IMPACT
COMPLIANCE & TESTING

NSPS EMISSION TEST REPORT

Title:	NSPS EMISSION TEST REPORT FOR A DIGESTER GAS FUELED INTERNAL COMBUSTION ENGINE – GENERATOR SET
Report Date:	October 7, 2019
Test Dates:	October 4, 2019

Facility Information	
Name	Michigan State University, South Campus Dairy Farm
Street Address	4261 Bennett Road
City, County	Lansing, Ingham

Facility Permit Information			
State Registration No.:	K3249	Permit No. :	MI-ROP-K3249-2016a

Testing Contractor	
Company	Impact Compliance and Testing, Inc.
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Project No.	1900195

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FOR A
DIGESTER GAS FUELED INTERNAL COMBUSTION
ENGINE – GENERATOR SET

MICHIGAN STATE UNIVERSITY
SOUTH CAMPUS DAIRY FARM

1.0 INTRODUCTION

Michigan State University (MSU) operates a digester gas fired, spark-ignition reciprocating internal combustion engine (SI-RICE) generator set located at the South Campus Dairy Farm in Lansing, Ingham County.

The SI-RICE has a power generation rating of 510 brake-horsepower (BHP). 40 CFR 60.4243(b)(2)(ii) of the SI-RICE NSPS specifies that owners and operators of new stationary spark-ignited RICE with a power rating greater than 500 horsepower, that have not been certified by the manufacturer relative to the NSPS, 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.

Emission testing for the SI-RICE was previously performed on September 20, 2018. The emission test was performed on October 4, 2019, which is within 8,760 run hours of the previous test event.

The testing consisted of triplicate, one-hour sampling periods for nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compound (VOC) emissions.

The compliance testing was performed by Impact Compliance and Testing, Inc. (ICT) representatives Andy Rusnak and Jory VanEss. The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated July 22, 2019 that was submitted to the Michigan Department of Environment, Great Lakes and Energy (EGLE) Air Quality Department (AQD) prior to the test event. Mr. Dan McGeen and Mr. Tom Gasloli from the EGLE-AQD were on-site to observe portions of the test event.

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Biogas containing methane is generated at the South Campus Dairy Farm from the anaerobic decomposition of a combination of feedstocks, including animal waste, food scraps, and waste grease from restaurants. The biogas (digester gas) is used to fuel the MAN Model No. E2842LE322 RICE (EUDIENGINE), which is connected to an electricity generator that produces electricity that is transferred to the local utility.

2.2 Rated Capacities and Air Emission Controls

The electricity generator has a rated electrical output of 380 kW.

EUDIENGINE is not equipped with add-on emission controls. Combustion air pollutant emissions are minimized by the design of the engine and the air to fuel ratio controller. Engine exhaust gas is released directly to atmosphere through a vertical release point without add-on post-combustion emission controls.

The fuel consumption rate is dependent on the fuel heat value (methane content). The engine will use an appropriate amount of fuel to maintain the desired output. The air-to-fuel ratio is set based on the gas quality (methane or heat content) of the digester gas that is used as fuel.

2.3 Sampling Locations

The RICE exhaust gas is directed through a muffler and is released to the atmosphere through a dedicated exhaust stack with a horizontal release point.

The sampling port for EUDIENGINE is located in a horizontal exhaust pipe prior to the muffler with an inner diameter of 8 inches. The section is equipped with a single sample port, providing a sampling location greater than 44 inches (>5.5 duct diameter) upstream and 36 inches (4.5 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

Appendix 1 provides a diagram of the emission test sampling location.

Table 3.1 Average engine operating conditions during the test periods

Emission Unit	Generator Output (kW)	Fuel Use (scfm)	Digester Gas CH_4 Content (%)	Digester Gas H_2S Content (ppm)
EUDIENGINE	347	107	65.9	8.8
Max Capacity	380	--	--	--

Table 3.2 Average measured exhaust gas concentrations for the RICE (three-test average)

Emission Unit	CO Emissions (ppmvd @15%O_2)	NOx Emissions (ppmvd @15%O_2)	VOC Emissions[1] (ppmvd @15%O_2)
EUDIENGINE	167	100	3.5
NSPS Limit	610	150	80

1. Measured as propane (C_3)

4.3 Exhaust Gas Moisture Content (USEPA Method 4)

The moisture content of the RICE exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. The moisture sampling was performed concurrently with the instrumental analyzer sampling. During each sampling period a gas sample was extracted at a constant 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. Moisture sampling was performed from a single centroid location.

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

NOx and CO pollutant concentrations in the RICE exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NOx analyzer and a TEI Model 48i non-dispersive infrared CO analyzer.

