1.0 Introduction

Waste Management of Michigan, Inc. (WMI) operates landfill gas (LFG)-fired reciprocating internal combustion engine and electricity generator sets (RICE gensets) and LFG fueled enclosed flares (enclosed flares) at the Eagle Valley Recycle and Disposal Facility (Eagle Valley RDF) in Orion, Oakland County, Michigan.

The State of Michigan Department of Environment, Great Lakes, and Energy – Air Quality Division (EGLE-AQD) has issued to WMI Renewable Operating Permit (ROP) No. MI-ROP-N3845-2015 (MI-ROP-N3845-2021 permit renewal is pending) and Permit to Install (PTI) No. 91-20 for operation of the renewable electricity generation facility, which consists of:

- Two (2) enclosed flares identified as emission units EUENCLOSEDFLARE3 and EUENCLOSEDFLARE4 (collectively FGENCLOSEDFLARES).
- Two (2) Caterpillar (CAT®) Model No. G3520C RICE gensets identified as emission units EUICENGINE1 and EUICENGINE2 (collectively FGICENGINES).

Air emission compliance testing was performed pursuant to conditions of MI-ROP-N3845-2015 (MI-ROP-N3845-2021 permit renewal is pending), PTI No. 91-20, the federal Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ), and the federal Standards of Performance for Municipal Solid Waste Landfills (40 CFR Subpart WWW).

The compliance testing presented in this report was performed by Impact Compliance & Testing, Inc. (ICT), a Michigan-based environmental consulting and testing company. ICT representatives Tyler Wilson, Blake Beddow, Andy Rusnak, and Clay Gaffey performed the field sampling and measurements September 21-23, 2021.

The enclosed flare performance tests consisted of triplicate, one-hour sampling periods for carbon monoxide (CO), volatile organic compounds (VOC, as non-methane hydrocarbons (NMHC or NMOC)), and opacity (visible emissions, VE). Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content were determined for each test period to calculate pollutant mass emission rates.

The engine emission performance tests consisted of triplicate, one-hour sampling periods for nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOC, as non-methane hydrocarbons (NMHC or NMOC)), sulfur dioxide (SO_2), and formaldehyde (HCOH). Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content were determined for each test period to calculate pollutant mass emission rates.

The exhaust gas sampling and analysis was performed using procedures specified in the Stack Test Protocol dated July 23, 2021, that was reviewed and approved by EGLE-AQD. Mr. Matt Karl and Mr. Robert Joseph of EGLE-AQD observed portions of the compliance testing.

Questions regarding this air emission test report should be directed to:

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2.0 Summary of Test Results and Operating Conditions

2.1 Purpose and Objective of the Tests

Conditions of MI-ROP-N3845-2015 (MI-ROP-N3845-2021 permit renewal is pending), PTI No. 91-20, the federal Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ), and the federal Standards of Performance for Municipal Solid Waste Landfills (40 CFR Subpart WWW) require WMI to test each enclosed flare in FGENCLOSEDFLARES and each RICE genset in FGICENGINES for air pollutant emissions. Enclosed Flare Nos. 3 and 4 (EUENCLOSEDFLARE3 and EUENCLOSEDFLARE4, respectively) and Engine Nos. 1 and 2 (EUICENGINE1 and EUICENGINE2, respectively) were tested during this compliance test event.

2.2 Operating Conditions During the Compliance Tests

The flare testing was performed while the enclosed flares were operated at normal routine operating conditions. For the enclosed flares, WMI representatives monitored and recorded the combustion zone temperature (°F), fuel use (scfm), and fuel methane content (%) at 15-minute intervals for each test period.

The engine testing was performed while the RICE gensets were operated at maximum operating conditions (within 10% of the rated electricity output of 1,600 kW). WMI representatives monitored and recorded the generated power output (kW), fuel use (scfm), fuel methane content (%), and air-to-fuel ratio at 15-minute intervals for each test period.

Appendix 2 provides operating records provided by WMI representatives for the test periods.

Average process operating data for each emission unit is presented in Tables 2.1, 2.3 and 6.1-6.4.

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled enclose flares and RICE gensets were each sampled for three (3) one-hour test periods during the compliance testing performed September 21-23, 2021.

Tables 2.2 and 2.4 present the average measured required air pollutant data for each emission unit (average of the three test periods).

Test results for each one-hour sampling period and comparison to the permitted emission rates are presented in Section 6.0 of this report.

Table 2.1 Average enclosed flare operating conditions during the test periods

Emission Unit	Combustion Temperature (°F)	LFG Fuel Use (scfm)	LFG CH_4 Content (%)
Flare No. 3	1,598	996	52.9
Flare No. 4	1,600	807	54.9

Table 2.2 Average measured air pollutant data for each enclosed flare (three-test average)

	CO		NMOC	VE
Emission Unit	(lb/hr)	(lb/hr)	(ppmv, dry, @ 3% O_2, as hexane)	(%)
Flare No. 3	0	-	0.26	0
Flare No. 4	-	0.24	0.24	0
Permit Limit	***24.3***	***6.1***	***20***	***-****

Note: A VE limit will likely be specified in MI-ROP-N3845-2021 when it becomes active.

