

FORTISTAR METHANE GROUP

EMISSIONS COMPLIANCE REPORT

For

O₂, SO₂, NO_x, CO, VOC and HCl From
Stack Testing of
Landfill Gas Combustion EG Turbine #1 and #3

At:

Arbor Hills Energy, LLC
10611 West Five Mile Road
Northville, Michigan 48168

Prepared by:

M3V, LLC



11925 E. 65th Street
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Test Date: March 10-11, 2015

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EXECUTIVE SUMMARY

Arbor Hill Energy, LLC, (Arbor Hills) owns and operates the Arbor Hills Landfill Gas-to-Energy Facility using landfill gas in Northville, Michigan. The ARBOR HILLS facility operates under the terms and conditions of the Permit No. MI-ROP-N2688-2011 issued by the Michigan Department of Environmental Quality (MDEQ) on January 24, 2011. The permit requires ARBOR HILLS to perform O₂, SO₂, CO, VOC, HCl and NO_x testing of EGT landfill gas turbine #1 and EGT landfill gas turbine #3, utilizing methods as approved by the MDEQ to document compliance with the permit requirements.

The testing performed on March 10 and 11, 2015 demonstrates that the EGT #1 and #3 Landfill Gas Turbines are emitting HCl, VOC, CO, SO₂ and NO_x below the permit limits as reflected in the Tables 1.1 and 1.2 below.

ARBOR HILLS retained M3V, LLC (M3V) to complete the 2015 emission measurements program.

The measurement program was completed following the Compliance Test Protocol submitted to MDEQ at least 30 days in advance of the testing date. Mr. Nathan Hude and Glen Erickson representatives of Michigan Department of Environmental Quality were present on site during the test. The emission measurements were conducted following the EPA's Code of Federal Regulations, Title 40, Part 60 (40 CFR 60), Appendix A, Reference Methods (RMs), 3A, 4, 6C, 7E, 10, 19 and 26 from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods.

The following personnel were involved with the testing program:

M3V, LLC	Valerian Simianu, Ph.D., P.E.
M3V, LLC	Karl Mastalski
ARBOR HILLS	Carlos Wilson
MDEQ	Nathan Hude
MDEQ	Glen Erickson

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Table 1-1 presents a summary of results for the O₂, HCl, VOC, CO, SO₂ and NO_x test program for EGT#1 and Table 1-2 presents a summary of results for the O₂, HCl, VOC, CO, SO₂ and NO_x test program for EGT#3.

**Table 1-1 - Summary of Test Results – EGT Turbine #1
(Ductburner ON = run 1, 2 and 3 – Ductburner OFF = run 4, 5 and 6)**

	NO_x Lb/hr	CO lb/hr	SO₂ lb/hr	HCl lb/hr	VOC lb/hr
Run 1	1.888	1.20	1.615	0.0071	0.095
Run 2	1.884	1.23	1.464	0.0073	0.080
Run 3	1.874	1.19	1.569	0.0071	0.081
Average	1.882	1.21	1.549	0.0071	0.09
Permit Limit	8.8+1.6=10.4	13.1+2.2=15.3	2.9+0.3=3.2	1.9+0.8=2.7	2.4+0.9=3.3
Run 4	1.750	0.87	1.028	0.0056	0.000
Run 5	1.760	0.89	1.029	0.0056	0.006
Run 6	1.763	0.95	1.021	0.0059	0.003
Average	1.758	0.91	1.026	0.0057	0.003
Permit Limit	8.8	13.1	2.9	1.9	2.4

**Table 1-2 - Summary of Test Results – EGT Turbine #3
(Ductburner ON = run 1, 2 and 3 – Ductburner OFF = run 4, 5 and 6)**

