Derenzo Environmental Services
Consulting and Testing

EMISSIONS TEST REPORT

Title	NSPS Emission Test Report for Landfill Gas-to-Energy Reciprocating Internal Combustion Engine Generator Sets
Report Date	October 25, 2017
Test Date(s)	September 27, 2017

Facility Information	
Name	Waste Management of Michigan,Inc. Eagle Valley Recycle and Disposal Facility (RDF)
Street Address City, County	600 West Silver Bell Road Orion, Oakland
Phone	(800) 796-9696

Facility Permit Information	
State Registration No.: N3845	Permit No.: MI-ROP-N3845-2015

Emission Unit ID	Description	Serial #
EUICENGINE1	CAT® G3520C RICE	GZJ00471
EUICENGINE2	CAT® G3520C RICE	GZJ00470

Testing Contractor	
Company	Derenzo Environmental Services
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1704005

NSPS EMISSION TEST REPORT
FOR
LANDFILL GAS-TO- ENERGY RICE GENERATOR SETS
AT THE
WASTE MANAGEMENT
EAGLE VALLEY RECYCLE AND DISPOSAL FACILITY

1.0 INTRODUCTION

Waste Management of Michigan, Inc. (WMI) operates two (2) Caterpillar (CAT®) Model No. G3520C gas-fired reciprocating internal combustion engine (RICE) electricity generator sets at the Eagle Valley Recycling and Disposal Facility in Orion, Oakland County, Michigan. The treated landfill gas (LFG) fueled RICE generator sets (Serial Nos. GZJ00471 and GZJ00470) are identified as emission unit EUICENGINE1 and EUICENGINE2 (Flexible Group ID: FGICENGINES) in the Renewable Operating Permit (MI-ROP-N3845-2015) issued by the Michigan Department of Environmental Quality, Air Quality Division (MDEQ-AQD).

Pursuant to the current permit and requirements of 40 CFR §60.4243(b)(2)(ii) of the *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines* (SI RICE NSPS, 40 CFR Part 60 Subpart JJJJ), WMI is required to perform testing for specific regulated air pollutant emissions exhausted from the RICE-generator sets every 8760 operating hours or three years, whichever comes first.

Emission testing for EUICENGINE1 and EUICENGINE2 was previously performed September 27, 2016. This test report presents the results of emission testing conducted on September 27, 2017. The testing was performed by Derenzo Environmental Services (DES) representatives Jason Logan and Kevin Anderson. Mr. James Dunn of WMI provided process coordination and operating parameter data acquisition.

The compliance demonstration consisted of triplicate, one-hour, test periods for the determination of nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC, as non-methane hydrocarbons) mass emission rates. The exhaust gas sampling and analysis was performed using procedures specified in the Test Protocol dated July 24, 2017 and approved by the MDEQ-AQD on August 28, 2017.

Questions regarding this emission test report should be directed to:

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Report Certification

This test report was prepared by DES based on field sampling data collected by DES. Facility process data was collected and provided by Waste Management of Michigan employees or representatives.

I certify that the testing was conducted in accordance with the approved test plan unless otherwise specified in this report. I believe the information provided in this report and its attachments are true, accurate, and complete.

Report Prepared By:

Kevin Anderson
Environmental Consultant
Derenzo Environmental Services

Reviewed By:

Robert L. Harvey, P.E.
General Manager
Derenzo Environmental Services

2.0 SUMMARY OF RESULTS

The exhaust from two (2) LFG-fueled RICE-generator sets (identified as EUICENGINE1 and EUICENGINE2) were sampled on September 27, 2017 to determine the concentration of NOx, CO and VOC. Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content was measured for each test period to calculate pollutant mass emission rates.

The testing was performed while each RICE operated at normal base load conditions (i.e., 1,600 kW peak electricity output +/- 10%). Test results and applicable emission limits are provided in the following table. The test results demonstrate compliance with emission limits specified in the SI RICE NSPS and MI-ROP-N3845-2015.

