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Air

FTIR AND METHOD 25A EMISSIONS TEST AT AN INTEGRATED IRON AND STEEL MANUFACTURING PLANT

Indiana Harbor Works of LTV Steel Company, Inc.
East Chicago, Indiana

EMISSIONS TEST
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East Chicago, Indiana

Prepared for

Office of Air Quality Planning and Standards
Emissions, Monitoring and Analysis Division
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PREFACE

This draft report was prepared by Midwest Research Institute (MRI) for the U. S. Environmental Protection Agency (EPA) under EPA Contract No. 68-D-98-027, Work Assignment No. 2-12. Mr. Michael Ciolek is the EPA Work Assignment Manager (WAM). Dr. Thomas Geyer is the MRI Work Assignment Leader (WAL). The field test was performed under EPA Contract No. 68-D2-0165, Work Assignment No. 4-20 and a draft report was submitted under EPA Contract No. 68-W6-0048, Work Assignment No. 2-08. Mr. Michael Ciolek was the EPA WAM for the Emission Measurement Center (EMC) under Work Assignment 4-20 and Mr. Michael Toney was the WAM under Work Assignment No. 2-08. Mr. John Hosenfeld was the MRI WAL under Work Assignment 2-08 and Dr. Thomas Geyer was the MRI task leader for Work Assignment 2-08, task 11.

This report presents the procedures, schedule, and test results for an emissions test performed at LTV Steel Company in East Chicago, Indiana. The emissions test used Fourier transform infrared (FTIR) sampling procedures to measure hazardous air pollutants (HAP's) and other pollutants and Method 25A to measure hydrocarbon species.

This report consists of one volume (416 pages) with seven sections and four appendices.

Midwest Research Institute

For John Hosenfeld
Program Manager

Approved:

Jeff Shular
Director, Environmental Engineering Department

September 30, 1999

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1.0 INTRODUCTION

1.1 BACKGROUND

The Emission Measurement Center (EMC) of the U. S. EPA directed MRI to conduct emissions testing at iron and steel manufacturing facilities, specifically on sintering processes. The test request for this industry was initiated from the Metals Group of the Emission Standards Division (ESD) and Source Characterization Group of the Emission Monitoring and Analysis Division (EMAD), both in the Office of Air Quality Planning and Standards (OAQPS). The test program was performed in June, 1997 under Work assignment No. 4-20, under EPA Contract No. 68-D2-0165. This draft report was prepared under Work Assignment No. 2-08, under Contract 68-W6-0048.

Initially, the project included two field tests: (1) a screening test with FTIR Method 320 to evaluate the data for detected HAP's, and (2) a separate FTIR emissions test at the same site after additional preparation based on the screening results. The emissions test was to include performance of the Method 301 spiking procedure with method validation for any detected HAP's. Immediately prior to the test EPA altered the Scope of Work for this project to include only one test for HAP screening and emissions measurements. No validation testing was performed.

The testing was performed on the sintering process at the Indiana Harbor Works of LTV Steel Company, Inc., in East Chicago, Indiana using EPA Draft FTIR Method 320[1] and EPA Method 25A. Method 320 is an extractive test method based on FTIR spectroscopy, which uses quantitative analytical procedures described in the EPA FTIR Protocol.[2] Data will be used to quantify and characterize HAP emissions and the performance of the control unit for MACT standard development for this industry.

1.2 PROJECT SUMMARY

The sintering process is used to agglomerate fine raw materials into a product suitable for charging into a blast furnace. It is a potentially significant source of HAP emissions, including both metal and organic compounds. The principal emission point at a sinter plant is the exhaust from the sintering machine windboxes. Emission controls for the Indiana Harbor Works Sinter Plant include an American Air Filter designed, double throat Kinpactor scrubber for the windbox emissions and a Zurn designed venturi scrubber for sinter breaker emissions. Testing was

conducted at the stack (outlet) and an inlet location to the Kinpactor scrubber for windbox emissions to determine the measurable emissions released during the sintering process.

Three test runs were conducted by MRI at each location over a 3 day period concurrently with manual method testing conducted by Eastern Research Group, Inc. (ERG). The FTIR samples were collected by alternating sampling between the Kinpactor scrubber inlet and stack, while the Method 25A testing was continuous at both locations. A summary of the FTIR and total hydrocarbon (THC) results is presented in Tables 1-1 and 1-2, respectively. The FTIR screening results for target analytes and other HAP's, which were not detected, is presented in Table 4-5.

In the draft report submitted in 1998, some of the heavier hydrocarbon emissions were represented by hexane in the FTIR results. Since the draft report was submitted, MRI has measured laboratory reference spectra of additional non-HAP hydrocarbon compounds. Including the new spectra in the revised analysis improved the toluene and hexane measurements. Four new compounds were detected: n-heptane, 1-pentene, 2-methyl-2-butene, and n-pentane. As a result, hexane was not detected and the inlet toluene concentrations are slightly lower compared to the draft report results. Documentation of the new reference spectra is provided in Appendix B.

The EPA Method 320 uses an extractive sampling procedure. A probe, pump, and heated line are used to transport sample from the test port to a gas manifold in a trailer that contains the FTIR equipment. Infrared spectra of a series of samples are recorded. Quantitative analysis of the spectra was performed after the FTIR data collection was completed. All spectral data and results were saved on computer media. A compact disk containing all FTIR data is provided with this report.

The EPA Method 25A also uses an extractive sampling procedure. The same sample transport system was used for both the FTIR and THC testing. Volume concentration data and results obtained from the samples were recorded and saved on computer media and reviewed after the test was completed.

1.3 PROJECT PERSONNEL

The EPA test program was administered by EMC. The Test Request was initiated by the Metals Group of the ESD and the Source Characterization Group of the EMAD, both in OAQPS. Some key project personnel are listed in Table 1-3.

TABLE 1-1. SUMMARY OF FTIR RESULTS

Compound		Scrubber Inlet			Scrubber Outlet (Stack)		
		Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
		6/25/97	6/26/97	6/27/97	6/25/97	6/26/97	6/27/97
Toluene	ppm	4.25	5.75	0.17	1.72	1.67	0.09
	lb/hr	16.19	21.34	0.66	7.41	7.21	0.37
Hexane	ppm	ND	ND	ND	ND	ND	ND
	lb/hr						
Ethylene	ppm	3.96	4.76	3.40	4.43	6.13	6.00
	lb/hr	4.60	5.37	4.08	5.80	8.03	7.79
Methane	ppm	18.1	20.1	16.2	15.8	17.7	13.9
	lb/hr	12.0	12.9	11.1	11.8	13.3	10.3
Sulfur Dioxide	ppm	93.6	79.0	83.3	24.8	11.8	10.0
	lb/hr	247.9	203.7	227.7	74.1	35.3	29.6
Carbon Monoxide	ppm	828	847	848	807	815	854
	lb/hr	959	955	1014	1056	1066	1106
Ammonia	ppm	4.58	8.21	7.27	0.44	2.08	1.70
	lb/hr	3.22	5.63	5.29	0.35	1.66	1.34
Formaldehyde	ppm	6.03	4.27	3.02	7.26	2.85	2.27
	lb/hr	7.49	5.16	3.88	10.19	4.01	3.15
n-Heptane	ppm	2.92	3.86	4.37	0.46	2.20	1.79
	lb/hr	12.12	15.57	18.70	2.16	10.28	8.30
1-Pentene	ppm	6.55	4.72	2.01	11.21	6.59	6.26
	lb/hr	19.01	13.32	6.02	36.72	21.60	20.31
2-Methyl-2-Butene	ppm	0.06	0.14	1.53	ND	ND	ND
	lb/hr	0.17	0.40	4.65			
n-Pentane	ppm	ND	ND	ND	0.27	ND	ND
	lb/hr				0.92		

TABLE 1-2. SUMMARY OF HYDROCARBON EMISSIONS RESULTS

Test data				
Run No.	1	2	3	Average
Date	25-Jun-97	26-Jun-97	27-Jun-97	
Time	0927-1701	0953-1536	0835-1346	
Scrubber inlet				
Gaseous concentrations (carbon equiv.)				
THC concentration, ppm (wet basis)	120.6	111.9	89.4	107.3
Methane concentration, ppm (wet basis)	18.5	20.4	16.5	18.5
Emissions data (carbon equiv.)				
THC emission rate, lb/hr	59.9	54.7	45.8	53.3
Total gaseous nonmethane organic carbon emission rate, lb/hr	50.6	44.2	37.4	44.1
Scrubber outlet (stack)				
Gaseous concentrations (carbon equiv.)				
THC concentration, ppm (wet basis)	80.7	81.0	73.8	78.5
Methane concentration, ppm (wet basis)	16.3	18.0	14.1	16.1
Emissions data (carbon equiv.)				
THC emission rate, lb/hr	45.2	45.4	41.0	43.9
Total gaseous nonmethane organic carbon emission rate, lb/hr	36.1	35.3	33.2	34.9

TABLE 1-3. PROJECT PERSONNEL

Organization and title	Name	Phone No.
LTV Steel Company, Inc. Indiana Harbor Works Area Manager, Environmental Services	Michael J. Thomas	(219) 391-2840
LTV Steel Company, Inc. Indiana Harbor Works General Supervisor, Sinter Plant & Ore Dock	Claude Harris, Jr.	(219) 391-3765
U. S. EPA, EMC Work Assignment Manager Work Assignment 4-20	Michael K. Ciolek	(919) 541-4921
U. S. EPA, EMC Work Assignment Manager Work Assignment 2-08	Michael L. Toney	(919) 541-5247
MRI Work Assignment Leader Work Assignment 4-20	Thomas J. Geyer	(919) 851-8181 Ext. 3120
MRI Work Assignment Leader Work Assignment 2-08	John Hosenfeld	(816) 753-7600 Ext. 1336

2.0 LTV STEEL'S SINTER PLANT

The material in Section 2 was prepared by Eastern Research Group (ERG) and provided to MRI by EMC. It is included in the report without MRI review.

2.1 OVERVIEW

The primary purpose of the sinter plant is to recover the iron value from waste materials generated at iron and steel plants by converting the materials to a product that can be used in the blast furnace (as burden material). Many of these wastes have little or no value otherwise and would require disposal if they could not be recycled by this process. A secondary purpose of the sinter plant is to incorporate blast furnace flux into the sinter rather than charging it separately into the furnace. Limestone wastes are converted to lime on the sinter grate, and the lime is used as a fluxing agent in the blast furnace. The raw material feed (sinter mix) consists of iron ore fines, chips from iron ore pellets, fine limestone, slag from the steelmaking furnace, scale from the steel rolling mill, residue from air and water pollution control equipment (blast furnace flue dust and filter cake), coke breeze (undersize coke that cannot be used in the blast furnace), and steel reverts.

There are currently nine sinter plants in operation in the U.S. A total of five of these plants use scrubbers to control emissions from the sinter plant windbox, and four use a baghouse. The sinter plant at LTV Steel in East Chicago, IN, was chosen for testing to evaluate hazardous air pollutants and emission control performance associated with sinter plants that use scrubbers.

2.2 PROCESS DESCRIPTION

LTV Steel's sinter plant at their Indiana Harbor Works was constructed in 1959 and is a part of the integrated iron and steel plant that also includes blast furnaces, basic oxygen furnaces (BOFs), ladle metallurgy, continuous casting, rolling mills, and galvanizing lines. The sinter plant has a maximum rated capacity of 5,280 tons per day (tpd) and operates 24 hours per day, 7 days a week. Typically, the plant produces 3,800 tpd and operates 24 hours per day for about 310 days per year. The sinter machine is 8 feet (ft) wide and 168 ft long. The major processing steps in the sinter plant include preparation of the sinter mix (feed material), sintering, discharge end operations (crushing and screening), and cooling of the sinter product. Figure 2-1 is a simplified schematic of the sintering process.

The typical feed composition of the sinter mix during the emission tests is shown in Table 2-1.

TABLE 2-1. SUMMARY OF SINTER MIX (FEED) COMPONENTS

Feed material	Percent of total for the day		
	Test 1 (6/25/97)	Test 2 (6/26/97)	Test 3 (6/27/97)
Pellet chips (ore)	41.1	40.9	41.3
Mill scale	13.2	14.3	14.4
Limestone	16.6	15.9	15.8
Flue dust	2.7	3.0	3.0
Coke breeze	0.8	0.8	0.9
BOF slag	9.1	9.1	8.9
Fines	7.4	8.2	7.6
NMT blend	3.8	3.2	4.2
Filter cake	5.3	4.6	3.9

The raw materials are fed from 10 storage bins by a table feeder onto a moving belt. This raw feed is mixed in a pug mill, where water is added to create the desired consistency in the mix. A "hearth layer" of material, which is undersize sinter material that is recycled from the screening operation, is first deposited on the grate bars of the sinter pallets, and then the feed mix is added to a depth of about 14 inches (in.).

The sinter feed passes through an ignition furnace that is 12 ft long. The furnace has nine side burners fueled by natural gas that ignite the surface of the sinter feed. The sinter pallets move continually through the ignition furnace at about 90 to 100 in. per minute (min) over 21 vacuum chambers called "windboxes."

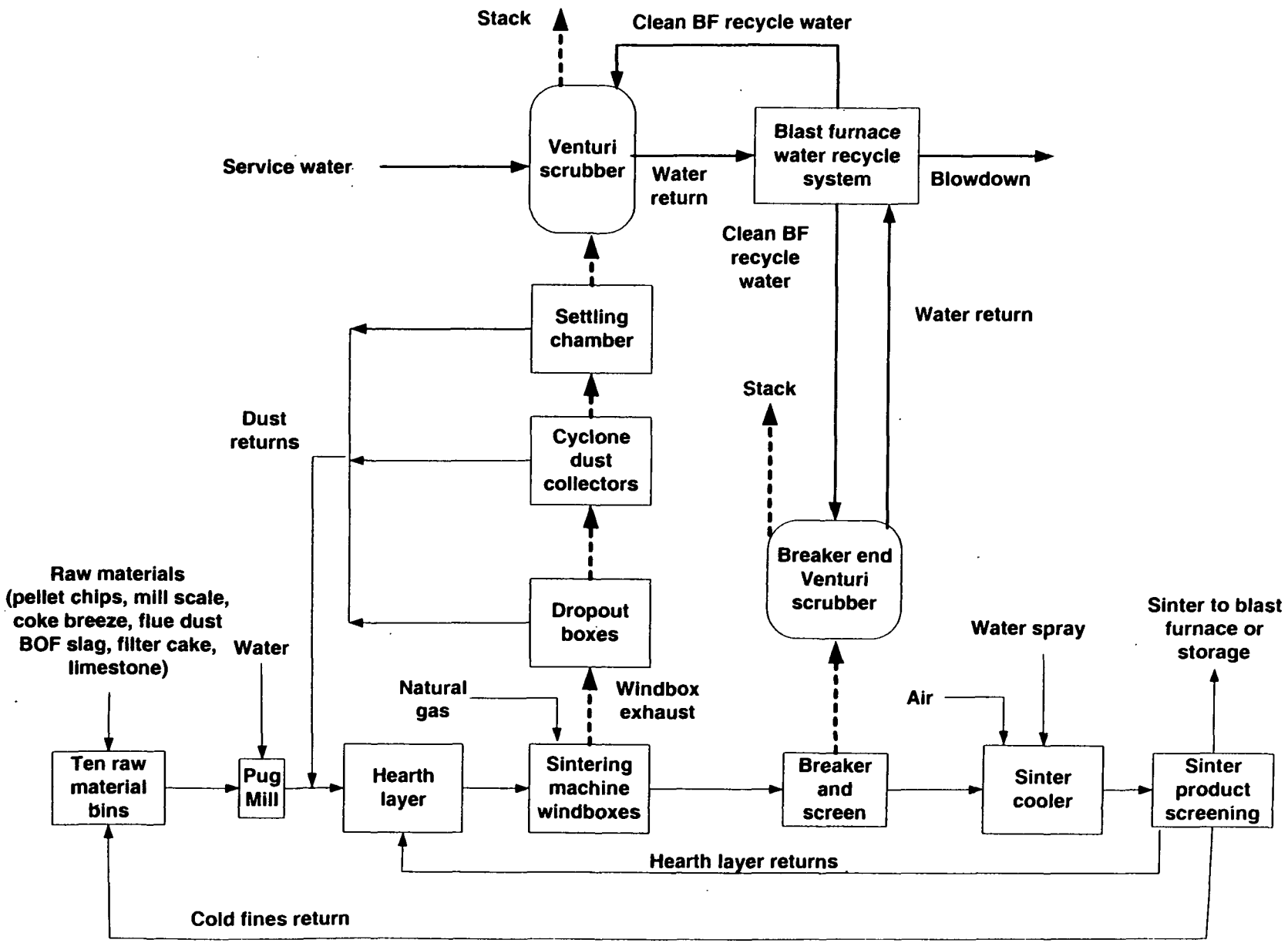


Figure 2-1. Schematic of material flow in the sinter plant.

A vacuum is created in the windbox by a 3,000 horsepower (hp) fan that draws heat through the sinter bed and creates the fused "sintered" product.

The red hot sinter from the furnace continues to be transported on the pallets to the breaker, where it is crushed, screened, and discharged to a rotary cooler. Three fans are used to create a forced draft to cool the hot sinter product. In addition, water sprays are used to cool the sinter and to suppress surface dust. The sinter is removed from the bottom of the cooler with a plow that deposits the cooled material onto a conveyor belt. The sinter is then conveyed over a double-deck screen and subsequently deposited into a storage bin. An ore car is used to transport the finished product to the blast furnace. Sinter material that passes through the screens ("fines") is returned to the sinter process for use as the hearth layer or for addition to the sinter mix.

Several operating parameters are monitored and controlled to ensure proper operation of the sinter machine. These parameters include the feed rate of each of the ten feed bins, the sinter furnace temperature, the temperature profile through the various windboxes, draft on the windboxes, speed of the grate, and percent water in the feed. The oil in the sinter feed, which comes primarily from rolling mill scale, is limited to 0.2 percent. During the testing, the coke feed rate appeared to be the parameter that was most often adjusted in order to control temperatures. To maintain the proper chemistry in the blast furnace, an important quality control parameter that is monitored and graphed on a control chart is the percent excess base:

$$(\%CaO+\%MgO) - (\%SiO_2 + \%Al_2O_3)$$

The sinter composition for the 3 tests days is summarized in Table 2-2 and shows that the percent excess base ranged from 13.6 to 13.7 compared to a target of 14.0.

TABLE 2-2. SUMMARY OF SINTER COMPOSITION

Component	Percent of total		
	Test 1 (6/25/97)	Test 2 (6/26/97)	Test 3 (6/27/97)
Fe	52.8	52.7	52.9
SiO_2	4.5	4.6	4.4
Al_2O_3	0.59	0.65	0.66
CaO	16.7	16.8	16.6
MgO	2.0	2.1	2.1
Excess base	13.6	13.7	13.6

2.3 EMISSION CONTROL EQUIPMENT

Emissions are generated in the process as sinter dust and combustion products and are discharged through the grates and windboxes to a common collector main. Coarse dust particles settle out of the air stream in the collector main and are discharged through flapper valves to a conveyor belt. This conveyor also receives the returns from a series of hoppers that collect any particles that fall under the sinter machine. This material is returned by conveyor to the sinter mix feed for recycle to the process. The exhaust then passes through a battery of cyclones and a series of chambers (originally designed for an electrostatic precipitator that is no longer used). The cyclones and chambers remove dust particles, which are also deposited onto a conveyor (through air actuated valves) for recycle to the process. The exhaust is moved by a 6,000 hp fan to the primary control device, which is a double-throat Kinpactor scrubber designed by American Air Filter. The parameters associated with the scrubber that are monitored include the pressure drop across the scrubber, flow rate of water to the scrubber, exhaust fan draft and amperage, and the scrubber water blowdown rate.

Typical operating conditions associated with the scrubber are summarized in Table 2-3.

TABLE 2-3. TYPICAL SCRUBBER PARAMETERS

Parameter	Typical value
Liquid/gas ratio	14 gal/1,000 acfm
Water flow rate	3,100 gal/min
Gas flow rate	265,000 scfm
Pressure drop	38 to 46 in. of water
pH of scrubber water	8
Inlet temperature	235° to 270°F
Outlet temperature	120°F
Blowdown rate	240 gal/min

A scrubber is also used to control emissions from the discharge end (i.e., breaker, screens). The discharge end scrubber was not evaluated as part of this test program.

Current State regulations limit particulate matter to 0.02 gr/dscf and 20 percent opacity (6-min average) for both scrubbers. In addition, the windbox scrubber is limited to a mass rate of 49.7 pounds per hour (lb/hr) and the discharge end scrubber is limited to 18.05 lb/hr.

2.4 MONITORING RESULTS DURING THE TESTS

The operating parameters associated with the process and control device were recorded at 15-minute intervals throughout each test day. The process parameters that were monitored included the feed rate from each of the 10 bins that were used in the sinter mix, the temperatures and the fan draft for the windboxes, percent water in the feed, sinter machine speed, and the sinter production rate. The emission control device parameters that were monitored included the pressure drop across the scrubber, the water flow rate, blowdown rate, fan draft, and fan amps. Tables 2-4 and 2-5 present a summary of the range of values for these parameters for each test period.

The process and control device appeared to be stable throughout the 3 test days; consequently, sampling was conducted under normal and representative conditions. The feed rates of mill scale and other materials were typical of the historical rates in recent years that had been reported by the plant. In addition, the oil content of the mill scale was typical (target is 0.2 percent, maximum) with an average of 0.21 percent oil (a range of 0.17 to 0.24 percent)

TABLE 2-4. PROCESS PARAMETER VALUES DURING THE TESTS

Parameter	Test 1 (6/25/97)	Test 2 (6/26/97)	Test 3 (6/27/97)
Feed rate (tph):			
Mill scale	25.2 (24.8 - 25.5)	25.2 (24.9 - 25.5)	25.2 (24.8 - 25.6)
BOF slag/filter cake	16.7 (16.1 - 17.9)	16.9 (15.9 - 18.2)	16.9 (15.5 - 17.9)
Fines	16.7 (16.1 - 17.6)	16.4 (15.9 - 18.0)	16.7 (15.3 - 18.0)
Pellet chips	77.4 (75.9 - 78.8)	77.7 (76.2 - 79.0)	77.6 (76.5 - 79.5)
Pellet fines-- blend	9.5 (8.5 - 10.2)	10.7 (10.1 - 11.4)	12.3 (11.3 - 13.6)
Limestone	27.2 (26.9 - 27.7)	27.5 (26.8 - 27.8)	27.7 (27.4 - 28.8)
Cold fines	19.6 (17.6 - 21.4)	17.2 (15.2 - 19.5)	17.8 (16.8 - 23.2)
Coke breeze	**1.7** (1.5 - 1.9)	**1.2** (0.9 - 1.5)	**0.7** (0.34 - 1.1)
Flue dust	5.9 (5.8 - 6.0)	5.9 (5.8 - 6.0)	5.9 (5.8 - 6.0)
BOF slag fines	7.9 (7.6 - 8.2)	9.3 (9.4 - 10.1)	10.0 (9.8 - 10.1)
Other parameters:			
Percent water	6.7 - 7.5	6.5 - 7.4	7.2 - 8.2
Grate speed	70 - 76	70 - 76	70 - 82
Windbox 20 temperature (°F)	453 - 656	474 - 659	334 - 571
Windbox draft (in. water)	13.6 - 17.4	13.3 - 18.2	14.2 - 18.2
Feed rate (tph)	205 - 210	201 - 212	209 - 213
Sinter production (tph)	155 - 158	153 - 161	159 - 161

TABLE 2-5. CONTROL DEVICE OPERATING PARAMETERS DURING THE TESTS

Parameter	Test 1 (6/25/97)	Test 2 (6/26/97)	Test 3 (6/27/97)
Pressure drop (in. water)	38.4 - 46.6	39.4 - 46.3	39.8 - 47.0
Water flow (gal/min)	3,040 - 3,085	3,080 - 3,130	3,080 - 3,110
Blowdown (gal/min)	236 - 239	242 - 246	241 - 244
Fan amps	663 - 695	685 - 700	700 - 730
Fan draft (in. water)	3.1 - 5.8	3.2 - 5.8	3.8 - 5.1
Type of water	service (lake)	recycled blast furnace	

based on the analysis of 5 samples. An examination of the monitoring data showed that the average pressure drop across the scrubber was 43.1, 42.8, and 42.4 in. of water for the 3 test days. The coke rate seemed to be the most variable parameter during the tests because adjustments were made frequently to change the sintering temperature. The coke rate for the 3 tests averaged 1.7, 1.15, and 0.67 tph; consequently, the emission test results may provide some insight into the effect of coke rate on emissions. The windbox temperatures also varied somewhat during the tests. Using Windbox 20 as an example, the average temperatures during the 3 tests were 538°, 567°, and 443°F.

2.5 ANALYSIS OF MONITORING AND TEST RESULTS

Table 2-6 summarizes the emission results for each run along with selected parameters that were monitored during the test. Only a few comparisons can be made because the process operated stably and consistently during the 3 test runs. One difference is that the coke (fuel) rate during Run 3 was only 39 percent of the rate during Run 1 and only 58 percent of the rate during Run 2. The lower fuel rate during Run 3 is reflected in the lower windbox temperature during Run 3, which was about 100°F lower than in the previous 2 runs. The pollutants most likely to be affected by the change in combustion conditions are dioxins, furans, and PAHs. During Run 3, the emission rates for all of these compounds were lower than in the previous 2 runs.

The highest emissions of particulate matter and lead occurred during Run 3. The cause is not conclusive, but some of the possible factors affecting this, perhaps in combination, were that Run 3 had the highest sinter feed and production rate and the lowest average pressure drop across the scrubber. In addition, Table 2-4 indicates that Run 3 had a higher feed rate of fines (pellet fines and BOF slag fines) than that recorded during the previous 2 runs. Service water was used

TABLE 2-6. SUMMARY OF RESULTS FOR EACH TEST RUN

Parameter	Units	Run 1	Run 2	Run 3	Average
PM[a] - inlet	lb/hr	419	479	550	483
PM - outlet	lb/hr	34	38	43	38
PM efficiency	percent	92	92	92	92
Lead - inlet	lb/hr	4.1	4.0	4.4	4.2
Lead - outlet	lb/hr	3.7	3.6	3.8	3.7
Lead efficiency	percent	9.8	10	14	12
HAP metals - in	lb/hr	4.5	4.5	4.9	4.6
HAP metals - out	lb/hr	3.8	3.7	3.9	3.8
Metals efficiency	percent	16	18	20	17
D/F congeners[b]	μg/hr	810	768	**694**	757
D/F TEQ[c]	μg/hr	93	91	**79**	88
Total D/F[d]	μg/hr	5,650	5,380	**4,820**	5,280
7 PAHs[e]	g/hr	1.9	2.0	**1.4**	1.7
16 PAHs	g/hr	69	78	**61**	69
TOTAL PAHs	g/hr	83	92	**73**	83
Sinter feed	tons/hr	208	208	211	209
Sinter production	tons/hr	156	159	160	158
Scrubber Δ p	in. water	43.1	42.8	42.4	42.8
Windbox 20 temperature	°F	538	567	**443**	516
Coke feed	tons/hr	1.7	1.2	**0.7**	1.2

[a] PM = particulate matter
[b] D/F congeners are those dioxins and furans that have a toxicity equivalent factor relative to 2,3,7,8-TCDD.
[c] D/F TEQ is the toxicity equivalent expressed relative to 2,3,7,8-TCDD.
[d] Total D/F are all dioxins and furans that were reported.
[e] PAH = polycyclic aromatic hydrocarbons.

in the scrubber during Run 1 and recycled blast furnace water was used during Runs 2 and 3. There is no obvious difference in emissions that can be clearly attributed to the type of scrubber water.

The major metal HAP that was found was lead, which accounted for over 97 percent of the total metal HAP emissions. Discussions with the plant and examination of data from the analysis of blast furnace fines and sludge indicated that a likely source of the lead emissions was

from this fine material recycled from the blast furnace. Data in the literature showed that the lead content of blast furnace dust and sludge was generally in the range of 0.01 to 0.1 percent. At a typical feed rate for the dust and sludge of 28,000 lb/hr (14 tons per hour [tph]), these materials would introduce 2.8 to 28 lb/hr of lead into the process, which could easily account for the lead that was found entering the scrubber (4.2 lb/hr). In addition, the small particle size of these pollution control residues from the blast furnace may increase the probability that they become airborne, and the volatility of lead and some lead compounds from combustion processes may tend to increase the concentration of lead in the windbox emissions.

Another interesting result is the very low emission rate of dioxins, relative to what had been reported from testing at German sinter plants. For example, the German study reported concentrations of 23 to 68 ng TEQ/m^3 from their initial studies and a range of 5 to 10 ng TEQ/m^3 for plants that optimized and improved their operation. The results for this sinter plant was much lower with an average concentration of 0.19 ng TEQ/m^3. On the basis of sinter production, the Germans reported emission levels in the range of 10 to 100 μg/Mg of sinter compared to a measured level of 0.6 μg/Mg of sinter for this plant. The LTV sinter plant had emissions of dioxins and furans that were on the order of 10 to 100 times less than that reported for German sinter plants.

The dioxin results are not unexpected because there are basic differences between the operation of LTV's sinter plant and the German plants. The German study attributed the formation of dioxin to the presence of chlorinated organics, primarily in cutting oils, that were in the waste materials fed to the sintering process. In addition, they stated that the use of electrostatic precipitators contributed to recombination and formation of dioxin. In contrast, the LTV plant has eliminated the purchase and use of chlorinated organics in their facility as part of a voluntary program of pollution prevention, and any new chemical purchases must be approved by the environmental department. Their rolling mill oils (lubricants and hydraulic fluids) do not contain chlorinated compounds. In addition, routine analysis of waste materials going to the sinter plant have not detected chlorinated solvent. Finally, the LTV plant does not use an electrostatic precipitator. Consequently, dioxin rates at LTV that are much lower than those reported by German sinter plants appear to be reasonable and explainable.

Table 2-7 through 2-9 presents a summary of the annual emissions and the emission factors derived from this test.

TABLE 2-7 SUMMARY OF RESULTS FOR PM AND HAP METALS

Pollutant	Concentration (gr/dscf)		Emission rate (lb/hr)		Efficiency (%)	Annual rate (tpy)[a]		Emission factor (lb/t sinter)	
	Inlet	Outlet	Inlet	Outlet		Inlet	Outlet	Inlet	Outlet
Particulate matter	0.23	0.017	483	38	92	1,800	142	3.1	0.24
Pollutant: HAP metals	Concentration (μg/DSCM)		Emission rate (g/hr)		Efficiency (%)	Annual rate (tpy)		Emission factor (lb/t sinter)	
	Inlet	Outlet	Inlet	Outlet		Inlet	Outlet	Inlet	Outlet
Mercury	0.96	1.5	0.41	0.69	0	3.3×10^{-3}	5.7×10^{-3}	5.7×10^{-6}	9.7×10^{-6}
Arsenic	4.3	1.1	1.8	0.50	73	1.5×10^{-2}	4.1×10^{-3}	2.5×10^{-5}	7.0×10^{-6}
Beryllium	0.054	0.052	0.023	0.023	0	1.9×10^{-4}	1.9×10^{-4}	3.2×10^{-7}	3.3×10^{-7}
Cadmium	20	17	8.4	7.8	7.4	6.9×10^{-2}	6.4×10^{-2}	1.2×10^{-4}	1.1×10^{-4}
Cobalt	0.30	0.050	0.18	0.023	87	1.5×10^{-3}	1.9×10^{-4}	2.5×10^{-6}	3.3×10^{-7}
Chromium	24	5.2	9.9	2.4	76	8.1×10^{-2}	1.9×10^{-2}	1.4×10^{-4}	3.3×10^{-5}
Manganese	400	17	171	7.9	95	1.4	6.4×10^{-2}	2.4×10^{-3}	1.1×10^{-4}
Nickel	23	22	9.8	9.9	0	8.0×10^{-2}	8.1×10^{-2}	1.4×10^{-4}	1.4×10^{-4}
Lead	4,500	3,700	1,900	1,690	11	16	$1.4 \times 10^{+1}$	2.7×10^{-2}	2.4×10^{-2}
Antimony	2.6	1.6	1.1	0.75	32	9.0×10^{-3}	6.1×10^{-3}	1.5×10^{-5}	1.0×10^{-5}
Selenium	13	8.7	5.5	4.0	28	4.5×10^{-2}	3.2×10^{-2}	7.7×10^{-5}	5.5×10^{-5}
Total HAP metals	5,000	3,800	2,100	1,700	18	17	$1.4 \times 10^{+1}$	2.9×10^{-2}	2.4×10^{-2}

[a] Based on operation for 24 hours per day for 310 days per year.

TABLE 2-8 SUMMARY OF RESULTS FOR PAHS

Pollutant: PAHs[a]	Concentration (μg/DSCM)	Emission rate (g/hr)	Annual emissions[b]	
			tpy	lb/ton sinter
Benzo(a)anthracene	0.53	0.24	0.0019	3.3×10^{-6}
Chrysene	1.3	0.60	0.0049	8.4×10^{-6}
Benzo(b)fluoranthene	1.2	0.54	0.0044	7.5×10^{-6}
Benzo(k)fluoranthene	0.22	0.10	0.00082	1.4×10^{-6}
Benzo(a)pyrene	0.23	0.11	0.00086	1.5×10^{-6}
Indeno(1,2,3-cd)pyrene	0.26	0.12	0.00096	1.6×10^{-6}
Dibenzo(a,h)anthracene	0.097	0.044	0.00036	6.1×10^{-7}
Total 7 PAHs	**3.9**	**1.7**	**0.014**	**2.4×10^{-5}**
Naphthalene	78	35	0.29	4.9×10^{-4}
Acenaphthylene	7.6	3.4	0.028	4.8×10^{-5}
Acenaphthene	3.5	1.6	0.013	2.2×10^{-5}
Fluorene	5.4	2.4	0.020	3.4×10^{-5}
Phenanthrene	43	19	0.16	2.7×10^{-4}
Anthracene	1.8	0.81	0.0067	1.1×10^{-5}
Fluoranthene	6.9	3.1	0.026	4.3×10^{-5}
Pyrene	3.0	1.4	0.011	1.9×10^{-5}
Benzo(g,h,l)perylene	0.36	0.16	0.0013	2.2×10^{-6}
Total 16 PAHs	**153**	**69**	**0.57**	**9.7×10^{-4}**
2-Methylnaphthalene	29	13	0.11	1.8×10^{-4}
2-Chloronaphthalene	0.039	0.018	0.00015	2.5×10^{-7}
Benzo(e)pyrene	0.76	0.30	0.0028	4.8×10^{-6}
Perylene	0.058	0.026	0.00022	3.7×10^{-7}
Total - all PAHs	**183**	**83**	**0.68**	**1.2×10^{-3}**

[a] PAH = polycyclic aromatic hydrocarbons.
[b] Based on operation for 24 hours per day for 310 days per year.

TABLE 2-9. SUMMARY OF RESULTS FOR DIOXINS AND FURANS

Pollutant	Concentration (ng/DSCM)	Emission rate (μg/hr)	Annual emissions[a]	
			g/yr	lb/ton sinter
D/F TEQ[b]	0.19	88	0.66	1.2×10^{-9}
D/F Congeners[c]	1.7	757	5.6	1.1×10^{-8}
D/F Total[d]	11.7	5,280	39	7.4×10^{-8}

[a] Based on operation for 24 hours per day for 310 days per year.
[b] D/F TEQ is the toxicity equivalent expressed relative to 2,3,7,8-TCDD.
[c] D/F congeners are those dioxins and furans that have a toxicity equivalent factor relative to 2,3,7,8-TCDD.
[d] Total D/F are all dioxins and furans that were reported.

3.0 TEST LOCATIONS

Figure 3-1 is a schematic showing an overview of the test site with a view of both locations. The exhaust gas at the outlet stack and scrubber inlet were analyzed from the same trailer position.

3.1 KINPACTOR SCRUBBER OUTLET - STACK

The test platform and test ports on the 150-ft stack were located at 125 ft above ground level. Access to the stack platform was provided by a spiral staircase around the exterior of the scrubber structure to a narrow platform and catwalk about half way up. A permanent caged ladder in three sections provided access from the catwalk to the stack test platform. The platform was 2 ft wide around the entire circumference of the stack. There were four 4-in. test ports 90° apart that were used for testing.

3.2 KINPACTOR SCRUBBER INLET - DUCT

Access to the scrubber inlet location was provided by scaffolding that had been constructed for this test. The sample port used by MRI was located approximately 20 ft above ground level and in a plane parallel and upstream of the manual test ports.

3.3 VOLUMETRIC FLOW

Table 3-1 summarizes the gas composition and flow data provided by ERG. ERG provided volumetric flow rates, moisture content, gas molecular weight, etc., as part of their manual testing; therefore, MRI did not conduct these tests.

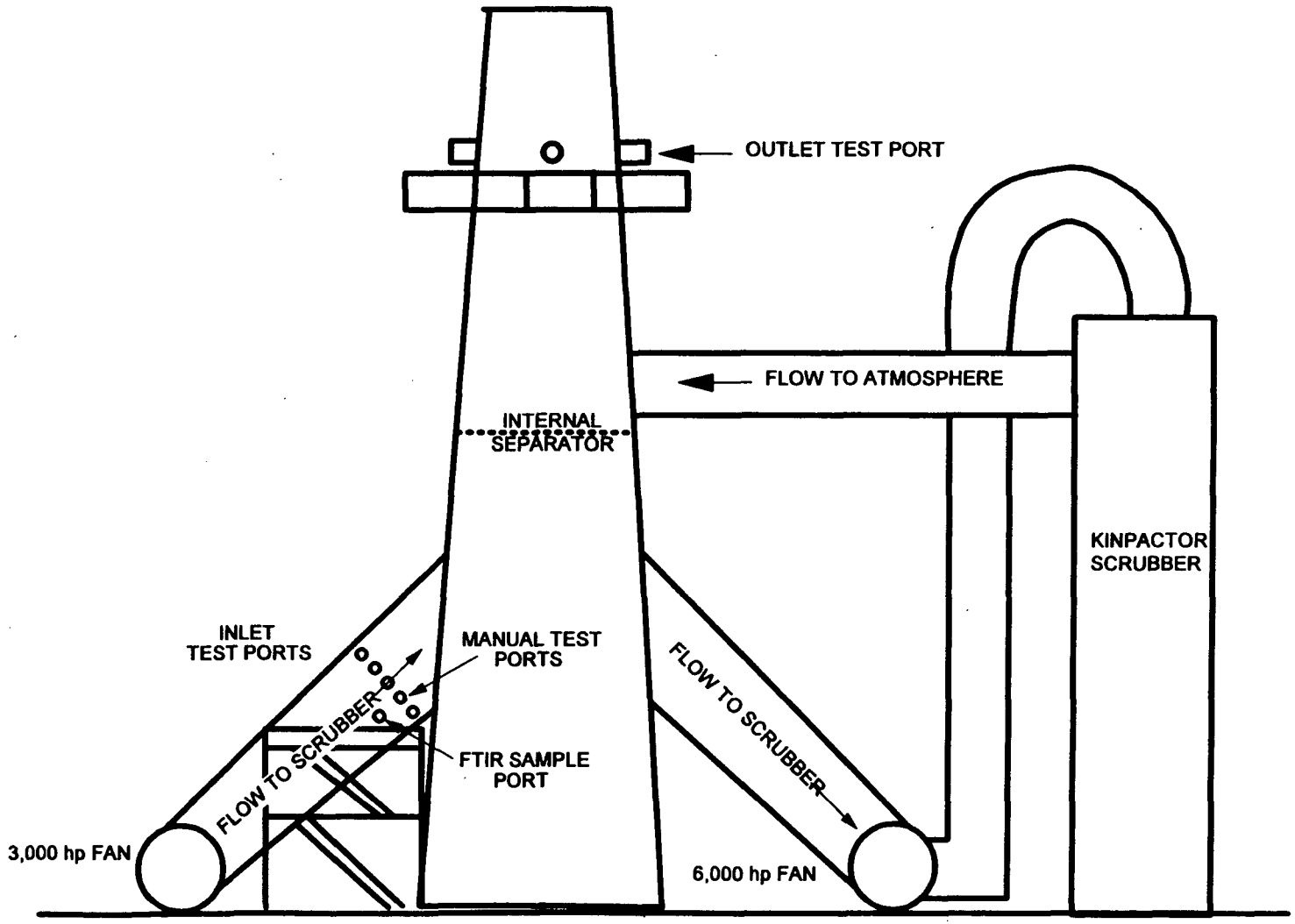


Figure 3-1. Test locations.

TABLE 3-1. SOURCE GAS COMPOSITION AND FLOW SUMMARY

Test data			
Run No.	1	2	3
Date	25-Jun-97	26-Jun-97	27-Jun-97
Scrubber inlet			
Oxygen, %	19.0	18.8	18.8
Carbon dioxide, %	2.5	3.3	3.3
Moisture content, %	6.6	6.8	6.8
Gas Stream velocity, fpm	6236	6058	6182
Volumetric flow rate, dscfm	248,105	241,027	255,583
Scrubber outlet (Stack)[a]			
Oxygen, %	17.5	17.5	18.2
Carbon dioxide, %	3.5	3.7	3.4
Moisture content, %	11.0	11.1	10.5
Gas Stream velocity, fpm	2961	2959	2916
Volumetric flow rate, dscfm	266,998	266,783	266,178

[a]Data presented in this section is the average of the dioxin and multi-metals tests.

4.0 RESULTS

4.1 TEST SCHEDULE

The test program at LTV Steel was completed from June 23 to June 27, 1997. Table 4-1 summarizes the sampling schedule. A complete record of all THC and FTIR sampling is in Appendices A and B. The FTIR and THC sampling was coordinated with the manual sampling conducted by ERG. Table 3-1 summarizes the gas composition and flow data provided by ERG.

TABLE 4-1. TEST SCHEDULE AT LTV STEEL COMPANY INDIANA HARBOR WORKS

Date	Task	Location [a]
6/23/97	Arrive on site and setup at inlet and outlet.	Scrubber inlet and outlet.
6/24/97	Completed set up and recorded spectra of preliminary samples. 14:00 - 16:45	
6/25/97	Test Run 1. FTIR and Method 25A in conjunction with manual methods by ERG. 8:37 - 18:05	
6/26/97	Test Run 2. FTIR and Method 25A in conjunction with manual methods by ERG. 9:10 - 17:20	
6/27/97	Test Run 3. FTIR and Method 25A in conjunction with manual methods by ERG. 8:43 - 13:45 Packed equipment and departed site	

[a]Location descriptions are in Section 2.

4.2 FIELD TEST PROBLEMS AND CHANGES

The flue gas at LTV contained concentrations of both water vapor and carbon dioxide (CO_2) high enough to cause interference in the FTIR frequency regions used in the sample analyses. Toluene vapor was used for the analyte quality assurance spiking. The CO_2 spectrum interfered with the strongest toluene infrared band near 730 cm^{-1} so the weaker toluene absorbance, in the analytical region 2,850 to 3,100 cm^{-1} range, was used for the analysis. The presence of other aliphatic (nonaromatic species such as methane and hexane) hydrocarbon species also contributed to the total infrared absorbance in the 2,850 to 3,100 cm^{-1} analytical region.

During testing the sample flow rate was not constant, particularly at the inlet. The flow continuously dropped due to particulate clogging of the pre-filter at the inlet probe tip. It was

necessary to periodically replace the fiberglass pre-filter, twice during runs one and two and once during run three, to restore the sample flow. The inconsistent sample flow rate may have had some effect on the spike recovery results (this is discussed further in Section 4.5). The flow drop during a typical spiking period (about 30 min) was not too severe.

The sampling procedure maintained continuous flow to two hydrocarbon analyzers, one analyzer for each location. One FTIR instrument was used to sample the two locations alternately and the FTIR cell was evacuated before switching locations. Opening a sample line to the evacuated cell caused a temporary pressure drop in that sample line, which caused a temporary loss of flow to the hydrocarbon analyzer and a corresponding decrease in the THC analyzer response. These events are noted in the Method 25A results. This problem was discovered early in the testing so MRI modified the sampling system configuration to minimize the effects. The affected hydrocarbon data (denoted with *** in the field data) were not included in the run averages. After this test program MRI installed back pressure regulators on the manifold vents to eliminate this problem.

The inlet probe was temporarily out of the stack each time the pre-filter was replaced. This operation did not affect the FTIR results because the pre-filter was always replaced when the FTIR system was sampling the outlet. The inlet hydrocarbon data for these periods were logged, but not included in the run averages.

Space was limited on the platform at the outlet location so that it was necessary to change the MRI outlet sampling port during one of the manual method port changes for each run. This port change did not affect the FTIR results because it was done while the FTIR system was sampling at the inlet location. However, the hydrocarbon data were still logged; these data are noted in the results and were not included in the run averages. The port changes caused the loss of 20, 30, and 26 min of THC data during runs 1, 2, and 3, respectively.

4.3 METHOD 25A RESULTS

Table 1-2 summarizes the Method 25A THC results at both the inlet and outlet. The mass emission data is presented as both THC and total gaseous nonmethane organic carbon (TGNMOC). The TGNMO was calculated using the procedures outlined in Section 5.7.2 of this report using methane concentrations from the FTIR analysis.

The THC emissions varied greatly with each test run and peaks in the THC concentration occurred at several points during each run. The inlet concentrations varied greater than the outlet concentrations as would be expected after a scrubber. No determinations can be made about the THC concentration variations without taking into account the process and scrubber operational conditions for the time period during each run. Table 4-2 shows the minimum and maximum THC concentrations for each test run.

TABLE 4-2. MINIMUM AND MAXIMUM THC CONCENTRATIONS

Run No.	ppmc		
	Minimum	Maximum	Average
Scrubber inlet			
1	77.1	172.5	120.6
2	53.1	160.8	111.9
3	54.6	141	89.4
Scrubber outlet (stack)			
1	67.2	108.6	80.7
2	56.7	117.9	81.0
3	54	95.1	73.8

The complete Method 25A results are included in Appendix A. The concentrations presented were measured by MRI, the mass emissions data, presented in Section 1.2, were calculated using volumetric flow results provided by ERG. The pre- and post-run calibrations and QA checks met the Method 25A criteria in all cases. Calibration QA results are included in Appendix A.

4.4 FTIR RESULTS

A summary of the FTIR results is presented in Table 1-1. Complete FTIR results at the inlet and outlet are presented in Tables B-1 and B-2, respectively. The infrared spectra showed evidence of water vapor, CO_2, carbon monoxide (CO), methane, formaldehyde, sulfur dioxide (SO_2), toluene, ethylene, hydrocarbon, and ammonia. New reference spectra of nine hydrocarbon compounds were used in the revised analysis results. The new reference spectra were measured in the laboratory and helped provide more accurate measurements of the HAPs hexane and toluene. A description of the analytical procedures used to prepare the FTIR results

is given in Section 4.5. The mass emission rates were calculated using flow data provided by ERG. Mass emission calculations for toluene include only the results from unspiked samples.

The inlet and outlet concentrations are similar for methane, hexane, and ethylene. Concentrations of formaldehyde (runs 2 and 3), ammonia, and SO_2 were reduced by the scrubber control device (approximately 67, 91, and 76 percent removal, respectively).

4.5 ANALYTE SPIKE RESULTS

A toluene gas standard was used for analyte spiking experiments for quality assurance only. Preferably, a spike standard combines the analyte and the tracer gas in the same cylinder, but the SF_6 and toluene were contained in two separate cylinders. Therefore, the spiking sequence was; first the sample was spiked with the SF_6 (or toluene) and, second, the sample was spiked with the toluene (or SF_6). This procedure was followed because it was not possible to obtain a mixture with both components in time to perform this test.

The spiked concentrations are summarized in Table B-3 and the analyte spike results are presented in Table 4-3. Samples were spiked with a measured amount of toluene vapor at the start and completion of each run at each location. A standard of SF_6 tracer gas was also spiked into the gas stream to determine the spike dilution factor. A description of the spike procedure is given in Section 4.4.1.

In most cases the calculated spike recoveries were greater than 130 percent, which is above the range allowed by Method 301 for a validation correction factor (between 70 and 130 percent). This does not reflect on the accuracy of the emissions results in Tables B-1 and B-2. The residual spectra (Figure 4-1), which show no significant (or negative) remaining absorbances, indicate that the computer program correctly measured the absorbances from the interfering species and the analytes.

Three factors contributed to the high recoveries; two are minor and one is major. These factors are discussed in order of increasing importance. One minor factor is that the total sample flow rate varied some during the sampling periods, but the variation was not large during any spiking period. This factor was only potentially significant at the inlet, where the initial

TABLE 4-3. SUMMARY OF SPIKE RESULTS

Scrubber Inlet

Run	Toluene Average Spike	Toluene Average Unspike	Toluene Tol(calc) spike - unspike	SF_6 Average Spike	SF_6 Average Unspike	SF_6 spike - unspike	DF	Cexp	Library spectra[a] % Recovery	Standard spectra[b] % Recovery
1	26.5	0	26.5	0.548	0.000	0.548	7.3	16.5	160	101
	33.8	1.2	32.7	0.666	0.000	0.666	6.0	20.1	163	103
2	33.1	4.4	28.7	0.658	0.000	0.658	6.1	19.9	145	91.3
	49.6	4.9	44.7	1.022	0.000	1.022	3.9	30.8	145	91.3
3	37.7	4.2	33.5	0.745	0.000	0.745	5.4	22.5	149	93.8
	56.5	0	56.5	1.211	0.000	1.211	3.3	36.5	155	97.6

Scrubber Outlet (Stack)

Run	Toluene Average Spike	Toluene Average Unspike	Toluene Tol(calc) spike - unspike	SF_6 Average Spike	SF_6 Average Unspike	SF_6 spike - unspike	DF	Cexp	Library spectra[a] % Recovery	Standard spectra[b] % Recovery
1	23.5	0	23.5	0.474	0.000	0.474	8.5	14.3	164	103
	27.2	0	27.2	0.512	0.000	0.512	7.8	15.4	176	111
2	28.3	0	28.3	0.563	0.000	0.563	7.1	17.0	166	105
	29.0	1.4	27.6	0.572	0.000	0.572	7.0	17.3	160	101
3	28.6	0	28.6	0.539	0.000	0.539	7.4	16.3	176	111
	25.2	0	25.2	0.472	0.000	0.472	8.5	14.2	177	111

[a]These recoveries were obtained using EPA library reference spectra for toluene.
[b]These were obtained using spectra of the toluene cylinder standard measured on site.

particulate filter was periodically replaced, however the spike recoveries were highest in the outlet samples. The second minor, but more significant factor relates to the determination of the unspiked toluene concentration in the spiked samples. Because the spiked samples were measured sequentially and because there was a variable unspiked toluene concentration, there is an undetermined uncertainty in the calculation of "spike minus unspike."

The spike recoveries were about 100 percent compared to the toluene spike standard. However, compared to the library toluene reference spectra, the recoveries seem high. The library spectra and the spectra of the toluene cylinder standard differ by about 37 percent. The two sets of spectra are compared in Table 4-4. This observation does not effect the spike recovery results, but it may have implications for the use of the toluene library reference spectra, and this may warrant further investigation. A similar, but smaller, effect was observed previously.[4]

TABLE 4-4. COMPARISON OF EPA TOLUENE REFERENCE SPECTRA TO SPECTRA OF TOLUENE CYLINDER STANDARD[a]

Toluene spectra	Source	Band area	Region (cm-1)	Spectra comparison using the band areas		Comparison of spectra using standard concentrations		
				Ratio (R_a)	$=1/R_a$	(ppm-m)/K	Ratio (R_b)	$=1/R_b$
153a4ara	EPA lib	23.4	3160.8 - 2650.1	5.4	**0.186**	4.94	4.8	**0.210**
153a4arc	EPA lib	4.4		1.0	**1.000**	1.04	1.0	**1.000**
1530624b	LTV test	33.4		7.7	**0.130**	5.80	5.6	**0.179**
1530624a	LTV test	33.6		7.7	**0.130**	5.80	5.6	**0.179**

[a] The relevant comparison is R_b/R_a. About 72 percent lower calculated spike concentrations are obtained using the cylinder standard spectra, 1530624a,b, instead of the library reference spectra.

4.6 SCREENING RESULTS

Estimated uncertainties for the HAP screening analysis are reported in Table 4-5. The spectra were analyzed for the potential analytes listed in the original test request and for other, principally hydrocarbon, species, which are in the EPA library of FTIR reference spectra or were measured in the laboratory after completion of the test. The procedure for estimating the uncertainties is described in Section 5.5. The compounds for which the spectra were screened and the analytical region(s) for each compound are given in Table 4-6. The reported uncertainties can be interpreted as the practical measurement limits imposed by the sampling conditions. The method of calculating uncertainties was identical to that used for the compounds reported in Tables B-1 and B-2 and depends on the noise in the residuals (Figure 4-1).

TABLE 4-5. SUMMARY OF ESTIMATED UNCERTAINTIES FOR UNDETECTED TARGET ANALYTES AT LTV STEEL

	Run 1		Run 2		Run 3	
Compound	Inlet uncertainty	Outlet uncertainty	Inlet uncertainty	Outlet uncertainty	Inlet uncertainty	Outlet uncertainty
Benzene (ch)	2.1	2.7	1.8	2.9	1.8	3.3
Methyl bromide (fp)	7.2	9.9	7.5	10.8	7.0	13.4
Methyl Chloride (ch)	5.1	7.2	4.5	7.6	4.4	8.7
Methyl chloroform (fp)	0.7	0.9	0.7	1.0	0.7	1.2
1,1-Dichloroethane (ch)	6.1	9.3	5.4	9.7	5.2	11.2
1,3-Butadiene (fp)	0.8	1.2	0.8	1.3	0.7	1.6
Carbon tetrachloride (fp)	0.13	0.20	0.13	0.22	0.12	0.28
Chlorobenzene (fp)	2.3	3.0	2.4	3.2	2.2	4.0
Cumene (ch)	2.1	2.9	1.8	3.0	1.8	3.5
Ethylbenzene (ch)	5.1	7.6	4.5	8.0	4.4	9.2
Methylene chloride (fp)	1.3	1.8	1.4	1.9	1.3	2.2
Propionaldehyde (ch)	1.1	1.7	1.0	1.8	1.0	2.1
Styrene (fp)	1.7	2.4	1.7	2.7	1.6	3.3
1,1,2,2-Tetrachloroethane (fp)	0.59	0.87	0.61	0.95	0.57	1.2
p-Xylene (ch)	3.9	5.9	3.4	6.2	3.3	7.1
o-Xylene (ch)	4.1	5.6	3.6	5.9	3.5	6.8
m-Xylene (ch)	9.4	12.1	8.3	12.7	8.1	14.7
Isooctane (ch)	0.50	0.67	0.44	0.70	0.42	0.81

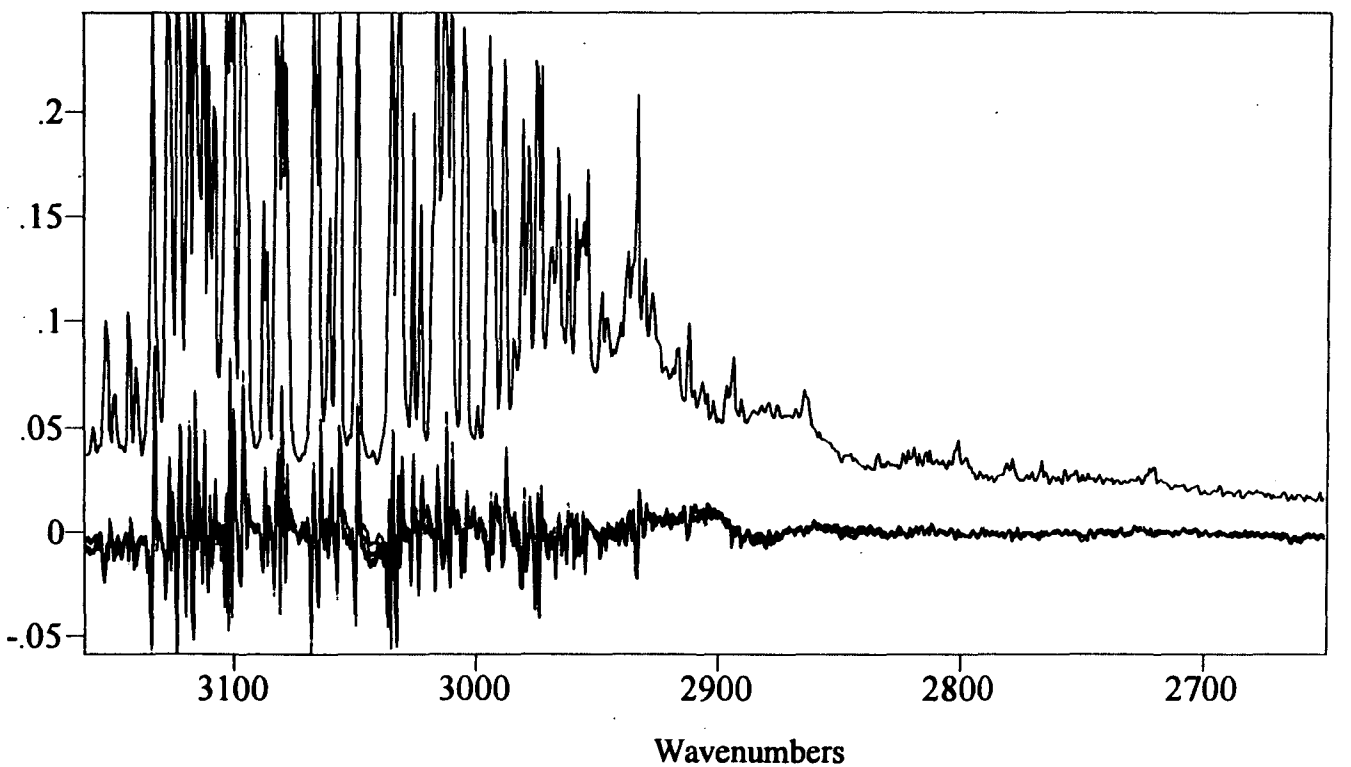
Analytical Region

(ch) - 2,650.1 - 3,160.8 cm
(fp) - 789.3 - 1275.0 cm^{-1}
Procedure for estimating uncertanties is described in Section 4.5.3

TABLE 4-6. PROGRAM INPUT FOR ANALYSIS OF SAMPLE SPECTRA

Compound name	File name	Region No.	ISC (* indicates arbitrary)	Reference	
				Meters	T (K)
Water	194hsub	1,2,3	100*		
Carbon monoxide	co20829a	1	167.1	22	394
Sulfur dioxide	198c1bsi	2	90.3	22	394
Carbon dioxide	co2ascal	1,2,3	415*		
Formaldehyde	087c1asa	3	4.436	22	394
Benzene	015a4ara	3	496.6	3	298
Methane	196c1bsd	3	16.09	22	394
Methyl bromide	106a4asb	2	485.3	3	298
Toluene	153a4arc	3	103.0	3	298
Methyl chloride	107a4asa	3	501.4	3	298
Methyl chloroform	108a4asc	2	98.8	3	298
1,1-dichloroethane	086b4asa	2	499.1	2.25	373
1,3-butadiene	023a4asc	2	98.4	3	298
Carbon tetrachloride	029a4ase	2	20.1	3	298
Chlorobenzene	037a4arc	2	502.9	3	298
Cumene	046a4asc	3	96.3	3	298
Ethyl benzene	077a4arb	3	515.5	3	298
Methylene chloride	117a4asa	2	498.5	3	298
Propionaldehyde	140b4anc	3	99.4	2.25	373
Styrene	147a4asb	2	550.7	3	298
1,1,2,2-tetrachloroethane	150b4asb	2	493.0	2.25	373
p-Xylene	173a4asa	2	488.2	3	298
o-Xylene	171a4asa	3	497.5	3	298
m-Xylene	172a4arh	2	497.8	3	298
Ethylene	CTS0626b	2	20.1	18.9	394
SF_6	Sf6_002	2	1.0029	22	394
Ammonia	174c1asc	2	10.0	20	388
Hexane	0950709a	3	46.9	10.3	399
butane	but0715a	3	100.0	11.25	397.8
n-heptane	hep0716a	3	49.97	10.3	398.3
pentane	pen0715a	3	49.99	10.3	397.9
1-pentene	1pe0712a	3	50.1	10.3	399
2-methyl-1-pentene	2m1p716a	3	50.08	10.3	398.2
2-methyl-2butene	2m2b716a	3	50.04	10.3	398.2
2-methyl-2-pentene	2m2p713a	3	51.4	10.3	398.6
Isooctane	1650715a	3	50.3	10.3	398.3
3-methylpentane	3mp0713a	3	50.0	10.3	398.5

Region No.	Upper cm-1	Lower cm-1
1	2,142.0	2,035.6
2	1,275.0	789.3
3	3,160.8	2,650.1



Top trace, "inls4012" post run sample spiked with toluene; bottom traces, (overlaid) subtracted residual spectra from samples "inls4001" to "inls4012."

Figure 4-1. Example residual spectra.

5.0 TEST PROCEDURES

The procedures followed in this field test are described in EPA Method 320 for using FTIR spectroscopy to measure HAP's, the EPA Protocol for extractive FTIR testing at industrial point sources and EPA Method 25A for measuring total gaseous organics. The objectives of the field test were to use the FTIR method to measure emissions from the processes, screen for HAP's in the EPA FTIR reference spectrum library, conduct analyte spiking for quality assurance, and analyze the spectra for compounds not in the EPA library. Additionally, manual measurements of gas temperature, gas velocities, moisture, CO_2, and O_2 by ERG were used to calculate the mass emissions rates.

The extractive sampling system shown in Figure 5-1 was used to transport sample gas from the test ports to the FTIR instrument and the THC analyzer.

5.1 SAMPLING SYSTEM DESCRIPTION

Flue gas was extracted through a 4-ft stainless steel probe and transported to the gas distribution manifold through heated, insulated, 3/8-in. OD Teflon® sample line. A KNF Neuberger heated head sample pump (Model NO35 ST.11I) was used to pull sample through the line at 10 to 15 liters per minute (Lpm). A Balston particulate filter (holder Model Number 30-25, filter element Model Number 100-25-BH, 99 percent removal efficiency at 0.1 μm) was connected in-line at the outlet of the sample probe. Temperature controllers monitored and regulated the sample line temperature at about 350°F.

Inside the FTIR trailer, the outlet of the sample pump was connected to the heated stainless steel gas manifold. Immediately inside the manifold the sample stream passed through a secondary particulate filter. The manifold contained 3/8-in. stainless steel tubing, three four-way valves and heated radiometers (0 to 20 Lpm) to allow the operator to control sample flow to the FTIR cell and THC analyzer. The three manifold outlets were used to supply sample to the FTIR gas cell and to two THC analyzers. Heated 1/4-in. OD, 20-ft long Teflon® lines connected the manifold outlet to the inlet of the FTIR gas cell and the THC analyzers. The manifold was maintained at about 300°F.

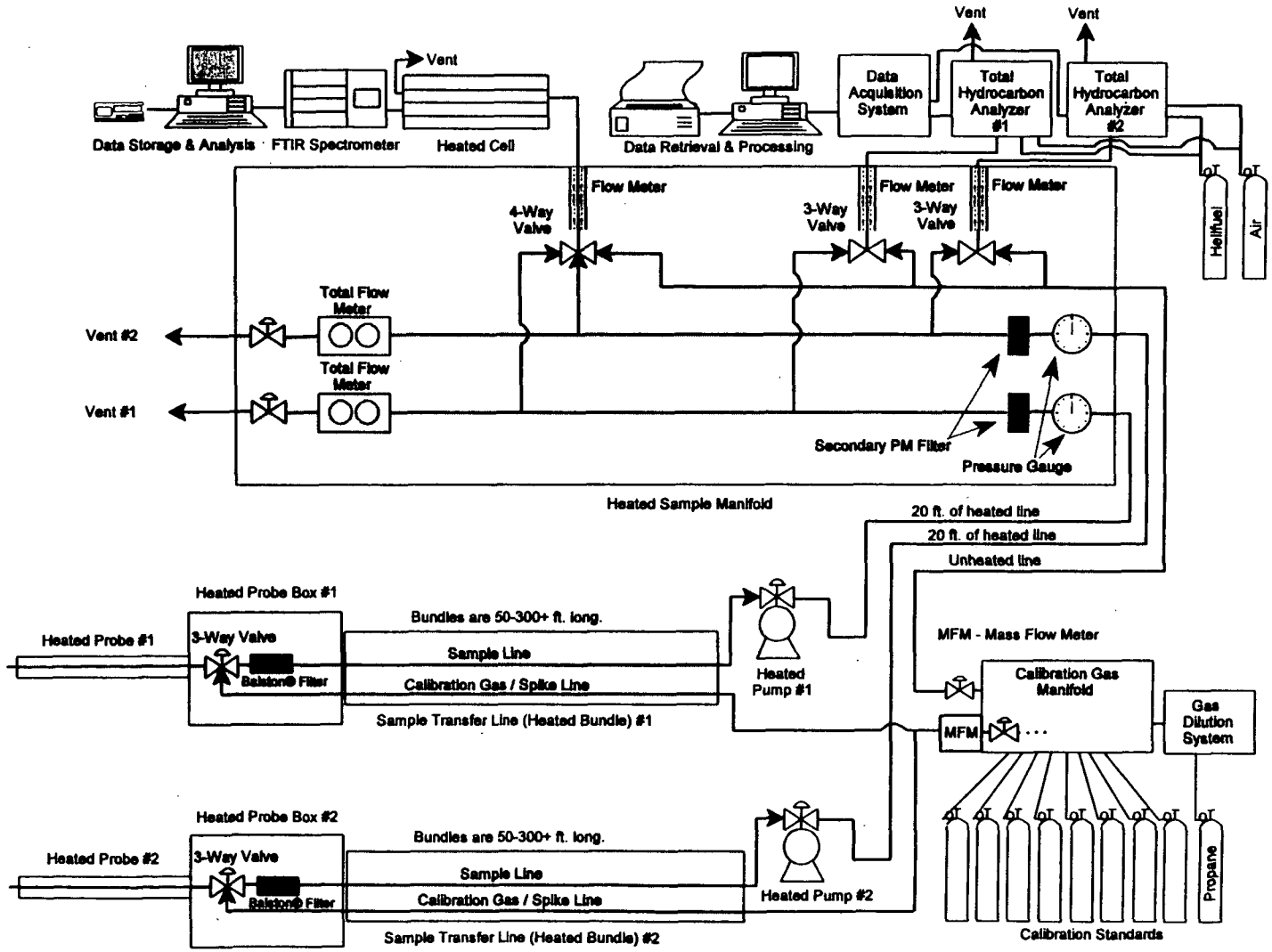


Figure 5-1. Extractive sampling system.

5.2 SAMPLING PROCEDURES

Sampling was conducted at both the scrubber inlet duct and the process stack. The two locations were sampled using two separate sampling systems which were both connected to the main manifold (Figure 5-1). A single FTIR instrument and two THC analyzers were used to sample both locations. The four-way valves on the outlets of the common manifold could be used to select sample from either location. The FTIR instrument was used to sample each location alternately, while the two THC analyzers were used to sample both locations simultaneously. Sample flow to each instrument was controlled by the use of the rotameter needle valves.

5.3 FTIR SAMPLING PROCEDURES

Figure 5-1 shows a schematic of the FTIR instrument and connections to the sample distribution manifold.

Sampling was conducted using either the batch or the continuous sampling procedures. All data were collected according to Method 320 sampling procedures, which are described below.

5.3.1 Batch Samples

In this procedure, the four-way valve on the manifold outlet was turned to divert a portion of the sample flow to the FTIR cell. A positive flow to the main manifold outlet vent was maintained as the cell was filled to just above ambient pressure. The cell inlet valve was then closed to isolate the sample, the cell outlet valve was open to vent the cell to ambient pressure, the spectrum of the static sample was recorded, and then the cell was evacuated for the next sample. This procedure was repeated to collect as many samples as possible during Run 1.

Batch sampling has the advantage that every sample is independent. The time resolution of the measurements is limited by the interval required to pressurize the cell, and record the spectrum, for this test the time resolution was 4 to 5 min. All of the spiked samples and all of the samples in Run 1 were collected using this procedure.

5.3.2 Continuous Sampling

The cell was filled as in the batch sampling procedure, but the cell inlet and outlet valves were then opened to keep gas continuously flowing through the cell. The inlet and outlet flows

were regulated to keep the sample at ambient pressure. The flow through the cell was maintained at about 5 Lpm (about 0.7 cell volumes per min). The cell volume was about 7 liters (L).

The FTIR instrument was automated to record spectra of the flowing sample about every 2 min. The analytical program was revised after the field tests and the spectra were analyzed to prepare the results reported in Section 4.

This procedure with automated data collection was used for all of the unspiked testing during Runs 2 and 3. Because spectra were collected continuously as the sample flowed through the cell, there was mixing between consecutive samples. The interval between independent measurements (and the time resolution) depended on the sample flow rate (through the cell), and the cell volume. The following explanation is taken from Performance Specification 15 for FTIR CEMS.

'The Time Constant (TC) is the period for one cell volume to flow through the cell. The TC determines the minimum interval for complete removal of an analyte from the cell volume. It depends on the sampling rate ($_{RS}$ in Lpm), the cell volume ($_{Cell}$ in L) and the analyte's chemical and physical properties.'

$$TC = \frac{V_{cell}}{R_s} \qquad (1)$$

Performance Specification 15 defines 5 * TC as the minimum interval between independent samples. In this test 5 *TC was about 7 minutes.

A stainless steel tube ran from the cell inlet connection point to the front of the cell. The outlet vent was at the back of the cell so that the flowing sample passed through the greatest portion of the cell volume.

5.4 ANALYTE SPIKING

Since no information about possible HAP emissions or flue gas composition was available for this source prior to the test, there was no plan for validating specific HAP's at this screening test. MRI conducted limited spiking for quality control (QC) purposes using a toluene (121 ppm in air) standard.

5.4.1 Analyte Spiking Procedures

The infrared spectrum is ideally suited for analyzing and evaluating spiked samples because many compounds have very distinct infrared spectra.

The reason for analyte spiking is to provide a QC check that the sampling system can transport the spiked analyte(s) to the instrument and that the quantitative analysis program can measure the analyte in the sample gas matrix. If at least 12 (independent) spiked and 12 (independent) unspiked samples are measured, then this procedure can be used to perform a Method 301 validation.[3] No validation was performed at this field test.

The spike procedure follows Sections 9.2 and 13 of EPA draft Method 320 in Appendix D. In this procedure a gas standard is measured directly in the cell. This direct measurement is then compared to measurements of the analyte in spiked samples. Ideally, the spike comprises about 1/10 or less of the spiked sample. The actual dilution ratio depends on the sample flow rate and the spike gas flow rate. The expected concentration of the spiked component is determined using a tracer gas, SF_6. The SF_6 concentration in the direct sample divided by the SF_6 concentration in the spiked sample(s) is used as the spike dilution factor (DF). The analyte standard concentration divided by DF gives the "expected" value (100 percent) of the spiked analyte recovery.

5.4.2 Analysis of Spiked Results

The toluene and SF_6 concentrations used in the evaluation of the spike recoveries in Table 4-3 were taken directly from the sample analyses reported in Tables B-1 and B-2. The concentrations in the spiked samples included a contribution from the spike gas and from any analyte present in the flue gas. The component of the spike recovery in the spiked samples was determined by subtracting the average of the unspiked samples from the measured (average) concentration in each spiked sample (spiked - unspiked). The percent recovery was determined by comparing the spiked - unspiked concentration to the calculated 100 percent recovery determined in Section 5.4.1.

5.5 ANALYTICAL PROCEDURES

Analytical procedures in the EPA FTIR Protocol[2] were followed for this test. A computer program was prepared with reference spectra shown in Table 4-6. The computer program[5] used mathematical techniques based on a K-matrix analysis.[6]

Initially, the spectra were reviewed visually to determined appropriate input for the computer program. Next an analysis was run on all of the sample spectra using all of the reference spectra listed in Table 4-6. The estimated uncertainty results for the undetected species

were reported in Table 4-4. Finally, the undetected compounds were removed from the analysis and the spectra were analyzed again using reference spectra only for the detected compounds. The results from this second analytical run are summarized in Table 1-1 and reported in Tables B-1 and B-2. The revised analysis for this report included reference spectra of n-heptane, 1-pentene, 2-methyl-2-butene, n-pentane, 2-methyl-2-pentene, 3-methylpentane, butane, and 2-methyl-1-pentene.

The same program that performed the analysis calculated the residual spectra (the difference between the observed and least squares fit absorbance values). Three residuals, one for each of the three analytical regions, were calculated for each sample spectrum. All of the residuals were stored electronically and are included with the electronic copy of the sample data provided with this report. Finally the computer program calculated the standard 1*sigma uncertainty for each analytical result, but the reported uncertainties are equal to 4*sigma.

The concentrations were corrected for differences in absorption path length and temperature between the reference and sample spectra using equation 2.

$$C_{corr} = \left(\frac{L_r}{L_s}\right)\left(\frac{T_s}{T_r}\right) C_{calc} \qquad (2)$$

where:

$C_{Corr.}$ = Concentration, corrected for path length and temperature.

$C_{Calc.}$ = Concentration, initial calculation (output of the analytical program designed for the compound).

L_r = Reference spectrum path length.

L_S = Sample spectrum path length.

T_S = Absolute temperature of the sample gas, K.

T_r = Absolute gas temperature of reference spectrum sample, K.

The sample path length was estimated by measuring the number of laser passes through the infrared gas cell. These measurements were recorded in the data records. The actual sample path length, L_S was calculated by comparing the sample CTS spectra to CTS spectra in the EPA FTIR reference spectrum library. The reference CTS were used as input for a K-matrix analysis. The calculated cell path length and the variation among the sample CTS over 3 days of testing, are reported in Table 5-2.

5.5.1 Computer Program Input

Table 4-6 presents a summary of the reference spectra input for the computer program used to screen the sample spectra. Table 5-1 summarizes the program input used to analyze the CTS spectra recorded at the field test. The CTS spectra were analyzed as an independent determination of the cell path length. To analyze the CTS spectra, MRI used 0.25 cm^{-1} spectra "cts0814b" and "cts0814c." These reference CTS spectra were recorded on the same dates as the toluene reference spectra used in the analysis. These spectra were deresolved in the same way as the toluene reference spectra using Section K.2.2 of the EPA FTIR protocol. The program analyzed the main two ethylene bands centered near 2,989 and 949 cm^{-1}. Table 5-2 summarizes the results of the CTS analysis. The cell path length from this analysis was used as L_S in equation 2.

5.5.2 EPA Reference Spectra

The toluene spectra used in the MRI analysis were taken from the EPA reference spectrum library (http://www.epa.gov/ttn/emc/ftir.html). The original sample and background interferograms were truncated to the first 16,384 data points. The new interferograms were then Fourier transformed using Norton-Beer medium apodization and no zero filling. The transformation parameters were chosen to agree with those used to collect the sample absorbance spectra. The new 1cm^{-1} toluene single beam spectra were combined with their deresolved single beam background spectra and converted to absorbance. This procedure was used to prepared spectral standards for toluene and other HAP's that were included in the analysis.

5.6 FTIR SYSTEM

The FTIR system used in this field test was a KVB/Analect RFX-40 interferometer. The gas cell is a heated variable path (D-22H) gas cell from Infrared Analysis, Inc. The path length of 36 laser passes was used for measurement at both locations. The inside of the cell walls have been treated with a Teflon® coating to minimize potential analyte losses. A mercury/cadmium/ telluride (MCT) liquid nitrogen detector was used. Spectra was collected at 1.0 cm^{-1}, the highest resolution of the RFX-40 system.

TABLE 5-1. PROGRAM INPUT FOR ANALYSIS AND CTS SPECTRA AND PATH LENGTH DETERMINATION (CTSLTV.MCP)[a]

Compound name	File name	ASC[b]	ISC[b]	% Difference
Ethylene	cts0814b.asd	1.007	1.014	0.69
Ethylene	cts0814c.asd	1.007	0.999	0.79

[a]Sample CTS spectra were analyzed from 1107 to 843 cm^{-1} and from 2992 to 2984cm^{-1}.
[b]ASC = accepted concentration. ISC = calculated concentration.

TABLE 5-2. RESULTS OF PATH LENGTH DETERMINATION

CTS spectra 20.01 ppm Ethylene	Path length calculations		
	Meters	Δ^a	$\%\Delta^a$
CTS0623A	18.75	0.46	2.48
CTS0624A	18.22	-0.07	-0.37
CTS0624B	18.09	-0.20	-1.09
CTS0625A	18.30	0.01	0.07
CTS0625B	18.07	-0.22	-1.20
CTS0626A	18.79	0.50	2.69
CTS0626B	17.96	-0.33	-1.86
CTS0627A	18.07	-0.22	-1.19
CTS0627B	18.25	-0.04	-0.22
CTS0627C	18.44	0.15	0.84
Average Path Length (M)	18.3		
Standard Deviation	0.287		

[a]Δ = calculated path length in meters minus the average path length.

The optical path length was measured by shining a He/Ne laser into the cell and adjusting the mirror tilt until the desired number of passes was achieved. The number of passes was recorded on the field data sheets in Appendix B. The path length in meters was determined by comparing calibration transfer standard (CTS, ethylene in nitrogen) spectra measured in the field to CTS spectra in the EPA reference spectrum library. Figure 5-1 instrument were integrated with the sampling system.

5.7 CONTINUOUS EMISSIONS MONITORING FOR THC

The guidelines set forth in Method 25A were used for sampling at LTV Steel with one exception. Section 7.2 of Method 25A specifies an analyzer drift determination hourly during the test period, this instruction was not followed.

The drift determination was not completed as specified to keep the FTIR and THC sampling synchronized as closely as possible. Drift checks would have involved THC and FTIR off-line periods of about 10 min per hour. Experience with the analyzers MRI was using indicates they are capable of stable operation over extended periods when the analyzers are operated in a climate controlled environment.

5.7.1 THC Sampling Procedures

The THC sampling was conducted continuously from both locations by the use of two separate analyzers. The same sample systems used for the FTIR sampling were used for the THC sampling. Sample gas was directed to the analyzers through a separate set of rotameters and control valves. Each test run was conducted from the start to the end of the manual test runs completed by ERG. A summary of specific procedures used is given below.

A brief description of each system component follows.

1. THC Analyzer- The THC concentration is measured using a flame ionization detector (FID). MRI used a J.U.M. Model VE-7 and a Ratfisch Model RS-55CA. The THC analyzers were operated on the zero to 100 ppm range throughout the test period. The fuel for the FID is 40 percent hydrogen and 60 percent helium mixture.

2. Data Acquisition System- MRI uses LABTECH notebook (Windows version), which is an integrated system that provides data acquisition, monitoring and control. The system normally writes data to a disk in the background while performing foreground tasks or displaying data in real time. The averaging period set for this test was 1 min.

3. Calibration Gases- Calibration gases were prepared from an EPA Protocol 1 cylinder of propane using an Environics Model 2020 gas dilution system which complies with the requirements of EPA Method 205. High, Medium and Low standards gases were generated to perform analyzer calibration checks. The calibration gases were generated from 5,278 ppm propane in nitrogen standard. The raw data is reported in ppm as propane, but is converted to an as carbon basis for reporting.

5.7.2 Hydrocarbon Emission Calculations

The hydrocarbon data is presented as both THC and TGNMO emissions in Table 1-2. To do this the THC emission data was first converted to an as carbon basis using equation 3 and then the THC emission rate was calculated using Equation 5.

$$C_C = KC_{meas} \tag{3}$$

where:

C_c = Organic concentration as carbon, ppmv.

C_{meas} = Organic concentration as measured, ppmv.

K = Carbon equivalent correction factor, 3 for propane.

The TGNMO concentration was calculated by subtracting the methane concentration measured by the FTIR from C_C (equation 4). The emission rate was then calculated using Equation 5.

$$C_{TGNMO} = C_C - C_{CH4} \tag{4}$$

where:

C_{TGNMO} = Total gaseous nonmethane organic concentration, ppmv

C_{CH4} = Methane concentration in gas stream, ppmv.

$$E_{TGNMO/THC} = \frac{\frac{C_{TGNMO/Cc}}{(1-B_{ws})} \times MW \times Q_{std} \times 60}{385.3 \times 10^6} \tag{5}$$

where:

$E_{TGNMO/THC}$ = TGNMO or THC mass emission rate, lb/hr

B_{ws} = moisture fraction in gas stream

MW = Molecular Weight of Carbon, 12 lb/lb-mole

Q_{std} = Volumetric Flowrate corrected to standard conditions, dscfm

60 = Conversion to hours, min/hr

385.3 = Molar Volume, ft^3/mole at standard conditions

10^6 = Conversion for decimal fraction to ppm

6.0 SUMMARY OF QA/QC PROCEDURES

6.1 SAMPLING AND TEST CONDITIONS

Before the test sample lines were checked for leaks and cleaned by purging with moist air (250°F). Following this, the lines were checked for contamination using dry nitrogen. This is done by heating the sampling lines to 250°F and purging with dry nitrogen. The FTIR cell was filled with some of the purging nitrogen and the spectrum of this sample was collected. This single beam spectrum was converted to absorbance using a spectral background of pure nitrogen (99.9 percent) taken directly from a cylinder. The lines were checked again on site before sampling, after each change of location, and after spiking.

During sampling spectra of at least 10 different samples were collected during each hour (five at each of two locations).

Each spectrum was assigned a unique file name and written to the hard disk and a backup disk under that file name. Each interferogram was also be saved under a file name that identifies it with its corresponding absorbance spectrum. All background spectra and calibration spectra were also stored on disks with their corresponding interferograms.

Notes on each calibration and sample spectrum were recorded on hard copy data sheets. Below are listed some sampling and instrument parameters that were documented in these records.

Sampling Conditions

- Line temperature
- Process conditions
- Sample flow rate
- Ambient pressure
- Time of sample collection

Instrument Configuration

- Cell volume (for continuous measurements)
- Cell temperature
- Cell path length
- Instrument resolution
- Number of scans co-added

- Length of time to measure spectrum
- Time spectrum was collected
- Time and conditions of recorded background spectrum
- Time and conditions of relevant CTS spectra
- Apodization

Hard copy records were also kept of all flue gas measurements, such as sample flow, temperature, moisture and diluent data.

Effluent was allowed to flow through the entire sampling system for at least 5 minutes before a sampling run started or after changing to a different test location. FTIR spectra were continuously monitored to ensure that there was no deviation in the spectral baseline greater than ±5 percent ($-0.02 \leq$ absorbance $\leq +0.02$). When this condition occurred, sampling was interrupted and a new background spectrum was collected. The run was then be resumed until completed or until it was necessary to collect another background spectrum.

6.2 FTIR SPECTRA

For a detailed description of QA/QC procedures relating to data collection and analysis, refer to the "Protocol For Applying FTIR Spectrometry in Emission Testing".[2]

A spectrum of the CTS was recorded at the beginning and end of each test day. A leak check of the FTIR cell was also performed according to the procedures in references 1 and 2. The CTS gas was 20.1 ppm ethylene in nitrogen. The CTS spectrum provided a check on the operating conditions of the FTIR instrumentation, e.g., spectral resolution and cell path length. Ambient pressure were recorded whenever a CTS spectrum was collected. The CTS spectra were compared to CTS spectra in the EPA library. This comparison is used to quantify differences between the library spectra and the field spectra so library spectra of HAP's can be used in the quantitative analysis.

Two copies of all interferograms, processed backgrounds, sample spectra, and the CTS were stored on separate computer disks. Additional copies of sample and CTS absorbance spectra were also be stored for data analysis. Sample absorbance spectra can be regenerated from the raw interferograms, if necessary.

The compact disk enclosed with this report contains one complete copy of all of the FTIR data recorded at the LTV field test. The data are organized into directories, whose titles identify

the contents. The data continuously are in directories identified by the date on which the data were recorded. The directory titles "BKG," "CTS,", "outlet," and "inlet," identify backgrounds, CTS spectra, and spectra of inlet and outlet samples, respectively. Additional sub-directories "AIF" and "ASF" identify inferograms and absorbance spectra, respectively. All of the sample data are in the Analect Instruments software format. The directories "refs" and "residuals" contain de-resolved reference spectra that were used in the analysis and the residual spectra, respectively. There are three residual spectra for each sample spectrum, a residual for each analytical region. The information on the enclosed disk with the data records in Appendix A meet the reporting requirements of the EPA FTIR Protocol and Method 320.

To measure HAP's detected in the gas stream MRI used spectra from the EPA library, when available.

6.3 METHOD 25A

6.3.1 Initial Checks

Before starting the first run, the following system checks were performed.

1. Zero and Span check of the analyzer;
2. Analyzer linearity check at intermediate levels; and
3. Response time of the system.

Calibration criteria for Method 25A is ±5 percent of calibration gas value.

6.3.2 Daily Checks

The following checks were made for each test run.

1. Zero/Span calibration and Linearity check prior to each test run; and
2. Final Zero and Span calibrations of the analyzer at the end of each test run.

The difference between initial and final zero and span checks agreed within ±3 percent of the instrument span.

7.0 REFERENCES

1. Test Method 320 (Draft) "Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy," **40 CFR Part 63, Appendix A**.

2. "Protocol For The Use of FTIR Spectrometry to Perform Extractive Emissions Testing at Industrial Sources," Revised, EPA Contract No. 68-D2-0165, Work Assignment 3-12, September, 1996.

3. "Method 301 - Field Validation of Pollutant Measurement Methods from Various Waste Media," **40 CFR Part 63, Appendix A**.

4. "Validation of EPA FTIR Method For Measuring HCl," T. J. Geyer and G. M. Plummer, Air and Waste Management Association Paper Number 97-MP74.05, 1997.

5. "An Examination of a Least Squares Fit FTIR Spectral Analysis Method," G. M. Plummer and W. K. Reagen, Air and Waste Management Association, Paper Number 96-WA65.03, 1996.

6. "Computer-Assisted Quantitative Infrared Spectroscopy," Gregory L. McClure (ed.), **ASTM Special Publication 934** (ASTM), 1987.

