		
Is the sample site selection an appropriate distance downstream from any flow disturbance?	✓	—	
Are all impingers cooled in an ice bath at all times?	✓		
Do the equipment operators have access to test protocols and methods, are data sheets available, and is equipment in good repair?	✓		

III. CDD/CDF SAMPLING TRAIN (continued)

A. Sample Preparation, Storage, and Shipping

Questions	Response: Yes	Response: No	Comments
Are all openings loosely capped when the sampling train is removed from the stack in order to prevent contamination?	✓		
Is the clean-up area clean and protected from the wind?	✓		
Is methylene chloride used in sample recovery and do sample recovery methods prevent contamination?	✓		
Do any visible particles remain inside the probe after rinsing?		✓	
Are sample containers labeled and sealed tight, and is the liquid level marked?	✓		
Is the XAD stored under refrigeration and is the XAD container carefully capped and stored to prevent loss of sample?	✓		
Are method and solvent blanks also included for analysis?	✓		
What percentage of the total samples are blanks?	—	—	50%
How long are the samples stored before extraction and analysis?	—	—	less < 1 + day 5

IV. SOLID SAMPLING AND ANALYSIS

Questions	Response: Yes	Response: No	Comments
Are Lime Slurry and Ash samples obtained by ENTROPY?	✓		
Is the ash sample a composite, and are composites mixed thoroughly and saved for analysis as described in ENTROPY's QAPP?	✓		
How are samples stored and shipped in order to assure preservation before being analyzed?	—		Brown bottles, transported by van to Entropy. <70°F
What is the holding time before solid samples are extracted and analyzed?	—		less 14 days
Are Ash and Lime Slurry samples labeled appropriately for analysis?	✓		

V. METHOD 3 SAMPLING AND ANALYSIS

Questions	Response: Yes	Response: No	Comments
Is the rate meter capable of measuring flow to within ±2% of the selected flow rate?		✓	Meter just indicator of ~~of~~ flow.
Has a leak check been performed on the flexible gas collection bag prior to sampling using a water manometer and are the results recorded?	✓		
Has a leak check been performed on the entire sampling train using a Hg manometer and are the results recorded?	✓		
Is the sampling point within the duct chosen to be at the centroid of the cross section or at a point no closer to the walls than 1.0 meter?	✓		
Has a leak check been performed on the orsat analyzer and are results recorded?	✓		
Is sampling performed at a constant rate?	✓		
Are sampling, analysis, and calculation procedures repeated until the dry molecular weights of any three grab samples differ from their mean by the following criteria?			
CO_2 $\leq 0.3\%$ absolute ($CO_2 > 4\%$)	✓		
or $\leq 0.2\%$ absolute ($CO_2 \leq 4\%$)	✓		
O_2 $\leq 0.2\%$ absolute ($O_2 \geq 15\%$)	✓		
or $\leq 0.3\%$ absolute ($O_2 < 15\%$)	✓		

V. METHOD 3 SAMPLING AND ANALYSIS
(continued)

Questions	Response Yes	Response No	Comments
What type of correction is determined for CO in order that nitrogen can be determined by difference after analyzing for CO_2 and O_2?	✓		Method 10 for CO.
Has calibration of the sampling apparatus and the orsat analyzer been checked within the last 3 months prior to this field test? Are calibration records available for inspection? no	✓		Ambient air for O_2. Good quick response indicates fresh reagents.

VI. GENERAL

Questions	Response		Comments
	Yes	No	
Are all samples properly labeled and is adequate sample custody performed?	✓		
Do the sample labels include the time the sample was collected and who collected it?	✓		
Is there a designated sample custodian?	✓		
Have QA Officers from ENTROPY been on-site to inspect the operation?	✓		
What precautions are being taken to ensure comparability between the CDD/CDF data taken under OAQPS funding at the spray dryer inlet with CDD/CDF data taken at the outlet to the control equipment?	yes		same as inlet.