	NO_x Lb/hr	CO lb/hr	SO₂ lb/hr	HCl lb/hr	VOC lb/hr
Run 1	1.824	0.96	1.303	0.0069	0.005
Run 2	1.810	0.89	1.334	0.0074	-0.003
Run 3	1.823	0.81	1.318	0.0070	-0.002
Average	1.819	0.89	1.319	0.0071	0.000
Permit Limit	8.8+1.6=10.4	13.1+2.2=15.3	2.9+0.3=3.2	1.9+0.8=2.7	2.4+0.9=3.3
Run 4	1.707	0.83	1.899	0.0058	-0.013
Run 5	1.705	0.78	1.009	0.0057	-0.006
Run 6	1.721	0.74	1.005	0.0057	-0.001
Average	1.711	0.78	1.304	0.0057	-0.006
Permit Limit	8.8	13.1	2.9	1.9	2.4

1.0 INTRODUCTION

ARBOR HILL owns and operates a landfill gas-to-energy facility located in Northville, Michigan. The ARBOR HILL facility operates under the terms and conditions of the Permit Number MI-ROP-N6288 - 2011 issued by the Michigan Department of Environmental Quality (MDEQ). The permit requires ARBOR HILL to demonstrate compliance with the VOC, HCl, CO, SO₂ and NO_x limitation requirements of the following table:

Equipment	Scenario	Pollutant	Permit limit lb/hr	Reference
EGT #1 or EGT #3	Duct Burner ON + Turbine	VOC	0.9+2.4=3.3	Permit section 3, page 95+90
		HCl	0.8+1.9=2.7	Permit section 3, page 95+90
		CO	2.2+13.1=15.3	Permit section 3, page 94+89
		SO ₂	0.3+2.9=3.2	Permit section 3, page 94+89
		NO _x	1.6+8.8=10.4	Permit section 3, page 94+89
	Duct Burner Off Only Turbine	VOC	2.4	Permit section 3, page 90
		HCl	1.9	Permit section 3, page 90
		CO	13.1	Permit section 3, page 89
		SO ₂	2.9	Permit section 3, page 89
		NO _x	8.8	Permit section 3, page 89

To demonstrate compliance, ARBOR HILL retained M3V to test the O₂, HCl, VOC, SO₂ and NO_x emissions. The testing performed on March 10 and 11, 2015 showed that ARBOR HILLS is in compliance with the permit requirements for all measured pollutants.

Dr. Valerian C. Simianu, M3V's Vice-President of Operations, was the designated Project Manager for this test program. Dr. Simianu can be contacted at 317-723-3839. Mr. Andrew Zalenski, Corporate Environmental Manager at Fortistar and Carlos Wilson of ARBOR HILLS assisted with the testing and production coordination. Testing was observed by Nathen Hude and Glen Erickson from the Air Quality Division of MDEQ.

The testing program followed the protocol submitted to MDEQ prior to the test. The following table provides a summary of the methodologies utilized for the testing program.

**Table 1.1 - Summary of Test Program - SOLAR TAURUS Gas Turbine
Arbor Hill Energys, Northville, Michigan**

Location	Scenario Runs	Pollutant	Method	Reference
EGT #1 or EGT #3 Exhaust Stack	Duct Burner On and the Turbine 3 runs (#1, #2 and #3)	VOC	25A	40 CFR 60, Appendix A
		HCl	26	
		CO	10	
		SO ₂	6C	
		NO _x	7E	
	Duct Burner Off Only Turbine 3 runs (#4, #5 and #6)	VOC	25A	
		HCl	26	
		CO	10	
		SO ₂	6C	
		NO _x	7E	

The measurement program was completed following the typical CO, HCl, VOC, SO₂, O₂ and NO_x methodology methods and with the applicable regulations set forth by the EPA's *Code of Federal Regulations, Title 40, Part 60 (40 CFR 60), Appendix A*, and the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods*.

Section 2.0 of this report presents a discussion of the results. The process operation information is summarized in Section 3.0. The analytical and sampling methods are discussed in Section 4.0. The test methodology is discussed in Section 5.0. A concise description of the quality assurance/quality control (QA/QC) procedures implemented is provided in Section 6.0. Appendix A of this document includes a summary of the emissions testing program with supporting data.

