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### **STATIONARY SOURCE SAMPLING REPORT**

**REFERENCE NO. 14505C**

**VOLUME 1**

**TEXT AND APPENDIX A**

#### **EMISSIONS TESTING FOR:**

**Particulate**

**Arsenic**

**Barium**

**Cadmium**

**Chromium**

**Hexavalent Chromium**

**Lead**

**Zinc**

**PERFORMED FOR: USED OIL RECYCLING COALITION**

**JULY 1995**

## REPORT CERTIFICATION

El Reference Number 14505C

The sampling and analysis performed for this report were carried out under my direction and supervision, and I hereby certify that the test report is authentic and accurate.

Signature: Tom E. Holder

Date: 4/12/96

Tom E. Holder  
Project Director  
Test Operations Division

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## EXECUTIVE SUMMARY

The Used Oil Recycling Coalition (UORC) contracted with Entropy, Inc. to evaluate metals emissions from used oil combustion. The primary objective of the study was to compile accurate data on emissions of lead for combustion sources utilizing used oil as a fuel. The secondary objective was to compile accurate emissions data for other metals including barium, cadmium, chromium, arsenic, and zinc.

The project was divided into two phases. In Phase I, Entropy, Inc. conducted a comprehensive literature search to determine if there were significant gaps in the available technical information regarding the emissions of metals from the combustion of used oil. In addition, an emissions inventory for used oil combustion sources was compiled to evaluate the emission quantities of each source category. Portions of the conclusions and recommendations for Entropy's Phase I report (dated April 27, 1994) are excerpted below.

In Phase II of the project, Entropy, Inc. conducted emissions test programs at two asphalt plants that combust used oil. Testing at one of the plants also involved the combustion of virgin oil. Asphalt plants were chosen for emissions testing because they are the single largest category of sources that burn used oil, and they consume approximately 43 percent of the total used oil collected and used as fuel in the United States.

The information from the study demonstrates that the combustion of used oil in asphalt plants equipped with baghouses in good working condition resulted in emissions of lead below detection limits. In fact, the emissions of lead and other metals from the combustion of used oil at both test facilities did not differ significantly from the emissions associated with the combustion of number 2 virgin oil at one of the test facilities.

### **Phase I Conclusions:**

1. Due to significant reductions in the concentrations of some of the metals in used oils, most of the metals emission test data obtained prior to 1985 is not representative of present-day emissions.
2. Due to the lead-in-gasoline phase-down requirements, lead levels in automotive used oil after processing have decreased substantially. Average levels are now in the range of 40 ppm, well below the pre-1985 levels of 200 to 1000 ppm.
3. Barium levels in used oil have decreased substantially due to changes in the composition of additive packages used for lubricating oils. Average levels in automotive used oils are now in the range of 10 ppm.
4. A large fraction of the metals contained in used oil fuel stays within the combustion chamber and is not emitted into the effluent stream. The metals are trapped as deposits on combustion chamber walls and heat exchange surfaces. For industrial boilers, commercial boilers, space heaters, and other small combustion sources, the quantities retained as permanent deposits are probably 50 percent of the total quantity of metals entering with the fuel.

5. A significant fraction of the metals contained in used oil fuel for industrial furnaces is captured by the product streams processed in the furnaces. These metals are trapped as permanent solid deposits in the surfaces of the product materials and are not emitted to the atmosphere. For cement kilns and asphalt plant rotary dryers, metal capture by-product materials can range from 20 percent to 90 percent.
6. Metal-containing particles formed due to vaporization in the combustion chamber and nucleation during gas stream cooling are primarily in the submicron size range. Multicyclone collectors are ineffective for this particle size range. The collection efficiencies for the types of wet scrubbers, electrostatic precipitators, and fabric filters employed on used oil combustion sources range from approximately 50 percent to greater than 99 percent.
7. Asphalt plants are the largest single category of sources burning used oil. They consume approximately 43 percent of the total used oil collected and used as fuel in the United States, and there are indications that the consumption rates are increasing. Metals removal in baghouse-controlled plants is very high. There is considerable uncertainty regarding the capability of wet scrubber controlled plants to collect metals-containing particles efficiently.
8. Utility boilers are an important consumer of used oil. More data are needed regarding the types of boilers that burn used oil, the types of fuels co-fired with used oil, the types of air pollution control systems on these boilers, and the used oil firing practices. There are no previously conducted air emissions studies on utility boilers regarding the potential metals emissions attributable to the burning of used oil.
9. Industrial boilers used for space heating and steam generation are important because of the quantities of used oil consumed and the limited air pollution control system capability. Emissions data are needed to evaluate the metals retention as deposits in the boilers and to evaluate the fractions removed as part of bottom ash or flyash streams. There are no relevant, up-to-date data concerning metals emissions from industrial boilers.
10. Space heaters are an important category due to the quantities of used oil burned and the lack of air pollution control systems. There is very little relevant, up-to-date emissions data. However, a study being coordinated by the State of Vermont is likely to provide valuable data. (See Volume 1, Appendix A of this report).
11. The NORA survey data indicates that small commercial boilers, apartment house boilers, and school boilers (collectively termed "residential/commercial" boilers) receive a relatively small fraction of the overall used oil generated in the United States.
12. Cement kilns and other types of industrial processes do not appear to be significant sources of metals emissions due to high particulate collection efficiencies and to metal capture in the product streams.

### **Phase I Recommendations:**

1. An emission test program should be conducted to characterize emissions from three types of used oil combustion sources: (1) asphalt plants, (2) utility boilers, and (3) industrial boilers. The tests should include analyses of the used oil fuel and the accumulation of metals on heat exchange surfaces and refractory within the boilers. The scope of the tests should include lead, barium, cadmium, chromium, arsenic, and zinc.
2. Air pollution emission data obtained as part of the State of Vermont study of space heaters should be requested as soon as it is available to further evaluate the environmental aspects of used oil combustion in space heaters. (See Volume 1, Appendix A of this report).

### **Phase II:**

Pursuant to the Phase I recommendations, extensive efforts were made to locate suitable combustion sources from all three recommended categories, but no suitable utility or industrial boilers were identified as test subjects. No utility boilers were identified that co-burned used oil with virgin oil. Although many utility boilers co-burn used oil with coal, these burners were determined not to be appropriate test subjects because the used oil generally constitutes a small constituent of the fuel load and because of the difficulties inherent in differentiating the very slight impact of metals associated with the combustion of used oil from the metals associated with the combustion of coal. A small number of potential industrial boiler candidates were identified and contacted. Ultimately, however, none would allow the testing to be performed. Thus, Phase II testing was limited to two asphalt plants.

Stack testing was conducted at two asphalt plants, designated as Facility A and B throughout this report, to determine the emissions of lead, barium, cadmium, chromium (hexavalent and total), arsenic, and zinc. At Facility A, tests were conducted during the combustion of virgin number 2 fuel oil (designated as Condition I) as well as used oil, which is referred to by the asphalt plants as number 4 recycled oil (designated as Condition II). At Facility B, tests were conducted during the combustion of number 4 recycled oil.

Comparison of the emissions from the different fuels fully supports the contention that metals removal in baghouse-controlled plants is very high. At Facility A, lead content of the recycled oil was 50 times higher than that of the virgin oil, yet emissions remained at or below the detection limit with corresponding removal efficiencies greater than 99.98 percent. A comparison of the average percent removal efficiencies for each metal under each of the test conditions is presented in the following table.

