KLEINFELDER

Coyote Canyon
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SOURCE TEST REPORT
BOILER AND FLARE SYSTEMS
LAIDLAW GAS RECOVERY SYSTEMS
COYOTE CANYON LANDFILL
IRVINE, CALIFORNIA

Prepared for

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SOURCE TEST REPORT
BOILER AND FLARE SYSTEMS
COYOTE CANYON LANDFILL

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ACRONYMS AND ABBREVIATIONS

AB 2588	California Air Toxics Hot Spots Information and Assessment Act
acfm	actual cubic feet per minute
ACS	American Chemical Society
BACT	Best Available Control Technology
°C	degrees Centigrade
CARB	California Air Resources Board
CEM	continuous emissions monitor
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
DNPH	2,4-dinitrophenylhydrazine
dscf	dry standard cubic feet
dscfm	dry standard cubic feet per minute
EPA	United States Environmental Protection Agency
°F	degrees Fahrenheit
FID	flame ionization detector
ft/sec	feet per second
GFC	gas filter correlation
gr/dscf	grains per dry standard cubic feet
Hg	mercury
HPLC	high-pressure liquid chromatography
HRGC	high-resolution gas chromatography
ID	identification
lb/hr	pounds per hour
LGRS	Laidlaw Gas Recovery Systems
LRMS	low-resolution mass spectrometry
MEL	Mobile Emissions Laboratory
mM	millimolar
N	normal
$NaHCO_3$	sodium bicarbonate
Na_2CO_3	sodium carbonate
NDIR	non-dispersive infrared detection method
NO_x	nitrogen oxides
NO_2	nitrogen dioxide
O_2	oxygen
PAH	polycyclic aromatic hydrocarbons
ppb,v	parts per billion by volume
ppm,v	parts per million by volume
PTC	Permit to Construct
SCAQMD	South Coast Air Quality Management District
scfm	standard cubic feet per minute
SO_x	sulfur oxides
SO_2	sulfur dioxide
TGNMO	total gaseous non-methane organic
% vol	percent by volume
XAD-2	nomenclature for PAH-capturing resin

1 EXECUTIVE SUMMARY

On behalf of Laidlaw Gas Recovery Systems (LGRS), Kleinfelder, Inc. performed a series of source emissions tests on the landfill gas-fired flare and boiler systems located at the Coyote Canyon Landfill site in Irvine, California. The source emissions tests were conducted from June 6 through 14, 1991 on both the boiler and flare #1 inlet and exhaust gases. Flare and boiler inlet tests were conducted to determine the quantities of reduced sulfur compounds, fixed gases, and methane and non-methane organics (total and speciated) entering the flare and boiler. Flare and boiler exhaust gas tests were conducted to determine the quantities of emitted methane and non-methane organics (total and speciated), nitrogen oxides, sulfur oxides, carbon monoxide, particulate matter, hydrochloric acid, formaldehyde, polycyclic aromatic hydrocarbons, and heavy metals.

The source tests were conducted to fulfill the requirements of the South Coast Air Quality Management District (SCAQMD) Permit to Construct (PTC) No. 154182 and 157115, and to quantify the emissions of substances regulated under the AB 2588 Air Toxics "Hot Spots" legislation. All test and analytical procedures conformed to the Source Test Protocol submitted to the SCAQMD on March 13, 1991.

During the testing period, the flare was operated under two conditions: one with a landfill gas flow rate near the 1992 standard cubic feet per minute (scfm) permit limit and a flare stack temperature of at least 1400°F, and the other with a landfill gas flow rate of 900 scfm, again with a stack temperature of at least 1400°F. The boiler was operated with a landfill gas flow rate of 9950 scfm. Results of the tests are summarized in Table 3-1. As illustrated on the table, for the flare, the emission rates of total gaseous non-methane organics (TGNMO) and carbon monoxide (CO) are much lower than those specified in the PTC. Sulfur oxides (SO_x) and oxides of nitrogen (NO_x) are emitted at rates near or slightly greater than the PTC conditions. For the boiler, the emission rates of total gaseous non-methane organics, oxides of nitrogen, and carbon monoxide are lower than those specified in the PTC. Sulfur oxides are emitted at rates greater than the PTC conditions. Although the boiler exit velocity was measured slightly below the permit value, the measured velocities were within the accuracy of pitot tube velocity measurements.

The particulate data collected during the tests appeared unreasonably high and inconsistent with previous observations. Therefore, no representative values were obtained during this test. A re-test of the boiler and flare system is scheduled for the week of August 5, 1991.

2 INTRODUCTION

Laidlaw Gas Recovery Systems (LGRS) retained Kleinfelder, Inc. to perform a source emissions test on the landfill gas fired boiler and flare system located at the Coyote Canyon Landfill in Irvine, California. The tests were performed from June 6 through 14, 1991.

This section summarizes the purpose of the source emissions tests, provides an overview of the procedures used during testing, and details the chronology of field testing activities. Section 3 provides summary tables of the results of testing, including emission rates and flare and boiler destruction efficiencies, for the various landfill gas inlet and exhaust gas components. A brief process description of the flare and boiler system is contained in Section 4. Sections 5 and 6 summarize the field sampling procedures and laboratory analytical methods employed during the program. Because the quantity of written material on these topics is voluminous, Sections 4, 5 and 6 provide only summaries of the relevant information. However, the complete information is readily available elsewhere. For example, a complete description of the flare and boiler system is available from the PTC application documents. Detailed descriptions of the test methods and analytical procedures can be found in the published California Air Resources Board (CARB) reference methods noted. Complete copies of the raw, original field and laboratory data are contained in Appendices A and B. Detailed results and sample calculations are provided in Appendices C and D. Equipment calibration records are included in Appendix E. Appendix F provides a copy of the relevant device permits.

2.1 Purpose and Objectives

The landfill gas extraction system and the landfill gas-fired flares and boiler are operated to reduce the potential for uncontrolled gaseous emissions and to recover the energy potential of the gas. Gas which might otherwise diffuse through the landfill cover or travel laterally beneath the surface is collected for combustion in the flare and boiler. Complete combustion of the landfill gas in the flare or boiler would result in the flare exhaust gases containing only carbon dioxide and water. Although combustion devices such as the ones installed at the Coyote Canyon Landfill are extremely effective at destroying the landfill gases through complete combustion, trace amounts of gases other than carbon dioxide and water are emitted. The purpose of the source test was to verify the destruction efficiency of the flare and boiler and to quantify the emissions of the trace gases that could be emitted from the flare and boiler exhausts.

Consistent with the need to verify performance, the test fulfilled the requirements of the SCAQMD Permit to Construct No. 154182 and 157115 and quantified the emissions of substances regulated under the AB 2588 Air Toxics "Hot Spots" legislation.

2.2 Procedures

The testing program was coordinated by Mr. Frank Enos of LGRS and Mr. Roland Hebert of Kleinfelder. Tables 2-1 and 2-2 provide a chronological log which depicts the sequence of field sampling events. The CARB procedures listed in the tables were described in the Source Test Protocol submitted to the SCAQMD on March 13, 1991. Details regarding each sampling method are summarized in Section 5. Field sampling records are contained in Appendix A. For reference to Tables 2-1 and 2-2, a summary is provided here for each of the field sampling activities and the associated CARB method.

