NSPS TIER III ALTERNATIVE TEST PROCEDURE

Richard W. Prosser
President
GC Environmental, Inc.
1230 North Jefferson Street, Suite J
Anaheim, California 92807
rprosser@gc-environmental.com

ABSTRACT

The New Source Performance Standards (NSPS) of the Clean Air Act (CAA) requires landfills to be tested to determine their potential to emit non-methane organic compounds (NMOCs). The procedures in the NSPS to perform these tests are complicated, costly and time consuming.

The NSPS allows alternative procedures to be used to determine the landfill gas (LFG) flow rate, a site specific k value for use in the LFG generation model, and LFG NMOC concentrations provided they are first approved by the Administrator as provided in § 60.752(b)(2)(i)(B) of the NSPS rule. Included in this paper are proposed alternative procedures for performing the tests necessary to quantify these values. The proposed methods can be used to replace either the Tier II test to quantify NMOCs in the LFG and/or the Tier III test to determine the site specific k value.

INTRODUCTION

The United States Environmental Protection Agency (EPA) requires landfill owners/operators to test for emissions of non-methane organic compounds (NMOCs). If the NMOC emissions exceed 50 Mg per year, the landfill owner/-operator is required to install a landfill gas collection system. To determine if a landfill emits more than 50 Mg of NMOCs per year, subpart WWW of the New Source Performance Standards (NSPS) defines a three tier process to estimate emissions. A summary of the process follows:

Tier I: In this test NMOCs are estimated by using equations defined in the NSPS rule using default generation modeling constants. The constants, Lo, k, and NMOCs are defined as the amount of methane gas that can be expected from a given mass of refuse, the rate refuse decomposes to make landfill gas (LFG), and the amount of NMOCs that are in the LFG respectively. The values of Lo, k, and NMOCs given in the rule are:

Lo	=	170 m^3/Mg
k	=	0.05 $year^{-1}$ for landfills located in regions with more than 25 inches of rain per year
k	=	0.02 $year^{-1}$ for landfills located in regions with less than 25 inches of rain per year
NMOCs	=	4000 ppm as hexane

Tier I calculations tend to overestimate the LFG emissions because of the high Lo and NMOC default values.

Tier II: In this test the concentration of NMOCs in the raw landfill gas is estimated by installing probes in the landfill, collecting gas samples and having them analyzed for NMOCs. Tier I calculations are repeated using the measured NMOC values determined by this procedure.

Tier III: In this test wells are installed in the landfill and operated to determine the actual rate of LFG generation. The Tier III test is performed per method 2E in the NSPS rule. The requirements of this method are summarized in Table 1. To get a better idea of the cost and effort required to perform a Tier III test, the work required for a hypothetical landfill is also shown on Table 1.

For this example the following assumptions are made:

- The depth of the landfill is 100 feet
- The landfill covers an area of 50 acres
- Refuse density is about 1200 lbs/cubic yard
- The refuse void fraction is 0.4

- Refuse fill rate has been constant for 20 years
- Rainfall for the landfill is about 9 inches per year (arid site)
- EPA NSPS modeling defaults for Lo and k are 170 cubic meters/Mg and 0.02 $year^{-1}$ respectively.
- Lo and k for this dry landfill are probably closer to 0.75 cubic feet/lb. and 0.02 $year^{-1}$

Calculations are made based on the above assumptions.

- The calculated landfill gas generation is about 400 scfm using the lower range Lo and 1200 using the NSPS Lo. Figure 1 shows the sample landfill methane generation curves.
- The landfill void volume is 87,120,000 cubic feet. This void volume is based on 40% void space in the refuse (per the NSPS rule).
- The time required to evacuate two void volumes at 400 cfm is about 150 days and at 1200 cfm about 50 days. The time required for a test area on the landfill should be the same because the LFG flow is proportional to the L.F. volume.