**Metals Removal Efficiency - Average of Three Test Runs**

Arsenic	Barium	Cadmium	Chromium	Lead	Zinc
<b>Facility A Virgin Number 2 Fuel Oil</b>					
> 98.63	> 92.06	> 97.86	> 96.07	> 95.33	> 70.49
<b>Facility A Recycled Number 4 Fuel Oil</b>					
> 98.70	98.72	> 99.42	99.05	> 99.98	99.97
<b>Facility B Recycled Number 4 Fuel Oil</b>					
> 98.03	96.59	> 98.56	98.74	> 99.95	99.96

At Facility B, lead content in the recycled oil was slightly lower than that in the recycled oil at Facility A, and removal efficiencies remained high - greater than 99.95 percent. At both facilities, removal efficiencies of the other metals tested were similarly high.

The information from the study indicates that the combustion of used oil in asphalt plants equipped with baghouses in good working condition resulted in low levels of emissions of lead and other metals at or below detection limits. In fact, the emissions of lead and other metals from the combustion of used oil at these facilities did not differ significantly from the emissions associated with the combustion of number 2 virgin fuel oil at Facility A. The mass balance calculations indicate overall removal efficiencies of 96.05 percent to 99.98 percent of the metals tested. Thus, the study demonstrates that the combustion of used oil in these types of asphalt plants is a good option for resource recovery.

## **1.0 INTRODUCTION**

### **1.1 Overview of Project Objectives**

The Used Oil Recycling Coalition (UORC) contracted with Entropy, Inc. to evaluate metals emissions from used oil combustion. The primary objective of the study was to compile accurate data on emissions of lead for combustion sources utilizing used oil as a fuel. The secondary objective was to compile accurate emissions data for other metals including barium, cadmium, chromium, arsenic, and zinc.

The project was divided into two phases. In Phase I, Entropy, Inc. conducted a comprehensive literature search to determine if there were significant gaps in the available technical information regarding the emissions of metals from the combustion of used oil. In addition, an emissions inventory for used oil combustion sources was compiled to evaluate the emission quantities of each source category.

In Phase II of the project, Entropy, Inc. conducted emissions test programs at two asphalt plants that combust used oil. Testing at one of the plants also involved the combustion of virgin oil to make a direct comparison of the metals emissions from the same system. Asphalt plants were chosen for emissions testing because they are the single largest category of sources that combust used oil, and they consume approximately 43 percent of the total used oil collected and used as fuel in the United States.

The Phase I report was submitted to the UORC on April 27, 1994. This report is the result of the tests conducted under Phase II.

### **1.2 Outline of Test Program**

The testing was conducted using well-established U.S. EPA Reference Methods under carefully controlled conditions fully documented in the Quality Assurance Project Plan (QAPP) submitted June 14, 1995 to the Used Oil Recycling Coalition. The QAPP was also submitted to the USEPA for review and comments. During each of the tests, fuel samples and solid waste samples were collected and analyzed to support the findings of the air emissions tests.

Pursuant to the Phase I recommendations, extensive efforts were made to locate suitable combustion sources from all three recommended categories, but no suitable utility or industrial boilers were identified as test subjects. No utility boilers were identified that co-burned used oil with virgin oil. Although many utility boilers co-burn used oil with coal, these burners were determined not to be appropriate test subjects because the used oil generally constitutes a small constituent of the fuel load and because of the difficulties inherent in differentiating the very slight impact of metals associated with the combustion of used oil from the metals associated with the

combustion of coal. A small number of potential industrial boiler candidates were identified and contacted. Ultimately, however, none would allow the testing to be performed. Thus, Phase II testing was limited to two asphalt plants.

This portion of the test program was conducted at two asphalt plants. **Table 1-1** is a test log that presents the test conditions, sampling locations, sampling objectives, sampling methods, test dates, and run numbers for the test program. Several runs utilized flue gas composition data from other runs; refer to **Table 1-1**.

Asphalt plants are the largest single category of sources that burn used oil. They consume approximately 43 percent of the total used oil collected and used as fuel. Fuel oil is burned in asphalt plants to heat and dry the aggregate prior to the addition of asphaltic binder. A single oil burner is mounted in a short rotary drier. The aggregate passes through the drier and is showered across the path of the hot combustion gas using a large number of flights (scoops) mounted on the interior surface of the drier. The plants tested were equipped with high-efficiency fabric filters for particulate emissions control.

At Facility A, during Condition I, the asphalt plant was burning virgin Number 2 fuel oil. During Condition II, recycled number 4 fuel oil was burned. At Facility B, a single condition was tested during the combustion of recycled number 4 fuel oil. Analysis of each of the fuels is included in this report.

**TABLE 1-1  
TEST LOG**

<b>Test Location</b>	<b>Sampling Objective</b>	<b>Test Method</b>	<b>Test Date</b>	<b>Run Numbers</b>	<b>Flue Gas Composition</b>
<b>Facility A Condition I</b>	Cr <sup>+6</sup>	SW-846 0013	07/10	I-M0013-1	I-M3-1
			07/10	I-M0013-2	I-M3-2
			07/10	I-M0013-3	I-M3-3
	Particulate and Metals	EPA 5/29	07/10	I-M5/29-1	I-M3-1
			07/10	I-M5/29-2	I-M3-2
			07/10	I-M5/29-3	I-M3-3
<b>Facility A Condition II</b>	Cr <sup>+6</sup>	SW-846 0013	07/11	II-M0013-1	II-M3-1
			07/11	II-M0013-2	II-M3-2
			07/11	II-M0013-3	II-M3-3
	Particulate and Metals	EPA 5/29	07/11	II-M5/29-1	II-M3-1
			07/11	II-M5/29-2	II-M3-2
			07/11	II-M5/29-3	II-M3-3
<b>Facility B</b>	Cr <sup>+6</sup>	SW-846 0013	07/13	M0013-1	M3-1
			07/13	M0013-2	M3-2
			07/14	M0013-3	M3-3
	Particulate and Metals	EPA 5/29	07/13	M5/29-1	M3-1
			07/13	M5/29-2	M3-2
			07/14	M5/29-3	M3-3

1.3 Test Participants

Table 1-2 lists the personnel involved in the test program.

**TABLE 1-2  
TEST PARTICIPANTS  
JULY 1995**

<b>Entropy, Inc.</b>	Tom E. Holder Project Director
	Lafayette B. Johnson Sampling Team Leader
	Donald J. Garnet Sampling Team Leader
	Joseph R. Winslow Laboratory Technician

## 2.0 SUMMARY OF RESULTS

### 2.1 Presentation

Tables 2-1 through 2-5 present test summaries; refer to the "List of Tables and Figures" of the "Table of Contents." Detailed test results are presented in Appendix B. Field data are given in Appendix C. Analytical data can be found in Appendix D.

### 2.2 Discussion

Asphalt plants consume approximately 43 percent of the used oil fuels generated in the United States. The National Asphalt Paving Association (NAPA) has estimated that the industry consumes as much as 200 million gallons per year. That consumption rate has increased during the last few years.

The data in this report show that metals in used oil fuels burned in asphalt plants are captured with high efficiency at units equipped with well-operated baghouses. Comparison of the emissions from the different fuels fully supports the contention that metals removal in baghouse-controlled plants is very high. At Facility A, lead content of the recycled oil was 50 times higher than that in the virgin oil, yet emissions remained at or below the detection limit with corresponding removal efficiencies greater than 99.98 percent. A comparison of the average percent removal efficiencies for each metal under each of the test conditions is presented in the following table.