- Sample traverse points were determined using **CARB Method 1.**
- Measurement of gas stream velocity, gas temperature, and gas pressure, as well as verification of the absence of cyclonic flow, were accomplished using **CARB Method 2.**
- Stack gas moisture content was measured using **CARB Method 4** in conjunction with the particulate sampling.
- Particulate matter was measured using **CARB Method 5.**
- Molecular weights of the stack gases (carbon dioxide, oxygen, and carbon monoxide) were determined using continuous monitors operated according to **CARB Method 100.**
- Emissions of gaseous products of combustion were continuously monitored with the Kleinfelder Mobile Emissions Laboratory according to **CARB Method 100.**
- Emissions of hydrogen chloride were sampled by **CARB Method 421.**
- Reduced sulfur, fixed gases, and total gaseous non-methane organic (TGNMO) compounds were sampled into evacuated Tedlar bags using **CARB Method 422.** The bags were submitted to an analytical laboratory for analysis within 48 hours of sampling.
- Total and hexavalent chromium emissions were measured using **CARB Method 425.**
- Polycyclic aromatic hydrocarbons (PAH) were sampled using **CARB Method 429.**

TABLE 2-1 CHRONOLOGICAL SAMPLING LOG

COYOTE CANYON LANDFILL
LANDFILL GAS-FIRED FLARE NO.1

Type	Run No.	Date	Time On	Time Off
CARB 5	1	06 Jun 91	1422	1631
CARB 100	1	06 Jun 91	1425	1555
CARB 5	2	08 Jun 91	0822	0954
CARB 100	2	08 Jun 91	0830	0930
CARB 100	3	08 Jun 91	1030	1130
CARB 5	3	08 Jun 91	1052	1238
CARB 100	4	08 Jun 91	1230	1330
CARB 421	1-Out	08 Jun 91	1325	1525
CARB 421	1-In	08 Jun 91	1349	1524
CARB 100	5	08 Jun 91	1430	1630
CARB 421	2-In	08 Jun 91	1609	1809
CARB 421	2-Out	08 Jun 91	1618	1825
CARB 100	6	08 Jun 91	1700	1800
CARB 421	3-In	08 Jun 91	1848	2028
CARB 421	3-Out	08 Jun 91	1849	2028
CARB 100	7	08 Jun 91	1855	1950
CARB 421	4-In	08 Jun 91	2052	2152
CARB 421	4-Out	08 Jun 91	2102	2244
CARB 5	4	08 Jun 91	2300	2440

Note: CARB Methods 1, 2, and 4 were performed in concert with every other isokinetic sampling method (i.e., Methods 5 and 421).

TABLE 2-2 CHRONOLOGICAL SAMPLING LOG

COYOTE CANYON LANDFILL
LANDFILL GAS-FIRED BOILER

Type	Run No.	Date	Time On	Time Off
CARB 100	1	10 Jun 91	1305	1405
CARB 5	1	10 Jun 91	1305	1435
CARB 5	2	10 Jun 91	1306	1436
CARB 100	2	10 Jun 91	1535	1635
CARB 421	1	10 Jun 91	1600	1820
CARB 421	2	10 Jun 91	1604	1736
CARB 436	1	11 Jun 91	0952	1200
CARB 425	1	11 Jun 91	0955	1202
CARB 436	2	11 Jun 91	1323	1530
CARB 425	2	11 Jun 91	1325	1532
ST-1B	1	11 Jun 91	1630	1700
ST-1B	2	11 Jun 91	1632	1702
ST-1B	3	11 Jun 91	1718	1748
CARB 430	1	12 Jun 91	1021	1051
CARB 429	1	12 Jun 91	1045	1440
CARB 428	1	12 Jun 91	1048	1443
CARB 430	2	12 Jun 91	1055	1125
CARB 430	3	12 Jun 91	1127	1157
CARB 428	2	13 Jun 91	0852	1306
CARB 429	2	13 Jun 91	0855	1309
CARB 436	3	13 Jun 91	1426	1633
CARB 425	3	13 Jun 91	1427	1635
CARB 428	3	14 Jun 91	0859	1306
CARB 429	3	14 Jun 91	1090	1308

Note: CARB Methods 1, 2, and 4 were performed in concert with every other isokinetic sampling method (i.e., Methods 5, 421, 425, 428, 429, and 436).

Samples collected by the various methods noted were analyzed by several individual laboratories. Analyses for fixed gases, methane and non-methane organics (total and speciated), hydrogen sulfide, and organic reduced sulfur compounds were performed by Atmosphere Assessment Associates at its Chatsworth, California facility. The PAH samples were analyzed by Eureka Laboratories in Sacramento, California. The remaining samples were analyzed by TMA/ARLI Laboratory in Monrovia, California. Section 6 describes the analytical procedures, while the laboratory data are provided in Appendix B.

3 SUMMARY OF SOURCE TEST RESULTS

This section provides tabulated results for each of the parameters measured during the source test. On Table 3-1, test results for criteria pollutants and total gaseous non-methane organics are compared to emission limits specified in the PTC. Measured source operational and analytical parameters are described in Table 3-2. Data for both the high flow and low flow landfill gas inlet rate conditions are summarized. Test results for formaldehyde, ammonia, hydrogen chloride, heavy metals, organic compounds, and polycyclic aromatic hydrocarbons are quantified respectively in Tables 3-3 through 3-7. Detailed results and example calculations are provided in Appendices C and D.

As is shown in the appendices, Kleinfelder measured the boiler stack diameter as 68 inches. However, on previous tests conducted by the SCAQMD, the diameter was measured as 66 inches. Therefore, it is possible that the volumetric flow rates, and, therefore, the boiler mass emission rates reported herein are 3 to 5 percent greater than actual. If this difference is significant to SCAQMD, a reconfirmation of the measured stack diameter and re-calculation of the mass emission rates could be conducted.

TABLE 3-1 LAIDLAW GAS RECOVERY SYSTEMS
COYOTE CANYON LANDFILL
COMPLIANCE TEST RESULTS

PARAMETER	UNITS	PERMIT	RUN 1	RUN 2	
		FLARE NO. 1	high flowrate		F.
Stack Temp	°F	> 1400	1700	1810	
LFG Flow	SCFM	6 1992	1920	1750	1835
TGNMO	lb/day	32	6.2	2.6	
NO_x	lb/day	47	45.1	48.9	
SO_2	lb/day	5	2.1	14.5	
CO	lb/day	946	218	88	
Part.	lb/day	9	NA[a]	NA	
		BOILER			
LFG Flow	SCFM	< 10000	9950	9950	9950
Velocity	ft/sec	≥ 115	110	111	
TGNMO	lb/day	160	145	77	
NO_x	lb/day	213	136	121	
	ppm@3%O_2	20	15.6	14.4	
SO_2	lb/day	24	84	77	
CO	lb/day	222	ND[b]	ND	
Part.	lb/day	21	NA	NA	

[a] - Particulate data collected appeared unreasonably high and inconsistent with previous observations. Therefore, no representative values were obtained during this test. A re-test of system for particulates is scheduled for week of August 5, 1991.

[b] - None detected at lower detection limit of 0.5 ppm,v

TABLE 3-2 TEST RESULTS - SOURCE EMISSION PARAMETERS
Coyote Canyon Landfill
Flare No. 1 - High Flow Rate

Parameter	Units	Run 2	Run 3	AVG
Stack Temperature	°F	1700	1810	
Moisture	% vol	9.30	10.81	
Gas Meter Volume	dscf	29.14	30.05	
Gas Velocity	ft/sec	19.9	18.5	
Gas Volume	acfm	78178	72418	
Gas Volume	dscfm	16998	14734	15866
Isokinetics	%	91.2	94.1	
Oxygen	% vol	9.8	8.8	
Carbon Dioxide	% vol	9.7	10.9	
Carbon Monoxide				
Concentration	ppm,v	120.5	56.3	88.4 ppm CO:
Emission Rate	lb/hr	9.08	3.67	6.375 lbs/hr.
Sulfur Dioxide				
Concentration	ppm,v	0.5	4.0	
Emission Rate	lb/hr	0.09	0.60	
Nitrogen Oxides				
Concentration	ppm,v	15.2	19.0	17.1 ppm Nox
Emission Rate	lb/hr	1.88	2.04	1.96
Particulate Matter				
Concentration	gr/dscf	NA[a]	NA	
Emission Rate	lb/hr	NA	NA	
Landfill Gas				
Flow Rate	SCFM	1920	1750	1835
Carbon Dioxide	% vol	35.8	35.8	
Oxygen	% vol	0.9	1.0	
Nitrogen	% vol	22.8	22.7	
Methane	% vol	39.3	39.3	0.39
Hydrogen Sulfide	ppm,v	42.6	42.2	CH_4 flowrate = 0.393 × 1835 = 721.1 scfm
Methyl Mercaptan	ppm,v	1.7	1.9	
Ethyl Mercaptan	ppm,v	1.0	1.7	
Carbon Disulfide	ppm,v	<0.5	<0.5	
Dimethyl Sulfide	ppm,v	7.7	8.0	
Dimethyl Disulfide	ppm,v	0.3	0.04	
TGNMO, Inlet[b]				
Concentration	ppm,v	6360	8835	
Feed Rate	lb/hr	23.17	29.34	
TGNMO, Outlet[c]				
Concentration	ppm,v	7.99	3.88	
Emission Rate	lb/hr	0.258	0.109	
Flare Efficiency[d]	%	98.9	99.6	

