Derenzo and Associates, Inc.

Environmental Consultants

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EMISSIONS TEST REPORT

Title	Compliance Test Report for the FGICENGINE2 Landfill Gas Fueled Internal Combustion Engines at the Sumpter Energy Associates, Pine Tree Acres Landfill Facility
Report Date	January 3, 2014
Test Date(s)	December 3, 2013

Facility Information	
Name	Sumpter Energy Associates at Pine Tree Acres Landfill
Street Address	36450 29 Mile Road
City, County	Lenox Township, Macomb County
Phone	(586) 749-3581

Facility Permit Information	
State Registration No.: N8004	Permit No.: MI-ROP-N8004-2008a

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1307007

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COMPLIANCE TEST REPORT
FOR THE
FGICENGINE2 LANDFILL GAS FUELED INTERNAL
COMBUSTION ENGINES AT THE
SUMPTER ENERGY ASSOCIATES, PINE TREE ACRES
LANDFILL FACILITY

1.0 INTRODUCTION

Sumpter Energy Associates at the Pine Tree Acres Landfill (SEA-PTA), State Registration No. N8004 operates two (2) Caterpillar (CAT®) Model No. G3520C landfill gas-fueled internal combustion (IC) engines and electricity generator sets at the SEA-PTA facility located in Lenox Township, Macomb County.

Installation and operation of the IC engines (EUENGINE8 and EUENGINE9, flexible emission group FGICENGINE2) are permitted by Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Renewable Operating Permit (ROP) No. MI-ROP-N8004-2008a, modified to include FGICENGINE2 on October 1, 2012. Prior to October 1, 2012, FGICENGINE2 was operating under Permit to Install (PTI) No. 103-09.

Conditions of ROP No. MI-ROP-N8004-2008a and 40 CFR Part 60 Subpart JJJJ (NSPS for spark ignition internal combustion engines) requires that performance testing be performed on the CAT® G3520C engines every 8,760 hours of operation (as determined through the use of a non-resettable hour meter) or three years, whichever occurs first, to demonstrate compliance with the emission limits in 40 CFR 60.4233(e).

The compliance demonstration consisted of triplicate, one-hour test runs for the determination of nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC, as non-methane hydrocarbons) concentrations. Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content was determined for each test period to calculate volumetric exhaust gas flowrate and pollutant mass emission rates.

The compliance testing for FGICENGINE2 was performed on December 3, 2013, by Derenzo and Associates, Inc., an environmental consulting and testing company based in Livonia, Michigan. Michael Brack, Daniel Wilson, and Jason Logan of Derenzo and Associates performed the testing. Process operations were coordinated by Mr. Mark Balowski of Sumpter Energy Associates. Mr. Mark Dziadosz and Ms. Becky Loftus, of the MDEQ-AQD observed the testing.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Protocol dated September 30, 2013 and approved by the MDEQ-AQD by letter on November 15, 2013.

Appendix A presents the approval letter received from the MDEQ-AQD for the landfill gas fueled internal combustion engine compliance testing. Questions regarding this emission test report should be directed to:

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2.0 SUMMARY OF RESULTS

The exhaust gas for the LFG-fueled IC engines was monitored for at three (3) one-hour test periods during which the NOx, CO, VOC, O_2, and CO_2 concentrations were measured using instrumental analyzers. Exhaust gas flowrate was measured prior to and following each one-hour test period to calculate pollutant mass emission rates.

Testing was performed while the IC engines were operated at normal base load conditions (i.e., 1,600 kW peak electricity output +/- 10%).

The following table presents a summary of the test results and comparison of the results to the permitted pollutant emission rates.