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> 98.70	98.72	> 99.42	99.05	> 99.98	99.97
<b>Facility B Recycled Number 4 Fuel Oil</b>					
> 98.03	96.59	> 98.56	98.74	> 99.95	99.96

At Facility B, lead content in the recycled oil was slightly lower than that in the recycled oil at Facility A, and removal efficiencies remained high - greater than 99.95 percent. At both facilities, removal efficiencies of the other metals tested were similarly high.

The high metal removal efficiencies of this study can be attributed to the characteristics of the combustion process and fabric filter collection. The metals vaporized in the burner flame have

ample opportunity to nucleate on the surfaces of the aggregate and the aggregate dust circulating through the combustion gas stream. The aggregate surface temperatures are much lower than the dewpoint temperatures for the metal vapors. In fact, the aggregate temperatures are far below the normal surface temperatures of the combustion chamber surfaces. Accordingly, condensation of these vapors is likely on the aggregate as well as on the aggregate dust. Metals captured by the aggregate are removed from the mass balance equation as part of the hardened asphaltic concrete. Metal emissions are further reduced in the equation by the fabric filters used at these plants. Because fabric filter efficiency is high even in the submicron range, metal vapor that nucleates on the aggregate dust is captured by the fabric filters.

### **2.3 Cyclonic Flow Checks**

A cyclonic flow check was performed at the Facility A sampling location to determine if any cyclonic flow existed. An average yaw angle of  $< 0.5^\circ$  was measured, indicating an acceptable location with respect to EPA Method 1 requirements.

**TABLE 2-1**  
**EMISSION RATES AND CONCENTRATIONS**  
**FACILITY A, CONDITION I**  
**JULY 1995**

	Rep 1	Rep 2	Rep 3	Average
<b>Concentration, gr/DSCF</b>				
Filterable Particulate	0.00174	0.00259	0.00245	0.00226
Arsenic	< 1.55E-07	< 2.27E-07	< 2.32E-07	< 2.05E-07
Barium	2.39E-06	1.54E-06	1.13E-06	1.69E-06
Cadmium	3.75E-07	5.69E-07	1.51E-07	3.65E-07
Chromium	4.66E-07	7.60E-07	5.58E-07	5.95E-07
Hexavalent Chromium	< 3.67E-07	< 4.80E-07	< 4.55E-07	< 4.34E-07
Lead	2.71E-07	< 1.34E-06	< 2.32E-07	< 6.14E-07
Zinc	5.27E-06	1.64E-05	4.63E-06	8.77E-06
<b>Concentration, gr/DSCF @ 12% CO2</b>				
Filterable Particulate	0.00317	0.00457	0.00420	0.00398
Arsenic	< 2.82E-07	< 4.01E-07	< 3.97E-07	< 3.60E-07
Barium	4.34E-06	2.71E-06	1.93E-06	2.99E-06
Cadmium	6.82E-07	1.00E-06	2.58E-07	6.47E-07
Chromium	8.48E-07	1.34E-06	9.57E-07	1.05E-06
Hexavalent Chromium	< 6.67E-07	< 8.47E-07	< 7.80E-07	< 7.65E-07
Lead	4.93E-07	< 2.37E-06	< 3.97E-07	< 1.09E-06
Zinc	9.58E-06	2.89E-05	7.94E-06	1.55E-05
<b>Concentration, gr/DSCF @ 7% O2</b>				
Filterable Particulate	0.00269	0.00414	0.00382	0.00335
Arsenic	< 2.39E-07	< 3.63E-07	< 3.62E-07	< 3.21E-07
Barium	3.68E-06	2.45E-06	1.76E-06	2.63E-06
Cadmium	5.79E-07	9.09E-07	2.35E-07	5.74E-07
Chromium	7.20E-07	1.21E-06	8.72E-07	9.34 E-07
Hexavalent Chromium	< 5.67E-07	< 7.67E-07	< 7.10E-07	< 6.81E-07
Lead	4.19E-07	< 2.14E-06	< 3.62E-07	< 9.74E-07
Zinc	8.13E-06	2.62E-05	7.23E-06	1.39E-05
<b>Emission Rate, lb/hr</b>				
Filterable Particulate	0.334	0.503	0.470	0.436
Arsenic	< 2.97E-05	< 4.42E-05	< 4.45E-05	< 3.95E-05
Barium	4.57E-04	2.99E-04	2.16E-04	3.24E-04
Cadmium	7.18E-05	1.11E-04	2.89E-05	7.06E-05
Chromium	8.92E-05	1.48E-04	1.07E-04	1.15E-04
Hexavalent Chromium	< 6.94E-05	< 8.84E-05	< 8.39E-05	< 8.06E-05
Lead	5.19E-05	< 2.61E-04	< 4.45E-05	< 1.19E-04
Zinc	1.01E-03	3.18E-03	8.90E-04	1.69E-03

**TABLE 2-2**  
**EMISSION RATES AND CONCENTRATIONS**  
**FACILITY A, CONDITION II**  
**JULY 1995**

	Rep 1	Rep 2	Rep 3	Average
<b>Concentration, gr/DSCF</b>				
Filterable Particulate	1.18E-03	1.19E-03	7.37E-04	1.04E-03
Arsenic	< 2.51E-07	< 2.10E-07	< 2.17E-07	< 2.26E-07
Barium	1.31E-06	9.79E-07	3.32E-06	1.87E-06
Cadmium	1.09E-07	1.15E-07	< 8.67E-08	< 1.04E-07
Chromium	9.88E-07	4.72E-07	4.16E-07	6.25E-07
Hexavalent Chromium	< 5.38E-07	< 4.13E-07	< 3.35E-07	< 4.29E-07
Lead	< 2.51E-07	< 2.10E-07	< 2.17E-07	< 2.26E-07
Zinc	3.52E-06	2.93E-06	4.77E-06	3.74E-06
<b>Concentration, gr/DSCF @ 12% CO<sub>2</sub></b>				
Filterable Particulate	0.00188	0.00256	0.00170	0.00205
Arsenic	< 4.02E-07	< 4.49E-07	< 5.00E-07	< 4.50E-07
Barium	2.09E-06	2.10E-06	7.66E-06	3.95E-06
Cadmium	1.75E-07	2.47E-07	< 2.00E-07	< 2.07E-07
Chromium	1.58E-06	1.01E-06	9.61E-07	1.18E-06
Hexavalent Chromium	< 8.60E-07	< 8.86E-07	< 7.73E-07	< 8.40E-07
Lead	< 4.02E-07	< 4.49E-07	< 5.00E-07	< 4.50E-07
Zinc	5.63E-06	6.29E-06	1.10E-05	7.64E-06
<b>Concentration, gr/DSCF @ 7% O<sub>2</sub></b>				
Filterable Particulate	0.00169	0.00218	0.00149	0.00179
Arsenic	< 3.60E-07	< 3.83E-07	< 4.37E-07	< 3.93E-07
Barium	1.87E-06	1.79E-06	6.68E-06	3.45E-06
Cadmium	1.56E-07	2.11E-07	< 1.75E-07	< 1.81E-07
Chromium	1.42E-06	8.63E-07	8.39E-07	1.04E-06
Hexavalent Chromium	< 7.71E-07	< 7.56E-07	< 6.75E-07	< 7.34E-07
Lead	< 3.60E-07	< 3.83E-07	< 4.37E-07	< 3.93E-07
Zinc	5.04E-06	5.37E-06	9.61E-06	6.67E-06
<b>Emission Rate, lb/hr</b>				
Filterable Particulate	0.202	0.172	0.103	0.159
Arsenic	< 4.33E-05	< 3.02E-05	< 3.04E-05	< 3.46E-05
Barium	2.25E-04	1.41E-04	4.64E-04	2.77E-04
Cadmium	1.88E-05	1.66E-05	< 1.21E-05	< 1.58E-05
Chromium	1.70E-04	6.79E-05	5.83E-05	9.87E-05
Hexavalent Chromium	< 8.63E-05	< 5.63E-05	< 4.58E-05	< 6.28E-05
Lead	< 4.33E-05	< 3.02E-05	< 3.04E-05	< 3.46E-05
Zinc	6.06E-04	4.23E-04	6.68E-04	5.66E-04