[a] - See Note Table 3-1
[b] - SCAQMD Method 25.1
[c] - SCAQMD Method 25.2
[d] - Based on feed and emission rates of TGNMO

TABLE 3-2 TEST RESULTS - SOURCE EMISSION PARAMETERS
Coyote Canyon Landfill
Flare No. 1 - Low Flow Rate

Parameter	Units	Run 1	Run 4	f.1a
Stack Temperature	°F	1673	1530	
Moisture	% vol	3.74	10.05	
Gas Meter Volume	dscf	27.83	32.98	
Gas Velocity	ft/sec	15.7	21.6	
Gas Volume	acfm	61740	84807	
Gas Volume	dscfm	14466	19850	17,158
Isokinetics	%	109.5	94.3	
Oxygen	% vol	9.8	11.5	
Carbon Dioxide	% vol	10.1	8.3	
Carbon Monoxide				
Concentration	ppm,v	10.3	11.9	11.10 ppm
Emission Rate	lb/hr	0.66	1.05	0.855 lbs/hr
Sulfur Dioxide				
Concentration	ppm,v	1.5	5.0	
Emission Rate	lb/hr	0.22	0.99	
Nitrogen Oxides				
Concentration	ppm,v	14.5	8.5	11.65 ppm
Emission Rate	lb/hr	1.52	1.23	1.375
Particulate Matter				
Concentration	gr/dscf	NA[a]	NA	
Emission Rate	lb/hr	NA	NA	
Landfill Gas				
Flow Rate	SCFM	900	900	900
Carbon Dioxide	% vol	33.8	34.3	
Oxygen	% vol	1.4	1.4	
Nitrogen	% vol	29.7	29.4	
Methane	% vol	33.7	34.3	0.34 x 900 = 306 cfm
Hydrogen Sulfide	ppm,v	37.4	46.4	
Methyl Mercaptan	ppm,v	3.2	3.7	
Ethyl Mercaptan	ppm,v	0.6	0.7	
Carbon Disulfide	ppm,v	0.06	0.05	
Dimethyl Sulfide	ppm,v	6.7	6.6	
Dimethyl Disulfide	ppm,v	0.07	0.04	
TGNMO, Inlet[b]				
Concentration	ppm,v	8010	9660	
Feed Rate	lb/hr	13.68	16.50	
TGNMO, Outlet[c]				
Concentration	ppm,v	2.36	2.10	
Emission Rate	lb/hr	0.065	0.079	
Flare Efficiency[d]	%	99.5	99.5	

[a] - See Note Table 3-1
[b] - SCAQMD Method 25.1
[c] - SCAQMD Method 25.2
[d] - Based on feed and emission rates of TGNMO

TABLE 3-2 TEST RESULTS - SOURCE EMISSION PARAMETERS
Coyote Canyon Landfill
Boiler

Parameter	Units	Run 1	Run 2	[illegible]
Stack Temperature	°F	214	214	
Moisture	% vol	3.55	6.35	
Gas Meter Volume	dscf	30.49	29.86	
Gas Velocity	ft/sec	109.8	111.0	
Gas Volume	acfm	166129	167950	
Gas Volume	dscfm	123790	121524	122,657
Isokinetics	%	101.2	101.0	
Oxygen	% vol	13.7	13.8	
Carbon Dioxide	% vol	6.2	6.3	
Carbon Monoxide				
Concentration	ppm,v	<0.5	<0.5	0.25 ppm co
Emission Rate	lb/hr	<0.3	<0.3	<0.15
Sulfur Dioxide				
Concentration	ppm,v	2.8	2.6	
Emission Rate	lb/hr	3.52	3.22	
Nitrogen Oxides				
Concentration	ppm,v	6.3	5.7	6.0 ppm Nox
Emission Rate	lb/hr	5.67	5.04	
Particulate Matter				
Concentration	gr/dscf	NA[a]	NA	
Emission Rate	lb/hr	NA	NA	
Landfill Gas				
Flow Rate	SCFM	9950	9950	9950
Carbon Dioxide	% vol	33.8	34.1	
Oxygen	% vol	1.3	1.4	
Nitrogen	% vol	28.9	29.1	
Methane	% vol	33.9	33.5	33.7 .337
Hydrogen Sulfide	ppm,v	47.4	45.4	
Methyl Mercaptan	ppm,v	2.5	2.8	
Ethyl Mercaptan	ppm,v	0.4	0.4	
Carbon Disulfide	ppm,v	0.07	0.07	
Dimethyl Sulfide	ppm,v	8.6	8.7	
Dimethyl Disulfide	ppm,v	0.05	0.04	
TGNMO, Inlet[b]				
Concentration	ppm,v	8960	4840	
Feed Rate	lb/hr	169	91	
TGNMO, Outlet[c]				
Concentration	ppm,v	25.8	20.2	
Emission Rate	lb/hr	6.06	4.66	
Destruction Efficiency[d]	%	96.4	94.9	

[a] - See Note Table 3-1
[b] - SCAQMD Method 25.1
[c] - SCAQMD Method 25.2
[d] - Based on feed and emission rates of TGNMO

TABLE 3-3 TEST RESULTS - FORMALDEHYDE
Coyote Canyon Landfill
Boiler

Parameter	Units	Run 1	Run 2	Run 3
Stack Temperature	°F	215	215	215
Moisture	% vol	8.49	8.73	8.66
Gas Meter Volume	dscf	1.15	1.07	1.03
Gas Velocity	ft/sec	111.6	111.7	111.7
Gas Volume	acfm	168936	169020	168995
Gas Volume	dscfm	119505	119243	119322
Oxygen	% vol	14.46	14.46	14.46
Carbon Dioxide	% vol	5.45	5.45	5.45
Formaldehyde	ppm,v	0.124	0.130	0.142
	lb/hr	0.071	0.073	0.080

TABLE 3-4 TEST RESULTS - AMMONIA AND HYDROGEN CHLORIDE
Coyote Canyon Landfill
Boiler and Flare

Parameter	Units	Run 1	Run 2	Run 3
		Boiler		
Ammonia	ppm,v	<3.97	<4.67	<4.21
	lb/hr	<1.40	<1.32	<1.31
Hydrogen Chloride	ppm,v	0.711	0.911	NA
	lb/hr	0.486	0.605	NA
		Flare No. 1		
Hydrogen Chloride	ppm,v	0.569	0.684	NA
	lb/hr	0.066	0.717	NA

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[a] Triplicate runs were taken for ammonia only.

TABLE 3-5 TEST RESULTS - HEAVY METALS
Coyote Canyon Landfill
Boiler

Parameter	Units	Run 1	Run 2	Run 3	avg.
Stack Temperature	°F	216	206	242	
Moisture	% vol	5.40	4.61	5.32	
Gas Meter Volume	dscf	51.82	50.38	44.40	
Isokinetic	%	104.2	102.4	108.1	
Gas Velocity	ft/sec	111.2	107.5	95.2	
Gas Volume	acfm	167941	162691	144124	
Gas Volume	dscfm	122385	121336	101293	115,005
Oxygen	% vol	13.92	13.67	13.95	
Carbon Dioxide	% vol	6.15	6.07	6.02	
Arsenic	lb/hr	2.35E-03	2.21E-03	1.92E-03	2.16E-03
Beryllium	lb/hr	<6.56E-04	<1.53E-04	<1.45E-04	1.59E-04
Cadmium	lb/hr	4.00E-03	3.38E-03	1.90E-03	3.09E-03
Chromium					
Hexavalent[a]	lb/hr	<4.26E-04	1.62E-04	3.43E-04	2.39E-04
Total	lb/hr	2.11E-02	3.44E-02	1.60E-02	2.38E-02
Copper	lb/hr	4.31E-03	6.60E-03	1.51E-03	4.14E-03
Lead	lb/hr	4.09E-03	3.41E-03	2.57E-03	3.36E-03
Manganese	lb/hr	2.26E-01	1.04E-01	3.95E-02	1.23E-01
Mercury	lb/hr	4.69E-05	4.14E-05	3.62E-05	4.15E-05
Nickel	lb/hr	3.16E-02	6.88E-02	2.23E-02	4.09E-02
Selenium	lb/hr	<2.97E-04	<3.03E-04	<2.87E-04	1.48E-04
Zinc	lb/hr	5.28E-02	5.00E-02	4.62E-02	4.97E-02