In this writer's opinion, the Tier III procedure is complicated, costly, and difficult to obtain accurate results. This procedure was used in the early 1980's when landfill tests were commonly performed to quantify LFG generation for energy recovery projects. These tests proved to be relatively inaccurate at predicting actual LFG generation rates and are rarely performed today except for NSPS compliance.

SUGGESTED NEW PROCEDURE

The new procedure is based on the fact that for a constant wind speed and atmospheric condition, the concentration of methane above a landfill's surface is proportional to the emission rate from the landfill. The procedure included herein has been developed using ISC modeling by SWANA members working on the alternative NSPS Compliance Committee. Field testing performed for Region 9 of the EPA has confirmed the viability of the proposed procedure. A summary of the proposed procedure is as follows:

- Divide the landfill into similar topographical areas each less than 5 acres. If hourly weather patterns are sufficiently variable so that a 5 acre parcel cannot be monitored during constant weather conditions, decrease the size of the areas to as small as 1 acre.
- Record wind speed and barometric pressure during all monitoring
- Walking at a constant speed of about 2.5 MPH, perform integrated surface sampling (ISS) 3 inches above the landfill surface. The walking pattern should provide complete coverage of the landfill (except for areas that are dangerous for the technician performing the monitoring). The distance between adjacent paths should be about 100 feet. Integrated surface sampling can be performed by collecting a Tedlar bag sample or using an integrating OVA as supplied by LandTec. A procedure for ISS is available from the South Coast Air Quality Management District Rule 1150.1.
- Perform a second monitoring event to confirm the first set of results. Monitoring should be performed when the barometric pressure is opposite the pressure during the first event. That is, if the monitoring was performed on a parcel in the morning when barometric pressure is typically increasing, perform the second monitoring event in the afternoon when the barometric pressure is typically decreasing.
- Using the wind speed information recorded during the collection of data for each ISS collected, calculate the methane emissions using the calculation procedures included herein.

CALCULATION PROCEDURES

The calculation procedures were developed using ISC dispersion modeling to calculate the dilution of LFG emitted from a landfill's surface. Modeling was performed based on a methane flux rate of 0.2 m3/m2/day over the entire landfill surface. The modeling provided the corresponding concentration of methane gas above the landfill surface. Modeling was also performed to determine the dilution effect caused by holding the sample wand of the monitoring instrument from 0.5 to 10 inches above the landfill's surface. Finally, consideration was given for the effect of the wind stability and the location of monitoring on the landfill. For these two variables, the proposed procedures used data calculated for stability class A wind conditions, and the average methane concentration across the landfill surface was used in the proposed procedure. These assumptions were made to simplify the calculations.

The equation that is used to calculate methane gas emissions is as follows:

Qi = Fi x FHti x Ai x Ci

- Qi = LFG flow for the test area
- Fi = The concentration flow factor This is a function of the surface emission concentration and the wind speed.
- Fi = ISS(ppm)/(1/(-0.000199+0.00572xWS (mph)))x(0.65617/1440) (Figure 2)
- FHti = Correction factor for the height of the sample wand above the landfill surface. The recommended height is 3 inches above the surface. This helps the technician avoid some of the vegetation on the landfill surface.
- FHti = 79.955/(-14.481xln(Hti)+85.827) (Figure 3)
- Ai = The surface area of the test (square feet). This area is different than the plan view area of the landfill because slopes will have a greater surface area than the corresponding plan view area.
- Ci = The methane gas to LFG conversion factor based on the methane concentration in the landfill gas. (Figure 4)
- ISS(ppm) = Surface concentration of methane from the ISS testing
- WS(mph) = Average wind speed during the ISS sampling. The graph and equations included herein are based on stability class A.
- Hti = Height of the sample wand above the landfill surface.

