

COMPLIANCE SOURCE TEST REPORT NEAL ROAD LANDFILL PARADISE, CA

PREPARED FOR:

Butte County Department of Public Works
7 Country Center Drive
Oroville, CA 95965

EQUIPMENT LOCATION:

Neal Road Sanitary Landfill
1023 Neal Rd.
Paradise, CA 95969

TEST DATE:

October 11, 2006

SUBMITTAL DATE:

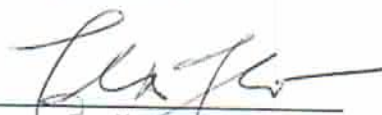
November 28, 2006

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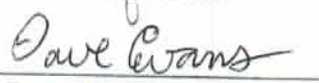

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TABLE OF CONTENTS

	<u>Page No.</u>
1.0 Introduction	1
2.0 Background	1
2.1 Design and Operation	1
2.2 Permit to Operate	1
3.0 Test Summary	1
3.1 Source Test Requirements	1
3.2 Source Test Methods Overview	2
3.3 Flare Performance	3
3.4 Criteria Pollutant Results	3
3.5 NMOC Results	3
4.0 Conclusion	3
5.0 Summary of Results	4
6.0 Sampling and Analytical Procedures	6
<u>Tables</u>	
3-1 Test Program Overview	2
5-1 Summary of Test Results	4
5-2 General Results	5
<u>Appendices</u>	
Appendix A - NO _x , CO, CO ₂ , O ₂ Data and Strip Charts	A-1
Appendix B – Lab Results	B-1
Appendix C – Particulate, Exhaust Volume Flow and Field Data Sheets	C-1
Appendix D - Inlet Volume Flow Data and Field Data Sheets	D-1
Appendix E - Quality Assurance / Quality Control Data	E-1
Appendix F- Calculations	F-1
Appendix G - Sample Location Diagram	G-1

1.0 INTRODUCTION

On October 11, 2006 SCEC conducted a source test on one landfill gas-fired flare at the Neal Road Landfill at Paradise, California. Testing was done as specified in the Source Test Plan that was submitted to Butte County Air Quality Management District (BCAQMD) on September 11, 2006.

The purpose of the source test program was to quantify emissions from the flare system for comparison with BCAQMD permit requirements and to assess the combustion efficiency of the flare. The source test described herein complies with the BCAQMD requirements as delineated in the Permit No. NRL-01-01.

2.0 BACKGROUND

2.1 Design and Operation

The flare has an 105.625" internal diameter and is 40' in height. It's design capacity is 1800 scfm. The flare is equipped with propane gas pilots and control systems to retain combusted landfill gas for 0.6 seconds at a temperature of 1,400 °F. A flame arrester is provided between the flare and the landfill gas supply piping. A safety control system shuts down the supply landfill gas valve and blower power in cases of flame-out or other alarm conditions. A filter is used for removing moisture and particulates from the landfill gas. One blower is used and induces a vacuum to pull landfill gas through piping from the landfill's gas extraction system and an identical blower is available for backup.

2.2 Permit to Operate

The application No. NRL-01-01 was issued by the BCAQMD. Among other parameters, the permit requires that criteria pollutants, nitrogen oxides (NO_x), carbon monoxide (CO), methane (CH₄), particulate matter (PM) and non-methane organic compounds (NMOC) be evaluated from the flare's exhaust. In addition, CH₄, NMOC, volume flow and heating value was evaluated from the flare inlet. NMOC destruction efficiency was also calculated.

3.0 TEST SUMMARY

3.1 Source Test Requirements

The original Source Test Plan submitted to BCAQMD was approved prior to testing. The plan proposed testing the flare to quantify criteria pollutant emissions and destruction efficiencies for non-methane hydrocarbons.

The Source Test Plan described specific measurement, sampling and analytical methods to be used during the testing. In addition, it specified the number of samples to be collected as well as their sampling locations (flare system inlet and flare exhaust).

3.0 TEST SUMMARY (continued)

3.2 Source Test Overview

SCEC conducted the compliance source tests of the flare system on October 11, 2006. The work was performed in accordance with the BCAQMD approved plan.