[a] CARB Method 425

TABLE 3-6 TEST RESULTS - ORGANICS
Coyote Canyon Landfill
Flare No. 1 - High Flow Rates

Parameter	Units	Run 1	Run 2
Landfill Gas Inlet			
Acetonitrile	ppb,v	17	17
Benzene	ppb,v	1620	1650
Benzyl Chloride	ppb,v	<20	<20
Chlorobenzene	ppb,v	<20	<20
Dichlorobenzene	ppb,v	236	230
1,1-dichloroethane	ppb,v	2340	2520
1,2-dichloroethane	ppb,v	115	131
1,1-dichloroethylene	ppb,v	342	331
Dichloromethane	ppb,v	7580	7120
Perchloroethene	ppb,v	5310	5120
Carbon Tetrachloride	ppb,v	<1	<1
Toluene	ppb,v	57500	59800
1,1,1-trichloroethane	ppb,v	178	167
Trichloroethene	ppb,v	2380	2230
Chloroform	ppb,v	2	2
Vinyl Chloride	ppb,v	1900	1840
m+p-xylenes	ppb,v	25500	26500
o-xylenes	ppb,v	8460	8790
Flare Exhaust Stack			
Acetonitrile	ppb,v	<0.8	<0.8
Benzene	ppb,v	0.287	0.2
Benzyl Chloride	ppb,v	<0.8	<0.8
Chlorobenzene	ppb,v	<0.1	0.1
Dichlorobenzene	ppb,v	<1.1	<1.1
1,1-dichloroethane	ppb,v	<0.4	<0.4
,2-dichloroethane	ppb,v	<0.2	<0.2
1,1-dichloroethylene	ppb,v	<0.1	<0.1
Dichloromethane	ppb,v	3.6	3.5
Perchloroethene	ppb,v	0.17	<0.1
Carbon Tetrachloride	ppb,v	<0.05	<0.0
Toluene	ppb,v	19.2	2.0
1,1,1-trichloroethane	ppb,v	0.44	0.2
Trichloroethene	ppb,v	0.14	<0.0
Chloroform	ppb,v	<0.1 .000	<0.0
Vinyl Chloride	ppb,v	<0.1	0.3
m+p-xylenes	ppb,v	1.28	0.9
o-xylenes	ppb,v	1.23	<0.5

assume det. limit @ 0.1 ppb

(7)R91-713

TABLE 3-6 TEST RESULTS - ORGANICS
Coyote Canyon Landfill
Flare No. 1 - Low Flow Rates

Parameter	Units	Run 1	Run 2	avg.
Landfill Gas Inlet				
Acetonitrile	ppb,v	25	25	21
Benzene	ppb,v	1580	1590	1610
Benzyl Chloride	ppb,v	<20	<20	10
Chlorobenzene	ppb,v	<20	<20	10
Dichlorobenzene	ppb,v	336	317	280
1,1-dichloroethane	ppb,v	3130	2870	2715
1,2-dichloroethane	ppb,v	228	231	176
1,1-dichloroethylene	ppb,v	369	359	350
Dichloromethane	ppb,v	9500	9640	8460
Perchloroethene	ppb,v	4730	4860	5005
Carbon Tetrachloride	ppb,v	<5	<5	1.5
Toluene	ppb,v	59300	60400	59250
1,1,1-trichloroethane	ppb,v	171	174	173
Trichloroethene	ppb,v	2470	2370	2363
Chloroform	ppb,v	3	3	2.5
Vinyl Chloride	ppb,v	1830	1830	1850
m+p-xylenes	ppb,v	21200	21100	23575
o-xylenes	ppb,v	6650	6590	7623
Flare Exhaust Stack				
Acetonitrile	ppb,v	<0.8	<0.8	0.4
Benzene	ppb,v	2.18	1.42	0.53
Benzyl Chloride	ppb,v	<0.8	<0.8	0.4
Chlorobenzene	ppb,v	<0.2	<0.2	0.06
Dichlorobenzene	ppb,v	<1.1	<1.1	0.55
1,1-dichloroethane	ppb,v	<0.4	<0.4	0.2
,2-dichloroethane	ppb,v	<0.2	<0.2	0.1
1,1-dichloroethylene	ppb,v	<0.1	<0.1	.05
Dichloromethane	ppb,v	54.7	58.2	
Perchloroethene	ppb,v	0.20	0.21	
Carbon Tetrachloride	ppb,v	0.06	0.067	
Toluene	ppb,v	21.6	21.7	
1,1,1-trichloroethane	ppb,v	1.24	1.34	
Trichloroethene	ppb,v	0.18	0.09	
Chloroform	ppb,v	0.34	0.25	
Vinyl Chloride	ppb,v	<0.1	<0.1	
m+p-xylenes	ppb,v	2.78	2.31	
o-xylenes	ppb,v	1.23	1.47	

TABLE 3-6 TEST RESULTS - ORGANICS
Coyote Canyon Landfill
Boiler

Parameter	Units	Run 1	Run 2	avg. all 6 tests
Landfill Gas Inlet				
Acetonitrile	ppb,v	13	12.6	
Benzene	ppb,v	1720	1740	
Benzyl Chloride	ppb,v	<20	<20	
Chlorobenzene	ppb,v	502	440	
Dichlorobenzene	ppb,v	266	258	
1,1-dichloroethane	ppb,v	1800	1700	
1,2-dichloroethane	ppb,v	108	96	
1,1-dichloroethylene	ppb,v	357	358	
Dichloromethane	ppb,v	9700	9600	
Perchloroethene	ppb,v	7910	9180	
Carbon Tetrachloride	ppb,v	<5	<5	
Toluene	ppb,v	59800	65200	
1,1,1-trichloroethane	ppb,v	206	175	
Trichloroethene	ppb,v	3010	3060	
Chloroform	ppb,v	1.9	1.9	
Vinyl Chloride	ppb,v	1850	1950	
m+p-xylenes	ppb,v	23600	25200	
o-xylenes	ppb,v	7440	7790	
Boiler Exhaust Stack				
Acetonitrile	ppb,v	0.67	0.52	
Benzene	ppb,v	52.3	39.5	
Benzyl Chloride	ppb,v	<0.8	<0.8	
Chlorobenzene	ppb,v	0.73	0.47	
Dichlorobenzene	ppb,v	<3.5	<3.5	
1,1-dichloroethane	ppb,v	<2	<2	
,2-dichloroethane	ppb,v	0.94	1.29	
1,1-dichloroethylene	ppb,v	<2	<2	
Dichloromethane	ppb,v	NA[a]	NA	
Perchloroethene	ppb,v	15.0	20.8	
Carbon Tetrachloride	ppb,v	<0.06	<0.06	
Toluene	ppb,v	117	127	
1,1,1-trichloroethane	ppb,v	1.01	0.92	
Trichloroethene	ppb,v	6.51	10.0	
Chloroform	ppb,v	0.20	0.17	
Vinyl Chloride	ppb,v	<0.5	<0.5	
m+p-xylenes	ppb,v	14.1	15.1	
o-xylenes	ppb,v	3.47	8.33	

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[a] The analytical laboratory reported concentrations of 14,000 and 9,670 ppb,v. This is obviously in error, since all other inlet data show concentrations of about 9,700 ppb,v and all other outlet data show concentrations of about 55 ppb,v.

r2 7-[illegible]