The site specific k value is calculated using the Tier I modeling procedures. Once the methane gas flow is known, modify the k value in the Tier I procedure until the flow rate measured and the flow rate calculated are equal. If the calculated k value is less than 0.0138 (this is equal to a 50 year half-life) it is recommended that the k value be defined as 0.0138 and Lo is modified until the methane gas flows are equal. This procedure is recommended because it makes little sense to have a half-life greater than 50 years. This rate of decomposition is so slow that the model indicates that the landfill will take several hundred years to decompose.

SAMPLE CALCULATION

To demonstrate the calculation procedure, calculations are performed for a test landfill. The landfill is divided into 10 segments. The concentration of methane from each segment is given in **Table 2**. The average wind speed is also given. The calculated LFG emission rate is 158 cfm.

If Tedlar bag samples were collected during the ISS, these could be analyzed for NMOCs by a laboratory. In this case the NMOC emission rate could be calculated directly by using the NMOC concentration instead of the LFG emission rate in **Table 2**. This procedure to directly calculate the NMOC emission rate is shown in **Table 3**.

ADVANTAGES AND DISADVANTAGES WITH THE PROCEDURE

There are a number of advantages and disadvantages with the above procedure. This section of the paper tries to define the more significant issues.

<u>Advantages</u>

- The LFG emissions are not dependent on knowing the waste mass in the landfill, the age of the waste or the waste composition. (This information is, however, needed to calculate the k value for the landfill).
- Leachate in the landfill or other barriers to LFG flow will not alter the results.
- The procedure can be performed quickly and at a fairly low cost.
- By not collecting LFG (as in a Tier III test) there is no condensate water disposal required.
- No special equipment is required to perform the test (i.e. blower and flare).
- Well or probe abandonment is not required following the test because they are not installed.
- The procedure cannot cause air infiltration into the landfill, hence, there is not additional risk of landfill fires.

Disadvantages

- The calculated LFG emission rate is not equal to the generation rate because aerobic attenuation in the landfill surface will decrease the emission rate. Additionally, subsurface LFG emissions are not measured. Subsurface emissions are not considered a significant issue because the methane and NMOCs that move horizontally in the soil will most likely be consumed by aerobic bacteria. The amount of subsurface gas that actually reaches the surface is considered small.
- Because of the difficulty of monitoring steep landfill slopes, these areas are omitted from the procedure. Slope emissions should be monitored to the extent possible by using an extended monitoring wand reaching up and down the slopes from the landfill benches and top deck as far as possible.
- Wind conditions need to be moderately constant.
- Two monitoring events may not provide adequate data to bracket the effect of barometric pressure on the gas emission rate.
- The extent of aerobic attenuation of methane and NMOCs in the landfill surface is not quantified.

CONCLUSION

The proposed procedure should provide a quick and easy low-cost alternative to the EPA Tier III test. This procedure will allow the methane gas emissions from a landfill to be calculated. The difficulty with this procedure is that it does not collect gas from the depths of the landfill but waits for it to come to the surface. Since the NSPS rule is geared towards surface emissions, this difficulty is not considered significant.

Table 1

METHOD 2E TEST PROCEDURES AND COSTS

Activity	Test Days Required	Cost	Reliability of Data Collected
Drill and Install 3 LFG Test Wells to ¾of the landfill depth	2	16,500.	LF Depth Typically Not Known Accurately
Drill and Install 27 deep pressure probes to ¼ the landfill depth	2	21,750.	LF Depth Typically Not Known Accurately
Drill and install 9 shallow pressure probes to 1/8 the landfill depth	1	3,375.	LF Depth Typically Not Known Accurately
Perform static well pressure and flow testing.	3	1,800.	Poor, due to variations in barometric pressure
Determine maximum vacuum that can be applied to a well	6	4,200.	Poor, because of slow LF response time and variations in barometric pressure
Determine the Radius of influence (ROI) of wells	0	575.	Poor, because of changes in barometric pressure, and the procedure only gives ROI to nearest 25 meters. ROI is variable in all directions.
Determine the depth of influence of the wells	0	290.	Procedure assumes a linear horizontal and vertical permeability. For landfills this is typical between 5 and 10 horizontal to vertical permeability
Calculate the void volume of waste influenced by the test wells	1	150.	The void volume of the waste is an empirical value and not well known
Perform long-term testing to evacuate 2 void volumes from a dry landfill	300	85,000.	Good data can be collected
Calculate k for the LFG generation model	0	300.	For arid landfills this is not reasonable because Lo is not changed to reflect the reduced methane yield
Apply the new k and calculate the new NMOCs emission rate	1	300.	The results of the NMOCs will be high because of the required procedures
Total	166	134,240	