Table 2.3 Average engine operating conditions during the test periods

Emission Unit	Generator Output (kW)	LFG Fuel Use (scfm)	LFG CH_4 Content (%)	Air / Fuel Ratio
Engine No. 1	1,643	557	54.3	7.2
Engine No. 2	1,640	546	54.6	7.3

Table 2.4 Average measured air pollutant data for each engine (three-test average)

	CO	NOx	VOC	HCOH	SO_2	
Emission Unit	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)	(lb/hr)	(lb/hr)	(tpy)
Engine No. 1	3.43	0.62	0.09	1.70	1.39	6.07
Engine No. 2	3.33	0.71	0.09	1.65	1.31	5.73
Permit Limit	***4.13***	***0.9***	***1.0***	***2.07***	***1.75***	***15.4***

3.0 Source and Sampling Location Description

3.1 General Process Description

WMI is permitted to operate two (2) enclosed flares and two (2) RICE-generator sets (CAT® Model No. G3520C) at its facility. The units are fired exclusively with LFG that is recovered from the Eagle Valley RDF facility and treated prior to use.

Table 3.1 Emission unit identification

Emission Unit	Permit Identification	Serial Number
Flare No. 3	EUENCLOSEDFLARE3	-
Flare No. 4	EUENCLOSEDFLARE4	-
Engine No. 1	EUICENGINE1	GZJ00418
Engine No. 2	EUICENGINE2	GZJ00443

3.2 Rated Capacities and Air Emission Controls

The CAT® G3520C engine generator sets each have a rated design capacity of:

- Engine Power: 2,233 brake horsepower (bhp)
- Electricity Generation: 1,600 kW

Each engine is equipped with an air-to-fuel ratio (AFR) controller that automatically blends the appropriate ratio of combustion air and treated LFG fuel.

The RICE are not equipped with add-on emission control devices. The AFR controller maintains efficient fuel combustion, which minimizes air pollutant emissions. Exhaust gas is exhausted directly to atmosphere through a noise muffler and vertical exhaust stack for each engine.

The 4,000 scfm rated enclosed flare (EUENCLOSEDFLARE3) has a maximum heat input capacity of 109 British thermal units per hour (MMBtu/hr).

The 1,000 scfm rated enclosed flare (EUENCLOSEDFLARE4) has a maximum heat input capacity of 27 MMBtu/hr.

The enclosed flares serve as the control device for LFG generated at the Eagle Valley RDF. The enclosed flares themselves are not equipped with add-on emission control equipment.

3.3 Sampling Locations

The Flare No. 3 exhaust gas is released to the atmosphere through a dedicated vertical exhaust stack. The vertical exhaust stack has an inner diameter of 144 inches. The vertical exhaust stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 72.0 inches (0.5 duct diameters) upstream and 456 inches (3.2 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

The Flare No. 4 exhaust gas is released to the atmosphere through a dedicated vertical exhaust stack. The vertical exhaust stack has an inner diameter of 84 inches. The vertical exhaust stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 42.0 inches (0.5 duct diameters) upstream and 366 inches (4.4 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

Each RICE exhaust gas is directed through a muffler and is released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point. The exhaust stacks for Engine Nos. 1 and 2 are identical. The exhaust stack sampling ports are located in individual horizontal exhaust ducts, located before each engine muffler, with an inner diameter of 16.0 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 60.0 inches (3.8 duct diameters) upstream and 54.0 inches (3.4 duct diameters) downstream from any flow disturbance.

All sample port locations satisfy the USEPA Method 1 criteria for a representative sample location. Individual traverse points were determined in accordance with USEPA Method 1.

Appendix 1 provides a diagram of the emission test sampling locations with actual stack dimension measurements.

4.0 Sampling and Analytical Procedures

A Stack Test Protocol for the air emission testing was reviewed and approved by EGLE-AQD. This section provides a summary of the sampling and analytical procedures that were used during the testing periods.

4.1 Summary of Sampling Methods

USEPA Method 1 [Flares & Engines]	Exhaust gas velocity measurement locations were determined based on the physical stack arrangement and requirements in USEPA Method 1.
USEPA Method 2 [Flares & Engines]	Exhaust gas velocity pressure was determined using a Type-S Pitot tube connected to a red oil incline manometer; temperature was measured using a K-type thermocouple connected to the Pitot tube.
USEPA Method 3A [Flares & Engines]	Exhaust gas O_2 and CO_2 content was determined using paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 4 [Flares]	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 6C [Engines]	Exhaust gas SO_2 concentration was determined using a pulsed ultraviolet fluorescence instrumental analyzer.
USEPA Method 7E [Engines]	Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 9 [Flares]	Exhaust gas plume observations were made by a certified observer of visible emissions.
USEPA Method 10 [Flares & Engines]	Exhaust gas CO concentration was measured using an infrared instrumental analyzer.
USEPA Method 25A / ALT-097 [Flares]	Exhaust gas NMOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column.
USEPA Method 25A / ALT-096 [Engines]	Exhaust gas VOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column.
ASTM Method D6348 [Engines]	Exhaust gas HCOH concentration and moisture content were measured using fourier transform infrared spectroscopy (FITR instrumental analyzer).

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

Exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 once during each test period. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure at each traverse point across the stack cross section. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked periodically throughout the test periods to verify the integrity of the measurement system.

The absence of significant cyclonic flow at each sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each velocity traverse point 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).

Appendix 3 provides exhaust gas flowrate calculations and field data sheets.

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

CO_2 and O_2 content in each exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a Servomex 4900 infrared gas analyzer. The O_2 content of the exhaust was monitored using a Servomex 4900 gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the 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 analyzers; therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition 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 upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document). Sampling times were recorded on field data sheets.