TABLE 3-7 TEST RESULTS - PAH, PCDD, PCDF
Coyote Canyon Landfill
Boiler

Parameter	Units	Run 1	Run 2	Run 3
Naphthalene	lb/hr	1.291E-01	1.051E-01	1.547E-01
Acenaphthylene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Acenaphthene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Fluorene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Phenanthrene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Anthracene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Fluoranthene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Pyrene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Benzo(a)anthracene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Chrysene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Benzo(b)fluoranthene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Benzo(k)fluoranthene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Benzo(a)pyrene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Benzo(g,h,i)perylene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Dibenzo(a,h)anthracene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
Indeno(1,2,3-cd)pyrene	lb/hr	<2.387E-04	<2.478E-04	<2.500E-04
PCDD	lb/hr	<4.339E-04	<3.835E-04	<3.780E-04
PCDF	lb/hr	<4.339E-04	<3.835E-04	<3.780E-04

4 PROCESS DESCRIPTION

The landfill gas collection and flare and boiler system is an environmentally beneficial system used to recover and control emissions of gas generated through the natural decomposition of waste buried in the landfill. The system consists of a series of landfill gas collection wells, gas manifold and pumping system, and the landfill gas-fired boiler and four flares. The collected gas is piped through a common manifold to the flares where the gas is combusted with air at a very high temperature. The high flare temperature, coupled with a designed residence time for gases in the combustion zone, is the key to achieving complete combustion of the landfill gases (i.e., converting the landfill gases to carbon dioxide and water through combustion with air). The flare design is consistent with Best Available Control Technology (BACT) requirements for treatment of landfill gas. The flare located at the Coyote Canyon Landfill is designed to combust landfill gas at temperatures in excess of 1400°F. The boiler is similarly designed for complete combustion of landfill gas. The boiler design heat input rate is 255 million BTU per hour.

Prior to combustion, the landfill gas passes through a condensate collection system to remove most of the entrained moisture. The landfill gas is fed to the flare or the boiler by a blower capable of delivering landfill gas flow rates required for proper flare or boiler operation. In addition, the flare is equipped with automatic combustion air dampers and flame arrestors. The flare also is designed with a flame failure detector that automatically shuts off the flow of landfill gas to the flare should the flame become extinguished. Operation of the flare within design parameters will ensure that sufficient flare temperature and residence time are achieved for essentially complete destruction of landfill gases.

5 FIELD SAMPLING PROCEDURES

This section summarizes the field sampling procedures used for the source test. This information is condensed from the applicable CARB and U.S. Environmental Protection Agency (EPA) standard methods for stationary source emissions tests. More extensive details concerning those methods are available in the complete test method documents published by the relevant agencies. Section 5.1 describes the general concepts underlying the field test methods and procedures, while the subsequent sections summarize the specific methods used in the Coyote Canyon Landfill source emissions test.

5.1 General Factors Involved in Sampling

During the Coyote Canyon Landfill flare and boiler system source emissions test, pre-approved standard test methods were applied utilizing instruments calibrated in accordance with calibration procedures specified in the individual methods. Appropriate sample custody records and other required field and laboratory documentation were maintained by the field sampling and laboratory staff. These records are included in Appendices A and B. Equipment calibration records are contained in Appendix E. Section 5.2 describes the chain of custody procedures used on this project.

The various test methods can be grouped into four categories. These categories include:

- Methods for proper withdrawal of the exhaust gases from the stack into the sampling equipment
- Methods for continuous monitoring of standard combustion parameters
- Methods for obtaining, transporting and directly analyzing exhaust gas in a laboratory
- Methods for collecting exhaust gas samples in specially prepared impingers that will later be analyzed in the laboratory.

Sections 5.3 and 5.4 describe the exhaust gas withdrawal procedures which are used to help ensure that the gases extracted for analysis are representative of actual flare and boiler exhaust gases. Section 5.5 describes the methods for continuous monitoring of standard combustion parameters. These parameters determine combustion performance and are used in deriving emission rates for the compounds sampled by the remaining methods.

Section 5.6 describes the method for extraction and direct analysis of exhaust gases. This method is used to obtain samples that will be analyzed for organic constituents, including the AB 2588 compounds. Sections 5.7 through 5.11 describe the various specially-designed impinger methods used to obtain samples for laboratory analyses of particulates, PAH, heavy metals, formaldehyde, and halogenated acid constituents.

5.2 Sample Custody Procedures

To help ensure sample integrity and traceability, Kleinfelder's standard chain-of-custody plan was used on this project. The elements of this plan include:

- Sampling train component identification
- Sample identification
- Sample labeling
- Documentation
- Chain-of-custody records.

The sequence of activities related to chain of custody and the sample identification and tracking procedures are described below.

- Sample train components, including filter holders, impingers, and other sampling equipment, were prepared in the laboratory and identified by tags and codes.
- The sample train was issued to the test team and the master log completed. Sample I.D. number stickers were issued according to the test identification code.
- The train was returned to the recovery area when a valid sample was obtained. The sample train was accompanied by all field data sheets.
- The recovery team recovered samples using appropriate containers, and affixed sample I.D. labels to the sample containers, master log, field data sheet, and train recovery sheet.
- Samples and their associated chain-of-custody forms were transferred to appropriate laboratory personnel.
- All samples were returned to Kleinfelder accompanied by the chain-of-custody forms.
- Samples were examined at each transfer point for integrity (broken containers, loss in liquid, or seal integrity).

Upon completing the required analysis, the chain-of-custody form was returned with the analytical results. The Project Manager for the test program ensured that all samples were analyzed and analytical results returned by the laboratory. Within each individual laboratory, that facility's standard procedures for chain of custody were utilized.

5.3 Location and Number of Traverse Points

To help ensure that the extracted exhaust gases analyzed by the appropriate test methods were representative of the actual exhaust gases leaving the flare and boiler, the location of sampling ports and the number of traverse points were determined using the procedure specified in CARB Method 1. The ideal sample port location is at least eight equivalent stack diameters (i.e., eight times the effective stack diameter) downstream of any physical obstruction that would disturb the air flow in the stack, and at least two equivalent diameters upstream of a second disturbance point (usually the exit point for the exhaust gases). Upstream disturbances can be caused by bends, baffles, tees, or other stack construction deviations from the standard "straight pipe" exhaust stack. The minimum requirement for a sampling port is a location two equivalent diameters downstream of a disturbance point and one-half equivalent diameter upstream from a second disturbance point. Additionally, at the sample location, exhaust gas stream flow characteristics should be free from eddy currents and from helical or cyclonic flow.

At an ideal test location as described in CARB Method 1, the exhaust gas velocity and temperature tend to remain constant across the diameter of the stack. The resultant velocity and temperature profiles are flat. Using the criteria described in CARB Method 1, traverse points were identified for the Coyote Canyon Landfill flare and boiler. The method for measuring temperature and velocity is described in Section 5.4.

5.4 Gas Flow and Temperature Measurements

Gas volumetric flow rate and temperature profiles were measured by conducting simultaneous velocity and temperature traverses following the procedures of CARB Method 2. A Chromel-Alumel (K type) thermocouple, attached to a digital indicator, was used to measure the gas temperature at each of the traverse points.

Gas velocity at each traverse point was measured with a calibrated "S" type pitot tube connected to an inclined manometer. The manometer indicates the pressure differential, in inches of water column, between the pressure at the tip of the pitot and the vented leg of the manometer (i.e., atmospheric pressure). This pressure differential is then converted to a velocity through application of the standard Bernoulli equations. The static pressure of the gas stream was measured using the pitot tube and manometer with the tips of the pitot turned perpendicular to the gas stream.

During the initial traverse at each sample location, the absence of cyclonic flow was verified. This was accomplished by turning the pitot tube perpendicular to the exhaust gas flow. If the indicated reading on the manometer did not change (i.e., remained at the "null" position), no cyclonic flow was present. If the manometer did not remain at the null position, the pitot tube was rotated until the manometer null indication was restored. The angle of rotation of the pitot tube is a measure of cyclonic flow in the exhaust gas. The angle of rotation was determined at each of the traverse points, and the average angle of rotation for the entire traverse calculated. If the average angle of rotation for the entire traverse was less than 10 degrees, the sample location is considered to be free of cyclonic flow and suitable for further testing.

