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APRIL - MAY 1993 ENTECH, INC., MODEL TOS-80 EMISSIONS MONITORING IN ANCHORAGE, ALASKA VOLUME I--TEXT

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By
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TABLE OF CONTENTS

	Page
LIST OF TABLES	iii
LIST OF ABBREVIATIONS	iv
SUMMARY	v
INTRODUCTION	1
PROCEDURES	3
Entech System Description	3
Oxygen and Carbon Dioxide Measurements	4
WRI Procedures	5
Special Problems Created by High Stack Temperatures	5
RESULTS	6
Stack Gas Flow Rate	6
Comparison of Am Test Oxygen Measurements with WRI Measurements	9
NO_x Measurements	11
Front-Half Particulates	11
Back-Half Particulates	11
Hydrogen Chloride Emissions	17
Metals Emissions	18
Organics Emissions	21
Toxicity Characteristic Leaching Procedure Test on Ash	22
DISCUSSION	33
Particulates	33
Acid Gases	33
Metals	34
Organics	35
CONCLUSIONS	37
RECOMMENDATIONS	38
ACKNOWLEDGEMENT	39
DISCLAIMER	39

REFERENCES..... 40

LIST OF TABLES

Table		Page
1.	Entech, Test Burn Statistics	2
2.	Stack Gas Flow Rates	7
3.	Comparison of Average Am Test Measurements with WRI Measurements for Oxygen	10
4.	Enerac 2000 NO_x Readings	12
5.	Front-Half Particulates Corrected to a 7% O_2 or 12% CO_2 Basis	13
6.	Back-Half Particulates Corrected to a 7% O_2 or 12% CO_2 Basis	15
7.	Hydrogen Chloride Emissions	17
8.	Metal Emissions as Measured mg/dscm	19
9.	Metal Emissions Corrected to a 7% Oxygen Basis	20
10.	Dioxins/Furans as Measured, ng/dscm	23
11.	Dioxin/Furan Measurements Corrected to a 7% Oxygen Basis, ng/dscm	24
12.	Stack Emission Semivolatiles as Measured, µg/dscm	26
13.	Stack Emission Polychlorobiphenyls as Measured, µg/dscm	28
14.	Toxicity Characteristic Leaching Procedure Test on Ash for Burns 1 and 2 (Metal) and Protocol Blanks, mg/L	30
15.	Toxicity Characteristic Leaching Procedure Test on Ash for Burns 3 Through 9 (Metals), mg/L	30
16.	Toxicity Characteristic Leaching Procedure Test on Ash	31

17. Hydrogen Chloride Emission Factors 34

ABBREVIATIONS

Unit	Meaning
dscf	dry standard cubic feet
dscm	dry standard cubic meter
ft^3	cubic feet
g	grams
gr	grain (grain = 1/7000 lb)
gr/dscf	grains per dry standard cubic feet; to convert to mg/dscm, multiply by 2288.
inch Hg	inches of mercury; a unit of pressure
L	liter
lb	pound
mg	milligram
mg/dscm	milligrams per dry standard cubic meter
mg/kg	milligrams per kilogram of solid
ng	nanograms
ng/dscm	nanograms per dry standard cubic meter
ng/Nm^3	nanograms per dry standard cubic meter normalized to a seven volume percent oxygen
ppm	parts per million by volume
psig	pounds per square inch gauge pressure
scfm	standard cubic feet per minute (at 70°F and 29.92 in Hg)
yd^3	cubic yard

SUMMARY

Western Research Institute (WRI) performed monitoring of selected emissions for Entech, Inc., on a TOS-80 Model incinerator in Anchorage, Alaska. Nine test burns were monitored from April 20 to May 8, 1993. Materials burned included municipal solid waste, tires, medical waste, railroad ties, used oil and auto fluff. Particulates, hydrogen chloride, and organics in metals emissions were measured from the stack exhaust gases for each burn. WRI used procedures described in 40 CFR Part 60, Appendix A, Methods 1 and 5 for particulate emissions; 40 CFR Part 60, Appendix A, Method 23 for organic emissions; 40 CFR Part 266, Appendix IX for metals emissions; and the Puget Sound Air Pollution Control Agency procedure for hydrogen chloride (HCl) emissions. EPA's Toxicity Characteristic Leaching Procedure (TCLP, 40 CFR Part 261, Appendix 2) was conducted on samples of the residual ash from each burn.

Particulate and HCl emissions were monitored using one impinger sampling train. Particulate emissions, corrected to a 12% carbon dioxide (CO_2) basis, were less than the 0.08 g/dscf limit set by the state of Alaska. One exception occurred during the early part of burn 1, when the operator's experiment with system capabilities resulted in visible emissions of black, particulate-laden smoke form the stack. Particulate emissions from most burns were <0.02 gr/dscf. The HCl emission factor calculated from the medical waste burn was 0.0052 lb per lb medical waste. HCl emissions for all burns ranged from 4 ppm to 140 ppm.

Samples of the stack gas for metals emissions determination were collected in an EPA-designated impinger sampling train. Up to 0.9 ng/dscm of lead and up to 0.16 ng/dscm of cadmium were detected in samples of the stack

gases from burns 2, 6, and 9. Ash from burns 2, 5/6, and 9 had higher than normal concentrations of these two metals. Ash from burn 6 failed the TCLP test for lead and burn 9 auto fluff failed the TCLP test for cadmium. Ash from burn 2 passed the TCLP test for both of these metals.

The high stack temperatures >1700°F (927°C) experienced during the tests caused decomposition of some metal parts on the sampling probes. This decomposition is believed to contribute to the moderate concentrations of chrome and nickel detected in impinger and acetone wash solutions. Zinc was found in gaseous emissions from all burns (up to 2 ng/dscm).

Organic emissions were measured with an impinger sampling train containing an XAD-2 resin trap. The high dioxin and furan levels were barely distinguishable from the field blank for most burns. Benzoic acid and phthalates were measured in some samples. Benzoic acid is believed to originate from products of decomposition of the XAD-2 resin used to trap organics. The phthalates are common in plastic materials and may be due to laboratory and field contamination.

INTRODUCTION

Entech, Inc., retained Western Research Institute (WRI) to measure emissions from their Model TOS-80 thermal oxidation demonstration plant located at Anchorage, Alaska. The system, which has a nominal capacity of 28 tons per day of municipal solid waste (MSW), consisted of a primary combustion/pyrolysis chamber where the waste was batch-loaded onto a grate. The MSW was loaded through the top of the primary chamber using conveyors without preparation other than a manual sort to remove large pieces such as wire rope. The contents of the primary chamber were ignited using natural gas as fuel.

Once combustion was under way, the primary chamber was operated in an air-starved mode. The gases given off were incinerated in a secondary combustion chamber, which has provision for natural gas addition to maintain temperature. When the pyrolysis was near completion, the primary chamber was operated in an excess-air mode to incinerate the residual char. Much of the ash fell through the grate and was removed manually after burn completion. A typical burn excluding ash cooldown lasted about 12 to 14 hours. The ash could also have been allowed to accumulate between burns, and then removed after a series of burns. This was done for burns 5 and 6.

A total of nine burns were completed during this test series. The burns were performed on alternate days starting on April 20 and ending on May 8, 1993. A listing of the burns is in Table 1. For each burn, WRI completed three particulate emission measurements (denoted particulate A, B, and C), three HCl emission measurements, one metals/mercury measurement, and one organic measurement. Results of emission measurements are presented in Appendix A.

Particulate A was collected near the start of the burn; sampling about 15 minutes after the start of combustion in the primary chamber. Particulate B was collected near mid burn; beginning about 3 to 4 hours after the start of combustion in the primary chamber. Particulate C was collected approximately 8 hours after the start of combustion in the primary chamber. The times of sampling are noted on the data sheets (Appendix B). Following the burn, samples of the ash were collected for the U.S. Environmental Protection Agency's (EPA) Toxicity

Characteristic Leaching Procedure tests after the remaining ash cooled.

Table 1. Entech Test Burn Statistics

Burn	Date	Description of Materials Consumed	Amount, lb	Natural Gas Used, ft^3	Ash, yd^3
1	4/20	18 yd^3 of MSW	6600	2750	1.8
2	4/22	16.5 yd^3 MSW, 4 yd^3 tires, oil waste	6400	3900	1.0
3	4/24	10.4 yd^3 medical waste, red bags in 7 cardboard boxes	629	880	1.5
4	4/26	23 Auto tires, 2 truck tires, whole	461	1210	0.5
5	4/28	18 yd^3 of MSW, 200 lb wooden pallets	6800	2240	1.5
6	4/30	16.5 yd^3 MSW, 3.7 yd^3 auto tires, 5.2 yd^3 medical waste, 20 lb cardboard	7642	2400	0.5
7	5/4	4.5 yd^3 auto fluff	2450	1400	0.75
8	5/6	10 gal used oil, 3.5 yd^3 of creosote-soaked railroad ties	3080	1100	0.25
9	5/8	7.2 yd^3 auto fluff	3975	1480	1.25

Notes: Information in Table 1 provided to WRI by Entech; MSW = municipal solid waste, yd^3 = cubic yards. Weights and cubic yard volumes are approximate.

PROCEDURES

Entech System Description

The wastes are [redacted]

The secondary combustion chamber has six burners where natural gas can be introduced. The secondary combustion chamber is a horizontal cylinder that is 4-ft in diameter and 15-ft long. The length of [redacted]

There are also five gas sensors for measuring oxygen, carbon monoxide, and sulfur dioxide. These sensors were linked to the data acquisition system. The gas sensors are listed below:

Primary off-gas, Thermox oxygen analyzer
Primary off-gas, Thermox carbon monoxide analyzer

Secondary stack gas, Anarad oxygen analyzer
Secondary stack gas, Anarad sulfur dioxide analyzer
Secondary stack gas, carbon monoxide analyzer (Infrared, IR, nondispersive)

Entech, also had a portable Anarad, nondispersive IR carbon dioxide analyzer that was not connected to the data acquisition system.

Oxygen and Carbon Dioxide Measurements

The data that WRI was contracted to measure (particulates, metals, HCl, and organics emissions) were corrected to a 7% oxygen or 12% carbon dioxide basis, as required by EPA protocols. The original plan was to obtain these measurements from Entech's data acquisition system. An independent tester (Am Test) was to certify that the data acquisition system was reading correctly for one of the burns.

The Anarad stack flue gas delivery system failed during the first burn. The Anarad technician was unable to put his system on line to provide reliable readings for any of the subsequent burns. WRI used its Enerac 2000 analyzer to provide supplemental stack gas readings. The oxygen measurement from the WRI Enerac 2000 analyzer agreed with the measurement from the Anarad oxygen analyzer before failure of the Anarad sampling line. WRI continued to take Enerac 2000 analyzer readings for burns 2 and 3. The Enerac 2000 analyzer also measured carbon monoxide, NO_x, and it has functions for calculating carbon dioxide.

WRI borrowed a portable Teledyne instrument owned by Entech to measure oxygen and carbon monoxide starting with burn 2. This instrument was used for all subsequent burns. The Teledyne instrument has electrochemical sensors and has an internal program for calibrating these sensors. WRI used the following procedure for the Enerac 2000 and Teledyne instrument: (1) check readings in ambient air to verify the instrument accuracy, (2) sample the stack gases for about five minutes, (3) remove the sampling probe, (4) and sample the ambient air.

The Enerac 2000 analyzer oxygen sensor failed after the third burn. WRI continued to use that instrument for carbon monoxide and NO_x measurements.

The independent stack tester (Am Test) monitored three burns (6, 8, and 9) for oxygen, carbon monoxide, and sulfur dioxide. Their results are recorded in a separate document by Entech (1993).

WRI borrowed the Anarad carbon dioxide analyzer for stack gas measurements for burns 7 and 8. A calibration gas (15.3% carbon dioxide in nitrogen) was used to check the instrument readings. The flue gas was sampled at the same location as the particulate sampling train.

WRI Procedures

WRI followed the procedures for isokinetic sampling listed in 40 CFR 60, Appendix A, Methods 1 and 5, and organic sampling, Method 23. Procedure 40 CFR 266 Appendix IX Section 3 was followed for metals/mercury sampling. Procedure 40 CFR 261, Appendix II, Method 1311 was followed for Toxicity Characteristic Leaching Procedure testing of the ash.

Procedure 40 CFR Part 60, Appendix A, Method 26 provides for separate measurement of hydrogen chloride. However, the burn scheduling and the requirement that a number of other parameters also be measured preclude using another sampling train for hydrogen chloride. The particulate sampling train was modified to incorporate a fifth impinger according to a procedure adapted by the Puget Sound Air Pollution Control Agency (1983 and 1988; listen in Appendix C). This procedure allows collection of both front-half and back-half particulates as well as collection of hydrogen chloride in the same sampling train. The procedures were sent to WRI courtesy of Fred Austin, (206) 343-8800, Puget Sound Air Pollution Control Agency, Seattle, Washington. The extra impinger contained a weak solution of sodium carbonate/bicarbonate in deionized-distilled water. The impinger solutions were analyzed for chlorides by ion chromatography following EPA Method 300.

Details of WRI procedures and data analysis are presented in Appendix A of this report.

Special Problems Created By High Stack Temperatures

Stack temperatures were measured at 10 ft below the top of the stack by a thermocouple connected directly to a temperature reader. These temperatures varied from about 1400°F to greater than 2000°F. Most temperatures were near 1700°F. These high temperatures created special problems. The EPA procedures (40 CFR 60, Appendix A, Methods 1 and 5) call for Teflon ferrules connecting the quartz liner to the nozzle assembly. However, because Teflon would have melted at these temperatures, heat-resistant graphite tape was used to seal the probe.

Stack velocities were approximately 12-ft per second for most burns. For all burns, a 0.5-inch diameter nozzle was used. Entech had purchased one stainless-steel nozzle,

two quartz liner inserts for the probes, and two stainless-steel probes. WRI provided two Inconel nozzles, a quartz liner, and a stainless-steel probe. All of the organic samples were collected with the WRI equipment. The high temperatures softened the stainless-steel nozzle. This caused the stainless steel to flake, and the nozzle was retired from service. One of the two Entech-supplied stainless-steel probes softened enough that it bowed slightly and cracked the quartz liner. This happened during burn 7, particulate sample C. Therefore, there is no particulate data for 7C.

WRI had concerns that the probe nozzle or graphite seal might flake, resulting in high apparent particulates in the acetone wash. To correct for this, a nozzle blank was prepared. This consisted of cleaning the probe, nozzle, and quartz liner with acetone and brushes. The probe and nozzle were then placed in the stack for 30 minutes at 1700°F without drawing any gases. The probes were removed from the stack and allowed to cool. After cooling, the nozzle was rinsed with acetone without using any brushes. This acetone rinse was called the nozzle blank. Despite this, WRI believes that the acetone washes include some particulates from the probe nozzle or graphite seal rather than from the stack gases.

The stainless steel pitot tube attached to the sample probe was not used because of the high temperatures. Instead, WRI used a standard pitot tube that was inserted into the stack only long enough to take an impact pressure reading. The pitot tube was connected to a separate inclined manometer rather than to the manometers that came with the Andersen stack sampler equipment. This setup was required because the pitot tube readings were on the order of 0.01 inches of water, and the manometer supplied with the Andersen equipment could not be read accurately for these low values.

The stainless steel probe for the Teledyne instrument also softened and deformed because of the heat.

RESULTS

Stack Gas Flow Rate

The stack gas velocity from the secondary combustion chamber was calculated from pitot tube measurements, the gas temperature, the gas pressure, and average gas molecular weight. A sample calculation is presented in Appendix A. The average molecular weight was calculated from the gas composition (Appendix A, Table A3). From the stack gas velocity, the stack gas flow rate was calculated using the cross sectional area (7.068 square feet). The actual gas flow rate was then corrected to standard conditions of 29.92 inch Hg and 68°F (20°C).

The results in Table 2 represent average conditions during the emissions sampling event. The times of measurement are noted on the data sheets (Appendix B). Particulate sample A was collected near the start of the burn, particulate sample

B at approximately mid burn, and particulate sample C near the end of the burn. Organics sampling spanned a period of time from about 1.5 hours into the burn through mid burn. Metals

Table 2. Stack Gas Flow Rates

Burn	Sample	Stack Velocity, ft/s	Actual Cubic Feet Per Minute	Standard Cubic Feet Per Minute, scfm
1	A	17.7	7513	1778
	B	15.5	6559	1550
	C	24.0	10,184	2340
	organics	18.0	7632	1752
	metals	16.3	6932	1599
2	A	14.0	5936	1449
	B	12.1	5113	1302
	C	12.4	5238	1310
	organics	12.6	5338	1311
	metals	12.1	5126	1276
3	A	14.1	5995	1419
	B	13.5	5707	1372
	C	13.6	5783	1383
	organics	13.4	5682	1363
	metals	13.0	5495	1314
4	A	13.0	5512	1316
	B	13.9	5908	1434
	C	10.3	4385	1101
	organics	13.5	5726	1367
	metals	10.9	4622	1143
5	A	11.7	4959	1287
	B	12.4	5255	1251
	C	12.4	5275	1261
	organics	11.9	5046	1221
	metals	13.2	5604	1335

Burn	Sample	Stack Velocity, ft/s	Actual Cubic Feet Per Minute	Standard Cubic Feet Per Minute, scfm
6	A	14.8	6265	1426

	B	11.2	4740	1153
	C	10.4	4427	1084
6	organics	11.2	4756	1158
	metals	15.1	6390	1461
7	A	10.5	4455	1227
	B	10.4	4419	1097
	C	9.9	4189	1048
	organics	10.3	4348	1100
	metals	10.0	4225	1062
8	A	11.5	4899	1246
	B	12.1	5147	1220
	C	12.1	5117	1207
	organics	11.9	5063	1203
	metals	12.1	5135	1208
9	A	11.5	4859	1244
	B	11.5	4876	1237
	C	11.1	4685	1182
	organics	11.8	5007	1256
	metals	11.1	4698	1182

Note: The numbers listed above for velocity have been rounded, but calculations were carried to additional significant figures. This is the reason why there are minor variations in gas flow rate for the same listed velocity.

sampling occurred near mid burn, when the temperatures in the primary combustion chamber approached their highest values. For one test, metals were sampled near the start of the burn to catch any mercury emissions.

The stack gas flow rates are necessary to calculate the total amount of emissions and other emission factors such as the weight of pollutants emitted per unit weight of waste burned.

The stack gas flow rates for most test burns were in the range of 1100 to 1400 scfm minute. A notable exception was burn 1 (Table 2), where higher stack gas flows were measured because additional air was delivered to the primary combustion chamber near the end of the burn. The calculated stack gas flow rate during burn 1, particulate C measurement is 2340 scfm per minute.

Comparison of Am Test Oxygen Measurements with WRI Measurements

Entech retained Am Test to independently measure the stack gases for oxygen, carbon monoxide, and sulfur dioxide; this was done for burns 6, 8, and 9. The original purpose of the Am Test measurements was to certify the Anarad sensors. However, the Anarad system was inoperative because of problems in the gas delivery hardware that conveyed flue gas to the Anarad instruments. The results of the Am Test measurements were made available to WRI. WRI measured oxygen and carbon monoxide using an Entech-furnished Teledyne instrument. WRI averaged the oxygen measurements taken over the sampling period and compared the Am Test averages with the Teledyne instrument averages (Table 3). The WRI averages for other burns are listed in Appendix A (Table A2).

The averages of the oxygen concentrations measured by the Teledyne instrument are higher than the Am Test values, except for two samples during burn 6. The raw data for both sets show considerable variations in oxygen concentration over the test period. WRI believes that part of the difference between the two values is because of the sampling intervals at which oxygen readings are taken. The Am Test data were taken at one-minute intervals, but there were some gaps in the data record that correspond to the periods during which WRI was taking data. Typically, WRI generally took readings with the Teledyne instrument only once during a traverse position at 10-, 12-, 13-, or 20-minute intervals, depending upon the sample. Some supplemental oxygen readings were also taken at irregular intervals. The differences in sampling interval will

naturally produce differing oxygen concentration averages between the instruments.

However, this does not explain why the Teledyne oxygen averages are higher for most data sets. Part of the answer may be because the Teledyne samples were taken at the same locations as the particulate samples (10-ft from the stack

Table 3. Comparison of Average Am Test Measurements with WRI Measurements for Oxygen

Burn	Sample	Am Test % O_2	Teledyne % O_2
6	A	5.76	7.58
	B	7.14	5.36
	C	no data; near 9% at start of C	9.74
	organics	6.46	5.95
	metals	5.64	7.84
8	A	6.48	7.9
	B	6.02	10.1
	C	6.37	9.9
	organics	5.51	10.4
	metals	6.19	8.1
9	A	5.04	5.88
	B	4.85	6.20
	C	7.66	9.87
	organics	5.72	7.07
	metals	7.08	7.43

exit), and the Am Test samples were taken at a location closer to the secondary combustion chamber (about 30-ft from the stack top, or 10-ft above the secondary combustion chamber).

WRI removed the Teledyne probe after each reading for burns 6, 8, and 9. This was done to see whether a 20.8 ± 0.5% oxygen reading was obtained when sampling atmospheric oxygen. There are also some gaps in the WRI data when the Teledyne instrument was in a calibration mode, or when the sample pump delivered insufficient gas flow.

The Teledyne instrument has an electrochemical sensor for measuring carbon monoxide. The carbon monoxide data were recorded by WRI on data sheets (Appendix B). Carbon monoxide was also measured and recorded using the Enerac 2000 electrochemical sensor. These data were compared with the measurements Am Test took using a nondispersive infrared instruments.

In general, the Enerac 2000 and Teledyne readings agreed with each other. All three instruments generally picked up occasional higher excursions (>20 ppm of CO). During normal conditions, the Am Test instrument showed less than 1 ppm of carbon monoxide, whereas, the electronic sensors picked up several parts per million of carbon monoxide.

WRI experienced a similar situation while testing a prototype Entech unit in Laramie, Wyoming. A rented nondispersive infrared carbon monoxide sensor gave readings less than 1 ppm, but the electrochemical sensor read several parts per million. Both instruments checked out with a 100 ppm calibration gas and with a zero carbon monoxide gas.

NO_x Measurements

The WRI-owned Enerac 2000 instrument has an electrochemical sensor for measuring NO_x (Table 4). These were recorded at irregular intervals for burns 1, 2, 3, and 4. No field calibration gas was used to check the instrument other than to check to see that a zero reading was obtained in atmospheric air.

Front-Half Particulates

Front-half particulates are those particulates collected on the filter, cyclone flask, probes, nozzles, and glassware up to the filter. Except for the filter, these particulates are removed from the sampling equipment by an acetone wash according to EPA protocols (40 CFR Part 60, Appendix A, Method 5). The solid material collected by this acetone wash is recognized by EPA and most state agencies as total particulates. The particulates are corrected to a 7% oxygen or 12% carbon dioxide basis, depending upon the state agency. The Alaska state agency permit is understood to be written around a 12% carbon dioxide basis (must be <0.08 gr/dscf), but newer federal regulations for large (>250 ton per day) MSW incinerators are written around a 7% oxygen basis. The sampling must be done isokinetically, which EPA defines as between 90% and 110% of isokinetic. WRI believes that the error generated by not sampling isokinetically is minimal because the particulates collected are very small and behave as a gas. No visible particulates were deposited in any of the

cyclone flasks. Table 5 was constructed from the raw data in Appendices A and B.

Back-Half Particulates

Back-half particulates are those solids collected in the glassware after the filter and in the impingers. These solids were analyzed according to procedures provided to WRI by the Puget Sound Air Pollution Control Agency. They are not part of the particulate sample required by the state of Alaska as far as WRI is aware. However, some states do require this back-half particulates. The back-half particulates consist of the residual solids remaining after the acetone wash of the glassware downstream of the filter in addition to the suspended solids in the impinger solutions. Table 6 was constructed from the raw data presented in Appendices A and B.

Table 4. Enerac 2000 NO_x Readings

Burn	Time	NO_x, ppm
1	12:06	105

2	07:19	71
	07:55	138
	08:43	177
	09:14	109
	10:48	60
	11:35	47
	12:04	30
	14:43	53
	15:24	57
	16:30	60
3	08:45	64
	09:46	66
	10:57	68
	12:30	62
	16:00	42
	16:40	47
4	07:17	71
	08:17	87
	08:20	89
	08:45	141
	09:40	161
	09:47	171
	10:00	67
	15:16	15

Table 5. Front-Half Particulates Corrected to a 7% O_2 or 12% CO_2 Basis

Burn	Sample	% O_2	% CO_2	% Isokinetic	Part. @ 7% O_2, gr/dscf	Part. @ 7% O_2, mg/dscm	Part. @ 12% CO_2, gr/dscf
1	A	8.8	9.5	90.2	0.57	1310	0.63
	B	8.8	9.5	104	<0.001	<2	<0.001
	C	12.0	6.3	91	0.028	63	0.034
2	A	3.0	13.2	124	0.018	41	0.021
	B	4.0	12.6	122	0.009	20	0.010
	C	8.9	10.4	101	0.005	10.5	0.005
3	A	4.4	12.2	107	0.009	20.1	0.010
	B	8.3	9.4	109.8	0.017	40	0.020
	C	7.2	10.3	102	<0.005	<10	<0.005
4	A	5.1	12.7	104	0.012	26.7	0.013
	B	7.4	10.9	105	0.019	42.4	0.020
	C	13.0	6.0	95	0.038	86.9	0.043
5	A	9.7	8.2	105	0.032	73.7	0.038
	B	6.3	10.8	97	0.007	15.1	0.008
5	C	8.3	9.0	93	0.013	29.2	0.015
6	A	7.6T	9.7	112	0.018	42.0	0.022
	A	5.8Am	XXXXX	112	0.016	37.0	XXXX
	B	5.4T	11.6	102	0.010	22.5	0.011
	B	7.1Am	XXXXX	102	0.011	25.4	XXXX
	C	9.7T	7.6	114	0.014	30.9	0.013
7	A	9.9T	7.0	103	0.037	85.4	0.051
	B	8.1T	9.4	103	0.006	12.7	0.0065
8	A	7.9T	10.4	110	<0.0005	<1	<0.0005

Table 5. Front-Half Particulates Corrected to a 7% O_2 or 12% CO_2 Basis (continued)

Burn	Sample	% O_2	% CO_2	% Isokinetic	Part. @ 7% O_2, gr/dscf	Part. @ 7% O_2, mg/dscm	Part. @ 12% CO_2, gr/dscf
	A	6.5Am	XXXX	110	<0.0005	<1	XXXX
	B	10.1T	8.3	105	0.015	34.2	0.017
	B	6.0Am	XXXX	105	0.011	24.8	XXXX
	C	9.6T	8.7	97	0.004	9.9	0.005
	C	6.4Am	XXXX	97	0.003	7.8	XXXX
9	A	5.9T	11.2	107	0.005	11.0	0.006
	A	5.0Am	XXXX	107	0.005	10.4	XXXX
	B	6.2T	11.0	105	0.019	44.2	0.022
	B	4.9Am	XXXX	105	0.018	40.7	XXXX
	C	9.9T	8.4	101	0.001	2.8	0.003
	C	7.8Am	XXXX	101	0.001	2.3	XXXX

Note: gr/dscf = grains per dry standard cubic feet; mg/dscm = milligrams per dry standard cubic meter. To convert from gr/dscf to mg/dscm, multiply by 2289. There is no particulate 7C because of a broken quartz liner. Duplicate readings for particulates for burns 6, 8, and 9 represent calculations based on different oxygen measuring instruments (T = Teledyne, Am = Am Test).

Table 6. Back-Half Particulates Corrected to a 7% O_2 or 12% CO_2 Basis

Burn	Sample	% O_2	% CO_2	% Isokinetic	Part. @ 7% O_2, gr/dscf	Part. @ 7% O_2, mg/dscm	Part. @ 12% CO_2, gr/dscf
1	A	8.8	9.5	90.2	0.042	96.8	0.047
	B	8.8	9.5	104	0.0057	13.1	0.006
	C	12.0	6.3	91	0.015	34.1	0.018
2	A	3.0	13.2	124	0.0005	1.2	0.0006
	B	4.0	12.6	122	0.002	5.3	0.003
	C	8.9	10.4	101	0.007	16.6	0.007
3	A	4.4	12.2	107	0.005	11.0	0.006
	B	8.3	9.4	109.8	0.006	11.0	0.006
	C	7.2	10.3	102	0.002	4.5	0.002
4	A	5.1	12.7	104	0.003	7.4	0.003
	B	7.4	10.9	105	0.016	35.6	0.017
	C	13.0	6.0	95	0.024	55.6	0.027
5	A	9.7	8.2	105	0.009	21.1	0.011
	B	6.3	10.8	97	0.005	11.3	0.006
	C	8.3	9.0	93	0.009	21.4	0.009
6	A	7.6T	9.7	112	0.011	25.9	0.013
	A	5.8Am	XXXX	112	0.010	22.8	xxxx
	B	5.4T	11.6	102	0.009	19.6	0.010
6	B	7.1Am	XXXX	102	0.010	22.1	xxxx
	C	9.7T	7.6	114	0.013	22.9	0.017
7	A	9.9T	7.0	103	0.012	28.1	0.017

Table 6. Back-Half Particulates Corrected to a 7% O_2 or 12% CO_2 Basis (continued)

Burn	Sample	% O_2	% CO_2	% isokinetic	Part. @ 7% O_2, gr/dscf	Part. @ 7% O_2, mg/dscm	Part. @ 12% CO_2, gr/dscf

	B	8.1T	9.4	103	0.005	12.7	0.005
8	A	7.9T	10.4	110	0.020	45.6	0.021
	A	6.5Am	XXXX	110	0.017	39.7	xxxx
	B	10.1T	8.3	105	0.008	17.4	0.009
	B	6.0Am	XXXX	105	0.006	12.7	xxxx
	C	9.6T	8.7	97	0.004	9.9	0.007
	C	6.4Am	XXXX	97	0.006	14.1	xxxx
9	A	5.9T	11.2	107	0.005	13.5	0.007
	A	5.0Am	XXXX	107	0.005	12.8	xxxx
	B	6.2T	11.0	105	0.004	9.9	0.005
	B	4.9Am	XXXX	105	0.004	9.1	XXXX
C	C	9.9T	8.4	101	0.002	5.0	0.002

Notes: gr/dscf = grains per dry standard cubic feet; mg/dscm = milligrams per dry standard cubic meter. To convert from gr/dscf to mg/dscm, multiply by 2289. There is no particulate 7C because of a broken quartz liner. Duplicate readings for particulates for burns 6, 8, and 9 represent calculations based on different oxygen measuring instrumentation (T = Teledyne, Am = Am Test).

Hydrogen Chloride Emissions

Hydrogen chloride is generated as the result of combustion of wastes that contain chlorine (e.g., plastics). Hydrogen chloride is absorbed by water vapor in the air to form hydrochloric acid. Table 7 was constructed from Appendix A Table A7.

Table 7. Hydrogen Chloride Emissions

Burn	Sample	Percent O_2	ppm HCl, as Measured	ppm HCl @ 7% Oxygen
1	A	8.8	50.0	57.4
	B	8.8	61.5	70.6
	C	12.0	55.3	35.6
2	A	3.0	101.6	78.6
	B	4.0	18.3	14.9
	C	8.9	26.8	30.9
3	A	4.4	66.8	56.4
	B	8.3	6.8	7.6
	C	7.2	31.8	32.6
4	A	5.1	68.5	60.4
	B	7.4	6.0	6.2
	C	13.0	12.7	22.2
5	A	9.7	63.5	78.7
	B	6.3	11.4	10.8
	C	8.3	19.5	21.5
6	A	7.6T	44.7	46.7
	A	5.8Am	44.7	41.7
	B	5.4T	15.6	13.9
	B	7.1Am	15.6	15.7
	C	9.7T	10.5	13.0

7	A	9.9T	81.2	102.4
	B	8.1T	9.5	10.3
	C	9.0T	17.7	20.5

Table 7. Hydrogen Chloride Emissions (continued)

Burn	Sample	Percent O_2	ppm HCl as Measured	ppm HCl @ 7% Oxygen
8	A	7.9T	67.4	72.5
8	A	6.5Am	67.4	62.7
	B	10.1T	4.2	5.4
	B	6.0Am	4.2	3.9
	C	9.6T	6.0	7.3
	C	6.4Am	6.0	5.7
9	A	5.9T	139.9	129.3
	A	5.0Am	139.9	122.3
	B	6.2T	4.8	4.5
	B	4.9Am	4.8	4.2
	C	9.9T	48.3	62.1
	C	7.8Am	48.3	50.5

Notes: Duplicate readings for HCl for burns 6, 8, and 9 represent calculations based on different oxygen measuring instrumentation (T = Teledyne, Am = Am Test).

Metals Emissions

Metals emissions were measured isokinetically using an impinger sampling train according to 40 CFR Part 266, Appendix IX, Section 3. Results from the analyses of the impinger and rinse solutions are presented as measured in Table 8 and corrected to a 7% oxygen basis in Table 9. Concentrations of antimony, arsenic, beryllium and thallium were below the analytical detection limits for all burns. Metals having the highest concentration were lead (0.011 to 0.935 mg/dscm), nickel (0.012 to 0.983 mg/dscm), and zinc (0.108 to 1.974 mg/dscm). Mercury was present in emissions from the MSW and auto fluff burns but was absent from the tire, medical waste, and railroad tie burn emissions. Burns 6 and 9 had higher-than-average cadmium and lead emissions.

Table 8. Metal Emissions as Measured (uncorrected for % O_2), mg/dscm

Burn	1	2	3	4	5	6	7	8	9
Sb	<0.02	<0.03	<0.02	<0.03	<0.03	0.052	<0.03	<0.03	<0.03
As	<0.25	<0.25	<0.25	<0.3	<0.25	<0.25	<0.3	<0.3	<0.3
Be	<0.0005	<0.0005	<0.0005	<0.0006	<0.0005	<0.0005	<0.0005	<0.0006	<0.0005
Cd	0.0022	0.152	0.0036	0.0028	0.0211	0.1614	0.0158	0.0119	0.0825
Cr	<0.001	0.047	0.022	0.0278	0.114	0.0333	0.00523	0.035	0.0118
Pb	0.037	0.935	0.0205	0.011	0.149	0.726	0.1853	0.1383	0.616
Mn	<0.01	0.016	0.10	0.149	0.0416	0.0371	0.0638	0.0763	0.0373
Hg	0.0123	0.134	<0.001	<0.001	0.1233	0.1985	0.0658	0.002	0.1175
Ni	0.012	0.069	0.518	0.456	0.3682	0.2755	0.290	0.983	0.2757
Tl	<0.01	<0.01	<0.01	<0.014	<0.013	<0.013	<0.013	<0.013	<0.013
Zn	0.9	0.718	0.108	0.1826	0.899	1.974	1.4914	1.3742	1.6375

Table 9. Metal Emissions Corrected to a 7% Oxygen Basis, mg/dscm

Burn	1	2	3	4	5	6
% O_2	8.7	6.8	7.8	10.3	7.8	7.84T
Sb	<0.02	<0.02	<0.02	<0.04	<0.03	0.055
As	<0.3	<0.25	<0.3	<0.04	<0.3	<0.3
Be	<0.0006	<0.0005	<0.0005	<0.0007	<0.0005	<0.0005
Cd	0.0025	0.15	0.0038	0.0037	0.022	0.172
Cr	<0.001	0.046	0.023	0.036	0.121	0.035
Pb	0.042	0.922	0.022	0.014	0.158	0.772
Mn	<0.01	0.016	0.11	0.206	0.044	0.039
Hg	0.014	0.132	<0.001	<0.001	0.131	0.211
Ni	0.014	0.068	0.55	0.60	0.39	0.29
Tl	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02
Zn	1.0	0.7	0.115	0.252	0.955	2.10

Burn	6	7	8	8	9	9
% O_2	5.64Am	9.2T	8.1T	6.19Am	7.43T	7.08Am
Sb	0.047	<0.04	<0.03	<0.03	<0.03	<0.03
As	<0.2	<0.4	<0.3	<0.3	<0.3	<0.3
Be	<0.0005	<0.0006	<0.0005	<0.0005	<0.0005	<0.0005
Cd	0.148	0.019	0.013	0.011	0.085	0.083
Cr	0.030	0.006	0.038	0.033	0.012	0.012
Pb	0.662	0.220	0.150	0.131	0.636	0.616
Mn	0.034	0.075	0.083	0.072	0.038	0.037
Hg	0.181	0.078	0.002	0.002	0.121	0.118
Ni	0.25	0.34	1.07	0.93	0.028	0.28
Tl	<0.01	<0.02	<0.02	<0.01	<0.01	<0.01
Zn	1.80	1.76	1.49	1.30	1.69	1.64

Notes: Two different oxygen measuring instruments were used for burns 6, 8, 9; T = Teledyne; Am = Am Test Certification.

Organics Emissions

The organic samples, including filter, impinger solutions, and XAD-2 resin trap, were refrigerated after sample collection. They were shipped the morning after the burns to Triangle Laboratories of Research Triangle Park, Inc., Durham, North Carolina, for analysis. The samples for the first four burns were accumulated and shipped as a lot. The results were reported as total quantity of organic species collected in units of picograms (pg) or nanograms (ng). The total quantities were divided by the total volume of gas sampled in dry standard cubic meters (dscm) at standard conditions of 68° (20°C) and 1 atmosphere (atm) of pressure. To comply with regulations, these numbers were further corrected to a 7% oxygen basis. The sampling time for each burn was exactly 4 hours. Stack gas flow rates are listed in Table 2. Sample volumes in dscm are listed below (see also Appendix A, Table A1):

Burn 1 - 2.0624
Burn 2 - 1.6730
Burn 3 - 1.7342
Burn 4 - 1.5147
Burn 5 - 1.2930
Burn 6 - 1.3060
Burn 7 - 1.4575
Burn 8 - 1.5470
Burn 9 - 1.5221

Organic concentrations are listed in Tables 10,11, 12, and 13. Table 10 lists dioxins/furans concentrations in nanograms per dry standard cubic meter for burns 1 through 9 and nanograms for the field blank. The field blank was prepared by preparing the sampling equipment as if for a run, but no sample was drawn. Except for burn 1, the concentrations of dioxins/furans were similar to the field blank. Table 11 lists the corrected concentrations of dioxins/furans concentrations to a 7% oxygen basis. Detection limits listed and data summary sheets, as received from Triangle Laboratories, are in Appendix D.

The results of the semivolatile analyses (EPA Method 8270) are listed in Table 12. Additional compounds measured but not detected are listed in Appendix D. Naphthalene, phenol, acenaphthene, and fluorene were also detected in a number of samples, especially the sample from burn 9.

Polychlorinated biphenyl concentrations are listed in Table 13. In this report, polychlorinated biphenyls include mono-, di-, and trichlorinated biphenyl. EMPC means estimated maximum possible concentration, and include the sum of all EMPC. Actual concentrations are probably much lower.

Toxicity Characteristic Leaching Procedure Tests on Ash

After cooling, the ash from each burn was collected and shipped to WRI for EPA's Toxicity Characteristic Leaching Procedure Tests (40 CFR Part 261, Appendix II, Method 1311, as revised in March 29, 1990, and June 29, 1990, Federal Register. The laboratory data from TCLP Tests on the ash samples are presented in Appendix E.

The ash from burn 5 was not removed from the primary chamber until burn 6 was completed; therefore, a combined sample (5/6) was collected and analyzed. The ash from burn 8 was segregated. Sample 8T contained ash from the top of the ash pile where mostly oil/tar was burned, whereas sample B contained ash taken near the bottom where mostly railroad ties were burned.

EPA protocol requires that 5 grams of ash be slurried with 96.5 mL deionized-distilled water and shaken for 10 minutes. The pH is measured. Hydrochloric acid (3.5 mL of 1 N HCl) is added to each sample. The acid slurries are heated to 50°C (122°F) and held at that temperature for 10 minutes. After cooling to room temperature, the pH is measured. If the pH is greater than 5, dilute acetic acid (pH 2.8) is used as the extracting fluid. If the pH is less than 5, dilute sodium acetate solution is used as the extracting fluid.

Sample 8T was the only sample for which the sodium acetate solution was used for leaching. All other sample used dilute acetic acid.

The leachate solution was analyzed for EPA-listed metals and semivolatile compounds. Pesticides and volatile compounds were not analyzed because they were believed not to be present. The results are in Tables 14, 15, and 16.

No semivolatiles were detected in any of the ash samples (Table 16). Heavy metals were present in the ash samples (Tables 14 and 15). The leachate for burn 5/6 ash exceeded the limit for lead set by the Resources Conservation and Recovery Act (RCRA) for a hazardous waste for lead (Tables 14 and 15). The ash for burn 9 exceeded the RCRA limit for cadmium.

WRI had some problems in obtaining a cadmium determination for the sodium acetate method blank. Sodium

acetate was used as the extracting fluid for sample 8T. However, sample 8T did pass the RCRA-limit test for all heavy metals.

Table 10. Dioxins/Furans as Measured, ng/dscm

Burn	Field Blank	1	2	3	4	5	6	7	8	9
Total TCDD	ND	3.01	ND	0.14	0.0067	ND	ND	ND	ND	ND
Total PeCDDD	ND	3.01	ND	0.098	0.013	ND	ND	ND	EMPC (0.0051)	ND
Total HxCDD	0.03	5.92	0.03	0.42	0.047	0.015	ND	ND	0.0051	0.028
Total HpCDD	0.42	4.66	0.22	0.69	0.22	0.42	ND	0.23	0.11	0.13
OCDD	1.8	2.91	0.77	1.27	0.87	1.13	EMPC (0.32)	0.73	0.45	0.51
Total TCDF	0.01	55.28	0.018	0.63	0.14	0.0075	ND	0.073	0.045	0.026
Total PeCDF	0.02	39.52	0.018	0.63	0.06	0.030	ND	0.087	0.013	0.0058
Total HxCDF	0.24	29.87	0.12	0.53	0.12	0.15	ND	0.53	0.051	0.070
Total HpCDF	0.66	9.30	0.28	0.69	0.22	0.53	ND	0.40	0.15	0.18
OCDF	0.54	1.31	EMPC (0.15)	0.49	0.13	0.32	ND	0.17	0.070	0.096
Totals	3.72	151.17	1.60	5.60	1.82	2.60	0.32	2.32	0.89	1.05

Notes: The abbreviation ND means that the chemical was not detected, and the analytical detection limit is given. EMPC means that the chemical was detected, and the estimated maximum possible concentration (EMPC) is given. J means that the chemical was detected but below the normal analytical detection limit; an estimated concentration is reported.

Table 11. Dioxin/Furan Measurements Corrected to a 7% Oxygen Basis, ng/dscm

Burn	1	2	3	4	5	6
% Oxygen	8.7	4.4	7.0	7.3	9.0	5.95T
Total TCDD	4.16	ND	0.14	0.0068	ND	ND
Total PeCDDD	4.16	ND	0.95	0.013	ND	ND
Total HxCDD	8.18	0.025	0.92	0.048	0.018	ND
Total HpCDD	6.44	0.19	0.69	0.22	0.49	ND
OCDD	4.02	0.65	1.27	0.89	1.32	EMPC (0.30)
Total TCDF	76.40	0.015	0.63	0.14	0.088	ND
Total PeCDF	54.62	0.015	0.63	0.06	0.035	ND
Total HxCDF	41.28	0.10	0.53	0.12	0.18	ND
Total HpCDF	12.85	0.24	0.69	0.22	0.62	ND
OCDF	1.81	EMPC (0.13)	0.49	0.13	0.37	ND
Totals	213.9	1.4	5.6	1.86	3.18	EMPC (0.3)

Notes: The abbreviation ND means that the chemical was not detected, and the analytical detection limit is given. EMPC means that the chemical was detected, and the estimated maximum possible concentration (EMPC) is given. J means that the chemical was detected but below the normal analytical detection limit; an estimated concentration is reported.

Table 11. Dioxin/Furan Measurements Corrected to a 7% Oxygen Basis, ng/dscm (continued)

Burn	6	7	8	8	9	9
% Oxygen	6.46Am	9.7T	10.4T	5.51Am	7.07T	5.72Am
Total TCDD	ND	ND	ND	ND	ND	ND
Total PeCDDD	ND	ND	EMPC (0.0067)	EMPC (0.0046)	ND	ND
Total HxCDD	ND	ND	0.0067	0.0046	0.028	0.026
Total HpCDD	ND	0.28	0.15	0.09	0.13	0.12
OCDD	EMPC (0.31)	0.90	0.59	0.41	0.51	0.47
Total TCDF	ND	0.09	0.059	0.041	0.026	0.024
Total PeCDF	ND	0.108	0.017	0.012	0.0058	0.0053
Total HxCDF	ND	0.66	0.067	0.046	0.070	0.064
Total HpCDF	ND	0.50	0.20	0.14	0.18	0.17
OCDF	ND	0.21	0.092	0.063	0.096	0.088
Totals	EMPC (0.31)	2.87	1.18	0.80	1.05	0.96

Notes: The abbreviation ND means that the chemical was not detected, and the analytical detection limit is given. EMPC means that the chemical was detected, and the estimated maximum possible concentration (EMPC) is given. J means that the chemical was detected but below the normal analytical detection limit; an estimated concentration is reported.

Table 12. Stack Emission Semivolatiles as Measured, µg/dscm

Burn	Field Blank	1	2	3	4	5	6	7	8	9
Phenol[a]	ND	27.98	2.07	9.59	ND	ND	ND	0.77	ND	ND
2-Chlorophenol[a]	ND	ND	ND	1.69	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.69[b]	0.29[b]	0.86[a] 0.97[b]	0.59[a] 0.74[b]	0.38[b]	0.15[b]	ND	ND	ND	ND
2-Methylphenol[a]	ND	8.34	ND	ND	ND	ND	ND	ND	ND	ND
3/4-Methylphenol[a]	ND	17.60	ND	ND	ND	ND	ND	ND	ND	ND
Nitrobenzene[a]	ND	2.20	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic Acid[a]	ND	395.09	147.98	327.33	ND	ND	143.22	118.97	213.17	512.26
2,4-Dichlorophenol[a]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	0.73[b]	ND	0.22[b]	ND	ND	ND	ND	ND	ND
Naphthalene[a]	4.74	15.56	3.71	5.55	2.42	9.37	7.34	ND	7.15	353.94
2-Methylnaphthalene[a]	ND	9.82	ND	ND	ND	ND	ND	ND	ND	16.90
2,4,6-Trichlorophenol	ND	ND	ND	0.56	ND	ND	ND	ND	ND	ND
2-Chloronaphthalene[a]	ND	ND	2.37	ND	1.40	1.99	ND	ND	ND	ND
Dimethylphthalate[a]	ND	5.06	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene[a]	ND	1.28	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene[a]	ND	1.24	ND	ND	ND	ND	ND	ND	ND	96.19
Dibenzofuran[a]	ND	1.87	ND	ND	ND	ND	ND	ND	ND	ND

[a] - Analyses by Method 8270 for Table 2 list of semivolatile compounds

[b] - Analyses by Method 8270 for chlorobenzenes and chlorophenols

Table 12. Stack Emission Semivolatiles as Measured, µg/dscm (continued)

Burn	Field Blank	1	2	3	4	5	6	7	8	9
Diethylphthalate	ND	6.97	ND	ND	ND	ND	ND	ND	2.64	4.37
Fluorene[a]	ND	1.45	ND	ND	ND	ND	ND	ND	ND	17.35
Phenanthrene[a]	ND	11.41	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene[a]	ND	0.64	ND	ND	ND	ND	ND	ND	ND	10.94
Di-n-butylphthalate[a]	ND	14.92	2.09	7.69	12.18	ND	17.59	5.25	217.12	7.94
Fluoranthene[a]	ND	2.57	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene[a]	ND	1.88	ND	ND	ND	ND	ND	ND	ND	ND
Butylbenzylphthalate[a]	5.38	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-Ethylhexyl)phthalate[a]	134.60	5.36	ND	ND	ND	ND	44.09	3.65	46.29	9.77
Chrysene[a]	ND	2.39	ND	ND	ND	ND	ND	ND	ND	ND

[a] - Analyses by Method 8270 for Table 2 list of semivolatile compounds

[b] - Analyses by Method 8270 for chlorobenzene and chlorophenols

ND - Not detected

Table 13. Stack Emission Polychlorobiphenyls as Measured, µg/dscm

Burn	Field Blank	1	2	3	4
Total Mono CB	0.008	EMPC (0.26)	ND	ND	ND
Total Di CB	EMPC (0.12)	EMPC (4.36)	0.0059	0.046	EMPC (1.74)
Total Tri CB	0.006	ND	EMPC (0.024)	EMPC (2.65)	0.013
Total Tetra CB	ND	ND	EMPC (0.0036)	0.040	ND
Total Penta CB	EMPC (0.13)	EMPC (2.08)	EMPC (0.10)	EMPC (3.52)	EMPC (0.43)
Total Hexa CB	ND	ND	ND	EMPC (0.17)	ND
Total Hepta CB	ND	ND	ND	ND	ND
Total Octa CB	ND	EMPC (0.29)	ND	ND	ND
Total Nona CB	ND	EMPC (0.53)	ND	ND	ND
Deca CB	ND	ND	ND	ND	ND
Total PCB	0.01	n/a	0.0059	0.086	0.013
Total PCB + EMPC	0.28	7.32	0.37	10.84	2.20

Mono CB = Monochlorinated biphenyls
Di CB = Dichlorinated biphenyls
Tri CB = Trichlorinated biphenyls
Tetra CB = Tetrachlorinated biphenyls
Penta CB = Pentachlorinated biphenyls
Hexa CB = Hexachlorinated biphenyls
Hepta CB = Heptachlorinated biphenyls
Octa CB = Octachlorinated biphenyls
Nona CB = Nonachlorinated biphenyls
Deca CB = Decachlorinated biphenyls
EMPC = Estimated maximum possible concentration

Table 13. Stack Emission Polychlorobiphenyls as Measured, µg/dscm (continued)

Burn	5	6	7	8	9
Total Mono CB	EMPC (0.015)	0.0053	0.0067	EMPC (0.00064)	0.0038
Total Di CB	0.0075	EMPC (0.75)	EMPC (1.20)	0.019	0.013
Total Tri CB	0.0075	0.0015	0.013	0.026	EMPC (0.058)
Total Tetra CB	0.0030	EMPC (0.0038)	EMPC (0.0027)	0.0038	0.0019
Total Penta CB	EMPC (0.19)	EMPC (0.11)	0.0013	EMPC (0.15)	EMPC (0.33)
Total Hexa CB	0.0038	EMPC (0.003)	ND	ND	EMPC (0.0032)
Total Hepta CB	0.006	EMPC (0.075)	EMPC (0.033)	EMPC (0.015)	EMPC (0.064)
Total Octa CB	EMPC (0.006	0.0030	EMPC (0.002)	EMPC (0.013)	EMPC (0.0019)
Total Nona Cb	EMPC (0.022)	ND	ND	ND	EMPC (0.019)
Deca CB	0.015	ND	ND	ND	ND
Total PCB	0.045	0.0075	0.02	0.021	0.019
Total PCB + EMPC	2.48	1.05	1.53	2.12	1.47

Mono CB = Monochlorinated biphenyls
Di CB = Dichlorinated biphenyls
Tri CB = Trichlorinated biphenyls
Tetra CB = Tetrachlorinated biphenyls
Penta CB = Pentachlorinated biphenyls
Hexa CB = Hexachlorinated biphenyls
Hepta CB = Heptachlorinated biphenyls
Octa CB = Octachlorinated biphenyls
Nona CB = Nonachlorinated biphenyls
Deca CB = Decachlorinated biphenyls
EMPC = Estimated maximum possible concentration

Table 14. Toxicity Characteristic Leaching Procedure Test on Ash for Burns 1 and 2 (Metals) and Protocol Blanks, mg/L

Element	AA Blank	AA Blank	SA Blank	RCRA Limit	Burn 1	Burn 2
Arsenic	<0.005	<0.100	<0.100	5	<0.100	<0.005
Barium	0.025	0.034	0.184	100	0.398	0.155
Cadmium	<0.010	<0.010	(2)	1	0.174	0.073
Chromium	<0.008	<0.008	<0.008	5	<0.008	0.025
Lead	0.208	<0.050	0.279	5	0.421	0.098
Mercury	<0.002	<0.002	<0.002	0.2	<0.002	<0.002
Selenium	<0.050	<0.100	<0.100	1	<0.100	<0.050
Silver	0.009	<0.007	0.011	5	<0.007	<0.007

Notes: AA Blank = acidic acid method blank (2 blanks done) SA Blank = sodium acetate method blank, goes with sample 8T. RCRA Limit = maximum concentration allowable under Resources Conservation and Recovery Act for a nonhazardous waste.

Table 15. Toxicity Characteristic Leaching Procedure Test on Ash for Burns 3 Through 9 (Metals), mg/L

Element	Burn 3	Burn 4	Burns 5/6	Burn 7	Burn 8 T	Burn 8 B	Burn 9
Arsenic	<0.005	<0.005	<0.100	<0.005	<0.100	0.011	<0.100
Barium	0.155	0.079	0.186	0.232	0.186	0.202	0.232
Cadmium	0.458	0.370	0.209	2.18	0.040	0.779	2.18
Chromium	0.082	<0.008	0.027	<0.008	<0.008	<0.008	<0.008
Lead	0.592	1.33	9.12	0.316	<0.050	0.208	0.316
Mercury	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Selenium	0.050	<0.05	<0.100	<0.05	<0.100	<0.05	<0.100
Silver	0.042	0.042	0.008	0.010	<0.007	0.009	0.010

Units: Combined ash for burns 5 & 6. Ash from top and bottom of burn 8 analyzed separately (8T, B).

Table 16. Toxicity Characteristic Leaching Procedure Test on Ash (Semivolatiles)

Burn	AA Blank	Anal. Blank	SA Blank	Inst. Blank	1	2	3
Pyridine	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
Phenol	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
1,4-dichlorobenzene	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
1.2-dichlorobenzene	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
2-methylphenol	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
4-methylphenol/3-methylphenol	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
Hexachloroethane	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
Nitrobenzene	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
Hexachlorobutadiene	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
2,4,6-trichlorophenol	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
2,4,5-trichlorophenol	U (52)	U (50)	U (52)	U (50)	U (93)	U (110)	U (96)
2,4-dinitrotoluene	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
Hexachlorobenzene	U (10)	U (10)	U (10)	U (10)	U (19)	U (22)	U (19)
2,3,4,6-tetrachlorophenol	U (52)	U (50)	U (52)	U (50)	U (93)	U (110)	U (96)
Pentachlorophenol	U (52)	U (50)	U (52)	U (50)	U (93)	U (110)	U (96)

Notes: U = compound not detected; detection limits in micrograms per liter in ( ). AA Blank = acidic acid method blank; SA Blank = sodium acetate method blank; Anal. Blank = analytical Blank; Inst. Blank = instrument blank. 8T = residue from top of burn 8; B = ash residue from bottom of burn 8. 5/6 = combined ash residue for burns 5 and 6.

Table 16. Toxicity Characteristic Leaching Procedure Test on Ash (Semivolatiles) (continued)

Burn	4	5/6	7	8T	B	9
Pyridine	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
Phenol	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
1,4-dichlorobenzene	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
1.2-dichlorobenzene	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
2-methylphenol	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
4-methylphenol/3-methylphenol	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
Hexachloroethane	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
Nitrobenzene	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
Hexachlorobutadiene	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
2,4,6-trichlorophenol	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
2,4,5-trichlorophenol	U (120)	U (100)	U (98)	U (89)	U (140)	U (200)
2,4-dinitrotoluene	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
Hexachlorobenzene	U (23)	U (20)	U (20)	U (18)	U (28)	U (40)
2,3,4,6-tetrachlorophenol	U (120)	U (100)	U (98)	U (89)	U (140)	U (200)
Pentachlorophenol	U (120)	U (100)	U (98)	U (89)	U (140)	U (200)

Notes: U = compound not detected; detection limits in micrograms per liter in ( ). AA Blank = acidic acid method blank; SA Blank = sodium acetate method blank; Anal. Blank = analytical Blank; Inst. Blank = instrument blank. 8T = residue from top of burn 8; B = ash residue from bottom of burn 8. 5/6 = combined ash residue for burns 5 and 6.

DISCUSSION

Particulates

The incinerator permit issued by the Alaska regulatory agency required that the stack emissions not exceed 0.08 gr/dscf corrected to 12% carbon dioxide. This limit was exceeded only during the first particulate sampling in burn 1, (sample 1A, Table 5). When the Entech unit was started for the first test, forced air was blown into the primary chamber, but the flue gas flow was constricted. This resulted in a series of puffs, and black smoke could be seen emitting from the stack. The particulate filter for sample A1 was also black. This situation represented an abnormal operating condition. The problem was corrected, and less than 0.001 gr/dscf was collected for the second sampling event (mid burn, sample 1B). Toward the end of the burn, excess air was fed to the primary combustion chamber. This resulted in a higher stack gas flow (2340 scfm versus 1048-1550 scfm for other sampling events, Table 2). The higher air introduction rate is believed to suspend some of the ash particles in the exhaust gas stream, resulting in higher-than-average (0.034 gr/dscf) particulate solids. The particulates collected on the filter during particulate sampling 1C were the same light gray color as the ash.

For the other burns, air was introduced at a more uniform rate, resulting in more uniform stack gas flow rates (Table 2). Particulate emissions were generally in the range of 0.001 to 0.022 gr/dscf, corrected to a 12% carbon dioxide basis. On a 7% oxygen basis, these values were lower. There were three sampling events where particulates exceeded 0.022 gr/dscf (4C, 5A, and 7A) but were well under 0.08 gr/dscf.

WRI believes that the actual particulate loadings for some samples may be lower than what was measured. The high temperatures resulted in some flaking of the nozzle and graphite seal, which may have contributed to the acetone wash residues.

Acid Gases

Acid gases include sulfur dioxide and hydrochloric acid (hydrogen chloride). Sulfur dioxide was not measured under this contract. Hydrochloric acid (hydrogen chloride)

as measured, varied from 4 ppm to 140 ppm (Table 7). The numbers were scattered, with no apparent correlation to burn or time.

An emission factor was calculated for each burn (Table 17) from measured HCl concentrations and stack gas flow rates. A 12-hour burn was used in calculating total amount of HCl emissions.

Table 17. Hydrogen Chloride Emission Factors

Burn	lb HCl Emitted	lb HCl Emitted per lb Material Burned
1	6.7	0.00102
2	4.6	0.00071
3	3.3	0.00521
4	2.5	0.00037
5	2.7	0.00027
6	2.0	0.00026
7	2.9	0.00116
8	2.1	0.00069
9	5.3	0.00134

The medical waste burn (burn 3) had the highest HCl emission factor. This is not surprising considering the high proportion of plastics. The two auto fluff burns (burns 7 and 9) had the next highest HCl emission factor; auto fluff contains a high proportion of plastic residues from automobiles.

Metals

Burn 9 (auto fluff), burn 6 (MSW and Medical Waste) and burn 2 (MSW and oily waste) had higher-than-average cadmium and lead emissions (Tables 8 and 9). Burn 9 ash leachate failed the Toxicity Characteristic Leaching Procedure (TCLP) for cadmium, and the burn 5/6 ash leachate (probably mostly burn 6) failed the TCLP for cadmium (Tables 14, 15, and 16). Burn 2 cadmium and lead emissions were also high, but the ash leachate passed the TCLP for these metals. Cadmium is used in electroplating automotive metal parts, and may be leached and absorbed by the plastic when auto fluff is separated from the metals and dewatered. The common source of mercury in municipal solid waste is batteries.