Prior to performing the source test, SCEC performed CARB Method 1 at both the flare inlet and exhaust to identify the optimum sampling traverse locations and number of sampling points per traverse. SCEC then obtained measurements of the average exhaust gas velocity, volumetric flow rate, temperature, dry molecular weight and moisture content using CARB Methods 2, 3 and 4, respectively. EPA Method 19 was used to determine exhaust flow rates.

NO_x, CO, O₂, and CO₂ data were collected on a data acquisition system (DAS) for all tests.

Exhaust samples from the flares were collected and analyzed to quantify emissions of NO_x, CO, O₂, CH₄ and NMOC. All exhaust samples were collected while traversing the stack to minimize gaseous stratification bias. Inlet and exhaust samples were tested for CH₄ and NMOC.

SCEC also evaluated the flare for NMOC destruction efficiency. SCEC collected landfill gas samples at the inlet of the flare station and flare exhaust samples and analyzed them for NMOC. Comparison of the inlet and exhaust sample results allowed the flare destruction efficiency to be calculated.

**TABLE 3-1
Test Program Overview
Compliance Program**

Parameter	Reference Method	Measurement Principle	Inlet	Outlet
Non-Methane Organic Compounds	EPA Method 18	GC/FID	-	3
	EPA Method 18		3	-
O ₂ , CO ₂ , CO, NO _x	EPA Method 3a,7e,10	Micro Fuel Cell, NDIR, Chemiluminescence	-	3
Flow Rate	CARB Method 2 EPA Method 19	Pitot Traverse Calculation	3	3 3
PM	CARB Method 5	Gravimetric	-	3
Moisture	CARB Method 4	Gravimetric	3	3

3.0 TEST SUMMARY (Continued)

3.3 Flare Performance

During the source tests the flare was operated with a landfill gas flow rates of 650 scfm. The flare combustion temperature controller was set at 1525°F and controlled by the bottom thermocouple.

3.4 Criteria Pollutant Results

The results of the criteria pollutant testing are shown in Table 5-1 and contained in Appendices A through D of this report. As indicated in Table 5-1 (Summary of Results), NO_x , CO and PM emissions were below the prescribed permit conditions.

3.5 NMOC Results

As shown in Table 5-1 emissions of NMOC were in compliance with all permit conditions. The NMOC emissions demonstrated compliance with the required destruction rate efficiency (>98%), and 20 ppm (as hexane) corrected to 3% O_2 .

4.0 CONCLUSIONS

Based on the results of this test program, the Neal Rd. Landfill flare system, is in compliance with all requirements of the permit. All exhaust emission rates (lb/hr and lbs/mmBTU) values were calculated using the EPA Method 19. All quality assurance requirements specified by the utilized test methods were met. The on-site NO_2 converter check, conducted on October 11, 2006 was found to be 97.9%.

5.0 Summary of Test Results

Table 5-1
SUMMARY OF TEST RESULTS
Butte County
Neal Road Flare
October 11, 2006

PARAMETER	INLET	EXHAUST	PERMIT LIMIT
O ₂ , %	0.64	15.35	
CO ₂ , %	36.30	5.10	
N ₂ , %	17.92	79.55	
H ₂ O, %	4.20	6.51	
Flow Rate, wscfm	678.1	12,122	
Flow Rate, dscfm	649.6	11,332	
Temperature, °F	99	1,131	
Btu/scf	450		
MMBtu/Hr	18.31		
NO _x :			
ppm		10.1	
ppm @ 3% O ₂		32.6	46
lb/hr (as NO ₂)		0.83	2.70
lb/day (as NO ₂)		20.0	
lb/MMBtu (as NO ₂)		0.046	0.06
lb/MMCF (as NO ₂)		21.41	
CO:			
ppm		31.8	
ppm @ 3% O ₂		102.8	
lb/hr		1.60	
lb/day		38.3	
lb/MMBtu		0.087	0.2
lb/MMCF		40.98	
Hydrocarbons:			
CH ₄ , ppm	444,000	28.27	
TGNMO, ppm (as CH ₄)	2,387	< 2.13	
TGNMO, lb/hr (as CH ₄)	3.9	0.06	
TGNMO, lb/MM Btu (as CH ₄)	-	0.003	
TGNMO, lb/day (as CH ₄)	94.4	1.48	
TGNMO, ppm (as hexane)		0.35	
TGNMO, ppm @ 3% O ₂ (as hexane)		1.13	<20ppm NSPS
TGNMO, lb/hr (as hexane)		0.06	
Destruction Eff. %		98.48	98
lb/MMCF		< 1.42	
Particulate (as PM ₁₀):			
gr/dscf		0.0028	0.076
lb/hr		0.264	0.924
lb/MM Btu		0.014	
lb/day		6.35	
lb/MMCF		6.78	