Emission Unit	Average NOx Emission Rate (g/bhp-hr)	Average NOx Emission Rate (lb/hr)	Average CO Emission Rate (g/bhp-hr)	Average CO Emission Rate (lb/hr)	Average VOC Emission Rate (g/bhp-hr)
EUENGINE8	0.46	2.19	2.51	11.9	0.14
EUENGINE9	0.51	2.41	3.20	15.1	0.16
Limits	0.60	3.0	3.3	16.3	1.0

3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

3.1 General Process Description

Landfill gas (LFG) is produced in the Pine Tree Acres Landfill from the anaerobic decomposition of disposed waste materials. The LFG is collected from both active and capped landfill cells using a system of wells that are connected to a central header (gas collection system). The collected LFG is treated and then directed to the SEA-PTA facility where it is used as fuel for the IC engine generators that produce electricity for transfer to the local utility.

FGICENGINE2 consists of two (2) CAT® Model No.G3520C IC engines (EUENGINE8 and EUENGINE9) that are connected to individual electricity generators.
Figure 1 presents a process flow diagram for the LFG electricity generation facility.

3.2 Rated Capacities, Type and Quantity of Raw Materials Used

The EUENGINE8 and EUENGINE9 engine generator sets have a design mechanical output of 2,242 brake horsepower (bhp) and a design electricity generation rate of 1,600 kilowatts (kW).

Fuel (treated landfill gas) consumption is regulated to maintain the required heat input rate to support engine operations and is dependent on the fuel heat value (methane content) of the treated landfill gas. The average engine fuel consumption rate for each engine is typically between 540 and 630 standard cubic feet per minute (scfm) at full load.

Appendix B provides engine generator process data collected during the compliance test.

3.3 Emission Control System Description

The CAT® G3520 IC engine uses an electronic air-to-fuel ratio controller to fire lean fuel mixtures and produce low combustion by-product emissions. Emissions from the combustion of LFG are released into the ambient air through a stack connected to the IC engine exhaust manifold and noise muffler.

3.4 Sampling Locations (USEPA Method 1)

The exhaust stack sampling port for the Model G3520C IC engines tested satisfied the USEPA Method 1 criteria for a representative sample location. The inner diameter of the engine exhaust stack is 16 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 72 inches (4.5 duct diameters) downstream and 144 inches (9.0 duct diameters) upstream from any flow disturbance.

Velocity pressure traverse locations for the sampling points were determined in accordance with USEPA Method 1.

Figure 2 presents the performance test sampling and measurement locations.

4.0 <u>TEST RESULTS AND DISCUSSION</u>

4.1 Purpose and Objectives of the Tests

Compliance testing for FGICENGINE2 (EUENGINE8 and EUENGINE9) is required by No. MI-ROP-N8004-2008a and CFR Part 60 Subpart JJJJ every 8,760 hours of operation (as determined through the use of a non-resettable hour meter) or three years, whichever occurs first.

The exhaust from each LFG-fueled IC engine was monitored for three (3) one-hour test periods during which the NOx, CO, VOC, O_2, and CO_2 concentrations were measured using instrumental analyzers.

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Exhaust gas moisture content was determined by gravimetric analysis of the weight gain in chilled impingers in accordance with USEPA Method 4. Velocity and volumetric flow rates were measured during pre-test and post-test times for the gaseous samples.

Testing was performed while the IC engines were operated at normal base load conditions (i.e., 1,600 kW electricity output +/- 5%).

4.2 Variations from Normal Sampling Procedures or Operating Conditions

The compliance tests for all pollutants were performed in accordance with the Test Protocol dated September 30, 2013; the MDEQ Approval Letter dated November 15, 2013, and the specified USEPA test methods.

Instrument calibrations and sampling period results satisfied the quality assurance verifications required by USEPA Methods 3A, 7E, 10 and 25A/ALT 096. No variations from the normal operating conditions of the IC engines occurred during the testing program.

4.3 Operating Conditions during Compliance Tests

The LFG-fueled IC engines were operated at base conditions load (within +/-10% of maximum design capacity) during the compliance testing. The average electricity generator output and fuel use values were recorded by the facility during each test event. Based on data provided by the facility operators, EUICENGINE8 operated at an average electricity generation rate of 1,537 kW during the test periods and consumed an average of 545 scfm of treated LFG. EUICENGINE9 operated at an average electricity generation rate of 1,525 kW during the test periods and consumed an average of 543 scfm of treated LFG.