WRI believes that the sampling nozzle contributed much of the chrome and nickel detected in the samples. The sampling nozzles are made of Inconel or stainless steel, depending upon the tests. This conclusion is based on the observation that almost all of the chromium and nickel originated in the nitric acid probe rinse of the nozzle.

All tests produced zinc emissions. Zinc is used in metal parts, in automotive protective paints, and in tires. It is also present in waste oils. Therefore, its presence is not surprising.

Organics

1. The organic sampling for burn 1 occurred when the series of smoke puffs were observed. This was because forced air was fed to the primary combustion chamber at the same time that the exhaust gas was constricted. The puffs were strong enough to make a noise that sounded like a small explosion in the primary chamber. The situation was corrected, but not before loading the filter with black particulate. The result was an average of 1.51 ng/dscm of dioxins/furans collected, which were weighted heavily toward trichlorinated dibenzofurans (TCDF) and pentachlorinated dibenzofurans (PeCDF) and relatively little octachlorinated dibenzo-p-dioxins (OCDD) or octachlorinated dibenzofurans (OCDF).

   High concentrations of TCDF and PeCDF are expected under reducing conditions; OCDD and OCDF are expected under excess-air conditions.

   For all other burns, total dioxins and furans were very low, and barely distinguishable from the field blank. The small amount that was detected was weighted in favor of OCDD and OCDF. These low levels are remarkable in that total dioxins/furans from typical MSW incinerators are on the order of 20 to 100 ng/dscm, and 100 to 400 ng/dscm for medical waste.

   WRI believes that this Entech Model TOS-80, as tested lends itself to low dioxin/furan formation. The particulate emissions are low, and flue gas mixing in the secondary combustion chamber allows for excellent destruction of products of incomplete combustion. Dioxin/furan emissions from MSW incinerators have been evaluated by a number of researchers (Hoffman et al. 1990; Acharya et al. 1991; Shaub and Tsang 1983). Hydrogen chloride or chlorine in the flue gas reacted with products of incomplete combustion (PICs: phenols, chlorobenzene, chlorophenols, polyaromatics), which are adsorbed onto fly ash particulates. These PICs,in turn form dioxins/furans.

2. Polychlorinated biphenyls (Table 13)

Low levels of polychlorinated biphenyls were detected for some burns, especially burns 1 and 3 . Burn 1 represents an abnormal situation, and burn 3 was the medical waste burn. The medical waste burn produced the most HCl emission per unit waste incinerated. The concentrations of polychlorinated biphenyls in the other burn samples
were barely greater than the field blank. Monochlorinated biphenyls were detected in the auto fluff emission burns (7 and 9).

3. Semivolatiles (Table 12)

A significant amount of benzoic acid was detected in several samples. The benzoic acid may be an artifact, originating from the XAD-2 resin or the graphite sealant rather than from the stack flue gas.

The phthalate (diethylphthalate, di-n-butylphthalate butylbenzylphthalate, and bis (2-ethylhexyl)phthalate) detected in some samples may also be an artifact.

Phthalates may originate from vapors emanating from plastics, such as plastic bags, plastic packing, or petri dishes used to store some filters. Phthalates were also measured in the field blank. In addition, 1,4-dichlorobenzene was detected in some samples including the field blank.

Phenol, 2-methylphenol and 3/4 methylphenol are measured in the burn 1 sample. Phenols adsorbed on fly ash are known to react with hydrogen chloride to form dioxins and furans. As explained earlier, the early stage of burn 1 was atypical.

One class of organic emissions that was detected in significant quantities includes naphthalene, acenapthene, fluorene, and anthracene from burn 9 (auto fluff). All are coal tar derivatives. These were not detected in burn 7 emissions.

CONCLUSIONS

1. Particle emissions were less than 0.08 gr/dscf, which is the limit set by the Alaska regulatory agency, corrected to a 12% carbon dioxide basis. The one exception was on startup for the first burn, a series of smoke puffs occurred when air was forced into the primary combustion chamber while the exhaust flue was restricted. Particulate emissions for most burns were <0.02 gr/dscf.

2. HCl emissions varied from 4 to 140 ppm. The medical waste burn produced the highest HCl emission factor (0.0052 lb HCl/lb material burned); the auto fluff emission factor was 0.0012 or 0.0013 lb HCl/lb material burned. MSW HCl emission factors vary, but are generally less than 0.001. The tire burn HCl emission factor was 0.0004 lb/lb material burned.

3. Metals detected in the emissions include cadmium chromium, nickel, lead, mercury, manganese, and zinc. Some of the chromium and nickel is believed to originate from the Inconel and stainless-steel sample probe and nozzles, and not from the stack. Mercury was measured in the MSW waste and auto fluff emissions, but was absent from emissions in the creosote railroad tie and automobile tire burns. Mercury was also absent from one of the medical waste burns.

4. Except for burn 1, dioxins and furans were barely detectable above the field blank. The concentrations were much lower than conventional MSW incinerations.

5. In general, organics were low, much less than conventional MSW incineration. Benzoic acid may be an artifact. Naphthalene, acenaphthene, and 2-methylnaphthalene were measured in the second auto fluff burn emissions.

6. The results of the Toxicity Characteristic Leaching Procedure on the ash were generally below RCRA limits. Two exceptions were burn 9 for cadmium and burn 5/6 combustion for lead. The burn 9 cadmium emissions were also higher than any other burn (0.083 ng/dscm).

RECOMMENDATIONS

1. Any future monitoring should use Inconel probes, Inconel nozzles, and quartz liners.

2. Oxygen and carbon dioxide sensors used for gas monitoring should be certified and tested before emissions sampling is started.

3. A smaller diameter stack [redacted] is [redacted] ack velocities should be in the range of [redacted]

4. Percent oxygen in the flue gas should be in the 4 to 10% range.

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DISCLAIMER

Mention of specific brand names or models of equipment is for information only and does not imply endorsement of any particular brand.

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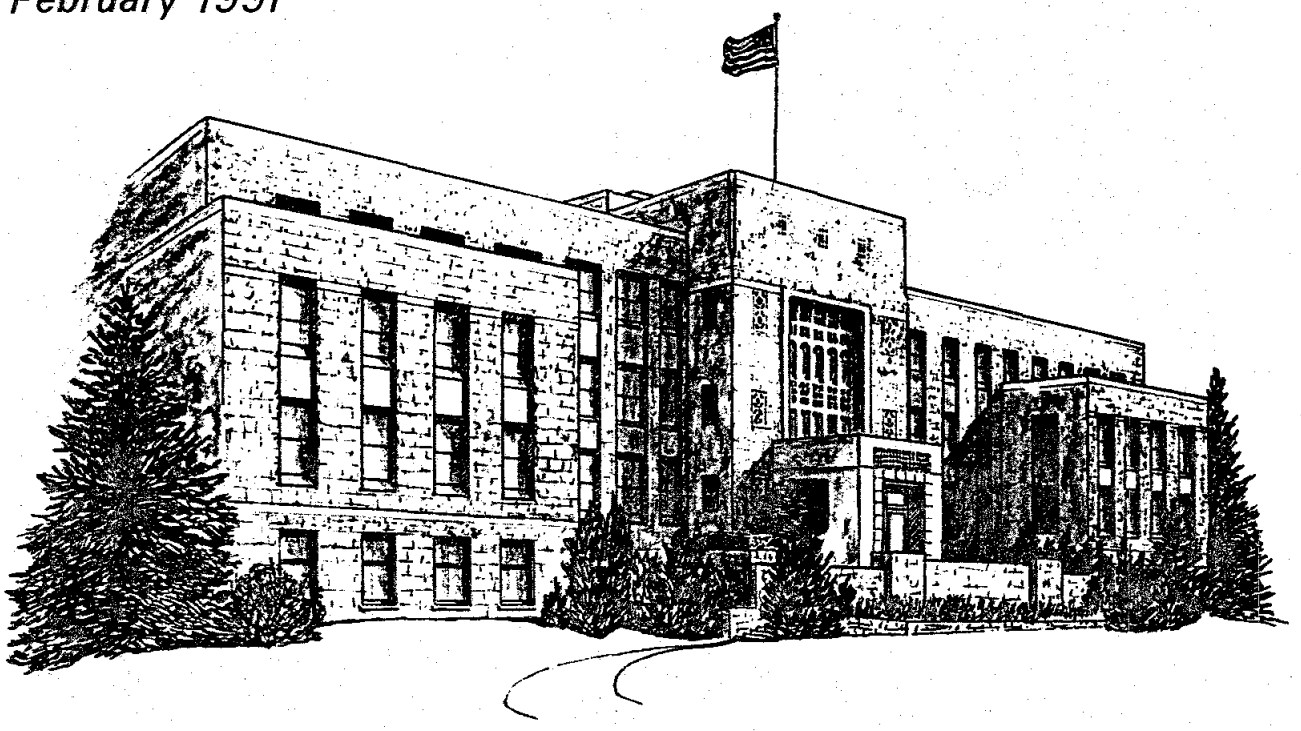
WESTERN RESEARCH INSTITUTE
The University of Wyoming Research Corporation

DECEMBER 1990 MUNICIPAL SOLID WASTE BURN TEST IN AN ENTECH THERMAL OXIDATION DEMONSTRATION PLANT AT WESTERN RESEARCH INSTITUTE

Prepared for
Entech, Inc.
Anchorage, Alaska

February 1991



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DECEMBER 1990 MUNICIPAL SOLID WASTE BURN TEST IN AN ENTECH THERMAL OXIDATION DEMONSTRATION PLANT AT WESTERN RESEARCH INSTITUTE

By
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George Huntington

February 1991
Revised April 1991[a]

For
Entech, Inc.
Anchorage, Alaska

By
Western Research Institute
Laramie, Wyoming

[a] The April 1991 revision updated the section on developing regulations

TABLE OF CONTENTS

	Page
LIST OF TABLES AND FIGURES	iii
LIST OF ABBREVIATIONS	iv
SUMMARY	v
INTRODUCTION	1
DEVELOPING REGULATIONS	1
METHODS	2
Burn Operations	2
Air and Natural Gas Measurements	2
Temperatures	3
Gas Analysis	3
Particulates, Percent Water, and HCl	3
Particulate Metals	5
Dioxins/Furans	5
Ash Analysis	6
DISCUSSION OF RESULTS	6
Temperatures	6
Acid Gas Emissions	6
Particulates and Particulate Metals	7
Percent Water in Stack	7
Dioxins/Furans	7
System Chloride Balance	8
Ash Analysis	8
CONCLUSIONS	9
RECOMMENDATIONS	9
ACKNOWLEDGEMENTS	10
DISCLAIMER	10
TABLES	11
APPENDIX A. MSW Burn August 21, 1990	20
APPENDIX B. Data Sheets Used in Field Operations During December 3, 1990 Burn	23
APPENDIX C. Triangle Laboratories Dioxin/Furan Summary Sheets December 3, 1990 Burn	24

LIST OF TABLES AND FIGURES

Table **Page**

1. Federal Standards for Large (>250 ton/day) Municipal Solid Waste Combustors..... 11
2. MSW Burn, December 3, 1990..... 11
3. Secondary Combustion Emissions, December 3 Burn..... 12
4. Natural Gas and Air Feeds, December 3 Burn..... 13
5. Particulate and HCl Emissions from Secondary Combustion Unit, December 3, 1990..... 14
6. Fronthalf Particulate Elemental Analysis..... 15
7. Dioxin/Furan Analysis of Emissions from Secondary Combustion Unit, December 3, 1990..... 16
8. Ash Analysis Excluding Glass and Metal Components..... 17

Figure

1. Entech Thermal Oxidation System Showing the Location of Thermocouples..... 18
2. Temperature Profiles..... 19

LIST OF ABBREVIATIONS

dscf	dry standard cubic feet
dscm	dry standard cubic meter
ft^3	cubic feet
g	gram
gr	grain (grain = 1/7000 lb)
gr/dscf	grains per dry standard cubic feet; to convert to mg/dscm, multiply by 2288.
inches Hg	inches of mercury; a unit of pressure
L	liter
lb	pound
mg	milligram
mg/dscm	milligrams per dry standard cubic meter
mg/kg	milligrams per kilogram of solid
mL	milliliters
MSW	municipal solid waste
ng	nanograms (10^9 nanograms = 1 gram)
ng/dscm	nanograms per dry standard cubic meter
ng/Nm^3	nanograms per cubic meter normalized to seven volume percent oxygen
ppm	parts per million by volume
psig	pounds per square inch gauge pressure
scfm	standard cubic feet per minute (at 70°F and 29.92 inches of Hg)
yd^3	cubic yard
wt %	weight %

SUMMARY

On December 3, 1990, 1,489 lb of municipal solid waste (MSW) obtained from the Albany County landfill and 250 lb of wood pallets were incinerated in an Entech thermal oxidation demonstration plant located at Western Research Institute (WRI). After the burn, the residual materials were separated into glass, metal, and ash components. This demonstrates that these materials can be recovered and recycled after incineration.

Particulate metal emissions collected during a 4-hour sampling period were 0.00063 gr/dscf (1.44 mg/dscm) corrected to a 7% oxygen basis. Acid gas emissions were 22 ppm HCl and <2 ppm SO_2, both corrected to a 7% oxygen basis. The calculated HCl emission factor based on 22 ppm HCl is 0.0004 lb HCl/lb MSW waste. Cadmium and lead emissions were 0.0059 and 0.04 mg/dscm respectively, corrected to a 7% oxygen basis. Dioxin emissions were 1.9 ng/dscm, and furan emissions were 3.6 ng/dscm. Average CO emissions were 7 ppm. NO_x varied from 19 to 76 ppm during the burn or an average of 33 ppm on a 7% oxygen basis. These are measurements without scrubbing or other pollution-control devices, other than the secondary combustion chamber.

These emissions comply with the new federal standards[a] for large incinerators (>250 ton per day) scheduled to be in effect by August 1991.

[a] Cadmium, lead, and mercury standards have not been promulgated at the writing of this report.

INTRODUCTION

Entech Inc. contracted Western Research Institute (WRI) to measure and analyze gas flows of an Entech thermal oxidation system using municipal solid waste (MSW) as feedstock. A burn was performed on December 3, 1990. One of the objectives of this burn was to measure emissions from the secondary combustion chamber, including (1) particulates, (2) particulate metals, and (3) EPA Method 23 dioxins/furans. Because the burn lasted a little more than seven hours, there was only time to take one 2 1/2-hour dioxin/furan measurement and one 4-hour particulate measurement. Sulfur dioxide, NO_x, and CO emissions were measured throughout the burn.

Entech also completed a demonstration MSW burn on August 21, 1990, for the benefit of potential clients. WRI was not contracted to measure emissions or gas flows. Entech provided WRI with a copy of temperature and other data taken. This copy and WRI commentary are presented in Appendix A.

DEVELOPING REGULATIONS

Proposed U.S. EPA rules (Federal Register, December 20, 1989) for MSW incinerators target dioxins/furans, particulate metals, HCl, SO_2, CO, and NO_x emissions. The December 20, 1989, also contained a proposed EPA-Method 23 protocal for measuring dioxins/furans. The Method 23 protocal was formally published as 40 CFR Part 60-Method 23 (Federal Register, February 13, 1991).

On November 15, 1990, the Clean Air Act Amendments became law, and they included a new section 129 that applied to solid waste incinerators. Section 129 set deadlines for issuing emissions standards and added mercury, cadmium, and lead to the list of regulated emissions. Standards for large MSW incinerators (>250 ton/day) were finalized, effective August 12, 1991 (Federal Register, February 11, 1991). Standards for small incinerators (<250 ton/day) must be promulgated within two years.

Regulatory limits for large incinerators are listed in table 1. The most stringent limit is on HCl, where the MSW incinerator must achieve less than 25 ppm, or be fitted with a scrubber or other pollution control devise capable of reducing the HCl by 95 percent. States may adopt even more stringent emission limits.

The term particulate metals, as used by regulatory agencies, is misleading. The term particulate metals is what WRI calls fronthalf particulates corrected to a 7% oxygen basis. The fronthalf particulates are all particulates collected by the particulate sampling train up to and including the particulate sampling filter. Solids collected downstream from the filter including the impinger solutions are termed the backhalf and are not included in the calculation for particulate metals. The language is misleading because WRI has analyzed the fronthalf particulates from various burns for metals and found that in many cases, the actual metal content was a small percentage of the total material collected. The balance was carbon (soot), silica, calcium, magnesium, sodium, etc.

A proposed rule under consideration (Federal Register, December 20, 1989) requiring at least 25% removal and recycle of materials prior to incineration was eliminated (U.S. EPA, January 11, 1991). State and local governments may still require recycling. For example, Kentucky requires that new incinerators must reduce the volume of the waste that they receive by 40% through recycling. This rule is of interest to Entech because the burn temperatures in the primary combustion chamber are controlled such that metal and glass components can be removed from the ash and recycled after the burn.

METHODS

Burn Operations

The burn date was December 3, 1990. The primary combustion chamber was loaded with 1,489 lb of household waste in plastic bags obtained from the Albany County landfill. They were placed on top of wooden pallets (250 lb) which, in turn, were set on the bottom grate of the primary combustion chamber. Light-off time was at 09:06 hours. The burn proceeded smoothly, except for a brief upset at 11:10 hours when a puff of black smoke was seen. Other than at that time, there were no visible emissions. Natural gas was fed to the bottom primary burner until 12:24 hours. During the late afternoon, temperatures in the primary combustion chamber decreased as the burn was nearing completion. At 16:45 hours, the burn was practically complete, and the natural gas to the secondary combustion chamber was cut off. The following morning, the residual materials were separated into glass (99 lb), metal (80 lb), and ash (153 lb) components. The burn characteristics are summarized in Table 2.

Air and Natural Gas Measurements

1. Natural Gas

Natural gas was measured using a gas meter servicing the system. Gas pressure was 20 psi. Laramie pressure was 11.6 psi for a total of 31.6 psi total gas line pressure. According to Northern Gas of Wyoming, the heat content of the gas (14.73 psi, 60°F) varies from 1030 to 1060 Btu/ft^3 (dry basis), with an average of 1045 Btu/ft^3 (dry basis) or 1025 Btu/ft^3 (wet basis). The natural gas supply contains no measurable sulfur or nitrogen.

2. Exhaust gas from secondary

The gas flow volume was calculated from pitot-tube measurements, temperatures (T_{16} of Figure 1), pressure, and gas combustion measured in the 19.9-inch-diameter stack. The results are in Table 3.

3. Air flow to primary combustion burners

A hot wire anemometer in a 2-inch line was used. The results are in Table 4.

4. Turbulent air flow to primary (excluding burner)

A hot wire anemometer in a [redacted] line was used. The results are in Table 4.

5. Air flow to secondary burners

A hot wire anemometer in a [redacted] line was used. The results are in Table 4.

6. Turbulent air flow to the secondary combustion chamber

This is a difficult measurement to obtain accurately. Turbulent air is drawn in to the system from the outside with a blower. [redacted] The flow is not uniform in the duct. Velocity readings for different spots and at different louver settings are presented in Appendix B. Normally, anemometer readings were taken in hole #5 at a depth of [redacted] into the duct. To convert this reading to an average velocity, a correction factor of [redacted] was applied if the reading was [redacted] or higher. The correction factor increases for readings under [redacted]. A different measuring hole was used for the August 21 burn (Appendix A) so a different correction factor was used for that burn.

Temperatures

Temperatures were measured using thermocouples installed at the locations shown in Figure 1. Thermocouple T_{16} was attached to the pitot tube used to measure stack velocity. Appendix B contains a record of temperature measurements. These data points were automatically recorded using a data logger. Selected thermocouple readings were graphed as a function of time since light-off of the primary combustion chamber (Figure 2).

Gas Analyses

An Entech-owned Enerac 2000 analyzer was used to measure O_2, CO_2, CO, NO_x, and SO_2 from the secondary combustion unit. The results are listed in Table 3. We frequently checked the instrument using atmospheric air, a 105 ppm CO calibration gas in nitrogen, or 50 ppm SO_2 gas in nitrogen.

Particulates, Percent Water, and HCl

Particulates were measured according to U.S. EPA methods (published as 40 CFR part 60 Appendix A, Method 5) using Andersen stack sampling equipment. WRI used a 3-ft stainless steel sampling probe with a quartz liner and fitted with a 0.5-inch-opening, stainless steel nozzle. The glass filter holder, glass cyclone, and filter (Andersen part number 50-320) were contained in a heated box (300°F/149°C) attached directly to the sampling probe. The sampling probe was insulated and heated, and had an attached pitot tube.

Some states require that particulate data be corrected to a 12% CO_2 basis. For many states, the particulate calculations do not include the backhalf (solids collected downstream from the filter, e.g., the glass impingers). However, other states (e.g., Washington) include the backhalf with data corrected to a 7% O_2 basis. Proposed regulations (Federal Register Dec. 20, 1989) call fronthalf particulates corrected to a 7% O_2 basis particulate metals and require that at least 120 scf of gas be collected. Current regulations require collection of only 30 scf.

Particulates were collected during the sampling times listed in Table 5. WRI sampled 123.9 scf of gas between 12:35 and 16:45 hours.

WRI followed the Puget Sound Air Pollution Control Agency procedures for sampling and analyzing the backhalf. WRI used five impingers: two containing double-distilled and deionized water; one containing 100 ml of a solution of 1 g $NaHCO_3$ and 2 g Na_2CO_3 dissolved in 4 L of double-distilled, deionized water; one blank, and one containing silica gel.

Following a test, 100 mL of the distilled water and the entire solution of $NaHCO_3/Na_2CO_3$ were set aside for chloride analyses. The remaining distilled water was used for total solids determination according to Puget Sound Air Pollution Control Agency procedures. These procedures call for (1) purging the impinger water with nitrogen or clean air; (2) rinsing all sample-exposed surfaces between the filter and sodium carbonate/bicarbonate impinger with acetone, and placing the washings in a tared beaker to dry; and (3) adding 50 to 100 mL of dichloroethane to the impinger distilled water solutions, spinning for ten minutes, and separating using a separatory funnel. The extraction is repeated. The separated dichloroethane solution is placed in a tared beaker and evaporated under a hood at room temperature. The remaining water is evaporated at less than 212°F (100°C). This procedure gives organic and inorganic total solids fractions for the backhalf.

The thermal oxidation unit was outfitted with a 24-ft-high stack for emissions sampling purposes. Sampling was done at the 17-ft level for the 19.9-inch-i.d. stack. The thermal oxidation unit was placed adjacent to the old 150-ton oil-shale retort located on WRI property just north of Laramie, Wyoming. The oil shale retort has the necessary scaffolding to support the stack and provide safe access for emissions sampling. The railing of the 150-ton retort also supported the particulate sampling train, which was mounted on a board and moved as a unit as the probe was moved to the different stack positions as required by EPA protocols (40 CFR Part 60 Appendix A, Methods 1 and 5)

The impingers used in the particulate sampling train were weighed before and after the test. The difference was the weight of water-collected gas. The impingers were set in an ice bath during sampling.

A portion of the impinger contents (double-distilled, deionized water and $NaHCO_3/Na_2CO_3$ solution) were set aside for chloride analysis by ion chromatograph (U.S. EPA Method 300.0). From this measurement, HCl emissions were calculated.

The particulate filter after the run was clean and was not darkened with soot or noticeable material. There were also no measurable particulates or solids in the backhalf.

Particulate Metals

The proposed regulations (Federal Register, December 20, 1989) for municipal solid waste incinerators call fronthalf particulates at 7% oxygen (what is collected on the filter, cyclone, and acetone wash of the sampling probes and glassware up to the filter) particulate metals. WRI took the fronthalf particulates collected and digested them in 100 mL of a 10% nitric acid solution for 24 hours. The solution was then analyzed for trace metals using inductively coupled plasma (ICP) emission spectroscopy. Four samples (acetone-wash residual, filter, acetone-wash residual blank, filter blank) were analyzed. Results are in Table 6.

Dioxins/Furans

Dioxins/furans were measured according to EPA Method 23 (Federal Register, December 20, 1989). WRI used a quartz-lined, 3-ft stainless steel sampling probe fitted with a 0.625-inch stainless steel nozzle, a 4-inch Teflon-lined filter holder, and a resin trap containing XAD-2 resin impregnated with surrogate dioxin/furan compounds (to check recovery). Three containers plus the XAD-2 resin were submitted to Triangle Laboratories in North Carolina for dioxin/furan analysis by high-resolution mass spectrometry. As required by EPA Method 23, container 1 contained the filter along with particulate and filter material. Container 2 contained acetone/dichloroethane rinsates from the sampling apparatus. Container 3 contained toluene rinsates from the apparatus. The content of container 1 was combined with the XAD-2 resin and extracted. The content of container 2 was concentrated and combined with the container 1/XAD-2 resin extract to yield the sample identified as MM5 2. The toluene rinsates from container 3 were concentrated, and the resulting sample is identified as TOL rinse 3. Research Triangle Laboratories also supplied WRI with the XAD-2 resin trap containing resin spiked with surrogate samples. The Triangle Laboratory summary sheets giving results are in Appendix C.

Different glassware and sampling probes were used for the dioxin/furan sample than those used for the particulate sampling train. However, the same hot box and gas flow meter was used. The dioxins/furans were sampled first, and then the equipment was used to sample particulates. The December 20, 1989, protocol requires that 70 cubic feet of gas is sampled isokinetically; 94.5 ft^3 was actually collected (Table 7). After the burn, the protocol was changed to require a 4-hour sampling time (Federal Register, February 11, 1991). The regulations also incorporate a final toluene quality assurance rinse (40 CFR part 60, Appendix A, Method 23, Paragraph 7.4). This was analyzed separate from the total sample catch, but was not counted as part of the total sample catch.

In regulatory language, the term dioxins means the total amount of polychlorinated dibenzo-p-dioxins (PCDD) present, the individual chemical species and isomers summed with no weighting factors given to relative toxicity. Furans means total polychlorinated dibenzofurans (PCDF). Polychlorinated means four or more atoms attached to the basic dioxin or furan chemical structure. Tetra (TCDD or TCDF) indicates four chlorine atoms, penta (PeCDD or PeCDF) indicates five, hexa (HxCDD or HxCDF) indicate 6, hepta (HpCDD or HpcDF) indicates 7, and octa (OCDD or OCDF) indicates 8. For example 2,3,7,8-TCDD is an abbreviation for 2,3,7,8-

tetrachlorinated dibenzo-p-dioxin with chlorine atoms on the 2, 3, 7, and 8 positions on the basic dioxin molecule.

Ash Analysis

After removal of metal and glass components, ash samples were subjected to proximate and chloride analyses. One ash sample was also digested in nitric acid. The material that failed to dissolve in nitric acid was called insolubles (Table 8). The insolubles represented 40.66% of the total ash material. The acid-soluble portion was analyzed for metals using inductive coupled plasma (ICP) emission spectroscopy. Results are listed in Table 8.

The proximate analysis is a published procedure (ASTM method D 3172). Moisture represents loss in weight when the sample is heated at 106°C (222°F) for one hour. When the ash was removed from the primary combustion chamber, it was probably free of moisture; however, some water may have been adsorbed prior to analysis. Volatiles represent loss in weight when the sample is heated at 950°C (1742°F) for 7 minutes in an oxygen-free atmosphere. Ash is the material remaining when the sample is heated at 750°C (1382°F) for 6 hours in air. Fixed carbon is inorganic (nonvolatile) carbon.

DISCUSSION OF RESULTS

Temperatures

Temperature data are in Appendix B; [redacted] The peak temperature reached in the secondary combustion chamber was 2046°F (1119°C); however, most readings ranged from 1900°F to 2000°F (1038 to 1093°C). The peak primary combustion chamber temperature reached was 1532°F (833°C) at the top portion. Temperatures near the bottom portion where the ash was located were cooler (peak near 700°F or 371°C).

In reviewing these temperatures, we conclude that they are a little higher than necessary to achieve a satisfactory burn. The secondary combustion chamber can be operated at about 1700°F (925°C) for this type of waste, with subsequent savings in natural gas. Reduced NO_x emissions will be a side benefit. The primary ignition burner can be turned off sooner with additional natural gas savings.

Acid Gas Emissions

Sulfur dioxide emissions were not detected (limits of detection were about 2 ppm). The impinger solutions for the particulate and dioxin/furan sampling periods were analyzed for sulfates. A small but measurable amount of sulfate was detected, which calculates to an equivalent of about 1 ppm sulfate. This was probably emitted as either sodium sulfate or sulfuric acid.

Significant chlorides were measured in the impinger solution. The chlorides calculate to an equivalent of 17.3 ppm HCl during the particulate sampling period (Table 5) or 22.5 ppm corrected to a 7%

oxygen basis. The impinger solutions for the dioxin/furan sampling period were also analyzed for chlorides by ion chromatography. The EPA Method 23 dioxin/furan protocol does not provide for an HCl determination this way. We do not know whether the XAD-2 resin trap will emit or adsorb chlorides during gas sampling. The total amount of chlorides analyzed in the impinger solutions was 238 mg.

Particulates and Particulate Metals

Particulates were sampled during the last half of the burn. The sampling time was a little over 4-hours, and 123.9 scf of gas was sampled isokinetically. Fronthalf particulates (particulate metals) calculated out to be 0.00063 gr/dscf corrected to a 7% oxygen basis (Table 5). This is below the 0.015 gr/dscf limitation for particulate metals from large MSW incinerators (Table 1). The units gr/dscf can be converted to mg/dscm by multiplying by 2288.

The backhalf particulate solids were below detection limits (0.0005 gr/dscf at 7% oxygen); the fronthalf particulates were taken to be equal to the total particulates.

The analytical results of fronthalf particulates for metal elements are listed in Table 6. About 60% of the fronthalf particulates were accounted for by this elemental scan. This procedure does not measure carbon, oxygen, sulfur, chlorine, or fluorine. The procedure does measure silicon, but this element is not reported in Table 6 because the nitric acid digestion does not solubilize silica. (A hydrofluoric acid digestion is required.)

We believe that oxygen in the form of metal oxides, with lesser amounts of silica, carbon, chlorides, and experimental error account for the remaining 40%. From Table 6, the major components of the particulates are calcium and sodium (probably present as oxides) with lesser amounts of magnesium, aluminum, and zinc.

Percent Water in Stack

Both the particulate and dioxin/furan samplings allow us to calculate a percent water in the flue gas. The water originates from evaporation of MSW water and combustion of natural gas and MSW waste (e.g., $2CH_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$). The percent water calculated for the particulate sampling was 3.2% by volume; for the dioxin/furan sampling, the water was 10.9% by volume. The flue gas flow rate (Table 3) is on a wet basis.

Dioxins/Furans

The data package received from Triangle Laboratories was several hundred pages. Only the data summary sheets are included in Appendix C. The heart of this data package is a sheet identified as Sample ID 12-3-90 Run #1, Sample Matrix: MM5. Also, in these summary sheets are surrogate recoveries from the XAD-2 resin, analyses of laboratory blanks, the toluene quality assurance rinse analyses, and confirmation analyses. At the end of Appendix C are calibration data for standards, including a list of all of the dioxin/furan species analyzed.

The total dioxins measured calculated to 1.92 mg/dscm. Furans were 3.61 ng/dscm. The final toluene quality assurance rinse did not pick up any additional measurable dioxins or furans.

Field operators reported an upset at 11:10 hours when a puff of black smoke was seen. This occurred during dioxin/furan sampling. The dioxin/furan filter ahead of the XAD-2 resin trap was blackened with soot (30.48 mg particulates collected). Typically, dioxins and furans are associated with soot particulates.

System Chloride Balance

The chloride in the ash was 1.23% (Table 3), which calculates to 1.88 lb of chloride. The ash weight was 153 lb. The HCl measured in the stack gas during the particulate sampling period (12:35 to 16:45 hours) was 17.3 ppm by volume. Assuming that the amount of chlorides measured during this period was representative of the entire burn, we calculate that 0.66 lb of chloride was emitted, or 0.68 lb as HCl. About 26% of the total chlorides were emitted up the stack.

Ash Analysis

Entech was able to recover glass and metal components following the burn. The remaining ash had the following dry basis composition wt %:

Volatiles	10.1
Fixed carbon	2.7
Inorganic insolubles	30.6
Aluminum as Al_2O_3	16.2
Calcium as $CaPO_4$	0.5
Calcium as CaO	10.1
Calcium as $CaCl_2$	1.3
Iron as Fe_2O_3	3.4
Magnesium as MgO	1.3
Manganese as MnO	0.1
Sodium as NaCl	0.7
Zinc as ZnO	0.4

These numbers were calculated from the values in Table 8. About 77% of the ash was accounted for. We believe that the inorganic insolubles are silica and other components that do not readily dissolve in the acid digestion.

CONCLUSIONS

1. Entech was able to segregate the material left after the December 3 and September 21 burns into ash, glass, and metal components.

2. Metal particulates (fronthalf) measured during the December 3 burn were 0.00063 gr/dscf (1.44 mg/dscm) corrected to a 7% oxygen basis.

3. HCl emissions, corrected to a 7% oxygen basis, averaged 22 ppm by volume. There were no measurable SO_2 emissions.

4. Dioxins emissions were 1.9 ng/dscm;. Furans emissions were 3.6 mg/dscm.

5. There was one brief upset at 11:10 hours on December 3. This was apparently the result of insufficient air supplied to the secondary combustion system. The upset occurred during dioxin/furan sampling.

RECOMMENDATIONS

1. Regulatory agencies generally require a minimum of three particulate metals and three Method 23 dioxins/furans measurements for compliance evaluation. Because these burns are batch, only one measurement can be taken per burn. Therefore, additional burns and measurements are recommended.

2. Future dioxin/furan measurements should be at least four hours to comply with recently developed rules (Federal Register, February 11, 1991)for MSW combustors. Because the test burns are batch and of short duration, separate burns are recommended for gathering dioxin/furan and particulate metal data.

3. Scrubbers or other acceptable pollution-control technology are recommended for larger systems to control acid gas emissions, in particular, HCl. For smaller systems, Entech should check with the regulatory agency. Hydrochloric acid emissions are primarily due to plastics in MSW waste.

4. The secondary combustion chamber can probably be operated at a lower temperature (e.g., 1700°F, 927°C). This will save natural gas and still achieve low CO emissions, low particulates emissions, and minimal dioxin/furan emissions. A test is recommended.

5. Diagnostic tests are recommended aimed to determine the causes of the occasional upset that occurs. One established cause is insufficient air oxygen to the secondary combustion chamber. A stack oxygen monitor tied into a control system is recommended. The control system can increase the air supply if oxygen drops below, for example, 2%.

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DISCLAIMER

Mention of specific brand names or models of equipment is for information only and does not imply endorsement of any particular brand.

Table 1. Federal Standards for Large (>250 ton/day) Municipal Solid Waste Combustors

	Monitoring[b] Requirement	Emission[a] Limit
Dioxins/furans	annual stack test	30 ng/dscm
Particulate metals	annual stack test	34 mg/dscm (0.015 gr/dscf)
HCl	annual stack test	30 ppm or 95% reduction
SO_2	24-hr geometric mean	30 ppm or 80% reduction
CO	4-hr average	50 ppm[c]
NO_x	24-hr arithmetic average	180 ppm
Opacity	6-minute average	10% opacity
Cadmium, lead, mercury	under consideration[d]	under consideration[d]

[a] All emission limits (except opacity) are on a 7% oxygen dry basis.

[b] SO_2, CO, and NO_x require continuous emission monitoring systems.

[c] The emission limit for CO applies to modular starved and excess air combustors. A coal and MSW waste incinerator has a 150 ppm CO limit.

[d] Clean Air Act requires U.S. EPA to promulgate limits by November 15, 1991.

Table 2. MSW Burn, December 3, 1990

Light-off time--secondary	08:35
Light-off time--primary	09:06
Shutdown time--secondary	16:45
Times natural gas fed to secondary	08:35 to 16:45
Times natural gas fed to bottom primary burner	09:06 to 12:24
Times natural gas fed to top primary burner	none
Total natural gas used	[redacted]
<u>MSW Loaded</u>	1,739 lb; 10.7 yd^3
bagged household waste (no tires)	1,489 lb
wooden pallets	250 lb
<u>Material Collected After Burn</u>	
recovered metals	80 lb
recovered glass	99 lb; 2.4 ft^3
ash	153 lb; 4.89 ft^3
Barometric pressure	23.13 inches Hg
Weather	clear; 3°F warming to 25°F

Table 3. Secondary Combustion Emissions, December 3 Burn

Time	Composition of Flue Gas					Flue Gas Flow[a], scfm (wet basis)
	% O_2	% CO_2	ppm CO	ppm NO_x	ppm SO_2	
08:35	10.3	6.1	5	11	<2	[redacted]
08:55	[b]	[b]	[b]	[b]	[b]	[redacted]
09:22	10.2	6.4	13	19	<2	[redacted]
09:50	11.7	5.6	3	30	<2	[redacted]
10:15	7.6	7.6	3	45	<2	[redacted]
10:45	7.8	7.5	5	40	<2	[redacted]
11:15[a]	2.9	10.1	65	76	<2	[redacted]
11:40	5.4	8.6	3	33	<2	[redacted]
12:15	6.4	8.2	13	31	<2	[redacted]
12:40	6.8	8.1	<2	22	<2	[redacted]
13:20	8.1	7.3	<2	19	<2	[redacted]
13:40	7.6	7.5	<2	19	<2	[redacted]
14:15	10.4	5,8	<2	22	<2	[redacted]
14:40	9.9	6.2	3	25	<2	[redacted]
15:00	10.8	5.7	<2	22	<2	[redacted]
15:20	11.6	5.3	<2	19	<2	[redacted]
15:40	13.9	4.1	<2	19	[b]	[redacted]
16:00	[b]	[b]	[b]	[b]	[b]	[redacted]
16:15	15.8	3.2	3	19	<2	[redacted]
Average[c]	9.06	6.75	7	28	<2	[redacted]

[a] Upset condition at 11:10 hours. Visible emissions, CO = 120 ppm.

[b] Reading not taken at time indicated.

[c] Average between 09:06 and 16:45 hours. On a 7% oxygen basis, CO = 9 ppm and NO_x = 33 ppm. The upset condition at 11:10 hours is ignored in computing the CO average.

Table 4. Natural Gas and Air Feeds, December 3

	Natural Gas[a]		Air Input[a]				
Time	Primary	Secondary	Primary Turbulent	Bottom Primary Burner	Top Primary Burner	Secondary Turbulent	Secondary Burner
08:35	0						
09:10							
09:30							
10:00							
10:30							
11:00							
11:15		5/8 position					
11:30							
12:00							
12:24							
12:30							
13:30							
14:00							
14:05							
14:30							
15:00							
15:23							
15:30							
16:00							
16:30							
16:45							

[a] Natural gas flow is in cubic feet per minute at 20 psig. Barometric pressure is 23.13 inches Hg. The air flows are in standard cubic feet per minute (70°F, 1 atm).

[b] Reading not taken.

Table 5. Particulate and HCl Emissions from Secondary Combustion Unit, December 3, 1990

Sampling times	12:35 to 16:45[a]
Sampling volume, dscf	123.9
Sampling volume, dscm	3.511
Average O_2 vol % during sampling time	10.21
Average CO_2 vol % during sampling time	6.08
Total water collected, grams	85
Water, vol %	3.15
HCl, ppm (dry basis)	17.3
<u>Fronthalf particulates, gr/dscf</u>	
as collected	0.000484
7% O_2 basis	0.00063
12% CO_2 basis	0.00096
<u>Backhalf particulates, gr/dscf</u>	
as collected	<0.0004[b]
7% O_2 basis	<0.0005[b]
12% CO_2 basis	<0.0008[b]
<u>Total particulates, gr/dscf</u>	
as collected	0.000484
7% O_2 basis	0.00063
12% CO_2 basis	0.00096
Calculated fronthalf particulates during burn, lb	0.03
Calculated total particulates during burn, lb	0.03

[a] Position charged from east-west to north-south traverse at 14:30.

[b] No measurable backhalf.

Table 6. Fronthalf Particulate Elemental Analysis

Element	Filter mg	Acetone Wash, mg	Concentration in flue gas[a], mg/dscm	7% O_2 basis[b], mg/dscm
Ag	<0.0007	<0.0007	<0.0002	<0.0003
Al	0.164	0.009	0.049	0.064
As	<0.01	<0.01	<0.003	<0.004
B	0.033	<0.002	0.01	0.012
Ba	0.004	<0.001	0.0011	0.0015
Be	<0.0002	<0.0002	<0.00006	<0.00008
Bi	<0.01	<0.01	<0.003	<0.004
Ca	0.85	<0.2[c]	0.24	0.31
Cd	0.015	0.001	0.0046	0.0059
Co	<0.0007	<0.0007	<0.0002	<0.0003
Cr	<0.0008	0.0008	0.0002	0.0003
Cu	0.003	0.002	0.0014	0.002
Fe	0.10	<0.02[c]	0.028	0.037
K	<5	<5	<2	<2
Li	0.002	<0.001	0.0006	0.0007
Mg	0.040	0.038	0.022	0.029
Mn	0.003	<0.003	0.0009	0.001
Mo	0.014	<0.001	0.004	0.005
Na	0.515	0.16	0.192	0.25
Ni	<0.002	<0.002	<0.0006	<0.0008
P	<0.1	<0.1	<0.03	<0.04
Pb	0.10	<0.005	0.03	0.04
Sb	<0.01	<0.01	<0.003	<0.004
Se	<0.01	<0.01	<0.003	<0.004
Sr	0.003	<0.0005	0.001	0.001
Th	<0.005	<0.005	<0.001	<0.002
V	<0.0008	<0.0008	<0.0002	<0.0003
Zn	0.299	<0.05[c]	0.085	0.11

[a] Concentration in flue gas = filter + acetone wash divided by the dry standard cubic meters of gas sampled (3.511 M^3).

[b] Concentration in flue gas corrected to a 7% oxygen basis.

[c] Elemental analysis result less than a field blank. The field blank result is given.

Table 7. Dioxin/Furan Analysis of Emissions from Secondary Combustion Unit, December 3, 1990

Sampling times	09:25 to 11:50
Sampling volume, dscf	94.45
Sampling volume, dscm	2.68
Average O_2 vol % during sampling time	7.08
Average CO_2 vol % during sampling time	7.9
Total water collected, g	244.3
Water, vol %	10.9
Particulates collected on filter, mg	30.48
Total polychlorinated dibenzo-p-dioxin (PCDD) collected, ng	5.14
Total polychlorinated dibenzofurans (PCDF) collected, ng	9.68
Total PCDD in final toluene quality assurance rinse, ng	<0.11
Total PCDF in final toluene quality assurance rinse, ng	<0.06
Dioxins (PCDD), ng/dscm, 7% O_2 basis	1.92
Furans (PCDF), ng/dscm, 7% O_2 basis	3.61

Table 8. Ash Analysis Excluding Glass and Metal Components

Proximate Analysis (Procedure ASTM D 3172)

	Sample 1	Sample 2
Moisture, %	1.2	1.3
Volatiles, %	9.9	10.1
Ash, %	86.3	85.8
Fixed Carbon, %	2.6	2.8

Chloride in Ash

Chloride, mg/kg	12,300 (1.23%)

ICP metal scan of acid digestion of ash, mg/kg

Insolubles	406,800
Ag	<7
Al	86,000
As	<100
B	450
Ba	890
Be	<2
Bi	<100
Ca	79,000
Cd	<10
Co	12
Cr	130
Cu	330
Fe	24,000
K	<49,000
Li	39
Mg	7,700
Mn	1,000
Mo	<10
Na	2,800
Ni	29
P	1,100
Pb	490
Sb	<100
Se	<100
Sr	210
Th	<50
V	36
Zn	3,100

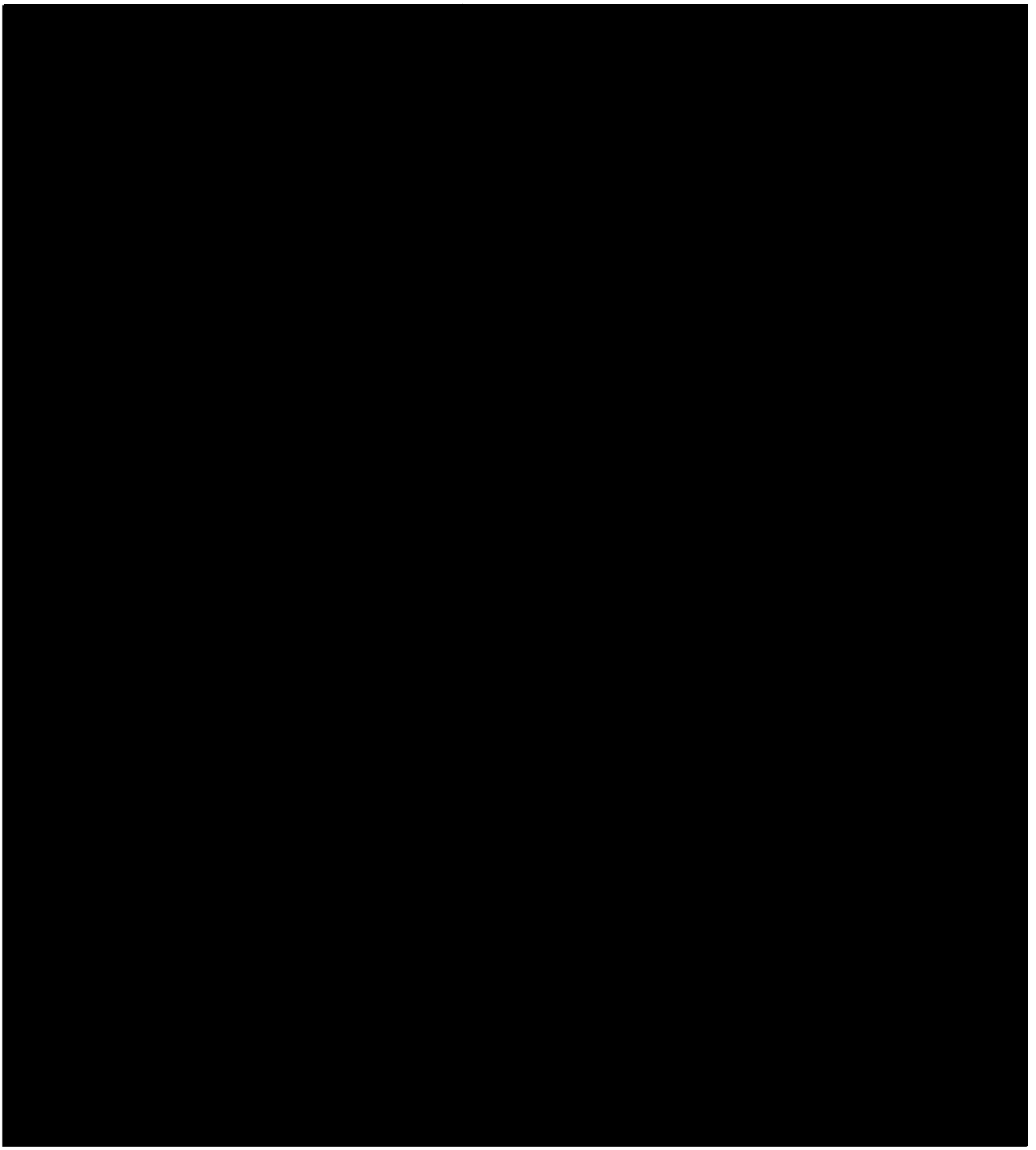


Figure 1. Entech Thermal Oxidation System Showing the Location of Thermocouples

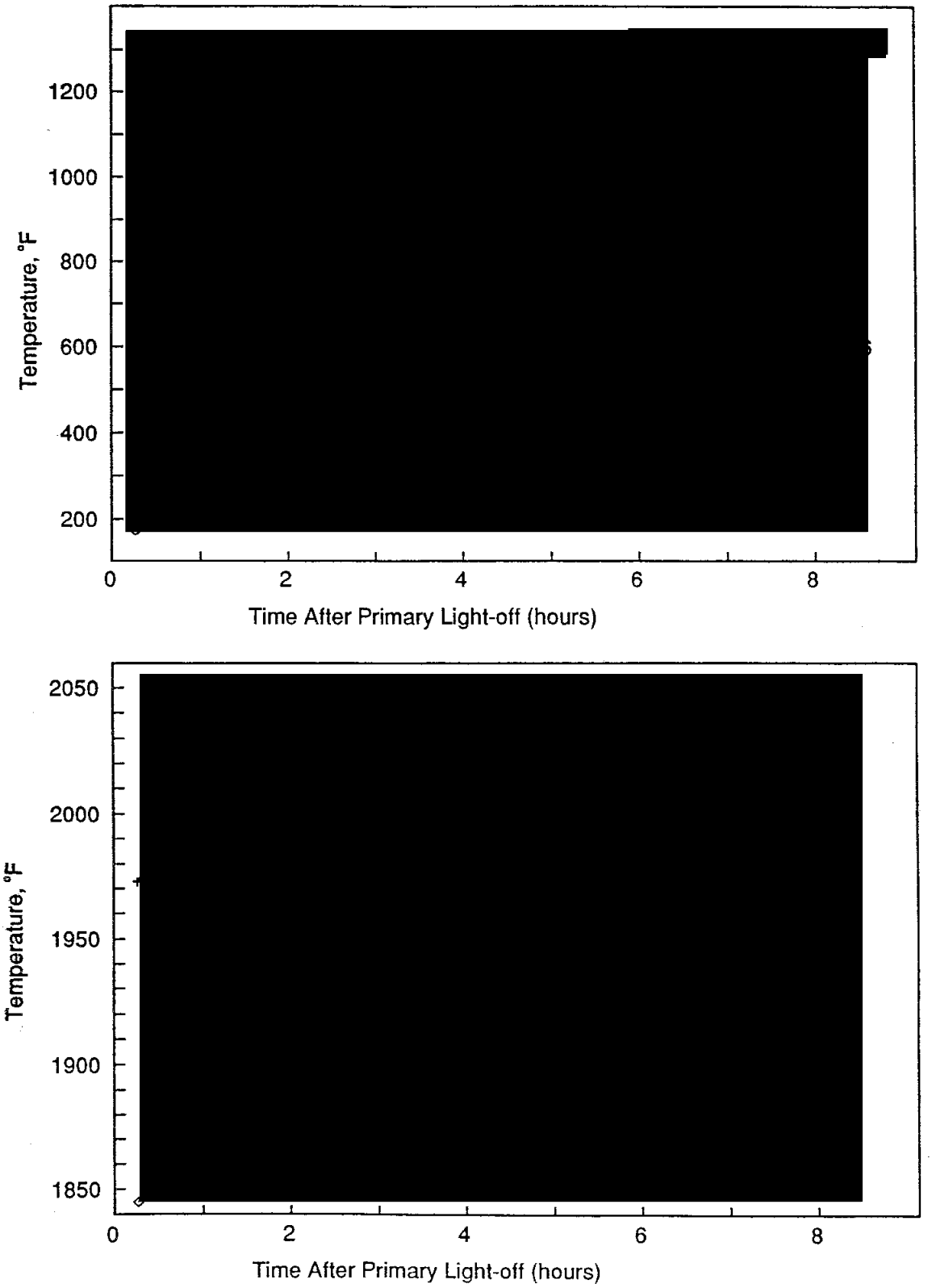


Figure 2. Temperature Profiles

APPENDIX A

MSW Burn August 21, 1990

DISCUSSION OF AUGUST 21, 1990 BURN

Entech personnel placed 1,837 lb of municipal solid waste (MSW) obtained from the Laramie landfill into the primary combustion chamber for the August 21, 1990, burn. The secondary combustion chamber was preheated starting at 09:35 hours. Primary combustion chamber light-off time was 10:20 hours. The burn continued until at least 16:40 hours; then, the secondary combustion chamber natural gas supply was turned off. A total of 6,600 cubic ft of natural gas was consumed for the burn. After the burn, the residual material was separated into glass (41 lb), metal (97 lb), and ash (197 lb) components.

Entech provided WRI with copies of data recorded during that burn; these copies are also presented in the following pages. WRI commentary on this information is as follows:

1. Temperatures

Peak primary combustion chamber temperature recorded was 1,400°F (782°C) at location T_7 at 14:25 hours. After this time, primary combustion chamber temperatures began to cool, indicating the burn was almost over. The secondary combustion chamber natural gas and air supply was turned off sometime just before 16:50 hours. The ash cooled to about 100°F (38°C) by 07:40 hours the next day. The pitot tube normally used to measure stack gas flow was not used at all for this burn. Temperature T_{16} (the thermocouple was attached to the pitot tube) remained low, and showed that the pitot tube was not inserted into the stack.

2. Enerac 2000 Analyzer readings on Stack Gas

Recorded carbon monoxide readings were in the 3 to 30 ppm range, except for upset conditions at 11:22, 11:38, and possibly 14:10 hours. The first upset (11:22 and 11:38) was caused by deliberate shutdown of the secondary combustion chamber so a potential client could observe the effects (smoke from the stack). It is not clear if there was an upset at 14:10 hours, other than a CO reading of 128 ppm at that time and another CO reading of 9 ppm at 14:11.

Recorded NO_x measurements were between 71 and 92 ppm. The limit of detection for SO_2 was 2 ppm; no SO_2 was measured. There was no record of any check of the Enerac 2000 analyzer with available calibration gases (CO, SO_2, NO_x) other than a reading of 20.9% oxygen in ambient air.

3. Air Flows and Natural Gas Consumption

The total natural gas consumption was [redacted]. At 16:00 hours, Entech recorded a natural gas consumption rate of [redacted] at 16:06 hours).

The anemometer readings for air imput were also recorded (ft/min). To convert these numbers to scfm per minute of air (assuming an air temperature of 60°F and 23 inches Hg), the following multipliers should be used:

Pod Air (Primary turbulent air): [redacted]
Pod Burn Air (Primary burner air):

Secondary Burner Air: [redacted]
Air Ring (Secondary Turbulent): [redacted]

The secondary combustion chamber exhaust flow was not measured. As a rough approximation, it is equal to the sum of the air flows and natural gas flows plus an additional 10% to allow for water vapor.

For example, at 11:45 hours, the calculated primary turbulent, primary burner, secondary burner, and secondary turbulent air flows were [redacted], respectively. Assuming a natural gas flow of 14 scfm, the calculated stack gas flow is [redacted]. At 14:50 hours, the calculated stack gas flow is [redacted] scfm.

During the earlier stages of the burn, very little turbulent air was supplied to the primary combustion chamber [redacted]). Toward the end of the burn, much more air was supplied [redacted]).

TEST: MSW DATE: 8/21/90 ENTECH CORPORATION PAGE 1

SECONDRY START TIME: 9:35 FUEL READING START: 848

PRIMARY " " 10:20 " " FINISH: 914

TEMPERATURE READINGS

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16
1020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8/22/90 0740	Combustion Air Fan													Ambient Air.		

MSW [redacted] ENTECH TOS 8/21/90

POD AIR	[redacted]	SECONDARY BURNER AIR	AIR RING	Time
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	S.P. on Pod .04			[redacted]
[redacted]	[redacted]			

ENERAL #2000 / STACK Emissions

ENTECH CORPORATION MSW 8/21/90

TIME	O2 %	NOX ppm	CO ppm	SO2	CO2 %	TEMP	COMB	EX-AIR	S.P.
10 45	0								
11:10	0	92	3	0	12%				
11:13		78	7		13.1				
11:16		93	9		13.8				
11:19		86	13	0	14.5				
11:21		85	29		15.0				
ulled probe for cooling. 11:32 ore pushed to reading off ale. 11:38 particles present									
11:52	5.2	86	13.0	0	11.8				
11:55	5.2	83	14		12.1				
11:58	4.7	85	9		12.1				
12:01 ulled probe for Cooling	4.6	79	11	0	12.3				
mbient Air	20.9	0	0		0				

APPENDIX B

Data Sheets Used in Field Operations

During December 3, 1990 Burn

ENTECH INCORPORATED

DATE: DEC 3, 1990

BURN TYPE: MSW

WEIGHTS & VOLUMES

MATERIAL WEIGHT INPUT: 1,739 Lbs

MATERIAL VOLUME: 10.72 Cubic Yards.

ASH WEIGHT: 80 lbs METAL
153 " ASH
99 " GLASS

ASH VOLUME: 1 1/4 METAL Barrel
2/3 ASH "
1/3 GLASS "

ENTECH INCORPORATED

DATE: 12/3/90 PAGE: 1 OF 1.

