Consumers Energy
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40 CFR Part 60 Subpart JJJJ Compliance Test Report

EUENGINE1

Consumers Energy Company
Huron Compressor Station
3520 Bay Port Road
Sebewaing, MI 48759

December 11, 2019

Test Date: November 5, 2019

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order 35467347

Version No.: 1.0

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EXECUTIVE SUMMARY

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) conducted nitrogen oxides (NO_x), carbon monoxide (CO) and Volatile Organic Compound (VOC) performance testing at the exhaust location of EUENGINE1, a 4-stroke, lean-burn (4SLB) natural gas-fired, reciprocating internal combustion engine (RICE) used to drive a natural gas compressor operating at the Huron Compressor Station located in Sebewaing, Michigan.

The test was conducted on November 5, 2019 to satisfy performance test requirements and verify compliance with United States Environmental Protection Agency (USEPA) 40 CFR Part 60, Subpart JJJJ, *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines.* The engine is also subject to 40 CFR Part 63, Subpart ZZZZ, *National Emissions Standards for Hazardous Air Pollutants* (NESHAP) *for Stationary Reciprocating Internal Combustion Engines,* however the NESHAP requirements do not apply because the unit meets the *new or reconstructed stationary RICE located at an area source* criteria in 40 CFR Part 63, Subpart ZZZZ, § 63.6590(c)(1), and as evidenced in this report, is compliant with 40 CFR Part 60 Subpart JJJJ.

A test protocol submitted to the Michigan Department of Environment, Great Lakes, and Energy (EGLE), September 9, 2019, was subsequently approved by Mr. Thomas Gasloli, Environmental Quality Analyst, in a letter dated September 25, 2019. No deviations from the approved stack test protocol or USEPA Reference Methods (RM) therein occurred.

Triplicate one-hour CO, NO_x, VOC (as NMOC) and oxygen (O_2) runs were conducted at the engine exhaust as specified in *Subpart JJJJ of Part 60 – Requirements for Performance Tests, Table 2,* following 40 CFR Part 60, Appendix A, RM 1, 3A, 4 (Alt-008), 7E, 10, and 25A. The measured concentrations were used to calculate emission rates using Equations 1 – 3 found in 40 CFR Part 60, Subpart JJJJ §60.4244(d) (e) and (f). During testing, the engine operated within ± 10 percent of 100 percent peak (or the highest achievable) load, as specified in 40 CFR §60.4244(a). A summary of EUENGINE1 test results and emission limits is provided in Table E-1.

Table E-1
Summary of EUENGINE1 Test Results and Emission Limits

Parameter	Units	Result	40 CFR Part 60, Subpart JJJJ Limit
NO_x	g/HP-hr	0.37	1.0
	ppmvd at 15% O_2	28	82
CO	g/HP-hr	0.1	2.0
VOC (as NMNEOC)	g/HP-hr	0.01	0.7
	ppmvd at 15% O_2	1.0	60

NO_x nitrogen oxides
CO carbon monoxide
VOC (as NMNEOC) volatile organic compounds as non-methane non-ethane organic compounds, reported as propane
g/HP-hr grams per horsepower hour

Detailed results are presented in Appendix Table 1. Sample calculations, field data sheets, and laboratory data sheets are presented in Appendices A, B, and C. Engine operating data and supporting documentation are provided in Appendices D and E.

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1.0 INTRODUCTION

This report summarizes compliance air emission results from tests conducted at the Consumers Energy Huron Compressor Station (HCS) in Sebewaing, Michigan.

1.1 Identification, Location, and Dates of Tests

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) conducted nitrogen oxides (NO_x), carbon monoxide (CO) and Volatile Organic Compound (VOC) performance testing at the exhaust location of EUENGINE1, a 4-stroke, lean-burn (4SLB) natural gas-fired, reciprocating internal combustion engine (RICE) used to drive a natural gas compressor operating at the Huron Compressor Station located in Sebewaing, Michigan.

A test protocol submitted to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) on September 9, 2019 was subsequently approved by Mr. Thomas Gasloli, Environmental Quality Analyst, in a letter dated September 25, 2019. There were no deviations from the approved stack test protocol or associated USEPA Reference Methods.

1.2 Purpose of Testing

The test was conducted on November 5, 2019 to satisfy performance test requirements and verify compliance with United States Environmental Protection Agency (USEPA) 40 CFR Part 60, Subpart JJJJ, *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines.* EUENGINE1 is also subject to 40 CFR Part 63, Subpart ZZZZ, *National Emissions Standards for Hazardous Air Pollutants* (NESHAP) *for Stationary Reciprocating Internal Combustion Engines,* however as a new stationary RICE located at an area source, 40 CFR 63 §63.6590(c)(1) states that NESHAP test requirements do not apply when the engine is meeting 40 CFR Part 60 Subpart JJJJ requirements. The applicable emission limits are shown in Table 1-1.