Appendix 4 provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of each enclosed flare exhaust gas stream was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. Exhaust gas moisture content measurements were performed concurrently with the instrumental analyzer sampling periods. 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 content of each RICE genset exhaust gas was determined as part of the HCOH concentration determination (i.e., using the FTIR instrumental analyzer). Discussion of the FTIR testing procedures is contained in Section 4.11 of this document.

4.5 SO_2 Concentration Measurements (USEPA Method 6C)

RICE genset exhaust gas SO_2 concentration measurements were performed using a Thermo Environmental Instruments, Inc. (TEI) Model 43i that uses pulsed ultraviolet fluorescence technology in accordance with USEPA Method 6C for the measurement of SO_2 concentration.

Appendix 4 provides SO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.6 NO_x Concentration Measurements (USEPA Method 7E)

NO_X pollutant concentrations in the RICE genset exhaust gas streams were determined using a TEI Model 42i High Level chemiluminescence NO_X analyzer.

Throughout each 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 and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on an ESC Model 8816 data acquisition system that logged data as one-minute averages. Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias.

Appendix 4 provides NO_X calculation sheets. Raw instrument response data are provided in Appendix 5.

4.7 Visible Emissions Observations (USEPA Method 9)

USEPA Method 9 procedures were used to evaluate the opacity of each enclosed flare exhaust gas stream during the emission sampling periods.

In accordance with USEPA Method 9, the qualified observer stood at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140° sector to his back.

Opacity observations were made at the point of greatest opacity in the portion of the plume where condensed water vapor was not present. Observations were made at 15-second intervals for at least 6-minutes for each enclosed flare.

All visual opacity determinations were performed by a qualified observer in accordance with USEPA Method 9, Section 3.

Opacity test data and the observer certificate are presented in Appendix 8.

4.8 CO Concentration Measurements (USEPA Method 10)

CO pollutant concentrations in the enclosed flare and RICE genset exhaust gas streams were determined using a California Analytical Instruments (CAI) Fuji ZRF infrared CO analyzer.

Throughout each 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 and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on an ESC Model 8816 data acquisition system that logged data as one-minute averages.

Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias.

Appendix 4 provides CO calculation sheets. Raw instrument response data are provided in Appendix 5.

4.9 Measurement of NMOC (USEPA Method 25A / ALT-097)

The NMOC concentration in each enclosed flare exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 25A / ALT-097. NMOC pollutant concentration was determined using a TEI Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains an internal gas chromatograph column that separates methane from non-methane components. The concentration of NMOC 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.

The USEPA Office of Air Quality Planning and Standards (OAQPS) has issued an alternate test method approving the use of the TEI 55i-series analyzer as an effective instrument for measuring NMOC from LFG fueled sources (ALT-097).

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

Prior to, and at the conclusion of each test, the instrument was calibrated using mid-range calibration (propane) and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document).

Appendix 4 provides NMOC calculation sheets. Raw instrument response data for the NMOC analyzer is provided in Appendix 5.

4.10 Measurement of VOC (USEPA Method 25A / ALT-096)

The VOC emission rate for each RICE genset was determined by measuring the nonmethane hydrocarbon (NMHC or NMOC) concentration in each engine exhaust gas stream. NMHC pollutant concentration was determined using a TEI Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains an internal gas chromatograph column that separates methane from non-methane components. 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.

The USEPA Office of Air Quality Planning and Standards (OAQPS) has issued an alternate test method approving the use of the TEI 55i-series analyzer as an effective instrument for measuring NMOC from gas-fueled RICE (ALT-096).

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).

Prior to, and at the conclusion of each test, the instrument was calibrated using mid-range calibration (propane) and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document).

Appendix 4 provides VOC calculation sheets. Raw instrument response data for the NMHC analyzer is provided in Appendix 5.

4.11 Measurement of HCOH and Moisture (ASTM Method D6348)

HCOH and moisture concentration in each RICE genset exhaust gas stream were determined using an MKS Multi-Gas 2030 Fourier transform infrared (FTIR) spectrometer in accordance with test method ASTM D6348.

The USEPA New Source Performance Standard (NSPS) for landfill gas fired engines (Subpart JJJJ) specifies ASTM D6348 as an acceptable test method for moisture concentration determinations. Additionally, the USEPA National Emissions Standard for Hazardous Air Pollutants (NESHAP) for landfill gas fired engines (Subpart ZZZZ) specifies ASTM D6348 as an acceptable test method for moisture and formaldehyde concentration determinations.

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

A calibration transfer standard (CTS), ethylene standard, and nitrogen zero gas were analyzed before and after each test run. Analyte spiking, of each engine, with acetaldehyde was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR. Data was collected at 0.5 cm-1 resolution. Instrument response was recorded using MG2000 data acquisition software.

Appendix 4 provides HCOH calculation sheets. Raw instrument response data for the FTIR analyzer is provided in Appendix 5.

4.12 Fuel Gas Measurement for H_2S (Draeger® Tubes)

The EGLE-AQD Test Protocol Approval Letter required the following additional process data to be recorded during the test program:

- *LFG TRS content*

ICT and/or WMI satisfied the additional process data request by performing one Draeger® tube measurement per test (photo included in Appendix 7).

A summary of LFG fuel H_2S measurements is presented in Table 6.5.

Appendix 7 provides a photo of the twelve (12) Draeger® tubes.

5.0 QA/QC Activities

5.1 Flow Measurement Equipment

Prior to arriving onsite, the instruments used during the source test to measure exhaust gas properties and velocity (pyrometer, Pitot tube, and scale) were calibrated to specifications in the sampling methods.

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 each 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).