Notes:

The results in this table are the averages of all measurements.

5.0 SUMMARY OF RESULTS (Continued)

TABLE 5-2
GENERAL RESULTS
Butte County
Neal Road Flare
October 11, 2006

Parameter	INLET				EXHAUST			
	First Run	Second Run	Third Run	Average	First Run	Second Run	Third Run	Average
O ₂ , %	0.52	0.46	0.95	0.64	15.52	15.14	15.40	15.35
CO ₂ , %	36.3	36.8	35.8	36.3	4.85	5.22	5.23	5.10
N ₂ , %	18.0	17.4	18.4	17.9	79.6	79.6	79.4	79.5
H ₂ O, %	3.8	4.4	4.40	4.20	6.78	6.70	6.05	6.51
Flow Rate, wscfm	670	710	655	678	12,404	12,337	11,626	12,122
Flow Rate, dscfm	644	678	626	650	11,563	11,510	10,923	11,332
Temperature, °F	96.0	101.0	100.0	99.0	1,125	1,126	1,143	1,131
Btu/scf	449	455	446	450				
MMBtu/Hr	18.05	19.38	17.52	18.31				
NO _x :								
ppm								
ppm @ 3% O ₂					9.69	10.71	9.92	10.11
lb/hr (as NO ₂)					32.3	33.3	32.3	32.6
lb/MM Btu (as NO ₂)					0.82	0.90	0.79	0.83
					0.045	0.046	0.045	0.046
CO:								
ppm								
ppm @ 3% O ₂					30.6	31.4	33.5	31.8
lb/hr					101.9	97.5	109.1	102.8
lb/MM Btu					1.568	1.601	1.623	1.597
					0.087	0.083	0.093	0.087
Hydrocarbons:								
CH ₄ , ppm	443,000	449,000	440,000	444,000	23.7	27.9	33.2	28.3
TGNMO, ppm (as CH ₄)	2,387	2,469	2,306	2,387	2.13	3.75	0.5	2.13
TGNMO, lb/hr (as CH ₄)	3.90	4.24	3.66	3.93	0.06	0.11	0.01	0.06
TGNMO, ppm (as hexane)	397.8	411.5	384.3	397.9	0.36	0.63	0.08	0.35
TGNMO, ppm @ 3% O ₂ (as hexane)	349.4	360.4	344.8	351.5	1.18	1.94	0.27	1.13
TGNMO, lb/hr (as hexane)	3.49	3.80	3.27	3.52	0.06	0.10	0.01	0.06
Destruction Eff, %					98.40	97.42	99.62	98.48
Particulate:								
Total Particulate, gr/dscf					0.0026	0.0020	0.0037	0.0028
gr/dscf @ 3% O ₂					0.0085	0.0064	0.0121	0.0090
gr/dscf @ 12% CO ₂					0.0063	0.0047	0.0085	0.0065
lb/hr					0.241	0.203	0.35	0.264

The exhaust volume flow values are based on EPA Method 19 calculation.

6.0 SAMPLING AND ANALYTICAL PROCEDURES

CARB METHOD 1 - SAMPLING AND VELOCITY TRAVERSE FOR STATIONARY SOURCES

A preliminary source test site assessment was performed prior to the source test in order to determine applicable testing port locations and sample point traverse locations. The stack diameter, and the distance upstream and downstream from sample ports to disturbances, (i.e. bends, flanges, etc.,) were measured. This information was utilized to determine the minimum number of sampling points per traverse, and the distance from the inner stack wall to each sample point location.