BURN TYPE: MSW

ENERAC READINGS

Time:	CO ppm	OXY %	NOX ppm	SO2 ppm	CO2 %	COMBUS. %	STACK Δ. P.	
0853	5	10.3	11	0.0	6.1	0.00	0.035	
0855							0.040	
0922	13	10.2	19	0.0	6.4	0.00	0.041	T/6 1206°
0925	began KK dioxin + furan sampling							
0950	3	11.7	30	0.0	5.6	0.00	0.040	T/6 1244
1015	3	7.6	45	Ø	7.6	0.00	0.045	T_E 90 T_6 80 T_{ay} 40 SGH-1 vac 6 : T/6 12
1045	5	7.8	40	Ø	7.5	0.00	0.055	T_E 90 T_6 60 T_{ay} 45 vacion 535.5 : T/6 11
1115	65	2.9	76	Ø	10.1	0.06	0.080	T/6: 1366°
1140	3	5.9	33	Ø	8.6	0.00	0.084	
1215	13	6.4	31	Ø	8.2	0.00	0.068	
1240	0	6.8	22	Ø	8.1	0.00		1227° T/6
1300	0	7.2	20	Ø	7.6	0.00	0.067	T_{16}: 1242°
1320	0	8.1	19	Ø	7.3	0.00	0.062	T_{16}: 1230°
1340	0	7.6	19	Ø	7.5	0.00	0.060	T_{16}: 1258°
1405	0	10.4	22	Ø	5.8	0.00	0.061	T_{16} 1211°
1440	3	9.9	25	Ø	6.2	0.00	0.072	T_{16}: 1207°
1500	0	10.8	22	Ø	5.7%	0.00	0.067	T_{16}: 1232°
1520	0	11.6	19	Ø	5.3%	0.00	0.077	T_{16}: 1255°
1540	0	13.9	19		4.1%	0.00	0.080	T_{16}: 1261°
1600							~~0.087~~ 0.077	T_{16}: 1098°
1615	8	15.8	19	Ø	3.2%	0.00	0.080	T_{16}: 1074°

At 4 Inch Depth

ENTECH INCORPORATED

DATE: Monday Dec. 3, 1990

PAGE: 1 OF 1

BURN TYPE: MSW

AIR FLOW & FUEL READINGS

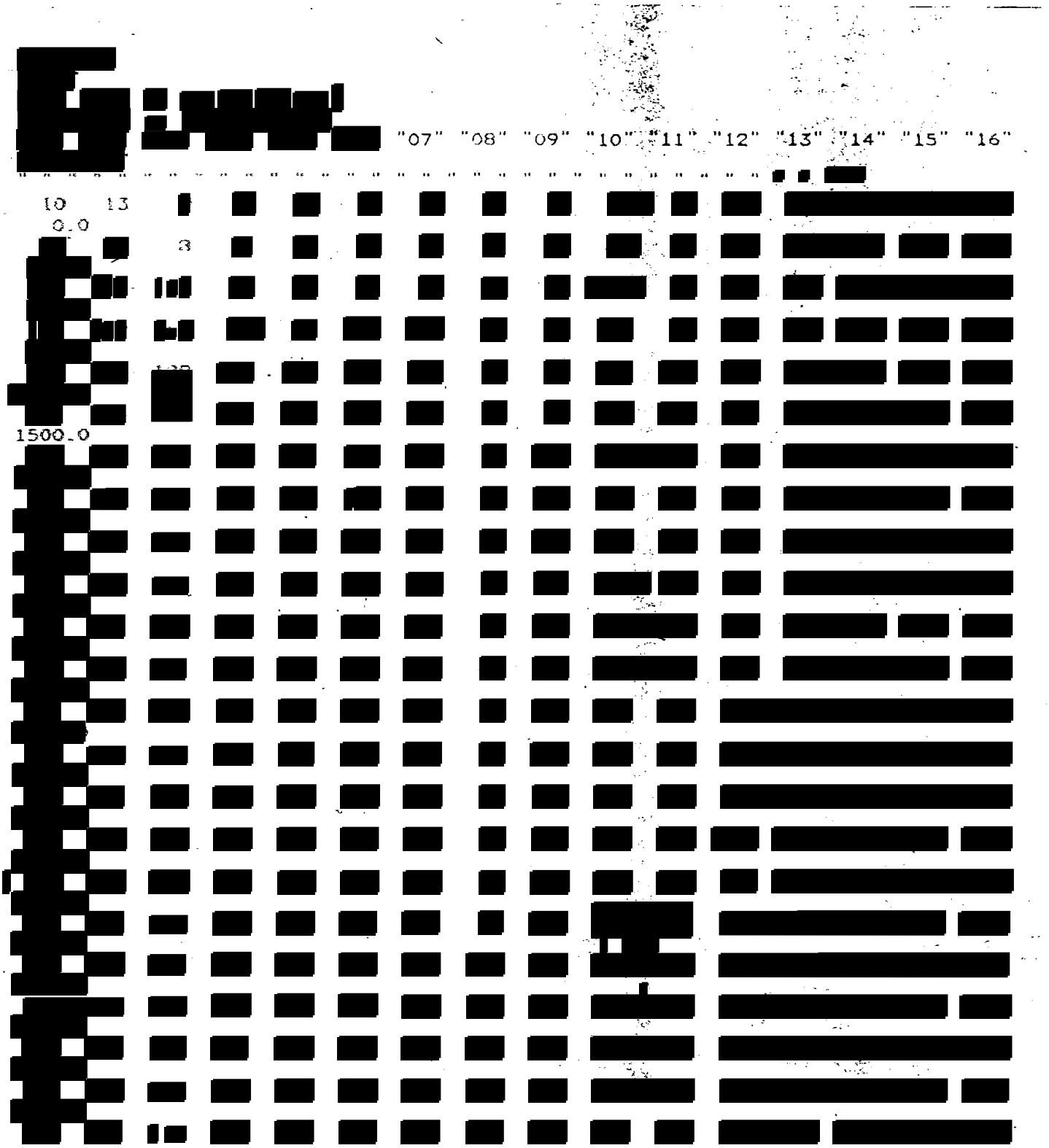
Time:	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
0910	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
0910	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
0930	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1000	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1030	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1030	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1100	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1110	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1115	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1130	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1200	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1224	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1230	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1330	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1400	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1405	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1430	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1500	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1523	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1530	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1600	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1630	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1645	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

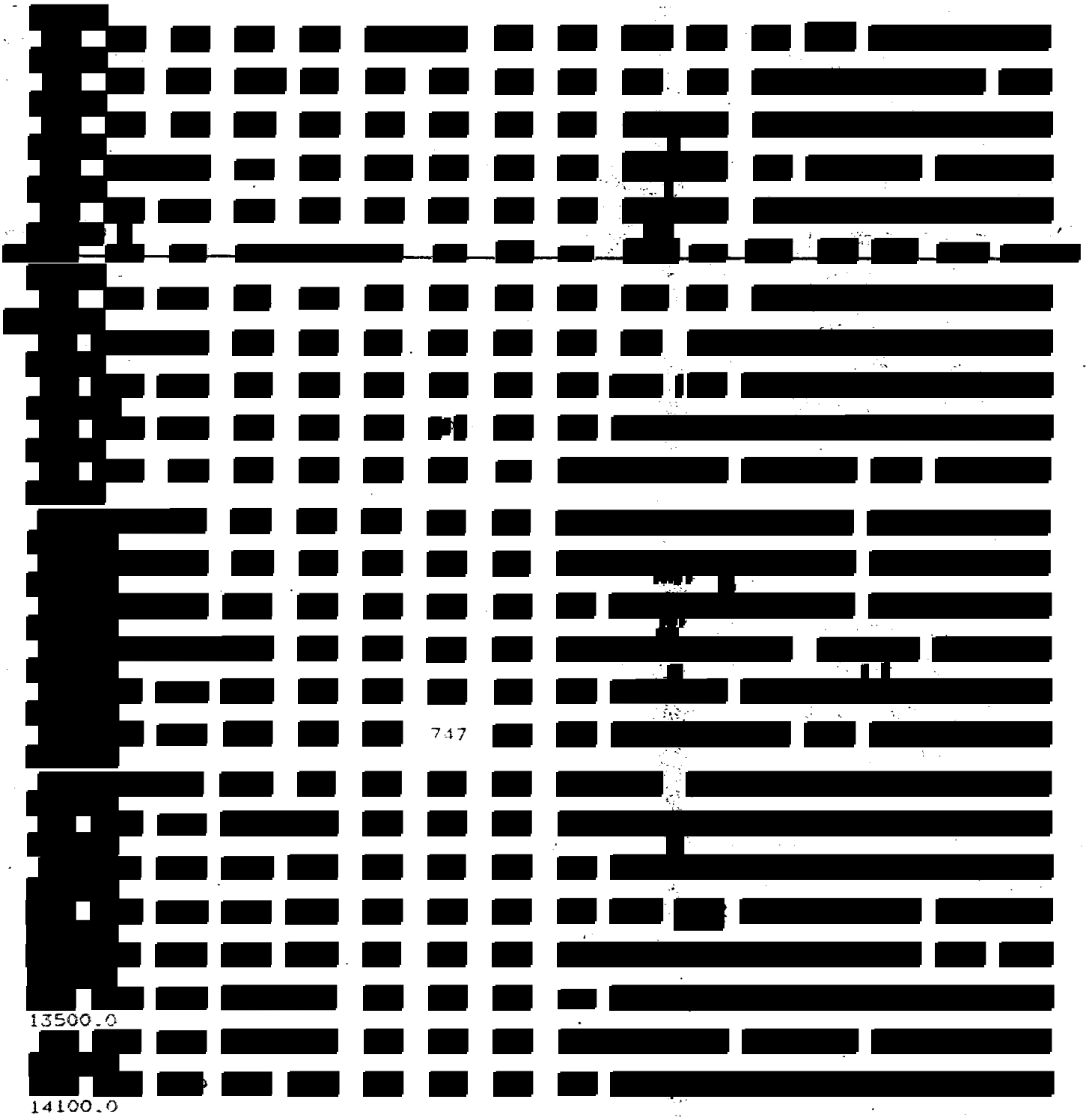
[redacted]

	Hole #	[redacted]								
Damper open 1/4	Depth of Probe Into Hole	[redacted]								
Damper open 2/3		[redacted]								
Damper Open Full		[redacted]								

[redacted] Turbulent Air Flow

Temperatures

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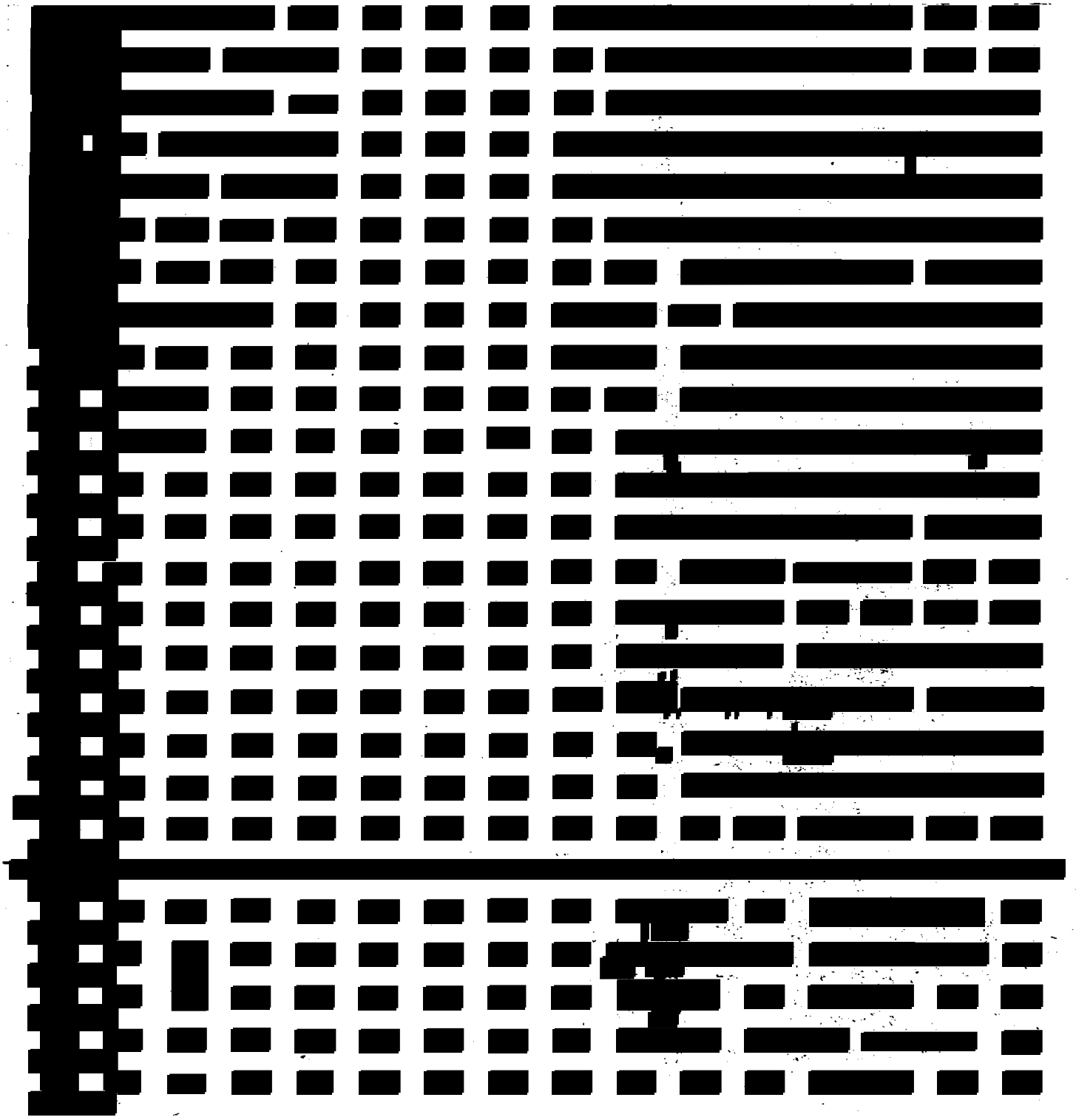
14100.0

21600.0



APPENDIX C

Triangle Laboratories

Dioxin/Furan Summary Sheets

December 3, 1990 Burn

TRIANGLE LABORATORIES, INC.
801-10 CAPITOLA DRIVE
RESEARCH TRIANGLE PARK, NC 27713

Phone: (919) 544-5729
Fax: (919) 544-5491

DATE :	* 06 FEBRUARY 1991
CLIENT ID :	* WESTERN RESEARCH INSTITUTE
P.O. NUMBER :	* 110640
TLI PROJECT No. :	* 17180M

CASE NARRATIVE
MODEL 8290X

ANALYSIS OF SAMPLES FOR THE PRESENCE OF POLYCHLORINATED DIBENZO-p-DIOXINS AND DIBENZOFURANS BY HIGH-RESOLUTION GAS CHROMATOGRAPHY / HIGH-RESOLUTION MASS SPECTROMETRY

Two MM5 samples were received from WESTCON RESEARCH INSTITUTE in good condition December 18, 1990 and stored in a refrigerator at 4°C. The samples were extracted and analyzed according to procedures described in the Triangle Labs User Manual provided with this data package. Any particular difficulties encountered during the sample handling by Triangle Labs will be discussed in the QA/QC remark section below.

Quality Assurance/Quality Control Samples

A laboratory method blank -- identified as the TLI Blank -- is prepared along with the batch of samples.

QA/QC Remarks

The release of this particular set of WESTCON RESEARCH INSTITUTE analytical data by Triangle Labs was authorized by the Quality Assurance Officer who has reviewed each sample data package individually following a series of inspections/reviews conducted at two other levels of the data production line. When applicable, general deviations from acceptable QA/QC requirements are identified below. Comments on the effect of these deviations upon the validity and reliability of the results can be obtained from the User Manual (Data Quality Objectives; Section 5). Specific QA/QC Problems Associated with this Particular Project are:

Sample Preparation Laboratory: None

Mass Spectrometry: None

Data Review:

Analytes were found in the TLI Blank at levels less than one-third the calculated theoretical method quantitation limit (TMQL) for the associated samples. Blank contamination levels of one-third TMQL or less are acceptable under TLI guidelines, as discussed in section 5.1.3.2 of the Data User's Manual; however, the OCDD isomer is not required to conform to one-third TMQL criteria.

Some samples in this project present QC ion instabilities as a result of quantitative interferences. The affected isomers are flagged "Q" on the report. Affected analytes may be overestimated or underestimated due to this interference. Quantitative interference is described in section 5.1.2.4.1 of the Data User's Manual.

Sample 12-3-90 RUN # 1 (TLI # 39-150-1 A,B,D) has a diphenyl ether peak in the DB-225 analysis which corresponds to the 2378-TCDF analyte peak , flagged "E". The 2378-TCDF and the Total TCDF concentrations may be overestimated.

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (a)

02/06/91

FILE NAME....: S910463 CLIENT.....: WRI TLI SAMPLE ID.: *
CONCAL.....: S910458 SAMPLE ID....: 12-3-90 RUN #1
ANALYST.....: MCC ANALYSIS DATE: 01/24/91 PROJECT NUMBER: 17180M
SAMPLE SIZE..: 1.00 SAMPLE MATRIX: MM5 DATE RECEIVED.: 12/28/89
ICAL DATE....: 11/29/90 SAMPLE ORIGIN: n/a DATE COLLECTED: / /
SPIKE FILE...: SPX23710 CLIENT PROJECT: n/a

NAME	AMT(ng)	NUMBER	DL	EMPC	RATIO	RT	FLAGS
2378-TCDD	ND		0.04				
12378-PeCDD	ND		0.09				
123478-HxCDD	ND		0.1				
123678-HxCDD	ND		0.1				
123789-HxCDD	ND		0.1				
1234678-HpCDD	EMPC			0.47			
OCDD	2.6				0.90	51:47	B
2378-TCDF	1.1				0.74	30:24	
12378-PeCDF	0.12				1.78	35:10	
23478-PeCDF	0.22				1.39	36:07	
123478-HxCDF	0.37				1.23	40:12	B
123678-HxCDF	0.17				1.26	40:23	
234678-HxCDF	0.21				1.19	41:11	B
123789-HxCDF	ND		0.1				
1234678-HpCDF	0.39				1.06	44:52	
1234789-HpCDF	ND		0.2				
OCDF	EMPC			0.36			
TOTAL TCDD	0.75	4		0.78	0.76		
TOTAL PeCDD	0.46	2		0.75	1.58		
TOTAL HxCDD	0.99	3			1.23		
TOTAL HpCDD	0.34	1		0.81	0.92		
TOTAL TCDF	6.3	12		6.9	0.75		
TOTAL PeCDF	1.7	6		2.8	1.62		
TOTAL HxCDF	1.2	5			1.24		
TOTAL HpCDF	0.48	1		0.66	1.06		

* 39-150-1 A,B,D

Reviewed By: [signature] 2/6/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (a) QA/QC SUMMARY

02/06/91

FILE NAME....:	S910463	CLIENT.....:	WRI	TLI SAMPLE ID.:	*
CONCAL.....:	S910458	SAMPLE ID....:	12-3-90 RUN #1		
ANALYST.....:	MCC	ANALYSIS DATE:	01/24/91	PROJECT NUMBER:	17180M
SAMPLE SIZE..:	1.00	SAMPLE MATRIX:	MM5	DATE RECEIVED.:	12/28/89
ICAL DATE....:	11/29/90	SAMPLE ORIGIN:	n/a	DATE COLLECTED:	/ /
SPIKE FILE...:	SPX23710			CLIENT PROJECT:	n/a

SURROGATE RECOVERY SUMMARY (TYPE A)

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
37Cl-TCDD	9.2	92.3		31:12	___
13C12-PeCDF 234	9.4	93.6	1.48	36:06	___
13C12-HxCDF 478	9.6	96.1	0.49	40:12	___
13C12-HxCDD 478	9.2	91.6	1.14	41:21	___
13C12-HpCDF 789	9.0	90.3	0.46	47:03	___

ALTERNATE STANDARDS RECOVERY SUMMARY (TYPE A)

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
13C12-HxCDF 789	6.1	61.2	0.53	42:19	___
13C12-HxCDF 234	6.5	64.8	0.53	41:09	___

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
13C12-2378-TCDF	6.1	61.3	0.75	30:22	___
13C12-2378-TCDD	6.7	66.7	0.79	31:10	___
13C12-PeCDF 123	5.3	53.0	1.44	35:09	___
13C12-PeCDD 123	4.4	44.5	1.50	36:35	___
13C12-HxCDF 678	7.0	70.2	0.51	40:21	___
13C12-HxCDD 678	8.0	79.6	1.22	41:29	___
13C12-HpCDF 678	5.4	54.2	0.45	44:50	___
13C12-HpCDD 678	5.9	59.3	1.10	46:23	___
13C12-OCDD	11.2	55.8	0.93	51:47	___

RECOVERY STANDARDS RECOVERY SUMMARY

NAME	RATIO	RT	FLAGS
13C12-1234-TCDD	0.80	30:58	___
13C12-HxCDD 789	1.22	41:58	___

* 39-150-1 A,B,D

Reviewed By: [signature] 2/6/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
CONFIRMATION ANALYSIS (DB-225)

02/06/91

FILE NAME....: T910459
CONCAL.....: T910447
ANALYST.....: MTB
SAMPLE SIZE..: 1.00
ICAL DATE....: 01/23/91
SPIKE FILE...: SPC2NF10

CLIENT.....: WRI
SAMPLE ID....: 12-3-90 RUN #1
ANALYSIS DATE: 01/27/91
SAMPLE MATRIX: MM5
SAMPLE ORIGIN: n/a

TLI SAMPLE ID.: *
PROJECT NUMBER: 17180M
DATE RECEIVED.: 12/28/90
DATE COLLECTED: / /
CLIENT PROJECT: n/a

NAME	AMT(ng)	NUMBER	DL	EMPC	RATIO	RT	FLAGS
2378-TCDD	EMPC			0.03			
2378-TCDF	EMPC			0.18			E
TOTAL TCDD	0.72	5		0.79	0.78		
TOTAL TCDF	6.5	23		6.7	0.78		E

SURROGATE STD. RECOVERY SUMMARY (TYPE A)

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
37Cl-TCDD	9.5	95.3		22:05	

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
13C12-2378-TCDF	7.3	73.0	0.79	23:28	
13C12-2378-TCDD	7.7	77.1	0.82	22:04	

RECOVERY STANDARDS RECOVERY SUMMARY

NAME	RATIO	RT	FLAGS
13C12-1234-TCDD	0.84	22:21	

* 39-150-1 A,B,D

Reviewed By: 2/6/91 C2NF_RPT 3.02, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (a)

02/05/91

FILE NAME....: S910462 CLIENT.....: WRI TLI SAMPLE ID.: n/a
CONCAL.....: S910458 SAMPLE ID....: TLI BLANK
ANALYST.....: MCC ANALYSIS DATE: 01/24/91 PROJECT NUMBER: 17180M
SAMPLE SIZE..: 1.00 SAMPLE MATRIX: n/a DATE RECEIVED.: / /
ICAL DATE....: 11/29/90 SAMPLE ORIGIN: n/a DATE COLLECTED: / /
SPIKE FILE...: SPX23710 CLIENT PROJECT: n/a

NAME	AMT(ng)	NUMBER	DL	EMPC	RATIO	RT	FLAGS
2378-TCDD	ND		0.02				
12378-PeCDD	ND		0.04				
123478-HxCDD	0.05				1.31	41:24	Q
123678-HxCDD	ND		0.04				
123789-HxCDD	0.03				1.43	42:01	Q
1234678-HpCDD	ND		0.07				
OCDD	EMPC			0.27			
2378-TCDF	ND		0.02				
12378-PeCDF	ND		0.03				
23478-PeCDF	ND		0.03				
123478-HxCDF	0.10				1.10	40:15	
123678-HxCDF	ND		0.03				
234678-HxCDF	0.07				1.27	41:12	Q
123789-HxCDF	EMPC			0.08			
1234678-HpCDF	ND		0.04				
1234789-HpCDF	ND		0.06				
OCDF	ND		0.1				
TOTAL TCDD	ND		0.02				
TOTAL PeCDD	ND		0.04				
TOTAL HxCDD	0.08	2			1.37		Q
TOTAL HpCDD	ND		0.07				
TOTAL TCDF	ND		0.02				
TOTAL PeCDF	ND		0.03				
TOTAL HxCDF	0.18	2		0.24	1.19		Q
TOTAL HpCDF	ND		0.05				

Reviewed By: Kv 2/5/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (a) QA/QC SUMMARY

02/05/91

FILE NAME....:	S910462	CLIENT.....:	WRI	TLI SAMPLE ID.:	n/a
CONCAL.....:	S910458	SAMPLE ID....:	TLI BLANK		
ANALYST.....:	MCC	ANALYSIS DATE:	01/24/91	PROJECT NUMBER:	17180M
SAMPLE SIZE..:	1.00	SAMPLE MATRIX:	n/a	DATE RECEIVED.:	/ /
ICAL DATE....:	11/29/90	SAMPLE ORIGIN:	n/a	DATE COLLECTED:	/ /
SPIKE FILE...:	SPX23710			CLIENT PROJECT:	n/a

SURROGATE RECOVERY SUMMARY (TYPE A)

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
37Cl-TCDD	8.1	80.6		31:12	
13C12-PeCDF 234	10.0	99.6	1.46	36:06	
13C12-HxCDF 478	9.8	97.7	0.52	40:14	
13C12-HxCDD 478	7.9	79.4	1.20	41:23	
13C12-HpCDF 789	8.1	81.2	0.44	47:03	

ALTERNATE STANDARDS RECOVERY SUMMARY (TYPE A)

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
13C12-HxCDF 789	2.5	24.9	0.52	42:21	V
13C12-HxCDF 234	3.9	39.3	0.51	41:11	Q V

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (ng)	% REC.	RATIO	RT	FLAGS
13C12-2378-TCDF	2.4	23.8	0.77	30:22	V
13C12-2378-TCDD	2.9	28.7	0.79	31:10	V
13C12-PeCDF 123	2.5	25.1	1.44	35:09	V
13C12-PeCDD 123	2.9	28.8	1.55	36:36	V
13C12-HxCDF 678	3.2	31.5	0.50	40:24	V
13C12-HxCDD 678	5.0	50.1	1.18	41:31	Q
13C12-HpCDF 678	2.6	26.4	0.45	44:51	
13C12-HpCDD 678	3.0	29.8	1.03	46:23	
13C12-OCDD	4.8	24.0	0.81	51:47	V

RECOVERY STANDARDS RECOVERY SUMMARY

NAME	RATIO	RT	FLAGS
13C12-1234-TCDD	0.82	30:58	
13C12-HxCDD 789	1.20	41:59	

Reviewed By: KV 2/5/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (b)

01/30/91

FILE NAME....:	S910475	CLIENT.....:	WRI	TLI SAMPLE ID.:	39-150-1C
CONCAL.....:	S910472	SAMPLE ID....:	12-3-90 RUN #1		
ANALYST.....:	CD	ANALYSIS DATE:	01/25/91	PROJECT NUMBER:	17180TR1
SAMPLE SIZE..:	1.00	SAMPLE MATRIX:	TOL RINSE	DATE RECEIVED.:	12/18/90
ICAL DATE....:	11/29/90	SAMPLE ORIGIN:	n/a	DATE COLLECTED:	/ /
SPIKE FILE...:	SPX2372K			CLIENT PROJECT:	n/a

NAME	AMT(pg)	NUMBER	DL	EMPC	RATIO	RT	FLAGS
2378-TCDD	ND		8.0				___
12378-PeCDD	ND		15.2				___
123478-HxCDD	ND		20.1				___
123678-HxCDD	ND		21.6				___
123789-HxCDD	ND		23.8				___
1234678-HpCDD	ND		57.1				___
OCDD	ND		157				___
2378-TCDF	ND		6.2				___
12378-PeCDF	ND		9.1				___
23478-PeCDF	ND		10.1				___
123478-HxCDF	ND		11.8				___
123678-HxCDF	ND		12.3				___
234678-HxCDF	ND		15.7				___
123789-HxCDF	ND		19.4				___
1234678-HpCDF	ND		22.6				___
1234789-HpCDF	ND		36.7				___
OCDF	ND		136				___
TOTAL TCDD	ND		8.0				___
TOTAL PeCDD	EMPC			27.9			___
TOTAL HxCDD	ND		21.7				___
TOTAL HpCDD	ND		57.1				___
TOTAL TCDF	ND		6.2				___
TOTAL PeCDF	ND		9.6				___
TOTAL HxCDF	ND		14.2				___
TOTAL HpCDF	ND		28.0				___

Reviewed By: [signature] 1/30/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (b) QA/QC SUMMARY

01/30/91

FILE NAME....:	S910475	CLIENT.....:	WRI	TLI SAMPLE ID.:	39-150-1C
CONCAL.....:	S910472	SAMPLE ID....:	12-3-90 RUN #1		
ANALYST.....:	CD	ANALYSIS DATE:	01/25/91	PROJECT NUMBER:	1718DTR1
SAMPLE SIZE..:	1.00	SAMPLE MATRIX:	TOL RINSE	DATE RECEIVED.:	12/18/90
ICAL DATE....:	11/29/90	SAMPLE ORIGIN:	n/a	DATE COLLECTED:	/ /
SPIKE FILE...:	SPX2372K			CLIENT PROJECT:	n/a

SURROGATE RECOVERY SUMMARY (TYPE B)

NAME	AMT (pg)	% REC.	RATIO	RT	FLAGS
37Cl-TCDD	1460	73.1		31:09	___
13C12-PeCDF 234	1200	60.2	1.44	36:04	___
13C12-HxCDF 478	2330	116	0.50	40:12	___
13C12-HxCDD 478	2310	116	1.24	41:21	___
13C12-HpCDF 789	1120	55.8	0.46	47:02	___

ALTERNATE STANDARDS RECOVERY SUMMARY (TYPE B)

NAME	AMT (pg)	% REC.	RATIO	RT	FLAGS
13C12-HxCDF 789	1290	64.6	0.57	42:19	___
13C12-HxCDF 234	1560	77.8	0.51	41:09	___

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (pg)	% REC.	RATIO	RT	FLAGS
13C12-2378-TCDF	1450	72.6	0.76	30:21	___
13C12-2378-TCDD	1760	87.8	0.77	31:08	___
13C12-PeCDF 123	1490	74.3	1.42	35:06	___
13C12-PeCDD 123	1380	68.8	1.42	36:34	___
13C12-HxCDF 678	2550	128	0.51	40:22	___
13C12-HxCDD 678	2830	142	1.33	41:29	___
13C12-HpCDF 678	1470	73.7	0.41	44:49	___
13C12-HpCDD 678	1320	66.2	1.06	46:21	___
13C12-OCDD	1500	37.5	0.91	51:44	___

RECOVERY STANDARDS RECOVERY SUMMARY

NAME	RATIO	RT	FLAGS
13C12-1234-TCDD	0.82	30:56	___
13C12-HxCDD 789	1.30	41:56	___

Reviewed By: [signature] 1/30/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (b)

01/30/91

FILE NAME....: S910473
CONCAL.....: S910472
ANALYST.....: CD
SAMPLE SIZE..: 1.00
ICAL DATE....: 11/29/90
SPIKE FILE...: SPX2372K

CLIENT.....: WRI
SAMPLE ID....: TLI BLANK
ANALYSIS DATE: 01/25/91
SAMPLE MATRIX: n/a
SAMPLE ORIGIN: n/a

TLI SAMPLE ID.: n/a
PROJECT NUMBER: 17180TR1
DATE RECEIVED.: / /
DATE COLLECTED: / /
CLIENT PROJECT: n/a

NAME	AMT(pg)	NUMBER	DL	EMPC	RATIO	RT	FLAGS
2378-TCDD	ND		16.6				___
12378-PeCDD	ND		31.6				___
123478-HxCDD	ND		42.6				___
123678-HxCDD	ND		45.7				___
123789-HxCDD	ND		50.4				___
1234678-HpCDD	ND		121				___
OCDD	ND		293				___
2378-TCDF	ND		14.0				___
12378-PeCDF	ND		20.6				___
23478-PeCDF	ND		22.9				___
123478-HxCDF	ND		28.0				___
123678-HxCDF	ND		29.2				___
234678-HxCDF	ND		37.3				___
123789-HxCDF	ND		46.1				___
1234678-HpCDF	ND		48.7				___
1234789-HpCDF	ND		79.3				___
OCDF	ND		253				___
TOTAL TCDD	ND		16.6				___
TOTAL PeCDD	ND		31.6				___
TOTAL HxCDD	ND		46.0				___
TOTAL HpCDD	ND		121				___
TOTAL TCDF	ND		14.0				___
TOTAL PeCDF	ND		21.7				___
TOTAL HxCDF	ND		33.8				___
TOTAL HpCDF	ND		60.3				___

Reviewed By: _____ 1/30/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC.
PCDD/PCDF 2378X ANALYSIS (b) QA/QC SUMMARY

01/30/91

FILE NAME....:	S910473	CLIENT.....:	WRI	TLI SAMPLE ID.:	n/a
CONCAL.....:	S910472	SAMPLE ID....:	TLI BLANK		
ANALYST.....:	CD	ANALYSIS DATE:	01/25/91	PROJECT NUMBER:	17180TR1
SAMPLE SIZE..:	1.00	SAMPLE MATRIX:	n/a	DATE RECEIVED.:	/ /
ICAL DATE....:	11/29/90	SAMPLE ORIGIN:	n/a	DATE COLLECTED:	/ /
SPIKE FILE...:	SPX2372K			CLIENT PROJECT:	n/a

SURROGATE RECOVERY SUMMARY (TYPE B)

NAME	AMT (pg)	% REC.	RATIO	RT	FLAGS
37Cl-TCDD	956	47.8		31:10	
13C12-PeCDF 234	794	39.7	1.49	36:06	V
13C12-HxCDF 478	1260	62.8	0.51	40:13	
13C12-HxCDD 478	1300	65.1	1.11	41:22	
13C12-HpCDF 789	633	31.6	0.50	47:02	

ALTERNATE STANDARDS RECOVERY SUMMARY (TYPE B)

NAME	AMT (pg)	% REC.	RATIO	RT	FLAGS
13C12-HxCDF 789	743	37.2	0.57	42:20	V
13C12-HxCDF 234	817	40.9	0.47	41:10	

INTERNAL STANDARDS RECOVERY SUMMARY

NAME	AMT (pg)	% REC.	RATIO	RT	FLAGS
13C12-2378-TCDF	907	45.3	0.68	30:21	
13C12-2378-TCDD	1190	59.6	0.79	31:09	
13C12-PeCDF 123	922	46.1	1.39	35:08	
13C12-PeCDD 123	927	46.4	1.61	36:35	
13C12-HxCDF 678	1270	63.7	0.51	40:23	
13C12-HxCDD 678	1590	79.3	1.25	41:30	
13C12-HpCDF 678	809	40.5	0.44	44:49	
13C12-HpCDD 678	744	37.2	1.02	46:22	
13C12-OCDD	955	23.9	0.88	51:45	V

RECOVERY STANDARDS RECOVERY SUMMARY

NAME	RATIO	RT	FLAGS
13C12-1234-TCDD	0.81	30:57	
13C12-HxCDD 789	1.18	41:58	

Reviewed By: [signature] 1/30/91 X237_RPT 3.04, LARS Version 3.18.05

TRIANGLE LABORATORIES, INC. Date: 11/29/90

Initial Calibration Summary for SM01129

JTH 12-80
11/30/90
11/30/90

Analysis Date....: 11/29/90 Method.....: M237

Instrument.....: S

Analytes	RF	SD	%RSD		RT	RT/LO	RT/HI	Ratio1	Ratio2	N
Total MCDF	1.949	0.358	18%		13:32	10:28	21:28	3.321		3
Total MCDD	2.242	0.522	23%		14:44	11:15	22:15	2.923		3
Total DCDF	0.470	0.085	18%		18:57	17:28	22:28	6.641		3
Total DCDD	1.186	0.201	17%		20:00	18:15	23:15	1.524		3
Total TriCDF	0.431	0.372	86%	**	24:23	21:28	26:28	1.017		3
Total TriCDD	0.632	0.077	12%		24:40	23:15	27:15	1.036		3
2378-TCDF	1.074	0.119	11%		30:28	26:28	34:28	0.771		5
TOTAL TCDF	1.074	0.119	11%					0.771		5
2378-TCDD	1.135	0.058	5%		31:16	27:15	35:15	0.781		5
TOTAL TCDD	1.135	0.058	5%					0.781		5
12378-PeCDF	1.405	0.093	7%		35:15	31:14	39:14	1.570		5
23478-PeCDF	1.266	0.076	6%		36:12			1.581		5
TOTAL PeCDF	1.335	0.083	6%					1.573		5
12378-PeCDD	1.605	0.089	6%		36:41	32:40	40:40	1.602		5
TOTAL PeCDD	1.605	0.089	6%					1.602		5
123478-HxCDF	1.565	0.144	9%		40:20	36:28	44:28	1.173		5
123678-HxCDF	1.505	0.107	7%		40:29			1.163		5
234678-HxCDF	1.178	0.145	12%		41:16			1.147		5
123789-HxCDF	0.952	0.112	12%		42:26			1.188		5
TOTAL HxCDF	1.300	0.126	10%					1.166		5
123478-HxCDD	1.248	0.107	9%		41:28	37:35	45:35	1.254		5
123678-HxCDD	1.165	0.094	8%		41:36			1.227		5
123789-HxCDD	1.057	0.092	9%		42:04			1.271		5
TOTAL HxCDD	1.157	0.097	8%					1.249		5
1234678-HpCDF	1.953	0.181	9%		44:55	40:54	48:54	0.953		5
1234789-HpCDF	1.199	0.116	10%		47:08			0.965		5
TOTAL HpCDF	1.576	0.138	9%					0.958		5
1234678-HpCDD	1.198	0.147	12%		46:28	42:27	50:27	1.010		5
TOTAL HpCDD	1.198	0.147	12%					1.010		5
OCDF	1.754	0.138	8%		52:05	47:50	55:50	0.940		5
OCDD	1.518	0.145	10%		51:51	47:50	55:50	0.841		5

Other Standards	RF	SD	%RSD	RT	RT/LO	RT/HI	Ratio1	Ratio2	N
37Cl-TCDD	1.015	0.033	3%	31:16	29:15	33:15			5
13C12-PeCDF 234	1.129	0.036	3%	36:11	33:14	37:14	1.505		5
13C12-HxCDF 478	0.957	0.035	4%	40:19			0.526		5
13C12-HxCDF 234	0.935	0.048	5%	41:15			0.519		5
13C12-HxCDF 789	0.780	0.043	6%	42:25			0.526		5
13C12-HxCDD 478	0.853	0.023	3%	41:28			1.207		5
13C12-HpCDF 789	0.753	0.032	4%	47:07	42:54	48:54	0.447		5

Internal Standards	RF	SD	%RSD	RT	RT/LO	RT/HI	Ratio1	Ratio2	N
13C12-2378-TCDF	1.784	0.069	4%	30:28	29:28	31:28	0.778		5
13C12-2378-TCDD	1.091	0.061	6%	31:15	29:15	33:15	0.805		5
13C12-PeCDF 123	0.902	0.074	8%	35:14	31:14	39:14	1.534		5
13C12-PeCDD 123	0.516	0.049	10%	36:40	32:40	40:40	1.574		5
13C12-HxCDF 678	1.397	0.082	6%	40:28	36:28	44:28	0.521		5
13C12-HxCDD 678	0.925	0.026	3%	41:35	37:35	45:35	1.204		5
13C12-HpCDF 678	1.015	0.057	6%	44:54	42:54	48:54	0.448		5
13C12-HpCDD 678	0.727	0.043	6%	46:27	45:27	47:27	1.039		5
13C12-OCDD	0.368	0.021	6%	51:50	49:50	53:50	0.890		5

TRIANGLE LABORATORIES, INC. Date: 11/29/90

Initial Calibration Summary for SM01129

Recovery Standards	RF	SD	%RSD	RT	RT/LO	RT/HI	Ratio1	Ratio2	N
13C12-1234-TCDD	1.000	0.000	0%	31:03			0.808		5
13C12-HxCDD 789	1.000	0.000	0%	42:04			1.197		5

*** End of Report ***

TRIANGLE LABORATORIES, INC. Date: 01/24/91

Continuing Calibration for S910458

Analysis Date....: 01/24/91 Method.....: M237

Operator.....: CAP Instrument..: S

Init Calibration.: SM01129 Std.Conc....: 50.00

ICal Date.....: 11/29/90

Final
HSK 1/24/91
1/24/91

Analyte Summary

Name	RF	Ratio 1&2	RT Lo/High	RT	Rel. RT	ICal RF	Delta RF	%D	Flags
Total MCDF	1.178	3.21	10:22 21:22	13:26	~~0.1124~~	~~1.949~~	~~0.771~~	~~39.5%~~	~~**~~
Total MCDD	1.145	2.92	11:09 22:09	14:38	0.4698	2.242	-1.097	-48.9%	**
Total DCDF	0.297	6.23	17:22 22:22	18:51	0.6207	0.470	-0.173	-36.9%	**
Total DCDD	1.231	1.59	18:09 23:09	19:53	0.6383	1.186	0.045	3.8%	
Total TriCDF	0.776	1.09	21:22 26:22	24:25	0.8041	0.431	0.345	80.1%	**
Total TriCDD	0.596	1.01	23:09 27:09	24:32	~~0.7876~~	~~0.632~~	~~-0.096~~	~~-5.7%~~	
2378-TCDF	0.950	0.72	26:22 34:22	30:22	1.0000	1.074	-0.124	-11.5%	
TOTAL TCDF	0.950	0.72				1.074	-0.124	-11.5%	
2378-TCDD	0.990	0.78	27:09 35:09	31:10	1.0005	1.135	-0.145	-12.8%	
TOTAL TCDD	0.990	0.78				1.135	-0.145	-12.8%	
12378-PeCDF	1.545	1.60	31:08 39:08	35:09	1.0005	1.405	0.140	9.9%	
23478-PeCDF	1.374	1.62		36:07	1.0280	1.266	0.108	8.5%	
TOTAL PeCDF	1.459	1.61				1.335	0.124	9.3%	
12378-PeCDD	1.887	1.63	32:35 40:35	36:36	1.0005	1.605	0.282	17.6%	
TOTAL PeCDD	1.887	1.63				1.605	0.282	17.6%	
123478-HxCDF	1.542	1.10	36:23 44:23	40:15	0.9967	1.565	-0.023	-1.5%	
123678-HxCDF	1.435	1.14		40:24	1.0004	1.505	-0.070	-4.6%	
234678-HxCDF	1.013	1.11		41:12	1.0202	1.178	-0.165	-14.0%	
123789-HxCDF	0.774	1.14		42:21	1.0487	0.952	-0.178	-18.7%	
TOTAL HxCDF	1.191	1.12				1.300	-0.109	-8.4%	
123478-HxCDD	1.096	1.21	37:30 45:30	41:23	0.9972	1.248	-0.152	-12.2%	
123678-HxCDD	1.074	1.37		41:31	1.0004	1.165	-0.091	-7.8%	
123789-HxCDD	0.925	1.24		42:00	1.0120	1.057	-0.132	-12.5%	
TOTAL HxCDD	1.032	1.27				1.157	-0.125	-10.8%	

TRIANGLE LABORATORIES, INC. Date: 01/24/91

Continuing Calibration for S910458

1234678-HpCDF	1.975	0.93	40:50 48:50	44:51	1.0004	1.953	0.022	1.1%	
1234789-HpCDF	1.122	0.96		47:03	1.0494	1.199	-0.077	-6.4%	
TOTAL HpCDF	1.549	0.94				1.576	-0.027	-1.7%	
1234678-HpCDD	1.194	1.01	42:23 50:23	46:24	1.0004	1.198	-0.004	-0.3%	
TOTAL HpCDD	1.194	1.01				1.198	-0.004	-0.3%	
OCDF	1.662	0.93	47:46 55:46	52:01	1.0048	1.754	-0.092	-5.3%	
OCDD	1.617	0.85	47:46 55:46	51:47	1.0003	1.518	0.099	6.5%	

Other Standard Summary

Name	RF	Ratio 1&2	RT Lo/High	RT	Rel. RT	ICal RF	Delta RF	%D	Flags
37Cl-TCDD	0.885		29:09 33:09	31:10	1.0005	1.015	-0.130	-12.8%	
13C12-PeCDF 234	1.153	1.42	31:08 39:08	36:06	1.0275	1.129	0.024	2.1%	
13C12-HxCDF 478	0.977	0.51		40:14	0.9963	0.957	0.020	2.1%	
13C12-HxCDF 234	0.894	0.48		41:10	1.0194	0.935	-0.041	-4.4%	
13C12-HxCDF 789	0.709	0.53		42:20	1.0483	0.780	-0.071	-9.1%	
13C12-HxCDD 478	0.779	1.18		41:23	0.9972	0.853	-0.074	-8.7%	
13C12-HpCDF 789	0.696	0.46	42:50 48:50	47:02	1.0491	0.753	-0.057	-7.5%	

Internal Standard Summary

Name	RF	Ratio 1&2	RT Lo/High	RT	Rel. RT	ICal RF	Delta RF	%D	Flags
13C12-2378-TCDF	1.709	0.75	29:22 31:22	30:22	1.0000	1.784	-0.075	-4.2%	
13C12-2378-TCDD	1.188	0.80	29:09 33:09	31:09	1.0000	1.081	0.107	9.9%	
13C12-PeCDF 123	0.848	1.43	31:08 39:08	35:08	1.0000	0.908	-0.060	-6.6%	
13C12-PeCDD 123	0.403	1.63	32:35 40:35	36:35	1.0000	0.516	-0.113	-22.0%	—
13C12-HxCDF 678	1.331	0.49	36:23 44:23	40:23	1.0000	1.397	-0.066	-4.7%	
13C12-HxCDD 678	1.075	1.21	37:30 45:30	41:30	1.0000	0.925	0.150	16.2%	
13C12-HpCDF 678	0.891	0.46	42:50 48:50	44:50	1.0000	1.015	-0.124	-12.2%	
13C12-HpCDD 678	0.708	1.02	45:23 47:23	46:23	1.0000	0.727	-0.019	-2.6%	
13C12-OCDD	0.435	0.89	49:46 53:46	51:46	1.0000	0.368	0.067	18.2%	

TRIANGLE LABORATORIES, INC. Date: 01/24/91

Continuing Calibration for S910458

Other Standard Summary

Name	RF	Ratio 1&2	RT Lo/High	RT	Rel. RT	ICal RF	Delta RF	%D	Flags
13C12-1234-TCDD	1.000	0.81		30:57	0.9936	1.000	0.000	0.0%	
13C12-HxCDD 789	1.000	1.27		41:59	1.0116	1.000	0.000	0.0%	

QC Front End Check: 2.5684

WRI-91-R013
Entech Report No. 12

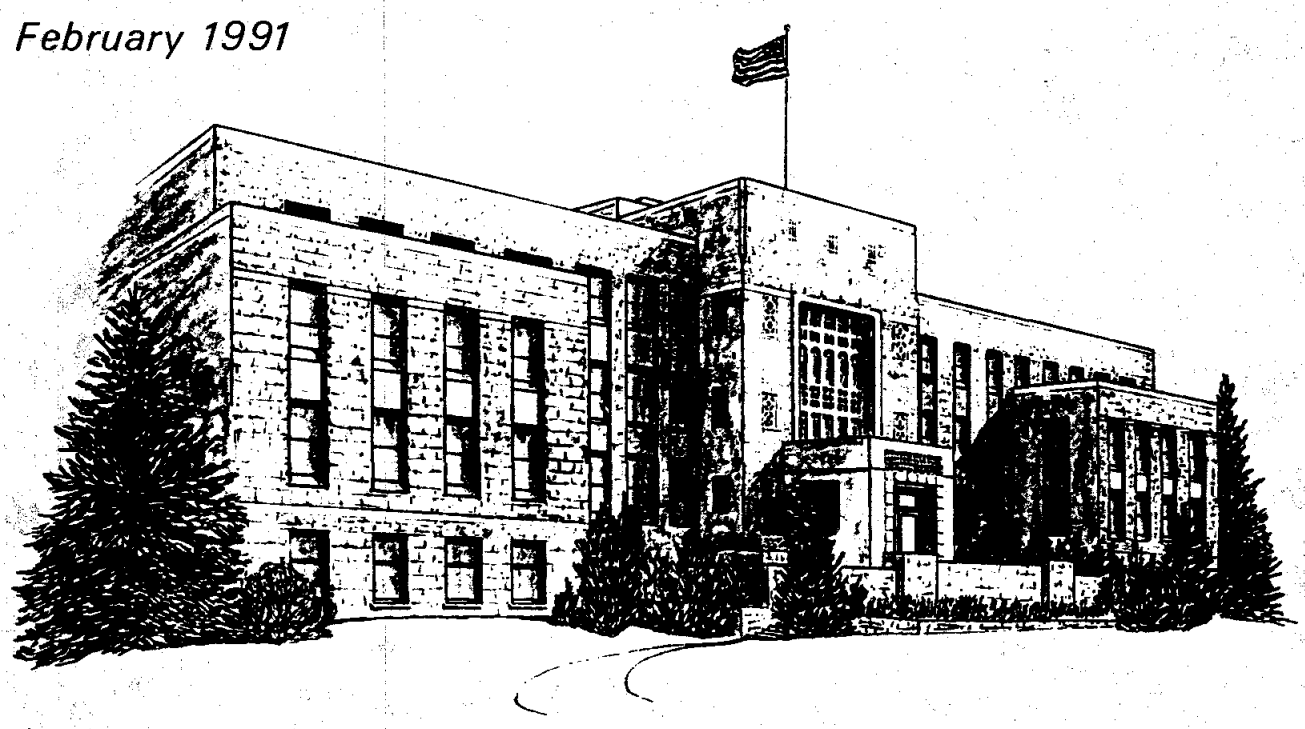
WESTERN RESEARCH INSTITUTE

DECEMBER 1990 TIRE BURN TESTS IN AN ENTECH THERMAL OXIDATION DEMONSTRATION PLANT AT WESTERN RESEARCH INSTITUTE

Prepared for

Entech, Inc.
Anchorage, Alaska

February 1991



AFFILIATE OF

UNIVERSITY OF WYOMING RESEARCH CORPORATION

WRI-91-R013

DECEMBER 1990 TIRE BURN TESTS IN AN ENTECH THERMAL OXIDATION DEMONSTRATION PLANT AT WESTERN RESEARCH INSTITUTE

By
John Nordin
George Huntington

February 1991

For
Entech, Inc.
Anchorage, Alaska

By
Western Research Institute
Laramie, Wyoming

TABLE OF CONTENTS

	Page
LIST OF TABLES AND FIGURES	iii
ABBREVIATIONS	iv
SUMMARY	v
INTRODUCTION	1
METHODS	2
Air and Natural Gas Measurements	2
Temperatures	3
Gas Analyses	3
Heat Content of Primary Combustion Gases	4
Particulates, Percent Water, and HCl	5
Particulate Metals	6
Ash Analyses	6
Wire-Basket Test	7
Capture of Particulates by Ceramic-Fiber Fabric	7
Liquids Condensed in Cold Trap	8
DISCUSSION OF TEST OPERATIONS	8
Temperatures	8
Sulfur Emissions	9
Particulates and Particulate Metals	10
HCl Measurements	11
Percent Water in Stack	11
Ash Analysis	11
Heat Content of the Primary Combustion Chamber Gases	12
Causes of Upset Conditions	13
CONCLUSIONS	15
RECOMMENDATIONS	15
ACKNOWLEDGMENTS	17
REFERENCES	35
DISCLAIMER	17
APPENDIX A. Field Recordings of Temperatures, Anemometer Readings, and Other Data: December 5 Burn	36
APPENDIX B. Field Recordings of Temperatures, Anemometer Readings, and Other Data: December 7 Burn	37

LIST OF TABLES AND FIGURES

Table		Page
1.	Tire Burn	18
2.	Secondary Combustion Chamber Emissions, December 5 Burn	19
3.	Secondary Combustion Chamber Sulfur Dioxide Emissions (gas chromatograph readings)	20
4.	Secondary Combustion Flue Gas Flows, December 7 Burn	21
5.	Natural Gas and Air Feeds, December 5	22
6.	Natural Gas and Air Feeds, December 7	23
7.	Corrected Gas Chromatograph Analysis at Vent Tube	24
8.	Particulate and HCl Emissions from Secondary Combustion Unit	25
9.	Fronthalf Particulate Elemental Analysis, December 5 Burn.	26
10.	Fronthalf Particulate Elemental Analysis, December 7 Burn.	27
11.	Ash Analyses (excluding steel belts)	28
12.	Wire Basket Test Results, December 7 Burn	29
13.	Metal Analysis of Condensed Hydrocarbon Liquid Collected from Primary Combustion Chamber Exhaust Gas During December 7 Burn	30
14.	Analysis of Condensed Hydrocarbon Liquid Collected from Primary Combustion Chamber Exhaust Gas During December 7 Burn	31
15.	Sulfur Dioxide Emission Factors and Secondary Combustion Temperatures for Tire Burns Performed Through December 1990	31
16.	Sulfur Dioxide Emissions	31

Figure		Page
1.	Entech Thermal Oxidation System Showing the Location of Thermocouples	32
2.	Temperature Profile, December 5	33
3.	Temperature Profile, December 7	34

ABBREVIATIONS

Unit	Meaning
dscf	dry standard cubic feet
dscm	dry standard cubic meter
ft^3	cubic feet
gr	grain (grain = 1/7000 lb)
gr/dscf	grains per dry standard cubic feet; to convert to mg/dscm, multiply by 2288.
inch Hg	inches of mercury; a unit of pressure
L	liter
lb	pound
mg	milligram
mg/dscm	milligrams per dry standard cubic meter
mg/kg	milligrams per kilogram of solid
ng	nanograms (10^9 nanograms = 1 gram)
ng/dscm	nanograms per dry standard cubic meter
ng/Nm^3	nanograms per dry standard cubic meter normalized to a seven volume percent oxygen
ppm	parts per million by volume
psig	pounds per square inch gauge pressure
scfm	standard cubic feet per minute (at 70°F and 29.92 in Hg)
yd^3	cubic yard

SUMMARY

On December 5 and December 7, 1990, whole used automobile tires were incinerated in the Entech thermal oxidation demonstration plant located at Western Research Institute's north site, just north of Laramie, Wyoming. The December 5 burn combusted 1,000 lb of tires, and the December 7 burn combusted 1,400 lb of tires. A proprietary pellet material, supplied by BECO Engineering and packaged in 1-lb bags, was placed among the tires before the start of the December 5 burn in hopes of controlling acid gas emissions.

Once the burns were underway, the gases leaving the primary combustion chamber had enough combustible heat content such that the secondary combustion chamber could be operated for a period without feeding natural gas as supplementary fuel. Temperatures up to 2510°F (1377°C) and 2230°F (1221°C) were reached in the secondary combustion chamber for the two respective burns. Hydrocarbons, which can be condensed as a liquid at ambient temperature, accounted for most of the combustible heat content of the primary combustion chamber gases entering the secondary combustion chamber [redacted]). Noncondensable hydrocarbons (e.g., carbon monoxide, methane, ethylene, propene) accounted for the remaining part of the combustible heat content [redacted] Btu/scf or less).

Sulfur dioxide emission factors were 0.010 and 0.0038 lb SO_2/lb tires for the December 5 and December 7 burns, respectively. Possibly as much as 90% of these sulfur dioxide emissions originated as part of the condensable combustibles that entered the secondary combustion chamber. There was apparently very little acid gas formation (e.g., H_2S, SO_2) in the primary combustion chamber; therefore, there was nothing to react with the BECO pellets. Most of the sulfur was carried by either vaporized or fine droplets of hydrocarbons. The higher sulfur dioxide emission factor for the December 5 burn was apparently due to a broken damper (collar). [redacted]

There were brief periods of upset during each burn where emissions were visible. Both upsets were apparently caused by insufficient air being supplied to the secondary to react with all of the combustibles. Fronthalf particulates, corrected to a 7% oxygen basis were in the range of 0.0078 to 0.0085 gr/dscf for each burn during non-upset conditions. During an upset period, fronthalf particulates were 0.032 gr/dscf (uncorrected for oxygen).

Regulatory language for municipal solid waste incinerators considers fronthalf particulates as particulate metals, but the actual metal content of the fronthalf particulates collected for these burns was less than 10%. Carbon soot was a major portion of the particulates collected. Zinc was the major metal component of the fronthalf particulates; the zinc measured 0.00006 to 0.0013 gr/dscf. Ash samples (steel belts removed) contained between 13 and 38% zinc.

INTRODUCTION

Entech Corporation contracted Western Research Institute (WRI) to measure and analyze gas flows on an Entech thermal oxidation system using whole tires as feedstock. Previous tire burns were performed on August 29, September 28, and October 17, 1990, and these are described in Nordin (1990a, b). This report describes the two tire burns performed on December 5 and December 7, 1990.

The specific purpose of these two burns was to (1) gather additional air emissions data including particulates and sulfur dioxide, (2) evaluate a technology claimed to reduce acid gas emissions, and (3) further investigate the discrepancy between the heat of combustion calculated from gas analysis and that calculated from a heat balance of the primary and secondary combustion chamber.

Regulatory agencies recommend a minimum of three particulate measurements for compliance testing; engineers reviewing Entech data recommended three identical burns. None of these conditions have been met. Because of a proposed EPA requirement that at least 120 ft^3 of gas should be sampled isokinetically for particulates, only one measurement can be taken per burn. In addition, conditions were not identical to tire burns performed in the past (e.g., different air flows, different numbers of automobile and truck tires.

Proprietary sorbent chemicals for acid gas removal were obtained from BECO Engineering, Glenshaw, Pennsylvania. The chemicals in 1-lb plastic bags are dispersed among the tires prior to the burn. The chemicals are supposed to sorb sulfur dioxide and other acid gas species such that the sulfur remains in the ash (as sulfates). The chemicals have the appearance of fertilizer pellets and are alkaline. WRI received assurances from BECO through Entech that the chemicals would not create a pollution problem (no heavy metals, chemicals are inorganic in nature).

All tire burns performed to date have been characterized by a period of at least one hour during which combustion could be sustained in the secondary combustion chamber at temperatures greater than 1800°F (982°C) without the addition of supplemental fuel (natural gas). The temperatures in the secondary chamber typically peaked near 2200°F (1204°C) with a maximum of 2517°F (1381°C) during of the October 17 burn. However, gas temperatures entering the secondary combustion chamber from the primary unit were typically around 1100°F (600°C). A system heat balance neglecting heat loss suggests that the gases entering the secondary combustion chamber must have a heat of combustion content near 500 or 600 Btu/ft^3. However, primary combustion chamber gases sampled and analyzed using a gas chromatograph rarely exceeded a combustible heat content of 100 Btu/ft^3. We thought that the reason for the discrepancy was because we had difficulties obtaining an uncombusted gas sample for analysis; the gas was undergoing combustion as it was sampled. In addition, hydrocarbon liquids that were combusted in the secondary combustion chamber but were knocked out in the sampling line and cold trap prior to the gas chromatograph were volatilized. For the December 7 burn, WRI set up a special cold trap to collect hydrocarbon liquids that were volatilized in the primary combustion chamber gases.

METHODS

The burn dates were December 5 and December 7, 1990. For the December 5 burn, the primary combustion chamber was loaded with 51 automobile tires (1,000 lb) and 19 lb of BECO material. The BECO material was contained in 1-lb plastic packets and was dispersed among the tires. The December 7 burn consisted of 73 automobile tires and no BECO material. After preheating the secondary combustion chamber using natural gas as fuel, the tires were ignited using the bottom burner in the primary combustion chamber. The bottom burner continued to operate throughout the December 7 burn. The top primary burner was not used during the December 7 burn. Both the bottom and top primary burners were used at various times (Table 1) during the December 5 burn.

As the two burns progressed, the gases leaving the primary combustion chamber had enough heat content due to combustibles that they could be combusted in the secondary combustion chamber without the addition of supplemental natural gas. When the temperature in the secondary combustion chamber dropped below about 1700°F (925°C), natural gas was fed to the secondary combustion chamber. Toward the end of the burn, the air supply to the primary was increased about tenfold to burn off the carbon in the ash. Burn times are summarized in (Table 1). The ash was collected, weighed, and analyzed following the burn.

Air and Natural Gas Measurements

1. Natural Gas

Natural gas was measured using a gas meter servicing the system. Natural gas gauge pressure was 20 psi. Laramie atmosphere pressure was 11.6 psi resulting in 31.6 psi total natural gas line pressure. According to Northern Gas of Wyoming, the heat content of the gas (14.73 psi, 60°F) varies from 1030 to 1060 Btu/ft^3 (dry basis), with an average of 1045 Btu/ft^3 (dry basis) or 1025 Btu/ft^3 (wet basis). The natural gas supply contains no measurable sulfur or nitrogen.

2. Exhaust Gas from Secondary

The gas flow was calculated from pitot-tube measurements, temperatures (Figure 1, T_{16}), pressure, and gas composition measured in the [redacted] stack.

3. Air Flow to Primary Combustion Burners

A hot-wire anemometer in a [redacted] line was used.

4. Turbulent Air Flow to Primary (excluding burner)

A hot-wire anemometer in a [redacted] line was used.

5. Air Flow to Secondary Burners

A hot-wire anemometer in a [redacted] line was used.

6. Turbulent Air Flow to the Secondary Combustion Chamber

The air velocity was measured at one position using a hot-wire anemometer in an [redacted] duct. Because the velocity was not uniform in this duct, a correction based upon the measuring position was applied to calculate an average velocity in the duct. The correction factor was calculated as follows (the numbers are air velocities in ft/min):

Position	3/4-inch Horiz. Position	4-inch Horiz. Position	7 1/4-inch Horiz. Position
1 1/2-inch vertical	[redacted]	[redacted]	[redacted]
6-inch vertical			
10 1/2-inch vertical			

Average Velocity: [redacted]
Intake Louvers: open
Measuring Position: [redacted] vertical, [redacted] horiz. and [redacted] downstream from blower exhaust [redacted])

Correction Factor = [redacted]

There were nine holes drilled into the side of the [redacted] duct. Some operator-recorded velocities measured in different holes and at different depths are listed in Appendix A. Normally, measurement were taken in hole number 5 at a 4-inch horizontal position, and a correction factor was applied to convert this measurement to an average velocity. This correction factor is [redacted] for measured velocities of [redacted] or greater. The correction factor increases for lower velocities.

7. Primary Combustion Chamber Pressure

This pressure was measured using an inclined water manometer.

Temperatures

Temperatures were measured using thermocouples installed at the locations shown in Figure 1. Thermocouple T_{16} was attached to the pitot tube that was used to measure stack velocity. Appendix A and B contain a record of temperature measurements recorded in the field. The fluctuating value of T_{16} does not mean that the stack temperature fluctuated but that temperatures were printed by a remote data logger when the pitot tube was withdrawn from the stack.