APPENDIX A

METHOD 25A AND VOLUMETRIC FLOW DATA

A-1 METHOD 25A RESULTS

LTV
Run 1
Date: 6/25/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
927	Inlet Spike	24.5
928	Inlet Spike	24.4
929	Inlet Spike	24.7
930	Inlet Spike	24.6
931	Inlet Spike	24.4
932	Inlet Spike	24.1
933	Inlet Spike	24.2
934	Inlet Spike	24.4
935	Inlet Spike	24.9
936	Inlet Spike	24.7
937	Inlet Spike	24.5
938	Inlet Spike	24.3
939	Inlet Spike	24.3
940	Inlet Spike	24.3
941	Inlet Spike	24.4
942	Inlet Spike	24.4
943	Inlet Spike	24.4
944	Inlet Spike	24.7
945	Inlet Spike	24.8
946	Inlet Spike	24.9
947	Inlet Spike	25.6
948	Inlet Spike	25.9
949	Inlet Spike	25.9
950	Inlet Spike	26.0
951	Inlet Spike	26.0
952	Inlet Spike	25.9
953	Inlet Spike	26.1
954	Inlet Spike	26.1
955	Inlet Spike	26.3
956	Inlet Spike	26.3
957	Inlet Spike	26.2
958	Inlet Spike	25.9
959	Inlet Spike	25.7
1000	Inlet Spike	25.8
1001	Inlet Spike	25.7
1002	Inlet Spike	25.4
1003	Inlet Spike	25.3
1004	37.4	24.9
1005	37.3	24.5
1006	37.1	24.4
1007	37.1	24.5
1008	36.9	24.3
1009	37.0	24.5
1010	37.1	24.0
1011	37.5	24.5
1012	37.1	24.1
1013	37.1	24.2

LTV
Run 1
Date: 6/25/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1014	37.1	24.2
1015	37.5	24.5
1016	38.0	24.9
1017	38.1	25.1
1018	38.7	25.3
1019	38.8	25.7
1020	38.5	25.5
1021	38.6	25.5
1022	38.6	25.7
1023	38.2	25.2
1024	38.5	25.6
1025	38.9	25.9
1026	39.1	25.9
1027	40.0	26.5
1028	40.3	26.7
1029	40.6	26.9
1030	41.1	27.6
1031	41.2	27.7
1032	40.8	27.3
1033	40.0	26.9
1034	38.7	26.4
1035	38.1	25.7
1036	37.5	25.2
1037	36.8	24.8
1038	36.1	24.5
1039	35.9	24.4
1040	36.1	24.3
1041	35.9	24.3
1042	35.9	24.4
1043	36.3	24.7
1044	36.4	24.7
1045	35.8	24.5
1046	35.5	24.4
1047	35.6	24.2
1048	36.1	24.2
1049	36.2	24.4
1050	36.6	25.0
1051	37.0	25.1
1052	37.3	25.3
1053	37.8	25.7
1054	37.8	25.8
1055	38.0	25.9
1056	38.2	26.3
1057	38.2	26.1
1058	38.4	26.3
1059	38.3	26.2
1100	38.1	26.2
1101	38.3	26.1

LTV
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Project No. : 3802-20-04-03-01
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Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1102	38.4	26.4
1103	38.1	26.3
1104	37.8	26.1
1105	37.5	25.8
1106	37.3	25.5
1107	37.2	25.5
1108	37.1	25.4
1109	36.6	25.3
1110	34.7	25.0
1111	26.0	24.6
1112	29.5	24.3
1113	33.7	24.2
1114	34.2	24.5
1115	34.1	24.3
1116	***	24.5
1117	***	24.4
1118	***	24.4
1119	33.8	24.5
1120	34.1	24.6
1121	***	24.7
1122	***	25.3
1123	***	25.6
1124	34.9	25.5
1125	35.3	25.7
1126	31.8	25.8
1127	***	25.6
1128	***	25.4
1129	***	25.5
1130	34.5	25.5
1131	34.6	25.5
1132	34.6	25.4
1133	34.7	25.4
1134	34.3	25.2
1135	34.3	25.4
1136	33.8	25.5
1137	33.5	25.2
1138	33.2	25.1
1139	33.3	25.5
1140	33.1	25.7
1141	33.0	24.2
1142	33.2	24.9
1143	32.6	26.0
1144	32.3	25.9
1145	32.0	23.3
1146	32.3	26.5
1147	34.3	27.2
1148	34.1	27.5
1149	34.2	28.1

LTV
Run 1
Date: 6/25/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1150	34.5	28.7
1151	34.4	29.0
1152	34.2	29.2
1153	33.9	29.0
1154	33.9	29.2
1155	34.0	29.4
1156	34.0	30.0
1157	34.4	30.1
1158	34.4	30.4
1159	34.4	30.6
1200	25.7	31.1
1201	44.4	31.6
1202	46.8	32.4
1203	47.8	32.8
1204	49.6	33.1
1205	50.9	34.1
1206	Filter Change	Filter Change
1207	Analyzers off line	Analyzers off line
1208		
1209	49.4	30.9
1210	50.5	31.3
1211	51.3	31.8
1212	52.0	32.1
1213	52.3	32.3
1214	52.7	32.3
1215	53.5	32.7
1216	53.5	32.9
1217	53.5	33.1
1218	54.0	33.7
1219	55.0	34.5
1220	56.0	35.2
1221	56.4	35.2
1222	56.9	35.6
1223	57.5	36.0
1224	56.8	36.2
1225	56.7	35.9
1226	56.4	35.5
1227	56.8	35.8
1228	56.6	35.7
1229	56.7	35.4
1230	57.1	34.8
1231	56.8	32.0
1232	55.5	31.6
1233	54.6	32.4
1234	54.1	32.6
1235	54.3	33.3
1236	53.5	33.4
1237	53.4	33.6

LTV
Run 1
Date: 6/25/97
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Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1238	52.5	33.5
1239	51.6	33.2
1240	51.3	33.2
1241	51.0	33.1
1242	50.1	32.7
1243	48.9	31.9
1244	47.8	31.2
1245	46.9	26.2
1246	46.2	29.9
1247	45.6	29.7
1248	45.1	27.6
1249	43.7	26.4
1250	42.8	27.9
1251	42.4	27.7
1252	42.4	27.7
1253	***	28.0
1254	42.6	28.2
1255	43.3	28.3
1256	44.3	28.9
1257	***	29.1
1258	43.6	29.5
1259	44.4	29.4
1300	44.0	29.3
1301	***	29.2
1302	42.5	29.2
1303	43.4	29.2
1304	***	29.1
1305	***	29.1
1306	42.9	29.4
1307	43.6	29.8
1308	43.7	29.2
1309	44.0	25.9
1310	44.0	29.3
1311	44.1	28.5
1312	44.4	26.6
1313	44.7	25.9
1314	45.0	30.1
1315	45.2	30.8
1316	44.8	30.1
1317	45.0	30.0
1318	44.6	30.7
1319	45.6	31.1
1320	45.2	30.3
1321	43.5	Port Change
1322	42.7	Port Change
1323	41.6	Port Change
1324	41.0	Port Change
1325	40.8	Port Change

LTV
Run 1
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Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1326	41.9	Port Change
1327	41.0	Port Change
1328	39.3	Port Change
1329	38.6	Port Change
1330	37.9	Port Change
1331	38.3	Port Change
1332	38.2	Port Change
1333	36.6	Port Change
1334	Filter Change	Port Change
1335	Filter Change	Port Change
1336	Filter Change	Port Change
1337	Filter Change	Port Change
1338	Leak Check	Port Change
1339	Leak Check	Port Change
1340	43.3	Port Change
1341	44.0	26.1
1342	44.6	26.4
1343	44.7	26.7
1344	44.1	26.9
1345	43.4	27.1
1346	43.3	26.8
1347	43.1	26.9
1348	42.5	26.8
1349	42.7	26.7
1350	42.9	26.7
1351	42.1	26.7
1352	41.9	26.4
1353	41.7	26.3
1354	41.7	26.3
1355	40.6	26.1
1356	40.4	25.9
1357	40.0	25.7
1358	39.7	25.2
1359	39.4	24.7
1400	39.3	24.8
1401	39.0	24.8
1402	39.4	25.0
1403	39.8	25.0
1404	40.0	25.9
1405	39.5	26.1
1406	39.0	25.6
1407	38.8	25.5
1408	39.0	26.0
1409	38.8	26.2
1410	39.2	25.8
1411	39.3	26.1
1412	39.5	26.6
1413	39.0	26.4

LTV
Run 1
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Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1414	37.2	26.1
1415	36.7	26.5
1416	35.1	26.8
1417	38.4	27.3
1418	38.6	27.5
1419	34.8	27.5
1420	36.1	27.7
1421	39.2	28.4
1422	39.4	28.6
1423	39.8	28.7
1424	40.1	29.3
1425	40.5	29.6
1426	41.1	30.2
1427	41.5	29.4
1428	41.6	29.2
1429	40.6	28.7
1430	39.1	28.3
1431	39.9	28.2
1432	40.2	28.0
1433	39.7	27.6
1434	39.0	26.9
1435	38.7	26.2
1436	38.3	26.2
1437	37.6	26.2
1438	36.7	25.8
1439	36.3	24.9
1440	35.7	24.5
1441	35.6	24.7
1442	35.8	24.9
1443	35.4	24.7
1444	34.9	23.8
1445	34.8	23.8
1446	34.9	24.4
1447	34.7	24.3
1448	34.4	23.6
1449	34.1	23.1
1450	34.0	23.3
1451	33.5	23.2
1452	33.0	23.1
1453	32.0	22.9
1454	30.2	22.8
1455	31.6	22.6
1456	32.6	22.7
1457	33.3	22.8
1458	32.0	23.0
1459	32.1	23.4
1500	34.0	23.8
1501	34.4	23.7

LTV
Run 1
Date: 6/25/97
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Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1502	34.6	23.7
1503	32.9	23.9
1504	33.5	24.1
1505	34.6	24.3
1506	35.4	24.5
1507	33.6	24.7
1508	33.4	24.8
1509	35.4	24.8
1510	36.0	24.7
1511	36.0	24.4
1512	36.1	24.0
1513	36.2	24.3
1514	36.2	24.6
1515	35.7	24.5
1516	35.5	23.9
1517	THC Flameout	23.7
1518	System Check	24.0
1519		24.0
1520		24.1
1521		23.7
1522		23.8
1523		24.2
1524		24.5
1525		24.4
1526		24.1
1527		24.4
1528		25.1
1529		25.4
1530		25.5
1531		22.4
1532		System Check
1533		THC off line
1534		
1535		
1536		
1537		
1538		
1539		
1540		
1541		
1542		
1543		
1544		
1545		
1546		
1547		
1548		
1549		

LTV
Run 1
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Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1550		
1551		
1552		
1553		
1554		
1555		24.2
1556		25.2
1557		26.1
1558		26.0
1559		26.1
1600		24.9
1601		24.6
1602		25.7
1603		26.2
1604		25.6
1605		28.0
1606		28.0
1607		28.7
1608		28.9
1609		29.0
1610	34.8	27.3
1611	34.8	25.5
1612	35.6	25.7
1613	36.1	25.8
1614	36.3	26.0
1615	34.6	25.9
1616	35.8	25.9
1617	37.6	26.2
1618	37.7	26.0
1619	38.4	26.3
1620	36.4	26.6
1621	37.7	26.7
1622	39.6	27.0
1623	40.4	27.1
1624	37.9	27.4
1625	39.8	27.7
1626	42.6	28.1
1627	43.5	28.6
1628	43.6	28.4
1629	44.1	28.5
1630	44.9	28.4
1631	45.3	28.4
1632	45.4	29.3
1633	45.6	29.6
1634	45.5	29.6
1635	45.2	29.3
1636	45.3	28.4
1637	44.9	28.3

LTV
Run 1
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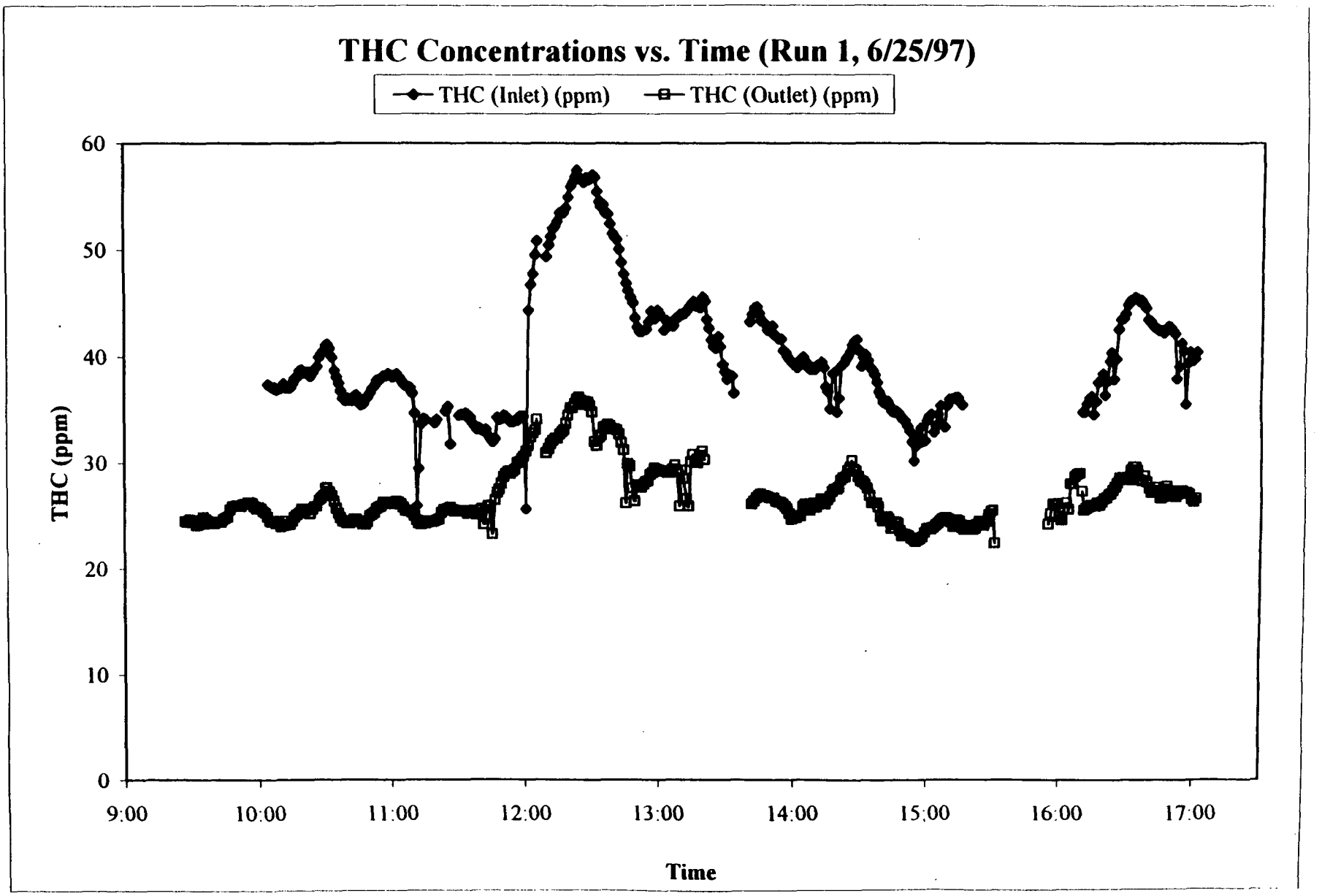
Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1638	44.6	28.8
1639	43.5	28.2
1640	43.4	27.6
1641	43.1	27.2
1642	42.8	27.4
1643	42.7	27.7
1644	42.5	27.7
1645	42.5	26.7
1646	42.3	26.8
1647	42.5	27.5
1648	42.9	27.8
1649	42.8	27.4
1650	42.5	27.0
1651	42.2	26.9
1652	38.0	26.8
1653	39.1	27.1
1654	41.3	27.4
1655	40.6	27.4
1656	35.6	27.2
1657	39.5	27.2
1658	40.5	27.1
1659	39.7	26.6
1700	39.9	26.4
1701	40.5	26.7
Minimum=	25.7	22.4
Maximum=	57.5	36.2
Average=	40.2	26.9

*** Sample flow fluctuation due to filling of FTIR cell
Data point not used in average


THC Concentrations vs. Time (Run 1, 6/25/97)
THC (Inlet) (ppm)
THC (Outlet) (ppm)
THC (ppm)
60
50
40
30
20
10
0
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Time

LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
953	30.6	Outlet Spike
954	30.5	Outlet Spike
955	31.0	Outlet Spike
956	30.5	Outlet Spike
957	30.4	Outlet Spike
958	30.6	Outlet Spike
959	30.9	Outlet Spike
1000	31.0	Outlet Spike
1001	30.9	Outlet Spike
1002	30.5	Outlet Spike
1003	30.6	Outlet Spike
1004	30.2	Outlet Spike
1005	30.1	Outlet Spike
1006	30.0	Outlet Spike
1007	29.5	Outlet Spike
1008	29.3	Outlet Spike
1009	29.8	Outlet Spike
1010	30.1	Outlet Spike
1011	30.0	Outlet Spike
1012	30.4	Outlet Spike
1013	30.5	Outlet Spike
1014	30.7	Outlet Spike
1015	30.7	Outlet Spike
1016	30.8	Outlet Spike
1017	31.0	Outlet Spike
1018	31.3	Outlet Spike
1019	30.8	Outlet Spike
1020	30.7	Outlet Spike
1021	30.7	Outlet Spike
1022	30.5	Outlet Spike
1023	30.1	Outlet Spike
1024	30.0	Outlet Spike
1025	30.1	Outlet Spike
1026	30.2	Outlet Spike
1027	30.3	Outlet Spike
1028	30.3	Outlet Spike
1029	30.4	Outlet Spike

LTV
Run 2
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Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1030	30.3	Outlet Spike
1031	30.2	Outlet Spike
1032	30.3	Outlet Spike
1033	30.0	Outlet Spike
1034	30.0	Outlet Spike
1035	30.6	Outlet Spike
1036	30.5	Outlet Spike
1037	30.3	Outlet Spike
1038	30.2	Outlet Spike
1039	30.1	Outlet Spike
1040	30.3	Outlet Spike
1041	30.4	Outlet Spike
1042	30.0	Outlet Spike
1043	30.6	Outlet Spike
1044	30.8	Outlet Spike
1045	30.7	Outlet Spike
1046	30.6	Outlet Spike
1047	29.8	Outlet Spike
1048	29.1	Outlet Spike
1049	28.8	Outlet Spike
1050	28.4	Outlet Spike
1051	28.3	Outlet Spike
1052	28.2	24.3
1053	28.4	24.6
1054	26.2	24.8
1055	26.6	24.7
1056	28.8	28.9
1057	29.2	29.7
1058	29.8	25.4
1059	29.9	24.4
1100	30.8	24.7
1101	31.0	24.8
1102	31.3	24.9
1103	31.6	24.9
1104	32.0	25.2
1105	32.3	25.4
1106	32.6	25.3

LTV
Run 2
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Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1107	33.1	25.7
1108	33.8	26.8
1109	34.2	27.2
1110	34.2	27.3
1111	34.2	27.2
1112	34.4	27.4
1113	34.3	27.4
1114	33.9	27.1
1115	33.5	26.5
1116	33.4	26.2
1117	32.5	25.6
1118	32.2	24.8
1119	32.2	25.3
1120	32.5	25.6
1121	32.6	25.8
1122	32.8	25.9
1123	33.0	26.3
1124	33.2	26.3
1125	33.6	26.7
1126	33.9	24.9
1127	34.1	21.9
1128	34.6	18.9
1129	35.0	21.1
1130	34.9	19.5
1131	34.6	19.5
1132	35.1	25.0
1133	35.2	25.2
1134	35.0	25.1
1135	35.1	25.1
1136	34.9	25.4
1137	34.7	26.1
1138	34.7	25.1
1139	35.0	25.2
1140	35.6	25.4
1141	36.1	25.8
1142	36.7	26.2
1143	36.7	26.5

LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1144	37.1	26.7
1145	36.9	26.8
1146	37.2	27.0
1147	37.3	27.2
1148	38.0	27.8
1149	38.5	28.5
1150	37.9	28.4
1151	38.3	28.3
1152	38.0	28.2
1153	37.9	28.0
1154	37.9	28.1
1155	37.9	32.8
1156	34.6	36.5
1157	34.5	37.4
1158	38.5	37.9
1159	38.2	38.1
1200	38.6	38.7
1201	38.6	39.3
1202	39.4	32.2
1203	40.0	29.8
1204	40.3	29.1
1205	40.1	28.8
1206	40.8	29.1
1207	40.7	29.3
1208	40.1	29.5
1209	39.4	29.7
1210	39.8	30.2
1211	39.5	30.5
1212	38.7	30.7
1213	37.9	30.5
1214	37.4	30.5
1215	36.8	30.5
1216	36.0	30.7
1217	35.9	30.7
1218	35.6	30.9
1219	34.7	31.2
1220	34.8	31.2

LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1221	40.6	31.5
1222	43.8	25.0
1223	44.0	33.6
1224	44.0	38.7
1225	44.4	35.5
1226	17.7	33.9
1227	43.9	33.8
1228	44.8	33.8
1229	43.6	33.7
1230	42.7	33.9
1231	42.9	35.0
1232	42.0	36.2
1233	Analyzers off line	Analyzers off line
1234	Filter Change	Port Change
1235		
1236		
1237		
1238		
1239		
1240		
1241		
1242		
1243		
1244		
1245		
1246		
1247		
1248		
1249		
1250		
1251		
1252		
1253		
1254		
1255		
1256		
1257		

LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1258		
1259		
1300		
1301		
1302		
1303	51.4	38.4
1304	50.6	38.9
1305	50.0	38.6
1306	52.3	38.3
1307	53.0	27.7
1308	52.7	29.9
1309	52.9	30.8
1310	53.6	31.0
1311	53.2	30.4
1312	51.8	29.2
1313	52.4	29.2
1314	52.5	29.2
1315	52.4	29.2
1316	51.9	28.8
1317	51.0	28.5
1318	50.4	28.1
1319	49.9	27.6
1320	49.9	27.5
1321	49.6	27.2
1322	48.8	26.8
1323	48.1	26.3
1324	47.4	26.0
1325	47.0	25.7
1326	46.4	25.6
1327	46.0	25.3
1328	45.7	25.2
1329	45.8	25.3
1330	45.9	25.2
1331	45.5	25.0
1332	45.0	24.8
1333	44.8	24.5
1334	44.4	24.3

LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1335	44.2	24.1
1336	43.8	24.0
1337	43.4	24.4
1338	42.8	27.9
1339	42.8	27.8
1340	42.6	27.8
1341	42.7	27.8
1342	42.4	27.9
1343	41.9	27.5
1344	41.7	27.3
1345	41.6	27.5
1346	41.6	27.4
1347	41.3	27.3
1348	40.9	26.9
1349	40.5	26.8
1350	40.2	26.5
1351	39.8	26.2
1352	39.8	26.2
1353	36.8	26.1
1354	32.7	26.2
1355	35.5	26.1
1356	35.1	25.8
1357	37.5	25.7
1358	30.7	25.6
1359	35.8	25.6
1400	36.9	25.4
1401	37.6	25.5
1402	37.5	25.3
1403	36.9	25.1
1404	36.7	25.0
1405	36.7	25.1
1406	35.9	25.0
1407	35.8	24.9
1408	36.3	25.5
1409	36.5	25.4
1410	36.4	25.3
1411	36.5	25.2

LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1412	36.8	25.3
1413	37.1	25.6
1414	37.1	25.6
1415	37.1	25.6
1416	37.2	25.7
1417	37.0	25.7
1418	37.7	26.2
1419	37.6	26.2
1420	37.7	26.2
1421	37.3	26.0
1422	37.0	25.6
1423	36.9	25.6
1424	36.7	25.3
1425	36.6	25.5
1426	36.0	25.1
1427	36.0	25.0
1428	36.5	24.9
1429	36.7	24.7
1430	37.8	25.0
1431	39.7	24.3
1432	40.0	20.6
1433	40.3	21.6
1434	40.8	22.8
1435	41.2	22.6
1436	41.4	22.6
1437	41.5	22.3
1438	41.8	22.3
1439	41.9	22.4
1440	41.5	22.2
1441	41.3	22.0
1442	41.6	23.2
1443	41.4	23.0
1444	41.7	23.2
1445	41.9	Analyzer off line
1446	42.0	23.9
1447	42.1	24.0
1448	42.5	23.3

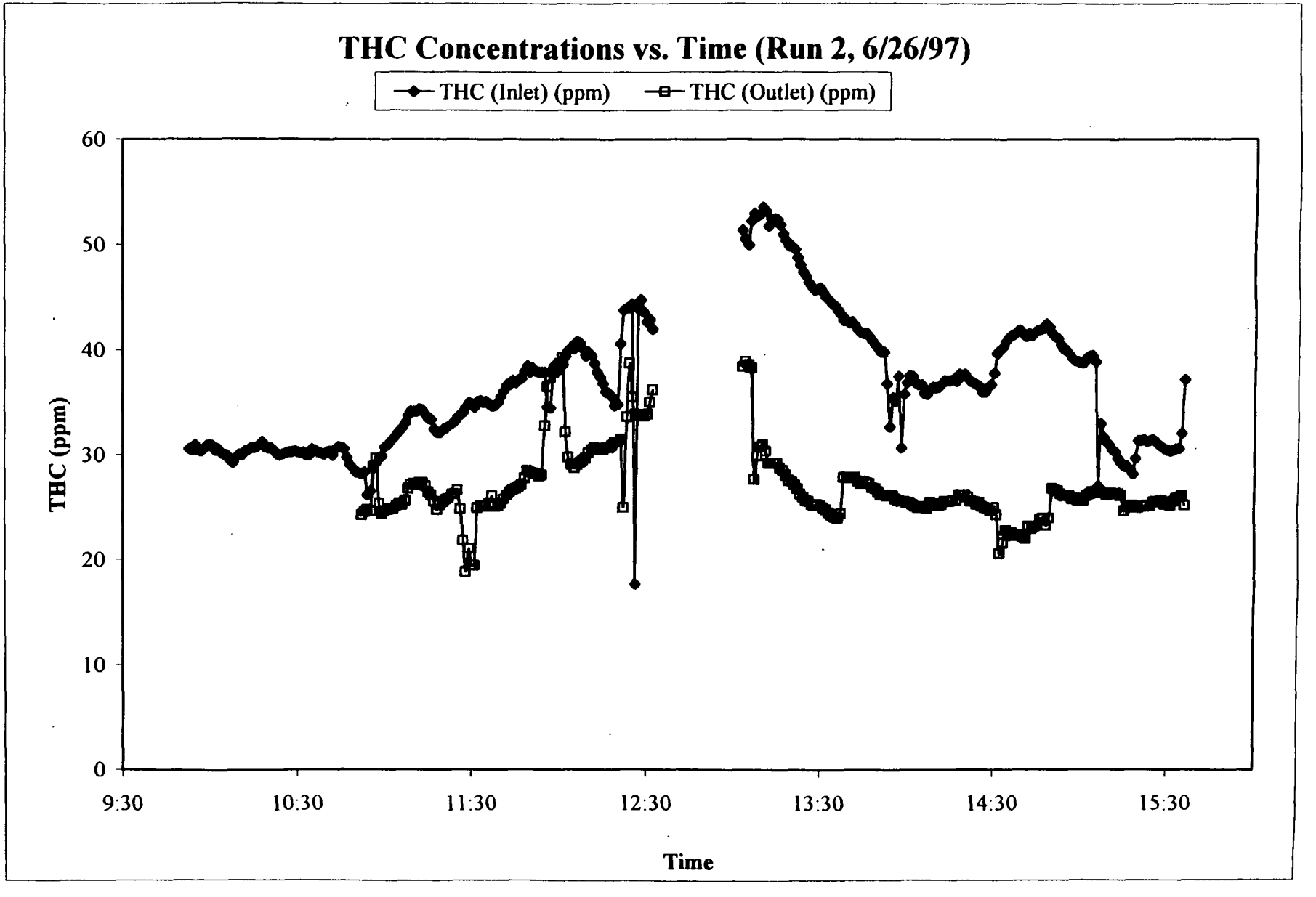
LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)		THC 2 (Outlet) (ppm)
1449	42.2		24.0
1450	41.6		26.8
1451	41.3		26.7
1452	41.1		26.6
1453	40.5		26.3
1454	40.1		26.1
1455	40.0		26.1
1456	39.6		26.1
1457	39.2		25.8
1458	39.0		25.9
1459	38.9		25.7
1500	38.8		25.8
1501	38.8		25.7
1502	39.3		26.1
1503	39.4		26.3
1504	39.5		26.5
1505	38.9		26.4
1506	27.1	A	26.5
1507	33.0	A	26.5
1508	31.7	A	26.4
1509	31.2	A	26.2
1510	31.0	A	26.4
1511	30.5	A	26.3
1512	30.3	A	26.4
1513	29.7	A	26.3
1514	29.3	A	26.1
1515	28.9	A	24.7
1516	29.0	A	25.0
1517	28.7	A	25.1
1518	28.2	A	25.2
1519	29.7	A	25.0
1520	31.4	A	25.0
1521	31.4	A	25.1
1522	31.5	A	25.1
1523	31.3	A	25.2
1524	31.4	A	25.2
1525	31.5	A	25.5

LTV
Run 2
Date: 6/26/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)		THC 2 (Outlet) (ppm)
1526	31.3	A	25.6
1527	31.0	A	25.5
1528	30.8	A	25.7
1529	30.6	A	25.3
1530	30.5	A	25.4
1531	30.4	A	25.2
1532	30.5	A	25.6
1533	30.6	A	25.9
1534	30.6	A	26.0
1535	32.1	A	26.1
1536	37.2		25.2
Minimum=	17.7		18.9
Maximum=	53.6		39.3
Average=	37.3		27.0

A -Sample flow drop due to filter plugging. Data not used in run average


THC Concentrations vs. Time (Run 2, 6/26/97)
THC (Inlet) (ppm)
THC (Outlet) (ppm)
60
50
40
30
20
10
0
THC (ppm)
9:30
10:30
11:30
12:30
13:30
14:30
15:30
Time

LTV
Run 3
Date: 6/27/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
835	28.2	Outlet Spike
836	27.7	Outlet Spike
837	27.3	Outlet Spike
838	27.5	Outlet Spike
839	27.4	Outlet Spike
840	27.1	Outlet Spike
841	26.8	Outlet Spike
842	26.8	Outlet Spike
843	26.9	Outlet Spike
844	27.0	Outlet Spike
845	27.5	Outlet Spike
846	26.8	Outlet Spike
847	27.8	Outlet Spike
848	28.3	Outlet Spike
849	28.1	Outlet Spike
850	28.0	Outlet Spike
851	28.4	Outlet Spike
852	28.2	Outlet Spike
853	28.2	Outlet Spike
854	28.3	Outlet Spike
855	28.3	Outlet Spike
856	27.6	Outlet Spike
857	27.3	Outlet Spike
858	27.8	Outlet Spike
859	27.9	Outlet Spike
900	28.0	Outlet Spike
901	28.3	Outlet Spike
902	28.0	Outlet Spike
903	27.8	Outlet Spike
904	27.5	Outlet Spike
905	27.4	Outlet Spike
906	27.0	Outlet Spike
907	26.3	Outlet Spike
908	26.6	Outlet Spike
909	26.9	Outlet Spike
910	26.3	Outlet Spike
911	26.1	Outlet Spike
912	25.9	Outlet Spike
913	25.5	Outlet Spike
914	25.0	Outlet Spike
915	Inlet Spike	24.1
916	Inlet Spike	23.9
917	Inlet Spike	24.0
918	Inlet Spike	24.2
919	Inlet Spike	24.2
920	Inlet Spike	24.4
921	Inlet Spike	24.2
922	Inlet Spike	23.8
923	Inlet Spike	23.4
924	Inlet Spike	23.2

LTV
Run 3
Date: 6/27/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
925	Inlet Spike	23.1
926	Inlet Spike	23.3
927	Inlet Spike	23.1
928	Inlet Spike	23.7
929	Inlet Spike	23.7
930	Inlet Spike	23.7
931	Inlet Spike	23.7
932	Inlet Spike	23.8
933	Inlet Spike	23.7
934	Inlet Spike	23.8
935	Inlet Spike	23.6
936	Inlet Spike	23.7
937	Inlet Spike	24.1
938	Inlet Spike	24.4
939	Inlet Spike	24.5
940	Inlet Spike	24.4
941	Inlet Spike	24.4
942	Inlet Spike	24.5
943	Inlet Spike	24.3
944	Inlet Spike	24.5
945	Inlet Spike	24.4
946	Inlet Spike	24.0
947	20.8	18.4
948	20.6	19.6
949	20.5	19.9
950	20.2	19.0
951	20.0	18.8
952	19.7	18.6
953	19.7	18.7
954	19.6	18.7
955	19.4	18.5
956	18.7	18.5
957	19.0	18.4
958	19.0	18.5
959	18.9	18.3
1000	18.6	18.2
1001	18.4	18.1
1002	18.3	18.0
1003	18.2	18.0
1004	18.6	18.3
1005	18.3	18.4
1006	18.2	18.7
1007	18.8	18.9
1008	26.0	21.0
1009	27.5	21.8
1010	27.9	21.9
1011	27.9	21.7
1012	28.1	21.7
1013	28.2	21.7
1014	28.7	21.9

LTV
Run 3
Date: 6/27/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1015	28.4	22.0
1016	28.3	21.7
1017	28.2	21.5
1018	27.8	23.0
1019	26.3	24.9
1020	***	24.7
1021	***	24.6
1022	***	24.5
1023	27.8	23.9
1024	27.5	23.7
1025	27.3	23.6
1026	27.3	23.3
1027	27.0	23.0
1028	26.8	22.6
1029	26.8	22.5
1030	26.7	22.6
1031	26.5	22.4
1032	26.6	22.5
1033	26.2	22.3
1034	26.0	22.5
1035	26.6	22.9
1036	27.4	23.3
1037	28.0	23.9
1038	28.2	24.3
1039	27.3	24.5
1040	27.1	24.6
1041	27.3	24.9
1042	27.3	25.0
1043	27.0	25.0
1044	26.5	25.1
1045	26.6	25.1
1046	26.8	25.4
1047	28.4	25.1
1048	29.9	25.1
1049	29.7	25.1
1050	29.4	25.0
1051	33.8	25.0
1052	34.9	23.7
1053	Filter Change	19.1
1054	38.7	21.7
1055	40.2	21.8
1056	41.0	21.6
1057	41.7	21.8
1058	42.2	21.7
1059	40.9	22.3
1100	36.3	24.6
1101	35.1	24.6
1102	34.4	24.9
1103	34.3	25.2
1104	33.4	25.2

LTV
Run 3
Date: 6/27/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1105	32.9	24.6
1106	32.6	Port Change
1107	***	
1108	***	
1109	***	
1110	***	
1111	***	
1112	***	
1113	***	
1114	***	
1115	29.4	
1116	29.6	
1117	29.6	
1118	29.7	
1119	29.0	
1120	28.6	
1121	28.8	
1122	28.5	
1123	28.6	
1124	28.4	
1125	28.1	
1126	28.6	
1127	28.8	
1128	28.9	
1129	28.8	
1130	28.6	
1131	28.1	
1132	29.2	24.4
1133	29.8	26.7
1134	28.8	26.6
1135	28.4	26.2
1136	27.8	25.6
1137	27.2	24.8
1138	27.5	25.2
1139	28.3	25.2
1140	27.9	25.0
1141	28.5	24.9
1142	30.7	24.9
1143	30.9	24.6
1144	29.8	24.2
1145	30.7	25.3
1146	30.6	25.4
1147	31.4	25.3
1148	30.8	25.2
1149	30.8	25.5
1150	30.7	25.8
1151	31.2	26.0
1152	31.0	25.6
1153	30.8	25.3
1154	31.0	25.6

LTV
Run 3
Date: 6/27/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1155	30.6	26.1
1156	30.8	26.0
1157	30.8	25.8
1158	30.5	25.7
1159	30.2	25.5
1200	30.1	25.3
1201	29.7	25.2
1202	29.7	25.4
1203	29.6	25.6
1204	29.0	25.6
1205	28.1	25.2
1206	28.6	25.1
1207	28.5	25.2
1208	28.3	24.7
1209	28.1	24.6
1210	27.6	24.5
1211	28.2	24.3
1212	27.9	24.4
1213	27.8	24.4
1214	27.0	24.8
1215	***	25.1
1216	***	25.5
1217	***	25.7
1218	***	25.5
1219	***	25.4
1220	***	25.0
1221	***	24.9
1222	***	25.0
1223	***	25.3
1224	***	25.1
1225	28.0	25.0
1226	29.4	25.3
1227	30.0	25.7
1228	30.6	26.2
1229	30.8	26.5
1230	30.9	26.7
1231	32.0	27.1
1232	31.8	27.6
1233	31.6	27.6
1234	31.1	27.6
1235	30.7	27.2
1236	30.7	27.2
1237	30.9	27.3
1238	30.9	26.9
1239	30.7	26.9
1240	30.0	26.9
1241	29.9	26.6
1242	29.3	26.5
1243	31.7	26.7
1244	33.4	26.7

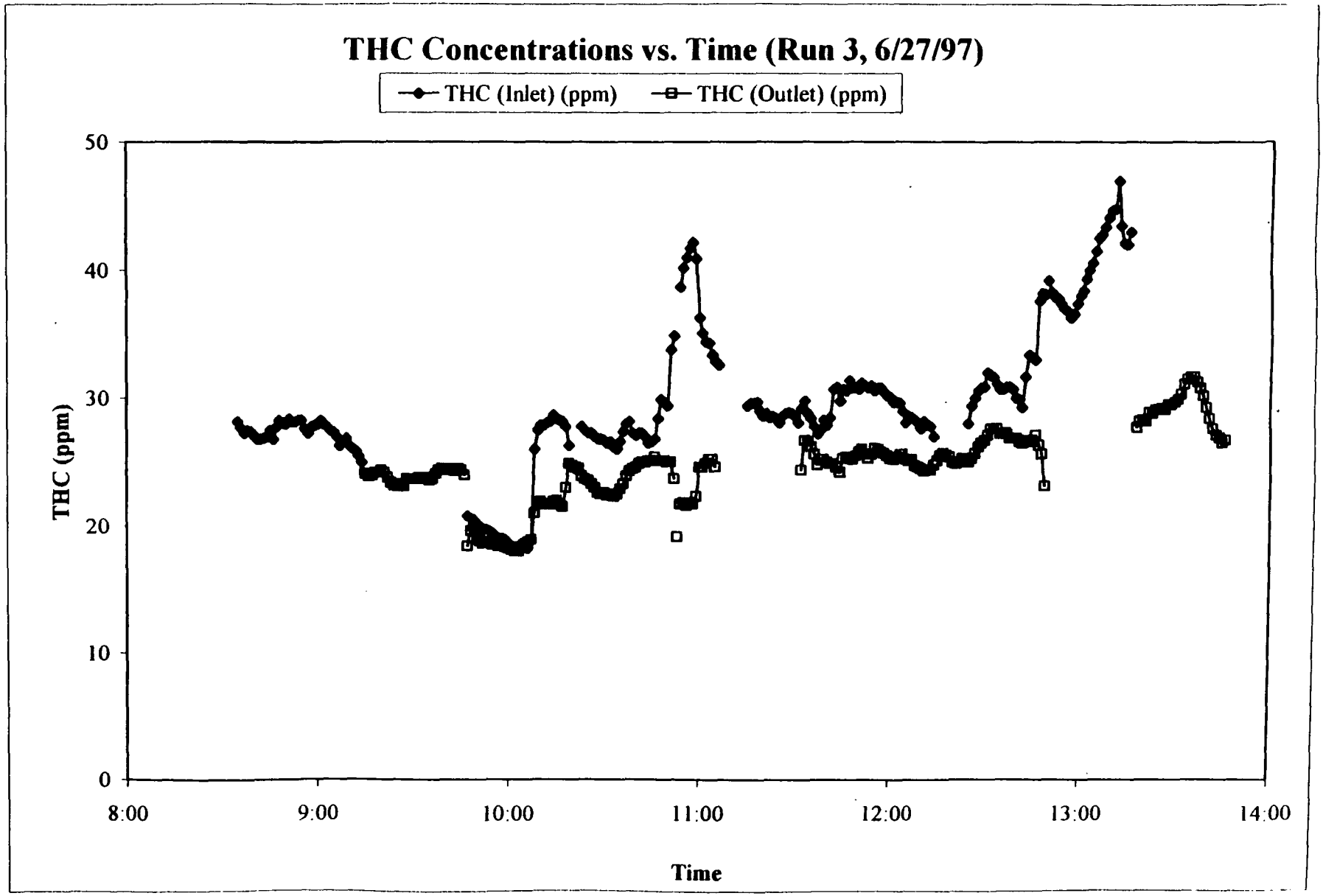
LTV
Run 3
Date: 6/27/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1245	33.2	26.6
1246	33.0	27.1
1247	37.6	26.3
1248	38.2	25.6
1249	38.1	23.1
1250	39.2	Outlet Spike
1251	38.3	Outlet Spike
1252	37.9	Outlet Spike
1253	37.8	Outlet Spike
1254	37.4	Outlet Spike
1255	37.0	Outlet Spike
1256	36.8	Outlet Spike
1257	36.3	Outlet Spike
1258	36.6	Outlet Spike
1259	37.4	Outlet Spike
1300	38.0	Outlet Spike
1301	38.4	Outlet Spike
1302	39.3	Outlet Spike
1303	40.0	Outlet Spike
1304	40.6	Outlet Spike
1305	41.5	Outlet Spike
1306	42.5	Outlet Spike
1307	42.8	Outlet Spike
1308	43.4	Outlet Spike
1309	44.1	Outlet Spike
1310	44.7	Outlet Spike
1311	44.8	Outlet Spike
1312	47.0	Outlet Spike
1313	43.5	Outlet Spike
1314	42.1	Outlet Spike
1315	42.0	Outlet Spike
1316	43.0	Outlet Spike
1317	Inlet Spike	Outlet Spike
1318	Inlet Spike	27.7
1319	Inlet Spike	28.2
1320	Inlet Spike	28.3
1321	Inlet Spike	28.2
1322	Inlet Spike	28.9
1323	Inlet Spike	28.8
1324	Inlet Spike	29.1
1325	Inlet Spike	29.1
1326	Inlet Spike	29.2
1327	Inlet Spike	29.1
1328	Inlet Spike	29.5
1329	Inlet Spike	29.5
1330	Inlet Spike	29.7
1331	Inlet Spike	29.9
1332	Inlet Spike	30.3
1333	Inlet Spike	31.1
1334	Inlet Spike	31.5

LTV
Run 3
Date: 6/27/97
Project No. : 3802-20-04-03-01
Operator: Gulick

Time (24 hour)	THC 1 (Inlet) (ppm)	THC 2 (Outlet) (ppm)
1335	Inlet Spike	31.7
1336	Inlet Spike	31.7
1337	Inlet Spike	31.3
1338	Inlet Spike	30.8
1339	Inlet Spike	30.2
1340	Inlet Spike	29.3
1341	Inlet Spike	28.4
1342	Inlet Spike	27.6
1343	Inlet Spike	27.1
1344	Inlet Spike	26.9
1345	Inlet Spike	26.5
1346	Inlet Spike	26.7
Minimum=	18.2	18.0
Maximum=	47.0	31.7
Average=	29.8	24.6

*** Sample flow fluctuation due to FTIR cell filling.
Data point not used in average


THC Concentrations vs. Time (Run 3, 6/27/97)
THC (Inlet) (ppm)
THC (Outlet) (ppm)
THC (ppm)
50
40
30
20
10
0
8:00
9:00
10:00
11:00
12:00
13:00
14:00
Time

A-2 METHOD 25A CALIBRATION AND QA CHECK DATA

Calibration Error Determination For 6/25/97

	Cal Gas Value	Measured Value	Difference as % of Cal Gas	Pass/ Fail
THC 1 Inlet	0.0	0.2	0.2	Pass
	90.4	90.8	0.4	Pass
	50.4	50.2	0.4	Pass
	35.2	35.4	0.6	Pass
THC 2 Outlet	0.0	0.3	0.3	Pass
	90.4	90.8	0.4	Pass
	50.4	50.0	0.8	Pass
	35.2	34.5	2.0	Pass

Pass/Fail Criteria is +/- 5% of Calibration gas.

Calibration Drift Determination for 6/25/97

Zero Drift

	Initial Value	Final Value	Difference as % of Span	Pass/ Fail
THC 1 Inlet	0.2	1.2	1.0	Pass
THC 2 Outlet	0.3	-0.4	0.7	Pass

Instrument Span for THC 1 and THC 2 is 100 ppm.
Pass/Fail Criteria is +/- 3% of Instrument Span.

Span Drift

	Initial Value	Final Value	Difference as % of Span	Pass/ Fail
THC 1 Inlet	90.8	90.2	0.6	Pass
THC 2 Outlet	90.8	91.7	0.9	Pass

strument Span for THC 1 and THC 2 is 100 ppm.
Pass/Fail Criteria is +/- 3% of Instrument Span.

Calibration Error Determination For 6/26/97

	Cal Gas Value	Measured Value	Difference as % of Cal Gas	Pass/ Fail
THC 1 Inlet	0.0	0.1	0.1	Pass
	90.4	91.2	0.9	Pass
	50.4	49.8	1.2	Pass
	35.2	34.3	2.6	Pass
THC 2 Outlet	0.0	0.2	0.2	Pass
	90.4	91.3	1.0	Pass
	50.4	50.0	0.8	Pass
	35.2	34.3	2.6	Pass

Pass/Fail Criteria is +/- 5% of Calibration gas.

Calibration Drift Determination for 6/26/97

Zero Drift

	Initial Value	Final Value	Difference as % of Span	Pass/ Fail
THC 1 Inlet	0.1	-1.0	1.1	Pass
THC 2 Outlet	0.2	0.6	0.4	Pass

Instrument Span for THC 1 and THC 2 is 100 ppm.
Pass/Fail Criteria is +/- 3% of Instrument Span.

Span Drift

	Initial Value	Final Value	Difference as % of Span	Pass/ Fail
THC 1 Inlet	91.2	88.4	2.8	Pass
THC 2 Outlet	91.3	91.0	0.3	Pass

strument Span for THC 1 and THC 2 is 100 ppm.
Pass/Fail Criteria is +/- 3% of Instrument Span.

Calibration Error Determination For 6/27/97

	Cal Gas Value	Measured Value	Difference as % of Cal Gas	Pass/ Fail
THC 1 Inlet	0.0	0.1	0.1	Pass
	90.4	91.0	0.7	Pass
	50.4	50.5	0.2	Pass
	35.2	35.0	0.6	Pass
THC 2 Outlet	0.0	0.2	0.2	Pass
	90.4	91.6	1.3	Pass
	50.4	50.8	0.8	Pass
	35.2	35.2	0.0	Pass

Pass/Fail Criteria is +/- 5% of Calibration gas.

Calibration Drift Determination for 6/27/97

Zero Drift

	Initial Value	Final Value	Difference as % of Span	Pass/ Fail
THC 1 Inlet	0.1	2.4	2.3	Pass
THC 2 Outlet	0.2	0.9	0.7	Pass

Instrument Span for THC 1 and THC 2 is 100 ppm.
Pass/Fail Criteria is +/- 3% of Instrument Span.

Span Drift

	Initial Value	Final Value	Difference as % of Span	Pass/ Fail
THC 1 Inlet	91.0	90.2	0.8	Pass
THC 2 Outlet	91.6	91.1	0.5	Pass

ıstrument Span for THC 1 and THC 2 is 100 ppm.
Pass/Fail Criteria is +/- 3% of Instrument Span.

Response Times

THC 1 Inlet	20 seconds
THC 2 Outlet	45 seconds

A-3 VOLUMETRIC FLOW DATA

A-3 VOLUMETRIC FLOW DATA

Facility:	LTV East Chicago
Date:	6/25/97
Location:	Outlet
Run Number:	1
Sample Type:	Dioxin

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.18
Absolute Stack Pressure (in H2O)	29.31
Stack Static Pressure (in H2O)	1.80
Average Stack Temperature (°F)	117.46
Stack Area (sq in)	16286.02
Actual Meter Volume (cu ft)	160.748
Average Meter Pressure (in H2O)	0.81
Average Meter Temperature (°F)	93.92
Moisture Collected (g)	388.80
Carbon Dioxide Concentration (%V)	3.5
Oxygen Concentration (%V)	17.5
Nitrogen Concentration (%V)	79.0
Dry Gas Meter Factor	0.9960
Nozzle Diameter (in)	0.217
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.622
Standard Metered Volume (dscf)	149.293
Standard Metered Volume (dscm)	4.228
Stack Moisture (%V)	10.94
Mole Fraction Dry Stack Gas	0.891
Dry Molecular Weight	29.26
Wet Molecular Weight	28.03
Stack Gas Velocity (fpm)	2908.67
Stack Gas Velocity (mpm)	886.56
Volumetric Flow Rate (acfm)	328962.48
Volumetric Flow Rate (acmm)	9316.22
Volumetric Flow Rate (dscfm)	262438.55
Volumetric Flow Rate (dscmm)	7432.26
Percent Isokinetic	104.38
Percent Excess Air	519.01
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

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BY DKO DATE 7-1-97

Facility:	LTV East Chicago
Date:	6/26/97
Location:	Outlet
Run Number:	2
Sample Type:	Dioxin

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.35
Absolute Stack Pressure (in H2O)	29.36
Stack Static Pressure (in H2O)	0.18
Average Stack Temperature (°F)	117.33
Stack Area (sq in)	16286.02
Actual Meter Volume (cu ft)	158.400
Average Meter Pressure (in H2O)	0.81
Average Meter Temperature (°F)	88.17
Moisture Collected (g)	394.70
Carbon Dioxide Concentration (%V)	3.5
Oxygen Concentration (%V)	17.5
Nitrogen Concentration (%V)	79.0
Dry Gas Meter Factor	0.9960
Nozzle Diameter (in)	0.217
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.623
Standard Metered Volume (dscf)	149.562
Standard Metered Volume (dscm)	4.236
Stack Moisture (%V)	11.07
Mole Fraction Dry Stack Gas	0.889
Dry Molecular Weight	29.26
Wet Molecular Weight	28.01
Stack Gas Velocity (fpm)	2932.41
Stack Gas Velocity (mpm)	893.80
Volumetric Flow Rate (acfm)	331647.76
Volumetric Flow Rate (acmm)	9392.26
Volumetric Flow Rate (dscfm)	264711.08
Volumetric Flow Rate (dscmm)	7496.62
Percent Isokinetic	103.67
Percent Excess Air	519.01
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

Facility:	LTV East Chicago
Date:	6/27/97
Location:	Outlet
Run Number:	3
Sample Type:	Dioxin

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.40
Absolute Stack Pressure (in H2O)	29.41
Stack Static Pressure (in H2O)	0.18
Average Stack Temperature (°F)	115.29
Stack Area (sq in)	16286.02
Actual Meter Volume (cu ft)	163.075
Average Meter Pressure (in H2O)	0.83
Average Meter Temperature (°F)	98.60
Moisture Collected (g)	368.20
Carbon Dioxide Concentration (%V)	3.5
Oxygen Concentration (%V)	17.5
Nitrogen Concentration (%V)	79.0
Dry Gas Meter Factor	0.9960
Nozzle Diameter (in)	0.217
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.631
Standard Metered Volume (dscf)	151.351
Standard Metered Volume (dscm)	4.286
Stack Moisture (%V)	10.29
Mole Fraction Dry Stack Gas	0.897
Dry Molecular Weight	29.26
Wet Molecular Weight	28.10
Stack Gas Velocity (fpm)	2965.93
Stack Gas Velocity (mpm)	904.02
Volumetric Flow Rate (acfm)	335439.29
Volumetric Flow Rate (acmm)	9499.64
Volumetric Flow Rate (dscfm)	271494.06
Volumetric Flow Rate (dscmm)	7688.71
Percent Isokinetic	102.29
Percent Excess Air	519.01
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

Facility:	LTV East Chicago
Date:	6/25/87
Location:	Outlet
Run Number:	1
Sample Type:	Multi metals

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.18
Absolute Stack Pressure (in H2O)	29.31
Stack Static Pressure (in H2O)	1.80
Average Stack Temperature (°F)	117.50
Stack Area (sq in)	16286.02
Actual Meter Volume (cu ft)	166.707
Average Meter Pressure (in H2O)	0.83
Average Meter Temperature (°F)	92.17
Moisture Collected (g)	404.40
Carbon Dioxide Concentration (%V)	3.5
Oxygen Concentration (%V)	17.5
Nitrogen Concentration (%V)	79.0
Dry Gas Meter Factor	0.9840
Nozzle Diameter (in)	0.217
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.640
Standard Metered Volume (dscf)	153.538
Standard Metered Volume (dscm)	4.348
Stack Moisture (%V)	11.05
Mole Fraction Dry Stack Gas	0.890
Dry Molecular Weight	29.26
Wet Molecular Weight	28.02
Stack Gas Velocity (fpm)	3013.70
Stack Gas Velocity (mpm)	918.58
Volumetric Flow Rate (acfm)	340841.82
Volumetric Flow Rate (acmm)	9652.63
Volumetric Flow Rate (dscfm)	271558.40
Volumetric Flow Rate (dscmm)	7690.53
Percent Isokinetic	103.74
Percent Excess Air	519.01
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

Facility:	LTV East Chicago
Date:	6/26/97
Location:	Outlet
Run Number:	2
Sample Type:	Multi metals

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.35
Absolute Stack Pressure (in H2O)	29.36
Stack Static Pressure (in H2O)	0.18
Average Stack Temperature (°F)	117.83
Stack Area (sq in)	16286.02
Actual Meter Volume (cu ft)	157.579
Average Meter Pressure (in H2O)	0.83
Average Meter Temperature (°F)	91.94
Moisture Collected (g)	390.00
Carbon Dioxide Concentration (%V)	3.8
Oxygen Concentration (%V)	17.4
Nitrogen Concentration (%V)	78.9
Dry Gas Meter Factor	0.9840
Nozzle Diameter (in)	0.217
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.608
Standard Metered Volume (dscf)	146.035
Standard Metered Volume (dscm)	4.136
Stack Moisture (%V)	11.18
Mole Fraction Dry Stack Gas	0.888
Dry Molecular Weight	29.30
Wet Molecular Weight	28.03
Stack Gas Velocity (fpm)	2984.84
Stack Gas Velocity (mpm)	909.78
Volumetric Flow Rate (acfm)	337576.99
Volumetric Flow Rate (acmm)	9560.18
Volumetric Flow Rate (dscfm)	268854.67
Volumetric Flow Rate (dscmm)	7613.96
Percent Isokinetic	99.66
Percent Excess Air	506.97
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

Facility:	LTV East Chicago
Date:	6/27/97
Location:	Outlet
Run Number:	3
Sample Type:	Multi metals

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.40
Absolute Stack Pressure (in H2O)	29.41
Stack Static Pressure (in H2O)	0.18
Average Stack Temperature (°F)	116.46
Stack Area (sq in)	16286.02
Actual Meter Volume (cu ft)	160.530
Average Meter Pressure (in H2O)	0.83
Average Meter Temperature (°F)	100.27
Moisture Collected (g)	369.60
Carbon Dioxide Concentration (%V)	3.3
Oxygen Concentration (%V)	18.8
Nitrogen Concentration (%V)	88.0
Dry Gas Meter Factor	0.9840
Nozzle Diameter (in)	0.217
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.612
Standard Metered Volume (dscf)	146.795
Standard Metered Volume (dscm)	4.157
Stack Moisture (%V)	10.61
Mole Fraction Dry Stack Gas	0.894
Dry Molecular Weight	32.07
Wet Molecular Weight	30.58
Stack Gas Velocity (fpm)	2865.84
Stack Gas Velocity (mpm)	873.51
Volumetric Flow Rate (acfm)	324119.17
Volumetric Flow Rate (acmm)	9179.06
Volumetric Flow Rate (dscfm)	260862.30
Volumetric Flow Rate (dscmm)	7387.62
Percent Isokinetic	103.25
Percent Excess Air	416.70
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

Facility:	LTV East Chicago
Date:	6/25/97
Location:	Inlet
Run Number:	1
Sample Type:	Multi metals

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.36
Absolute Stack Pressure (in H2O)	28.95
Stack Static Pressure (in H2O)	-5.60
Average Stack Temperature (°F)	222.04
Stack Area (sq in)	8190.00
Actual Meter Volume (cu ft)	67.248
Average Meter Pressure (in H2O)	1.66
Average Meter Temperature (°F)	92.08
Moisture Collected (g)	93.20
Carbon Dioxide Concentration (%V)	2.5
Oxygen Concentration (%V)	19.0
Nitrogen Concentration (%V)	88.5
Dry Gas Meter Factor	0.9840
Nozzle Diameter (in)	0.103
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.259
Standard Metered Volume (dscf)	62.194
Standard Metered Volume (dscm)	1.761
Stack Moisture (%V)	6.60
Mole Fraction Dry Stack Gas	0.934
Dry Molecular Weight	31.96
Wet Molecular Weight	31.04
Stack Gas Velocity (fpm)	6236.47
Stack Gas Velocity (mpm)	1900.88
Volumetric Flow Rate (acfm)	354699.39
Volumetric Flow Rate (acmm)	10045.09
Volumetric Flow Rate (dscfm)	248105.45
Volumetric Flow Rate (dscmm)	7026.35
Percent Isokinetic	102.66
Percent Excess Air	433.62
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

Facility:	LTV East Chicago
Date:	6/26/97
Location:	Inlet
Run Number:	2
Sample Type:	Multi metals

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.45
Absolute Stack Pressure (in H2O)	29.04
Stack Static Pressure (in H2O)	-5.60
Average Stack Temperature (°F)	222.63
Stack Area (sq in)	8190.00
Actual Meter Volume (cu ft)	68.915
Average Meter Pressure (in H2O)	1.62
Average Meter Temperature (°F)	93.31
Moisture Collected (g)	98.60
Carbon Dioxide Concentration (%V)	3.3
Oxygen Concentration (%V)	18.8
Nitrogen Concentration (%V)	88.0
Dry Gas Meter Factor	0.9840
Nozzle Diameter (in)	0.103
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.266
Standard Metered Volume (dscf)	63.785
Standard Metered Volume (dscm)	1.806
Stack Moisture (%V)	6.79
Mole Fraction Dry Stack Gas	0.932
Dry Molecular Weight	32.07
Wet Molecular Weight	31.11
Stack Gas Velocity (fpm)	6057.53
Stack Gas Velocity (mpm)	1846.33
Volumetric Flow Rate (acfm)	344521.82
Volumetric Flow Rate (acmm)	9756.86
Volumetric Flow Rate (dscfm)	241027.11
Volumetric Flow Rate (dscmm)	6825.89
Percent Isokinetic	108.38
Percent Excess Air	416.70
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

Facility:	LTV East Chicago
Date:	6/27/97
Location:	Inlet
Run Number:	3
Sample Type:	Multi metals

Total Sampling Time (min)	240.0
Corrected Barometric Pressure (in Hg)	29.51
Absolute Stack Pressure (in H2O)	29.10
Stack Static Pressure (in H2O)	-5.60
Average Stack Temperature (°F)	198.00
Stack Area (sq in)	8190.00
Actual Meter Volume (cu ft)	67.276
Average Meter Pressure (in H2O)	1.68
Average Meter Temperature (°F)	96.88
Moisture Collected (g)	96.60
Carbon Dioxide Concentration (%V)	3.3
Oxygen Concentration (%V)	18.8
Nitrogen Concentration (%V)	88.0
Dry Gas Meter Factor	0.9840
Nozzle Diameter (in)	0.103
Pitot Constant	0.84
Average Sampling Rate (dscfm)	0.259
Standard Metered Volume (dscf)	62.045
Standard Metered Volume (dscm)	1.757
Stack Moisture (%V)	6.84
Mole Fraction Dry Stack Gas	0.932
Dry Molecular Weight	32.07
Wet Molecular Weight	31.11
Stack Gas Velocity (fpm)	6181.78
Stack Gas Velocity (mpm)	1884.21
Volumetric Flow Rate (acfm)	351588.97
Volumetric Flow Rate (acmm)	9957.00
Volumetric Flow Rate (dscfm)	255583.34
Volumetric Flow Rate (dscmm)	7238.12
Percent Isokinetic	99.42
Percent Excess Air	416.70
Concentration (g/dscm)	0.00
Concentration (kg/hr)	0.00
Concentration (ppmv)	0.00
Emissions (lb/hr)	0.00

APPENDIX B

FTIR DATA

B-1 FTIR FIELD DATA RECORDS

LTV STEEL COMPANY INC.

Date	Time	Location	Spiked	Unspiked	Event/Notes
6/23/97	16:48-16:49	Inlet			Ambient Sample
6/24/97	13:33-13:59	Inlet		X	
	14:00-14:58	Inlet	X		
	15:03-15:41	Outlet	X		
	16:03-16:25	Inlet		X	
	16:29-16:44	Inlet		X	In inlet but from outlet
6/25/97	8:27-9:15	Outlet	X		
	9:27-10:03	Inlet	X		
	10:15-10:30	Outlet		X	
	10:30	Outlet			Port change
	10:33-10:46	Inlet		X	
	10:48-10:51	Outlet		X	
	11:11-11:29	Inlet		X	
	11:32-11:47	Outlet		X	
	12:06-12:07	Outlet			Filter change/Analyzers off line
	12:06-12:07	Inlet			Filter change/Analyzers off line
	12:17-12:34	Inlet		X	
	12:36-12:50	Outlet		X	
	12:53-13:05	Inlet		X	
	13:09-13:21	Outlet		X	
	13:21-13:40	Outlet			Port change
	13:34-13:37	Inlet			Filter change
	13:38-13:39	Inlet			Leak check
	13:40	Outlet			Leak check
	13:47-13:55	Inlet		X	
	13:58-14:12	Outlet		X	
	14:16-14:31	Inlet		X	
	14:35-14:50	Outlet		X	
	14:54-15:09	Inlet		X	
	15:05	Outlet			Port change
	15:12-15:46	Inlet		X	
	15:15	Inlet			Changed glass wool plug at inlet
	15:17	Inlet			THC flame out/system check
	15:33	Outlet			THC off line/system check
	15:49-16:07	Outlet		X	
	16:10-16:25	Inlet		X	
	16:31-16:47	Outlet		X	
	16:52-16:57	Inlet		X	
	17:02-17:27	Inlet	X		
	17:34-18:03	Outlet	X		
	18:05				Nitrogen purge

LTV STEEL COMPANY INC.

Date	Time	Location	Spiked	Unspiked	Event/Notes
6/26/97	9:09-9:41	Inlet	X		
	9:53-10:51	Outlet	X		
	10:55-11:25	Inlet		X	
	11:29-11:55	Outlet		X	
	11:57-12:21	Inlet		X	
	12:24-12:32	Outlet		X	
	12:33	Outlet			Port change
	12:33-12:34	Inlet			Analyzers off line/filter change
	12:33-12:34	Outlet			Analyzers off line/filter change
	12:35-13:05	Inlet		X	
	13:08-13:33	Outlet		X	
	13:39				Take new background
	14:00-14:30	Inlet		X	
	14:45	Outlet			Analyzer off line
	14:33-15:03	Outlet		X	
	15:07-15:35	Inlet		X	
	15:39-15:51	Outlet		X	
	15:59-16:33	Inlet	X		
	16:44-17:22	Outlet	X		
6/27/97	8:35-9:14	Outlet	X		
	9:15-9:46	Inlet	X		
	9:40	Outlet			Port change
	9:49-10:18	Outlet	X		Start outlet process software
	10:21-10:51	Inlet	X		
	10:53	Inlet			Filter change
	11:06	Outlet			Filter change
	11:07-11:42	Inlet		X	
	11:44-12:14	Outlet		X	
	12:16-12:45	Inlet			
	12:25	Outlet			Port change
	12:49-12:50	Outlet			
	12:50-13:17	Outlet	X		
	13:17-13:46	Inlet	X		

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:**

PLANT: LTV **DATE:** 6/23-24/1997 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
16:48-16:49	INLA00001	36 passes	Ambient sample line 2/inlet Line 2 check	50	1	121 C	Ambient			623A
6/24/97										
13:33-13:34	INLA1001	36 passes	Ambient air line 2/inlet may be contaminated			121C	Ambient			624B
			w/ 25 A propane cal							
12:57-12:58	INLA1002	36 passes	Ambient air spike line open							
			Synchronized time with HC analyzers							
14:00			Probe @ inlet SF6 spike @ 1 lpm						138 #2	
14:02-14:03	INLS1003	36 passes	spiked w/SF6 @ 1.00 lpm 4 ppm SF6						138	624B
14:05-14:06	INLS1004	36 passes	Spiked probe out of stack						138	624B
14:08-14:09	INLS1005	36 passes	Spiked probe out of stack	50/200	1	121C	in stack		137	624B
14:11			Started toluene (121 ppm) spike @ 1.0 lpm				S			
14:16-14:17	INLS1006	36 passes	Toluene @ 1.0 lpm				S		140	624B
14:23-14:24	INLS1007	36 passes	Toluene @ 1.0 lpm	50/200	1	121C	S(tol)		140	624B
14:28-14:29	INLS1008	36 passes	Toluene @ 1.0 lpm	50/200	1	121C	S(tol)		140	624B
14:30			Turned toluene flow (spike) to 2.00 lpm						140	
14:35-14:36	INLS1009	36 passes	Toluene spike @ 2.00 lpm	50/200	1	121C	S(tol)		140	624B
14:39-14:41	INLS1010	36 passes	Toluene spike @ 2.00 lpm	50/200	1	121C	S(tol)		140	624B
14:43-14:44	INLS1011	36 passes	Toluene spike @ 2.00 lpm	50/200	1	121C	S(tol)		140	624B
14:46			Turned on SF6 spike @ 14:46							
14:51-14:52	INLS1012	36 passes	SF6 spike @ 1.95 lpm	50/200	1	121C	S(SF6)		140	624B
14:54-14:55	INLS1013	36 passes	SF6 spike @ 1.95 lpm	50/200	1	121C	S(SF6)		140	624B
14:57-14:58	INLS1014	36 passes	SF6 spike @ 1.95 lpm	50/200	1	121C	S(SF6)		140	624B

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 BAROMETRIC:

PLANT: LTV DATE: 6/24/97 OPERATOR: Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
15:03			SF6 to outlet @ 2.00 lpm				SF6		110	
15:10-15:12	OUTS1001	36 passes	SF6 spike @ 2.00 lpm	50/200	1	121C	SF6 2 lpm		110	624B
15:14-15:16	OUTS1002	36 passes	SF6 spike @ 2.00 lpm	50/200	1	121C	SF6 2 lpm		110	624B
15:19-15:21	OUTS1003	36 passes	SF6 spike @ 2.00 lpm	50/200	1	121C	SF6 2 lpm		110	624B
15:24			toluene out @ 2 lpm						110	624B
15:31-15:33	OUTS1004	36 passes	toluene out @ 2 lpm	50/200	1	121C	tol 2lpm		110	624B
15:35-15:37	OUTS1005	36 passes	toluene out @ 2 lpm	50/200	1	121C	tol 2lpm		110	624B
15:37-15:41	OUTS1006	36 passes	toluene out @ 2 lpm	50/200	1	121C	tol 2lpm		110	624B
15:45			Spike off							
16:03-16:04	INLV1014	36 passes	Inlet unspiked	50/200	1	121C	U		140	624B
16:10-16:12	INLV1015	36 passes	Inlet unspiked	50/200	1	121C	U		140	624B
16:18-16:20	INLV1016	36 passes	Inlet unspiked	50/200	1	121C	U		100	624B
16:23-16:25	INLV1017	36 passes	Inlet unspiked	50/200	1	121C	U		100	624B
16:29-16:31	INLV1018	36 passes	Outlet unspiked	50/200	1	121C	U		80	624B
16:33-16:35	INLV1019	36 passes	Outlet unspiked	50/200	1	121C	U		80	624B
16:37-16:39	INLV1020	36 passes	Outlet unspiked	50/200	1	121C	U		80	624B
16:42-16:44	INLV1021	36 passes	Outlet unspiked	50/200	1	121C	U		80	624B
			The previous four were stored in the inlet							
			directory but are from the outlet							
			No official run today 6/24							

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:** 746.7 - 755 mm

PLANT: LTV **DATE:** 6/25/97 **OPERATOR:** Henning

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
8:27			Outlet SF6 spike flow @ 2lpm				S		105	625A
8:37-8:40	OUTS2001	36 passes	Outlet SF6 spike flow @ 2lpm	50	1	121	S		107	625A
8:42-8:45	OUTS2002	36 passes	Outlet SF6 spike flow @ 2lpm	50	1	121	S		107	625A
8:48-8:51	OUTS2003	36 passes	Outlet SF6 spike flow @ 2lpm	50	1	121	S		107	625A
8:52			Stop spike SF6							
8:52			Outlet toluene spike @ 2lpm				S		107	625A
8:59-9:01	OUTS2004	36 passes	Outlet toluene spike @ 2lpm	50	1	121	S		107	625A
9:04-9:07	OUTS2005	36 passes	Outlet toluene spike @ 2lpm	50	1	121	S		107	625A
9:10-9:12	OUTS2006	36 passes	Outlet toluene spike @ 2lpm	50	1	121	S		107	625A
9:15			finish outlet spike							
9:15			inlet toluene spike @ 2 lpm							
9:23-9:25	INS2001	36 passes	inlet toluene spike @ 2 lpm	50	1	121	S		85	625A
9:28-9:331	INS2002	36 passes	inlet toluene spike @ 2 lpm	50	1	121	S		140	625A
9:34-9:36	INS2003	36 passes	inlet toluene spike @ 2 lpm	50	1	121	S		140	625A
9:38-9:41	INS2004	36 passes	inlet toluene spike @ 2 lpm	50	1	121	S		140	625A
9:43			finish toluene spike							
9:43			inlet SF6 spike flow @ 2lpm							
9:50-9:53	INS2005	36 passes	inlet SF6 spike flow @ 2lpm	50	1	121	S		140	625A
9:55-9:58	INS2006	36 passes	inlet SF6 spike flow @ 2lpm	50	1	121	S		140	625A
10:00-10:02	INS2007	36 passes	inlet SF6 spike flow @ 2lpm	50	1	121	S		140	625A
10:09			Continuous flow through outlet							
10:15	OUTU2007	36 passes	Outlet unspiked	50	1	121	U		100	625A
10:19-10:20	OUTU2008	36 passes	Outlet unspiked	50	1	121	U		100	625A
10:23-10:25	OUTU2009	36 passes	Outlet unspiked	50	1	121	U		100	625A
10:28-10:30	OUTU2010	36 passes	Outlet unspiked	50	1	121	U		100	625A
10:33-10:35	INU2008	36 passes	Inlet unspiked sample	50	1	121	U		120	625A
10:37-10:39	INU2009	36 passes	Inlet unspiked sample	50	1	121	U		120	625A
10:40-10:42	INU2010	36 passes	Inlet unspiked sample	50	1	121	U		85	625A
10:44-10:46	INU2011	36 passes	Inlet unspiked sample	50	1	121	U		70	625A
10:48-10:51	OUTU2011	36 passes	Outlet sample	50	1	121	U		100	625A

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-98-11 **BAROMETRIC:** 746.7-755 torr

PLANT: LTV **DATE:** 6/25/97 **OPERATOR:** Henning / Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
10:57-10:59	OUTU2012	36 passes	Outlet sample	50	1	121C	U		100	625A
11:01-11:03	OUTU2013	36 passes	Outlet sample	50	1	121C	U		100	625A
11:05-11:08	OUTU2014	36 passes	Outlet sample	50	1	121C	U		100	625A
11:11-11:13	INL2012	36 passes	Inlet sample	50	1	121C	U		80	625A
11:16-11:18	INL2013	36 passes	Inlet sample	50	1	121C	U		80	625A
11:21-11:23	INL2014	36 passes	Inlet sample	50	1	121C	U		75	625A
11:27-11:29	INL2015	36 passes	Inlet sample	50	1	121C	U		75	625A
11:32-11:34	OUT2015	36 passes	Outlet sample	50	1	121C	U		100	625A
11:37-11:39	OUT2016	36 passes	Outlet sample	50	1	121C	U		100	625A
11:41-11:43	OUT2017	36 passes	Outlet sample	50	1	121C	U		100	625A
11:45-11:47	OUT2018	36 passes	Outlet sample	50	1	121C	U		100	625A
12:10			Manual runs restarted							
12:17-12:20	INLU2016	36 passes	Inlet sample (changed plug at inlet ~ 12:00)	50/200	1	121C	U		140	625B
12:24-12:25	INLU2017	36 passes	Inlet sample	50/200	1	121C	U		140	625B
12:28-12:30	INLU2018	36 passes	Inlet sample	50/200	1	121C	U		140	625B
12:32-12:34	INLU2019	36 passes	Inlet sample	50/200	1	121C	U		140	625B
12:36-12:38	OUTU2019	36 passes	Outlet unspiked sample	50/200	1	121C	U		100	625B
12:41-12:43	OUTU2020	36 passes	Outlet unspiked sample	50/200	1	121C	U		100	625B
12:45-12:46	OUTU2021	36 passes	Outlet unspiked sample	50/200	1	121C	U		100	625B
12:48-12:50	OUTU2022	36 passes	Outlet unspiked sample	50/200	1	121C	U		100	625B
12:53-12:54	INLU2020	36 passes	Inlet sample	50/200	1	121C	U		110	625B
12:57-12:58	INLU2021	36 passes	Inlet sample	50/200	1	121C	U		110	625B
13:01-13:02	INLU2022	36 passes	Inlet sample	50/200	1	121C	U		100	625B
13:04-13:05	INLU2023	36 passes	Inlet sample	50/200	1	121C	U		100/90	625B
13:09-13:10	OUTU2023	36 passes	Outlet sample						100	
13:12-13:14	OUTU2024	36 passes	Outlet sample	50/200	1	121C	U		100	625B
13:16-13:17	OUTU2025	36 passes	Outlet sample	50/200	1	121C	U		100	625B
13:20-13:21	OUTU2026	36 passes	Outlet sample	50/200	1	121C	U		100	625B
13:34			change plug on inlet probe						140	
13:34-13:35	INLU2024	36 passes	Inlet sample						140	625C
13:40			leak check @ outlet probe is good							

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:** 746.7 - 755 torr

PLANT: LTV **DATE:** 6/25/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
13:47-13:49	INLU2025	36 passes	Inlet sample	50/200	1	121C	U		140	625C
13:51-13:52	INLU2026	36 passes	Inlet sample	50/200	1	121C	U		140	625C
13:54-13:55	INLU2027	36 passes	Inlet sample	50/200	1	121C	U		140	625C
13:58-14:00	OUTU2027	36 passes	Outlet sample	50/200	1	121C	U		95	625C
14:03-14:04	OUTU2028	36 passes	Outlet sample	50/200	1	121C	U		95	625C
14:06-14:07	OUTU2029	36 passes	Outlet sample	50/200	1	121C	U		95	625C
14:10-14:12	OUTU2030	36 passes	Inlet sample	50/200	1	121C	U		95	625C
14:16-14:17	INLV2028	36 passes	Inlet sample	50/200	1	121C	U		125	625C
14:19-14:21	INLV2029	36 passes	Inlet sample	50/200	1	121C	U		110	625C
12:24-14:27	INLV2030	36 passes	Inlet sample	50/200	1	121C	U		110	625C
14:29-14:31	INLV2031	36 passes	Inlet sample	50/200	1	121C	U		100	625C
14:35-14:37	OUTV2031	36 passes	Outlet sample	50/200	1	121C	U		100	625C
14:40-14:42	OUTV2032	36 passes	Outlet sample	50/200	1	121C	U		100	625C
14:44-14:46	OUTV2033	36 passes	Outlet sample	50/200	1	121C	U		100	625C
14:48-14:50	OUTV2034	36 passes	Outlet sample	50/200	1	121C	U		100	625C
14:54-14:56	INLV2032	36 passes	Inlet sample	50/200	1	121C	U		85	625C
14:58-15:00	INLV2033	36 passes	Inlet sample	50/200	1	121C	U		90	625C
15:03-15:04	INLV2034	36 passes	Inlet sample	50/200	1	121C	U		50	625C
15:07-15:09	INLV2035	36 passes	Inlet sample	50/200	1	121C	U		50	625C
15:15			Changed Glass wool plug at inlet							
15:12-15:14	OUTV2035	36 passes	Outlet sample	50/200	1	121C	U		100	625C
15:17-15:19	OUTV2036	36 passes	Outlet sample	50/200	1	121C	U		100	625C
15:21-15:23	OUTV2037	36 passes	Outlet sample	50/200	1	121C	U		100	625C
15:25-15:27	OUTV2038	36 passes	Outlet sample	50/200	1	121C	U		100	625C
15:32-15:34	INLV2036	36 passes	Inlet sample	50/200	1	121C	U		140	625C
15:36-15:38	INLV2037	36 passes	Inlet sample	50/200	1	121C	U		140	625C
15:40-15:42	INLV2038	36 passes	Inlet sample	50/200	1	121C	U		140	625C
15:44-15:46	INLV2039	36 passes	Inlet sample	50/200	1	121C	U		150* (THC off)	625C
15:49-15:51	OUTV2039	36 passes	Outlet sample	50/200	1	121C	U		110	625C
15:54-15:56	OUTV2040	36 passes	Outlet sample	50/200	1	121C	U		110	625C
16:00-16:02	OUTV2041	36 passes	Outlet sample	50/200	1	121C	U		100	625C
16:05-16:07	OUTV2042	36 passes	Outlet sample	50/200	1	121C	U		100	625C
16:10-16:12	INLV2040	36 passes	Inlet sample	50/200	1	121C	U		120	625C
16:15-16:16	INLV2041	36 passes	Inlet sample	50/200	1	121C	U		120	625C
16:20-16:22	INLV2042	36 passes	Inlet sample	50/200	1	121C	U		120 THC back on	625C

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:** 746.7 - 755 torr

PLANT: LTV **DATE:** 6/25/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
16:24-16:25	INLV2043	36 passes	Inlet sample	50/200	1	121C	U		120	625C
16:31-16:33	OUTU2043	36 passes	Outlet sample	50/200	1	121C	U		95	625C
16:36-16:38	OUTU2044	36 passes	Outlet sample	50/200	1	121C	U		95	625C
16:41-16:43	OUTU2045	36 passes	Outlet sample	50/200	1	121C	U		95	625C
16:45-16:47	OUTU2046	36 passes	Outlet sample	50/200	1	121C	U		95	625C
			INLU2044,45,46 were misnamed but were actually outlet spectra							
16:52-16:54	INLU2047	36 passes	Inlet sample	50/200	1	121C	U		100	625C
16:56-16:57	INLU2048	36 passes	Inlet sample	50/200	1	121C	U		100	625C
17:02			SF6 spike on @ 2 lpm							
17:06-17:07	INLS2049	36 passes	Inlet spiked w/SF6	50/200	1	121C	S		140	625C
17:08-17:10	INLS2050	36 passes	Inlet spiked w/SF6	50/200	1	121C	S		140	625C
17:12-17:13	INLS2051	36 passes	Inlet spiked w/SF6	50/200	1	121C	S		140	625C
17:14			Toluene spike on to the inlet							
17:18-17:19	INLS2052	36 passes	Inlet spiked w/toluene 2 lpm	50/200	1	121C	S (tol)		143	625C
17:23-17:24	INLS2053	36 passes	Inlet spiked w/toluene 2 lpm	50/200	1	121C	S (tol)		143	625C
17:26-17:27	INLS2054	36 passes	Inlet spiked w/toluene 2 lpm	50/200	1	121C	S (tol)		143	625C
17:28			Toluene spike to the outlet @ 2.00lpm						110	
17:34-17:36	OUTS2047	36 passes	Outlet sample	50/200	1	121C	S(tol)		110	625C
17:38-17:40	OUTS2048	36 passes	Outlet sample	50/200	1	121C	S(tol)		110	625C
17:43-17:45	OUTS2049	36 passes	Outlet sample	50/200	1	121C	S(tol)		110	625C
17:48			Started SF6 spike to outlet @ 2.00 lpm							
17:52-17:54	OUTS2050	36 passes	Outlet sample	50/200	1	121C	S(SF6)		110	625C
17:56-17:58	OUTS2051	36 passes	Outlet sample	50/200	1	121C	S(SF6)		110	625C
18:01-18:03	OUTS2052	36 passes	Outlet sample	50/200	1	121C	S(SF6)		110	625C
18:04			Stop spike							
18:05			Nitrogen purge							
			*****Computer time 12 hrs behind - files from 6-25 am are logged as from 6/24 pm							

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:** 749.1 - 762 torr

PLANT: LTV **DATE:** 6/26/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES - (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
9:04			Inlet SF6 spike				SF6 @ 2lpm		140	
9:09-9:11	INLS3001	36 passes	Inlet sample	50/200	1	121	S		138	626B
9:16-9:18	INLS3002	36 passes	Inlet sample	50/200	1	121	S		138	626B
9:21-9:23	INLS3003	36 passes	Inlet sample	50/200	1	121	S		138	626B
9:26			Inlet toluene spike				tol @ 2 lpm		138	626B
9:31-9:33	INLS3004	36 passes	Inlet sample	50/200	1	121	S		138	626B
9:36-9:38	INLS3005	36 passes	Inlet sample	50/200	1	121	S		138	626B
9:39-9:41	INLS3006	36 passes	Inlet sample	50/200	1	121	S		138	626B
9:43			Outlet toluene spike				tol @ 2 lpm		90	626B
9:49-9:52	OUTS3001	36 passes	Outlet sample	50/200	1	121	tol @ 2 lpm		90	626B
9:56-9:59	OUTS3002	36 passes	Outlet sample	50/200	1	121	tol @ 2 lpm		90	626B
10:02-10:05	OUTS3003	36 passes	Outlet sample	50/200	1	121	tol @ 2 lpm		90	626B
10:18-10:21	OUTS3004	36 passes	Outlet sample	50/200	1	121	tol @ 2 lpm		90	626B
10:23-10:27	OUTS3005	36 passes	Outlet sample	50/200	1	121	tol @ 2 lpm		90	626B
10:28			Outlet SF6 spike						90	626B
10:34-10:37	OUTS3006	36 passes	Outlet sample	50/200	1	121	S		90	626B
10:40-10:43	OUTS3007	36 passes	Outlet sample	50/200	1	121	S		90	626B
10:45-10:49	OUTS3008	36 passes	Outlet sample	50/200	1	121	S		90	626B
10:55	16260004	36 passes	Inlet sample	50	1	121	U		total=95, cell ~7lpm	626B
	16260005		Process software - start (1 collection ~ 55 sec)					cell pres=	total=95, cell ~7lpm	626B
	16260006							753 mmHg		626B
11:25	16260034	36 passes	Stop inlet sample					@ 11:20		626B
11:29	16260038	36 passes	Outlet sample	50	1	121	U	753 mmHg	total=70, cell~5.5lpm	626B
11:55	16260065	36 passes	Stop outlet							626B
11:57	16260067	36 passes	Inlet sample	50	1	121	U	756 mmHg	total=80, cell~7.0lpm	626B
12:21	16260091	36 passes	Stop inlet							626B
12:24	16260093	36 passes	Start outlet sample	50/200	1	121	U	754.4	total=70, cell~5.5lpm	626B
12:32	16260101	36 passes	Probe out of outlet stack (port change)-last outlet sample							626B
12:35	16260103	36 passes	Inlet sample (changed glass wool plug@ 12:30)						total=140, cell~7lpm	626B
13:05	16260136	36 passes	Last inlet sample						total=110, cell~7lpm	626B
12:50			Outlet probe back in stack & box heaters turned							626B
			back on							

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:** 749.1 - 762 torr

PLANT: LTV **DATE:** 6/26/97 **OPERATOR:** Geyer / Honning

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
13:08	16260138	36 passes	Outlet sample	50/200	1	121C	U		total=90, cell~5lpm	626B
13:23			Cell pressure ~ 758							
13:33	16260164	36 passes	Last outlet sample	200						
13:39			Take new background							
14:00	16260165	36 passes	Inlet sample (start)	50	1	121C	U		total=100,cell~5lpm	626C
14:30	16260196	36 passes	Stop inlet							
14:33	16260199	36 passes	Outlet sample	50	1	121C	U		total=70,cell~5lpm	626C
15:03	16260231	36 passes	Stop outlet							
15:07	16260234	36 passes	Inlet sample	50	1	121C	U		total=85,cell~5lpm	626C
15:35	16260264	36 passes	Inlet stop							
15:39	16260268	36 passes	Outlet sample *spike w/ propane for THC cal*	50	1	121C	U		total=70,cell~5lpm	626C
15:49			spike w/propane off							
15:51	16260281	36 passes	Outlet off							
15:53			toluene spike - inlet							
15:59-16:01	INLS3007	36 passes	Inlet spike - toluene (static)	50	1	121	S		not recorded	626C
16:05-16:07	INLS3008	36 passes	Inlet spike - toluene (dynamic)	50	1	121	S		135	
16:09-16:11	INLS3009	36 passes	Inlet spike - toluene (static)	50	1	121	S		140	
16:14-16:16	INLS3010	36 passes	Inlet spike - toluene (static)	50	1	121	S		140	
16:17			SF6 spike - inlet							
16:23-16:25	INLS3011	36 passes	SF6 spike - inlet	50	1	121	S		140	
16:27-16:29	INLS3012	36 passes	SF6 spike - inlet	50	1	121	S		140	
16:31-16:33	INLS3013	36 passes	SF6 spike - inlet	50	1	121	S		140	
16:35			Outlet SF6 spike							
16:44-16:47	OUTS3009	36 passes	Outlet SF6 spike	50	1	121	S		100	
16:50	OUTS3010	36 passes	Outlet SF6 spike	50	1	121	S		100	
16:55-16:58	OUTS3011	36 passes	Outlet SF6 spike	50	1	121	S		100	
17:00			Outlet spike toluene 2 lpm							
17:06-17:09	OUTS3012	36 passes	Outlet spike toluene 2 lpm	50	1	121	S		100	
17:12-17:15	OUTS3013	36 passes	Outlet spike toluene 2 lpm	50	1	121	S		100	
17:17-17:20	OUTS3014	36 passes	Outlet spike toluene 2 lpm	50	1	121	S		100	

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:** 751 mm Hg -762

PLANT: LTV **DATE:** 6/27/97 **OPERATOR:** Henning/Bayes

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
8:35			Spike SF6 outlet @ 2 lpm							627B
8:43-8:46	OUTS4001	36 passes	Outlet sample	50/200	1	121	S		90	627B
8:49-8:51	OUTS4002	36 passes	Outlet sample	50/200	1	121	S		90	627B
8:53-8:55	OUTS4003	36 passes	Outlet sample	50/200	1	121	S		90	627B
8:57			Spike toluene outlet @ 2lpm							627B
9:02-9:04	OUTS4004	36 passes	Outlet sample	50/200	1	121	S		90	627B
9:06-9:08	OUTS4005	36 passes	Outlet sample	50/200	1	121	S		90	627B
9:11-9:13	OUTS4006	36 passes	Outlet sample	50/200	1	121	S			627B
9:14			spike toluene inlet @ 2lpm							627B
9:19-9:20	INLS4001	36 passes	Inlet sample	50/200	1	121	S		140	627B
9:24-9:25	INLS4002	36 passes	Inlet sample	50/200	1	121	S		140	627B
9:27-9:29	INLS4003	36 passes	Inlet sample	50/200	1	121	S		140	627B
9:30			Spike SF6 inlet @ 2lpm							627B
9:34	INLS4004	36 passes	Inlet sample	50/200	1	121	S		135	627B
9:38-9:39	INLS4005	36 passes	Inlet sample	50/200	1	121	S		135	627B
9:41-9:42	INLS4006	36 passes	Inlet sample	50/200	1	121	S		135	627B
9:49	16270001	36 passes	Start outlet - process software						total=75, cell~5lpm	627B
10:07								753 mm Hg	total=75, cell~5lpm	
10:18	16270032	36 passes	Stop outlet	50/200	1	121	S			627B
10:21	16270035	36 passes	Start inlet						total=70, cell~5lpm	627B
10:39									total=60, cell~5lpm	
10:51	16270066	36 passes	Stop inlet						total=60, cell~5lpm	627B
10:52			Changed inlet filter							
10:54	16270068	36 passes	Start outlet						total=70, cell~5lpm	627B
11:06	16270079		Stop @ outlet for port change (last good outlet file)							
11:07			Start fill @ inlet							
11:08	16270081	36 passes	First good spectrum from inlet	50/200	1	121	U		total=140, cell~7lpm	
11:42	16270117	36 passes	Stop at inlet							
11:40			Flow drop at the outlet after port change now only about 30							
11:44			Start sample to cell							
11:47	16270122	36 passes	First sample from outlet	50/200	1	121	U		total=90, cell~4lpm	
12:14	16270150	36 passes	Last outlet sample						total=90, cell~4lpm	
12:16	16270152	36 passes	First inlet sample						total=130, cell~6lpm	
12:46	16270184	36 passes	Last inlet sample						cell~4lpm	

FTIR FIELD DATA FORM

(FTIR Sampling Data)

PROJECT NO. 4701-08-11 **BAROMETRIC:** 751.6-742 torr

PLANT: LTV **DATE:** 6/27/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	SPIKED/ UNSPIKED	SAMPLE COND.	SAMPLE FLOW	BKG
12:45			Restart at last port							
12:49			Start filling with outlet sample							
12:50	16270186	36 passes	First outlet spectrum	50/200	1	121C			total=90, cell-5lpm	
			Started SF6 spike to outlet							
	16270188	36 passes	Stop continuous monitoring							
12:54-12:55	OUTS4007	36 passes	Outlet sample	50/200	1	121	S (SF6)		90	
12:56-12:58	OUTS4008	36 passes	Outlet sample	50/200	1	121	S (SF6)		90	
13:01-13:02	OUTS4009	36 passes	Outlet sample	50/200	1	121	S (SF6)		90	
13:03			Start toluene spike to outlet @ 2lpm				S(tol)			
13:06-13:08	OUTS4010	36 passes	Outlet sample	50/200	1	121	S(tol)		90	
13:11-13:12	OUTS4011	36 passes	Outlet sample	50/200	1	121	S(tol)		90	
13:15-13:16	OUTS4012	36 passes	Outlet sample	50/200	1	121	S(tol)		90	
13:16			Start toluene spike to inlet @ 2lpm							
13:21-13:22	INL4007	36 passes	Inlet sample	50/200	1	121	S(tol)		90	
13:24-13:26	INL4008	36 passes	Inlet sample	50/200	1	121	S(tol)		90	
13:27-13:29	INL4009	36 passes	Inlet sample	50/200	1	121	S(tol)		90	
13:30			Start SF6 spike to inlet							
13:35-13:37	INL4010	36 passes	Inlet sample	50/200	1	121	S(SF6)		90	
13:40-13:41	INL4011	36 passes	Inlet sample	50/200	1	121	S(SF6)		90	
13:43-13:45	INL4012	36 passes	Inlet sample	50/200	1	121	S(SF6)		85	

LTV Data Sheet for FTIR Sampling.

_____ Operator

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
6/23/97	1648-1649	INLA0000	36 passes	Ambient Sample Line 2/inlet Line 2 check.	50	1.0	121 C	Ambient	—		623 A
6/24/97	1333-1334	INLA1009	"	Ambient Air Line 2 Inlet							
	1257-1258	INLA1002		may be Contaminated w/ 2% propane cal			121 C	"	—		624B
				Ambient Air spiked open							
				Synchronized time with HC analyzers							
	1400	Probe in	@ Inlet	SF_6 spike @ 1 lpm						138 (#2)	
6/24/97	1402-1403	INLS1003	"	spiked w/ SF_6 @ 1.00 lpm		4 ppm	SF_6			138	624B
	1405-1406	INLS1004		" Probe out of Stack						138	"
	1408-1409	INLS1005	"	"	50/200	1.0	121 C	in Stack	—	137	"
	1411			Started toluene (121 ppm)	spike @	1.00	lpm	S			
	1416-1417	INL1006	"	Toluene @ 1.00 lpm				S		140	"
	1423-1424	INLS1007	"	"	50/200	1.0	121 C	S (Hot)	—	"	"
	1428-1429	INLS1008	"	"	"	"	"	"	"	"	"
	1430			Turned Toluene flow (spike) to 2.00 lpm						"	
	1435-1436	INLS1009	"	toluene spike @ 2.00 lpm	50/200	"	"	" 2 lpm	—	140	"
	1439-1441	INLS1010	"	"	"	"	"	"		"	"
	1443-1444	INLS1011		"							
6/24/97	1446			Turned on SF_6 spike @ 1446							
	1453-1454	INLS1012	"	SF_6 spike @ 1.95 lpm	50/200	1.0	"	"	—	140	"
	1454-1455	INLS1013	"								
	1457-1458	INLS1014	"								

LTV Data Sheet for FTIR Sampling.

_____ Operator

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
6/24/97	1503		SF6 to	[illegible] @ 2.00 lpm				SF6		110	
	1510-1512	OUTS1001		SF6 spike @ 2.00 lpm	50/200	1.0	121	SF6 2lpm	—	110	C2YB
	1514-1516	OUTS1002		"	"	"	"	"		110	"
	1519-1521	OUTS1003		"	"	"	"	"		110	"
	1524			Toluene out @ 2 lpm						110	"
	1531-1533	OUTS1004		"	"	"	"	Tol 2lpm		110	"
	1535-1537	OUTS1005		"	"	"	"	"		110	"
	1539-1541	OUTS1006		"	"	"	"	"		110	"
	Spike off @ 1545										
7/16	1603-1604	INLV1014	36 passes	Inlet unspiked	50/200	1.0	121 C	u	—	140	"
	1610-1612	INLV1015	"	"	50/200	1.0	121 C	u	—	140	"
JMH	1618-1620	INLV1016	"	"	50/200	1.0	121 C	u	—	100	"
"	1623-1625	INLV1017	"	"	50/200	1.0	121 C	u	—	100	"
Organic											
	1629-1631	INLV1018	"	Outlet unspiked	50/200	1.0	121 C	u	—	80	"
	1633-1635	INLV1019	"	"	50/200	1.0	121 C	u	—	80	"
	1637-1639	INLV1020	"	"	50/200	1.0	121 C	u	—	80	"
	1642-1644	INLV1021	"	"	"	"	"	"	—	80	"
				in outlet duct line, but pan called							
	No official Run today 6/24										

LTV Data Sheet for FTIR Sampling.