TABLE 2

Average Methane Gas Concentration = 45%

Input Data					Calculations			
Area No.	Area Sq Ft (Ai)	PPM Methane	Wand ht (inches)	Avg Wind Speed	Concentration Flow Factor (cfm methane/sq foot) (Fi)	Wand Ht Factor Fhti	Methane Gas Flow CFM	LFG Flow CFM
1	200000	3	3	2.5	1.93E-05	1.144	4.41	9.80
2	200000	3	3	5	3.88E-05	1.144	8.88	19.73
3	200000	6	3	5	7.77E-05	1.144	17.76	39.47
4	190000	1	3	5	1.29E-05	1.144	2.81	6.25
5	100000	15	3	3	0.000116	1.144	13.26	29.46
6	125000	10	1.5	3	7.73E-05	1.000	9.66	21.47
7	200000	3	3	3	2.32E-05	1.144	5.30	11.78
8	200000	5	3	3	3.86E-05	1.144	8.84	19.64
9	200000	0	3	3	0	1.144	0.00	0.00
10	200000	0	3	3	0	1.144	0.00	0.00
Totals	**1815000**						**71**	**158**
Acres	41.7							

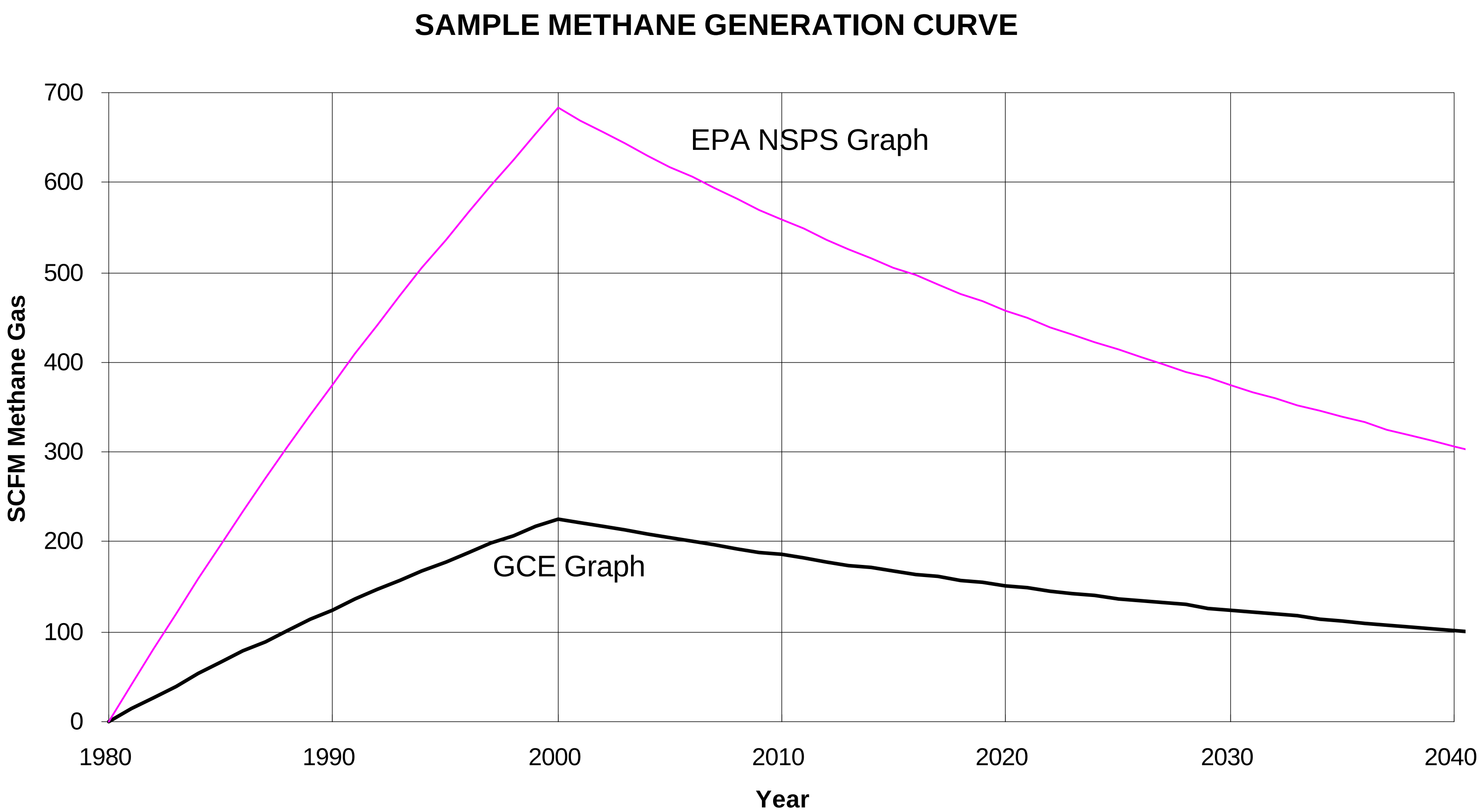
TABLE 3

Input Data					Calculations			