Pollutant	Results for EUICENGINE1 (g/bhp-hr)	Results for EUICENGINE2 (g/bhp-hr)	Emission Limits (g/bhp-hr)
NOx	0.7	0.6	0.9 g/bhp (MI-ROP-N3845-2015) 2.0 g/bhp-hr (NSPS JJJJ)
CO	2.86	2.74	4.13 g/bhp (MI-ROP-N3845-2015) 5.0 g/bhp-hr (NSPS JJJJ)
VOC	0.13	0.11	1.0 g/bhp (MI-ROP-N3845-2015) 1.0 g/bhp-hr (NSPS JJJJ)

3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

3.1 General Process Description

Landfill gas (LFG) is produced in the Eagle Valley Landfill from the anaerobic decomposition of disposed waste materials. The LFG is collected from landfill cells using a system of wells that are connected to a central header (gas collection system). The collected LFG is treated and used as fuel for the two (2) CAT® Model No.G3520C RICE-generator sets that produce electricity for transfer to the local utility.

3.2 Rated Capacities, Type and Quantity of Raw Materials Used

Each CAT® G3520C RICE-genet consists of a spark ignition, lean-burn, RICE fueled by treated LFG and a connected electricity generator. The RICE has a rated mechanical output of 2,233 bhp and the connected generator produces 1,600 kW of electricity. Fuel consumption is regulated to maintain the required heat input rate to support engine operations and is dependent on the fuel heat value (methane content). Emission testing was performed while each unit operated within 10% of the design capacity electricity generation rate of 1,600 kW.

3.3 Emission Control System Description

The CAT® G3520C RICE do not have add-on emission control equipment. The electronic air-to-fuel ratio controllers automatically adjust the air-to-fuel ratio to maintain efficient fuel combustion, which minimizes air pollutant emissions. Exhaust gas is exhausted directly to the atmosphere through noise mufflers and vertical exhaust stacks.

3.4 Sampling Locations (USEPA Method 1)

The exhaust stack sampling port for the CAT® G3520C RICE satisfied the USEPA Method 1 criteria for a representative sample location. The inner diameter of each engine exhaust stack is 16 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 54 inches (3.4 duct diameters) downstream and 60 inches (3.8 duct diameters) upstream from any flow disturbance.

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

Figure 1 presents exhaust stack information and the performance test sampling locations.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the compliance testing was prepared by DES and reviewed by the MDEQ-AQD. This section provides a summary of the sampling and analytical procedures that were used during the test and presented in the test plan.

Attachment A provides a copy of the MDEQ-AQD test protocol approval letter.

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

RICE exhaust stack gas velocity and volumetric flow rate were determined using USEPA Method 2 during each 60-minute test period. An S-type Pitot tube connected to a red-oil manometer was used to determine gas velocity pressure. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. Exhaust gas velocity pressure and temperature were measured once during each one-hour sampling period. The Pitot tube and connective tubing were leak-checked to verify the integrity of the measurement system.

The absence of cyclonic flow for each sampling location was verified 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).

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

CO_2 and O_2 content in the RICE exhaust 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 RICE 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 content correspond to standard dry gas conditions. The instrument was calibrated using appropriate calibration gases to determine accuracy and system bias (described in Section 5.4 of this document).

Figure 2 presents the instrument analyzer sampling train.

4.3 Exhaust Gas Moisture Content Determinations (Method 4)

The moisture content of the RICE exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train, which was performed during each instrumental analyzer sampling period. 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 3 presents the moisture sampling train schematic.

4.4 NOx and CO Concentration Measurements (USEPA Method 7E and 10)

NOx and CO pollutant concentrations in the RICE exhaust gas were determined using a chemiluminescence NOx analyzer and NDIR CO analyzer. 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 Section 4.2 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.

4.5 VOC Concentration Measurements (USEPA Method 25A / ALT 096)

VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in the RICE exhaust gas. NMHC pollutant concentration was determined using a Thermo Environmental Instruments (TEI) Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains an internal gas chromatograph column that separates methane from non-methane components and has been approved by the USEPA for measuring VOC relative to 40 CFR Part 60 Subpart JJJJ compliance test demonstrations (Alternative Test Method 096 or ALT-096). The concentration of NMHC in the sampled gas stream, after separation from methane, is determined relative to a propane standard using a flame ionization detector in accordance with USEPA Method 25A.

Samples of the exhaust gas were delivered directly to the instrumental analyzer using the Teflon® heated sample line to prevent condensation. The sample to the NHMC analyzer was not conditioned to remove moisture. Therefore, VOC measurements correspond to standard conditions with no moisture correction (wet basis).

The instrumental analyzer was calibrated using certified propane concentrations in hydrocarbon-free air to demonstrate detector linearity and determine calibration drift and zero drift error.