AP _____ Operator

Gain = 2R

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
6/28	0837			Outlet SF6 spike flow @ 2lpm				Spk		105	CO2SA
	0837-0840	OUTS2001	[illegible]	[illegible] "	50	10	121	Spk	—	107	"
	0842-0845	OUTS2002	"	"	"	"	"	"		"	"
	0848-0851	OUTS2003	"	"	"	"	"	"		"	"
	0852			Stop spike SF6							
	0852			Outlet Toluene spike @ 2lpm				Spk		"	"
	0859-0901	OUTS2004	"	"	"	"	"	"		"	"
	0904-0907	OUTS2005	"	"	"	"	"	"		"	"
	0910-0912	OUTS2006	"	"	"	"	"	"		"	"
	0915			finish outlet spk							
	0915			Inlet Toluene spike @ 2lpm							
	0923-0925	INS2001	"	" -flowthrough	"	"	"	"		85	"
	0928-0931	INS2002	"	" X	"	"	"	"		140	"
	0934-0936	INS2003	"	"	"	"	"	"		140	"
	0938-0941	INS2004	"	"	"	"	"	"		140	"
	0943			finish Toluene spk							
	0943			Inlet SF6 spike flow @ 2lpm				"			"
	0960-0963	INS2005		"	"	"	"	"		140	"
	0968-0968	INS2006		"	"	"	"	"		140	"
	1000-1002	INS2007		"	"	"	"	"		140	"
	1007			continuous flowthrough - outlet						~~[illegible]~~	
	1015	OUTS2007		Outlet unspike	"	"	"	"		~~[illegible]~~ 100	"
	1017-1020	OUTS2008		outlet unspike	"	"	"	"		100	"
	1023-1025	OUTS2009		Outlet unspike	"	"	"	"		100	"
	1028-1030	OUTS2010		"	"	"	"	"		100	"
	1033-1035	INS2008		Inlet unspike sample	"	"	"	"		120	"
	1037-1039	INS2009		"	"	"	"	"		120	"
	1040-1042	INS2010		"	"	"	"	"		85	"
	1044-1046	INS2011		"	"	"	"	"		70	"
	1048-1051	OUTS2011		Outlet sample	"	"	"	"		100	"
	1057-1059	OUTS2012		"	"	"	"	"		100	"
	1101-1103	OUTS2013		"	"	"	"	"		100	"
	1105-1108	OUTS2014		"	"	"	"	"		100	"
Inlet	1111-1113	INS2012		INLET sample	"	"	"	"		80	"
	1116-1118	INS2013		"	"	"	"	"		80	"
	1121-1123	INS2014		"	"	"	"	"		75	

6/28/17

Manual Sample Run started @ 9:30 } 1
1st Port change is 10:30
Restart @ 12:10 } 2

2nd Restart @ 14:05 } 3
3rd Port change @ 15:05
3rd Restart @ 16:00

LTV Data Sheet for FTIR Sampling.

_____ Operator

GAIN = 2R

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
JMH 6/25/97	1127-1129	INL2015		INLET Sample	50	1.0	121 C	U		75	625A
"	~~1127-1129~~ JMH										
"	1132-1134	OUT2015		Outlet Sample	50	1.0	121	U		100	"
	1137-1139	OUT2016		"	"	"	"	"		100	"
	1141-1143	OUT2017		"	"	"	"	"		"	"
	1145-1147	OUT2018		"	"	"	"	"			"
	12:10	flowed	hours	Restarted.							
	1217-1220	INL2020	36 pairs	Inlet Sample	50/200	1.0	121 C	U	—	140	625B
				Changed plug @ inlet @ 12:20							
	1224-1229	INLU2017	"	Inlet Sample	50/200	—	—				
	1228-1230	INLU2018									
	1232-1234	INLU2019									
6/25/96	1236-1238	OUTU2019	"	Outlet unspiked Sample						100	625B
	1241-1243	OUTU2020									
	1245-1246	OUTU2021									
	1248-1250	OUTU2022									
	1253-1254	INLU2020		INLET Sample						110	
	1257-1258	INLU2021									
	1301-1302	INLU2022								100	
	1304-1305	INLU2023								100 / 90	
	1309-1310	OUTU2023		Outlet Sample						100	
	1312-1314	OUTU2024		"	50/200	1.0	121 C	U	—	100	625B
	1316-1319	OUTU2025		"							
Alarm Outlet Probe	1320-1321	OUTU2026									
	1334			Change plug on inlet Probe.						140	
	1344-1335	INLU2024								140	625C
	1340			leak check @ outlet Probe is good.							
6/26	1347-1349	INLU2025	36 pairs	Inlet Sample	50/200	1.0	121 C	U		140	625C
	1351-1352	INLU2026									
	1354-1355	INLU2027								140	
		~~INLU2028~~									
	1356-1400	OUTU2027	"	Outlet Sample	50/200	1.0	121 C	U		95	625C

LTV Data Sheet for FTIR Sampling.

_____ Operator

Gain = 2K

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
11/25/97	1403 - 1404	OUTV 2028	36 passes	Outlet Sample	50/200	1.0	121 c	U	—	75	625 c
	1406 - 1407	OUTV2029									
	1410 - 1412	OUTV 2030								95	
	1416 - 1417	INLV2028		Inlet Sample	50	1.0	121 c	U		125	
	1419 - 1421	INLV2029		"						110	
	1424 - 1427	INLV2030		"						110	
	1429 - 1431	INLV2031		"						100	
	1435 - 1437	OUTV 2031		Outlet Sample						100	
	1440 - 1442	OUTV 2032		"						100	
	1444 - 1446	OUTV2033		"							
	1448 - 1450	OUTV2034		"							
	1454 - 1456	INLV2032		INLET SAMPLE						85	
	1458 - 1500	INLV2033		"						90	
	1503 - 1504	INLV2034		"						50	
	1507 - 1509	INLV2035		"						50	
	1512 - 1514	OUTV2035		OUTLET SAMPLE						100	
	1517 - 1519	OUTV2036		"						100	
	1521 - 1523	OUTV2037		"						100	
	1525 - 1527	OUTV2038		"						100	
										~~100~~ DN	
	1532 - 1534	INLV2036		Inlet Sample						140	
	1536 - 1538	INLV2037		"						140	
	1540 - 1542	INLV2038		"						140	
	1544 - 1546	INLV2039		"						150* - (THC off)	
	1549 - 1551	OUTV2039		OUTLET SAMPLE						110	
	1554 - 1556	OUTV 2040		"						110	
	1600 - 1602	OUTV2041		"						100	
	1605 - 1607	OUTV2042		"						100	
	1610 - 1612	INLV2040		INLET SAMPLE						~~110~~ 120	
	1615 - 1616	INLV 2041		"						120	
	1620 - 1622	INLV 2042		"						THC back	
off to	1624 - 1625	INLV2043		"						[illegible]	

1515 → Change to Inlet sample

LTV Data Sheet for FTIR Sampling.

Inlet Rotameter getting clouded with something solid and is difficult to read. JJG

_____ Operator

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
6/25/97	1631-1638	OUTU2043	36 passes	outlet sample.	50/200	1.0	121 C	Unspike	—	95	625C
	1636-1638	OUTU2044	"							→	
	1641-1643	OUTU2045								→	
JJG	1645-1647	OUTU2046		unit U 2044, 45, 46 were mistyped but are actually outlet spectra							
				were given these names.							
JJG	1652-1654	INLU2047	"	inlet Samples	50/200	1.0	121 C	unspike	—	100	625C
	1650-1651	INLU2048									
	1702	SF6	Spike on								
	1706-1707	INLS2049	36 p	Inlet spiked w/ SF6	50/200	1.0	121C	spiked	SF6 @ 2.00 lpm	140	625C
	1708-1710	INLS2050	"						→	140	
	1712-1713	INLS2051	"							→	625C
	1714		"	Toluene spike on. to the inlet.							
	1718-1719	INLS2052	"	Inlet sample spiked w/ Toluene			121C	S Tol	— @	2.00 lpm Flow 143	625C
	1723-1724	INLS2053	"	Toluene spike inlet @ 2.00 lpm						→	
	1726-1727	INLS2054	"	"						→	
	1728			Toluene Spike to the Outlet at 2.00 lpm.						110	
	1734-1736	OUTS2047	"	Outlet sample	50/200	1.0	121 C	S(Tol @ 2.00 lpm)		110	625C
	1738-1740	OUTS2048	"	"	"	"	"	"		110	"
	1743-1745	OUTS2049	"	"	"	"	"	"			"
	1748			Started SF6 spike in outlet @ 2.00 lpm.							
	1752-1754	OUTS2050		Outlet sample	50/200	1.0	121 C	S(SF6 @ 2 lpm)		110	625C
	1756-1758	OUTS2051		"	"	"	"	"		110	"
	1801-1803	OUTS2052		"	"	"	"	"		110	"
	1804			TSP spike							
	1805			Nitrogen purge							

☆ Computer time 12 hrs behind - files from 6/25 Am are logged as from 6/24 PM

LTV Data Sheet for FTIR Sampling.

_____ Operator

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow		BKG
6/26/97	0904			Inlet SF6 spike				SF6 @ 2lpm	–	140		
	0907-0911	INLS3001	36 Scans	Inlet Sample	50/200	1.0	121	Spk	–	138		6/26 B
	0916-0918	INLS3002	"	"	"	"	"	"		138		"
	0921-0923	INLS3003	"	"	"	"	"	"		138		"
	0926			Inlet Toluene Spike				Bre 2lpm		138		"
	0931-0933	INLS3004		Inlet Sample	50/200	1.0	121	Spk	—	138		"
	0936-0938	INLS3005	"	"	"	"	"	"	—	138		"
	0939-0941	INLS3006	"	"	"	"	"	"	—	138		"
	0943			Outlet Toluene Spike				Bre 2lpm		90		"
	0949-0952	OUTS3001	36 Scans	Outlet Sample	50/200	1.0	121	"	—	90		"
No spike	0956-0959	OUTS3002	"	"	"	"	"	"	—	90		"
	1002-1005	OUTS3003	"	"	"	"	"	"	—	90		"
	1008-1011	OUTS3004	"	"	"	"	"	"	—	90		"
	1013-1017	OUTS3005	"	"	"	"	"	"	—	90		"
	1018			Outlet SF6 spike						90		
	1034-1037	OUTS3006	"	Outlet Sample	"	"	"	"	—	90		"
	1040-1043	OUTS3007	"	"	"	"	"	"	—	90		"
	1045-1048	OUTS3008	"	"	"	"	"	"	—	90		"
										Total	Cell	
	1055	16260004	"	INLET SAMPLE	50	1.0	121	U	Cell pressure = 753 mmHg	95	~7.0 lpm	"
	↓	" 5		Picus Software - START								
		" 6		1 collection ≈ 55 sec					@ 11:20	95	~7.0 lpm	
	1125	16260034	"	STOP INLET SAMPLE								
										Total	Cell	
	1129	16260038		OUTLET Sample	"	"	"	U		70	~5.5 lpm	"
	1155	16260065		STOP OUTLET					Cell Press = 753			
	1157	16260067		INLET SAMPLE	"	"	"	U		80	~7.0 lpm	"
	1221	16260091		STOP INLET	"	"	"		Cell Press = 756			
	1224	16260093		Start outlet sample	50/200	"	"	"	754.4	70	5.5 lpm	6/26 B
No	1232	16260101		Probe out of outlet sample					changing Port.			
	1235	16260103		Inlet Sample					changed glass wool plug	140	~7 lpm	"
	1305	16260136		Port inlet Sample					@ 1230	110	~7 lpm	
	1250			outlet Probe back in stack &	Box heaters turned back on.							

Manual Start @ 9:55
1st Port Stop @ 10:55
2nd Port Start @ 11:25
2nd Port Stop @ 12:25

3rd Port Start 13:05
3rd Port Stop 14:05
4th Port Start 14:35

LTV Data Sheet for FTIR Sampling.

_____ Operator

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow (Total)	Sample Flow (cell)	BKG
6/26/97	1308	16260038	36 psig	Outlet Sample	50/200	1.0	121 C	UN	—	90	~5lpm	6/26 B
	1323			Cell Pressure	~258					70	5lpm	
	1333	16260164		Last outlet Sample	200							
	~~1344~~	1334		Take New background								
	1400	16260165		Inlet Sample (Start)	50	1.0	121 °C	U	-	100	~5lpm	6/26 C
	1430	16260196		STOP INLET								
	1433	16260199		OUTLET SAMPLE	50	1.0	121°C	U		70	~5lpm	"
	1503	16260231		stop outlet	50	1.0						
	1507	16260234		Inlet sample	50	1.0	121	U		85	~5lpm	"
	1535	16260264		INLET STOP								
	1539	16260268	*	OUTLET Sample*	50	1.0	121	U		70	~5lpm	"
	≈1541 Spike off			(*spike w/ Propane)								
				fill cell								
	1551	16260281		Outlet off								
	1553			Toluene Spike - Inlet								
	1551-1603	INLS3007	*	Inlet Spike - Toluene (Static)	50	1.0	121	S	Not Analyzed			"
	1605-1607	INLS3008		" (Dynamic)	50	1.0	121	S		135		
	1609-1611	INLS3009		Inlet Spike Toluene (Static)	50	"	"	"		140		
	1611-1616	INLS3010		"						140		
	1617			SF_6 Spike - Inlet								
	1623-1625	INLS3011		"					S	140		
	1627-1629	INLS3012		"					S	140		
	1631-1633	INLS3013		"					S	140		
	1635			Outlet SF_6 Spike								
	1644-1647	OUTS3004		"	"	"	"	"		100		
	1650-	OUTS3005		"	"	"	"	"		100		
	1655-1658	OUTS3011		"	"	"	"	"		100		
	1700			Outlet spike Toluene 24hr								
	1700-1709	OUTS3006		"	"	"	"	"		100		
	1712-1715	OUTS3013		"	"	"	"	"		100		
	1717-1720	OUTS3014		"	"	"	"	"		100		

* All continuous files copied to ~~Outlet ASF~~

LTV Data Sheet for FTIR Sampling.

_____ Operator 6/27/97 Barometric Pressure - 751 mm

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
6/27/97	0835			Spike SF6 Outlet @ 2lpm							06/27 B
	0843 0846	outs4001	36 Pass	Outlet Sample	50/200	1.0	121	Spk	—	90	"
	0848-0851	outs4002	"	"	"	"	"	"		90	"
	0853-0855	outs4003	"	"	"	"	"	"		90	"
	0857			Spike Toluene Outlet @ 2lpm							
	0901-0904	outs4004	"	Outlet Sample	"	"	"	"		90	"
	0906-0908	outs4005	"	"	"	"	"	"		90	"
	0911-0913	outs4006	"	"	"	"	"	"			"
	0914			Spike Toluene Inlet @ 2lpm							
	0914-0917	[illegible]	"	Inlet Sample	"	"	"	"		140	"
	0924-0925	INLS4002	"	"	"	"	"	"		140	"
	0927-0929	INLS4003	"	"	"	"	"	"		140	"
	0930			Spike SF6 Inlet @ 2lpm							
	0934-	INLS4004	36 Pass	Inlet Sample	50/200	1.0	121	Spk		135	"
	0940-0941	INLS4005	"	"	"	"	"	"		135	"
	0941-0942	INLS4006	"	"	"	"	"	"		135	"
										Total / Cell	
	949	16270001	"	START OUTLET Process software	"	"	"	"		75 / ~5.0lpm	"
	10:18 1018	16270032		STOP OUTLET					Cell Press = 753 mmHg	75 / ~5.0lpm @ 10:00	
										~~70 / 5.0lpm~~	
	1021	16270035		START INLET						70 / ~5.0lpm	
	1051	16270066		STOP INLET					10:39	60 / ~5.0lpm	
				10:52 Changed Inlet filter							
	1054	16270068		START OUTLET						70 / ~5.0lpm	

MANUAL

Run Start Port 1 - 840
Port change - 940
Port 2 - 1040

Port 3 - 11:25
Port change 12:25
Port 4 - 12:45

LTV Data Sheet for FTIR Sampling.

_____ Operator

Date	Sample time	File name	Path	Location/Notes	#scans	Res (cm-1	Cell Temp (F)	Spk/Unsp	Sample Cond.	Sample Flow	BKG
6/21/99	11:06	16270074		stop @ outlet for Port change			good outlet file				
	11:07			Start fill @ inlet.							
	11:08	16270088	36 passes	fill good spectrum from inlet	50/200	1.0	121 C	un	—	140	27 lpm
	11:42	16270117		stop at inlet							
	1140			flow drop at the Outlet after port change. now stay about 30							
	1144			Start sample to cell.		flow back up from outlet (11:44)					
	11:47	16270128	36	fill sample from Outlet.	50/200	1.0	121 C	un	—	90	4 lpm
	12:14	16270150		last outlet sample.						40	4 lpm
	12:16	16270152		first inlet sample						130	26 lpm
	12:46	16270184		last inlet sample							[illegible] lpm
	1245			Restart at last Port							
	1249			Start filling with outlet sample							
	1250	16270186	36	first outlet spectrum	50/200	1.0	121 C			90	5 lpm
	1250			Started SF6 spike to outlet			1.95 lpm				
		[illegible]		stop continuous Monitoring							
	1000 - 1255	OUT54007	36	outlet sample	50/200	1.0	121	Spk-Ska		90	
	1256 - 1258	OUT54008	"	"	"	"	"	"		90	
	1301 - 1304	OUT54009	"	"	"	"	"	"		90	
	1303			Start Toluene spike outlet		@ 200 lpm					
	1308 - 1310	OUT54010	"	outlet sample	"	"	"	"		90	
	1311 - 1313	OUT54011	"	"	"	"	"	"		90	
	1315 - 1316	OUT54012									
	1316			Start Toluene spike Inlet @ 200 lpm							
	1320 - 1322	IN14007	"	Inlet Sample	50/200	1.0	121	Spk-Ska		90	
	1324 - 1326	IN14008	"	"	"	"	"	"		90	
	1327 - 1329	IN14009	"	"	"	"	"	"		90	
	1330			Start SF6 spike Inlet							
	1335 - 1337	IN14010	"	Inlet Sample	"	"	"	"		90	
	1340 - 1341	IN14011	"	"	"	"	"	"		90	
	1343 - 1345	IN14012								85	

-1881 cell

FTIR FIELD DATA FORM

PROJECT NO. 4701-08-11 *(Background and calibration spectra.)* **BAROMETRIC:**

PLANT: LTV **DATE:** 6/23/1997-6/24/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	PRESSURE	BKG	APOD	NOTES
16:28	BKG0623A	36 passes	N2 flow through cell	200	1	121C	751.6		NB/med	
16:39	CTS0623A	36 passes	20.01 ppm ethylene	50/200	1	121C	750	A	NB/med	
17:09	SF60423A	36 passes	4.0 ppm SF6	50/200	1	121C	749.2	623A	NB/med	
6/24/97			Barometric Pressure				748.9			
			Vacuum leak check							
			T=0, P=3.2 torr							
			T=1min., P=14.4torr	4% = ~ 33 torr						
			T=2 min, P=23.2 torr							
9:39	BKG0624A	36 passes	N2 ~ 2lpm through cell	200	1	121C	749.9torr		NB/med	
9:50	CTS0624A	36 passes	20.01 ppm ethylene	50/200	1	121C	750	624A	NB/med	flow @ 5lpm
9:55	CTS0624B	36 passes	20.01 ppm ethylene 2nd fill	50/200	1	121C	750	624A	NB/med	flow @ 5lpm
11:25	121 a,b,c,d,e		Toluene regulator(540) had some contamination that is being purged out - contamination mostly gone							
12:50	1530624a	36 passes	Toluene 121 ppm	50/200	1	121C		A	NB/med	
12:56	1530624b	36 passes	Toluene 121 ppm	still some contamination						
12:04	SF60624a		4.0 ppm SF6	50/200	1	121C	750.5	624A	NB/med	flow @ 4lpm
12:15	BKG0624B		N2 4 lpm through cell	200	1	121C	749.9		NB/med	

FTIR FIELD DATA FORM

PROJECT NO. 4701-08-11 *(Background and calibration spectra.)* **BAROMETRIC:** 747.0 mmHg

PLANT: LTV **DATE:** 6/25/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	PRESSURE	BKG	APOD	NOTES
	BKG0625A	36 passes	N2 flowing	200	1	121C	748.5		NB/med	
8:17	CTS0625A	36 passes	20 ppm ethylene (Taylor barometer)	50/200	1	121C	748.5	625A	NB/med	
8:41			Taylor Barometer x-2409				747			
12:10	BKG0625B	36 passes	Slightly wetter than A	200	1	121C	747.6		NB/med	
12:14	NIT01		Nitrogen in cell compared to 625B							
13:40	BKG625C	36 passes	Dryer than B	200	1	121C	755		NB/med	
18:36	BKG625D	36 passes	N2	200	1	121C	747.3		NB/med	
18:40	CTS0625B	36 passes	Ethylene	200	1	121C	746.7	625D	NB/med	

FTIR FIELD DATA FORM

(Background and calibration spectra.)

PROJECT NO. 4701-98-11 **BAROMETRIC:**

PLANT: LTV **DATE:** 6/26/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	PRESSURE	BKG	APOD	NOTES
7:43	BKG0626A	36 passes	N2 through cell	200	1	121C	750.3		NB/med	
7:46	CTS0626A	36 passes	20 ppm ethylene	50/200	1	121C	751.1	626A	NB/med	
8:30	BKG0626B	36 passes	N2 through cell	200	1	121C	751.1		NB/med	
13:47	BKG0626C	36 passes	N2 through cell	200	1	121C	762		NB/med	
17:33	BKG0626D	36 passes	N2 through cell	200	1	121C	753		NB/med	
17:45	CTS0626B	36 passes	N2 through cell	200	1	121C	749.1	626D	NB/med	

FTIR FIELD DATA FORM

PROJECT NO. 4701-08-11 *(Background and calibration spectra.)* **BAROMETRIC:**

PLANT: LTV **DATE:** 6/27/97 **OPERATOR:** Geyer

SAMPLE TIME	FILE NAME	PATH		NUMBER SCANS	RES (cm-1)	CELL TEMP (F)	PRESSURE	BKG	APOD	NOTES
7:34	BKG0627A	36 passes	N2 through cell	200	1	121C	752.3		NB/med	
7:40	CTS0627A	36 passes	20 ppm ethylene	50	1	121C	752.9	627A	NB/med	
7:45	CTS0627B	36 passes	20 ppm ethylene	50	1	121C	751.6	627A	NB/med	
8:38	BKG0627B	36 passes	N2 through cell	200	1	121C	753.2		NB/med	
13:53	BKG0627C	36 passes	N2 through cell	200	1	121C	751.6		NB/med	
	CTS0627C	36 passes	20 ppm ethylene	50	1	121C	752.2	627C	NB/med	

Background and calibration spectra.

_____ Operator

	Date	Time	File Name	Path	Location/Notes	#scans	Res (cm-1)	Cell temp (F)	Pressure	BKG	Apod	Notes
	6/23/97	1628	BK606 23A	36 passes	N_2 flow through cell	200	1.0	121 C	751.6	—	NB/med	
		1639	CTS0623A	"	20.01 ppm ethylene	50/200	"	"	750.0	A	"	
		1707	SF6 06/23A	"	4.0 ppm SF_6	50/200	"	"	749.2	623A	"	
	6/24/97								748.9			
		Vacuum	leak check		T=0 P = 3.2 torr							
					T=1 min P = 14.4 torr			4% = ~ 33 torr				
					T=2 min P = 23.2 torr							
		9:39	BK0624A	36 passes	N_2 ~ 2 lpm through cell	200	1.0	121 C	749.9 torr	—	NB/med	
		9:50	CTS0624A	"	20.01 ppm ethylene	50/200	1.0	"	750.0	624A	"	flow through (a) 5 lpm
		9:55	CTS0624B	"	" 2nd fill	"	"	"	"	"	"	"
		11:25			Toluene Regulator (540) had some contamination in the lines giving pungent odor.							
			121 a, b, c	p^2, one	Contamination mostly gas.							
		1250	1530624a	36 passes	Toluene 121 ppm	50/200	1.0	121 C		A	NB/med	
		1256	1530624b		" "	"		still some contamination.				2nd fill.
		1204	SF6 0624a	"	4.0 ppm SF_6	"	flow through @ 4 lpm		750.5	624a	NB/med	
		1215	BK0624B	"	N_2 4 lpm through cell	200	1.0	121 C	749.9	—	"	
	6/25/97		BK0625A	36 passes	N_2 flowing	200	1.0	121 C	748.5	—	NB/med	—
		0817	~~[illegible]~~ CTS0625A	"	20 ppm ethylene	50/200	"	"	"	625A	"	—
		0841			Taylor Barometer	2-2489			742.0			
		1210	BK0625B	"	slightly with flow A	200	1.0	121 C	741.6	—	NB med	—
		1217	NIT01		nitrogen in cell	compared to 625B						
		1340	BK0625C	"	Dryer than B	200	1.0	121 C	755.0	—	"	—
		1836	BK0625D	"	N_2	200	1.0	121 C	741.3	—	NB/med	—
		1840	CTS0625B	"	Ethylene	200	1.0	121 C	746.7	—	NB/med	—

AQ Parm load LTV

Background and calibration spectra.

_____ Operator

Date	Time	File Name	Path	Location/Notes	#scans	Res (cm-1)	Cell temp (F)	Pressure	BKG	Apod	Notes
6/26/97	743	BK60626A	30 psi	N_2 through Cell	200	1.0	121 C	750.3	—	NB/med	
	746	CTS0626A	"	20 ppm Ethylene	50/50	"	"	751.1	626A	"	
	930	BK60626B	"	N_2 through cell	200	"	"	"	"	"	
	1347	BK60626C	"	"	"	"	"	762	—	"	
	1733	BK0626(D)	"	"	"	"	"	753	—	NB/med	—
	1745	CTS0626B						749.1			
6/27/97	734	BK60627A	30 psi	N_2 through Cell	200	1.0	121 C	752.3	—	NB/med	—
	740	CTS0627A	"	20 ppm Ethylene	50	"	"	752.9	627A	"	
	745	CTS0627B	"	"	"	"	"	751.6	"	"	
	938	BK60627B	"	N_2 through cell	200	"	"	753.2	—	"	—
	1353	BK60627C	"	N_2	200	1.0	121	751.6	—	"	
		CTS0627C	"	20 ppm Ethylene	50	"	121	752.2	—	"	

B-2 FTIR FLOW AND TEMPERATURE READINGS

L. Steel

RUN NO. 2 SAMPLING LOCATION Sinter Plant Scrubber inlet p. 1 of 6

DATE 6/25/97 PROJECT NO. OPERATOR L. Henning / T. Geyer

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft³ INITIAL		* VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		* STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VAC., in. Hg	IMPINGER TEMP., °F	* SAMPLE BOX TEMP., °F	* PROBE TEMP., °F	FILTER TEMP., °F		
		DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F							
	0920			2.9			217					305	298			
	0950			2.9			211					305	300			
	1025			2.7			212					302	305			
	1055			2.6			214					305	299			
	1125			2.7			218					304	302			
	1155			2.8			221					305	302			
	1225			2.7			223					304	297			
	1255			2.7			218					305	299			
	1425			2.8			219					305	301			
	1455			2.6			248					305	301			
	1525			2.7			237					305	302			
	1555			2.7			238					306	301			
	1625			2.6			229					305	302			
	1655			2.7			236					305	300			

COMMENTS

LTV Steel

RUN NO. 2 | SAMPLING LOCATION Sinter Plant Stack -OUTLET | p. 2 of 6

DATE 6/25/97 | PROJECT NO. | OPERATOR L. Henning/ T. Geyer

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft³ INITIAL _____ DESIRED	ACTUAL	* VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ACTUAL	* STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\ in}$), °F	OUTLET ($T_{m\ out}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	* SAMPLE BOX TEMP., °F	* PROBE TEMP., °F	FILTER TEMP., °F		
	0820			0.82			117				279	302	302			
	0950			0.78			116					320	278			
	1025			0.75			117					302	300			
	1055			0.78			117					300	298			
	1125			0.81			116					300	298			
	1155			0.77			117					300	302			
	1225			0.73			117					300	298			
	1255			0.73			117					299	298			
	1325			0.85			119					301	298			
	1455			0.86			117					302	301			
	1525			0.79			119					300	301			
	1555			0.68			119					300	300			
	1625			0.72			119					300	303			
	1655			0.70			119					300	303			

COMMENTS

RUN NO. 3 SAMPLING LOCATION LTU Steel Sinter Plant Scrubber Inlet p. 3 of 6

DATE 6/26/97 PROJECT NO. OPERATOR T. Geyer

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft³ INITIAL		VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
		DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F							
	10:20			3.5			218					305	299			
	10:50			3.5			219					305	301			
	11:20			3.4			230					305	301			
	11:50			3.5			231					305	298			
	12:20			3.4			245					305	301			
	12:52			3.5			237					306	301			
	13:22			2.7			231					305	299			
	13:50			2.7			233					305	302			
	14:20			2.5			223					305	299			
	14:50			2.7			215					305	301			
	15:20			2.6			214					305	300			

COMMENTS

RUN NO. 3 SAMPLING LOCATION LTV Steel Sinter Plant Stack p. 4 of 6

DATE 6/26/97 PROJECT NO. OPERATOR T. Geyer

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft^3 INITIAL		VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
		DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F							
	10:20			0.74			116					299	302			
	10:50			0.76			115					300	301			
	11:20			0.72			117					300	298			
	11:50			0.76			118					277	301			
	12:20			0.55			118					300	302			
	12:52			out/out Probe out of Stack for Port change												
	13:22			0.77			118					302	300			
	1350			0.81			118					299	300			
	14:20			0.72			117					300	299			
	14:50			0.74			116					301	299			
	1520			0.86			116					300	298			

COMMENTS

RUN NO. 4 SAMPLING LOCATION LTV Steel Sinter Plant Scrubber Inlet p. 5 of 6

DATE 27 Jun 97 PROJECT NO. OPERATOR L. Henning / T. Geyer

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft³ INITIAL		VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
		DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F							
	0905			2.9			195						300	305		
	0935			2.6			212						306	302		
	1005			2.6			202						294	305		
	1035			2.6			208						304	300		
	11:10			2.7			191						300	305		
	11:38			2.8			196						299	306		
	12:07			2.7			190						304	305		
	12:37			2.8			187						305	301		
	13:07			2.7			207						305	301		
	13:37			2.6			209						305	302		

COMMENTS

RUN NO. 4 SAMPLING LOCATION LTV Steel Sinter Plant Stack p. 6 of 6

DATE 27JUN97 PROJECT NO. OPERATOR L. Henning / T. Geyer

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft^3 INITIAL		VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F		
		DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F							
	0905			0.85			115						300	301		
	0935			0.84			115						300	300		
	1005			0.91			116						303	300		
	1035			0.84			114						300	303		
	1110		Probe out for		Port change..											
	11:38			.65			114						300	207		
	12:07			.76			114						303	303		
	12:37			0.72			115						300	302		
	13:07			0.72			116						300	302		
	13:37			0.70			118						300	297		

COMMENTS

just turned back on

B-3 FTIR RESULTS

TABLE B-1. FTIR RESULTS (ppm) AND EMISSION RATES AT THE LTV SCRUBBER INTLET [a]

Date	Time	File Name [b]	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
6/25/97	9:27	NLS2001	736.7	8.5	14.22	71.2	1.7	3.14	5.6	0.5	0.116	14.5	0.3	0.160	1.6	0.2
	9:33	NLS2002	774.3	9.3	14.95	85.5	1.8	3.77	4.8	0.5	0.099	15.5	0.3	0.171	2.3	0.2
	9:37	NLS2003	788.0	9.6	15.21	82.8	1.9	3.66	4.1	0.5	0.085	16.2	0.4	0.178	2.4	0.2
	9:43	NLS2004	779.6	9.4	15.05	81.7	1.9	3.61	5.9	0.5	0.123	15.4	0.4	0.170	2.4	0.2
	9:54	NLS2005	811.6	10.1	15.67	86.7	2.0	3.83	3.8	0.5	0.079	15.8	0.4	0.174	3.0	0.2
	9:58	NLS2006	815.3	10.2	15.74	96.5	2.0	4.26	3.8	0.5	0.078	15.5	0.4	0.171	3.1	0.2
	10:02	NLS2007	810.1	10.0	15.64	100.8	2.0	4.45	3.4	0.5	0.071	15.2	0.4	0.168	3.1	0.2
	10:36	NLV2008	874.2	11.5	16.87	118.3	2.2	5.22	5.4	0.57	0.113	17.9	0.40	0.197	3.3	0.3
	10:39	NLV2009	851.7	11.4	16.44	98.0	2.2	4.33	4.3	0.57	0.088	16.8	0.40	0.185	3.4	0.3
	10:43	NLV2010	846.4	11.2	16.34	91.5	2.2	4.04	3.9	0.59	0.082	16.9	0.41	0.187	3.4	0.3
	10:47	NLV2011	853.7	11.2	16.48	102.8	2.2	4.54	4.1	0.58	0.084	16.8	0.41	0.186	3.5	0.3
	11:13	NLV2012	811.4	10.4	15.66	110.0	2.1	4.85	5.3	0.56	0.109	16.4	0.40	0.181	3.2	0.3
	11:18	NLV2013	801.9	10.5	15.48	102.1	2.2	4.51	4.9	0.57	0.102	16.3	0.40	0.180	3.4	0.3
	11:24	NLV2014	811.6	10.7	15.67	91.2	2.2	4.02	5.8	0.58	0.119	16.7	0.41	0.185	3.6	0.3
	11:29	NLV2015	818.0	10.9	15.79	93.0	2.2	4.10	5.3	0.59	0.110	16.8	0.42	0.186	3.6	0.3
	12:20	NLV2016	842.6	10.8	16.27	80.3	2.2	3.54	8.8	0.62	0.182	24.2	0.43	0.267	1.8	0.3
	12:26	NLV2017	858.5	11.2	16.57	81.8	2.3	3.61	7.7	0.64	0.159	25.6	0.44	0.282	2.1	0.3
	12:30	NLV2018	854.5	11.4	16.50	86.5	2.3	3.82	7.1	0.64	0.146	25.2	0.44	0.278	2.3	0.3
	12:34	NLV2019	861.5	11.5	16.63	92.4	2.3	4.08	6.9	0.66	0.143	24.5	0.46	0.270	2.4	0.3
	12:54	NLV2020	826.7	11.0	15.96	123.9	2.2	5.47	6.0	0.63	0.125	19.5	0.44	0.216	2.4	0.3
	12:59	NLV2021	858.2	11.5	16.57	137.9	2.3	6.08	6.3	0.65	0.130	20.5	0.45	0.227	2.7	0.3
	13:03	NLV2022	837.6	11.1	16.17	114.9	2.3	5.07	6.1	0.65	0.126	20.3	0.45	0.224	2.7	0.3
	13:06	NLV2023	843.7	11.3	16.29	105.0	2.3	4.63	6.2	0.65	0.128	19.8	0.46	0.219	2.9	0.3
	13:46	NLV2024	824.5	11.1	15.92	76.8	2.3	3.39	5.5	0.65	0.115	18.5	0.46	0.204	2.3	0.3
	13:49	NLV2025	818.4	10.8	15.80	64.4	2.3	2.84	5.6	0.65	0.117	18.0	0.45	0.199	2.6	0.3
	13:52	NLV2026	816.0	11.0	15.75	71.7	2.3	3.17	5.5	0.65	0.114	17.7	0.45	0.195	2.8	0.3
	13:56	NLV2027	820.3	11.2	15.83	91.7	2.3	4.05	5.4	0.65	0.112	17.5	0.45	0.193	2.8	0.3
	14:17	NLV2028	814.3	10.9	15.72	75.9	2.3	3.35	6.5	0.67	0.134	16.9	0.47	0.186	2.9	0.3
	14:21	NLV2029	829.2	11.7	16.01	63.6	2.4	2.81	5.9	0.70	0.121	17.2	0.49	0.190	3.1	0.3
	14:27	NLV2030	867.3	12.2	16.74	77.9	2.5	3.44	10.2	0.72	0.212	17.6	0.50	0.194	3.1	0.3
	14:32	NLV2031	881.8	12.6	17.02	103.1	2.5	4.55	7.7	0.73	0.159	17.8	0.51	0.196	3.4	0.3
	14:56	NLV2032	783.6	10.5	15.13	100.7	2.2	4.44	7.6	0.65	0.157	15.4	0.45	0.169	2.7	0.3
	15:00	NLV2033	788.4	10.6	15.22	85.2	2.2	3.76	6.9	0.65	0.144	15.8	0.46	0.175	2.9	0.3
	15:05	NLV2034	799.1	10.9	15.43	84.7	2.3	3.74	7.0	0.68	0.145	16.2	0.47	0.179	3.0	0.3
	15:09	NLV2035	815.2	11.3	15.74	91.6	2.3	4.04	6.9	0.68	0.142	16.8	0.47	0.186	3.2	0.3
	15:34	NLV2036	814.5	11.2	15.72	97.9	2.3	4.32	6.2	0.72	0.129	17.1	0.50	0.188	2.7	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name [b]	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	15:38	NLV2037	807.8	11.2	15.59	84.9	2.4	3.75	5.3	0.71	0.110	17.3	0.49	0.190	2.9	0.3
	15:42	NLV2038	813.6	11.4	15.71	83.7	2.4	3.69	5.9	0.70	0.122	16.6	0.49	0.183	3.0	0.3
	15:46	NLV2039	813.5	11.2	15.70	104.9	2.3	4.63	4.9	0.69	0.101	16.5	0.48	0.182	2.9	0.3
	16:13	NLV2040	808.8	11.0	15.61	80.2	2.3	3.54	5.6	0.70	0.115	16.4	0.49	0.181	2.7	0.3
	16:17	NLV2041	808.7	11.0	15.61	85.7	2.3	3.78	5.1	0.70	0.107	16.6	0.49	0.183	2.9	0.3
	16:22	NLV2042	817.2	11.1	15.77	88.7	2.3	3.91	5.2	0.69	0.109	17.0	0.48	0.187	3.0	0.3
6/25/97	16:26	NLV2043	818.3	11.3	15.80	85.6	2.3	3.78	5.3	0.71	0.110	17.5	0.50	0.193	3.1	0.3
	16:54	NLV2047	818.1	11.3	15.79	114.7	2.4	5.06	5.5	0.7	0.114	16.9	0.5	0.186	3.0	0.3
	16:58	NLV2048	823.8	11.5	15.90	114.5	2.4	5.05	5.4	0.7	0.113	16.7	0.5	0.185	3.3	0.3
	17:07	NLS2049	712.2	8.9	13.75	88.4	1.9	3.90	4.7	0.6	0.097	13.8	0.4	0.153	2.4	0.3
	17:10	NLS2050	712.9	9.1	13.76	78.6	2.0	3.47	3.7	0.6	0.077	13.8	0.4	0.152	2.7	0.3
	17:14	NLS2051	721.2	9.3	13.92	71.8	2.1	3.17	5.1	0.6	0.106	14.4	0.4	0.159	2.8	0.3
	17:20	NLS2052	741.9	9.4	14.32	84.3	2.0	3.72	4.2	0.6	0.086	15.3	0.4	0.168	2.0	0.3
	17:24	NLS2053	734.1	9.3	14.17	80.7	2.0	3.56	4.3	0.6	0.090	15.5	0.4	0.171	2.0	0.3
	17:27	NLS2054	726.1	9.3	14.02	74.8	2.0	3.30	4.3	0.6	0.088	15.4	0.4	0.170	2.1	0.3
		Average -->	827.8	11.2	15.98	93.6	2.3	4.13	6.0	0.66	0.125	18.1	0.46	0.200	2.9	0.3

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
6/26/97	9:11	NLS3001	767.0	8.7	14.81	114.4	1.7	5.05	8.0	0.4	0.165	15.4	0.3	0.170	1.8	0.2
	9:18	NLS3002	753.1	8.6	14.54	101.1	1.7	4.46	5.7	0.4	0.118	14.5	0.3	0.160	1.9	0.2
	9:22	NLS3003	768.8	9.0	14.84	106.8	1.8	4.71	4.7	0.4	0.098	14.4	0.3	0.159	2.0	0.2
	9:34	NLS3004	764.6	8.9	14.76	73.6	1.7	3.25	5.7	0.4	0.119	14.2	0.3	0.157	1.5	0.2
	9:38	NLS3005	800.2	9.6	15.45	97.7	1.8	4.31	4.4	0.5	0.091	15.0	0.3	0.166	1.7	0.2
	9:42	NLS3006	781.5	9.3	15.09	107.0	1.8	4.72	4.8	0.5	0.099	15.3	0.3	0.169	1.7	0.2
	10:55	16260004	847.2	10.7	16.35	120.3	2.1	5.31	2.3	0.53	0.047	17.4	0.37	0.192	2.7	0.2
	10:56	16260005	851.7	10.9	16.44	121.0	2.2	5.34	2.2	0.54	0.045	17.5	0.38	0.193	2.9	0.2
	10:57	16260006	860.3	11.2	16.61	123.3	2.2	5.44	2.3	0.54	0.047	17.7	0.38	0.195	3.1	0.2
	10:58	16260007	862.8	11.1	16.66	124.0	2.2	5.47	2.3	0.54	0.048	17.7	0.38	0.195	3.3	0.2
	10:59	16260008	860.0	11.1	16.60	123.9	2.2	5.47	2.3	0.55	0.048	17.8	0.38	0.197	3.3	0.2
	11:00	16260009	861.7	11.1	16.63	123.1	2.2	5.43	2.4	0.55	0.049	18.0	0.38	0.198	3.5	0.3
	11:00	16260010	870.8	11.5	16.81	120.6	2.2	5.32	2.4	0.57	0.049	18.1	0.40	0.200	3.6	0.3
	11:01	16260011	870.0	11.3	16.79	115.6	2.2	5.10	2.4	0.56	0.050	18.1	0.39	0.200	3.7	0.3
	11:02	16260012	872.9	11.3	16.85	110.5	2.2	4.87	2.3	0.58	0.048	18.2	0.40	0.201	3.7	0.3
	11:03	16260013	882.1	11.6	17.03	105.8	2.2	4.67	2.3	0.58	0.048	18.4	0.40	0.203	3.9	0.3
	11:04	16260014	881.5	11.5	17.02	99.8	2.2	4.41	2.3	0.57	0.047	18.5	0.40	0.204	3.9	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	11:05	16260015	888.8	11.7	17.16	96.4	2.3	4.25	2.2	0.58	0.045	18.5	0.41	0.205	4.0	0.3
	11:06	16260016	892.4	12.0	17.23	95.5	2.3	4.21	2.3	0.59	0.047	18.6	0.41	0.206	4.0	0.3
	11:07	16260017	894.4	12.0	17.27	98.0	2.3	4.32	2.4	0.59	0.049	18.8	0.41	0.207	4.1	0.3
	11:08	16260018	898.1	12.1	17.34	102.4	2.3	4.52	2.4	0.59	0.049	19.0	0.41	0.209	4.2	0.3
	11:09	16260019	897.3	12.0	17.32	108.4	2.3	4.78	2.4	0.59	0.050	18.9	0.41	0.208	4.2	0.3
6/26/97	11:09	16260020	901.1	12.3	17.40	115.6	2.3	5.10	2.5	0.60	0.052	18.9	0.42	0.209	4.3	0.3
	11:10	16260021	900.2	12.2	17.38	124.2	2.3	5.48	2.5	0.60	0.052	18.9	0.42	0.208	4.3	0.3
	11:11	16260022	898.7	12.0	17.35	132.1	2.3	5.83	2.6	0.58	0.055	18.9	0.41	0.209	4.3	0.3
	11:12	16260023	892.9	11.9	17.24	136.5	2.3	6.02	2.7	0.59	0.055	18.8	0.41	0.208	4.3	0.3
	11:13	16260024	890.8	12.0	17.20	136.7	2.3	6.03	2.7	0.58	0.057	18.7	0.41	0.207	4.4	0.3
	11:14	16260025	882.3	11.9	17.03	135.0	2.3	5.96	2.8	0.58	0.057	18.6	0.41	0.205	4.4	0.3
	11:15	16260026	884.0	11.9	17.07	131.2	2.3	5.79	2.9	0.58	0.059	18.4	0.40	0.203	4.4	0.3
	11:16	16260027	865.4	11.5	16.71	121.6	2.2	5.36	2.8	0.57	0.057	18.2	0.40	0.201	4.4	0.3
	11:17	16260028	861.1	11.4	16.62	111.9	2.2	4.94	2.7	0.57	0.057	18.0	0.40	0.198	4.4	0.3
	11:18	16260029	860.6	11.5	16.61	106.2	2.2	4.69	2.7	0.57	0.055	18.0	0.40	0.198	4.4	0.3
	11:19	16260030	850.2	11.1	16.41	103.6	2.2	4.57	2.6	0.57	0.054	17.9	0.40	0.197	4.4	0.3
	11:20	16260031	846.2	11.0	16.33	104.0	2.2	4.59	2.6	0.57	0.054	17.9	0.40	0.197	4.4	0.3
	11:21	16260032	850.3	11.1	16.41	106.4	2.2	4.70	2.6	0.57	0.054	18.1	0.40	0.199	4.5	0.3
	11:21	16260033	852.1	11.2	16.45	107.6	2.2	4.75	2.7	0.57	0.056	18.2	0.39	0.201	4.5	0.3
	11:22	16260034	855.1	11.2	16.51	110.0	2.2	4.85	2.7	0.57	0.056	18.2	0.40	0.201	4.5	0.3
	11:57	16260067	846.8	11.0	16.35	100.8	2.2	4.45	3.2	0.59	0.065	20.7	0.41	0.228	3.6	0.3
	11:58	16260068	849.8	11.1	16.41	100.4	2.2	4.43	3.4	0.60	0.071	20.8	0.42	0.230	3.8	0.3
	11:59	16260069	845.5	11.0	16.32	98.5	2.2	4.35	3.5	0.59	0.073	20.9	0.41	0.231	3.9	0.3
	12:00	16260070	850.4	11.0	16.42	95.7	2.2	4.22	3.7	0.59	0.076	21.2	0.41	0.234	3.9	0.3
	12:01	16260071	848.2	11.0	16.37	94.1	2.2	4.15	3.7	0.59	0.077	21.5	0.41	0.237	4.0	0.3
	12:02	16260072	854.6	11.3	16.50	95.2	2.2	4.20	3.8	0.58	0.080	21.8	0.41	0.241	4.1	0.3
	12:02	16260073	862.1	11.3	16.64	96.4	2.3	4.25	3.9	0.60	0.081	22.1	0.42	0.244	4.2	0.3
	12:03	16260074	866.0	11.5	16.72	96.9	2.2	4.28	4.0	0.60	0.083	22.3	0.42	0.246	4.2	0.3
	12:04	16260075	863.1	11.1	16.66	95.9	2.3	4.23	4.1	0.60	0.085	22.3	0.42	0.246	4.3	0.3
	12:05	16260076	866.3	11.2	16.72	94.4	2.3	4.17	4.2	0.59	0.087	22.5	0.41	0.249	4.3	0.3
	12:06	16260077	862.8	11.1	16.65	93.4	2.2	4.12	4.2	0.59	0.088	22.7	0.41	0.250	4.4	0.3
	12:07	16260078	878.7	11.6	16.96	93.0	2.3	4.10	4.3	0.60	0.088	22.9	0.42	0.253	4.4	0.3
	12:08	16260079	871.0	11.3	16.81	91.9	2.3	4.06	4.5	0.59	0.093	23.0	0.41	0.254	4.4	0.3
	12:09	16260080	871.5	11.2	16.82	92.5	2.2	4.08	4.5	0.59	0.094	23.3	0.41	0.257	4.5	0.3
	12:10	16260081	878.9	11.5	16.97	92.9	2.3	4.10	4.8	0.60	0.099	23.3	0.42	0.257	4.5	0.3
	12:10	16260082	877.9	11.5	16.95	93.1	2.3	4.11	4.8	0.59	0.100	23.5	0.41	0.259	4.5	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	12:11	16260083	876.2	11.6	16.91	92.3	2.3	4.07	4.9	0.59	0.101	23.6	0.41	0.260	4.5	0.3
	12:12	16260084	877.3	11.3	16.94	91.7	2.3	4.05	4.9	0.60	0.102	23.6	0.42	0.261	4.6	0.3
	12:13	16260085	876.6	11.5	16.92	90.4	2.3	3.99	5.0	0.60	0.103	23.6	0.42	0.260	4.5	0.3
	12:14	16260086	873.8	11.3	16.87	89.3	2.3	3.94	5.0	0.60	0.103	23.7	0.42	0.261	4.6	0.3
	12:15	16260087	876.5	11.6	16.92	87.9	2.3	3.88	5.0	0.60	0.103	23.8	0.42	0.263	4.6	0.3
6/26/97	12:16	16260088	874.4	11.3	16.88	86.9	2.3	3.84	4.9	0.60	0.102	23.9	0.42	0.263	4.6	0.3
	12:17	16260089	867.5	11.2	16.75	86.1	2.3	3.80	4.9	0.62	0.102	23.8	0.43	0.262	4.5	0.3
	12:18	16260090	870.2	11.2	16.80	85.6	2.3	3.78	4.8	0.61	0.100	23.8	0.43	0.262	4.6	0.3
	12:19	16260091	871.4	11.3	16.82	85.5	2.3	3.77	4.8	0.61	0.100	24.0	0.43	0.265	4.6	0.3
	12:34	16260103	882.6	11.8	17.04	89.2	2.3	3.94	4.0	0.62	0.082	24.5	0.44	0.270	3.9	0.3
	12:34	16260104	879.1	11.6	16.97	90.6	2.3	4.00	4.2	0.62	0.087	24.3	0.43	0.268	4.0	0.3
	12:35	16260105	878.0	11.6	16.95	91.0	2.3	4.01	4.2	0.63	0.088	24.2	0.44	0.267	4.1	0.3
	12:36	16260106	878.6	11.7	16.96	89.3	2.3	3.94	4.3	0.63	0.089	24.3	0.44	0.268	4.2	0.3
	12:37	16260107	882.1	11.8	17.03	87.9	2.4	3.88	4.4	0.62	0.091	24.4	0.43	0.269	4.2	0.3
	12:38	16260108	881.0	11.7	17.01	86.8	2.3	3.83	4.5	0.63	0.093	24.6	0.44	0.271	4.3	0.3
	12:39	16260109	886.6	11.9	17.11	86.9	2.4	3.83	4.5	0.63	0.093	24.6	0.44	0.272	4.4	0.3
	12:40	16260110	878.9	11.7	16.97	86.9	2.4	3.84	4.6	0.63	0.094	24.5	0.44	0.271	4.5	0.3
	12:41	16260111	877.3	11.6	16.93	86.5	2.3	3.82	4.5	0.64	0.094	24.5	0.45	0.270	4.5	0.3
	12:42	16260112	874.9	11.7	16.89	85.2	2.3	3.76	4.5	0.64	0.094	24.4	0.44	0.269	4.5	0.3
	12:43	16260113	871.3	11.6	16.82	84.0	2.3	3.71	4.6	0.63	0.096	24.5	0.44	0.270	4.6	0.3
	12:44	16260114	871.0	11.6	16.81	82.6	2.3	3.64	4.6	0.62	0.096	24.6	0.43	0.271	4.6	0.3
	12:44	16260115	863.7	11.3	16.67	80.6	2.3	3.55	4.6	0.62	0.095	24.6	0.44	0.271	4.6	0.3
	12:45	16260116	859.6	11.2	16.59	78.8	2.3	3.48	4.7	0.62	0.096	24.6	0.43	0.271	4.7	0.3
	12:46	16260117	864.0	11.3	16.68	77.2	2.3	3.41	4.6	0.62	0.095	24.8	0.43	0.273	4.7	0.3
	12:47	16260118	863.3	11.3	16.66	75.1	2.3	3.31	4.7	0.61	0.097	24.9	0.43	0.275	4.7	0.3
	12:48	16260119	869.0	11.5	16.77	72.8	2.3	3.21	4.6	0.64	0.095	24.9	0.45	0.274	4.6	0.3
	12:49	16260120	860.2	11.2	16.61	69.4	2.3	3.06	4.5	0.63	0.094	25.0	0.44	0.276	4.6	0.3
	12:50	16260121	860.7	11.2	16.62	66.8	2.3	2.95	4.5	0.62	0.093	25.2	0.44	0.278	4.7	0.3
	12:51	16260122	863.8	11.3	16.67	64.6	2.3	2.85	4.3	0.64	0.090	25.2	0.45	0.278	4.6	0.3
	12:52	16260123	867.9	11.5	16.75	62.6	2.3	2.76	4.4	0.63	0.092	25.6	0.44	0.283	4.8	0.3
	12:53	16260124	872.6	11.5	16.85	62.6	2.4	2.76	4.4	0.66	0.090	25.8	0.46	0.284	4.7	0.3
	12:54	16260125	875.6	11.6	16.90	62.8	2.4	2.77	4.5	0.64	0.093	26.3	0.45	0.290	4.8	0.3
	12:54	16260126	881.1	11.8	17.01	64.1	2.4	2.83	4.6	0.65	0.095	26.8	0.45	0.296	4.7	0.3
	12:55	16260127	886.0	11.8	17.10	66.7	2.4	2.94	4.8	0.65	0.100	27.1	0.46	0.299	4.8	0.3
	12:56	16260128	887.6	11.8	17.13	70.8	2.4	3.12	4.9	0.67	0.101	27.4	0.46	0.302	4.8	0.3
	12:57	16260129	888.2	11.8	17.14	74.5	2.4	3.29	5.1	0.66	0.105	27.3	0.46	0.301	4.8	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	12:58	16260130	892.2	12.0	17.22	78.8	2.4	3.48	5.2	0.67	0.107	27.3	0.46	0.302	4.8	0.3
	12:59	16260131	886.7	11.8	17.12	80.4	2.4	3.55	5.2	0.68	0.108	27.1	0.47	0.299	4.9	0.3
	13:00	16260132	879.8	11.7	16.98	80.1	2.4	3.53	5.3	0.65	0.109	26.8	0.45	0.295	4.8	0.3
	13:01	16260133	877.3	11.5	16.94	79.6	2.4	3.51	5.5	0.65	0.113	26.5	0.45	0.292	4.8	0.3
	13:02	16260134	884.7	11.7	17.08	79.9	2.4	3.52	5.5	0.66	0.114	26.2	0.46	0.289	4.6	0.3
6/26/97	13:03	16260135	878.8	11.7	16.96	79.2	2.4	3.50	5.6	0.66	0.116	25.9	0.46	0.285	4.7	0.3
	13:04	16260136	878.0	11.6	16.95	78.3	2.4	3.46	5.6	0.66	0.115	25.5	0.46	0.281	4.7	0.3
	14:00	16260165	814.8	10.4	15.73	69.0	2.1	3.04	4.4	0.58	0.091	17.1	0.41	0.189	2.3	0.3
	14:00	16260166	817.2	10.6	15.78	67.1	2.2	2.96	4.6	0.61	0.096	17.0	0.43	0.187	2.3	0.3
	14:01	16260167	808.4	10.3	15.61	64.8	2.2	2.86	4.7	0.61	0.098	16.9	0.43	0.186	2.4	0.3
	14:02	16260168	807.9	10.4	15.60	61.9	2.2	2.73	4.9	0.60	0.101	16.9	0.42	0.186	2.5	0.3
	14:03	16260169	806.9	10.4	15.58	59.3	2.2	2.62	4.8	0.61	0.100	16.8	0.43	0.185	2.6	0.3
	14:04	16260170	807.7	10.5	15.59	57.1	2.2	2.52	4.9	0.62	0.100	16.8	0.43	0.185	2.6	0.3
	14:05	16260171	798.2	10.2	15.41	54.5	2.1	2.40	4.9	0.60	0.101	16.8	0.42	0.185	2.7	0.3
	14:06	16260172	799.3	10.3	15.43	53.2	2.2	2.35	4.9	0.61	0.101	17.1	0.43	0.188	2.8	0.3
	14:07	16260173	802.9	10.4	15.50	52.5	2.2	2.31	4.9	0.61	0.101	17.4	0.43	0.192	2.9	0.3
	14:08	16260174	803.8	10.3	15.52	52.3	2.1	2.31	4.8	0.60	0.099	17.5	0.42	0.193	2.9	0.3
	14:09	16260175	805.9	10.5	15.56	52.1	2.2	2.30	4.7	0.62	0.097	17.3	0.43	0.191	3.0	0.3
	14:09	16260176	803.7	10.5	15.51	51.0	2.2	2.25	4.6	0.62	0.096	17.1	0.43	0.189	3.0	0.3
	14:10	16260177	804.9	10.4	15.54	51.3	2.2	2.26	4.7	0.61	0.097	17.1	0.43	0.189	3.1	0.3
	14:11	16260178	808.8	10.6	15.61	50.6	2.2	2.23	4.6	0.63	0.096	17.1	0.44	0.189	3.2	0.3
	14:12	16260179	813.2	10.7	15.70	49.7	2.2	2.19	4.6	0.63	0.096	17.2	0.44	0.190	3.2	0.3
	14:13	16260180	814.2	10.7	15.72	49.1	2.2	2.16	4.6	0.63	0.096	17.3	0.44	0.191	3.2	0.3
	14:14	16260181	816.6	10.7	15.76	48.4	2.2	2.14	4.7	0.63	0.097	17.3	0.44	0.191	3.3	0.3
	14:15	16260182	818.1	10.7	15.79	47.9	2.2	2.11	4.7	0.63	0.097	17.4	0.44	0.192	3.3	0.3
	14:16	16260183	819.0	10.8	15.81	47.7	2.2	2.10	4.7	0.65	0.097	17.3	0.45	0.191	3.4	0.3
	14:17	16260184	818.5	10.7	15.80	47.7	2.2	2.10	4.7	0.64	0.097	17.5	0.44	0.193	3.4	0.3
	14:18	16260185	816.2	10.8	15.76	48.9	2.2	2.16	4.7	0.64	0.098	17.5	0.45	0.193	3.4	0.3
	14:18	16260186	818.2	10.8	15.79	50.7	2.2	2.24	4.7	0.65	0.097	17.6	0.45	0.194	3.5	0.3
	14:19	16260187	821.1	10.9	15.85	52.8	2.3	2.33	4.7	0.66	0.097	17.4	0.46	0.192	3.5	0.3
	14:20	16260188	812.0	10.6	15.67	54.2	2.2	2.39	4.7	0.64	0.097	17.4	0.45	0.192	3.5	0.3
	14:21	16260189	816.1	10.7	15.75	55.8	2.2	2.46	4.7	0.65	0.098	17.4	0.46	0.192	3.5	0.3
	14:22	16260190	812.9	10.8	15.69	56.3	2.2	2.48	4.7	0.65	0.097	17.3	0.45	0.190	3.5	0.3
	14:23	16260191	810.0	10.8	15.64	55.3	2.2	2.44	4.7	0.64	0.097	17.2	0.45	0.190	3.6	0.3
	14:24	16260192	809.2	10.6	15.62	55.1	2.2	2.43	4.7	0.65	0.097	17.2	0.45	0.190	3.6	0.3
	14:25	16260193	811.3	10.8	15.66	54.4	2.2	2.40	4.7	0.64	0.098	17.2	0.44	0.190	3.6	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	14:26	16260194	803.6	10.5	15.51	54.4	2.2	2.40	4.7	0.65	0.097	17.0	0.45	0.188	3.6	0.3
	14:27	16260195	804.9	10.4	15.54	53.6	2.2	2.37	4.7	0.64	0.098	17.1	0.44	0.189	3.6	0.3
	14:28	16260196	811.7	10.6	15.67	53.1	2.2	2.34	4.7	0.63	0.096	17.2	0.44	0.190	3.6	0.3
	15:06	16260234	815.1	11.0	15.73	52.9	2.2	2.34	3.8	0.63	0.079	17.0	0.44	0.188	2.7	0.3
	15:07	16260235	809.0	10.8	15.62	52.0	2.2	2.30	4.4	0.63	0.091	17.0	0.44	0.188	2.8	0.3
6/26/97	15:08	16260236	803.5	10.5	15.51	52.6	2.2	2.32	4.6	0.64	0.096	16.8	0.45	0.186	2.8	0.3
	15:09	16260237	796.0	10.2	15.37	52.9	2.2	2.33	4.8	0.64	0.099	16.8	0.45	0.186	2.8	0.3
	15:10	16260238	796.6	10.2	15.38	53.6	2.2	2.37	4.9	0.64	0.101	16.8	0.45	0.185	2.9	0.3
	15:10	16260239	803.5	10.6	15.51	54.5	2.2	2.41	4.9	0.65	0.102	16.7	0.46	0.184	3.0	0.3
	15:11	16260240	808.8	11.0	15.61	55.5	2.3	2.45	5.0	0.66	0.104	16.8	0.46	0.186	3.0	0.3
	15:12	16260241	802.5	10.6	15.49	56.2	2.2	2.48	5.0	0.65	0.103	16.7	0.45	0.185	3.1	0.3
6/26/97	15:13	16260242	799.9	10.5	15.44	56.2	2.2	2.48	5.1	0.64	0.105	16.7	0.45	0.184	3.1	0.3
	15:14	16260243	799.5	10.4	15.43	56.8	2.2	2.50	5.0	0.64	0.104	16.7	0.44	0.184	3.2	0.3
	15:15	16260244	800.9	10.4	15.46	57.0	2.2	2.52	5.0	0.65	0.104	16.7	0.45	0.184	3.2	0.3
	15:16	16260245	805.8	10.7	15.56	57.6	2.2	2.54	5.1	0.64	0.105	16.7	0.45	0.185	3.3	0.3
	15:17	16260246	805.6	10.4	15.55	57.9	2.2	2.55	5.1	0.64	0.105	16.8	0.45	0.185	3.3	0.3
	15:18	16260247	805.8	10.5	15.56	57.6	2.2	2.54	5.1	0.64	0.107	16.9	0.44	0.186	3.3	0.3
	15:19	16260248	805.6	10.4	15.55	58.0	2.2	2.56	5.2	0.64	0.107	16.8	0.45	0.186	3.3	0.3
	15:19	16260249	805.5	10.4	15.55	58.5	2.2	2.58	5.1	0.65	0.106	16.8	0.45	0.185	3.2	0.3
	15:20	16260250	815.4	10.9	15.74	59.7	2.2	2.64	5.2	0.64	0.109	16.8	0.45	0.186	3.4	0.3
	15:21	16260251	812.7	10.5	15.69	60.0	2.2	2.65	5.2	0.65	0.107	16.8	0.45	0.185	3.4	0.3
	15:22	16260252	815.1	10.6	15.74	60.7	2.2	2.68	5.2	0.63	0.108	16.9	0.44	0.186	3.5	0.3
	15:23	16260253	821.3	10.9	15.85	61.3	2.2	2.71	5.1	0.65	0.106	17.0	0.45	0.187	3.4	0.3
	15:24	16260254	824.2	10.9	15.91	60.7	2.2	2.68	5.3	0.65	0.110	17.0	0.45	0.188	3.5	0.3
	15:25	16260255	824.8	10.9	15.92	60.3	2.2	2.66	5.2	0.65	0.107	17.0	0.45	0.188	3.4	0.3
	15:26	16260256	814.1	10.6	15.72	59.9	2.2	2.64	5.3	0.65	0.110	17.0	0.45	0.188	3.6	0.3
	15:27	16260257	825.8	11.1	15.94	61.5	2.3	2.72	5.3	0.66	0.109	17.2	0.46	0.190	3.5	0.3
	15:28	16260258	824.2	10.9	15.91	62.4	2.2	2.75	5.2	0.66	0.108	17.2	0.46	0.190	3.5	0.3
	15:29	16260259	825.0	11.0	15.93	63.9	2.2	2.82	5.2	0.66	0.108	17.1	0.46	0.188	3.5	0.3
	15:29	16260260	814.6	10.5	15.73	64.1	2.2	2.83	5.3	0.65	0.109	17.1	0.45	0.189	3.5	0.3
	15:30	16260261	823.7	10.9	15.90	64.4	2.2	2.84	5.3	0.66	0.110	17.2	0.46	0.189	3.5	0.3
	15:31	16260262	818.2	10.6	15.80	63.7	2.2	2.81	5.2	0.65	0.108	17.2	0.45	0.190	3.5	0.3
	15:32	16260263	823.7	10.9	15.90	62.8	2.2	2.77	5.3	0.67	0.109	17.2	0.46	0.190	3.5	0.3
	15:33	16260264	828.0	11.0	15.98	61.6	2.3	2.72	5.2	0.67	0.108	17.4	0.47	0.192	3.6	0.3
	16:00	INLS3007	703.9	8.2	13.59	23.9	1.8	1.05	4.9	0.5	0.101	14.4	0.4	0.159	1.4	0.2
	16:06	INLS3008	763.2	9.3	14.73	39.1	1.9	1.72	5.0	0.6	0.104	15.5	0.4	0.171	1.9	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	16:10	INLS3009	713.6	8.4	13.78	50.2	1.8	2.21	4.5	0.5	0.093	14.3	0.4	0.158	1.6	0.3
	16:15	INLS3010	683.9	8.0	13.20	43.6	1.7	1.93	4.6	0.5	0.096	13.7	0.4	0.151	1.4	0.2
	16:24	INLS3011	712.6	8.3	13.76	46.4	1.8	2.05	4.4	0.5	0.090	14.0	0.4	0.155	2.2	0.2
	16:28	INLS3012	716.8	8.5	13.84	42.4	1.8	1.87	4.6	0.5	0.096	14.0	0.4	0.154	2.3	0.2
	16:33	INLS3013	723.5	8.5	13.97	53.7	1.8	2.37	4.6	0.5	0.095	14.2	0.4	0.157	2.3	0.2
	6/26/97	Average -->	847.3	11.1	16.36	79.0	2.3	3.49	4.3	0.62	0.088	20.1	0.43	0.222	3.9	0.3

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
6/27/97	9:21	INLS4001	770.6	9.0	14.9	112.0	1.7	4.941	4.5	0.4	0.094	14.2	0.3	0.157	1.7	0.2
	9:25	INLS4002	765.1	9.0	14.8	102.0	1.7	4.499	4.3	0.4	0.088	13.8	0.3	0.152	1.9	0.2
	9:29	INLS4003	760.2	9.0	14.7	99.2	1.7	4.375	3.9	0.4	0.081	14.0	0.3	0.155	2.0	0.2
	9:35	INLS4004	760.6	8.9	14.7	96.1	1.7	4.242	3.9	0.4	0.081	13.3	0.3	0.147	2.4	0.2
	9:40	INLS4005	765.4	9.0	14.8	96.8	1.7	4.271	3.5	0.4	0.073	13.6	0.3	0.150	2.5	0.2
	9:44	INLS4006	767.7	9.1	14.8	96.2	1.8	4.246	3.2	0.4	0.066	13.4	0.3	0.148	2.6	0.2
	10:21	16270035	864.0	11.34	16.7	115.5	1.98	5.095	3.2	0.50	0.066	16.3	0.35	0.180	3.5	0.2
	10:22	16270036	858.2	11.25	16.6	114.3	1.96	5.043	3.6	0.50	0.074	16.2	0.35	0.179	3.5	0.2
	10:23	16270037	855.2	11.15	16.5	112.8	1.96	4.977	3.9	0.51	0.081	15.9	0.35	0.175	3.6	0.2
	10:23	16270038	850.5	11.12	16.4	111.0	1.98	4.900	3.7	0.51	0.076	15.8	0.36	0.174	3.6	0.2
	10:24	16270039	844.4	11.07	16.3	108.9	1.95	4.805	3.8	0.50	0.078	15.7	0.35	0.173	3.6	0.2
	10:25	16270040	838.0	10.77	16.2	108.0	1.95	4.765	3.8	0.50	0.079	15.7	0.36	0.173	3.7	0.2
	10:26	16270041	836.0	10.92	16.1	107.7	1.92	4.753	3.8	0.49	0.079	15.6	0.35	0.172	3.7	0.2
	10:27	16270042	828.7	10.94	16.0	108.3	1.93	4.778	3.8	0.49	0.079	15.5	0.35	0.171	3.8	0.2
	10:28	16270043	824.4	10.57	15.9	108.7	1.92	4.794	3.8	0.50	0.078	15.3	0.35	0.169	3.8	0.2
	10:29	16270044	822.7	10.68	15.9	110.6	1.91	4.881	3.8	0.50	0.079	15.3	0.35	0.169	3.8	0.2
	10:30	16270045	821.8	10.66	15.9	109.7	1.88	4.839	3.8	0.48	0.078	15.3	0.34	0.169	3.9	0.2
	10:31	16270046	815.7	10.45	15.7	107.0	1.90	4.721	3.7	0.49	0.077	15.2	0.35	0.168	3.8	0.2
	10:32	16270047	814.2	10.52	15.7	101.9	1.90	4.498	3.7	0.49	0.076	15.2	0.35	0.168	3.9	0.2
	10:33	16270048	812.2	10.33	15.7	96.0	1.92	4.235	3.7	0.50	0.076	15.3	0.36	0.168	3.9	0.2
	10:33	16270049	812.3	10.58	15.7	91.0	1.93	4.014	3.6	0.51	0.075	15.2	0.36	0.168	3.9	0.3
	10:34	16270050	813.9	10.45	15.7	86.1	1.95	3.800	3.6	0.51	0.074	15.3	0.36	0.169	3.9	0.3
	10:35	16270051	830.7	10.92	16.0	82.4	1.98	3.636	3.5	0.54	0.073	15.4	0.38	0.170	3.9	0.3
	10:36	16270052	833.2	10.91	16.1	79.7	1.97	3.515	3.5	0.51	0.072	15.7	0.36	0.173	4.0	0.2
	10:37	16270053	842.1	11.25	16.3	79.2	1.99	3.494	3.5	0.52	0.072	15.8	0.37	0.174	4.0	0.3
	10:38	16270054	845.1	11.14	16.3	80.5	2.01	3.552	3.3	0.53	0.068	15.9	0.37	0.176	4.1	0.3
	10:39	16270055	849.2	11.22	16.4	83.6	2.04	3.689	3.2	0.54	0.066	16.1	0.38	0.177	4.1	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	10:40	16270056	851.5	11.30	16.4	87.5	2.02	3.860	3.1	0.53	0.065	16.2	0.37	0.178	4.2	0.3
	10:41	16270057	859.2	11.60	16.6	92.3	2.04	4.073	3.0	0.53	0.063	16.3	0.38	0.179	4.2	0.3
	10:42	16270058	855.7	11.51	16.5	95.8	2.05	4.229	3.0	0.53	0.063	16.3	0.38	0.179	4.2	0.3
	10:42	16270059	851.7	11.40	16.4	98.1	2.01	4.329	3.0	0.52	0.062	16.3	0.37	0.180	4.2	0.3
	10:43	16270060	859.5	11.81	16.6	99.4	2.05	4.385	3.1	0.53	0.064	16.4	0.38	0.180	4.3	0.3
6/27/97	10:44	16270061	859.0	11.63	16.6	99.9	2.04	4.407	3.1	0.53	0.065	16.4	0.37	0.181	4.3	0.3
	10:45	16270062	856.2	11.64	16.5	100.1	2.05	4.419	3.1	0.53	0.064	16.5	0.38	0.182	4.3	0.3
	10:46	16270063	856.0	11.70	16.5	98.3	2.06	4.339	3.2	0.54	0.066	16.4	0.38	0.181	4.3	0.3
	10:47	16270064	850.2	11.56	16.4	96.3	2.07	4.250	3.2	0.55	0.066	16.3	0.39	0.179	4.3	0.3
	10:48	16270065	847.3	11.55	16.4	94.0	2.07	4.146	3.3	0.55	0.068	16.4	0.39	0.181	4.3	0.3
	10:49	16270066	841.2	11.23	16.2	90.8	2.07	4.006	3.3	0.55	0.069	16.2	0.39	0.179	4.3	0.3
	11:07	16270081	905.2	13.09	17.5	81.4	2.20	3.590	2.2	0.59	0.045	17.2	0.41	0.190	3.8	0.3
	11:08	16270082	892.9	12.58	17.2	85.8	2.21	3.784	1.9	0.58	0.040	17.0	0.41	0.188	3.8	0.3
	11:09	16270083	890.0	12.70	17.2	89.4	2.22	3.947	2.0	0.58	0.041	16.8	0.41	0.185	3.9	0.3
	11:10	16270084	888.6	12.52	17.2	93.0	2.18	4.102	2.1	0.58	0.042	16.6	0.41	0.184	4.0	0.3
	11:11	16270085	885.8	12.42	17.1	98.3	2.21	4.337	2.0	0.59	0.041	16.7	0.42	0.184	4.1	0.3
	11:12	16270086	884.9	12.33	17.1	102.5	2.21	4.524	2.0	0.59	0.042	16.7	0.42	0.184	4.2	0.3
	11:13	16270087	883.9	12.50	17.1	105.4	2.19	4.651	2.1	0.59	0.043	16.4	0.41	0.181	4.2	0.3
	11:14	16270088	884.1	12.63	17.1	107.6	2.20	4.747	2.2	0.60	0.045	16.3	0.43	0.180	4.3	0.3
	11:15	16270089	873.7	12.07	16.9	107.4	2.15	4.739	2.3	0.58	0.048	16.2	0.41	0.179	4.3	0.3
	11:15	16270090	873.4	12.28	16.9	106.1	2.18	4.683	2.3	0.59	0.048	16.1	0.42	0.178	4.3	0.3
	11:16	16270091	871.4	12.56	16.8	104.5	2.13	4.612	2.3	0.57	0.048	16.1	0.41	0.178	4.4	0.3
	11:17	16270092	859.7	11.84	16.6	101.7	2.14	4.488	2.4	0.57	0.049	16.1	0.41	0.178	4.4	0.3
	11:18	16270093	861.1	12.11	16.6	99.6	2.17	4.395	2.3	0.59	0.048	16.0	0.42	0.177	4.4	0.3
	11:19	16270094	850.7	11.51	16.4	96.4	2.16	4.252	2.5	0.58	0.051	16.0	0.41	0.177	4.4	0.3
	11:20	16270095	865.2	12.94	16.7	93.2	2.17	4.113	2.5	0.59	0.052	16.0	0.42	0.177	4.5	0.3
	11:21	16270096	850.5	11.71	16.4	88.2	2.19	3.892	2.4	0.58	0.050	16.0	0.41	0.177	4.5	0.3
	11:22	16270097	848.2	11.84	16.4	83.8	2.13	3.698	2.5	0.58	0.052	16.1	0.41	0.177	4.6	0.3
	11:23	16270098	849.4	11.70	16.4	80.0	2.14	3.529	2.6	0.59	0.053	16.2	0.42	0.179	4.5	0.3
	11:24	16270099	853.5	11.99	16.5	76.8	2.18	3.390	2.5	0.60	0.052	16.2	0.42	0.179	4.6	0.3
	11:24	16270100	857.3	12.00	16.5	73.6	2.19	3.246	2.6	0.61	0.054	16.3	0.43	0.180	4.5	0.3
	11:25	16270101	865.3	12.37	16.7	69.9	2.18	3.086	2.6	0.60	0.054	16.5	0.43	0.182	4.6	0.3
	11:26	16270102	866.7	12.17	16.7	66.6	2.20	2.937	2.6	0.61	0.054	16.7	0.43	0.184	4.6	0.3
	11:27	16270103	865.9	12.08	16.7	64.0	2.20	2.825	2.5	0.61	0.052	16.8	0.43	0.185	4.7	0.3
	11:28	16270104	873.3	12.24	16.9	63.2	2.20	2.790	2.5	0.62	0.052	16.8	0.44	0.185	4.7	0.3
	11:29	16270105	874.0	12.34	16.9	63.2	2.21	2.788	2.6	0.61	0.053	17.0	0.43	0.187	4.7	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	11:30	16270106	878.6	12.76	17.0	64.3	2.19	2.836	2.6	0.61	0.055	16.9	0.43	0.186	4.7	0.3
	11:31	16270107	868.4	11.77	16.8	66.2	2.18	2.920	2.6	0.61	0.054	16.8	0.43	0.186	4.7	0.3
	11:32	16270108	878.7	12.21	17.0	69.9	2.15	3.083	2.7	0.61	0.056	16.7	0.43	0.184	4.7	0.3
	11:33	16270109	880.6	12.50	17.0	75.1	2.14	3.315	2.9	0.59	0.059	16.7	0.42	0.185	4.7	0.3
	11:33	16270110	871.5	11.86	16.8	80.0	2.14	3.529	3.0	0.59	0.062	16.5	0.42	0.182	4.7	0.3
6/27/97	11:34	16270111	865.9	11.79	16.7	86.8	2.12	3.830	3.1	0.59	0.064	16.4	0.42	0.181	4.7	0.3
	11:35	16270112	857.3	11.45	16.5	92.0	2.11	4.061	3.1	0.59	0.065	16.2	0.42	0.179	4.7	0.3
	11:36	16270113	848.0	11.24	16.4	95.8	2.10	4.229	3.2	0.59	0.066	15.9	0.41	0.176	4.7	0.3
	11:37	16270114	834.2	11.04	16.1	97.6	2.07	4.308	3.2	0.58	0.066	15.7	0.41	0.173	4.6	0.3
	11:38	16270115	824.7	10.81	15.9	96.4	2.05	4.254	3.2	0.57	0.066	15.5	0.40	0.171	4.6	0.3
	11:39	16270116	815.7	10.64	15.7	92.9	2.02	4.099	3.1	0.57	0.065	15.3	0.40	0.168	4.6	0.3
	11:40	16270117	806.3	10.57	15.6	87.6	1.99	3.866	3.2	0.56	0.065	15.1	0.40	0.167	4.6	0.3
	12:15	16270152	840.4	11.52	16.2	60.8	2.15	2.684	1.8	0.62	0.037	15.9	0.44	0.176	4.2	0.3
	12:16	16270153	836.4	11.38	16.1	62.6	2.14	2.761	2.0	0.62	0.042	16.0	0.44	0.176	4.2	0.3
	12:17	16270154	831.1	11.12	16.0	63.8	2.17	2.815	2.1	0.64	0.044	15.9	0.45	0.176	4.3	0.3
	12:18	16270155	827.8	11.02	16.0	63.4	2.17	2.799	2.2	0.63	0.045	15.9	0.45	0.175	4.3	0.3
	12:19	16270156	821.2	11.13	15.9	61.5	2.15	2.714	2.3	0.63	0.047	15.8	0.45	0.175	4.4	0.3
	12:20	16270157	814.6	10.83	15.7	58.7	2.14	2.592	2.2	0.63	0.046	15.7	0.45	0.173	4.5	0.3
	12:21	16270158	816.1	11.07	15.8	55.0	2.16	2.427	2.3	0.64	0.047	15.7	0.45	0.174	4.5	0.3
	12:21	16270159	817.5	11.14	15.8	52.5	2.17	2.317	2.2	0.64	0.046	15.8	0.46	0.174	4.5	0.3
	12:22	16270160	811.4	10.82	15.7	50.1	2.18	2.210	2.2	0.65	0.046	15.7	0.46	0.173	4.6	0.3
	12:23	16270161	813.7	11.15	15.7	47.8	2.18	2.107	2.4	0.65	0.050	15.7	0.46	0.174	4.6	0.3
	12:24	16270162	811.6	10.89	15.7	45.4	2.17	2.001	2.7	0.65	0.055	15.7	0.46	0.173	4.6	0.3
	12:25	16270163	813.9	10.91	15.7	43.1	2.16	1.903	2.8	0.64	0.059	15.8	0.45	0.174	4.6	0.3
	12:26	16270164	819.4	11.23	15.8	42.4	2.20	1.872	2.9	0.65	0.060	16.0	0.46	0.176	4.7	0.3
	12:27	16270165	827.2	11.33	16.0	42.7	2.19	1.884	3.0	0.66	0.061	16.1	0.47	0.178	4.6	0.3
	12:28	16270166	841.1	11.83	16.2	44.0	2.24	1.940	3.0	0.67	0.062	16.4	0.48	0.181	4.7	0.3
	12:29	16270167	846.8	11.98	16.3	45.5	2.26	2.009	3.0	0.68	0.063	16.5	0.48	0.182	4.7	0.3
	12:30	16270168	852.0	12.18	16.4	47.0	2.27	2.072	3.0	0.68	0.063	16.6	0.48	0.183	4.7	0.3
	12:31	16270169	862.3	12.42	16.6	49.4	2.30	2.181	3.1	0.69	0.065	16.8	0.49	0.185	4.8	0.3
	12:32	16270170	855.7	12.03	16.5	52.1	2.30	2.298	3.1	0.69	0.065	16.9	0.49	0.186	4.7	0.3
	12:33	16270171	862.3	12.26	16.6	56.6	2.33	2.498	3.3	0.71	0.068	16.9	0.50	0.186	4.7	0.3
	12:33	16270172	857.4	12.19	16.6	61.0	2.27	2.690	3.4	0.70	0.070	16.9	0.50	0.186	4.8	0.3
	12:34	16270173	846.9	11.65	16.3	66.0	2.28	2.911	3.5	0.70	0.072	16.8	0.50	0.185	4.8	0.3
	12:35	16270174	849.3	12.20	16.4	71.1	2.24	3.137	3.6	0.69	0.074	16.9	0.48	0.187	4.8	0.3
	12:36	16270175	845.6	11.83	16.3	77.0	2.26	3.398	3.7	0.70	0.077	16.9	0.49	0.187	4.8	0.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	12:37	16270176	846.3	12.11	16.3	81.9	2.23	3.612	3.8	0.69	0.080	16.9	0.49	0.186	4.8	0.3
	12:38	16270177	833.2	11.50	16.1	85.2	2.22	3.759	3.9	0.68	0.080	16.9	0.48	0.186	4.8	0.3
	12:39	16270178	839.5	11.80	16.2	87.5	2.25	3.860	4.0	0.70	0.083	16.9	0.49	0.186	4.8	0.3
	12:40	16270179	834.2	11.70	16.1	88.9	2.23	3.924	4.0	0.69	0.083	16.8	0.49	0.185	4.8	0.3
	12:41	16270180	834.1	11.73	16.1	89.9	2.21	3.966	4.1	0.68	0.085	16.7	0.48	0.184	4.8	0.3
6/27/97	12:42	16270181	832.1	11.76	16.1	91.3	2.20	4.031	4.2	0.67	0.088	16.8	0.47	0.185	4.8	0.3
	12:42	16270182	835.2	11.74	16.1	93.2	2.21	4.112	4.4	0.68	0.090	16.7	0.48	0.184	4.8	0.3
	12:43	16270183	835.1	11.69	16.1	96.3	2.21	4.251	4.7	0.68	0.097	16.7	0.48	0.184	4.8	0.3
	12:44	16270184	838.3	11.67	16.2	99.9	2.23	4.406	4.7	0.69	0.098	16.6	0.49	0.183	4.8	0.3
	13:22	INLS4007	690.5	8.3	13.3	61.4	1.8	2.707	4.0	0.6	0.082	14.3	0.4	0.157	2.2	0.3
	13:25	INLS4008	685.8	8.5	13.2	54.2	1.9	2.391	3.8	0.6	0.079	14.1	0.4	0.155	2.3	0.3
	13:29	INLS4009	691.1	8.8	13.3	43.7	1.9	1.930	3.7	0.6	0.077	14.0	0.4	0.155	2.4	0.3
	13:36	INLS4010	718.2	8.9	13.9	60.9	1.9	2.687	3.9	0.6	0.081	14.3	0.4	0.157	3.0	0.3
	13:41	INLS4011	672.3	8.2	13.0	59.0	1.8	2.603	3.7	0.5	0.077	12.4	0.4	0.137	3.2	0.2
	13:45	INLS4012	657.2	8.1	12.7	48.1	1.8	2.124	3.9	0.5	0.080	11.4	0.4	0.126	3.3	0.2
		Average --->	847.6	11.59	16.4	83.3	2.12	3.675	3.0	0.59	0.063	16.2	0.42	0.179	4.4	0.3

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
6/25/97	9:27	INLS2001	1.9	0.5	0.036	1.6	0.3	0.019	48.1	0.7	0.5	4.1	0.6		0.6
	9:33	INLS2002	2.6	0.4	0.049	3.5	0.3	0.041	26.7	0.8	0.3	3.8	0.6		0.6
	9:37	INLS2003	2.7	0.5	0.051	4.3	0.4	0.050	26.6	0.8	0.3	3.8	0.6		0.7
	9:43	INLS2004	2.5	0.5	0.047	3.8	0.4	0.045	26.2	0.9	0.3	4.0	0.7	0.7	0.6
	9:54	INLS2005	3.6	0.5	0.069	4.3	0.4	0.051		1.2		3.3	0.6		0.6
	9:58	INLS2006	3.6	0.5	0.069	4.8	0.4	0.056		1.2		3.1	0.6		0.6
	10:02	INLS2007	3.5	0.5	0.068	4.9	0.4	0.058		1.2		2.8	0.6		0.6
	10:36	INLV2008	3.6	0.52	0.070	3.1	0.4	0.037		1.3		4.1	0.7		0.7
	10:39	INLV2009	3.3	0.52	0.063	4.6	0.4	0.054		1.3		3.2	0.7		0.7
	10:43	INLV2010	3.2	0.52	0.063	5.5	0.4	0.064		1.4		3.2	0.7		0.7
	10:47	INLV2011	3.2	0.53	0.062	5.7	0.4	0.067		1.3		3.2	0.7		0.7
	11:13	INLV2012	3.2	0.51	0.062	3.4	0.4	0.039		1.3		3.6	0.7		0.7
	11:18	INLV2013	3.2	0.52	0.062	4.6	0.4	0.054		1.3		3.4	0.7		0.7
	11:24	INLV2014	3.2	0.52	0.062	4.6	0.4	0.054		1.4		3.8	0.7		0.7
	11:29	INLV2015	3.3	0.53	0.063	4.9	0.4	0.057		1.4		3.7	0.7		0.7
	12:20	INLV2016	6.4	0.54	0.123	3.4	0.4	0.040	7.8	1.0	0.086	9.9	0.8		2.3
	12:26	INLV2017	7.0	0.55	0.136	4.6	0.4	0.053	8.4	1.0	0.093	9.9	0.8		2.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	12:30	INLV2018	7.0	0.55	0.135	5.1	0.4	0.060	8.5	1.0	0.094	9.5	0.8		2.3
	12:34	INLV2019	6.7	0.56	0.129	5.2	0.4	0.061	8.3	1.1	0.092	9.3	0.8		2.4
	12:54	INLV2020	4.9	0.54	0.095	3.1	0.4	0.036	6.6	1.0	0.072	7.2	0.8		2.3
	12:59	INLV2021	5.0	0.56	0.097	4.1	0.4	0.048	6.6	1.1	0.073	7.6	0.8		2.4
	13:03	INLV2022	5.2	0.55	0.100	4.3	0.4	0.050	6.7	1.1	0.074	7.3	0.8		2.4
	13:06	INLV2023	4.9	0.56	0.095	4.7	0.4	0.055	6.7	1.1	0.074	7.1	0.8		2.4
	13:46	INLV2024	4.3	0.55	0.083	6.2	0.4	0.073	6.3	1.1	0.069	7.3	0.8		2.4
	13:49	INLV2025	4.1	0.54	0.080	6.7	0.4	0.079	6.4	1.1	0.070	7.4	0.8		2.4
	13:52	INLV2026	4.0	0.54	0.078	7.2	0.4	0.085	6.2	1.1	0.068	7.0	0.8		2.4
	13:56	INLV2027	3.8	0.55	0.073	7.2	0.4	0.085	6.2	1.1	0.068	7.0	0.8		2.4
	14:17	INLV2028	3.5	0.56	0.067	3.4	0.4	0.040	5.7	1.1	0.062	7.2	0.8		2.5
	14:21	INLV2029	3.7	0.58	0.071	4.5	0.5	0.053	5.6	1.1	0.062	7.3	0.9		2.6
	14:27	INLV2030	3.5	0.59	0.068	3.2	0.5	0.037	4.0	1.3	0.044	8.7	1.0	2.1	0.8
	14:32	INLV2031	3.8	0.60	0.074	4.3	0.5	0.050	5.7	1.2	0.063	8.4	0.9		2.7
6/25/97	14:56	INLV2032	3.0	0.53	0.058	3.1	0.4	0.036	4.4	1.1	0.049	6.8	0.8		2.4
	15:00	INLV2033	3.1	0.54	0.061	4.0	0.4	0.046	4.7	1.1	0.051	6.8	0.8		2.4
	15:05	INLV2034	3.1	0.55	0.060	4.4	0.4	0.052	4.9	1.1	0.054	7.1	0.8		2.5
	15:09	INLV2035	3.3	0.56	0.064	4.5	0.4	0.053	4.9	1.1	0.054	7.2	0.8		2.5
	15:34	INLV2036	3.6	0.56	0.070	4.2	0.4	0.050	4.7	1.2	0.052	7.1	0.9		2.7
	15:38	INLV2037	3.4	0.57	0.066	5.2	0.5	0.061	4.9	1.2	0.054	6.5	0.9		2.6
	15:42	INLV2038	3.3	0.57	0.063	5.2	0.5	0.061	4.7	1.2	0.051	6.7	0.9		2.6
	15:46	INLV2039	3.4	0.56	0.066	5.7	0.4	0.067	4.8	1.1	0.053	6.0	0.8		2.6
	16:13	INLV2040	3.2	0.55	0.062	3.3	0.4	0.038	4.2	1.1	0.046	6.4	0.9		2.6
	16:17	INLV2041	3.3	0.55	0.063	4.0	0.4	0.047	4.5	1.1	0.050	6.2	0.8		2.6
	16:22	INLV2042	3.5	0.54	0.067	4.1	0.4	0.048	4.5	1.1	0.049	6.3	0.8		2.6
	16:26	INLV2043	3.6	0.56	0.070	4.8	0.4	0.056	4.7	1.2	0.052	6.7	0.9		2.6
	16:54	INLV2047	3.4	0.6	0.067	3.3	0.5	0.039		1.7		6.5	0.9		2.7
	16:58	INLV2048	3.4	0.6	0.066	4.4	0.5	0.052		1.7		6.4	0.9		2.7
	17:07	INLS2049	3.2	0.5	0.062	3.5	0.4	0.041	3.5	1.0	0.039	4.5	0.7		2.2
	17:10	INLS2050	3.3	0.5	0.064	4.0	0.4	0.047		1.4		4.3	0.8		2.3
	17:14	INLS2051	3.3	0.5	0.063	4.0	0.4	0.046		1.5		5.3	0.8		2.4
	17:20	INLS2052	2.7	0.5	0.052	4.1	0.4	0.049	32.9	1.1	0.363	5.2	0.8	1.2	0.7
	17:24	INLS2053	2.8	0.5	0.054	3.9	0.4	0.046	34.0	1.1	0.375	5.3	0.8	1.3	0.7
	17:27	INLS2054	2.9	0.5	0.056	4.2	0.4	0.050	34.6	1.1	0.382	5.2	0.8	1.4	0.7
		Average —>	4.0	0.55	0.077	4.6	0.4	0.054	4.2	1.2	0.047	6.6	0.8	0.1	2.1