**TABLE 2-3**  
**PERCENT REMOVAL EFFICIENCIES, lb/hr**  
**FACILITY A**  
**JULY 1995**

	Arsenic	Barium	Cadmium	Chromium	Lead	Zinc
<b>CONDITION I</b>						
<b>Run 1</b>						
Fuel	< 0.0032	< 0.0032	< 0.0032	< 0.0032	< 0.0032	< 0.0032
Stack Emissions	< 0.0000297	0.000457	0.0000718	0.0000892	0.0000519	0.00101
Removal Efficiency	> 99.08	> 85.88	> 97.78	> 97.21	> 98.40	> 68.80
<b>Run 2</b>						
Fuel	< 0.0033	< 0.0033	< 0.0033	< 0.0033	< 0.0033	0.0062
Stack Emissions	< 0.0000442	0.000299	0.000111	0.000148	< 0.000261	0.00318
Removal Efficiency	> 98.65	> 90.88	> 96.62	> 95.49	> 92.04	48.71
<b>Run 3</b>						
Fuel	< 0.0032	< 0.0032	< 0.0032	< 0.0032	< 0.0032	0.0115
Stack Emissions	< 0.0000445	0.000216	0.0000289	0.000107	< 0.0000445	0.00089
Removal Efficiency	> 98.61	> 93.24	> 99.10	> 96.65	> 98.61	92.26
<b>CONDITION II</b>						
<b>Run 1</b>						
Fuel	< 0.0030	0.0320	0.0030	0.0091	0.1872	2.520
Stack Emissions	< 0.0000433	0.000225	0.0000188	0.000170	< 0.0000433	0.000606
Removal Efficiency	> 98.58	99.30	99.37	98.13	> 99.98	99.98
<b>Run 2</b>						
Fuel	< 0.0025	0.0267	0.0026	0.0069	0.1574	2.107
Stack Emissions	< 0.0000302	0.000141	0.0000166	0.0000679	< 0.0000302	0.000423
Removal Efficiency	> 98.78	99.47	99.36	99.02	> 99.98	99.98
<b>Run 3</b>						
Fuel	< 0.0022	0.0227	0.0023	0.0063	0.1323	1.756
Stack Emissions	< 0.0000304	0.000464	< 0.0000121	0.0000583	< 0.0000304	0.000668
Removal Efficiency	> 98.62	97.96	> 99.47	99.08	> 99.98	99.96

**TABLE 2-4  
RUN-BY-RUN TESTS SUMMARIES  
FACILITY B  
JULY 1995**

	Rep 1	Rep 2	Rep 3	Average
<b>Concentration, gr/DSCF</b>				
Filterable Particulate	1.54E-03	7.60E-04	8.27E-04	1.04E-03
Arsenic	< 2.53E-07	< 2.10E-07	< 2.13E-07	< 2.25E-07
Barium	6.03E-06	4.52E-06	4.24E-06	4.93E-06
Cadmium	< 1.01E-07	2.29E-07	2.15E-07	< 1.82E-07
Chromium	7.10E-07	5.72E-07	6.90E-07	6.57E-07
Hexavalent Chromium	< 3.54E-07	< 3.50E-07	< 3.42E-07	< 3.49E-07
Lead	< 2.53E-07	< 2.10E-07	< 2.13E-07	< 2.25E-07
Zinc	4.06E-06	3.79E-06	4.26E-06	4.04E-06
<b>Concentration, gr/DSCF @ 12% CO2</b>				
Filterable Particulate	0.00293	0.00149	0.00155	0.00199
Arsenic	< 4.83E-07	< 4.14E-07	< 3.99E-07	< 4.32E-07
Barium	1.15E-05	8.90E-06	7.95E-06	9.45E-06
Cadmium	< 1.93E-07	4.51E-07	4.03E-07	< 3.49E-07
Chromium	1.35E-06	1.13E-06	1.29E-06	1.26E-06
Hexavalent Chromium	< 6.74E-07	< 6.88E-07	< 6.41E-07	< 6.68E-07
Lead	< 4.83E-07	< 4.14E-07	< 3.99E-07	< 4.32E-07
Zinc	7.72E-06	7.45E-06	7.99E-06	7.72E-06
<b>Concentration, gr/DSCF @ 7% O2</b>				
Filterable Particulate	0.00249	0.00126	0.00131	0.00169
Arsenic	< 4.10E-07	< 3.48E-07	< 3.37E-07	< 3.65E-07
Barium	9.75E-06	7.49E-06	6.70E-06	7.98E-06
Cadmium	< 1.64E-07	3.80E-07	3.40E-07	< 2.95E-07
Chromium	1.15E-06	9.47E-07	1.09E-06	1.06E-06
Hexavalent Chromium	< 5.72E-07	< 5.79E-07	< 5.40E-07	< 5.64E-07
Lead	< 4.10E-07	< 3.48E-07	< 3.37E-07	< 3.65E-07
Zinc	6.55E-06	6.27E-06	6.73E-06	6.52E-06
<b>Emission Rate, lb/hr</b>				
Filterable Particulate	0.376	0.203	0.219	0.266
Arsenic	< 6.19E-05	< 5.61E-05	< 5.63E-05	< 5.81E-05
Barium	0.00147	0.00121	0.00112	0.00127
Cadmium	< 2.48E-05	6.12E-05	5.69E-05	< 4.76E-05
Chromium	1.73E-04	1.53E-04	1.83E-04	1.70E-04
Hexavalent Chromium	< 9.28E-05	< 9.19E-05	< 8.63E-05	< 9.03E-05
Lead	< 6.19E-05	< 5.61E-05	< 5.63E-05	< 5.81E-05
Zinc	9.91E-04	1.01E-03	1.13E-03	1.04E-03

**TABLE 2-5**  
**PERCENT REMOVAL EFFICIENCIES, lb/hr**  
**FACILITY B**  
**JULY 1995**

	Arsenic	Barium	Cadmium	Chromium	Lead	Zinc
Run 1						
Fuel	< 0.0030	0.0372	0.0031	0.0143	0.1191	2.607
Stack Emissions	< 0.0000619	0.00147	< 0.0000248	0.000173	< 0.0000619	0.000991
Removal Efficiency	> 97.91	96.05	> 99.20	98.79	> 99.95	99.96
Run 2						
Fuel	< 0.0029	0.0362	0.0033	0.0117	0.1196	2.499
Stack Emissions	< 0.0000561	0.00121	0.0000612	0.000153	< 0.0000561	0.00101
Removal Efficiency	> 98.06	96.66	98.15	98.70	> 99.95	99.96
Run 3						
Fuel	< 0.0030	0.0379	0.0034	0.0146	0.1252	2.686
Stack Emissions	< 0.0000563	0.00112	0.0000569	0.000183	< 0.0000563	0.00113
Removal Efficiency	> 98.13	97.05	98.34	98.74	> 99.96	99.96