The engine generator sets have a design mechanical output of 2,242 bhp and a corresponding design electricity generation rate of 1,600 kW. The mechanical output of the engine (bhp) cannot be directly measured. Therefore, it is calculated based on the generator output using the following equation:
Engine Output (bhp) = $(kW_{avg}) / (0.957) / (0.7457\ kW/bhp)$

Where: kW_{avg} = average recorded kW generation rate
0.957 = engine to generator efficiency (95.7%)
0.7457 = unit conversion of kW to bhp

4.4 Air Pollutant Sampling Results

The IC engines performance tests were performed on December 3, 2013. The exhaust for each LFG-fueled IC engine (EUICENGINE8 and EUICENGINE9) was monitored for three (3) one-hour test periods during which the NO_x, CO, VOC, O_2, and CO_2 concentrations were measured using instrumental analyzers. The measured pollutant concentrations were corrected for sampling system calibration and bias pursuant to equations in specified in the USEPA reference test methods.

Exhaust gas moisture content was determined by gravimetric analysis of the weight gain in chilled impingers in accordance with USEPA Method 4. Velocity and volumetric flow rate were measured near the beginning and end of each sampling period. NOx, CO, and VOC mass emission rates were calculated from the pre-test and post-test flowrate averages for each 60-minute sampling period. All emission testing results were below permitted limits, demonstrating the compliance of EUICENGINE8 and EUICENGINE9 with ROP No. MI-ROP-N8004-2008a and 40 CFR Part 60 Subpart JJJJ.

Table 1 presents measured exhaust gas conditions and air pollutant emission rates for EUICENGINE8.

Table 2 presents measured exhaust gas conditions and air pollutant emission rates for EUICENGINE9.

Appendix C provides computer calculated and field data sheets for the IC engine tests.

Appendix D provides raw instrumental analyzer response data for each test period.

5.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the compliance testing was prepared by Derenzo and Associates and reviewed by the MDEQ (sampling procedures for all parameters were presented in the test plan). This section provides a summary of the sampling and analytical procedures that were used during the test.

Appendix E presents sample procedures and diagrams for the USEPA sampling methods.

5.1 Exhaust Gas Velocity and Flowrate Determination (USEPA Method 2)

IC engine exhaust stack gas velocity was determined using USEPA Method 2 prior to and following each 60-minute sampling period. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked to verify the integrity of the measurement system.

The absence of cyclonic flow was verified on a representative exhaust using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at all of the velocity traverse points with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

The calculated pre-test and post-test volumetric flowrate values were averaged and used for calculating the mass emission rate for each pollutant for that test period.

5.2 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the IC engine exhaust gas stream was measured continuously throughout each one-hour test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a non-dispersive infrared (NDIR) gas analyzer. The O_2 content of the exhaust was monitored using a gas analyzer that utilizes a Paramagnetic sensor.

During each one-hour sampling period, a continuous sample of the IC engine exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzer. Therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. The instrument was calibrated using appropriate calibration gases to determine accuracy and system bias (described in Section 6.4 of this document).

Figure 3 presents a diagram of the instrument analyzer train.

Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

5.3 Exhaust Gas Moisture Content Determinations (Method 4)

Moisture content of the IC engine exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train, which was performed concurrently with the instrumental analyzer sampling methodologies. A non-heated probe was used for the moisture determinations as the engine exhaust temperature exceeded 400 °F. During each sampling period, a gas sample was extracted at a predetermined rate from the source where moisture was removed from the sampled gas stream using impingers that were submersed in an ice bath. At the conclusion of each sampling period, the moisture gain in the impingers was determined gravimetrically by weighing each impinger to determine net weight gain.

Figure 4 presents a diagram of the moisture sampling train.

Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

5.4 NOx and CO Concentration Measurements (USEPA Methods 7E and 10)

NOx, and CO pollutant concentrations in the exhaust of the IC engine were determined using a chemiluminescence NOx analyzer and an NDIR CO analyzer.

Three (3) one-hour sampling periods were performed for the IC engine exhaust testing. Throughout each one-hour test period, a continuous sample of the engine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system described in Appendix E of this document, and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on a data logging system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages. Prior to, and at the conclusion of each test, the instruments were calibrated using appropriate upscale calibration and zero gas to determine analyzer calibration error and system bias. Sampling times were recorded on field data sheets.

5.5 VOC Concentration Measurements (USEPA Method ALT 096)

The exhaust gas VOC concentrations were measured using a Flame Ionization Analyzer (FIA) instrumental analyzer in accordance with USEPA Alt 096 for direct measurement of VOC (non-methane organic compounds) concentrations. The TEI Model 55i methane, non-methane hydrocarbon analyzer has been approved by the USEPA for the measurement of IC engine exhaust gas VOC concentration when demonstrating compliance with NSPS Subpart JJJJ.

Samples of the exhaust gas were delivered to the instrument analyzer using an extractive gas sampling system that prevents condensation or contamination of the sample. The exhaust gas samples were delivered directly to the instrument analyzer. Therefore VOC measurements correspond to standard conditions with no moisture correction (wet basis).

The specified instrument analyzer was calibrated using certified propane concentrations in hydrocarbon-free air.

Figure 3 presents a diagram of the instrument analyzer train.

Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

Appendix C presents the computer calculated and field data from the testing program.

6.0 INTERNAL QA/QC ACTIVITIES

6.1 NO_x Converter Efficiency Test

The NO_2 – NO conversion efficiency of the TEI Model 42C instrumental analyzer was verified prior to the commencement of the performance tests. The instrument analyzer NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. A USEPA Protocol 1 certified NO_2 calibration gas was used to verify the efficiency of the NO_2 – NO converter.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (the calculated NO_2 – NO conversion efficiency is greater than or equal to 90%).

6.2 Sampling System Response Time Determination

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

Sampling periods did not commence until the sampling probe had been in place for at least twice the system response time.

6.3 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NOx, CO, O_2 and CO_2 have had an interference response test performed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e. gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 3.0% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

6.4 Instrument Calibration and System Bias Checks

At the beginning of the test day, initial three-point instrument calibrations were performed by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were preformed prior to and at the conclusion of each sampling period by introducing the appropriate upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and verifying the instrument response against the initial instrument calibration readings. If the drift error is within 3% of the span over the period of the test run, the test run is considered acceptable.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NOx, CO, Propane, and zeroed using pure nitrogen or hydrocarbon free air.

6.5 Meter Box Calibrations

The dry gas meter sampling console used for moisture testing was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering consol calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

Appendix G presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas certifications, interference test results, meter box calibration records, and pitot tube calibration records).

Report Prepared By:

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Environmental Consultant

Report Reviewed By:

Michael J. Brack, QSTI
Field Services Manager

Table 1. Summary of Engine No. 8 (EUENGINE8) Test Results (CAT G3520C)
Sumpter Energy Associates - Pine Tree Acres