Gas Analyses

1. Enerac 2000 Analyzer

An Entech-owned Enerac 2000 analyzer was used to measure O_2, CO_2, CO, NO_x, and SO_2 from the secondary combustion unit for the December 5 burn. The analyzer was periodically checked against several calibration gases (105 ppm CO in nitrogen; 50 ppm SO_2 in nitrogen and air). The instrument correctly read the 105-ppm CO but did not read the 50-ppm sulfur dioxide calibration gas at the start of the test. The results of the Enerac 2000 analyzer readings and gas flows calculated from pitot tube readings are

listed in Table 2. The Enerac 2000 analyzer was inoperative for the December 7 burn, except for a few carbon monoxide readings at the start of the test.

2. Gas Chromatograph Measurements

Samples of secondary combustion effluent were withdrawn from the stack [redacted] above the secondary combustion chamber) using gas bombs. These samples were injected into a Hewlett-Packard 5840A gas chromatograph fitted with a flame ionization detector. This instrument measured SO_2, H_2S, COS, CS_2, thiophene, and mercaptans to an accuracy of one part per million. Only sulfur dioxide was detected (Table 3). Gas flows are listed in Tables 2 and 4.

Gas was also continuously pumped from the primary combustion chamber to a second gas chromatograph (Hewlett-Packard 5830A) that was programmed to sample automatically at 40-minute intervals. The sample line became plugged from condensing liquids during the December 5 burn, so the data obtained was useless. The sample line was connected to the vent tube (Figure 1) and pumped through a cold trap and filter to remove condensables for the December 7 burn. The gas chromatograph results for the December 7 burn are listed in Table 7. Gas flow rates in the vent tube (Table 7) were calculated from summary the individual air flow rates (Table 6) and a nitrogen balance.

Heat Content of Primary Combustion Chamber Gases

The heat content of the primary combustion chamber gases was calculated from the gas chromatograph readings, as follows:

$$H = \sum_i \frac{C_i \, H_i}{100}$$

where H = heat content in Btu/ft^3

C_i = percent (by volume) of species i

H_i = heat content of species i in Btu/ft^3

The following values of H_i were used (Btu/ft^3):

hydrogen	275
carbon monoxide	322
methane	913
ethane	1641
ethylene	1513
propane	2385
butane	3113
isobutane	3105
pentane	3709

Particulates, Percent Water, and HCl

Particulates were measured according to U.S. EPA methods (published as 40 CFR Part 60 Appendix A, Methods 1 and 5) using Andersen stack sampling equipment. WRI used a 3-ft stainless steel sampling probe with a quartz liner and fitted with a 0.5-inch-opening stainless steel nozzle. The glass filter holder, glass cyclone flask, and filter (Andersen part number 50-320) were contained in a heated box (300°F/149°C) attached directly to the sampling probe. The sampling probe was insulated and heated with an attached pitot tube. A separate pitot tube was used to measure pressures. The gas flows listed in Tables 2 and 3 were calculated from these pressure measurements.

Some states require that particulate data be corrected to a 12% CO_2 basis. For many states, the particulate calculations do not include the backhalf (solids collected downstream from the filter, e.g., the glass impingers). However, other states (e.g., Washington) include the backhalf with data corrected to a 7% O_2 basis. Proposed regulations (Federal Register, Dec. 20, 1989) call fronthalf particulates corrected to a 7% O_2 basis particulate metals and require that at least 120 standard cubic feet of gas be collected. Current regulations require collection of only 30 standard cubic feet of gas.

WRI followed the Puget Sound Air Pollution Control Agency procedures for sampling and analyzing the backhalf. WRI used five impingers: an empty impinger; two containing type 1 water; one containing 100 mL of a solution of 0.5 gram $NaHCO_3$ and 1.0 g Na_2CO_3 dissolved in 2 L of type 1 water; and one containing silica gel. Type 1 water is deionized; distilled water.

Following each test, 100 mL of type 1 water and 100 mL of $NaHCO_3/Na_2CO_3$ solution were set aside for chloride analyses. The remaining type 1 water was used for total solids determination according to Puget Sound Air Pollution Control Agency procedures. These procedures call for (1) purging the impinger water with nitrogen or clean air; (2) rinsing all sample-exposed surfaces between the filter and first impinger with acetone, and placing the washings in a tared beaker to dry; and (3) adding 50 to 100 mL of dichloroethane to the impinger distilled water solutions, spinning for ten minutes, and separating using a separatory funnel. The extraction is repeated. The separated dichloroethane solution was placed in a tared beaker and evaporated under a hood at room temperature. The remaining water was evaporated at less than 212°F (100°C). This procedure gave organic and inorganic total solids fractions for the backhalf.

The thermal oxidation unit was outfitted with a [redacted] and [redacted] inch-i.d. stack for emissions sampling purposes. Sampling was done at the [redacted]t level. The thermal oxidation unit was placed adjacent to the old 150-ton oil shale retort located on WRI property just north of Laramie, Wyoming. The oil shale retort has the necessary scaffolding to support the stack and provide safe access for emissions sampling. The railing of the 150-ton retort also supported the particulate sampling train, which was mounted on a board and moved as a unit as the probe was moved to the different stack positions required by EPA protocols (40 CFR Part 60 Appendix A, Methods 1 and 5).

The impingers used in the particulate sampling train were weighed before and after the test. The difference in weight was the weight of water collected from the gas. The impingers were set in an ice bath during sampling.

The sampling times for the two burns are listed in Table 8. These sampling times sometimes coincided with upset conditions when black smoke was emitted from the stack. An upset condition occurred on December 5 at 13:18 to 13:20 hours. The stack operators turned off the stack sampler at the start of the upset (13:18 hours), so only a small amount of black soot was collected. Sampling resumed at 13:55 hours. For the December 7 burn, an upset occurred at 12:07 hours. This time, the stack operators did not turn off the stack sampler; consequently, a considerable amount of soot was collected by the particulate sampler. We decided to change the particulate collection filter midway into the sampling period. This was done when the stack sampler position was changed from sampling an east-west traverse to a north-south traverse. Consequently, there are two numbers for particulates listed for December 7. The higher particulate loading value (0.033 gr/dscf) reflects the soot collected during the upset. The lower particulate loading value (0.0085 gr/dscf) represents normal conditions.

Particulate Metals

The proposed regulations (Federal Register, Dec. 20, 1989) for municipal solid waste incinerators call fronthalf particulates at 7% oxygen particulate metals. (This is what is collected on the filter, cyclone, and acetone wash of the sampling probes and glassware up to the filter.)

WRI digested the fronthalf particulates collected in 100 mL of a 10% nitric acid solution for 24 hours. The solution was then analyzed for trace metals using inductively coupled plasma (ICP) emission spectroscopy. Four samples were analyzed: acetone-wash residual, filter, acetone-wash residual blank, filter blank. The results are listed in Tables 9 and 10.

Although we analyzed for mercury and silicon, these elements are not listed in Tables 9 and 10 because any reported results are misleading (mercury not detected; silicon detected). The 10% nitric acid leach is not capable of dissolving silica from the filter and acetone wash; a hydrofluoric acid or similar leach is required. Mercury requires a special sampling procedure that uses potassium permanganate or iodine monochloride solutions in the impingers and is analyzed by a different procedure. WRI can follow these procedures, but they were not done because of the added expense.

Ash Analyses

Samples of ash were collected after each burn for proximate (ASTM procedure D 3172), sulfur, metals, and sulfates analyses. The metals analysis was performed by nitric acid digestion of the ash. The insolubles (ash that fails to dissolve in the acid) were measured and reported on a mg/kg of original ash sample. For example, an insoluble value of 213,000 mg/kg means that 21.3% of the original ash sample failed

to dissolve when digested with acid. The soluble portion of the ash was analyzed for metals using ICP spectroscopy. The results are reported as mg/kg of original sample.

For the December 7 burn, three trays were set up under the grate in the primary combustion chamber to collect the ash. Thus, three ash samples were generated.

Percent sulfur was determined using a Fisher sulfur analyzer. This procedure involves combusting the sample in the laboratory and measuring the total sulfur dioxide given off. It does not include sulfur tied up as sulfates. Sulfates were measured separately.

Wire-Basket Test

Shredded automobile tires (including belts) were mixed with different amounts and kinds of sorbent materials and placed in wire baskets (December 7 burn) or pails (December 5 burn). The pails were suspended in the primary combustion chamber near the bottom but above the grate at the south end of the chamber. The baskets were placed on the grate in the southeast corner of the primary combustion chamber.

The purpose of these tests was to determine whether or not sorbents mixed in with tires could effectively remove sulfur otherwise would be emitted as sulfur dioxide from the stack. The effectiveness of the procedure would be evaluated by comparing sulfur and sulfate content of the ash. A higher sulfate or sulfur content in the ash indicates better removal.

Placement of the material in pails (December 5 burn) did not work. Some unburned tire material and char was left after the test. The enclosed environment of the pails did not allow adequate air to enter the system and support combustion in the same way that combustion took place in the primary combustion chamber.

For the December 7 burn, the materials were placed in open wire baskets with screens. This permitted air flow through the material. The contents of the baskets are listed in Table 12. Approximately 1660-g portions of shredded tires were mixed with either sodium bicarbonate, calcium hydroxide, BECO materials, or combinations thereof (Table 12). After the test, the ash was analyzed for sulfur and sulfates.

Capture of Particulates by Ceramic-Fiber Fabric

An attempt was made to capture particulates from the primary combustion chamber using a ceramic-fiber fabric designed to operate to 2200°F (1204°C). The ceramic-fabric that we tested was Nextel™ 312 woven fabric, a product of the 3M Corporation. The material was supplied to WRI by Entech Inc. Entech was unable to supply any information on the style, air permeability, or particle capture efficiency. 3M does have air permeability information on four styles of this fabric, but WRI was not able to determine which style was supplied for the test.

Roughly 4 scfm of primary combustion chamber exhaust gas was passed through approximately 2 ft^2 of fabric for about three hours. The

sampling location was at the vent tube. The filter sock was tied around a 2-inch pipe as the pipe entered a closed 55-gallon drum. A blower was attached to the drum outlet for moving the gas through the system. No attempt was made to accurately measure times and flow rates or filter area because it was apparent at the outset of the test that the fabric was not fine enough to capture particulates. Smoke was visible on the outlet side of the fabric filter. Inspection of the filter after the test showed that it failed to capture particulate soot. The sampling point for this test was not the same location as the sampling point for the gas chromatograph.

Liquids Condensed in Cold Trap

A cold trap was installed for the ceramic-fabric filter system between 09:35 and 11:55 hours on December 7, to condense any hydrocarbon liquids for analysis.

A blower was used to move the gas sample from the vent tube through the cold trap and then the ceramic-fabric filter. The sample time was from 09:35 to 11:55 hours on December 7. At the end of this period, a 187-g sample of the liquid in the cold trap was removed and analyzed (Tables 13 and 14). The total amount of gas passed through the cold trap was not accurately measured (anemometer placed at the gas exhaust), but we believe that the total gas was between 500 and 1000 scf. The liquid collected and analyzed included the water portion.

The sampling location and cold trap used to collect liquids for analysis was the system used for the ceramic-filter test and not the gas chromatograph system. The cold trap was a U-bend in a 2-inch-diameter steel pipe. The U-bend was immersed in a 55-gallon drum of cold water. The condensed liquid was collected at the bottom of the U-bend. This system was not very efficient for collecting hydrocarbon liquids. The inside piping system downstream from the U-bend and at the blower exhaust after the ceramic-fabric filter was coated with additional hydrocarbon liquids. However, the ceramic-fabric filter failed to remove the hydrocarbon droplets or soot.

DISCUSSION OF TEST OPERATIONS

Temperatures

The thermocouple temperature readings automatically recorded by the data logger are listed in Appendix A and B. Readings T_1, T_2, and T_3 at the top of the primary combustion chamber (Figure 1) are most representative of the gases leaving the primary combustion chamber. The average of readings T_1, T_2, and T_3 was plotted as a function of time (zero time = primary light-off time) for the December 5 and 7 burns. Reading T_6 is representative of the interior of the primary combustion chamber. Readings T_{14} and T_{15} are representative of the secondary combustion chamber. Primary and secondary combustion chamber temperatures have been plotted in Figure 2 for the December 5 burn and in Figure 3 for the December 7 burn.

Entech operators reported difficulties in using the collar (damper) at the vent tube for the December 5 burn. As a result, the burning proceeded at a fast rate relative to the December 7 burn. Temperatures of 2510°F (1377°C) were reached in the secondary combustion chamber. The collar was repaired prior to the December 7 burn; temperatures of 2230°F (1221°C) were reached in the secondary combustion chamber for that burn, except for one brief peak of 2500°F (1371°C).

Sulfur Emissions

The sulfur dioxide emissions are listed in Table 3. From this information and from times (Table 1), gas flow rates (Tables 2 and 4), and ash analyses (Table 11); sulfur balances and emission factors were calculated (Table 15). The sulfur dioxide emission factors for the December 5 and December 7 burns were 0.010 and 0.0038 lb SO_2 per lb of tires, respectively. A sulfur balance on the system showed that a greater portion of the sulfur went up the stack for the December 5 burn (60%) compared with the December 7 burn (54%). Sulfur dioxide emission factors for all tire burns performed to date are listed in Table 15. For the October 17, 1990, tire burn, Nordin (1990b) calculated that 60% of the total sulfur was emitted as sulfur dioxide; the emission factor for that burn was 0.0077 lb SO_2/lb tires. This compares with 41% of the original sulfur for the August 29, 1990, burn, emission factor 0.0026. This is higher than the 41% total sulfur and 0.0026 emission factor for the August 29, 1990, burn.

The sulfur dioxide emission factor and the percent of total sulfur emitted up the stack as sulfur dioxide appears to be related to temperatures in the secondary combustion chamber. Higher temperatures resulted in more sulfur dioxide emissions. When the emission factor was in the range of 0.0021 to 0.0028 lb SO_2/lb tires, temperatures were 2111°F (1155°C) or lower. When the temperatures were above 2500°F (1371°C), the emission factors were 0.0077 or 0.01 lb SO_2/lb tires (Table 15). The December 5 burn peak secondary combustion temperature was 2510°F (1377°C); the emission factor was 0.010 lb SO_2/lb tires. The December 7 burn secondary combustion temperature was generally below 2200°F (1204°C), except for one peak of 2500°F (1371°C)) which lasted only a few minutes. The emission factor was 0.0038 lb SO_2/lb tires. This correlation of high temperature with high emission factor appears to apply during the time when no natural gas is added to the secondary combustion chamber (Table 1).

The December 5 burn used a proprietary BECO pellet material packaged in 1-lb bags. Nineteen bags were placed among the tires, and this material was supposed to sorb acid gas emissions. The sulfur dioxide emission factor for the December 5 burn was the highest calculated for any burn to date. Other parameters, especially the rate of burn and temperatures, appears to have a much greater influence on sulfur dioxide emissions than use of BECO pellets.

The wire-basket test (Table 12) yields some additional information on whether or not sorbents mixed in with shredded waste tires can potentially control sulfur dioxide emissions. The sorbents were mixed in with the shredded tires. Such a thorough mixing can not be achieved for an actual burn using whole tires. The shredded tires were a standard

stock material that WRI has used for pyrolysis tests to recover oil and combustible gases in various reactors. The use of sorbents (BECO or calcium hydroxide sorbent) resulted in slightly greater capturing efficiency and slightly lower sulfur dioxide emission factors than shredded tires with no sorbents. The sodium bicarbonate sorbent resulted in the lowest emission factor. However, the wire-basket tests were crude, and the temperatures in the wire baskets were not recorded. Also, operators reported that some of the ash material was lost through the wire basket screen as the burn progressed. Therefore, we have exercised caution in drawing conclusions from the wire-basket tests.

We believe that gaseous sulfur emissions simply do not contact the BECO pellets during a burn. The BECO pellets are supposed to vaporize and react with the sulfur dioxide or hydrogen sulfide in the primary combustion chamber. Even so, the contact time is minimal. The reaction products, if formed, are ammonium sulfide or ammonium sulfite. The ammonium sulfide or ammonium sulfite is burned in the secondary combustion chamber producing sulfur dioxide, which is emitted up the stack. We question how the BECO pellets can control sulfur dioxide emissions when the pellet bags are dispersed among the tires.

Data collected to date from tire burns suggest that sulfur dioxide emissions can be reduced but not eliminated by controlling the burn rate and temperatures using the primary burners, vent tube damper (collar), and regulating air flow into the primary. If further sulfur dioxide emissions reduction is desired, Entech must use scrubbers or one of the dry sorbent injection technologies (e.g., sorbent injection into the flue gas or spray dryer followed by baghouse, use of sorbents in a fluidized-bed combustor with baghouse). Many of these dry sorbent injection technologies are currently used or being tested at coal-fired power plants.

If Entech desires further sorbent tests in which the sorbent is mixed with the waste, some preliminary laboratory screening tests should be done. The burn can be better controlled in the laboratory, and all of the sulfur dioxide gas emissions can be captured in absorbing solutions for obtaining an accurate sulfur balance. The burn can be done in an oxidizing or reducing atmosphere. Costs of the prescreening laboratory tests will be less than those incurred when experimenting with different sorbents in the primary combustion chamber.

Particulates and Particulate Metals

Fronthalf particulate concentrations, corrected to a 7% oxygen basis, are 0.0078 gr/dscf for the December 5 burn. Backhalf particulates are low, <0.0003 gr/dscf. The particulate sampling filter did collect a little soot. There was an upset condition at 13:18 hours when visible stack emissions occurred. The stack emissions were accompanied by high CO readings and low (<1%) oxygen. The particulate sampler was shut-off at 13:18 hours (Table 8), but it was not soon enough to avoid sampling some soot-laden exhaust. The cause of the upset on December 5 burn was related to a stuck or broken collar damper (Figure 1) located in the vent tube. The damper controls the gas flow from the primary combustion chamber to the secondary. The damper was inoperative; apparently it fell off. Operators were able to adjust air flows and burner rates so

emissions were not visible, but the burn proceeded at a faster rate. Therefore, without the damper to control the rate of burning in the primary combustion chamber, the sulfur dioxide emissions were higher. The collar was repaired before the December 7 burn.

Another brief upset occurred at 12:07 hours on December 7. Operators were able to eliminate visible emissions by shutting off the natural gas supply to the secondary combustion chamber. The gases from the primary combustion chamber had enough combustible heat content that combustion was maintained without adding supplemental natural gas. However, we continued to sample for particulates during this period. The overall fronthalf particulates during the December 7 first sampling period (Table 8) was 0.033 gr/dscf. This is higher than the 0.0085 gr/dscf measured between 13:50 and 16:10. In contrast, the fronthalf particulates collected during an August 29, 1990, tire burn when no upset occurred was much lower (0.00020 gr/dscf).

Results of the metal analysis for fronthalf particulates collected are listed in Tables 9 and 10. The sum of the metals analyzed for the December 5 (Table 9) burn only account for about 5% of the total fronthalf particulates collected. For the December 7 burn, the metals analyzed account for only 5.5% and 7.0% of the fronthalf particulates collected for the two sampling periods (Table 10). We believe that the material that is unaccounted for is mostly carbon soot with lesser amounts of oxygen (metals captured as oxides), sulfur, chlorine as chloride, and silicon as silicates.

HCL Measurements

The impinger solutions from the particulate sampling runs were analyzed for chlorides. Almost all of the chlorides were captured in the impingers containing deionized,distilled water, and very little (<5%) of the chlorides were captured in the sodium carbonate-bicarbonate buffer. Assuming that all of the chlorides were present as HCl, concentrations of 3.4 ppm and 10 ppm were calculated in the flue gas for the respective December 5 and December 7 burns.

Percent Water in Stack

The calculated volume percentage of water in the stack is 1.5% for the December 5 burn and 7.2% for the December 7 burn during the times when particulates were sampled. This is much lower than the whopping 22 to 24.3% water for the August 29, 1990, burn. Water measurements for other tire burns have been near 8% with one low reading of 1% (first part of October 25, 1988 tire burn). It is not clear why the percent water fluctuates this much.

Ash Analysis

Ash analyses results are listed in Table 11. A major metal component of the ash (steel belts removed) is zinc, with concentrations varying from 13 to 38%. From the information in Table 11, the following compositions can be calculated:

	December 5, %	December 7 (Sample 1), %
Volatiles	14.0	11.1
Inorganic insolubles	7.3	16.3
Sulfur as Sulfate	4.4	6.3
Aluminum as Al_2O_3	6.6	5.6
Calcium as CaO	7.0	0.4
Iron as Fe_2O_3	1.1	0.6
Magnesium as MgO	0.6	1.0
Sodium as NaO	0.7	0.9
Phosphorus as PO_4	0.4	0.8
Zinc as ZnO	16.2	39.9
Fixed carbon	31.1	5.9
	89.4%	88.8%

About 89% of the ash minerals were accounted for. Sulfur, probably present as sulfides, accounts for 3%. Inorganic unsolubles include material other than volatiles that did not dissolve in the acid digestion (e.g., silica sand).

Heat Content of the Primary Combustion Chamber Gases

December 5, from 12:40 to 13:10, and on December 7, from 10:30 to 11:17, and 12:10 to 13:00 on the gases leaving the primary combustion chamber contained enough combustibles so that they burned in the secondary combustion chamber without adding natural gas. Temperatures up to 2510°F (1377°C) and 2230°F (1221°C) were measured in the secondary combustion chamber for the December 5 and 7 burns. There was a brief peak temperature of 2500°F (1371°C) for the December 7 burn. If an energy balance is done on the system, the gases leaving the combustion chamber must contain combustibles of approximately 700 Btu/dscf to achieve these secondary combustion temperatures. Yet, we were only able to account for a maximum of 77 Btu/dscf based on gas chromatograph analyses (Table 7).

We were able to condense a liquid containing 48% water and a heat of combustion of 9200 to 9975 Btu/lb (Table 14), or about 18,000 Btu/lb on a water-free basis. Unfortunately, we were not able to determine the concentration of the hydrocarbon condensables in the primary combustion chamber gas. A concentration of 0.03 to 0.035 lb of hydrocarbon per cubic feet of primary combustion gas can account for enough combustibles to achieve these temperatures in the secondary combustion chamber.

The primary combustion chamber exit gas typically contained 10 to 12% CO_2, 4 to 5% CO, and 2% CH_4 at a flow rate of about 30 dry scfm (Table 7). The exit gas leaving the secondary combustion chamber when no natural gas was fed to the secondary combustion chamber typically contained 10 to 14% CO_2 at a flow rate of about 800 to 1000 scfm on a wet basis. A system carbon balance shows that about 0.9 lb carbon per minute must be present in the primary combustion chamber exhaust gas in addition to the carbon measured as CO, CO_2, CH_4, and CH_2CH_2 measured with the gas chromatograph. For a gas flow rate of 30 scfm, the carbon content should be about 0.03 lb of carbon per cubic feet of gas. Assuming that the carbon is in the form of a hydrocarbon liquid of formula C_yH_{2y}, this calculates to a concentration of about 0.035 lb of

condensable hydrocarbons per cubic feet of gas. This agrees with the hydrocarbon concentration that is required to achieve the temperatures in the secondary combustion chamber.

During an earlier burn (September 28, 1990), we measured the carbon soot concentration of the gases leaving the primary combustion chamber. This was about 1-2 gr/dscf, which calculates to less than 0.0003 lb/dscf.

Therefore, we believe that the major combustible component in the primary combustion chamber gases is condensable hydrocarbons in the form of a vapor or minute droplets. This material is sufficient to heat the secondary combustion chamber to greater than 1800°F (982°C) without the addition of supplemental natural gas.

Finally, we analyzed the condensed liquid and measured 1.4% sulfur and 48% water (Table 14). Based on a hydrocarbon content of 0.035 lb/scfm of gas and 30 scfm of gas leaving the primary combustion chamber, we calculate that the vaporized hydrocarbon material entering the secondary combustion chamber accounts for 3.4 lb/hr of sulfur dioxide emissions. This is a major contributor to the sulfur dioxide emission factor (Table 16). The more liquids volatilize, the greater the temperature in the secondary combustion chamber achieved, and the greater the sulfur dioxide emission factor.

We also reviewed the primary combustion chamber gas chromatograph analyses for the September 28 and October 17, 1990, burns (Nordin 1990b). We conclude that the instrument did correctly measure sulfur dioxide and hydrogen sulfide in the primary combustion chamber and did correctly measure the calibration gases for hydrogen sulfide and sulfur dioxide. However, only very low concentrations of these compounds were detected. Carbon sulfide, carbon disulfide, and thiophene were also detected. The gas chromatograph will not detect sulfur in the hydrocarbon liquids. A system sulfur balance shows that these sulfur gases measured in the primary chamber account for less than 10% of the total sulfur dioxide emitted from the stack. We believe that the balance of the sulfur dioxide originates in the hydrocarbon condensables.

The BECO pellets are designed to remove acid gases and not hydrocarbon condensables. Even if the contact time was adequate to remove hydrogen sulfide and sulfur dioxide, the pellets could not remove the other sulfur contaminants.

Causes of Upset Conditions

Upset conditions occurred at 12:18 hours on December 5 and at 12:07 hours on December 7, when black smoke was emitted. The upset condition on December 5 occurred at about the same time the vent tube damper (collar in Figure 1) was stuck and apparently broke off. The secondary combustion chamber exhaust gas (Table 2) contained less than 1% oxygen during this period. High CO and smoke is emitted when insufficient air is added to support combustion.

The upset condition on December 7 was corrected when operators shut off the natural gas supply to the secondary combustion system. Enough combustibles (both vaporized liquids as well as CO, CH_4, etc.) were

entering the secondary combustion chamber from the primary combustion chamber to support combustion. Although this is not confirmed by flue gas oxygen measurements, we believe that insufficient air was being fed to the secondary combustion chamber to react with all of the combustible gases. Consequently, shutting off the natural gas removed one source of combustible gas.

When reviewing upset condition times for all burns performed to date at WRI, the following causes can be documented:

1. The air supply to the secondary is insufficient to react with the combustible gases present, and the oxygen content of the flue gas is less than 1%.

2. The temperature in the secondary combustion chamber is less than about 1400°F (760°C) while a burn is in progress.

3. A disturbance in the gas flow occurs in the secondary combustion chamber. For example, if the primary combustion chamber door is opened during windy conditions this can result in an upset. Even a strong wind gust can affect the stack gas velocity profile and CO emissions.

4. The flow from the primary combustion chamber is excessive, especially if the gas is relatively cool. There have been situations where CO emissions have decreased when the primary combustion gas flow is greater than 100-200 scfm by turning on the top primary burner to heat the gas. The exact conditions for this situation is not well defined.

5. The secondary combustion chamber natural gas fuel-to-air ratio is not balanced for the burners.

6. If sodium hydroxide solution is injected as fine droplets into the primary combustion chamber to control acid gas emissions, carbon monoxide emissions from the secondary combustion chamber may be significantly higher. The sodium scavenges free radical oxygen ($O_2 \rightarrow 2O$) in the secondary combustion chamber, so it is unavailable for reaction with CO to form CO_2. This circumstance differs from other situations in that black smoke does not accompany the higher CO readings.

CONCLUSIONS

1. The gases leaving the primary combustion chamber had enough combustible heat content to enable the secondary combustion chamber to operate for an hour or longer above of 1800°F (982°C) without the addition of supplementary natural gas.

2. The major combustible component in the primary combustion chamber exhaust gases was hydrocarbons, normally liquid under ambient temperatures. The hydrocarbons were present as a vapor or minute droplets.

3. When placed among the tires in the primary combustion chamber the BECO pellets failed to reduce sulfur dioxide emissions. The pellets did not sufficiently contact sulfur gases or condensable hydrocarbons formed in the primary combustion chamber to capture the sulfur in the ash.

4. The vaporizing hydrocarbons from the primary combustion chamber are the major carriers of sulfur that is combusted in the secondary combustion chamber forming sulfur dioxide emissions. The more hydrocarbons vaporize, the greater the temperatures in the secondary combustion chamber, and the greater the sulfur dioxide emissions.

RECOMMENDATIONS

1. If sulfur dioxide emissions are to be eliminated or at least reduced, one of two methods is viable and should be pursued.

   Method 1: The sulfur dioxide is removed from the secondary combustion chamber stack gas using scrubbers, dry sorbent injection and removal of spent sorbent using a cyclone and a baghouse, or similar technologies.

   Method 2: The combustible hydrocarbons (which are at under ambient temperature) should be removed from the primary combustion chamber exhaust gas (by cooling, mist eliminators and knock-out pots, etc.) before the gases enter the secondary combustion chamber. If this is not feasible, the sulfur dioxide emissions should at least be reduced by controlling the rate of burning in the primary combustion chamber. Entech already demonstrated that sulfur dioxide emission factors of less than 0.003 lb SO_2/lb of tires can be achieved. Lower emission factors probably can be obtained by controlling the burning rate. This approach is useful for burning a mixture of municipal trash and tires, when lower temperatures must be maintained in the primary combustion chamber so glass and metal components may be separated and recycled after the burn.

2. More work needs to be done to understand and prevent the occasional upset conditions that occur. An upset condition is defined as a brief period of visible emissions (black smoke) and high CO emissions. A series of tests is recommended. A good carbon monoxide analyzer, such as an infrared nondispersive type, with gas

preconditioning, CO_2 correction, and calibration gas injection, should be rented or purchased. Variables to be evaluated for these tests should include (1) secondary combustion chamber burner angle, (2) secondary combustion chamber natural gas and air flow rates, (3) secondary combustion chamber turbulent air flow rate, and (4) primary combustion chamber gas exit conditions (temperature, gas flow, and combustibles). Tests should also be conducted with the primary top burner on and off. Measured parameters should include (1) exhaust gas percent oxygen and flow rate, (2) CO emissions, (3) temperatures, and (4) appearance of the secondary combustion chamber flame pattern when viewed from the top of a stack (a remotely operated TV video camera may help). These tests will be very useful when sizing a secondary combustion chamber to service primary combustion chambers of different sizes.

3. An automatic control loop is recommended on the secondary combustion chamber. If the oxygen concentration in the flue gas drops below [redacted], the air supply to the secondary should be increased, or the natural gas supply to the secondary is decreased or even shut off if the secondary combustion temperature exceeds 1900°F (1038°C).

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DISCLAIMER

Mention of specific brand names or models of equipment is for information only and does not imply endorsement of any particular brand.

Table 1. Tire Burn

	December 5	December 7
Lightoff time--secondary	09:40	07:45
Lightoff time--primary	11:40	09:35
Shutdown time--secondary	17:30	18:00[a]
Time natural gas fed to secondary	09:40 to 12:40 13:10 to 17:30	07:45 to 10:30 11:17 to 12:10 13:00 to 18:00[a]
Time natural gas fed to bottom primary burner	13:00; 13:10 to 17:30[b]	09:35 to 17:15
Time natural gas fed to top primary burner	11:40 to 12:25[b]	none
Total natural gas used, ft^3	[redacted]	[redacted]
Total tires weight loaded, lb	1000	1400
Number of tires loaded	51	73
Number of 1-lb BECO packets loaded	19	none
Ash collected excluding steel belts, lb	113 (3.67 ft^3)	98 (3.6 ft^3)
Steel belts, lb	93	142
Barometric pressure, inches Hg	22.94	23.09 (start); 23.06 (end)

[a] Shutdown time not verified for December 7 burn

[b] Times not verified

Table 2. Secondary Combustion Chamber Emissions, December 5 Burn

Time	Composition of Flue Gas				Flue Gas Flow, scfm (wet basis)
	% O_2	% CO_2	ppm CO	ppm NO_x	
11:55	8.6	9.3	8	21	
12:12	7.0	10.5	3	42	
12:50	11.3	7.0	33	71	
13:05	7.6	10.1	10	130	
13:15	2.5	14.1	47	191	
13:18	1.5	[a]	220	[a]	[a]
13:18.5	0.7	[a]	>2000[d]	[a]	[a]
13:57	2.3	[a]	>1500	[a]	
14:08	5.5	11.6	35	145	
14:11	[a]	[a]	47	[a]	
14:20	9.7	8.5	45	112	
14:55	2.8	13.5	28	59	
15:35	6.1	11.1	13	30	
15:55	9.3	8.7	<2	20	
16:20	[a]	[a]	[a]	[a]	
16:45	11.5	7.1	<2	22	
17:00	11.4	7.1	<2	22	
17:15	10.9	7.5	<2	22	
Average[b]	6.2	11.2	15[c]	75	

[a] Data not taken at times indicated. The Enerac 2000 analyzer function for SO_2 was inoperative.

[b] Time-weighted average between 11:55 and 17:15 hours.

[c] 155 ppm CO average includes upset at 13:18 and 13:57 hours. 15 ppm excludes this upset.

[d] The high CO reading was accompanied by visible black smoke (13:18 to 13:20). Some puffs of black smoke were seen at 13:22 hours. The collar was jammed and broken (13:30 hours). A brief upset occurred again at 14:30 hours (CO = 900 ppm; puff of black smoke seen).

Table 3. Secondary Combustion Chamber Sulfur Dioxide Emissions[a]

Date	Time	SO_2, ppm[b]
December 5	12:05	151
	13:05	381
	13:15	380
	14:05	416
	15:15	362
	16:05	157
	16:30	145
	17:05	138
	Time-Weighted Average	199
December 7	12:00	17
	13:12	17
	14;05	125
	15:00	67
	16:00	40
	17:00	148
	18:00	119
	Time-Weighted Average	76

[a] Emissions measured by gas chromatography.

[b] H_2S, COS, CS_2, and other sulfur species not detected.

Table 4. Secondary Combustion Flue Gas Flows, December 7 Burn[a]

Time	Flue Gas[b] Flow, scfm
10:22	[redacted]
10:42	
11:02	
11:30	
11:50	
12:42	
13:53	
14:20	
14:45	
15:05	
15:40	
16:15	
16:55	
17:25	
17:45	
Time Weighted Average (09:35-18:00)	

[a] Enerac 2000 analyzer inoperative after 10:42 hr, so gas compositions were not measured in the secondary combustion flue gas. At 10:20 hr, CO = 25 ppm; 10:22 hr, CO = 30. Oxygen = 8%.

[b] Calculated from pitot tube readings, temperature, and assumed gas molecular weight of 28.9, wet basis.

Table 5. Natural Gas and Air Feeds, December 5[a]

	Natural Gas[a]		Air Input[a]				
Time	Primary	Secondary	Primary Turbulent	Bottom Primary Burner	Top Primary Burner	Secondary Turbulent	Secondary Burner
11:10	2[c]						
11:45							
12:20							
12:25	2[e]						
12:40	0						
13:00	<1[d]						
13:10							
14:15							
15:30							
17:19						[b]	
17:30							

[a] Natural gas flow is in cubic feet per minute at 20 psig. Barometric pressure is 22.94 inches Hg. The air flows are in standard cubic feet per minute (70°F, 1 atm). Input air was 38°F.

[b] Data not recorded at time indicated.

[c] Top burner only operating.

[d] Top burner off; bottom burner with flame.

[e] Bottom burner with no flame.

Table 6. Natural Gas and Air Feeds, December 7

	Natural Gas[a]		Air Input[a]				
				Bottom	Top[b]		
Time	Primary	Secondary	Primary Turbulent	Primary Burner	Primary Burner	Secondary Turbulent	Secondary Burner
10:10							
10:30							
11:00							
11:17							
11:30							
12:07	Smoke seen from secondary. Natural gas turned off to secondary						
12:10	3	0					
12:30							
13:00	Natural gas fed to secondary						
13:00		3					
14:30							
15:00							
15:40							
16:35							
17:15					0		

[a] Natural gas flow is in cubic feet per minute at 20 psig. Barometric pressure is 22.94 inches Hg. The air flows are in standard cubic feet per minute (70°F, 1 atm). Input air was 38°F.

[b] Top primary burner not used during December 7 test. Bottom primary burner used throughout burn.

Table 7. Gas Chromatograph Analysis, Primary Combustion Chamber December 7, 1990 Burn

Time	Volume Percent (dry basis)											Heat[a] Content	Calcd.[c] Flow
	H_2	N_2	O_2	Ar	CO_2	CO	CH_4	CH_3CH_3	CH_2CH_2	C_3[b]	C_4		

[a] Sample at 09:41 hours from top of combustion chamber. Sample line became plugged with liquids after this reading. Starting at 11:34 hours, samples were taken at vent tube, which has a cold trap and filter.

[b] C_3 hydrocarbon was propylene. Propane detected at 14:28 hrs.

[c] Heat content is in Btu/dscf. Gas flow is in dscf/min.

Table 8. Particulate and HCl Emissions from Secondary Combustion Unit

Burn Date	December 5	December 7 (two samples)
Sampling times	11:55 to 13:18 13:55 to 14:30 14:55 to 17:33	10:20 to 10:30 (1st) 10:38 to 13:36 (1st) 13:50 to 16:10 (2nd)
Sampling Volume, dscf	124.8	61,4; 61.0[a]
Average O_2, vol % during sampling time	6.2	7.3
Average CO_2, vol % during sampling time	11.2	10.9
Total water collected, grams	40.4	199.6
Water, vol %	1.5	7.2
HCl, ppm by volume (dry basis)	3.4	10
Fronthalf particulates		
As collected, gr/dscf	0.00826	0.0324[b]; 0.00828
7% O_2 basis, gr/dscf	0.00781	0.033; 0.0085
12% CO_2 basis, gr/dscf	0.00885	0.036; 0.0094
Backhalf particulates		
As collected, gr/dscf	<0.0003	0.0081
7% O_2 basis, gr/dscf	<0.0003	0.0083
12% CO_2 basis, gr/dscf	<0.0003	0.0089
Total Particulates		
As collected, gr/dscf	0.0086	0.0405; 0.0164
7% O_2 basis, gr/dscf	0.0081	0.0413; 0.0168
12% CO_2 basis, gr/dscf	0.0092	0.045; 0.0183
Calculated fronthalf particulate during burn, lb	0.4	0.5
Calculated total particulates during burn, lb	0.4	1.0

[a] Particulate filter changed at 13:36 hours: 61.4 scf and 61.0 scf of flue gas passed through respective filters. The filter was changed because an upset at 12:07 hours loaded the first filters with soot.

[b] Considerable soot collected on the filter due to an upset at 12:07 hours on December 7.

Table 9. Fronthalf Particulate Elemental Analysis, December 5 Burn

Element	Filter, mg	Acetone Wash, mg	Concentration in flue gas[a], mg/dscm	7% O_2 basis[b], mg/dscm
Ag	<0.0007	<0.0007	<0.0002	<0.0002
Al	0.086	0.063	0.042	0.040
As	<0.01	<0.01	<0.003	<0.003
B	0.11	0.001	0.031	0.030
Ba	<0.001	0.003	0.001	0.001
Be	<0.0002	<0.0002	<0.0001	<0.0001
Bi	<0.01	<0.01	<0.003	<0.003
Ca	0.22	0.28	0.141	0.134
Cd	0.002	0.005	0.002	0.002
Co	<0.0007	0.003	0.001	0.001
Cr	<0.0008	0.016	0.0045	0.0043
Cu	<0.0006	0.024	0.0068	0.0064
Fe	0.032	0.43	0.0131	0.0124
K	<5	<5	<2	<2
Li	<0.001	0.004	0.0011	0.001
Mg	0.021	0.173	0.055	0.052
Mn	0.002	0.111	0.032	0.030
Mo	0.062	0.056	0.033	0.032
Na	0.175	1.15	0.375	0.355
Ni	<0.002	0.124	0.035	0.033
P	<0.1	<0.1	<0.003	<0.003
Pb	0.027	0.112	0.039	0.037
Sb	<0.01	<0.01	<0.003	<0.003
Se	<0.01	<0.01	<0.003	<0.003
Sr	0.002	<0.001	0.0006	0.0005
Th	<0.005	<0.005	<0.002	<0.002
V	<0.0008	<0.0008	<0.0003	<0.0003
Zn	0.037	0.163	0.151	0.143

[a] Concentration in flue gas = filter + acetone wash divided by the dry standard cubic meters of gas sampled (3.534 cubic meters).

[b] Concentration in flue gas corrected to a 7% oxygen basis.

Table 10. Fronthalf Particulate Elemental Analysis, December 7 Burn, ng

Element	First Filter 10:20-13:36 mg	Second Filter 13:50-16:10 mg	Acetone Wash mg	Concentration in flue gas at a 7% O_2 basis[a]	
				10:20-13:36	13:50-16:10
Ag	<0.0007	<0.0007	<0.0007	<0.0004	<0.0004
Al	0.079	0.006	0.009	0.048	0.006
As	<0.01	<0.01	<0.01	<0.005	<0.005
B	0.024	0.003	<0.002	0.014	0.002
Ba	<0.001	<0.001	0.002	0.001	0.001
Bi	0.04	<0.01	<0.01	0.023	<0.005
Ca	0.26	0.07	0.10	0.18	0.07
Cd	0.012	<0.001	0.004	0.008	0.001
Co	<0.0007	<0.0007	<0.0007	<0.0004	<0.0004
Cr	<0.0008	<0.0008	0.005	0.003	0.003
Cu	<0.0006	<0.0006	0.012	0.007	0.007
Fe	0.027	0.015	0.16	0.062	0.055
K	<5	<5	<5	<3	<3
Li	0.002	<0.001	0.001	0.0014	<0.001
Mg	0.022	0.014	0.163	0.060	0.055
Mn	<0.0003	<0.0003	0.111	0.03	0.03
Mo	<0.002	<0.002	0.056	0.016	0.016
Na	0.235	0.175	1.15	0.466	0.434
P	<0.1	<0.1	<0.1	<0.06	<0.06
Pb	0.19	0.011	0.112	0.14	0.039
Sb	0.037	<0.01	0.01	0.024	0.003
Se	<0.01	<0.01	0.01	0.003	0.003
Sr	0.002	<0.0005	<0.001	0.001	<0.0005
Th	<0.005	<0.005	<0.005	<0.002	<0.002
V	<0.0008	<0.0008	<0.0008	<0.0005	<0.0005
Zn	5.2	1.0	0.163	3.05	0.63

[a] Concentration in flue gas = filter + 1/2 (acetone wash) divided by the dry standard cubic meters of gas sampled (1,739 cubic meters for filter 1, 1.727 cubic meters for filter 2). Units are mg/dscm. The times for the first and second filters are 10:20-13:36 and 13:50-16:10 respectively.

Table 11. Ash Analyses (excluding steel belts)

	December 5 Burn	December 7 Burn		
	One Sample	Sample 1	Sample 2	Sample 3
Proximate Analysis (Procedure ASTM D 3172) Dry Basis				
Volatiles, %	14.0	11.1	11.4	7.8
Ash, %	55.0	83.0	85.7	87.7
Fixed carbon, %	31.1	5.9	3.0	4.5
Sulfur, Chloride, and Zinc Analysis				
Sulfur, %	3.01; 3.0[a]	3.0	2.7	2.2
Sulfates, %	4.39	6.32	5.53	5.14
Chloride, %	0.0272	0.033	0.124	0.027
Zinc, %	13%	32	38	32
Ammonia, mg/kg	not done	1.7	5.6	5.1
ICPL Metal Scan of Acid Digestion of Ash, mg/kg				
Insolubles	213,000	274,000	254,000	330,000
Ag	<6.5	<6.8	<6.9	<5.8
Al	35,000	30,000	38,000	46,000
As	<92	<98	<98	<82
B	102	110	210	220
Ba	130	<98	350	180
Be	<1.8	<2	<2	<1.6
Bi	<92	<98	<98	<82
Ca	50,000	2,700	18,000	11,000
Cd	15	11	20	8.9
Co	720	2,000	2,300	2,100
Cr	31	20	40	41
Cu	76	140	220	160
Fe	8,700	5,200	8,500	6,900
K	<47,000	<49,000	<49,000	<42,000
Li	39	63	50	92
Mg	3,400	5,300	6,500	4,200
Mn	160	74	130	96
Mo	<9.2	15	24	20
Na	4,100	5,200	8,000	5,600
Ni	31	24	87	44
P	1,700	2,900	1,800	2,800
Pb	530	280	520	570
Sb	<92	<98	<98	<82
Se	<92	<98	<98	<82
Sr	140	57	72	96
Th	<46	<49	<49	<41
V	20	35	57	55
Zn	130,000	320,000	380,000	320,000

[a] Duplicate analysis.

Table 12. Wire Basket Test Results, December 7 Burn

Basket Number	0	1	2	3	4
Input to Basket, g					
Tire Material[a]	1,654	1,672	1,654	1,656	1,654
Sodium bicarbonate	0	36	18	0	0
Calcium hydroxide	0	0	8	16	0
BECO material	0	0	0	0	47.2
Ash Analysis after Burn					
Sulfate, mg/kg	35,900	82,600	51,170	35,300	35,600
Sulfur, %	1.7	3.1	2.1	2.6	2.1
Percent of Original Sulfur in Tires Remaining in Ash	43	90	55	59	56
Calculated Sulfur Dioxide Emissions Factor, lb SO_2/lb tires	0.015	0.0027	0.012	0.011	0.012
Proximate Analysis of Ash					
Volatiles, %	7.7	13.8	8.8	10.0	12.8
Ash, %	79.1	83.1	86.6	78.8	76.2
Fixed Carbon, %	13.2	3.1	4.6	11.2	11.2

[a] Shredded tire material with steel belts. The shredded tire material contained 1.35% sulfur.

Table 13. Metal Analysis of Condensed Hydrocarbon Liquid Collected from Primary Combustion Chamber Exhaust Gas During December 7 Burn

Element	Metal, mg/kg
Ag	<1.0
Al	49
As	<15
B	4.6
Ba	<1.5
Be	<0.3
Bi	<15
Ca	308
Cd	<1.5
Co	<1.0
Cr	<4
Cu	<0.9
Fe	6,700
K	<75,000
Li	1.5
Mg	23
Mn	14
Mo	<1.5
Na	21
Ni	<3
P	<150
Pb	<7.4
Sb	<15
Se	<15
Sr	0.85
Th	<7.4
V	<1.2
Zn	68

Table 14. Analysis of Condensed Hydrocarbon Liquid Collected from Primary Combustion Chamber Exhaust Gas During December 7 Burn

Heating Value (ASTM D 240)	
Sample 1, Btu/lb	[redacted]
Sample 2, Btu/lb	
Percent Sulfur	1.4
Percent Water (ASTM D 4377)	47.7

Table 15. Sulfur Dioxide Emission Factors and Secondary Combustion Temperatures for Tire Burns Performed Through December 1990

Date of Burn	Emission Factor, lb SO_2/lb Tires	Highest Sustained Secondary Combustion Chamber Temperature, °F
October 25, 1988	0.0028	not measured
May 17, 1990	0.0027	2,111
May 23, 1990	0.0021	2,081
August 29, 1990	0.0026	2,055
September 28, 1990	0.0025	1,999
October 17, 1990	0.0077	2,517
December 5, 1990	0.0100	2,510
December 7, 1990	0.0038	2,200

Table 16. Sulfur Dioxide Emissions

	December 5 Burn With BECO	December 7 Burn Without BECO
Tires, lb	1,000	1,400
Ash (excluding steel belts), lb	113	98
Calculated sulfur dioxide emissions, lb	10.0	5.3
Emission factor, lb SO_2/lb of tires	0.010	0.0038
Total sulfur (including sulfur in sulfates) in ash, lb	5.10	4.43
Percent of original sulfur in tires remaining in ash	34	46

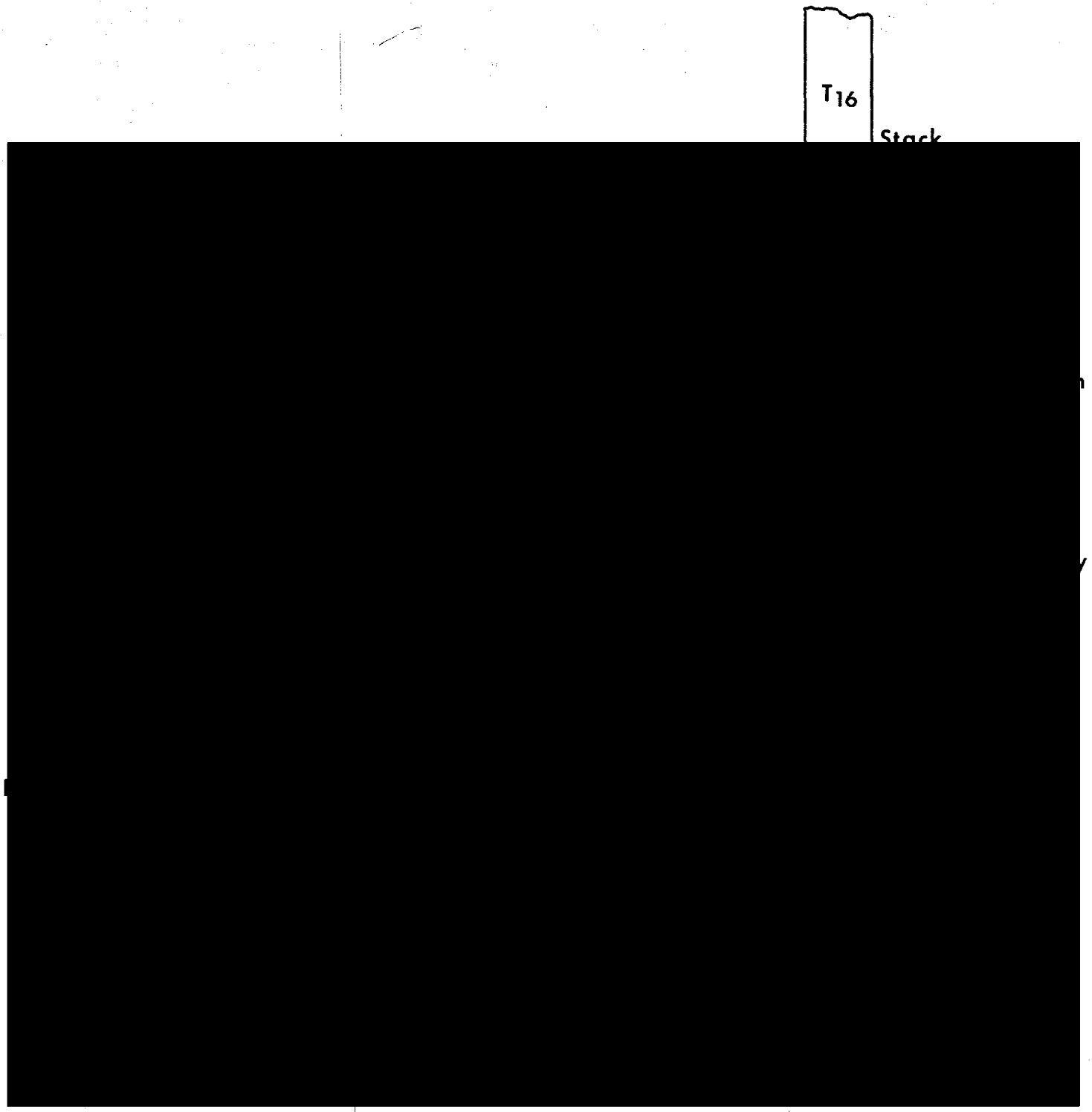


Figure 1. Entech Thermal Oxidation System Showing the Location of Thermocouples

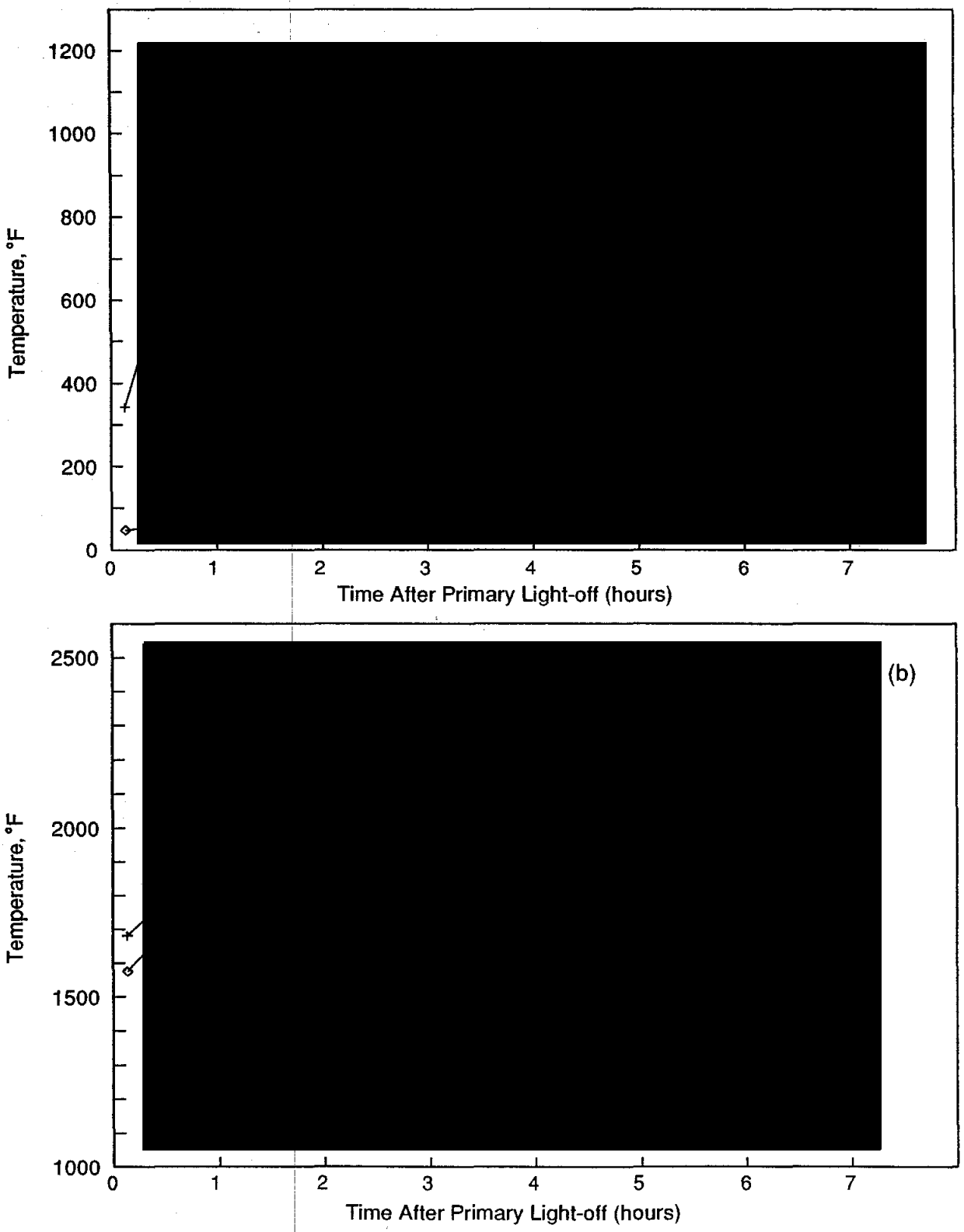


Figure 2. Temperature Profile of Tire Burn on December 5, 1990. (a) Primary combustion chamber and (b) secondary combustion chamber.

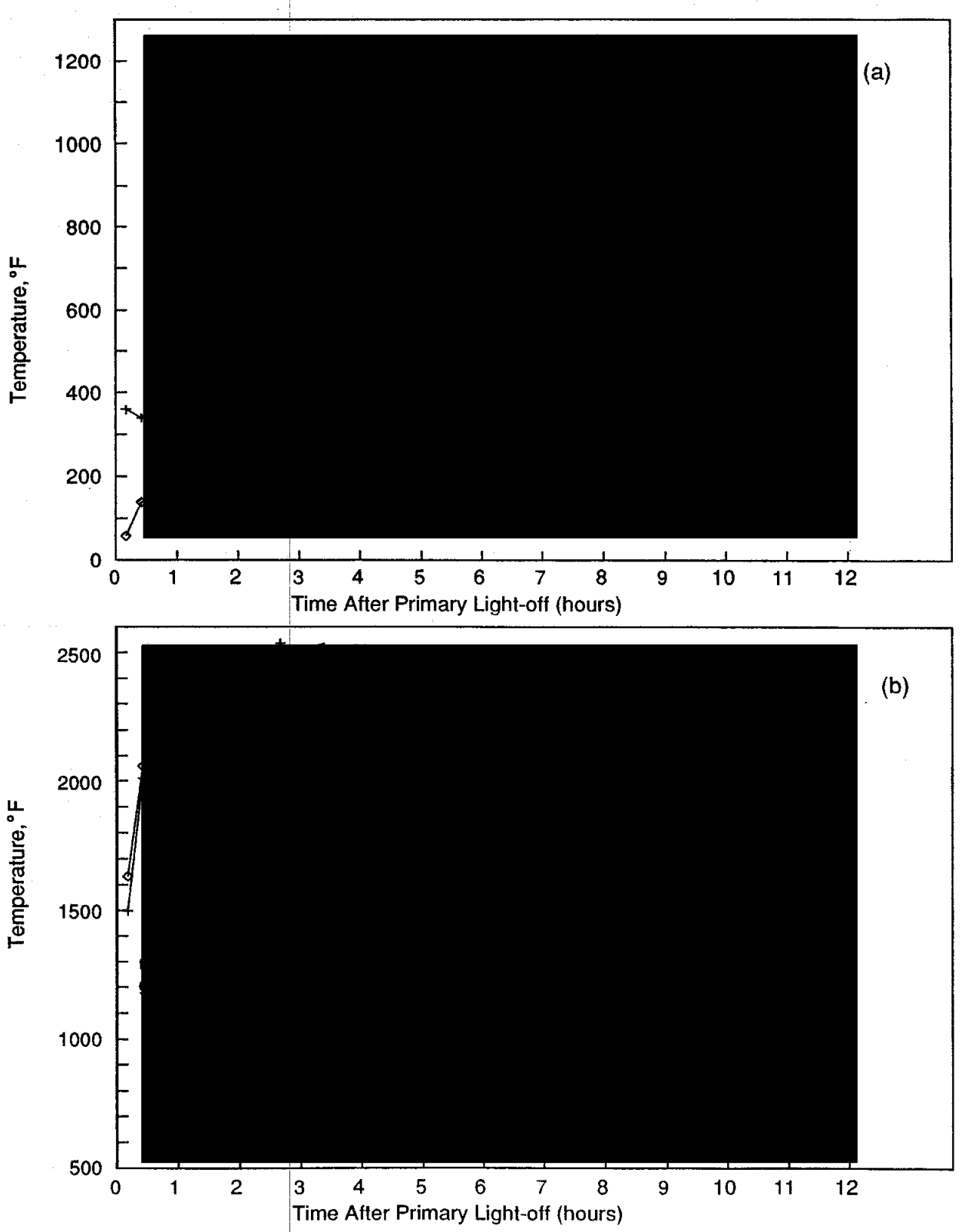


Figure 3. Temperature Profile of Tire Burn on December 7, 1990. (a) Primary combustion chamber and (b) secondary combustion chamber.

REFERENCES

Nordin, J.S., 1990a, Evaluation of a Tire Burn in an Entech Corporation Thermal Oxidation Demonstration Plant. August 1990 Test at Western Research Institute. WRI-90-R046. Entech Report No. 9.

Nordin, J.S., 1990b Evaluation of Two Tire Burns in an Entech Corporation Thermal Oxidation Demonstration Plant. September-October 1990 Tests at Western Research Institute. WRI-90-R047. Entech Report No. 10.

APPENDIX A

Field Recordings of Temperatures, Anemometer Readings, and Other Data, December 5 Burn

ENTECH INCORPORATED

DATE: 12·5·90

BURN TYPE: TIRES

WEIGHTS & VOLUMES

MATERIAL WEIGHT INPUT: 1000 PDS (51 TIRES)

MATERIAL VOLUME: 3'×8'×8'

ASH WEIGHT: 113# ASH
95# WIRE

ASH VOLUME: ½ BARREL ASH
(1) BARREL WIRE

Gas Meter Shut Down 1467

ENTECH INCORPORATED

DATE: Dec. 5, 1990 PAGE: 1 OF 1.