5.2 NO_x Converter Efficiency Test

The NO_2 – NO conversion efficiency of the TEI Model 42i analyzer was verified prior to the RICE genset portion of the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_x concentration is within 90% of the expected value.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_X concentration was 101.1% of the expected value).

5.3 Gas Divider Certification (USEPA Method 205)

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 delivered 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.

5.4 Methane/NMOC Separation Study

A demonstration of the TEI Model 55i methane / non-methane organic compound separation efficiency was performed onsite (once prior to each enclosed flare test date: 9/21/2021 and 9/22/2021). The analyzer was challenged with a Certified Standard Spec blend gas containing 1,004 ppmv methane and 10.94 ppmv non-methane compounds (specifically propane) for the demonstration. The TEI Model 55i instrumental analyzer was calibrated using certified cylinders of 2,538 ppmv methane and 15.03 ppmv propane. The blend gas was then injected into the analyzer and the measured methane and non-methane concentrations were recorded using a data logger. The measured methane concentration stabilized at 999 ppmv and the measured NMOC concentration stabilized at 10.7 ppmv 9/21/2021. The measured methane concentration stabilized at 1,007 ppmv and the measured NMOC concentration stabilized at 10.6 ppmv 9/22/2021. The demonstrations indicate that the non-methane components (propane) did not elute with the methane (i.e., the internal column is highly efficient in separating methane and non-methane compounds).

5.5 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_X, CO, SO_2, 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 2.5% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

5.6 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 NO_x, CO, SO_2, CO2, 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, NO_x, CO, and SO_2 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.

5.7 Determination of Exhaust Gas Stratification

A stratification test was performed for each exhaust stack. The stainless-steel sample probe was positioned at multiple sample points across each plane 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 concentration data for each exhaust stack indicated that the measured O_2 and CO_2 concentrations did not vary by more than 5% of the mean across the stack diameter. Therefore, each exhaust stack was considered to be unstratified and the compliance test sampling was performed at a single sampling location within each exhaust stack.

5.8 System Response Time

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 greatest system response time.

5.9 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.

5.10 FTIR QA/QC Activities

At the beginning of the RICE genset test day, a calibration transfer standard (CTS, ethylene gas), analyte of interest (acetaldehyde) and nitrogen calibration gas was directly injected into the FTIR to evaluate the unit response.

Prior to and after each test run the CTS was analyzed. The ethylene was passed through the entire system (system purge) to verify the sampling system response and to ensure that the sampling system remained leak-free at the stack location. Nitrogen was also be passed through the sampling system to ensure the system is free of contaminants.

Analyte spiking, of the emission unit, with acetaldehyde was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR and assure the ability of the FTIR to quantify that compound in the presence of effluent gas.

As part of the data validation procedure, reference spectra were manually fit to that of the sample spectra (two spectra from each test period) and a concentration was determined. Concentration data was manually validated using the MKS MG2000 method analyzer software. The software used multi-point calibration curves to quantify each spectrum. The software-calculated results were compared with the measured concentrations to ensure the quality of the data.

Appendix 6 presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, methane/NMHC separation study records, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, meter box calibration records, and field equipment calibration records).

6.0 Results

6.1 Test Results and Allowable Limits

Enclosed flare and RICE genset operating data and air pollutant concentration and emission measurement results for each one-hour test period are presented in Tables 6.1 through 6.4.

The measured air pollutant concentrations and emission rates for each emission unit are less than the allowable limits specified in MI-ROP-N3845-2015 (MI-ROP-N3845-2021 permit renewal is pending), PTI No. 91-20, the federal Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ), and the federal Standards of Performance for Municipal Solid Waste Landfills (40 CFR Subpart WWW). The allowable limits are listed in the following tables.

	CO		NMOC	VE
Flare Nos. 3 & 4	(lb/hr)	(lb/hr)	(ppmv, dry, @ 3% O_2, as hexane)	(%)
Permit Limit	*24.3*	*6.1*	*20*	-*

Note: A VE limit will likely be specified in MI-ROP-N3845-2021 when it becomes active.

	CO	NOx	VOC	HCOH	SO_2	
Engine Nos. 1 & 2	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)	(lb/hr)	(lb/hr)	(tpy)
Permit Limit	*4.13*	*0.9*	*1.0*	*2.07*	*1.75*	*15.4*

6.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing for all pollutants was performed in accordance with USEPA methods and the approved Stack Test Protocol. The enclosed flares were operated at normal routine operating conditions. The RICE gensets were operated within 10% of maximum output (1,600 kW generator output for CAT® G3520C RICE). No variations from normal operating conditions occurred during the test periods.

Table 6.1 Measured exhaust gas conditions and air pollutant emission rates for Flare No. 3 (EUENCLOSEDFLARE3)

Test No. Test date Test period (24-hr clock)	1 9/21/2021 827-927	2 9/21/2021 952-1052	3 9/21/2021 1115-1215	Three Test Average
Fuel flowrate (scfm)	1,002	992	993	996
Combustion temperature (°F)	1,598	1,597	1,599	1,598
LFG methane content (%)	53.1	52.9	52.7	52.9
Exhaust Gas Composition				
CO_2 content (% vol)	6.03	5.97	6.13	6.04
O_2 content (% vol)	14.6	14.7	14.6	14.6
Moisture (% vol)	8.5	8.2	8.4	8.4
Exhaust gas temperature (°F)	1,318	1,334	1,343	1,332
Exhaust gas flowrate (dscfm)	18,341	18,316	18,246	18,301
Exhaust gas flowrate (scfm)	20,047	19,950	19,913	19,970
Carbon Monoxide				
CO conc. (ppmvd)	0	0	0	0
CO emissions (lb/hr)	0	0	0	0
CO permit limit (lb/hr)	-	-	-	*24.3*
Non-Methane Organic Compounds				
NMOC conc. (ppmv)[1]	0.14	0.18	0.20	0.17
NMOC emissions (ppmvd as C_6)[2]	0.21	0.28	0.30	0.26
NMOC permit limit (ppmvd as C_6)[2]	-	-	-	*20*
Visible Emissions				
VE emissions (%)	0.0	0.0	0.0	0.0
VE permit limit (%)[3]	-	-	-	-