5.0 <u>QA/QC ACTIVITIES</u>

5.1 NOx 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%).

5.2 Calibration Gas Divider Field Validation

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified (within the last 12 months) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivers calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

5.3 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.

5.4 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the NOx, CO, CO_2 and O_2 analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the 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 determining the instrument response against the initial instrument calibration readings.

At the beginning of each test day, appropriate high-range, mid-range, and low-range span gases followed by a zero gas were introduced to the NMHC analyzer, in series at a tee connection, which is installed between the sample probe and the particulate filter, through a poppet check valve. After each one hour test period, mid-range and zero gases were re-introduced in series at the tee connection in the sampling system to check against the method's performance specifications for calibration drift and zero drift error.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NOx, and CO in nitrogen and zeroed using hydrocarbon free nitrogen. The NMHC (VOC) instrument was calibrated with USEPA Protocol 1 certified concentrations of propane in air and zeroed using hydrocarbon-free air. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

5.5 Determination of Exhaust Gas Stratification

A stratification test for the RICE exhaust stack was performed during the performance test sampling periods. The stainless steel sample probe was positioned at sample points correlating to 16.7, 50.0 (centroid) and 83.3% of each stack diameter. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded data for each RICE exhaust stack gas indicate that the measured NOx concentration did not vary by more than 5% of the mean across either stack diameter. Therefore, the stack gas of the engine was considered to be unstratified and the compliance test sampling was performed at a single sampling location within the engine exhaust stack.

5.6 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 console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

The digital pyrometer in the metering console was calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Attachment E 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).

6.0 TEST RESULTS AND DISCUSSION

6.1 Purpose and Objectives of the Tests

MI-ROP-N3845-2015 and 40 CFR 60.4243(b)(2)(ii) of the SI RICE NSPS specify that owners and operators of new stationary spark-ignited RICE with a power rating greater than 500 horsepower must conduct an initial performance test and conduct subsequent performance testing every 8,760 hours of engine operation or 3 years, whichever comes first, thereafter to demonstrate compliance.

The recorded engine hours at the beginning of Test No. 1 for EUICENGINE1 and EUICENGINE2 were 52,277 and 52,163, respectively and are within 8,760 operating hours of those recorded during the previous test event on September 27, 2016.

6.2 Operating Conditions During the Compliance Test

Each LFG-fueled RICE was operated at base load conditions (100% rated capacity +/- 10%) during the compliance testing. Engine operating and process data identified in the test protocol approval letter were recorded at 15-minute intervals during each test period. Additional engine settings and operational data were recorded during each test period at the request of the MDEQ-AQD. The process operating data recorded by the facility operators are provided in Attachment B."

Engine output (bhp) cannot be measured directly. Therefore, it is calculated based on the recorded electricity output, the generator efficiency (95.7%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp). The following equation was used to calculate average engine horsepower for each test period based on a linear relationship between engine output and electricity generator output:

Engine output (bhp) = Electricity output (kW) / (0.957) / (0.7457 kW/hp)

Operating parameters are summarized in the following table.

	EUICENGINE1	EUICENGINE2
Average Electrical Rate (kW)	1,619	1,624
Average Engine Output (bhp)	2,259	2,266
Average LFG Flow (scfm)	550	564

6.3 Air Pollutant Sampling Results

The exhaust gas for each LFG-fueled RICE 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.

Exhaust gas moisture content was determined by gravimetric analysis of the weight gain in chilled impingers in accordance with USEPA Method 4. Exhaust gas velocity was measured during each one hour test period. The calculated exhaust gas volumetric flowrate (average of the pre-test and post-test measurements) was used to calculate NOx, CO and VOC mass emission rates.

Tables 6.1 and 6.2 present measured exhaust gas conditions and calculated air pollutant emission rates for LFG-fueled RICE, EUICENGINE1 and EUICENGINE2, respectively.

Attachment C provides computer calculated and field data sheets for the RICE tests.