BURN TYPE: Tires

AIR FLOW & FUEL READINGS

[redacted]

ENTECH INCORPORATED

DATE: 12/5/90 PAGE: 1 OF .

BURN TYPE: Tires & BECO

ENERAC READINGS

Time:	CO ppm	OXY %	NOX ppm	SO2 ppm	CO2 %	COMBUS. %	STACK Δ. P.	
11:55	8	8.6	21		9.3	0.00	0.042	T/C: 1040°
12:12	3	7.0	~~7.0~~ 42		10.5	0.00	0.045	T/C: 1063°
12:50	33	11.3	71		7.0	0.00	0.055	T/C: 1261°
13:05	10	7.6	130	Ø	10.1	0.00	0.055	T/C: 1127°
13:15	47	2.5	191		14.1	0.00	0.085	T/C: 1309°
13:15	220	1.5						
13:18:30	>2000	0.7					0.087	T/C: 1407°
13:57	>1500	2.3						
14:08	35	5.5	145		11.6	0.00	0.075	T/C: 1297°
14:11	47							
14:20	45	9.7	112		5.5	0.00	0.067	T/C: 1055°
14:55	28	2.8	59		13.5	0.00	0.061	T/C: 1258°
15:35	13	6.1	30		11.1	0.00	0.052	T/C: 1174°
15:55	0	9.3	20		5.7	0.00	0.058	T/C: 1180°
16:20							0.065	T/C: 876°
16:45	0	11.5	22		7.1	0.00	0.055	T/C: 1023°
17:00	0	11.4	22		7.1	0.00	0.053	T/C: 1052°
17:15	0	10.9	22		7.5	0.00	0.025	T/C: 1032°

Barometric pressure 22.94 in Hg

ENTECH INCORPORATED

DATE: 12·5·80 PAGE: 1 OF 1.

BURN TYPE: TIRES

Primary Start Time: 11:40 AM

Secondary Start Time: 9:40 AM

Fuel Reading Start: 1433

Fuel Reading Finish: 1467

Time:	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

- Shut Down Time - 1730 -

Temperatures

"ENTECH"
"TOU"
"The time is ~~10:25~~ 11·10· :15.26."
"The date is 12-05-1990."
"01" "02" "03" "04" "05" "06" "07" "08" "09" "10" "11" "12" "13" "14" "15" "16"
"SECONDS"

[redacted]

[redacted] 863 [redacted] 435 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]60		
856		
841		
821		
808		734
792	813	
783		
778		

APPENDIX B

Field Recordings of Temperatures, Anemometer Readings, and Other Data, December 7 Burn

ENTECH INCORPORATED

DATE: Dec. 7, 1990

BURN TYPE: Tires

WEIGHTS & VOLUMES

MATERIAL WEIGHT INPUT: 1400

73 Tires

MATERIAL VOLUME: 73 Auto Tires

Varie Sizes

ASH WEIGHT: ASH VOLUME:

ENTECH INCORPORATED

DATE: Dec. 7, 1990 PAGE: 1 OF .

BURN TYPE: Tires

AIR FLOW & FUEL READINGS

	[redacted]	[redacted]	[redacted]	[redacted]	[redacted] 2ndry turb.	Fuel Meter	S.P.Prim.	D/C	Vac.
0935	[redacted]					[redacted]			
1010	[redacted]								
1030									
1100									
1117									
1130									
1207									
1210									
1230									
1300									
1300									
1430									
1500									
1540									
1635									
1715									

Primary Ign. Air Bottom - Burning All Thru Test

Prim. Ign. Air Top - Not Used This Test

ENTECH INCORPORATED

DATE: 12/7/90 PAGE: 1 OF .

BURN TYPE: Tires & BECO

ENERAC READINGS

Time:	CO ppm	OXY %	NOX ppm	SO2 ppm	CO2 %	COMBUS. %	STACK Δ. P.	
10:03	0	21.4	0		0.0	0.00		ambient
10:20	25							
10:22	30		0				0.037	T16: 1251°
10:42	Enerac malfunctioning						0.069	T16: 1312°
11:02							0.055	T16: 1318°
11:30							0.048	T16: 1360°
11:50		20.9%			0.0%		0.041	T16: 1348°
12:42	filter clogging:		0.27 on orifice		Ti: 98°	To: 84° vac: 19"	0.057	T16: 1322°
13:53							0.058	T16: 1382°
14:20	Ti: 106°	To: 82°	Temp: 52°				0.050	T16: 1334°
14:45	Ti: 102°	To: 81°					0.067	T16: 1341°
15:05	Ti: 104°	To: 82°	Temp: 53°				0.057	T16: 1281°
15:40							0.057	T16: 1240°
16:15							0.067	T16: 1331°
16:55							0.080	T16: 1291°
17:25	151,200 cf		2cf/sec				0.083	T16: 1227°
17:45							0.082	T16: 1214°

ENTECH INCORPORATED

DATE: Dec. 7, 1990 PAGE: 1 OF .

BURN TYPE: Tires

Primary Start Time: 0935

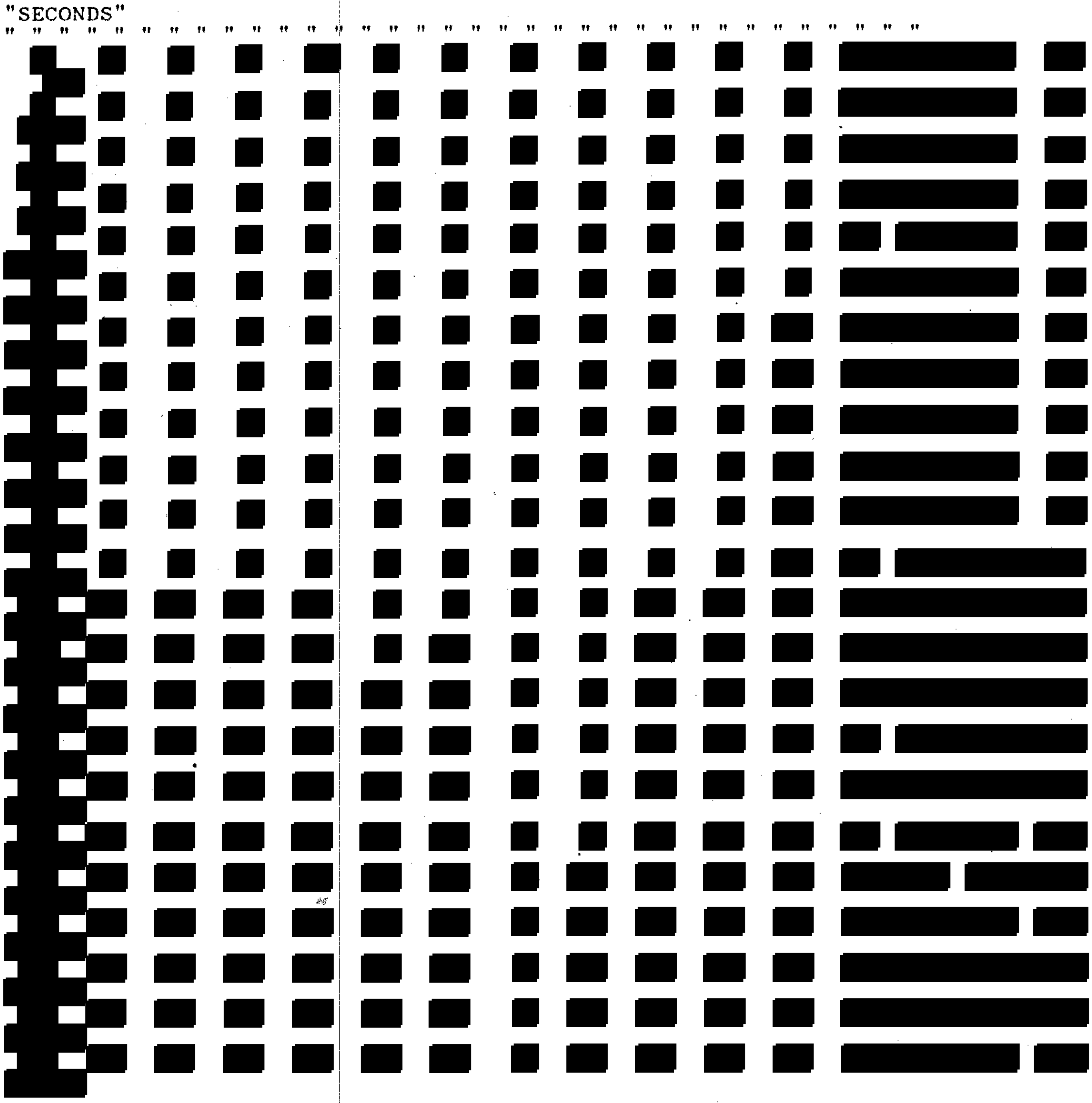
Secondary Start Time: 0745

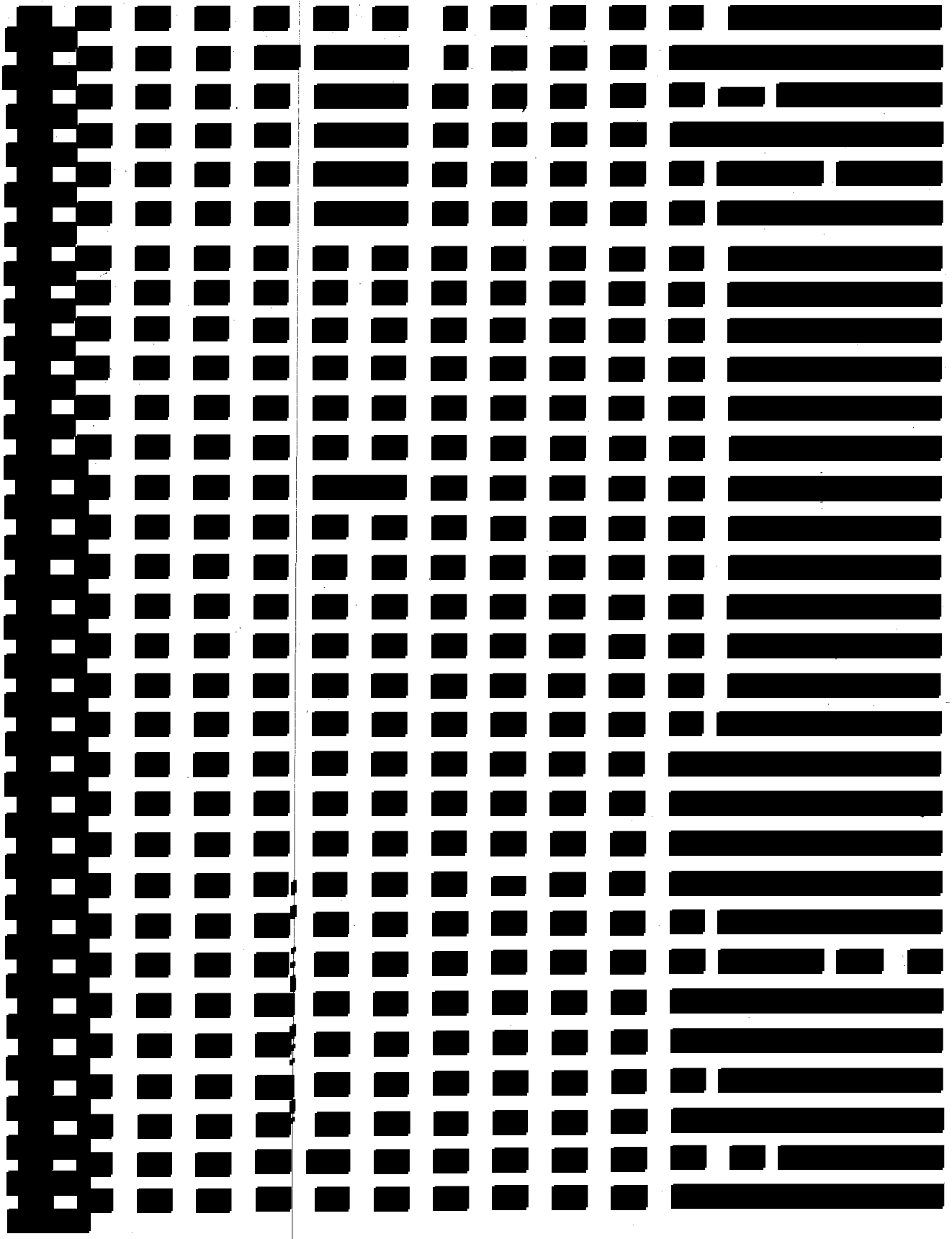
Fuel Reading Start: 1470 Ignite Primary Fuel 481

Fuel Reading Finish:

Time:	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	
10:30																	AUTO IGN.
11:17																	RE-IGN.
12:10																	AUTO IGN
13:05																	RE-IGN.

"ENTECH"
"TOU"
"The time is 07:45:54.76."
"The date is 12-07-1990."
"01" "02" "03" "04" "05" "06" "07" "08" "09" "10" "11" "12" "13" "14" "15" "16"
"SECONDS"





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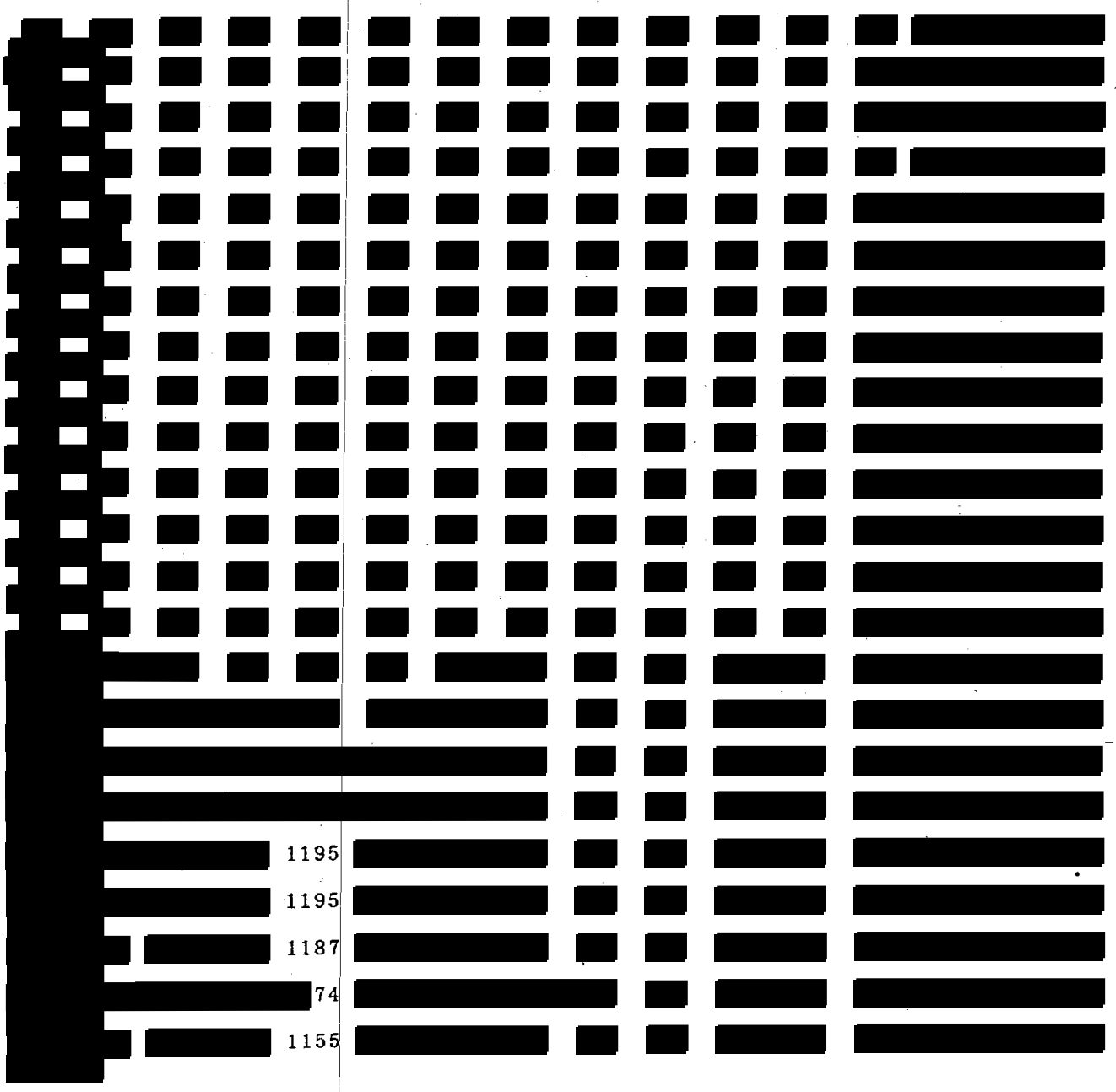
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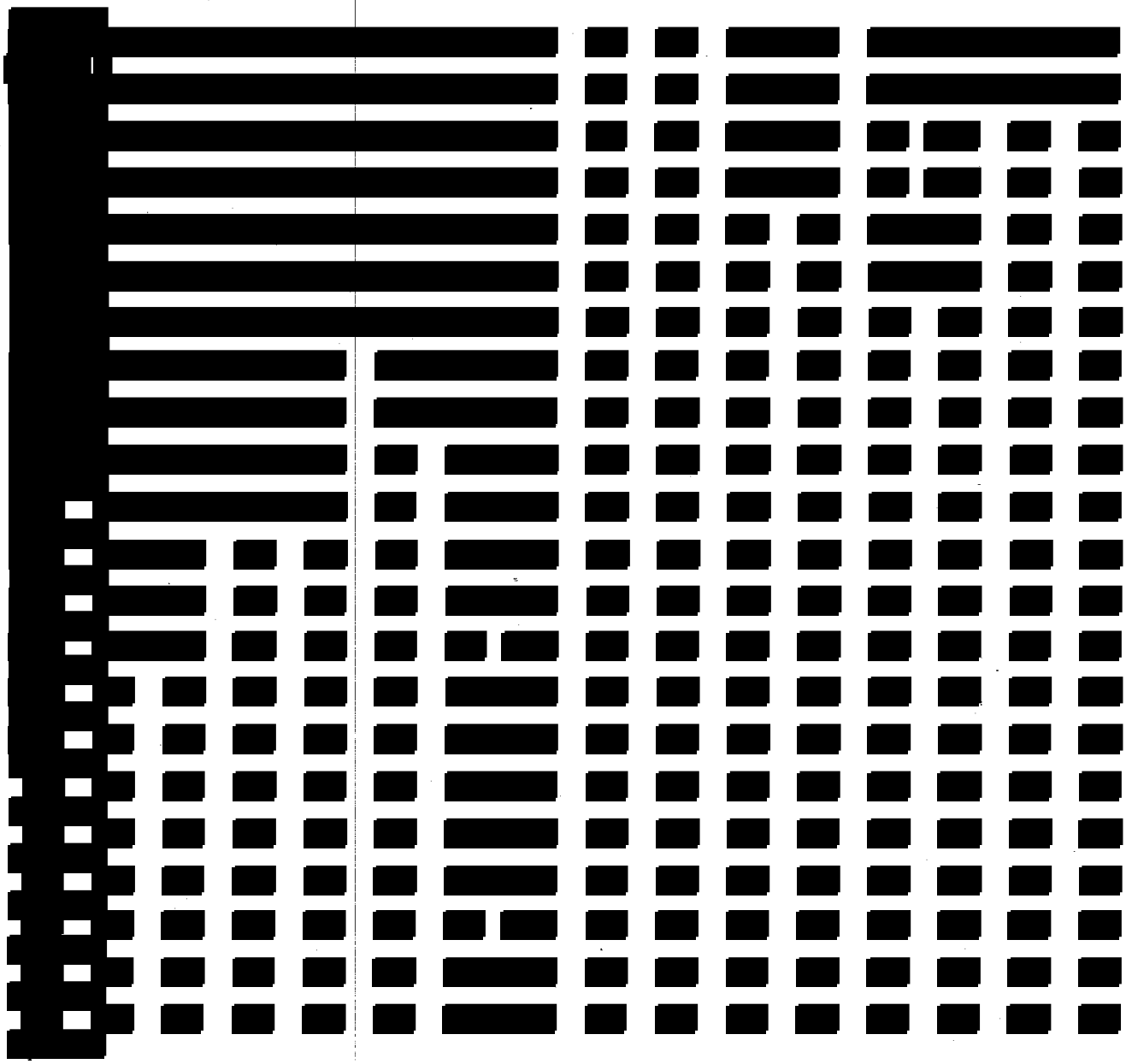
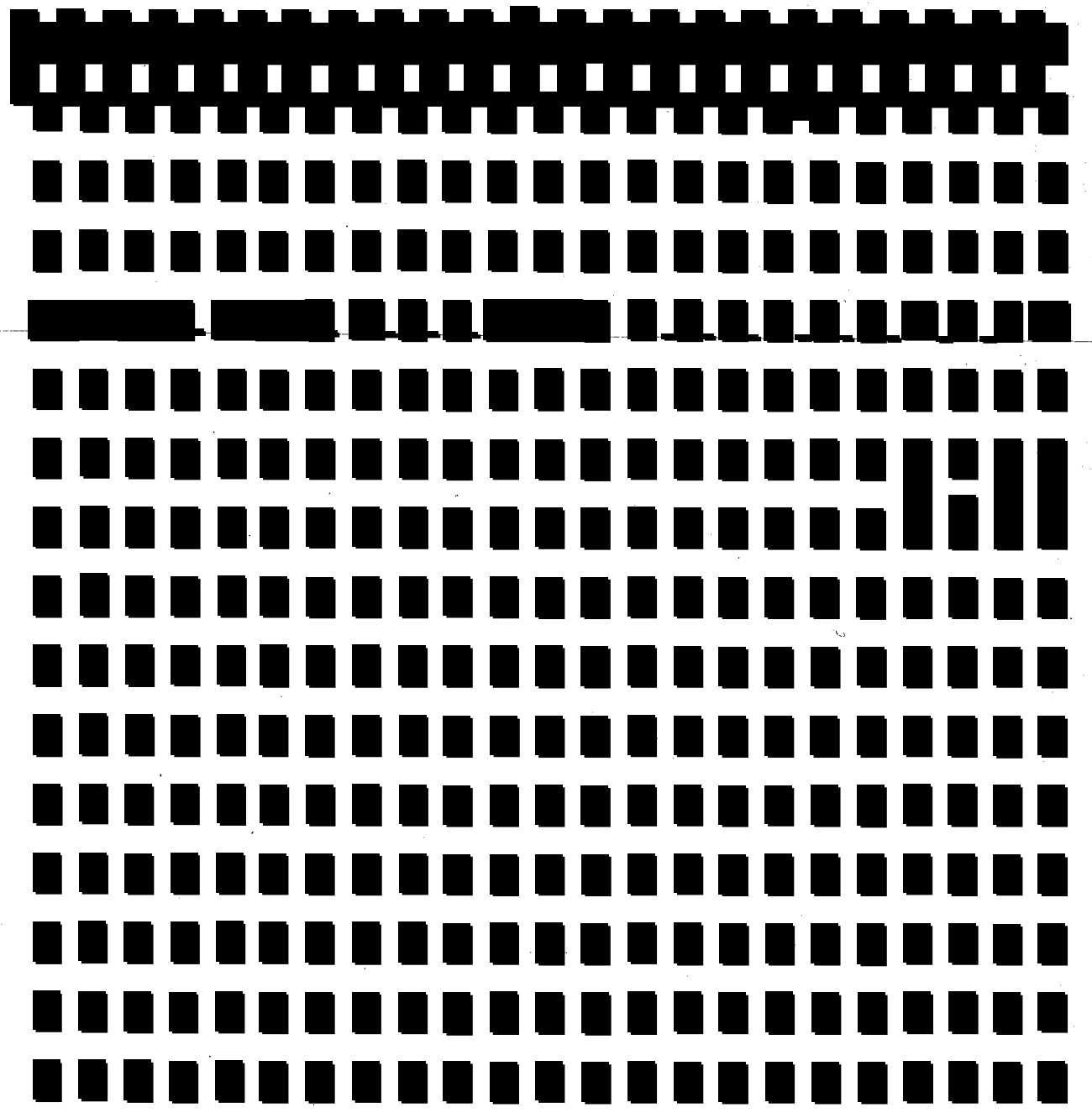




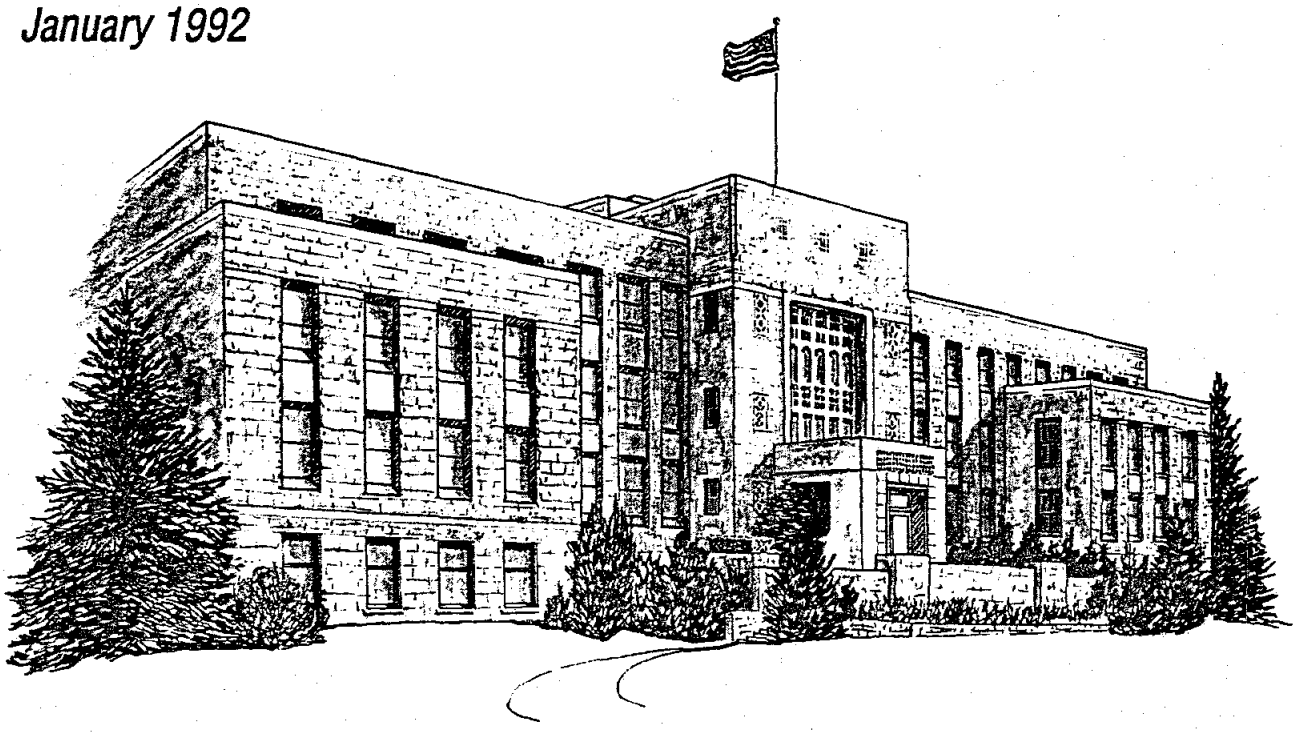
WRI-92-R009
Entech Report No. 14

WESTERN RESEARCH INSTITUTE
The University of Wyoming Research Corporation

SEPTEMBER 1991 TIRE BURN TEST IN AN ENTECH THERMAL OXIDATION DEMONSTRATION PLANT AT WESTERN RESEARCH INSTITUTE

Prepared for
Entech, Inc.
Anchorage, Alaska

January 1992



WRI-92-R009

SEPTEMBER 1991 TIRE BURN TEST IN AN ENTECH THERMAL OXIDATION DEMONSTRATION PLANT AT WESTERN RESEARCH INSTITUTE

By
John S. Nordin

January 1992

For
Entech, Inc.
Anchorage, Alaska

By
The University of Wyoming Research Corporation
a.k.a. Western Research Institute
Laramie, Wyoming

TABLE OF CONTENTS

	Page
LIST OF TABLES AND FIGURES	iii
SUMMARY	iv
INTRODUCTION	1
METHODS	2
DISCUSSION OF RESULTS	4
CONCLUSIONS	8
RECOMMENDATIONS	8
ACKNOWLEDGEMENTS	9
DISCLAIMER	9
REFERENCES	10
APPENDIX A. Approval Letter from Wyoming DEQ	11
APPENDIX B. Entech Field Notes	13
APPENDIX C. Medical Waste Burn, September 19, 1991	18

LIST OF TABLES AND FIGURES

Table		Page
1.	Tire Burn, September 17, 1991	2
2.	Secondary Combustion Chamber Emissions	5
3.	Primary Combustion Chamber Off-Gas Sulfur Analyses	5
4.	Air and Natural Gas Feeds	6
5.	Ash Analyses (excluding steel belts)	6

Figure		Page
1.	Entech Thermal Oxidation System Showing the Location of Thermocouples	3

SUMMARY

On September 17, 1991, 631 lb of whole used automobile tires were incinerated in the Entech thermal oxidation demonstration plant located at the Western Research Institute (WRI) north site, just north of Laramie, Wyoming.

The average sulfur dioxide emissions measured for the 6.5-hour burn was 18 ppm. The calculated sulfur dioxide emission factor was 0.0011 lb SO_2/lb of tires burned. Roughly 30% of the available sulfur was emitted as sulfur dioxide, and the rest remained in the ash. This emission factor was lower than that calculated for previous tire burns.

The tires burned cooler and relatively uneven compared with other burns. The ash contained some unburned or partly burned tire residue. Entech was not successful in producing liquids from tires in the primary combustion chamber during this test burn as originally planned.

INTRODUCTION

Eight burns of used automobile/truck tires have been completed using the Entech thermal oxidation system located at Western Research Institute's (WRI) north site, just north of Laramie, Wyoming. The burns were performed on various dates (October 25, 1988; May 17 and 23, August 29, September 28, October 17, December 5 and 7, 1990) These burns are discussed in previous reports (Nordin and Huntington 1991, Entech Report No. 12). Sulfur dioxide was the major pollutant of concern. For each of these burns, a sulfur dioxide emission factor was calculated, which ranged from 0.0021 to 0.010 lb SO_2 per lb of tires burned.

The higher sulfur dioxide emission factors could be correlated with higher burn temperatures. The burn temperature could be controlled by controlling the air flow to the primary combustion chamber for a given quantity of tires once ignition was underway. When temperatures of about 500°F (260°C) were reached in the primary under air-starved or pyrolysis conditions, the tires liquefied or gasified producing small droplets and/or vapors, which were combusted in the secondary combustion chamber. Temperatures greater than 1800°F (982°C) and sometimes as high as 2517°F (1381°C) were reached in the secondary combustion chamber as the result of combustion of tire hydrocarbon components without the need to add any supplemental fuel.

During the tire burns on December 7, 1990, some of the primary combustion chamber off-gas was routed to a cold trap/condenser where a hydrocarbon liquid was recovered. A sulfur material balance for that burn demonstrated that most of the sulfur was carried in this hydrocarbon liquid. When the hydrocarbon was combusted in the secondary combustion chamber, this was the source of most of the sulfur dioxide emissions. Details concerning conditions necessary to produce and recover tire liquids remained unanswered.

Therefore, Entech Inc. contracted with WRI to measure and analyze gas flows including sulfur dioxide emissions for a ninth tire burn. This burn was performed September 17, 1991, and is the subject of this report. The purposes of this burn were to (1) understand the circumstances in which hydrocarbon liquids are produced and can be recovered, (2) obtain another sulfur dioxide emission factor related to operating temperatures, and (3) perform a demonstration test for an Entech consultant that was retained to evaluate the process. Particulate sampling (EPA method 5) was not done for the September 17, 1991, burn because sampling during previous burns demonstrated that particulates of less than 0.015 gr/dscf (34 mg/dscm) could be maintained. (If a higher particulate reading was measured, it was correlated with a brief upset condition.)

As a permit condition, the Wyoming Department of Environmental Quality (DEQ) requires a 14-day advance notice for any burn where sulfur dioxide emissions exceed 30 ppm. This includes tire burns. Not enough lead time was provided to WRI to satisfy the 14-day advance notice. Wyoming DEQ approved the burn (letter dated September 13, Appendix A) with a warning that future burns will be denied if the 14-day advance notice is not satisfied. To minimize sulfur dioxide emissions, a WRI-

Entech decision was made to do the September 17 burn using a smaller quantity of tires (631 lb, 30 tires) compared with other burns (1000 to 1500 lb, about 70 tires).

The September 17 burn was performed under the direction of Dr. Russell Renk, of VRCA, Anchorage, Alaska.

METHODS

The burn date was September 17, 1991. The primary combustion chamber was loaded with 30 automobile tires (631 lb). After preheating the secondary combustion chamber using the four natural-gas-fired burners, the tires were ignited with the bottom primary chamber burner. Supplemental natural gas continued to be fed to the secondary combustion chamber throughout the burn. The natural gas feed was approximately 2.5 cfm per burner. Unlike previous tire burns, the off-gas from the primary combustion chamber did not have enough heat content to maintain combustion in the secondary combustion chamber without the addition of natural gas. After the burn was completed, the ash components were weighed and sampled for analysis. The burn times, natural gas used, and quantity of ash collected are summarized in Table 1.

Table 1. Tire Burn, September 17, 1991

Lightoff time - secondary	
Lightoff time - primary	
Burn termination (shut off air and natural gas) time	
Total natural gas used, ft^3[a]	
Total tires loaded, lb	
Number of tires loaded, lb	
Ash collected excluding steel belts, lb	
Steel belts remaining after burn, lb	
Ambient temperature at start, °F	
Ambient temperature at finish, °F	
Ambient pressure at start, mm Hg	
Ambient pressure at finish, mm Hg	

[a] Natural gas at 20 psi gauge pressure and 60°F. Natural gas was continuously supplied to secondary (08:25 to 14:20 hours) combustion chamber. Natural gas was supplied to the primary combustion chamber bottom burner between 09:40 and 10:00.

Temperatures were measured throughout the burn using thermocouples installed at the locations shown in Figure 1. The temperatures were recorded by Entech Inc. personnel; their data are listed in Appendix B. Thermocouple T_{16} was attached to the pitot tube that was used to measure

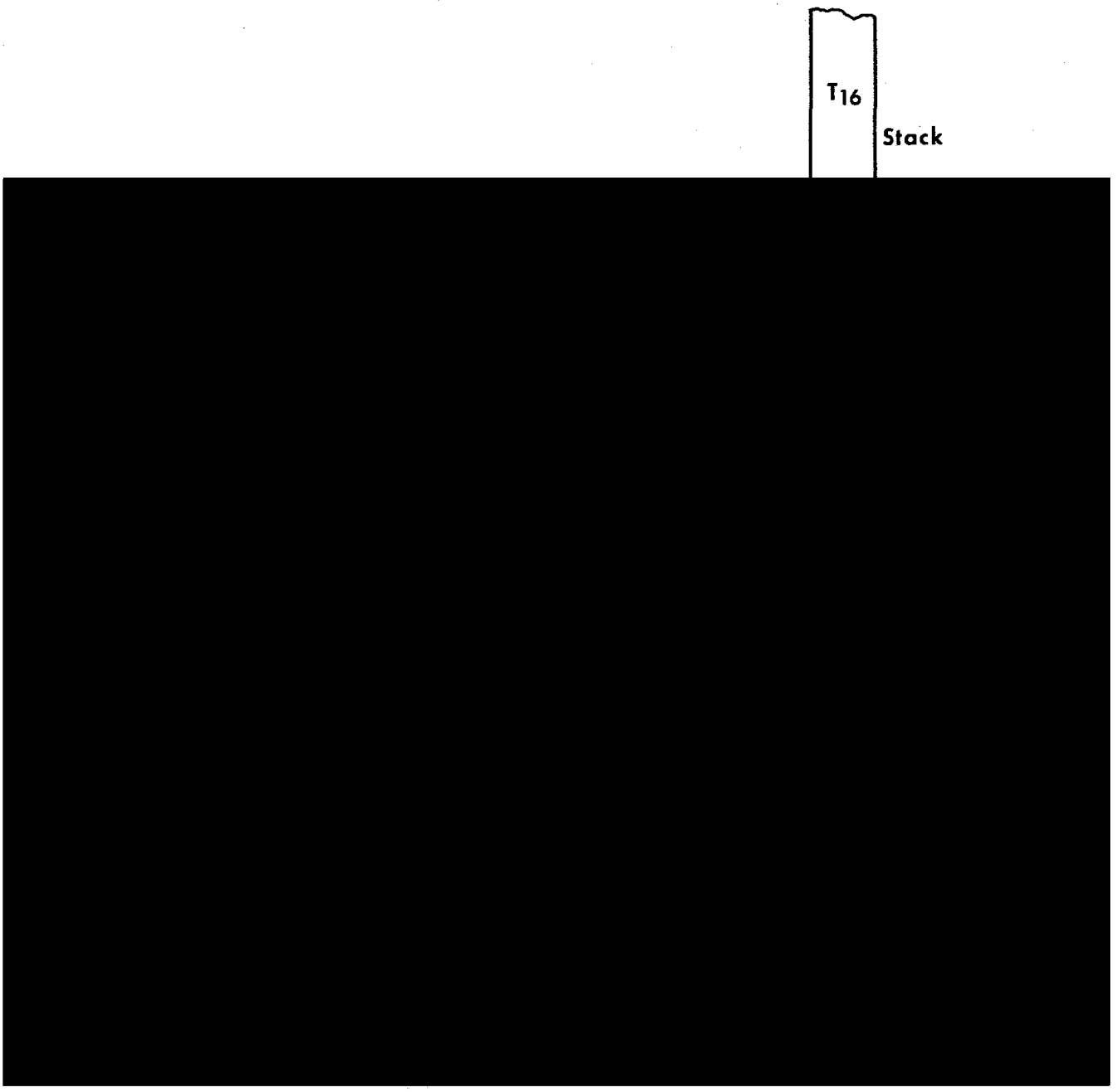


Figure 1. Entech Thermal Oxidation System Showing the Location of Thermocouples

difference between impact and static pressure, from which a stack velocity was calculated. From pitot-tube measurements, absolute pressure (23.12 inches Hg), and stack diameter [redacted], the exhaust gas flow rate was calculated.

The emission measurements and pitot-tube readings were taken at the 17-ft level on the [redacted] stack leaving the secondary combustion unit. The thermal oxidation unit (Figure 1) was located adjacent to the old 150-ton oil shale retort, which had the scaffolding and platform to support the stack and provide safe access for emission measurement.

Exhaust gas analyses were performed using an Enerac 2000 analyzer (O_2, CO_2, CO, and NO_x). The analyzer was periodically checked against several calibration gases (98 ppm CO in nitrogen, 50 ppm SO_2 in nitrogen, and air). The instrument correctly read the CO and percent O_2 but failed to correctly measure SO_2. Therefore, to measure SO_2, gas bombs were taken. The gas was injected into a Hewlett-Packard 5840A gas chromatograph fitted with a flame ionization detector. This instrument measured SO_2, H_2S, COS, CS_2, thiophene, and mercaptans to an accuracy of one part per million. Gas bomb samples were taken of primary and secondary combustion chamber exhaust gases.

Air flows were calculated from hot-wire anemometer measurements, air temperatures, and barometric pressures. There were four air input flows:

[redacted]

A portion of the primary combustion chamber off-gas was routed through a water-cooled condenser and ice-cold trap to condense vaporizing hydrocarbons. A blower was fitted to the exhaust. The off-gas flow was measured using an anemometer. However, primary combustion chamber burn conditions were such that only a small amount of hydrocarbons were vaporized. The liquid condensed in the cold trap was water. Therefore, that part of the test was abandoned several hours into the burn (at about 12:50 hours). The liquid collected was submitted for analysis (% water, % sulfur).

DISCUSSION OF RESULTS

The results of the test burn are summarized in Tables 2, 3, 4, and 5. Information on temperatures is listed in Appendix B.

Table 2. Secondary Combustion Chamber Emissions

Time	Composition of Flue Gas[c]					Flue Gas Flow, scfm (wet basis)
	% O_2	% CO_2	ppm CO	ppm NO_x	ppm SO_2[a]	
09:55	3.7	9.8	39	140	15	[redacted]
10:25	4.3	9.4	30	172	22	
10:55	4.2	9.5	28	172	15	
11:25	4.9	9.3	20	130	25	
11:55	4.5	9.2	23	126	37	
12:25	5.6	8.7	21	95	13	
13:20	3.8	9.5	21	107	30[b]	
13:50	9.7	6.4	18	65	18	
14:20	10.4	5.9	16	53	not taken	
14:20 Shutdown						

[a] Gas bomb sample for sulfur dioxide measurement using gas chromatograph. No other sulfur species was detected by gas chromatograph.

[b] Taken at 13:10 hours.

[c] Dry basis.

Table 3. Primary Combustion Chamber Off-Gas Sulfur Analysis[a]

Time	Sulfur Analysis, ppm					
	H_2S	COS	SO_2	CS_2	Methyl Mercaptan	Thiophene
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[a] Off-gas goes to secondary combustion chamber

Table 4. Air and Natural Gas Feeds

Time	Natural Gas, cfm		Air Input			
	Primary	Secondary	Primary Turbulent	Bottom Primary Burner	Secondary Turbulent	Secondary Burner
[illegible]	[illegible]	[illegible]	--	--	--	--

[a] Gasket on observation port in primary came off at 12:50 resulting in an air short circuit. Air flows not measured after 12:50.

Table 5. Ash Analysis (excluding steel belts)

	Ash Sample			
	1	2	3	4
Proximate (ASTM D#3172)				
% Moisture	0.3	1.2	1.0	0.1
% Volatiles	22.3	8.1	18.3	0.0
% Ash	9.1	52.9	50.9	99.9
% Fixed Carbon	68.4	37.8	29.9	0.0
Percent Sulfur[a]	2.5	2.5	--	--

[a] Different samples of ash than what was used for proximate analyses

The material left after the burn consisted of 63 lb of ash-like material and 75 lb of steel belts; this material varied in appearance. The analyses listed in Table 5 confirmed that parts of the residual were completely burned (99 + % ash), some was partially burned (53% ash), and some remained relatively unburned (9.1% ash). Overall, the residual sulfur remaining in the ash was 2.5% (1.3 lb).

The watery material collected in the cold trap (about 1 liter) was analyzed and found to contain 0.6% sulfur and about 99% water.

The flue gas flow leaving the secondary combustion chamber was higher than what could be accounted for by measurements of air input (Tables 2 and 4). Entech Inc. personnel report problems with the observation port gasket in the primary combustion chamber, which would result in additional input air. The observation port is several inches in diameter and could account for perhaps another 100 scfm or more.

There is also a possibility that the flue gas flow based on pitot tube measurements may be reading high, but WRI could not prove it. The pitot tube manometer was zeroed at the start and was nulled after each reading. When the S-type pitot tube is rotated 90° in the flue gas stream, a zero pressure reading should occur. For the purpose of this report, the gas flow was calculated based on pitot tube readings using a pitot tube coefficient of 0.84.

The average sulfur dioxide in the stack was 18 ppm (dry basis). The peak sulfur dioxide measured was 37 ppm. Based on the flue gas flows (Table 2), the total calculated sulfur dioxide emitted for the burn is 0.67 lb. The calculated sulfur dioxide emission factor is 0.0011 lb SO_2 per lb of tires. This is much less than the sulfur dioxide emitted from other tire burns (emission factors 0.0021 to 0.010 lb SO_2/lb tires).

A sulfur material balance shows that of the total sulfur present, about 30% went up the stack as sulfur dioxide and 70% remained behind in the ash. A burn performed on December 5, 1990 (Nordin and Huntington, 1991, Entech Report No. 12), had a sulfur dioxide emission factor of 0.01; 66% of the sulfur was emitted as sulfur dioxide, and 34% of the sulfur remained behind in the ash. Part of the reason may be due to a lower average sulfur content of the tires used in the September 17, 1991 run (0.39% S) compared with the December 5, 1990 run (0.51% S).

However, parts of the primary combustion chamber ran cool for the September 17, 1991, burn. The tires did not liquefy and volatilize as compared with other burns. At no time could a temperature greater than 1800°F (982°C) be maintained in the secondary combustion chamber without supplemental natural gas. When the burn was completed, there was some unburned residue. We believe that the cooler temperatures were responsible for lower sulfur dioxide emissions.

The cooler temperatures may be due, in part, to a smaller tire load than used for other burns and due to air shortcutting in the top part of the primary combustion chamber from the observation port.

No tests were carried out converting the tire ash to bricks or evaluating its use as an agriculture supplement (see Wyoming DEQ letter, Appendix A) because the test left unburned or partially burned ash material (Table 5).

CONCLUSIONS

1. Uneven primary combustion chamber temperatures apparently were responsible for some unburned tire residue after the test.

2. Lower overall temperatures in the primary combustion chamber resulted in a lower sulfur dioxide emission factor and a higher percentage of sulfur remaining in the ash compared with other burns.

RECOMMENDATIONS

1. Air input must be carefully measured and controlled for these tests.

2. To avoid unburned residues, we suggest lighting the bottom burner to increase ash temperature and increasing the air flow to the bottom for about 15 minutes at the end of the burn.

ACKNOWLEDGEMENTS

The author wishes to acknowledge Steve Lindblom for emissions measurements, Bob Cummings for sulfur emission analysis, and Don Kerr, Dave Genkinger, and Tom Diewold for operation of the Entech thermal oxidation system.

DISCLAIMER

Mention of specific brand names or models of equipment is for information only and does not imply endorsement of any particular brand.

REFERENCES

Nordin, J.S. and G.S. Huntington, 1991, December 1990 Tire Burn Tests in an Entech Thermal Oxidation Demonstration Plant at Western Research Institute, unpublished report to Entech, Inc., WRI-91-R013.

APPENDIX A

Approval Letter From Wyoming

Department of Environmental Quality

THE STATE OF WYOMING

MIKE SULLIVAN
GOVERNOR

Department of Environmental Quality

Herschler Building • 122 West 25th Street • Cheyenne, Wyoming 82002

Administration	Air Quality Division	Land Quality Division	Solid Waste Management Program	Water Quality Division
(307) 777-7937	(307) 777-7391	(307) 777-7756 FAX (307) 634-0799	(307) 777-7752	(307) 777-7781 FAX (307) 777-5973

September 13, 1991

Mr. John S. Nordin
Western Research Institute
P.O. Box 3395
University Station
Laramie, Wyoming 82071-3395

Dear Mr. Nordin:

The Air Quality Division has received your supplemental information regarding the proposed burning of tires and medical waste which is to be conducted during the week of September 16, 1991. For the tire burn, you have indicated that a stream of gas from the primary combustion chamber will be condensed prior to introducing it to the secondary combustion chamber. Sulfur is expected to be captured in the condensed liquid and not emitted as sulfur dioxide from the incinerator stack. Ash from this burn will be analyzed to see if it can be used as an agricultural feed supplement.

In the medical waste burn, a small amount of material will be burned to demonstrate the ability of this unit to fully combust the charge. Additionally, the ash from this burn will be used to form construction bricks and these bricks will then be tested for leaching characteristics.

The calculations provided by WRI indicates that the air pollutants generated by these burns will be insignificant in quantity and air quality impact. Permission to conduct these burns, as described, is hereby granted. I must caution you that the permit which was issued for this incinerator contains a permit condition which requires at least 14 days advance notice for any burn which must be approved by the Administrator. In all future burn requests, if this 14 day advance notice is not provided the Division will automatically deny the request.

If you have any questions regarding this matter, please feel free to contact this office.

Sincerely,

Charles A. Collins

Charles A. Collins
Administrator
Air Quality Division

APPENDIX B

Entech Field Notes

ENTECH INCORPORATED

DATE: Tuesday 9-17-91

BURN TYPE: Tires

WEIGHTS & VOLUMES

MATERIAL WEIGHT INPUT: 631 lbs.

MATERIAL VOLUME: 30 Tires

ASH WEIGHT: 75 lb wire
63 lb ash

ASH VOLUME:

ENTECH INCORPORATED

DATE: 9/17/91 PAGE: OF .

BURN TYPE: TIRE

ENERAC READINGS

Time:	CO ppm	OXY %	NOX ppm	SO2 ppm	CO2 %	COMBUS. %	STACK Δ. P.	STACK TEMP (°F)	[illegible]
0955	39	3.7	140	—	9.8		0.050	1325	Y
1025	30	4.3	172	—	9.4		0.050	1420	Y
1055	28	4.2	172	—	9.5		0.049	1394	Y
1125	20	4.9	130	—	9.3		0.055	1240	Y
1155	23	4.5	126	—	9.2		0.042	1281	Y
1225	21	5.6	95	—	8.7		0.038	1265	Y
1320	21	3.8	107	—	9.5		0.062	1240	Y
1350	18	9.7	65		6.4		0.050	1242	Y
1420	16	10.4	53		5.9		0.049	724 @1421	

ENTECH INCORPORATED

DATE: Tuesday 9-17-91 PAGE: 1 OF .

BURN TYPE: Tires

AIR FLOW & FUEL READINGS [redacted]

[redacted]

ENTECH INCORPORATED

DATE: Tuesday 9-17-91 PAGE: 1 OF .

BURN TYPE: Tires

Primary Start Time: 09:40

Secondary Start Time: 08:25

Fuel Reading Start: 1751

Fuel Reading Finish:

[redacted]

APPENDIX C

Medical Waste Burn, September 19, 1991

Entech, Inc. completed a demonstration medical waste burn on September 19, 1991, for potential Entech clients. WRI was not contracted to participate in this burn other than to answer questions.

Entech procured sharps and red bag waste from Ivinson Memorial Hospital, Laramie, Wyoming, and placed them inside eleven 2-ft^3 cardboard boxes. The boxes were loaded into the primary combustion chamber. The weights, including the cardboard boxes, were 219 lb of sharps and 339 lb of red bag waste. After the burn, 81 lb of ash including metal components were collected. WRI was provided with temperatures and other field notes for the burn (data follows).

This burn is presented in this report because it was mentioned in the Wyoming DEQ approval letter and WRI desires to acknowledge that the burn was done.

ENTECH INCORPORATED DATE: Thurs. 9-19-91 PAGE: 1 OF 1.

[redacted]

ENTECH INCORPORATED

DATE: Thurs. 9-19-91 PAGE: 1 OF 1.

BURN TYPE: Medical Waste

AIR FLOW & FUEL READINGS

[redacted]

WESTERN RESEARCH INSTITUTE

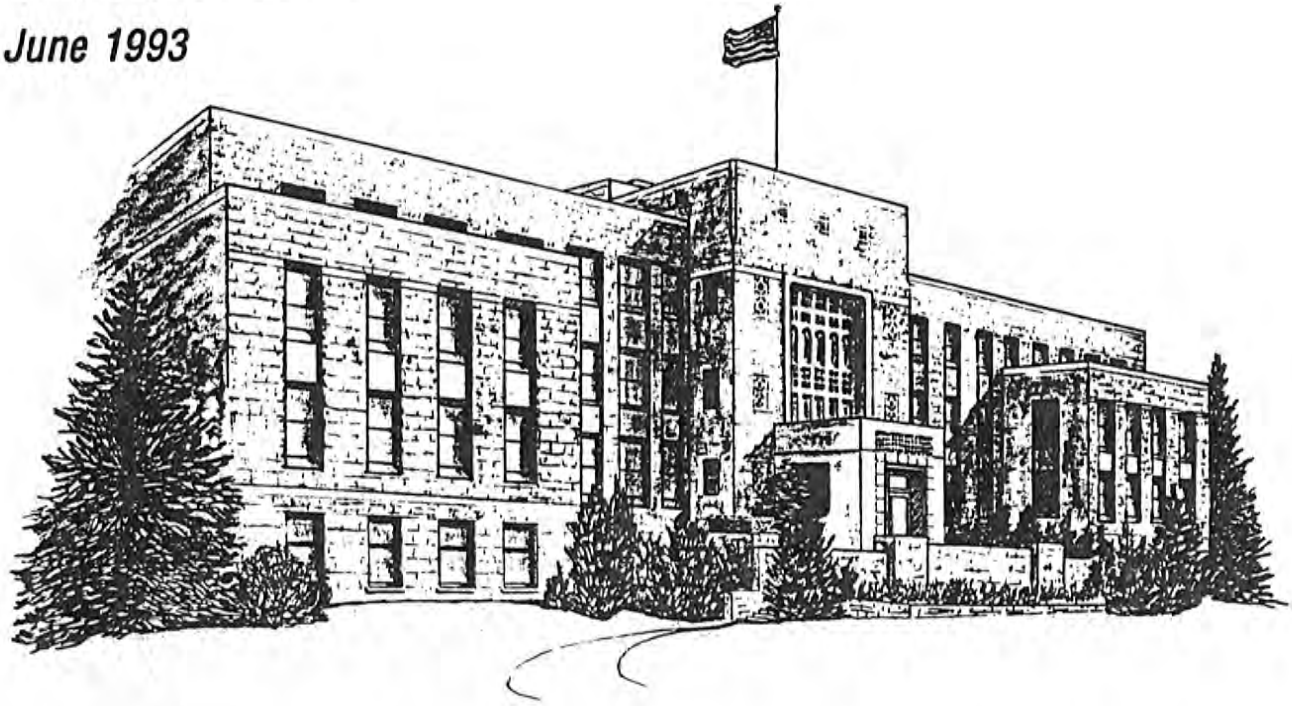
"Providing solutions to energy and environmental problems"

VOLUME II -- APPENDICES

APRIL-MAY 1993 ENTECH, INC., MODEL TOS-80 EMISSIONS MONITORING IN ANCHORAGE, ALASKA

Prepared for
NATCHIQ
Anchorage, Alaska

June 1993



WRI-93-R024

APRIL - MAY 1993 ENTECH, INC., MODEL TOS-80 EMISSIONS MONITORING IN ANCHORAGE, ALASKA VOLUME II--APPENDICES

By
John Nordin
Steve Lindblom

June 1993

For
NATCHIQ
Anchorage, Alaska

By
Western Research Institute
Laramie, Wyoming

TABLE OF CONTENTS

		Page
APPENDIX A.	Western Research Institute Emission Data	1
APPENDIX B.	Field Data Sheets	25
APPENDIX C.	Puget Sound Air Pollution Control Agency Methods	71
APPENDIX D.	Organic Emission Data	88
APPENDIX E.	TCLP Test Data	121

APPENDIX A

Western Research Institute Emission Data

CONTENTS OF APPENDIX A

	Page
WESTERN RESEARCH INSTITUTE EMISSIONS DATA	1
Procedures	3
Pitot Tube Readings	4
Isokinetic Sampling	4
Field Data Sheet Example	5

LIST OF TABLES

Table		Page
A1.	Data Sheet Summary	7
A2.	Average Teledyne or Enerac 2000 Analyzer Readings for Percent Oxygen and Carbon Dioxide	9
A3.	Molecular Weights Used in Stack Velocity Calculations	11
A4.	Particulates Collected By Acetone Washes . . .	13
A5.	Front-Half Particulates	14
A6.	Back-Half Particulates	16
A7.	Hydrogen Chloride	17
A8.	Mercury Sampling	19
A9.	Metals Sampling	19
A10.	Filter Weights After Drying In Oven at 550°C .	24

WESTERN RESEARCH INSTITUTE DATA

Procedures

The procedures for isokinetic sampling as defined in 40 CFR Part 60, Appendix A, Methods 1 and 5 were followed. Western Research Institute (WRI) used a 0.5-inch diameter nozzle and quartz liner sample probe. Three such probes were used, one owned by WRI and two purchased by Entech for this project. WRI supplied two Inconel nozzles, and Entech supplied one stainless-steel nozzle. A graphite sealant was used to seal the stack end of the quartz liner. Environmental Protection Agency (EPA) protocol specifies Teflon seals; however, Teflon cannot be used at the stack sampling temperatures experienced (up to 2100°F). Teflon tape was used for all other connections including the quartz liner connection to the glass cyclone in the hot box. No stopcock grease was used for any of the connections. When the Teflon tape was applied to the ball-and-socket joints, the leak rate of the assembly was less than 0.01 cubic feet per minute at 15 inches of mercury (Hg) vacuum. Except for the first particulate samples collected, the vacuum was less than 3 inches of Hg for all tests. The procedure was to record the vacuum as 0 on the enclosed forms if the pressure drop was less than 3 inches of Hg.

The burns were performed on alternate days, starting on April 20 and ending May 8, for a total of nine burns. For each burn, WRI completed three particulate sampling events, each with at least 30 dry standard cubic feet (dscf) of stack gas collected, one metals/mercury sampling event (also with at least 30 dscf), and one EPA method 23 dioxin/furan sampling event lasting four hours. The burns were batch loaded and lasted typically 12 to 14 hours excluding ash cooling.

Normal procedure was to start sampling for particulates 15 to 20 minutes after lightoff of the primary combustion chamber (particulate A). After sampling at the six stack positions along the first stack traverse, according to EPA protocol (40 CFR Part 60, Appendix A, Method 1), the sampling train was repositioned for the second traverse at a second sample port (90° from first sample port), and samples were collected from six positions. The organic sample collection was initiated at the first sample port while particulates were collected at the second sampling port.

When particulate A was completed, a second particulate train (particulate B) was started at the second sampling port. When the organic and particulate B sampling trains completed the first traverse, these sampling trains then traded sample ports. When particulate B sampling was complete, WRI began

sampling for metals/mercury. When organics sampling was complete, WRI began the third particulate sampling (particulate C).

For one burn, the metals/mercury sampling was initiated early, before sampling for organics, to collect any mercury that might be emitted. The entire sampling took place during a 10- to 11-hour period. The sample time at each of the 12 sampling positions was 20 minutes for organics and 10, 12, or 13 minutes for particulates and metals/mercury.

Pitot Tube Readings

WRI used a single standard pitot tube for all pressure readings at each position. The pitot tube was zeroed prior to each reading; the reading was taken; and the pitot tube was removed from the hot stack environment (up to 2000°F). The time that the pitot tube was in the stack was less than 30 seconds per position. The orifice coefficient was 0.84.

The data sheets show variations in pitot tube readings from 0.007 to about 0.035 inches of water with most readings near 0.010 inches. These variations were due to changes in the gas flow in the stack at the time the measurements were taken and were not due to the sampling location within the stack. WRI confirmed that pitot tube readings taken at approximately the same time but at different stack positions were identical. The gas velocity in feet per second was calculated according to the formula:

$$v=85.49C\sqrt{P\frac{T}{SM}}$$

where C = pitot tube coefficient, 0.84
P = pitot tube reading in inches of water
T = stack temperature at sampling nozzle, °R
S = static pressure, inches of Hg
M = molecular weight of gas

Isokinetic Sampling

Isokinetic sampling means that the gas sampling rate through the 0.5-inch nozzle must be the same as the stack gas flow velocity . The gas sampling rate at the nozzle should be A = v(60)(0.0013535) actual cubic feet per minute. As the gas passes through the impinger train, the gas is cooled and water condenses. The gas sampling rate (G) as read by the gas meter should be G = A(1 - w)(TM/T) cubic feet per minute where w is the volume fraction of water, TM is the average gas

temperature at the meter in degrees Rankin (°R), and T is the stack temperature in °R. Isokinetic is documented as the volume of stack gas sampled divided by G(100%).

After each test, the fraction of water was calculated from measuring the volume of water collected in the impingers and the silica gel. It varied from slightly less than 2% to about 15% water. The molecular weight was also calculated and is shown in Table A3.