1. Measured as non-methane hydrocarbons as propane.
2. Parts per million by volume, dry basis (ppmvd) as hexane (C_6) @ 3% oxygen.
3. A VE limit will likely be specified in MI-ROP-N3845-2021 when it becomes active.

Table 6.2 Measured exhaust gas conditions and air pollutant emission rates for Flare No. 4 (EUENCLOSEDFLARE4)

Test No. Test date Test period (24-hr clock)	1 9/22/2021 850-950	2 9/22/2021 1014-1114	3 9/22/2021 1136-1236	Three Test Average
Fuel flowrate (scfm)	801	814	806	807
Combustion temperature (°F)	1,599	1,601	1,601	1,600
LFG methane content (%)	55.0	54.9	54.9	54.9
Exhaust Gas Composition				
CO_2 content (% vol)	7.86	7.85	7.92	7.88
O_2 content (% vol)	12.7	12.6	12.6	12.6
Moisture (% vol)	9.4	9.3	9.3	9.3
Exhaust gas temperature (°F)	1,564	1,576	1,568	1,569
Exhaust gas flowrate (dscfm)	9,778	14,271	11,065	11,704
Exhaust gas flowrate (scfm)	10,797	15,727	12,193	12,906
Carbon Monoxide				
CO conc. (ppmvd)	3.54	8.13	1.58	4.42
CO emissions (lb/hr)	0.15	0.51	0.08	0.24
CO permit limit (lb/hr)	-	-	-	*6.1*
Non-Methane Organic Compounds				
NMOC conc. (ppmv)[1]	0.21	0.26	0.15	0.21
NMOC emissions (ppmvd as C_6)[2]	0.25	0.31	0.18	0.24
NMOC permit limit (ppmvd as C_6)[2]	-	-	-	*20*
Visible Emissions				
VE emissions (%)	0.0	0.0	0.0	0.0
VE permit limit (%)[3]	-	-	-	-

1. Measured as non-methane hydrocarbons as propane.
2. Parts per million by volume, dry basis (ppmvd) as hexane (C_6) @ 3% oxygen.
3. A VE limit will likely be specified in MI-ROP-N3845-2021 when it becomes active.

Table 6.3 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 1 (EUICENGINE1)

Test No. Test date Test period (24-hr clock)	1 9/23/2021 1156-1256	2 9/23/2021 1316-1416	3 9/23/2021 1439-1539	Three Test Average
Fuel flowrate (scfm)	554	558	560	557
Generator output (kW)	1,635	1,641	1,652	1,643
Engine output (bhp)	2,281	2,290	2,306	2,292
LFG methane content (%)	54.5	54.3	53.9	54.3
Air-to-fuel ratio	7.2	7.2	7.2	7.2
Exhaust Gas Composition				
CO_2 content (% vol)	12.5	12.6	12.5	12.5
O_2 content (% vol)	7.59	7.55	7.58	7.58
Moisture (% vol)	13.6	13.6	13.6	13.6
Exhaust gas temperature (°F)	975	971	971	972
Exhaust gas flowrate (dscfm)	4,620	4,596	4,592	4,603
Exhaust gas flowrate (scfm)	5,347	5,319	5,314	5,327
Nitrogen Oxides				
NO_X conc. (ppmvd)	94.1	94.1	94.5	94.2
NO_X emissions (lb/hr)	3.12	3.10	3.11	3.11
NO_X emissions (g/bhp-hr)	0.62	0.61	0.61	0.62
NO_X permit limit (g/bhp-hr)	-	-	-	*0.9*
Carbon Monoxide				
CO conc. (ppmvd)	861	863	864	863
CO emissions (lb/hr)	17.4	17.3	17.3	17.3
CO emissions (g/bhp-hr)	3.45	3.43	3.41	3.43
CO permit limit (g/bhp-hr)	-	-	-	*4.13*
Volatile Organic Compounds				
VOC conc. (ppmv)	12.1	12.4	12.2	12.2
VOC emissions (lb/hr)	0.44	0.45	0.45	0.45
VOC emissions (g/bhp-hr)	0.09	0.09	0.09	0.09
VOC permit limit (g/bhp-hr)	-	-	-	*1.0*
Formaldehyde				
HCOH conc. (ppmv)	68.4	68.1	68.0	68.1
HCOH emissions (lb/hr)	1.71	1.70	1.69	1.70
HCOH permit limit (lb/hr)	-	-	-	*2.07*
Sulfur Dioxide				
SO_2 conc. (ppmvd)	28.2	31.5	30.8	30.2
SO_2 emissions (lb/hr)	1.30	1.44	1.41	1.39
SO_2 permit limit (lb/hr)	-	-	-	*1.75*
SO_2 emissions (tpy)	5.70	6.33	*6.18*	6.07
SO_2 permit limit (tpy)	-	-	-	*15.4*

Table 6.4 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 2 (EUICENGINE2)

