SCS ENGINEERS







Current MSW Industry Position and State of the Practice on Methane Destruction Efficiency in Flares, Turbines, and Engines

Presented to:

Solid Waste Industry for Climate Solutions (SWICS)

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July, 2007
File No. 01198086.09 Task 1

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1.0 BACKGROUND

The White Paper titled "Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills" submitted July 18, 2007 to the Solid Waste Industry for Climate Solutions (SWICS) proposed updated values for landfill gas (LFG) collection efficiency and methane oxidation, and argued the inclusion of carbon sequestration in landfill emission estimates to provide more accurate accounting of greenhouse gas (GHG) emissions in the state's GHG emission inventory. In support of that White Paper, SCS Engineers has prepared this report to detail the Municipal Solid Waste (MSW) Industry's view on methane destruction through combustion.

2.0 INTRODUCTION AND OBJECTIVES

Methane is a very important contributor to global warming, with a global warming potential 21 to 23 times that of carbon dioxide. Furthermore, methane has a short atmospheric lifetime of about 10 years, so changes in methane sources can affect atmospheric concentrations in a relatively short time scale. MSW landfills are recognized sources of methane through emissions of LFG. The primary means of methane reduction in landfills is collection and destructive combustion in flares, turbines, and engines.

2.1 STATE OF CRITICAL NEED

Current landfill New Source Performance Standards (NSPS) requirements call for an estimated 98% destruction efficiency from LFG control devises. The NSPS rule was created in 1996 as a means to create reduction in ozone precursor compounds in LFG. The rule regulated non-methane organic compound (NMOC) emissions from landfills, not methane; however, in most cases, methane is destroyed as a byproduct.

In developing its statewide inventory, the California Air Resources Board (CARB) chose 98% as default methane destruction value because it did not have access to actual source test data. Source test data is now readily available for many landfills with control devices.

Source tests from 26 LFG flares have been reviewed for this white paper. Based on calculations from these data, a total methane feed rate of 92840 metric tons/year has been calculated. By using the default destruction rate of 98%, the emission rate from these flares is estimated to be 1935 metric tons/year of methane; however, these source tests found the flares emission rate to be only 50 metric tons/year of methane. The default value overestimated the emissions by more than 3,900%. This overestimation clearly shows the need to update the default value.

2.2 OBJECTIVES

The current default methane destruction rate of 98% is not representative of current LFG control technology. It grossly overestimates the emissions from controlled LFG. This report seeks to determine a more representative value for the destruction rate of methane from these three types of LFG control systems.

3.0 GENERAL BACKGROUND

LFG is produced by the anaerobic decomposition of waste containing carbon from landfills. In 1994, the United States Environmental Protection Agency (USEPA) ruled that LFG emissions were collectable and therefore subject to regulation under the federal Clean Air Act. Per NSPS and other federal state and local regulations, most modern landfills collect LFG with a control system consisting of vertical wells, horizontal conduits, and a pumping system. Once the gas is collected by the control system, it is sent to a control device such as a flare, engine, or turbine. The control system is required for the destruction of NMOC emissions, but also serves to combust the methane into carbon dioxide.

The emissions data from LFG fueled control devices have become much more available since 1996 due to increased control technology and reporting requirements. When landfills become subject to NSPS, they are required to report stack gas emissions from control devices. The USEPA and other regulatory agencies have developed sampling methods to determine NMOC emissions from control devices, and many reports now include all the information necessary to determine methane destruction efficiency.

4.0 PROPOSED NEW VALUES FOR METHANE DESTRUCTION EFFICIENCY

Based on the data presented in this paper, it is recommended that new values for methane destruction be proposed in order to accurately determine the GHG emissions from LFG control systems. Below are the proposed values:

- 99.96% for flares
- 98.34% for engines
- 99.97 % for turbines

These values were calculated by taking the average values from the source tests that are summarized in Tables 1 through 3 (attached). These values should be used when site specific data are not available.

5.0 SUMMARY OF DATA

The proposed new values for methane destruction efficiency were determined by reviewing compliance reports for 26 flares, 17 engines, and 2 turbines and calculating the actual methane destruction efficiency. A summary of the source tests is included in Tables 1 through 3. The paragraphs below describe the ways methane destruction efficiency was obtained from the reports.

Some reports had already calculated the mass flow rates of methane in both the inlet fuel and the stack. With this data, the destruction efficiency could be determined with Equation 1 shown below.

Equation 1: $Eff = \left(1 - \frac{mout}{min}\right) * 100\%$

Where:
Eff = the efficiency
mout = the methane mass flow rate in the stack gas
min is the methane mass flow rate in the feed

In many cases, the methane flow rates had to be calculated from other available data in the source test reports. In many cases, the mass flow rate of methane in the fuel or stack gas had to be calculated using the volumetric concentration and the stream flow rate. In those cases, Equation 2 was used to find the mass flow in a stream so Equation 1 could be applied.