CARB METHOD 2 - VELOCITY AND VOLUMETRIC FLOW RATE

The velocity of the gas stream was determined using an "S" type pitot tube, a magnehelic differential pressure gauge or inclined manometer, and type "K" thermocouple with a digital temperature measuring device. The calibrated pitot tube was connected to the calibrated magnehelic gauge or inclined manometer and leak checked at 80-100% of full scale. A temperature and delta P was obtained at each traverse point, and a duct static pressure was measured and recorded. The dry standard volumetric flow rate was determined from the gas velocity data, stack pressure, stack gas moisture content, stack gas molecular weight, and cross-sectional area of duct. The exhaust flow rates were calculated by EPA Method 19.

CALCULATIONS

$$MW_D = 0.44 (\%CO_2) + 0.32 (\%O_2) + 0.28 (\%N_2 + \%CO)$$

$$MW_W = MW_D (1 - BW_S) + (BW_S)$$

Where:

- MW_D = Dry Molecular Weight of Exhaust Gas, lb/lb mole
- MW_W = Wet Molecular Weight of Exhaust Gas, lb/lb mole
- BW_S = Exhaust Gas Moisture Content
- %CO₂ = Percent CO₂ by Volume (dry basis)
- %O₂ = Percent O₂ by Volume (dry basis)
- %N₂ = Percent N₂ by Volume (dry basis) Calculated by Differences
- %CO = Percent CO by Volume (dry basis)

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

CARB METHOD 3 - GAS ANALYSIS FOR DRY MOLECULAR WEIGHT AND EXCESS AIR SAMPLING AND ANALYTICAL PROCEDURES

An inlet gas samples were collected in Tedlar bags and analyzed by EPA Method 3C. The exhaust gas sample was analyzed for CO₂ and O₂ using EPA Method 3a.

CARB METHOD 4 - DETERMINATION OF MOISTURE CONTENT IN STACK GASES

Moisture content was determined using a sampling train consisting of a stainless steel probe, Teflon line, four impingers in an ice water bath, leak free pump, vacuum gauge, and temperature compensated dry gas meter. Prior to sampling a leak check of the sampling train was performed to insure system integrity. After the initial check, the initial meter reading, inlet meter temperature, and outlet meter temperature were recorded and the sample pump started. The sample rate was adjusted to approximately 1 cubic foot per minute and sampled for approximately 30 minutes or until a minimum of 20 corrected cubic feet of sample gas was obtained. Additionally, tare weights of the charged individual impingers were recorded using an electronic balance capable of weighing to the nearest 0.1 grams or less.

After sampling, the final meter readings and the final weights of each impinger were determined and recorded. Percent moisture content was calculated from the weight of water collected and the dry gas volume sampled.

CALCULATIONS

$$\text{Moisture (B}_w\text{)} = \frac{\text{Vwstd}}{\text{Vmstd} + \text{Vwstd}} \times 100$$

$$\text{Where: } \text{Vwstd} = \frac{0.0464 \text{ ft}^3}{\text{ml}} * \text{Vol H}_2\text{O Collected (ml)}$$

$$\text{Vmstd} = \text{Y Meter} * \frac{520^\circ\text{R}}{29.92 \text{ in Hg}} * \frac{\text{Vol Metered}}{\text{Temp. Meter}} * \text{Pres. Meter.}$$

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

CARB Method 5 - Particulate Emissions

A series of preliminary measurements were made prior to conducting the test. CARB Methods 1, 2, and 3 were performed to determine location and number of traverse points, average gas velocity, and gas molecular weight, respectively. Percent moisture content was estimated based on previous test data. The results of these measurements were used to determine the appropriate nozzle size for isokinetic sampling.

The apparatus was prepared on-site in our mobile emissions laboratory. The absorption train was charged with freshly prepared chemicals, weighed on a calibrated top loading digital balance to the nearest 0.1 grams, and assembled. The first two impingers contained 100 ml of deionized distilled water (DI H₂O), impinger three was empty, and impinger four contained approximately 400 grams of indicating silica gel. An ambient temperature filter was located between the third and fourth impinger. The probe was brushed out and rinsed with distilled water and acetone.