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
6/26/97	9:11	INLS3001	3.4	0.4	0.066	1.4	0.3	0.016	4.0	0.7	0.044	4.7	0.5		1.5
	9:18	INLS3002	3.2	0.4	0.061	1.8	0.3	0.022	4.1	0.7	0.045	3.5	0.5		1.5
	9:22	INLS3003	3.3	0.5	0.064	2.3	0.3	0.027	4.1	0.7	0.045	3.3	0.5		1.5
	9:34	INLS3004	2.1	0.4	0.041	2.1	0.3	0.025	32.5	0.7	0.358	3.8	0.6	1.4	0.5
	9:38	INLS3005	2.5	0.4	0.048	2.9	0.3	0.034	33.5	0.8	0.369	3.7	0.6	1.0	0.5
	9:42	INLS3006	2.5	0.4	0.048	2.9	0.3	0.034	33.4	0.8	0.368	3.6	0.6	1.0	0.5
	10:55	16260004	3.6	0.51	0.070	4.3	0.4	0.050	4.3	0.9	0.047	3.0	0.7		2.0
	10:56	16260005	3.7	0.52	0.071	5.1	0.4	0.060	4.3	0.9	0.047	2.9	0.7		2.0
	10:57	16260006	3.7	0.52	0.072	5.6	0.4	0.066	4.5	0.9	0.050	2.8	0.7		2.0
	10:58	16260007	3.8	0.52	0.073	6.0	0.4	0.070	4.4	0.9	0.049	2.8	0.7		2.0
	10:59	16260008	3.8	0.52	0.074	6.2	0.4	0.073	4.7	0.9	0.051	2.9	0.7		2.0
	11:00	16260009	3.9	0.53	0.075	6.4	0.4	0.075	4.7	0.9	0.051	2.8	0.7		2.0
	11:00	16260010	3.9	0.54	0.075	6.6	0.4	0.078	4.7	0.9	0.052	2.8	0.7		2.1
	11:01	16260011	3.9	0.53	0.075	6.7	0.4	0.079	5.0	0.9	0.055	2.8	0.7		2.1
	11:02	16260012	4.0	0.54	0.077	6.7	0.4	0.079	4.9	0.9	0.054	2.8	0.7		2.1
	11:03	16260013	4.0	0.54	0.077	6.8	0.4	0.080	4.8	0.9	0.053	2.8	0.7		0.8
	11:04	16260014	4.0	0.53	0.077	6.8	0.4	0.080	4.9	0.9	0.054	2.8	0.7		0.7
	11:05	16260015	4.1	0.54	0.079	7.0	0.4	0.082	4.8	1.0	0.053	2.7	0.7		0.8
	11:06	16260016	4.2	0.55	0.080	7.2	0.4	0.085	5.3	1.0	0.058	3.0	0.7		0.8
	11:07	16260017	4.2	0.55	0.081	7.4	0.4	0.087	5.2	1.0	0.058	3.0	0.7		0.8
	11:08	16260018	4.3	0.55	0.083	7.5	0.4	0.088	5.3	1.0	0.058	3.1	0.7		0.8
	11:09	16260019	4.3	0.55	0.082	7.7	0.4	0.090	5.3	1.0	0.058	3.1	0.7		0.8
	11:09	16260020	4.3	0.56	0.083	7.8	0.4	0.091	5.1	1.0	0.057	3.0	0.7		0.8
	11:10	16260021	4.3	0.56	0.083	7.9	0.4	0.092	5.2	1.0	0.057	3.0	0.7		0.8
6/26/97	11:11	16260022	4.3	0.55	0.083	8.0	0.4	0.093	5.0	1.0	0.055	2.9	0.7		0.8
	11:12	16260023	4.3	0.55	0.083	8.0	0.4	0.094	5.0	1.0	0.055	3.0	0.7		0.8
	11:13	16260024	4.3	0.55	0.082	8.0	0.4	0.094	5.0	1.0	0.055	2.7	0.7		0.8
	11:14	16260025	4.2	0.55	0.081	8.0	0.4	0.094	5.1	1.0	0.056	2.6	0.7		0.8
	11:15	16260026	4.1	0.54	0.080	8.1	0.4	0.095	5.0	1.0	0.055	2.7	0.7		0.8
	11:16	16260027	4.0	0.53	0.078	8.1	0.4	0.095	4.9	0.9	0.054	2.4	0.7		0.8
	11:17	16260028	4.0	0.53	0.078	8.0	0.4	0.094	4.8	0.9	0.052	2.3	0.7		0.7
	11:18	16260029	4.0	0.53	0.077	8.0	0.4	0.094	4.7	0.9	0.052	2.4	0.7		0.8
	11:19	16260030	4.1	0.53	0.078	7.9	0.4	0.093	4.8	0.9	0.052	2.4	0.7		0.7
	11:20	16260031	4.1	0.53	0.078	8.0	0.4	0.094	4.7	0.9	0.051	2.4	0.7		0.8
	11:21	16260032	4.1	0.52	0.079	8.1	0.4	0.095	4.7	0.9	0.052	2.3	0.7		0.7
	11:21	16260033	4.1	0.52	0.080	8.1	0.4	0.095	4.9	0.9	0.054	2.4	0.7		0.7

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	11:22	16260034	4.2	0.53	0.081	8.1	0.4	0.096	5.0	0.9	0.055	2.3	0.7		0.8
	11:57	16260067	5.1	0.53	0.098	6.7	0.4	0.079	5.1	1.0	0.056	3.6	0.7		2.2
	11:58	16260068	5.1	0.53	0.098	7.1	0.4	0.083	4.9	1.0	0.054	3.6	0.7		2.2
	11:59	16260069	5.1	0.54	0.099	7.3	0.4	0.085	5.0	1.0	0.056	3.7	0.7		2.2
6/26/97	12:00	16260070	5.2	0.54	0.100	7.5	0.4	0.088	5.3	1.0	0.058	3.8	0.7		2.2
	12:01	16260071	5.2	0.54	0.101	7.5	0.4	0.089	5.3	1.0	0.058	3.8	0.7		2.2
	12:02	16260072	5.4	0.54	0.104	7.7	0.4	0.090	5.4	1.0	0.059	3.8	0.7		2.1
	12:02	16260073	5.5	0.54	0.106	7.8	0.4	0.092	5.4	1.0	0.060	4.0	0.7		2.2
	12:03	16260074	5.6	0.54	0.107	8.0	0.4	0.093	5.8	1.0	0.063	4.0	0.7		2.2
	12:04	16260075	5.5	0.54	0.107	8.0	0.4	0.094	5.8	1.0	0.064	4.0	0.7		0.8
	12:05	16260076	5.7	0.54	0.109	7.9	0.4	0.093	5.9	1.0	0.065	4.0	0.7		0.8
	12:06	16260077	5.7	0.54	0.110	8.0	0.4	0.094	6.1	1.0	0.068	4.0	0.7		0.8
	12:07	16260078	5.8	0.54	0.112	8.1	0.4	0.095	5.8	1.0	0.064	4.1	0.7		2.2
	12:08	16260079	5.8	0.54	0.112	8.3	0.4	0.097	6.0	1.0	0.066	4.2	0.7		2.2
	12:09	16260080	5.9	0.54	0.114	8.3	0.4	0.098	5.9	1.0	0.065	4.2	0.7		0.8
	12:10	16260081	6.0	0.55	0.115	8.3	0.4	0.098	6.2	1.0	0.069	4.4	0.7		0.8
	12:10	16260082	6.1	0.54	0.117	8.3	0.4	0.098	6.1	1.0	0.067	4.4	0.7		0.8
	12:11	16260083	6.0	0.54	0.116	8.3	0.4	0.098	6.2	1.0	0.069	4.4	0.7		0.8
	12:12	16260084	6.0	0.55	0.117	8.4	0.4	0.098	6.0	1.0	0.066	4.4	0.7		0.8
	12:13	16260085	6.1	0.55	0.117	8.4	0.4	0.099	6.3	1.0	0.070	4.5	0.7		0.8
	12:14	16260086	6.1	0.55	0.118	8.4	0.4	0.099	6.3	1.0	0.070	4.5	0.7		0.8
	12:15	16260087	6.1	0.54	0.118	8.3	0.4	0.097	6.2	1.0	0.068	4.5	0.7		2.2
	12:16	16260088	6.1	0.54	0.118	8.3	0.4	0.098	6.1	1.0	0.067	4.5	0.7		2.2
	12:17	16260089	6.2	0.55	0.119	8.3	0.4	0.098	6.2	1.0	0.068	4.6	0.8		2.2
	12:18	16260090	6.1	0.55	0.118	8.4	0.4	0.099	6.3	1.0	0.069	4.6	0.7		0.8
	12:19	16260091	6.2	0.55	0.119	8.4	0.4	0.099	6.2	1.0	0.068	4.6	0.7		2.2
	12:34	16260103	6.5	0.56	0.126	7.5	0.4	0.088	6.4	1.0	0.070	5.1	0.8		2.3
	12:34	16260104	6.4	0.56	0.124	7.9	0.4	0.093	6.4	1.0	0.070	5.1	0.8		2.3
	12:35	16260105	6.4	0.56	0.124	8.3	0.4	0.098	6.1	1.0	0.067	5.1	0.8		2.3
	12:36	16260106	6.4	0.56	0.123	8.6	0.4	0.101	6.3	1.0	0.069	5.1	0.8		2.3
	12:37	16260107	6.5	0.56	0.125	9.0	0.4	0.106	6.4	1.0	0.071	5.2	0.8		2.3
	12:38	16260108	6.5	0.56	0.127	9.4	0.4	0.110	6.6	1.0	0.073	5.2	0.8		2.3
	12:39	16260109	6.5	0.57	0.126	9.6	0.5	0.113	6.5	1.0	0.071	5.2	0.8		2.3
	12:40	16260110	6.5	0.56	0.127	9.7	0.4	0.114	6.4	1.0	0.070	5.0	0.8		2.3
	12:41	16260111	6.5	0.56	0.125	9.8	0.4	0.115	6.3	1.1	0.070	5.1	0.8		2.3
	12:42	16260112	6.4	0.56	0.125	9.9	0.4	0.116	6.3	1.0	0.070	5.1	0.8		2.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	12:43	16260113	6.5	0.56	0.126	9.8	0.4	0.116	6.6	1.0	0.073	5.0	0.8		0.8
	12:44	16260114	6.5	0.56	0.126	9.8	0.4	0.115	6.7	1.0	0.074	4.9	0.8		0.8
6/26/97	12:44	16260115	6.5	0.56	0.126	9.8	0.4	0.115	6.5	1.0	0.072	4.9	0.8		2.3
	12:45	16260116	6.5	0.55	0.126	9.8	0.4	0.115	6.6	1.0	0.073	4.8	0.8		2.3
	12:46	16260117	6.6	0.55	0.128	9.9	0.4	0.116	6.5	1.0	0.071	4.9	0.8		2.3
	12:47	16260118	6.7	0.55	0.129	10.1	0.4	0.119	6.4	1.0	0.070	4.9	0.7		2.2
	12:48	16260119	6.6	0.55	0.128	10.3	0.4	0.121	5.7	1.1	0.063	4.1	0.9	1.3	0.7
	12:49	16260120	6.7	0.55	0.130	10.3	0.4	0.121	5.8	1.1	0.064	4.2	0.9	1.4	0.7
	12:50	16260121	6.7	0.56	0.129	10.3	0.4	0.121	6.6	1.0	0.073	5.1	0.8		2.3
	12:51	16260122	6.9	0.56	0.132	10.3	0.4	0.120	5.8	1.1	0.064	4.2	0.9	1.5	0.7
	12:52	16260123	6.9	0.56	0.134	10.2	0.4	0.120	6.8	1.0	0.075	5.2	0.8		2.3
	12:53	16260124	7.0	0.57	0.135	10.1	0.5	0.119	6.6	1.1	0.073	5.4	0.8		2.4
	12:54	16260125	7.3	0.57	0.140	10.0	0.4	0.118	6.9	1.1	0.076	5.6	0.8		2.3
	12:54	16260126	7.4	0.57	0.144	10.0	0.5	0.117	7.2	1.1	0.080	5.9	0.8		2.4
	12:55	16260127	7.6	0.57	0.146	9.9	0.5	0.117	7.6	1.1	0.084	5.7	0.9		2.4
	12:56	16260128	7.6	0.58	0.148	10.0	0.5	0.117	7.4	1.1	0.081	6.1	0.8		2.4
	12:57	16260129	7.6	0.58	0.147	10.1	0.5	0.118	7.6	1.1	0.084	6.2	0.8		2.4
	12:58	16260130	7.6	0.59	0.147	10.1	0.5	0.118	7.3	1.1	0.080	6.1	0.8		2.4
	12:59	16260131	7.6	0.58	0.146	9.9	0.5	0.117	7.5	1.1	0.083	5.7	0.9		2.4
	13:00	16260132	7.4	0.58	0.143	9.8	0.5	0.115	7.2	1.1	0.079	5.8	0.8		2.4
	13:01	16260133	7.3	0.57	0.141	9.6	0.5	0.113	7.1	1.1	0.078	5.8	0.8		2.4
	13:02	16260134	7.2	0.58	0.140	9.5	0.5	0.111	6.1	1.2	0.068	5.1	0.9	1.6	0.8
	13:03	16260135	7.1	0.57	0.138	9.3	0.5	0.110	5.9	1.2	0.065	4.7	1.0	1.7	0.8
	13:04	16260136	7.0	0.57	0.135	9.2	0.5	0.109	5.7	1.2	0.063	4.5	1.0	1.6	0.8
	14:00	16260165	3.6	0.51	0.070	6.3	0.4	0.074	6.1	1.0	0.067	5.8	0.7		2.2
	14:00	16260166	3.6	0.52	0.070	6.5	0.4	0.077	6.0	1.0	0.066	6.0	0.7		2.3
	14:01	16260167	3.7	0.52	0.071	6.7	0.4	0.079	6.1	1.0	0.067	6.0	0.7		2.3
	14:02	16260168	3.6	0.52	0.071	7.0	0.4	0.082	6.1	1.0	0.067	5.9	0.7		2.2
	14:03	16260169	3.6	0.52	0.070	7.2	0.4	0.084	5.9	1.0	0.065	5.8	0.7		2.3
	14:04	16260170	3.6	0.52	0.070	7.4	0.4	0.087	6.0	1.0	0.066	6.0	0.8		2.3
	14:05	16260171	3.6	0.51	0.070	7.7	0.4	0.090	6.2	1.0	0.068	5.9	0.7		2.2
	14:06	16260172	3.6	0.52	0.070	7.9	0.4	0.093	6.0	1.0	0.067	5.9	0.7		2.3
	14:07	16260173	3.6	0.52	0.070	8.1	0.4	0.095	6.1	1.0	0.068	5.8	0.7		2.3
	14:08	16260174	3.7	0.51	0.071	8.2	0.4	0.097	6.0	1.0	0.067	5.8	0.7		2.2
	14:09	16260175	3.7	0.52	0.071	8.3	0.4	0.098	5.9	1.0	0.065	5.7	0.8		2.3
	14:09	16260176	3.7	0.52	0.071	8.4	0.4	0.098	6.1	1.0	0.068	5.8	0.8		2.3

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	14:10	16260177	3.6	0.52	0.071	8.5	0.4	0.100	6.0	1.0	0.066	5.7	0.7		2.3
	14:11	16260178	3.7	0.52	0.071	8.6	0.4	0.101	6.2	1.0	0.068	5.8	0.8		2.3
	14:12	16260179	3.7	0.53	0.072	8.7	0.4	0.102	6.1	1.0	0.067	5.8	0.8		2.3
	14:13	16260180	3.7	0.53	0.072	8.7	0.4	0.102	6.2	1.0	0.068	5.9	0.8		2.3
	14:14	16260181	3.7	0.53	0.072	8.7	0.4	0.102	6.1	1.0	0.068	5.7	0.8		2.3
	14:15	16260182	3.7	0.53	0.072	8.7	0.4	0.103	6.2	1.0	0.068	5.9	0.8		2.3
	14:16	16260183	3.7	0.53	0.073	8.9	0.4	0.105	6.2	1.1	0.069	5.9	0.8		2.4
	14:17	16260184	3.8	0.53	0.073	9.0	0.4	0.106	6.1	1.0	0.068	5.8	0.8		2.3
	14:18	16260185	3.8	0.54	0.073	9.0	0.4	0.106	6.5	1.1	0.071	5.9	0.8		2.4
	14:18	16260186	3.8	0.54	0.073	9.1	0.4	0.107	6.3	1.1	0.070	5.8	0.8		2.4
	14:19	16260187	3.8	0.54	0.073	9.1	0.4	0.107	6.2	1.1	0.068	5.8	0.8		2.4
	14:20	16260188	3.7	0.53	0.072	9.0	0.4	0.106	6.3	1.1	0.070	5.8	0.8		2.4
	14:21	16260189	3.7	0.54	0.072	9.0	0.4	0.106	6.2	1.1	0.068	5.8	0.8		2.4
	14:22	16260190	3.7	0.53	0.071	9.0	0.4	0.106	6.2	1.1	0.068	5.7	0.8		2.4
	14:23	16260191	3.7	0.53	0.071	8.9	0.4	0.105	6.1	1.1	0.068	5.6	0.8		2.4
	14:24	16260192	3.6	0.53	0.070	9.0	0.4	0.106	6.2	1.1	0.069	5.5	0.8		2.4
6/26/97	14:25	16260193	3.6	0.53	0.070	9.1	0.4	0.107	6.0	1.0	0.066	5.4	0.8		2.3
	14:26	16260194	3.6	0.53	0.070	9.3	0.4	0.109	6.0	1.1	0.066	5.6	0.8		2.4
	14:27	16260195	3.6	0.53	0.070	9.4	0.4	0.110	6.2	1.0	0.069	5.7	0.8		2.3
	14:28	16260196	3.7	0.53	0.071	9.3	0.4	0.110	5.9	1.0	0.066	5.6	0.8		2.3
	15:06	16260234	3.6	0.53	0.069	4.9	0.4	0.058	5.6	1.0	0.062	5.3	0.8		2.3
	15:07	16260235	3.5	0.53	0.067	5.3	0.4	0.062	5.5	1.0	0.061	5.5	0.8		2.3
	15:08	16260236	3.5	0.53	0.068	5.8	0.4	0.068	5.4	1.1	0.059	5.7	0.8		2.4
	15:09	16260237	3.5	0.53	0.067	6.1	0.4	0.071	5.5	1.1	0.060	5.8	0.8		2.4
	15:10	16260238	3.5	0.53	0.068	6.4	0.4	0.075	5.6	1.1	0.062	5.8	0.8		2.4
	15:10	16260239	3.5	0.53	0.067	6.6	0.4	0.077	5.5	1.1	0.061	5.7	0.8		2.4
	15:11	16260240	3.5	0.54	0.068	6.8	0.4	0.080	5.4	1.1	0.060	5.7	0.8		2.4
	15:12	16260241	3.5	0.53	0.067	7.0	0.4	0.082	5.2	1.1	0.057	5.7	0.8		2.4
	15:13	16260242	3.4	0.53	0.066	7.1	0.4	0.083	5.5	1.1	0.060	5.6	0.8		2.4
	15:14	16260243	3.4	0.53	0.065	7.2	0.4	0.085	5.3	1.0	0.059	5.5	0.8		2.3
	15:15	16260244	3.4	0.53	0.065	7.4	0.4	0.086	5.5	1.1	0.060	5.6	0.8		2.4
	15:16	16260245	3.4	0.53	0.067	7.5	0.4	0.088	5.5	1.1	0.060	5.6	0.8		2.4
	15:17	16260246	3.4	0.53	0.065	7.7	0.4	0.090	5.7	1.1	0.063	5.7	0.8		2.4
	15:18	16260247	3.5	0.53	0.067	7.8	0.4	0.092	5.6	1.0	0.062	5.7	0.8		2.3
	15:19	16260248	3.5	0.53	0.067	7.9	0.4	0.093	5.5	1.1	0.061	5.7	0.8		2.4
	15:19	16260249	3.4	0.53	0.066	8.0	0.4	0.094	4.9	1.1	0.055	5.3	0.9	1.0	0.7

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	15:20	16260250	3.5	0.53	0.068	8.1	0.4	0.095	5.6	1.1	0.061	5.6	0.8		2.4
	15:21	16260251	3.5	0.53	0.067	8.0	0.4	0.094	5.5	1.1	0.060	5.8	0.8		2.4
	15:22	16260252	3.4	0.53	0.067	8.0	0.4	0.094	5.5	1.0	0.061	5.7	0.8		2.3
6/26/97	15:23	16260253	3.5	0.53	0.067	8.0	0.4	0.094	4.9	1.2	0.054	5.3	0.9	1.0	0.7
	15:24	16260254	3.5	0.53	0.067	8.2	0.4	0.096	5.7	1.1	0.063	5.8	0.8		0.8
	15:25	16260255	3.5	0.53	0.068	8.2	0.4	0.096	4.9	1.1	0.054	5.3	0.9	1.0	0.7
	15:26	16260256	3.5	0.54	0.067	8.3	0.4	0.097	5.7	1.1	0.063	5.9	0.8		2.4
	15:27	16260257	3.5	0.54	0.068	8.4	0.4	0.099	5.0	1.2	0.055	5.4	0.9	1.0	0.8
	15:28	16260258	3.5	0.54	0.068	8.5	0.4	0.100	4.8	1.2	0.053	5.3	0.9	1.1	0.7
	15:29	16260259	3.5	0.53	0.067	8.5	0.4	0.100	4.5	1.2	0.050	5.2	0.9	1.2	0.8
	15:29	16260260	3.5	0.53	0.068	8.5	0.4	0.100	4.9	1.1	0.054	5.3	0.9	1.2	0.7
	15:30	16260261	3.5	0.54	0.067	8.5	0.4	0.100	4.9	1.2	0.054	5.3	0.9	1.2	0.8
	15:31	16260262	3.4	0.53	0.066	8.4	0.4	0.099	4.9	1.2	0.054	5.2	0.9	1.1	0.7
	15:32	16260263	3.5	0.54	0.067	8.4	0.4	0.099	5.0	1.2	0.056	5.3	0.9	1.2	0.8
	15:33	16260264	3.5	0.54	0.068	8.5	0.4	0.100	4.9	1.2	0.054	5.4	0.9	1.2	0.8
	16:00	INLS3007	2.0	0.4	0.039	3.2	0.3	0.038	45.6	0.9	0.503	5.1	0.7	1.3	0.6
	16:06	INLS3008	2.4	0.5	0.046	4.7	0.4	0.056	47.2	1.0	0.520	5.6	0.7	1.7	0.6
	16:10	INLS3009	2.0	0.4	0.038	5.0	0.3	0.059	50.8	0.9	0.560	5.1	0.7	1.6	0.6
	16:15	INLS3010	1.8	0.4	0.036	4.6	0.3	0.054	51.0	0.9	0.563	5.0	0.7	1.5	0.6
	16:24	INLS3011	3.4	0.5	0.066	4.8	0.3	0.057	5.5	0.8	0.061	4.8	0.6		1.9
	16:28	INLS3012	3.5	0.5	0.068	5.3	0.3	0.062	4.4	0.8	0.049	4.9	0.6		1.9
	16:33	INLS3013	3.6	0.5	0.069	5.3	0.3	0.062	4.5	0.8	0.049	4.9	0.6		1.9
		Average -->	4.8	0.54	0.092	8.2	0.4	0.096	5.8	1.0	0.063	4.7	0.8	0.1	1.8

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
6/27/97	9:21	INLS4001	2.3	0.4	0.045	3.5	0.3	0.041	38.0	0.8	0.419	4.0	0.6	0.9	0.5
	9:25	INLS4002	2.0	0.4	0.039	4.0	0.3	0.047	37.5	0.7	0.414	3.4	0.5	1.3	0.5
	9:29	INLS4003	2.0	0.4	0.040	4.7	0.3	0.055	37.5	0.7	0.414	3.3	0.5	1.2	0.5
	9:35	INLS4004	3.2	0.4	0.061	4.6	0.3	0.054	3.7	0.7	0.041	2.6	0.5	0.9	0.5
	9:40	INLS4005	3.2	0.5	0.062	4.7	0.3	0.055	3.5	0.7	0.039	2.5	0.5	0.8	0.5
	9:44	INLS4006	3.1	0.5	0.061	4.7	0.3	0.055	3.6	0.7	0.040	2.4	0.5	0.7	0.5
	10:21	16270035	3.4	0.48	0.065	4.7	0.38	0.056	4.2	0.82	0.047	3.0	0.6		0.7
	10:22	16270036	3.3	0.47	0.063	4.8	0.37	0.057	4.1	0.82	0.046	3.1	0.6		0.7

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	10:23	16270037	3.2	0.47	0.062	5.0	0.37	0.059	4.2	0.83	0.046	3.2	0.6		0.7
6/2797	10:23	16270038	3.2	0.47	0.062	5.3	0.38	0.063		1.16		2.3	0.7	1.5	0.5
	10:24	16270039	3.1	0.47	0.060	5.6	0.37	0.066		1.14		2.3	0.7	1.5	0.5
	10:25	16270040	3.1	0.47	0.059	5.9	0.37	0.069		1.15		2.2	0.7	1.4	0.5
	10:26	16270041	3.0	0.46	0.058	6.1	0.37	0.071		1.13		2.0	0.7	1.5	0.5
	10:27	16270042	3.0	0.46	0.058	6.2	0.37	0.073		1.12		1.9	0.6	1.5	0.5
	10:28	16270043	2.9	0.46	0.056	6.4	0.37	0.075		1.13		1.8	0.7	1.5	0.5
	10:29	16270044	2.9	0.46	0.056	6.4	0.36	0.075		1.13		1.9	0.7	1.6	0.5
	10:30	16270045	2.9	0.45	0.056	6.5	0.36	0.076		1.10		1.7	0.6	1.6	0.5
	10:31	16270046	2.9	0.45	0.057	6.6	0.36	0.077		1.12		1.8	0.6	1.5	0.5
	10:32	16270047	2.9	0.45	0.056	6.7	0.36	0.079		1.12		1.7	0.6	1.6	0.5
	10:33	16270048	2.9	0.46	0.057	6.8	0.37	0.080		1.15		1.7	0.7	1.6	0.5
	10:33	16270049	2.9	0.46	0.055	7.0	0.37	0.083		1.17		1.8	0.7	1.6	0.5
	10:34	16270050	2.9	0.47	0.057	7.2	0.37	0.084		1.17		1.8	0.7	1.7	0.5
	10:35	16270051	3.0	0.48	0.057	7.4	0.38	0.086		1.22		1.9	0.7	1.6	0.6
	10:36	16270052	3.0	0.47	0.058	7.5	0.38	0.087		1.16		1.9	0.7	1.7	0.5
	10:37	16270053	3.1	0.48	0.059	7.6	0.38	0.089		1.18		2.0	0.7	1.7	0.6
	10:38	16270054	3.1	0.48	0.061	7.7	0.38	0.090		1.20		2.0	0.7	1.7	0.6
	10:39	16270055	3.1	0.49	0.060	7.7	0.39	0.090		1.22		2.0	0.7	1.7	0.6
	10:40	16270056	3.2	0.49	0.062	7.7	0.39	0.091		1.20		1.9	0.7	1.7	0.6
	10:41	16270057	3.2	0.49	0.062	7.6	0.39	0.090		1.21		1.9	0.7	1.7	0.6
	10:42	16270058	3.3	0.49	0.063	7.6	0.39	0.089		1.21		2.0	0.7	1.8	0.6
	10:42	16270059	3.2	0.48	0.063	7.5	0.38	0.088		1.17		2.0	0.7	1.8	0.6
	10:43	16270060	3.3	0.49	0.064	7.6	0.39	0.089		1.21		2.1	0.7	1.7	0.6
	10:44	16270061	3.3	0.49	0.064	7.6	0.39	0.090		1.20		2.0	0.7	1.8	0.6
	10:45	16270062	3.3	0.49	0.065	7.7	0.39	0.090		1.22		2.0	0.7	1.8	0.6
	10:46	16270063	3.3	0.49	0.064	7.7	0.39	0.090		1.22		1.9	0.7	1.9	0.6
	10:47	16270064	3.3	0.50	0.064	7.7	0.39	0.090		1.24		2.1	0.7	1.8	0.6
	10:48	16270065	3.3	0.50	0.065	7.6	0.40	0.089		1.24		2.1	0.7	1.8	0.6
	10:49	16270066	3.2	0.50	0.063	7.5	0.40	0.088		1.26		2.0	0.7	1.8	0.6
	11:07	16270081	3.7	0.53	0.071	5.1	0.42	0.060	4.4	0.97	0.049	3.0	0.7		0.8
	11:08	16270082	3.7	0.53	0.071	5.5	0.42	0.065		1.33		2.2	0.8	1.3	0.6
	11:09	16270083	3.6	0.53	0.070	5.9	0.42	0.069		1.33		2.1	0.8	1.3	0.6
	11:10	16270084	3.6	0.52	0.070	6.2	0.42	0.072		1.33		2.0	0.8	1.4	0.6
	11:11	16270085	3.6	0.53	0.069	6.4	0.42	0.075		1.34		2.0	0.8	1.4	0.6
	11:12	16270086	3.5	0.53	0.068	6.6	0.42	0.077		1.35		1.8	0.8	1.5	0.6

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	11:13	16270087	3.5	0.53	0.068	6.8	0.42	0.080		1.34		1.7	0.8	1.5	0.6
	11:14	16270088	3.5	0.53	0.067	7.1	0.42	0.083		1.37		1.8	0.8	1.5	0.6
	11:15	16270089	3.4	0.52	0.066	7.1	0.41	0.084		1.32		1.6	0.8	1.5	0.6
	11:15	16270090	3.4	0.52	0.065	7.1	0.42	0.084		1.35		1.7	0.8	1.5	0.6
	11:16	16270091	3.4	0.51	0.066	7.1	0.41	0.084		1.31		1.5	0.8	1.5	0.6
	11:17	16270092	3.3	0.51	0.065	7.2	0.41	0.084		1.31		1.5	0.8	1.5	0.6
	11:18	16270093	3.3	0.52	0.064	7.2	0.41	0.084		1.34		1.7	0.8	1.6	0.6
6/27/97	11:19	16270094	3.3	0.52	0.063	7.3	0.41	0.085		1.32		1.6	0.8	1.7	0.6
	11:20	16270095	3.5	0.52	0.068	7.5	0.41	0.088		1.35		1.5	0.8	1.7	0.6
	11:21	16270096	3.4	0.52	0.065	7.6	0.42	0.089		1.33		1.7	0.8	1.7	0.6
	11:22	16270097	3.3	0.51	0.064	7.5	0.41	0.088		1.33		1.6	0.8	1.6	0.6
	11:23	16270098	3.4	0.51	0.065	7.6	0.41	0.089		1.34		1.7	0.8	1.7	0.6
	11:24	16270099	3.4	0.52	0.065	7.8	0.42	0.091		1.37		1.6	0.8	1.6	0.6
	11:24	16270100	3.4	0.53	0.066	7.9	0.42	0.093		1.38		1.9	0.8	1.7	0.6
	11:25	16270101	3.4	0.52	0.066	8.1	0.42	0.095		1.38		1.9	0.8	1.7	0.6
	11:26	16270102	3.5	0.53	0.067	8.1	0.42	0.095		1.40		2.0	0.8	1.8	0.7
	11:27	16270103	3.5	0.53	0.067	8.1	0.42	0.095		1.39		2.0	0.8	1.7	0.7
	11:28	16270104	3.6	0.53	0.070	8.1	0.42	0.095		1.42		2.0	0.8	1.8	0.7
	11:29	16270105	3.5	0.53	0.068	8.1	0.42	0.095		1.40		1.9	0.8	1.8	0.7
	11:30	16270106	3.5	0.53	0.068	8.1	0.42	0.096		1.39		1.9	0.8	1.8	0.7
	11:31	16270107	3.4	0.52	0.067	8.1	0.42	0.095		1.39		2.0	0.8	1.8	0.7
	11:32	16270108	3.5	0.52	0.067	8.1	0.41	0.095		1.39		1.9	0.8	1.8	0.7
	11:33	16270109	3.5	0.51	0.067	8.1	0.41	0.095		1.35		1.9	0.8	1.8	0.6
	11:33	16270110	3.5	0.51	0.067	8.2	0.41	0.096		1.35		2.0	0.8	1.9	0.6
	11:34	16270111	3.3	0.51	0.065	8.2	0.40	0.097		1.35		1.8	0.8	1.8	0.6
	11:35	16270112	3.3	0.51	0.064	8.2	0.40	0.096		1.35		1.7	0.8	1.9	0.6
	11:36	16270113	3.2	0.50	0.062	8.1	0.40	0.095		1.34		1.6	0.8	1.8	0.6
	11:37	16270114	3.1	0.50	0.061	8.0	0.39	0.094		1.32		1.4	0.8	1.8	0.6
	11:38	16270115	3.1	0.49	0.059	8.0	0.39	0.094		1.29		1.4	0.7	1.7	0.6
	11:39	16270116	3.0	0.48	0.058	8.0	0.39	0.094		1.31		1.2	0.8	1.7	0.6
	11:40	16270117	3.0	0.48	0.058	8.0	0.38	0.094		1.28		1.4	0.7	1.6	0.6
	12:15	16270152	3.4	0.51	0.066	5.3	0.41	0.062		1.43		1.5	0.8	1.2	0.7
	12:16	16270153	3.4	0.51	0.066	5.7	0.41	0.067		1.42		1.7	0.8	1.3	0.7
	12:17	16270154	3.4	0.52	0.066	6.1	0.41	0.071		1.46		1.7	0.8	1.2	0.7
	12:18	16270155	3.4	0.52	0.067	6.3	0.41	0.074		1.45		1.7	0.8	1.2	0.7
	12:19	16270156	3.4	0.52	0.066	6.6	0.41	0.077		1.45		1.5	0.8	1.3	0.7

TABLE B-1. CONTINUED (LTV Scrubber Inlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	2-Methyl-2-Butene	Unc
	12:20	16270157	3.4	0.51	0.065	6.7	0.41	0.079		1.45		1.5	0.8	1.3	0.7
	12:21	16270158	3.4	0.52	0.066	6.9	0.41	0.081		1.47		1.5	0.8	1.3	0.7
	12:21	16270159	3.4	0.52	0.066	7.0	0.41	0.082		1.48		1.5	0.8	1.4	0.7
	12:22	16270160	3.4	0.52	0.066	7.1	0.42	0.084		1.50		1.5	0.9	1.3	0.7
	12:23	16270161	3.4	0.52	0.065	7.4	0.42	0.086		1.49		1.6	0.9	1.4	0.7
	12:24	16270162	3.4	0.52	0.065	7.5	0.41	0.088		1.49		1.7	0.9	1.4	0.7
	12:25	16270163	3.4	0.52	0.065	7.5	0.41	0.089		1.47		1.8	0.8	1.5	0.7
	12:26	16270164	3.5	0.53	0.067	7.6	0.42	0.090		1.49		1.8	0.9	1.5	0.7
	12:27	16270165	3.5	0.53	0.067	7.7	0.42	0.091		1.51		2.0	0.9	1.5	0.7
	12:28	16270166	3.6	0.54	0.070	7.8	0.43	0.092		1.55		2.2	0.9	1.5	0.7
	12:29	16270167	3.6	0.54	0.070	7.9	0.43	0.092		1.56		2.3	0.9	1.5	0.7
	12:30	16270168	3.7	0.54	0.071	7.9	0.43	0.092		1.57		2.4	0.9	1.6	0.7
	12:31	16270169	3.8	0.55	0.073	7.9	0.44	0.092		1.60		2.4	0.9	1.6	0.7
	12:32	16270170	3.8	0.55	0.074	7.8	0.44	0.092		1.58		2.6	0.9	1.6	0.7
	12:33	16270171	3.9	0.56	0.076	7.9	0.44	0.093		1.63		2.8	0.9	1.6	0.8
	12:33	16270172	4.0	0.54	0.077	8.0	0.43	0.094		1.61		2.8	0.9	1.6	0.7
	12:34	16270173	4.0	0.55	0.077	8.1	0.43	0.095		1.61		2.7	0.9	1.6	0.7
	12:35	16270174	4.0	0.54	0.077	8.2	0.43	0.096		1.58		2.6	0.9	1.6	0.7
	12:36	16270175	4.0	0.54	0.076	8.1	0.43	0.096		1.60		2.8	0.9	1.5	0.7
	12:37	16270176	3.9	0.53	0.075	8.1	0.43	0.095		1.59		2.8	0.9	1.5	0.7
	12:38	16270177	3.9	0.53	0.076	8.0	0.42	0.094		1.57		2.6	0.9	1.5	0.7
6/27/97	12:39	16270178	3.9	0.54	0.076	8.0	0.43	0.094		1.60		2.6	0.9	1.5	0.7
	12:40	16270179	3.9	0.53	0.076	7.9	0.42	0.093		1.58		2.6	0.9	1.6	0.7
	12:41	16270180	3.8	0.53	0.074	7.9	0.42	0.093		1.57		2.6	0.9	1.5	0.7
	12:42	16270181	3.8	0.53	0.074	7.9	0.42	0.092		1.54		2.6	0.9	1.6	0.7
	12:42	16270182	3.9	0.53	0.075	7.9	0.42	0.093		1.57		2.7	0.9	1.6	0.7
	12:43	16270183	3.9	0.53	0.075	8.0	0.42	0.094		1.57		2.8	0.9	1.6	0.7
	12:44	16270184	3.8	0.53	0.074	8.0	0.43	0.094		1.59		2.8	0.9	1.6	0.7
	13:22	**INLS4007**	**2.3**	**0.4**	**0.044**	**2.6**	**0.3**	**0.030**	**54.7**	**1.0**	**0.603**	**3.2**	**0.7**	**1.2**	**0.6**
	13:25	**INLS4008**	**2.1**	**0.4**	**0.041**	**3.6**	**0.4**	**0.042**	**57.3**	**1.0**	**0.632**	**3.0**	**0.8**	**1.3**	**0.7**
	13:29	**INLS4009**	**2.2**	**0.5**	**0.042**	**4.0**	**0.4**	**0.047**	**57.4**	**1.0**	**0.633**	**3.2**	**0.8**	**1.3**	**0.7**
	13:36	**INLS4010**	**4.2**	**0.5**	**0.082**	**4.2**	**0.4**	**0.050**		**1.3**		**2.1**	**0.7**	**1.1**	**0.6**
	13:41	**INLS4011**	**3.6**	**0.5**	**0.070**	**4.7**	**0.4**	**0.055**		**1.3**		**1.8**	**0.7**		**0.6**
	13:45	**INLS4012**	**3.2**	**0.5**	**0.063**	**5.2**	**0.3**	**0.061**		**1.2**		**1.7**	**0.6**		**0.6**
		Average -->	3.4	0.51	0.066	7.3	0.40	0.085	0.2	1.34	0.002	2.0	0.8	1.5	0.6

* Blank spaces indicate the compound was not detected in that sample. These are included in the averages as zero concentrations.

File Names are in the data records in Appendix B. Bold face type indicates a sample that was spiked with SF_6 or toluene. Spiked samples are not included in the run averages.

TABLE B-2. FTIR RESULTS (ppm) AND EMISSION RATES AT THE LTV SCRUBBER OUTLET [a]

Date	Time	File Name[b]	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
6/25/97	8:41	OUTS2001	798.4	10.9	17.41	32.0	2.3	1.60	9.2	0.6	0.215	14.8	0.4	0.184		3.0
	8:46	OUTS2002	813.2	11.9	17.73	33.3	2.4	1.66	6.0	0.7	0.141	15.0	0.5	0.187	1.9	0.3
	8:52	OUTS2003	811.8	12.0	17.70	39.4	2.5	1.96	6.1	0.7	0.142	14.8	0.5	0.184	1.9	0.3
	9:02	OUTS2004	785.8	13.9	17.13	27.4	2.9	1.36	6.4	0.8	0.150	14.5	0.6	0.181		4.1
	9:08	OUTS2005	767.2	14.0	16.73	19.1	3.0	0.95	8.3	0.9	0.193	14.1	0.6	0.176		4.3
	9:13	OUTS2006	769.0	14.8	16.77	19.7	3.0	0.98	7.5	0.9	0.175	14.1	0.6	0.175		4.4
	10:15	OUT2U007	827.9	19.3	18.05	35.9	3.5	1.79	9.0	1.0	0.210	14.9	0.7	0.186		5.1
	10:22	OUTV2008	846.8	24.8	18.46	37.9	3.5	1.89	9.4	1.0	0.219	15.5	0.7	0.194		5.1
	10:26	OUTV2009	861.8	26.6	18.79	22.8	3.6	1.14	5.8	1.0	0.135	15.4	0.7	0.192	2.0	0.5
	10:31	OUTV2010	871.5	23.8	19.00	20.0	3.6	1.00	6.0	1.0	0.139	16.2	0.7	0.201		5.2
	10:54	OUTV2011	831.2	17.1	18.12	26.5	3.2	1.32	12.3	0.9	0.288	15.5	0.7	0.193	2.8	0.4
	11:00	OUTV2012	858.8	20.5	18.72	31.4	3.5	1.56	5.5	1.0	0.128	15.9	0.7	0.198	2.3	0.5
	11:04	OUTV2013	841.1	20.1	18.34	28.0	3.5	1.39	5.5	1.0	0.129	15.8	0.7	0.197	2.3	0.5
	11:08	OUTV2014	845.6	21.5	18.43	34.8	3.5	1.74	6.2	1.0	0.144	15.3	0.7	0.190	2.3	0.5
	11:34	OUTV2015	794.3	17.9	17.32	20.5	3.5	1.02	5.3	1.0	0.124	14.8	0.7	0.185		5.2
	11:39	OUTV2016	779.7	16.5	17.00	22.0	3.4	1.09	5.7	1.0	0.134	15.0	0.7	0.186		5.2
	11:43	OUTV2017	787.8	18.6	17.17	21.1	3.5	1.05	3.6	1.1	0.084	16.1	0.7	0.201		5.3
	11:47	OUTV2018	793.4	20.3	17.30	13.3	3.6	0.66	3.4	1.1	0.079	15.8	0.7	0.197		5.4
	12:39	OUTV2019	853.1	17.8	18.60	22.9	3.4	1.14	8.4	1.0	0.196	21.5	0.7	0.268		5.1
	12:43	OUTV2020	842.0	19.3	18.35	21.1	3.6	1.05	8.2	1.1	0.192	20.3	0.8	0.253		5.5
	12:47	OUTV2021	814.3	24.1	17.75	29.9	3.7	1.49	5.4	1.1	0.127	18.7	0.8	0.233		5.6
	12:50	OUTV2022	815.1	19.4	17.77	43.4	3.6	2.16	5.4	1.1	0.126	17.9	0.8	0.223		5.6
	13:11	OUTV2023	823.7	21.6	17.96	30.7	3.6	1.53	4.5	1.1	0.105	18.0	0.8	0.225		5.6
	13:15	OUTV2024	828.9	16.0	18.07	32.7	3.3	1.63	6.6	1.0	0.154	18.2	0.7	0.227		5.1
	13:18	OUTV2025	826.2	15.8	18.01	30.7	3.2	1.53	5.0	1.0	0.118	18.4	0.7	0.229	1.4	0.5
	13:22	OUTV2026	763.2	72.8	16.64	24.3	4.1	1.21	6.6	1.2	0.153	16.5	0.9	0.206		6.3
	14:01	OUTV2027	759.5	22.3	16.56	14.6	3.8	0.73	7.4	1.2	0.174	14.5	0.8	0.181		5.9
	14:04	OUTV2028	788.9	48.7	17.20	12.7	3.8	0.63	9.2	1.2	0.215	15.6	0.8	0.195	1.4	0.5
	14:08	OUTV2029	791.9	15.3	17.26	13.2	3.2	0.66	10.6	1.0	0.247	15.7	0.7	0.195	1.9	0.5
	14:12	OUTV2030	799.9	14.4	17.44	14.2	3.1	0.71	8.3	1.0	0.194	15.7	0.7	0.196	2.1	0.4
	14:37	OUTV2031	826.8	19.1	18.02	54.1	3.6	2.70	7.7	1.1	0.181	15.5	0.8	0.192		5.5
	14:42	OUTV2032	797.0	18.4	17.38	44.7	3.6	2.23	8.2	1.1	0.192	14.6	0.8	0.182		5.6
	14:46	OUTV2033	791.6	17.3	17.26	35.4	3.5	1.77	8.7	1.1	0.204	14.3	0.8	0.179		5.6
	14:51	OUTV2034	780.5	19.4	17.02	35.1	3.6	1.75	8.0	1.1	0.188	13.7	0.8	0.171		5.7
	15:15	OUTV2035	779.2	18.3	16.99	17.1	3.6	0.85	7.5	1.1	0.174	15.1	0.8	0.188		5.8
	15:19	OUTV2036	768.7	21.1	16.76	13.9	3.9	0.69	7.3	1.2	0.171	14.6	0.8	0.182		6.1
	15:24	OUTV2037	780.4	17.7	17.01	6.8	3.6	0.34	8.7	1.1	0.204	14.8	0.8	0.185		6.8

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name[b]	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formal-dehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	15:28	OUTV2038	791.7	20.0	17.26	6.7	3.7	0.34	7.7	1.2	0.180	15.0	0.8	0.187		5.9
	15:52	OUTV2039	776.4	21.5	16.92	14.6	3.8	0.73	7.0	1.2	0.164	14.0	0.8	0.174		6.0
	15:57	OUTV2040	779.9	27.7	17.00	10.7	3.8	0.53	8.1	1.2	0.189	14.0	0.8	0.175		6.0
	16:03	OUTV2041	781.9	20.1	17.05	19.0	3.7	0.95	8.4	1.2	0.197	13.9	0.8	0.173		5.9
	16:08	OUTV2042	772.7	17.4	16.85	16.0	3.6	0.80	8.5	1.1	0.199	14.1	0.8	0.175		5.7
	16:33	OUTV2043	812.1	17.2	17.70	24.8	3.6	1.23	8.1	1.1	0.190	16.4	0.8	0.204		5.8
	16:39	INLV2044	808.6	23.2	17.63	31.8	3.8	1.58	7.6	1.2	0.177	16.0	0.9	0.199		6.1
	16:43	INLV2045	796.7	20.3	17.37	27.9	3.7	1.39	7.9	1.2	0.184	15.5	0.8	0.193		6.0
	16:48	INLV2046	801.1	24.7	17.46	27.9	3.7	1.39	7.9	1.2	0.184	15.0	0.8	0.187		6.1
	17:36	OUTS2047	747.3	13.9	16.29	16.5	3.2	0.82	7.6	1.1	0.177	15.7	0.8	0.196		5.4
	17:41	OUTS2048	766.3	14.0	16.71	14.0	3.2	0.70	8.0	1.1	0.186	15.9	0.8	0.198		5.5
	17:46	OUTS2049	782.5	15.1	17.06	25.3	3.3	1.26	8.7	1.1	0.202	16.6	0.8	0.207		5.7
	17:56	OUTS2050	746.2	13.7	16.27	30.4	3.1	1.52	8.2	1.1	0.192	15.5	0.7	0.193		5.4
6/25/97	18:00	OUTS2051	728.4	14.7	15.88	23.0	3.4	1.15	7.7	1.1	0.180	14.3	0.8	0.178		5.8
	18:04	OUTS2052	727.7	14.2	15.86	18.8	3.3	0.94	7.5	1.1	0.174	14.0	0.8	0.175		5.7
		Average -->	807.3	21.9	17.60	24.8	3.6	1.23	7.3	1.1	0.170	15.8	0.8	0.197	0.5	4.5

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formalde hyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
6/26/97	9:53	OUTS3001	785.0	11.6	17.11	51.5	2.4	2.57	7.3	0.6	0.172	14.6	0.4	0.182	1.6	0.3
	9:59	OUTS3002	848.5	13.8	18.50	55.0	2.7	2.74	6.9	0.7	0.160	16.0	0.5	0.200	1.9	0.3
	10:04	OUTS3003	851.4	14.5	18.56	50.3	2.8	2.51	6.0	0.7	0.141	16.0	0.5	0.199	2.0	0.3
	10:21	OUTS3004	780.8	11.2	17.02	48.1	2.3	2.40	6.2	0.6	0.145	14.5	0.4	0.181	1.4	0.3
	10:26	OUTS3005	777.7	11.3	16.95	38.8	2.4	1.93	6.3	0.6	0.147	14.4	0.5	0.180	1.5	0.3
	10:37	OUTS3006	782.6	11.1	17.06	50.4	2.3	2.51	5.9	0.6	0.139	14.1	0.4	0.176	1.9	0.3
	10:43	OUTS3007	785.3	11.3	17.12	51.8	2.4	2.58	5.8	0.6	0.136	14.1	0.4	0.176	1.9	0.3
	10:49	OUTS3008	778.9	11.7	16.98	57.0	2.4	2.84	5.9	0.6	0.138	13.9	0.5	0.173	2.0	0.3
	11:28	16260038	841.2	14.4	18.34	46.2	2.9	2.30	2.8	0.8	0.065	17.1	0.6	0.212	3.3	0.4
	11:29	16260039	841.4	14.8	18.34	44.7	3.0	2.23	3.2	0.8	0.075	17.1	0.6	0.213	3.2	0.4
	11:30	16260040	844.4	15.1	18.41	42.8	3.0	2.13	2.6	0.9	0.062	17.1	0.6	0.213	3.1	0.4
	11:31	16260041	837.9	15.0	18.27	41.2	3.0	2.05	2.4	0.9	0.055	17.2	0.6	0.214	3.1	0.4
	11:32	16260042	837.7	15.4	18.26	40.6	3.1	2.02	2.3	0.9	0.053	17.3	0.6	0.215	3.0	0.4
	11:33	16260043	836.2	15.5	18.23	38.9	3.1	1.94	2.2	0.9	0.052	17.4	0.6	0.216	3.0	0.4
	11:33	16260044	824.5	14.8	17.97	37.1	3.0	1.85	2.2	0.9	0.052	17.2	0.6	0.214	3.0	0.4
	11:34	16260045	824.3	15.0	17.97	35.6	3.1	1.77	2.2	0.9	0.052	17.2	0.6	0.214	2.9	0.4

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formaldehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	11:35	16260046	818.9	15.0	17.85	34.0	3.0	1.70	2.2	0.9	0.051	17.1	0.6	0.213	2.9	0.4
	11:36	16260047	822.0	15.3	17.92	32.9	3.1	1.64	2.3	0.9	0.053	17.1	0.6	0.212	2.9	0.4
	11:37	16260048	818.3	14.8	17.84	30.7	3.1	1.53	2.2	0.9	0.051	16.9	0.6	0.211	2.9	0.4
	11:38	16260049	818.5	15.0	17.84	28.5	3.1	1.42	2.3	0.9	0.053	17.1	0.6	0.213	2.9	0.4
	11:39	16260050	817.0	14.8	17.81	26.5	3.1	1.32	2.2	0.9	0.052	17.2	0.6	0.214	2.8	0.4
	11:40	16260051	823.5	15.1	17.95	26.1	3.1	1.30	2.2	0.9	0.052	17.3	0.6	0.215	2.9	0.4
	11:41	16260052	821.3	14.8	17.90	25.2	3.1	1.26	2.2	0.9	0.053	17.4	0.6	0.217	2.8	0.4
	11:42	16260053	824.5	15.1	17.97	24.8	3.2	1.23	2.3	0.9	0.054	18.0	0.6	0.225	2.9	0.4
	11:42	16260054	824.9	14.7	17.98	24.3	3.1	1.21	2.3	0.9	0.053	18.2	0.6	0.226	2.9	0.4
	11:43	16260055	832.7	15.4	18.15	25.2	3.1	1.25	2.3	0.9	0.053	18.0	0.6	0.224	2.9	0.4
	11:44	16260056	842.3	16.1	18.36	26.4	3.1	1.31	2.3	0.9	0.054	18.1	0.6	0.225	2.9	0.4
	11:45	16260057	836.7	15.5	18.24	27.8	3.1	1.38	2.3	0.9	0.054	17.9	0.6	0.223	2.8	0.4
	11:46	16260058	845.8	15.8	18.44	28.9	3.2	1.44	2.3	0.9	0.055	18.0	0.6	0.225	2.9	0.4
	11:47	16260059	842.2	15.3	18.36	29.9	3.2	1.49	2.4	0.9	0.055	18.2	0.6	0.227	2.9	0.4
	11:48	16260060	847.4	16.1	18.47	30.3	3.2	1.51	2.4	0.9	0.056	18.3	0.6	0.229	2.8	0.4
	11:49	16260061	849.4	15.9	18.52	31.1	3.2	1.55	2.4	0.9	0.056	18.4	0.7	0.229	2.8	0.4
	11:50	16260062	846.6	15.9	18.46	31.7	3.2	1.58	2.4	0.9	0.057	18.4	0.6	0.230	2.8	0.4
6/26/97	11:51	16260063	844.1	16.0	18.40	32.2	3.2	1.61	2.5	0.9	0.058	18.5	0.6	0.230	2.8	0.4
	11:52	16260064	840.3	15.5	18.32	31.6	3.2	1.58	2.5	0.9	0.058	18.5	0.6	0.230	2.8	0.4
	11:53	16260065	841.3	16.0	18.34	31.0	3.2	1.55	2.6	0.9	0.061	18.5	0.7	0.230	2.7	0.4
	12:23	16260093	868.4	16.0	18.93	18.4	3.1	0.92	3.5	0.9	0.083	22.3	0.6	0.278	3.4	0.4
	12:24	16260094	859.5	15.9	18.74	18.1	3.1	0.90	3.7	0.9	0.087	22.5	0.6	0.280	3.2	0.4
	12:25	16260095	850.2	15.1	18.53	18.3	3.2	0.91	3.5	0.9	0.082	22.4	0.7	0.279	3.0	0.4
	12:25	16260096	854.4	16.1	18.63	18.8	3.3	0.93	3.5	1.0	0.082	22.3	0.7	0.278	3.0	0.4
	12:26	16260097	850.2	15.9	18.53	18.2	3.3	0.91	3.5	1.0	0.081	22.6	0.7	0.281	2.9	0.4
	12:27	16260098	851.9	16.2	18.57	19.2	3.2	0.96	3.4	1.0	0.079	22.4	0.7	0.279	3.0	0.4
6/26/97	12:28	16260099	847.6	16.1	18.48	19.0	3.3	0.95	3.4	1.0	0.080	22.2	0.7	0.277	2.9	0.4
	12:29	16260100	856.4	16.5	18.67	18.2	3.3	0.91	3.5	1.0	0.081	22.4	0.7	0.279	2.9	0.4
	12:30	16260101	858.1	16.5	18.71	17.6	3.3	0.88	3.5	1.0	0.082	22.6	0.7	0.282	2.9	0.4
	13:07	16260138	878.6	17.0	19.15	5.4	3.2	0.27	1.8	0.9	0.041	22.4	0.7	0.278	3.7	0.4
	13:08	16260139	877.6	17.3	19.13	4.7	3.3	0.23	2.2	1.0	0.051	22.2	0.7	0.276	3.6	0.5
	13:09	16260140	875.2	18.2	19.08		3.5		2.3	1.0	0.055	22.3	0.7	0.277	3.4	0.5
	13:10	16260141	866.0	19.0	18.88		3.7		2.4	1.1	0.056	22.1	0.8	0.275	3.2	0.5
	13:11	16260142	867.4	22.4	18.91		3.9		2.5	1.1	0.057	21.5	0.8	0.268	3.1	0.5
	13:12	16260143	858.6	40.8	18.72		4.0		2.5	1.2	0.060	21.3	0.8	0.265	3.0	0.5
	13:13	16260144	864.3	41.2	18.84		4.1		2.6	1.2	0.061	21.2	0.8	0.264	2.9	0.6

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formaldehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	13:14	16260145	847.4	50.5	18.47		4.2		2.8	1.2	0.066	21.0	0.9	0.261	2.9	0.6
	13:15	16260146	860.2	49.2	18.75		4.2		2.8	1.2	0.066	20.7	0.9	0.257	2.8	0.6
	13:16	16260147	846.8	40.7	18.46		4.2		3.0	1.2	0.070	20.5	0.9	0.255	2.9	0.6
	13:16	16260148	863.6	49.4	18.83		4.2		2.9	1.2	0.069	20.3	0.9	0.253	2.8	0.6
	13:17	16260149	856.6	42.7	18.67		4.2		3.1	1.2	0.071	20.1	0.9	0.250	2.8	0.6
	13:18	16260150	849.5	39.1	18.52		4.1		3.0	1.2	0.071	19.9	0.8	0.248	2.9	0.5
	13:19	16260151	869.3	40.9	18.95		4.1		3.1	1.2	0.073	19.8	0.8	0.247	2.9	0.5
	13:20	16260152	848.5	40.0	18.50		4.2		3.0	1.2	0.071	19.5	0.9	0.243	2.8	0.6
	13:21	16260153	841.0	39.4	18.33	5.1	4.2	0.25	3.1	1.2	0.072	19.3	0.9	0.240	2.8	0.6
	13:22	16260154	847.7	49.7	18.48	6.0	4.2	0.30	3.1	1.2	0.074	18.9	0.9	0.236	2.8	0.6
	13:23	16260155	835.9	50.4	18.22	6.1	4.2	0.30	3.1	1.2	0.073	18.8	0.9	0.234	2.8	0.6
	13:24	16260156	833.7	55.9	18.18	6.5	4.3	0.32	3.2	1.2	0.074	18.5	0.9	0.230	2.8	0.6
	13:25	16260157	855.6	49.1	18.65	7.2	4.3	0.36	3.3	1.2	0.076	18.2	0.9	0.227	2.8	0.6
	13:26	16260158	829.9	39.2	18.09	8.3	4.2	0.41	3.1	1.2	0.073	18.1	0.9	0.225	2.8	0.6
	13:27	16260159	839.9	45.9	18.31	8.2	4.3	0.41	3.1	1.3	0.072	17.8	0.9	0.221	2.7	0.6
	13:27	16260160	846.8	49.2	18.46	7.2	4.4	0.36	3.1	1.3	0.073	17.8	0.9	0.222	2.7	0.6
	13:28	16260161	829.2	55.5	18.08	6.4	4.4	0.32	3.1	1.3	0.072	17.6	0.9	0.220	2.7	0.6
	13:29	16260162	837.3	55.9	18.25	7.0	4.4	0.35	3.0	1.3	0.070	17.6	0.9	0.220	2.7	0.6
6/26/97	13:30	16260163	817.2	60.0	17.82	7.5	4.5	0.37	3.1	1.3	0.073	17.5	0.9	0.218	2.6	0.6
	13:31	16260164	833.7	60.5	18.17	9.1	4.4	0.45	3.1	1.3	0.073	17.3	0.9	0.216	2.6	0.6
	14:32	16260199	779.9	55.6	17.00		4.5		1.4	1.3	0.032	15.5	0.9	0.193	1.1	0.6
	14:33	16260200	780.9	49.2	17.02		4.5		2.0	1.3	0.047	15.4	0.9	0.192	1.0	0.6
	14:34	16260201	776.0	59.9	16.92		4.7		2.5	1.4	0.059	15.5	1.0	0.193	1.1	0.6
	14:35	16260202	785.5	59.6	17.12		4.7		2.8	1.4	0.067	15.6	1.0	0.195	1.1	0.6
	14:36	16260203	778.7	59.8	16.98		4.6		3.0	1.3	0.069	15.8	0.9	0.196	1.3	0.6
	14:37	16260204	780.2	59.9	17.01		4.8		3.0	1.4	0.070	15.7	1.0	0.195	1.1	0.6
	14:38	16260205	790.3	59.7	17.23		4.7		2.7	1.4	0.063	15.8	1.0	0.196	1.4	0.6
	14:39	16260206	782.5	59.8	17.06		4.7		3.3	1.4	0.078	15.7	1.0	0.195	1.2	0.6
	14:40	16260207	785.1	59.6	17.12		4.8		3.3	1.4	0.078	15.7	1.0	0.195	1.2	0.6
	14:40	16260208	787.8	59.9	17.17		4.8		3.3	1.4	0.078	15.6	1.0	0.194	1.2	0.6
	14:41	16260209	772.5	59.8	16.84		4.8		3.5	1.4	0.082	15.6	1.0	0.194	1.1	0.6
	14:42	16260210	772.7	60.1	16.84		4.7		3.7	1.4	0.086	15.5	1.0	0.194		6.9
	14:43	16260211	766.0	60.2	16.70		4.7		3.3	1.4	0.076	15.6	1.0	0.194	1.1	0.6
	14:44	16260212	770.8	59.9	16.80		4.7		2.7	1.4	0.063	15.7	1.0	0.196	1.3	0.6
	14:45	16260213	769.3	60.3	16.77		4.6		3.1	1.4	0.072	15.7	1.0	0.196	1.0	0.6
	14:46	16260214	779.5	60.4	16.99		4.7		3.4	1.4	0.080	15.5	1.0	0.193		6.9

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formaldehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	14:47	16260215	769.7	60.4	16.78		4.6		3.1	1.4	0.072	15.9	1.0	0.198	1.1	0.6
	14:48	16260216	776.4	60.4	16.93		4.6		2.7	1.4	0.063	15.6	1.0	0.194	1.3	0.6
6/26/97	14:49	16260217	767.8	60.2	16.74		4.6		3.6	1.4	0.083	15.4	1.0	0.192		6.9
	14:50	16260218	769.1	60.1	16.77		4.6		3.7	1.3	0.086	15.4	0.9	0.192		6.8
	14:51	16260219	767.4	60.6	16.73		4.5		3.0	1.3	0.069	15.3	0.9	0.190	1.4	0.6
	14:51	16260220	773.7	48.4	16.87		4.5		3.7	1.3	0.086	15.1	0.9	0.189		6.6
	14:52	16260221	763.9	60.6	16.65		4.5		3.4	1.4	0.080	14.9	0.9	0.186	1.1	0.6
	14:53	16260222	753.8	60.5	16.43		4.6		3.5	1.4	0.081	14.8	1.0	0.185	1.0	0.6
	14:54	16260223	751.3	60.5	16.38		4.6		3.8	1.3	0.088	14.7	0.9	0.183		6.7
	14:55	16260224	745.7	56.5	16.26		4.5		3.1	1.3	0.072	14.6	0.9	0.182	1.2	0.6
	14:56	16260225	741.7	55.7	16.17		4.5		3.1	1.3	0.071	14.6	0.9	0.182	1.2	0.6
	14:57	16260226	730.3	55.3	15.92		4.5		3.7	1.3	0.086	14.3	0.9	0.178		6.8
	14:58	16260227	729.6	60.6	15.91		4.5		3.0	1.3	0.070	14.4	0.9	0.179	1.2	0.6
	14:59	16260228	734.4	55.7	16.01		4.5		3.1	1.3	0.073	14.5	0.9	0.181	1.2	0.6
	14:59	16260229	730.9	56.0	15.93		4.5		3.5	1.3	0.082	14.4	0.9	0.179	0.9	0.6
	15:00	16260230	739.2	60.4	16.11		4.5		3.0	1.3	0.071	14.6	0.9	0.181	1.2	0.6
	15:01	16260231	737.1	57.9	16.07		4.6		3.0	1.3	0.070	14.5	0.9	0.181	1.1	0.6
	15:38	16260268	644.3	14.7	14.05		3.6		4.0	1.1	0.094	10.6	0.8	0.132	1.4	0.5
	15:39	16260269	514.7	9.6	11.22		2.9		4.1	0.9	0.097	6.9	0.7	0.086	1.3	0.4
6/26/97	15:40	16260270	425.3	7.5	9.27		2.5		3.8	0.8	0.089	5.0	0.6	0.062	1.1	0.4
THC	15:41	16260271	378.5	6.9	8.25		2.5		3.4	0.8	0.081	4.0	0.6	0.050	0.9	0.4
cal	15:42	16260272	363.8	6.6	7.93		2.4		3.1	0.8	0.072	4.0	0.6	0.050		4.0
gas	15:43	16260273	326.1	6.1	7.11		2.3		1.9	1.1	0.045	4.1	0.7	0.051		4.1
dilution	15:44	16260274	301.9	5.6	6.58		2.2		1.4	1.2	0.032	4.3	0.9	0.054		4.3
data not	15:45	16260275	290.7	5.4	6.34		2.2			1.4		4.3	0.9	0.054		4.4
used in	15:45	16260276	354.1	6.4	7.72		2.4			1.3		5.4	0.9	0.067		4.6
average	15:46	16260277	538.0	12.2	11.73		3.4		1.8	1.3	0.041	8.4	0.9	0.104		5.6
	15:47	16260278	616.2	34.6	13.43		4.2		2.7	1.3	0.064	9.9	0.9	0.124		6.5
	15:48	16260279	661.0	54.7	14.41		4.6		2.6	1.4	0.061	11.4	1.0	0.142		6.9
	15:49	16260280	691.8	54.3	15.08		4.9		2.3	1.4	0.053	12.5	1.0	0.156		7.2
	15:50	16260281	709.5	58.8	15.47		5.0		2.0	1.5	0.047	13.2	1.0	0.164		7.4
	16:48	OUTS3009	747.2	22.1	16.29		3.7		6.9	1.1	0.161	13.0	0.8	0.162		5.8
	16:53	OUTS3010	726.3	15.8	15.83		3.6		5.9	1.1	0.138	13.1	0.8	0.163		5.8
	16:58	OUTS3011	737.6	18.3	16.08		3.6		5.7	1.1	0.133	13.7	0.8	0.171		5.7
	17:09	OUTS3012	749.8	17.4	16.35		3.5		7.1	1.1	0.166	16.0	0.8	0.199		5.7
	17:15	OUTS3013	749.4	16.9	16.34		3.5		5.7	1.1	0.134	16.4	0.8	0.204		5.7

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formaldehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	17:20	OUTS3014	738.6	16.1	16.10		3.5		5.9	1.1	0.138	16.2	0.8	0.202		5.6
	6/26/97	Average -->	814.8	38.0	17.76	11.8	3.9	0.59	2.9	1.1	0.067	17.7	0.8	0.221	2.2	1.1

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formaldehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
6/27/97	8:46	OUTS4001	770.0	16.0	16.79	21.2	3.1	1.06	11.0	0.8	0.257	11.7	0.6	0.145		4.0
	8:51	OUTS4002	764.4	50.6	16.66	25.9	3.8	1.29	5.6	1.0	0.131	11.8	0.7	0.147		4.9
	8:55	OUTS4003	798.1	49.4	17.40	28.6	3.6	1.42	5.8	0.9	0.135	12.2	0.7	0.151		4.8
	9:03	OUTS4004	783.7	49.0	17.08	29.0	3.6	1.45	5.6	1.0	0.131	12.8	0.7	0.159		4.9
	9:08	OUTS4005	761.1	62.1	16.59	29.7	3.7	1.48	5.8	1.0	0.135	12.6	0.7	0.157		5.1
	9:13	OUTS4006	740.4	47.6	16.14	29.3	3.7	1.46	5.2	1.0	0.122	12.2	0.7	0.152		5.0
	9:48	16270001	902.9	65.0	19.68	31.6	4.7	1.57	1.2	1.2	0.029	14.5	0.9	0.181	0.8	0.6
	9:49	16270002	909.2	64.5	19.82	30.8	4.8	1.54	1.7	1.2	0.040	14.5	0.9	0.180	0.9	0.6
	9:50	16270003	909.1	64.1	19.82	30.2	4.8	1.50	1.8	1.2	0.043	14.5	0.9	0.181	1.0	0.6
	9:51	16270004	909.5	64.3	19.83	29.3	4.9	1.46	1.9	1.3	0.045	14.3	0.9	0.178	0.9	0.6
	9:52	16270005	900.2	66.0	19.63	28.4	4.9	1.41	2.0	1.3	0.047	14.2	0.9	0.176	1.0	0.6
6/27/97	9:52	16270006	904.7	64.6	19.72	28.3	5.0	1.41	2.1	1.3	0.050	14.4	0.9	0.180	1.0	0.6
	9:53	16270007	911.0	64.3	19.86	30.0	5.0	1.49	2.1	1.3	0.049	14.1	0.9	0.175	1.0	0.6
	9:54	16270008	901.4	63.8	19.65	31.7	5.0	1.58	2.2	1.3	0.051	14.2	0.9	0.176	1.0	0.6
	9:55	16270009	901.5	64.5	19.65	33.2	5.1	1.65	2.2	1.3	0.051	14.0	0.9	0.174	1.0	0.6
	9:56	16270010	901.5	64.3	19.65	34.3	5.1	1.71	2.2	1.3	0.052	13.8	0.9	0.172	1.0	0.6
	9:57	16270011	898.1	64.4	19.58	34.4	5.0	1.71	2.3	1.3	0.053	14.2	0.9	0.176	1.1	0.6
	9:58	16270012	894.4	64.3	19.50	34.2	5.0	1.70	2.3	1.3	0.053	14.1	0.9	0.176	1.1	0.6
	9:59	16270013	892.9	64.1	19.47	33.2	5.0	1.65	2.3	1.3	0.055	13.9	0.9	0.173	1.1	0.6
	10:00	16270014	828.0	57.1	18.05	30.7	5.0	1.53	2.4	1.3	0.057	13.8	0.9	0.172	1.2	0.6
	10:01	16270015	845.8	58.7	18.44	28.0	5.0	1.40	2.4	1.3	0.055	13.6	0.9	0.169	1.1	0.6
	10:02	16270016	817.9	56.4	17.83	25.4	5.0	1.26	2.5	1.3	0.058	13.6	0.9	0.170	1.2	0.6
	10:02	16270017	887.7	64.5	19.35	21.9	5.0	1.09	2.5	1.3	0.058	13.5	0.9	0.168	1.2	0.6
	10:03	16270018	900.3	64.1	19.63	19.2	5.1	0.95	2.5	1.3	0.058	13.7	0.9	0.171	1.2	0.6
	10:04	16270019	900.5	63.9	19.63	18.1	5.0	0.90	2.5	1.3	0.058	13.7	0.9	0.171	1.2	0.6
	10:05	16270020	899.2	64.4	19.60	17.0	5.0	0.85	2.5	1.3	0.058	14.0	0.9	0.174	1.3	0.6
	10:06	16270021	906.3	63.8	19.76	16.5	4.9	0.82	2.5	1.3	0.058	14.1	0.9	0.176	1.4	0.6
	10:07	16270022	909.8	63.7	19.83	16.5	5.0	0.82	2.4	1.3	0.057	14.3	0.9	0.178	1.3	0.6
	10:08	16270023	913.4	63.7	19.91	16.2	5.0	0.81	2.5	1.3	0.059	14.5	0.9	0.181	1.4	0.6
	10:09	16270024	873.1	58.6	19.03	15.4	5.0	0.77	2.6	1.3	0.060	14.6	0.9	0.182	1.4	0.6
	10:10	16270025	916.9	64.1	19.99	14.5	5.1	0.72	2.6	1.3	0.061	14.6	0.9	0.182	1.5	0.6

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formaldehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	10:11	16270026	911.4	64.2	19.87	13.6	5.2	0.68	2.6	1.4	0.060	14.4	1.0	0.180	1.4	0.6
6/27/97	10:12	16270027	910.5	64.1	19.85	13.5	5.2	0.67	2.6	1.4	0.060	14.5	1.0	0.181	1.3	0.6
	10:12	16270028	913.3	63.8	19.91	14.3	5.1	0.71	2.6	1.3	0.060	14.5	0.9	0.181	1.4	0.6
	10:13	16270029	913.3	63.5	19.91	15.3	5.3	0.76	2.7	1.3	0.062	14.9	0.9	0.185	1.4	0.6
	10:14	16270030	907.2	63.7	19.78	16.6	5.2	0.83	2.6	1.4	0.061	14.7	1.0	0.183	1.3	0.6
	10:15	16270031	914.6	63.5	19.94	17.8	5.3	0.89	2.6	1.4	0.062	14.6	1.0	0.182	1.3	0.6
	10:16	16270032	906.6	63.2	19.76	18.9	5.4	0.94	2.6	1.4	0.060	14.7	1.0	0.183	1.3	0.6
	10:53	16270068	885.4	64.9	19.30		4.7			1.3		14.1	0.9	0.176	1.9	0.6
	10:54	16270069	886.7	64.4	19.33		4.8			1.3		14.1	0.9	0.176	1.9	0.6
	10:55	16270070	891.2	64.4	19.43		5.0			1.4		14.1	1.0	0.176	1.7	0.6
	10:56	16270071	899.1	64.0	19.60		5.1		1.5	1.4	0.035	14.2	1.0	0.177	1.8	0.6
	10:57	16270072	900.1	63.6	19.62		5.2		1.7	1.4	0.039	14.2	1.0	0.177	1.7	0.6
	10:58	16270073	898.6	62.9	19.59		5.3		1.7	1.4	0.040	14.4	1.0	0.179	1.7	0.6
	10:59	16270074	903.2	62.9	19.69		5.3		1.7	1.4	0.039	14.5	1.0	0.180	1.6	0.6
	11:00	16270075	911.1	62.8	19.86		5.5		1.8	1.4	0.042	14.6	1.0	0.182	1.6	0.7
	11:01	16270076	916.8	62.6	19.99		5.6		1.8	1.4	0.043	14.9	1.0	0.185	1.7	0.7
	11:01	16270077	915.2	63.2	19.95		5.4		1.8	1.4	0.041	14.9	1.0	0.185	1.6	0.7
	11:02	16270078	921.1	63.0	20.08		5.6		1.7	1.5	0.039	14.9	1.0	0.185	1.5	0.7
	11:03	16270079	924.8	62.3	20.16		5.6		1.8	1.5	0.043	15.1	1.0	0.188	1.5	0.7
	11:47	16270122	796.6	18.2	17.37		3.7		2.7	1.0	0.062	13.9	0.7	0.173	3.6	0.5
	11:48	16270123	796.1	17.4	17.36		3.7		2.7	1.0	0.064	13.8	0.7	0.172	3.6	0.5
	11:48	16270124	795.5	17.1	17.34		3.8		2.8	1.0	0.065	13.9	0.7	0.173	3.5	0.5
	11:49	16270125	797.7	17.4	17.39		3.8		2.8	1.0	0.065	13.9	0.7	0.173	3.5	0.5
	11:50	16270126	791.5	39.7	17.25		4.1		2.5	1.1	0.058	13.6	0.8	0.170	3.2	0.5
	11:51	16270127	796.9	58.8	17.37		5.2			1.3		13.4	0.9	0.166	2.6	0.6
	11:52	16270128	787.8	58.5	17.17		5.1		1.5	1.3	0.034	13.5	0.9	0.169	2.6	0.6
	11:53	16270129	790.4	59.3	17.23		4.8		2.2	1.3	0.051	13.5	0.9	0.169	2.8	0.6
	11:54	16270130	807.0	48.4	17.59		4.5		2.5	1.2	0.059	13.8	0.9	0.172	2.9	0.6
	11:55	16270131	802.3	59.7	17.49		4.7		2.4	1.3	0.055	13.9	0.9	0.173	2.9	0.6
	11:56	16270132	831.4	60.3	18.12		5.0		2.1	1.3	0.049	13.8	0.9	0.172	2.6	0.6
	11:56	16270133	814.0	58.2	17.74		5.3		2.0	1.4	0.046	13.7	1.0	0.171	2.4	0.6
	11:57	16270134	802.5	57.5	17.49		5.2		2.2	1.4	0.052	13.5	1.0	0.168	2.4	0.6
	11:58	16270135	815.6	57.6	17.78		5.1		2.4	1.4	0.055	13.7	1.0	0.171	2.5	0.6
	11:59	16270136	819.2	58.6	17.86		5.0		2.5	1.4	0.059	13.4	1.0	0.168	2.4	0.6
	12:00	16270137	814.3	59.4	17.75		4.9		2.7	1.4	0.063	13.5	1.0	0.168	2.5	0.6
	12:01	16270138	785.9	57.9	17.13		4.8		2.7	1.4	0.063	13.4	1.0	0.167	2.5	0.6

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	CO	Unc	Emissions lbs/hr	SO_2	Unc	Emissions lbs/hr	Formaldehyde	Unc	Emissions lbs/hr	Methane	Unc	Emissions lbs/hr	n-Heptane	Unc
	12:02	16270139	796.1	58.3	17.35		4.8		2.8	1.4	0.066	13.4	1.0	0.167	2.4	0.6
6/27/97	12:03	16270140	791.1	58.5	17.25		4.7		2.9	1.3	0.069	13.6	0.9	0.169	2.6	0.6
	12:04	16270141	788.5	58.6	17.19		4.6		2.9	1.3	0.068	13.6	0.9	0.170	2.6	0.6
	12:05	16270142	784.0	58.5	17.09		4.6		2.8	1.3	0.066	13.5	0.9	0.168	2.4	0.6
	12:05	16270143	777.8	54.1	16.96		4.7		2.7	1.3	0.064	13.4	0.9	0.167	2.4	0.6
	12:06	16270144	782.2	58.4	17.05		4.7		2.9	1.4	0.067	13.4	1.0	0.167	2.4	0.6
	12:07	16270145	811.3	60.4	17.69		4.6		2.9	1.3	0.067	13.4	0.9	0.166	2.5	0.6
	12:08	16270146	780.9	59.2	17.02		4.6		2.9	1.3	0.069	13.2	0.9	0.165	2.5	0.6
	12:09	16270147	767.0	58.6	16.72		4.5		3.0	1.3	0.069	13.1	0.9	0.163	2.4	0.6
	12:10	16270148	764.9	58.8	16.67		4.5		2.8	1.3	0.066	13.0	0.9	0.162	2.4	0.6
	12:11	16270149	765.5	58.8	16.69		4.7		2.8	1.4	0.066	12.9	1.0	0.161	2.4	0.6
	12:12	16270150	752.4	58.0	16.40		4.7		2.8	1.4	0.065	13.0	1.0	0.162	2.3	0.6
	12:49	16270186	785.8	57.1	17.13		5.3		2.3	1.5	0.053	13.6	1.1	0.169		7.7
	12:50	16270187	769.8	58.0	16.78		5.2		4.1	1.5	0.097	13.2	1.1	0.164		7.6
	12:51	16270188	742.5	56.8	16.19		5.0		3.1	1.5	0.072	12.3	1.0	0.153		7.5
	12:55	OUT4S007	678.7	75.6	14.80		4.7		5.7	1.4	0.133	11.2	1.0	0.139		7.2
	12:59	OUTS4008	686.2	49.0	14.96		4.2		3.9	1.3	0.091	11.2	0.9	0.139	2.1	0.6
	13:02	OUTS4009	728.0	24.3	15.87		3.9		2.0	1.2	0.046	12.3	0.9	0.153	2.0	0.6
	13:09	OUTS4010	763.1	63.1	16.63		3.8		3.7	1.2	0.087	14.5	0.8	0.180		6.1
	13:12	OUTS4011	771.0	62.7	16.81		3.9		2.9	1.2	0.068	14.6	0.9	0.182		6.1
	13:16	OUTS4012	752.3	48.4	16.40		3.9		2.5	1.2	0.058	14.1	0.9	0.176		6.3
		Average -->	853.6	58.7	18.61	10.0	4.92	0.50	2.3	1.3	0.053	13.9	0.9	0.174	1.8	0.9

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
6/25/97	8:41	OUTS2001	2.2	0.6	0.049		0.4			1.4		4.4	1.4	2.6	0.6
	8:46	OUTS2002	3.1	0.6	0.068		0.5			1.5		5.5	0.8		1.0
	8:52	OUTS2003	3.3	0.6	0.071		0.5			1.5		5.2	0.8		1.4
	9:02	OUTS2004	3.3	0.7	0.072		0.5		23.4	1.3	0.291	9.1	0.4		1.1
	9:08	OUTS2005	3.1	0.7	0.068		0.6		23.7	1.4	0.295	9.7	0.4		1.2
	9:13	OUTS2006	3.2	0.7	0.070		0.6		23.4	1.4	0.292	9.3	0.4		1.2
	10:15	OUT2U007	3.8	0.8	0.083	0.8	0.7	0.010		2.3		8.9	2.1	1.4	1.0
	10:22	OUTV2008	3.7	0.8	0.081		0.7			2.3		8.7	2.1	2.0	1.1
	10:26	OUTV2009	4.1	0.9	0.089		0.7			2.4		6.3	1.3		2.2
	10:31	OUTV2010	4.3	0.9	0.094		0.7			2.4		8.9	2.2	1.4	1.1

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	10:54	OUTV2011	3.2	0.8	0.070	1.3	0.6	0.018		2.2		7.2	1.1		2.0
6/25/97	11:00	OUTV2012	4.1	0.8	0.089		0.7			2.3		5.8	1.2		2.1
	11:04	OUTV2013	4.1	0.8	0.091		0.7			2.3		5.9	1.2		2.2
	11:08	OUTV2014	4.0	0.8	0.087		0.7			2.3		5.8	1.2		2.2
	11:34	OUTV2015	4.1	0.8	0.090	1.7	0.7	0.022		2.4		7.0	2.2	1.9	1.1
	11:39	OUTV2016	4.1	0.8	0.090	0.8	0.7	0.011		2.3		7.0	2.2	1.7	1.1
	11:43	OUTV2017	4.5	0.8	0.099		0.7			2.4		7.2	2.2	1.1	1.1
	11:47	OUTV2018	4.7	0.9	0.104		0.7			2.4		9.4	0.5		1.1
	12:39	OUTV2019	6.7	0.8	0.147	1.3	0.6	0.017	7.3	1.7	0.091	14.8	0.5		1.1
	12:43	OUTV2020	6.5	0.9	0.142		0.7		6.7	1.8	0.084	13.7	0.5		1.1
	12:47	OUTV2021	6.3	0.9	0.137		0.7		6.4	1.8	0.080	11.5	0.5		1.2
	12:50	OUTV2022	5.8	0.9	0.128		0.7		6.0	1.8	0.075	11.1	0.5		1.2
	13:11	OUTV2023	6.0	0.9	0.130	1.4	0.7	0.019	6.3	1.8	0.078	11.6	0.5		1.2
	13:15	OUTV2024	5.7	0.8	0.124		0.6		6.2	1.7	0.077	12.4	0.5		1.1
	13:18	OUTV2025	5.8	0.8	0.126		0.6		5.8	1.6	0.072	8.4	1.2		1.6
	13:22	OUTV2026	5.8	1.0	0.126		0.8		5.7	2.0	0.070	11.5	0.6		1.3
	14:01	OUTV2027	4.2	0.9	0.092	0.8	0.7	0.011		2.7		13.0	0.5		1.2
	14:04	OUTV2028	3.8	0.9	0.084		0.7		7.0	2.0	0.087	12.1	1.5		3.3
	14:08	OUTV2029	3.4	0.8	0.075		0.6		6.7	1.7	0.083	11.6	1.3		2.8
	14:12	OUTV2030	3.7	0.7	0.081		0.6		4.9	1.6	0.061	9.2	1.2		1.5
	14:37	OUTV2031	4.3	0.9	0.093	1.4	0.7	0.018		2.5		12.2	2.3	1.3	1.1
	14:42	OUTV2032	4.0	0.9	0.088	0.7	0.7	0.010		2.6		14.2	0.5		1.2
	14:46	OUTV2033	3.8	0.8	0.084		0.7			2.5		13.8	0.5		1.2
	14:51	OUTV2034	3.9	0.9	0.086		0.7			2.6		13.2	0.5		1.2
	15:15	OUTV2035	4.2	0.9	0.091	1.7	0.7	0.022		2.6		13.8	0.5		1.2
	15:19	OUTV2036	4.1	0.9	0.090	0.9	0.7	0.012		2.8		13.3	0.6		1.3
	15:24	OUTV2037	3.8	0.9	0.084		0.7			2.6		14.1	0.5		1.2
	15:28	OUTV2038	4.0	0.9	0.088		0.7			2.7		13.6	0.5		1.2
	15:52	OUTV2039	3.8	0.9	0.084	1.5	0.7	0.020		2.7		13.1	0.5		1.2
	15:57	OUTV2040	3.8	0.9	0.082	0.9	0.7	0.012		2.7		13.6	0.5		1.2
	16:03	OUTV2041	3.6	0.9	0.078		0.7			2.7		13.6	0.5		1.2
	16:08	OUTV2042	3.7	0.9	0.081		0.7			2.6		13.6	0.5		1.2
	16:33	OUTV2043	4.3	0.9	0.094	1.5	0.7	0.019		2.6		15.1	0.5		1.2
	16:39	INLV2044	4.6	0.9	0.100	0.8	0.7	0.011		2.8		14.4	0.6		1.3
	16:43	INLV2045	4.3	0.9	0.094		0.7			2.7		14.0	0.6		1.2
	16:48	INLV2046	4.2	0.9	0.091		0.7			2.8		13.9	0.6		1.3
	17:36	OUTS2047	3.7	0.8	0.080	1.5	0.6	0.019	26.9	1.8	0.335	11.0	2.3	1.4	1.1

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	17:41	OUTS2048	4.0	0.8	0.087	0.8	0.6	0.011	27.3	1.8	0.340	11.7	2.3	1.3	1.1
6/25/97	17:46	OUTS2049	4.4	0.8	0.095		0.6		27.3	1.8	0.340	14.6	0.5		1.2
	17:56	OUTS2050	4.5	0.8	0.099		0.6			2.4		10.7	2.2	1.4	1.1
	18:00	OUTS2051	4.5	0.9	0.099		0.6			2.6		12.8	0.5		1.2
	18:04	OUTS2052	4.3	0.9	0.094		0.6			2.6		12.4	0.5		1.2
		Average -->	4.4	0.9	0.097	0.4	0.7	0.006	1.7	2.3	0.021	11.2	1.0	0.3	1.4

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
6/26/97	9:53	OUTS3001	2.7	0.6	0.059	1.0	0.5	0.014	28.5	1.1	0.355	6.0	0.8		1.9
	9:59	OUTS3002	3.5	0.6	0.077	0.8	0.5	0.011	7.3	1.2	0.090	6.3	0.9		1.6
	10:04	OUTS3003	3.7	0.7	0.081	0.6	0.5	0.009		1.7		5.9	0.9		1.6
	10:21	OUTS3004	2.7	0.6	0.059		0.4		28.1	1.1	0.349	5.4	0.8		1.4
	10:26	OUTS3005	2.8	0.6	0.060		0.5		28.3	1.1	0.352	5.4	0.8		1.4
	10:37	OUTS3006	3.5	0.6	0.077		0.4			1.4		4.5	0.8		1.3
	10:43	OUTS3007	3.5	0.6	0.077		0.5			1.5		4.6	0.8		1.4
	10:49	OUTS3008	3.4	0.6	0.075		0.5			1.5		4.2	0.8		1.4
	11:28	16260038	4.8	0.7	0.105	4.0	0.6	0.053		1.9		3.9	1.0		1.8
	11:29	16260039	4.8	0.7	0.105	3.7	0.6	0.049		1.9		4.0	1.0		1.8
	11:30	16260040	4.9	0.7	0.108	3.2	0.6	0.042		1.9		4.0	1.0		1.8
	11:31	16260041	5.0	0.7	0.109	2.8	0.6	0.038		2.0		3.8	1.1		1.8
	11:32	16260042	5.0	0.7	0.110	2.6	0.6	0.034		2.0		3.8	1.1		1.9
	11:33	16260043	5.1	0.7	0.111	2.4	0.6	0.032		2.0		3.7	1.1		1.9
	11:33	16260044	5.0	0.7	0.110	2.2	0.6	0.029		2.0		3.8	1.1		1.9
	11:34	16260045	5.1	0.7	0.112	2.1	0.6	0.028		2.0		3.8	1.1		1.8
	11:35	16260046	5.1	0.7	0.111	2.0	0.6	0.026		2.0		3.7	1.1		1.9
	11:36	16260047	5.1	0.7	0.110	1.9	0.6	0.025		2.0		3.8	1.1		1.9
	11:37	16260048	5.1	0.7	0.111	1.8	0.6	0.024		2.0		3.8	1.1		1.9
	11:38	16260049	5.1	0.7	0.112	1.8	0.6	0.023		2.0		3.7	1.1		1.9
	11:39	16260050	5.1	0.7	0.112	1.7	0.6	0.022		2.0		4.0	1.1		1.9
	11:40	16260051	5.2	0.7	0.113	1.6	0.6	0.022		2.0		3.8	1.1		1.9
	11:41	16260052	5.2	0.7	0.114	1.6	0.6	0.021		2.1		4.2	1.1		1.9
	11:42	16260053	5.3	0.8	0.115	1.5	0.6	0.020		2.1		4.2	1.1		1.9
	11:42	16260054	5.3	0.7	0.116	1.5	0.6	0.020		2.0		4.2	1.1		1.9
	11:43	16260055	5.4	0.7	0.117	1.4	0.6	0.019		2.1		4.2	1.1		1.9
	11:44	16260056	5.4	0.7	0.119	1.4	0.6	0.019		2.0		4.2	1.1		1.9
	11:45	16260057	5.5	0.8	0.119	1.4	0.6	0.018		2.1		4.4	1.1		1.9