Test No.	1	2	3	
Test date	12/03/13	12/03/13	12/03/13	Test
Test period (24-hr clock)	9:15 -10:15	10:50-11:50	12:25-13:25	Avg.
Generator output (kW)	1,530	1,547	1,535	1,537
Engine Horsepower (Hp)	2,144	2,168	2,151	2,154
Exhaust gas composition				
CO_2 content (% vol)	11.6	11.7	11.7	11.7
O_2 content (% vol)	8.36	8.33	8.29	8.33
Moisture (% vol)	11.9	11.6	11.8	11.8
Exhaust gas flowrate				
Standard conditions (scfm)	5,134	5,130	5,161	5,142
Dry basis (dscfm)	4,530	4,529	4,552	4,537
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	66.6	67.1	68.5	67.4
NO_X emissions (lb/hr NO_2)	2.16	2.18	2.24	2.19
NO_X emissions (g/bhp-hr)	0.46	0.46	0.47	0.46
NO_X permit limit (g/bhp-hr)				*0.60*
Carbon monoxide emission rates				
CO conc. (ppmvd)*	595.9	601.3	605.9	601.0
CO emissions (lb/hr)	11.8	11.9	12.0	11.9
CO permit limit (lb/hr)				*16.3*
CO emissions (g/bhp-hr)	2.49	2.49	2.54	2.51
CO permit limit (g/bhp-hr)				*3.30*
VOC/NMHC emission rates				
VOC conc. (ppmv C_3)*	18.6	18.5	18.3	18.5
VOC emissions (lb/hr)	0.66	0.65	0.65	0.65
VOC emissions (g/bhp-hr)	0.14	0.14	0.14	0.14
VOC permit limit (g/bhp-hr)				*1.0*

* Corrected for calibration bias.

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Table 2. Summary of Engine No. 9 (EUENGINE9) Test Results (CAT G3520C)
Sumpter Energy Associates - Pine Tree Acres

Test No.	1	2	3	
Test date	12/03/13	12/03/13	12/03/13	Test
Test period (24-hr clock)	14:15-15:15	15:46-16:46	17:20-18:20	Avg.
Generator output (kW)	1,537	1,521	1,516	1,525
Engine Horsepower (Hp)	2,154	2,132	2,124	2,137
Exhaust gas composition				
CO_2 content (% vol)	11.7	11.7	11.7	11.7
O_2 content (% vol)	8.29	8.27	8.24	8.27
Moisture (% vol)	11.6	11.7	11.9	11.7
Exhaust gas flowrate				
Standard conditions (scfm)	5,348	5,376	5,343	5,356
Dry basis (dscfm)	4,726	4,740	4,706	4,724
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)*	70.5	70.5	72.1	71.0
NO_X emissions (lb/hr NO_2)	2.39	2.40	2.43	2.41
NO_X permit limit (lb/hr)				*3.00*
NO_X emissions (g/bhp-hr)	0.50	0.51	0.52	0.51
NO_X permit limit (g/bhp-hr)				*0.60*
Carbon monoxide emission rates				
CO conc. (ppmvd)*	726.5	730.6	734.1	730.4
CO emissions (lb/hr)	15.0	15.1	15.1	15.1
CO permit limit (lb/hr)				*16.3*
CO emissions (g/bhp-hr)	3.16	3.22	3.22	3.20
CO permit limit (g/bhp-hr)				*3.30*
VOC/NMHC emission rates				
VOC conc. (ppmv C_3)*	21.1	21.1	21.0	21.1
VOC emissions (lb/hr)	0.77	0.78	0.77	0.77
VOC emissions (g/bhp-hr)	0.16	0.17	0.16	0.16
VOC permit limit (g/bhp-hr)				*1.0*

* Corrected for calibration bias.