The sampling apparatus was sealed and transported to the sampling site where it was assembled and leak tested at 15 inches of mercury vacuum. The probe was positioned into the duct at the first traverse point with the nozzle out of the flow.

The nozzle was positioned into the gas flow and the vacuum pump was started immediately and adjusted to obtain an isokinetic sample rate. A complete traverse was performed while sampling for eight minutes per sample point. Upon completion of the traverse the vacuum pump was turned off and the probe was transferred into the next sample port where an identical traverse was performed. Duct conditions (temperature, delta-P) and sampling conditions (meter temperature, meter volume, meter pressure, impinger temperature, and absorption train vacuum) were monitored and recorded regularly for each sample point.

Upon completion of the sampling run, the apparatus was leak checked at a vacuum greater than the highest observed vacuum. Any leak was recorded and the apparatus was sealed and transported to the mobile laboratory. The filter-to-impinger Teflon line was rinsed with a known amount of distilled water into the first impinger.

Particulate Analysis

The filter and any loose particulate were carefully removed from the filter holder with tweezers. The filter was then placed into a labeled petri dish and transported to the SCEC laboratory. The nozzle and probe were rinsed and brushed three times with acetone. The sample fractions were combined, bottled, labeled, and fluid levels marked for transportation to SCEC laboratory for analysis. An aliquot of the DI H₂O was similarly treated for blank analysis.

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

CARB Method 5- Particulate Emissions (cont.)

The absorption train was inspected for abnormalities and disassembled. The impingers were weighed on a top loading digital balance for a percent moisture determination. The contents of impingers 1 and 2, and impinger 3 were quantitatively transferred into the probe/nozzle bottle, sealed, labeled, and fluid level marked for transportation to the SCEC laboratory for analysis.

The filter was transferred to an oven and heated at 105 degrees C for 2-3 hours and then placed in a desiccator for 24 hours. The filter was weighed on a Mettler digital balance to the nearest 0.1 mg or one percent of the total filtrate weight (weighed to a constant weight).

The contents of the nozzle, probe and impingers samples were evaporated, desiccated, and weighed to a constant weight.

The net weight of particulate was calculated from all the fractions. Concentrations (gr/dscf) and emissions (lb/hr) were calculated and reported based on the sampling data and the net weight of particulate.

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

EPA METHOD 3A, 7E, and 10

CONTINUOUS GASEOUS EMISSIONS SAMPLING

Ref: United States Environmental Protection Agency (USEPA) 40 CFR 60, Appendix A, Method 3A, 7E and 10, July 2005.

A continuous sample was extracted from the stack through a stainless steel probe, coarse filter, sample conditioner (condensate train) and then drawn via 3/8" Teflon line to the Mobile Emissions Laboratory (MEL). The sample was filtered again through a fine Balston filter and finally delivered to the analyzers through the sample manifold and dedicated flow meters.

Prior to beginning the compliance test, a system leak check and calibration check was performed. The leak check was accomplished by plugging the probe tip and drawing >25" Hg vacuum on the entire sampling system. When all flow meters indicated 0.000 scfh flow, the system was proven to be free of all leaks. A system calibration check (SCC) was performed by valving calibration gas to the probe tip and drawing sample. SCC did not exceed 5%.

After zeroing all analyzers, EPA Protocol I gases were used to calibrate each analyzer within 80-90% full scale of the selected range. Each analyzer, individually, was then spanned within 40-60% of the selected range by introducing blended gas from the on-board Horiba 5 point capillary gas divider.

All concentrations from the NO_x, CO, CO₂, and O₂ analyzers were recorded on a Johnson Yokogawa DR240 and a data acquisition system (DAS). The data was reduced via computer in SCEC's Laboratory.