Test No. Test date Test period (24-hr clock)	1 9/23/2021 739-839	2 9/23/2021 858-958	3 9/23/2021 1017-1117	Three Test Average
Fuel flowrate (scfm)	543	548	547	546
Generator output (kW)	1,645	1,637	1,637	1,640
Engine output (bhp)	2,295	2,284	2,285	2,288
LFG methane content (%)	54.6	54.6	54.5	54.6
Air-to-fuel ratio	7.3	7.3	7.2	7.3
Exhaust Gas Composition				
CO_2 content (% vol)	12.7	12.7	12.7	12.7
O_2 content (% vol)	7.42	7.30	7.26	7.33
Moisture (% vol)	13.7	13.7	13.6	13.7
Exhaust gas temperature (°F)	989	986	985	987
Exhaust gas flowrate (dscfm)	4,380	4,468	4,504	4,451
Exhaust gas flowrate (scfm)	5,074	5,175	5,216	5,155
Nitrogen Oxides				
NO_X conc. (ppmvd)	113	111	112	112
NO_X emissions (lb/hr)	3.55	3.56	3.60	3.57
NO_X emissions (g/bhp-hr)	0.70	0.71	0.72	0.71
NO_X permit limit (g/bhp-hr)	-	-	-	*0.9*
Carbon Monoxide				
CO conc. (ppmvd)	863	863	864	863
CO emissions (lb/hr)	16.5	16.8	17.0	16.8
CO emissions (g/bhp-hr)	3.26	3.34	3.37	3.33
CO permit limit (g/bhp-hr)	-	-	-	*4.13*
Volatile Organic Compounds				
VOC conc. (ppmv)	12.8	12.7	12.6	12.7
VOC emissions (lb/hr)	0.45	0.45	0.45	0.45
VOC emissions (g/bhp-hr)	0.09	0.09	0.09	0.09
VOC permit limit (g/bhp-hr)	-	-	-	*1.0*
Formaldehyde				
HCOH conc. (ppmv)	68.3	68.2	68.3	68.3
HCOH emissions (lb/hr)	1.62	1.65	1.67	1.65
HCOH permit limit (lb/hr)	-	-	-	*2.07*
Sulfur Dioxide				
SO_2 conc. (ppmvd)	29.5	29.7	29.0	29.4
SO_2 emissions (lb/hr)	1.29	1.33	1.30	1.31
SO_2 permit limit (lb/hr)	-	-	-	*1.75*
SO_2 emissions (tpy)	5.66	5.81	5.71	5.73
SO_2 permit limit (tpy)	-	-	-	*15.4*

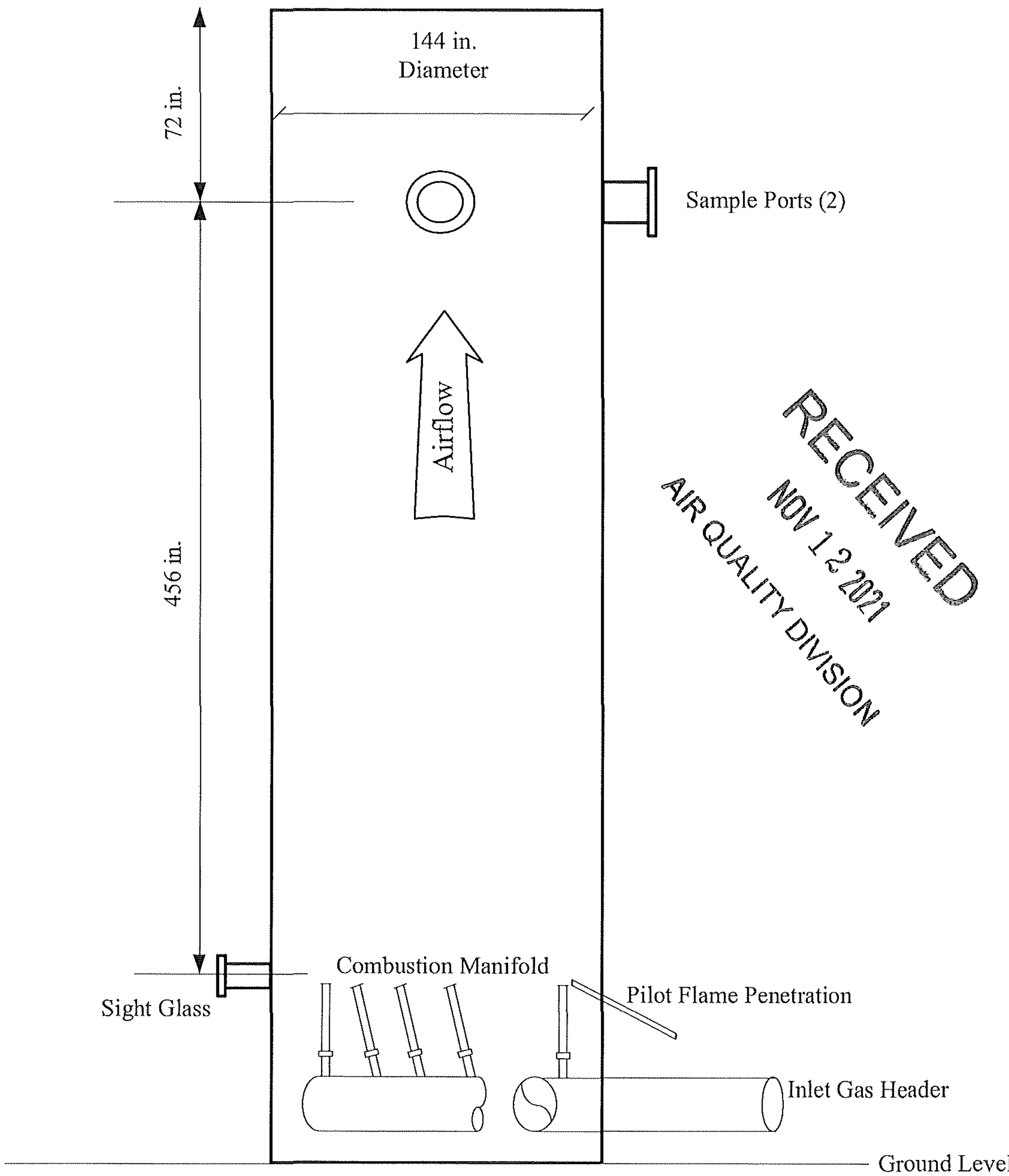
Table 6.5 Summary of LFG fuel H_2S measurements (Draeger® Tubes)