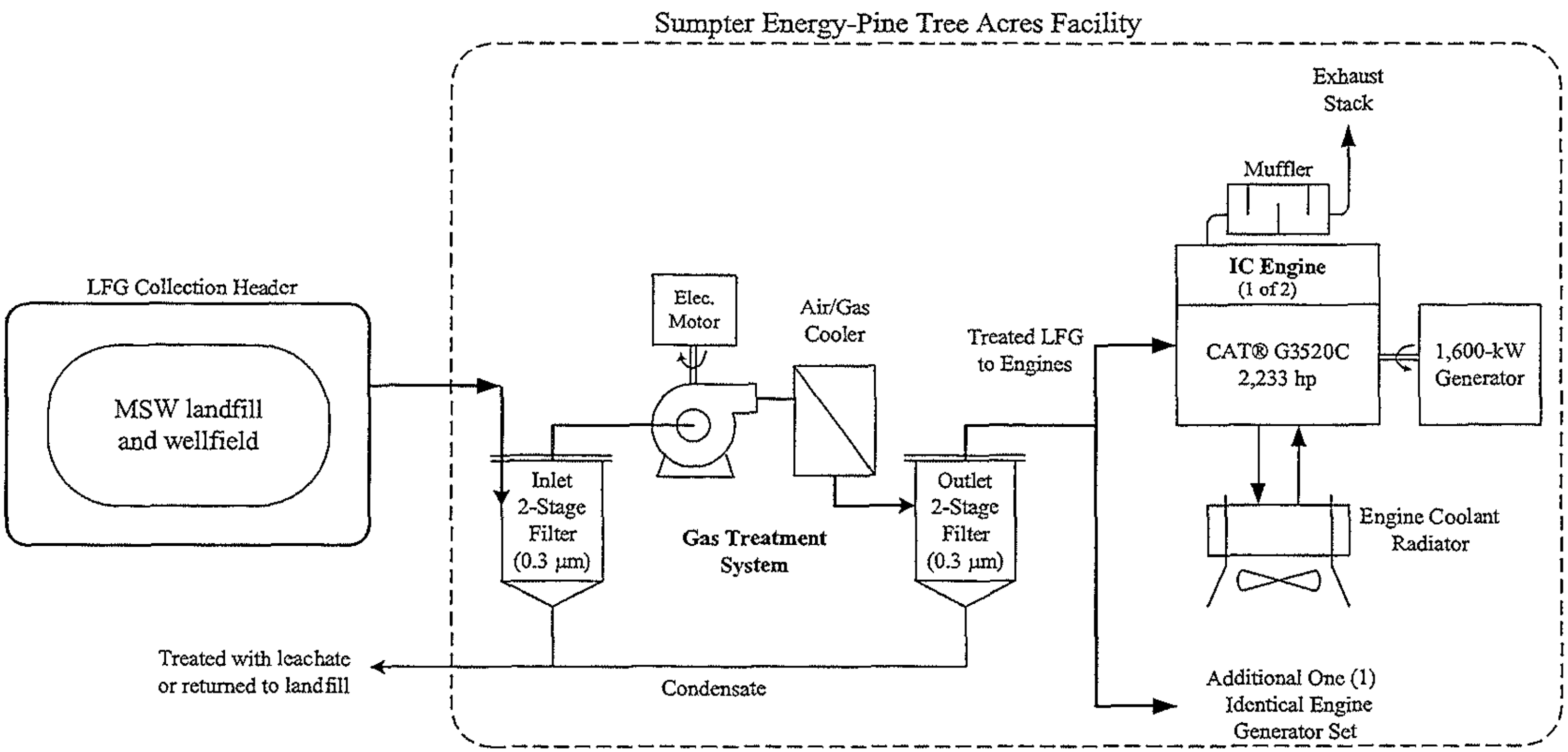
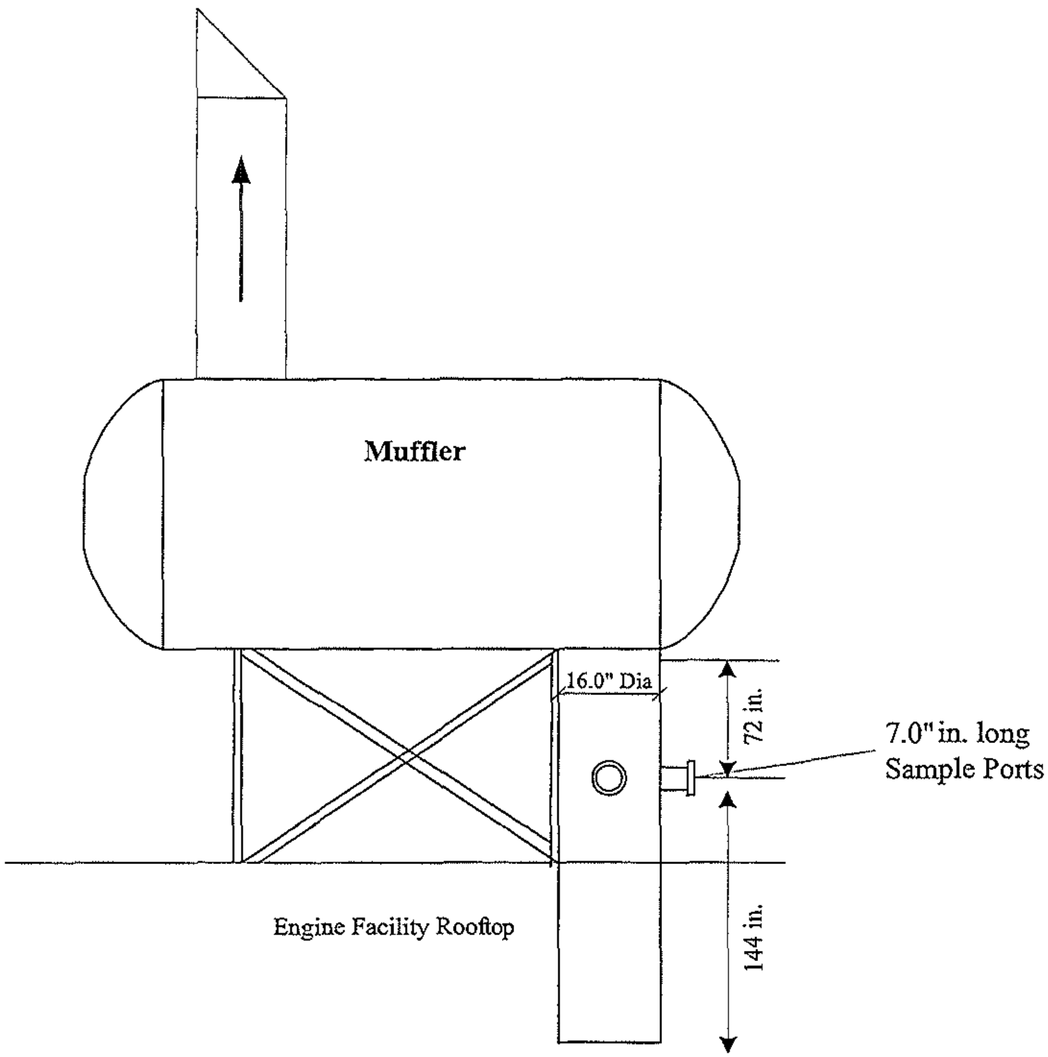