5.5 Continuous Emission Monitors

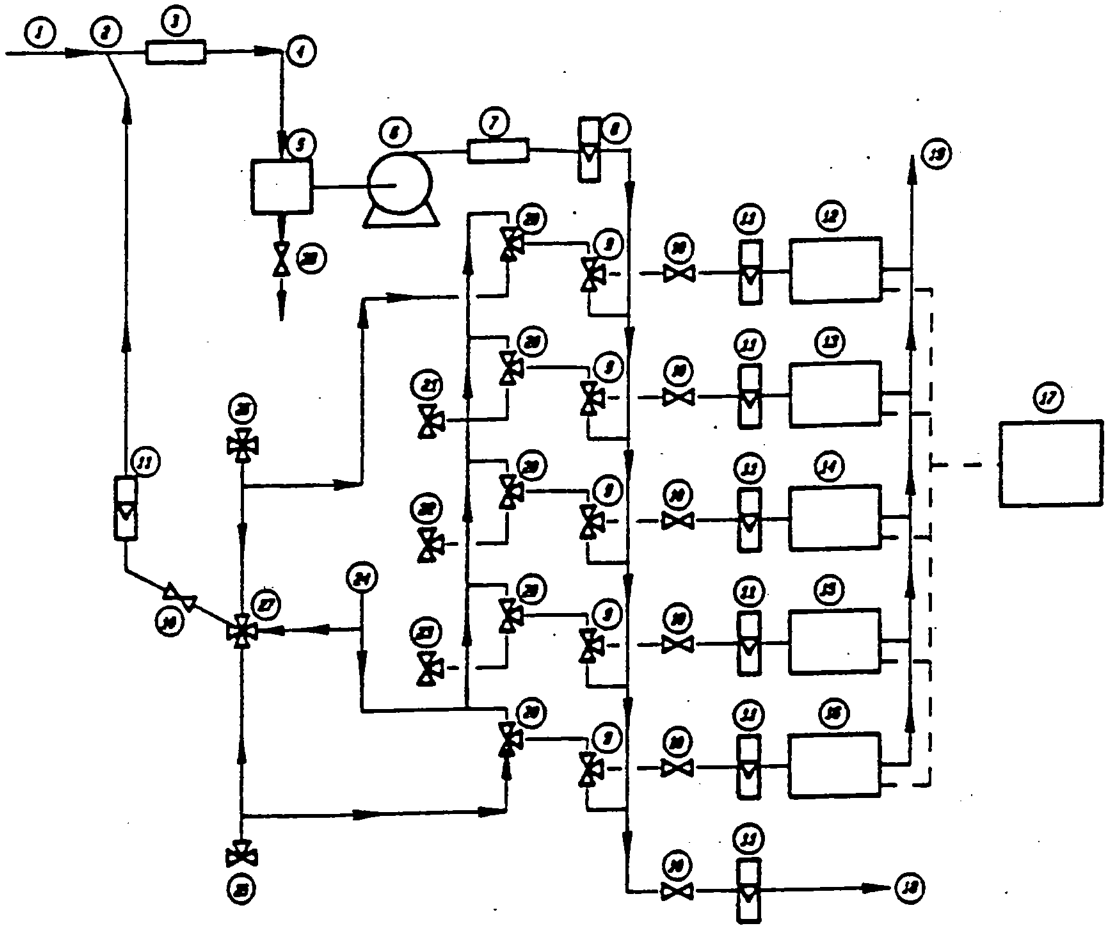
Once an acceptable sampling location was determined by CARB Methods 1 and 2, standard combustion parameters were sampled and analyzed with on-line continuous emission monitors (CEMs) housed in the Kleinfelder Mobile Emissions Laboratory (MEL). These monitors determine carbon dioxide (CO_2), oxygen (O_2), carbon monoxide (CO), nitrogen oxides (NO_x), and sulfur dioxide (SO_2) concentrations in the sampled exhaust gas. Procedures for CEM instrumental sampling are contained in CARB Method 100. Instrument quality control requirements are contained in 40 CFR 60, Appendix A, Method 6C. Requirements for analyzer instrument calibration procedures, error checks, and system bias checks are contained within the methods. The instruments used on this project are listed in Table 5-1, along with methods of detection and applicable operating ranges. The instrument results were electronically transmitted to a strip chart recorder. Copies of the strip charts for the tests conducted are included in Appendix A.

TABLE 5-1 CONTINUOUS EMISSION MONITORING EQUIPMENT

Parameter	Manufacturer	Model	Range	Principle of Detection
SO_2	Western Research	721AT2	0 -200 ppm	Ultraviolet
NO_x	TECO	10A	0 - 100 ppm	Chemiluminesence
O_2	Teledyne	320A	0 - 25%	Fuel Cell
CO_2	ACS	3300	0 - 20%	NDIR
CO	TECO	48	0 - 100 ppm	GFC NDIR

Two of the more critical aspects of continuous emissions monitoring are transporting and conditioning the gas sample from the exhaust gas stream to the instruments, because particulate matter and water vapor can interfere with instrument performance. Particulate matter and water vapor were removed by using an in-line fiberglass filter and a water condenser, respectively. The sample probe was constructed of stainless steel, and the sample lines were heated Teflon. The heated components were maintained at a temperature of 248° ± 25°F to ensure that no moisture condensed in the sampling lines which could remove stack gas constituents prior to their being measured by the MEL instrumentation. After the heated stack gas passed through the in-line filter and condenser, the gas was pumped through a Teflon line to the instrument manifold. A three-way sample valve was located immediately downstream of the filter to allow calibration gases to flow through the entire system for quality control checks. A schematic of the complete CEM system is presented in Figure 5-1. As required by the CARB and EPA methods, each analyzer was multi-point calibrated with a suitable zero gas and at least two upscale span gases, one of which was certified as an EPA Protocol 1 gas. The span gases for each parameter were in the appropriate concentrations described in CARB Method 100.

Figure 5-1



1. SAMPLE PROBE
2. CALIBRATION GAS PORT
3. PARTICULATE FILTER
4. HEATED TEFLON SAMPLE LINE
5. CONDENSER
6. SAMPLE PUMP
7. BACK-UP KNOCK-OUT
8. SAMPLE FLOWMETER
9. SAMPLE/CALIBRATE VALVE
10. CONTROL VALVE
11. FLOWMETER
12. NO_x ANALYZER
13. O_2 ANALYZER
14. CO_2 ANALYZER
15. CO ANALYZER
16. SO_2 ANALYZER
17. CHART RECORDER
18. EXCESS FLOW EXHAUST
19. ANALYZER EXHAUST
20. ZERO GAS/SPAN GAS VALVE
21. O_2 CALIBRATION VALVE (MID/HIGH SPAN)
22. CO_2 CALIBRATION VALVE (MID/HIGH SPAN)
23. CO CALIBRATION VALVE (MID/HIGH SPAN)
24. ZERO GAS
25. SO_2 CALIBRATION VALVE (MID/HIGH SPAN)
26. NO_x CALIBRATION VALVE (MID/HIGH/NO-NO_2 SPAN)
27. PROBE CALIBRATION VALVE
28. CONDENSATE DRAIN VALVE

KLEINFELDER

MOBILE EMISSIONS LABORATORY
SCHEMATIC DIAGRAM

FIGURE

PROJECT NO.

FILED AS: 71MEL

5.6 Tedlar Bag Samples

The two methods of sampling and analyzing the flare and boiler exhaust gases other than the CEMs described in Section 5.5 are: (1) extraction of exhaust gases for transport and direct gaseous analysis at the laboratory (termed "bag sampling"); and (2) extraction of exhaust gases and bubbling the gases through specially prepared impingers for later analysis at the laboratory through wet chemistry and similar methods (termed "impinger sampling"). Bag sampling methods were used to evaluate fixed gases, hydrogen sulfide, organic reduced sulfur compounds, methane and non-methane organics.

For the bag samples, the procedures of CARB Method 422 were used with an integrated Tedlar bag sampling system. The sampling system included a stainless steel probe which was inserted into the stack. A Teflon sample line was connected to the probe and run to the Tedlar bag contained in a rigid, light-sealed container. A sample pump, equipped with a needle valve for flow control and flow meter to measure the flow rate, was used to evacuate the bag. As the bag was evacuated, stack gas from the probe and Teflon sample line filled the bag. At the completion of the sample period, the Tedlar bag was removed, sealed and transported to the analytical laboratory for the appropriate analyses.