Area No.	Area Sq Ft (Ai)	PPM NMOCs as Hexane	Wand ht (inches)	Avg Wind Speed	Concentration Flow Factor (cfm NMOCs/sq foot) (Fi)	Wand Ht Factor (Fhti)	NMOCs Flow CFM	NMOC Emission Rate lbs/day (MW of 86)
1	200000	0.009	3	2.5	5.78E-08	1.144	0.01	4.32
2	200000	0.009	3	5	1.16E-07	1.144	0.03	8.69
3	200000	0.018	3	5	2.33E-07	1.144	0.05	17.39
4	190000	0.003	3	5	3.88E-08	1.144	0.01	2.75
5	100000	0.045	3	3	3.48E-07	1.144	0.04	12.98
6	125000	0.030	1.5	3	2.32E-07	1.000	0.03	9.46
7	200000	0.009	3	3	6.96E-08	1.144	0.02	5.19
8	200000	0.015	3	3	1.16E-07	1.144	0.03	8.65
9	200000	0.000	3	3	0	1.144	0.00	0.00
10	200000	0.000	3	3	0	1.144	0.00	0.00
Totals	**1815000**						**0**	**69**

Acres 41.7

NMOC Emission Rate (MG/Year) 11.5

Figure 1



SAMPLE METHANE GENERATION CURVE
700
600
500
400
300
200
100
0
SCFM Methane Gas
EPA NSPS Graph
GCE Graph
1980
1990
2000
2010
2020
2030
2040
Year