### **3.0 PROCESS DESCRIPTION AND OPERATION**

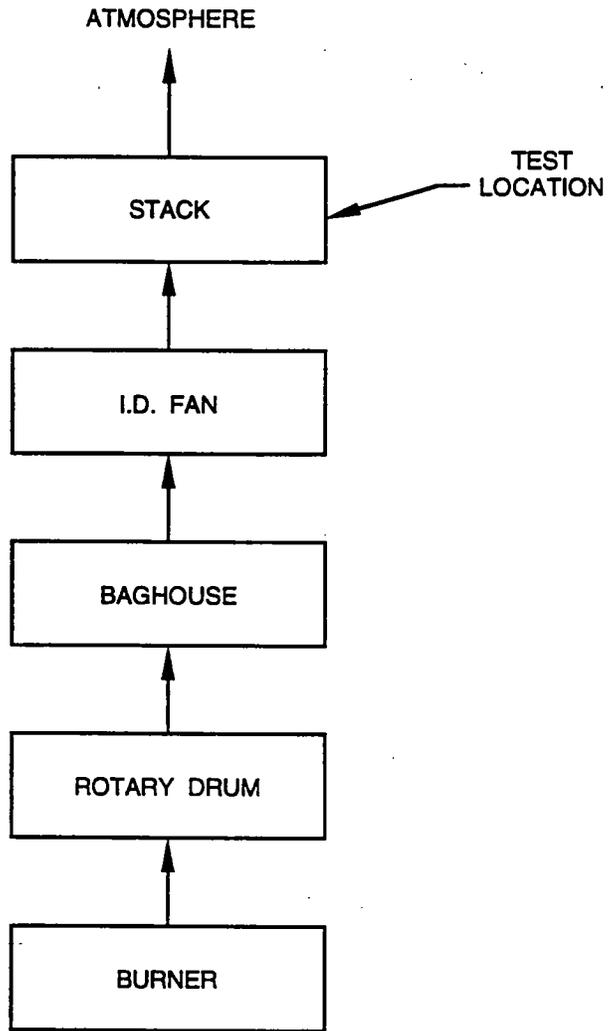
#### **3.1 General**

Facility A is an Astec, Inc. rotary drum mix asphaltic concrete plant. This facility has the capability of burning #2 and #4 fuel oil or natural gas. The plant can produce 350 tons per hour of asphaltic concrete paving material.

Facility B is an Astec, Inc. rotary drum mix asphaltic concrete plant. Testing was conducted with the plant operating near the rated capacity of 400 tons per hour.

#### **3.2 Source Air Flow**

**Figure 3-1** is an air flow schematic showing the passage of flue gases exhausted from the asphalt plants. The air flow schematic is identical for both Facility A and Facility B.



Air flow schematic identical for Facilities A and B.

FIGURE 3-1. ASPHALT PLANT AIR FLOW SCHEMATIC

## **4.0 SAMPLING AND ANALYTICAL PROCEDURES**

### **4.1 General**

All sampling and analytical procedures were those recommended by the United States Environmental Protection Agency. This section provides brief descriptions of the sampling and analytical procedures.

### **4.2 Sampling Points**

The number and location of the sampling points were determined according to the procedures outlined in EPA Method 1. As shown in **Figure 4-1**, Facility A's stack cross section was divided into 24 equal areas with six sampling points on each of four axes. As shown in **Figure 4-2**, Facility B's stack cross section was divided into 24 equal areas with six sampling points on each of four axes.

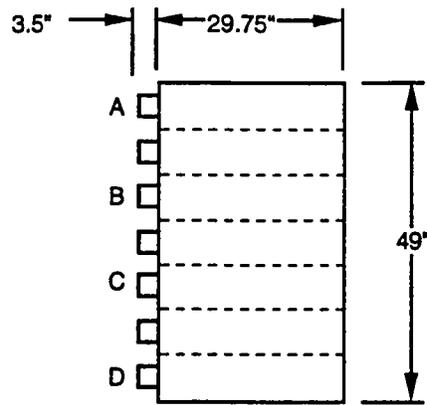
### **4.3 Cyclonic Flow Check**

A Type S Pitot tube assembly, Magnehelic gauges, and a universal protractor (angle finder) were used to determine the flow angles at each of the sampling or velocity traverse points. At each point, the Pitot tube was positioned at a right angle to the air flow. The angles were determined by rotating the Pitot tube until a null reading was obtained on the Magnehelic gauges. When the null reading was obtained, the angle of the Pitot tube was recorded.

### **4.4 Volumetric Air Flow Rates**

#### **4.4.1 Flue Gas Velocity**

The flue gas velocity and volumetric flow rate were determined according to the procedures outlined in EPA Method 2. Velocity head measurements ( $\Delta P$ ) were made using Type S Pitot tubes conforming to the geometric specifications outlined in EPA Method 2. Accordingly, each has been assigned a coefficient of 0.84. Differential pressures were measured with Magnehelic gauges of appropriate range. Flue gas temperatures were measured with chromel-alumel thermocouples equipped with hand-held digital readouts.