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	11:46	16260058	5.5	0.8	0.119	1.4	0.6	0.018		2.1		4.4	1.1		2.0
6/26/97	11:47	16260059	5.5	0.8	0.121	1.3	0.6	0.018		2.1		4.4	1.1		2.0
	11:48	16260060	5.6	0.8	0.122	1.3	0.6	0.017		2.1		4.6	1.1		2.0
	11:49	16260061	5.6	0.8	0.121	1.2	0.6	0.016		2.1		4.6	1.1		2.0
	11:50	16260062	5.6	0.8	0.122	1.2	0.6	0.016		2.1		4.7	1.1		2.0
	11:51	16260063	5.7	0.8	0.124	1.2	0.6	0.016		2.1		4.5	1.1		2.0
	11:52	16260064	5.6	0.8	0.123	1.1	0.6	0.015		2.1		4.6	1.1		2.0
	11:53	16260065	5.7	0.8	0.124	1.1	0.6	0.015		2.1		4.7	1.1		2.0
	12:23	16260093	6.8	0.7	0.149	4.4	0.6	0.058	5.0	1.5	0.063	5.7	1.1		2.0
	12:24	16260094	6.9	0.7	0.152	4.0	0.6	0.053	4.6	1.5	0.057	5.9	1.1		2.0
	12:25	16260095	7.0	0.8	0.153	3.5	0.6	0.046	4.7	1.5	0.059	6.0	1.1		2.0
	12:25	16260096	7.0	0.8	0.153	3.2	0.6	0.042	4.7	1.6	0.058	6.1	1.2		2.1
	12:26	16260097	7.0	0.8	0.153	2.9	0.6	0.039	4.6	1.6	0.058	6.0	1.2		2.1
	12:27	16260098	7.1	0.8	0.154	2.7	0.6	0.036	4.4	1.6	0.055	5.9	1.2		2.1
	12:28	16260099	7.0	0.8	0.153	2.6	0.6	0.034	4.8	1.6	0.059	6.1	1.2		2.1
	12:29	16260100	7.1	0.8	0.154	2.4	0.6	0.032	4.4	1.6	0.055	6.1	1.2		2.1
	12:30	16260101	7.1	0.8	0.156	2.3	0.6	0.031	4.7	1.6	0.058	6.2	1.2		2.1
	13:07	16260138	7.1	0.8	0.155	3.9	0.6	0.052		2.2		5.0	1.2		2.0
	13:08	16260139	7.0	0.8	0.153	3.7	0.6	0.049		2.3		5.4	1.2		2.1
	13:09	16260140	6.9	0.8	0.151	3.4	0.7	0.046		2.3		5.8	1.3		2.2
	13:10	16260141	7.1	0.8	0.154	3.3	0.7	0.044		2.5		6.1	1.3		2.3
	13:11	16260142	7.1	0.9	0.156	3.2	0.7	0.042		2.6		6.3	1.4		2.4
	13:12	16260143	7.2	0.9	0.157	3.0	0.8	0.040		2.7		6.3	1.4		2.5
	13:13	16260144	7.2	1.0	0.157	2.9	0.8	0.038		2.7		6.5	1.5		2.6
	13:14	16260145	7.1	1.0	0.155	2.7	0.8	0.036		2.8		6.6	1.5		2.6
	13:15	16260146	6.9	1.0	0.151	2.6	0.8	0.034		2.8		6.5	1.5		2.7
	13:16	16260147	6.8	1.0	0.150	2.4	0.8	0.032		2.8		6.4	1.5		2.6
	13:16	16260148	6.7	1.0	0.146	2.3	0.8	0.030		2.8		6.4	1.5		2.6
	13:17	16260149	6.6	1.0	0.143	2.1	0.8	0.028		2.8		6.4	1.5		2.6
	13:18	16260150	6.4	0.9	0.140	2.0	0.8	0.027		2.7		6.2	1.5		2.5
	13:19	16260151	6.4	1.0	0.140	1.9	0.8	0.025		2.7		6.0	1.5		2.6
	13:20	16260152	6.3	1.0	0.138	1.8	0.8	0.024		2.8		6.1	1.5		2.6
	13:21	16260153	6.5	1.0	0.142	1.8	0.8	0.024		2.8		6.1	1.5		2.6
	13:22	16260154	6.4	1.0	0.139	1.7	0.8	0.023		2.8		6.1	1.5		2.7
	13:23	16260155	6.3	1.0	0.137	1.7	0.8	0.022		2.8		5.9	1.5		2.6
	13:24	16260156	6.1	1.0	0.134	1.7	0.8	0.022		2.9		6.0	1.5		2.7
	13:25	16260157	6.1	1.0	0.134	1.6	0.8	0.021		2.8		5.9	1.5		2.6

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	13:26	16260158	6.1	1.0	0.132	1.6	0.8	0.021		2.8		5.8	1.5		2.6
6/26/97	13:27	16260159	6.0	1.0	0.131	1.5	0.8	0.020		2.9		5.8	1.6		2.7
	13:27	16260160	6.0	1.0	0.130	1.5	0.8	0.020		2.9		6.0	1.5		2.7
	13:28	16260161	6.0	1.1	0.131	1.5	0.8	0.019		2.9		5.8	1.6		2.7
	13:29	16260162	6.0	1.1	0.132	1.5	0.8	0.020		2.9		5.7	1.6		2.8
	13:30	16260163	5.9	1.1	0.129	1.4	0.9	0.019		3.0		5.9	1.6		2.8
	13:31	16260164	5.9	1.1	0.130	1.4	0.8	0.019		3.0		5.9	1.6		2.8
	14:32	16260199	6.5	1.0	0.142	3.7	0.9	0.050	5.4	2.2	0.067	7.8	1.6		2.1
	14:33	16260200	6.6	1.1	0.143	3.6	0.9	0.047	5.5	2.2	0.069	8.3	1.6		2.2
	14:34	16260201	6.7	1.1	0.146	3.3	0.9	0.044	5.5	2.3	0.069	8.4	1.7		2.2
	14:35	16260202	6.7	1.1	0.147	3.1	0.9	0.041	5.6	2.3	0.070	8.6	1.7		2.3
	14:36	16260203	6.7	1.1	0.146	2.9	0.9	0.038	5.0	2.2	0.062	8.1	1.6		2.2
	14:37	16260204	6.8	1.1	0.148	2.7	0.9	0.035	5.2	2.3	0.065	8.7	1.7		2.3
	14:38	16260205	6.7	1.1	0.147	2.5	0.9	0.034		2.4		8.4	1.7		2.3
	14:39	16260206	6.8	1.1	0.149	2.5	0.9	0.033	5.3	2.3	0.066	8.5	1.7		3.0
	14:40	16260207	6.9	1.1	0.150	2.3	0.9	0.030	5.0	2.3	0.063	8.4	1.7		3.0
	14:40	16260208	6.8	1.1	0.149	2.2	0.9	0.029	5.1	2.3	0.064	8.5	1.7		2.3
	14:41	16260209	6.8	1.1	0.149	2.1	0.9	0.028	5.5	2.3	0.069	8.7	1.7		3.0
	14:42	16260210	6.7	1.1	0.147	2.1	0.9	0.027	6.0	2.2	0.075	11.3	0.6		1.4
	14:43	16260211	6.7	1.1	0.146	1.9	0.9	0.026	5.4	2.3	0.067	8.4	1.7		3.0
	14:44	16260212	6.6	1.1	0.144	1.8	0.9	0.024		2.4		8.3	1.7		2.3
	14:45	16260213	6.4	1.1	0.140	1.7	0.9	0.023	5.1	2.3	0.063	8.6	1.7		2.9
	14:46	16260214	6.4	1.1	0.140	1.6	0.9	0.022	6.1	2.2	0.076	11.2	0.6		1.9
	14:47	16260215	6.3	1.1	0.138	1.6	0.9	0.021	5.1	2.2	0.064	8.4	1.7		2.2
	14:48	16260216	6.2	1.1	0.136	1.6	0.9	0.021		3.2		8.2	1.7		3.0
	14:49	16260217	6.1	1.1	0.133	1.5	0.9	0.020	5.9	2.2	0.073	11.2	0.6		1.9
	14:50	16260218	6.0	1.1	0.131	1.4	0.9	0.019	5.3	2.2	0.066	11.1	0.6		1.4
	14:51	16260219	5.9	1.1	0.129	1.4	0.9	0.019		2.3		7.9	1.7		2.2
	14:51	16260220	5.9	1.0	0.129	1.4	0.9	0.019	5.8	2.2	0.073	10.9	0.6		1.4
	14:52	16260221	5.7	1.0	0.125	1.3	0.9	0.018	5.0	2.2	0.062	8.1	1.7		2.9
	14:53	16260222	5.8	1.1	0.127	1.3	0.9	0.017	5.2	2.3	0.065	8.4	1.7		3.0
	14:54	16260223	5.8	1.1	0.126	1.3	0.9	0.017	5.5	2.2	0.068	10.7	0.6		1.9
	14:55	16260224	5.7	1.0	0.125	1.2	0.9	0.016		3.1		7.9	1.6		2.9
	14:56	16260225	5.7	1.0	0.125	1.2	0.9	0.016		3.0		7.8	1.6		2.9
	14:57	16260226	5.8	1.0	0.126	1.2	0.9	0.015	5.2	2.2	0.065	10.3	0.6		1.9
	14:58	16260227	5.8	1.0	0.127	1.2	0.8	0.016		3.1		7.7	1.6		2.1
	14:59	16260228	6.0	1.1	0.130	1.2	0.9	0.016		3.0		7.8	1.6		2.1

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	14:59	16260229	6.0	1.0	0.131	1.2	0.9	0.015	4.8	2.2	0.060	8.0	1.6		2.9
6/26/97	15:00	16260230	6.2	1.1	0.135	1.1	0.9	0.015		3.1		7.6	1.6		2.9
	15:01	16260231	6.2	1.1	0.135	1.2	0.9	0.016		2.3		8.0	1.6		2.2
	15:38	16260268	4.2	0.9	0.093	3.1	0.7	0.041		2.6		6.1	1.4		2.4
	15:39	16260269	3.3	0.7	0.071	2.0	0.6	0.027		2.1		3.8	1.1		2.0
	15:40	16260270	2.6	0.6	0.056	1.5	0.5	0.019		1.9		2.4	1.0		1.7
THC	15:41	16260271	2.3	0.6	0.050	1.2	0.5	0.016		1.8		2.0	1.0		1.7
cal	15:42	16260272	2.1	0.6	0.045	1.1	0.5	0.014		1.4		9.5	2.3		9.1
gas	15:43	16260273	1.8	0.6	0.039	1.0	0.4	0.013		1.6		4.2	2.9		9.3
dilution	15:44	16260274	1.6	0.6	0.034	0.8	0.4	0.011		1.8			3.4		9.7
data not	15:45	16260275	1.5	0.6	0.032	0.9	0.4	0.012		1.9			3.7		10.0
used in	15:45	16260276	2.0	0.6	0.043	0.9	0.5	0.012		1.9			3.7		10.5
average	15:46	16260277	3.8	0.8	0.084	1.3	0.7	0.017		2.1		11.1	3.4		12.8
	15:47	16260278	4.9	1.0	0.107	1.5	0.8	0.019		2.3		27.2	1.3		14.8
	15:48	16260279	5.6	1.1	0.122	1.5	0.9	0.020		2.3		22.0	0.7		15.7
	15:49	16260280	5.9	1.1	0.130	1.5	0.9	0.020		2.3		16.4	0.8		16.4
	15:50	16260281	6.4	1.2	0.139	1.6	1.0	0.021		3.4		13.7	0.7		16.8
	16:48	OUTS3009	4.3	0.9	0.093	1.2	0.7	0.016		2.6		11.1	0.5		1.2
	16:53	OUTS3010	4.6	0.9	0.100	0.8	0.7	0.011		2.6		10.5	0.5		1.2
	16:58	OUTS3011	4.8	0.9	0.106		0.7		4.1	1.8	0.050	9.7	0.5		1.2
	17:09	OUTS3012	5.2	0.8	0.114		0.7		29.0	1.8	0.362	10.4	0.5		1.2
	17:15	OUTS3013	5.5	0.8	0.119		0.7		29.1	1.9	0.363	9.6	0.5		1.6
	17:20	OUTS3014	5.3	0.8	0.117		0.7		28.8	1.8	0.358	9.9	0.5		1.2
		Average -->	6.1	0.9	0.134	2.1	0.7	0.028	1.7	2.3	0.021	6.6	1.3		2.5

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
6/27/97	8:46	OUTS4001	3.1	0.8	0.068		0.6			1.8		11.3	0.4		0.8
	8:51	OUTS4002	4.1	1.0	0.090	0.8	0.7	0.010		2.2		8.8	0.5		1.0
	8:55	OUTS4003	4.2	1.0	0.093	0.9	0.7	0.012		2.2		9.0	0.4		1.0
	9:03	OUTS4004	3.8	0.9	0.084	0.8	0.7	0.011	28.2	1.6	0.351	8.5	0.5		1.3
	9:08	OUTS4005	3.8	0.9	0.083	0.9	0.7	0.012	29.0	1.6	0.362	8.5	0.5		1.4
	9:13	OUTS4006	3.7	0.9	0.080	1.0	0.7	0.013	28.5	1.6	0.355	8.1	0.5		1.4
	9:48	16270001	5.1	1.1	0.112	2.6	0.9	0.035		2.8		6.8	1.5		2.6

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	9:49	16270002	5.2	1.2	0.114	2.3	0.9	0.030		2.8		6.6	1.5		2.7
	9:50	16270003	5.2	1.1	0.115	2.1	0.9	0.028		2.8		6.3	1.5		2.7
	9:51	16270004	5.3	1.2	0.115	1.9	0.9	0.025		2.9		6.7	1.6		2.7
	9:52	16270005	5.3	1.2	0.116	1.8	0.9	0.024		2.9		6.5	1.6		2.7
6/27/97	9:52	16270006	5.3	1.2	0.116	1.7	0.9	0.023		2.9		6.7	1.6		2.7
	9:53	16270007	5.3	1.2	0.117	1.6	1.0	0.021		2.9		6.6	1.6		2.8
	9:54	16270008	5.4	1.2	0.117	1.5	0.9	0.020		2.9		6.6	1.6		2.8
	9:55	16270009	5.3	1.2	0.116	1.5	1.0	0.020		3.0		6.7	1.6		2.8
	9:56	16270010	5.3	1.2	0.116	1.4	1.0	0.019		3.0		6.7	1.6		2.9
	9:57	16270011	5.3	1.2	0.116	1.4	1.0	0.019		3.0		6.3	1.6		2.8
	9:58	16270012	5.3	1.2	0.115	1.4	0.9	0.019		3.0		6.3	1.6		2.8
	9:59	16270013	5.3	1.2	0.116	1.3	1.0	0.018		3.0		6.6	1.6		2.8
	10:00	16270014	5.2	1.2	0.114	1.4	1.0	0.018		3.0		6.3	1.6		2.8
	10:01	16270015	5.2	1.2	0.114	1.4	0.9	0.018		3.0		6.4	1.6		2.8
	10:02	16270016	5.2	1.2	0.114	1.3	1.0	0.018		3.0		6.2	1.6		2.8
	10:02	16270017	5.2	1.2	0.114	1.4	1.0	0.018		3.0		6.3	1.6		2.8
	10:03	16270018	5.3	1.2	0.115	1.4	1.0	0.018		3.0		6.5	1.6		2.9
	10:04	16270019	5.2	1.2	0.114	1.3	1.0	0.018		3.0		6.4	1.6		2.8
	10:05	16270020	5.3	1.2	0.116	1.4	0.9	0.018		3.0		6.3	1.6		2.8
	10:06	16270021	5.4	1.2	0.117	1.4	0.9	0.018		3.0		6.4	1.6		2.8
	10:07	16270022	5.4	1.2	0.118	1.4	1.0	0.018		3.0		6.6	1.6		2.9
	10:08	16270023	5.5	1.2	0.119	1.4	1.0	0.018		3.0		6.4	1.6		2.8
	10:09	16270024	5.4	1.2	0.119	1.4	1.0	0.018		3.0		6.7	1.6		2.8
	10:10	16270025	5.5	1.2	0.119	1.4	1.0	0.018		3.1		6.5	1.6		2.9
	10:11	16270026	5.4	1.3	0.119	1.4	1.0	0.018		3.1		6.9	1.7		2.9
	10:12	16270027	5.5	1.2	0.121	1.4	1.0	0.018		3.1		7.0	1.7		2.9
	10:12	16270028	5.6	1.2	0.121	1.4	1.0	0.018		3.1		6.8	1.7		2.9
	10:13	16270029	5.6	1.3	0.123	1.4	1.0	0.019		3.1		6.8	1.7		2.9
	10:14	16270030	5.6	1.3	0.122	1.4	1.0	0.019		3.1		7.1	1.7		2.9
	10:15	16270031	5.6	1.3	0.122	1.4	1.0	0.018		3.1		7.0	1.7		3.0
	10:16	16270032	5.6	1.3	0.122	1.4	1.0	0.019		3.2		7.1	1.7		3.0
	10:53	16270068	5.2	1.1	0.114	2.2	0.9	0.029		2.9		5.3	1.6		2.7
	10:54	16270069	5.5	1.1	0.120	2.0	0.9	0.026		3.0		5.7	1.6		2.8
	10:55	16270070	5.8	1.2	0.127	1.8	1.0	0.024		3.1		6.2	1.7		2.9
	10:56	16270071	6.0	1.2	0.130	1.7	1.0	0.023		3.1		5.9	1.7		2.9
	10:57	16270072	6.3	1.2	0.137	1.6	1.0	0.022		3.2		6.3	1.7		3.0
	10:58	16270073	6.5	1.2	0.141	1.6	1.0	0.021		3.2		6.2	1.7		3.0

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	10:59	16270074	6.7	1.2	0.145	1.5	1.0	0.020		3.2		6.7	1.7		3.0
6/27/97	11:00	16270075	6.9	1.3	0.151	1.5	1.0	0.020		3.3		6.9	1.8		3.1
	11:01	16270076	7.0	1.3	0.153	1.5	1.1	0.020		3.3		6.6	1.8		3.1
	11:01	16270077	6.9	1.3	0.151	1.4	1.0	0.019		3.3		6.8	1.8		3.1
	11:02	16270078	7.1	1.3	0.155	1.4	1.1	0.019		3.4		7.1	1.8		3.2
	11:03	16270079	7.1	1.3	0.156	1.4	1.1	0.019		3.4		7.2	1.8		3.2
	11:47	16270122	5.1	0.9	0.111	2.1	0.7	0.028		2.3		4.1	1.2		2.1
	11:48	16270123	5.3	0.9	0.115	1.9	0.7	0.025		2.3		4.0	1.2		2.1
	11:48	16270124	5.5	0.9	0.120	1.7	0.7	0.023		2.3		4.1	1.2		2.2
	11:49	16270125	5.6	0.9	0.123	1.7	0.7	0.022		2.3		4.3	1.3		2.2
	11:50	16270126	6.2	1.0	0.134	1.7	0.8	0.022		2.6		4.8	1.4		2.4
	11:51	16270127	7.5	1.3	0.163	1.7	1.0	0.022		3.1		5.1	1.6		2.9
	11:52	16270128	7.6	1.2	0.165	1.6	1.0	0.021		3.0		5.2	1.6		2.8
	11:53	16270129	7.2	1.2	0.157	1.6	1.0	0.021		3.0		5.3	1.6		2.8
	11:54	16270130	7.0	1.1	0.153	1.6	0.9	0.021		2.8		5.1	1.5		2.6
	11:55	16270131	7.1	1.1	0.154	1.6	0.9	0.022		2.9		5.2	1.5		2.7
	11:56	16270132	7.4	1.2	0.162	1.6	1.0	0.021		3.1		5.5	1.7		2.9
	11:56	16270133	7.7	1.3	0.168	1.6	1.0	0.022		3.2		5.9	1.7		3.0
	11:57	16270134	7.5	1.2	0.164	1.7	1.0	0.022		3.2		5.9	1.7		3.0
	11:58	16270135	7.4	1.2	0.161	1.7	1.0	0.023		3.2		5.7	1.7		3.0
	11:59	16270136	7.2	1.2	0.157	1.8	1.0	0.024		3.2		6.1	1.7		3.0
	12:00	16270137	7.0	1.2	0.154	1.8	1.0	0.024		3.1		5.7	1.7		2.9
	12:01	16270138	6.8	1.1	0.149	1.8	0.9	0.024		3.1		5.6	1.7		3.0
	12:02	16270139	6.8	1.1	0.148	1.8	0.9	0.024		3.1		6.0	1.7		2.9
	12:03	16270140	6.7	1.1	0.147	1.8	0.9	0.024		3.1		5.5	1.6		2.9
	12:04	16270141	6.7	1.1	0.145	1.9	0.9	0.025		3.0		5.6	1.6		2.8
	12:05	16270142	6.6	1.1	0.144	1.9	0.9	0.025		3.1		5.8	1.7		2.9
	12:05	16270143	6.5	1.1	0.142	1.9	0.9	0.025		3.1		5.6	1.6		2.9
	12:06	16270144	6.5	1.1	0.142	1.8	0.9	0.024		3.1		5.7	1.7		2.9
	12:07	16270145	6.4	1.1	0.140	1.9	0.9	0.025		3.1		5.4	1.6		2.9
	12:08	16270146	6.4	1.1	0.140	1.9	0.9	0.025		3.0		5.5	1.6		2.9
	12:09	16270147	6.3	1.1	0.138	1.8	0.9	0.024		3.1		5.5	1.6		2.9
	12:10	16270148	6.3	1.1	0.138	1.9	0.9	0.025		3.1		5.4	1.6		2.9
	12:11	16270149	6.5	1.1	0.141	1.9	0.9	0.025		3.1		5.4	1.7		2.9
	12:12	16270150	6.5	1.1	0.142	1.9	0.9	0.025		3.1		5.5	1.7		2.9
	12:49	16270186	4.9	1.2	0.107	3.3	1.0	0.044		3.5		11.0	0.7		2.1
	12:50	16270187	4.7	1.3	0.102	3.1	1.0	0.041	6.5	2.5	0.081	11.2	0.7		2.1

TABLE B-2. CONTINUED. (LTV Scrubber Outlet)

Date	Time	File Name	Ethylene	Unc	Emissions lbs/hr	Ammonia	Unc	Emissions lbs/hr	Toluene	Unc	Emissions lbs/hr	1-Pentene	Unc	Pentane	Unc
	12:51	16270188	4.8	1.3	0.106	3.0	0.9	0.039		3.4		10.5	0.7		2.1
6/27/97	12:55	OUT4S007	5.1	1.2	0.111	2.9	0.9	0.039		3.3		11.1	0.7		1.5
	12:59	OUTS4008	5.1	1.1	0.111	2.4	0.8	0.031		3.0		4.6	1.6		2.8
	13:02	OUTS4009	5.3	1.0	0.116	1.7	0.7	0.023		2.8		4.2	1.5		2.7
	13:09	OUTS4010	4.9	0.9	0.107	1.2	0.7	0.015	24.6	2.0	0.306	9.6	0.6		1.7
	13:12	OUTS4011	5.1	0.9	0.111	1.1	0.7	0.014	25.7	2.0	0.320	10.0	0.6		1.7
	13:16	OUTS4012	4.6	0.9	0.101	1.0	0.7	0.013	25.3	2.0	0.315	9.1	0.6		1.7
		Average -->	6.0	1.2	0.131	1.7	0.9	0.023	0.1	3.0	0.001	6.3	1.6		2.8

[a] Blank spaces indicate the compound was not detected in that sample. These are included in the averages as zero concentrations.
[B] File Names are in the data records in Appendix B. Bold face type indicates a sample that was spiked with SF_6 or toluene. Spiked samples are not included in the run averages.

TABLE B-3. SUMMARY OF SPIKED AND UNSPIKED CONCENTRATIONS AT LTV [a]

LTV Inlet			Toluene		SF6	
File Name	Date	Time	Spiked ppm	Unspiked ppm	Spiked ppm	Unspiked ppm
Run 1 Start						
INLS2002	6/25/97	9:33	26.7			0.000
INLS2003		9:37	26.6			0.000
INLS2004		9:43	26.2			0.000
INLS2005		9:54		0.0	0.536	
INLS2006		9:58		0.0	0.555	
INLS2007		10:02		0.0	0.553	
	Average Spike		26.5		0.548	
	Average Unspike			0.0		0.000
Run 1 End						
INLV2046	6/25/97	16:48				0.000
INLV2047		16:54				0.000
INLV2048		16:58				0.000
INLS2049		17:07		3.5	0.665	
INLS2050		17:10		0.0	0.668	
INLS2051		17:14		0.0	0.664	
INLS2052		17:20	32.9			
INLS2053		17:24	34.0			
INLS2054		17:27	34.6			
	Average Spike		33.8		0.666	
	Average Unspike			1.2		0.000
Run 2 Start						
INLS3001	6/26/97	9:11			0.660	
INLS3002		9:18			0.658	
INLS3003		9:22			0.657	
INLS3004		9:34	32.5			0.000
INLS3005		9:38	33.5			0.000
INLS3006		9:42	33.4			0.000
16260004		10:55		4.3		
16260005		10:56		4.3		
16260006		10:57		4.5		
	Average Spike		33.1		0.658	
	Average Unspike			4.4		0.000

LTV Outlet			Toluene		SF6	
File Name	Date	Time	Spiked ppm	Unspiked ppm	Spiked ppm	Unspiked ppm
Run 1 Start			Spiked	Unspiked	Spiked	Unspiked
OUTS2001	6/25/97	8:41		0.0	0.465	
OUTS2002		8:46		0.0	0.479	
OUTS2003		8:52		0.0	0.479	
OUTS2004		9:02	23.4			0.000
OUTS2005		9:08	23.7			0.000
OUTS2006		9:13	23.4			0.000
	Average Spike		23.5		0.474	
	Average Unspike			0.0		0.000
Run 1 End						
INLV2044	6/25/97	16:39		0.0		
INLV2045		16:43		0.0		
INLV2046		16:48		0.0		
OUTS2047		17:36	26.9			0.000
OUTS2048		17:41	27.3			0.000
OUTS2049		17:46	27.3			0.000
OUTS2050		17:56			0.504	
OUTS2051		18:00			0.515	
OUTS2052		18:04			0.515	
	Average Spike		27.2		0.512	
	Average Unspike			0.0		0.000
Run 2 Start						
OUTS3001	6/26/97	9:53	28.5			
OUTS3002		9:59				
OUTS3003		10:04				0.000
OUTS3004		10:21	28.1			0.000
OUTS3005		10:26	28.3			0.000
OUTS3006		10:37		0.0	0.568	
OUTS3007		10:43		0.0	0.562	
OUTS3008		10:49		0.0	0.559	
	Average Spike		28.3		0.563	
	Average Unspike			0.0		0.000

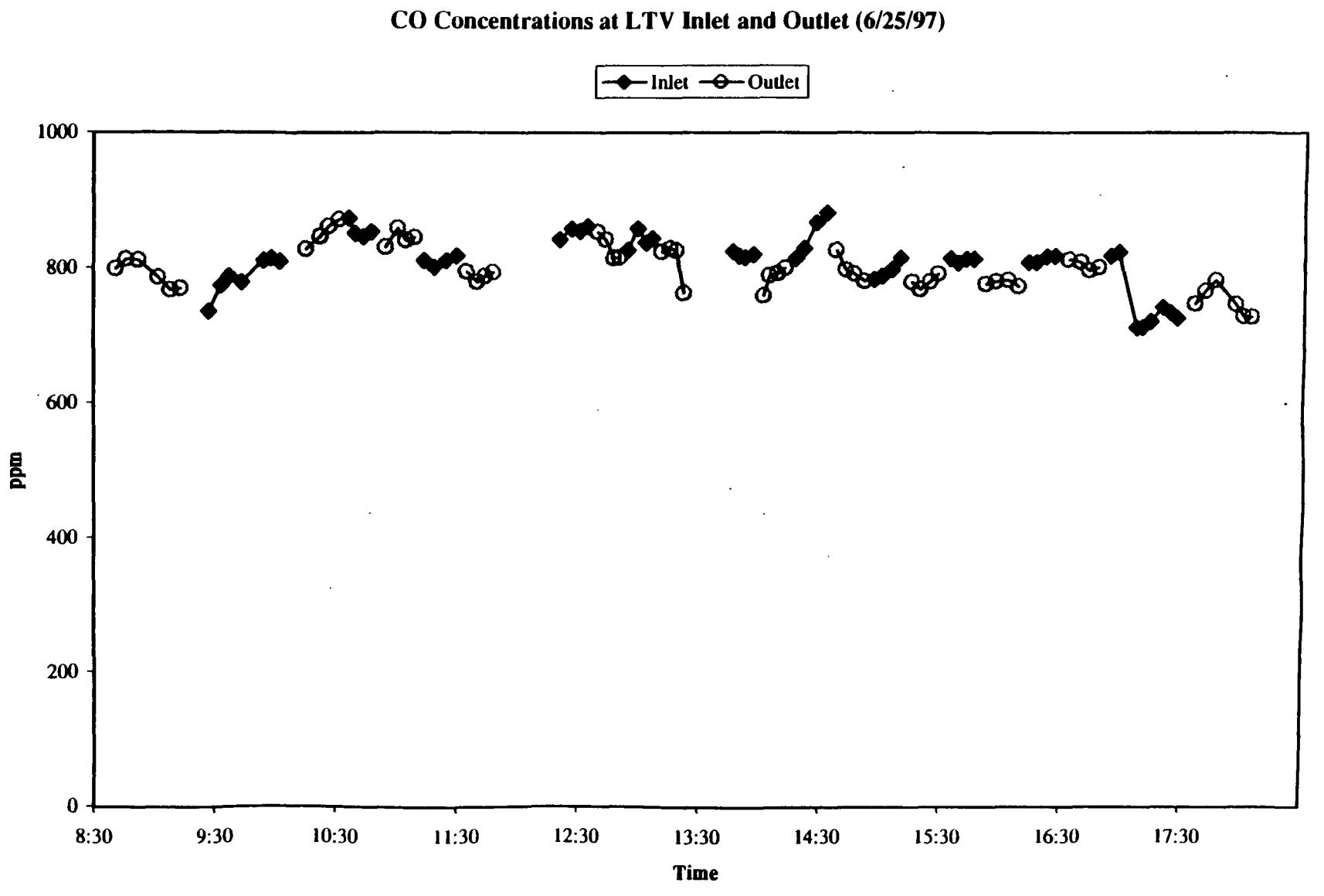
[a] These results are taken from Tables B-1 and B-2 and are summarized in Table 4-3.

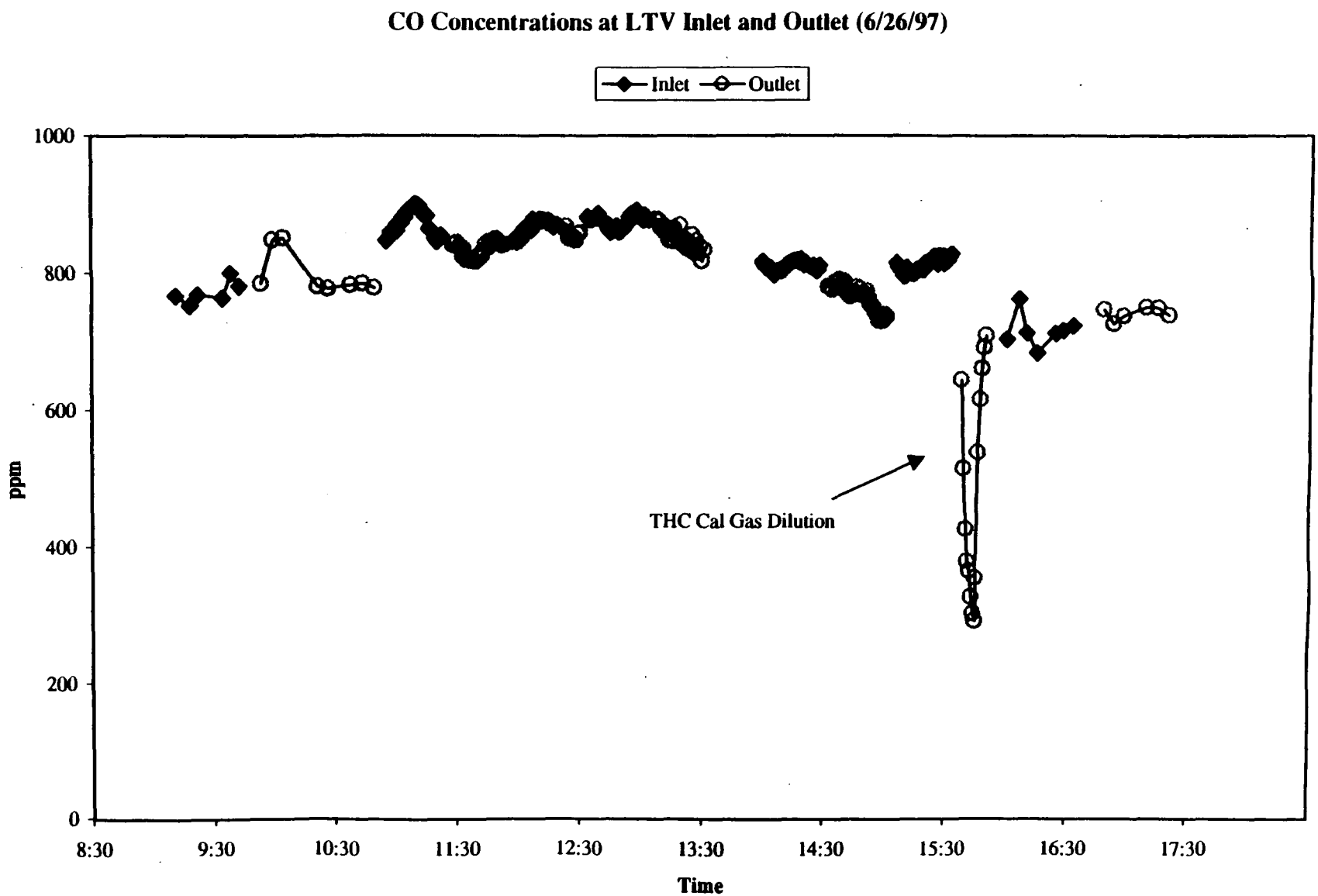
TABLE B-3. SUMMARY OF SPIKED AND UNSPIKED CONCENTRATIONS AT LTV [a]

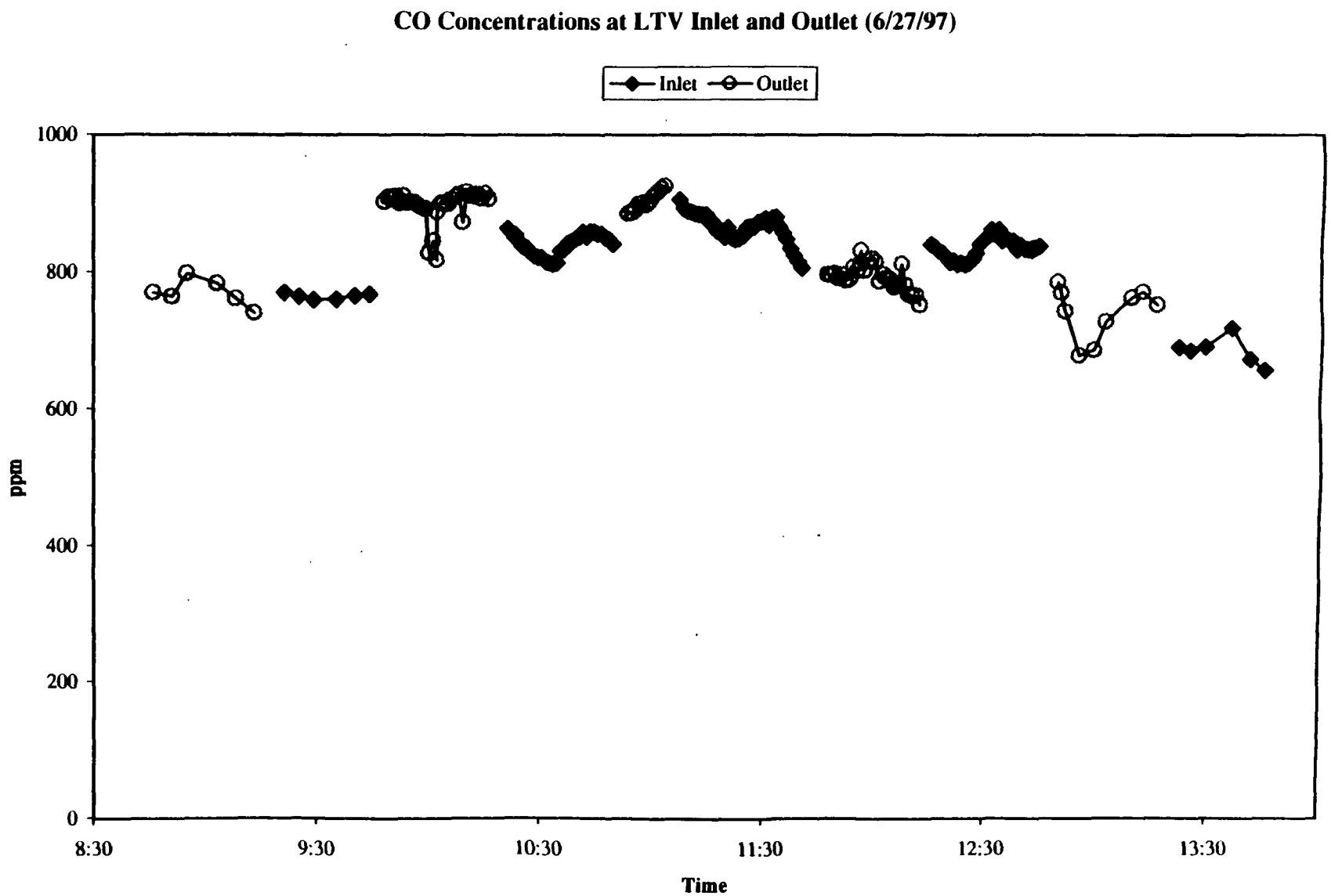
LTV Inlet File Name	Date	Time	Toluene Spiked ppm	Toluene Unspiked ppm	SF6 Spiked ppm	SF6 Unspiked ppm
Run 2 End						
16260261	6/26/97	15:30		4.9		
16260262		15:31		4.9		
16260263		15:32		5.0		
16260264		15:33				
INLS3007		16:00				
INLS3008		16:06	47.2			0.000
INLS3009		16:10	50.8			0.000
INLS3010		16:15	51.0			0.000
INLS3011		16:24			0.997	
INLS3012		16:28			1.038	
INLS3013		16:33			1.029	
	Average Spike		49.6		1.022	
	Average Unspike			4.9		0.000
Run 3 Start						
INLS4001	6/27/97	9:21	38.0			
INLS4002		9:25	37.5			
INLS4003		9:29	37.5			
INLS4004		9:35			0.730	
INLS4005		9:40			0.749	
INLS4006		9:44			0.756	
16270035		10:21		4.2		0.000
16270036		10:22		4.1		0.000
16270037		10:23		4.2		0.000
	Average Spike		37.7		0.745	
	Average Unspike			4.2		0.000
Run 3 End						
16270182	6/27/97	12:42		0.0		
16270183		12:43		0.0		
16270184		12:44		0.0		
INLS4007		13:22	54.7			0.000
INLS4008		13:25	57.3			0.000
INLS4009		13:29	57.4			0.000
INLS4010		13:36			1.167	
INLS4011		13:41			1.223	
INLS4012		13:45			1.243	
	Average Spike		56.5		1.211	
	Average Unspike			0.0		0.000

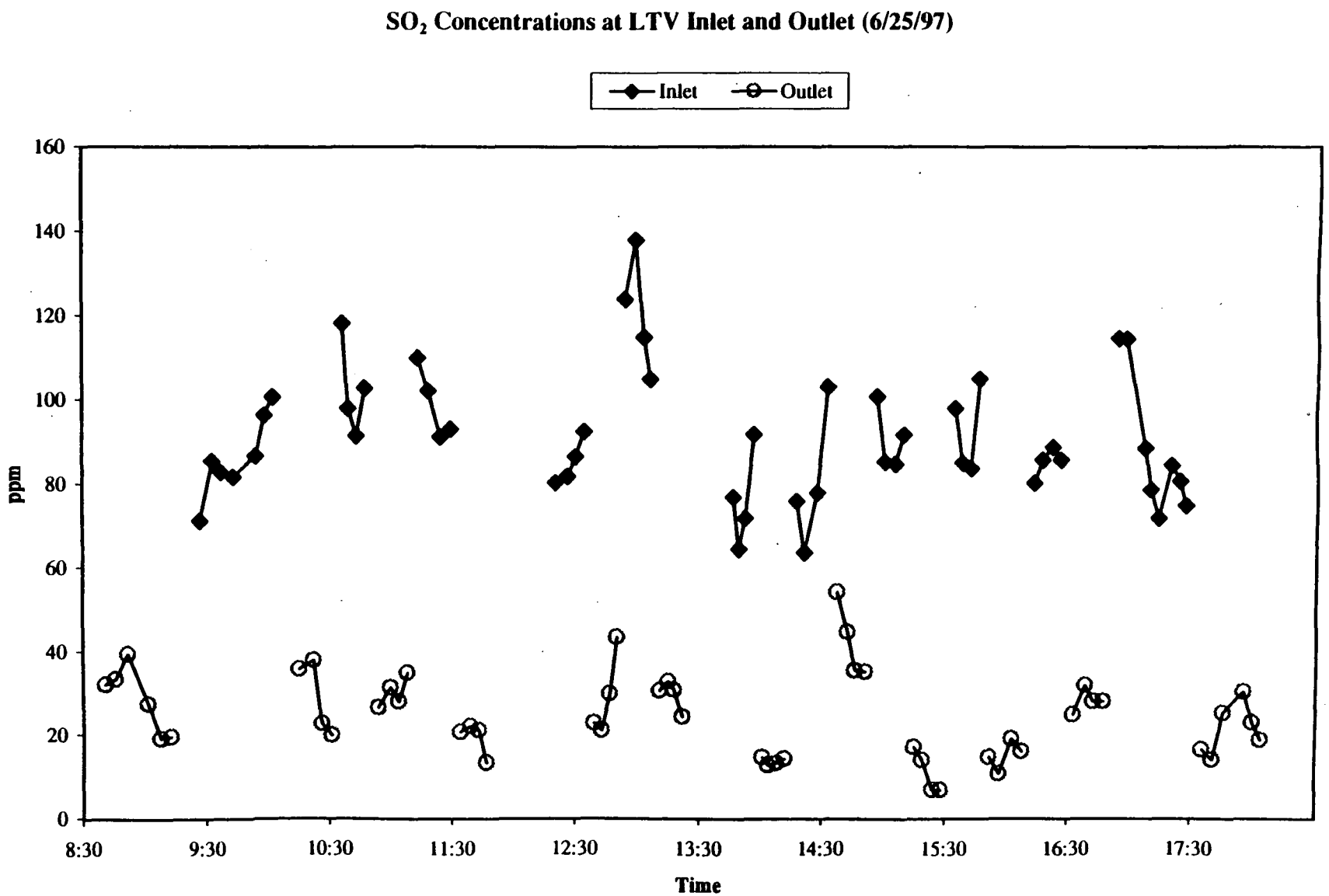
LTV Outlet File Name	Date	Time	Toluene Spiked ppm	Toluene Unspiked ppm	SF6 Spiked ppm	SF6 Unspiked ppm
Run 2 End						
OUTS3009	6/26/97	16:48		0.0	0.571	
OUTS3010		16:53		0.0	0.574	
OUTS3011		16:58		4.1	0.573	
OUTS3012		17:09	29.0			0.000
OUTS3013		17:15	29.1			0.000
OUTS3014		17:20	28.8			0.000
	Average Spike		29.0		0.572	
	Average Unspike			1.4		0.000
Run 3 Start						
OUTS4001	6/27/97	8:46		0.0	0.542	
OUTS4002		8:51		0.0	0.544	
OUTS4003		8:55		0.0	0.532	
OUTS4004		9:03	28.2			0.000
OUTS4005		9:08	29.0			0.000
OUTS4006		9:13	28.5			0.000
	Average Spike		28.6		0.539	
	Average Unspike			0.0		0.000
Run 3 End						
OUT4S007	6/27/97	12:55		0.0	0.438	
OUTS4008		12:59		0.0	0.487	
OUTS4009		13:02		0.0	0.490	
OUTS4010		13:09	24.6			0.000
OUTS4011		13:12	25.7			0.000
OUTS4012		13:16	25.3			0.000
	Average Spike		25.2		0.472	
	Average Unspike			0.0		0.000

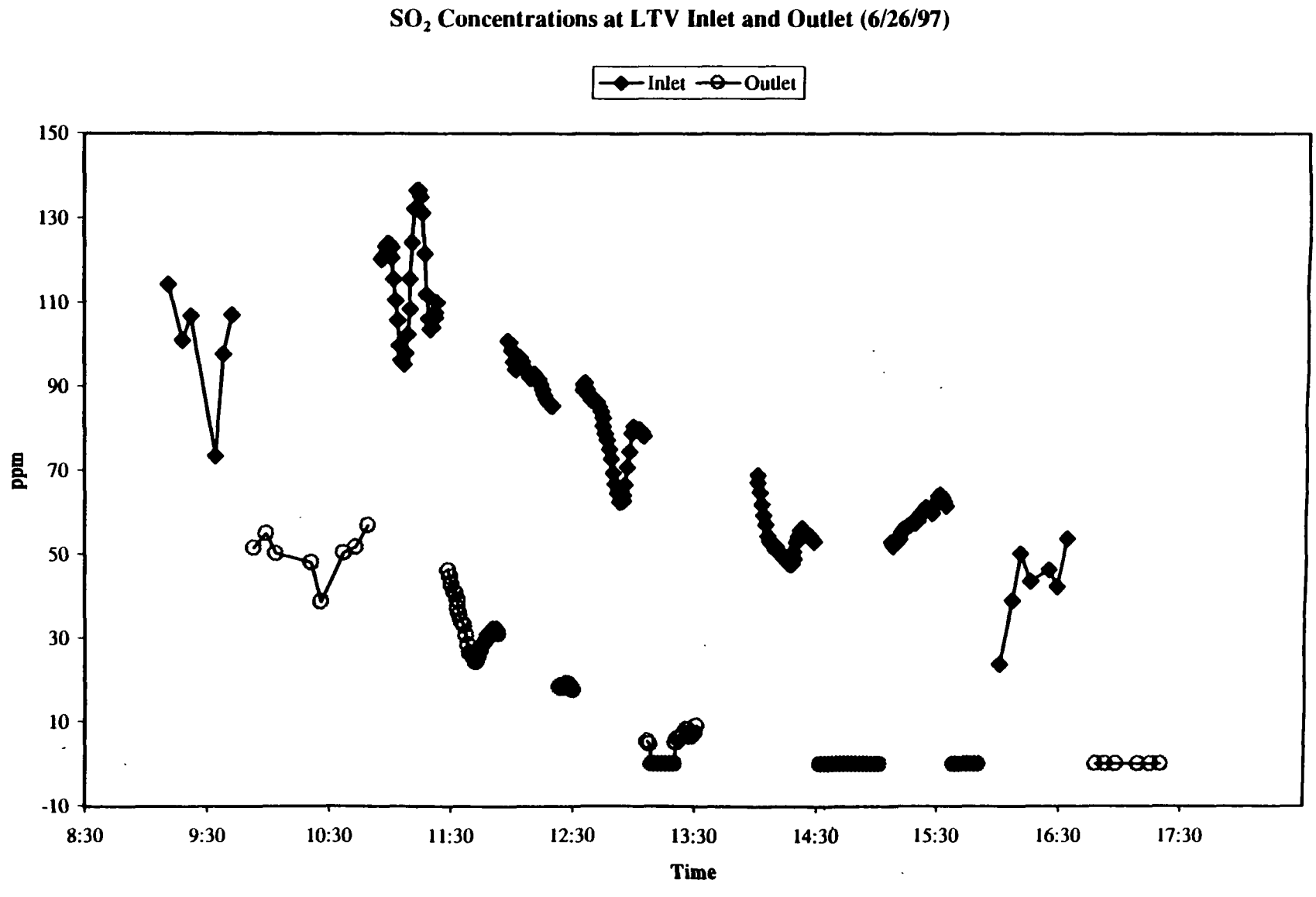
[a] These results are taken from Tables B-1 and B-2 and are summarized in Table 4-3.

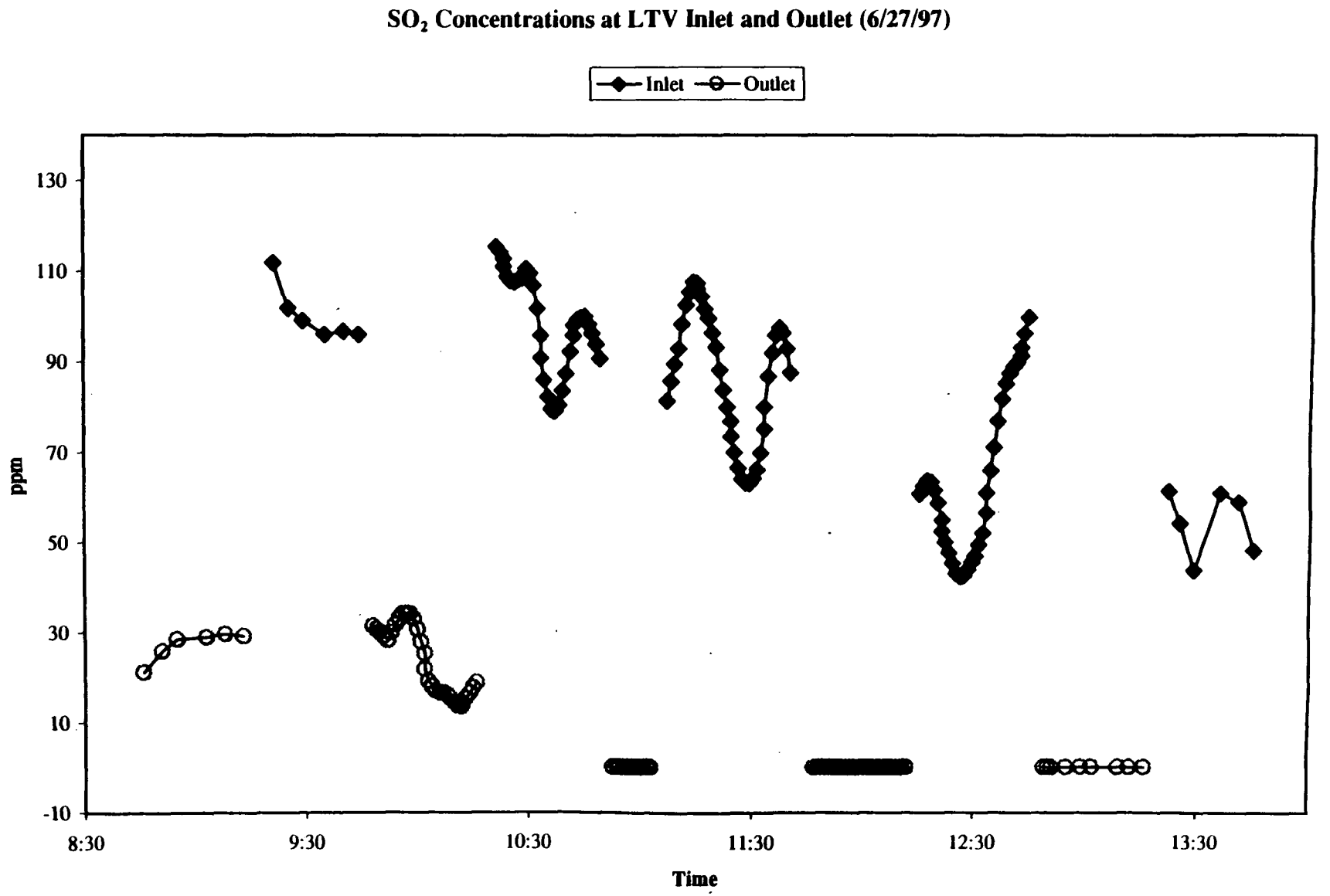

CO Concentrations at LTV Inlet and Outlet (6/25/97)
Inlet
Outlet
1000
800
600
400
200
0
ppm
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
Time

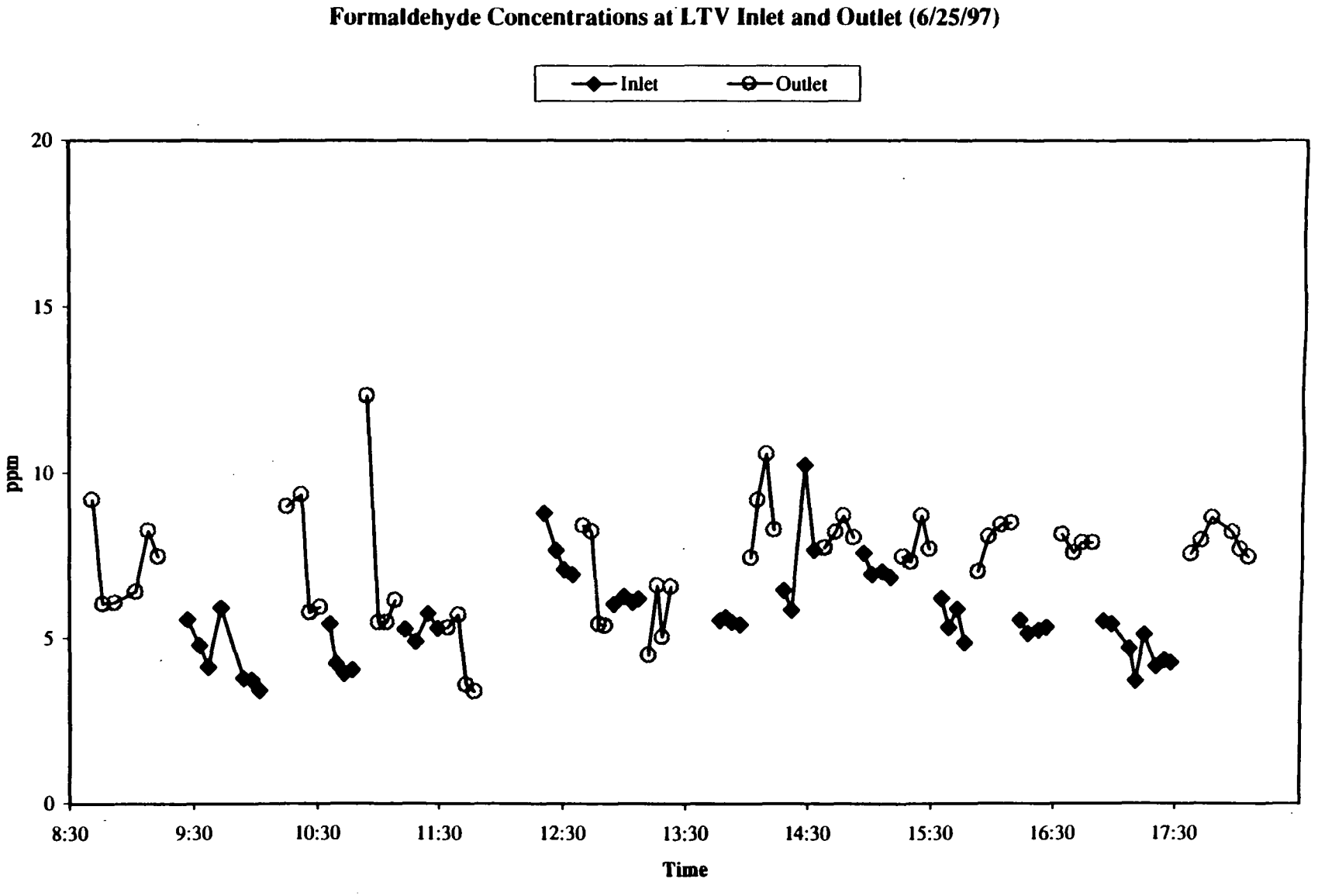

CO Concentrations at LTV Inlet and Outlet (6/26/97)
Inlet
Outlet
1000
800
600
400
200
0
ppm
THC Cal Gas Dilution
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
Time

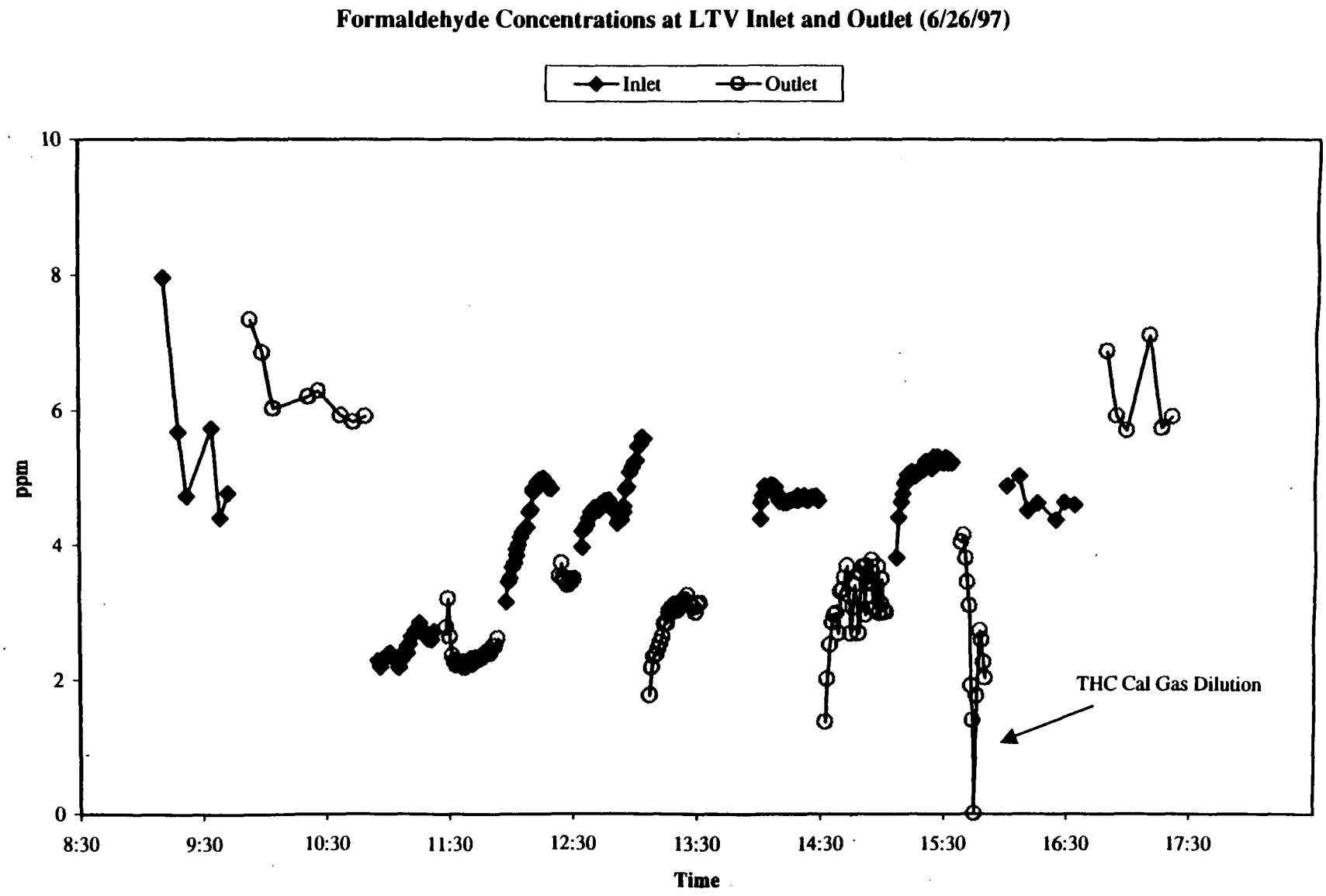

CO Concentrations at LTV Inlet and Outlet (6/27/97)
Inlet
Outlet
1000
800
600
400
200
0
ppm
8:30
9:30
10:30
11:30
12:30
13:30
Time

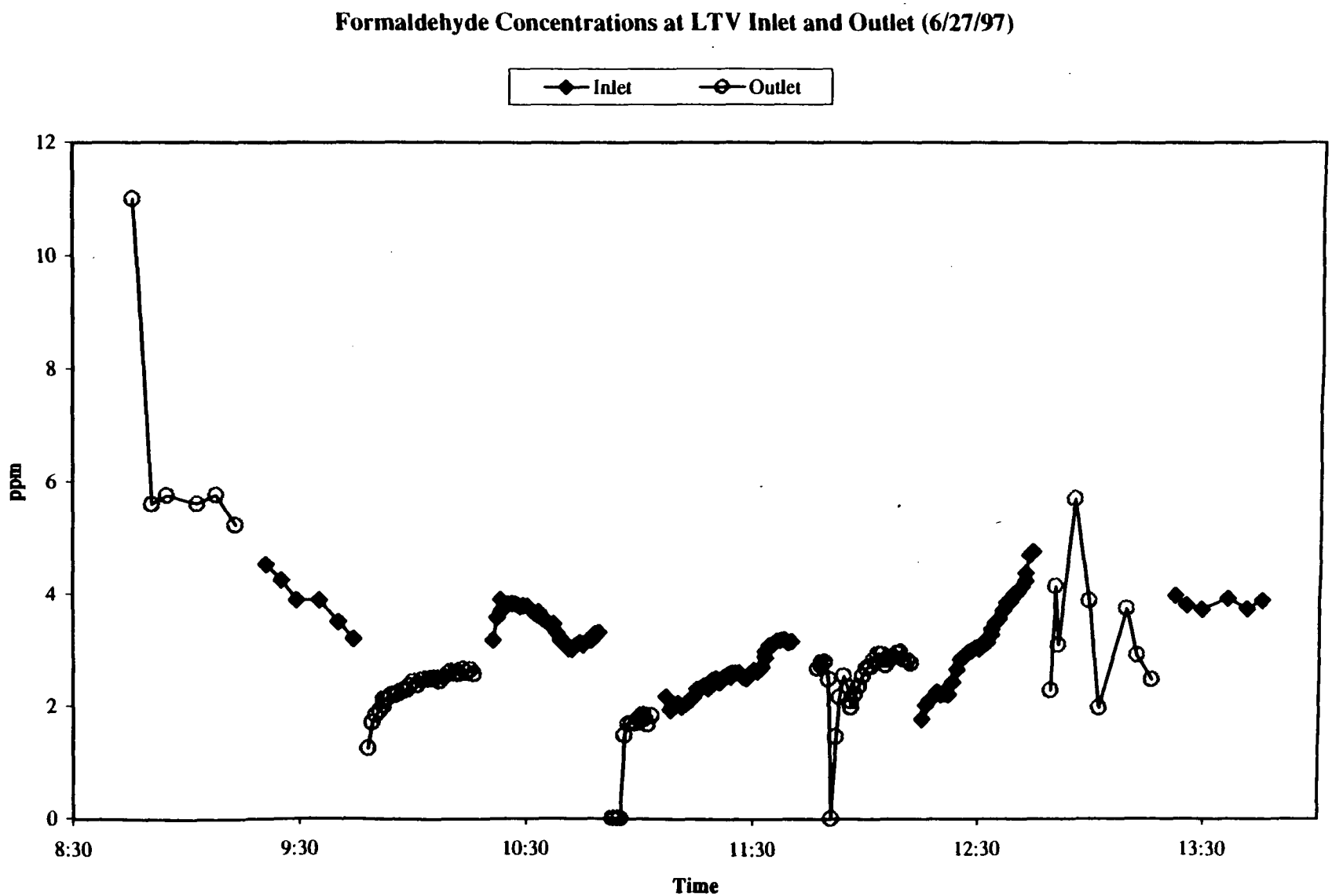

SO2 Concentrations at LTV Inlet and Outlet (6/25/97)
Inlet
Outlet
ppm
160
140
120
100
80
60
40
20
0
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
Time


SO2 Concentrations at LTV Inlet and Outlet (6/26/97)
Inlet
Outlet
150
130
110
90
70
50
30
10
-10
ppm
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
Time


SO2 Concentrations at LTV Inlet and Outlet (6/27/97)
Inlet
Outlet
130
110
90
70
50
30
10
-10
ppm
8:30
9:30
10:30
11:30
12:30
13:30
Time


Formaldehyde Concentrations at LTV Inlet and Outlet (6/25/97)
Inlet
Outlet
20
15
10
5
0
ppm
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
Time


Formaldehyde Concentrations at LTV Inlet and Outlet (6/26/97)
Inlet
Outlet
ppm
10
8
6
4
2
0
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
Time
THC Cal Gas Dilution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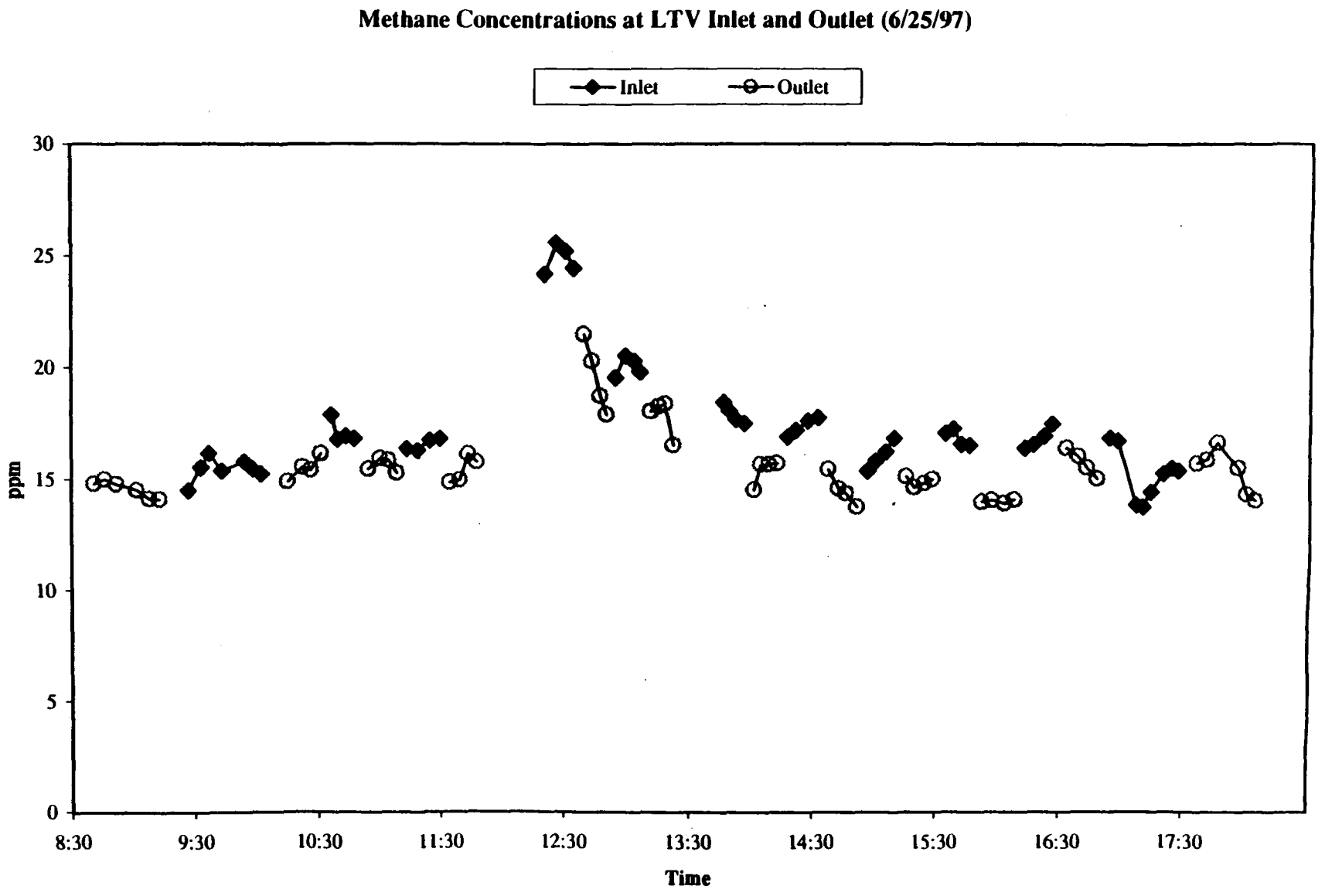
Time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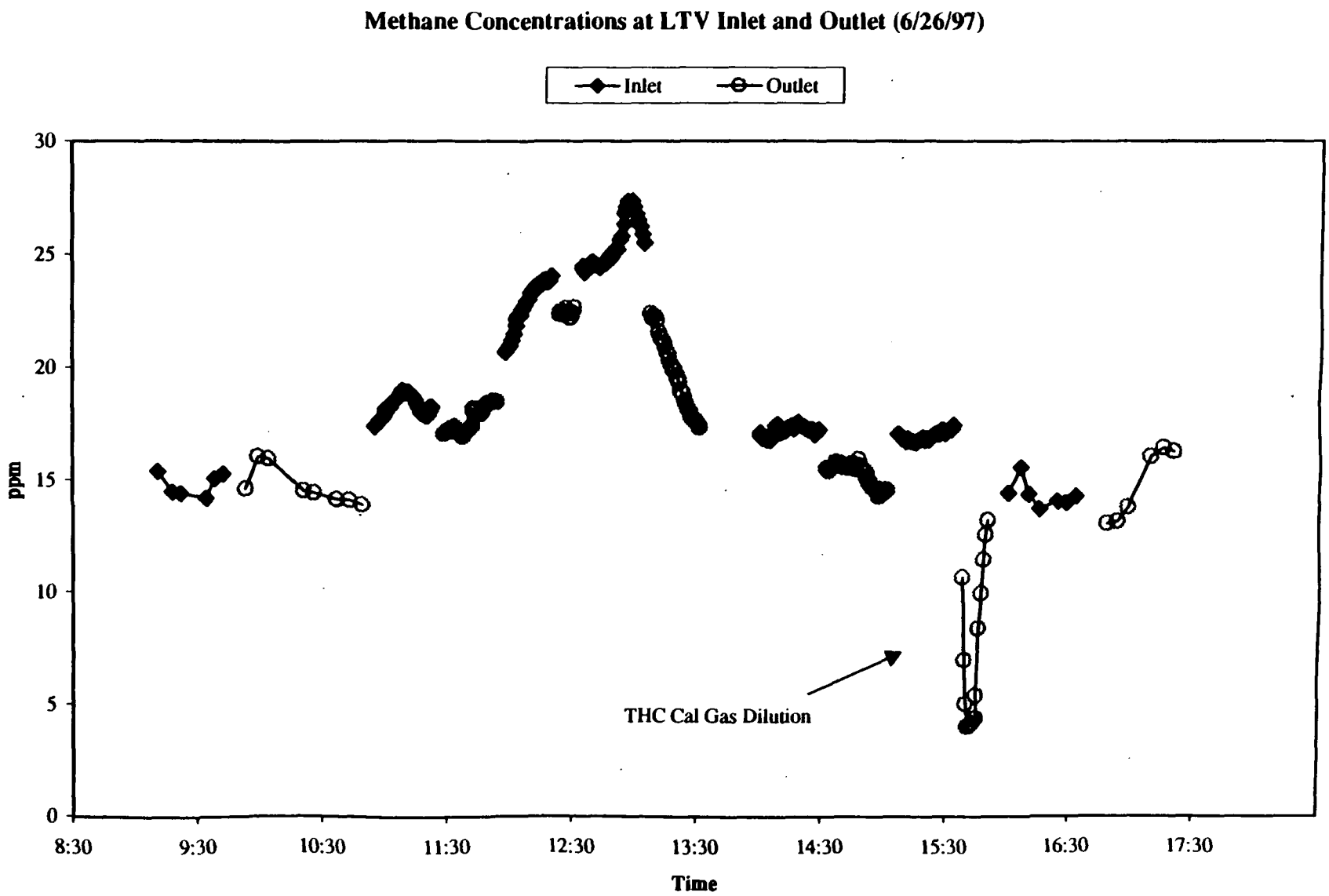
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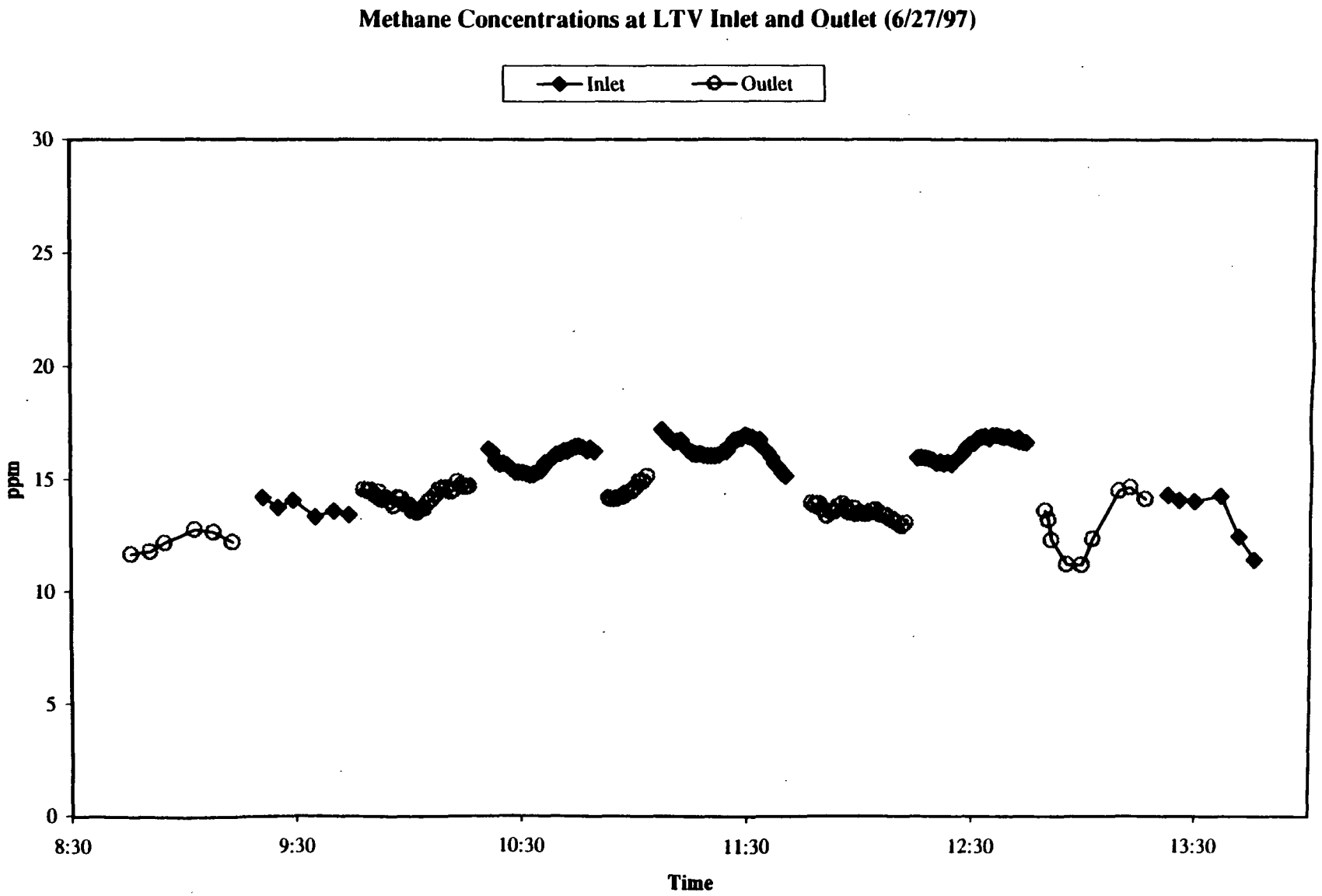
Time
THC Cal Gas Dilution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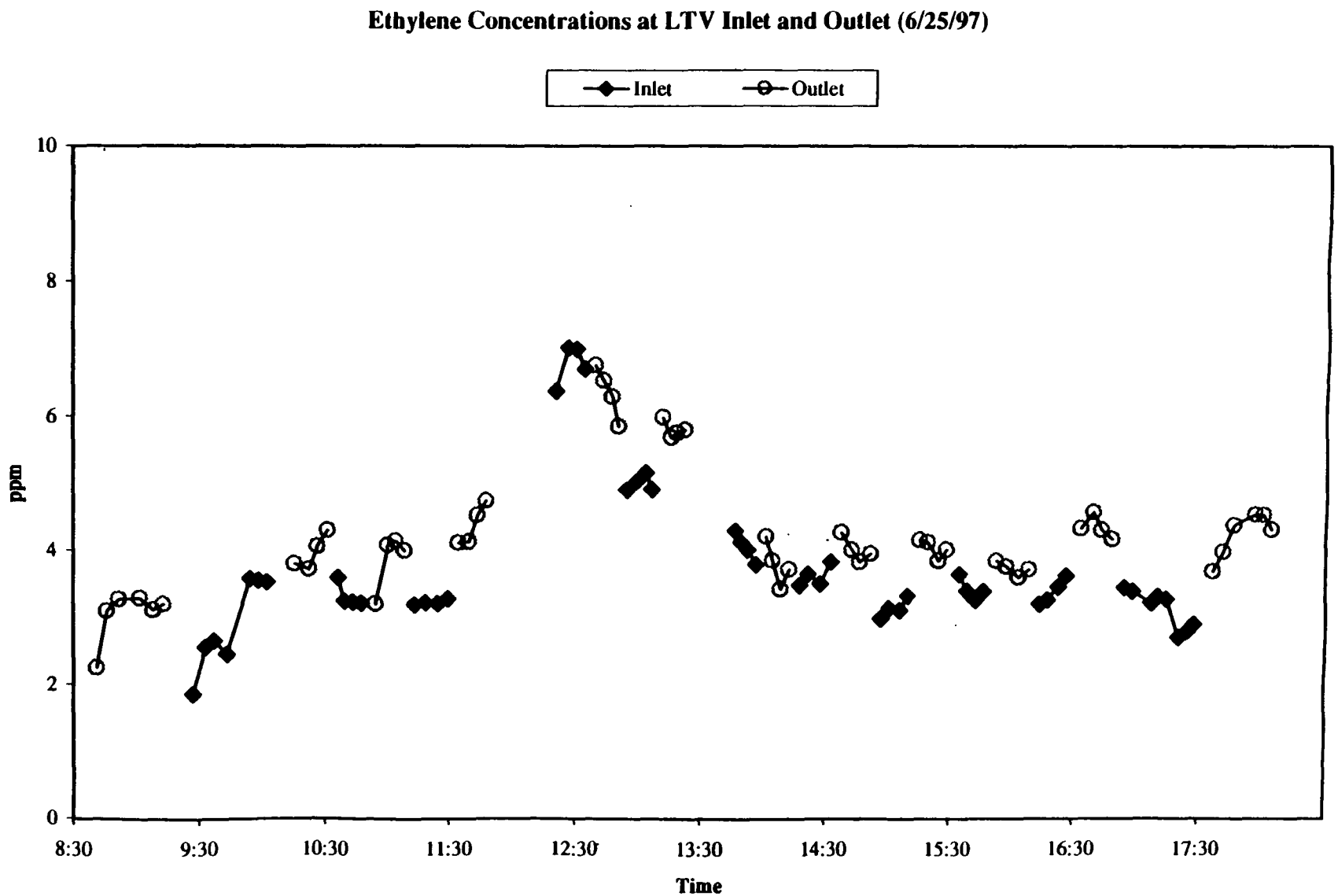
Time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Outlet
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6
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ppm
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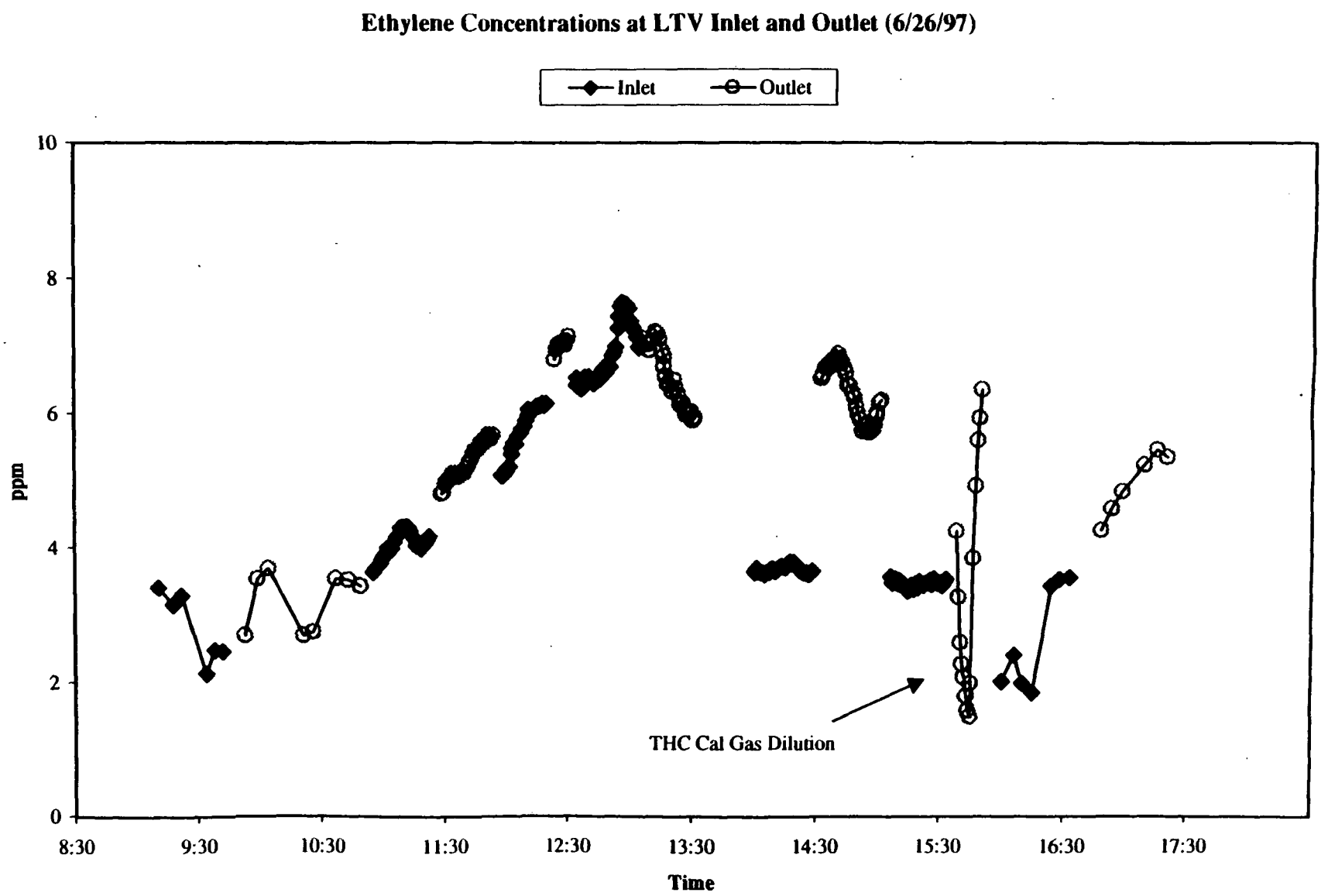
Time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ppm
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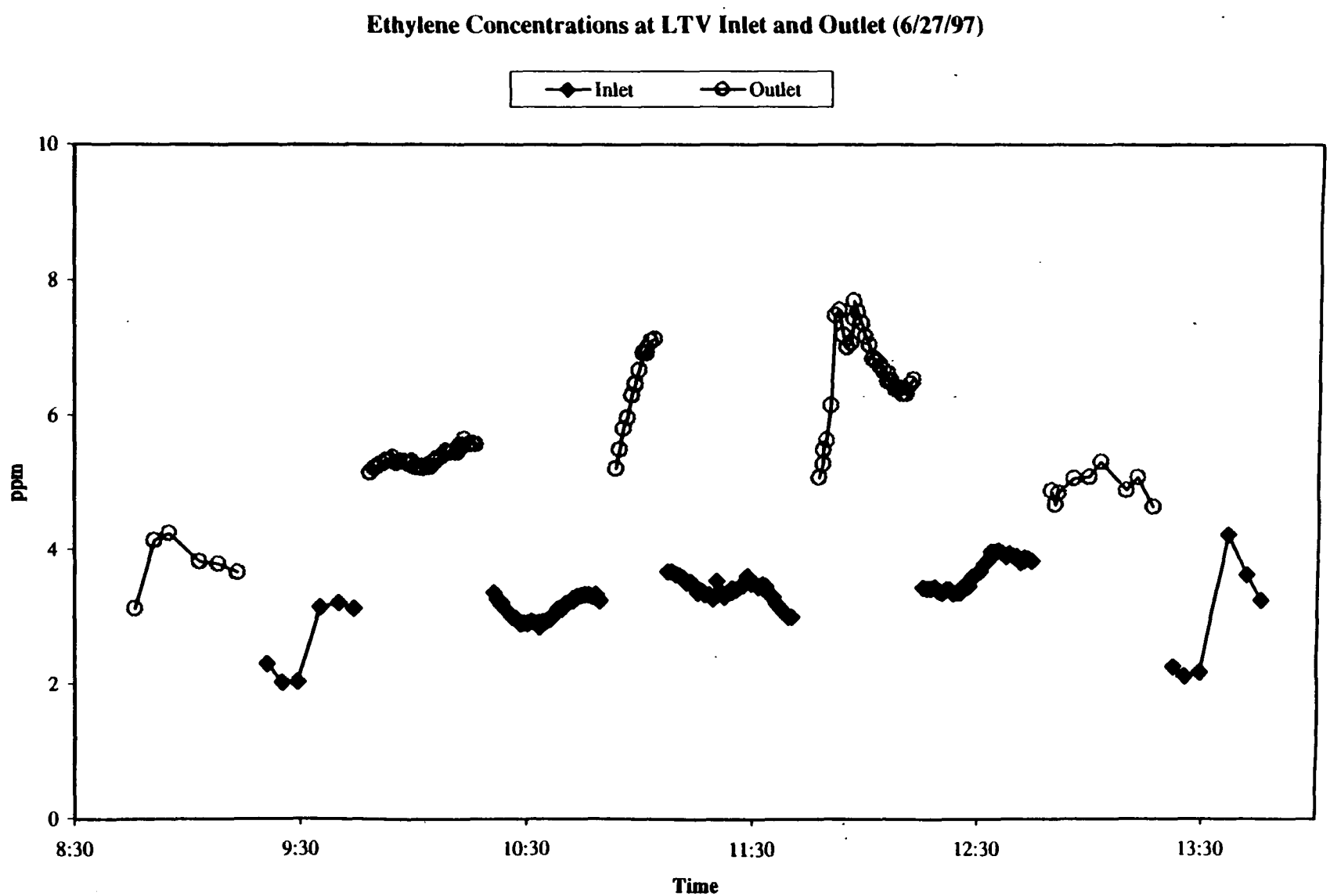
Time
THC Cal Gas Dilution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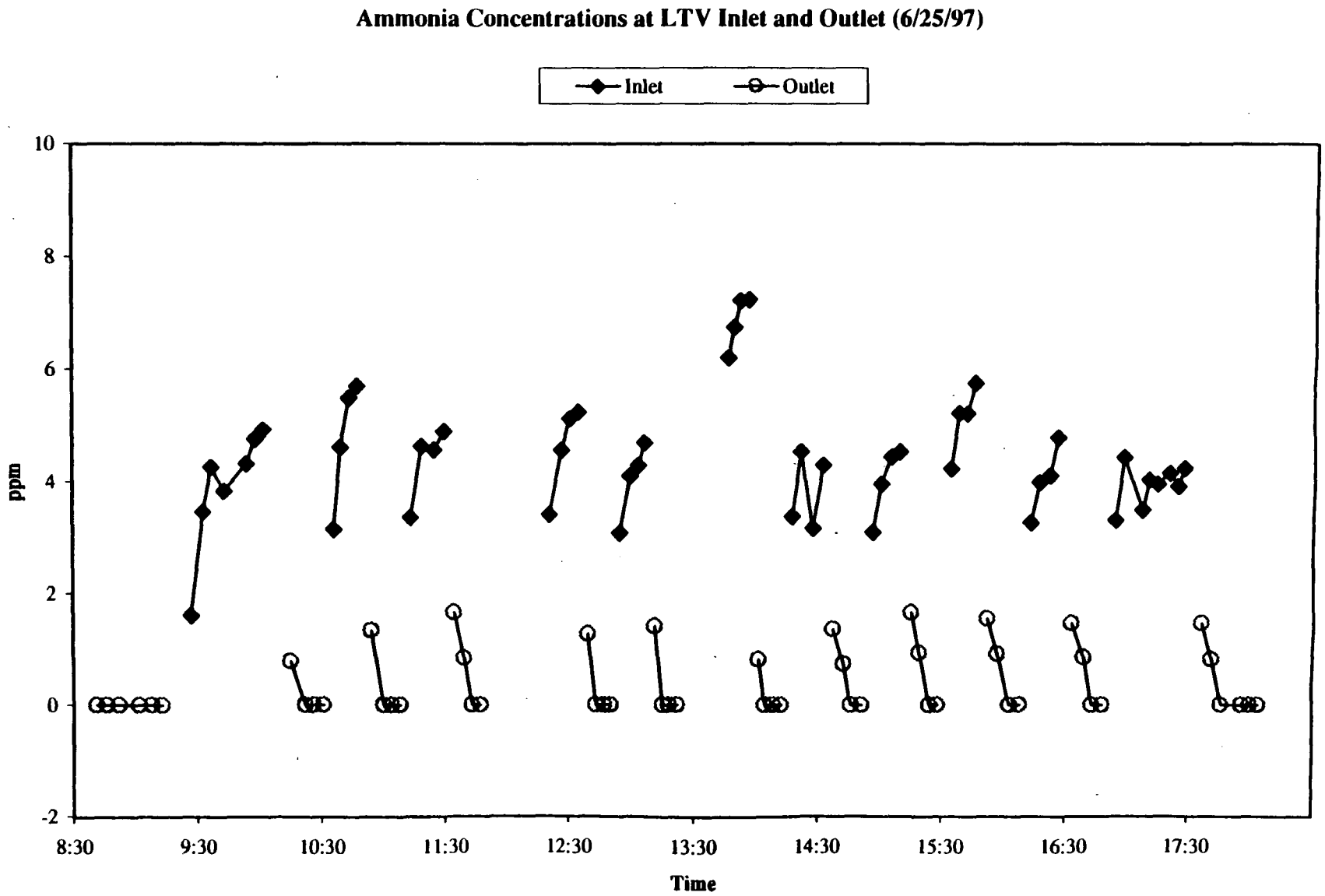
Time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Outlet
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ppm
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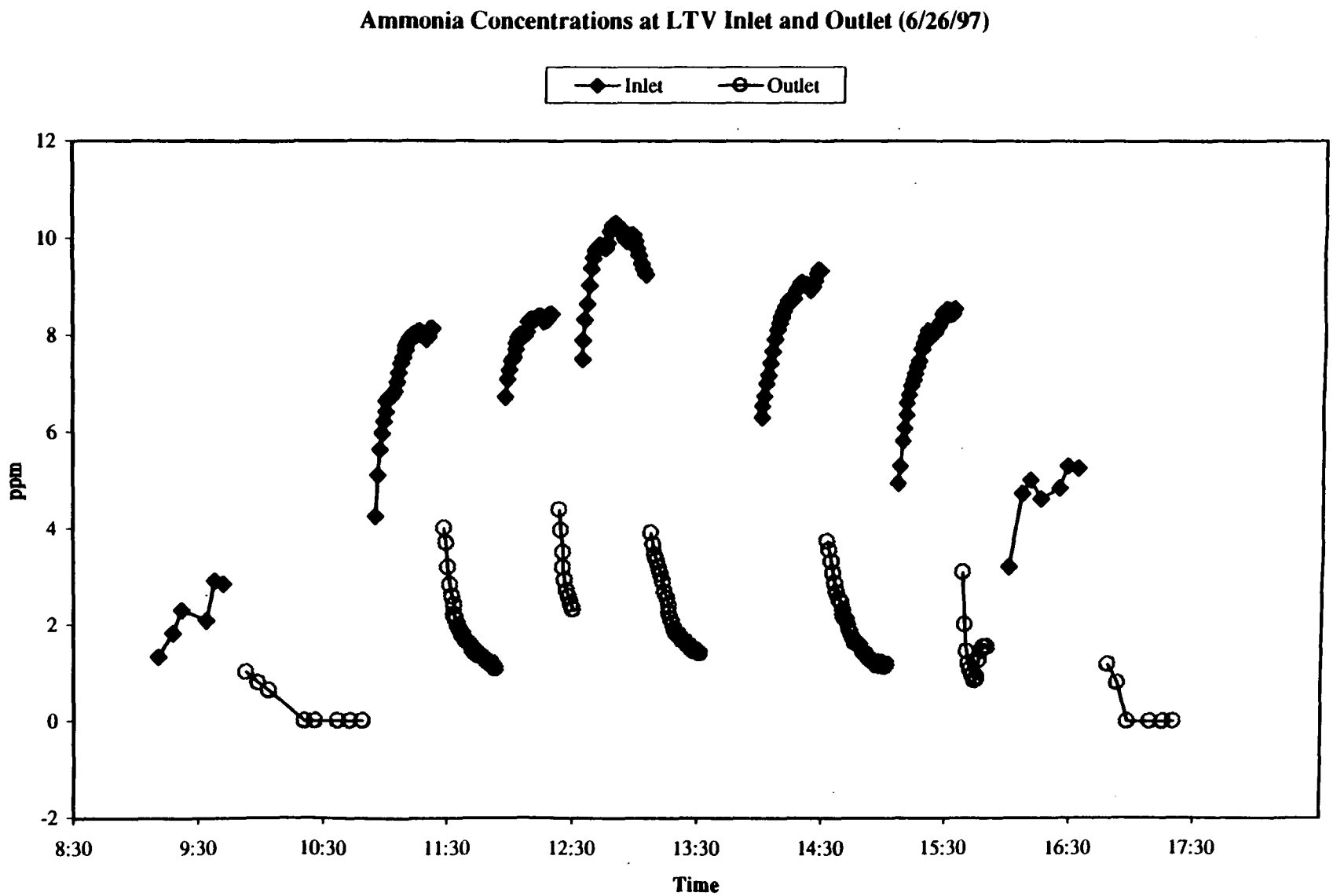
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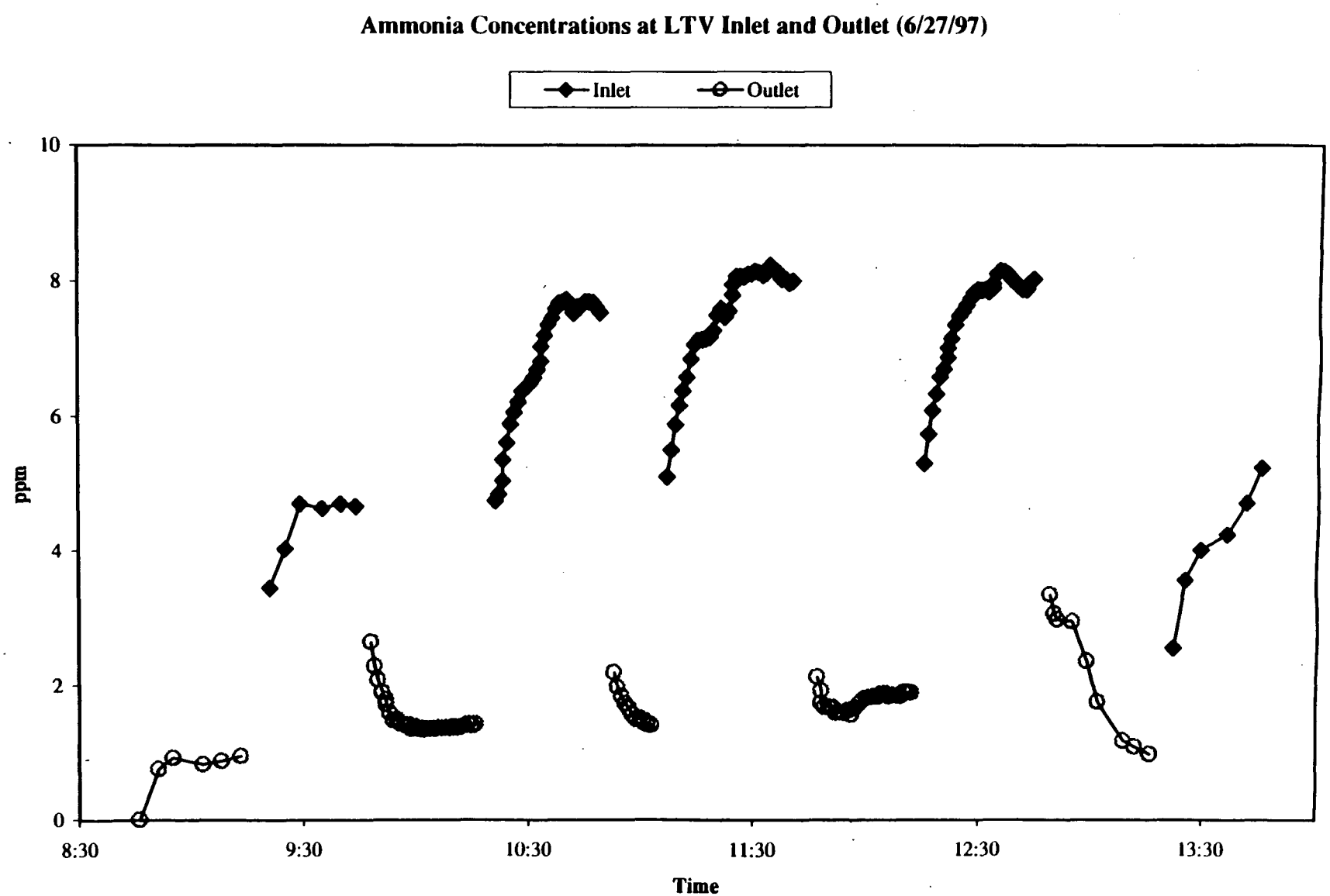
Ammonia Concentrations at LTV Inlet and Outlet (6/27/97)
Inlet
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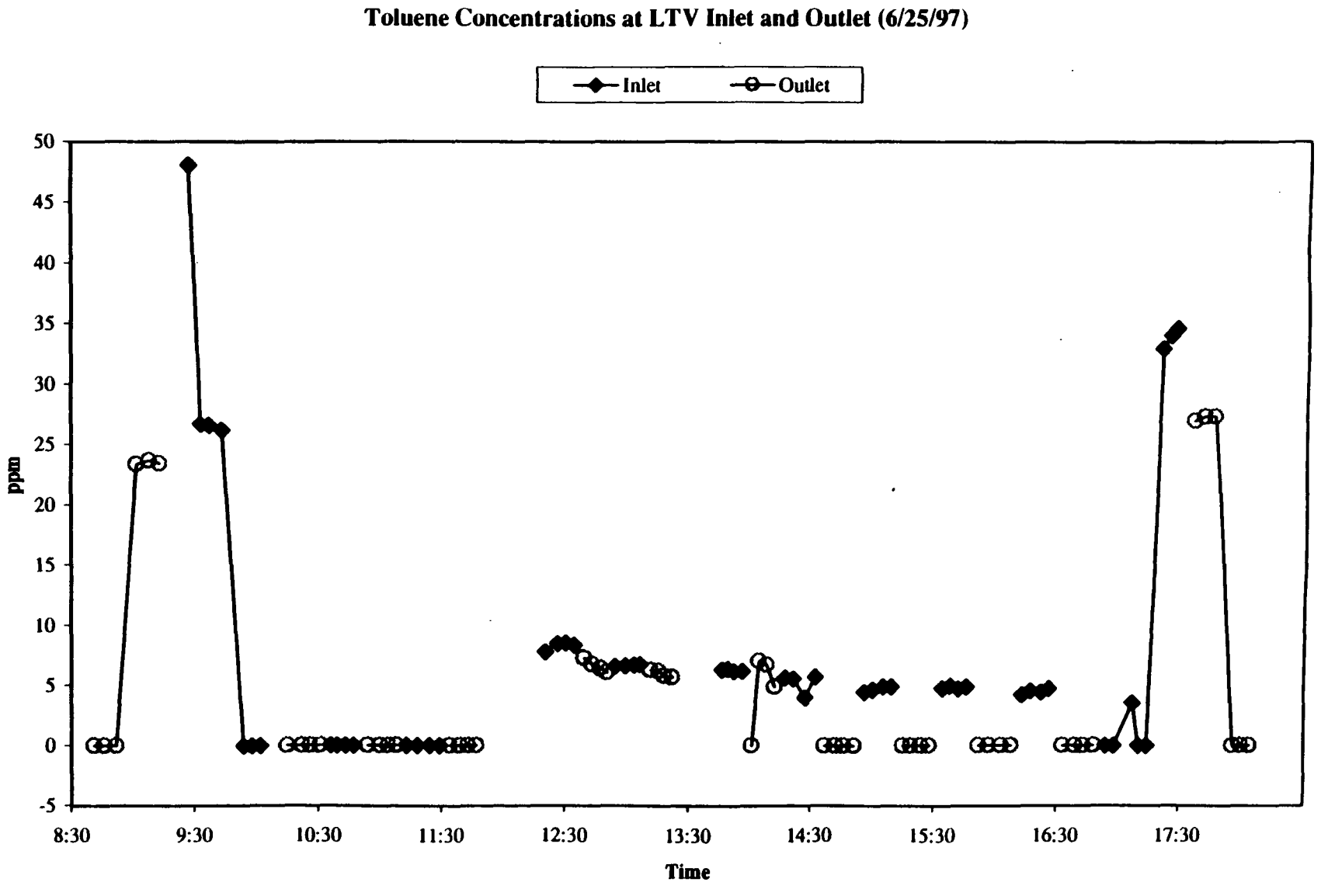
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ppm
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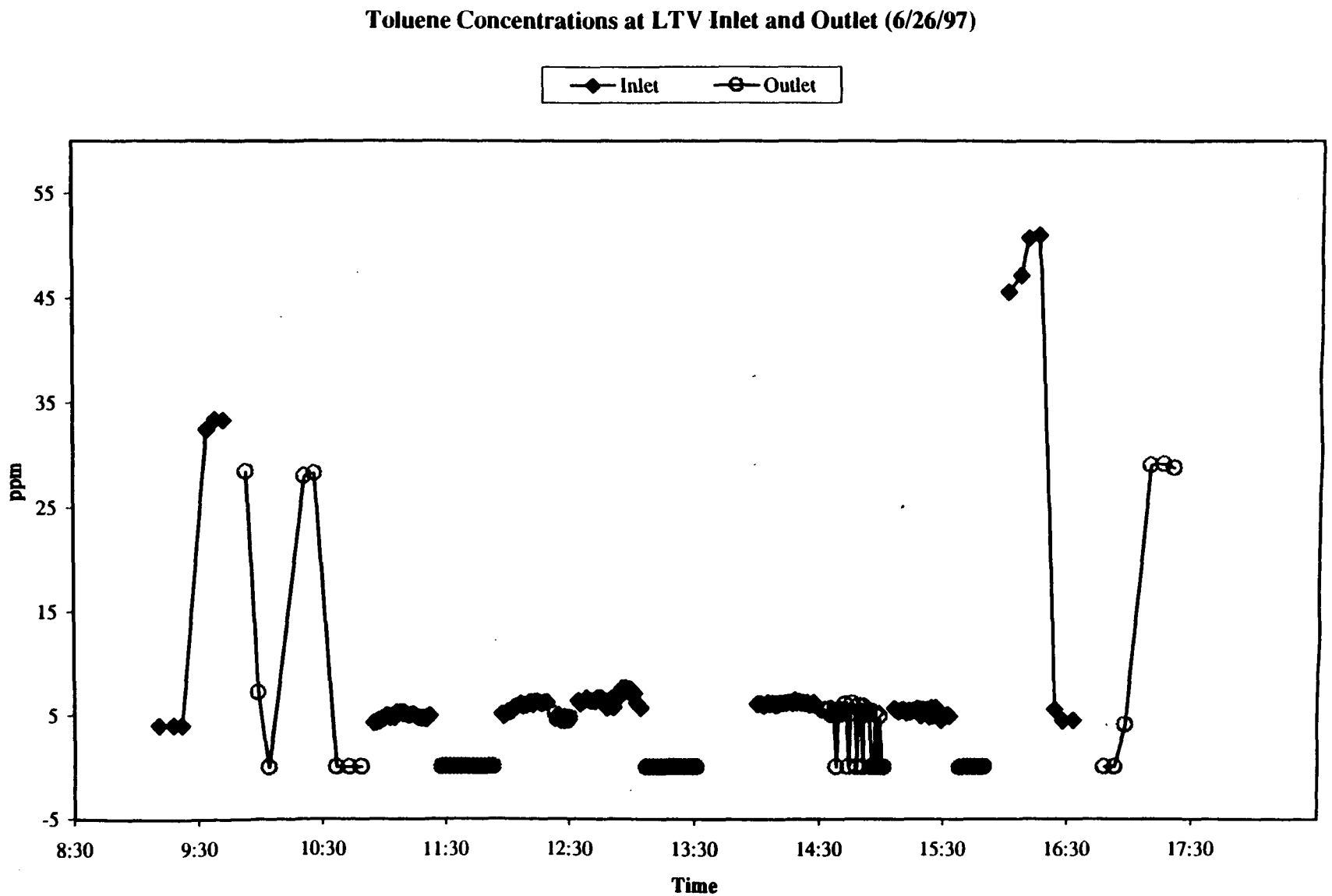
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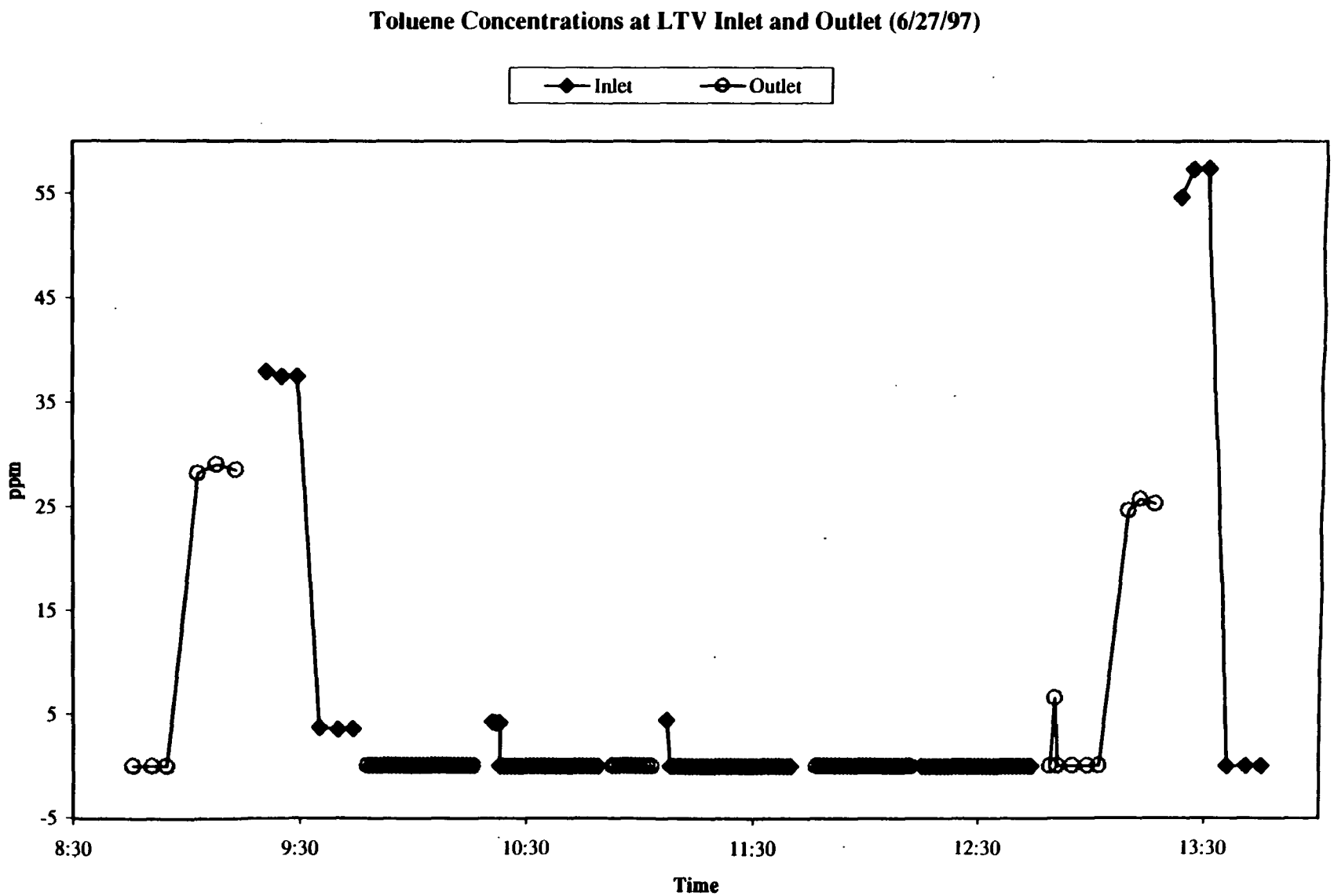
Toluene Concentrations at LTV Inlet and Outlet (6/27/97)
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B-4 HYDROCARBON REFERENCE SPECTRA