Test No.	1 H_2S (ppm)	2 H_2S (ppm)	3 H_2S (ppm)	3-Test Avg. H_2S (ppm)
Enclosed Flare No. 3 (9/21/2021)	200	220	200	207
Enclosed Flare No. 4 (9/22/2021)	200	240	230	223
Engine No. 1 (9/23/2021)	260	240	240	247
Engine No. 2 (9/23/2021)	280	260	260	267

APPENDIX 1

- Sample Port Diagrams

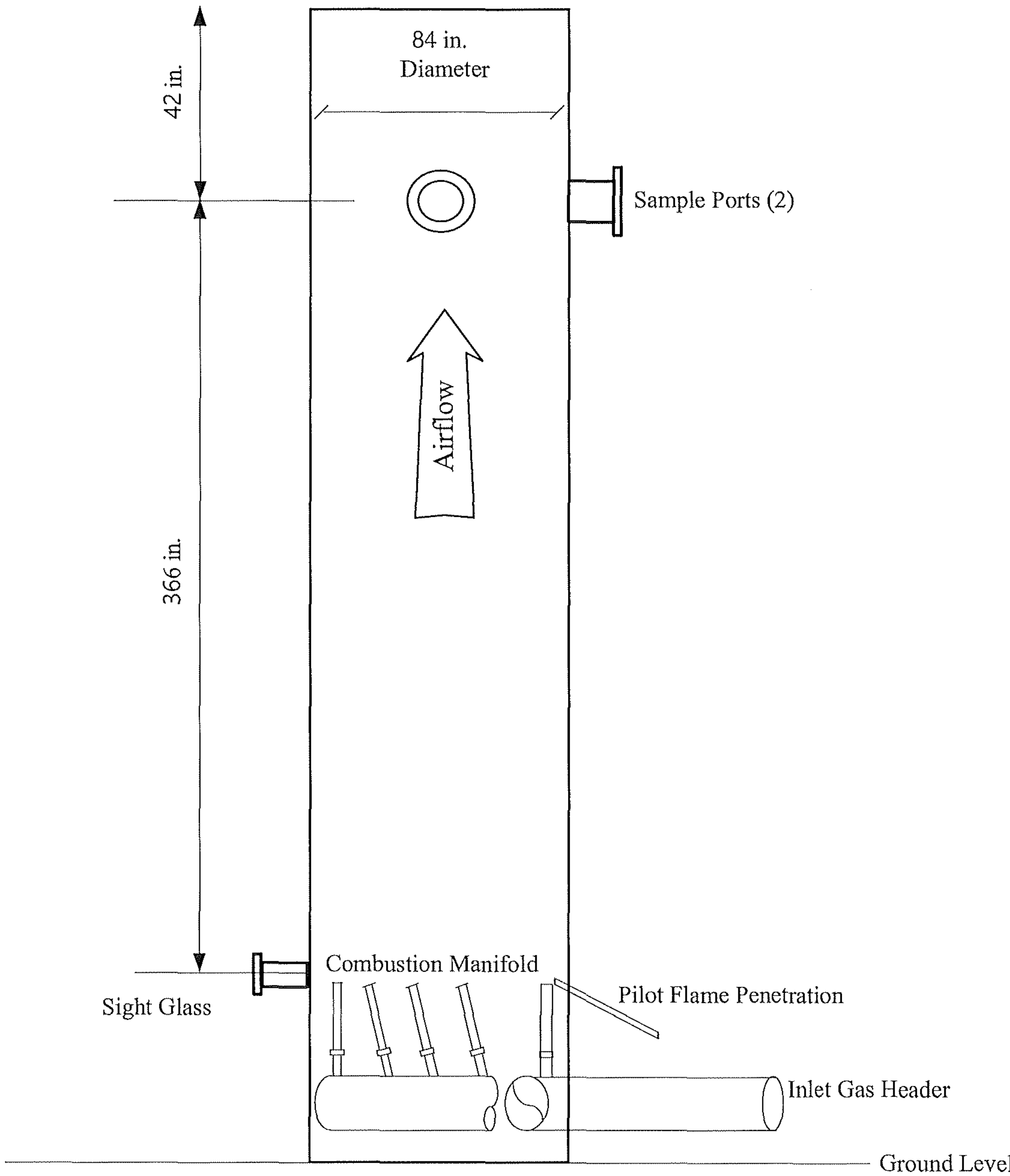
EUENCLOSEDFLARE3



Enclosed Flare Sampling and Measurement Locations

7/9/2021	**WMI Eagle Valley RDF** **Enclosed Flare #3 Exhaust Sample Location**		
	Scale None	Sheet 1 of 1	IMPACT COMPLIANCE & TESTING