5.7 Particulate Sampling

The method utilized for particulate sampling and analysis relies on a specially-designed impinger system. The basis of the particulate sampling system is described in CARB Method 5. In addition to being the specific method for obtaining particulate samples, CARB Method 5 also forms the basis for all the other impinger sampling methods described in Sections 5.8 through 5.11.

It is critical for Method 5 sampling that the samples be obtained isokinetically. Acceptable isokinetic rates for sampling range from 90 percent to 110 percent. The isokinetic percentage is the best single criterion in assessing the validity of an individual test run. An isokinetic percentage of 100 percent means that the nozzle inlet velocity is identical to the undisturbed mainstream stack gas exhaust velocity, and that the withdrawn sample accurately represents stack gas conditions.

As required by CARB Method 5, the diameter of the button-hook nozzle tip used to extract the exhaust gas from the stack must be of the size necessary to maintain the isokinetic rate. The necessary nozzle diameter was calculated based upon the velocity traverses described in Section 5.4. The selected nozzle was securely attached to the upstream end of a stack sampling probe, and the downstream end of the probe was connected by a heated Teflon line to a particulate filter. The Teflon line and the filter holder were maintained at 248° ± 25° F throughout the test.

The sample gas passed through the particulate filter to a glass impinger train. The train consisted of four impingers in series. The first and second impingers each contained 100 milliliters of deionized, distilled water. The third impinger was dry, and the fourth contained approximately 400 grams of moisture-indicating silica gel to collect vapors and/or moisture not already captured by the condenser.

The second impinger was a standard Greenburg-Smith type impinger, while the first, third, and fourth were modified by replacing the standard tip with a 1/2-inch-diameter glass tube. The entire impinger train was immersed in an ice-water bath to aid in moisture condensation and to protect the dry gas meter from excessive temperatures. The outlet temperature from the fourth impinger was measured and ice was added to the system to maintain the temperature below 68° F.

From the impinger train, the sample gas was conducted through an umbilical cord to the control console which contained the following pieces of equipment in sequence: a coarse on-off valve; a needle valve on the pump bypass for flow control; an airtight vacuum pump; a calibrated dry gas totalizing meter; and a calibrated orifice tube. The orifice was equipped with pressure taps connected across an inclined manometer to help ensure that isokinetic sampling rates were maintained during each test.

The entire sampling system was subjected to a leak check prior to each run. The inlet of the nozzle was plugged and a 15-inch mercury vacuum held for at least one minute. Sampling could not commence until the leakage rate was less than 0.02 cubic feet per minute (cfm) or 4 percent of the anticipated average sampling rate for that sampling run.

Upon completion of each test, the soiled filter was removed from the holder and placed in a sealed Petri dish. The nozzle, probe, flexible Teflon line, and the front half of the filter holder were washed internally with deionized water. Any remaining particulate matter, especially in the probe, was removed by a nylon brush followed by a final deionized water rinse. All washings were stored in sealed nonreactive sample bottles for subsequent laboratory analysis.

The contents of the first three impingers were measured gravimetrically. The impinger contents, connecting glassware, and impinger washings were stored in a separate, sealed, nonreactive sample bottle for subsequent laboratory analysis.

The silica gel in the fourth impinger was reweighed to determine the weight gain. If the silica gel was not totally spent, it was reused in subsequent tests. If spent, it was removed, and fresh material added before reuse.

Analysis of the samples for particulate matter was conducted using CARB Method 5 procedures. Each run set consisted of three samples: 1) the probe, nozzle, filter holder front half, and flexible line wash; 2) the filter; and 3) the impinger contents, connecting glassware and their associated wash.

5.8 Polycyclic Aromatic Hydrocarbon Sampling

Polycyclic aromatic hydrocarbon (PAH) sampling is conducted with an impinger system based upon CARB Method 5. According to AB 2588, there are 16 separate substances that comprise the PAH content of stack gases. All 16 substances were analyzed by the laboratory.

Exhaust gas samples were collected using CARB Method 429. CARB Method 429 is based upon the CARB Method 5 impinger train system (including the requirement for isokinetic sampling) with the addition of an adsorbent cartridge of XAD-2 resin that "traps" PAH vapors. The sample train consisted of a glass nozzle, heated probe, heated Teflon sample line, heated Teflon or Teflon-coated glass fiber filter, glass condenser, XAD-2 sorbent module, and the impinger train. The components of the sampling train were treated the same as in Method 5, except that no sealant grease was used in any portions of the sample train.

The most difficult aspect of Method 429 is ensuring that inadvertent PAH contamination of the sample does not occur through the use of materials other than Teflon and glass or through the use of solvents that may contain trace amounts of PAH. Therefore, for this project, all recovery solvents (methanol, toluene, and methylene chloride) were nano-grade quality, distilled in glass, and stored in their original glass containers. In addition, the reagent water was deionized, distilled, and stored in glass containers with Teflon-lined screw caps.

5.9 Heavy Metals Sampling

Sampling for heavy metals was conducted in accordance with CARB Method 436. This method contains the same requirements for isokinetic sampling as CARB Method 5. The Method 436 sampling train design was based on the CARB multi-metal draft methodology (drafted November 8, 1990). The method was used to detect and quantify arsenic, cadmium, chromium, copper, manganese, nickel, and zinc.

The Method 436 sample train consisted of a quartz nozzle, heated probe, heated Teflon sample line, heated glass fiber filter, and the impinger train. Heated components were maintained at 248±25°F. The impinger train consisted of five impingers in series. The first two impingers each contained 100 milliliters of 5 percent nitric acid and 10 percent hydrogen peroxide. The third impinger was dry, and the fourth contained about 400 grams of indicating silica gel. The impinger train was maintained at ice-water conditions to attain gas exit temperatures of no more than 68°F.

Upon completion of each test, the soiled filter was removed from the holder and sealed in its container. The nozzle, probe, Teflon sample line, and front half of the filter holder were washed three times using a total volume of 100 milliliters of acetone, and then three times with 0.1N nitric acid (100 milliliters total volume) while brushing all exposed surfaces with a nonmetallic brush. All acetone and nitric acid washings were placed in separate sealed sample bottles for subsequent analysis.

The contents of the first three impingers were measured gravimetrically and, along with their associated washings of a total of 100 milliliters of 0.1N nitric acid, were stored in a sealed sample bottle. The fourth impinger was reweighed in the field to the nearest 0.1 milligram, and the impinger re-sealed for subsequent recovery or reuse. Samples of unexposed filters and unused reagents were carried through the entire process as analytical blanks.

Careful field preparation and sample recovery procedures were implemented in order to obtain representative results. All impinger and recovery solutions were prepared from ACS-certified reagent grade or equivalent quality reagents and stored in acid-cleaned glass containers, while reagent water was distilled and deionized and stored in glass containers with Teflon-lined screw caps.

5.10 Formaldehyde Sampling

Formaldehyde sampling was performed by CARB Method 430. This impinger method is based upon CARB Method 5, except that midget impingers are used and the impingers are filled with 2,4-dinitrophenylhydrazine (DNPH) to "trap" the formaldehyde. The Method 430 sample train consisted of a heated probe, flexible heated Teflon sample line, and three midget impingers in series. The first two impingers each contained 10 milliliters of DNPH in hydrochloric acid, and the third impinger was dry. A drying tube filled with silica gel was located after the third impinger and before the metering console in order to protect the equipment. After the sampling event, the midget impingers were sealed and transported to the laboratory for analysis.

5.11 Halogenated Acids Sampling

Halogenated acids (hydrochloric acid) were sampled using a CARB Method 421 sampling system. The operation of the sampling system was identical to the CARB Method 5 procedures. This method collects only those halogenated acids which pass through the filter at its elevated temperature (i.e., gaseous acids). The sample of exhaust gas was withdrawn isokinetically from the source through a heated (248° ± 25°F) probe. The sample then passed through a glass fiber filter maintained in the same temperature range as the probe, and then through a Teflon sample line and into the impinger train. The train consisted of four impingers in series. The first two impingers were each charged with 100 milliliters of 3 mM sodium bicarbonate ($NaHCO_3$) and 2.4 mM sodium carbonate (Na_2CO_3). The third impinger was dry, and the fourth was filled with 400 grams of indicating silica gel.