Any collected particulates were small and were therefore assumed to be entrained in the stack gas. No particulates were collected in the cyclone flask.

Field Data Sheet Example

Gas meter readings and times were recorded at the start and end of each of the 12 traverse positions. Because two sampling trains were often operating simultaneously, and they could not be allowed to interfere with each other, the sampling pump was shut off as noted on the data sheets.

Sampled gas volumes were measured with two gas meters designated WRI or Anderson. The WRI gas meter has a correction factor of [redacted]. The volume of gas sampled were checked against each other by connecting the gas meters in series and the [redacted] correction factor was found to be true for the gas sampling rates used at the Entech incinerator.

Example Calculation:

Burn 7, Particulate A, May 4, 1993. Auto Fluff.

The volume of gas sampled was (978.53 - 952.89)(1.25) = 32.05 cubic ft. The total sample time was 144 minutes (12 minutes at each traverse point). The net increase in impinger weight due to water condensing was 70.41 grams (of which 6.11 grams was collected in the silica gel impinger, 60.68 was in the first impinger, and the balance in the other impingers).

The atmospheric pressure corrected for 250 ft elevation was 29.24 in Hg. The average temperature was 518°R.

The volume of gas collected, in dry standard cubic feet (dscf), at standard conditions of 68°F (20°C) and 29.92 inches Hg was:

$$32.05\left(\frac{29.24}{29.92}\right)\left(\frac{528}{518}\right)=31.92\,dscf$$

The volume of water in this gas was:

$$(70.41)\left[\frac{385.32}{(18)(453.6)}\right]=3.32\,ft^3$$

where 385.32 is the volume of one pound-mole of gas at standard conditions.

The percent of water was:

$$\frac{3.32}{3.32+31.92}(100\%)=9.42\%$$

For this run, averages of the 12 points were used for calculating temperatures and pitot tube impact pressures. The static pressure was essentially the atmospheric pressure. The average temperature was 1873°R. The average molecular weight was 28.89. The average pitot tube reading was 0.0095 inches water. The average stack gas velocity was:

$$v=85.49(0.49)\sqrt{0.0095\frac{1873}{(29.24)(29.68)}}=10.29\,ft/s$$

For isokinetic sampling conditions, WRI should be sampling at the rate of:

$$(10.42)(60)(0.0013635)(1-0.0924)\left(\frac{518}{1873}\right)=0.211\,dcfm$$

WRI actually sampled at the rate of 32.05/144 = 0.2226 dcfm, which is equivalent to an overall average of 105% of isokinetic.

Table A1. Data Sheet Summary

Burn	Sample	Sample Volume dcf	Sample Volume dscf	% Water	% IsoKinetic
1 - 4/20	A	33.97	34.52	7.0	90.2
	B	35.56	36.78	3.0	104
	C	45.39	45.26	8.4	91
	organics	71.65	72.83	7.4	94
	metals	42.10	41.83	<2	115
2 - 4/22	A	37.02	38.12	10.86	124
	B	34.19	35.05	5.3	122
	C	31.62	32.55	1.87	101
	organics	59.08	59.57	2	99.5
	metals	36.94	36.73	4.4	107
3 - 4/24	A	39.95	40.33	4.21	107
	B	39.40	38.44	8.26	109.8
	C	35.30	35.44	7.97	102
	organics	61.03	61.24	6.59	105
	metals	36.60	35.71	2.0	99
4 - 4/26	A	32.05	31.92	9.42	104
	B	41.40	40.01	4.48	105
	C	31.18	31.41	5.27	95
	organics	53.49	52.87	2	86
	metals	31.78	30.54	2.17	98
5 - 4/28	A	35.20	35.23	12.70	105
	B	34.57	34.30	4.67	97
	C	31.19	32.03	4.17	93
	organics	45.64	46.92	2.29	80
	metals	35.90	35.61	10.35	100
6 - 4/30	A	42.45	42.17	4.61	112
	B	31.19	30.98	4.59	102
	C	35.30	34.48	7.25	114
	organics	46.12	46.93	2.03	91
	metals	35.51	36.00	11.0	99

Table A1. Data Sheet Summary (continued)

Burn	Sample	Sample Volume dscf	Sample Volume dscf	% Water	% Isokinetic
7 - 5/4	A	32.05	31.93	9.47	103
	B	35.23	34.56	2.01	
	C	30.81	30.76	2.78	100
	organics	51.47	52.96	2	107
	metals	32.03	31.06	8.08	106
8 - 5/6	A	33.46	33.73	10.1	110
	B	33.01	32.27	8.88	105
	C	32.23	33.31	1.1	97
	organics	54.63	55.08	1.2	101
	metals	31.44	30.97	7.55	101
9 - 5/8	A	34.30	34.22	7.75	107
	B	33.69	33.29	6.94	105
	C	32.04	32.44	2.0	101
	organics	53.75	55.09	2.0	101
	metals	31.90	32.30	5.76	102

Notes: To convert cubic feet to cubic meters, multiply by 0.028317. Times of sampling are shown on data sheets.

Table A2. Average Teledyne or Enerac 2000 Analyzer Readings for Percent Oxygen and Carbon Dioxide

Burn	Sample	% O_2	% CO_2
1	A	8.8	9.5
	B	8.8	9.5
	C	12.0	6.3
	organics	8.8	9.5
	metals	8.8	9.5
2	A	3.0	13.2
	B	4.0	12.6
	C	8.9	10.4
	organics	4.4	12.4
	metals	6.8	10.4
3	A	4.4	12.2
	B	8.3	9.4
	C	7.2	10.3
	organics	7.0	10.3
	metals	7.9	9.8
4	A	5.1	12.7
	B	7.4	10.9
	C	13.0	6.0
	organics	7.3	10.9
	metals	10.3	8.0
5	A	9.72	8.2
	B	6.34	10.8
	C	8.33	9.0
	organics	9.04	8.9
	metals	7.76	9.3
6	A	7.58	9.7
	B	5.36	11.6
	C	9.74	7.6

Table A2. Average Teledyne or Enerac 2000 Analyzer Reading for Percent Oxygen and Carbon Dioxide (continued)

Burn	Sample	% O_2	% CO_2
	organics	5.95	11.1
6	metals	7.84	9.1
7	A	9.9	7.0
	B	8.06	9.4
	C	9.3	8.7
	organics	9.7	8.0
	metals	9.2	8.5
8	A	7.9	10.4
	B	10.1	8.3
	C	9.6	8.7
	organics	10.4	7.9
	metals	8.1	9.8
9	A	5.88	11.225
	B	6.2	10.95
	C	9.87	8.43
	organics	7.07	10.7
	metals	7.43	10.2

Notes: Burn 1 data limited, Enerac 2000 readings. Burn 4 particulate C readings for oxygen may be high; Teledyne pump not delivering adequate flue gas because of low battery charge.

Table A3. Molecular Weights Used in Stack Velocity Calculations

Burn	Sample	% O_2	% CO_2	% N_2	% H_2O	MW
1	A	8.2	8.8	76.0	7.0	29.04
	B	8.5	9.2	79.3	3.0	29.51
	C	11.0	5.8	74.8	8.4	28.53
	organics	8.1	5.4	79.1	7.4	28.45
	metals	8.6	9.3	80.1	2	29.63
2	A	2.9	11.8	74.4	10.9	28.91
	B	3.1	11.9	79.7	5.3	29.50
	C	8.7	10.3	79.1	1.9	29.81
	organics	4.3	12.2	81.5	2	29.92
	metals	6.5	9.9	79.2	4.4	29.40
3	A	4.2	11.7	79.9	4.2	29.34
	B	7.6	8.6	75.5	8.3	28.85
	C	6.6	9.5	75.9	8.0	28.98
	organics	6.5	9.6	77.3	6.6	29.80
	metals	7.7	9.6	80.7	2	29.64
4	A	4.9	12.1	78.3	4.7	29.68
	B	7.1	10.4	78.0	4.5	29.50
	C	12.3	5.7	76.7	5.3	28.80
	organics	7.2	10.7	80.1	2	29.80
	metals	10.1	7.8	79.9	2.2	29.43
5	A	8.5	7.2	71.6	12.7	28.22
	B	6.0	10.3	79.0	4.7	29.42
	C	8.0	8.6	79.2	4.2	29.28
	organics	8.8	8.7	80.2	2.3	29.52
	metals	7.0	9.2	73.4	10.4	28.71
6	A	7.2	9.3	78.9	4.6	29.32
	B	5.1	11.1	79.2	4.6	29.52
	C	9.0	7.0	76.7	7.3	28.75
	organics	5.8	10.9	81.3	2.0	29.78

Table A3. Molecular Weights Used in Stack Velocity Calculations (continued)

Burn	Sample	% O_2	% CO_2	% N_2	% H_2O	MW
6	metals	7.0	8.1	73.9	11.0	28.48
7	A	9.0	6.3	75.2	9.5	28.42
	B	7.9	9.2	80.9	2.0	29.59
	C	9.0	8.5	79.7	2.8	29.44
	organics	9.5	7.8	80.7	2	29.43
	metals	8.5	7.8	75.6	8.1	28.80
8	A	7.1	9.3	73.5	10.1	28.76
	B	9.2	7.6	74.3	8.9	28.69
	C	9.4	8.6	80.9	1.1	29.64
	organics	10.3	7.8	80.7	1.2	29.54
	metals	7.5	9.1	75.8	7.6	29.00
9	A	5.4	10.3	76.5	7.8	29.08
	B	5.8	10.2	76.2	6.9	28.92
	C	9.7	8.3	80.0	2	29.52
	organics	6.9	10.5	80.6	2	29.76
	metals	7.0	9.6	77.6	5.8	29.24

Notes: Oxygen and carbon dioxide concentrations are averages calculated from Teledyne or Enerac 2000 Analyzer measurements corrected to a wet percentage basis. Water is from impinger weight measurements. Nitrogen is calculated by difference.

MW = molecular weight

Table A4. Particulates Collected By Acetone Washes

Burn	Sample	Front, g	Back, g	Corrected Front, g	Corrected Back, g
Blank	Blank	0.0003	0.0010	XXXXXXXX	XXXXXXXXX
Nozzle 2 Blank	Nozzle 2 Blank	0.0059	XXXXXXXX	XXXXXXXX	XXXXXXXXX
Nozzle 3 Blank	Nozzle 3 Blank	0.0089	XXXXXXXX	XXXXXXXX	XXXXXXXXX
1	A	0.3371	0.0587	0.3309	0.0577
	B	0.021	0.00398	0.0148	0.0029
	C	0.0242	0.0032	0.018	0.0022
2	A	0.0287	-0.0003	0.0225	-0.0013
	B	0.0214	0.0030	0.0152	0.0020
	C	0.0138	0.0027	0.0076	0.0017
3	A	0.0195	0.0036	0.0133	0.0026
	B	0.0228	0.0020	0.0226	0.0010
	C	0.0111	0.0003	0.0049	-0.0007
4	A	0.0206	0.0025	0.0144	0.0015
	B	0.0266	0.0062	0.0204	0.0052
	C	0.0111	0.0029	0.0049	0.0019
5	A	0.0476	0.0015	0.0414	0.0005
	B	0.0153	0.0048	0.0091	0.0038
	C	0.0228	0.0054	0.0166	0.0044
6	A	0.0115	0.0065	0.0053	0.0054
	B	0.0265	0.0003	0.0203	-0.0007
	C	0.0165	0.0031	0.0103	0.0021
7	A	0.0551	0.0014	0.0495	0.0004
	B	0.0116	0.003	0.0054	0.0020
	C	0.0267	0.022	0.0205	0.0210
8	A	0.0139	0.0136	0.0077	0.0126
	B	0.0038	0.0036	-0.0021	0.0026
	C	0.006	0.0023	-0.0032	0.0013
9	A	0.0235	-0.0009	0.0173	-0.0019
	B	0.0315	0.0002	0.0253	-0.0008
	C	0.0127	0.0002	0.0035	-0.0008

Table A5. Front-Half Particulates

Burn	Sample	Final Filter,g	Filter Tare,g	Net Filter,g	Acetone Corrected Front, g	Gas Sampled dscm	mg/dscm
1	A	1.38168	0.5960	0.78568	0.3309	0.9775	1142
	B	0.23771	0.2516	-0.01389	0.0148	1.0415	0.874
	C	0.63398	0.5999	0.03408	0.0180	1.2816	40.6
2	A	0.63695	0.6022	0.03475	0.0225	1.0794	53.0
	B	0.62078	0.6116	0.00918	0.0152	0.9925	24.6
	C	0.21666	0.2159	0.00076	0.0076	0.9217	9.1
3	A	0.61186	0.5980	0.01386	0.0133	1.1420	23.8
	B	0.61881	0.6022	0.01661	0.0226	1.0885	36.0
	C	0.20677	0.2161	-0.00933	0.0076	1.0036	1.7
4	A	0.6130	0.6000	0.0130	0.0144	0.9039	30.3
	B	0.6275	0.6030	0.0245	0.0204	1.0885	41.2
	C	0.6420	0.6027	0.0393	0.0049	0.8894	49.7
5	A	0.61662	0.5987	0.01792	0.0414	0.9976	59.5
	B	0.5992	0.5929	0.0063	0.0091	0.9713	15.9
	C	0.5975	0.5901	0.0074	0.0166	0.9070	26.5
6	A	0.6330	0.5903	0.0427	0.0053	1.1941	40.2
	B	0.5988	0.6006	0.0018	0.0203	0.8770	25.2

Table A5. Front-Half Particulates (continued)

Burn	Sample	Final Filter,g	Filter Tare,g	Net Filter, g	Acetone Corrected Front, g	Gas Sampled dscm	mg/ dscm
6	C	0.6197	0.6057	0.0140	0.0103	0.9763	24.9
7	A	0.61175	0.6000	0.0117	0.0495	0.9042	67.7
	B	0.59467	0.5886	0.0061	0.0054	0.9786	11.7
	C	XXXX	XXXX	XXXX	0.0205	0.8710	XXXX
8	A	0.59157	0.6008	-.0092	0.0077	0.9551	<1
	B	0.62141	0.5971	0.0243	0.000	0.9138	26.6
	C	0.62042	0.6096	0.0108	-0.0032	0.9432	8.1
9	A	0.6045	0.6103	-.0058	0.0173	0.9690	11.9
	B	0.6122	0.5934	0.0188	0.0253	0.9426	46.8
	C	0.6010	0.6025	-.0015	0.0035	0.9186	2.2

Notes: g = grams; mg = milligrams; dscm = dry standard cubic meter. Portions of filter for tests 1B and 3C separated and is included in the acetone wash. Test 7C no data (broken liner).

Table A6. Back-Half Particulates

Burn	Sample	Corrected Acetone, g	Organic TDS, g	Inorganic TDS, g	Gas Sampled dscm	mg/ dscm
1	A	0.0577	0.0069	0.0179	0.9775	84.4
	B	0.0029	<0.002	0.0090	1.0415	11.4
	C	0.0022	<0.002	0.0261	1.2816	22.0
2	A	-0.0013	<0.002	0.0116	1.0794	1.5
	B	0.0020	<0.002	0.0045	0.9925	6.5
	C	0.0017	0.0032	0.0084	0.9217	14.4
3	A	0.0026	<0.002	0.0123	1.1420	13.0
	B	0.0010	<0.002	0.0098	1.0885	9.9
	C	-0.0007	<0.002	0.0045	1.0036	4.5
4	A	0.0015	<0.002	0.0061	0.9039	8.4
4	B	0.0052	<0.002	0.0325	1.0885	34.6
	C	0.0019	0.0038	0.0226	0.8894	31.8
5	A	0.0005	<0.002	0.0165	0.9976	17.0
	B	0.0038	<0.002	0.0078	0.9713	11.9
	C	0.0044	0.0035	0.0063	0.9070	15.6
6	A	0.0054	<0.002	0.0242	1.1941	24.8
	B	-0.0007	<0.002	0.0192	0.8770	21.9
	C	0.0027	0.0034	0.0174	0.9763	24.1
7	A	0.0004	<0.002	0.0198	0.9042	22.3
	B	0.0020	<0.002	0.0064	0.9786	8.6
	C	0.0210	0.0048	0.0112	0.8710	42.5
8	A	0.0126	<0.002	0.0277	0.9551	41.6
	B	0.0026	<0.002	0.0098	0.9138	13.6
	C	0.0013	0.0039	0.0057	0.9432	11.6
9	A	-0.0019	<0.002	0.0141	0.9690	14.6
	B	-0.0008	<0.002	0.0099	0.9426	10.5
	C	-0.0008	0.0036	<0.002	0.9186	3.9
	Blank	0.0010	<0.002	<0.002	XXXXXX	XXXX

Note: Negative corrected acetone numbers counted as 0.0000.

Table A7. Hydrogen Chloride

Burn	Sample	Impinger 1, 2 chloride,mg	Impinger 3 chloride, mg	Gas Sampled, dscm	ppm HCl
blank	blank	0.04	0.23	XXXXXX	XXXXXXX
1	A	57.6	0.32	0.9775	50.0
	B	94.5	0.29	1.0415	61.5
	C	104.7	0.25	1.2816	55.3
2	A	161.8	0.32	1.0794	101.6
	B	26.7	0.30	0.9925	18.3
	C	36.5	0.26	0.9217	26.8
3	A	112.5	0.32	1.1420	66.8
	B	11.4	0.21	1.0885	6.8
	C	47.2	0.24	1.0036	31.8
4	A	91.5	0.25	0.9039	68.5
	B	9.6	0.10	1.0885	6.0
	C	16.7	0.28	0.8894	12.7
5	A	93.6	0.01	0.9976	63.5
	B	16.4	0.23	0.9713	11.4
	C	26.2	0.24	0.9070	19.5
6	A	78.6	0.40	1.1941	44.7
	B	15.0	0.24	0.8770	15.6
	C	15.2	0.26	0.9763	10.5

Table A7. Hydrogen Chloride (continued)

Burn	Sample	Impinger 1, 2 chloride,mg	Impinger 3 chloride, mg	Gas Sampled, dscm	ppm HCl
7	A	108.3	0.38	0.9042	81.2
	B	13.7	0.30	0.9786	9.5
	C	22.8	0.28	0.8710	17.7
8	A	95.0	0.01	0.9551	67.4
	B	5.7	0.22	0.9138	4.2
	C	8.3	0.23	0.9432	6.0
9	A	200.0	0.39	0.9690	139.9
	B	6.6	0.36	0.9426	4.8
	C	65.4	0.30	0.9186	48.3

Table A8. Mercury Sampling

Burn	Hg in Filters, HNO3, Rinses, mg	Hg in KMnO4 Impingers, mg	Gas Sampled, dscm	mg/dscm
Blank	0.000138	0.0024	None	XXXXXXXXXX
1	0.00133	0.0158	1.1845	0.0123
2	0.11739	0.0245	1.0401	0.1340
3	<0.0004	0.0011	1.0112	<0.001
4	0.00062	0.0009	0.8648	<0.001
5	0.11746	0.0094	1.0084	0.1233
6	0.19244	0.0086	1.0194	0.1985
7	0.0512	0.0092	0.8795	0.0658
8	0.00248	0.0011	0.8770	0.002
9	0.0973	0.0127	0.9146	0.1175

Table A9. Metals Sampling

Burn	Element	mg on Filter	mg Washes, Impinger	mg Corr.	Gas Sampled, dscm
1	Antimony	<0.025	<0.02	<0.02	1.1845
	Arsenic	<0.25	<0.02	<0.25	1.1845
	Beryllium	<0.0005	<0.0004	<0.0005	1.1845
	Cadmium	0.0020	0.0013	0.0026	1.1845
	Chromium	0.0088	0.0011	<0.001	1.1845
	Lead	0.029	0.0209	0.044	1.1845
	Manganese	0.0123	0.0056	<0.01	1.1845
	Mercury	<0.00014	0.00133	0.0012	1.1845
	Nickel	<0.005	0.018	0.0143	1.1845
	Thallium	<0.0125	<0.0006	<0.012	1.1845
	Zinc	0.0380	1.074	1.05	1.1845
2	Antimony	<0.025	<0.03	<0.03	1.0401
	Arsenic	<0.25	<0.03	<0.25	1.0401
	Beryllium	<0.0005	<0.0005	<0.0005	1.0401

Table A9. Metals Sampling (continued)

Burn	Element	mg on Filter	mg Washes, Impinger	mg Corr.	Gas Sampled, dscm
2	Cadmium	0.133	0.0259	0.1582	1.0401
	Chromium	0.0603	0.0096	0.0494	1.0401
	Lead	0.817	0.1619	0.972	1.0401
	Manganese	0.0275	0.01596	0.0166	1.0401
	Mercury	0.00169	0.1157	0.1173	1.0401
	Nickel	<0.005	0.075	0.0713	1.0401
	Thallium	<0.0125	<0.001	<0.013	1.0401
	Zinc	0.5063	0.2572	0.746	1.0401
3	Antimony	<0.025	<0.02	<0.02	1.0112
	Arsenic	<0.25	<0.02	<0.25	1.0112
	Beryllium	<0.0005	<0.0004	<0.0005	1.0112
	Cadmium	0.0008	0.00426	0.0036	1.0112
	Chromium	0.0188	0.0238	0.0221	1.0112
	Lead	0.005	0.02196	0.0207	1.0112
	Manganese	0.0265	0.1012	0.1009	1.0112
	Mercury	<0.00014	<0.0004		1.0112
	Nickel	<0.005	0.528	0.524	1.0112
	Thallium	<0.0125	<0.001	<0.01	1.0112
	Zinc	0.0315	0.0944	0.109	1.0112
4	Antimony	<0.025	<0.02	<0.025	0.8648
	Arsenic	<0.25	<0.02	<0.25	0.8648
	Beryllium	<0.0005	<0.0005	<0.0005	0.8648
	Cadmium	0.0019	0.00122	0.00246	0.8648
	Chromium	0.0233	0.0212	0.024	0.8648
	Lead	0.006	0.0094	0.009	0.8648
	Manganese	0.023	0.1328	0.129	0.8648
	Mercury	<0.00014	0.00062	0.00048	0.8648

Table A9. Metals Sampling (continued)

Burn	Element	mg on Filter	mg Washes, Impinger	mg Corr.	Gas Sampled, dscm
	Nickel	0.041	0.357	0.3943	0.8648
	Thallium	<0.0125	<0.001	<0.013	0.8648
4	Zinc	0.0398	0.1351	0.15794	0.8648
5	Antimony	<0.025	<0.03	<0.03	1.0084
	Arsenic	<0.25	<0.03	<0.25	1.0084
	Beryllium	<0.0005	<0.0005	<0.0005	1.0084
	Cadmium	0.0138	0.00812	0.02126	1.0084
	Chromium	0.1533	0.03155	0.1149	1.0084
	Lead	0.094	0.0625	0.15026	1.0084
	Manganese	0.0263	0.0425	0.042	1.0084
	Mercury	0.00329	0.11417	0.11732	1.0084
	Nickel	0.076	0.299	0.3713	1.0084
	Thallium	<0.0125	<0.001	<0.013	1.0084
	Zinc	0.1643	0.7591	0.90644	1.0084
6	Antimony	<0.025	0.053	0.053	1.0194
	Arsenic	<0.25	<0.025	<0.25	1.0194
	Beryllium	<0.0005	<0.0005	<0.0005	1.0194
	Cadmium	0.1433	0.02191	0.16455	1.0194
	Chromium	0.0413	0.01315	0.03395	1.0194
	Lead	0.639	0.1072	0.740	1.0194
	Manganese	0.0385	0.0261	0.0378	1.0194
	Mercury	0.00815	0.18429	0.1923	1.0194
	Nickel	0.017	0.2674	0.2807	1.0194
	Thallium	<0.0125	<0.001	<0.013	1.0194
	Zinc	1.2895	0.7398	2.0123	1.0194
7	Antimony	<0.025	<0.025	<0.025	0.8795
	Arsenic	<0.25	<0.025	<0.25	0.8795
	Beryllium	<0.0005	<0.0005	<0.0005	0.8795
	Cadmium	0.0085	0.00604	0.01388	0.8795

Table A9. Metals Sampling (continued)

Burn	Element	mg on Filter	mg Washes, Impinger	mg Corr.	Gas Sampled, dscm
	Chromium	0.010	0.0151	0.0046	0.8795
	Lead	0.107	0.0622	0.1630	0.8795
7	Manganese	0.0360	0.0469	0.0561	0.8795
	Mercury	<0.00014	0.0512	0.0511	0.8795
	Nickel	<0.005	0.2585	0.2548	0.8795
	Thallium	<0.0125	<0.001	<0.0125	0.8795
	Zinc	0.225	1.1037	1.3117	0.8795
8	Antimony	<0.025	<0.02	<0.025	0.8770
	Arsenic	<0.25	<0.024	<0.25	0.8770
	Beryllium	<0.0005	<0.0005	<0.0005	0.8770
	Cadmium	0.0043	0.0068	0.0104	0.8770
	Chromium	0.0183	0.0332	0.031	0.8770
	Lead	0.059	0.0685	0.12126	0.8770
	Manganese	0.0183	0.0754	0.0669	0.8770
	Mercury	<0.00014	0.00248	0.00234	0.8770
	Nickel	0.010	0.8562	0.8625	0.8770
	Thallium	<0.0125	<0.001	<0.0125	0.8770
	Zinc	0.0293	1.1929	1.2052	0.8770
9	Antimony	<0.025	<0.02	<0.025	0.9146
	Arsenic	<0.25	<0.02	<0.25	0.9146
	Beryllium	<0.0005	<0.0005	<0.0005	0.9146
	Cadmium	0.0545	0.0216	0.07544	0.9146
	Chromium	0.0185	0.0128	0.0108	0.9146
	Lead	0.397	0.1727	0.5635	0.9146
	Manganese	0.014	0.04692	0.03408	0.9146
	Mercury	<0.00014	0.097298	0.09716	0.9146
	Nickel	0.012	0.2439	0.2522	0.9146

Table A9. Metals Sampling (continued)

Burn	Element	mg on Filter	mg Washes, Impinger	mg Corr.	Gas Sampled, dscm
	Thallium	<0.0125	<0.001	<0.0125	0.9146
	Zinc	0.120	0.5077	0.6107	0.9146
Blank	Antimony	<0.025	<0.02	XXXXX	None
	Arsenic	<0.25	<0.02	XXXXX	None
Blank	Beryllium	<0.0005	<0.0004	XXXXXX	None
	Cadmium	<0.0001	0.00066	XXXXXX	None
	Chromium	0.0055	0.015	XXXXXX	None
	Lead	<0.0013	0.00624	XXXXXX	None
	Manganese	0.0070	0.01984	XXXXXX	None
	Mercury	<0.00014	0.000138	XXXXXX	None
	Nickel	<0.005	0.0037	XXXXXX	None
	Thallium	<0.0125	<0.001	XXXXXX	None
	Zinc	0.0163	0.00066	XXXXXX	None

Notes: mg. corr. = mg collected on filter plus washes and impingers minus blank; if blank is reported as less than some value, a zero value was assigned to the blank correction.

Table A10. Filter Weights After Drying In Oven at 550°C

Burn	Sample	Wt on Filter, g	Wt After Drying at 550°C, g	Fraction Lost
1	A	0.7923	0.3414	0.57
	B	ind.	ind.	ind.
	C	0.0329	0.0293	0.11
2	A	0.0346	0.0272	0.21
	B	0.0089	0.0050	0.44
	C	ind.	ind.	ind.
3	A	0.0115	0.0115	0.00
	B	0.0059	0.0045	0.24
	C	ind.	ind.	ind.
4	A	0.0345	0.00	1.0
	B	0.0241	0.0021	0.91
	C	ind.	ind.	ind.
5	A	0.0182	0.0135	0.26
	B	0.0059	0.0023	0.61
5	C	0.0049	0.0058	0.23
6	A	0.0405	0.0331	0.18
	B	ind.	ind.	ind.
	C	0.0139	0.0021	0.85
7	A	0.0122	0.0066	0.46
	B	0.0051	0.0036	0.29
8	A	0.0130	0.0031	0.76
	B	ind.	ind.	ind.
	C	0.0093	0.0083	0.11
9	A	0.0288	0.0256	0.11
	B	0.0168	0.0143	0.15
	C	ind.	ind.	ind.

Notes: After the tests were complete and filter weights measured as per EPA protocol, Entech requested WRI to heat the glass filters to 550°C to see whether there is any loss in weight.; ind. = insufficient material to obtain a definite weight from which a tare weight could be subtracted.

APPENDIX B

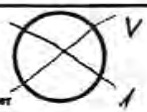
Field Data Sheets

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04/09/93
Burn Start Time 0840
Sampling For: metals/merc
Test No. Burn #1
Ambient Temperature Start 40 °F
Ambient Temperature End _____ °F
Barometric Pressure 30.13
Wind Conditions none
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type stainless/quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	~~Percent~~ CO_2 PPM

[redacted]

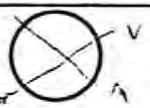
1300 NOX - 96 ppm

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04/07/93
Burn Start Time _____
Sampling For: Organics
Test No. Burn # 1
Ambient Temperature Start 35 °F
Ambient Temperature End _____ °F
Barometric Pressure 30.13
Wind Conditions lt. Breeze
Precipitation none

Sample Box No. [illegible]
Meter Box No. Anderson - Entech
Pitot Tube No. [illegible] WRI
Pitot Tube Coefficient 0.84
Probe Type Short
Probe Length [illegible] single
Nozzle 0.5"
Nozzle Diameter [illegible] 0.05
Filter No. _____
Heater Setting 250°F
Cryogenic Trap 4/14/93

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

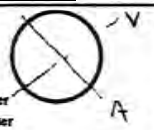
Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2
[redacted]													

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 042093
Burn Start Time 0540 SC 0523
Sampling For: [illegible] A
Test No. Burn #1 15 min [illegible] MSW + 2 tires
Ambient Temperature Start 35 °F
Ambient Temperature End ____ °F
Barometric Pressure 30.13
Wind Conditions Lt. Breeze
Precipitation none

Sample Box No. [illegible]
Meter Box No. WRF
Pitot Tube No. 1
Pitot Tube Coefficient 0.84
Probe Type stainless/quartz
Probe Length L
Nozzle 0.50"
Nozzle Diameter ____
Filter No. ____
Heater Setting 1 275°F

Leak Rate, cfm < 0.03
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2

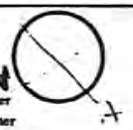
[redacted]

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 040093
Burn Start Time 0840
Sampling For: Particulates B
Test No. Burn #1
Ambient Temperature Start 47 °F
Ambient Temperature End _____ °F
Barometric Pressure 30.13
Wind Conditions 14 breeze
Precipitation none

Sample Box No. _____
Meter Box No. Anderson
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type _____
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°

Leak Rate, cfm L 0.15
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

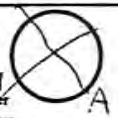
Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2
[redacted]													

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 042093
Burn Start Time 0840
Sampling For: Particulates C
Test No. Burn #1
Ambient Temperature Start 40 °F
Ambient Temperature End ____ °F
Barometric Pressure 30.13
Wind Conditions lt. breeze
Precipitation None

Sample Box No. ____
Meter Box No. WRI
Pitot Tube No. ____
Pitot Tube Coefficient 0.84
Probe Type stainless/quartz
Probe Length L
Nozzle ____
Nozzle Diameter 0.50"
Filter No. ____
Heater Setting 250°

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	~~Percent~~ CO_2 ppm
[redacted]													
												11.8	14
													9.14
												12.2	11

Temp 2000 hrs 45°F winds WNW Clear pressure 30.10 mm Hg falling
@ 9MPH

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04/27/93
Burn Start Time _____
Sampling For: merc/metals
Test No. Burn 2
Ambient Temperature Start 35 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.43
Wind Conditions Lt. Breeze
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient .84
Probe Type stainless/quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250° F

Leak Rate, cfm _____
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

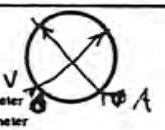
Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	ppm CO
[redacted]												4.0	12.6	17
												4.9	11.9	13
												5.6	11.4	12
												5.8	11.3	9
												6.6	10.7	6
												7.0	10.4	5
												6.9	10.4	4
												7.2	10.2	4
												7.4	10.1	3
												7.5	10.0	3
												7.8	9.8	2
												10.9	5.9	6

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 22 93
Burn Start Time _____
Sampling For: Organics
Test No. Burn 2
Ambient Temperature Start 31 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.93
Wind Conditions Lt Breeze
Precipitation none

Sample Box No. _____
Meter Box No. Andersen
Pitot Tube No. _____
Pitot Tube Coefficient _____
Probe Type Stainless / quartz
Probe Length 5
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250° F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2 (Teledyne)	Percent CO_2 (Teledyne)	CO ppm
[redacted]														
												4.6	12.2	22
												3.7	13.2	21
												3.9	12.7	21
												4.4	12.3	16
												5.4	11.5	11

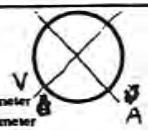
trap prepared 033193

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 23 93
Burn Start Time
Sampling For: Part A
Test No. Burn 2
Ambient Temperature Start 31 °F
Ambient Temperature End °F
Barometric Pressure 29.13
Wind Conditions None
Precipitation None

Sample Box No.
Meter Box No. WRI
Pitot Tube No.
Pitot Tube Coefficient 1.54
Probe Type Stainless/quartz
Probe Length L
Nozzle
Nozzle Diameter 0.5"
Filter No.
Heater Setting 250° F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Teledyne Percent O_2	Percent CO_2
[redacted]													
												[illegible]	
												2.7	13.2
												[illegible]	
												4.6	12.0
												1.5	
												2.5	
												3.8	

Teledyne

0513 Teledyne CO_2 13.7%
0546 13.2%, CO 58ppm, O_2 2.7%

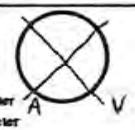
4tons incl 5 tires
many baby diapers

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 22 93
Burn Start Time 6:20 AM — 500 5AM
Sampling For: Fire B
Test No. Burn 2
Ambient Temperature Start 35 °F
Ambient Temperature End ____ °F
Barometric Pressure 29.93
Wind Conditions 14 Bxee
Precipitation None

Sample Box No. ____
Meter Box No. WRI
Pitot Tube No. ____
Pitot Tube Coefficient 0.84
Probe Type Stainless/Quartz
Probe Length L
Nozzle ____
Nozzle Diameter 0.5"
Filter No. ____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

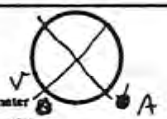
Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2 (Teledyne)	Percent CO_2	
[redacted]														
												4.0	12.6	16
												4.2	12.5	18
												4.5	12.2	11
												3.9	12.7	23
												3.8	12.8	27
												4.0	12.6	23
												3.8	12.8	22
												4.1	12.5	19
												4.0	12.6	22

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 22 93
Burn Start Time _____
Sampling For: Part. C
Test No. Burn 2
Ambient Temperature Start 49 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.93
Wind Conditions Breeze
Precipitation None

Sample Box No. _____
Meter Box No. Andersen
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type _____
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250° F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

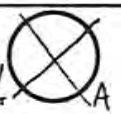
Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter. °F	Temp. Last Impinger °F	Percent O_2 (Teledyne)	Percent CO_2 (Teledyne)	CO PPM
[redacted]												7.2	10.2	3
												7.2	10.2	3
												7.4	10.1	3
												7.6	9.9	4
												7.7	9.9	2
												7.8	9.8	2
												4.4	12.9	2
												8.9	9.0	6
												10.1	8.1	5
												9.4	8.6	3
												9.6	8.4	3
												9.0	8.9	11
												9.9	8.2	10

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 011493
Burn Start Time _____
Sampling For: Metals/misc
Test No. Burn 3
Ambient Temperature Start 50 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.75
Wind Conditions lt Breeze
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type _____
Probe Length L
Nozzle _____
Nozzle Diameter 0.51"
Filter No. _____
Heater Setting 250°

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–	7.4	10.1	
											–			
											–	8.4	9.4	2
											–	11.6		0
											–	7.5	10	6
											–	7.3	10.5	14
											–	5.7	[redacted]	25
											–	7.6	NR	9
											–			
											–			
											–			
											–			

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 0 4 2 4 9 3
Burn Start Time
Sampling For: Organics
Test No. Burn 3
Ambient Temperature Start 46 °F
Ambient Temperature End °F
Barometric Pressure 29.75
Wind Conditions 11 Breeze
Precipitation None

Sample Box No.
Meter Box No. Intersin
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length
Nozzle
Nozzle Diameter 0.5"
Filter No.
Heater Setting 250°

Leak Rate, cfm < 0.00
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]									–	–	43	5.2	11.7	8
									–	–	42	4.5	12.3	10
									–	–	42	5.2	11.7	13
									–	–	46	6.5	10.8	16
									–	–	47	6.9	10.5	14
									–	–	50	6.9	10.4	6
									–	–	52			
									–	–	46	7.0	10.4	21
									–	–	48			
									–	–	53	[illegible]	[illegible]	84
									–	–	57	6.6	10.7	5
									–	–	60	11.9	6.7	5
									–	–				

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 1-13-93
Burn Start Time _____
Sampling For: Part. 4
Test No. Burn 3
Ambient Temperature Start 33 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.75
Wind Conditions lt. Breeze
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type stainless/quartz
Probe Length _____
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											—	~~1.2~~	~~14.6~~	~~73~~
											—	1.2	14.6	73
											—	1.7	14.3	47
											—	4.4	12.3	26
											—	5.2	11.7	13
											—	5.5	11.3	12
											—	6.0	11.2	10
											—	5.9	Not reading	9
											—	5.5	11.5	9
											—	5.7	11.1	12
											—	5.6	not reading	8
											—	5.8	11.7	10

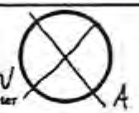
Andersen sampler is down. 0615 Andersen pump replaced & up 0830
At 0652 a breaker blew & we lost power. Need new fuse

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 042493
Burn Start Time _____
Sampling For: Pait. B
Test No. Burn 3
Ambient Temperature Start 40 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.75
Wind Conditions lt Breeze
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

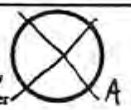
Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											—	6.3	10.9	14
											—	6.4	10.9	15
											—	6.8	10.6	13
											—	8.8		5
											—	9.5	8.9	9
											—	9.3	8.5	8
											—	10.8	7.8	6
											—	6.9	10.5	17
											—	6.6	11.1	11
											—	10.7	—	7
											—	8.7	8.5	
											—	[illegible]	8.9	2

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 04 93
Burn Start Time _____
Sampling For: Part C
Test No. Burn 3
Ambient Temperature Start 50 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.75
Wind Conditions lt. wind
Precipitation none

Sample Box No. _____
Meter Box No. Andersen
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless / quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												7.2	10.3	7
												7.3	NR	14
												7.0	NR	13
												11.1	NR	6
												6.7	10.5	10
												5.0	11.8	4
												5.7	11.4	50
												7.6	NR	9

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 26 93
Burn Start Time Tires
Sampling For: Metals/Hg
Test No. Run 4
Ambient Temperature Start 50 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.72
Wind Conditions None
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.51"
Filter No. _____
Heater Setting 250° F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

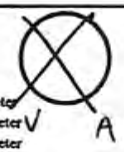
Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											—	6.9	11.0	18
											—	9.3	9.3	14
											—			
											—	10.0	NR	2
											—			
											—	9.4	9.1	9
											—			
											—	11.1	NR	2
											—			
											—	11.7	NR	0
											—	12.0	NR	0
											—	12.2	NR	0
											—			
											—			

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 26 93
Burn Start Time ~~[illegible]~~ 0524
Sampling For: Organics
Test No. Run 4
Ambient Temperature Start 38 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.72
Wind Conditions _____
Precipitation _____

Sample Box No. _____
Meter Box No. Andersen
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 5
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]									–	–	41	4.9	12.8	11
									–	–	41	6.7	NR	23
									–	–	45			
									–	–	49			
									–	–	48	8.1	NR	20
									–	–	49	7.4	NR	16
									–	–	54	7.3	NR	7
									–	–	47	7.9	NR	6
									–	–	49	7.5	10.6	22
									–		50	7.9	10.4	15
									–	–	50	6.9	11.0	18
									–	–	52	7.6	9.0	22
									–					
									–	–				

CO & O_2 dropped + CO shot up

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 042693
Burn Start Time 23 Times Secondary 5:51 primary 5:22AM
Sampling For: Part. A
Test No. Burn 4
Ambient Temperature Start 30 °F S
Ambient Temperature End _____ °F
Barometric Pressure 29.72 at 4:30 AM
Wind Conditions calm
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/Quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											—	11.0	7.9	13
											—	4.3	13.5	11
											—	3.0	14.3	30
											—	6.3	11.8	9
											—	8.3	NR	4
											—	5.2	12.6	10
											—	5.7	12.1	17
											—	5.2	12.5	10
											—	2.5	14.6	26
											—	1.0	15.8	30
											—	1.9	NR	48
											—	6.7	NR	24
											—			
											—			

0615 primary flame went out
0620 primary ignited again
0810 O_2 dropped & CO shot up.
0820 OK

moisture = 4.72%
103.5% of isokinetic

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 042693
Burn Start Time TIME 5
Sampling For: Run 6. B
Test No. Burn 4
Ambient Temperature Start 40 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.72
Wind Conditions none
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type _____
Probe Length 2
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–	5.7	12.2	25
											–	7.7	NR	17
											–	8.0	10.9	17
											–	7.3	10.5	23
											–	6.7	NR	5
											–	6.8	11.2	21
											–	7.3	NR	7
											–	7.5	10.7	13
											–	7.8	NR	8
											–	7.5	10.6	22
											–	8.3	NR	4
											–	7.9	10.4	15
											–			
											–			

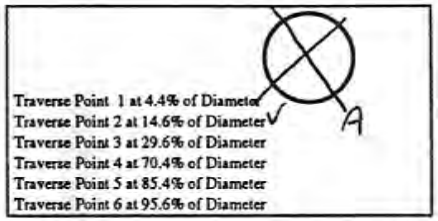
Moisture = 4.48%
Isokinetic = 103.7%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 26 93
Burn Start Time Turn
Sampling For: Part. C
Test No. Run 4
Ambient Temperature Start 50 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.72
Wind Conditions none
Precipitation none

Sample Box No. _____
Meter Box No. Freeze
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type stainless/quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]														
												11.2	NR	1
												12.1	NR	C
												12.1	NR	C
												12.4	NR	C
												[illegible]		[illegible]
												12.4	NR	C
												13.6	NR	C
												14.0	NR	C
												14.5	NR	C
												15.1	NR	C

[redacted] water 5.27%

% usable data = 94.6%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04/28/95
Burn Start Time secondary 0501 primary 0535
Sampling For: Merc./metals
Test No. Burn 5
Ambient Temperature Start 42 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.67
Wind Conditions Lt. Breeze
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–	8.1	NR	34
											–			
											–	8.1	NR	16
											–	4.4	11.7	28
											–	8.2	NR	22
											–	8.9	NR	16
											–			
											–	8.9	9.0	145
											–			
											–			
											–			
											–			
											–			
											–			

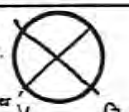
% of isokinetic = 99.9%
% water 10.35%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 042893
Burn Start Time Secondary 0501 Primary 0535
Sampling For: Organics
Test No. Burn 5
Ambient Temperature Start 46 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.97
Wind Conditions _____
Precipitation _____

Sample Box No. _____
Meter Box No. Anderson
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 5
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO PPM
[redacted]												12.2	NR	4
												12.1	NR	4
												9.2	8.7	16
												7.6	NR	11
												9.7	NR	5
												18.6	2.5	34
												3.7	NR	[illegible]
												7.8	9.5	40↑
												7.5	NR	38
												8.7	NR	43

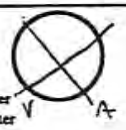
XAD resin was forced into the union before the 1st impinger.
Resin was washed back into trap with type II H_2O.
1100 secondary was accidently shut off but was back up within the minute
1136 Burped sending visible particulates out stack

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 6-22-93
Burn Start Time Secondary 0501 Primary 0535
Sampling For: Park. A
Test No. Burn 5
Ambient Temperature Start 40 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.67
Wind Conditions none
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle [illegible]
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]"



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												8.0	NR	NR
												10.4	NR	NR
												6.7	NR	NR
												6.5	10.6	15
												9.0	8.9	10
												7.3	10.2	15
												9.9	NR	4
												12.2	NR	4
												15.5	3.9	10
												12.0	NR	4
												9.2	8.7	10

1st two impingers foamy.

Traverse U26 was sampled too quickly – sampler had trouble remaining stable.

Percent Water = 12.7%

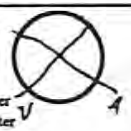
% of Isokinetic = 105.7%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 04 28 93
Burn Start Time secondary 0501 primary 0535
Sampling For: Part. B
Test No. Burn 5
Ambient Temperature Start 40 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.67
Wind Conditions Lt. Breze
Precipitation none

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/ quartz
Probe Length 6'
Nozzle _____
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–	7.6	NR	11
											–	7.9	9.6	22
											–	7.7	9.9	13
											–	10.3	7.9	18
											–	7.8	9.8	29
											–	7.5	9.9	37
											–			
											–	6.9	NR	25
											–	2.7	13.4	OFF scale
											–	3.7	12.6	120 ↑
											–			
											–	2.8	13.5	40

at 0902 CO went up around 150 ppm briefly. then down to 16.
at 1029 CO went up to ≈ 450 then down to 25 as a result of secondary being down ≈ 1 minute.
at 1046 CO went off scale and O_2 dropped to 2.7% at 1054 probe was pulled.
1126 Burped sending visible particulates out stack.

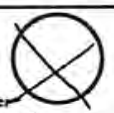
% water = 4.67%
% volumetric = 95.9%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 042893
Burn Start Time secondary 0501, [illegible]
Sampling For: Part. C
Test No. Burn 5
Ambient Temperature Start 40 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.67
Wind Conditions _____
Precipitation _____

Sample Box No. _____
Meter Box No. _____
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type _____
Probe Length _____
Nozzle _____
Nozzle Diameter 0.51"
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter ✓
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												6.5	16.7	950
												2.5	13.8	500
												9.6	NR	1130
												12.8	NR	1/8
												13.5	NR	22

1515 Air increased to secondary

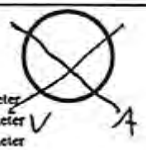
WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 043093
Burn Start Time
Sampling For: merc/metals
Test No. Burn 6
Ambient Temperature Start 45 °F
Ambient Temperature End °F
Barometric Pressure 29.76
Wind Conditions lt. Breeze to moderate
Precipitation none

lead primary 1355
17.5 primary 1350

Sample Box No.
Meter Box No. Anderson
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 6
Nozzle 2
Nozzle Diameter 0.5"
Filter No.
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]														
												8.2*		
												7.8*		
												5.2	11.6	56
												5.9	NR	6
												12.1	NR	6

meric 2000

% arctes = 11.0%
Isokinetic = 99.6%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 043093
Burn Start Time
Sampling For: Organics
Test No. Burn 6
Ambient Temperature Start 48 °F
Ambient Temperature End °F
Barometric Pressure 26.76
Wind Conditions Breeze
Precipitation None

Sample Box No.
Meter Box No. Andersen
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 5
Nozzle 3
Nozzle Diameter 0.511
Filter No.
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]														
												4.6	NR	48
												6.1	NR	162
												4.8	NR	33
												7.8	NR	5
												0.7	15.0	[illegible]
												2.8	13.8	[illegible]
												3.7	NR	11
												7.2	NR	46 ↓
												7.8	NR	9
												8.1	NR	12
												11.9	NR	5

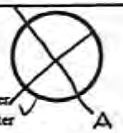
water = 2.03%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 043093
Burn Start Time Fire Primary 1350
Sampling For: Part. A
Test No. Burn 6
Ambient Temperature Start 45 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.76
Wind Conditions Lt Breeze to moderate
Precipitation None

Sample Box No. _____
Meter Box No. WRI Meter Correction, 250
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 2
Nozzle 1
Nozzle Diameter 0.54
Filter No. _____
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water .018	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											—			
											—			
											—			
											—			
											—			
											—			
											—	[redacted]		
											—	9.1		
											—			
											—	6.3	NR	12
											—	5.8	NR	6
											—	9.1	8.2	11
											—			
											—			

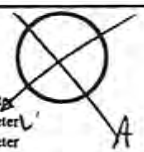
water = 4.61 %

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 043093
Burn Start Time
Sampling For: Part. B
Test No. Burn 6
Ambient Temperature Start ____ °F
Ambient Temperature End ____ °F
Barometric Pressure 29.76
Wind Conditions
Precipitation none

Sample Box No.
Meter Box No. WRI Meter 1,250
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type stainless/quartz
Probe Length 6
Nozzle
Nozzle Diameter 0.5"
Filter No.
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter °F	Temp. Outlet Dry Gas Meter °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CU
[redacted]											—	2.9	13.6	46
											—	5.6	NR	10
											—	6.0	NR	11
											—	6.4	NR	9
											—	9.5	NR	4
											—	1.8	14.8	87
											—	1.5	14.2	133
											—	5.3	11.5	56
											—	3.7	NR	11
											—	6.8	10.5	65
											—	7.5	NR	14
											—	7.9	NR	9
											—			
											—			

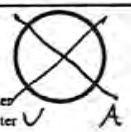
Water = 4.59%
Isokinetic = [redacted] 101%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 043093
Burn Start Time
Sampling For: Part. C
Test No. Burn 6
Ambient Temperature Start 40 °F
Ambient Temperature End °F
Barometric Pressure 29.50 (end of test)
Wind Conditions lt. Breeze
Precipitation none

Sample Box No.
Meter Box No. WRI
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 6
Nozzle 2
Nozzle Diameter 0.5"
Filter No.
Heater Setting 250°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–	6.3	11.1	47
											–	11.9	NR	5
											–	10.6	NR	2
											–	10.3	NR	2
											–			
											–			
											–	7.1	NR	16
											–	13.3	NR	6
											–	8.7	NR	1
											–	[illegible]	[illegible]	6
											–			
											–			
											–			
											–			

Water = 7.25%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050493
Burn Start Time
Sampling For: Metals/merc
Test No. Burn #7
Ambient Temperature Start 42 °F
Ambient Temperature End °F
Barometric Pressure 29.39
Wind Conditions H. Breeze
Precipitation None

Sample Box No.
Meter Box No. WES
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 2
Nozzle Diameter 0.5"
Filter No.
Heater Setting 250°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–	10.4		5
											–			
											–			
											–			
											–		4.5 unrecd	
											–			
											–			
											–		5.9 unrecd	
											–		6.5 unrecd	
											–		5.9 unrecd	
											–	8.0 recovered	3.5 unrecd 8	
											–		6.7 unrecd	
											–			
											–			

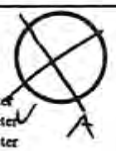
Water = 8.08%
Isokinetic = 108%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050493
Burn Start Time
Sampling For: Organics
Test No. Burn #7
Ambient Temperature Start 35 °F
Ambient Temperature End °F
Barometric Pressure 29.39
Wind Conditions calm
Precipitation none

Sample Box No.
Meter Box No. Andersen
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 5
Nozzle 3
Nozzle Diameter 0.5"
Filter No. 0.6004
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]														
												8.5	9.2	21
												10.3		12
												10.4	NR	3

Re-checked for leak at USI.

Isokinetic = 106 %
Moisture = 1 %

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 05048
Burn Start Time 0524 ~~Secondary~~ Primary
Sampling For: Part. A
Test No. Burn #7
Ambient Temperature Start 35 °F
Ambient Temperature End 40 °F
Barometric Pressure 29.39
Wind Conditions Lt. Breeze
Precipitation none

Sample Box No.
Meter Box No. WRI
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 6
Nozzle 2
Nozzle Diameter 0.5"
Filter No. 0.6000 Tared Wt.
Heater Setting 250° F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter °F	Temp. Outlet Dry Gas Meter °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2
[redacted]											–		
											–		
											–		
											–		
											–		
											–		
											–		
											–	10.4 Enerac	
											–		
											–		
											–		
											–		

CO ppm

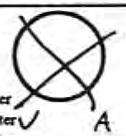
Water = 9.47%
Isokinetic = 104%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050493
Burn Start Time
Sampling For: Part. B
Test No. Burn #7
Ambient Temperature Start ____ °F
Ambient Temperature End ____ °F
Barometric Pressure 29.39
Wind Conditions
Precipitation none

Sample Box No.
Meter Box No. WRI
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 1
Nozzle Diameter 0.5"
Filter No. 0.5886
Heater Setting 250° F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter ✓
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–			
											–			
											–	7.8	9.7	7
											–	6.7	NR	1
											–	5.3	11.4	20
											–			
											–			
											–			
											–			
											–	4.3	NR	18
											–			
											–	4.2	NR	10
											–			
											–			

Teledyne

0700 Filter oven not heating, switched boxes + re-checked system for leaks.

Water = 2.01%
Isokinetic = 102%

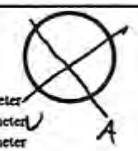
.20

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 05/04/93
Burn Start Time
Sampling For: Part. C
Test No. Burn #7
Ambient Temperature Start 42 °F
Ambient Temperature End °F
Barometric Pressure ~~29.39~~ 29.29 end
Wind Conditions Lt. Breeze
Precipitation None

Sample Box No.
Meter Box No. Andersen
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 1
Nozzle Diameter 0.5"
Filter No. ~~0.59~~ 0.5957
Heater Setting 250°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]													4.7 average	
													6.0 average	
													6.5 average	
													5.2 average	
													5.2 average	
													6.6 average	
													6.4 average	
													6.5 average	
													7.6 average	
													5.7 average	
													5.3 average	
													6.6 average	
0460	1642	1643	879.5	879.71	3	1611		0.09	59	50	48		out	

quartz liner broken at end of test
Invalidate test.

water = 2.8%
Isokinetic = 99.5%

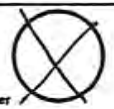
60

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050693
Burn Start Time
Sampling For: Metals/merc
Test No. Burn #8
Ambient Temperature Start 40 °F
Ambient Temperature End °F
Barometric Pressure 29.40
Wind Conditions Breezy - windy
Precipitation none

Sample Box No.
Meter Box No. WRI
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 2
Nozzle Diameter 0.5"
Filter No.
Heater Setting 250°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

A

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												11.6T	4.7A NRT	5T
												6.9T	5.0A 10.6T	11T
												6.2T	11.0T 5.2A	15T
												8.6T	NRT 5.8A	13T
												6.3T	NRT 5.5A	20T
												6.7T	4.5A 10.4T	14T
												11.0T	4.0A 7.3T	4T
												7.0T	4.9A NRT	13T
												8.0T	3.1A	10T
												7.2T	7.7T 2.8A	9T
												11.5T	2.8A NRT	4T

Sampled 30.93 std cubic feet
Water = 7.6%

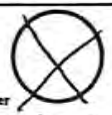
Isokinetic = 102%

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050693 iced/kraft6/01
Burn Start Time [illegible] Priming
Sampling For: organics
Test No. Burn #8
Ambient Temperature Start 37 °F
Ambient Temperature End ____ °F
Barometric Pressure 29.40 mm Hg.
Wind Conditions very light (<5 mph) from SE
Precipitation [illegible] 1330 1330

Sample Box No. ____
Meter Box No. Anderson
Pitot Tube No. ____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 5
Nozzle 3
Nozzle Diameter 0.5"
Filter No. ____
Heater Setting 250°F - 300°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

A

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											-	7.4 T	10.2 T 3.9 A	21 T
											-	10.8 T	7.5 T 3.9 A	12 T
											-	9.6 T	7.3 T	14 T
											-	12.0 T	6.2 T 6.4 T	6 T
											-		[illegible]	
											-	7.0 T	NR T 5.7 A	6 T
											-	14.4 T	4.8 T 3.9 A	7 T
											-	13.4 T	4.0 A NR T	2 T
											-	7.8 T	3.3 NR T	4 T
											-	12.3 T	6.4 T 5.6 A	9 T
											-	12.0 T	6.7 T 4.3 A	13 T
											-	6.9 T	5.0 A 10.8 T	11 T

Sampled 55.00 std cubic feet (dry)
Water = 1.2%
Isokinetic = 101%

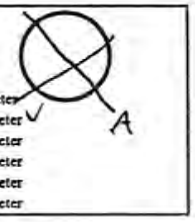
Teledyne Ambient 0900 O_2 = 21.4 CO = Ø CO_2 = NR

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050693
Burn Start Time 0825 Primary
Sampling For: Park A
Test No. Burn # 8
Ambient Temperature Start 39 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.40
Wind Conditions None
Precipitation None

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 2
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting ~~250°F~~ 300° F-350°

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter ✓
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												Teledyne 2.5	Teledyne 13.7	Teledyne 47
												4.7T*	12.6T*	21T*
												10.0T	7.6T	2T
												11.8T	7.0T 3.2A	12T
												8.8T	8.5T 5.3A	5T
												5.3T	11.9T 6.0A	7T
												8.0T	9.5T 4.2A	11T
													3.6A	
												11.4T	7.2T 3.7A	9T
												11.2T	7.4T 4.0A	11T
												2.6T	13.6T 4.6A	37T
												10.4T	6.2T 4.8A	12

1616 lost power for 1min - power was intermitent for next 5 min. estimated off line ≈ 2min.
810 cubic feet of rakized gas used for burn A

* T = Teledyne unit
A = Anarad unit

Sampled 33.7 l dry SCFT
Percent Water = 10.1%
Isokinetic = 110%

0.231

63

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050693
Burn Start Time 0825 Primary
Sampling For: Particulates B
Test No. Burn # 8
Ambient Temperature Start 43 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.40
Wind Conditions ~~[illegible]~~ Lt. Breeze from NW
Precipitation ~~none~~ min 1320 - 1330

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 2
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 250°F - 300°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												11.0 T	6.0 A 7.3 T	8 T
												7.1 T	6.3 A NRT	6 T
												11.9 T	5.3 A NRT	5 T
												8.0 T	5.2 A 9.9 T	7 T
												6.8 T	10.6 T 5.1 A	10 T
												12.7 T	NRT 3.7 A	3 T
												13.2 T	4.2 A NRT	2 T
												8.2 T	9.5 T 3.7 A	9 T
												11.9 T	2.1 A NRT	11 T
												12.3 T	6.4 T 3.6 A	9 T

lost power from 11:50:00 - 11:50:33 approx.