TRAVERSE POINTS

- 4 AXES
- 6 POINTS PER AXIS
- 24 TOTAL POINTS

SECTION K-K

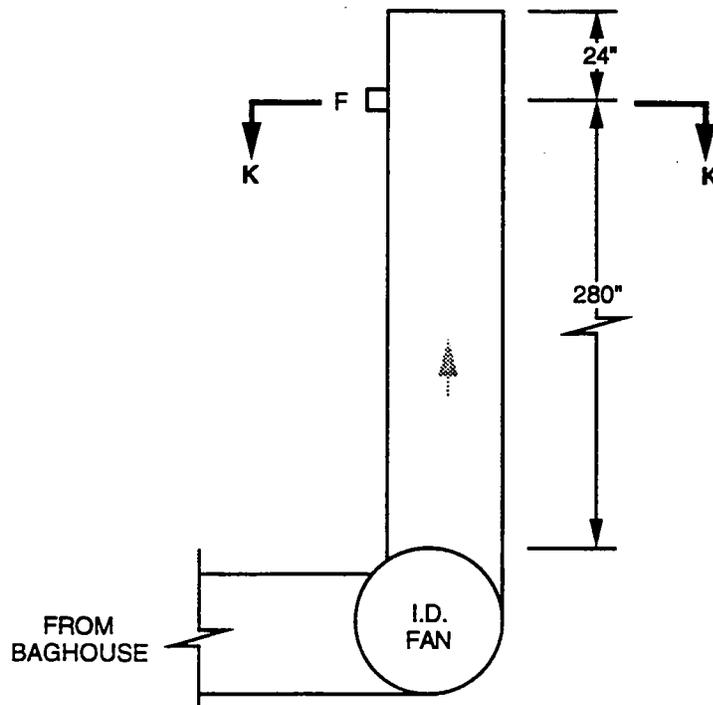


FIGURE 4-1. FACILITY A STACK TEST LOCATION

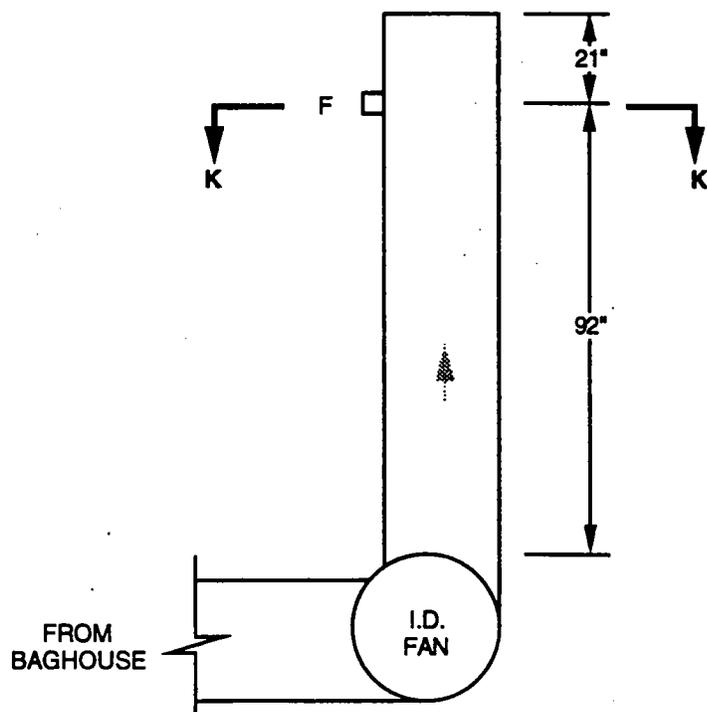
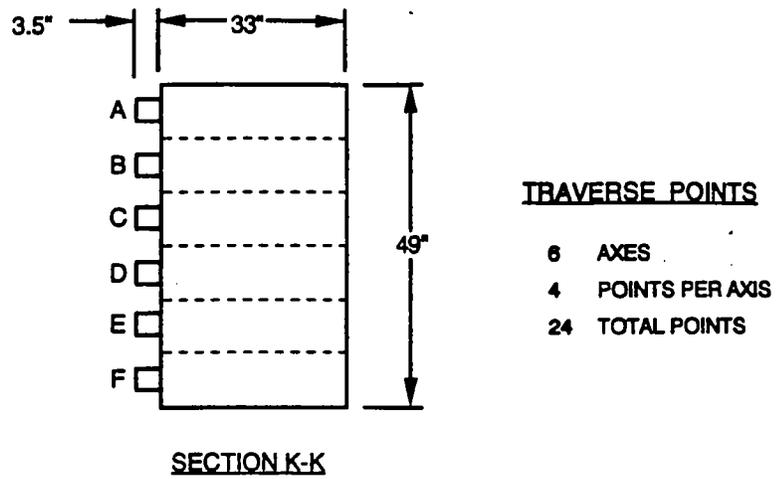


FIGURE 4-2. FACILITY B STACK TEST LOCATION

#### 4.4.2 Flue Gas Composition

Sample Collection. Flue gas samples were collected using the multipoint, integrated sampling technique outlined in EPA Method 3. A stainless steel probe and a peristaltic pump delivering 500 to 750 mL/min of flue gas were used to fill a Tedlar bag. Moisture was removed by means of a knockout jar located prior to the pump. Sampling was of the same duration (except purges following port changes) as the pollutant emissions runs.

Sample Analysis. Analysis for carbon dioxide and oxygen was performed using an Orsat apparatus. The analytical results were used to determine the flue gas composition and excess air.

#### 4.4.3 Flue Gas Moisture Content

The moisture content was determined in conjunction with the appropriate pollutant emissions methods discussed in the following sections.

### 4.5 Emissions Determinations

#### 4.5.1 Particulate and Metals

Sample Collection. Samples were withdrawn isokinetically from the source using a combined EPA Method 5 and EPA Method 29 sampling train. The sampling train consisted of a glass nozzle, a heated glass probe with a Type S Pitot tube attached, a filter, four chilled impingers, and a metering console. The particulate sample was collected on a Pallflex 2500QAT-UP quartz filter maintained at a temperature of  $248^{\circ}\text{F} \pm 25^{\circ}\text{F}$ . The first impinger remained empty, the second and third impingers each contained 100 mL of 5% nitric acid ( $\text{HNO}_3$ )/10% hydrogen peroxide ( $\text{H}_2\text{O}_2$ ), and the fourth contained preweighed silica gel. Each run was a minimum of two hours in duration with a minimum sample volume of 60 dry standard cubic feet. Each of the 24 points was sampled for 5 minutes, resulting in net run times of 120 minutes.

Sample Recovery. A Teflon spatula and Teflon coated tweezers were used to remove the filter from the filter holder and place it in a 250 mL glass jar. The reagents were returned to the original bottles, weighed, the weights recorded on the labels, and the liquid levels marked. The silica gel was returned to the original container, weighed, and the weight recorded on the label. The volume of water vapor condensed in the impingers and the volume of water vapor collected in the silica gel were summed and entered into moisture content calculations.

The nozzle, probe, and fronthalf of the filter holder were rinsed with 100 mL of acetone into a 500 mL jar followed by rinsing with 100 mL of 0.1N  $\text{HNO}_3$  into a second 500 mL jar. A Teflon probe brush was used for cleaning the probe.

The backhalf of the filter holder and the first, second, and third impingers were rinsed with 100 mL of 0.1N  $\text{HNO}_3$  into the 1000 mL jar containing the  $\text{HNO}_3/\text{H}_2\text{O}_2$  reagent.

Sample Analyses. EPA Method 5 analytical procedures were used to analyze the filter and front-half acetone rinse for particulate.

For the metals analyses, the front-half acetone and HNO<sub>3</sub> rinses were evaporated to near dryness in a Teflon beaker. The filter, loose particulate, 3 mL of concentrated HNO<sub>3</sub>, and 5 mL of concentrated HF were added to the beaker. The sample was digested on a hot plate until brown fumes were evident, indicating the destruction of organic matter. After the addition of concentrated HNO<sub>3</sub>, the reagent and impinger rinses were evaporated to near dryness in a Teflon beaker on a hot plate. After cooling, 3 mL of concentrated HNO<sub>3</sub> and 5 mL of concentrated HF were added to the beaker and the sample was fumed on a hot plate to destroy organic residue. The prepared filter and HNO<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> reagent samples were combined, brought to a final volume of 100 mL with 10% HNO<sub>3</sub>, and analyzed for all metals with a Perkin Elmer 3030 atomic absorption analyzer using the appropriate SW-846 methods. Duplicate metals analyses were performed for approximately 10% of the emissions samples.

#### **4.5.2 Hexavalent Chromium**

Samples were withdrawn isokinetically from the source using the sampling train outlined in the EPA draft hexavalent chromium (Cr<sup>+6</sup>) method.

Sample Collection. The sampling train consisted of a quartz nozzle, a pump/sprayer assembly for continuously recirculating the reagent to the nozzle, a quartz probe with a Type S Pitot tube attached, five chilled impingers (four Teflon and one glass), and a metering console.