Equation 2: $ms = \frac{\frac{cs}{1{,}000{,}000} * Vs * \frac{1000L}{m^3} * \frac{16.04g}{mol} * \frac{60min}{hr}}{\frac{35.31ft^3}{m^3} * \frac{24.45L}{mol} * \frac{453.59g}{lb}} = cs * Vs * 2.458 * 10^{-6} \frac{lb}{hr}$

Where:
ms = the methane mass flow rate of stream s in lb/hr
cs = concentration of stream is in ppm by volume
Vs = the volumetric flow rate of stream s in dscfm

When the total hydrocarbon (THC) and NMOC flow rates were both available, the methane flow rate could be found with Equation 3 and Equation 1 could be used to find the destruction efficiency.

Equation 3: $ms = mTHCs - mNMOCs$

Where:
THC = the mass flow rate of THC in stream s
mNMOC = the mass flow rate of NMOC in stream s

In some cases, the methane concentration in the stack gas was below the laboratory detection limit. In these cases, the detection limit was used as the concentration of methane in the stack gas. This substitution underestimates the destruction efficiency of methane calculated, so the calculations are still conservative.

6.0 CONCLUSIONS

These new default values for the methane destruction efficiency of LFG control devices will accurately define the controlled methane emissions from MSW landfills. The default value of 98% efficiency was chosen to be conservative when little data were available. Current reporting programs have resulted in an abundance of information about flare, engine, and turbine destruction efficiencies. Methane destruction technology has also progressed to a point that has left the default value dated and methane emissions will continue to be grossly overestimated as long as default values are used.

The need is critical to update the current methane destruction value from 98% to at least 99.96% for flares, 98.34% for engines, and 99.97 for turbines. These values will provide policy makers with more accurate values when evaluating the effects of MSW landfills on GHG inventories.

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Table 1 - Flare Destruction Efficiencies

Landfill Name	Source Name	Test Date	Data from Reports									Notes
			Total Inlet Flow Rate (scfm)	Inlet Methane Concentration (volumetric fraction)	Inlet THC Flow (lbs/hr)	Inlet TNMHC Flow (lbs/hr)	Inlet Methane Flow Rate (lbs/hr)	Outlet Flow Rate (dscfm)	Outlet Methane Concentration (volumetric fraction)	Outlet Methane Flow Rate (lbs/hr)	Methane Destruction Efficency (%)	
Redwood Landfill		9/29/03					1553.86			0.3780	99.9757	1
City of Palo Alto Landfill		10/4/06					279.97			0.0270	99.9904	1
Redwood Landfill		7/8/04			1775.6	1.33	1774.27			0.1100	99.9938	1
Shoreline Amphitheatre		8/18/04					42.52			0.0020	99.9953	1
West Contra Costa Sanitary Landfill		12/5/05					86.63			0.0020	99.9977	1
Redwood Landfill		9/29/03					1553.86			0.3870	99.9751	1
West Contra Costa Sanitary Landfill		7/24/03			490	2.5	487.50			0.0100	99.9979	1
28th Street Landfill	Flare 1990	9/30/04	703	0.411			710.20	7523	5.53E-06	0.1023	99.9856	2
28th Street Landfill	Flare 1997	9/30/04	683	0.435333			730.84	8656	9.80E-07	0.0209	99.9971	2
Newby Island Landfill		3/30/98					1463			0.0320	99.9978	2
Yuba Sutter Landfill		5/18/00	301	0.454			335.90	1962	1.00E-06	0.0048	99.9986	1,2
28th Street Landfill	Flare 9313	8/21/00	713	0.403			706.28	8672	8.75E-06	0.1865	99.9736	2
28th Street Landfill	Flare 14749	8/22/00	753	0.411			760.71	11917	7.60E-06	0.2226	99.9707	2
Shoreline Amphitheatre		8/14/06					31.30			0.001	99.9968	2
Sacramento Landfill	Flare 1990	9/27/06	856.8	0.491667			1035.46	13459	3.46E-06	0.1145	99.9889	2
Sacramento Landfill	Flare 1997	9/27/06	869.9	0.475667			1017.08	12079	1.30E-05	0.3854	99.9621	2
Rio Rancho Landfill		1/5/07			466.77	102.65	364.12	4489	2.25E-05	0.248	99.9318	2
West Contra Costa Sanitary Landfill		11/15/06					97.31			0.023	99.9764	1
28th Street Landfill	Flare 1990	9/21/05	650.9	0.481667			770.62	9975	1.00E-06	0.025	99.9968	2
28th Street Landfill	Flare 1997	9/21/05	672.3	0.479333			792.10	9705	3.74E-06	0.089	99.9887	2
Pottstown Landfill	Flare 1	9/29/05	2360	0.4383			2542.53	30708	1.24E-04	9.360	99.6319	2
Pottstown Landfill	Flare 3	9/29/05	1700	0.4177			1745.40	14033	1.00E-06	0.034	99.9980	1,2
Redwood Landfill		9/29/03					1553.86			0.378	99.9757	1