A = analyzed unit
T = Teledyne unit

Sampled 32.23 dry SF.
Water = 8.88%
Isokinetic = 107%

1320 It started raining until 1330

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050693
Burn Start Time 0835 primary
Sampling For: Part. C
Test No. Burn #9
Ambient Temperature Start 42 °F
Ambient Temperature End ____ °F
Barometric Pressure 29.40
Wind Conditions wind 15-20 mph SE
Precipitation none

Sample Box No. ____
Meter Box No. Anderson
Pitot Tube No. ____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 5
Nozzle 3
Nozzle Diameter 0.5"
Filter No. ____
Heater Setting 250°F - 350°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter ✓
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											—	11.0T	4.0A 7.3T	14
											—	7.0T	NRT 4.9A	13T
											—	8.0T	3.1A NRT	10T
											—	13.7T	4.2A NRT	5T
											—	8.5	3.4A NRT	4T
											—	7.4T	NRT NRA	6T
											—	6.0T	10.8T	20T
											—	7.9T	NRA NRT	13T
											—	9.8T	NRA NRT	5T
											—	12.5T	12.9T	3T
											—	11.4T 4.3T	NRT	4T
											—	12.5T	NRT	3T

A = Anaard unit
T = Teledyne unit

Sampled 33.26 dry SCF
Water = 1.13%
Isokinetic = 97%

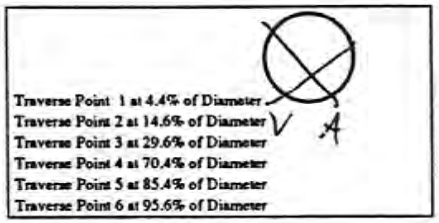
wind gusts to ≈ 15 on pitot tube

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050893
Burn Start Time
Sampling For: merc/metals
Test No. Burn # 9
Ambient Temperature Start 45 °F
Ambient Temperature End 50 °F
Barometric Pressure 29.80
Wind Conditions lt. Breeze NW
Precipitation none

Sample Box No. WRI (Green)
Meter Box No. WRI
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type stainless/quartz
Probe Length L
Nozzle 2
Nozzle Diameter 0.5"
Filter No.
Heater Setting 300-350°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]



Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												5.7T	11.3T	12T
												6.5T	10.7T	22T
												6.8T	10.6T	18T
												6.9T	10.5T	17T
												7.3T	10.2T	21T
												7.5T	10.0T	17T
												7.8T	9.8T	13T
												7.6T	10.0T	9T
												8.2T	9.2T	14T
												10.0	NRT	7

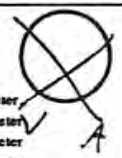
Sampled 31.90 cubic feet (dry) in 144 minutes

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050893
Burn Start Time _____
Sampling For: Organics
Test No. Burn # 9
Ambient Temperature Start 40 °F
Ambient Temperature End 50 °F
Barometric Pressure 29.60
Wind Conditions Slight breeze
Precipitation none

Sample Box No. _____
Meter Box No. Andersen
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 3
Nozzle 3
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 300-350°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]



Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											–	6.2 T	11.1 T	21 T
											–	5.0 T	12.0 T	7 T
											–	8.7 T	9.3 T	13 T
											–	13.6 T	N/C T	5 T
											–			
											–			
											–			
											–	6.4 T	11.0	CC-16
											–	6.1 T	11.1 T	13
											–	6.2 T	11.0 T	12
											–	5.0 T	11.9 T	10 T
											–	6.4 T	10.8 T	18 T
											–			
											–			

T = Teledyne unit

Sampled 53.5 dry ft cube feet [illegible]

Ambient teledyne 21.1% O2, 3 ppm CO

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050893
Burn Start Time 0507 Primary — Autoclef
Sampling For: Part. A
Test No. Burn # 9
Ambient Temperature Start 36 °F
Ambient Temperature End ____ °F
Barometric Pressure 29.80 R
Wind Conditions slight breeze
Precipitation none

Sample Box No. ____
Meter Box No. WRI
Pitot Tube No. ____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 2
Nozzle Diameter 0.5"
Filter No. ____
Heater Setting 300 - 350°F

Leak Rate, cfm < 0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]												8.7 T	9.0 T	
												~~12.4 T~~	~~6.9 T~~	10 T
												5.8 T	11.3 T	81 T
												5.1 T	11.9 T	82 T
												3.6 T	12.9 T	30 T
												5.2 T	11.7 T	18 T
												5.1 T	11.6 T	24 T
												7.0 T	10.3 T	25 T
												5.9 T	11.2 T	7 T
												6.3 T	10.9 T	14 T
												5.0 T	10.6 T	7 T
												4.1 T	12.6 T	35 T
												8.7	9.3 T	13 T

T = teledyne

Sampled 34.30 st. cubic feet (dry) in 144 minutes

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050893
Burn Start Time _____
Sampling For: Part. B
Test No. Burn #9
Ambient Temperature Start 41 °F
Ambient Temperature End _____ °F
Barometric Pressure 29.80
Wind Conditions 1-. Breeze
Precipitation None

Sample Box No. _____
Meter Box No. WRI
Pitot Tube No. _____
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length L
Nozzle 2
Nozzle Diameter 0.5"
Filter No. _____
Heater Setting 300 - 350° F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in. of water	Temp. Inlet Dry Gas Meter, °F	Temp. Outlet Dry Gas Meter, °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]														
												T 5.8%	T 11.1%	CO=22
												6.2T	11.1T	13T
												6.5T	10.7T	19T
												6.3T	10.9	13T

Sampled 33.69 cubic feet @ 144 grams (dry)

WRI EPA METHOD 5 SAMPLING FOR ENTECH, INC

Location: Anchorage, Alaska
Date: 050893
Burn Start Time
Sampling For: Part. C
Test No. Burn #9
Ambient Temperature Start 47 °F
Ambient Temperature End °F
Barometric Pressure ~~30.00~~ 29.84
Wind Conditions lt. Breeze
Precipitation None

Sample Box No.
Meter Box No. Andersen
Pitot Tube No.
Pitot Tube Coefficient 0.84
Probe Type Stainless/quartz
Probe Length 5
Nozzle 3
Nozzle Diameter 0.5"
Filter No.
Heater Setting 300 - 350°F

Leak Rate, cfm <0.02
Stack Inside Diameter [redacted]

Traverse Point 1 at 4.4% of Diameter
Traverse Point 2 at 14.6% of Diameter
Traverse Point 3 at 29.6% of Diameter
Traverse Point 4 at 70.4% of Diameter
Traverse Point 5 at 85.4% of Diameter
Traverse Point 6 at 95.6% of Diameter

Traverse Point Number	Sampling Time Start	Sampling Time End	Gas Meter Start	Gas Meter End	Vacuum mm Hg	Stack Temp. °F	Pitot Tube ΔP, in of water	ΔP across orifice meter in of water	Temp. Inlet Dry Gas Meter °F	Temp. Outlet Dry Gas Meter °F	Temp. Last Impinger °F	Percent O_2	Percent CO_2	CO ppm
[redacted]											—	7.4 T	10.1 T	9 T
											—	7.8 T	9.8 T	14 T
											—	9.6 T	8.1 T	10 T
											—	7.6 T	10.0	11 T
											—	8.2 T	9.2 T	14 T
											—	8.3 T	NR T	5 T
											—			
											—	8.5 T	9.2 T	7 T
											—	14.4 T	5.1	6 T
											—	11.8 T	NR T	3 T
											—	12.5	NR T	2 T
											—	12.5	NR T	2 T

Sampled 32.04 st cubic feet (dry) in 144 minutes.

APPENDIX C

Puget Sound Air Pollution Control Agency Methods

Particulate Source Test Procedures

Adopted by Puget Sound Air Pollution Control Agency
Board of Directors

August 11, 1983

Engineering Division

Puget Sound Air Pollution Control Agency

200 West Mercer Street, Room 205

P.O. Box 9863

Seattle, Washington 98109

August 11, 1983

AIR POLLUTION SAMPLING PROCEDURES

Air pollution sampling to meet requirements of Puget Sound Air Pollution Control Agency must be coordinated with this Agency in order to allow communication and observation by the Agency representative. Three to five days is normally required to arrange for Agency personnel to observe the source test observation during sample periods for compliance purposes.

SOURCE SAMPLING REPORT FORMAT

Reports of source emission testing submitted to this Agency must include information as specified in the attached enclosure. This format will insure all pertinent information will be included in the report since much of the information may be unavailable after the testing is complete. Test reports failing to comply with these procedures will be subject to rejection as inadequate.

The intent of this criteria is to establish a uniform basis of information for evaluating source compliance. If you have any questions concerning the information the report must contain, please contact Fred Austin or Jim Nolan at (206) 296-7435.

Very truly yours,

Fredrick L. Austin
Air Pollution Source Analyst - I

FLA:am

Enclosure
C:(ENFORCE)FLAPROC.DOC

SOURCE TEST GUIDELINES

1. An owner shall, within thirty (30) days (unless otherwise stated) of plant equipment start-up, perform a source test(s) at owners expense, to demonstrate to the satisfaction of the Control Officer that the emissions from the air pollution generating equipment are in compliance with all the standards of Regulation I and II or conditions of orders of the Control Officer or Board of Directors.

2. Test methods and procedures for the stack sampling and analysis shall comply with those set forth by Section 9.09 of Regulation I. Sampling shall be performed so as to obtain a representative sample(s) of major emission points. An Agency representative may audit the test at any time. The samples shall be taken over such a period or periods as are necessary to accurately determine the maximum emissions which occur while the equipment is operating at or above the rated capacity of the equipment. The operating conditions of the equipment shall be determined by the levels existing during the passing compliance source test.

3. A written report shall be submitted within thirty (30) days (unless otherwise stated) of the test which includes: (a) detailed information on testing and test calculations, (b) records of the plant operation; and (c) other information pertinent to the test. The attachments show the information required for an acceptable source test report.

4. Any question about any provision of this stipulation shall be decided by the Control Officer. Failure of the owners to perform any provision of an order issued by the Control Officer or Board of Directors of the Puget Sound Air Pollution Control Agency will be subject to appropriate legal action by the Agency.

5. The Agency shall be notified two weeks in advance of any source test. Any questions concerning such test shall be resolved before the test is conducted.

(6/9/88)
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SOURCE TEST POLICY

Puget Sound Air Pollution Control Agency requires air pollution source emissions to be characterized and evaluated for compliance with Agency regulations and standards. If an emission test or instrument certification test is required, the test must meet all applicable reference methods. When a compliance test is preformed it must be conducted by an independent, unbiased, technically qualified test team who has preformed acceptable tests of comparable nature and has demonstrated to the Agency's satisfaction their ability to conduct a compliance test. All tests must be conducted in such a manner, as to provide valid scientifically defensible results using acceptable reference methods which accurately represent conditions during normal or stated operational periods of the air pollution generating, controlling or measuring system. The Agency requires sufficient time for engineering review and acceptance of submitted test plans and prior notification for field tests (usually two weeks). The Agency reserves the right to witness any and all portions of the test. The source test report must be submitted by the test firm to the responsible party for review and acceptance. This source test report and any additional required information must than be submitted, by the responsible party, to the Agency for final approval. Any deviations from Agency requirements or acceptable testing techniques may void the test. Acceptable techniques and procedures are on file with the Agency and are available upon request.

(6/9/88)
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A. Source Identification

1. Plant name and location.
2. Source equipment sampled.
3. Testing company or agency, name and address.

B. Certification

1. Certification by team leader.
2. Certification by reviewer (e.g., P.E.).

C. Introduction

1. Test purpose.
2. Test location, type of process.
3. Test dates.
4. Pollutants tested.
5. Observers' name from this Agency.
6. Any other important background information.

D. Summary of Results

1. Raw field data sheets signed by source test team leaders.
2. Emission results in appropriate units.
3. Process data, as related to determination of compliance.
4. Discussion of sources of errors and quality assurance procedures.

E. Source Operation

1. Description of process production level and control devices.
2. Process and control equipment flow diagram if complex process.
3. Process and control device operating parameters during the test, including comparison to normal operation if different.
4. Representativeness of raw materials and products during the test as compared to normal operation.
5. Process start-ups, shutdowns, and other operational changes during tests (time of start and stop).
6. Description, analysis and representativeness of fuels.

F. Sampling and Analysis Procedures

1. Sampling port location and dimension cross-sectioned.
2. Sampling point description, including labeling system.
3. Sampling train description.
4. Brief description of sampling procedures, with discussion of deviations from standard methods.
5. Brief description of analytical procedures, with discussion of deviations from standard methods.

(12/12/84)
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G. Appendix

1. Complete results with example calculations.
2. Raw field data signed by source test team leader.
3. Laboratory report signed by analyst.
4. Chain of custody if specified by this Agency.
5. Raw production data, signed by plant official.
6. Calibration and quality assurance procedures and results.
7. Project participants and titles.
8. Related correspondence.
9. Procedures used for analysis.
10. Photos of the test location if requested.

(12/12/84)
C:(ENFORCE)STOTLINE.DOC

SOURCE SAMPLING REPORT FORMAT

Results of the performance test shall be submitted to the Agency by the facility representative within thirty (30) days of the completion of the field work (unless otherwise stated). The report must include, but not limited to, the following:

1. Information is shown in the SOURCE TEST REPORT OUTLINE.
2. Certification by the test team leader that the sampling and analytical procedures, and data presented in the report are authentic and accurate.
3. Certification by a responsible representative of the testing firm (preferably by a professional engineer) that all the testing details and conclusions are accurate and valid.
4. Certification on the process rate sheet by the facility representative of facility operations during the performance test. (See Item 10 below and Sections E.3-5 in SOURCE TEST REPORT OUTLINE).
5. Data sheets should have all applicable blanks filled in.
6. Verification of source test observation by Agency personnel during sample collection.
7. Incorporation of Agency approved methodology for source sampling procedures and analysis where appropriate.
8. All calculations must be made using the applicable equations as shown in the Federal Register. An example calculation should be shown for one run.
9. Final results must be presented in English and metric units, if appropriate, and contain two significant digits for each run. Values may be rounded to three significant digits for the final results or all digits may be carried in the computer and only rounded to two significant digits for the final results. All rounding of numbers will be performed in accordance with the ASTM 380 procedures.
10. The detail of Section E.3 and E.4 (SOURCE TEST REPORT OUTLINE) must be sufficient to document how the process and control device was operating during the test. This must include items such as production rate, type of raw material, fuel and products and characterization of the gas stream to the control device. Critical control device parameters must also be reported such as pressure drop, flow rates, make-up water rates, recycle water solids content for scrubbers; voltages, currents, spark rates, and rapping cycle times for electrostatic precipitators; pressure drop and cleaning cycles for baghouses.
11. The quality assurance procedures discussed in Item G.6. (SOURCE TEST REPORT OUTLINE) refer to the Quality Assurance Handbook, Vol III, Station Source Specific Methods (EPA 600/4-77-027b).

(12/12/84)

Unless otherwise authorized by the Control Officer, all particulate source sampling performed to demonstrate compliance with the emission standards of Regulation I shall be done using current Environmental Protection Agency Methods 1-5 contained in 40 CFR Part 60, Appendix A, as modified in Section II of this document.

II. Procedure for Determining Particulate Matter in the Impinger Catch (Back Half)

The analysis and calculations for Method 5 shall conform to that described by EPA in the current 40 CFR Part 60, Appendix A, except that the back half catch shall be included as particulate matter. The back half weight is the sum of the impinger catch (organic and inorganic) and the back half acetone rinse weights.

A. Sample Recovery of the Back Half

1. Purging

Whenever SO_2 interference is suspected, purge the impingers immediately after the test run is complete with N_2 or clean air for a minimum of one-half the sample volume.

2. Impinger Liquid

Measure the volume of water collected in all impingers and place the water from the first three impingers in a container. Thoroughly rinse all sample-exposed surfaces between the filter and fourth impinger with water and place in above container.

3. Acetone Rinse

Thoroughly rinse all sample-exposed surfaces between the filter and the fourth impinger with acetone and place the washings in a tared beaker to dry.

B. Analysis of the Back Half

1. Impinger Liquid Extraction

a. Add 50-100 mℓ of dichloromethane to the impinger liquid.

b. Spin for at least ten minutes.

c. Pour the liquid into a separatory funnel and drain the organic phase into a tared beaker (organic fraction).

d. Drain the remaining liquid into a beaker and repeat Steps a, b, and c. Perform the extraction several times with fresh dichloromethane until the organic fraction is clear. Keep each organic extraction in a separate beaker.

e. Following the last extraction, drain the remaining liquid from the separatory funnel into a tared beaker (inorganic fraction).

f. Allow the organic fraction beakers to dry under a hood at room temperature.

g. Evaporate the inorganic fraction in such a manner that the beaker contents do not become exposed to temperatures greater than 212° F.

h. Dry weighed beakers containing a sample of the dichloromethane and a sample of distilled deionized water to check for blank weight.

i. Desiccate organic, inorganic and blank beakers for at least 24 hours at room temperature in a desiccator containing silica gel. Weigh to a constant weight and report the results to the nearest 0.1 mg.

2. <u>Back Half Acetone Rinse</u>

a. Dry the acetone rinse in a hood at room temperature.

b. Desiccate and weigh the beaker to constant weight and record.

HYDROCHLORIC ACID

SOURCE SAMPLING PROCEDURES

ADOPTED BY PUGET SOUND AIR POLLUTION CONTROL AGENCY

BOARD OF DIRECTORS

JUNE 1988

COMPLIANCE DIVISION

Puget Sound Air Pollution Control Agency
200 West Mercer Street
Seattle, Washington 98119-3958

(6/9/88)
C:(ENFORCE)FLA1-7A.DOC

I. Introduction

Puget Sound Air Pollution Control Agency Regulation I, Section 9.10 restricts the emissions of hydrochloric acid gases. Compliance with the limits contained in this regulation shall be determined using the following procedures adopted by the Board, unless an alternate procedure is approved in writing by the Control Officer.

II. Source Sampling Procedures

All hydrochloric acid (HCL) analysis of the impinger solution will follow the current Environmental Protection Agency Test Method, The Determination of Inorganic Anions in Water by Ion Chromatography - Method 300.00 (copy attached), or such alternate procedures approved in writing by the Control Officer.

All hydrochloric acid (HCL) sampling performed to demonstrate compliance with the emission standards of Regulation I shall conform to the current Particulate Source Test Procedures with the following modifications:

A. Use a quartz or borosilicate glass liner to sample the stack emissions in the presence of condensed corrosive acids.

B. Use 100 ml of eluent solution in the third impinger which shall contain 30mM sodium bicarbonate ($NaHco_3$) and 24 mM sodium carbonate (Na_2CO_3)

C. A blank impinger may be used between the third impinger and the dessicant impinger to protect the indicator silica gel from becoming saturated. If the dessicant becomes saturated, the test is void.

D. The first two impinger liquid solutions are analyzed separately for particulate and will follow the Particulate Source Test Procedure, except each impinger filled with distilled-deionized (DI) water shall have an appropriate sized aliquot processed separately for HCL.

E. The collected water in the eluent solution, blank impinger and dessicant will not be processed for particulate. This collected water will be considered to contain the same concentration of particulate as found in the second water impinger.

Agency acceptance of the results from this testing method will be restricted to analysts demonstrating acceptable expertise in sampling and analytical quality control.
(6/9/88)
C:(ENFORCE)FLA1-7A.DOC

United States
Environmental Protection
Agency

Environmental Monitoring and
Support Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/4-84-017 Mar 1984

EPA

APPROVED BY EPA FOR CHLORIDE, NITRATE AND SULFATE ANALYSIS IN DRINKING WATER

Test Method
The Determination of Inorganic Anions in Water by Ion Chromatography — Method 300.0

James W. O'Dell, John D. Pfaff, Morris E. Gales, and Gerald D. McKee

RECEIVED
FEB 2 1988
PUGET SOUND AIR POLLUTION
CONTROL AGENCY

1. Scope and Application

1.1 This method covers the determination of the following inorganic anions

Analyte	Storet No Total	Dissolved
Chloride	00940	—
Fluoride	00951	00950
Nitrate-N	00620	—
Nitrite-N	00615	—
Ortho-Phosphate-P	—	00671
Sulfate	00945	—

1.2 This is an ion chromatographic (IC) method applicable to the determination of the anions listed above in drinking water, surface water, and mixed domestic and industrial wastewater

1.3 The Method Detection Limit (MDL, defined in Section 13) for the above analytes is listed in Table 1. The MDL for a specific matrix may differ from those listed depending upon the nature of the sample

1.4 This method is restricted to use by or under the supervision of analysts experienced in the use of ion chromatography and in the interpretation of the resulting ion chromatogram Each analyst must demonstrate the ability to generate acceptable results with this method, using the procedure described in Section 10 2

1.5 When this method is used to analyze unfamiliar samples for any of the above anions, anion identification should be supported by the addition of spike solutions covering the anions of interest The spike procedure is described in Section 11 6

2. Summary of Method

2.1 A small volume of sample, typically 2 to 3 mL, is introduced into an ion chromatograph The anions of interest are separated and measured, using a system comprised of a guard column, separator column, suppressor column, and conductivity detector

3. Definitions

3.1 Stock standard solution — a concentrated solution containing a certified standard that is a method analyte. Stock standard solutions are used to prepare secondary standard solutions.

3.2 Calibration standards — a solution of analytes prepared in the laboratory from stock standard solutions and diluted as needed to prepare aqueous calibration solutions

3.3 Quality control check sample — a solution containing known concentrations of analytes, prepared by a laboratory other than the laboratory performing the analysis The analyzing laboratory uses this solution to demonstrate that it can

obtain acceptable identifications and measurements with a method.

3.4 Performance evaluation sample — a solution of method analytes distributed by the Quality Assurance Branch (QAB), Environmental Monitoring and Support Laboratory (EMSL-Cincinnati), USEPA, Cincinnati, Ohio, to multiple laboratories for analysis. A volume of the solution is added to a known volume of reagent water and analyzed with procedures used for samples. Results of analyses are used by the QAB to determine statistically the accuracy and precision that can be expected when a method is performed by a competent analyst. Analyte true values are unknown to the analyst.

3.5 Laboratory control standards — a solution of analytes prepared in the laboratory by adding appropriate volumes of the stock standard solutions to reagent water.

3.6 Laboratory duplicates — two aliquots of the same sample that are treated exactly the same throughout laboratory analytical procedures. Analyses of laboratory duplicates indicate precision associated with laboratory procedures but not the sample collection, preservation, or storage procedures.

3.7 Field duplicates — two samples taken at the same time and place under identical circumstances and treated exactly the same throughout field and laboratory procedures. Analyses of field duplicates indicate the precision associated with sample collection, preservation and storage, as well as with laboratory procedures.

4. Interferences

4.1 Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or spiking can be used to solve most interference problems.

4.2 The water dip or negative peak that elutes near and can interfere with the fluoride peak can be eliminated by the addition of the equivalent of 1 mL of concentrated eluent (7.3 100X) to 100 mL of each standard and sample.

4.3 Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baseline in ion chromatograms.

4.4 Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.20 microns require filtration to prevent damage to instrument columns and flow systems.

5. Safety

5.1 Normal, accepted laboratory safety practices should be followed during reagent preparation and instrument operation. No known carcinogenic materials are used in this method.

6. Apparatus and Materials

6.1 Balance — Analytical, capable of accurately weighing to the nearest 0.0001 g.

6.2 Ion chromatograph — Analytical system complete with ion chromatograph and all required accessories including syringes, analytical columns, compressed air, detector, and stripchart recorder. A data system is recommended for peak integration.

6.2.1 Anion guard column, 4 x 50 mm, Dionex P/N 030825, or equivalent.

6.2.2 Anion separator column, 4 x 250 mm, Dionex P/N 030827, or equivalent.

6.2.3 Anion suppressor column, fiber, Dionex P/N 35350, or equivalent.

6.2.4 Detector — Conductivity cell, approximately 6 µL volume, Dionex, or equivalent.

7. Reagents and Consumable Materials

7.1 Sample bottles. Glass or polyethylene of sufficient volume to allow replicate analyses of anions of interest.

7.2 Reagent water. Distilled or deionized water, free of the anions of interest. Water should contain particles no larger than 0.20 microns.

7.3 Eluent solution. Sodium bicarbonate (CAS RN 144-55-8) 0.003 M, sodium carbonate (CAS RN 497-19-8) 0.0024M. Dissolve 1.0081 g sodium bicarbonate ($NaHCO_3$) and 1.0176 g of sodium carbonate (Na_2CO_3) in reagent water and dilute to 4 liters.

7.4 Regeneration solution (fiber suppressor). Sulfuric acid (CAS RN 7664-93-9) 0.025N. Dilute 2.8 mL conc. sulfuric acid (H_2SO_4) to 4 liters with reagent water.

7.5 Stock standard solutions, 1000 mg/L (1 mg/mL). Stock standard solutions may be purchased as certified solutions or prepared from ACS reagent grade materials (dried at 105°C for 30 min.) as listed below.

7.5.1 Chloride (Cl^-) 1000 mg/L. Dissolve 1.6485 g sodium chloride (NaCl, CAS RN 7647-14-5) in reagent water and dilute to 1 liter.

7.5.2 Fluoride (F^-) 1000 mg/L. Dissolve 2.2100 g sodium fluoride (NaF, CAS RN 7681-49-4) in reagent water and dilute to 1 liter.

7.5.3 Nitrate (NO_3^--N) 1000 mg/L. Dissolve 6.0679 g sodium nitrate ($NaNO_3$, CAS RN 7631-99-4) in reagent water and dilute to 1 liter.

7.5.4 Nitrite (NO_2^--N) 1000 mg/L. Dissolve 4.9257 g sodium nitrite ($NaNO_2$, CAS RN 7632-00-0) in reagent water and dilute to 1 liter.

7.5.5 Phosphate (PO_4^{3-}-P) 1000 mg/L. Dissolve 4.3937 g potassium phosphate (KH_2PO_4, CAS RN 7778-77-0) in reagent water and dilute to 1 liter.

7.5.6 Sulfate (SO_4^{2-}) 1000 mg/L. Dissolve 1.8141 g potassium sulfate (K_2SO_4, CAS RN 7778-80-5) in reagent water and dilute to 1 liter.

7.5.7 Stability of standards. Stock standards (7.5) are stable for at least one month when stored at 4°C. Dilute working standards should be prepared weekly, except those that contain nitrite and phosphate should be prepared fresh daily.

8. Sample Collection, Preservation and Storage

8.1 Samples should be collected in scrupulously clean glass or polyethylene bottles.

8.2 Sample preservation and holding times for the anions that can be determined by this method are as follows:

Analyte	Preservation	Holding Time
Chloride	None required	28 days
Fluoride	None required	28 days
Nitrate-N	Cool to 4°C	48 hours
Nitrite-N	Cool to 4°C	48 hours
O-Phosphate-P	Filter and cool to 4°C	48 hours
Sulfate	Cool to 4°C	28 days

8.3 The method of preservation and the holding time for samples analyzed by this method are determined by the anions of interest. In a given sample, the anion that requires the most preservation treatment and the shortest holding time will determine the preservation treatment and holding time for the total sample.

9. Calibration and Standardization

9.1 Establish ion chromatographic operating parameters equivalent to those indicated in Table 1.

9.2 For each analyte of interest, prepare calibration standards at a minimum of three concentration levels and a blank by adding accurately measured volumes of one or more stock standards (7.5) to a volumetric flask and diluting to volume with reagent water. If the working range exceeds the linear range of the system, a sufficient number of standards must be analyzed to allow an accurate calibration curve to be established. One of the standards should be representative of a concentration near, but above, the method detection limit if the system is operated on an applicable attenuator range. The other standards should correspond to the range of concentrations expected in the sample or should define the working range of the detector. Unless the attenuator range settings are proven to be linear, each setting must be calibrated individually.

9.3 Using injections of 0.1 to 1.0 mL (determined by injection loop volume) of each calibration standard, tabulate peak height or area responses against the concentration. The results are used to prepare a calibration curve for each analyte. During this procedure, retention times must be recorded. The retention time is inversely proportional to the concentration.

9.4 The working calibration curve must be verified on each working day, or whenever the anion eluent is changed, and after every 20 samples. If the response or retention time for any analyte varies from the expected values by more than ± 10%, the test must be repeated, using fresh calibration standards. If the results are still more than ± 10%, an entire new calibration curve must be prepared for that analyte.

9.5 Nonlinear response can result when the separator column capacity is exceeded (overload ng). Maximum column loading (all anions) should not exceed about 400 ppm.

10. Quality Control

10.1 Each laboratory using this method should have a formal quality control program. The minimum requirements of this program consist of an initial demonstration of laboratory capability (10.2) and the analysis of spiked samples as a continuing check on performance. The laboratory should maintain performance records to define the quality of data that are generated.

10.1.1 In recognition of the rapid advances occurring in chromatography, the analyst is permitted certain options to improve the separations or lower the cost of measurements. Each time such modifications to the method are made, the analyst is required to repeat the procedure in Section 10.2.

10.1.2 The laboratory should spike and analyze a minimum of 10% of all samples to monitor continuing laboratory performance. Field and laboratory duplicates should also be analyzed.

10.2 Before performing any analyses, the analyst should demonstrate the ability to generate acceptable accuracy and precision with this method, using a laboratory control standard.

10.2.1 Select a representative spike concentration for each analyte to be measured. Using stock standards, prepare a quality control check sample concentrate in reagent water 100 times more concentrated than the selected concentrations.

10.2.2 Using a pipet, add 1.00 mL of the check sample concentrate (10.2.1) to each of a minimum of four 100-mL aliquots of reagent water. Analyze the aliquots according to the procedure in Section 11.

10.2.3 Calculate the average percent recovery (R) and the standard deviation(s) of the percent recovery, for the results.

10.2.4 Using the appropriate data from Table 2, determine the recovery and single operator precision expected for the method, and compare these results to the values calculated in Section 10.2.3. If the data are not comparable within control limits (10.3.1), review potential problem areas and repeat the test.

10.3 The analyst must calculate method performance criteria and define the performance of the laboratory for each spike concentration of analyte being measured.

10.3.1 Calculate upper and lower control limits for method performance as follows:

Upper Control Limit (UCL) = R + 3 s
Lower Control Limit (LCL) = R - 3 s

where R and s are calculated as in Section 10.2.3. The UCL and LCL can be used to construct control charts that are useful in observing trends in performance.

10.4 The laboratory should develop and maintain separate accuracy statements of laboratory performance for water and wastewater samples. An accuracy statement for the method is defined as R ± s. The accuracy statement should be developed by the analyses of four aliquots of water or wastewater, as described in Section 10.2.2, followed by the calculation of R and s.

10.5 Before processing any samples, the analyst must demonstrate through the analysis of an aliquot of reagent water that all glassware and reagent interferences are under control. Each time there is a change in reagents, a laboratory reagent blank must be processed as a safeguard against laboratory contamination.

10.6 It is recommended that the laboratory adopt additional quality assurance practices for use with this method. The specific practices that are most productive depend upon the needs of the laboratory and the nature of the samples. Field duplicates may be analyzed to monitor the precision of the sampling technique. When doubt exists over the identification of a peak in the chromatogram, confirmatory techniques such as sample dilution and spiking must be used. Whenever possible, the laboratory should perform analysis of quality control check samples and participate in relevant performance evaluation sample studies.

11. Procedure

11.1 Table 1 summarizes the recommended operating conditions for the ion chromatograph. Included in this table are estimated retention times that can be achieved by this method. Other columns, chromatographic conditions, or

detectors may be used if the requirements of Section 10.2 are met.

11.2 Check system calibration daily and, if required, recalibrate as described in Section 9.

11.3 Load and inject a fixed amount of well mixed sample. Flush injection loop thoroughly, using each new sample. Use the same size loop for standards and samples. Record the resulting peak size in area or peak height units. An automated constant volume injection system may also be used.

11.4 The width of the retention time window used to make identifications should be based upon measurements of actual retention time variations of standards over the course of a day. Three times the standard deviation of a retention time can be used to calculate a suggested window size for a compound. However, the experience of the analyst should weigh heavily in the interpretation of chromatograms.

11.5 If the response for the peak exceeds the working range of the system, dilute the sample with an appropriate amount of reagent water and reanalyze.

11.6 If the resulting chromatogram fails to produce adequate resolution, or if identification of specific anions is questionable, spike the sample with an appropriate amount of standard and reanalyze.

Note: Retention time is inversely proportional to concentration. Nitrate and sulfate exhibit the greatest amount of change, although all anions are affected to some degree. In some cases, this peak migration can produce poor resolution or misidentification.

12. Calculation

12.1 Prepare separate calibration curves for each anion of interest by plotting peak size in area, or peak height units of standards against concentration values. Compute sample concentration by comparing sample peak response with the standard curve.

12.2 Report results in mg/L.

13. Precision and Accuracy — Method Detection Limit

13.1 The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations listed in Table 1 were obtained using reagent water.

13.2 Single-operator accuracy and precision for reagent, drinking and surface water, and mixed domestic and industrial wastewater are listed in Table 2.

14. References

14.1 Annual Book of ASTM Standards, Part 31 Water, proposed test method for "Anions in Water by Ion Chromatography," p. 1485-1492 (1982).

14.2 Standard Methods for the Examination of Water and Wastewater, Method 400Z, "Anions by Ion Chromatography" proposed for the 16th Edition of Standard Methods.

14.3 Dionex, IC 16 operation and maintenance manual, PN 30579, Dionex Corp., Sunnyvale, California 94086.

14.4 Method detection limit (MDL) as described in "Trace Analyses for Wastewater," J. Glaser, D. Foerst, G. McKee, S. Quave, W. Budde, *Environmental Science and Technology*, Vol. 15, Number 12, p. 1426, December 1981.

Table 1. Chromatographic Conditions and Method Detection Limits in Reagent Water

Analyte	Retention[1] Time (Min)	Relative Retention Time	Method[2] Detection Limit mg/L
Fluoride	1.2	1.0	0.005
Chloride	3.4	2.8	0.015
Nitrite-N	4.5	3.8	0.004
O-Phosphate-P	9.0	7.5	0.061
Nitrate-N	11.3	9.4	0.013
Sulfate	21.4	17.8	0.206

Standard Conditions:

[1] Columns — As specified in 6.2 Sample Loop — 100 µL
Detector — As specified in 6.2 Pump Volume — 2.30 mL/Min
Eluent — As specified in 7.3

[1] Concentrations of mixed standard (mg/L)
Fluoride 3.0 O-Phosphate-P 9.0
Chloride 4.0 Nitrate-N 30.0
Nitrite-N 10.0 Sulfate 50.0

[2] MDL calculated from data obtained using an attenuator setting of 1 µMHO full scale. Other settings would produce an MDL proportional to their value.

Table 2 Single-Operator Accuracy and Precision

Analyte	Sample Type	Spike (mg/L)	Number of Replicates	Mean Recovery %	Standard Deviation (mg/L)
Chloride	RW	0.050	7	97.7	0.0047
	DW	10.0	7	98.2	0.289
	SW	1.0	7	105.0	0.139
	WW	7.5	7	82.7	0.445
Fluoride	RW	0.24	7	103.1	0.0009
	DW	9.3	7	87.7	0.075
	SW	0.50	7	74.0	0.0038
	WW	1.0	7	92.0	0.011
Nitrate-N	RW	0.10	7	100.9	0.0041
	DW	31.0	7	100.7	0.356
	SW	0.50	7	100.0	0.0058
	WW	4.0	7	94.3	0.058
Nitrite-N	RW	0.10	7	97.7	0.0014
	DW	19.6	7	103.3	0.150
	SW	0.51	7	88.2	0.0053
	WW	0.52	7	100.0	0.018
O-Phosphate-P	RW	0.50	7	100.4	0.019
	DW	45.7	7	102.5	0.386
	SW	0.51	7	94.1	0.020
	WW	4.0	7	97.3	0.04
Sulfate	RW	1.02	7	102.1	0.066
	DW	98.5	7	104.3	1.475
	SW	10.0	7	111.6	0.709
	WW	12.5	7	134.9	0.466

RW = Reagent Water SW = Surface Water
DW = Drinking Water WW = Wastewater

APPENDIX D

Organic Emission Data

ENTEC, INC.

TL-RTP Project: 23636 — Method 8290 PCDD/PCDF Analysis (aa)

Client Sample: FIELD BLANK — Analysis File: S931978

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	04/27/93	Spike File:	SPX23704
TLRTP ID:	65-054-4A-D	Date Extracted:	04/30/93	ICAL:	SD54123
		Date Analyzed:	05/12/93	CONCAL:	S931968
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	S931974	% Lipid:	n/a
GC Column:	DB-5	Analyst:	SA	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.007				—
1,2,3,7,8-PeCDD	ND	0.009				—
1,2,3,4,7,8-HxCDD	ND	0.01				—
1,2,3,6,7,8-HxCDD	0.02			1.40	32:47	—
1,2,3,7,8,9-HxCDD	ND	0.01				—
1,2,3,4,6,7,8-HpCDD	0.42			0.98	35:47	B
1,2,3,4,6,7,8,9-OCDD	1.8			0.93	38:58	B
2,3,7,8-TCDF	ND	0.006				—
1,2,3,7,8-PeCDF	ND	0.007				—
2,3,4,7,8-PeCDF	ND	0.007				—
1,2,3,4,7,8-HxCDF	EMPC		0.01			B
1,2,3,6,7,8-HxCDF	ND	0.005				—
2,3,4,6,7,8-HxCDF	EMPC		0.02			B
1,2,3,7,8,9-HxCDF	ND	0.008				—
1,2,3,4,6,7,8-HpCDF	0.12			1.14	34:50	AS, B
1,2,3,4,7,8,9-HpCDF	EMPC		0.01			
1,2,3,4,6,7,8,9-OCDF	0.54			0.90	39:08	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	ND		0.007				—
Total PeCDD	ND		0.009				—
Total HxCDD	0.03	1		0.06	1.40		—
Total HpCDD	0.42	1		0.56	0.98		—
Total TCDF	0.01	1			0.67		—
Total PeCDF	0.02	1			1.59		—
Total HxCDF	0.24	3		0.39	1.11		—
Total HpCDF	0.66	2		0.67	1.06		—

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ENTEC, INC.

TL-RTP Project: **23636r2** — Method 23 PCDD/PCDF Analysis (a)

Client Sample: **BURN #1** — Analysis File: **T931966**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	04/27/93	Spike File:	SPX2374A
TLRTP ID:	65-054-1A-D	Date Extracted:	04/30/93	ICAL:	TD54133
		Date Analyzed:	05/15/93	CONCAL:	T931960
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a.	Blank File:	T931965	% Lipid:	n/a
GC Column:	DB-5.	Analyst:	MC	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	0.20			0.77	34:09	—
1,2,3,7,8-PeCDD	0.75			1.70	39:21	—
1,2,3,4,7,8-HxCDD	1.1			1.11	43:11	B
1,2,3,6,7,8-HxCDD	0.93			1.24	43:15	B
1,2,3,7,8,9-HxCDD	3.2			1.20	43:35	PR, B
1,2,3,4,6,7,8-HpCDD	4.9			0.99	46:48	B
1,2,3,4,6,7,8,9-OCDD	6.0			0.86	50:37	B
2,3,7,8-TCDF	19.2			0.76	33:22	—
1,2,3,7,8-PeCDF	2.9			1.51	38:04	—
2,3,4,7,8-PeCDF	7.0			1.56	38:56	—
1,2,3,4,7,8-HxCDF	19.3			1.13	42:18	B
1,2,3,6,7,8-HxCDF	4.5			1.10	42:26	B
2,3,4,6,7,8-HxCDF	9.0			1.15	43:02	B
1,2,3,7,8,9-HxCDF	0.33			1.08	43:52	PR, B
1,2,3,4,6,7,8-HpCDF	11.0			0.96	45:41	B
1,2,3,4,7,8,9-HpCDF	1.1			0.98	47:19	B
1,2,3,4,6,7,8,9-OCDF	2.7			0.88	50:48	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	6.2	14			0.75		—
Total PeCDD	6.2	8		8.2	1.66		—
Total HxCDD	12.2	7			1.22		—
Total HpCDD	9.6	2			1.00		—
Total TCDF	114	20		114	0.74		—
Total PeCDF	81.5	17		82.5	1.53		—
Total HxCDF	61.6	15		61.7	1.16		—
Total HpCDF	19.2	4			0.95		—

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ENTEC, INC.

TL-RTP Project: 23636
Client Sample: BURN #2

Method 8290 PCDD/PCDF Analysis (aa)
Analysis File: S931976

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	04/27/93	Spike File:	SPX23704
TLRTP ID:	65-054-2A-D	Date Extracted:	04/30/93	ICAL:	SD54123
		Date Analyzed:	05/12/93	CONCAL:	S931968
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	S931974	% Lipid:	n/a
GC Column:	DB-5	Analyst:	SA	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.008				—
1,2,3,7,8-PeCDD	ND	0.01				—
1,2,3,4,7,8-HxCDD	ND	0.02				—
1,2,3,6,7,8-HxCDD	0.02			1.06	32:47	—
1,2,3,7,8,9-HxCDD	ND	0.01				—
1,2,3,4,6,7,8-HpCDD	0.27			1.07	35:47	B
1,2,3,4,6,7,8,9-OCDD	1.3			0.90	38:58	B
2,3,7,8-TCDF	EMPC		0.02			—
1,2,3,7,8-PeCDF	ND	0.007				—
2,3,4,7,8-PeCDF	ND	0.007				—
1,2,3,4,7,8-HxCDF	EMPC		0.02			B
1,2,3,6,7,8-HxCDF	0.005			1.05	32:05	—
2,3,4,6,7,8-HxCDF	0.02			1.06	32:35	B
1,2,3,7,8,9-HxCDF	ND	0.009				—
1,2,3,4,6,7,8-HpCDF	0.10			1.12	34:50	B
1,2,3,4,7,8,9-HpCDF	0.01			1.01	36:13	
1,2,3,4,6,7,8,9-OCDF	EMPC		0.26			B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	ND		0.008				—
Total PeCDD	ND		0.01				—
Total HxCDD	0.05	3		0.05	1.10		—
Total HpCDD	0.37	2			1.05		—
Total TCDF	0.03	4		0.07	- 0.75		—
Total PeCDF	0.03	2		0.05	1.63		—
Total HxCDF	0.21	6		0.23	1.14		—
Total HpCDF	0.48	3			1.05		—

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TL-RTP Project: **23636** Method 8290 PCDD/PCDF Analysis (aa)
Client Sample: **BURN #3** Analysis File: **S931977**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	04/27/93	Spike File:	SPX23704
TLRTP ID:	65-054-3A-D	Date Extracted:	04/30/93	ICAL:	SD54123
		Date Analyzed:	05/12/93	CONCAL:	S931968
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	S931974	% Lipid:	n/a
GC Column:	DB-5	Analyst:	SA	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.004				—
1,2,3,7,8-PeCDD	0.01			1.59	29:23	—
1,2,3,4,7,8-HxCDD	0.02			1.39	32:42	—
1,2,3,6,7,8-HxCDD	0.07			1.19	32:47	
1,2,3,7,8,9-HxCDD	0.06			1.31	33:04	PR
1,2,3,4,6,7,8-HpCDD	0.83			1.07	35:47	B
1,2,3,4,6,7,8,9-OCDD	2.2			0.89	38:58	B
2,3,7,8-TCDF	0.27			0.71	23:47	—
1,2,3,7,8-PeCDF	0.07			1.49	28:16	—
2,3,4,7,8-PeCDF	0.14			1.46	29:02	—
1,2,3,4,7,8-HxCDF	0.21			1.05	31:57	B
1,2,3,6,7,8-HxCDF	EMPC		0.10			
2,3,4,6,7,8-HxCDF	0.17			1.24	32:35	B
1,2,3,7,8,9-HxCDF	ND	0.005				
1,2,3,4,6,7,8-HpCDF	0.32			0.98	34:50	B
1,2,3,4,7,8,9-HpCDF	0.04			1.02	36:13	
1,2,3,4,6,7,8,9-OCDF	0.85			0.97	39:09	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	0.24	6		0.30	0.78		—
Total PeCDD	0.17	6		0.44	1.50		—
Total HxCDD	0.73	7			1.26		—
Total HpCDD	1.2	2			1.01		—
Total TCDF	1.1	11		1.2	0.74		—
Total PeCDF	1.1	10		1.3	1.49		
Total HxCDF	0.92	7		1.3	1.17		E
Total HpCDF	1.2	3			0.99		—

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ENTEC, INC.

TL-RTP Project: **23636** Method 8290 PCDD/PCDF Analysis (aa)
Client Sample: **TEST BURN #4** Analysis File: **S931979**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	04/28/93	Spike File:	SPX23704
TLRTP ID:	65-064-1A-D	Date Extracted:	04/30/93	ICAL:	SD54123
		Date Analyzed:	05/12/93	CONCAL:	S931968
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	S931974	% Lipid:	n/a
GC Column:	DB-5	Analyst:	SA	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.004				—
1,2,3,7,8-PeCDD	ND	0.006				—
1,2,3,4,7,8-HxCDD	ND	0.007				—
1,2,3,6,7,8-HxCDD	EMPC		0.01			—
1,2,3,7,8,9-HxCDD	0.01			1.15	33:04	B
1,2,3,4,6,7,8-HpCDD	0.22			0.96	35:47	B
1,2,3,4,6,7,8,9-OCDD	1.3			0.91	38:58	B
2,3,7,8-TCDF	0.06			0.65	23:47	—
1,2,3,7,8-PeCDF	0.008			1.37	28:15	—
2,3,4,7,8-PeCDF	0.02			1.46	29:02	
1,2,3,4,7,8-HxCDF	0.03			1.11	31:57	PR, B
1,2,3,6,7,8-HxCDF	EMPC		0.006			
2,3,4,6,7,8-HxCDF	0.03			1.11	32:35	PR, B
1,2,3,7,8,9-HxCDF	ND	0.005				
1,2,3,4,6,7,8-HpCDF	0.08			1.12	34:50	B
1,2,3,4,7,8,9-HpCDF	EMPC		0.006			
1,2,3,4,6,7,8,9-OCDF	0.19			0.81	39:09	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	0.01	1			0.82		—
Total PeCDD	0.02	2		0.04	1.49		—
Total HxCDD	0.07	4		0.09	1.24		—
Total HpCDD	0.33	2			1.01		—
Total TCDF	0.21	8		0.34	0.73		—
Total PeCDF	0.09	7		0.18	1.52		
Total HxCDF	0.18	5		0.25	1.17		E
Total HpCDF	0.33	2		0.33	1.06		—

X237_PSR v 1.04, LARS 5/16/08

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ENTEC, INC.

TL-RTP Project: **23636** Method 8290 PCDD/PCDF Analysis (aa)
Client Sample: **BURN #5** Analysis File: **S931980**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	04/30/93	Spike File:	SPX23704
TLRTP ID:	65-084-1A-D	Date Extracted:	04/30/93	ICAL:	SD54123
		Date Analyzed:	05/12/93	CONCAL:	S931968
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	S931974	% Lipid:	n/a
GC Column:	DB-5	Analyst:	VCA	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.01				—
1,2,3,7,8-PeCDD	ND	0.02				—
1,2,3,4,7,8-HxCDD	ND	0.03				—
1,2,3,6,7,8-HxCDD	EMPC		0.02			—
1,2,3,7,8,9-HxCDD	ND	0.02				—
1,2,3,4,6,7,8-HpCDD	0.42			1.15	35:47	B
1,2,3,4,6,7,8,9-OCDD	1.5			0.86	38:58	B
2,3,7,8-TCDF	0.01			0.66	23:47	—
1,2,3,7,8-PeCDF	ND	0.01				—
2,3,4,7,8-PeCDF	ND	0.01				—
1,2,3,4,7,8-HxCDF	0.02			1.12	31:55	B
1,2,3,6,7,8-HxCDF	ND	0.01				—
2,3,4,6,7,8-HxCDF	ND	0.02				—
1,2,3,7,8,9-HxCDF	ND	0.02				—
1,2,3,4,6,7,8-HpCDF	0.14			1.08	34:50	B
1,2,3,4,7,8,9-HpCDF	ND	0.02				—
1,2,3,4,6,7,8,9-OCDF	0.42			0.99	39:08	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	ND		0.01				—
Total PeCDD	ND		0.02				—
Total HxCDD	0.02	1		0.05	1.14		—
Total HpCDD	0.56	2			1.15		—
Total TCDF	0.01	1		0.03	0.66		—
Total PeCDF	EMPC			0.04			
Total HxCDF	0.20	2		0.42	1.14		E
Total HpCDF	0.71	2			1.05		—

X237_PSR v.1.04, LARS 5.10/08

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ENTEC, INC.

TL-RTP Project: **23774** Method 23 PCDD/PCDF Analysis (aa)
Client Sample: **BURN #6** Analysis File: **T932106**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	05/04/93	Spike File:	SPX23704
TLRTP ID:	65-110-1A-E	Date Extracted:	05/13/93	ICAL:	TD54133
		Date Analyzed:	05/23/93	CONCAL:	T932103
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	T932105	% Lipid:	n/a
GC Column:	DB-5	Analyst:	RWG	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.04				—
1,2,3,7,8-PeCDD	ND	0.06				—
1,2,3,4,7,8-HxCDD	ND	0.05				—
1,2,3,6,7,8-HxCDD	ND	0.03				—
1,2,3,7,8,9-HxCDD	ND	0.04				—
1,2,3,4,6,7,8-HpCDD	ND	0.06				—
1,2,3,4,6,7,8,9-OCDD	EMPC		0.43			b
2,3,7,8-TCDF	ND	0.04				—
1,2,3,7,8-PeCDF	ND	0.04				—
2,3,4,7,8-PeCDF	ND	0.04				—
1,2,3,4,7,8-HxCDF	ND	0.05				—
1,2,3,6,7,8-HxCDF	ND	0.04				—
2,3,4,6,7,8-HxCDF	ND	0.05				—
1,2,3,7,8,9-HxCDF	ND	0.05				—
1,2,3,4,6,7,8-HpCDF	ND	0.04				—
1,2,3,4,7,8,9-HpCDF	ND	0.07				—
1,2,3,4,6,7,8,9-OCDF	ND	0.09				—

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	ND		0.04				—
Total PeCDD	ND		0.06				—
Total HxCDD	ND		0.04				—
Total HpCDD	ND		0.06				—
Total TCDF	ND		0.04				—
Total PeCDF	ND		0.04				—
Total HxCDF	ND		0.05				—
Total HpCDF	ND		0.05				—

X227_PSR v.1.05, LARS 5/6/10

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ENTEC, INC.

TL-RTP Project: **23774** Method 23 PCDD/PCDF Analysis (aa)
Client Sample: **BURN #7** Analysis File: **T932107**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	05/06/93	Spike File:	SPX23704
TLRTP ID:	65-140-1A-E	Date Extracted:	05/13/93	ICAL:	TD54133
		Date Analyzed:	05/23/93	CONCAL:	T932103
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	T932105	% Lipid:	n/a
GC Column:	DB-5	Analyst:	RWG	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.01				—
1,2,3,7,8-PeCDD	ND	0.02				—
1,2,3,4,7,8-HxCDD	ND	0.03				—
1,2,3,6,7,8-HxCDD	ND	0.02				—
1,2,3,7,8,9-HxCDD	ND	0.02				—
1,2,3,4,6,7,8-HpCDD	0.26			1.13	46:37	B
1,2,3,4,6,7,8,9-OCDD	1.1			0.82	50:24	B
2,3,7,8-TCDF	0.02			0.73	32:59	—
1,2,3,7,8-PeCDF	ND	0.01				—
2,3,4,7,8-PeCDF	ND	0.01				—
1,2,3,4,7,8-HxCDF	ND	0.02				—
1,2,3,6,7,8-HxCDF	ND	0.01				—
2,3,4,6,7,8-HxCDF	ND	0.02				—
1,2,3,7,8,9-HxCDF	ND	0.02				—
1,2,3,4,6,7,8-HpCDF	EMPC		0.09			B,PR
1,2,3,4,7,8,9-HpCDF	ND	0.03				—
1,2,3,4,6,7,8,9-OCDF	0.26			0.92	50:36	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	ND		0.01				—
Total PeCDD	ND		0.02				—
Total HxCDD	ND		0.02				—
Total HpCDD	0.34	2			1.06		—
Total TCDF	0.11	5		0.23	0.79		—
Total PeCDF	0.13	4		0.16	1.43		—
Total HxCDF	0.79	5		0.79	1.26		—
Total HpCDF	EMPC			0.60			E

X217_PSR v.1.05, LARS 5.06.16

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TL-RTP Project: **23774** — Method 23 PCDD/PCDF Analysis (aa)

Client Sample: **BURN #8** — Analysis File: **T932108**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	05/10/93	Spike File:	SPX23704
TLRTP ID:	65-158-1A-E	Date Extracted:	05/13/93	ICAL:	TD54133
		Date Analyzed:	05/23/93	CONCAL:	T932103
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	T932105	% Lipid:	n/a
GC Column:	DB-5	Analyst:	RWG	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.02				—
1,2,3,7,8-PeCDD	ND	0.01				—
1,2,3,4,7,8-HxCDD	ND	0.02				—
1,2,3,6,7,8-HxCDD	0.006			1.33	43:03	—
1,2,3,7,8,9-HxCDD	ND	0.01				—
1,2,3,4,6,7,8-HpCDD	0.12			0.98	46:37	E
1,2,3,4,6,7,8,9-OCDD	0.70			0.95	50:23	B
2,3,7,8-TCDF	0.03			0.87	33:00	—
1,2,3,7,8-PeCDF	ND	0.01				—
2,3,4,7,8-PeCDF	ND	0.01				—
1,2,3,4,7,8-HxCDF	ND	0.01				—
1,2,3,6,7,8-HxCDF	ND	0.008				—
2,3,4,6,7,8-HxCDF	0.01			1.15	42:49	E
1,2,3,7,8,9-HxCDF	ND	0.01				—
1,2,3,4,6,7,8-HpCDF	0.06			1.09	45:28	E
1,2,3,4,7,8,9-HpCDF	ND	0.02				—
1,2,3,4,6,7,8,9-OCDF	0.11			0.87	50:35	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	ND		0.02				—
Total PeCDD	EMPC			0.008			—
Total HxCDD	0.008	1			1.33		—
Total HpCDD	0.17	2			1.05		—
Total TCDF	0.07	2		0.14	0.86		E
Total PeCDF	EMPC			0.02			—
Total HxCDF	0.08	3		0.13	1.15		E
Total HpCDF	0.23	2			1.08		—

X207_PSR v1.05, LARS 5.16.10

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TL-RTP Project: **23774** Method 23 PCDD/PCDF Analysis (aa)
Client Sample: **BURN #9** Analysis File: **T932109**

Client Project:	n/a				
Sample Matrix:	M23TRAIN	Date Received:	05/11/93	Spike File:	SPX23704
TLRTP ID:	65-164-1A-E	Date Extracted:	05/13/93	ICAL:	TD54133
		Date Analyzed:	05/23/93	CONCAL:	T932103
Sample Size:	1.000	Dilution Factor:	n/a	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	T932105	% Lipid:	n/a
GC Column:	DB-5	Analyst:	WG	% Solids:	n/a

Analytes	Amt. (ng)	DL	EMPC	Ratio	RT	Flags
2,3,7,8-TCDD	ND	0.004				—
1,2,3,7,8-PeCDD	ND	0.005				—
1,2,3,4,7,8-HxCDD	ND	0.008				—
1,2,3,6,7,8-HxCDD	0.008			1.39	43:03	—
1,2,3,7,8,9-HxCDD	ND	0.006				—
1,2,3,4,6,7,8-HpCDD	0.15			1.02	46:36	B
1,2,3,4,6,7,8,9-OCDD	0.80			0.84	50:23	B
2,3,7,8-TCDF	0.01			0.66	32:58	—
1,2,3,7,8-PeCDF	ND	0.004				—
2,3,4,7,8-PeCDF	ND	0.004				—
1,2,3,4,7,8-HxCDF	ND	0.005				—
1,2,3,6,7,8-HxCDF	ND	0.004				—
2,3,4,6,7,8-HxCDF	0.009			1.12	42:48	B
1,2,3,7,8,9-HxCDF	ND	0.006				—
1,2,3,4,6,7,8-HpCDF	0.06			1.14	45:28	B,PR
1,2,3,4,7,8,9-HpCDF	ND	0.007				—
1,2,3,4,6,7,8,9-OCDF	0.15			0.79	50:34	B

Totals	Amt. (ng)	Number	DL	EMPC	Ratio	RT	Flags
Total TCDD	ND		0.004				—
Total PeCDD	ND		0.005				—
Total HxCDD	0.02	3			1.32		—
Total HpCDD	0.21	2			0.99		—
Total TCDF	0.04	4		0.07	0.72		—
Total PeCDF	0.009	1		0.03	1.74		E
Total HxCDF	0.11	4		0.20	1.16		E
Total HpCDF	0.28	2			1.08		—

X237_PSR v1.05 LARS 5/06/10

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Entech, Inc.

TL-RTP Project: **23637** — Modified Method 680 PCB Analysis
Client Sample: **Field Blank** — Analysis File: **YB35000**

Client Project:					
Sample Matrix:	MM5	Date Received:	04/27/93	Spike File:	SPPCBF01
TLRTP ID:	65-54-4A,B,D	Date Extracted:	04/30/93	ICAL:	PCBY411
		Date Analyzed:	05/04/93	CONCAL:	YB340
Sample Size:	1.000	Dilution Factor:	2	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB34900	% Lipid:	n/a
		Analyst:	RKO	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	0.008	1		0.02	3.27		—
Total DiCB	EMPC			0.12			
Total TriCB	0.006	1		0.03	1.05		Recalc
Total TetraCB	ND		0.003				—
Total PentaCB	EMPC			0.13			—
Total HexaCB	ND		0.003				—
Total HeptaCB	ND		0.003				—
Total OctaCB	ND		0.005				—
Total NonaCB	ND		0.005				—
DecaCB	ND		0.008				—
TOTAL PCB	0.01						
TOTAL PCB + EMPC	0.28						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.74	74.2	0.81	24.07	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.62	61.8	0.92	27.40	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.61	60.8	1.27	25.45	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.81	20.02	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.31	28.42	—

Data Reviewer: SA 05/13/93

PCBF_PSR v.1.02, LARS 5.06.07

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Entech, Inc.

TL-RTP Project: 23637 — Modified Method 680 PCB Analysis
Client Sample: **Burn #1** — Analysis File: **YB36100**

Client Project:					
Sample Matrix:	MM5	Date Received:	04/27/93	Spike File:	SPPCBF01
TLRTP ID:	65-54-1A,B,D	Date Extracted:	04/30/93	ICAL:	PCBY411
		Date Analyzed:	05/05/93	CONCAL:	YB358
Sample Size:	1.000	Dilution Factor:	2	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB34900	% Lipid:	n/a
		Analyst:	RKO	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	EMPC			0.54			—
Total DiCB	EMPC			9.0			—
Total TriCB	ND		0.003				—
Total TetraCB	ND		0.003				—
Total PentaCB	EMPC			4.3			—
Total HexaCB	ND		0.005				—
Total HeptaCB	ND		0.005				
Total OctaCB	EMPC			0.06			Recalc
Total NonaCB	EMPC			1.1			—
DecaCB	ND		0.01				—
TOTAL PCB	n/a						
TOTAL PCB + EMPC	15.1						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.84	84.4	0.81	24.13	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	1.2	116	0.93	27.42	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	1.1	112	1.25	25.52	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.80	20.07	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.26	28.47	—

Data Reviewer: SA 05/13/93

PCBF_PSR v 1.02, LARS 5/06/07

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Entech, Inc.

TL-RTP Project: 23637 — Modified Method 680 PCB Analysis
Client Sample: Burn #2 — Analysis File: YB35200

Client Project:					
Sample Matrix:	MM5	Date Received:	04/27/93	Spike File:	SPPCBF01
TLRTP ID:	65-54-2A,B,D	Date Extracted:	04/30/93	ICAL:	PCBY411
		Date Analyzed:	05/04/93	CONCAL:	YB340
Sample Size:	1.000	Dilution Factor:	2	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB34900	% Lipid:	n/a
		Analyst:	RKO	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	ND		0.001				—
Total DiCB	0.01	1		0.41	1.63		
Total TriCB	EMPC			0.04			B Recalc
Total TetraCB	EMPC			0.006			
Total PentaCB	EMPC			0.17			Recalc
Total HexaCB	ND		0.003				—
Total HeptaCB	ND		0.003				—
Total OctaCB	ND		0.005				—
Total NonaCB	ND		0.005				—
DecaCB	ND		0.008				—
TOTAL PCB	0.01						
TOTAL PCB + EMPC	0.62						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.83	83.4	0.80	24.07	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.73	73.4	0.94	27.40	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.71	70.6	1.30	25.45	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.81	20.02	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.30	28.42	—

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PCBF PSR v 1.02 LAKs 5 06 07

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Entech, Inc.