Reference Spectra of Hydrocarbon Compounds

The purpose of measuring reference spectra of some hydrocarbon compounds was to aid the analyses of FTIR sample spectra from iron and steel foundries and from integrated iron and steel plants. Four facilities were tested at these sources. At each facility hydrocarbon compounds were detected in the emissions. Because the EPA library of FTIR reference spectra contains only spectra of hazardous air pollutant (HAP) compounds, only quantitative reference spectra of hexane and isooctane were available to analyze the sample hydrocarbon emissions. As a result the hydrocarbon emissions were represented primarily by "hexane" in the draft report results. Many hydrocarbon compounds have infrared spectra which are similar to that of hexane in the spectral region near 2900 cm^{-1}. MRI selected nine candidate hydrocarbon compounds and measured their reference spectra in the laboratory. In addition MRI measured new high-temperature reference spectra of hexane and isooctane. The new reference spectra of these 11 compounds were included in revised analyses of the sample spectra. The FTIR results presented in the revised test reports show the measured concentrations of the detected hydrocarbons and also show revised concentrations of hexane and toluene. The hexane concentrations, in particular, are generally lower because the infrared absorbance from the hydrocarbon emissions is partly measured by the new reference spectra. As an example, figure B-1 illustrates the similarities among a sample spectrum and reference spectra of hexane and n-heptane.

MRI prepared a laboratory plan specifying the procedures for measuring the reference spectra. The EPA-approved laboratory plan is included in this appendix. The data sheets, check lists and other documentation are also included. During the measurements some minor changes were made to the laboratory plan procedures. These changes don't affect the data quality, but did allow the measurements to be completed in less time. This was necessary because the plan review process was more length than anticipated.

The following changes were to the procedures. The spectra were measured at 1.0 cm^{-1} resolution, which was the highest resolution of the sample spectra. It was unnecessary to use a heated line connection between the mass flow meter and the gas cell because the gas temperature in the cell was maintained without the heated line. Leak checks were conducted at positive pressure only because all of the laboratory measurements were conducted at ambient pressure. The reference spectra, CTS spectra, and background spectra will be provided on a disk with a separate reference spectrum report.

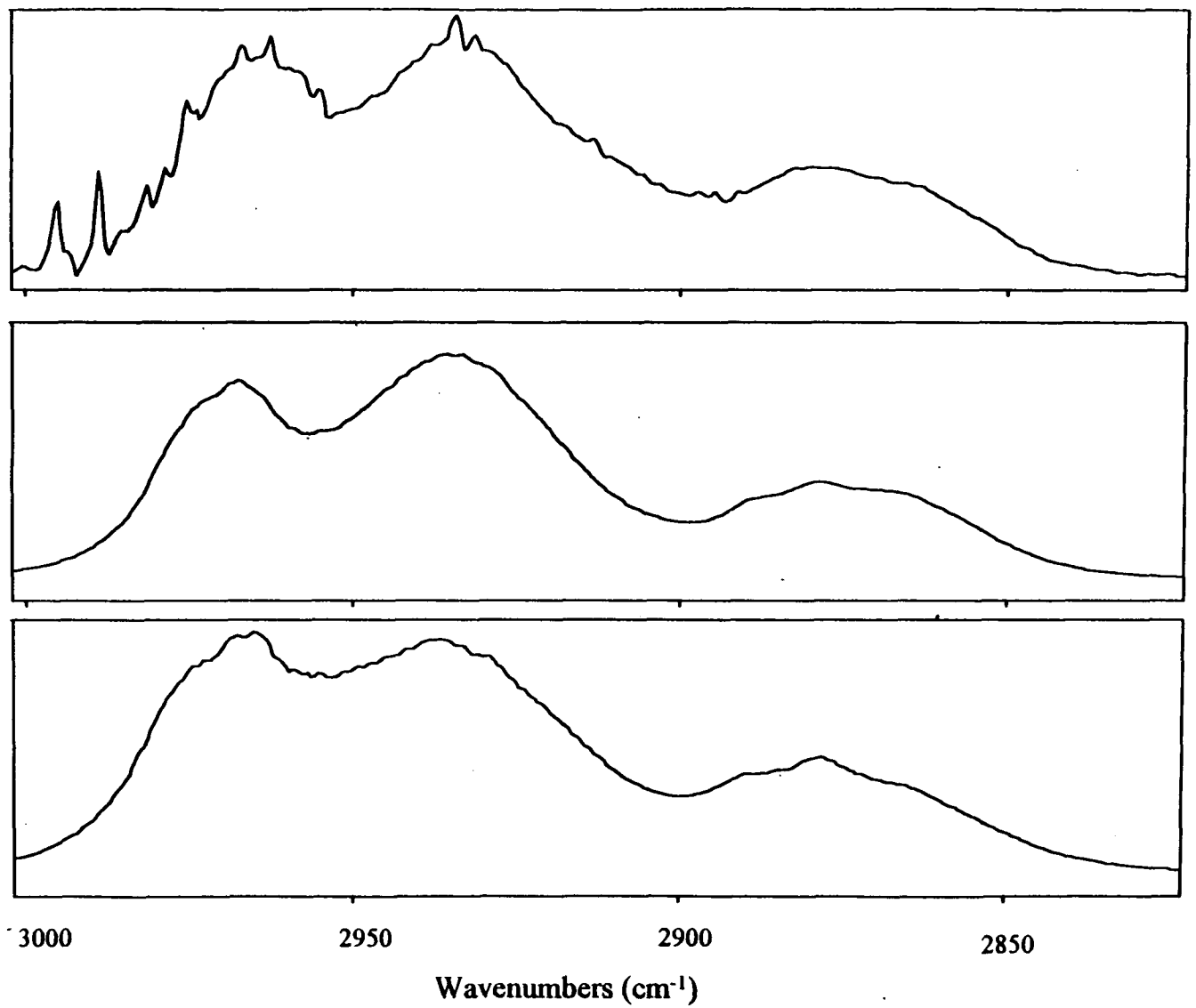

Figure B-1. Top trace, example sample spectrum; middle trace, n-heptane reference spectrum; bottom trace, n-hexane reference Spectrum.

LABORATORY PLAN FOR REFERENCE SPECTRUM MEASUREMENTS

DRAFT

Prepared for

Office of Air Quality Planning and Standards
Emissions, Monitoring and Analysis Division
Emission Measurement Center (MD-19)
Research Triangle Park, North Carolina 27711
Mr. Michael Ciolek
Work Assignment Manager

EPA Contract No. 68-D-98-027
Work Assignment 2-12 and 2-13
MRI Project No. 4951-12 and 4951-13

June 14, 1999

MIDWEST RESEARCH INSTITUTE 5520 Dillard Road, Suite 100, Cary, NC 27511-9232 • (919) 851-8181

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FIGURE AND TABLE LIST

Figure 1. Measurement system configuration 4

TABLE 1. ORGANIC COMPOUNDS SELECTED FOR THE LABORATORY STUDY 3

Laboratory Plan For Reference Spectrum Measurements
EPA Contract No. 68-D-98-027, Work Assignments 2-12 and 2-13
MRI Work Assignments 4951-12 and 4951-13

1.0 INTRODUCTION

In 1997 Midwest Research Institute (MRI) completed FTIR field tests at two iron and steel sintering facilities and at two iron and steel foundries. The tests were completed under EPA Contract No. 68-D2-0165, work assignments 4-20 and 4-25 for the sintering plants and foundries, respectively. The draft test reports were completed in 1998 under EPA Contract No. 68-W6-0048, work assignment 2-08, tasks 11 and 08 for the sintering plants and foundries, respectively.

Results from the data analyses indicated that the emissions from some locations included a mixture of hydrocarbon compounds, one of which was hexane. The EPA spectral library of FTIR reference spectra is comprised primarily of hazardous air pollutants (HAPs) identified in Title III of the 1990 Clean Air Act Amendments and, therefore, contains a limited number of aliphatic hydrocarbon compounds. MRI will measure reference spectra of some additional organic compounds that may have been part of the sample mixtures. The new reference spectra will be used in revised analyses of the sample spectra. The revised analyses will provide a better measure of the non-hexane sample components and, therefore, more accurate hexane measurements.

A Quality Assurance Project Plan (QAPP) was submitted for each source under EPA Contract No. 68-D2-0165, work assignments 4-20 and 4-25. When the QAPPs were prepared it was not anticipated that laboratory measurements would be required. This document describes the laboratory procedures and is an addition to the QAPPs.

This document outlines the technical approach and specifies the laboratory procedures that will be followed to measure the FTIR reference spectra. Electronic copies of the new reference spectra will be submitted to EPA with corresponding documentation. The laboratory procedures are consistent with EPA's Protocol for the Use of Extractive Fourier Transform Infrared (FTIR) Spectrometry for the Analyses of Gaseous Emissions From Stationary Sources, revised 1996.

1.1 Objective

The objective is to obtain accurate hexane measurements from FTIR spectra recorded at field tests at iron and steel sintering plants and at steel foundry plants. The approach is to measure reference spectra of some organic compounds that are not included in the EPA reference spectrum library and then use these new reference spectra in revised analyses of the field test spectra. The revised analyses will provide better discrimination of the hexane component from the absorbance bands of the organic mixture.

1.2 Background

Spectra of samples measured at the field test sites contained infrared absorbance features that may be due to a mixture of non-aromatic organic compounds. The samples were measured using quantitative reference spectra in the EPA library and the hexane reference spectra provided the best model for the observed absorbance features. The EPA library contains a limited number of reference spectra, primarily HAPs, listed in Title III of the 1990 Clean Air Act Amendments, which includes hexane. To obtain accurate measurements of target components it is helpful to use reference spectra of all compounds in the sample gas mixture. In this case it was decided to measure reference spectra of some additional organic compounds, which are similar in structure and have spectral features similar to hexane. The revised analyses will measure the sample absorbance in the 2900 cm^{-1} region using a combination of the hexane and new reference spectra. The revised analyses should provide more accurate hexane measurements, by measuring the non-hexane sample components more accurately.

2.0 TECHNICAL APPROACH

The analytical region used to measure hexane lies near 2900 cm^{-1}. Other aliphatic hydrocarbons with structures similar to hexane exhibit similar absorbance band shapes in this region. MRI viewed spectra of aliphatic organic compounds to identify some likely components of the sample spectra. Table 1 identifies the compounds that were selected for reference spectrum measurements. Cylinder standards of the selected compounds will be purchased from a commercial gas supplier. The standards will be about 50 ppm of the analyte in a balance of nitrogen. The cylinders will contain gravimetric standards (analytical accuracy of ±1 percent) in a balance of nitrogen.

2.1 Measurement System

A controlled, measured flow of the gas standard will be directed from the cylinder to the infrared gas cell. The gas cell is a CIC Photonics Pathfinder. This is a variable path White cell with an adjustable path length from 0.4 to 10 meters. The path lengths have been verified by measurements of ethylene spectra compared to ethylene spectra in the EPA FTIR spectral library. The inner cell surface is nickel coated alloy to minimize reactions of corrosive compounds with the cell surfaces. The cell windows are ZnSe. The cell is heat-wrapped and insulated. Temperature controllers and digital readout are used to control and monitor the cell temperature in two heating zones. The gas temperature inside the cell will be recorded using a T-type thermocouple temperature probe inserted through a 1/4 in. Swagelok fitting. The gas temperature will be maintained at about 120°C. Documentation of the temperature probe and thermometer calibration will be provided with the report.

TABLE 1. ORGANIC COMPOUNDS SELECTED FOR THE LABORATORY STUDY

Compound Name	Boiling Point (°C)
n–hexane[a]	69
n-heptane	98.4
Pentane	36.1
isooctane[a]	99.2
1-pentene	30
2-methyl,1-pentene	60.7
2-methyl,2-butene	38.6
2-methyl,2-pentene	67.3
3-methylpentane	63.3
Butane	-0.5

[a] Hexane and isooctane are HAPs. Their reference spectra will be re-measured because the reference spectra in the EPA library were measured at ambient temperature.

The instrument is an Analect Instruments (Orbital Sciences) RFX-65 optical bench equipped with a mercury-cadmium-telluride (MCT) detector. The RFX-65 instrument is capable of measuring spectra at 0.125 cm^{-1} resolution. The reference spectra will be measured at 0.25 cm^{-1} or 0.50 cm^{-1} resolution. Gas pressure in the sample cell will be measured using an Edwards barocell pressure sensor equipped with an Edwards model 1570 digital readout. A record of the pressure sensor calibration will be provided with the report.

A continuous flow of the gas standard will be maintained through the cell as the spectra are recorded. A mass flow meter will be used to monitor the gas flow (Sierra Instruments, Inc., model No. 822S-L-2-OK1-PV1-V1-A1, 0 to 5 liters per minute).

The instrument system will be configured to measure 0.25 cm^{-1} or 0.50 cm^{-1} resolution spectra. The measurement configuration is shown in Figure 1. Calibration transfer standards (CTS) will be measured each day before any reference spectra are measured and after reference spectra measurements are completed for the day.

2.2 Procedure

Information will be recorded in a laboratory notebook. Additionally, the instrument operator will use check lists to document that all procedures are completed. There will be three checklists for: (1) daily startup prior to any reference measurements, (2) reference spectrum measurements, and (3) daily shut down after reference measurements are completed. Example checklists are at the end of this document.

The information recorded in the laboratory notebook includes; the cell temperature, ambient pressure, background, CTS and spectrum file names, sample temperatures and pressures for each measurement, cell path length settings, number of background and sample scans, instrument

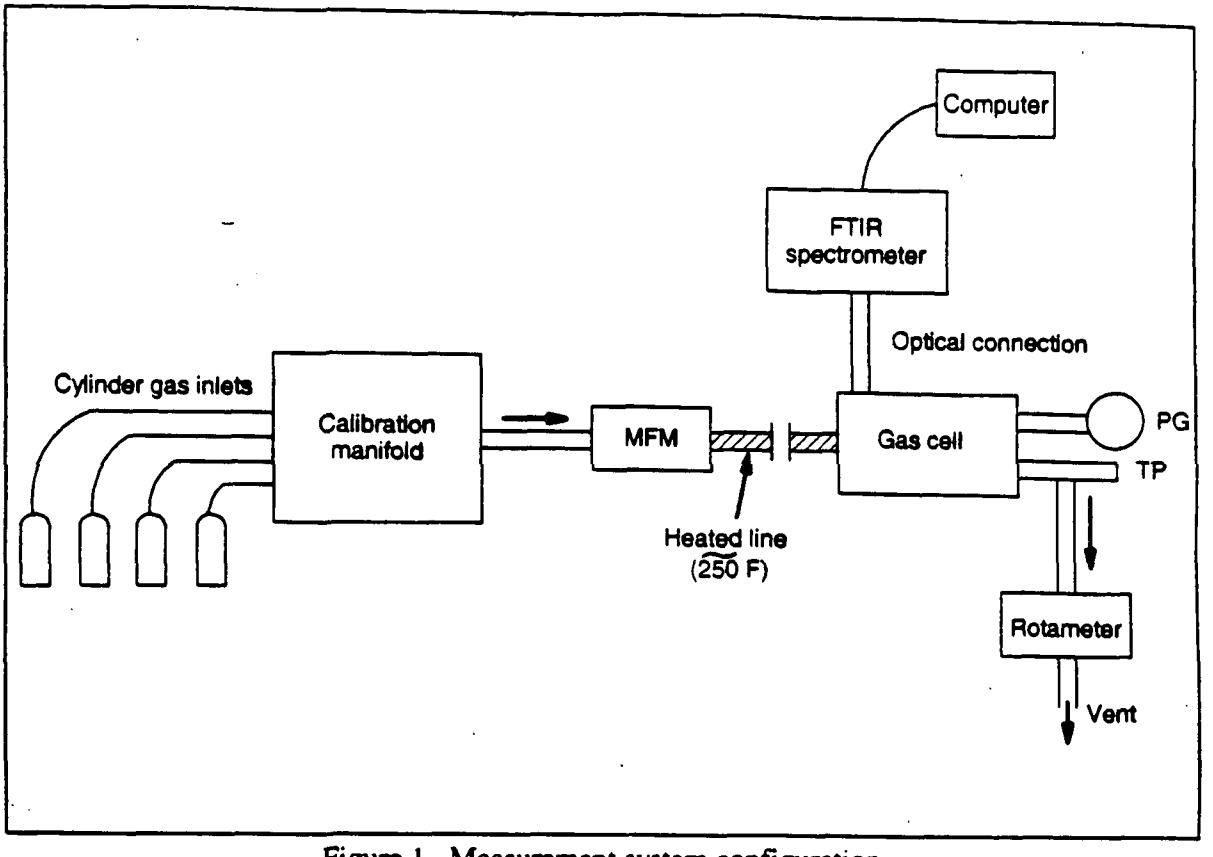

Figure 1. Measurement system configuration.
PG = pressure gauge; TP = temperature probe; MFM = mass flow meter.

resolution, gas standard concentration, sample cylinder identification, and sample flow rates for each measurement. Certificates of Analysis for all gas standards used in the project will be provided with the report.

The MCT detector will be cooled with liquid nitrogen and allowed to stabilize before measurements begin.

The cell will be filled with dry nitrogen and vented to ambient pressure. The pressure, in torr, will be recorded from the digital barocell readout. The cell will then be evacuated and leak checked under vacuum to verify that the vacuum pressure leak, or out-gassing, is no greater than 4 percent of the cell volume within a 1-minute period. The cell will then be filled with nitrogen and a background will be recorded as the cell is continuously purged with dry nitrogen. After the background spectrum is completed the cell will be evacuated and filled with the CTS gas. The CTS spectrum will be recorded as the cell is continuously purged with the CTS gas standard. The purge flow rates will be 0.5 to 1.0 LPM (liters per minute) as measured by the mass flow meter.

After the background and CTS measurements are completed the cell will be filled with a reference gas sample. The reference spectra will be recorded as the cell is continuously purged at 0.5 to 1.0 LPM with gas standard. The gas flow will be monitored with a mass flow meter before the gas enters a heated line, and with a rotameter after the gas exits the cell. The mass flow meter is calibrated for nitrogen in the range 0 to 5 LPM. The purpose of the heated line connection is to help maintain the gas temperature inside the cell. This may only require placing a heat wrap on the line where the gas enters the cell.

The gas temperature of each nitrogen background, CTS, and reference gas will be recorded as its spectrum is collected.

Several preliminary spectra will be recorded to verify that the in-cell gas concentration has stabilized. Stabilization usually occurs within 5 minutes after the gas is first introduced into the cell with the measurement system that will be used for this project. Duplicate (or more) reference spectra will be collected for each flowing sample. The second reference spectrum will be recorded at least 5 minutes after the first spectrum is completed while the continuous gas flow is maintained.

At least 100 scans will be co-added for all background, CTS , and reference interferograms.

A new background single beam spectrum will be recorded for each new compound or more frequently if the absorbance base line deviates by more than ±0.02 absorbance units from zero absorbance in the analytical region.

After reference spectrum measurements are completed each day, the background and CTS measurements will be repeated.

The CTS gas will be an ethylene gas standard, either 30 or 100ppm in nitrogen (±1 percent) or methane (about 50 ppm in nitrogen, ±1 percent). The methane CTS may be particularly suitable for the analytical region near 2900 cm^{-1}.

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

The following procedures will be followed to assure data quality.

3.1 Spectra Archiving

Two copies of all recorded spectra will be stored, one copy on the computer hard drive and a second copy on an external storage medium. The raw interferograms will be stored in addition to the absorbance spectra. After the data are collected, the absorbance spectra will be converted to Grams (Galactic Industries) spectral format. The spectra will be reviewed by a second analyst and all of the spectra, including the Grams versions will be provided with a report and documentation of the reference spectra.

3.2 CTS Spectra

The CTS spectra will provide a record of the instrument stability over the entire project. The precision of the CTS absorbance response will be analyzed and reported. All of the CTS spectra will be archived with the background and reference spectra.

3.3 Sample Pressure

The barocell gauge calibration will be NIST traceable and will be documented in the reference spectrum report. The ambient pressure will be recorded daily and all of the samples will be maintained near ambient pressure within the IR gas cell.

3.4 Sample Temperature

The IR gas cell is equipped with a heating jacket and temperature controllers. The temperature controller readings will be recorded whenever spectra are recorded. Additionally, the temperature of each gas sample will be measured as its spectrum is collected using a calibrated temperature probe and digital thermometer. The calibration record will be provided with the reference spectrum report. The gas sample will be preheated before entering the cell by passing through a heated 20 ft. Teflon line. The Teflon line temperature will be maintained at about 120°C. The line temperature controllers will be adjusted to keep the gas sample temperature near 120°C.

3.5 Spectra

MRI will record parameters used to collect each interferogram and to generate each absorbance spectrum. These parameters include: spectral resolution, number of background and sample scans, cell path length, and apodization. The documentation will be sufficient to allow an independent analyst to reproduce the reference absorbance spectra from the raw interferograms.

3.6 Cell Path Length

The cell path length for various settings is provided by the manufacturer's documentation. The path length will be verified by comparing ethylene CTS spectra to ethylene CTS spectra in the EPA spectral library.

3.7 Reporting

A report will be prepared that describes the reference spectrum procedures. The report will include documentation of the laboratory activities, copies of data sheets and check lists, and an electronic copy of all spectra and interferograms.

3.8 Documentation

Laboratory analysts will use three check lists to document data recording activities. The check lists are appended to this plan. The checklists: (1) record start up activities such as instrument settings, background and CTS spectra, (2) record reference spectra activities, and (3) record daily shut down procedures, including post-reference spectra background and CTS measurements.

In addition to the check lists the operator will record notations in a laboratory notebook. Copies of the check lists and note book pages will be provided with the reference spectrum report.

A draft of the reference spectrum report will be provided with the revised test reports. The reference spectrum report will then be finalized and submitted separately.

SHIPPING ORDER

MIDWEST RESEARCH INSTITUTE

425 Volker Boulevard, Kansas City, Missouri 64110

☐ TRANSFER ☐ RETURN FOR CREDIT

☐ EXCHANGE ☐ RETURN FOR REPAIR

144099

REFER TO THIS NO. IN ALL CORRESPONDENCE

TO Midwest Research Institute
5520 DILLARD ROAD
SUITE 100
Cary NC 27511-9232

DATE 5-10-99

VIA Best Way	☐ A.M. ☐ P.M. ☐ PREPAID ☐ COLLECT	INSURE: ☐ YES ☐ NO AMOUNT
REQUESTED BY Dave Upton	Charge No. 041 or Bill Recipient Acct. No.	REFERENCE

QUANTITY	DESCRIPTION OF MATERIAL	PRESENT LOCATI
1	Barocel pressure transducer	
1	Edwards Indicator	
1	H#21 Omega Indicator	
1	Type T thermocouple	

SIGNED Dave Upton

Victor

PACKING SLIP

MRI 11 (Rev. 8/92)

Attachment 1

Instrument Found Out of Tolerance

Instrument: 1570 indicator with W60041111 Capacitance Manometer

Manufacturer: Edwards

MRI Number: ~~N/A~~ EE 3U Y-6472 & Y-6473

Serial Number: 4237 & 80412159

Acceptance Criteria: MFG Accuracy

Date of calibration or test that revealed the out of tolerance condition: 5-6-99

Date of previous calibration: UNKNOWN

Responsible person: Tom Geyer (Must receive a copy of this report)

Tested/Calibrated by: Dave Upton Date: 5-6-99

Reviewed by: [illegible] Date: 5/6/1999

Unit read 7.9 to 9.7 torr high. Adjusted to mfg tolerance.

I hereby certify that I have received a copy of this report and will notify the appropriate people and take the appropriate actions necessary to determine what data may have been corrupted and what corrective actions are indicated.

Signed: [illegible] (Responsible person)

Date: 5/14/99

Attachment 1
Pressure Gauge Calibration Data Sheet

MRI No. ~~N/A~~ 4-6472 & 4-6473 Model No. / Type 1570 with W60041111 Serial No. 4237 S/N 80412159
Report No. ____

Noun barocel pressure indicator Ambient Temperature 73°F Ambient Humidity 41%

Applied Pressure	Initial Check	Final Check	Tolerance ±	Pass	Fail
500 TORR	507.9 TORR	500.5 TORR	1.2 TORR	✓	
600 TORR	608.3 TORR	600.2 TORR	1.4 TORR	✓	
700 TORR	708.6 TORR	699.9 TORR	1.5 TORR	✓	
750 TORR	758.7 TORR	749.8 TORR	1.6 TORR	✓	
800 TORR	808.8 TORR	799.7 TORR	1.7 TORR	✓	
900 TORR	909.2 TORR	899.4 TORR	1.9 TORR	✓	
1000 TORR	1009.7 TORR	999.3 TORR	2.1 TORR	✓	

Cumulative uncertainties of the standards used to perform this calibration did not exceed the requirements of MRI-0701 and ISO 10012-1.

Standards Used: MRI No.	Date Calibrated	Date Due Calibration
4-6413	1-22-99	1-22-00

Notes/Adjustments/Repairs/Modifications:
Transducer total accuracy specifications: 0.15% Rdg (accuracy) + 0.01% FS (repeatability) + 0.005% FS (zero temp coef) + 0.02% Rdg (span temp coef). Indicator total accuracy: 0.005% RDG + 2 counts. Total system accuracy above.
adjusted indicator zero + fullscale and transducer zero

Limitations for use:
Not calibrated below 500 TORR

Date Calibrated: 5-6-99 Date Due Recalibration: 5-6-00 Cal Interval: 12 month

Calibration Performed by: Dave Cotton Date: 5-6-99

Reviewed by: [signature] Date: 5/6/1999

Attachment
Calibration Data Sheet

MRI No.: — Model No./Type: TTSS-18G-12 Serial No.: T99130 Report No.: —

Noun: "T" Thermocouple Ambient Temperature: 74° F Ambient Humidity: 31%

Applied temperature	Initial check		Final check	Tolerance ±	Pass	Fail
°C	mv.	Calculated °C	Same	°C		
-25.0	-0.9237	-24.5	Same	1.0	✓	
0.0	0.0059	0.2	Same	1.0	✓	
100.0	4.2749	99.9	Same	1.0	✓	
150.0	6.7043	150.0	Same	1.1	✓	
200.0	9.2911	200.1	Same	1.5	✓	
300.0	14.8765	300.3	Same	2.2	✓	
400.0	20.8913	400.3	Same	3.0		

Cumulative uncertainties of the standards used to perform this calibration did not exceed the requirements of MRI-0701 and ISO 10012-1.

Standards used: MRI No.	Date calibrated	Date due calibration
Y-5835	12-4-98	12-4-99
012601	5-26-98	5-26-99
012600	4-23-99	4-23-00
012693	1-7-99	1-7-00

Notes/Adjustments/Repairs/Modifications:
N/A

Limitations for use:
N/A

Date Calibrated: 5-7-99 Date Due Recalibration: 5-7-00 Cal Interval: 1 Year

Calibration Performed by: Dave Upton Date: 5-7-99

Reviewed by: [signature] Date: 5-10-99

Attachment
Calibration Data Sheet

MRI No.: Y-6474 Model No./Type: HH21 Serial No.: T-206821 Report No.: —

Noun: Thermocouple Thermometer Ambient Temperature: 74° F Ambient Humidity: 28°

Applied temperature	Initial check	Final check	Tolerance ±	Pass	Fail
"T" -200°C	-200.4°C	Same	0.8°C	✓	
"T" -100°C	-100.3°C		0.7°C	✓	
"T" 0°C	-0.2°C		0.6°C	✓	
"T" 100°C	99.7°C		0.7°C	✓	
"T" 150°C	149.7°C		0.75°C	✓	
"T" 200°C	199.6°C		0.8°C	✓	
"T" 300°C	299.7°C		0.9°C	✓	
"T" 400°C	399.7°C	Same	1.0°C	✓	

Cumulative uncertainties of the standards used to perform this calibration did not exceed the requirements of MRI-0701 and ISO 10012-1.

Standards used: MRI No.	Date calibrated	Date due calibration
Y-5835	12-4-98	12-4-99

Notes/Adjustments/Repairs/Modifications:
NONE

Limitations for use:
Type T thermocouples only

Date Calibrated: 5-7-99 Date Due Recalibration: 5-7-00 Cal Interval: 1 Year

Calibration Performed by: Dan Upton Date: 5-7-99

Reviewed by: [signature] Date: 5-10-99

Scott Specialty Gases

Shipped From: 6141 EASTON ROAD, BLDG 1 PO BOX 310
PLUMSTEADVILLE PA 18949-0310
Phone: 215-766-8861 Fax: 215-766-2070

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH
SCOTT KLAMM
425 VOLKER BLVD

KANSAS CITY MO 64110

PROJECT #: 01-01788-006
PO#: 033452
ITEM #: 01021951 5AL
DATE: 3/31/98

CYLINDER #: ALM025384 ANALYTICAL ACCURACY: +/-5%
FILL PRESSURE: 2000 PSIG

BLEND TYPE : CERTIFIED WORKING STD

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
ETHYLENE	20.	PPM	20.0	PPM
NITROGEN		BALANCE		BALANCE

ANALYST: Genya Rogut
GENYA ROGUT

Scott Specialty Gases

Shipped From: 1750 EAST CLUB BLVD
DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34162-005
PO#: 038546
ITEM #: 12022751 1AL
DATE: 5/26/99

CYLINDER #: ALM046483
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/26/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
METHANE	50.	PPM	52.6	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: B.M. BECTON

Scott Specialty Gases

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DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34162-004
PO#: 038546
ITEM #: 12022232 1AL
DATE: 5/25/99

CYLINDER #: ALM045092
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/25/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
N-HEXANE	50.	PPM	49.6	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: L. TAYLOR

Scott Specialty Gases

Shipped From: 1750 EAST CLUB BLVD
DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34167-006
PO#: 038545
ITEM #: 1202M2034951AL
DATE: 5/27/99

CYLINDER #: ALM037409
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/27/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
3-METHYLPENTANE	50.	PPM	50.0	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: L TAYLOR

Scott Specialty Gases

Shipped From: 1750 EAST CLUB BLVD
DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34162-006
PO#: 038546
ITEM #: 1202P2000801AL
DATE: 5/27/99

CYLINDER #: ALM041358
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/27/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
N-PENTANE	50.	PPM	49.99	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: L. TAYLOR

Scott Specialty Gases

Shipped From: 1750 EAST CLUB BLVD
DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34167-005
PO#: 038545
ITEM #: 1202M2034941AL
DATE: 5/26/99

CYLINDER #: ALM054078
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/26/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
2-METHYL-2-PENTENE	50.	PPM	51.4	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: B.M. BECTON

Scott Specialty Gases

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DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34167-004
PO#: 038545
ITEM #: 1202M2034961AL
DATE: 5/26/99

CYLINDER #: ALM005876
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/26/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
2-METHYL 2-BUTENE	50.	PPM	50.04	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: L. TAYLOR

Scott Specialty Gases

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DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34167-003
PO#: 038545
ITEM #: 1202M2034971AL
DATE: 5/26/99

CYLINDER #: ALM017936
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/26/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
2-METHYL-1-PENTENE	50.	PPM	50.08	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: L. TAYLOR

Scott Specialty Gases

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DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34162-003
PO#: 038546
ITEM #: 1202N2007311AL
DATE: 5/26/99

CYLINDER #: AAL21337
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/26/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
N-HEPTANE	50.	PPM	49.97	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: L. TAYLOR

Scott Specialty Gases

Shipped From: 1750 EAST CLUB BLVD
DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34167-002
PO#: 038545
ITEM #: 1202P2019421AL
DATE: 5/27/99

CYLINDER #: ALM041929
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/27/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
1-PENTENE	50.	PPM	50.1	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: B.M. BECTON

Scott Specialty Gases

Shipped From: 1750 EAST CLUB BLVD
DURHAM NC 27704
Phone: 919-220-0803 Fax: 919-220-0808

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH

CROSSROADS CORP PARK
5520 DILLARD RD,SUITE 100
CARY NC 27511

PROJECT #: 12-34162-001
PO#: 038546
ITEM #: 12021152 1AL
DATE: 5/25/99

CYLINDER #: ALM020217
FILL PRESSURE: 2000 PSIG

ANALYTICAL ACCURACY: +-1%
PRODUCT EXPIRATION: 5/25/2000

BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
N-BUTANE	50.	PPM	51.3	PPM
NITROGEN		BALANCE		BALANCE

NIST TRACEABLE BY WEIGHT

ANALYST: B.M. Becton
B.M. BECTON

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7-7-99

OPERATOR: Geyer

			Initials
Check cell temperature			23.8 °C
Verify temperature using thermocouple probe and hand-held readout			JG
Purge cell with dry nitrogen and vent to ambient pressure			749.9 torr
Record ambient pressure in cell, (P_b)			JG
~~Vacuum~~ **Leak Check Procedure:** (positive Pressure)			
Evacuate cell to baseline pressure.			
Isolate cell (close cell inlet and cell outlet)			
Record time and baseline pressure (P_{min})	11:07:45 Time	775.4 P_{min}	JG
Leave cell isolated for one minute			
Record time and cell pressure (P_{max})	11:06:45 Time	775.7 P_{max}	JG
Calculate "leak rate" for 1 minute			
$\Delta P = P_{min} - P_{max}$		0.3 ΔP	JG
Calculate "leak rate" as percentage of total pressure			
$\% V_L = (\Delta P/P_b) * 100$		1.16% $\% V_L$	JG
$\lvert \% V_L \rvert$ should be < 4			

(of difference between P_{max} and $P_{ambient}$)

Record Nitrogen Background	
Purge cell with dry nitrogen	JG
Verify cell is as dry as previous background	JG
Record ambient pressure using cell Barocell gauge	749.9
Record nitrogen flow rate (about sampling flow rate)	0.8 LPM (751.5 torr)
Collect Background (AQBK) under continuous flow and ambient pressure	0.8 LPM JG
Record information in data book.	JG
Copy Background to C-drive and backup using batch file.	JG BK60707A

Record CTS Spectrum	
Record Cell path length setting	
Purge ~~Evacuate~~ Cell	10:03 JG
Fill Cell with CTS gas	11:23 JG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	1.0 LPM
Record cylinder ID Number	AB 18472
Record CTS gas cylinder identity and concentration	Ethylene in N_2 (104.4 ppm)
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	
Record Barytron pressure during collect	751.0
~~Record information on "Background and Calibrations" data sheet.~~ dr JG	
Verify that spectrum and interferogram were copied to directories.	JG
Record CTS Spectrum File Name	CTS0707A

Reviewed by: [signature]

Date: 7/7/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7/7/99

OPERATOR: T. Bayer

			Initials
Check cell temperature			
Verify temperature using thermocouple probe and hand-held readout			
Purge cell with dry nitrogen and vent to ambient pressure			
Record ambient pressure in cell, (P_b)			
Vacuum Leak Check Procedure:			
Evacuate cell to baseline pressure.			
Isolate cell (close cell inlet and cell outlet)			
Record time and baseline pressure (P_{min})			
Leave cell isolated for one minute	Time	P_{min}	
Record time and cell pressure (P_{max})			
Calculate "leak rate" for 1 minute	Time	P_{max}	
$\Delta P = P_{min} - P_{max}$			
Calculate "leak rate" as percentage of total pressure		ΔP	
$\% V_L = (\Delta P/P_b) * 100$			
$\lvert \% V_L \rvert$ should be < 4		$\% V_L$	

Record Nitrogen Background	
Purge cell with dry nitrogen	
Verify cell is as dry as previous background	
Record ambient pressure using cell Barocell gauge	
Record nitrogen flow rate (about sampling flow rate)	
Collect Background (**AQBK**) under continuous flow and ambient pressure	
Record information in data book.	
Copy Background to C-drive and backup using batch file.	BK60707A

Record CTS Spectrum	
Record Cell path length setting	10.03
Purge ~~Evacuate~~ Cell	
Fill Cell with **CTS gas**	
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	1.0 LPM
Record cylinder ID Number	ALM025384
Record CTS gas cylinder identity and concentration	20.0 ppm Ethylene in N
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	
Record Barytron pressure during collect	~~752.0~~ 751.8
~~Record information on "Background and Calibrations" data sheet~~	
Verify that spectrum and interferogram were copied to directories.	
Record CTS Spectrum File Name	CTS0707B

Reviewed by: [signature] Date: 7/7/99

Project No. 1951-12-13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7-8-99

OPERATOR: T. Geyer

			Initials
Check cell temperature			24.0 °C
Verify temperature using thermocouple probe and hand-held readout			J/c
Purge cell with dry nitrogen and vent to ambient pressure			
Record ambient pressure in cell, (P_b)			750.5 torr
~~Vacuum~~ Leak Check Procedure:			
Positive Pressure — Evacuate (Purge) cell to baseline (Maximum) pressure.			JG
Isolate cell (close cell inlet and cell outlet)			JG
Record time and baseline pressure (P_{min})	10:36:10 (Time)	779.0 (P_{min})	JG
Leave cell isolated for one minute			
Record time and cell pressure (P_{max})	10:35:10 (Time)	779.3 (P_{max})	JG
Calculate "leak rate" for 1 minute			
$\Delta P = P_{min} - P_{max}$		0.3 (ΔP)	JG
Calculate "leak rate" as percentage of total pressure			
$\% V_L = (\Delta P/P_b) * 100$		1.04 (% V_L)	JG
$\lvert \% V_L \rvert$ should be < 4			

% of $P_{max} - P_{ambient}$

Record Nitrogen Background

Purge cell with dry nitrogen	JG
Verify cell is as dry as previous background	JG
Record ambient pressure using cell Barocell gauge	750.5
Record nitrogen flow rate (about sampling flow rate)	0.47 LPM
Collect Background (AQBK) under continuous flow and ambient pressure	JG
Record information in data book.	JG
Copy Background to C-drive and backup using batch file.	JG

Record CTS Spectrum

Record Cell path length setting	
~~Evacuate~~ Cell	10.03
Purge ~~Fill~~ Cell with CTS gas	JG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	JG
Record cylinder ID Number	AL402584
Record CTS gas cylinder identity and concentration	20 ppm Ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	JG
Record Barytron pressure during collect	752.7 @ 0.90c
Record information on "Background and Calibrations" data sheet.	JG
Verify that spectrum and interferogram were copied to directories.	JG
Record CTS Spectrum File Name	CS0708A

Reviewed by: [signature]

Date: 7/8/99

Project No. 4951 - 12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7/9/99

OPERATOR: J. Geyer

			Initials
Check ~~cell~~ gas in cell temperature			
Verify temperature using thermocouple probe and hand-held readout			JB
Purge cell with dry nitrogen and vent to ambient pressure			126.6 °C
Record ambient pressure in cell, (P_b)			751.4 torr
~~Vacuum~~ Leak Check Procedure:			
Positive Pressure Purge ~~Evacuate~~ Isolate cell ~~to baseline~~ at ambient pressure.			
Isolate cell (close cell inlet and cell outlet)			JG
Record time and baseline pressure (P_{min})	11:08:30 Time	770.8 P_{min}	JG
Leave cell isolated for one minute			JG
Record time and cell pressure (P_{max}) Start	11:09:30 Time	771.5 P_{max}	JG
Calculate "leak rate" for 1 minute			
$\Delta P = P_{min} - P_{max}$		0.7 ΔP	JG
Calculate "leak rate" as percentage of total pressure			
$\% V_L = (\Delta P/P_b) * 100$		3.5 $\% V_L$	JG
$\lvert \% V_L \rvert$ should be < 4			

% of P_{max} - $P_{ambient}$

Record Nitrogen Background	
Purge cell with dry nitrogen	JG
Verify cell is as dry as previous background	JG
Record ambient pressure using cell Barocell gauge	JG
Record nitrogen flow rate (about sampling flow rate)	0.49 LPM
Collect Background (AQBK) under continuous flow and ambient pressure	JG
Record information in data book.	JG
Copy Background to C-drive and backup using batch file.	JG

Record CTS Spectrum	
Record Cell path length setting	10.03
Purge ~~Evacuate~~ Cell	JG
Fill Cell with CTS gas	JG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	JG
Record cylinder ID Number	ALM025384
Record CTS gas cylinder identity and concentration	20.0 ppm Ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	JG
Record Barytron pressure during collect	JG
Record information on "Background and Calibrations" data sheet.	JG
Verify that spectrum and interferogram were copied to directories.	
Record CTS Spectrum File Name	CTS0709A

Reviewed by: J. Geyer

Date: 7/9/99

Project No. 4951-12, 17

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7/12/99

OPERATOR: T. Gayes

			Initials
Check cell temperature			126.5°C TJG
Verify temperature using thermocouple probe and hand-held readout			TJG
Purge cell with dry nitrogen and vent to ambient pressure			753.3 torr
Record ambient pressure in cell, (P_b)			TJG
~~Vacuum~~ Leak Check Procedure:			
Pressure ~~Evacuate~~ Purge cell to ~~baseline~~ Maximum pressure.			TJG
Isolate cell (close cell inlet and cell outlet)			TJG
Record time and baseline pressure (P_{min})	8:52:30 (Time)	773.3 (P_{min})	TJG
Leave cell isolated for one minute			
Record time and cell pressure (P_{max})	8:51:30 (Time)	774.0 (P_{max})	TJG
Calculate "leak rate" for 1 minute			
$\Delta P = P_{min} - P_{max}$		0.70	TJG
Calculate "leak rate" as percentage of total pressure			
$\% V_L = (\Delta P/P_b) * 100$		3.4%	TJG
$\lvert \% V_L \rvert$ should be < 4		(ΔP) ($\% V_L$)	

% of $P_{max} - P_{initial}$

Record Nitrogen Background	
Purge cell with dry nitrogen	1.1 LPM
Verify cell is as dry as previous background	TJG
Record ambient pressure using cell Barocell gauge	753.3
Record nitrogen flow rate (about sampling flow rate)	1.1 LPM
Collect Background (AQBK) under continuous flow and ambient pressure	TJG
Record information in data book.	TJG
Copy Background to C-drive and backup using batch file.	TJG

Record CTS Spectrum	
Record Cell path length setting	10.03 TJG
~~Evacuate~~ Cell	—
Fill Cell with CTS gas	TJG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	TJG 1.17 LPM
Record cylinder ID Number	ALM025384
Record CTS gas cylinder identity and concentration	20.0 ppm Ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	TJG
Record Barytron pressure during collect	756.1
Record information on "Background and Calibrations" data sheet.	TJG
Verify that spectrum and interferogram were copied to directories.	TJG
Record CTS Spectrum File Name	C150712A

Reviewed by: Thomas J. Gayes

Date: 7/12/99

Project No 4951-12,13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7/13/99

OPERATOR: T. Geyer

			Initials
Check cell temperature			126.4 °C
Verify temperature using thermocouple probe and hand-held readout			752.9 torr
Purge cell with dry nitrogen and vent to ambient pressure			
Record ambient pressure in cell, (P_b)			752.9 torr
~~**Vacuum Leak Check Procedure:**~~ overpressure			
pressure ~~Evacuate~~ cell to baseline pressure.			
Isolate cell (close cell inlet and cell outlet)			
Record time and baseline pressure (P_{min})	10:42:03 Time	771.4 P_{min}	
Leave cell isolated for one minute			
Record time and cell pressure (P_{max})	10:41:03 Time	771.8 P_{max}	
Calculate "leak rate" for 1 minute			
$\Delta P = P_{min} - P_{max}$		0.4 ΔP	
Calculate "leak rate" as percentage of total pressure			
$\% V_L = (\Delta P/P_b) * 100$		2.1 $\% V_L$	
$\lvert \% V_L \rvert$ should be < 4			

% of $P_{max} - P_{ambient}$

Record Nitrogen Background	
Purge cell with dry nitrogen	
Verify cell is as dry as previous background	
Record ambient pressure using cell Barocell gauge	
Record nitrogen flow rate (about sampling flow rate)	
Collect Background (AQBK) under continuous flow and ambient pressure	
Record information in data book.	
Copy Background to C-drive and backup using batch file.	

Record CTS Spectrum	
Record Cell path length setting	
Ref ~~Evacuate~~ Cell	10.03 s/6
Fill Cell with CTS gas	
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	
Record cylinder ID Number	AL402538 4
Record CTS gas cylinder identity and concentration	20 ppm Ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	
Record Barytron pressure during collect	
Record information on "Background and Calibrations" data sheet.	
Verify that spectrum and interferogram were copied to directories.	
Record CTS Spectrum File Name	CTS0713A

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Date: 7/15/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7/15/99

OPERATOR: T. Geyer

			Initials
Check cell temperature			
Verify temperature using thermocouple probe and hand-held readout			TG
Purge cell with dry nitrogen and vent to ambient pressure			125.6
Record ambient pressure in cell, (P_b)			TG
Vacuum Leak Check Procedure:			754.8 torr
Purge ~~Evacuate~~ cell to baseline pressure. (1 min)			TG
Isolate cell (close cell inlet and cell outlet)			TG
Record time and baseline pressure (P_{min})	11:28:15 Time	774.4 P_{min}	TG
Leave cell isolated for one minute			TG
Record time and cell pressure (P_{max})	11:27:05 Time	774.8 P_{max}	TG
Calculate "leak rate" for 1 minute			
$\Delta P = P_{min} - P_{max}$		0.4 ΔP	TG
Calculate "leak rate" as percentage of total pressure			
$\% V_L = (\Delta P/P_b) * 100$		2.0% $\% V_L$	TG
$\lvert \% V_L \rvert$ should be < 4			

% of $P_{max} - P_{ambient}$

Record Nitrogen Background	
Purge cell with dry nitrogen	TG
Verify cell is as dry as previous background	TG
Record ambient pressure using cell Barocell gauge	754.8 TG
Record nitrogen flow rate (about sampling flow rate)	1.03 LPM
Collect Background (AQBK) under continuous flow and ambient pressure	TG
Record information in data book.	TG
Copy Background to C-drive and backup using batch file.	TG

Record CTS Spectrum	
Record Cell path length setting	10.03
Purge ~~Evacuate~~ Cell	TG
Fill Cell with CTS gas	TG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	TG
Record cylinder ID Number	AL-N-2538
Record CTS gas cylinder identity and concentration	20.0 ppm ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	TG
Record Barytron pressure during collect	757.1
Record information on "Background and Calibrations" data sheet.	TG
Verify that spectrum and interferogram were copied to directories.	TG
Record CTS Spectrum File Name	CT0715A

Reviewed by: TG

Date: 7/16/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Start up Procedure

DATE: 7/16/99

OPERATOR: T. Gayer

			Initials
Check cell temperature			
Verify temperature using thermocouple probe and hand-held readout			TG
Purge cell with dry nitrogen and vent to ambient pressure			125.3 °C
Record ambient pressure in cell, (P_b)			TG
Vacuum Leak Check Procedure:			755.2
Purge ~~Evacuate~~ cell to ~~baseline~~ P_{max} pressure.			TG
Isolate cell (close cell inlet and cell outlet)			TG
Record time and baseline pressure (P_{min})	9:52:40	778.5 torr	TG
Leave cell isolated for one minute	Time	P_{min}	TG
Record time and cell pressure (P_{max})	9:51:40	778.2	TG
Calculate "leak rate" for 1 minute	Time	P_{max}	
$\Delta P = P_{min} - P_{max}$		0.7	TG
Calculate "leak rate" as percentage of total pressure		ΔP	
$\% V_L = (\Delta P/P_b) * 100$		2.9	TG
$\lvert \% V_L \rvert$ should be < 4		$\% V_L$	
		% of P_{max} - $P_{ambient}$	

Record Nitrogen Background	
Purge cell with dry nitrogen	TG
Verify cell is as dry as previous background	TG
Record ambient pressure using cell Barocell gauge	TG 755.2
Record nitrogen flow rate (about sampling flow rate)	0.98 LPM
Collect Background (AQBK) under continuous flow and ambient pressure	TG
Record information in data book.	TG
Copy Background to C-drive and backup using batch file.	TG

Record CTS Spectrum	
Record Cell path length setting	10 m
Purge ~~Evacuate~~ Cell	TG
Fill Cell with CTS gas	TG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	ALM025384
Record cylinder ID Number	20.0 ppm
Record CTS gas cylinder identity and concentration	TG
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	757.1
Record Barytron pressure during collect	TG
Record information on "Background and Calibrations" data sheet.	TG
Verify that spectrum and interferogram were copied to directories.	CTS0716A
Record CTS Spectrum File Name	

Reviewed by: TG

Date: 7/16/99

FTIR DATA FORM

Background and Calibration Spectra

PROJECT NO. 4951-12 and 13

BAROMETRIC: 749.9 torr

SITE: NCO Laboratory

DATE: 7/7/99

OPERATOR: T. Geyer

TIME	FILE NAME	(Dial) PATH	NOTES	NUMBER SCANS	Resolution (cm-1)	Gas TEMP (F)	Gas PRESSURE	BKG	APOD
10:47	BKG0707A	10.03	N_2 through cell @ 0.8 LPM	500	1.0	23.8	751.5	—	NB/med
11:37	CTS0707A	"	104.4 ppm Ethylene @ 1.0 LPM	500	1.0	23.8	751.8	707A	"
12:45	CTS0707B	"	20.0 ppm Ethylene 1.0 LPM	500	1.0	23.8	751.8	707A	"
~~13:31~~	~~BKG0707B~~	~~5.07~~	~~N_2 @ 0.8 LPM~~	~~500~~	~~1.0~~	~~23.5~~	~~751.2~~	~~—~~	~~"~~
1345	CTS0707C	10.03	200 ppm Ethylene @ 1.0 LPM	500	1.0	23.5	751.7	707A	NB/med

Did not do

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FTIR DATA FORM

Background and Calibration Spectra

PROJECT NO. 4951-12 and 13

BAROMETRIC: 750.5

SITE: NCO Laboratory

DATE: 7/8/99

OPERATOR: T. Geyer

TIME	FILE NAME	(Dial) PATH	NOTES	NUMBER SCANS	Resolution (cm-1)	Gas TEMP (F)	Gas PRESSURE	BKG	APOD	
10:40	BKG0708A	10.03	N_2 through cell @ 0.47LPM after realign.	500	1.0	24.0	751.3	—	NB/mod.	
11:32	CTS0708A	10.03	20.0 ppm Ethylene @ 0.90 LPM	500	1.0	23.8	752.7	708A	"	
16:05	BKG0708B	10.03	N_2 @ 0.50 LPM GAIN is now 2R for same signal as cold cell (~70%). Did not realign after heating	500	1.0	126.5°C	749.9	—	NB/mod	Ambient =749.0
16:26	CTS0708B	10.03	Ethylene @ 0.97 LPM 20.0 ppm	500	1.0	126.4°C	750.8	708B	NB/mod	"

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FTIR DATA FORM

Background and Calibration Spectra

PROJECT NO. 4951-12 and 13 BAROMETRIC: 751.4

SITE: NCO Laboratory DATE: 7/9/99 OPERATOR: T. Geyer

TIME	FILE NAME	(Dial) PATH	NOTES	NUMBER SCANS	Resolution (cm-1)	Gas TEMP (F)	Gas PRESSURE	BKG	APOD
13:13	BKG0709A	10.03	N_2 @ 0.49 LPM	500	1.0	126.2	751.3	—	NB/Hamm
13:44	CTS0709A	10.03	20 ppm Ethylene @ 0.89 LPM	500	1.0	126.3	752.0	A	"
14:14	1960709A	10.03	52.6 ppm Methane in N_2 @ 1.09 LPM ALM046483	500	1.0	126.3	752.2	A	"
14:27	1960709B	10.03	52.6 ppm Methane in N_2 @ 1.10 LPM ALM046483	500	1.0	126.3	752.1	A	"
14:55	BKG0709B	10.03	N2 @ ~~0.45~~ 0.90 LPM	500	1.0	126.3	751.3 ~~750.4~~	✓	"
16:03	CTS0709B	10.03	20.0 ppm Ethylene @ 0.43 LPM	500	1.0	126.1	751.0	B	"
16:25	1960709~~B~~ C JG	10.03	52.6 ppm Methane in N_2 @ 1.11 LPM ALM046483	500	1.0	126.1	751.3	B	"
16:39	1960709D	10.03	52.6 ppm Methane @ 1.10 LPM	500	1.0	126.1	751.2	B	"

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FTIR DATA FORM

Background and Calibration Spectra

PROJECT NO. 4951-12 and 13 BAROMETRIC: 752.9

SITE: NCO Laboratory DATE: 7/13/99 OPERATOR: T. Gayer

TIME	FILE NAME	(Dial) PATH	NOTES	NUMBER SCANS	Resolution (cm-1)	Gas TEMP (F)	Gas PRESSURE	BKG	APOD
11:00	BKG0713A	10.03	N_2 through cell @ 0.95 LPM Higher purge today for drier BKG	500	1.0	125.3	754.9	–	N/B med
11:15	BKG0713B	10.03	Same conditions RaD becomes compartmentalized drier	500	1.0	125.4	754.9	–	"
11:54	BKG0713C	10.03	Same conditions w/ dryer cabinet 0.97 LPM	500	1.0	125.4	755.0	–	"
12:30	CTS0713A	10.03	20.0 ppm Ethylene in N_2 ALM#25384 @ 0.95 LPM	500	1.0	125.5	755.0	713 C	"
13:03	CTS0713B	10.03	" @ 0.92 LPM	500	1.0	125.6	754.8	"	"
13:22	1960713A	10.03	52.6 ppm Methane @ 1.02 LPM	500	1.0	125.5	755.1	713 C	"
14:53	CTS0713C	10.03	20.0 ppm Ethylene @ 0.99 LPM	500	1.0	125.4	759.7	713 C	"
15:08	1960713B	10.03	52.6 ppm Methane @ 1.12 LPM	500	1.0	125.4	755.0	713 C	"

Gain = 2

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FTIR DATA FORM

Background and Calibration Spectra

PROJECT NO. 4951-12 and 13 BAROMETRIC: 753.3

SITE: NCO Laboratory DATE: 7/12/99 OPERATOR: T. Geyer

TIME	FILE NAME	(Dial) PATH	NOTES	NUMBER SCANS	Resolution (cm-1)	Gas TEMP (F)	Gas PRESSURE	BKG	APOD	
10:40	BKG0712A	10.03	N_2 through cell @ 1.12 LPM	500	1.0	126.0	756.3	—	NB/Mod	GAIN = 2
10:55	CTS0712A	10.03	20.0 ppm Ethylene in N_2 @ 1.06 LPM	500	1.0	126.0	756.1	712 A	"	"
11:10	CTS0712B	10.03	20. ppm Ethylene @ 0.79 LPM (712A was ~10% low)	500	1.0	126.2	755.9	"	"	"
12:20	1960712A	10.03	52.6 ppm Methane in N_2 @ 0.99 LPM ALM0946983	500	1.0	126.1	755.9	712 A	"	"
12:45	BKG0712B	10.03	N_2 @ 1.11 LPM	500	1.0	126.1	756.0	—	"	"
14:40	CTS0712C	10.03	20.0 ppm Ethylene @ 1.10 LPM	500	1.0	126.3	755.6	712 B	"	"
14:56	1960712B	10.03	52.6 ppm Methane in N_2 @ 1.06 LPM	500	1.0	126.4	755.5	712 B	"	"

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FTIR DATA FORM

Background and Calibration Spectra

PROJECT NO. 4951-12 and 13 **BAROMETRIC:** 754.8 torr

SITE: NCO Laboratory **DATE:** 7/15/99 **OPERATOR:** T. Geyer

TIME	FILE NAME	(Dial) PATH	NOTES	NUMBER SCANS	Resolution (cm-1)	Gas TEMP (F)	Gas PRESSURE	BKG	APOD	
11:40	BKG0715A	10.03	N2 through cell @ 1.09 LPM	500	1.0	125.5	757.1 ~~754.8~~	–	N/B mod	Gain=2
12:15	CTS0715A	10.03	20.0 ppm Ethylene @ 1.07 LPM ALM025384	500	1.0	125.2	757.1	A	"	"
12:36	1960715A	10.03	52.6 ppm Methane @ 1.09 LPM	500	1.0	125.2	757.0	A	"	"
14:03	BKG0715B	10.03	N2 @ 1.00 LPM	500	1.0	125.1	756.6	–	"	"
16:00	CTS0715B	10.03	20.0 ppm Ethylene 0.97 LPM ALM025384	500	1.0	125.0	755.8	715B	"	"
16:20	1960715B	10.03	ALM 46483 @ 1.05 LPM Methane (52.6 ppm)	500	1.0	125.0 ~~1.05 LPM~~	755.8	715B	"	"

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FTIR DATA FORM

Background and Calibration Spectra

PROJECT NO. 4951-12 and 13 **BAROMETRIC:** 755.2

SITE: NCO Laboratory **DATE:** 7/16/99 **OPERATOR:** T. Gayer

TIME	FILE NAME	(Dial) PATH	NOTES	NUMBER SCANS	Resolution (cm-1)	Gas TEMP (°F)	Gas PRESSURE	BKG	APOD	
11:25	BK0716A	10.03	N_2 through cell @ 0.98 LPM	500	1.0	125.1°C	757.2	–	NB/Med	Gain = 2
12:39	CT0716A	10.03	20.0 ppm Ethylene @ 1.00 LPM	500	1.0	125.2	757.0	716A	"	"
12:51	1960716A	10.03	52.6 ppm Methane AL46 46483 @ 1.09 LPM	500	1.0	125.1	757.2	716A	"	"
15:15	CT50716B	10.03	20.0 ppm Ethylene APM025984 @ 1.0 LPM	500	1.0	125.2	756.1	716A	"	"
15:33	19607MA	10.03	52.6 ppm Methane @ 0.99 LPM	500	1.0	125.2°C	756.1	716A	"	"

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Project No. 4951-12 ,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7-9-99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	Hexane
Start Time (data collect)	15:24
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK60709B
Record CTS Spectrum File Name	CTS0709AB /19607[redacted]
Record Compound Name	Hexane
Record Cylinder Identification Number	ALM045092
Record Cylinder Concentration	49.6 ppm
Record Spectrum File Name	0950709A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.00 LPM
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	757.3 mmHg
Record sample flow rate through cell	1.002 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	15:34
	126.2°C

Reviewed by: [signature]

Date: 7/15/99

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7-9-99

OPERATOR: T. Gayer

	Initials
Reference Spectrum Sample	HEXANE 0950709B
Start Time 15:36	
Record Cell path length setting	10.03
Record Background Spectrum File Name	BKG0709B
Record CTS Spectrum File Name	CTS0709A,B 1960709 A-1
Record Compound Name	HEXANE
Record Cylinder Identification Number	ALM045092
Record Cylinder Concentration	49.6 ppm
Record Spectrum File Name	0950709B
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.09 LPM
Allow to equilibrate for 5 minutes	Continued from "A"
Record sample pressure in cell	751.5 ppm
Record sample flow rate through cell	1.09 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	15:46
	126.1 °C

Reviewed by: [signature]

Date: 7/15/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7-12-99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	~~13:11~~ 1-pentene
Start Time	13:14
Record Cell path length setting	10.03
Record Background Spectrum File Name	BKG0712 B
Record CTS Spectrum File Name	CTS0712 A-C, 1
Record Compound Name	1-Pentene
Record Cylinder Identification Number	ALM041929
Record Cylinder Concentration	50.1 ppm
Record Spectrum File Name	IPE0712A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.00 LPM
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	765.6
Record sample flow rate through cell	1.00 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	13:29
	126.0°C

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Date: 7/15/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/12/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	1-Pentene
Start Time	13:38
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK60712 B
Record CTS Spectrum File Name	CTS0712A-C 1960712
Record Compound Name	1-Pentene
Record Cylinder Identification Number	ALM41929
Record Cylinder Concentration	50.1 ppm
Record Spectrum File Name	1PE0712B
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.03 LPM
Allow to equilibrate for 5 minutes continued from A	TG
Record sample pressure in cell	755.6
Record sample flow rate through cell	1.03 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	13:48
	126.1°C

Reviewed by: TG

Date: 7/15/99

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7-12-99

OPERATOR: T Geyer

	Initials
Reference Spectrum Sample	~~[illegible]~~ n-heptane
Start Time	14:10
Record Cell path length setting	10.03
Record Background Spectrum File Name	BKG0712B
Record CTS Spectrum File Name	CTS0712A-C 19607[redacted]
Record Compound Name	n-heptane
Record Cylinder Identification Number	AAL 21337
Record Cylinder Concentration	49.97 ppm
Record Spectrum File Name	HSP0712A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.00 LPM
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	755.2 torr
Record sample flow rate through cell	1.00 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	14:20

Reviewed by: [signature]

Date: 7/15/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/12/99

OPERATOR: T. Gayle

	Initials
Reference Spectrum Sample	n-heptane
Start Time	14:20
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK0712 B
Record CTS Spectrum File Name	CTS0712 A-C, HP0712 A,
Record Compound Name	n-heptane
Record Cylinder Identification Number	AAL21337
Record Cylinder Concentration	49.97 ppm
Record Spectrum File Name	HEP0712 B
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.00 LPM
Allow to equilibrate for 5 minutes Continued from A	TG
Record sample pressure in cell	755.3
Record sample flow rate through cell	1.00 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	14:39

Reviewed by: T. Gayle

Date: 7/15/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/13/99

OPERATOR: T. Gayer

	Initials
Reference Spectrum Sample	2-methyl-2-pentene
Start Time	13:46
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK60713C
Record CTS Spectrum File Name	CTS0713A-C 1960[redacted]
Record Compound Name	2-methyl-2-pentene
Record Cylinder Identification Number	DLM54078
Record Cylinder Concentration	51.4 ppm
Record Spectrum File Name	2M2P713A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.00 LPM
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	754.9
Record sample flow rate through cell	1.00 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	14:55

Reviewed by: [signature]

Date: 7/15/99

Project No. 4961-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/13/99

OPERATOR: T. Geyer

		Initials
Reference Spectrum Sample		2-methyl-2-pentene
Start Time		13:54
Record Cell path length setting	10.03	
Record Background Spectrum File Name		BK0713C
Record CTS Spectrum File Name		CT0713AC (960713A,C
Record Compound Name		2-methyl-2 pentene
Record Cylinder Identification Number		ALM054078
Record Cylinder Concentration		51.4 ppm
Record Spectrum File Name		2M2P7138
Fill cell to ambient pressure with gas from cylinder standard		TG
Open cell outlet vent valve		TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate		TG
Allow to equilibrate for 5 minutes	Continued from A	TG
Record sample pressure in cell		754.9
Record sample flow rate through cell		0.98 LPM
Start spectrum collect program		TG
Record information in data book		TG
Copy Spectrum and Interferogram to backup directories		TG
End Time		14:05

Reviewed by: T. Geyer

Date: 7/15/99

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/13/99

OPERATOR: J. Geyer

	Initials
Reference Spectrum Sample	3-methylpentane
Start Time	14:21
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK0713C
Record CTS Spectrum File Name	CTS0713AC 19607[redacted]
Record Compound Name	3-methylpentane
Record Cylinder Identification Number	ALM037409
Record Cylinder Concentration	50.0 ppm
Record Spectrum File Name	3MP0713A
Fill cell to ambient pressure with gas from cylinder standard	JG
Open cell outlet vent valve	JG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.00 LPM
Allow to equilibrate for 5 minutes	JG
Record sample pressure in cell	754.6
Record sample flow rate through cell	1.00 LPM
Start spectrum collect program	JG
Record information in data book	JG
Copy Spectrum and Interferogram to backup directories	JG
End Time	14:30

Reviewed by: J. Geyer

Date: 7/15/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/13/99

OPERATOR: T. Gayer

	Initials
Reference Spectrum Sample	3-methylpentane
Start Time	14:34
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK60713C
Record CTS Spectrum File Name	CTS0713A-C 19600713A
Record Compound Name	3-methylpentane
Record Cylinder Identification Number	ALM037409
Record Cylinder Concentration	50.0 ppm
Record Spectrum File Name	3MP0713B
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	0.98 LPM
Allow to equilibrate for 5 minutes Continued for A	TG
Record sample pressure in cell	754.6 torr
Record sample flow rate through cell	0.96 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	1444

Reviewed by: TG

Date: 7/15/99

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/15/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	(2,2,4-trimethylpentane) isooctane
Start Time (start purge)	12:52
Record Cell path length setting	10.03
Record Background Spectrum File Name	BKG0715A
Record CTS Spectrum File Name	CTS0715A,B 19607[redacted]A
Record Compound Name	isooctane
Record Cylinder Identification Number	~~AC19[illegible]~~ ALM[redacted]
Record Cylinder Concentration	50.3 ppm
Record Spectrum File Name	1650715A
Fill cell to ambient pressure with gas from cylinder standard	1/6
Open cell outlet vent valve	1/6
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.06 LPM
Allow to equilibrate for 5 minutes	1/6
Record sample pressure in cell	757.0
Record sample flow rate through cell	1.02 LPM
Start spectrum collect program	1/6
Record information in data book	1/6
Copy Spectrum and Interferogram to backup directories	1/6
End Time	13:08
	125.2 °C

Reviewed by: [signature]

Date: 7/16/99

Project No. 7951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/15/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	Isooctane
Start Time	1310
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK60715A
Record CTS Spectrum File Name	CTS0715A,B 1960715A,B
Record Compound Name	Isooctane
Record Cylinder Identification Number	AL0044698
Record Cylinder Concentration	50.3 ppm
Record Spectrum File Name	1650715A
Fill cell to ambient pressure with gas from cylinder standard continued from A	7/6
Open cell outlet vent valve	7/6
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	0.98
Allow to equilibrate for 5 minutes	7/6
Record sample pressure in cell	756.9
Record sample flow rate through cell	0.98
Start spectrum collect program	7/6
Record information in data book	7/6
Copy Spectrum and Interferogram to backup directories	7/6
End Time	

Reviewed by: [signature]

Date: 7/16/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/13/99

OPERATOR: T. Guest

	Initials
Reference Spectrum Sample	n-Pentane
Start Time	14:30
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK607158
Record CTS Spectrum File Name	CTS0715A,B 960715A
Record Compound Name	n-Pentane
Record Cylinder Identification Number	AL-0241358
Record Cylinder Concentration	49.99
Record Spectrum File Name	Pen0715A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	TG 1.07 LPM
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	756.4
Record sample flow rate through cell	1.09 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	14:48
	124.9 °C

Reviewed by: [signature]

Date: 7/16/99

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/15/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	n-Butane
Start Time	15:06
Record Cell path length setting	10.03
Record Background Spectrum File Name	BKG0715B
Record CTS Spectrum File Name	CTS0715A,B 190715A
Record Compound Name	Butane
Record Cylinder Identification Number	ALM020217
Record Cylinder Concentration	51.3 ppm
Record Spectrum File Name	BuT0715A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.06 LPM
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	756.1 torr
Record sample flow rate through cell	1.00 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	TG 15:23
	124.9°C

Reviewed by: 7/16 [signature]

Date: 7/16/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/15/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample continued from "A"	Butane
Start Time	10:07
Record Cell path length setting	10.03
Record Background Spectrum File Name	712B
Record CTS Spectrum File Name	CT)0712A,B 1960[redacted]
Record Compound Name	Butane
Record Cylinder Identification Number	AL0020217
Record Cylinder Concentration	51.3 ppm
Record Spectrum File Name	BUT0715A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	1.02
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	756.1
Record sample flow rate through cell	1.02
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	15:40
	124.9°C

Reviewed by: TG

Date: 7/16/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/16/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	2-methyl-2-butene
Start Time	13:08
Record Cell path length setting	10.03
Record Background Spectrum File Name	BK960716A
Record CTS Spectrum File Name	CTS0716A,B 1960716
Record Compound Name	2M
Record Cylinder Identification Number	AL40058716
Record Cylinder Concentration	50.04 ppm
Record Spectrum File Name	2M20716A
Fill cell to ambient pressure with gas from cylinder standard	TG
Open cell outlet vent valve	TG
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	TG
Allow to equilibrate for 5 minutes	TG
Record sample pressure in cell	756.8
Record sample flow rate through cell	1.00 LPM
Start spectrum collect program	TG
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	TG
End Time	13:30
	125.2°C

Reviewed by: TG

Date: 7/16/99

Project No. 4451-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/16/99

OPERATOR: T. Gayer

		Initials
Reference Spectrum Sample		2-methyl-2-butene
Start Time	13:30	10-03
Record Cell path length setting		
Record Background Spectrum File Name		BK60716A
Record CTS Spectrum File Name		CTS0716A,B MG0716A,B
Record Compound Name		2/6
Record Cylinder Identification Number		ALM005576
Record Cylinder Concentration		50.04 ppm
Record Spectrum File Name		2M20716B
Fill cell to ambient pressure with gas from cylinder standard		2/6
Open cell outlet vent valve		2/6
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate		2/6
Allow to equilibrate for 5 minutes	Continued from "A"	2/6
Record sample pressure in cell		756.6 Torr
Record sample flow rate through cell		0.95 LPM
Start spectrum collect program		2/6
Record information in data book		2/6
Copy Spectrum and Interferogram to backup directories		2/6
End Time		1540

Reviewed by: [signature]

Date: 7/16/99

Project No. _____

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: _____ OPERATOR: _____

	Initials
Reference Spectrum Sample	
Start Time	_____
Record Cell path length setting	_____
Record Background Spectrum File Name	_____
Record CTS Spectrum File Name	_____
Record Compound Name	_____
Record Cylinder Identification Number	_____
Record Cylinder Concentration	_____
Record Spectrum File Name	_____
Fill cell to ambient pressure with gas from cylinder standard	_____
Open cell outlet vent valve	_____
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	_____
Allow to equilibrate for 5 minutes	_____
Record sample pressure in cell	_____
Record sample flow rate through cell	_____
Start spectrum collect program	_____
Record information in data book	_____
Copy Spectrum and Interferogram to backup directories	_____
End Time	_____

Reviewed by: _____ Date: _____

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/16/99

OPERATOR: T Geyer

	Initials
Reference Spectrum Sample	2-methyl-1-pentene
Start Time	1349
Record Cell path length setting	10.03
Record Background Spectrum File Name	2K60716A
Record CTS Spectrum File Name	CTS0716A 1960
Record Compound Name	7/6
Record Cylinder Identification Number	ALM017936
Record Cylinder Concentration	50.08 ppm
Record Spectrum File Name	2M1P716A
Fill cell to ambient pressure with gas from cylinder standard	7/6
Open cell outlet vent valve	7/6
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	7/6 1.05LPM
Allow to equilibrate for 5 minutes	7/6
Record sample pressure in cell	756.4
Record sample flow rate through cell	1.06 LPM
Start spectrum collect program	7/6
Record information in data book	
Copy Spectrum and Interferogram to backup directories	
End Time	