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

6.4 Variations from Normal Sampling Procedures or Operating Conditions

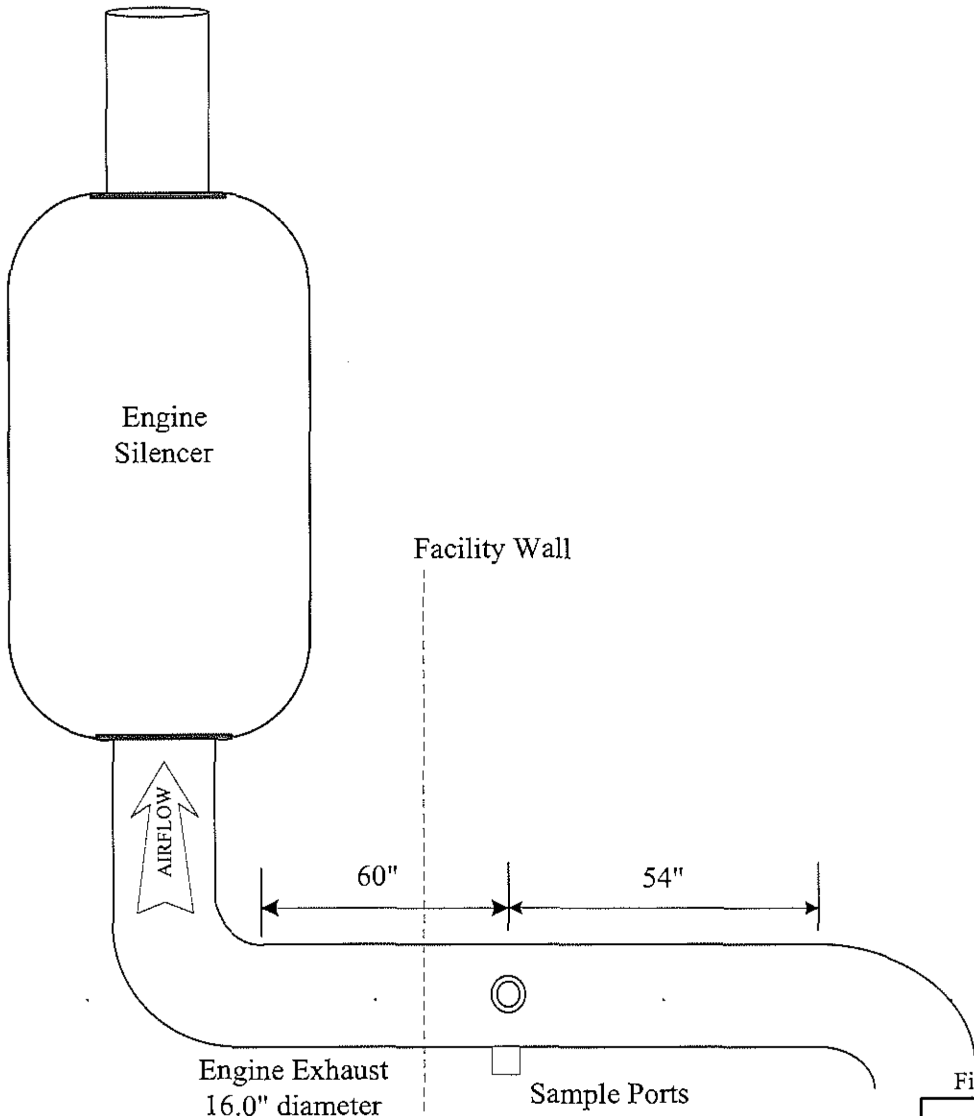
The LFG-fueled RICE were operated normally at the conditions specified in Attachment B and Tables 6.1 and 6.2. The compliance tests for all pollutants were performed in accordance with the approved Test Protocol and USEPA stationary source test methods.

Table 6.1 Measured operating data, exhaust gas conditions and air pollutant emission rates for EUICENGINE1
CAT® G3520C Serial No. GZJ00471