5.12 Total and Hexavalent Chromium Sampling

A sampling train was configured according to the CARB Method 425. The sample was extracted through a glass or Teflon lined probe connected to four impingers in series via a Teflon sample line. The first two impingers were each charged with 100 milliliters of 0.02N sodium bicarbonate ($NaHCO_3$), the third was dry, and the fourth contained 400 grams of indicating silica gel. An ambient temperature Teflon filter was placed between the third and fourth impingers.

5.13 Dioxin and Furan Sampling

The system described below applies to the determination of polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF) in emissions from stationary sources at nanogram to picogram levels.

Samples were collected using CARB Method 428. The train design was based on a validated emission collection system with the addition of an adsorbent cartridge of XAD-2 resin to collect vaporous emissions of PCDD and PCDF. It was isokinetically operated according to the method with stringent clean-up and recovery procedures. Only the total amounts of each PCDD and PCDF can be measured with this system. It has not been proven that the distribution of PCDD and PCDF within the sample train is representative of the distribution within the stack gas for particulate and gaseous PCDD and PCDF.

The sample train consisted of: a glass or stainless steel nozzle; heated glass, stainless steel, or Teflon lined probe; glass fiber filter; Teflon sample line; glass condenser; XAD-2 sorbent module; and the impinger train. Heated components were maintained at 248 ± 25° F. The condenser was designed to allow sufficient cooling of the stack gas to maintain a gas exit temperature of no more than 68° F. The impinger train consisted of four impingers in series, the first two each containing 100 milliliters of water, the third impinger being dry, and the fourth containing 400 grams of indicating silica gel. No sealant grease was used in any portion of the sample train.

Sample recovery is critical. All recovery solvents, methanol, benzene, and methylene chloride, were of nanograde quality, distilled in glass, and stored in their original containers. Reagent water was deionized, distilled, and stored in glass containers with Teflon-lined screw caps.

5.14 Ammonia Sampling

Ammonia was sampled according to the procedures delineated in Method ST-1B published by the Bay Area Air Quality Management District. A system similar to SCAQMD 5.2 was used. The impinger solution was 0.1N hydrochloric acid instead of water. The sample was taken at a constant rate of 0.50 to 0.75 cubic feet per minute for a period of 30 minutes. At the conclusion of the sample run, the system was purged with ambient air for 10 minutes. Samples were quantitatively recovered.

6 ANALYTICAL PROCEDURES

This section briefly summarizes the analytical methods used to quantify the presence of the various exhaust components sampled as described in Section 5. Samples were analyzed within 48 hours after collection.

6.1 Moisture Content

In order to determine the emission rates of the various constituents analyzed, the moisture content of the sampled stack gas was determined in accordance with CARB Method 4. The total moisture gain for each test run is equivalent to the difference between the initial impinger volume and the final impinger solution volume before washing (measured gravimetrically to the nearest 0.1 milligram), plus the weight gain of the silica gel for that test run. This method was used to determine the moisture content of the sampled gases.

6.2 Tedlar Bags

The Tedlar bag samples were analyzed differently by the laboratories depending upon the chemical species of interest in each bag sample. Fixed gases, hydrogen sulfide, and organic reduced sulfur compounds were analyzed using gas chromatography with the appropriate columns and detectors according to standard analytical methods. Methane and total gaseous non-methane organics were analyzed using Method 25.2 as published by the South Coast Air Quality Management District. This method determines the total organic content of the sample by gas chromatography which separates the non-methane organics from carbon monoxide, carbon dioxide, and methane. The remaining non-methane organics are then oxidized to carbon dioxide, reduced to methane, and measured using a flame ionization detector (FID). In order to determine the quantities of specific organic compounds, the Tedlar bag samples were analyzed using gas chromatographic techniques. Depending upon the compound, the species were quantified either by using direct injection to specified columns and measurement by compound-specific detectors or by using mass spectrophotometric techniques.

6.3 Particulate Analysis

Particulate analysis consists of determining the weight of particulate matter trapped on the filters and sampling system as described previously. Prior to weighing for analysis, all filters, including blanks, were desiccated for a minimum of 24 hours and weighed to constant weight. "Constant weight" means that the difference between two consecutive weighings is less than 0.5 milligrams or 1 percent of the resultant net weight, whichever is greater, with no less than 6 hours of desiccation time between weighings. All liquid samples were evaporated to dryness at 105°C in tared beakers, desiccated and weighed to constant weight. The resulting weight data, coupled with the standard combustion parameter measurements, then were used to determine the particulate emission rates.

For quality assurance checks, samples of unexposed filters and unused reagents were stored as blanks. A system blank was also collected by washing down the nozzle, probe, filter holder, and Teflon line before a test.

6.4 Polycyclic Aromatic Hydrocarbons

As required by CARB Method 429, PAH samples collected on the XAD-2 resin were shipped to the laboratory for analysis. Method 429 analysis begins with a compound-specific extraction of the content of the XAD-2 resin. The extract as well as the wash solutions were analyzed for specific PAH compounds using high-resolution capillary-column gas chromatography coupled with low-resolution mass spectrometry (HRGC/LRMS). Because of the complexity of the analysis, the method includes addition of known quantities of internal standards to the sample for internal quality assurance checks.

6.5 Heavy Metals

The impingers used to collect samples for heavy metals were analyzed in accordance with CARB Method 436. The Method 436 samples first were acid-digested to dissolve inorganics and to remove organics that could interfere with the analysis. Samples were analyzed for cadmium, chromium, copper, manganese, nickel, and zinc using inductively-coupled argon plasma emission spectroscopy. The arsenic analysis was performed using atomic absorption spectrophotometry.

The total and hexavalent chromium samples collected by CARB Method 425 were analyzed using Method 425 methodology. The total chromium fraction was acid-digested and analyzed using graphite-tube furnace atomic absorption. The hexavalent chromium fraction was extracted in an alkaline solution and analyzed by the diphenylcarbazide colorimetric method.

6.6 Formaldehyde

The midget impingers collected by Method 430 for formaldehyde analysis were transported to the laboratory where the DNPH sample solutions were extracted with chloroform, washed with hydrochloric acid, and evaporated to dryness. The dry residue was then dissolved in acetonitrile. The analysis was performed using reverse-phase high-pressure liquid chromatography with an ultraviolet adsorption detector.

6.7 Halogenated Acids

Samples for analysis of halogenated acids were obtained as described in Section 5.11 as required by CARB Method 421. The impinger solutions obtained were analyzed for chloride by ion chromatography with a conductivity detector. The chloride peaks were identified by characteristic retention times and quantified by reference to external standards. The amount of chloride ion is directly related to the amount of acid present in the stack gas.

6.8 Total and Hexavalent Chromium

Samples for analysis were obtained as described in Section 5.12. The hexavalent chromium was analyzed via visible range spectrophotometry using diphenylcarbazide or ion chromatography. The total chromium, after acid digestion, was analyzed via direct flame AA or graphite furnace AA as applicable, based on the desired detection limit and stack gas concentration.

6.9 Dioxin and Furan

The analysis includes the addition of internal standards in known quantities. A matrix specified extraction was performed, followed by clean-up and the analysis of the extract for PCDD and PCDF using high-resolution capillary column gas chromatography coupled with either low resolution mass spectrometry (HRGC/LRMS) or high resolution mass spectrometry (HRGC/HRMS).

6.10 Ammonia

The analysis consisted of messlerization and direct measurement of the ammonia concentration with a spectrophotometer. Standard solutions were used to generate a calibration curve of ammonia concentration versus absorbance.

Appendix B provides copies of the laboratory results obtained by the various analytical methods described above. If additional information concerning the precise analytical procedures is needed, the published reference methods should be consulted.

7 LIMITATIONS

This report was prepared in general accordance with the accepted standard of care that existed in Southern California at the time the report was written. It should be recognized that determining all possible emission scenarios and chemicals is difficult. Judgments leading to conclusions and recommendations are generally made with an incomplete knowledge of the facility. Kleinfelder should be notified for additional consultation if the client wishes to reduce the uncertainties beyond the level associated with this report. No warranty, expressed or implied, is made.

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