Figure 2

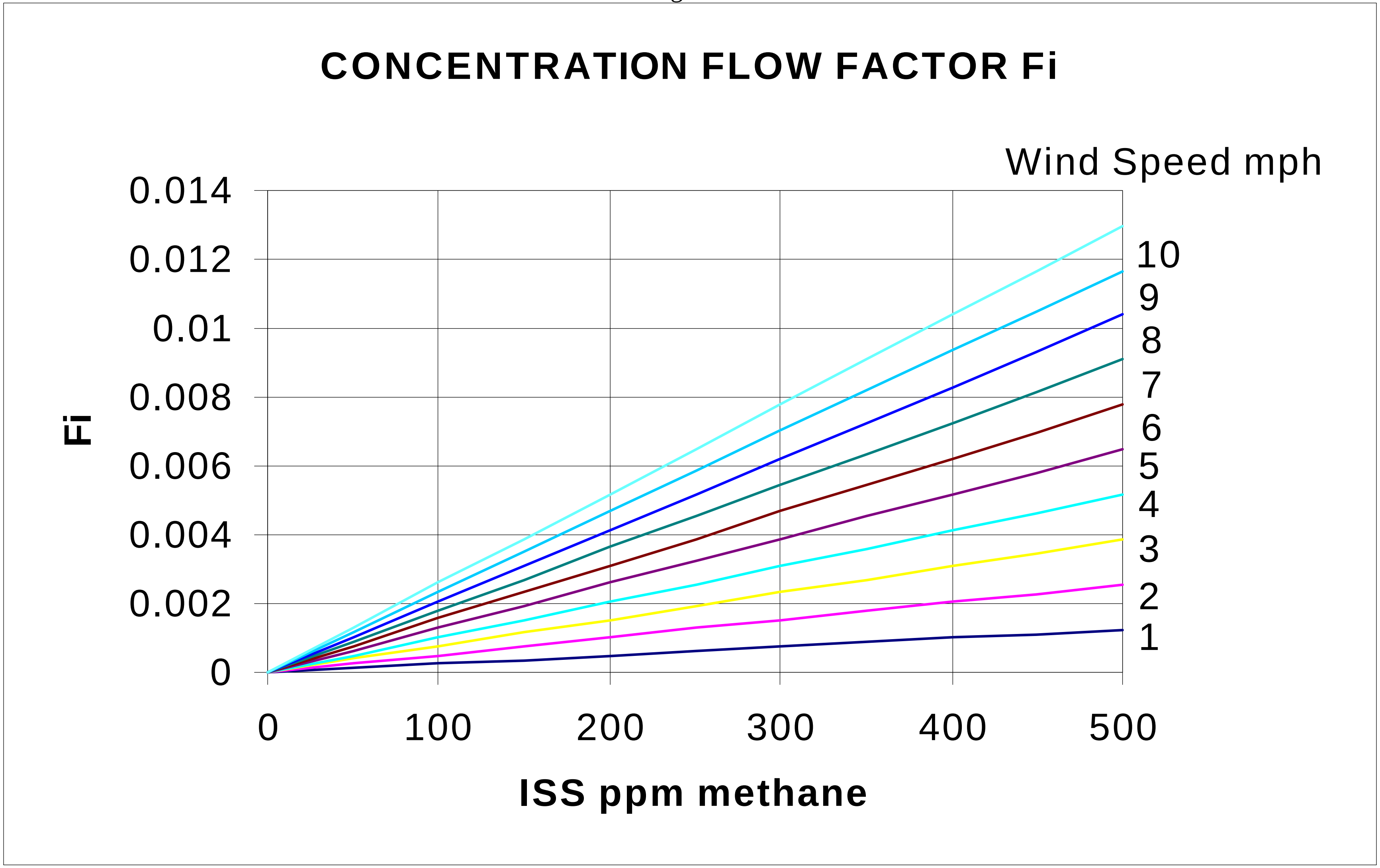

CONCENTRATION FLOW FACTOR Fi
Wind Speed mph
Fi
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
10
9
8
7
6
5
4
3
2
1
0
100
200
300
400
500
ISS ppm methane