EQUATIONS:

$$\text{CO ppm} = (\text{CO}\% \text{FS} - \text{Average CO Zero}) \times \frac{\text{CO Cal Gas Value}}{\text{Average CO Span} - \text{Average CO Zero}}$$

$$\text{ppm @ 3\% O}_2 = \text{ppm obsv.} \times 17.95 / (20.95 - \% \text{O}_2 \text{ obsv.})$$

$$\text{ppm @ 15\% O}_2 = \text{ppm obsv.} \times 5.95 / (20.95 - \% \text{O}_2 \text{ obsv.})$$

$$\text{lb/hr (NO}_x\text{/CO/NMHC)} = \text{ppm obsv.} \times 1.558 \times 10^{-7} \times \text{DSCFM calc.} \times \text{MW (@ 68}^\circ\text{F)}$$

$$\text{lb/MM Btu (NO}_x\text{/CO)} = \text{ppm obsv.} \times \text{MW} \times \text{F factor (DSCF/MM Btu)} \times 2.5853 \times 10^{-9} \times \frac{20.9}{(20.9 - \% \text{O}_2 \text{ obsv.})}$$

Molecular Weight (MW)

NO_x = 46

CO = 28

NMHC as CH₄ = 16

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

CONTINUOUS MONITORING LAB - TVIV

O₂ ANALYZER, PARAMAGNETIC

SERVOMEX SERIES 1400/1420B
Serial No.: 01420/B664

Response Time (0-90%)	< 15 seconds
Accuracy	Better than 0.1% O ₂ under constant conditions
Temperature	0.005% O ₂ , 0.04% of reading per degree C change
Output	4-20 mA (isolated), 0-IV (unisolated)
Ranges	0-5%, 10, 25, 50, and 100%

NO_x CHEMILUMINESCENT ANALYZER

THERMO ELECTRON MODEL 42H
S/N 42H-49814-284

Response Time (0-90%)	2.5 seconds in NO mode 5.0 seconds in NO _x mode
Noise	25 PPB
Zero Drift (24 hrs)	50 PPB
Detection Limit	50 PPB
Span Drift (24 hrs)	1% of full scale
Linearity	+/- 1% of full scale
Sample Flow Rate	25 cc/min.
Bypass Flow Rate	250 to 1100 cc/min.
Output	NO, NO ₂ , NO _x , 0-10V, Selectable Voltage 4-20 mA, RS-232
Ranges	0-10 ppm, 0-20 ppm, 0-100 ppm, 0-200 ppm, 0-500 ppm, 0-1000 ppm, 0-2000 ppm, 0-5000 ppm

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

CONTINUOUS MONITORING LAB - TVIV

CO GAS FILTER CORRELATION

Non-Dispersive Infrared

THERMO ELECTRON MODEL 48H

S/N 48H-35546-250

Response Time (0-95%)

10 seconds

Span Drift

+/- 1% full scale in 24 hours

Zero Drift

+/- 0.2 ppm in 24 hours

Linearity

+/- 1% full scale, all ranges

Accuracy

+/- 0.1 ppm

Output

0-10mV, 0-100mV, 0-1V, 0-5V, 0-10V

Range

1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2500, 5000, 10000, 20000, and 50000 ppm

CO₂ NON-DISPERSIVE INFRARED

HORIBA MODEL PIR 2000 S/N 107014

Span Drift

+/- 1% per 24 hours at full scale

Zero Drift

+/- 1% per 24 hours at full scale

Response Time

Selectable 0.5 - 1.2 seconds

Repeatability

+/- 0.5% of full scale

Output

0-10mV, 0-100mV, 0-1V, 0-5V

Range

20 ppm minimum to 100%

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

CONTINUOUS MONITORING LAB - TVIV

STRIP CHART RECORDER

YOKOGAWA MODEL DR240

Scan Cycle Time	1-60 seconds
Scanning Rate	60ms/Channel
Input Impedance	More than 10 M ohms for 2V or lower ranges, approximately 1 M ohms on 6V or higher ranges
Input Bias	Less than 10mA
Temperature Spread on Terminals	0.3% among input terminals
Temperature Coefficient	Zero drift 0.01% of range/°C Full span 0.01% of range/°C
Max. Allowable Input Voltage	60 VDC
Chart Speed	1-15,000 mm/hr
Recording Accuracy	+/- 0.1% of effective
Chart Speed Accuracy	+/- 0.1% for recordings greater than 1m

MOBILE EMISSIONS LABORATORY

Fully Insulated

Air Conditioned

On-Board Computer System

6.0 SAMPLING AND ANALYTICAL PROCEDURES (Continued)

Figure 6-1