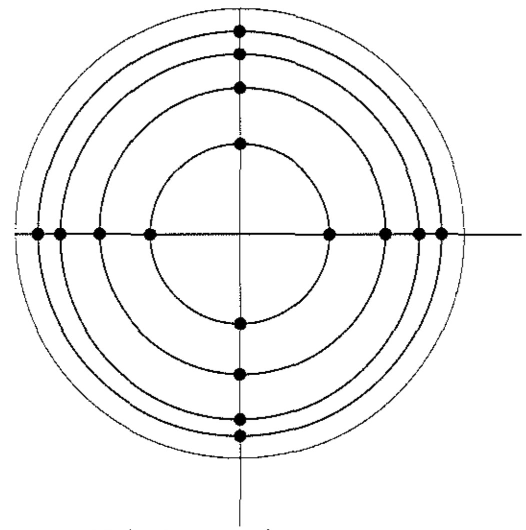
Test No. Test date Test period (24-hr clock)	1 09/27/17 12:25-13:25	2 09/27/17 13:50-14:50	3 09/27/17 15:10-16:10	Test Avg.
Generator output (kW)	1,619	1,617	1,622	1,619
Engine Horsepower (Hp)	2,259	2,257	2,263	2,259
Engine Fuel Use (scfm)	552	550	548	550
LFG Methane Content (% CH4)	52.1	52.2	52.1	52.1
LFG BTU Content (Btu/scf)	474	475	474	474
Exhaust gas composition				
CO_2 content (% vol)	12.0	11.9	11.9	11.9
O_2 content (% vol)	8.06	8.11	8.17	8.11
Moisture (% vol)	10.6	17.1	14.5	14.1
Exhaust gas flowrate				
Standard conditions (scfm)	5,756	5,797	5,727	5,760
Dry basis (dscfm)	5,145	4,803	4,896	4,948
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)	92.0	94.2	93.7	93.3
NO_X emissions (lb/hr NO_2)	3.40	3.24	3.29	3.31
NO_X emissions (g/bhp-hr)	0.68	0.65	0.66	0.66
NO_X permit limit (g/bhp-hr)				*0.90*
Carbon monoxide emission rates				
CO conc. (ppmvd)	663	656	657	659
CO emissions (lb/hr)	14.9	13.8	14.0	14.2
CO emissions (g/bhp-hr)	2.99	2.76	2.81	2.86
CO permit limit (g/bhp-hr)				*4.13*
VOC/NMHC emission rates				
VOC conc. (ppmv C_3)	16.5	16.7	16.8	16.7
VOC emissions (lb/hr)	0.65	0.67	0.66	0.66
VOC emissions (g/bhp-hr)	0.13	0.13	0.13	0.13
VOC permit limit (g/bhp-hr)				*1.0*

Table 6.2 Measured operating data, exhaust gas conditions and air pollutant emission rates for EUICENGINE2
CAT® G3520C Serial No. GZJ00470

Test No.	1	2	3	
Test date	09/27/17	09/27/17	09/27/17	Test
Test period (24-hr clock)	8:00-9:00	9:23-10:23	10:45-11:45	Avg.
Generator output (kW)	1,624	1,626	1,622	1,624
Engine Horsepower (Hp)	2,266	2,269	2,264	2,266
Engine Fuel Use (scfm)	564	563	564	564
LFG Methane Content (% CH4)	51.7	51.7	51.4	51.6
LFG BTU Content (Btu/scf)	470	470	468	470
Exhaust gas composition				
CO_2 content (% vol)	12.2	12.1	12.1	12.2
O_2 content (% vol)	7.73	7.79	7.82	7.78
Moisture (% vol)	12.8	15.5	14.1	14.1
Exhaust gas flowrate				
Standard conditions (scfm)	5,471	5,577	5,681	5,576
Dry basis (dscfm)	4,770	4,714	4,882	4,789
Nitrogen oxides emission rates				
NO_X conc. (ppmvd)	92.8	91.7	92.3	92.25
NO_X emissions (lb/hr NO_2)	3.17	3.10	3.23	3.17
NO_X emissions (g/bhp-hr)	0.63	0.62	0.65	0.63
NO_X permit limit (g/bhp-hr)				*0.90*
Carbon monoxide emission rates				
CO conc. (ppmvd)	656	657	654	656
CO emissions (lb/hr)	13.7	13.5	13.9	13.7
CO emissions (g/bhp-hr)	2.74	2.70	2.79	2.74
CO permit limit (g/bhp-hr)				*4.13*
VOC/NMHC emission rates				
VOC conc. (ppmv C_3)	14.5	14.5	14.3	14.4
VOC emissions (lb/hr)	0.54	0.55	0.56	0.55
VOC emissions (g/bhp-hr)	0.11	0.11	0.11	0.11
VOC permit limit (g/bhp-hr)				*1.0*