The first impinger contained 150 mL 0.1N potassium hydroxide (KOH), the second and third impingers each contained 75 mL of 0.1N KOH, the fourth impinger remained empty, and the fifth impinger contained preweighed silica gel. Each of the 24 points was sampled for 5 minutes, resulting in net run times of 120 minutes.

A posttest nitrogen purge was used as a safeguard against conversion of hexavalent chromium to trivalent.

Sample Recovery. Following the nitrogen purge, the KOH reagent was returned to the original container, weighed, the weight recorded on the label, and the liquid level marked. The silica gel was returned to the original container, weighed, and the weight recorded on the label. The volume of water vapor condensed in the impingers and the volume of water vapor collected in the silica gel were summed and entered into moisture content calculations. All sample exposed portions of the sample train were first rinsed four times with DI water into the jar containing the KOH reagent followed by rinsing three times with 0.1N HNO<sub>3</sub> into a separate jar. The combined KOH reagent and DI water rinse were then pressure filtrated into a graduated cylinder to remove insoluble matter which could cause hexavalent conversion.

Sample Analysis. The combined KOH reagent/DI water rinse were analyzed for Cr+6 using ion chromatography coupled with a post-column reactor (IC/PCR).

#### **4.6 Equipment Calibration**

Pertinent calibration data are provided in **Appendix E**.

## 5.0 QUALITY ASSURANCE/QUALITY CONTROL

### 5.1 General

Entropy, Inc. (EI) is committed to the continued implementation of a Quality Assurance Program to assure the quality of sampling and analytical procedures of environmental measurement data. The Quality Assurance measures taken during this test project equal or exceed the minimum QA/QC recommendations as set forth by the U.S. Environmental Protection Agency (EPA) for a particular method.

The following sections outline the QA program implemented by EI to justify the validity of test procedures. As applicable, the QA system for the various test programs addresses the following areas:

- Preventive Maintenance & Equipment Calibration
- Sample Processing
- Analytical Instrument Calibration
- Blanks and Spiked Samples
- Internal/External System Checks
- Data Reduction & Validation
- QA/QC Summary

### 5.2 Preventive Maintenance and Equipment Calibration

An effective preventive maintenance program decreases downtime and thus increases data completeness and quality. Pretest and posttest equipment calibrations are conducted in a manner and at a frequency which meets or exceeds U.S. EPA specifications.

Each item transported to the field is inspected to detect equipment problems which may originate during periods of storage. All equipment returning from the field is cleaned, repaired, reconditioned, and recalibrated as necessary. Routine maintenance on equipment (dry gas meters, pumps, Magnehelics, manometers, Pitot tubes, and nozzles) is carried out periodically for leaks, corrosion, dents, or any other damage. **Table 5-1** shows the activities for equipment calibration.

**TABLE 5-1  
IN-HOUSE EQUIPMENT CALIBRATION**

Apparatus	Calibration Method And Frequency	Specifications	Corrective Action
Type S Pitot Tubes	Standards contained in EPA Method 2	Coefficient of $0.84 \pm 0.02$	Refurbish or recalibrate
	Visual inspection prior to shipment to test site and again prior to each day of testing		
Manometers	Leak checked before and after each field use		Adjust or replace
Magnehelic Gauges	Initially calibrate over full range	0-10" water column	
	After each field use, checked against inclined manometer at average settings encountered during testing	Within $\pm 5\%$	Repair and Recalibrate
Thermometers - Impinger - Dry Gas Meter - Filter Box	After purchase and prior to each field use, using ASTM Hg-in-glass thermometer	Impinger = $\pm 2^\circ\text{F}$ DGM = $\pm 5.4^\circ\text{F}$ FB = $\pm 5.4^\circ\text{F}$	Adjust, determine correction factor, or reject
	After purchase and prior to each field use, using ASTM mercury-in-glass thermometer		
Thermocouple/ Potentiometer	After purchase. 3-point (ice bath, boiling water, and hot oil) using ASTM Hg-in-glass thermometer	$\pm 1.5\%$ of absolute temperature	Adjust, determine correction factor, or reject
	Before and after each field use, compared to ASTM Hg-in-glass thermometer at ambient conditions		
Dry Gas Meter and Orifice	Full calibration (every 6 months) over wide range of orifice settings to obtain calibration factor (isokinetic meter box)	DGM = $\pm 0.02$ from avg. coeff. for each run Orifice = $\pm 0.15"$ H <sub>2</sub> O over delta H range of 0.4"-4.0"	Adjust or replace
	10-minute quick calibration before sending to test site and again prior to each day of field use (isokinetic)	$\pm 3\%$ of full calibration $\bar{\gamma}$ $\pm 5\%$ of full calibration $\bar{\gamma}$	Use if no backup Do not use
	Calculate $\bar{\gamma}_{qa}$ * on-site for each test run to determine if the meter gamma ( $\bar{\gamma}$ ) has changed (EPA Method 5 Section 5.3.2 Alternate Procedures as approved by Administrator)	Average $\bar{\gamma}_{qa}$ must be within $\pm 5\%$ of full calibration $\bar{\gamma}$	Perform post test calibration at average delta H and highest vacuum encountered during testing to determine if meter gamma has changed (isokinetic)
	If $\bar{\gamma}_{qa}$ fails or is not acceptable to the Administrator, a post test calibration will be performed at average delta H and highest vacuum encountered during testing to determine if meter gamma has changed (isokinetic)	$\pm 5\%$ of full calibration $\bar{\gamma}$ (initial or recalibration) that yields the lowest sample volume for the testing is used for calculations	Recalibrate or replace
Dry Gas Meter Transfer Standard	Annual calibrations conducted in triplicate using EPA wet test meter. Calibrations conducted at 7 flow rates from 0.25 to 1.40 cfm.	$\pm 2\%$ of average factor for each calibration run	Adjust and recalibrate

\* See Appendix D for EMTIC guideline document

**TABLE 5-1 (Continued)  
IN-HOUSE EQUIPMENT CALIBRATION**

Apparatus	Calibration Method And Frequency	Specifications	Corrective Action
Barometer	Before and after each field use against an aneroid barometer	$\pm 0.1''$ mercury	Adjust to agree
	Reference barometer adjusted for elevation differences		
Probe Nozzle	Average of 5 I.D. measurements using a micrometer. Visual inspection before and after each field use	Difference between high and low measurement $\leq 0.004''$	Repair and recalibrate

### 5.3 Sample Processing

Entropy, Inc. employs systems which ensure the integrity of an environmental sample from the time of acquisition, through analysis, and ultimately to proper disposal. These systems are necessary to allow valid conclusions to be drawn from analytical results separated in time and space from the sampling operation. In addition, these systems recognize that samples are occasionally of value even after analytical results have been reported.

Samples are collected, transported, and stored in clean containers which are constructed of materials inert to the analytical matrix. Containers are used which allow air tight seals. When necessary, containers are employed which prevent photochemical reactions. All sample containers are labeled with the following information:

- Unique source identifier
- Sample run identifier
- Analyte identifier
- Sample matrix identifier
- Sample analyst identifier

Additional information relating to the sample is recorded on the data sheet for the sampling run that afforded the subject sample. Accordingly, the sampling data sheet contains all the information listed above, plus the date and time the sample was acquired and supplemental information such as observations pertinent to the quality of the sample. For condensed samples, e.g., samples in liquid media, the sample levels are marked on the outside of the container; this mark is used to indicate sample loss, and as such, may serve as a reference in adjusting results accordingly.