Table 1 - Flare Destruction Efficiencies

Landfill Name	Source Name	Test Date	Data from Reports									Notes
			Total Inlet Flow Rate (scfm)	Inlet Methane Concentration (volumetric fraction)	Inlet THC Flow (lbs/hr)	Inlet TNMHC Flow (lbs/hr)	Inlet Methane Flow Rate (lbs/hr)	Outlet Flow Rate (dscfm)	Outlet Methane Concentration (volumetric fraction)	Outlet Methane Flow Rate (lbs/hr)	Methane Destruction Efficency (%)	
28th Street Landfill	Flare 14749	7/11/00	1242	0.506			1544.74	1272	6.09E-06	0.019	99.9988	2
Rio Rancho Landfill		1/29/07	299.7	0.5767			424.83	4489	2.72E-05	0.300	99.9294	
City of Palo Alto Landfill	Flare A-3	10/4/06					279.97			0.027	99.9904	1
										Average Efficency:	99.9613	

NOTES:

1 Methane outlet below detection limit

2 scfm assumed to be standard at 68F, 1 atm

Table 2 - Engine Destruction Efficiencies

Landfill Name	Source Name	Test Date	Data From Reports									Notes
			Total Inlet Flow Rate (scfm)	Inlet Methane Concentration (volumetric fraction)	Inlet Methane Flow Rate (lbs/hr)	Total Outlet Flow Rate (dcsfm)	Outlet Methane Concentration (volumetric fraction)	Outlet THC Flow Rate (lbs/hr)	Outlet TNMHC Flow (lbs/hr)	Outlet Methane Flow Rate (lbs/hr)	Methan Destruction Efficency (%)	
Altamont Landfill	Engine 1	7/23/03	529	0.51	721.96			10.5	0.39	10.110	98.60	2
Altamont Landfill	Engine 2	7/23/03	557.6	0.505	692.14			10.53	0.42	10.110	98.54	2
Bradley Landfill	Engine 1	4/16/03	586.2	0.3935	566.99	4102	9.78E-04			9.861	98.26	2
Bradley Landfill	Engine 2	4/16/03	587.4	0.466	672.82	4146	8.74E-04			8.907	98.68	2
Bradley Landfill	Engine 3	4/16/03	607.1	0.4565	681.21	4041	1.02E-03			10.171	98.51	2
Bradley Landfill	Engine 4	4/16/03	600.4	0.466	687.71	3962	9.97E-04			9.709	98.59	2
Bradley Landfill	Engine 5	9/15/03	601.49	0.459	678.61	4042	9.69E-04			9.627	98.58	2
El Sobrante Landfill	Engine 1	12/19/03	642.4	0.415471	656.04	4294	9.31E-04			9.821	98.50	2
El Sobrante Landfill	Engine 2	12/19/03	612.5	0.412337	620.78	4242	8.60E-04			8.967	98.56	2
Simi Valley	Engine 1	1/27/04	609.13	0.462	691.73	4465	1.55E-03			17.011	97.54	
Simi Valley	Engine 2	1/27/04	597.85	0.462	678.92	4303	1.49E-03			15.781	97.68	
Altamont Landfill	Engine 1	4/22/04	355.25	0.549	479.39			11.18	0.61	10.570	97.80	
Altamont Landfill	Engine 2	4/22/04	397.83	0.565	552.49			9.179	0.63	8.549	98.45	
Simi Valley	Engine 1	3/15/04	539.13	0.486	644.04	4300	1.22E-03			12.852	98.00	
ALZA M3 Facility		3/23/06	347	0.49	417.93	2770	6.55E-04			4.460	98.93	2
Simi Valley	Engine 1	3/15/04	539.13	0.6853	908.15	4300	1.22E-03			12.852	98.58	
Altamont Landfill	Engine 1	4/22/04	355.25	0.549	479.39	3017	1.41E-03			10.456	97.82	
Altamont Landfill	Engine 2	4/22/04	397.83	0.565	552.49	3386	1.02E-03			8.464	98.47	
										Average of Total:	98.34	

NOTES:

2 scfm assumed to be standard at 68F, 1 atm

Table 3 - Turbine Destruction Efficiencies

Landfill Name	Source Name	Test Date	Data from Reports:							Notes
			Total Inlet Flow (lbs/hr)	Inlet Methane Concentration (volumetric fraction)	Inlet Methane Flow Rate (lbs/hr)	Outlet Flow Rate (dscfm)	Outlet Methane Concentration (volumetric fraction)	Outlet Methane Flow Rate (lbs/hr)	Methan Destruction Efficency (%)	
Pottstown Landfill	Turbine 1	9/27/05	1523	0.4193	1569.7	40964	2.706E-06	0.272	99.98	2
Pottstown Landfill	Turbine 2	9/27/05	1549	0.417	1587.7	42045	4.197E-06	0.434	99.97	2
								Average of Total:	99.978	

NOTES:

2 scfm assumed to be standard at 68F, 1 atm