2.0 RESULTS

The HCl, VOC, CO, SO₂, O₂ and NO_x test program was conducted for the EUTURBINE1-S3 and EUTURBINE3-S3 EGT gas turbines. Field measurements were conducted to obtain representative stack pollutant emissions results. Results show that ARBOR HILLS is in compliance with the permit emission requirements.

The measurement procedures used to complete the test program are accepted EPA RM procedures and defined in 40 CFR 60, Appendix A.

2.1 PROCESS OPERATION

ARBOR HILLS owns and operates a landfill gas to power generating station located in Northville, Michigan facility. The landfill gas is being captured from the adjacent landfills and directed to the plant's engines or turbine-generators for power generation.

During the testing, the power generating process was run under normal conditions. The EGT #1 Gas Turbine was running in between 3600 to 3750 KW and EGT #3 at 3200 to 3376 KW.

2.2 MEASUREMENTS RESULTS

Table 2.1 provides a detailed summary of the emissions testing program with supporting data included in Appendix A through C.

**Table 2.1 – O₂, SO₂, CO, HCl, VOC and NO_x Emissions
Measurements Results - Arbor Hills, Michigan**

FGTurbines#1-S3 + Ductburner#1				
PARAMETERS	Run 1	Run 2	Run 3	Average
Date	3/10/2015	3/10/2015	3/10/2015	3/10/2015
O ₂ (% dry)	13.82	13.81	13.82	13.823
F Factor	9440	9467	9410	9439
Stack Flow (SCFM)	7118.35	7142.04	6989.96	7083.45
Gas Flow (SCFM)	1625	1608	1579	1604
SO ₂ ppm	22.78	20.58	22.54	21.97
NO _x ppm	37.05	36.84	37.46	37.12
HCl (mg/ft ³)	0.033	0.034	0.034	0.0337
VOC (mg/ft ³)	0.44	0.37	0.39	0.40
CO (ppm)	38.84	39.38	39.23	39.15
Power KW	3750	3716.7	3625	3697.22
SO ₂ (lb/hr)	1.615	1.464	1.569	1.549
NO _x (lb/hr)	1.888	1.884	1.874	1.882
HCl (lb/hr)	0.0071	0.0073	0.0071	0.0071
VOC (lb/hr)	0.095	0.080	0.081	0.085
CO (lb/hr)	1.20	1.23	1.19	1.21

**Table 2.2 – O₂, SO₂, CO, HCl, VOC and NO_x Emissions
Measurements Results - Arbor Hills, Michigan**

FGTurbines#1-S3 (Ductburner#1OFF)				
PARAMETERS	Run 4	Run 5	Run 6	Average
Date	3/10/2015	3/10/2015	3/10/2015	3/10/2015
O ₂ (% dry)	15.44	15.57	15.66	15.56
F Factor	9363	9383	9407	9384
Landfill gas Flow (SCFM)	1538.67	1537.00	1515.50	1530.39
Stack gas flow (SCFM)	6798.01	6830.53	6816.61	6815.05
SO ₂ ppm	15.18	15.13	15.04	15.12
NO _x ppm	35.96	36.00	36.13	36.03
HCl (mg/ft ³)	0.028	0.028	0.029	0.0287
VOC (mg/ft ³)	0.00	0.03	0.01	0.01
CO (ppm)	29.52	29.94	32.05	30.50
Power KW	3600	3590	3610	3600
SO ₂ (lb/hr)	1.028	1.029	1.021	1.026
NO _x (lb/hr)	1.750	1.760	1.763	1.758
HCl (lb/hr)	0.0056	0.0056	0.0059	0.0057
VOC (lb/hr)	0.000	0.006	0.003	0.003
CO (lb/hr)	0.87	0.89	0.95	0.91