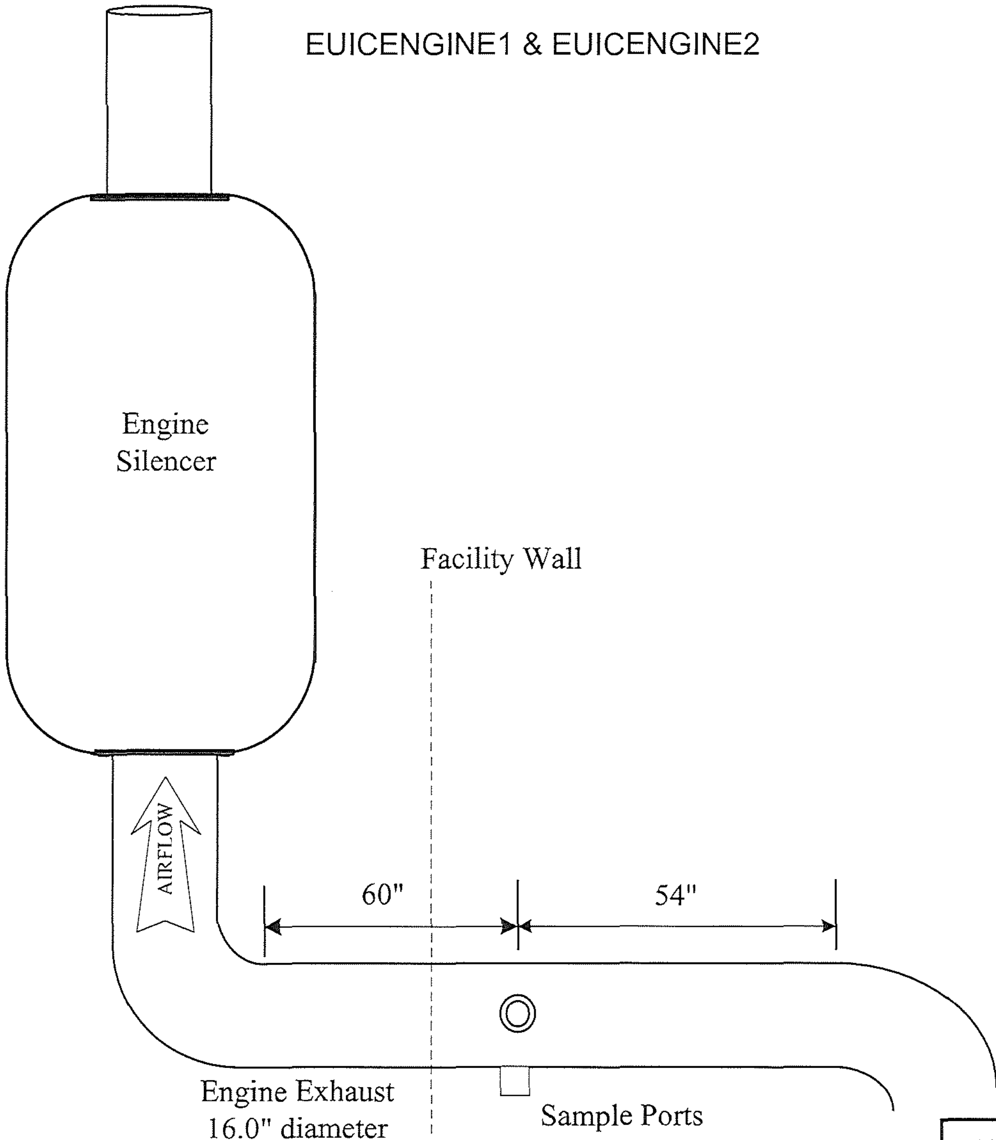
EUENCLOSEDFLARE4



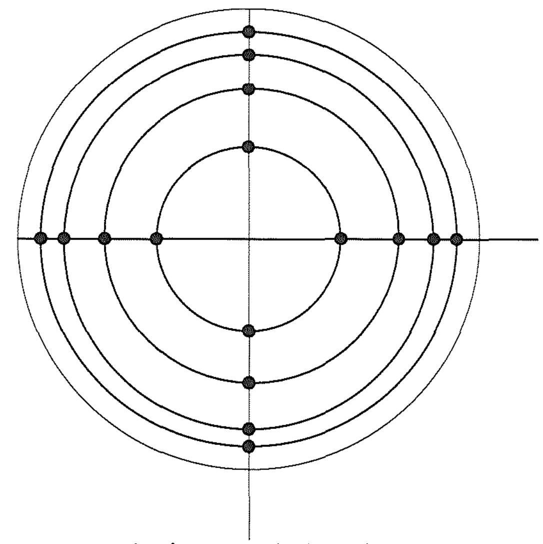
Enclosed Flare Sampling and Measurement Locations

7/9/2021	**WMI Eagle Valley RDF** **Enclosed Flare #4 Exhaust Sample Location**		
	Scale None	Sheet 1 of 1	IMPACT COMPLIANCE & TESTING

EUICENGINE1 & EUICENGINE2



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"

11/4/2015	**Eagle Valley Landfill Gas Fueled Engine Exhaust Sample Locations**	
	Scale None	Sheet 1 of 1

IMPACT COMPLIANCE & TESTING

Appendix 2

- Facility Operating Records