Reviewed by: _____ Date: _____

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/16/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	2-methyl-1-pentene
Start Time (continued from "A")	10:07
Record Cell path length setting	716A
Record Background Spectrum File Name	CTS716A 1767/6A
Record CTS Spectrum File Name	
Record Compound Name	
Record Cylinder Identification Number	ALM017936
Record Cylinder Concentration	50.08
Record Spectrum File Name	2M1P716B
Fill cell to ambient pressure with gas from cylinder standard	ok
Open cell outlet vent valve	ok
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	ok
Allow to equilibrate for 5 minutes	ok
Record sample pressure in cell	756.3
Record sample flow rate through cell	0.97 LPM
Start spectrum collect program	ok
Record information in data book	ok
Copy Spectrum and Interferogram to backup directories	ok
End Time	1440

Reviewed by: _____ Date: _____

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/16/99

OPERATOR: T. Geyer

	Initials
Reference Spectrum Sample	n-heptane
Start Time	1425
Record Cell path length setting	10.03
Record Background Spectrum File Name	716 A
Record CTS Spectrum File Name	CTS0716A 19600716A
Record Compound Name	N/A
Record Cylinder Identification Number	ARL21337
Record Cylinder Concentration	49.97 ppm
Record Spectrum File Name	HEP0716A
Fill cell to ambient pressure with gas from cylinder standard	N/A
Open cell outlet vent valve	N/A
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	0.97 LPM
Allow to equilibrate for 5 minutes	N/A
Record sample pressure in cell	N/A 756.1
Record sample flow rate through cell	0.95 LPM
Start spectrum collect program	N/A
Record information in data book	TG
Copy Spectrum and Interferogram to backup directories	N/A
End Time	1450

Reviewed by: _____ Date: _____

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
FTIR Reference Spectrum Checklist

DATE: 7/16/99

OPERATOR: T. Gayer

	Initials
Reference Spectrum Sample	n-heptane
Start Time continued from "A"	—
Record Cell path length setting	10.03
Record Background Spectrum File Name	716A
Record CTS Spectrum File Name	CTS0716A 1960716A
Record Compound Name	—
Record Cylinder Identification Number	AAL21337
Record Cylinder Concentration	49.97
Record Spectrum File Name	HG.P0716A
Fill cell to ambient pressure with gas from cylinder standard	7/16
Open cell outlet vent valve	7/16
Adjust sample flow through cell to 0.5 to 1 LPM. Record flow rate	7/16
Allow to equilibrate for 5 minutes	7/16
Record sample pressure in cell	756.1
Record sample flow rate through cell	0.96 LPM
Start spectrum collect program	7/16
Record information in data book	7/16
Copy Spectrum and Interferogram to backup directories	7/16
End Time	15:00

Reviewed by: _____ Date: _____

FTIR DATA FORM

Sampling Data

PROJECT NO. 4951-12 and 13

BAROMETRIC: 751.4

SITE: NCO Laboratory

DATE: 7/9/99

OPERATOR: T. Bayer

Time	File Name	(Dial) Path	NOTES	Scans	Resolution (cm-1)	Gas Temp (°C)	Flow Rate	Gas Pressure	BKG
15:24	0950709A	10.03	Hexane (49.6 ppm in N_2) @ 1.0 LPM ALM045092	500	1.0	126.2 ~~751.3~~	1.0 LPM	torr 751.3	709 B
15:36	0950709~~A~~ B	10.03	Hexane, 49.6 ppm in N_2 ALM045092	500	1.0	126.1	1.09 LPM	751.5	709 B

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07-07-99

Reviewed by [signature]
Date 7/9/99

FTIR DATA FORM

Sampling Data

PROJECT NO. 4951-12 and 13

BAROMETRIC: 753.1

SITE: NCO Laboratory

DATE: 7/12/99

OPERATOR: T. Geyer

Time	File Name	(Dial) Path	NOTES	Scans	Resolution (cm-1)	Gas Temp (°C)	Flow Rate	Gas Pressure	BKG
13:14	1PE0702A	10.03	50.1 ppm 1-Pentane ALMP 419 29 ~~[illegible]~~	500	1.0	126.0	1.00 LPM	755.6	B
13:38	1PE0712B	10.03	50.1 ppm 1-Pentene	500	1.0	126.1	1.03 LPM	755.6	B
14:10	HEP0712A	10.03	49.97 ppm n-heptane AAL 21337	500	1.0	126.2	1.00 LPM	755.2	B
14:20	HEP0712B	10.03	"	500	1.0	126.4	1.00 LPM	755.3	B

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Date 7/12/99

FTIR DATA FORM

Sampling Data

PROJECT NO. 4951-12 and 13

BAROMETRIC: 752.9

SITE: NCO Laboratory

DATE: 7/13/99

OPERATOR: T. Geyer

Time	File Name	(Dial) Path	NOTES	Scans	Resolution (cm-1)	Gas Temp (°C)	Flow Rate	Gas Pressure	BKG
13:46	2M2P713A	10.03	2-methyl-2-pentene ALMØ 54078 51.4 ppm	500	1.0	125.6	1.00 LPM	754.9	713C
13:56	2M2P713B	10.03	"	500	1.0	125.6	0.98 LPM	754.9	713C
14:21	3MP0713A	10.03	3-Methylpentane (50.0 ppm) ALMØ 37409	500	1.0	125.5	1.00 LPM	754.6	713C
14:34	3MPØ713B	10.03	"	500	1.0	125.5	0.98 LPM	754.6	713C

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Reviewed by [signature]
Date 7/13/99

FTIR DATA FORM

Sampling Data

PROJECT NO. 4951-12 and 13

BAROMETRIC: 754.8 torr

SITE: NCO Laboratory

DATE: 7/15/99

OPERATOR: T. Geyer

Time	File Name	(Dial) Path	NOTES	Scans	Resolution (cm-1)	Gas Temp (°C)	Flow Rate	Gas Pressure	BKG
12:58	1650715A	10.03	Iso octane 50.3 ppm in N_2 ALM044693	500	1.0	125.3	1.02 LPM	756.9	715A
13:13 ~~13:10~~	1650715B	10.03	Isooctane @ 0.98 LPM	500	1.0	125.2°c	0.98 LPM	756.9	715A
14:37	PEN0715A	10.03	n-Pentane @ 1.09 LPM	500	1.0	124.9°c	1.09	756.2	715 B
14:48	PEN0715B	10.03	n-Pentane @ ALM0241358	500	1.0	124.9	1.10	756.5	715 B
15:13 ~~15:08~~	But0715A	10.03	Butane 51.3 ppm ALM020217	500	1.0	124.8	1.00 LPM	756.1	715 B
15:30	BUT0715B	10.03	51.3 ppm Butane	500	1.0	124.9	1.02 LPM	756.0	715 B

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07-07-99

Reviewed by AGV
Date 7/14/99

FTIR DATA FORM

Sampling Data

PROJECT NO. 4951-12 and 13 **BAROMETRIC:** 755.2

SITE: NCO Laboratory **DATE:** 7/16/99 **OPERATOR:** T. Boyer

Time	File Name	(Dial) Path	NOTES	Scans	Resolution (cm-1)	Gas Temp (°C)	Flow Rate	Gas Pressure	BKG
13:16	~~2M2~~ 2M2 0716A	10.03	2-methyl-2-butene ALM00 5876, 60.04 ppm	500	1.0	125.2	1.00 LPM	756.8	716A
1330	2M2 0716B 2M2 0716C	10.03	2-methyl-2-butene	500	1.0	125.2	0.95 LPM	756.6	716A
1352	2M1P716A	10.03	2-methyl-1-pentene ALM01936 50.08 ppm	500	1.0	125.2	1.00 LPM	756.4	716A
1410	2M1P716B	10.03	2-methyl-1-pentene	500	1.0	125.1	0.97	756.3	716A
1440	HEP0716A	10.03	n-heptane 49.97 ppm AAL21337 {re-measure because 1/2 CTS was low}	500	1.0	125.3	0.95 LPM	756.1	716A
1450	HEP0716B	10.03	n-heptane	500	1.0	125.3	0.96 LPM	756.1	716A

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07-07-99

Reviewed by T. Boyer
Date 7/16/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Shut Down Procedure

DATE: 9-7-99

OPERATOR: T. Geyer

	Initials
Purge sample from cell using ambient air or nitrogen	
Record Nitrogen Background	
Purge cell with dry nitrogen	JG
Verify cell is as dry as previous background	
Record ambient pressure using cell Barocell gauge	
Record nitrogen flow rate (about sampling flow rate)	
Collect Background (AQBK) under continuous flow and ambient pressure	
Record information in data book.	
Copy Background to C-drive and backup using batch file.	
Record CTS Spectrum	
Evacuate Cell	
Fill Cell with CTS gas	
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	
Record cylinder ID Number	
Record CTS gas cylinder identity and concentration	
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	
Record Barytron pressure during collect	
Record information on "Background and Calibrations" data sheet.	
Verify that spectrum and interferogram were copied to directories.	
Record CTS Spectrum File Name	CTS0707e
Close cylinders	JG
Evacuate or Purge CTS from cell using nitrogen	JG
Leave cell under low nitrogen purge or under vacuum	JG
Fill MCT detector dewar	JG

Reviewed by: J. Geyer

Date: 7/7/99

Project No. 4951.12.13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Shut Down Procedure

DATE: 7/8/99

OPERATOR: T. Geyer

	Initials
Cell has been heated for ~ 4 hrs. and is still stabilizing. This Background & CTS are for stability to tomorrow's measurements	
Purge sample from cell using ambient air or nitrogen	
Record Nitrogen Background	
Purge cell with dry nitrogen	
Verify cell is as dry as previous background	no
Record ambient pressure using cell Barocell gauge	749.0
Record nitrogen flow rate (about sampling flow rate)	0.50 LPM
Collect Background (AQBK) under continuous flow and ambient pressure	
Record information in data book.	
Copy Background to C-drive and backup using batch file.	
Record CTS Spectrum	
Purge ~~Evacuate~~ Cell	
Fill Cell with CTS gas	
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	0.99 LPM
Record cylinder ID Number	ALM25384
Record CTS gas cylinder identity and concentration	20 ppm Ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	
Record Barytron pressure during collect	751.0 torr
Record information on "Background and Calibrations" data sheet.	
Verify that spectrum and interferogram were copied to directories.	
Record CTS Spectrum File Name	CTS0708B
Close cylinders	
Evacuate or Purge CTS from cell using nitrogen	
Leave cell under low nitrogen purge or under vacuum	
Fill MCT detector dewar	

Reviewed by: [signature]

Date: 7/8/99

Project No. 4951-12-5 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Shut Down Procedure

DATE: 7/9/99

OPERATOR: T. Geyer

	Initials
Purge sample from cell using ambient air or nitrogen	
Record Nitrogen Background	
Purge cell with dry nitrogen	JG
Verify cell is as dry as previous background	JG
Record ambient pressure using cell Barocell gauge	749.1
Record nitrogen flow rate (about sampling flow rate)	
Collect Background (AQBK) under continuous flow and ambient pressure 709 B	
Record information in data book.	JG
Copy Background to C-drive and backup using batch file.	JG
Record CTS Spectrum	
Purge Evacuate Cell	JG
Fill Cell with CTS gas	JG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	JG
Record cylinder ID Number	ALM025384
Record CTS gas cylinder identity and concentration Also methane - see data sheet. JG	20 ppm ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	JG
Record Barytron pressure during collect	JG 751.1
Record information on "Background and Calibrations" data sheet.	JG
Verify that spectrum and interferogram were copied to directories.	JG
Record CTS Spectrum File Name	CTS 0709B
Close cylinders	JG
Evacuate or Purge CTS from cell using nitrogen	JG
Leave cell under low nitrogen purge or under vacuum	JG
Fill MCT detector dewar	–

Reviewed by: [signature]

Date: 7/12/99

Project No. 4951-12-13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Shut Down Procedure

DATE: 7/12/99

OPERATOR: T. Geyer

	Initials
Purge sample from cell using ambient air or nitrogen	
Record Nitrogen Background	
Purge cell with dry nitrogen	
Verify cell is as dry as previous background	
Record ambient pressure using cell Barocell gauge	753.1
Record nitrogen flow rate (about sampling flow rate)	
Collect Background (AQBK) under continuous flow and ambient pressure	
Record information in data book.	
Copy Background to C-drive and backup using batch file.	

used Background "D"

Record CTS Spectrum	
~~Evacuate Cell~~	
Fill Cell with CTS gas	
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	1.10 LPM
Record cylinder ID Number	ALM 25384
Record CTS gas cylinder identity and concentration	20.0 ppm ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	
Record Barytron pressure during collect	755.3
Record information on "Background and Calibrations" data sheet.	
Verify that spectrum and interferogram were copied to directories.	
Record CTS Spectrum File Name	CTS0712C
Close cylinders	
Evacuate or Purge CTS from cell using nitrogen	
Leave cell under low nitrogen purge or under vacuum	
Fill MCT detector dewar	

Reviewed by: T. Geyer

Date: 7/15/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Shut Down Procedure

DATE: 7/13/99

OPERATOR: T. Geyer

		Initials
Purge sample from cell using ambient air or nitrogen		
Record Nitrogen Background		
Purge cell with dry nitrogen		
Verify cell is as dry as previous background		
Record ambient pressure using cell Barocell gauge		
Record nitrogen flow rate (about sampling flow rate)		
Collect Background (AQBK) under continuous flow and ambient pressure	wd BKG0713C	
Record information in data book.		
Copy Background to C-drive and backup using batch file.		
Record CTS Spectrum		
Evacuate Cell		
Fill Cell with CTS gas		
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)		
Record cylinder ID Number		ALM0 25384
Record CTS gas cylinder identity and concentration		20 ppm Ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.		
Record Barytron pressure during collect		754.7
Record information on "Background and Calibrations" data sheet.		
Verify that spectrum and interferogram were copied to directories.		
Record CTS Spectrum File Name		CTS0713C
Close cylinders		
Evacuate or Purge CTS from cell using nitrogen		
Leave cell under low nitrogen purge or under vacuum		
Fill MCT detector dewar		

Reviewed by: [illegible]

Date: 7/15/99

Project No. 4951-12,13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Shut Down Procedure

DATE: 7/15/99

OPERATOR: T. Geyer

	Initials
Purge sample from cell using ambient air or nitrogen	
Record Nitrogen Background	
Purge cell with dry nitrogen	
Verify cell is as dry as previous background	
Record ambient pressure using cell Barocell gauge	
Record nitrogen flow rate (about sampling flow rate)	
Collect Background (AQBK) under continuous flow and ambient pressure	
Record information in data book.	
Copy Background to C-drive and backup using batch file.	
Record CTS Spectrum	
Evacuate Cell	TG
Fill Cell with CTS gas	TG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	TG
Record cylinder ID Number	ALM025384
Record CTS gas cylinder identity and concentration	20 ppm ethylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	TG
Record Barytron pressure during collect	TG
Record information on "Background and Calibrations" data sheet.	TG
Verify that spectrum and interferogram were copied to directories.	TG
Record CTS Spectrum File Name	TG CTS07150
Close cylinders	TG
Evacuate or Purge CTS from cell using nitrogen	TG
Leave cell under low nitrogen purge or under vacuum	TG
Fill MCT detector dewar	—

used BKG "9"

Reviewed by: TG

Date: 7/16/99

Project No. 4951-12, 13

MIDWEST RESEARCH INSTITUTE
DAILY CHECKLIST
Shut Down Procedure

DATE: 7/16/99

OPERATOR: T. Geyer

	Initials
Purge sample from cell using ambient air or nitrogen	TG
Record Nitrogen Background	
Purge cell with dry nitrogen	
Verify cell is as dry as previous background	
Record ambient pressure using cell Barocell gauge	
Record nitrogen flow rate (about sampling flow rate) using "BK0716A"	
Collect Background (AQBK) under continuous flow and ambient pressure	
Record information in data book.	
Copy Background to C-drive and backup using batch file.	
Record CTS Spectrum	
~~Evacuate~~ purge Cell	TG
Fill Cell with CTS gas	TG
Open cell outlet and purge cell with CTS at sampling rate (1 to 5 LPM)	TG
Record cylinder ID Number	ALM025384
Record CTS gas cylinder identity and concentration	20.0 ppm Thylene
Record and copy spectrum and interferogram to C-drive and back up using CTS batch file.	TG
Record Barytron pressure during collect	TG
Record information on "Background and Calibrations" data sheet.	TG
Verify that spectrum and interferogram were copied to directories.	TG
Record CTS Spectrum File Name	CTS0716B
Close cylinders	TG
Evacuate or Purge CTS from cell using nitrogen	TG
Leave cell under low nitrogen purge or under vacuum	TG
Fill MCT detector dewar	—

Reviewed by: T. Geyer

Date: 7/16/99

APPENDIX C

EQUIPMENT CALIBRATION CERTIFICATES

Equipment Description

THC 1 -- JUM Model VE-7
THC 2 -- Ratfisch Model RS-55CA
Data Logger -- Labtech Notebook
Computer -- Winbook 486-100
Printer -- Panasonic Model KXP1180
Cal Gas Dilution System -- Environics Model 2020

C-1 CALIBRATION GAS CERTIFICATES

Scott Specialty Gases

Shipped From: 6141 EASTON ROAD PO BOX 310
PLUMSTEADVILLE PA 18949-0310
Phone: 215-766-8861 Fax: 215-766-2070

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH
DAVE ALBURTY, X1525
425 VOLKER BLVD

KANSAS CITY MO 64110

PROJECT #: 01-89796-005
PO#: 029872
ITEM #: 01023912 4AL
DATE: 5/13/97

CYLINDER #: ALM057730 ANALYTICAL ACCURACY: +/- 2%
FILL PRESSURE: 2000 PSIG
BLEND TYPE : CERTIFIED MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
TOLUENE	120.	PPM	121.	PPM
AIR		BALANCE		BALANCE

CERTIFIED

ANALYST: G. Rogut
GENYA ROGUT

Scott Specialty Gases

Shipped From: 1290 COMBERMERE STREET
TROY MI 48083
Phone: 248-589-2950
Fax: 248-589-2134

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH
MELISSA TUCKER; # 026075
425 VOLKER BLVD

KANSAS CITY MO 64110

PROJECT #: 05-97268-00
PO#: 026075
ITEM #: 05023822 4A
DATE: 6/03/96

CYLINDER #: A7853
FILL PRESSURE: 2000 PSI

ANALYTICAL ACCURACY: +/- 2%
PRODUCT EXPIRATION: 6/03/1997

BLEND TYPE : CERTIFIED MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
SULFUR HEXAFLUORIDE	4.	PPM	4.01	PPM
NITROGEN		BALANCE		BALANCE

CERTIFIED MASTER GAS

ANALYST: Sarah Rister

Scott Specialty Gases

Shipped From: 6141 EASTON ROAD PO BOX 310
PLUMSTEADVILLE PA 18949-0310
Phone: 215-766-8861 Fax: 215-766-2070

CERTIFICATE OF ANALYSIS

MIDWEST RESEARCH
TOM GEYER
425 VOLKER BLVD

KANSAS CITY MO 64110

PROJECT #: 01-88514-001
PO#: 029257
ITEM #: 01021951 1AL
DATE: 3/25/97

CYLINDER #: ALM023940 ANALYTICAL ACCURACY: +-1%
FILL PRESSURE: 2000 PSIG
BLEND TYPE : GRAVIMETRIC MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
ETHYLENE	20.	PPM	20.01	PPM
NITROGEN		BALANCE		BALANCE

CERTIFIED

ANALYST: G. Kogut
GENYA KOGUT

LIQUID CARBONIC
CYLINDER GAS PRODUCTS
5700 SOUTH ALAMEDA STREET • LOS ANGELES, CA 90058
310-585-6184
FAX 310-585-6592

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

CUSTOMER Env. & Indust. Dist. P.O NUMBER 50110032 52:032295-1

REFERENCE STANDARD

COMPONENT		NIST SRM NO.	CYLINDER NO.	CONCENTRATION
PROPANE	GMIS	vs 2649	SA 7651	5019 ppm

ANALYSIS RESULTS

R=REFERENCE STANDARD Z=ZERO GAS C=GAS CANDIDATE

1. COMPONENT PROPANE GMIS ANALYZER MAKE-MODEL-SN HP 5890 SERIES II S/N 3310A46533
ANALYTICAL PRINCIPLE GC/ FLAME IONIZATION LAST CALIBRATION DATE 03/28/95
FIRST ANALYSIS DATE 04/07/95 SECOND ANALYSIS DATE

Z	0	R	2607332	C	2744525	CONC.	5283 ppm	Z	R	C	CONC.
R	2612210	Z	0	C	2745146	CONC.	5274 ppm	R	Z	C	CONC.
Z	0	C	2737157	R	2608984	CONC.	5278 ppm	Z	C	R	CONC.
U/M	uV-s				MEAN TEST ASSAY		5278 ppm	U/M	uV-s		MEAN TEST ASSAY

Values not valid below 150 psig

THIS CYLINDER NO. SA 8458
HAS BEEN CERTIFIED ACCORDING TO SECTION EPA-600/R93/224
OF TRACEABILITY PROTOCOL NO. Rev. 9/93
PROCEDURE G1
CERTIFIED ACCURACY ± 1 % NIST TRACEABLE
CYLINDER PRESSURE 2000 PSIG
CERTIFICATION DATE 04/07/95
EXPIRATION DATE 04/07/98 TERM 36 MONTHS

CERTIFIED CONCENTRATION

PROPANE	5278 ppm
NITROGEN	BALANCE

ANALYZED BY [signature] CERTIFIED BY [signature] JOHN T. YOUNG

C-2 ENVIRONICS MASS FLOW METER CALIBRATIONS

S/N 2073

ENVIRONICS FLOW CONTROLLER CALIBRATION SHEET

Mf #: 1, Description: AIR , Size: 10000. SCCM, K-factor: 1.0

SERIAL # AW9502150

This flow controller was calibrated using a Sierra Cal Bench(TM), a traceable Primary Flow Standard Calibration System. This calibration is referenced to dry air at a temperature of 22F (__C) and a pressure of 29.92 in.Hg (760Torr).

	Set Flow	True Flow
5 %	500.0 CCM	498.79 CCM
10 %	1000.0 CCM	1009.0 CCM
20 %	2000.0 CCM	2029.8 CCM
30 %	3000.0 CCM	3058.2 CCM
40 %	4000.0 CCM	4088.8 CCM
50 %	5000.0 CCM	5121.9 CCM
60 %	6000.0 CCM	6143.3 CCM
70 %	7000.0 CCM	7178.3 CCM
80 %	8000.0 CCM	8206.3 CCM
90 %	9000.0 CCM	9224.6 CCM
100%	10000. CCM	10252. CCM

Calibration data was last saved on Friday 03 January 97 at 16:22:00

Verified by: Karl Santiago Date: 1 - 3 - 97

ENVIRONICS FLOW CONTROLLER CALIBRATION SHEET

Mf #: 2, Description: AIR , Size: 10000. SCCM, K-factor: 1.0

SERIAL # AW9502157

This flow controller was calibrated using a Sierra Cal Bench(TM), a traceable Primary Flow Standard Calibration System. This calibration is referenced to dry air at a temperature of 32F (__C) and a pressure of 29.92 in.Hg (760Torr).

	Set Flow	True Flow
5 %	500.0 CCM	510.51 CCM
10 %	1000.0 CCM	1021.4 CCM
20 %	2000.0 CCM	2046.9 CCM
30 %	3000.0 CCM	3074.8 CCM
40 %	4000.0 CCM	4103.8 CCM
50 %	5000.0 CCM	5136.6 CCM
60 %	6000.0 CCM	6156.8 CCM
70 %	7000.0 CCM	7182.5 CCM
80 %	8000.0 CCM	8203.3 CCM
90 %	9000.0 CCM	9219.5 CCM
100%	10000. CCM	10233. CCM

Calibration data was last saved on Friday 03 January 97 at 17:09:00

Verified by: Karl Sentiamy Date: 1 - 3 - 97

ENVIRONICS FLOW CONTROLLER CALIBRATION SHEET

Mf #: 3, Description: AIR , Size: 1000.0 SCCM, K-factor: 1.0

SERIAL # AW9502153

This flow controller was calibrated using a Sierra Cal Bench(TM), a traceable Primary Flow Standard Calibration System. This calibration is referenced to dry air at a temperature of 22F (__C) and a pressure of 29.92 in.Hg (760Torr).

	Set Flow	True Flow
5 %	50.0 CCM	50.515 CCM
10 %	100.0 CCM	101.84 CCM
20 %	200.0 CCM	204.84 CCM
30 %	300.0 CCM	306.67 CCM
40 %	400.0 CCM	408.82 CCM
50 %	500.0 CCM	510.43 CCM
60 %	600.0 CCM	611.44 CCM
70 %	700.0 CCM	713.59 CCM
80 %	800.0 CCM	816.61 CCM
90 %	900.0 CCM	918.19 CCM
100%	1000.0 CCM	1021.3 CCM

Calibration data was last saved on Friday 03 January 97 at 17:55:00

Verified by: Mark Santiago Date: 1 - 3 - 97

ENVIRONICS FLOW CONTROLLER CALIBRATION SHEET

Mf #: 4, Description: AIR , Size: 100.0 SCCM, K-factor: 1.0

SERIAL # AW9612049

This flow controller was calibrated using a Sierra Cal Bench(TM), a traceable Primary Flow Standard Calibration System. This calibration is referenced to dry air at a temperature of 32F (__C) and a pressure of 29.92 in.Hg (760Torr).

	Set Flow		True Flow	
5 %	5.0	CCM	5.236	CCM
10 %	10.0	CCM	10.269	CCM
20 %	20.0	CCM	20.434	CCM
30 %	30.0	CCM	30.524	CCM
40 %	40.0	CCM	40.606	CCM
50 %	50.0	CCM	50.636	CCM
60 %	60.0	CCM	60.683	CCM
70 %	70.0	CCM	70.779	CCM
80 %	80.0	CCM	80.917	CCM
90 %	90.0	CCM	91.035	CCM
100%	100.0	CCM	101.12	CCM

Calibration data was last saved on Friday 03 January 97 at 19:11:00

Verified by: Karl Sentiemy Date: 1 - 3 - 97

APPENDIX D

TEST METHODS

D-1 EPA METHOD 320

Appendix A of part 63 is amended by adding, in numerical order, Methods 320 and 321 to read as follows:

Appendix A to Part 63-Test Methods

*****

TEST METHOD 320

MEASUREMENT OF VAPOR PHASE ORGANIC AND INORGANIC EMISSIONS BY EXTRACTIVE FOURIER TRANSFORM INFRARED (FTIR) SPECTROSCOPY

1.0 Introduction.

Persons unfamiliar with basic elements of FTIR spectroscopy should not attempt to use this method. This method describes sampling and analytical procedures for extractive emission measurements using Fourier transform infrared (FTIR) spectroscopy. Detailed analytical procedures for interpreting infrared spectra are described in the "Protocol for the Use of Extractive Fourier Transform Infrared (FTIR) Spectrometry in Analyses of Gaseous Emissions from Stationary Sources," hereafter referred to as the "Protocol." Definitions not given in this method are given in appendix A of the Protocol. References to specific sections in the Protocol are made throughout this Method. For additional information refer to references 1 and 2, and other EPA reports, which describe the use of FTIR spectrometry in specific field measurement applications and validation tests. The sampling procedure described here is

extractive. Flue gas is extracted through a heated gas transport and handling system. For some sources, sample conditioning systems may be applicable. Some examples are given in this method. Note: sample conditioning systems may be used providing the method validation requirements in Sections 9.2 and 13.0 of this method are met.

1.1 Scope and Applicability.

1.1.1 Analytes. Analytes include hazardous air pollutants (HAPs) for which EPA reference spectra have been developed. Other compounds can also be measured with this method if reference spectra are prepared according to section 4.6 of the protocol.

1.1.2 Applicability. This method applies to the analysis of vapor phase organic or inorganic compounds which absorb energy in the mid-infrared spectral region, about 400 to 4000 cm^{-1} (25 to 2.5 µm). This method is used to determine compound-specific concentrations in a multi-component vapor phase sample, which is contained in a closed-path gas cell. Spectra of samples are collected using double beam infrared absorption spectroscopy. A computer program is used to analyze spectra and report compound concentrations.

1.2 Method Range and Sensitivity. Analytical range and sensitivity depend on the frequency-dependent analyte absorptivity, instrument configuration, data collection parameters, and gas stream composition. Instrument factors

include: (a) spectral resolution, (b) interferometer signal averaging time, (c) detector sensitivity and response, and (d) absorption path length.

1.2.1 For any optical configuration the analytical range is between the absorbance values of about .01 (infrared transmittance relative to the background = 0.98) and 1.0 (T = 0.1). (For absorbance > 1.0 the relation between absorbance and concentration may not be linear.)

1.2.2 The concentrations associated with this absorbance range depend primarily on the cell path length and the sample temperature. An analyte absorbance greater than 1.0, can be lowered by decreasing the optical path length. Analyte absorbance increases with a longer path length. Analyte detection also depends on the presence of other species exhibiting absorbance in the same analytical region. Additionally, the estimated lower absorbance (A) limit (A = 0.01) depends on the root mean square deviation (RMSD) noise in the analytical region.

1.2.3 The concentration range of this method is determined by the choice of optical configuration.

1.2.3.1 The absorbance for a given concentration can be decreased by decreasing the path length or by diluting the sample. There is no practical upper limit to the measurement range.

1.2.3.2 The analyte absorbance for a given concentration

may be increased by increasing the cell path length or (to some extent) using a higher resolution. Both modifications also cause a corresponding increased absorbance for all compounds in the sample, and a decrease in the signal throughput. For this reason the practical lower detection range (quantitation limit) usually depends on sample characteristics such as moisture content of the gas, the presence of other interferants, and losses in the sampling system.

1.3 Sensitivity. The limit of sensitivity for an optical configuration and integration time is determined using appendix D of the Protocol: Minimum Analyte Uncertainty, (MAU). The MAU depends on the RMSD noise in an analytical region, and on the absorptivity of the analyte in the same region.

1.4 Data Quality. Data quality shall be determined by executing Protocol pre-test procedures in appendices B to H of the protocol and post-test procedures in appendices I and J of the protocol.

1.4.1 Measurement objectives shall be established by the choice of detection limit (DL_i) and analytical uncertainty (AU_i) for each analyte.

1.4.2 An instrumental configuration shall be selected. An estimate of gas composition shall be made based on previous test data, data from a similar source or information

gathered in a pre-test site survey. Spectral interferants shall be identified using the selected DL_i and AU_i and band areas from reference spectra and interferant spectra. The baseline noise of the system shall be measured in each analytical region to determine the MAU of the instrument configuration for each analyte and interferant (MIU_i).

1.4.3 Data quality for the application shall be determined, in part, by measuring the RMS (root mean square) noise level in each analytical spectral region (appendix C of the Protocol). The RMS noise is defined as the RMSD of the absorbance values in an analytical region from the mean absorbance value in the region.

1.4.4 The MAU is the minimum analyte concentration for which the AU_i can be maintained; if the measured analyte concentration is less than MAU_i, then data quality are unacceptable.

2.0 Summary of Method.

2.1 Principle. References 4 through 7 provide background material on infrared spectroscopy and quantitative analysis. A summary is given in this section.

2.1.1 Infrared absorption spectroscopy is performed by directing an infrared beam through a sample to a detector. The frequency-dependent infrared absorbance of the sample is measured by comparing this detector signal (single beam spectrum) to a signal obtained without a sample in the beam

path (background).

2.1.2 Most molecules absorb infrared radiation and the absorbance occurs in a characteristic and reproducible pattern. The infrared spectrum measures fundamental molecular properties and a compound can be identified from its infrared spectrum alone.

2.1.3 Within constraints, there is a linear relationship between infrared absorption and compound concentration. If this frequency dependent relationship (absorptivity) is known (measured), it can be used to determine compound concentration in a sample mixture.

2.1.4 Absorptivity is measured by preparing, in the laboratory, standard samples of compounds at known concentrations and measuring the FTIR "reference spectra" of these standard samples. These "reference spectra" are then used in sample analysis: (1) compounds are detected by matching sample absorbance bands with bands in reference spectra, and (2) concentrations are measured by comparing sample band intensities with reference band intensities.

2.1.5 This method is self-validating provided that the results meet the performance requirement of the QA spike in sections 8.6.2 and 9.0 of this method, and results from a previous method validation study support the use of this method in the application.

2.2 Sampling and Analysis. In extractive sampling a probe

assembly and pump are used to extract gas from the exhaust of the affected source and transport the sample to the FTIR gas cell. Typically, the sampling apparatus is similar to that used for single-component continuous emission monitor (CEM) measurements.

2.2.1 The digitized infrared spectrum of the sample in the FTIR gas cell is measured and stored on a computer. Absorbance band intensities in the spectrum are related to sample concentrations by what is commonly referred to as Beer's Law.

$$A_i = a_i \, b \, c_i \qquad \textbf{(1)}$$

where:

A_i = absorbance at a given frequency of the ith sample component.

a_i = absorption coefficient (absorptivity) of the ith sample component.

b = path length of the cell.

c_i = concentration of the ith sample component.

2.2.2 Analyte spiking is used for quality assurance (QA). In this procedure (section 8.6.2 of this method) an analyte is spiked into the gas stream at the back end of the sample probe. Analyte concentrations in the spiked samples are compared to analyte concentrations in unspiked samples.

Since the concentration of the spike is known, this procedure can be used to determine if the sampling system is removing the spiked analyte(s) from the sample stream.

2.3 Reference Spectra Availability. Reference spectra of over 100 HAPs are available in the EPA FTIR spectral library on the EMTIC (Emission Measurement Technical Information Center) computer bulletin board service and at internet address http://info.arnold.af.mil/epa/welcome.htm. Reference spectra for HAPs, or other analytes, may also be prepared according to section 4.6 of the Protocol.

2.4 Operator Requirements. The FTIR analyst shall be trained in setting up the instrumentation, verifying the instrument is functioning properly, and performing routine maintenance. The analyst must evaluate the initial sample spectra to determine if the sample matrix is consistent with pre-test assumptions and if the instrument configuration is suitable. The analyst must be able to modify the instrument configuration, if necessary.

2.4.1 The spectral analysis shall be supervised by someone familiar with EPA FTIR Protocol procedures.

2.4.2 A technician trained in instrumental test methods is qualified to install and operate the sampling system. This includes installing the probe and heated line assembly, operating the analyte spike system, and performing moisture and flow measurements.

3.0 Definitions.

See appendix A of the Protocol for definitions relating to infrared spectroscopy. Additional definitions are given in sections 3.1 through 3.29.

3.1 Analyte. A compound that this method is used to measure. The term "target analyte" is also used. This method is multi-component and a number of analytes can be targeted for a test.

3.2 Reference Spectrum. Infrared spectrum of an analyte prepared under controlled, documented, and reproducible laboratory conditions according to procedures in section 4.6 of the Protocol. A library of reference spectra is used to measure analytes in gas samples.

3.3 Standard Spectrum. A spectrum that has been prepared from a reference spectrum through a (documented) mathematical operation. A common example is de-resolving of reference spectra to lower-resolution standard spectra (Protocol, appendix K to the addendum of this method). Standard spectra, prepared by approved, and documented, procedures can be used as reference spectra for analysis.

3.4 Concentration. In this method concentration is expressed as a molar concentration, in ppm-meters, or in (ppm-meters)/K, where K is the absolute temperature (Kelvin). The latter units allow the direct comparison of concentrations from systems using different optical

configurations or sampling temperatures.

3.5 Interferant. A compound in the sample matrix whose infrared spectrum overlaps with part of an analyte spectrum. The most accurate analyte measurements are achieved when reference spectra of interferants are used in the quantitative analysis with the analyte reference spectra. The presence of an interferant can increase the analytical uncertainty in the measured analyte concentration.

3.6 Gas Cell. A gas containment cell that can be evacuated. It is equipped with the optical components to pass the infrared beam through the sample to the detector. Important cell features include: path length (or range if variable), temperature range, materials of construction, and total gas volume.

3.7 Sampling System. Equipment used to extract the sample from the test location and transport the sample gas to the FTIR analyzer. This includes sample conditioning systems.

3.8 Sample Analysis. The process of interpreting the infrared spectra to obtain sample analyte concentrations. This process is usually automated using a software routine employing a classical least squares (cls), partial least squares (pls), or K- or P- matrix method.

3.9 One hundred percent line. A double beam transmittance spectrum obtained by combining two background single beam spectra. Ideally, this line is equal to 100 percent

transmittance (or zero absorbance) at every frequency in the spectrum. Practically, a zero absorbance line is used to measure the baseline noise in the spectrum.

3.10 Background Deviation. A deviation from 100 percent transmittance in any region of the 100 percent line. Deviations greater than ± 5 percent in an analytical region are unacceptable (absorbance of 0.021 to -0.022). Such deviations indicate a change in the instrument throughput relative to the background single beam.

3.11 Batch Sampling. A procedure where spectra of discreet, static samples are collected. The gas cell is filled with sample and the cell is isolated. The spectrum is collected. Finally, the cell is evacuated to prepare for the next sample.

3.12 Continuous Sampling. A procedure where spectra are collected while sample gas is flowing through the cell at a measured rate.

3.13 Sampling resolution. The spectral resolution used to collect sample spectra.

3.14 Truncation. Limiting the number of interferogram data points by deleting points farthest from the center burst (zero path difference, ZPD).

3.15 Zero filling. The addition of points to the interferogram. The position of each added point is interpolated from neighboring real data points. Zero

filling adds no information to the interferogram, but affects line shapes in the absorbance spectrum (and possibly analytical results).

3.16 Reference CTS. Calibration Transfer Standard spectra that were collected with reference spectra.

3.17 CTS Standard. CTS spectrum produced by applying a de-resolution procedure to a reference CTS.

3.18 Test CTS. CTS spectra collected at the sampling resolution using the same optical configuration as for sample spectra. Test spectra help verify the resolution, temperature and path length of the FTIR system.

3.19 RMSD. Root Mean Square Difference, defined in EPA FTIR Protocol, appendix A.

3.20 Sensitivity. The noise-limited compound-dependent detection limit for the FTIR system configuration. This is estimated by the MAU. It depends on the RMSD in an analytical region of a zero absorbance line.

3.21 Quantitation Limit. The lower limit of detection for the FTIR system configuration in the sample spectra. This is estimated by mathematically subtracting scaled reference spectra of analytes and interferences from sample spectra, then measuring the RMSD in an analytical region of the subtracted spectrum. Since the noise in subtracted sample spectra may be much greater than in a zero absorbance spectrum, the quantitation limit is generally much higher

than the sensitivity. Removing spectral interferences from the sample or improving the spectral subtraction can lower the quantitation limit toward (but not below) the sensitivity.

3.22 Independent Sample. A unique volume of sample gas; there is no mixing of gas between two consecutive independent samples. In continuous sampling two independent samples are separated by at least 5 cell volumes. The interval between independent measurements depends on the cell volume and the sample flow rate (through the cell).

3.23 Measurement. A single spectrum of flue gas contained in the FTIR cell.

3.24 Run. A run consists of a series of measurements. At a minimum a run includes 8 independent measurements spaced over 1 hour.

3.25 Validation. Validation of FTIR measurements is described in sections 13.0 through 13.4 of this method. Validation is used to verify the test procedures for measuring specific analytes at a source. Validation provides proof that the method works under certain test conditions.

3.26 Validation Run. A validation run consists of at least 24 measurements of independent samples. Half of the samples are spiked and half are not spiked. The length of the run is determined by the interval between independent samples.

3.27 Screening. Screening is used when there is little or no available information about a source. The purpose of screening is to determine what analytes are emitted and to obtain information about important sample characteristics such as moisture, temperature, and interferences. Screening results are semi-quantitative (estimated concentrations) or qualitative (identification only). Various optical and sampling configurations may be used. Sample conditioning systems may be evaluated for their effectiveness in removing interferences. It is unnecessary to perform a complete run under any set of sampling conditions. Spiking is not necessary, but spiking can be a useful screening tool for evaluating the sampling system, especially if a reactive or soluble analyte is used for the spike.

3.28 Emissions Test. An FTIR emissions test is performed according specific sampling and analytical procedures. These procedures, for the target analytes and the source, are based on previous screening and validation results. Emission results are quantitative. A QA spike (sections 8.6.2 and 9.2 of this method) is performed under each set of sampling conditions using a representative analyte. Flow, gas temperature and diluent data are recorded concurrently with the FTIR measurements to provide mass emission rates for detected compounds.

3.29 Surrogate. A surrogate is a compound that is used in

a QA spike procedure (section 8.6.2 of this method) to represent other compounds. The chemical and physical properties of a surrogate shall be similar to the compounds it is chosen to represent. Under given sampling conditions, usually a single sampling factor is of primary concern for measuring the target analytes: for example, the surrogate spike results can be representative for analytes that are more reactive, more soluble, have a lower absorptivity, or have a lower vapor pressure than the surrogate itself.

4.0 Interferences.

Interferences are divided into two classifications: analytical and sampling.

4.1 Analytical Interferences. An analytical interference is a spectral feature that complicates (in extreme cases may prevent) the analysis of an analyte. Analytical interferences are classified as background or spectral interference.

4.1.1 Background Interference. This results from a change in throughput relative to the single beam background. It is corrected by collecting a new background and proceeding with the test. In severe instances the cause must be identified and corrected. Potential causes include: (1) deposits on reflective surfaces or transmitting windows, (2) changes in detector sensitivity, (3) a change in the infrared source output, or (4) failure in the instrument electronics. In

routine sampling throughput may degrade over several hours. Periodically a new background must be collected, but no other corrective action will be required.

4.1.2 Spectral Interference. This results from the presence of interfering compound(s) (interferant) in the sample. Interferant spectral features overlap analyte spectral features. Any compound with an infrared spectrum, including analytes, can potentially be an interferant. The Protocol measures absorbance band overlap in each analytical region to determine if potential interferants shall be classified as known interferants (FTIR Protocol, section 4.9 and appendix B). Water vapor and CO_2 are common spectral interferants. Both of these compounds have strong infrared spectra and are present in many sample matrices at high concentrations relative to analytes. The extent of interference depends on the (1) interferant concentration, (2) analyte concentration, and (3) the degree of band overlap. Choosing an alternate analytical region can minimize or avoid the spectral interference. For example, CO_2 interferes with the analysis of the 670 cm^{-1} benzene band. However, benzene can also be measured near 3000 cm^{-1} (with less sensitivity).

4.2 Sampling System Interferences. These prevent analytes from reaching the instrument. The analyte spike procedure is designed to measure sampling system interference, if any.

4.2.1 Temperature. A temperature that is too low causes condensation of analytes or water vapor. The materials of the sampling system and the FTIR gas cell usually set the upper limit of temperature.

4.2.2 Reactive Species. Anything that reacts with analytes. Some analytes, like formaldehyde, polymerize at lower temperatures.

4.2.3 Materials. Poor choice of material for probe, or sampling line may remove some analytes. For example, HF reacts with glass components.

4.2.4 Moisture. In addition to being a spectral interferant, condensed moisture removes soluble compounds.

5.0 Safety.

The hazards of performing this method are those associated with any stack sampling method and the same precautions shall be followed. Many HAPs are suspected carcinogens or present other serious health risks. Exposure to these compounds should be avoided in all circumstances. For instructions on the safe handling of any particular compound, refer to its material safety data sheet. When using analyte standards, always ensure that gases are properly vented and that the gas handling system is leak free. (Always perform a leak check with the system under maximum vacuum and, again, with the system at greater than ambient pressure.) Refer to section 8.2 of this method for

leak check procedures. This method does not address all of the potential safety risks associated with its use. Anyone performing this method must follow safety and health practices consistent with applicable legal requirements and with prudent practice for each application.

6.0 Equipment and Supplies.

Note: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

The equipment and supplies are based on the schematic of a sampling system shown in Figure 1. Either the batch or continuous sampling procedures may be used with this sampling system. Alternative sampling configurations may also be used, provided that the data quality objectives are met as determined in the post-analysis evaluation. Other equipment or supplies may be necessary, depending on the design of the sampling system or the specific target analytes.

6.1 Sampling Probe. Glass, stainless steel, or other appropriate material of sufficient length and physical integrity to sustain heating, prevent adsorption of analytes, and to transport analytes to the infrared gas cell. Special materials or configurations may be required in some applications. For instance, high stack sample temperatures may require special steel or cooling the probe.

For very high moisture sources it may be desirable to use a dilution probe.

6.2 Particulate Filters. A glass wool plug (optional) inserted at the probe tip (for large particulate removal) and a filter (required) rated for 99 percent removal efficiency at 1-micron (e.g., Balston™) connected at the outlet of the heated probe.

6.3 Sampling Line/Heating System. Heated (sufficient to prevent condensation) stainless steel, polytetrafluoroethane, or other material inert to the analytes.

6.4 Gas Distribution Manifold. A heated manifold allowing the operator to control flows of gas standards and samples directly to the FTIR system or through sample conditioning systems. Usually includes heated flow meter, heated valve for selecting and sending sample to the analyzer, and a by-pass vent. This is typically constructed of stainless steel tubing and fittings, and high-temperature valves.

6.5 Stainless Steel Tubing. Type 316, appropriate diameter (e.g., 3/8 in.) and length for heated connections. Higher grade stainless may be desirable in some applications.

6.6 Calibration/Analyte Spike Assembly. A three way valve assembly (or equivalent) to introduce analyte or surrogate spikes into the sampling system at the outlet of the probe upstream of the out-of-stack particulate filter and the FTIR

analytical system.

6.7 Mass Flow Meter (MFM). These are used for measuring analyte spike flow. The MFM shall be calibrated in the range of 0 to 5 L/min and be accurate to ± 2 percent (or better) of the flow meter span.

6.8 Gas Regulators. Appropriate for individual gas standards.

6.9 Polytetrafluoroethane Tubing. Diameter (e.g., 3/8 in.) and length suitable to connect cylinder regulators to gas standard manifold.

6.10 Sample Pump. A leak-free pump (e.g., KNF™), with by-pass valve, capable of producing a sample flow rate of at least 10 L/min through 100 ft of sample line. If the pump is positioned upstream of the distribution manifold and FTIR system, use a heated pump that is constructed from materials non-reactive to the analytes. If the pump is located downstream of the FTIR system, the gas cell sample pressure will be lower than ambient pressure and it must be recorded at regular intervals.

6.11 Gas Sample Manifold. Secondary manifold to control sample flow at the inlet to the FTIR manifold. This is optional, but includes a by-pass vent and heated rotameter.

6.12 Rotameter. A 0 to 20 L/min rotameter. This meter need not be calibrated.

6.13 FTIR Analytical System. Spectrometer and detector,

capable of measuring the analytes to the chosen detection limit. The system shall include a personal computer with compatible software allowing automated collection of spectra.

6.14 FTIR Cell Pump. Required for the batch sampling technique, capable of evacuating the FTIR cell volume within 2 minutes. The pumping speed shall allow the operator to obtain 8 sample spectra in 1 hour.

6.15 Absolute Pressure Gauge. Capable of measuring pressure from 0 to 1000 mmHg to within ± 2.5 mmHg (e.g., Baratron™).

6.16 Temperature Gauge. Capable of measuring the cell temperature to within ± 2°C.

6.17 Sample Conditioning. One option is a condenser system, which is used for moisture removal. This can be helpful in the measurement of some analytes. Other sample conditioning procedures may be devised for the removal of moisture or other interfering species.

6.17.1 The analyte spike procedure of section 9.2 of this method, the QA spike procedure of section 8.6.2 of this method, and the validation procedure of section 13 of this method demonstrate whether the sample conditioning affects analyte concentrations. Alternatively, measurements can be made with two parallel FTIR systems; one measuring conditioned sample, the other measuring unconditioned

sample.

6.17.2 Another option is sample dilution. The dilution factor measurement must be documented and accounted for in the reported concentrations. An alternative to dilution is to lower the sensitivity of the FTIR system by decreasing the cell path length, or to use a short-path cell in conjunction with a long path cell to measure more than one concentration range.

7.0 Reagents and Standards.

7.1 Analyte(s) and Tracer Gas. Obtain a certified gas cylinder mixture containing all of the analyte(s) at concentrations within ± 2 percent of the emission source levels (expressed in ppm-meter/K). If practical, the analyte standard cylinder shall also contain the tracer gas at a concentration which gives a measurable absorbance at a dilution factor of at least 10:1. Two ppm SF_6 is sufficient for a path length of 22 meters at 250 °F.

7.2 Calibration Transfer Standard(s). Select the calibration transfer standards (CTS) according to section 4.5 of the FTIR Protocol. Obtain a National Institute of Standards and Technology (NIST) traceable gravimetric standard of the CTS (± 2 percent).

7.3 Reference Spectra. Obtain reference spectra for each analyte, interferant, surrogate, CTS, and tracer. If EPA reference spectra are not available, use reference spectra

prepared according to procedures in section 4.6 of the EPA FTIR Protocol.

8.0 Sampling and Analysis Procedure.

Three types of testing can be performed: (1) screening, (2) emissions test, and (3) validation. Each is defined in section 3 of this method. Determine the purpose(s) of the FTIR test. Test requirements include: (a) AU_i, DL_i, overall fractional uncertainty, OFU_i, maximum expected concentration ($CMAX_i$), and t_{AN} for each, (b) potential interferants, (c) sampling system factors, e.g., minimum absolute cell pressure, (P_{min}), FTIR cell volume (V_{ss}), estimated sample absorption pathlength, L_s', estimated sample pressure, P_s', T_s', signal integration time (t_{ss}), minimum instrumental linewidth, MIL, fractional error, and (d) analytical regions, e.g., m = 1 to M, lower wavenumber position, FL_m, center wavenumber position, FC_m, and upper wavenumber position, FU_m, plus interferants, upper wavenumber position of the CTS absorption band, FFU_m, lower wavenumber position of the CTS absorption band, FFL_m, wavenumber range FNU to FNL. If necessary, sample and acquire an initial spectrum. From analysis of this preliminary spectrum determine a suitable operational path length. Set up the sampling train as shown in Figure 1 or use an appropriate alternative configuration. Sections 8.1 through 8.11 of this method provide guidance on pre-test calculations in the EPA

protocol, sampling and analytical procedures, and post-test protocol calculations.

8.1 Pretest Preparations and Evaluations. Using the procedure in section 4.0 of the FTIR Protocol, determine the optimum sampling system configuration for measuring the target analytes. Use available information to make reasonable assumptions about moisture content and other interferences.

8.1.1 Analytes. Select the required detection limit (DL_i) and the maximum permissible analytical uncertainty (AU_i) for each analyte (labeled from 1 to i). Estimate, if possible, the maximum expected concentration for each analyte, $CMAX_i$. The expected measurement range is fixed by DL_i and $CMAX_i$ for each analyte (i).

8.1.2 Potential Interferants. List the potential interferants. This usually includes water vapor and CO_2, but may also include some analytes and other compounds.

8.1.3. Optical Configuration. Choose an optical configuration that can measure all of the analytes within the absorbance range of .01 to 1.0 (this may require more than one path length). Use Protocol sections 4.3 to 4.8 for guidance in choosing a configuration and measuring CTS.

8.1.4. Fractional Reproducibility Uncertainty (FRU_i). The FRU is determined for each analyte by comparing CTS spectra taken before and after the reference spectra were measured.

The EPA para-xylene reference spectra were collected on 10/31/91 and 11/01/91 with corresponding CTS spectra "cts1031a," and "cts1101b." The CTS spectra are used to estimate the reproducibility (FRU) in the system that was used to collect the references. The FRU must be < AU. Appendix E of the protocol is used to calculate the FRU from CTS spectra. Figure 2 plots results for 0.25 cm^{-1} CTS spectra in EPA reference library: S_3 (cts1101b - cts1031a), and S_4 [(cts1101b + cts1031a)/2]. The RMSD (SRMS) is calculated in the subtracted baseline, S_3, in the corresponding CTS region from 850 to 1065 cm^{-1}. The area (BAV) is calculated in the same region of the averaged CTS spectrum, S_4.

8.1.5 Known Interferants. Use appendix B of the EPA FTIR Protocol.

8.1.6 Calculate the Minimum Analyte Uncertainty, MAU (section 1.3 of this method discusses MAU and protocol appendix D gives the MAU procedure). The MAU for each analyte, i, and each analytical region, m, depends on the RMS noise.

8.1.7 Analytical Program. See FTIR Protocol, section 4.10. Prepare computer program based on the chosen analytical technique. Use as input reference spectra of all target analytes and expected interferants. Reference spectra of additional compounds shall also be included in the program

if their presence (even if transient) in the samples is considered possible. The program output shall be in ppm (or ppb) and shall be corrected for differences between the reference path length, L_R, temperature, T_R, and pressure, P_R, and the conditions used for collecting the sample spectra. If sampling is performed at ambient pressure, then any pressure correction is usually small relative to corrections for path length and temperature, and may be neglected.

8.2 Leak-check.

8.2.1 Sampling System. A typical FTIR extractive sampling train is shown in Figure 1. Leak check from the probe tip to pump outlet as follows: Connect a 0- to 250-mL/min rate meter (rotameter or bubble meter) to the outlet of the pump. Close off the inlet to the probe, and record the leak rate. The leak rate shall be ≤ 200 mL/min.

8.2.2 Analytical System Leak check. Leak check the FTIR cell under vacuum and under pressure (greater than ambient). Leak check connecting tubing and inlet manifold under pressure.

8.2.2.1 For the evacuated sample technique, close the valve to the FTIR cell, and evacuate the absorption cell to the minimum absolute pressure P_{min}. Close the valve to the pump, and determine the change in pressure ΔP_v after 2 minutes.

8.2.2.2 For both the evacuated sample and purging techniques, pressurize the system to about 100 mmHg above

atmospheric pressure. Isolate the pump and determine the change in pressure ΔP_p after 2 minutes.

8.2.2.3 Measure the barometric pressure, P_b in mmHg.

8.2.2.4 Determine the percent leak volume $\%V_L$ for the signal integration time t_{ss} and for ΔP_{max}, i.e., the larger of ΔP_v or ΔP_p, as follows:

$$\%V_L = 50\, t_{SS} \frac{\Delta P_{max}}{P_{SS}} \qquad \textbf{(2)}$$

where 50 = 100% divided by the leak-check time of 2 minutes.

8.2.2.5 Leak volumes in excess of 4 percent of the FTIR system volume V_{ss} are unacceptable.

8.3 Detector Linearity. Once an optical configuration is chosen, use one of the procedures of sections 8.3.1 through 8.3.3 to verify that the detector response is linear. If the detector response is not linear, decrease the aperture, or attenuate the infrared beam. After a change in the instrument configuration perform a linearity check until it is demonstrated that the detector response is linear.

8.3.1 Vary the power incident on the detector by modifying the aperture setting. Measure the background and CTS at three instrument aperture settings: (1) at the aperture setting to be used in the testing, (2) at one half this aperture and (3) at twice the proposed testing aperture.

Compare the three CTS spectra. CTS band areas shall agree to within the uncertainty of the cylinder standard and the RMSD noise in the system. If test aperture is the maximum aperture, collect CTS spectrum at maximum aperture, then close the aperture to reduce the IR throughput by half. Collect a second background and CTS at the smaller aperture setting and compare the spectra again.

8.3.2 Use neutral density filters to attenuate the infrared beam. Set up the FTIR system as it will be used in the test measurements. Collect a CTS spectrum. Use a neutral density filter to attenuate the infrared beam (either immediately after the source or the interferometer) to approximately 1/2 its original intensity. Collect a second CTS spectrum. Use another filter to attenuate the infrared beam to approximately 1/4 its original intensity. Collect a third background and CTS spectrum. Compare the CTS spectra. CTS band areas shall agree to within the uncertainty of the cylinder standard and the RMSD noise in the system.

8.3.3 Observe the single beam instrument response in a frequency region where the detector response is known to be zero. Verify that the detector response is "flat" and equal to zero in these regions.

8.4 Data Storage Requirements. All field test spectra shall be stored on a computer disk and a second backup copy must stored on a separate disk. The stored information

includes sample interferograms, processed absorbance spectra, background interferograms, CTS sample interferograms and CTS absorbance spectra. Additionally, documentation of all sample conditions, instrument settings, and test records must be recorded on hard copy or on computer medium. Table 1 gives a sample presentation of documentation.

8.5 Background Spectrum. Evacuate the gas cell to ≤ 5 mmHg, and fill with dry nitrogen gas to ambient pressure (or purge the cell with 10 volumes of dry nitrogen). Verify that no significant amounts of absorbing species (for example water vapor and CO_2) are present. Collect a background spectrum, using a signal averaging period equal to or greater than the averaging period for the sample spectra. Assign a unique file name to the background spectrum. Store two copies of the background interferogram and processed single-beam spectrum on separate computer disks (one copy is the back-up).

8.5.1 Interference Spectra. If possible, collect spectra of known and suspected major interferences using the same optical system that will be used in the field measurements. This can be done on-site or earlier. A number of gases, e.g. CO_2, SO_2, CO, NH_3, are readily available from cylinder gas suppliers.

8.5.2 Water vapor spectra can be prepared by the following

procedure. Fill a sample tube with distilled water. Evacuate above the sample and remove dissolved gasses by alternately freezing and thawing the water while evacuating. Allow water vapor into the FTIR cell, then dilute to atmospheric pressure with nitrogen or dry air. If quantitative water spectra are required, follow the reference spectrum procedure for neat samples (protocol, section 4.6). Often, interference spectra need not be quantitative, but for best results the absorbance must be comparable to the interference absorbance in the sample spectra.

8.6 Pre-Test Calibrations

8.6.1 Calibration Transfer Standard. Evacuate the gas cell to ≤ 5 mmHg absolute pressure, and fill the FTIR cell to atmospheric pressure with the CTS gas. Alternatively, purge the cell with 10 cell volumes of CTS gas. (If purge is used, verify that the CTS concentration in the cell is stable by collecting two spectra 2 minutes apart as the CTS gas continues to flow. If the absorbance in the second spectrum is no greater than in the first, within the uncertainty of the gas standard, then this can be used as the CTS spectrum.) Record the spectrum.

8.6.2 QA Spike. This procedure assumes that the method has been validated for at least some of the target analytes at the source. For emissions testing perform a QA spike. Use

a certified standard, if possible, of an analyte, which has been validated at the source. One analyte standard can serve as a QA surrogate for other analytes which are less reactive or less soluble than the standard. Perform the spike procedure of section 9.2 of this method. Record spectra of at least three independent (section 3.22 of this method) spiked samples. Calculate the spiked component of the analyte concentration. If the average spiked concentration is within 0.7 to 1.3 times the expected concentration, then proceed with the testing. If applicable, apply the correction factor from the Method 301 of this appendix validation test (not the result from the QA spike).

8.7 Sampling. If analyte concentrations vary rapidly with time, continuous sampling is preferable using the smallest cell volume, fastest sampling rate and fastest spectra collection rate possible. Continuous sampling requires the least operator intervention even without an automated sampling system. For continuous monitoring at one location over long periods, Continuous sampling is preferred. Batch sampling and continuous static sampling are used for screening and performing test runs of finite duration. Either technique is preferred for sampling several locations in a matter of days. Batch sampling gives reasonably good time resolution and ensures that each spectrum measures a

discreet (and unique) sample volume. Continuous static (and continuous) sampling provide a very stable background over long periods. Like batch sampling, continuous static sampling also ensures that each spectrum measures a unique sample volume. It is essential that the leak check procedure under vacuum (section 8.2 of this method) is passed if the batch sampling procedure is used. It is essential that the leak check procedure under positive pressure is passed if the continuous static or continuous sampling procedures are used. The sampling techniques are described in sections 8.7.1 through 8.7.2 of this method.

8.7.1 Batch Sampling. Evacuate the absorbance cell to ≤ 5 mmHg absolute pressure. Fill the cell with exhaust gas to ambient pressure, isolate the cell, and record the spectrum. Before taking the next sample, evacuate the cell until no spectral evidence of sample absorption remains. Repeat this procedure to collect eight spectra of separate samples in 1 hour.

8.7.2 Continuous Static Sampling. Purge the FTIR cell with 10 cell volumes of sample gas. Isolate the cell, collect the spectrum of the static sample and record the pressure. Before measuring the next sample, purge the cell with 10 more cell volumes of sample gas.

8.8 Sampling QA and Reporting.

8.8.1 Sample integration times shall be sufficient to

achieve the required signal-to-noise ratio. Obtain an absorbance spectrum by filling the cell with N_2. Measure the RMSD in each analytical region in this absorbance spectrum. Verify that the number of scans used is sufficient to achieve the target MAU.

8.8.2 Assign a unique file name to each spectrum.

8.8.3 Store two copies of sample interferograms and processed spectra on separate computer disks.

8.8.4 For each sample spectrum, document the sampling conditions, the sampling time (while the cell was being filled), the time the spectrum was recorded, the instrumental conditions (path length, temperature, pressure, resolution, signal integration time), and the spectral file name. Keep a hard copy of these data sheets.

8.9 Signal Transmittance. While sampling, monitor the signal transmittance. If signal transmittance (relative to the background) changes by 5 percent or more (absorbance = -.02 to .02) in any analytical spectral region, obtain a new background spectrum.

8.10 Post-test CTS. After the sampling run, record another CTS spectrum.

8.11 Post-test QA.

8.11.1 Inspect the sample spectra immediately after the run to verify that the gas matrix composition was close to the expected (assumed) gas matrix.

8.11.2 Verify that the sampling and instrumental parameters were appropriate for the conditions encountered. For example, if the moisture is much greater than anticipated, it may be necessary to use a shorter path length or dilute the sample.

8.11.3 Compare the pre- and post-test CTS spectra. The peak absorbance in pre- and post-test CTS must be ± 5 percent of the mean value. See appendix E of the FTIR Protocol.

9.0 Quality Control.

Use analyte spiking (sections 8.6.2, 9.2 and 13.0 of this method) to verify that the sampling system can transport the analytes from the probe to the FTIR system.

9.1 Spike Materials. Use a certified standard (accurate to ± 2 percent) of the target analyte, if one can be obtained. If a certified standard cannot be obtained, follow the procedures in section 4.6.2.2 of the FTIR Protocol.

9.2 Spiking Procedure. QA spiking (section 8.6.2 of this method) is a calibration procedure used before testing. QA spiking involves following the spike procedure of sections 9.2.1 through 9.2.3 of this method to obtain at least three spiked samples. The analyte concentrations in the spiked samples shall be compared to the expected spike concentration to verify that the sampling/analytical system is working properly. Usually, when QA spiking is used, the

method has already been validated at a similar source for the analyte in question. The QA spike demonstrates that the validated sampling/analytical conditions are being duplicated. If the QA spike fails then the sampling/analytical system shall be repaired before testing proceeds. The method validation procedure (section 13.0 of this method) involves a more extensive use of the analyte spike procedure of sections 9.2.1 through 9.2.3 of this method. Spectra of at least 12 independent spiked and 12 independent unspiked samples are recorded. The concentration results are analyzed statistically to determine if there is a systematic bias in the method for measuring a particular analyte. If there is a systematic bias, within the limits allowed by Method 301 of this appendix, then a correction factor shall be applied to the analytical results. If the systematic bias is greater than the allowed limits, this method is not valid and cannot be used.

9.2.1 Introduce the spike/tracer gas at a constant flow rate of ≤ 10 percent of the total sample flow, when possible. (Note: Use the rotameter at the end of the sampling train to estimate the required spike/tracer gas flow rate.) Use a flow device, e.g., mass flow meter (± 2 percent), to monitor the spike flow rate. Record the spike flow rate every 10 minutes.

9.2.2 Determine the response time (RT) of the system by continuously collecting spectra of the spiked effluent until the spectrum of the spiked component is constant for 5 minutes. The RT is the interval from the first measurement until the spike becomes constant. Wait for twice the duration of the RT, then collect spectra of two independent spiked gas samples. Duplicate analyses of the spiked concentration shall be within 5 percent of the mean of the two measurements.

9.2.3 Calculate the dilution ratio using the tracer gas as follows:

$$DF = \frac{SF_{6(spk)}}{SF_{6(dir)}} \tag{3}$$

where:

$$CS = DF * Spike_{dir} + Unspike(1 - DF) \tag{4}$$

DF = Dilution factor of the spike gas; this value shall be ≥10.

$SF_{6(dir)}$ = SF_6 (or tracer gas) concentration measured directly in undiluted spike gas.

$SF_{6(spk)}$ = Diluted SF_6 (or tracer gas) concentration measured in a spiked sample.

$Spike_{dir}$ = Concentration of the analyte in the spike standard measured by filling the FTIR cell directly.

CS = Expected concentration of the spiked samples.

Unspike = Native concentration of analytes in unspiked samples

10.0 Calibration and Standardization.

10.1 Signal-to-Noise Ratio (S/N). The RMSD in the noise must be less than one tenth of the minimum analyte peak absorbance in each analytical region. For example if the minimum peak absorbance is 0.01 at the required DL, then RMSD measured over the entire analytical region must be $\leq$ 0.001.

10.2 Absorbance Path length. Verify the absorbance path length by comparing reference CTS spectra to test CTS spectra. See appendix E of the FTIR Protocol.

10.3 Instrument Resolution. Measure the line width of appropriate test CTS band(s) to verify instrument resolution. Alternatively, compare CTS spectra to a reference CTS spectrum, if available, measured at the nominal resolution.

10.4 Apodization Function. In transforming the sample interferograms to absorbance spectra use the same

apodization function that was used in transforming the reference spectra.

10.5 FTIR Cell Volume. Evacuate the cell to ≤ 5 mmHg. Measure the initial absolute temperature (T_i) and absolute pressure (P_i). Connect a wet test meter (or a calibrated dry gas meter), and slowly draw room air into the cell. Measure the meter volume (V_m), meter absolute temperature (T_m), and meter absolute pressure (P_m); and the cell final absolute temperature (T_f) and absolute pressure (P_f). Calculate the FTIR cell volume V_{SS}, including that of the connecting tubing, as follows:

$$V_{SS} = \frac{V_m \frac{P_m}{T_m}}{\left[\frac{P_f}{T_f} - \frac{P_i}{T_i}\right]} \qquad \textbf{(5)}$$

11.0 Data Analysis and Calculations.

Analyte concentrations shall be measured using reference spectra from the EPA FTIR spectral library. When EPA library spectra are not available, the procedures in section 4.6 of the Protocol shall be followed to prepare reference spectra of all the target analytes.

11.1 Spectral De-resolution. Reference spectra can be converted to lower resolution standard spectra (section 3.3

of this method) by truncating the original reference sample and background interferograms. Appendix K of the FTIR Protocol gives specific deresolution procedures. Deresolved spectra shall be transformed using the same apodization function and level of zero filling as the sample spectra. Additionally, pre-test FTIR protocol calculations (e.g., FRU, MAU, FCU) shall be performed using the de-resolved standard spectra.

11.2 Data Analysis. Various analytical programs are available for relating sample absorbance to a concentration standard. Calculated concentrations shall be verified by analyzing residual baselines after mathematically subtracting scaled reference spectra from the sample spectra. A full description of the data analysis and calculations is contained in the FTIR Protocol (sections 4.0, 5.0, 6.0 and appendices). Correct the calculated concentrations in the sample spectra for differences in absorption path length and temperature between the reference and sample spectra using equation 6,

$$C_{corr} = \left(\frac{L_r}{L_s}\right)\left(\frac{T_s}{T_r}\right)\left(\frac{P_r}{P_s}\right) C_{calc} \qquad \textbf{(6)}$$

where:

C_{corr} = Concentration, corrected for path length.

C_{calc} = Concentration, initial calculation (output of the analytical program designed for the compound).

L_r = Reference spectra path length.

L_s = Sample spectra path length.

T_s = Absolute temperature of the sample gas, K.

T_r = Absolute gas temperature of reference spectra, K.

P_s = Sample cell pressure.

P_r = Reference spectrum sample pressure.

12.0 Method Performance.

12.1 Spectral Quality. Refer to the FTIR Protocol appendices for analytical requirements, evaluation of data quality, and analysis of uncertainty.

12.2 Sampling QA/QC. The analyte spike procedure of section 9 of this method, the QA spike of section 8.6.2 of this method, and the validation procedure of section 13 of this method are used to evaluate the performance of the sampling system and to quantify sampling system effects, if any, on the measured concentrations. This method is self-validating provided that the results meet the performance requirement of the QA spike in sections 9.0 and 8.6.2 of this method and results from a previous method validation study support the use of this method in the application. Several factors can contribute to uncertainty in the measurement of spiked samples. Factors which can be controlled to provide better accuracy in the spiking procedure are listed in sections 12.2.1 through 12.2.4 of this method.

12.2.1 Flow meter. An accurate mass flow meter is accurate to ± 1 percent of its span. If a flow of 1 L/min is monitored with such a MFM, which is calibrated in the range of 0-5 L/min, the flow measurement has an uncertainty of 5 percent. This may be improved by re-calibrating the meter at the specific flow rate to be used.

12.2.2 Calibration gas. Usually the calibration standard is certified to within ± 2 percent. With reactive analytes, such as HCl, the certified accuracy in a commercially available standard may be no better than ± 5 percent.

12.2.3 Temperature. Temperature measurements of the cell shall be quite accurate. If practical, it is preferable to measure sample temperature directly, by inserting a thermocouple into the cell chamber instead of monitoring the cell outer wall temperature.

12.2.4 Pressure. Accuracy depends on the accuracy of the barometer, but fluctuations in pressure throughout a day may be as much as 2.5 percent due to weather variations.

13.0 Method Validation Procedure.

This validation procedure, which is based on EPA Method 301 (40 CFR part 63, appendix A), may be used to validate this method for the analytes in a gas matrix. Validation at one source may also apply to another type of source, if it can be shown that the exhaust gas characteristics are similar at both sources.

13.1 Section 5.3 of Method 301 (40 CFR part 63, appendix A), the Analyte Spike procedure, is used with these modifications. The statistical analysis of the results follows section 6.3 of EPA Method 301. Section 3 of this method defines terms that are not defined in Method 301.

13.1.1 The analyte spike is performed dynamically. This means the spike flow is continuous and constant as spiked samples are measured.

13.1.2 The spike gas is introduced at the back of the sample probe.

13.1.3 Spiked effluent is carried through all sampling components downstream of the probe.

13.1.4 A single FTIR system (or more) may be used to collect and analyze spectra (not quadruplicate integrated sampling trains).

13.1.5 All of the validation measurements are performed sequentially in a single "run" (section 3.26 of this method).

13.1.6 The measurements analyzed statistically are each independent (section 3.22 of this method).

13.1.7 A validation data set can consist of more than 12 spiked and 12 unspiked measurements.

13.2 Batch Sampling. The procedure in sections 13.2.1 through 13.2.2 may be used for stable processes. If process emissions are highly variable, the procedure in section

13.2.3 shall be used.

13.2.1 With a single FTIR instrument and sampling system, begin by collecting spectra of two unspiked samples. Introduce the spike flow into the sampling system and allow 10 cell volumes to purge the sampling system and FTIR cell. Collect spectra of two spiked samples. Turn off the spike and allow 10 cell volumes of unspiked sample to purge the FTIR cell. Repeat this procedure until the 24 (or more) samples are collected.

13.2.2 In batch sampling, collect spectra of 24 distinct samples. (Each distinct sample consists of filling the cell to ambient pressure after the cell has been evacuated.)

13.2.3 Alternatively, a separate probe assembly, line, and sample pump can be used for spiked sample. Verify and document that sampling conditions are the same in both the spiked and the unspiked sampling systems. This can be done by wrapping both sample lines in the same heated bundle. Keep the same flow rate in both sample lines. Measure samples in sequence in pairs. After two spiked samples are measured, evacuate the FTIR cell, and turn the manifold valve so that spiked sample flows to the FTIR cell. Allow the connecting line from the manifold to the FTIR cell to purge thoroughly (the time depends on the line length and flow rate). Collect a pair of spiked samples. Repeat the procedure until at least 24 measurements are completed.

13.3 Simultaneous Measurements With Two FTIR Systems. If unspiked effluent concentrations of the target analyte(s) vary significantly with time, it may be desirable to perform synchronized measurements of spiked and unspiked sample. Use two FTIR systems, each with its own cell and sampling system to perform simultaneous spiked and unspiked measurements. The optical configurations shall be similar, if possible. The sampling configurations shall be the same. One sampling system and FTIR analyzer shall be used to measure spiked effluent. The other sampling system and FTIR analyzer shall be used to measure unspiked flue gas. Both systems shall use the same sampling procedure (i.e., batch or continuous).

13.3.1 If batch sampling is used, synchronize the cell evacuation, cell filling, and collection of spectra. Fill both cells at the same rate (in cell volumes per unit time).

13.3.2 If continuous sampling is used, adjust the sample flow through each gas cell so that the same number of cell volumes pass through each cell in a given time (i.e. $TC_1 = TC_2$).

13.4 Statistical Treatment. The statistical procedure of EPA Method 301 of this appendix, section 6.3 is used to evaluate the bias and precision. For FTIR testing a validation "run" is defined as spectra of 24 independent samples, 12 of which are spiked with the analyte(s) and 12

of which are not spiked.

13.4.1 Bias. Determine the bias (defined by EPA Method 301 of this appendix, section 6.3.2) using equation 7:

$$B = S_m - CS \tag{7}$$

where:

B = Bias at spike level.

S_m = Mean concentration of the analyte spiked samples.

CS = Expected concentration of the spiked samples.

13.4.2 Correction Factor. Use section 6.3.2.2 of Method 301 of this appendix to evaluate the statistical significance of the bias. If it is determined that the bias is significant, then use section 6.3.3 of Method 301 to calculate a correction factor (CF). Analytical results of the test method are multiplied by the correction factor, if $0.7 \leq CF \leq 1.3$. If is determined that the bias is significant and CF > ± 30 percent, then the test method is considered to "not valid."

13.4.3 If measurements do not pass validation, evaluate the sampling system, instrument configuration, and analytical system to determine if improper set-up or a malfunction was the cause. If so, repair the system and repeat the validation.

14.0 Pollution Prevention.

The extracted sample gas is vented outside the enclosure containing the FTIR system and gas manifold after the analysis. In typical method applications the vented sample volume is a small fraction of the source volumetric flow and its composition is identical to that emitted from the source. When analyte spiking is used, spiked pollutants are vented with the extracted sample gas. Approximately 1.6 x 10^{-4} to 3.2 x 10^{-4} lbs of a single HAP may be vented to the atmosphere in a typical validation run of 3 hours. (This assumes a molar mass of 50 to 100 g, spike rate of 1.0 L/min, and a standard concentration of 100 ppm). Minimize emissions by keeping the spike flow off when not in use.

15.0 Waste Management.

Small volumes of laboratory gas standards can be vented through a laboratory hood. Neat samples must be packed and disposed according to applicable regulations. Surplus materials may be returned to supplier for disposal.

16.0 References.

1. "Field Validation Test Using Fourier Transform Infrared (FTIR) Spectrometry To Measure Formaldehyde, Phenol and Methanol at a Wool Fiberglass Production Facility." Draft. U.S. Environmental Protection Agency Report, EPA Contract No. 68D20163, Work Assignment I-32, September 1994.

2. "FTIR Method Validation at a Coal-Fired Boiler".

Prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No.: EPA-454/R95-004, NTIS No.: PB95-193199. July, 1993.

3. "Method 301 - Field Validation of Pollutant Measurement Methods from Various Waste Media," **40 CFR part 63, appendix A**.

4. "Molecular Vibrations; The Theory of Infrared and Raman Vibrational Spectra," E. Bright Wilson, J. C. Decius, and P. C. Cross, Dover Publications, Inc., 1980. For a less intensive treatment of molecular rotational-vibrational spectra see, for example, "Physical Chemistry," G. M. Barrow, chapters 12, 13, and 14, McGraw Hill, Inc., 1979.

5. "Fourier Transform Infrared Spectrometry," Peter R. Griffiths and James de Haseth, **Chemical Analysis**, **83**, 16-25,(1986), P. J. Elving, J. D. Winefordner and I. M. Kolthoff (ed.), John Wiley and Sons.

6. "Computer-Assisted Quantitative Infrared Spectroscopy," Gregory L. McClure (ed.), **ASTM Special Publication 934** (ASTM), 1987.

7. "Multivariate Least-Squares Methods Applied to the Quantitative Spectral Analysis of Multicomponent Mixtures," **Applied Spectroscopy**, **39**(10), 73-84, 1985.

Table 1. EXAMPLE PRESENTATION OF SAMPLING DOCUMENTATION.

Sample Time	Spectrum File Name	Background File Name	Sample conditioning	Process condition

Sample Time	Spectrum File	Interferogram	Resolution	Scans	Apodization	Gain	CTS Spectrum

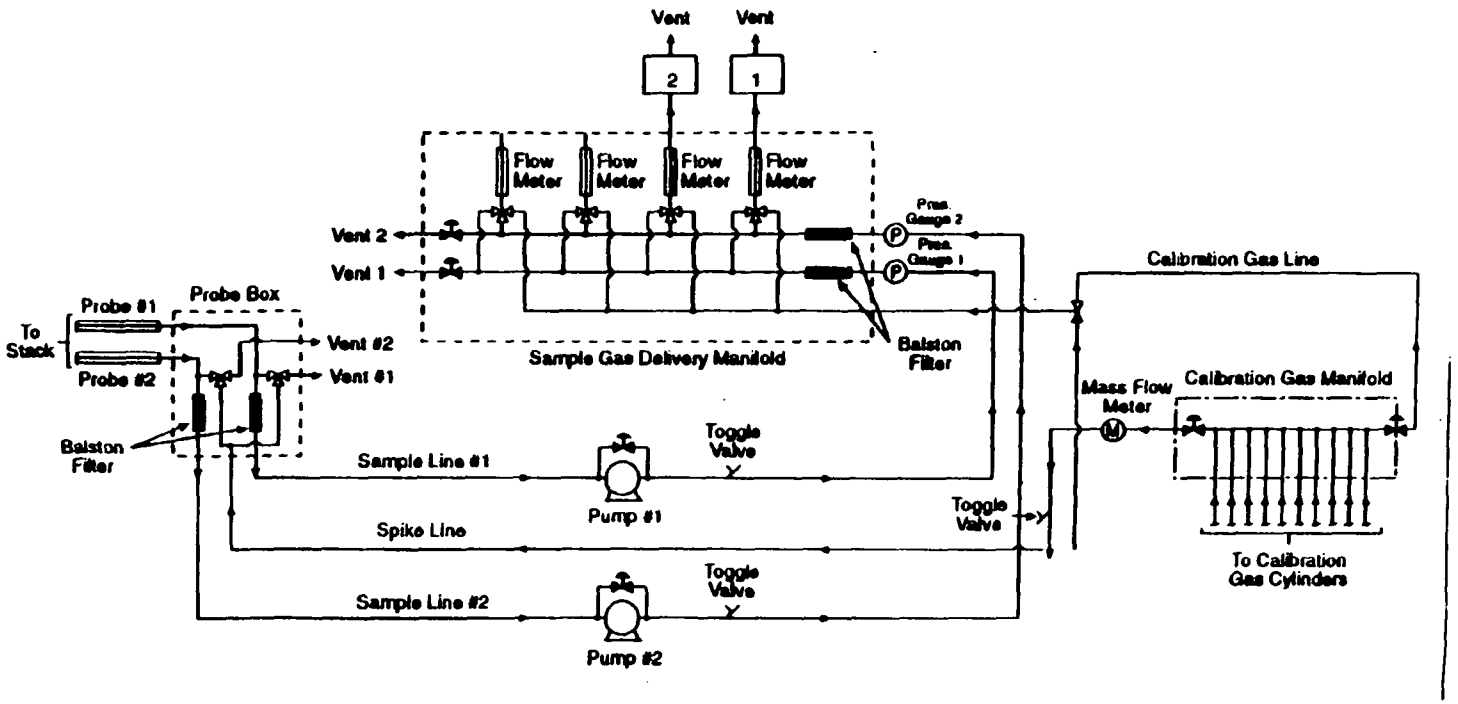

Figure 1. Extractive FTIR sampling system.

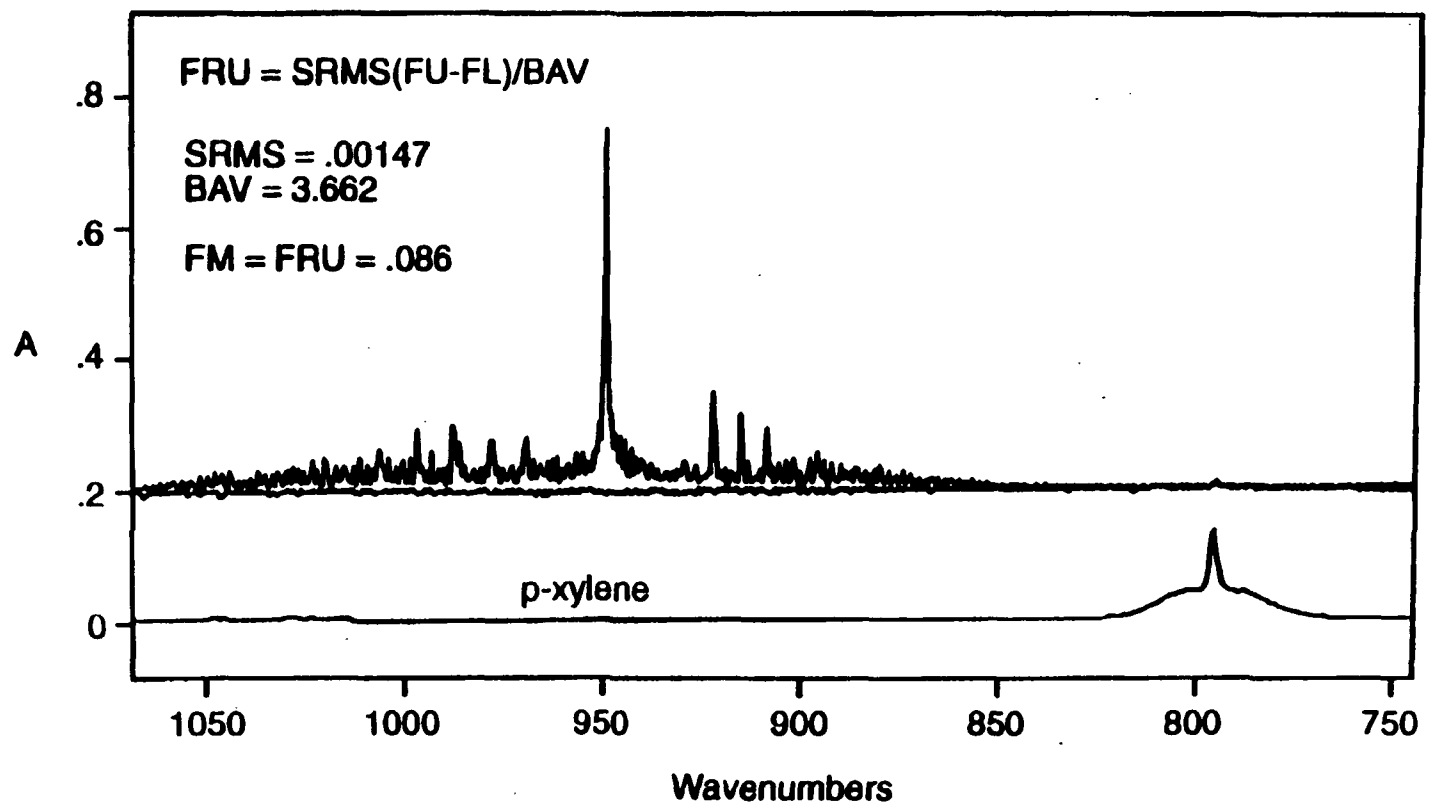

Figure 2. Fractional Reproducibility. Top: average of cts1031a and cts1101b. Bottom: Reference spectrum of p-xylene.

D-2 EPA FTIR PROTOCOL

PROTOCOL FOR THE USE OF EXTRACTIVE FOURIER TRANSFORM INFRARED (FTIR) SPECTROMETRY FOR THE ANALYSES OF GASEOUS EMISSIONS FROM STATIONARY SOURCES

INTRODUCTION

The purpose of this document is to set general guidelines for the use of modern FTIR spectroscopic methods for the analysis of gas samples extracted from the effluent of stationary emission sources. This document outlines techniques for developing and evaluating such methods and sets basic requirements for reporting and quality assurance procedures.

1.0 NOMENCLATURE

1.1 Appendix A lists definitions of the symbols and terms used in this Protocol, many of which have been taken directly from American Society for Testing and Materials (ASTM) publication E 131-90a, entitled "Terminology Relating to Molecular Spectroscopy."

1.2 Except in the case of background spectra or where otherwise noted, the term "spectrum" refers to a double-beam spectrum in units of absorbance vs. wavenumber (cm^{-1}).

1.3 The term "Study" in this document refers to a publication that has been subjected to EPA- or peer-review.

2.0 APPLICABILITY AND ANALYTICAL PRINCIPLE

2.1 Applicability. This Protocol applies to the determination of compound-specific concentrations in single- and multiple-component gas phase samples using double-beam absorption spectroscopy in the mid-infrared band. It does not specifically address other FTIR applications, such as single-beam spectroscopy, analysis of open-path (non-enclosed) samples, and continuous measurement techniques. If multiple spectrometers, absorption cells, or instrumental linewidths are used in such analyses, each distinct operational configuration of the system must be evaluated separately according to this Protocol.

2.2 Analytical Principle.

2.2.1 In the mid-infrared band, most molecules exhibit characteristic gas phase absorption spectra that may be recorded by FTIR systems. Such systems consist of a source of mid-infrared radiation, an interferometer, an enclosed sample cell of known absorption pathlength, an infrared detector, optical elements for the transfer of infrared radiation between components, and gas flow control and measurement components. Adjunct and integral computer systems are used for controlling

the instrument, processing the signal, and for performing both Fourier transforms and quantitative analyses of spectral data.

2.2.2 The absorption spectra of pure gases and of mixtures of gases are described by a linear absorbance theory referred to as Beer's Law. Using this law, modern FTIR systems use computerized analytical programs to quantify compounds by comparing the absorption spectra of known (reference) gas samples to the absorption spectrum of the sample gas. Some standard mathematical techniques used for comparisons are classical least squares, inverse least squares, cross-correlation, factor analysis, and partial least squares. Reference A describes several of these techniques, as well as additional techniques, such as differentiation methods, linear baseline corrections, and non-linear absorbance corrections.

3.0 GENERAL PRINCIPLES OF PROTOCOL REQUIREMENTS

The characteristics that distinguish FTIR systems from gas analyzers used in instrumental gas analysis methods (e.g., EPA Methods 6C and 7E) are: (1) Computers are necessary to obtain and analyze data; (2) chemical concentrations can be quantified using previously recorded infrared reference spectra; and (3) analytical assumptions and results, including possible effects of interfering compounds, can be evaluated after the quantitative analysis. The following general principles and requirements of this Protocol are based on these characteristics.

3.1 Verifiability and Reproducibility of Results. Store all data and document data analysis techniques sufficient to allow an independent agent to reproduce the analytical results from the raw interferometric data.

3.2 Transfer of Reference Spectra. To determine whether reference spectra recorded under one set of conditions (e.g., optical bench, instrumental linewidth, absorption pathlength, detector performance, pressure, and temperature) can be used to analyze sample spectra taken under a different set of conditions, quantitatively compare "calibration transfer standards" (CTS) and reference spectra as described in this Protocol. (Note: The CTS may, but need not, include analytes of interest). To effect this, record the absorption spectra of the CTS (a) immediately before and immediately after recording reference spectra and (b) immediately after recording sample spectra.

3.3 Evaluation of FTIR Analyses. The applicability, accuracy, and precision of FTIR measurements are influenced by a number of interrelated factors, which may be divided into two classes:

3.3.1 Sample-Independent Factors. Examples are system configuration and performance (e.g., detector sensitivity and infrared source output), quality and applicability of reference

absorption spectra, and type of mathematical analyses of the spectra. These factors define the fundamental limitations of FTIR measurements for a given system configuration. These limitations may be estimated from evaluations of the system before samples are available. For example, the detection limit for the absorbing compound under a given set of conditions may be estimated from the system noise level and the strength of a particular absorption band. Similarly, the accuracy of measurements may be estimated from the analysis of the reference spectra.

3.3.2 Sample-Dependent Factors. Examples are spectral interferants (e.g., water vapor and CO_2) or the overlap of spectral features of different compounds and contamination deposits on reflective surfaces or transmitting windows. To maximize the effectiveness of the mathematical techniques used in spectral analysis, identification of interferants (a standard initial step) and analysis of samples (includes effects of other analytical errors) are necessary. Thus, the Protocol requires post-analysis calculation of measurement concentration uncertainties for the detection of these potential sources of measurement error.

4.0 PRE-TEST PREPARATIONS AND EVALUATIONS

Before testing, demonstrate the suitability of FTIR spectrometry for the desired application according to the procedures of this section.

4.1 Identify Test Requirements. Identify and record the test requirements described below in 4.1.1 through 4.1.5. These values set the desired or required goals of the proposed analysis; the description of methods for determining whether these goals are actually met during the analysis comprises the majority of this Protocol.

4.1.1 Analytes (specific chemical species) of interest. Label the analytes from i = 1 to I.

4.1.2 Analytical uncertainty limit (AU_i). The AU_i is the maximum permissible fractional uncertainty of analysis for the ith analyte concentration, expressed as a fraction of the analyte concentration in the sample.

4.1.3 Required detection limit for each analyte (DL_i, ppm). The detection limit is the lowest concentration of an analyte for which its overall fractional uncertainty (OFU_i) is required to be less than its analytical uncertainty limit (AU_i).

4.1.4 Maximum expected concentration of each analyte ($CMAX_i$, ppm).

4.2 Identify Potential Interferants. Considering the chemistry of the process or results of previous Studies, identify potential interferants, i.e., the major effluent constituents and any relatively minor effluent constituents that possess either strong absorption characteristics or strong structural similarities to any analyte of interest. Label them 1 through N_j, where the subscript "j" pertains to potential interferants. Estimate the concentrations of these compounds in the effluent ($CPOT_j$, ppm).