**Table 2.3 – O₂, SO₂, CO, HCl, VOC and NO_x Emissions
Measurements Results - Arbor Hills, Michigan**

FGTurbines#3-S3 + Ductburner#3				
PARAMETERS	Run 1	Run 2	Run 3	Average
Date	3/11/2015	3/11/2015	3/11/2015	3/11/2015
O ₂ (% dry)	14.36	14.42	14.34	14.37
F Factor	9435	9411	9413	9419.66
Landfill Gas Flow (SCFM)	1614.33	1596.00	1566.00	1592.11
Stack gas flow (SCFM)	6982.24	6877.22	6745.23	6868.23
SO ₂ ppm	18.74	19.48	19.62	19.28
NO _x ppm	36.50	36.76	37.76	37.01
HCl (mg/ft ³)	0.033	0.035	0.034	0.034
VOC (mg/ft ³)	0.02	-0.01	-0.01	-0.001
CO (ppm)	31.48	29.64	27.66	29.59
Power KW	3373.33	3305.00	3235.00	3304.44
SO ₂ (lb/hr)	1.303	1.334	1.318	1.319
NO _x (lb/hr)	1.824	1.810	1.823	1.819
HCl (lb/hr)	0.0069	0.0074	0.0070	0.0071
VOC (lb/hr)	0.005	-0.003	-0.002	0.000
CO (lb/hr)	0.96	0.89	0.81	0.89

**Table 2.4 – O₂, SO₂, CO, HCl, VOC and NO_x Emissions
Measurements Results - Arbor Hills, Michigan**

FGTurbines#3-S3 (Ductburner#3 OFF)				
PARAMETERS	Run 4	Run 5	Run 6	Average
Date	3/11/2015	3/11/2015	3/11/2015	3/11/2015
O ₂ (% dry)	15.66	15.82	15.95	15.81
F Factor	9410	9398	9398	9402.26
Landfill Gas Flow (SCFM)	1550.50	1527.50	1518.00	1532.00
Stack Gas Flow (SCFM)	6686.08	6581.22	6533.18	6600.16
SO ₂ ppm	28.51	15.39	15.45	19.78
NO _x ppm	35.67	36.149	36.80	36.22
HCl (mg/ft ³)	0.028	0.028	0.028	0.028
VOC (mg/ft ³)	-0.06	-0.03	0.00	-0.03
CO (ppm)	28.51	27.16	26.11	27.26
Power KW	3210	3160	3140	3170
SO ₂ (lb/hr)	1.899	1.009	1.005	1.304
NO _x (lb/hr)	1.707	1.705	1.721	1.711
HCl (lb/hr)	0.058	0.057	0.057	0.057
VOC (lb/hr)	-0.013	-0.006	-0.001	-0.006
CO (lb/hr)	0.83	0.78	0.74	0.78

3.0 TEST METHODOLOGY

The testing program was performed according to the following accepted and approved EPA RMs as contained in the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods*, and the *40 CFR 60, Appendix A*. Any deviations from the standard RM procedures are detailed in this chapter. The general procedures followed to complete this measurement evaluation included:

RM 1	"Sample and Velocity Traverses for Stationary Sources",
RM 2	"Determination of Stack Gas Velocity and Volumetric Flow Rate (Type-S Pitot Tube)",
RM 3A	"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)",
RM 4	"Determination of Moisture Content in Stack Gases",
RM 6C	"Determination of Sulfur Dioxide Concentrations in Emissions",
RM 7E	"Determination of Nitrogen Oxides Emissions from Stationary Sources",
RM 10	"Determination of Carbon Monoxide",
RM 19	"Determination of Sulfur Dioxide, Nitrogen Oxides via F factor",
RM 26	"Determination of Hydrogen Chloride".

3.1 SUPPORT MEASUREMENTS FOR STACK PARAMETERS

RMs 1 through 4, 6C, 7E, 10, 19 and 26A were performed to provide support data for emission rate calculations. Ideally, measurements should be performed at least eight stack diameters downstream and two diameters upstream from any flow disturbance. RM 1, selection of sample points for velocity traverses, was conducted prior to the initiation of each set of measurements. Gas Volumetric Flow Rate was determined during each run from the stoichiometric gas usage following method 19.

3.1.1 Selection of Traverse Points

RM 1, "Sample and Velocity Traverses for Stationary Sources," was followed for the selection of measurement points at each stack test location. The number of traverse points were determined based on the test port location and was necessary to attain representative volumetric flow rate measurements.