For transport from the field to the laboratory, samples are stored in sealed containers and secured in a fashion which minimizes movement and thus prevents breakage of containers. Containers used for transporting glass are packed with foam. Samples which require chilling are kept cold until analyzed.

Samples remain in the custody of the sampler, from acquisition until conveyance to the sample custodian. All custody transfers are signed and documented on a record of custody form, which remains with the sample until turned over to the custodian.

Analytical data are identified in a manner identical to that of the sampling data. Accordingly, all data generated from the analysis of samples are documented with the following information:

- Source identifier
- Sample run identifier
- Analyte identifier
- Sample matrix identifier
- Analyst identifier
- Analysis date

Portions of samples remaining after analysis are returned to their original sample containers. These samples are stored in designated storage areas until their destruction is authorized.

#### **5.4 Instrument Calibration**

Instrument calibration is one of the most important functions in generating precise and accurate quality data. All of the contract laboratories involved in the analytical testing for the test program maintain rigorous QA programs for instrument calibration.

#### **5.5 Blanks and Spikes**

Field blanks, method blanks, trip blanks, lab-proof blanks and filter blanks are obtained, digested and analyzed when applicable. The blanks reflect the background contamination obtained from the various sources during the sampling and analysis. Thus, data adjustment or correction can be made accordingly.

In most cases, it is not necessary to digest and analyze the method blanks, reagent blanks or the lab-proof blanks unless the field blank shows a high level of contamination. If a high level of contamination is present, it is imperative to individually analyze the above blanks to help determine the cause of contamination.

Spiked samples are used to check on the performance of a routine analysis or the recovery efficiency of a method. During spiking, a known amount of stock solutions of the substance of interest is added to the sample prior to sample extraction, digestion, and analysis.

### **5.6 Internal/External System Audit Checks**

System and performance audits are routine elements of all Entropy QA/QC programs.

Internal Systems Audit: The following sampling equipment checks were conducted prior to sample collection.

- All sampling equipment was thoroughly checked to ensure clean and operable components.
- Equipment was inspected for possible damage from shipment.
- The oil manometers or Magnehelic gauges were leveled and zeroed.
- The temperature measurement systems were checked for damage and operability by measuring the ambient temperature.

Performance Audits: Performance audits of the laboratory are conducted prior to the processing of any compliance samples for analysis. Audit materials typically include samples available from the EPA prior to new source testing. Also, samples of known concentration are prepared in-house or obtained from the EPA for Internal QA checks.

External Systems Audits: Entropy is subject to a system audit each time a test is conducted for any Air Pollution Control agency. This procedure entails an EPA observer on-site to do qualitative evaluation of performance to demonstrate compliance with the applicable regulations.

### **5.7 Data Reduction and Validation**

The test team leader is responsible for reviewing and validating data as they are acquired. Each team leader has extensive knowledge of sampling methodology and the characteristics of the process being measured and is capable of evaluating the accuracy, representativeness, and completeness of raw data on-site. Action to replace inadequate data can be taken immediately.

Data obtained during calibrations and test runs are recorded on standardized forms which are checked twice for completeness and accuracy by the QA Director or his designated representative. Data reduction and consistency are achieved by using the standardized forms and using Entropy's in-house computer facilities.

### 5.8 QA/QC Summary

All chemicals used were American Chemical Society (ACS), High Performance Liquid Chromatography (HPLC), or pesticide grade. The deionized, distilled water utilized met or exceeded the American Society for Testing and Materials (ASTM) specifications for Type-I reagent water. Pretest and posttest leak checks were conducted on each sampling train.

Acetone reagent blanks were analyzed for each of the test conditions. The acetone reagent blank for Facility A, Condition I was analyzed for particulate with 2.39 mg/53 mL detected. The acetone reagent blank for Facility A, Condition II was analyzed for particulate with 0.84 mg/30 mL detected. The acetone reagent blank for Facility B was analyzed for particulate with 5.53 mg/35 mL detected.

Field blanks were prepared and analyzed for metals; a matrix spike was conducted; and duplicate analyses were conducted. Tables 5-2 and 5-3 present the results for Facility A Conditions I and II, respectively. The results for Facility B are presented in Table 5-4.

**TABLE 5-2  
METALS BLANKS, MATRIX SPIKES,  
AND DUPLICATE ANALYSES RESULTS  
FACILITY A, CONDITION I  
JULY 1995**

	Field Blank, $\mu\text{g}^{\text{a}}$	Matrix Spike Recovery, % <sup>a</sup>	First Analysis, $\mu\text{g}$	Second Analysis, $\mu\text{g}^{\text{b}}$	Relative % Difference <sup>c</sup>
Arsenic	< 1.00	90.2	< 1.00	< 1.00	NA
Barium	5.25	90.7	6.630	6.88	1.85
Cadmium	< 0.400	107	2.490	2.51	0.40
Chromium	1.75	94.9	3.380	3.30	1.20
Lead	< 1.00	90	5.900	5.89	0.08
Zinc	12	106	72.0	72.0	0.00
Chromium (VI)	< 1.1	94.8	< 1.5	< 1.5	NA

(a) Conducted on repetition 3.

(b) Conducted on repetition 2.

(c) Not applicable if one or both results are below the detection limit.

**TABLE 5-3  
METALS BLANKS, MATRIX SPIKES,  
AND DUPLICATE ANALYSES RESULTS  
FACILITY A, CONDITION II  
JULY 1995**

	Field Blank, $\mu\text{g}^{\text{a}}$	Matrix Spike Recovery, % <sup>a</sup>	First Analysis, $\mu\text{g}$	Second Analysis, $\mu\text{g}^{\text{b}}$	Relative % Difference <sup>c</sup>
Arsenic	< 1.00	93	< 1.00	< 1.00	NA
Barium	4.51	97.3	4.67	4.66	0.107
Cadmium	< 0.400	99.7	0.552	0.550	.181
Chromium	1.64	93.4	2.00	2.050	1.235
Lead	< 1.00	96	< 1.00	< 1.00	NA
Zinc	< 10	104	14.00	14.00	0.00
Chromium (VI)	1.12	94.8	< 1.5	< 1.5	NA

(a) Conducted on repetition 3.

(b) Conducted on repetition 2.

(c) Not applicable if one or both results are below the detection limit.

**TABLE 5-4  
METALS BLANKS, MATRIX SPIKES,  
AND DUPLICATE ANALYSES RESULTS  
FACILITY B  
JULY 1995**

	Field Blank, $\mu\text{g}^{\text{a}}$	Matrix Spike Recovery, % <sup>a</sup>	First Analysis, $\mu\text{g}$	Second Analysis, $\mu\text{g}^{\text{b}}$	Relative % Difference <sup>c</sup>
Arsenic	< 1.00	90.8	< 1.00	< 1.00	NA
Barium	10.4	88.3	21.2	21.8	1.40
Cadmium	< 0.400	104	1.10	1.08	0.92
Chromium	2.61	93.1	2.77	2.67	1.84
Lead	< 1.00	90.9	< 1.00	< 1.00	NA
Zinc	< 1.00	102	18.00	18.00	0.00
Chromium (VI)	0.821	102	< 1.5	< 1.5	NA

(a) Conducted on repetition 3.

(b) Conducted on repetition 2.

(c) Not applicable if one or both results are below the detection limit.