TL-RTP Project: **23637**
Client Sample: **Burn #3**

Modified Method 680 PCB Analysis
Analysis File: **YB35100**

Client Project:					
Sample Matrix:	MM5	Date Received:	04/27/93	Spike File:	SPPCBF01
TLRTP ID:	65-54-3A,B,D	Date Extracted:	04/30/93	ICAL:	PCBY411
		Date Analyzed:	05/04/93	CONCAL:	YB340
Sample Size:	1.000	Dilution Factor:	2	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB34900	% Lipid:	n/a
		Analyst:	RKO	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	ND		0.003				—
Total DiCB	0.08	2		7.7			—
Total TriCB	EMPC			4.6			—
Total TetraCB	0.07	1		0.25	0.91		—
Total PentaCB	EMPC			6.1			—
Total HexaCB	EMPC			0.03			—
Total HeptaCB	ND		0.005				—
Total OctaCB	ND		0.005				—
Total NonaCB	ND		0.008				—
DecaCB	ND		0.01				—
TOTAL PCB	0.15						
TOTAL PCB + EMPC	18.8						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.73	73.0	0.81	24.07	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.65	64.8	0.93	27.40	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.59	59.0	1.29	25.45	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.81	20.02	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.30	28.42	—

Data Reviewer: SA 05/13/93

PCBF_PSR v 1.02, LARS v 16.07

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Phone: (919) 544-5729 • Fax: (919) 544-5491

Printed: 17:26 05/13/93

Entech, Inc.

TL-RTP Project: **23637**
Client Sample: **Test Burn #4**

Modified Method 680 PCB Analysis
Analysis File: **YB35300**

Client Project:					
Sample Matrix:	MM5	Date Received:	04/28/93	Spike File:	SPPCBF01
TLRTP ID:	65-64-1A,B,D	Date Extracted:	04/30/93	ICAL:	PCBY411
		Date Analyzed:	05/04/93	CONCAL:	YB340
Sample Size:	1.000	Dilution Factor:	2	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB34900	% Lipid:	n/a
		Analyst:	RKO	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	ND		0.001				—
Total DiCB	EMPC			2.6			—
Total TriCB	0.02	4		0.09			B
Total TetraCB	ND		0.003				—
Total PentaCB	EMPC			0.64			—
Total HexaCB	ND		0.003				—
Total HeptaCB	ND		0.003				—
Total OctaCB	ND		0.005				—
Total NonaCB	ND		0.008				—
DecaCB	ND		0.01				—
TOTAL PCB	0.02						
TOTAL PCB + EMPC	3.3						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	1.0	105	0.81	24.07	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.85	84.6	0.93	27.40	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.79	79.0	1.26	25.45	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.81	20.02	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.30	28.42	—

Data Reviewer: SA 05/13/93

PCBF_PSR v:1.02, LARS 5.06.07

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Entech, Inc.

TL-RTP Project: **23637** — Modified Method 680 PCB Analysis
Client Sample: **Burn #5** — Analysis File: **YB36000**

Client Project:					
Sample Matrix:	MM5	Date Received:	04/30/93	Spike File:	SPPCBF01
TLRTP ID:	65-84-1A,B,D	Date Extracted:	04/30/93	ICAL:	PCBY411
		Date Analyzed:	05/05/93	CONCAL:	YB358
Sample Size:	1.000	Dilution Factor:	2	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB34900	% Lipid:	n/a
		Analyst:	RKO	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	EMPC			0.02			—
Total DiCB	0.01	1		2.7	1.35		—
Total TriCB	0.01	1		0.20	1.02		B
Total TetraCB	0.004	1		0.007	0.89		—
Total PentaCB	EMPC			0.25			—
Total HexaCB	0.005	1			1.33		—
Total HeptaCB	0.008	1			0.88		—
Total OctaCB	EMPC			0.009			—
Total NonaCB	EMPC			0.03			—
DecaCB	0.02					31.53	—
TOTAL PCB	0.06						
TOTAL PCB + EMPC	3.3						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.90	90.4	0.80	24.05	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.75	75.2	0.95	27.40	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.75	75.4	1.29	25.45	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.81	20.00	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.30	28.42	—

Data Reviewer: SA 05/13/93

PCBF_PSR v 1.02, LARS 5 06 07

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ENTECH

TL-RTP Project: **23775** — Modified Method 680 PCB Analysis
Client Sample: **BURN #6** — Analysis File: **YB46600**

Client Project:					
Sample Matrix:	M23	Date Received:	05/04/93	Spike File:	SPPCBF01
TLRTP ID:	65-110-1A,B,	Date Extracted:	05/13/93	ICAL:	PCBY514
		Date Analyzed:	05/17/93	CONCAL:	YB462
Sample Size:	1.000	Dilution Factor:	2.0	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB46500	% Lipid:	n/a
		Analyst:	MM	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	0.007	2					B
Total DiCB	EMPC			1.0			—
Total TriCB	0.002	1		0.08	1.15		B, PRECALC
Total TetraCB	EMPC			0.005			—
Total PentaCB	EMPC			0.15			B, PRECALC
Total HexaCB	EMPC			0.003			—
Total HeptaCB	EMPC			0.10			—
Total OctaCB	0.004	1		0.05	0.76		—
Total NonaCB	ND		0.001				—
DecaCB	ND		0.001				—
TOTAL PCB	0.01						
TOTAL PCB + EMPC	1.4						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.97	96.5	0.82	25.82	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.83	83.3	0.94	28.87	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.72	72.5	1.32	27.05	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.81	21.78	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.31	29.85	—

Data Reviewer: MM 05/27/93

PCBF PSR v 1.02.1 ARS 5/6/10

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ENTECH

TL-RTP Project: **23775** — Modified Method 680 PCB Analysis
Client Sample: **BURN #7** — Analysis File: **YB46700**

Client Project:					
Sample Matrix:	M23	Date Received:	05/06/93	Spike File:	SPPCBF01
TLRTP ID:	65-140-1A,B,	Date Extracted:	05/13/93	ICAL:	PCBY514
		Date Analyzed:	05/17/93	CONCAL:	YB462
Sample Size:	1.000	Dilution Factor:	2.0	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB46500	% Lipid:	n/a
		Analyst:	MM	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	0.01	2		0.02			B,BECALC.
Total DiCB	EMPC			1.8			
Total TriCB	0.02	3		0.19			B,BECALC.
Total TetraCB	EMPC			0.004			
Total PentaCB	0.002	1		0.21	0.65		B,BECALC
Total HexaCB	ND		0.001				—
Total HeptaCB	EMPC			0.05			—
Total OctaCB	EMPC			0.003			—
Total NonaCB	ND		0.001				—
DecaCB	ND		0.001				—
TOTAL PCB	0.03						
TOTAL PCB + EMPC	2.3						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.74	73.8	0.80	25.82	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.65	64.5	0.95	28.87	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.75	74.9	1.31	27.05	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.82	21.78	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.28	29.85	—

Data Reviewer: MJ 05/27/93

PCBF_PSR v 1.02, LARS 5/06/10

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ENTECH

TL-RTP Project: **23775**
Client Sample: **BURN #8**

Modified Method 680 PCB Analysis
Analysis File: **YB46800**

Client Project:					
Sample Matrix:	M23	Date Received:	05/10/93	Spike File:	SPPCBF01
TLRTP ID:	65-158-1A,B,	Date Extracted:	05/13/93	ICAL:	PCBY514
		Date Analyzed:	05/17/93	CONCAL:	YB462
Sample Size:	1.000	Dilution Factor:	2.0	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB46500	% Lipid:	n/a
		Analyst:	MM	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	EMPC			0.001			RECALC.
Total DiCB	0.03	1		2.8	1.63		
Total TriCB	0.04	5		0.16			B, RECALC
Total TetraCB	0.006	2		0.02			
Total PentaCB	EMPC			0.24			B, RECALC
Total HexaCB	ND		0.001				—
Total HeptaCB	EMPC			0.07			
Total OctaCB	EMPC			0.02			BECALC.
Total NonaCB	ND		0.001				—
DecaCB	ND		0.001				—
TOTAL PCB	0.07						
TOTAL PCB + EMPC	3.3						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	0.96	95.9	0.82	25.85	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	0.76	76.4	0.95	28.90	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.71	70.7	1.29	27.08	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.82	21.78	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.31	29.87	—

Data Reviewer: JW 05/27/93

PCBF_PSR v 1.02, LABS 5/6/10

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ENTECH

TL-RTP Project: **23775** — Modified Method 680 PCB Analysis
Client Sample: **BURN #9** — Analysis File: **YB46900**

Client Project:					
Sample Matrix:	M23	Date Received:	05/11/93	Spike File:	SPPCBF01
TLRTP ID:	65-164-1A,B,	Date Extracted:	05/13/93	ICAL:	PCBY514
		Date Analyzed:	05/17/93	CONCAL:	YB462
Sample Size:	1.000	Dilution Factor:	2.0	% Moisture:	n/a
Dry Weight:	n/a	Blank File:	YB46500	% Lipid:	n/a
		Analyst:	MM	% Solids:	n/a

Analytes	Amt. (ug)	Number	DL	EMPC	Ratio	RT	Flags
Total MonoCB	0.006	1		0.07	2.79		B
Total DiCB	0.02	1		1.4	1.71		
Total TriCB	EMPC			0.09			B, RECALC
Total TetraCB	0.003	1			0.89		
Total PentaCB	EMPC			0.52			B, JW 5/23
Total HexaCB	EMPC			0.005			—
Total HeptaCB	EMPC			0.10			
Total OctaCB	EMPC			0.003			RECALC
Total NonaCB	EMPC			0.03			—
DecaCB	ND		0.001				—
TOTAL PCB	0.03						
TOTAL PCB + EMPC	2.3						

Internal Standards	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-3,3',4,4'-TetraCB	1.2	116	0.82	25.85	—
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OctaCB	1.1	113	0.94	28.90	—

Alternate Standard	Amt. (ug)	% Recovery	Ratio	RT	Flags
$^{13}C_{12}$-2,2',4,4',5,5'-HexaCB	0.96	96.3	1.32	27.08	—

Recovery Standards	Ratio	RT	Flags
$^{13}C_{12}$-2,2',5,5'-TetraCB	0.81	21.78	—
$^{13}C_{12}$-3,3',4,4',5,5'-HexaCB	1.31	29.87	—

Data Reviewer: JW 05/27/93

Page 1 of 1

PCBF_PSR v 1.02 LARS 5/6/10

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Triangle Laboratories of RTP
Project Summary for Project 23637B

Filename :	ZC853	ZC847	ZC848
Client Id:	BURN #1	BURN #2	BURN #3
Units :	ug	ug	ug
Phenol	57.71	3.80	16.63
bis(2-Chloroethyl)ether	(9.32)	(5.94)	(4.82)
2-Chlorophenol	(8.89)	(5.67)	2.93
1,3-Dichlorobenzene	(8.05)	(5.14)	(4.16)
1,4-Dichlorobenzene	(7.82)	1.46	1.02
1,2-Dichlorobenzene	(8.58)	(5.47)	(4.43)
Benzyl alcohol	(14.74)	(9.41)	(7.62)
2,2'-oxybis(1-Chloropropane)	(8.13)	(5.19)	(4.20)
2-Methylphenol	17.21	(6.44)	(5.22)
3/4-Methylphenol	36.29	(6.07)	(4.92)
N-Nitroso-di-n-propylamine	(11.58)	(7.39)	(5.99)
Hexachloroethane	(13.01)	(8.30)	(6.73)
Nitrobenzene	4.53	(5.19)	(4.50)
Isophorone	(3.46)	(2.77)	(2.40)
2-Nitrophenol	(14.23)	(11.41)	(9.90)
2,4-Dimethylphenol	(6.82)	(5.47)	(4.74)
bis(2-Chloroethoxy)methane	(6.07)	(4.87)	(4.22)
Benzoic acid	816.04	249.62	567.64
2,4-Dichlorophenol	(9.13)	(7.32)	(6.34)
1,2,4-Trichlorobenzene	(7.48)	(6.00)	(5.20)
Naphthalene	32.08	6.26	9.63
4-Chloroaniline	(5.82)	(4.67)	(4.05)
Hexachlorobutadiene	(11.24)	(9.02)	(7.82)
4-Chloro-3-methylphenol	(7.78)	(6.24)	(5.41)
2-Methylnaphthalene	20.25	(3.46)	(3.00)
Hexachlorocyclopentadiene	(6.87)	(10.81)	(8.99)
2,4,6-Trichlorophenol	(7.18)	(11.30)	(9.40)
2,4,5-Trichlorophenol	(7.09)	(11.16)	(9.29)
2-Chloronaphthalene	(2.70)	4.00	(3.53)
2-Nitroaniline	(8.17)	(12.86)	(10.70)
Dimethylphthalate	10.44	(3.76)	(3.13)
2,6-Dinitrotoluene	(10.32)	(16.25)	(13.52)
2,4-Dinitrotoluene	(7.01)	(11.03)	(9.18)
Acenaphthylene	2.64	(2.55)	(2.12)
3-Nitroaniline	(10.64)	(16.74)	(13.93)
Acenaphthene	2.55	(4.22)	(3.51)
2,4-Dinitrophenol	(27.47)	(43.24)	(35.98)
4-Nitrophenol	(14.85)	(23.37)	(19.44)
Dibenzofuran	3.86	(2.90)	(2.41)
Diethylphthalate	14.38	(3.40)	5.58
4-Chlorophenyl-phenylether	(4.50)	(7.09)	(5.90)
Fluorene	3.00	(3.61)	(3.01)

Triangle Laboratories of RTP
Project Summary for Project 23637B

Filename :	ZC853	ZC847	ZC848
Client Id:	BURN #1	BURN #2	BURN #3
Units :	ug	ug	ug
4-Nitroaniline	(7.16)	(11.28)	(9.38)
4,6-Dinitro-2-methylphenol	(6.76)	(22.38)	(15.44)
N-Nitrosodiphenylamine	(2.16)	(7.15)	(4.93)
4-Bromophenyl-phenylether	(4.36)	(14.43)	(9.96)
Hexachlorobenzene	(2.88)	(9.54)	(6.58)
Pentachlorophenol	(5.55)	(18.38)	(12.68)
Phenanthrene	23.54	(2.76)	(1.91)
Anthracene	1.32	(2.86)	(1.97)
Di-n-butylphthalate	30.77	3.52	13.33
Fluoranthene	5.31	(1.84)	(1.27)
Pyrene	3.88	(1.26)	(0.90)
Butylbenzylphthalate	(1.19)	(2.37)	(1.68)
3,3'-Dichlorobenzidine	(2.38)	(4.75)	(3.37)
bis(2-Ethylhexyl)phthalate	11.06	(1.74)	(1.23)
Benzo(a)anthracene	(0.73)	(1.46)	(1.04)
Chrysene	4.94	(1.65)	(1.17)
Di-n-octylphthalate	(1.19)	(0.97)	(0.75)
Benzo(b)fluoranthene	(1.47)	(1.19)	(0.93)
Benzo(k)fluoranthene	(1.48)	(1.20)	(0.93)
Benzo(a)pyrene	(1.51)	(1.22)	(0.95)
Indeno(1,2,3-cd)pyrene	(1.23)	(1.00)	(0.77)
Dibenz(a,h)anthracene	(1.57)	(1.27)	(0.99)
Benzo(g,h,i)perylene	(1.42)	(1.16)	(0.90)

Triangle Laboratories of RTP
Project Summary for Project 23637B

Filename :	ZC849	ZC850	ZC846
Client Id:	TEST BURN #4	BURN #5	FIELD BLANK
Units :	ug	ug	ug
Phenol	(4.55)	(5.60)	(4.61)
bis(2-Chloroethyl)ether	(5.60)	(6.89)	(5.67)
2-Chlorophenol	(5.35)	(6.57)	(5.41)
1,3-Dichlorobenzene	(4.84)	(5.95)	(4.90)
1,4-Dichlorobenzene	(4.70)	(5.78)	(4.76)
1,2-Dichlorobenzene	(5.16)	(6.34)	(5.22)
Benzyl alcohol	(8.86)	(10.90)	(8.97)
2,2'-oxybis(1-Chloropropane)	(4.89)	(6.01)	(4.95)
2-Methylphenol	(6.07)	(7.46)	(6.15)
3/4-Methylphenol	(5.72)	(7.03)	(5.79)
N-Nitroso-di-n-propylamine	(6.96)	(8.56)	(7.05)
Hexachloroethane	(7.82)	(9.62)	(7.92)
Nitrobenzene	(4.48)	(5.63)	(4.62)
Isophorone	(2.39)	(3.00)	(2.46)
2-Nitrophenol	(9.85)	(12.36)	(10.14)
2,4-Dimethylphenol	(4.72)	(5.92)	(4.86)
bis(2-Chloroethoxy)methane	(4.20)	(5.27)	(4.33)
Benzoic acid	(12.33)	76.55	(12.71)
2,4-Dichlorophenol	(6.31)	(7.93)	(6.50)
1,2,4-Trichlorobenzene	(5.17)	(6.49)	(5.33)
Naphthalene	3.62	12.45	4.74
4-Chloroaniline	(4.03)	(5.06)	(4.15)
Hexachlorobutadiene	(7.78)	(9.76)	(8.01)
4-Chloro-3-methylphenol	(5.38)	(6.75)	(5.54)
2-Methylnaphthalene	(2.98)	(3.74)	(3.07)
Hexachlorocyclopentadiene	(8.46)	(10.34)	(7.79)
2,4,6-Trichlorophenol	(8.84)	(10.81)	(8.14)
2,4,5-Trichlorophenol	(8.73)	(10.68)	(8.04)
2-Chloronaphthalene	2.09	2.65	(3.06)
2-Nitroaniline	(10.06)	(12.31)	(9.27)
Dimethylphthalate	(2.94)	(3.60)	(2.71)
2,6-Dinitrotoluene	(12.71)	(15.55)	(11.71)
2,4-Dinitrotoluene	(8.63)	(10.55)	(7.95)
Acenaphthylene	(1.99)	(2.44)	(1.84)
3-Nitroaniline	(13.10)	(16.02)	(12.07)
Acenaphthene	(3.30)	(4.04)	(3.04)
2,4-Dinitrophenol	(33.83)	(41.38)	(31.16)
4-Nitrophenol	(18.28)	(22.36)	(16.84)
Dibenzofuran	(2.27)	(2.77)	(2.09)
Diethylphthalate	(2.66)	7.42	(2.45)
4-Chlorophenyl-phenylether	(5.54)	(6.78)	(5.11)
Fluorene	(2.83)	(3.46)	(2.60)

Triangle Laboratories of RTP
Project Summary for Project 23637B

Filename :	ZC849	ZC850	ZC846
Client Id:	TEST BURN #4	BURN #5	FIELD BLANK
Units :	ug	ug	ug
4-Nitroaniline	(8.82)	(10.79)	(8.13)
4,6-Dinitro-2-methylphenol	(16.13)	(20.33)	(17.19)
N-Nitrosodiphenylamine	(5.15)	(6.50)	(5.49)
4-Bromophenyl-phenylether	(10.40)	(13.11)	(11.08)
Hexachlorobenzene	(6.87)	(8.66)	(7.33)
Pentachlorophenol	(13.25)	(16.69)	(14.12)
Phenanthrene	(1.99)	(2.51)	(2.12)
Anthracene	(2.06)	(2.60)	(2.20)
Di-n-butylphthalate	18.23	11.48	(1.18)
Fluoranthene	(1.33)	(1.67)	(1.42)
Pyrene	(1.03)	(1.32)	(1.03)
Butylbenzylphthalate	(1.93)	(2.49)	5.38
3,3'-Dichlorobenzidine	(3.86)	(4.98)	(3.89)
bis(2-Ethylhexyl)phthalate	(1.41)	(1.82)	134.60
Benzo(a)anthracene	(1.19)	(1.54)	(1.20)
Chrysene	(1.34)	(1.73)	(1.35)
Di-n-octylphthalate	(0.98)	(1.08)	(0.92)
Benzo(b)fluoranthene	(1.21)	(1.33)	(1.14)
Benzo(k)fluoranthene	(1.21)	(1.33)	(1.14)
Benzo(a)pyrene	(1.24)	(1.36)	(1.17)
Indeno(1,2,3-cd)pyrene	(1.01)	(1.11)	(0.95)
Dibenz(a,h)anthracene	(1.29)	(1.41)	(1.21)
Benzo(g,h,i)perylene	(1.17)	(1.28)	(1.10)

Triangle Laboratories of RTP
Project Summary for Project 23775b

Filename :	ZC962	ZC963	ZC964
Client Id:	SBLK 051393	BURN #6	BURN #7
Units :	ug	ug	ug

Phenol	(12.30)	(10.21)	1.15
bis(2-Chloroethyl)ether	(14.07)	(11.68)	(11.22)
2-Chlorophenol	(14.27)	(11.85)	(11.38)
1,3-Dichlorobenzene	(12.65)	(10.50)	(10.08)
1,4-Dichlorobenzene	(12.24)	(10.16)	(9.76)
1,2-Dichlorobenzene	(12.60)	(10.46)	(10.04)
Benzyl alcohol	(25.54)	(21.20)	(20.35)
2,2'-oxybis(1-Chloropropane)	(9.11)	(7.57)	(7.26)
2-Methylphenol	(15.75)	(13.07)	(12.55)
3/4-Methylphenol	(15.35)	(12.74)	(12.23)
N-Nitroso-di-n-propylamine	(14.73)	(12.22)	(11.74)
Hexachloroethane	(12.83)	(10.65)	(10.23)
Nitrobenzene	(8.91)	(7.69)	(6.55)
Isophorone	(5.52)	(4.77)	(4.06)
2-Nitrophenol	(28.43)	(24.53)	(20.87)
2,4-Dimethylphenol	(10.29)	(8.88)	(7.56)
bis(2-Chloroethoxy)methane	(10.33)	(8.92)	(7.59)
Benzoic acid	52.18	190.30	178.41
2,4-Dichlorophenol	(16.54)	(14.27)	(12.14)
1,2,4-Trichlorobenzene	(12.09)	(10.43)	(8.88)
Naphthalene	(4.86)	9.75	(3.57)
4-Chloroaniline	(10.80)	(9.32)	(7.93)
Hexachlorobutadiene	(10.91)	(9.41)	(8.01)
4-Chloro-3-methylphenol	(11.12)	(9.59)	(8.16)
2-Methylnaphthalene	(7.73)	(6.67)	(5.68)
Hexachlorocyclopentadiene	(10.81)	(9.40)	(8.11)
2,4,6-Trichlorophenol	(18.47)	(16.07)	(13.86)
2,4,5-Trichlorophenol	(17.02)	(14.80)	(12.77)
2-Chloronaphthalene	(7.58)	(6.60)	(5.69)
2-Nitroaniline	(11.86)	(10.32)	(8.90)
Dimethylphthalate	(5.20)	(4.52)	(3.90)
2,6-Dinitrotoluene	(23.88)	(20.77)	(17.92)
2,4-Dinitrotoluene	(14.98)	(13.03)	(11.24)
Acenaphthylene	(4.63)	(4.03)	(3.47)
3-Nitroaniline	(20.06)	(17.45)	(15.05)
Acenaphthene	(6.34)	(5.52)	(4.76)
2,4-Dinitrophenol	(43.66)	(37.98)	(32.76)
4-Nitrophenol	(11.18)	(9.73)	(8.39)
Dibenzofuran	(4.95)	(4.30)	(3.71)
Diethylphthalate	(3.56)	4.35	(2.67)
4-Chlorophenyl-phenylether	(8.89)	(7.74)	(6.67)
Fluorene	(5.52)	(4.80)	(4.14)

Triangle Laboratories of RTP
Project Summary for Project 23775b

Filename :	ZC962	ZC963	ZC964
Client Id:	SBLK 051393	BURN #6	BURN #7
Units :	ug	ug	ug

SA 5-20-93

4-Nitroaniline	(16.07)	(13.98)	(12.06)
4,6-Dinitro-2-methylphenol	(23.61)	(20.29)	(19.30)
N-Nitrosodiphenylamine	(9.07)	(7.79)	(7.41)
4-Bromophenyl-phenylether	(13.22)	(11.36)	(10.81)
Hexachlorobenzene	(10.72)	(9.22)	(8.77)
Pentachlorophenol	(14.78)	(12.70)	(12.08)
Phenanthrene	(3.45)	(2.97)	(2.82)
Anthracene	(3.46)	(2.98)	(2.83)
Di-n-butylphthalate	24.77	23.38	7.88
Fluoranthene	(1.99)	(1.71)	(1.63)
Pyrene	(1.78)	(1.69)	(1.55)
Butylbenzylphthalate	(2.86)	(2.71)	(2.48)
3,3'-Dichlorobenzidine	(5.71)	(5.41)	(4.96)
bis(2-Ethylhexyl)phthalate	14.49	58.59	5.48
Benzo(a)anthracene	(1.75)	(1.66)	(1.52)
Chrysene	(1.98)	(1.88)	(1.72)
Di-n-octylphthalate	(1.38)	(1.19)	(1.05)
Benzo(b)fluoranthene	(1.89)	(1.62)	(1.44)
Benzo(k)fluoranthene	(1.93)	(1.66)	(1.47)
Benzo(a)pyrene	(1.95)	(1.67)	(1.48)
Indeno(1,2,3-cd)pyrene	(1.85)	(1.59)	(1.41)
Dibenz(a,h)anthracene	(2.44)	(2.10)	(1.86)
Benzo(g,h,i)perylene	(2.02)	(1.74)	(1.54)

Triangle Laboratories of RTP
Project Summary for Project 23775b

Filename :	ZC965	ZC966
Client Id:	BURN #8	BURN #9
Units :	ug	ug
Phenol	(8.57)	(7.67)
bis(2-Chloroethyl)ether	(9.81)	(8.77)
2-Chlorophenol	(9.95)	(8.90)
1,3-Dichlorobenzene	(8.81)	(7.88)
1,4-Dichlorobenzene	(8.53)	(7.63)
1,2-Dichlorobenzene	(8.78)	(7.85)
Benzyl alcohol	(17.79)	(15.92)
2,2'-oxybis(1-Chloropropane)	(6.35)	(5.68)
2-Methylphenol	(10.97)	(9.82)
3/4-Methylphenol	(10.70)	(9.57)
N-Nitroso-di-n-propylamine	(10.26)	(9.18)
Hexachloroethane	(8.94)	(8.00)
Nitrobenzene	(6.42)	(5.37)
Isophorone	(3.98)	(3.33)
2-Nitrophenol	(20.47)	(17.13)
2,4-Dimethylphenol	(7.41)	(6.20)
bis(2-Chloroethoxy)methane	(7.44)	(6.23)
Benzoic acid	332.48	799.11
2,4-Dichlorophenol	(11.91)	(9.97)
1,2,4-Trichlorobenzene	(8.70)	(7.29)
Naphthalene	11.15	552.14
4-Chloroaniline	(7.78)	(6.51)
Hexachlorobutadiene	(7.86)	(6.58)
4-Chloro-3-methylphenol	(8.01)	(6.70)
2-Methylnaphthalene	(5.57)	26.36
Hexachlorocyclopentadiene	(7.78)	(7.19)
2,4,6-Trichlorophenol	(13.30)	(12.29)
2,4,5-Trichlorophenol	(12.25)	(11.32)
2-Chloronaphthalene	(5.46)	(5.04)
2-Nitroaniline	(8.54)	(7.89)
Dimethylphthalate	(3.74)	(3.46)
2,6-Dinitrotoluene	(17.19)	(15.89)
2,4-Dinitrotoluene	(10.79)	(9.97)
Acenaphthylene	(3.33)	180.05
3-Nitroaniline	(14.44)	(13.34)
Acenaphthene	(4.57)	(4.22)
2,4-Dinitrophenol	(31.44)	(29.05)
4-Nitrophenol	(8.05)	(7.44)
Dibenzofuran	(3.56)	(3.29)
Diethylphthalate	4.12	6.82
4-Chlorophenyl-phenylether	(6.40)	(5.92)
Fluorene	(3.97)	27.07

Triangle Laboratories of RTP
Project Summary for Project 23775b

Filename :	ZC965	ZC966
Client Id:	BURN #8	BURN #9
Units :	ug	ug
4-Nitroaniline	(11.57)	(10.69)
4,6-Dinitro-2-methylphenol	(18.39)	(16.45)
N-Nitrosodiphenylamine	(7.06)	(6.32)
4-Bromophenyl-phenylether	(10.30)	(9.21)
Hexachlorobenzene	(8.36)	(7.47)
Pentachlorophenol	(11.51)	(10.30)
Phenanthrene	(2.69)	17.07
Anthracene	(2.70)	(2.41)
Di-n-butylphthalate	338.65	12.39
Fluoranthene	(1.55)	(1.39)
Pyrene	(1.26)	(0.98)
Butylbenzylphthalate	(2.02)	(1.57)
3,3'-Dichlorobenzidine	(4.04)	(3.14)
bis(2-Ethylhexyl)phthalate	72.20	15.24
Benzo(a)anthracene	(1.24)	(0.96)
Chrysene	(1.40)	(1.09)
Di-n-octylphthalate	(0.92)	(0.63)
Benzo(b)fluoranthene	(1.26)	(0.87)
Benzo(k)fluoranthene	(1.29)	(0.88)
Benzo(a)pyrene	(1.30)	(0.89)
Indeno(1,2,3-cd)pyrene	(1.24)	(0.85)
Dibenz(a,h)anthracene	(1.63)	(1.12)
Benzo(g,h,i)perylene	(1.35)	(0.93)

Triangle Laboratories of RTP
Project Summary for Project 23637

Filename :	YB424	YB420	YB417
Client Id:	Burn #1	Burn #2	Burn #3
Units :	ug	ug	ug
2-Chlorophenol	(2.01)	(0.32)	3.75
1,3-Dichlorobenzene	(2.08)	(0.33)	(0.32)
1,4-Dichlorobenzene	0.60	1.64	1.29
1,2-Dichlorobenzene	(2.13)	(0.34)	(0.33)
3/4-Chlorophenol	(0.50)	(0.08)	(0.08)
1,3,5-Trichlorobenzene	(2.44)	(0.38)	(0.37)
2,4-Dichlorophenol	(2.70)	(0.42)	0.67
2,5-Dichlorophenol	(2.67)	(0.42)	(0.41)
2,3-Dichlorophenol	(3.47)	(0.54)	(0.53)
1,2,4-Trichlorobenzene	1.51	(0.40)	0.38
2,6-Dichlorophenol	(2.70)	(0.42)	(0.41)
1,2,3-Trichlorobenzene	(2.62)	(0.41)	(0.40)
1,2,3,5-Tetrachlorobenzene	(2.61)	(0.41)	(0.40)
1,2,4,5-Tetrachlorobenzene	(2.52)	(0.39)	(0.38)
2,3,5-Trichlorophenol	(3.79)	(0.57)	(0.59)
2,4,6-Trichlorophenol	(3.81)	(0.57)	0.98
2,4,5-Trichlorophenol	(3.57)	(0.54)	(0.55)
2,3,4-Trichlorophenol	(4.02)	(0.61)	(0.62)
3,5-Dichlorophenol	(2.58)	(0.39)	(0.40)
1,2,3,4-Tetrachlorobenzene	(2.60)	(0.39)	(0.40)
2,3,6-Trichlorophenol	(3.77)	(0.57)	(0.58)
3,4-Dichlorophenol	(2.92)	(0.44)	(0.45)
Pentachlorobenzene	(3.10)	(0.47)	(0.48)
2,3,5,6-Tetrachlorophenol	(4.41)	(0.66)	(0.68)
2,3,4,5-Tetrachlorophenol	(5.39)	(0.81)	(0.83)
Hexachlorobenzene	(3.82)	(0.60)	(0.66)
Pentachlorophenol	(6.12)	(0.96)	(1.05)

Triangle Laboratories of RTP
Project Summary for Project 23637

Filename :	YB418	YB419	YB415
Client Id:	Test Burn #4	Burn #5	Field Blank
Units :	ug	ug	ug
2-Chlorophenol	(0.27)	(0.29)	(0.25)
1,3-Dichlorobenzene	(0.28)	(0.30)	(0.26)
1,4-Dichlorobenzene	0.57	0.20	0.69
1,2-Dichlorobenzene	(0.29)	(0.31)	(0.26)
3/4-Chlorophenol	(0.07)	(0.07)	(0.06)
1,3,5-Trichlorobenzene	(0.33)	(0.37)	(0.30)
2,4-Dichlorophenol	(0.37)	(0.41)	(0.33)
2,5-Dichlorophenol	(0.36)	(0.41)	(0.33)
2,3-Dichlorophenol	(0.47)	(0.53)	(0.43)
1,2,4-Trichlorobenzene	(0.35)	(0.40)	(0.32)
2,6-Dichlorophenol	(0.37)	(0.41)	(0.33)
1,2,3-Trichlorobenzene	(0.35)	(0.40)	(0.32)
1,2,3,5-Tetrachlorobenzene	(0.35)	(0.40)	(0.32)
1,2,4,5-Tetrachlorobenzene	(0.34)	(0.39)	(0.31)
2,3,5-Trichlorophenol	(0.51)	(0.55)	(0.46)
2,4,6-Trichlorophenol	(0.51)	(0.56)	(0.46)
2,4,5-Trichlorophenol	(0.48)	(0.52)	(0.43)
2,3,4-Trichlorophenol	(0.54)	(0.59)	(0.48)
3,5-Dichlorophenol	(0.35)	(0.38)	(0.31)
1,2,3,4-Tetrachlorobenzene	(0.35)	(0.38)	(0.31)
2,3,6-Trichlorophenol	(0.51)	(0.55)	(0.45)
3,4-Dichlorophenol	(0.39)	(0.43)	(0.35)
Pentachlorobenzene	(0.42)	(0.45)	(0.37)
2,3,5,6-Tetrachlorophenol	(0.59)	(0.64)	(0.53)
2,3,4,5-Tetrachlorophenol	(0.72)	(0.79)	(0.65)
Hexachlorobenzene	(0.50)	(0.56)	(0.46)
Pentachlorophenol	(0.80)	(0.89)	(0.74)

Triangle Laboratories of RTP
Project Summary for Project 23775c

Filename :	YB495	YB496	YB497
Client Id: SA 5-20-93	SBLK 051393	Burn #6	Burn #7
Units :	ug	ug	ug
2-Chlorophenol	(2.25)	(1.78)	(1.60)
1,3-Dichlorobenzene	(2.32)	(1.84)	(1.65)
1,4-Dichlorobenzene	(2.40)	(1.90)	(1.70)
1,2-Dichlorobenzene	(2.48)	(1.97)	(1.76)
3/4-Chlorophenol	(1.34)	(1.06)	(0.95)
1,3,5-Trichlorobenzene	(3.06)	(2.51)	(2.13)
2,4-Dichlorophenol	(2.75)	(2.25)	(1.91)
2,5-Dichlorophenol	(2.87)	(2.34)	(1.99)
2,3-Dichlorophenol	(3.50)	(2.86)	(2.43)
1,2,4-Trichlorobenzene	(3.40)	(2.78)	(2.36)
2,6-Dichlorophenol	(2.80)	(2.29)	(1.94)
1,2,3-Trichlorobenzene	(3.08)	(2.52)	(2.14)
1,2,3,5-Tetrachlorobenzene	(3.46)	(2.83)	(2.41)
1,2,4,5-Tetrachlorobenzene	(4.21)	(3.45)	(2.93)
2,3,5-Trichlorophenol	(6.40)	(5.45)	(4.77)
2,4,6-Trichlorophenol	(4.12)	(3.51)	(3.07)
2,4,5-Trichlorophenol	(3.97)	(3.38)	(2.96)
2,3,4-Trichlorophenol	(5.71)	(4.86)	(4.26)
3,5-Dichlorophenol	(2.70)	(2.30)	(2.02)
1,2,3,4-Tetrachlorobenzene	(3.37)	(2.88)	(2.52)
2,3,6-Trichlorophenol	(4.42)	(3.76)	(3.30)
3,4-Dichlorophenol	(2.77)	(2.36)	(2.07)
Pentachlorobenzene	(3.97)	(3.38)	(2.96)
2,3,5,6-Tetrachlorophenol	(5.04)	(4.30)	(3.76)
2,3,4,5-Tetrachlorophenol	(5.07)	(4.32)	(3.79)
Hexachlorobenzene	(5.56)	(4.69)	(4.15)
Pentachlorophenol	(7.60)	(6.41)	(5.67)

Triangle Laboratories of RTP
Project Summary for Project 23775c

Filename :	YB498	YB499
Client Id:	Burn #8	Burn #9
Units :	ug	ug
2-Chlorophenol	(1.42)	(1.69)
1,3-Dichlorobenzene	(1.46)	(1.75)
1,4-Dichlorobenzene	(1.51)	2.34
1,2-Dichlorobenzene	(1.56)	(1.87)
3/4-Chlorophenol	(0.84)	(1.01)
1,3,5-Trichlorobenzene	(2.01)	(2.33)
2,4-Dichlorophenol	(1.80)	(2.09)
2,5-Dichlorophenol	(1.88)	(2.18)
2,3-Dichlorophenol	(2.29)	(2.67)
1,2,4-Trichlorobenzene	(2.22)	(2.59)
2,6-Dichlorophenol	(1.83)	(2.13)
1,2,3-Trichlorobenzene	(2.02)	(2.35)
1,2,3,5-Tetrachlorobenzene	(2.27)	(2.64)
1,2,4,5-Tetrachlorobenzene	(2.76)	(3.21)
2,3,5-Trichlorophenol	(4.63)	(5.29)
2,4,6-Trichlorophenol	(2.98)	(3.40)
2,4,5-Trichlorophenol	(2.87)	(3.28)
2,3,4-Trichlorophenol	(4.13)	(4.72)
3,5-Dichlorophenol	(1.96)	(2.23)
1,2,3,4-Tetrachlorobenzene	(2.44)	(2.79)
2,3,6-Trichlorophenol	(3.20)	(3.65)
3,4-Dichlorophenol	(2.00)	(2.29)
Pentachlorobenzene	(2.87)	(3.28)
2,3,5,6-Tetrachlorophenol	(3.65)	(4.17)
2,3,4,5-Tetrachlorophenol	(3.67)	(4.19)
Hexachlorobenzene	(4.06)	(4.80)
Pentachlorophenol	(5.55)	(6.56)

APPENDIX E

TCLP Test Data

Analytical Blank

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
LAB BLANK 5/19

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/19/93
Date Analyzed: 930609 16:52
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery		Corrected uG/L	
110-86-1	Pyridine	10	U	0	U	10	U
108-95-2	Phenol	10	U	41		24	U
106-46-7	1,4-Dichlorobenzene	10	U	38		26	U
95-50-1	1,2-Dichlorobenzene	10	U	38		26	U
95-48-7	2-Methylphenol	10	U	42		24	U
106-44-5	4-Methylphenol/3-Methylphenol	10	U	37		27	U
67-72-1	Hexachloroethane	10	U	33		30	U
98-95-3	Nitrobenzene	10	U	34		29	U
87-68-3	Hexachlorobutadiene	10	U	34		29	U
88-06-2	2,4,6-Trichlorophenol	10	U	57		18	U
95-95-4	2,4,5-Trichlorophenol	50	U	61		82	U
121-14-2	2,4-Dinitrotoluene	10	U	53		19	U
118-74-1	Hexachlorobenzene	10	U	34		29	U
58-90-2	2,3,4,6-Tetrachlorophenol	50	U	83		50	U
87-86-5	Pentachlorophenol	50	U	45		110	U

TCLP method Blank
Sodium Acetate Buffer
Som pH = 4.93 ± 0.05

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-53 EXT-1-BLK

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/19/93
Date Analyzed: 930609 18:08
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup _ Yes XX No
Separatory Funnel Extraction _ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery		Corrected uG/L	
110-86-1	Pyridine	10	U	0	U	10	U
108-95-2	Phenol	10	U	41		24	U
106-46-7	1,4-Dichlorobenzene	10	U	38		26	U
95-50-1	1,2-Dichlorobenzene	10	U	38		26	U
95-48-7	2-Methylphenol	10	U	42		24	U
106-44-5	4-Methylphenol/3-Methylphenol	10	U	37		27	U
67-72-1	Hexachloroethane	10	U	33		30	U
98-95-3	Nitrobenzene	10	U	34		29	U
87-68-3	Hexachlorobutadiene	10	U	34		29	U
88-06-2	2,4,6-Trichlorophenol	10	U	57		18	U
95-95-4	2,4,5-Trichlorophenol	52	U	61		85	U
121-14-2	2,4-Dinitrotoluene	10	U	53		19	U
118-74-1	Hexachlorobenzene	10	U	34		29	U
58-90-2	2,3,4,6-Tetrachlorophenol	52	U	83		52	U
87-86-5	Pentachlorophenol	52	U	45		120	U

TCLP Method Blank
Acetic Acid Soln
pH = 2.88 ± 0.05

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-531-EXF-2-BLK

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/19/93
Date Analyzed: 930609 18:46
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected ug/L		XMS Recovery		Corrected ug/L	
110-86-1	Pyridine	10	U	0	U	10	U
108-95-2	Phenol	10	U	41		24	U
106-46-7	1,4-Dichlorobenzene	10	U	38		26	U
95-50-1	1,2-Dichlorobenzene	10	U	38		26	U
95-48-7	2-Methylphenol	10	U	42		24	U
106-44-5	4-Methylphenol/3-Methylphenol	10	U	37		27	U
67-72-1	Hexachloroethane	10	U	33		30	U
98-95-3	Nitrobenzene	10	U	34		29	U
87-68-3	Hexachlorobutadiene	10	U	34		29	U
88-06-2	2,4,6-Trichlorophenol	10	U	57		18	U
95-95-4	2,4,5-Trichlorophenol	52	U	61		85	U
121-14-2	2,4-Dinitrotoluene	10	U	53		19	U
118-74-1	Hexachlorobenzene	10	U	34		29	U
58-90-2	2,3,4,6-Tetrachlorophenol	52	U	83		52	U
87-86-5	Pentachlorophenol	52	U	45		120	U

Instrument Blank

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
BLANK

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/14/93
Date Analyzed: 930609 17:30
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery	Corrected uG/L	
110-86-1	Pyridine	10	U	8	120	U
108-95-2	Phenol	10	U	46	22	U
106-46-7	1,4-Dichlorobenzene	10	U	42	24	U
95-50-1	1,2-Dichlorobenzene	10	U	41	24	U
95-48-7	2-Methylphenol	10	U	45	22	U
106-44-5	4-Methylphenol/3-Methylphenol	10	U	40	25	U
67-72-1	Hexachloroethane	10	U	39	26	U
98-95-3	Nitrobenzene	10	U	42	24	U
87-68-3	Hexachlorobutadiene	10	U	40	25	U
88-06-2	2,4,6-Trichlorophenol	10	U	56	18	U
95-95-4	2,4,5-Trichlorophenol	50	U	61	82	U
121-14-2	2,4-Dinitrotoluene	10	U	52	19	U
118-74-1	Hexachlorobenzene	10	U	39	26	U
58-90-2	2,3,4,6-Tetrachlorophenol	50	U	81	50	U
87-86-5	Pentachlorophenol	50	U	41	120	U

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-501-EXF-2-BLK

TCLP Method Blank
~~Sodium Acetate Buf~~
Acetic Acid Soln
pH = 2.88 ± 0.05

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/14/93
Date Analyzed: 930609 22:31
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery	Corrected uG/L	
110-86-1	Pyridine	10	U	8	120	U
108-95-2	Phenol	10	U	46	22	U
106-46-7	1,4-Dichlorobenzene	10	U	42	24	U
95-50-1	1,2-Dichlorobenzene	10	U	41	24	U
95-48-7	2-Methylphenol	10	U	45	22	U
106-44-5	4-Methylphenol/3-Methylphenol	10	U	40	25	U
67-72-1	Hexachloroethane	10	U	39	26	U
98-95-3	Nitrobenzene	10	U	42	24	U
87-68-3	Hexachlorobutadiene	10	U	40	25	U
88-06-2	2,4,6-Trichlorophenol	10	U	56	18	U
95-95-4	2,4,5-Trichlorophenol	52	U	61	85	U
121-14-2	2,4-Dinitrotoluene	10	U	52	19	U
118-74-1	Hexachlorobenzene	10	U	39	26	U
58-90-2	2,3,4,6-Tetrachlorophenol	52	U	81	52	U
87-86-5	Pentachlorophenol	52	U	41	130	U

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
735-531-M1-TCLP

~~TCLP Method Blank~~
~~Sodium Acetate Buffer~~
~~Soln. pH = 4.93 ± 0.05~~
TCLP Extract of Burn
#1 ash - EXF #3

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/19/93
Date Analyzed: 930609 19:23
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L	XMS Recovery	Corrected uG/L
110-86-1	Pyridine	19 U	0 U	19 U
108-95-2	Phenol	19 U	41	46 U
106-46-7	1,4-Dichlorobenzene	19 U	38	50 U
95-50-1	1,2-Dichlorobenzene	19 U	38	50 U
95-48-7	2-Methylphenol	19 U	42	45 U
106-44-5	4-Methylphenol/3-Methylphenol	19 U	37	51 U
67-72-1	Hexachloroethane	19 U	33	58 U
98-95-3	Nitrobenzene	19 U	34	56 U
87-68-3	Hexachlorobutadiene	19 U	34	56 U
88-06-2	2,4,6-Trichlorophenol	19 U	57	33 U
95-95-4	2,4,5-Trichlorophenol	93 U	61	150 U
121-14-2	2,4-Dinitrotoluene	19 U	53	36 U
118-74-1	Hexachlorobenzene	19 U	34	56 U
58-90-2	2,3,4,6-Tetrachlorophenol	93 U	83	93 U
87-86-5	Pentachlorophenol	93 U	45	210 U

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-50-2-TCLP

TCLP Extract of Burn #2 ash

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/14/93
Date Analyzed: 930609 23:08
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected ug/L		XMS Recovery	Corrected ug/L	
110-86-1	Pyridine	22	U	8	280	U
108-95-2	Phenol	22	U	46	48	U
106-46-7	1,4-Dichlorobenzene	22	U	42	52	U
95-50-1	1,2-Dichlorobenzene	22	U	41	54	U
95-48-7	2-Methylphenol	22	U	45	49	U
106-44-5	4-Methylphenol/3-Methylphenol	22	U	40	55	U
67-72-1	Hexachloroethane	22	U	39	56	U
98-95-3	Nitrobenzene	22	U	42	52	U
87-68-3	Hexachlorobutadiene	22	U	40	55	U
88-06-2	2,4,6-Trichlorophenol	22	U	56	39	U
95-95-4	2,4,5-Trichlorophenol	110	U	61	180	U
121-14-2	2,4-Dinitrotoluene	22	U	52	42	U
118-74-1	Hexachlorobenzene	22	U	39	56	U
58-90-2	2,3,4,6-Tetrachlorophenol	110	U	81	140	U
87-86-5	Pentachlorophenol	110	U	41	270	U

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-50-3-TCLP

TCLP Extract of Burn # 3 ash

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/14/93
Date Analyzed: 930609 23:46
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		%MS Recovery	Corrected uG/L	
110-86-1	Pyridine	19	U	8	240	U
108-95-2	Phenol	19	U	46	41	U
106-46-7	1,4-Dichlorobenzene	19	U	42	45	U
95-50-1	1,2-Dichlorobenzene	19	U	41	46	U
95-48-7	2-Methylphenol	19	U	45	42	U
106-44-5	4-Methylphenol/3-Methylphenol	19	U	40	48	U
67-72-1	Hexachloroethane	19	U	39	49	U
98-95-3	Nitrobenzene	19	U	42	45	U
87-68-3	Hexachlorobutadiene	19	U	40	48	U
88-06-2	2,4,6-Trichlorophenol	19	U	56	34	U
95-95-4	2,4,5-Trichlorophenol	96	U	61	160	U
121-14-2	2,4-Dinitrotoluene	19	U	52	37	U
118-74-1	Hexachlorobenzene	19	U	39	49	U
58-90-2	2,3,4,6-Tetrachlorophenol	96	U	81	96	U
87-86-5	Pentachlorophenol	96	U	41	230	U

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-50-4-TCLP

TCLP Extract of Burn #4 Ash

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/14/93
Date Analyzed: 930610 00:23
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery	Corrected uG/L	
110-86-1	Pyridine	23	U	8	290	U
108-95-2	Phenol	23	U	46	50	U
106-46-7	1,4-Dichlorobenzene	23	U	42	55	U
95-50-1	1,2-Dichlorobenzene	23	U	41	56	U
95-48-7	2-Methylphenol	23	U	45	[illegible]	U
106-44-5	4-Methylphenol/3-Methylphenol	23	U	40	58	U
67-72-1	Hexachloroethane	23	U	39	59	U
98-95-3	Nitrobenzene	23	U	42	55	U
87-68-3	Hexachlorobutadiene	23	U	40	58	U
88-06-2	2,4,6-Trichlorophenol	23	U	56	41	U
95-95-4	2,4,5-Trichlorophenol	120	U	61	200	U
121-14-2	2,4-Dinitrotoluene	23	U	52	44	U
118-74-1	Hexachlorobenzene	23	U	39	59	U
58-90-2	2,3,4,6-Tetrachlorophenol	120	U	81	120	U
87-86-5	Pentachlorophenol	120	U	41	290	U

TCLP Extract of Burns 5/6 ash Ext # 2

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-53 B5/6 TCLP

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/19/93
Date Analyzed: 930609 20:01
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		%MS Recovery		Corrected uG/L	
110-86-1	Pyridine	20	U	0	U	20	U
108-95-2	Phenol	20	U	41		49	U
106-46-7	1,4-Dichlorobenzene	20	U	38		53	U
95-50-1	1,2-Dichlorobenzene	20	U	38		53	U
95-48-7	2-Methylphenol	20	U	42		48	U
106-44-5	4-Methylphenol/3-Methylphenol	20	U	37		54	U
67-72-1	Hexachloroethane	20	U	33		61	U
98-95-3	Nitrobenzene	20	U	34		59	U
87-68-3	Hexachlorobutadiene	20	U	34		59	U
88-06-2	2,4,6-Trichlorophenol	20	U	57		35	U
95-95-4	2,4,5-Trichlorophenol	100	U	61		160	U
121-14-2	2,4-Dinitrotoluene	20	U	53		38	U
118-74-1	Hexachlorobenzene	20	U	34		59	U
58-90-2	2,3,4,6-Tetrachlorophenol	100	U	83		100	U
87-86-5	Pentachlorophenol	100	U	45		220	U

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-50-7-TCLP

TCLP Extract of Burn # 7 ash

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/14/93
Date Analyzed: 930610 01:38
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery	Corrected uG/L		not required
110-86-1	Pyridine	20	U	8	250	U	
108-95-2	Phenol	20	U	46	43	U	
106-46-7	1,4-Dichlorobenzene	20	U	42	48	U	
95-50-1	1,2-Dichlorobenzene	20	U	41	49	U	
95-48-7	2-Methylphenol	20	U	45	44	U	
106-44-5	4-Methylphenol/3-Methylphenol	20	U	40	50	U	
67-72-1	Hexachloroethane	20	U	39	51	U	
98-95-3	Nitrobenzene	20	U	42	48	U	
87-68-3	Hexachlorobutadiene	20	U	40	50	U	
88-06-2	2,4,6-Trichlorophenol	20	U	56	36	U	
95-95-4	2,4,5-Trichlorophenol	98	U	61	160	U	
121-14-2	2,4-Dinitrotoluene	20	U	52	38	U	
118-74-1	Hexachlorobenzene	20	U	39	51	U	
58-90-2	2,3,4,6-Tetrachlorophenol	98	U	81	98	U	
87-86-5	Pentachlorophenol	98	U	41	240	U	

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-531-MB TOP TCLP

TCLP Extract of Burn #8 (top) ash - Exf #1

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/19/93
Date Analyzed: 930609 20:38
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery		Corrected uG/L	
110-86-1	Pyridine	18	U	0	U	18	U
108-95-2	Phenol	18	U	41		44	U
106-46-7	1,4-Dichlorobenzene	18	U	38		47	U
95-50-1	1,2-Dichlorobenzene	18	U	38		47	U
95-48-7	2-Methylphenol	18	U	42		43	U
106-44-5	4-Methylphenol/3-Methylphenol	18	U	37		49	U
67-72-1	Hexachloroethane	18	U	33		55	U
98-95-3	Nitrobenzene	18	U	34		53	U
87-68-3	Hexachlorobutadiene	18	U	34		53	U
88-06-2	2,4,6-Trichlorophenol	18	U	57		32	U
95-95-4	2,4,5-Trichlorophenol	89	U	61		150	U
121-14-2	2,4-Dinitrotoluene	18	U	53		34	U
118-74-1	Hexachlorobenzene	18	U	34		53	U
58-90-2	2,3,4,6-Tetrachlorophenol	89	U	83		89	U
87-86-5	Pentachlorophenol	89	U	45		200	U

TCLP Extract of Burn #8 (Bottom) ash

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-50-8-TCLP

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/14/93
Date Analyzed: 930610 01:01
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L		XMS Recovery	Corrected uG/L	
110-86-1	Pyridine	28	U	8	350	U
108-95-2	Phenol	28	U	46	61	U
106-46-7	1,4-Dichlorobenzene	28	U	42	67	U
95-50-1	1,2-Dichlorobenzene	28	U	41	68	U
95-48-7	2-Methylphenol	28	U	45	62	U
106-44-5	4-Methylphenol/3-Methylphenol	28	U	40	70	U
67-72-1	Hexachloroethane	28	U	39	72	U
98-95-3	Nitrobenzene	28	U	42	67	U
87-68-3	Hexachlorobutadiene	28	U	40	70	U
88-06-2	2,4,6-Trichlorophenol	28	U	56	50	U
95-95-4	2,4,5-Trichlorophenol	140	U	61	230	U
121-14-2	2,4-Dinitrotoluene	28	U	52	54	U
118-74-1	Hexachlorobenzene	28	U	39	72	U
58-90-2	2,3,4,6-Tetrachlorophenol	140	U	81	140	U
87-86-5	Pentachlorophenol	140	U	41	340	U

Lab Name : WESTERN RESEARCH INST
Case No : ENTECH

Sample Number
785-531-#9 TCLP

TCLP Extract of Burn #9 ash Exf #2

ORGANICS ANALYSIS DATA SHEET
(Page 2)

Semivolatile Compounds

Concentration: LOW
Date Extracted: 05/19/93
Date Analyzed: 930609 21:16
Conc/Dil Factor: 1.0
Percent Moisture: 0.0

GPC Cleanup __ Yes XX No
Separatory Funnel Extraction __ Yes
Continu..s Liquid-Liquid Extraction XX Yes

C.A.S. Number		Uncorrected uG/L	XMS Recovery	Corrected uG/L
110-86-1	Pyridine	40 U	0 U	40 U
108-95-2	Phenol	40 U	41	98 U
106-46-7	1,4-Dichlorobenzene	40 U	38	110 U
95-50-1	1,2-Dichlorobenzene	40 U	38	110 U
95-48-7	2-Methylphenol	40 U	42	95 U
106-44-5	4-Methylphenol/3-Methylphenol	40 U	37	110 U
67-72-1	Hexachloroethane	40 U	33	120 U
98-95-3	Nitrobenzene	40 U	34	120 U
87-68-3	Hexachlorobutadiene	40 U	34	120 U
88-06-2	2,4,6-Trichlorophenol	40 U	57	70 U
95-95-4	2,4,5-Trichlorophenol	200 U	61	330 U
121-14-2	2,4-Dinitrotoluene	40 U	53	75 U
118-74-1	Hexachlorobenzene	40 U	34	120 U
58-90-2	2,3,4,6-Tetrachlorophenol	200 U	83	200 U
87-86-5	Pentachlorophenol	200 U	45	440 U

WESTERN RESEARCH INSTITUTE
The University of Wyoming Research Corporation

ANALYTICAL RESEARCH DIVISION
Results of Analysis

Client Sorini
Batch 6141
Submission Date 5/13/93 ENTECH TCLP Extractions
Normal Turnaround 6/1/93

Element	785,50-2-TCLP Burn #2	785,50-3-TCLP Burn #3	785,50-4-TCLP Burn #4	785,50-7-TCLP Burn #7
Arsenic	<0.005 mg/L	<0.005 mg/L	<0.005 mg/L	<0.005 mg/L
Barium	0.155 mg/L	0.155 mg/L	0.079 mg/L	0.232 mg/L
Cadmium	0.073 mg/L	0.458 mg/L	0.370 mg/L	2.18 mg/L
Chromium	0.025 mg/L	0.082 mg/L	<0.008 mg/L	<0.008 mg/L
Lead	0.098 mg/L	0.592 mg/L	1.33 mg/L	0.316 mg/L
Mercury	<0.002 mg/L	<0.002 mg/L	<0.002 mg/L	<0.002 mg/L
Selenium	<0.050 mg/L	<0.050 mg/L	<0.050 mg/L	<0.050 mg/L
Silver	<0.007 mg/L	0.042 mg/L	0.020 mg/L	0.010 mg/L

Element	785,50-8-TCLP Burn #8-Bottom	785,50-Exf-a-BLK Method Blank
Arsenic	0.011 mg/L	<0.005 mg/L
Barium	0.202 mg/L	0.025 mg/L
Cadmium	0.779 mg/L	<0.010 mg/L
Chromium	<0.008 mg/L	<0.008 mg/L
Lead	0.208 mg/L	<0.050 mg/L
Mercury	<0.002 mg/L	<0.002 mg/L
Selenium	<0.050 mg/L	<0.050 mg/L
Silver	0.009 mg/L	<0.007 mg/L

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The University of Wyoming Research Corporation

ANALYTICAL RESEARCH DIVISION
Results of Analysis

Client Sorini
Batch 6154
Submission Date 5/18/93
Normal Turnaround 6/17/93

ENTECH TCLP Extracts

Element	TCLP Extract of Burn #1 Ash 785,53-1-TCLP	TCLP Extract of Burn #5/6 Ash 785,53-5/6-TCLP	TCLP Extract of Burn #8 (top) Ash 785,53-8-TCLP	TCLP Extract of Burn #9 Ash 785,53-9-TCLP
Arsenic	<0.100 mg/L	<0.100 mg/L	<0.100 mg/L	<0.100 mg/L
Barium	0.398 mg/L	0.186 mg/L	0.186 mg/L	0.232 mg/L
Cadmium	0.174 mg/L	0.209 mg/L	0.040 mg/L	2.18 mg/L
Chromium	<0.008 mg/L	0.027 mg/L	<0.008 mg/L	<0.008 mg/L
Lead	0.421 mg/L	9.12 mg/L	<0.050 mg/L	0.316 mg/L
Mercury	<0.002 mg/L	<0.002 mg/L	<0.002 mg/L	<0.002 mg/L
Selenium	<0.100 mg/L	<0.100 mg/L	<0.100 mg/L	<0.100 mg/L
Silver	<0.007 mg/L	0.008 mg/L	<0.007 mg/L	0.010 mg/L

Element	TCLP Method Blank - Goes with #8 (top) 785,53-EXF-1-BLK	TCLP Method Blank Goes with remaining samples 785,53-EXF-2-BLK
Arsenic	<0.100 mg/L	<0.100 mg/L
Barium	0.184 mg/L	0.034 mg/L
Cadmium	2.04 mg/L	<0.010 mg/L
Chromium	<0.008 mg/L	<0.008 mg/L
Lead	0.279 mg/L	<0.050 mg/L
Mercury	<0.002 mg/L	<0.002 mg/L
Selenium	<0.100 mg/L	<0.100 mg/L
Silver	0.011 mg/L	<0.007 mg/L

Regulatory Levels –

As → 5.0 mg/L
Ba → 100.0 mg/L
Cd → 1.0 mg/L
Pb → 5.0 mg/L
Se → 1.0 mg/L
Hg → 0.2 mg/L
Ag → 5.0 mg/L
Cr → 5.0 mg/L

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