This was performed by taking the cross-sectional area of the effluent stack at the measurement location and dividing it into equal areas. Traverse points were located at the center of each of the equal areas. No stratification of concentrations was observed in the stack and previous stack tests demonstrated no stratification.

3.1.2 Flow Rate Determination

The volumetric flow rate at each stack test location was measured using Gas Volumetric Flow Rate was determined during each run from the stoichiometric gas usage following method 19. The values were recorded during the test on field data forms and the volumetric flow rate was calculated. The values are attached in the Appendix A.

In addition to velocity pressures, gas temperatures were measured and recorded concurrently with all the differential pressure data. The temperature was measured with a Type-K thermocouple attached to a digital temperature indicator. Temperature readings were recorded from the display of the calibrated digital temperature indicator.

The average stack gas velocity was calculated using the effluent molecular weight, average measured velocity head (differential pressure), and average measured gas temperature via F factor as recommended by Method 19. The flow rate results are presented in terms of dscfm.

3.1.3 Determination of O₂ and CO₂ Concentrations

RM 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)", was conducted to determine the diluent O₂ and CO₂ concentration of the effluent. Oxygen and CO₂ concentrations (%) were determined by CEM using a Servomex Model 1400B Paramagnetic O₂ analyzer and Infrared (IR) CO₂ analyzer. The instrument range for both the O₂ and CO₂ instruments is 0 to 25 percent of the full-scale.

RM 3A analyzer calibration requirements include three point calibrations using EPA Protocol 1 gas standards and stringent instrument drift requirements. Calibrations were completed at 80-100 percent of the span value, 40-60 percent of the span value, and zero percent of the span value (ultra-pure nitrogen for both analyzers).

The O₂ and CO₂ analyzers were subjected to a zero and two up-scale calibration gases prior to and upon completion of each set of emission measurements. The gas standards were certified and traceable to EPA Protocol 1 specifications that require that the gas concentration be within ± 1 percent of the documented value. The response of the analyzers compared to each certified calibration standard must be within ± 2 percent of the analyzer span value for each component as required by the method.

To calibrate the instruments, the gas standards were introduced directly to the monitors at the sample inlet located on the back of each instrument. The amount of bias for O₂ and CO₂ CEMS was also determined. This was accomplished by introducing zero and one span gas to the CEMS at the point in which the sample probe and heated sample filter are connected. The response of the analyzers to the direct zero and span gases (bias check) must be less than ± 5 percent of the span value for each component as required by the method. The bias calibration check was performed prior to and upon completion of each sample run.

The magnitude of calibration drift was also calculated. Calibration drift is the difference in the initial (pre-test) bias calibration response and the final (post-test) bias calibration response for the same gas standard. The calibration drift was within ± 3 percent of the span over each sample run for each O₂ and CO₂ gas standard as required by the method.

3.1.4 Moisture Content Determination

The effluent moisture content at each oxidizer stack location was determined using RM 4, "Determination of Moisture Content in Stack Gases". The determination of moisture content was accomplished using a condenser and pump assembly connected between a sample probe and metering system.

Throughout each sample run, a known volume of gas (measured by a dry gas meter) was passed through the condenser assembly. Upon completion of each sample run, the total amount of condensate collected was gravimetrically measured and the net gain calculated. The total moisture gain, volume of gas extracted, and measured meter temperature data were used to calculate the actual moisture content of the effluent.

3.1.5 Determination of Sulfur Dioxide and Nitrogen Oxide Emissions

RMs 7E and 6C are both instrumental analysis methods used for the NO_x and SO₂ determination. Stack gas was withdrawn through a heated line and the emissions were analyzed on site using an analyzer with specific detectors. Details of the instrumentation are presented in Appendix B.

3.1.6 Determination of Total Hydrocarbon Emissions

For RM25A, Flue gas is drawn into a Flame Ionization Analyzer at a constant sampling rate. The sample is being brought to the analyzer via heated sampling line. The Instrument was calibrated in accordance with M25A form 40 CFR 60 Appendix A.