Stack Cross Section

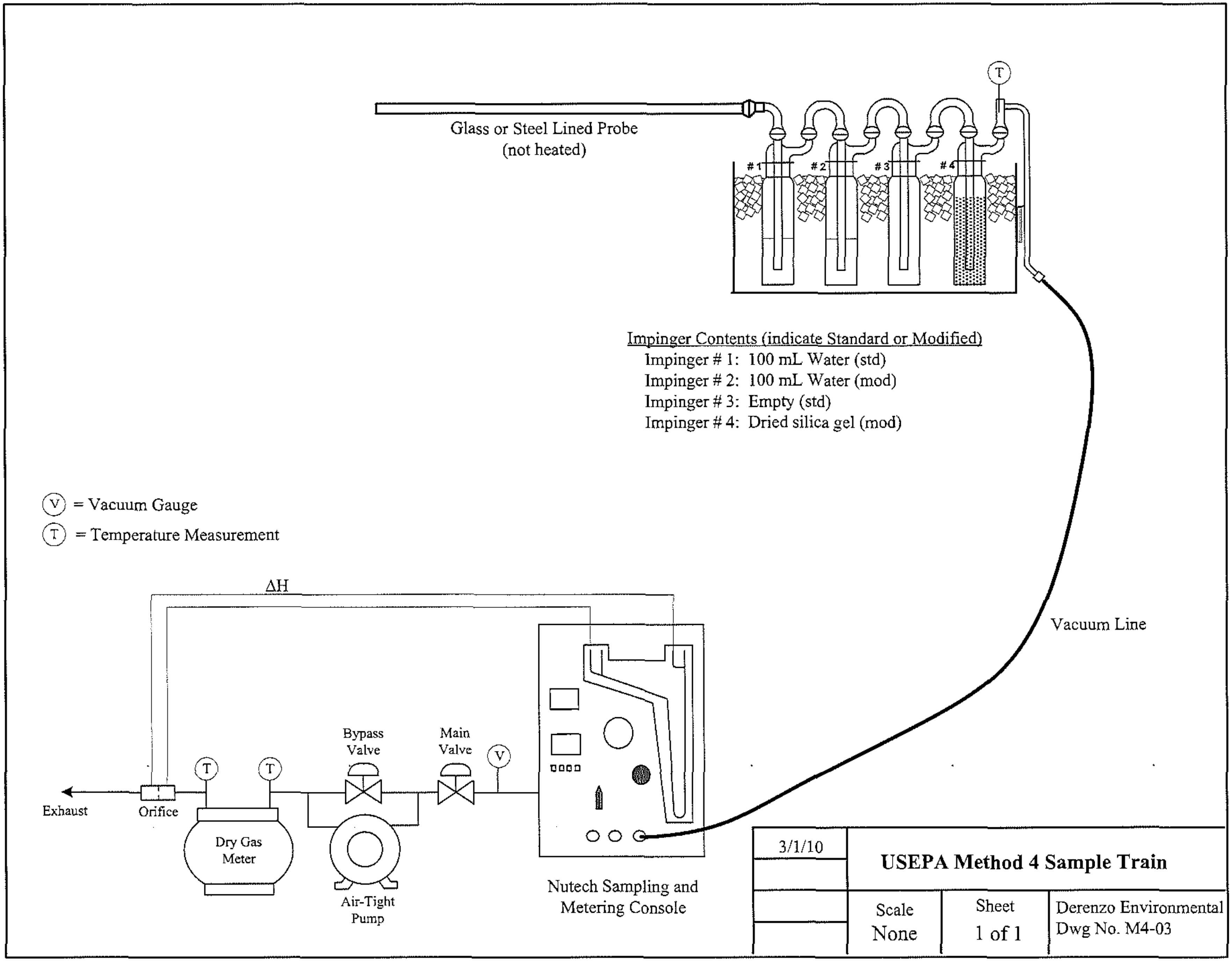


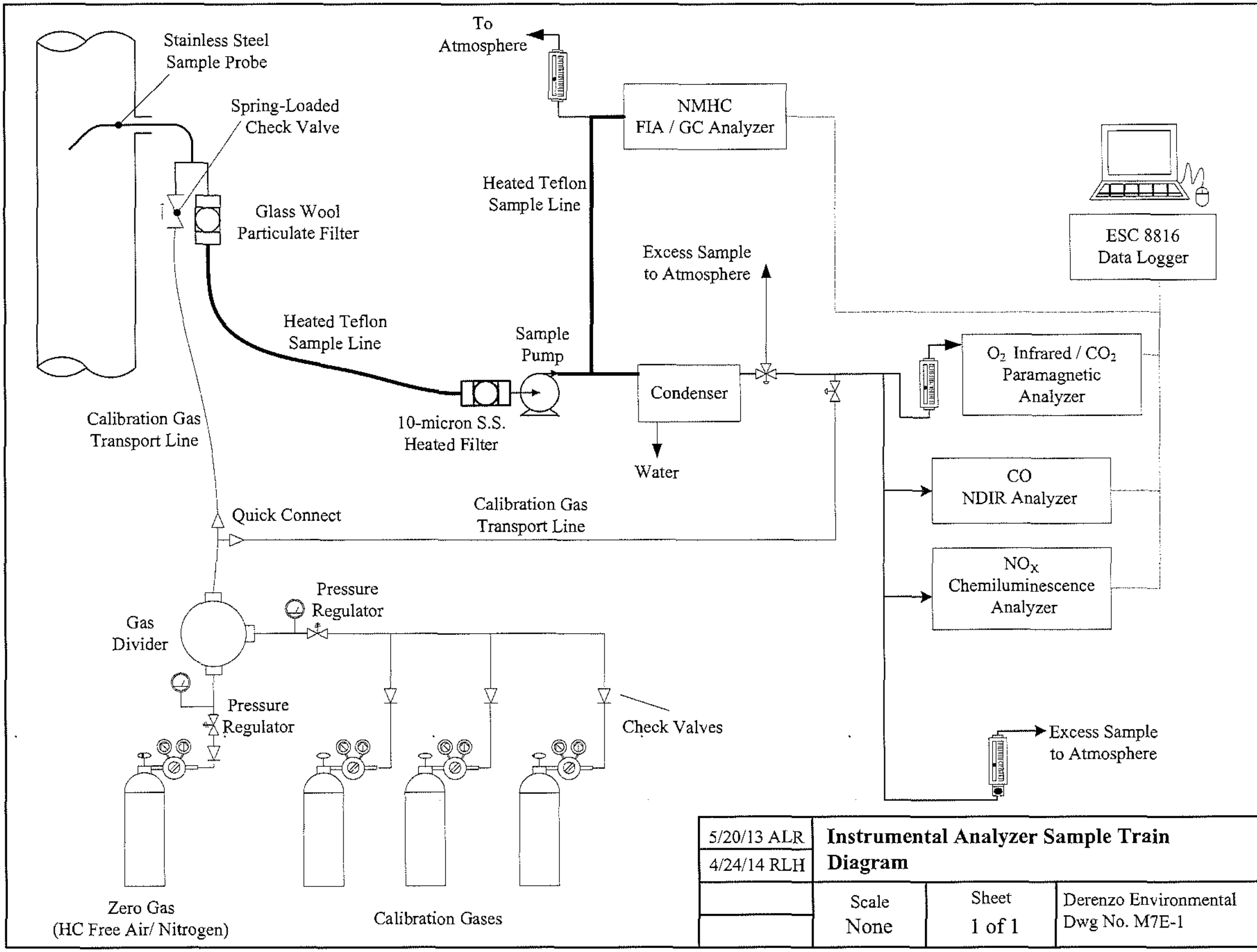
Velocity sample locations
(as measured from stack wall)

1	0.5"
2	1.7"
3	3.1"
4	5.2"
5	10.8"
6	12.9"
7	14.3"
8	15.5"

Figure 1

11/4/2015	**Eagle Valley Landfill Gas Fueled Engine Exhaust Sample Locations**		
	Scale None	Sheet 1 of 1	Derenzo Environmental Project No.:1704005


Glass or Steel Lined Probe
(not heated)
T
1
2
3
4
Impinger Contents (indicate Standard or Modified)
Impinger # 1: 100 mL Water (std)
Impinger # 2: 100 mL Water (mod)
Impinger # 3: Empty (std)
Impinger # 4: Dried silica gel (mod)
V = Vacuum Gauge
T = Temperature Measurement
ΔH
Vacuum Line
Bypass Valve
Main Valve
V
T
T
Exhaust
Orifice
Dry Gas Meter
Air-Tight Pump
Nutech Sampling and Metering Console
3/1/10
USEPA Method 4 Sample Train
Scale
None
Sheet
1 of 1
Derenzo Environmental
Dwg No. M4-03



5/20/13 ALR 4/24/14 RLH	**Instrumental Analyzer Sample Train Diagram**		
	Scale None	Sheet 1 of 1	Derenzo Environmental Dwg No. M7E-1