A continuous sample of the RICE exhaust gas was delivered to the instrumental analyzers using the sampling and conditioning system described previously in this section. 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.

Appendix 3 provides CO and NOx calculation sheets. Raw instrument response data are provided in Appendix 4.

4.5 Measurement of Volatile Organic Compounds (USEPA Method 25A / ALT-096)

VOC emissions were determined by measuring the non-methane hydrocarbon (NMHC) concentration in the RICE exhaust gas. NMHC pollutant concentration was determined using a Thermo Environmental Instruments (TEI) Model 55i Methane / Non-methane 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 NMHC analyzer was not conditioned to remove moisture. Therefore, VOC measurements correspond to standard conditions with no moisture correction (wet basis). The measured VOC/NMHC concentration values were corrected to dry gas conditions (ppmvd) using the measured exhaust gas moisture content.

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

5.4 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NOx, CO, O_2 and CO_2 have had an interference response test preformed 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.

5.5 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, O_2 and CO_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.

5.6 Determination of Exhaust Gas Stratification

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

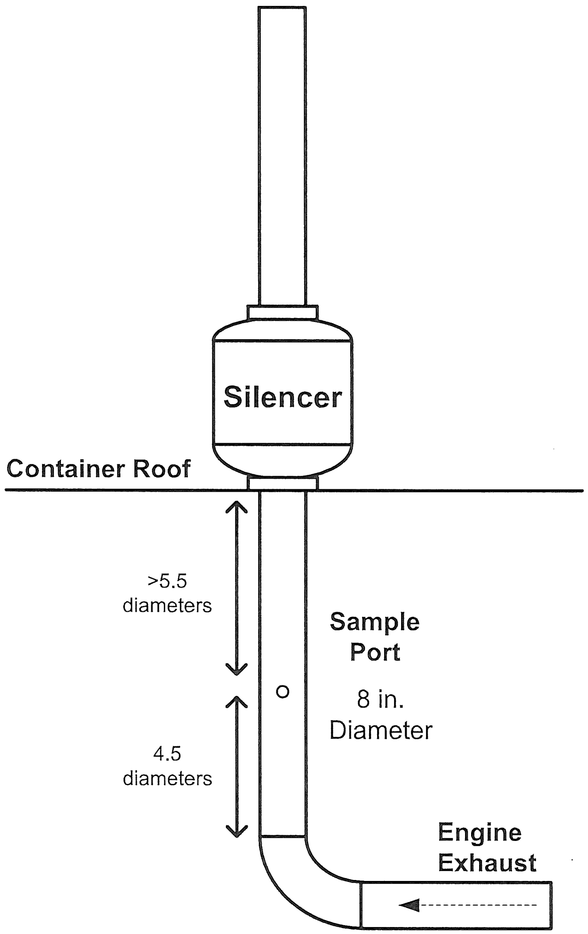
The recorded data for each RICE exhaust stack gas indicate that the measured CO_2, CO and O_2 concentrations did not vary by more than 5% of the mean across the stack diameter. Therefore, the RICE stack gas was considered to be non-stratified and the compliance test sampling was performed at a single sampling location within the RICE exhaust stack.

Table 6.1 Measured exhaust gas conditions and NOx, CO and VOC air pollutant emission rates for EUDIENGINE

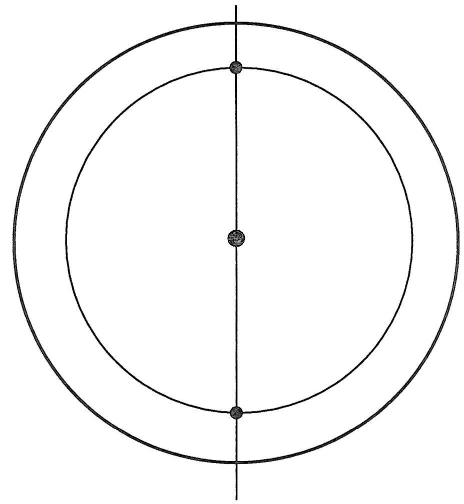
Test Number: Test Date: Test Period Begin:	1 10/04/19 0915-1015	2 10/04/19 1042-1142	3 10/04/19 1204-1304	Three Test Average
Engine operating parameters				
Generator Output (kW)	347	347	346	347
Fuel Use Rate (scfm)	107	107	108	107
Fuel CH_4 Content (%)	66.1	66.0	65.7	65.9
Fuel H_2S Content (ppm)	8.0	8.4	10.0	8.8
Exhaust gas composition				
O_2 content (% vol)	6.85	6.90	6.93	6.89
CO_2 content (% vol)	11.6	11.6	11.6	11.6
Moisture (% vol)	14.7	13.6	13.7	14.0
NOx emission rates				
NOx concentration (ppmvd)	254	231	230	238
NOx corrected to 15% O_2 (ppmvd)	107	97.4	97.0	100
NOx NSPS limit (ppmvd @15% O_2)	-	-	-	*150*
CO emission rates				
CO concentration (ppmvd)	395	397	396	396
CO corrected to 15% O_2 (ppmvd)	166	167	167	167
CO NSPS limit (ppmvd @ 15% O_2)	-	-	-	*610*
VOC emission rates				
VOC concentration (ppmv C_3)	8.15	6.90	6.26	7.10
VOC corrected to 15% O_2, dry (ppmvd)	4.01	3.37	3.06	3.48
VOC NSPS limit (ppmvd @15% O_2)	-	-	-	*80*