4.3 Select and Evaluate the Sampling System. Considering the source, e.g., temperature and pressure profiles, moisture content, analyte characteristics, and particulate concentration), select the equipment for extracting gas samples. Recommended are a particulate filter, heating system to maintain sample temperature above the dew point for all sample constituents at all points within the sampling system (including the filter), and sample conditioning system (e.g., coolers, water-permeable membranes that remove water or other compounds from the sample, and dilution devices) to remove spectral interferants or to protect the sampling and analytical components. Determine the minimum absolute sample system pressure (P_{min}, mmHg) and the infrared absorption cell volume (V_{SS}, liter). Select the techniques and/or equipment for the measurement of sample pressures and temperatures.

4.4 Select Spectroscopic System. Select a spectroscopic configuration for the application. Approximate the absorption pathlength (L_S', meter), sample pressure (P_S', kPa), absolute sample temperature T_S', and signal integration period (t_{SS}, seconds) for the analysis. Specify the nominal minimum instrumental linewidth (MIL) of the system. Verify that the fractional error at the approximate values P_S' and T_S' is less than one half the smallest value AU_i (see Section 4.1.2).

4.5 Select Calibration Transfer Standards (CTS's). Select CTS's that meet the criteria listed in Sections 4.5.1, 4.5.2, and 4.5.3.

> <u>Note</u>: It may be necessary to choose preliminary analytical regions (see Section 4.7), identify the minimum analyte linewidths, or estimate the system noise level (see Section 4.12) before selecting the CTS. More than one compound may be needed to meet the criteria; if so, obtain separate cylinders for each compound.

4.5.1 The central wavenumber position of each analytical region lies within 25 percent of the wavenumber position of at least one CTS absorption band.

4.5.2 The absorption bands in 4.5.1 exhibit peak absorbances greater than ten times the value RMS_{EST} (see Section 4.12) but less than 1.5 absorbance units.

4.5.3 At least one absorption CTS band within the operating range of the FTIR instrument has an instrument-independent linewidth no greater than the narrowest analyte absorption band; perform and document measurements or cite Studies to determine analyte and CTS compound linewidths.

4.5.4 For each analytical region, specify the upper and lower wavenumber positions (FFU_m and FFL_m, respectively) that bracket the CTS absorption band or bands for the associated analytical region. Specify the wavenumber range, FNU to FNL, containing the absorption band that meets the criterion of Section 4.5.3.

4.5.5 Associate, whenever possible, a single set of CTS gas cylinders with a set of reference spectra. Replacement CTS gas cylinders shall contain the same compounds at concentrations within 5 percent of that of the original CTS cylinders; the entire absorption spectra (not individual spectral segments) of the replacement gas shall be scaled by a factor between 0.95 and 1.05 to match the original CTS spectra.

4.6 Prepare Reference Spectra.

Note: Reference spectra are available in a permanent soft copy from the EPA spectral library on the EMTIC (Emission Measurement Technical Information Center) computer bulletin board; they may be used if applicable.

4.6.1 Select the reference absorption pathlength (L_R) of the cell.

4.6.2 Obtain or prepare a set of chemical standards for each analyte, potential and known spectral interferants, and CTS. Select the concentrations of the chemical standards to correspond to the top of the desired range.

4.6.2.1 Commercially-Prepared Chemical Standards. Chemical standards for many compounds may be obtained from independent sources, such as a specialty gas manufacturer, chemical company, or commercial laboratory. These standards (accurate to within ±2 percent) shall be prepared according to EPA Protocol 1 (see Reference D) or shall be traceable to NIST standards. Obtain from the supplier an estimate of the stability of the analyte concentration; obtain and follow all the supplier's recommendations for recertifying the analyte concentration.

4.6.2.2 Self-Prepared Chemical Standards. Chemical standards may be prepared as follows: Dilute certified commercially prepared chemical gases or pure analytes with ultra-pure carrier (UPC) grade nitrogen according to the barometric and volumetric techniques generally described in Reference A, Section A4.6.

4.6.3 Record a set of the absorption spectra of the CTS {R1}, then a set of the reference spectra at two or more concentrations in duplicate over the desired range (the top of the range must be less than 10 times that of the bottom), followed by a second set of CTS spectra {R2}. (If self-prepared standards are used, see Section 4.6.5 before disposing of any of the standards.) The maximum accepted standard concentration-pathlength product (ASCPP) for each compound shall be higher than the maximum estimated concentration-pathlength products for both analytes and known interferants in the effluent gas. For each analyte, the minimum ASCPP shall be no greater than ten times the concentration-pathlength product of that analyte at its required detection limit.

4.6.4 Permanently store the background and interferograms in digitized form. Document details of the mathematical process for generating the spectra from these interferograms. Record the sample pressure (P_R), sample temperature (T_R), reference absorption pathlength (L_R), and interferogram signal integration period (t_{SR}). Signal integration periods for the background interferograms shall be $\geq t_{SR}$. Values of P_R, L_R, and t_{SR} shall not deviate by more than ±1 percent from the time of recording {R1} to that of recording {R2}.

4.6.5 If self-prepared chemical standards are employed and spectra of only two concentrations are recorded for one or more compounds, verify the accuracy of the dilution technique by analyzing the prepared standards for those compounds with a secondary (non-FTIR) technique as follows:

4.6.5.1 Record the response of the secondary technique to each of the four standards prepared.

4.6.5.2 Perform a linear regression of the response values (dependant variable) versus the accepted standard concentration (ASC) values (independent variable), with the regression constrained to pass through the zero-response, zero ASC point.

4.6.5.3 Calculate the average fractional difference between the actual response values and the regression-predicted values (those calculated from the regression line using the four ASC values as the independent variable).

4.6.5.4 If the average fractional difference value calculated in Section 4.6.5.3 is larger for any compound than the corresponding AU_i, the dilution technique is not sufficiently accurate and the reference spectra prepared are not valid for the analysis.

4.7 Select Analytical Regions. Using the general considerations in Section 7 of Reference A and the spectral characteristics of the analytes and interferants, select the analytical regions for the application. Label them m = 1 to M. Specify the lower, center and upper wavenumber positions of each

analytical region (FL_m, FC_m, and FU_m, respectively). Specify the analytes and interferants which exhibit absorption in each region.

4.8 Determine Fractional Reproducibility Uncertainties. Using Appendix E, calculate the fractional reproducibility uncertainty for each analyte (FRU_i) from a comparison of {R1} and {R2}. If $FRU_i > AU_i$ for any analyte, the reference spectra generated in Section 4.6 are not valid for the application.

4.9 Identify Known Interferants. Using Appendix B, determine which potential interferant affects the analyte concentration determinations. If it does, relabel the potential interferant as "known" interferant, and designate these compounds from k = 1 to K. Appendix B also provides criteria for determining whether the selected analytical regions are suitable.

4.10 Prepare Computerized Analytical Programs.

4.10.1 Choose or devise mathematical techniques (e.g, classical least squares, inverse least squares, cross-correlation, and factor analysis) based on Equation 4 of Reference A that are appropriate for analyzing spectral data by comparison with reference spectra.

4.10.2 Following the general recommendations of Reference A, prepare a computer program or set of programs that analyzes all the analytes and known interferants, based on the selected analytical regions (4.7) and the prepared reference spectra (4.6). Specify the baseline correction technique (e.g., determining the slope and intercept of a linear baseline contribution in each analytical region) for each analytical region, including all relevant wavenumber positions.

4.10.3 Use programs that provide as output [at the reference absorption pathlength (L_R), reference gas temperature (T_R), and reference gas pressure (P_R)] the analyte concentrations, the known interferant concentrations, and the baseline slope and intercept values. If the sample absorption pathlength (L_S), sample gas temperature (T_S) or sample gas pressure (P_S) during the actual sample analyses differ from L_R, T_R, and P_R, use a program or set of programs that applies multiplicative corrections to the derived concentrations to account for these variations, and that provides as output both the corrected and uncorrected values. Include in the report of the analysis (see Section 7.0) the details of any transformations applied to the original reference spectra (e.g., differentiation), in such a fashion that all analytical results may be verified by an independent agent from the reference spectra and data spectra alone.

4.11 Determine the Fractional Calibration Uncertainty. Calculate the fractional calibration uncertainty for each analyte (FCU_i) according to Appendix F, and compare these values to the

fractional uncertainty limits (AU_i; see Section 4.1). If $FCU_i > AU_i$), either the reference spectra or analytical programs for that analyte are unsuitable.

4.12 Verify System Configuration Suitability. Using Appendix C, measure or obtain estimates of the noise level (RMS_{EST}, absorbance) of the FTIR system; alternatively, construct the complete spectrometer system and determine the values RMS_{Sm} using Appendix G. Estimate the minimum measurement uncertainty for each analyte (MAU_i, ppm) and known interferant (MIU_k, ppm) using Appendix D. Verify that (a) $MAU_i < (AU_i)(DL_i)$, $FRU_i < AU_i$, and $FCU_i < AU_i$ for each analyte and that (b) the CTS chosen meets the requirements listed in Section 4.5.

5.0 SAMPLING AND ANALYSIS PROCEDURE

5.1 Analysis System Assembly and Leak-Test. Assemble the analysis system. Allow sufficient time for all system components to reach the desired temperature. Then determine the leak-rate (L_R) and leak volume (V_L), where $V_L = L_R\ t_{SS}$. Leak volumes shall be ≤4 percent of V_{SS}.

5.2 Verify Instrumental Performance. Measure the noise level of the system in each analytical region using the procedure of Appendix G. If any noise level is higher than that estimated for the system in Section 4.12, repeat the calculations of Appendix D and verify that the requirements of Section 4.12 are met; if they are not, adjust or repair the instrument and repeat this section.

5.3 Determine the Sample Absorption Pathlength. Record a background spectrum. Then, fill the absorption cell with CTS at the pressure P_R and record a set of CTS spectra {R3}. Store the background and unscaled CTS single beam interferograms and spectra. Using Appendix H, calculate the sample absorption pathlength (L_S) for each analytical region. The values L_S shall not differ from the approximated sample pathlength L_S' (see Section 4.4) by more than 5 percent.

5.4 Record Sample Spectrum. Connect the sample line to the source. Either evacuate the absorption cell to an absolute pressure below 5 mmHg before extracting a sample from the effluent stream into the absorption cell, or pump at least ten cell volumes of sample through the cell before obtaining a sample. Record the sample pressure P_S. Generate the absorbance spectrum of the sample. Store the background and sample single beam interferograms, and document the process by which the absorbance spectra are generated from these data. (If necessary, apply the spectral transformations developed in Section 5.6.2). The resulting sample spectrum is referred to below as S_S.

Note: Multiple sample spectra may be recorded according to the procedures of Section 5.4 before performing Sections 5.5 and 5.6.

5.5 Quantify Analyte Concentrations. Calculate the unscaled analyte concentrations RUA_i and unscaled interferant concentrations RUI_k using the programs developed in Section 4. To correct for pathlength and pressure variations between the reference and sample spectra, calculate the scaling factor $R_{LPS} = (L_R P_R T_S)/(L_S P_S T_R)$. Calculate the final analyte and interferant concentrations $RSA_i = R_{LPS} RUA_i$ and $RSI_k = R_{LPS} RUI_k$.

5.6 Determine Fractional Analysis Uncertainty. Fill the absorption cell with CTS at the pressure P_S. Record a set of CTS spectra {R4}. Store the background and CTS single beam interferograms. Using Appendix H, calculate the fractional analysis uncertainty (FAU) for each analytical region. If the FAU indicated for any analytical region is larger than the required accuracy requirements determined in Section 4.1, then comparisons to previously recorded reference spectra are invalid in that analytical region, and the analyst shall perform one or both of the following procedures:

5.6.1 Perform instrumental checks and adjust the instrument to restore its performance to acceptable levels. If adjustments are made, repeat Sections 5.3, 5.4 (except for the recording of a sample spectrum), and 5.5 to demonstrate that acceptable uncertainties are obtained in all analytical regions.

5.6.2 Apply appropriate mathematical transformations (e.g., frequency shifting, zero-filling, apodization, smoothing) to the spectra (or to the interferograms upon which the spectra are based) generated during the performance of the procedures of Section 5.3. Document these transformations and their reproducibility. Do not apply multiplicative scaling of the spectra, or any set of transformations that is mathematically equivalent to multiplicative scaling. Different transformations may be applied to different analytical regions. Frequency shifts shall be smaller than one-half the minimum instrumental linewidth, and must be applied to all spectral data points in an analytical region. The mathematical transformations may be retained for the analysis if they are also applied to the appropriate analytical regions of all sample spectra recorded, and if all original sample spectra are digitally stored. Repeat Sections 5.3, 5.4 (except the recording of a sample spectrum), and 5.5 to demonstrate that these transformations lead to acceptable calculated concentration uncertainties in all analytical regions.

6.0 POST-ANALYSIS EVALUATIONS

Estimate the overall accuracy of the analyses performed in Section 5 as follows:

6.1 Qualitatively Confirm the Assumed Matrix. Examine each analytical region of the sample spectrum for spectral evidence of unexpected or unidentified interferants. If found, identify the interfering compounds (see Reference C for guidance) and add them to the list of known interferants. Repeat the procedures of Section 4 to include the interferants in the uncertainty calculations and analysis procedures. Verify that the MAU and FCU values do not increase beyond acceptable levels for the application requirements. Re-calculate the analyte concentrations (Section 5.5) in the affected analytical regions.

6.2 Quantitatively Evaluate Fractional Model Uncertainty (FMU). Perform the procedures of either Section 6.2.1 or 6.2.2:

6.2.1 Using Appendix I, determine the fractional model error (FMU) for each analyte.

6.2.2 Provide statistically determined uncertainties FMU for each analyte which are equivalent to two standard deviations at the 95% confidence level. Such determinations, if employed, must be based on mathematical examinations of the pertinent sample spectra (not the reference spectra alone). Include in the report of the analysis (see Section 7.0) a complete description of the determination of the concentration uncertainties.

6.3 Estimate Overall Concentration Uncertainty (OCU). Using Appendix J, determine the overall concentration uncertainty (OCU) for each analyte. If the OCU is larger than the required accuracy for any analyte, repeat Sections 4 and 6.

7.0 REPORTING REQUIREMENTS

[Documentation pertaining to virtually all the procedures of Sections 4, 5, and 6 will be required. Software copies of reference spectra and sample spectra will be retained for some minimum time following the actual testing.]

8.0 REFERENCES

A) Standard Practices for General Techniques of Infrared Quantitative Analysis (American Society for Testing and Materials, Designation E 168-88).

B) The Coblentz Society Specifications for Evaluation of Research Quality Analytical Infrared Reference Spectra (Class II); Anal. Chemistry 47, 945A (1975); Appl. Spectroscopy 44, pp. 211-215, 1990.

C) Standard Practices for General Techniques for Qualitative Infrared Analysis, American Society for Testing and Materials, Designation E 1252-88.

D) "Traceability Protocol for Establishing True Concentrations of Gases Used for Calibration and Audits of Continuous Emissions Monitors (Protocol Number 1)," June 1978, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods, EPA-600/4-77-027b, August 1977.

APPENDIX A

DEFINITIONS OF TERMS AND SYMBOLS

A.1 Definitions of Terms

absorption band - a contiguous wavenumber region of a spectrum (equivalently, a contiguous set of absorbance spectrum data points) in which the absorbance passes through a maximum or a series of maxima.

absorption pathlength - in a spectrophotometer, the distance, measured in the direction of propagation of the beam of radiant energy, between the surface of the specimen on which the radiant energy is incident and the surface of the specimen from which it is emergent.

analytical region - a contiguous wavenumber region (equivalently, a contiguous set of absorbance spectrum data points) used in the quantitative analysis for one or more analyte.

Note: The quantitative result for a single analyte may be based on data from more than one analytical region.

apodization - modification of the ILS function by multiplying the

interferogram by a weighing function whose magnitude varies with retardation.

background spectrum - the single beam spectrum obtained with all system components without sample present.

baseline - any line drawn on an absorption spectrum to establish a reference point that represents a function of the radiant power incident on a sample at a given wavelength.

Beers's law - the direct proportionality of the absorbance of a compound in a homogeneous sample to its concentration.

calibration transfer standard (CTS) gas - a gas standard of a compound used to achieve and/or demonstrate suitable quantitative agreement between sample spectra and the reference spectra; see Section 4.5.1.

compound - a substance possessing a distinct, unique molecular structure.

concentration (c) - the quantity of a compound contained in a unit quantity of sample. The unit "ppm" (number, or mole, basis) is recommended.

concentration-pathlength product - the mathematical product of concentration of the species and absorption pathlength. For

reference spectra, this is a known quantity; for sample spectra, it is the quantity directly determined from Beer's law. The units "centimeters-ppm" or "meters-ppm" are recommended.

derivative absorption spectrum - a plot of rate of change of absorbance or of any function of absorbance with respect to wavelength or any function of wavelength.

double beam spectrum - a transmission or absorbance spectrum derived by dividing the sample single beam spectrum by the background spectrum.

Note: The term "double-beam" is used elsewhere to denote a spectrum in which the sample and background interferograms are collected simultaneously along physically distinct absorption paths. Here, the term denotes a spectrum in which the sample and background interferograms are collected at different times along the same absorption path.

fast Fourier transform (FFT) - a method of speeding up the computation of a discrete FT by factoring the data into sparse matrices containing mostly zeros.

flyback - interferometer motion during which no data are recorded.

Fourier transform (FT) - the mathematical process for converting an amplitude-time spectrum to an amplitude-frequency spectrum, or vice versa.

Fourier transform infrared (FTIR) spectrometer - an analytical system that employs a source of mid-infrared radiation, an interferometer, an enclosed sample cell of known absorption pathlength, an infrared detector, optical elements that transfer infrared radiation between components, and a computer system. The time-domain detector response (interferogram) is processed by a Fourier transform to yield a representation of the detector response vs. infrared frequency.

Note: When FTIR spectrometers are interfaced with other instruments, a slash should be used to denote the interface; e.g., GC/FTIR; HPCL/FTIR, and the use of FTIR should be explicit; i.e., FTIR not IR.

frequency, ν - the number of cycles per unit time.

infrared - the portion of the electromagnetic spectrum containing wavelengths from approximately 0.78 to 800 microns.

interferogram, $I(\sigma)$ - record of the modulated component of the interference signal measured as a function of retardation by the detector.

interferometer - device that divides a beam of radiant energy into two or more paths, generate an optical path difference between the beams, and recombines them in order to produce repetitive interference maxima and minima as the optical retardation is varied.

linewidth - the full width at half maximum of an absorption band in units of wavenumbers (cm^{-1}).

mid-infrared - the region of the electromagnetic spectrum from approximately 400 to 5000 cm^{-1}.

pathlength - see "absorption pathlength."

reference spectra - absorption spectra of gases with known chemical compositions, recorded at a known absorption pathlength, which are used in the quantitative analysis of gas samples.

retardation, σ - optical path difference between two beams in an interferometer; also known as "optical path difference" or "optical retardation."

scan - digital representation of the detector output obtained during one complete motion of the interferometer's moving assembly or assemblies.

scaling - application of a multiplicative factor to the absorbance values in a spectrum.

single beam spectrum - Fourier-transformed interferogram, representing the detector response vs. wavenumber.

Note: The term "single-beam" is used elsewhere to denote any spectrum in which the sample and background interferograms are recorded on the same physical absorption path; such usage differentiates such spectra from those generated using interferograms recorded along two physically distinct absorption paths (see "double-beam spectrum" above). Here, the term applies (for example) to the two spectra used directly in the calculation of transmission and absorbance spectra of a sample.

standard reference material - a reference material, the composition or properties of which are certified by a recognized standardizing agency or group.

Note: The equivalent ISO term is "certified reference material."

transmittance, T - the ratio of radiant power transmitted by the sample to the radiant power incident on the sample. Estimated in FTIR spectroscopy by forming the ratio of the single-beam sample and background spectra.

wavenumber, $\bar{v}$ - the number of waves per unit length.

Note: The usual unit of wavenumber is the reciprocal centimeter, cm^{-1}. The wavenumber is the reciprocal of the wavelength, λ, when λ is expressed in centimeters.

zero-filling - the addition of zero-valued points to the end of a measured interferogram.

Note: Performing the FT of a zero-filled interferogram results in correctly interpolated points in the computed spectrum.

A.2 Definitions of Mathematical Symbols

A, absorbance - the logarithm to the base 10 of the reciprocal of the transmittance (T).

$$A = \log_{10}\left(\frac{1}{T}\right) = -\log_{10}T \qquad (1)$$

AAI_{im} - band area of the ith analyte in the mth analytical region, at the concentration (CL_i) corresponding to the product of its required detection limit (DL_i) and analytical uncertainty limit (AU_i) .

AAV_{im} - average absorbance of the ith analyte in the mth analytical region, at the concentration (CL_i) corresponding to the product of its required detection limit (DL_i) and analytical uncertainty limit (AU_i) .

ASC, accepted standard concentration - the concentration value assigned to a chemical standard.

ASCPP, accepted standard concentration-pathlength product - for a chemical standard, the product of the ASC and the sample absorption pathlength. The units "centimeters-ppm" or "meters-ppm" are recommended.

AU_i, analytical uncertainty limit - the maximum permissible fractional uncertainty of analysis for the ith analyte concentration, expressed as a fraction of the analyte concentration determined in the analysis.

AVT_m - average estimated total absorbance in the mth analytical region.

$CKWN_k$ - estimated concentration of the kth known interferant.

$CMAX_i$ - estimated maximum concentration of the ith analyte.

$CPOT_j$ - estimated concentration of the jth potential interferant.

DL_i, **required detection limit** - for the ith analyte, the lowest concentration of the analyte for which its overall fractional uncertainty (OFU_i) is required to be less than the analytical uncertainty limit (AU_i).

FC_m - center wavenumber position of the mth analytical region.

FAU_i, **fractional analytical uncertainty** - calculated uncertainty in the measured concentration of the ith analyte because of errors in the mathematical comparison of reference and sample spectra.

FCU_i, **fractional calibration uncertainty** - calculated uncertainty in the measured concentration of the ith analyte because of errors in Beer's law modeling of the reference spectra concentrations.

FFL_m - lower wavenumber position of the CTS absorption band associated with the mth analytical region.

FFU_m - upper wavenumber position of the CTS absorption band associated with the mth analytical region.

FL_m - lower wavenumber position of the mth analytical region.

FMU_i, **fractional model uncertainty** - calculated uncertainty in the measured concentration of the ith analyte because of errors in the absorption model employed.

FN_L - lower wavenumber position of the CTS spectrum containing an absorption band at least as narrow as the analyte absorption bands.

FN_U - upper wavenumber position of the CTS spectrum containing an absorption band at least as narrow as the analyte absorption bands.

FRU_i, **fractional reproducibility uncertainty** - calculated uncertainty in the measured concentration of the ith analyte because of errors in the reproducibility of spectra from the FTIR system.

FU_m - upper wavenumber position of the mth analytical region.

IAI_{jm} - band area of the jth potential interferant in the mth analytical region, at its expected concentration ($CPOT_j$).

IAV_{im} - average absorbance of the ith analyte in the mth analytical region, at its expected concentration ($CPOT_j$).

$ISC_{i \text{ or } k}$, indicated standard concentration - the concentration from the computerized analytical program for a single-compound reference spectrum for the ith analyte or k^{th} known interferant.

kPa - kilo-Pascal (see Pascal).

L_S' - estimated sample absorption pathlength.

L_R - reference absorption pathlength.

L_S - actual sample absorption pathlength.

MAU_i - mean of the MAU_{im} over the appropriate analytical regions.

MAU_{im}, minimum analyte uncertainty - the calculated minimum concentration for which the analytical uncertainty limit (AU_i) in the measurement of the ith analyte, based on spectral data in the mth analytical region, can be maintained.

MIU_j - mean of the MIU_{jm} over the appropriate analytical regions.

MIU_{jm}, minimum interferant uncertainty - the calculated minimum concentration for which the analytical uncertainty limit $CPOT_j/20$ in the measurement of the jth interferant, based on spectral data in the mth analytical region, can be maintained.

MIL, minimum instrumental linewidth - the minimum linewidth from the FTIR system, in wavenumbers.

<u>Note</u>: The MIL of a system may be determined by observing an absorption band known (through higher resolution examinations) to be narrower than indicated by the system. The MIL is fundamentally limited by the retardation of the interferometer, but is also affected by other operational parameters (e.g., the choice of apodization).

N_i - number of analytes.

N_j - number of potential interferants.

N_k - number of known interferants.

N_{scan} - the number of scans averaged to obtain an interferogram.

OFU_i - the overall fractional uncertainty in an analyte concentration determined in the analysis ($OFU_i = MAX\{FRU_i, FCU_i, FAU_i, FMU_i\}$).

Pascal (Pa) - metric unit of static pressure, equal to one Newton per square meter; one atmosphere is equal to 101,325 Pa;

1/760 atmosphere (one Torr, or one millimeter Hg) is equal to 133.322 Pa.

P_{min} - minimum pressure of the sampling system during the sampling procedure.

P_S' - estimated sample pressure.

P_R - reference pressure.

P_S - actual sample pressure.

RMS_{Sm} - measured noise level of the FTIR system in the mth analytical region.

RMSD, root mean square difference - a measure of accuracy determined by the following equation:

$$RMSD = \sqrt{\left(\frac{1}{n}\right) \sum_{i=1}^{n} e_i^2} \qquad (2)$$

where:

n = the number of observations for which the accuracy is determined.

e_i = the difference between a measured value of a property and its mean value over the n observations.

<u>Note</u>: The RMSD value "between a set of n contiguous absorbance values (A_i) and the mean of the values" (A_M) is defined as

$$RMSD = \sqrt{\left(\frac{1}{n}\right) \sum_{i=1}^{n} (A_i - A_M)^2} \qquad (3)$$

RSA_i - the (calculated) final concentration of the ith analyte.

RSI_k - the (calculated) final concentration of the kth known interferant.

t_{scan}, **scan time** - time used to acquire a single scan, not including flyback.

t_S, **signal integration period** - the period of time over which an interferogram is averaged by addition and scaling of individual scans. In terms of the number of scans N_{scan} and scan time t_{scan}, $t_S = N_{scan} t_{scan}$.

t_{SR} - signal integration period used in recording reference spectra.

t_{SS} - signal integration period used in recording sample spectra.

T_R - absolute temperature of gases used in recording reference spectra.

T_S - absolute temperature of sample gas as sample spectra are recorded.

TP, Throughput - manufacturer's estimate of the fraction of the total infrared power transmitted by the absorption cell and transfer optics from the interferometer to the detector.

V_{SS} - volume of the infrared absorption cell, including parts of attached tubing.

W_{ik} - weight used to average over analytical regions k for quantities related to the analyte i; see Appendix D.

Note that some terms are missing, e.g., BAV_m, OCU, $RMSS_m$, SUB_S, SIC_i, SAC_i, S_S

APPENDIX B

IDENTIFYING SPECTRAL INTERFERANTS

B.1 General

B.1.1 Assume a fixed absorption pathlength equal to the value L_S'.

B.1.2 Use band area calculations to compare the relative absorption strengths of the analytes and potential interferants. In the mth analytical region (FL_m to FU_m), use either rectangular or trapezoidal approximations to determine the band areas described below (see Reference A, Sections A.3.1 through A.3.3); document any baseline corrections applied to the spectra.

B.1.3 Use the average total absorbance of the analytes and potential interferants in each analytical region to determine whether the analytical region is suitable for analyte concentration determinations.

> Note: The average absorbance in an analytical region is the band area divided by the width of the analytical region in wavenumbers. The average total absorbance in an analytical region is the sum of the average absorbances of all analytes and potential interferants.

B.2 Calculations

B.2.1 Prepare spectral representations of each analyte at the concentration $CL_i = (DL_i)(AU_i)$, where DL_i is the required detection limit and AU_i is the maximum permissible analytical uncertainty. For the mth analytical region, calculate the band area (AAI_{im}) and average absorbance (AAV_{im}) from these scaled analyte spectra.

B.2.2 Prepare spectral representations of each potential interferant at its expected concentration ($CPOT_j$). For the mth analytical region, calculate the band area (IAI_{jm}) and average absorbance (IAV_{jm}) from these scaled potential interferant spectra.

B.2.3 Repeat the calculation for each analytical region, and record the band area results in matrix form as indicated in Figure B.1.

B.2.4 If the band area of any potential interferant in an analytical region is greater than the one-half the band area of any analyte (i.e., $IAI_{jm} > 0.5\ AAI_{im}$ for any pair ij and any m), classify the potential interferant as known interferant. Label the known interferants k = 1 to K. Record the results in matrix form as indicated in Figure B.2.

B.2.5 Calculate the average total absorbance (AVT_m) for each analytical region and record the values in the last row of the matrix described in Figure B.2. Any analytical region where AVT_m >2.0 is unsuitable.

FIGURE B.1 Presentation of Potential Interferant Calculations

	Analytical Regions 1 . . . . . M
Analyte Labels	
1	AAI_{11} . . . . AAI_{1M}
.	. .
.	. .
I	AAI_{I1} . . . . AAI_{IM}
Potential Interferant Labels	
1	IAI_{11} . . . . IAI_{1M}
.	. .
.	. .
J	IAI_{J1} . . . . IAI_{JM}

FIGURE B.2 Presentation of Known Interferant Calculations

	Analytical Regions 1 . . . . . M
Analyte Labels	
1	AAI_{11} . . . . . AAI_{1M}
.	. .
.	. .
I	AAI_{I1} . . . . . AAI_{IM}
Known Interferant Labels	
1	IAI_{11} . . . . . IAI_{1M}
.	. .
.	. .
K	IAI_{K1} . . . . . IAI_{KM}
Total Average Absorbance	AVT_1 AVT_M

APPENDIX C

ESTIMATING NOISE LEVELS

C.1 General

C.1.1 The root-mean-square (RMS) noise level is the standard measure of noise in this Protocol. The RMS noise level of a contiguous segment of a spectrum is defined as the RMS difference (RMSD) between the absorbance values which form the segment and the mean value of that segment (see Appendix A).

C.1.2 The RMS noise value in double-beam absorbance spectra is assumed to be inversely proportional to: (a) the square root of the signal integration period of the sample single beam spectra from which it is formed, and (b) to the total infrared power transmitted through the interferometer and absorption cell.

C.1.3 Practically, the assumption of C.1.2 allow the RMS noise level of a complete system to be estimated from the following four quantities:

(a) RMS_{MAN} - the noise level of the system (in absorbance units), without the absorption cell and transfer optics, <u>under those conditions necessary to yield the specified minimum instrumental linewidth</u>, e.g., Jacquinot stop size.

(b) t_{MAN} - the manufacturer's signal integration time used to determine RMS_{MAN}.

(c) t_{SS} - the signal integration time for the analyses.

(d) TP - the manufacturer's estimate of the fraction of the total infrared power transmitted by the absorption cell and transfer optics from the interferometer to the detector.

C.2 Calculations

C.2.1 Obtain the values of RMS_{MAN}, t_{MAN}, and TP from the manufacturers of the equipment, or determine the noise level by direct measurements with the completely constructed system proposed in Section 4.

C.2.2 Calculate the noise value of the system (RMS_{EST}) as follows:

$$RMS_{EST} = RMS_{MAN} \; TP \sqrt{\frac{t_{ss}}{t_{MAN}}} \qquad (4)$$

APPENDIX D

ESTIMATING MINIMUM CONCENTRATION MEASUREMENT UNCERTAINTIES (MAU and MIU)

D.1 General

Estimate the minimum concentration measurement uncertainties for the ith analyte (MAU_i) and j^{th} interferant (MIU_j) based on the spectral data in the mth analytical region by comparing the analyte band area in the analytical region (AAI_{im}) and estimating or measuring the noise level of the system (RMS_{EST} or RMS_{Sm}).

Note: For a single analytical region, the MAU or MIU value is the concentration of the analyte or interferant for which the band area is equal to the product of the analytical region width (in wavenumbers) and the noise level of the system (in absorbance units). If data from more than one analytical region is used in the determination of an analyte concentration, the MAU or MIU is the mean of the separate MAU or MIU values calculated for each analytical region.

D.2 Calculations

D.2.1 For each analytical region, set RMS = RMS_{Sm} if measured (Appendix G), or set RMS = RMS_{EST} if estimated (Appendix C).

D.2.2 For each analyte associated with the analytical region, calculate

$$MAU_{im} = (RMS)(DL_i)(AU_i)\frac{(FU_m - FL_m)}{AAI_{im}} \qquad (5)$$

D.2.3 If only the mth analytical region is used to calculate the concentration of the ith analyte, set $MAU_i = MAU_{im}$.

D.2.4 If a number of analytical regions are used to calculate the concentration of the ith analyte, set MAU_i equal to the weighted mean of the appropriate MAU_{im} values calculated above; the weight for each term in the mean is equal to the fraction of the total wavenumber range used for the calculation represented by each analytical region. Mathematically, if the set of analytical regions employed is $\{m'\}$, then the MAU for each analytical region is

$$MAU_i = \sum_{k \in \{m'\}} W_{ik} \; MAU_{ik} \tag{6}$$

where the weight W_{ik} is defined for each term in the sum as

$$W_{ik} = (FM_k - FL_k)\left(\sum_{p \in \{m'\}} [FM_p - FL_p]\right)^{-1} \tag{7}$$

D.2.5 Repeat Sections D.2.1 through D.2.4 to calculate the analogous values MIU_j for the interferants j = 1 to J. Replace the value $(AU_i)(DL_i)$ in the above equations with $CPOT_j/20$; replace the value AAI_{im} in the above equations with IAI_{jm}.

APPENDIX E

DETERMINING FRACTIONAL REPRODUCIBILITY UNCERTAINTIES (FRU)

E.1 General

To estimate the reproducibility of the spectroscopic results of the system, compare the CTS spectra recorded before and after preparing the reference spectra. Compare the difference between the spectra to their average band area. Perform the calculation for each analytical region on the portions of the CTS spectra associated with that analytical region.

E.2 Calculations

E.2.1 The CTS spectra {R1} consist of N spectra, denoted by S_{1i}, i=1, N. Similarly, the CTS spectra {R2} consist of N spectra, denoted by S_{2i}, i=1, N. Each S_{ki} is the spectrum of a single compound, where i denotes the compound and k denotes the set {Rk} of which S_{ki} is a member. Form the spectra S_3 according to $S_{3i} = S_{2i}-S_{1i}$ for each i. Form the spectra S_4 according to $S_{4i} = [S_{2i}+S_{1i}]/2$ for each i.

E.2.2 Each analytical region m is associated with a portion of the CTS spectra S_{2i} and S_{1i}, for a particular i, with lower and upper wavenumber limits FFL_m and FFU_m, respectively.

E.2.3 For each m and the associated i, calculate the band area of S_{4i} in the wavenumber range FFU_m to FFL_m. Follow the guidelines of Section B.1.2 for this band area calculation. Denote the result by BAV_m.

E.2.4 For each m and the associated i, calculate the RMSD of S_{3i} between the absorbance values and their mean in the wavenumber range FFU_m to FFL_m. Denote the result by $SRMS_m$.

E.2.5 For each analytical region m, calculate the quantity

$$FM_m = SRMS_m(FFU_m - FFL_m)/BAV_m$$

E.2.6 If only the mth analytical region is used to calculate the concentration of the ith analyte, set $FRU_i = FM_m$.

E.2.7 If a number p_i of analytical regions are used to calculate the concentration of the ith analyte, set FRU_i equal to the weighted mean of the appropriate FM_m values calculated above. Mathematically, if the set of analytical regions employed is {m'}, then

$$FRU_i = \sum_{k \in \{m'\}} W_{ik} FM_k \qquad (8)$$

where the W_{ik} are calculated as described in Appendix D.

APPENDIX F

DETERMINING FRACTIONAL CALIBRATION UNCERTAINTIES (FCU)

F.1 General

F.1.1 The concentrations yielded by the computerized analytical program applied to each single-compound reference spectrum are defined as the indicated standard concentrations (ISC's). The ISC values for a single compound spectrum should ideally equal the accepted standard concentration (ASC) for one analyte or interferant, and should ideally be zero for all other compounds. Variations from these results are caused by errors in the ASC values, variations from the Beer's law (or modified Beer's law) model used to determine the concentrations, and noise in the spectra. When the first two effects dominate, the systematic nature of the errors is often apparent; take steps to correct them.

F.1.2 When the calibration error appears non-systematic, apply the following method to estimate the fractional calibration uncertainty (FCU) for each compound. The FCU is defined as the mean fractional error between the ASC and the ISC for all reference spectra with non-zero ASC for that compound. The FCU for each compound shall be less than the required fractional uncertainty specified in Section 4.1.

F.1.3 The computerized analytical programs shall also be required to yield acceptably low concentrations for compounds with ISC=0 when applied to the reference spectra. The limits chosen in this Protocol are that the ISC of each reference spectrum for each analyte or interferant shall not exceed that compound's minimum measurement uncertainty (MAU or MIU).

F.2 Calculations

F.2.1 Apply each analytical program to each reference spectrum. Prepare a similar table as that in Figure F.1 to present the ISC and ASC values for each analyte and interferant in each reference spectrum. Maintain the order of reference file names and compounds employed in preparing Figure F.1.

F.2.2 For all reference spectra in Figure F.1, verify that the absolute value of the ISC's are less than the compound's MAU (for analytes) or MIU (for interferants).

F.2.3 For each analyte reference spectrum, calculate the quantity (ASC-ISC)/ASC. For each analyte, calculate the mean of these values (the FCU_i for the ith analyte) over all reference spectra. Prepare a similar table as that in Figure F.2 to present the FCU_i and analytical uncertainty limit (AU_i) for each analyte.

FIGURE F.1

Presentation of Accepted Standard Concentrations (ASC's)
and Indicated Standard Concentrations (ISC's)

Compound Name	Reference Spectrum File Name	ASC (ppm)	ISC (ppm) Analytes i=1.....I			Interferants j=1.....J		

FIGURE F.2

Presentation of Fractional Calibration Uncertainties (FCU's)
and Analytical Uncertainties (AU's)

Analyte Name	FCU (%)	AU (%)

APPENDIX G

MEASURING NOISE LEVELS

G.1 General

The root-mean-square (RMS) noise level is the standard measure of noise. The RMS noise level of a contiguous segment of a spectrum is the RMSD between the absorbance values that form the segment and the mean value of the segment (see Appendix A).

G.2 Calculations

G.2.1 Evacuate the absorption cell or fill it with UPC grade nitrogen at approximately one atmosphere total pressure.

G.2.2 Record two single beam spectra of signal integration period t_{SS}.

G.2.3 Form the double beam absorption spectrum from these two single beam spectra, and calculate the noise level RMS_{Sm} in the M analytical regions.

APPENDIX H

DETERMINING SAMPLE ABSORPTION PATHLENGTH (L_S) AND FRACTIONAL ANALYTICAL UNCERTAINTY (FAU)

H.1 General

Reference spectra recorded at absorption pathlength (L_R), gas pressure (P_R), and gas absolute temperature (T_R) may be used to determine analyte concentrations in samples whose spectra are recorded at conditions different from that of the reference spectra, i.e., at absorption pathlength (L_S), absolute temperature (T_S), and pressure (P_S). Appendix H describes the calculations for estimating the fractional uncertainty (FAU) of this practice. It also describes the calculations for determining the sample absorption pathlength from comparison of CTS spectra, and for preparing spectra for further instrumental and procedural checks.

H.1.1 Before sampling, determine the sample absorption pathlength using least squares analysis. Determine the ratio L_S/L_R by comparing the spectral sets {R1} and {R3}, which are recorded using the same CTS at L_S and L_R, and T_S and T_R, but both at P_R.

H.1.2 Determine the fractional analysis uncertainty (FAU) for each analyte by comparing a scaled CTS spectral set, recorded at L_S, T_S, and P_S, to the CTS reference spectra of the same gas, recorded at L_R, T_R, and P_R. Perform the quantitative comparison after recording the sample spectra, based on band areas of the spectra in the CTS absorbance band associated with each analyte.

H.2 Calculations

H.2.1 Absorption Pathlength Determination. Perform and document separate linear baseline corrections to each analytical region in the spectral sets {R1} and {R3}. Form a one-dimensional array $\mathbf{A}_R$ containing the absorbance values from all segments of {R1} that are associated with the analytical regions; the members of the array are A_{Ri}, i = 1, n. Form a similar one-dimensional array $\mathbf{A}_S$ from the absorbance values in the spectral set {R3}; the members of the array are A_{Si}, i = 1, n. Based on the model $\mathbf{A}_S = r\mathbf{A}_R + \mathbf{E}$, determine the least-squares estimate of r', the value of r which minimizes the square error $\mathbf{E}^2$. Calculate the sample absorption pathlength $L_S = r'(T_S/T_R)L_R$.

H.2.2 Fractional Analysis Uncertainty. Perform and document separate linear baseline corrections to each analytical region in the spectral sets {R1} and {R4}. Form the arrays $\mathbf{A}_S$ and $\mathbf{A}_R$ as described in Section H.2.1, using values from {R1} to form $\mathbf{A}_R$, and values from {R4} to form $\mathbf{A}_S$. Calculate the values

$$NRMS_E = \sqrt{\sum_{i=1}^{n}\left[A_{Si} - \left(\frac{T_R}{T_S}\right)\left(\frac{L_S}{L_R}\right)\left(\frac{P_S}{P_R}\right)A_{Ri}\right]^2} \tag{9}$$

and

$$IA_{AV} = \frac{1}{2}\sum_{i=1}^{n}\left[A_{Si} + \left(\frac{T_R}{T_S}\right)\left(\frac{L_S}{L_R}\right)\left(\frac{P_S}{P_R}\right)A_{Ri}\right] \tag{10}$$

The fractional analytical uncertainty is defined as

$$FAU = \frac{NRMS_E}{IA_{AV}} \tag{11}$$

APPENDIX I

DETERMINING FRACTIONAL MODEL UNCERTAINTIES (FMU)

I.1 General

To prepare analytical programs for FTIR analyses, the sample constituents must first be assumed; the calculations in this appendix, based upon a simulation of the sample spectrum, verify the appropriateness of these assumptions. The simulated spectra consist of the sum of single compound reference spectra scaled to represent their contributions to the sample absorbance spectrum; scaling factors are based on the indicated standard concentrations (ISC) and measured (sample) analyte and interferant concentrations, the sample and reference absorption pathlengths, and the sample and reference gas pressures. No band-shape correction for differences in the temperature of the sample and reference spectra gases is made; such errors are included in the FMU estimate. The actual and simulated sample spectra are quantitatively compared to determine the fractional model uncertainty; this comparison uses the reference spectra band areas and residuals in the difference spectrum formed from the actual and simulated sample spectra.

I.2 Calculations

I.2.1 For each analyte (with scaled concentration RSA_i), select a reference spectrum SA_i with indicated standard concentration ISC_i. Calculate the scaling factors

$$RA_i = \frac{T_R\, L_S\, P_S\, RSA_i}{T_S\, L_R\, P_R\, ISC_i} \qquad (12)$$

and form the spectra SAC_i by scaling each SA_i by the factor RA_i.

I.2.2 For each interferant, select a reference spectrum SI_k with indicated standard concentration ISC_k. Calculate the scaling factors

$$RI_k = \frac{T_R\, L_S\, P_S\, RSI_k}{T_S\, L_R\, P_R\, ISC_k} \qquad (13)$$

and form the spectra SIC_k by scaling each SI_k by the factor RI_k.

I.2.3 For each analytical region, determine by visual inspection which of the spectra SAC_i and SIC_k exhibit absorbance bands within the analytical region. Subtract each spectrum SAC_i

and SIC_k exhibiting absorbance from the sample spectrum S_S to form the spectrum SUB_S. To save analysis time and to avoid the introduction of unwanted noise into the subtracted spectrum, it is recommended that the calculation be made (1) only for those spectral data points within the analytical regions, and (2) for each analytical region separately using the original spectrum S_S.

I.2.4 For each analytical region m, calculate the RMSD of SUB_S between the absorbance values and their mean in the region FFU_m to FFL_m. Denote the result by $RMSS_m$.

I.2.5 For each analyte i, calculate the quantity

$$FM_m = \frac{RMSS_m (FFU_m - FFL_m) AU_i DL_i}{AAI_i RSA_i} \tag{14}$$

for each analytical region associated with the analyte.

I.2.6 If only the mth analytical region is used to calculate the concentration of the ith analyte, set $FMU_i = FM_m$.

I.2.7 If a number of analytical regions are used to calculate the concentration of the ith analyte, set FM_i equal to the weighted mean of the appropriate FM_m values calculated above. Mathematically, if the set of analytical regions employed is $\{m'\}$, then

$$FMU_i = \sum_{k \in \{m'\}} W_{ik} FM_k \tag{15}$$

where W_{ik} is calculated as described in Appendix D.

APPENDIX J

DETERMINING OVERALL CONCENTRATION UNCERTAINTIES (OCU)

The calculations in previous sections and appendices estimate the measurement uncertainties for various FTIR measurements. The lowest possible overall concentration uncertainty (OCU) for an analyte is its MAU value, which is an estimate of the absolute concentration uncertainty when spectral noise dominates the measurement error. However, if the product of the largest fractional concentration uncertainty (FRU, FCU, FAU, or FMU) and the measured concentration of an analyte exceeds the MAU for the analyte, then the OCU is this product. In mathematical terms, set $OFU_i = MAX\{FRU_i, FCU_i, FAU_i, FMU_i\}$ and $OCU_i = MAX\{RSA_i*OFU_i, MAU_i\}$.

APPENDIX K

SPECTRAL DE-RESOLUTION PROCEDURES

K.1 General.

High resolution reference spectra can be converted into lower resolution standard spectra for use in quantitative analysis of sample spectra. This is accomplished by truncating the number of data points in the original reference sample and background interferograms.

De-resolved spectra must meet the following requirements to be used in quantitative analysis.

(a) The resolution must match the instrument sampling resolution. This is verified by comparing a de-resolved CTS spectrum to a CTS spectrum measured on the sampling instrument.

(b) The Fourier transformation of truncated interferograms (and their conversion to absorbance spectra) is performed using the same apodization function (and other mathematical corrections) used in converting the sample interferograms into absorbance spectra.

K.2 Procedures

This section details three alternative procedures using two different commercially available software packages. A similar procedures using another software packages is acceptable if it is based on truncation of the original reference interferograms and the results are verified by Section K.3.

K.2.1 KVB/Analect Software Procedure - The following example converts a 0.25 cm^{-1} 100 ppm ethylene spectrum (cts0305a) to 1 cm^{-1} resolution. The 0.25 cm^{-1} CTS spectrum was collected during the EPA reference spectrum program on March 5, 1992. The original data (in this example) are in KVB/Analect FX-70 format.

(i) **decomp cts0305a.aif,0305dres,1,16384,1**

"decomp" converts cts0305a to an ASCII file with name 0305dres. The resulting ASCII interferogram file is truncated to 16384 data points. Convert background interferogram (bkg0305a.aif) to ASCII in the same way.

(ii) **compose 0305dres,0305dres.aif,1**

"Compose" transforms truncated interferograms back to spectral format.

(iii) **IG2SP 0305dres.aif,0305dres.dsf,3,1,low cm^{-1},high cm^{-1}**

"IG2SP" converts interferogram to a single beam spectrum using Norton-Beer medium apodization, 3, and no zero filling, 1. De-resolved interferograms should be transformed using the same apodization and zero filling that will be used to collect sample spectra. Choose the desired low and high frequencies, in cm^{-1}. Transform the background interferogram in the same way.

(iv) **DVDR 0305dres.dsf,bkg0305a.dsf,0305dres.dlf**

"DVDR" ratios the transformed sample spectrum against the background.

(v) **ABSB 0305dres.dlf,0305dres.dlf**

"ABSB" converts the spectrum to absorbance.

The resolution of the resulting spectrum should be verified by comparison to a CTS spectrum collected at the nominal resolution. Refer to Section K.3.

K.2.2 Alternate KVB/Analect Procedure -- In either DOS (FX-70) or Windows version (FX-80) use the "Extract" command directly on the interferogram.

(i) **EXTRACT CTS0305a.aif,0305dres.aif,1,16384**

"Extract" truncates the interferogram to data points from to 16384 (or number of data points for desired nominal resolution). Truncate background interferogram in the same way.

(ii) Complete steps (iii) to (v) in Section K.2.1.

K.2.3 Grams™ Software Procedure - Grams™ is a software package that displays and manipulates spectra from a variety of instrument manufacturers. This procedure assumes familiarity with basic functions of Grams™.

This procedure is specifically for using Grams to truncate and transform reference interferograms that have been imported into Grams from the KVB/Analect format. Table K-1 shows data files and parameter values that are used in the following procedure.

The choice of all parameters in the ICOMPUTE.AB call of step 3 below should be fixed to the shown values, with the exception of the "Apodization" parameter. This parameter should be set (for both background and sample single beam conversions) to the type of apodization function chosen for the de-resolved spectral library.

TABLE K-1. GRAMS DATA FILES AND DE-RESOLUTION PARAMETERS.

Desired Nominal Spectral Resolution (cm^{-1})	Data File Name	Parameter "N" Value
0.25	Z00250.sav	65537
0.50	Z00500.sav	32769
1.0	Z01000.sav	16385
2.0	Z02000.sav	8193

(i) **Import** using "File/Import" the desired *.aif file. Clear all open data slots.

(ii) **Open** the resulting *.spc interferogram as file #1.

(iii) **Xflip** - *If the x-axis is increasing from left to right, and the ZPD burst appears near the left end of the trace, omit this step.*

In the "Arithmetic/Calc" menu item input box, type the text below. Perform the calculation by clicking on "OK" (once only), and, when the calculation is complete, click the "Continue" button to proceed to step (iv). Note the comment in step (iii) regarding the trace orientation.

xflip:#s=#s(#0,#N)+50

(iv) **Run ICOMPUTE.AB** from "Arithmetic/Do Program" menu. Ignore the "subscripting error," if it occurs.

The following menu choices should be made before execution of the program (refer to Table K-1 for the correct choice of "N":)

First: **N** Last: **0** Type: **Single Beam**
Zero Fill: **None** Apodization: **(as desired)**
Phasing: **User**
Points: **1024** Interpolation: **Linear** Phase:
Calculate

(v) **As** in step (iii), in the "**Arithmetic/Calc**" menu item enter and then run the following commands (refer to Table 1 for appropriate "**FILE,**" which may be in a directory other than "c:\mdgrams.")

setffp 7898.8805, 0 : loadspc "c:\mdgrams\ FILE" : #2=#s+#2

(vi) Use "**Page Up**" to activate file #2, and then use the "**File/Save As**" menu item with an appropriate file name to save the result.

K.3 Verification of New Resolution

K.3.1 Obtain interferograms of reference sample and background spectra. Truncate interferograms and convert to absorbance spectra of desired nominal resolution.

K.3.2 Document the apodization function, the level of zero filling, the number of data points, and the nominal resolution of the resulting de-resolved absorbance spectra. Use the identical apodization and level of zero filling when collecting sample spectra.

K.3.3 Perform the same de-resolution procedure on CTS interferograms that correspond with the reference spectra (reference CTS) to obtain de-resolved CTS standard spectra (CTS standards). Collect CTS spectra using the sampling resolution and the FTIR system to be used for the field measurements (test CTS). If practical, use the same pathlength, temperature, and standard concentration that were used for the reference CTS. Verify, by the following procedure that CTS linewidths and intensities are the same for the CTS standards and the test CTS.

K.3.4 After applying necessary temperature and pathlength corrections (document these corrections), subtract the CTS standard from the test CTS spectrum. Measure the RMSD in the resulting subtracted spectrum in the analytical region(s) of the CTS band(s). Use the following equation to compare this RMSD to the test CTS band area. The ratio in equation 7 must be no greater than 5 percent (0.05).

$$\frac{RMSS_i \times n(FFU_i - FFL_i)}{A_{CTS\text{-}test}} \leq .05 \qquad (16)$$

RMSS=RMSD in the ith analytical region in subtracted result, test CTS minus CTS standard.

n=number of data points per cm^{-1}. Exclude zero filled points.

FFU_i &=The upper and lower limits (cm^{-1}), respectively, of the FFL_i analytical region.

$A_{test\text{-}CTS}$=band area in the ith analytical region of the test CTS.

D-3 EPA METHOD 25A

METHOD 25A-DETERMINATION OF TOTAL GASEOUS ORGANIC CONCENTRATION USING A FLAME IONIZATION ANALYZER

1. Applicability and Principle

1.1 Applicability. This method applies to the measurement of total gaseous organic concentration of vapors consisting primarily of alkanes, alkenes, and/or arenes (aromatic hydrocarbons). The concentration is expressed in terms of propane (or other appropriate organic calibration gas) or in terms of carbon.

1.2 Principle. A gas sample is extracted from the source through a heated sample line, if necessary, and glass fiber filter to a flame ionization analyzer (FIA). Results are reported as volume concentration equivalents of the calibration gas or as carbon equivalents.

2. Definitions

2.1 Measurement Systems. The total equipment required for the determination of the gas concentration. The system consists of the following major subsystems:

2.1.1 Sample Interface. That portion of the system that is used for one or more of the following: sample acquisition, sample transportation, sample conditioning, or protection of the analyzer from the effects of the stack effluent.

2.1.2 Organic Analyzer. That portion of the system that senses organic concentration and generates an output proportional to the gas concentration.

2.2 Span Value. The upper limit of a gas concentration measurement range that is specified for affected source categories in the applicable part of the regulations. The span value is established in the applicable regulation and is usually 1.5 to 2.5 times the applicable emission limit. If no span value is provided, use a span value equivalent to 1.5 to 2.5 times the expected concentration. For convenience, the span value should correspond to 100 percent of the recorder scale.

2.3 Calibration Gas. A known concentration of a gas in an appropriate diluent gas.

2.4 Zero Drift. The difference in the measurement system response to a zero level calibration gas before and after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

2.5 Calibration drift. The difference in the measurement system response to a midlevel calibration gas before and after a stated period of operation during which no unscheduled maintenance, repair or adjustment took place.

2.6 Response Time. The time interval from a step change in pollutant concentration at the inlet to the emission measurement system to the time at which 95 percent of the corresponding final value is reached as displayed on the recorder.

2.7 Calibration Error. The difference between the gas concentration indicated by the measurement system and the known concentration of the calibration gas.

3. Apparatus.

A schematic of an acceptable measurement system is shown in Figure 25A-1. The essential components of the measurement system are described below:

3.1 Organic Concentration Analyzer. A flame ionization analyzer (FIA) capable of meeting or exceeding the specifications in this method.

3.2 Sample Probe. Stainless steel, or equivalent, three-hole rake type. Sample holes shall be 4 mm in diameter or smaller and located at 16.7, 50, and 83.3 percent of the equivalent stack diameter. Alternatively, a single opening probe may be used so that a gas sample is collected from the centrally located 10 percent area of the stack cross-section.

3.3 Sample Line. Stainless steel or Teflon * tubing to transport the sample gas to the analyzer. The sample line should be heated, if necessary, to prevent condensation in the line.

3.4 Calibration Valve Assembly. A three way valve assembly to direct the zero and calibration gases to the analyzers is recommended. Other methods, such as quick-connect lines, to route calibration gas to the analyzers are applicable.

3.5 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter should be heated to prevent any condensation.

* Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

3.6 Recorder. A strip-chart recorder, analog computer, or digital recorder for recording measurement data. The minimum data recording requirement is one measurement value per minute, Note: This method is often applied in highly explosive areas. Caution and care should be exercised in choice of equipment and installation.

4. Calibration and Other Gases.

Gases used for calibrations, fuel, and combustion air (if required) are contained in compressed gas cylinders. Preparation of calibration gases shall be done according to the procedure in Protocol No. 1, listed in Citation 2 of Bibliography. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ±2 percent from the certified value. For calibration gas values not generally available (i.e., organics between 1 and 10 percent by volume), alternative methods for preparing calibration gas mixtures, such as dilution systems, may be used with prior approval of the Administrator.

Calibration gases usually consist of propane in air or nitrogen and are determined in terms of the span value. Organic compounds other than propane can be used following the above guidelines and making the appropriate corrections for response factor.

4.1 Fuel. A 40 percent H_2/60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value.

4.2 Zero Gas. High purity air with less than 0.1 parts per million by volume (ppmv) of organic material (propane or carbon equivalent) or less than 0.1 percent of the span value, whichever is greater.

4.3 Low-level Calibration Gas. An organic calibration gas with a concentration equivalent to 25 to 35 percent of the applicable span value.

4.4 Mid-level Calibration Gas. An organic calibration gas with a concentration equivalent to 45 to 55 percent of the applicable span value.

4.5 High-level Calibration Gas. An organic calibration gas with a concentration equivalent to 80 to 90 percent of the applicable span value.

5. Measurement System Performance Specifications

5.1 Zero Drift. Less than ±3 percent of the span value.

5.2 Calibration Drift. Less than ±3 percent of span value.

5.3 Calibration Error. Less than ±5 percent of the calibration gas value.

6. Pretest Preparations

6.1 Selection of Sampling Site. The location of the sampling site is generally specified by the applicable regulation or purpose of the test; i.e., exhaust stack, inlet line, etc. The sample port shall be located at least 1.5 meters or 2 equivalent diameters upstream of the gas discharge to the atmosphere.

6.2 Location of Sample Probe. Install the sample probe so that the probe is centrally located in the stack, pipe, or duct and is sealed tightly at the stack port connection.

6.3 Measurement System Preparation. Prior to the emission test, assemble the measurement system following the manufacturer's written instructions in preparing the sample interface and the organic analyzer. Make the system operable.

FIA equipment can be calibrated for almost any range of total organics concentrations. For high concentrations of organics (>1.0 percent by volume as propane) modifications to most commonly available analyzers are necessary. One accepted method of equipment modification is to decrease the size of the sample to the analyzer through the use of a smaller diameter sample capillary. Direct and continuous measurement of organic concentration is a necessary consideration when determining any modification design.

6.4 Calibration Error Test. Immediately prior to the test series, (within 2 hours of the start of the test) introduce zero gas and high-level calibration gas at the calibration valve assembly. Adjust the analyzer output to the appropriate levels, if necessary. Calculate the predicted response for the low-level and mid-level gases based on a linear response line between the zero and high-level responses. Then introduce low-level and mid-level calibration gases successively to the measurement system. Record the analyzer responses for low-level and mid-level calibration gases and determine the differences between the measurement system responses and the predicted responses. These differences must be less than 5 percent of the respective calibration gas value. If not, the measurement system is not acceptable and must be replaced or repaired prior to testing. No adjustments to the measurement system shall be conducted after the calibration and before the drift check (Section 7.3). If adjustments are necessary before the completion of the test series, perform the drift checks prior to the required adjustments and repeat the calibration following the adjustments. If multiple electronic ranges are to be used, each additional range must be checked with a mid-level calibration gas to verify the multiplication factor.

6.5 Response Time Test. Introduce Zero gas into the measurement system at the calibration valve assembly. When the system output has stabilized, switch quickly to the high-level calibration gas. Record the time from the

concentration change to the measurement system response equivalent to 95 percent of the step change. Repeat the test three times and average the results.

7. Emission Measurement Test Procedure

7.1 Organic Measurement. Begin sampling at the start of the test period, recording time and any required process information as appropriate. In particular, note on the recording chart periods of process interruption or cyclic operation.

7.2 Drift Determination. Immediately following the completion of the test period and hourly during the test period, reintroduce the zero and mid-level calibration gases, one at a time, to the measurement system at the calibration valve assembly. (Make no adjustments to the measurement system until after both the zero and calibration drift checks are made.) Record the analyzer response. If the drift values exceed the specified limits, invalidate the test results preceding the check and repeat the test following corrections to the measurement system. Alternatively, recalibrate the test measurement system as in Section 6.4 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period).

8. Organic Concentration calculations

Determine the average organic concentration in terms of ppmv as propane or other calibration gas. The average shall be determined by the integration of the output recording over the period specified in the applicable regulation. If results are required in terms of ppmv as carbon, adjust measured concentrations using Equation 25A-1.

$$C_C = KC_{meas} \qquad \text{Eq. 25A-1}$$

Where:

C_c = Organic concentration as carbon, ppmv.

C_{meas} = Organic concentration as measured, ppmv.

K = Carbon equivalent correction factor.

K = 2 for ethane.

K = 3 for propane.

K = 4 for butane.

K = Appropriate response factor for other organic calibration gases.

9. Bibliography

1. Measurement of Volatile Organic Compounds-Guideline Series. U.S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-450/2-78-041. June 1978. p. 46-54.

2. Traceability Protocol for Establishing True Concentrations of Gases Used for Calibration and Audits of Continuous Source Emission Monitors (Protocol No. 1). U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory. Research Triangle Park, NC. June 1978.

3. Gasoline Vapor Emission Laboratory Evaluation-Part 2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC. EMB Report No. 75-GAS-6. August 1975.

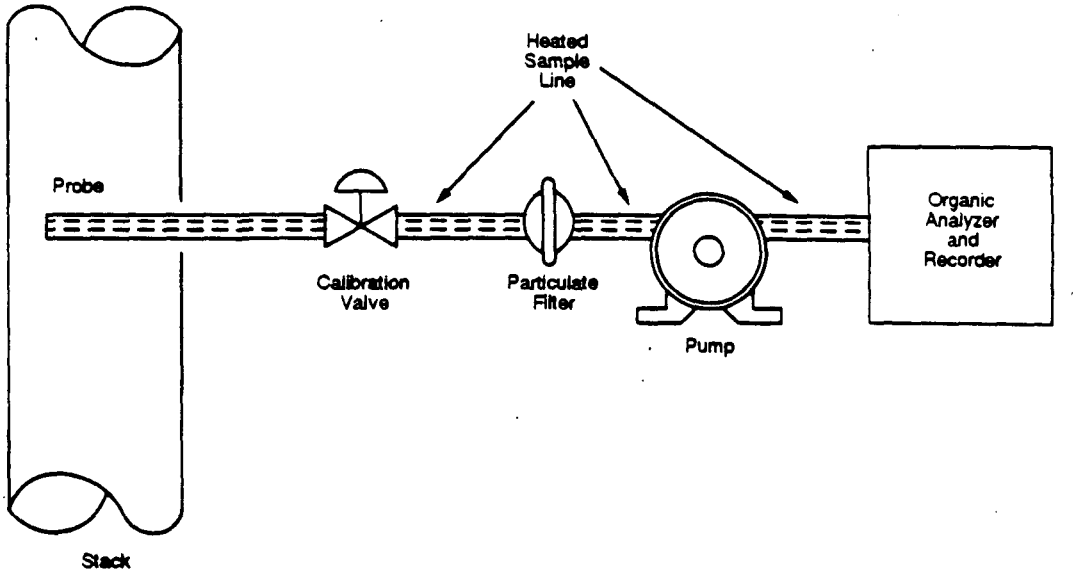

Figure 25A-1. Organic Concentration Measurement System.

D-4 EPA DRAFT METHOD 205

DRAFT--DO NOT CITE OR QUOTE

The EPA proposes to amend Title 40, Chapter I, Part 51 of the Code of Federal Regulations as follows:

1. The authority citation for Part 51 continues to read as follows: Authority: Section 110 of the Clean Air Act as amended. 42 U.S.C. 7410.

2. Appendix M, Table of Contents is amended by adding an entry to read as follows:

Method 205--Verification of Gas Dilution Systems for Field Instrument Calibrations

3. By adding Method 205 to read as follows:

Method 205 - Verification of Gas Dilution Systems for Field Instrument Calibrations

1. INTRODUCTION

1.1 Applicability. A gas dilution system can provide known values of calibration gases through controlled dilution of high-level calibration gases with an appropriate dilution gas. The instrumental test methods in 40 CFR Part 60 -- e.g., Methods 3A, 6C, 7E, 10, 15, 16, 20, 25A and 25B -- require on-site, multi-point calibration using gases of known concentrations. A gas dilution system that produces known low-level calibration gases from high-level calibration gases, with a degree of confidence similar to that for Protocol[1] gases, may be used for compliance tests in lieu of multiple calibration gases when the gas dilution system is demonstrated to meet the requirements of this method. The Administrator may also use a gas dilution system in order to produce a wide range of Cylinder Gas Audit concentrations when conducting performance specifications according to Appendix F, 40 CFR Part 60. As long as the acceptance criteria of this method are met, this method is applicable to gas dilution systems using any type of dilution technology, not solely the ones mentioned in this method.

1.2 Principle. The gas dilution system shall be evaluated on one analyzer once during each field test. A precalibrated analyzer is chosen, at the discretion of the source owner or operator, to demonstrate that the gas dilution system produces predictable gas concentrations spanning a range of concentrations. After meeting the requirements of this method, the remaining analyzers may be calibrated with the dilution system in accordance to the requirements of the applicable method for the duration of the field test. In Methods 15 and 16, 40 CFR Part 60, Appendix A, reactive compounds may be lost in the gas dilution system. Also, in Methods 25A and 25B, 40 CFR Part 60, Appendix A, calibration with target compounds other than propane is allowed. In these cases, a laboratory evaluation is required once per year in order to assure the Administrator that the system will dilute these reactive gases without significant loss. **Note:** The laboratory evaluation is required only if the source owner or operator plans to utilize the dilution system to prepare gases mentioned above as being reactive.

2. SPECIFICATIONS

2.1 Gas Dilution System. The gas dilution system shall produce calibration gases whose measured values are within ±2 percent of the predicted values. The predicted values are calculated based on the certified concentration of the supply gas (Protocol gases, when available, are recommended for their accuracy) and the gas flow rates (or dilution ratios) through the gas dilution system.

injection shall differ by more than ±2 percent from the average instrument response for that dilution. **3.2.5** For each level of dilution, calculate the difference between the average concentration output recorded by the analyzer and the predicted concentration calculated in Section 3.2.2. The average concentration output from the analyzer shall be within ±2 percent of the predicted value.

3.2.6 Introduce the mid-level supply gas directly into the analyzer, bypassing the gas dilution system. Repeat the procedure twice more, for a total of three mid-level supply gas injections. Calculate the average analyzer output concentration for the mid-level supply gas. The difference between the certified concentration of the mid-level supply gas and the average instrument response shall be within ±2 percent.

3.3 If the gas dilution system meets the criteria listed in Section 3.2, the gas dilution system may be used throughout that field test. If the gas dilution system fails any of the criteria listed in Section 3.2, and the tester corrects the problem with the gas dilution system, the procedure in Section 3.2 must be repeated in its entirety and all the criteria in Section 3.2 must be met in order for the gas dilution system to be utilized in the test.

4. REFERENCES

1. "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards," EPA-600/R93/224, Revised September 1993.

D-5 HCl VALIDATION PAPER

For Presentation at the Air & Waste Management Association's 90th Annual Mee
& Exhibition, June 8-13, 1997, Toronto, Ontario, Canada

97-MP74.05

Validation of EPA FTIR Method For Measuring HCl

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Introduction

In 1997 EPA is preparing to publish a sampling method (Draft Method 320)[1] based on the use of Fourier transform infrared (FTIR) spectroscopy to measure emissions of hazardous air pollutants (HAPs). This method establishes sampling procedures for measuring HAPs and employs analytical procedures in the EPA FTIR Protocol.[2]

In 1996 EPA conducted a field test at a source with HCl emissions. The test goal was to use the FTIR Draft Method 320 to measure vapor phase pollutants at this source. Measurements were conducted on the inlet and outlet of a control device. Hydrogen chloride (HCl) was a target pollutant for this source and, for this reason, some samples were spiked from a cylinder containing a standard concentration of 103 ppm HCl. Results of HCl measurements are presented along with a Method 301[3] statistical analysis of spiked and unspiked samples, and a comparison of results obtained using EPA reference spectra and results obtained using spectra of the HCl gas standard to measure the sample concentrations.

Experimental

The source tested in this project was a coal burning process with a relatively low moisture content (3 to 4% by volume). Flue gas temperatures were between 400 and 500°F. The principal components of the gas stream were water vapor, CO_2, SO_2, and NO.

Sampling System

The sampling system is depicted in Figure 1. The sample was extracted through a 4-ft long, 0.5-in diameter stainless steel probe. Sample was transported through heated 3/8-in Teflon line using a KNF Neuberger heated head sample pump (Model NO35 ST.11I). A Balston particulate filter (holder Model Number 30-25, filter element Model Number 100-25-BH, 99 percent removal efficiency at 0.1 μm) was connected in-line at the outlet of the sample probe. The sample line was heat wrapped and insulated. Temperature controllers were used to monitor and regulate the sample line temperature at about 350° F. The stainless steel manifold contained 3/8-in tubing, rotameters and 4-way valves to monitor and control the sample flow to the FTIR gas cell. The manifold temperature was maintained between 300 to 310°F.

The FTIR system included an Analect instruments Model RFX-40 interferometer equipped with a [illegible] band MCT detector. Samples were contained in an Infrared Analysis Model D22H variable path gas [illegible]. The cell temperature was maintained at 250°F.

Sampling Procedure

A series of discreet batch samples was collected by filling the cell above ambient pressure and closing the inlet valve to isolate the sample. An outlet valve was briefly opened to vent the sample to ambient pressure. The spectrum of the static sample was recorded. Then the cell was evacuated for the next sample. Each spectrum consisted of 50 co-added scans. The minimum time between consecutive samples was about 2 minutes. Inlet and outlet runs were conducted at the same time: the two location were sampled alternately with the one FTIR system. The minimum time between consecutive measurements was about 3 to 5 minutes.

Path Length Determinations

Two path lengths were used in this test. The cell was adjusted to 40 beam passes for the first two test runs and reduced to 20 beam passes for a third test run. The number of beam passes was measured by shining a He/Ne laser through the optical path and observing the number of laser spots on the field mirror. The path lengths in meters were determined by comparing CTS EPA reference spectra to the CTS spectra collected at each path length.

Absorption path lengths were determined from a comparison of the field test CTS spectra and EPA library CTS spectra of ethylene (C_2H_4). For high temperature spectra, the EPA library interferograms cts0115a.aif and bkg0115a.aif were de-resolved to the appropriate spectral resolution (either 1 or 2 cm^{-1}) according to the procedures of reference 2 (Appendix K). The same procedure was used to generate low-temperature spectra from the original interferometric data in the EPA library files cts0829a.aif and bkg0829a.aif. The resulting files were used in least squares fits to the appropriate field CTS spectra (see reference 2, Appendix H) in two regions (the FP, or "fingerprint" region from 790 to 1139 cm^{-1} and the CH, or "CH-stretch region" from 2760 to 3326 cm^{-1}). The fit results for each region, test, and set of test sampling conditions were averaged. They and their average uncertainties are presented in Table 1. The CH values were used in analytical region 4 where HCl was measured.

Analyte Spiking

Draft Method 320[1] contains a procedure for spiking the flue gas with one or more of the target analytes. The spike procedure closely follows Section 6.3 of reference 3. The primary purpose of analyte spiking is to provide a quality assurance check on the sampling system to determine if analyte losses occur in transport to the analyzer. A second purpose is to test the analytical program to verify that the analyte(s) can be measured in the sample matrix. If at least 12 (independent) spiked and 12 (independent) unspiked samples are measured then a Method 301 statistical analysis can be performed on the results to "validate" the method.

Figure 1 shows the sampling configuration used for the analyte spike. This procedure is described in detail elsewhere[1]. In this test, a measured flow of the gas standard was preheated to the sample line temperature before being introduced into the extracted flue gas at the back of the probe. The spiked sample then passed through all of the sample components to the gas cell where the spectrum was recorded. A series of unspiked samples was measured, the spike was turned on and then a complete

series of spiked samples was measured. The spike then was turned off to make additional unspike measurements. Ideally, the spike comprises 1/10 or less of the sample mixture. The dilution is estim.. by comparing the spike flow to the total flow, but the actual dilution is determined measuring a tracer (SF_6) concentration in the spiked samples and comparing that to tracer concentration in the undiluted gas standard.[1]

Usually the tracer is spiked with the analyte standard. In this test the SF_6 standard and HCl standard were contained in separate cylinders so the SF_6 was spiked first, then the HCl was spiked, and finally the SF_6 was spiked again. The total sample flow stayed constant during the entire sampling period. The spike flow was also held constant to insure that the dilution ratio was the same when the SF_6 was spiked as when the HCl was spiked.

Quantitative Analysis

FTIR analysis is performed in two steps: (1) collecting spectra of samples, and (2) analyzing the spectra to determine concentrations of detected compounds. The quantitative analysis step usually is performed with an automated program that relates sample absorbance intensities to absorbance intensities at known concentrations in reference spectra.[2] The Protocol[2] describes procedures for preparing reference spectra and Method 320[1] requires the analyst to use reference spectra prepared with the Protocol procedures. To date, the only existing set of reference spectra for HCl and most Clean Air Act HAPs is in the EPA FTIR spectral library (http://info.arnold.af.mil/epa/welcome.htm).

The Calibration Transfer Standard[2] is the key requirement in using reference spectra for quantitative analysis. CTS spectra help the analyst characterize differences in resolution, path length, temperature, and sample pressure between the instrument system used to collect reference spectra and the system used to collect the sample spectra. Table 1 illustrates how the CTS spectra were used to determine the optical path lengths for the system used in this test. The HCl reference spectra were de-resolved in the same way as the CTS reference spectra before they were used in the quantitative analysis.

References 4 through 8 comprise a thorough description of one technique for analyzing FTIR absorbance spectra. Two different analytical routines were used in this study. The first was prepared by Rho Squared using the programming language ARRAY BASIC™ (GRAMS,™ Version 3.02, Galactic Industries Corporation, Salem, New Hampshire). The "classical least squares" (CLS) or "K-Matrix" technique and the associated computer program "4FIT" are described in Reference 9. The terminology and basic analytical approach employed in this work are described in the "EPA FTIR Protocol" (Reference 2). The second routine used the K-matrix analytical program "Multicomp" version 6.0 (Analect Instruments).

The two analyses were performed independently by different analysts and then compared without modification.

Reference Spectra

The program "4FIT" used as input EPA FTIR library spectra of HCl de-resolved to 1 cm^{-1} and normalized for absolute temperature, concentration, and absorption path length. The resulting files were

averaged to provide a "reduced absorptivity" (see Reference 9), which was stored in the spectra. 097.alf and employed in all subsequent HCl analyses. The HCl analysis was applied to the de-resc EPA library HCl spectra to determine the fractional calibration uncertainty (FCU), which is presented in Table 2.

During the test MRI recorded spectra of samples taken directly from an HCl cylinder standard (103 ppm HCl in nitrogen, ± 5% accuracy from Scott Specialty Gases). Four independent HCl "calibration" spectra were measured at each of the two instrument configurations used to collect the data presented in Figures 2 and 3. The Fractional Calibration Uncertainty for each set of four spectra and the analytical region for the "Multicomp" analysis is presented in Table 2.

Even though the two sets of results are identified by the program names "4FIT" and "Mulitcomp," it is important to note that the "Multicomp" results were reproduced by the program "4FIT" when the HCl calibration spectra were used as input for "4FIT." Therefore, any differences in the analyses are not attributable to the programs, but to the use of different input spectra.

Results

HCl Concentrations

Table 3 summarizes results from the three test runs at the two locations. The agreement between the "4FIT" and the "Multicomp" analyses is very good except for the third run. This run was conducted after the path length had been decreased from 40 to 20 laser passes.

The two comparisons plotted in Figures 2 and 3 are indicated in Table 3. The Run 2 outlet results (Figure 2) are typical of those obtained for the Run 2 inlet results recorded on the same day and the Run 1 inlet and outlet results recorded a day earlier. The close agreement was typical also for two data sets collected at another field test in one test run. For 3 of the 6 data sets presented in Table 3, the results obtained with program "4FIT," using de-resolved EPA library reference spectra and the CTS-derived absorption path lengths, are nearly identical (within the 4 σ uncertainty) to those obtained using "Multicomp," which employed the field HCl calibration standard spectra without an explicit absorption path length determination. The average percent difference of the Run 2 inlet results was slightly higher than the 4σ uncertainty, but this percent difference corresponded to an average difference of 1.7 ppm. The error bars in Figures 2 and 3 correspond to the 4σ statistical uncertainties in the "4FIT" HCl concentrations.

Method 301 Analysis

Tables 4 and 5 present the results of the method 301 statistical analysis of the spiked and unspiked "4FIT" and "Multicomp" Run 3 outlet results, respectively. Note that the nearly constant difference of about 19 percent in the two analyses has almost no effect on the Method 301 statistical analyses, which indicate no significant bias in the HCl measurements. This is because the statistical treatment analyzes differences between spiked and unspiked measurements and compares the differences to an expected value of the spike. Since the same offset is apparent in the "Multicomp" analysis of both the spiked and unspiked results, the calculated bias is not affected.

This is another indication that the difference in the "4FIT" and "Multicomp" run 3 results is not due to a measurement or analytical error. It is likely due either to an anomaly in the Run 3 path length determination for the CH stretch region or to an error associated with using the HCl "calibration spectra as input for the "Multicomp" program. As stated above, the "4FIT" program reproduced the "Multicomp" results when using the HCl "calibration" spectra as input.

Discussion

The uncertainties for the four data sets in Runs 1 and 2 are approximately equal to the small differences between the "4FIT" and "Multicomp" results. The excellent agreement of the two analyses is noteworthy for several reasons. HCl is notoriously difficult both in terms of sampling and data analysis, due (respectively) to the compound's high chemical reactivity and the details of the infrared spectrum which make the analysis susceptible to instrument resolution errors. The results also provide a direct comparison between two fundamentally different analytical approaches, one relying on *in situ* calibration of the instrument using actual calibration gas standards, and the other using the calibration transfer concept.

This comparison is somewhat clouded by the results depicted in Figure 3, which show the HCl concentration determined during Run 3 at the outlet. These are also typical of the results for another data set recorded on the same day at the inlet. Unlike the Runs 1 and 2 data, the Run 3 data indicate a statistically meaningful difference of approximately 18% between the "4FIT" and "Multicomp" results. We stress that this difference is **not** attributable to errors in the computer programs, which produced reliable results in these and many independent test cases. Rather, the difference seems be related to an anomaly in the absorption path length determinations presented in Table 1. Note that the CTS-derived absorption path length for (nominally) 20 passes, corresponding to the Run 3 data, are 10.2 meters 14.3 meters for the CH-stretch and "fingerprint" (FP) analytical regions. The difference between the CH and FP results is much larger for this particular day of testing than on the other two test days, represented in the table by the 16- and 40- pass results. (It is also anomalous with respect to results obtained using the same instrument in another field test completed within nine days of the testing addressed here.) Moreover, were the average of the CH and FP region values (12.2 meters) used for the HCl concentration values rather than the CH region value of 10.2 meters, the level of agreement between the two sets of analytical results for the Run 3 data would be comparable to that of the Run 1 and 2 data discussed immediately above.

We have attempted to determine the cause of this difference by considering of a number of possible operational and instrumental problems. However, no single systematic effect seems sufficient. Because consistent path length determinations were carried out both before and after the HCl measurements in question, a sudden change in instrument performance must be ruled out. Gas pressure and dilution effects cannot cause the type of wavenumber-dependent effects observed in the CTS spectra; subsequent laboratory measurements of C_2H_4 indicated that temperature variations, like pressure and dilution effects, would lead to path length errors in the same direction for the CH and FP regions. Because the same EPA CTS ethylene spectra were used in all the path length determinations and led to excellent statistical results in all cases, potential data processing errors in the deresoluton procedure are also insufficient to explain

the anomalous results. However, we note that the observed 18% discrepancy still allows high co... in the data and the infrared technique, and the discrepancy is obvious mainly because of the overall ... quality of the data set and statistical results.

Conclusions

The evaluation presented in this paper demonstrates that the EPA FTIR Protocol analytical procedures based on the use of laboratory reference spectra to determine analyte concentrations in sample spectra give excellent, and verifiable, results. This is true even for HCl, which is difficult to sample, and even when the reference spectra are deresolved to match the sample spectra.

Two independent analyses using different programs and different spectral input data were performed on 6 FTIR data sets collected at a site with HCl emissions. The alternate analyses produced nearly identical results in 4 of the data sets. In two of the data sets the agreement was also good, but the average discrepancy of about 18 percent between results produced by the alternate analyses was larger than the average measurement uncertainty of about 5.5 percent. A preliminary evaluation of this discrepancy has not determined the exact cause, but it is probably attributable to an anomaly in the measurement of the absorption path length for the one test run.

These results also demonstrate the need for careful instrument performance checks and preparation of library reference spectra. Strict QA/QC standard procedures are required to produce accurate measurements. The Method 301 validation results showed no significant bias in the FTIR measurements of HCl at this test, but the validation procedure cannot reveal a constant offset "error" that is applied equally to both spiked and unspiked samples.

Acknowledgments

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References

1) Draft Method 320, "Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy," EPA Contract No. 68-D2-0165, Work Assignment 3-08, July, 1996.

2) "Protocol For The Use of FTIR Spectrometry to Perform Extractive Emissions Testing at Industrial Sources," EPA Contract No. 68-D2-0165, Work Assignment 3-12, EMTIC Bulletin Board, September, 1996.

3) "Method 301 - Field Validation of Pollutant Measurement Methods from Various Waste Media," **40 CFR Part 63, Appendix A.**

4. D.M. Haaland and R.G. Easterling, "Improved Sensitivity of Infrared Spectroscopy by the App n of Least Squares Methods," Appl. Spectrosc. 34(5):539-548 (1980).

5. D.M. Haaland and R.G. Easterling, "Application of New Least-Squares Methods for the Quantitative Infrared Analysis of Multicomponent Samples," Appl. Spectrosc. 36(6):665-673 (1982).

6. D.M. Haaland, R.G. Easterling and D.A. Vopicka, "Multivariate Least-Squares Methods Applied to the Quantitative Spectral Analysis of Multicomponent Samples," Appl. Spectrosc. 39(1):73-84 (1985).

7. W.C. Hamilton, Statistics in Physical Science, Ronald Press Co., New York, 1964, Chapter 4.

8. P.R. Griffiths and J.A. DeHaseth, Fourier Transform Infrared Spectroscopy, John Wiley and Sons, New York, 1986, ISBN 0-471-09902-3.

9. G. M. Plummer and W. K. Reagen, "An Examination of a Least Squares Fit FTIR Spectral Analysis Method," Air and Waste Management Association, Paper Number 96-WA65.03, Nashville, 1996.

10. T. J. Geyer, "Method 301 Validation of Fourier Transform Infrared (FTIR) spectroscopy For Measuring Formaldehyde and Carbonyl Sulfide," Air and Waste Management Association, Paper Number. 96-RA110.03, Nashville, 1996.

Table 1. Pathlength Determination Results.

	CTS Conditions		CH region		FP region	
	# Passes	Temp (K)	Result (m)	% uncert.	Result (m)	% uncert.
	16	293	6.5	2.9	6.7	1.3
	20	293	11.0	2.6	11.3	1.6
Run 3 (Figure 3)	20	393	10.2	2.5	14.3	2.2
	40	293	19.2	5.5	20.0	1.8
Run2 (Figure 2)	40	393	20.2	2.6	23.4	1.6

Table 2. Fractional Calibration Uncertainties (FCU in Reference 2) For the Two Quantitative Analyses.

Compound	FCU (%)	Analytical Region (cm^{-1})
HCl "4fit"	4.6	2747 - 2848
HCl "Mcomp"		2569 - 2871
Run 2 *	1.05	
Run 3 *	3.14	

* Spectra of four samples from the cylinder standard (103 ppm HCl in nitrogen) were used in the "Mcomp" analysis. The spectra were measured at the same instrument configuration used in each run.

Table 3. Summary of results comparisons in 4 runs (8 data sets).

Data Set	Average "4FIT" Results		Average "Multicomp" Result		
	HCl ppm	% 4 * σ [1]	HCl ppm	% Difference [2]	No. of Results [3]
Run 1 Inlet	43.3	3.9	42.1	2.9	36
Run 1 Outlet	34.5	4.1	32.9	4.4	30
Run 2 Inlet	14.8	7.7	13.1	11.8 [4]	16
Run 2 Outlet (Figure 2)	48.0	4.5	46.4	3.2	33
Run 3 Inlet	62.5	5.6	50.9	18.6	41
Run 3 Outlet (Figure 3)	58.0	5.5	47.3	18.4	52

1 - Average percent uncertainty in the 4FIT results.
2 - Equals (4FIT-Multicomp)/4FIT.
3 - Equals the number of spectra included in the average. Results from condenser and ambient air samples were not included in the averages.
4 - Flow restriction during this run may have caused HCl losses resulting in lower measured concentrations for this run. An average difference of 1.7 ppm corresponded to a relatively large percent difference of 11.8 % on the smaller average concentration for this run.

Table 4. Method 301 statistical analysis of "4FIT" HCl results in Figure 3.

	Unspiked			Spiked		
	HCl ppm	d_i	$(d_i)^2$	HCl ppm	d_i	$(d_i)^2$
Run Average =	57.18 *	9.68	52.561	62.14 *	4.74	25.784
Statistical Results	SD =	2.093		SD =	1.466	
	F =	0.491		SD_{pooled} =	1.807	
	RSD=	3.7				
	Bias =	**-0.088**		**Exp Conc =**	**5.05**	
	t =	**0.12**		**CF =**	**1.02**	

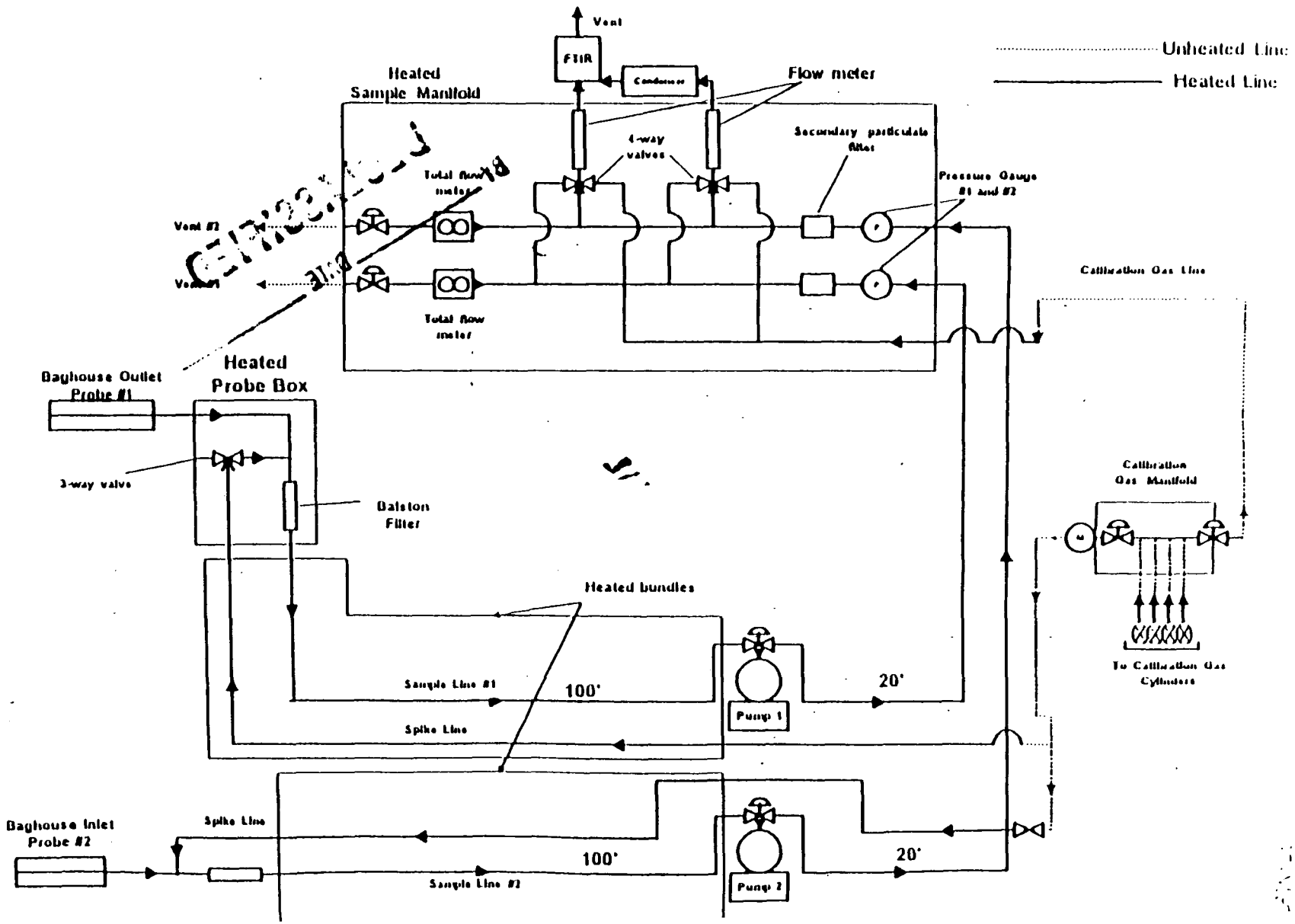
* Represents the average result in 12 unspiked or spiked samples. Statistical variables are described in Section 6.3 of EPA Method 301.[3] Procedure for determining spiked dilution factor and expected concentration, Exp Conc, is described in reference 10.

Table 5. Summary of Method 301 statistical analysis of "Multicomp" results in Figure 3.

	Unspiked			Spiked		
	HCl ppm	d_i	$(d_i)^2$	HCl ppm	d_i	$(d_i)^2$
Run Average =	45.88 *	8.62	34.242	50.86 *	3.51	21.496
Statistical Results	SD =	1.689		SD =	1.338	
	F =	0.628		SD_{pooled} =	1.524	
	RSD=	3.7				
	Bias =	**-0.070**		**Exp Conc =**	**5.05**	
	t =	**0.11**		**CF =**	**1.01**	

* Represents the average result in 12 unspiked or spiked samples. Statistical variables are described in Section 6.3 of EPA Method 301.[3] Procedure for determining spiked dilution factor and expected concentration, Exp Conc, is described in reference 10.

Figure 1. Extractive sampling system.



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16. ABSTRACT

The purpose of this testing program was to obtain emissions data by using FTIR and EPA Method 25a on a sintering process to quantify and characterize HAP emissions and the performance of the control unit for MACT development for this industry.(Integrated Iron and Steel).

17. MACT Rule Support — KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
	MACT Support for the Integrated Iron and Steel Industry (Sintering)	

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