Figure 3

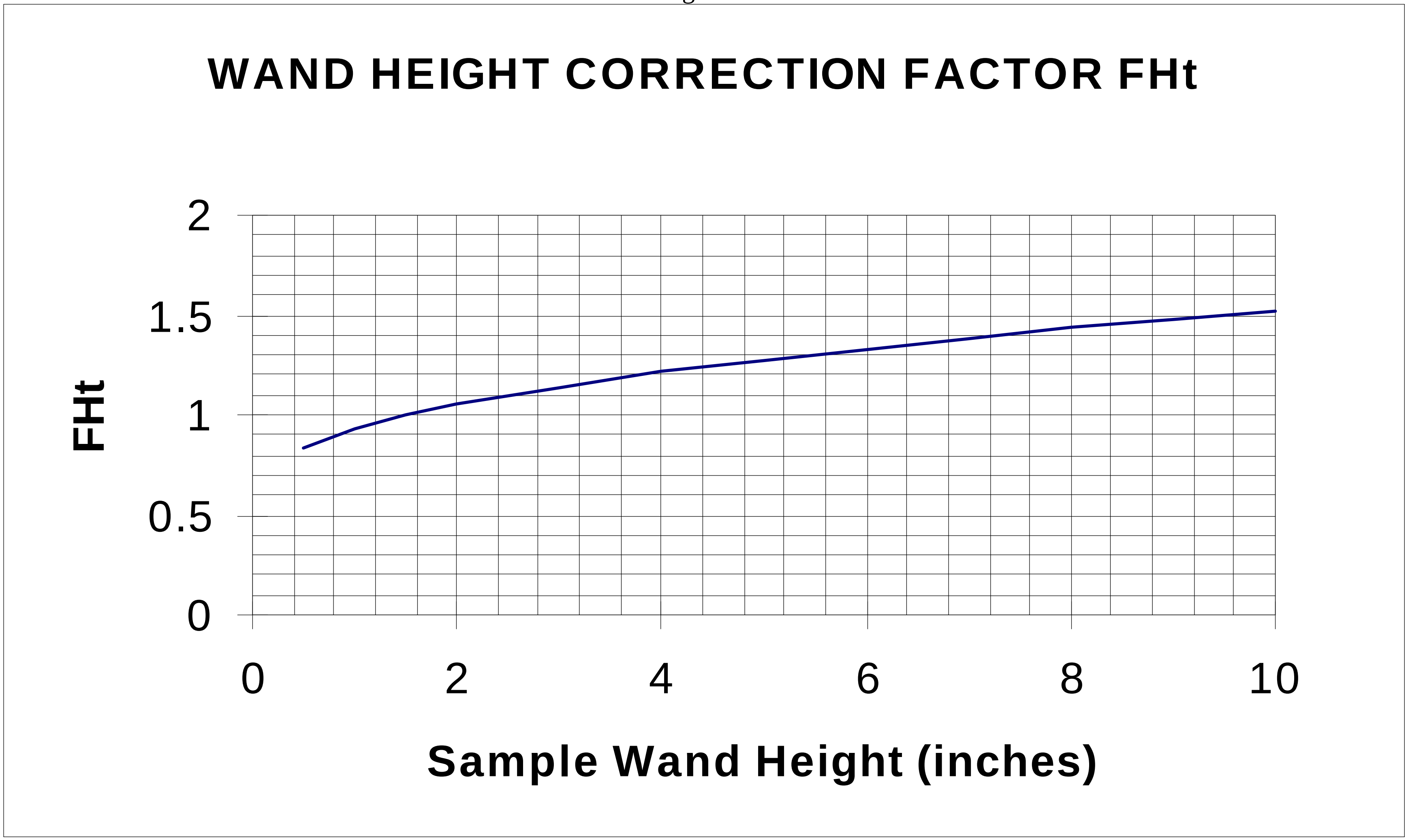
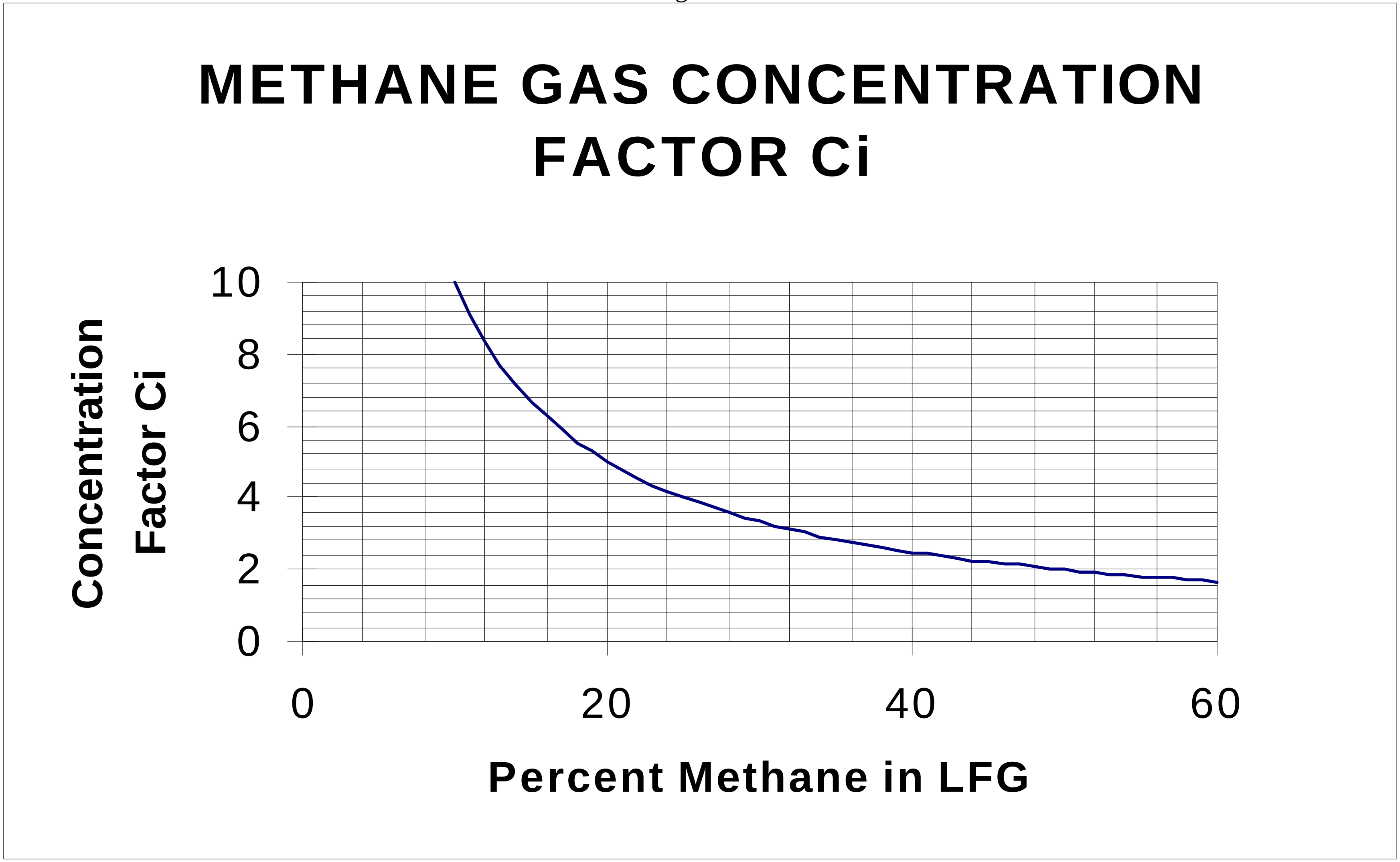

WAND HEIGHT CORRECTION FACTOR FHt
FHt
2
1.5
1
0.5
0
0
2
4
6
8
10
Sample Wand Height (inches)

Figure 4


METHANE GAS CONCENTRATION FACTOR Ci
Concentration Factor Ci
10
8
6
4
2
0
0
20
40
60
Percent Methane in LFG