APPENDIX 1

Stack and Sample Train Drawings



Exhaust Stack
Cross-Section



Stratification test locations as measured from stack wall

Pt. #	in.	% Diameter
1	1.34	16.7
2	4.00	50
3	6.66	83.3

10-7-19	**MSU South Campus Anaerobic Digester Engine Exhaust Sample Location, MAN Model No. E2842LE322**		
	Scale None	Sheet 1 of 1	ICT Drawing No.: MSU-01

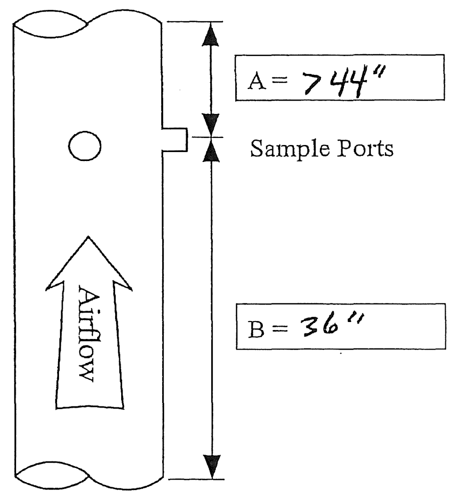
Impact Compliance and Testing, Inc.

USEPA Method 2
Gas Velocity Measurement Data Sheet

Company	MSU Digester	No. of Points	
Source Designation	IC Engine	Operator(s)	
Test Date	10 / 4 / 19	Pitot Type	Type S or Standard
Test Number	Preliminary	Pitot Identification	
Time (24-hr clock)		O_2 Content (%)	
Barometric Press. (in. Hg)		CO_2 Content (%)	
Static Pressure (in. H_2O)		Wet Bulb Temp.	

Inches from Stack Wall	Traverse Point Number	Stack Temperature (°F)	Velocity Head (in. H_2O)	Null Angel (zero angle)

Stack / Duct Measurements

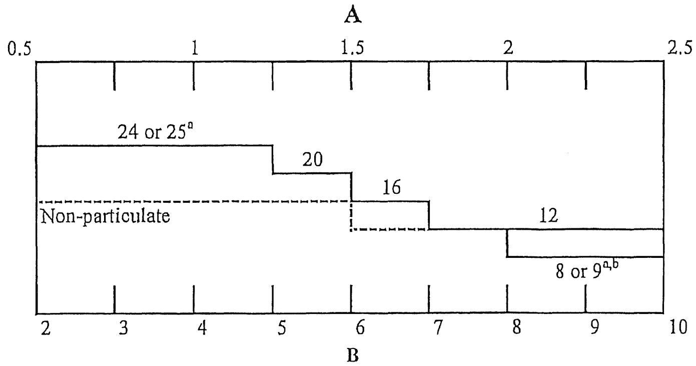


Round Duct Dia. (D) 8" + 4.5" nipple

Square Duct (LxW) x

Square Duct Dia. (De):
De = 2LW / (L+W)

Straight Length: (diameters) A / D ______ B / D ______



a- Higher No. for rectanguar stacks
b- For stacks between 12 and 24 in.

Traverse Point	No. of Traverse Points Per Dia. 6	8	10	12
1	4.4	3.2	2.6	2.1
2	14.6	10.5	8.2	6.7
3	29.6	19.4	14.6	11.8
4	70.4	32.2	22.6	17.7
5	85.4	67.7	34.2	25.0
6	95.6	80.6	65.8	35.6
7		89.5	77.4	64.4
8		96.8	85.4	75.0
9			91.8	82.3
10			97.4	88.2
11				93.3
12				97.9