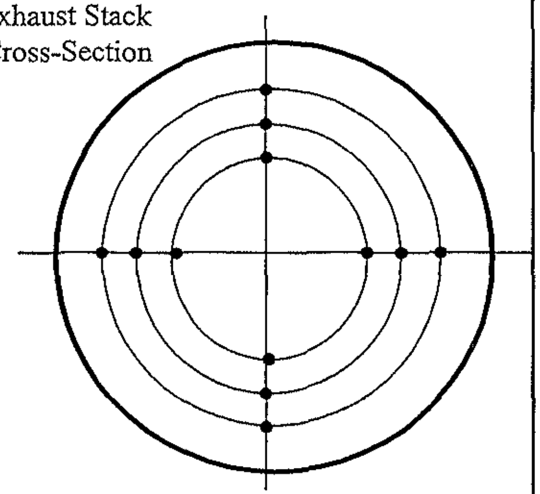
Figure 1.

Pine Tree Acres Facility **LFG Electricity Generation Facility**		
Scale None	Sheet 1 of 1	Derenzo and Associates Project No. 1307007

Engine Exhausts



Exhaust Stack
Cross-Section



Velocity sample locations as measured from sample port opening

Sample Port	
Pt. #	in.
1	7.70
2	9.34
3	11.74
4	18.26
5	20.66
6	22.30

Figure 2

Pine Tree Acres Facility
Exhaust Sample Locations

Scale	Sheet	Derenzo and Associates
None	1 of 1	Project No. 1307007