Table 1-1
EUENGINE1 Emission Limits

Parameter	Emission Limit	Units[1]	Applicable Requirement
NO_x	1.0	g/HP-hr	40 CFR Part 60, Subpart JJJJ, Table 1
	82	ppmvd at 15% O_2	
CO	2.0	g/HP-hr	
VOC (as NMN**E**OC)	0.7	g/HP-hr	
	60	ppmvd at 15% O_2	

NO_x nitrogen oxides
CO carbon monoxide
VOC (as NMNEOC) volatile organic compounds as non-methane non-ethane organic compounds, reported as propane
g/HP-hr grams per horsepower hour
ppmvd at 15% O_2 part per million by volume, dry basis

[1]*Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/HP-hr or ppmvd at 15 percent O2* (40 CFR Part 60, Subpart JJJJ, Table 1(a))

1.3 Brief Description of Source

EUENGINE1 is coupled to a compressor used to transport natural gas into storage fields or transmission lines. An initial compliance demonstration was conducted on December 8, 2016, with this November 5, 2019 continuous compliance demonstration the follow up.

1.4 Contact Information

Table 1-2 contains the test affiliated persons names, addresses and telephone numbers for further information regarding the test and test report.

Table 1-2
Contact Information

Program Role	Contact	Address
State Regulatory Administrator	Ms. Karen Kajiya-Mills Technical Programs Unit Manager 517-335-4874 kajiya-millsk@michigan.gov	Michigan Department of Environment, Great Lakes & Energy (EGLE) 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Technical Programs Field Inspector	Mr. Tom Gasloli Field Operations Section 517-284-6778 gaslolit@michigan.gov	
State Regulatory Inspector	Mr. Chris Hare District Supervisor 989-894-6215 karlm@michigan.gov	EGLE – Air Quality Division Saginaw Bay District 401 Ketchum Street, Suite B Bay City, Michigan 48708
Responsible Official	Mr. Gregory Baustian Executive Director of Gas Compression 616-237-4009 gregory.baustian@cmsenergy.com	Consumers Energy Company Zeeland Generation 425 N. Fairview Road Zeeland, Michigan 49464
Corporate Air Quality Contact	Ms. Amy Kapuga Senior Engineer 517-788-2201 amy.kapuga@cmsenergy.com	Consumers Energy Company Environmental Services Department 1945 West Parnall Road Jackson, Michigan 49201
Field Environmental Coordinator	Mr. Thomas Fox Senior Engineer 989-667-5153 thomas.fox@cmsenergy.com	Consumers Energy Company Bay City Customer Service Center 4141 E. Wilder Road Bay City, MI 48706
Test Facility	Mr. Chuck Kelly Gas Field Lead 586-784-2096 charles.kelly@cmsenergy.com	Consumers Energy Company Ray Compressor Station 69333 Omo Road Armada, Michigan 48005
Test Team Representative	Mr. Joe Mason, QSTI Sr. Engineering Technical Analyst 616-738-3385 joe.mason@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460

2.0 SUMMARY OF RESULTS

2.1 Operating Data

During the performance test, the engine fired natural gas, and pursuant to §60.4244(a), operated within 10% of 100 percent peak (or the highest achievable) load. The performance testing was conducted with the engines operating at an average load >91%

torque and horsepower, based on the maximum manufacturer's design capacity at engine and compressor site conditions. Refer to Appendix D for detailed operating data.

2.2 Applicable Permit Information

EUENGINE1 qualified for a State of Michigan Permit to Install (PTI) exemption due to the Caterpillar Model G3512B engine ratings and specifications, and because it is the only air emission source at Huron Compressor Station. EUENGINE1 operates in accordance with the *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines*, 40 CFR Part 60, Subpart JJJJ.

2.3 Results

The test results in Table 2-1 indicate EUENGINE1 complies with the applicable NO_x, CO and VOC emission limits.

Table 2-1
Summary of EUENGINE1 Test Results and Emission Limits

Parameter	Units	Result	40 CFR Part 60, Subpart JJJJ Limit
NO_x	g/HP-hr	**0.37**	1.0
CO	g/HP-hr	**0.06**	2.0
VOC (as NMNEOC)	g/HP-hr	**0.01**	0.7

NO_x nitrogen oxides
CO carbon monoxide
VOC (as NMNEOC) volatile organic compounds as non-methane non-ethane organic compounds, reported as propane
g/HP-hr grams per horsepower hour

Detailed results are presented in Appendix Table 1. A discussion of the results is presented in Section 5.0. Sample calculations, field data sheets, and laboratory data sheets are presented in Appendices A, B, and C. Engine operating data and supporting documentation are provided in Appendices D and E.

3.0 SOURCE DESCRIPTION

The Huron Compressor Station is a natural gas compressor station. The facility operates EUENGINE1 to run a compressor to maintain pressure of natural gas in order to move it in and out of storage reservoirs and along the pipeline system. A summary of the engine specifications from vendor data are provided in Table 3-1.

Table 3-1
Summary of Engine Specifications

Parameter[1]	EUENGINE1
Make	Caterpillar
Model	G3512B
Output (brake-horsepower)	1,035
Heat Input, LHV (mmBtu/hr)	8.47
Exhaust Flow Rate (ACFM, wet)	6,725
Exhaust Gas Temp. (°F)	975
Engine Outlet O_2 (Vol-%, dry)	9.5
Engine Outlet CO_2 (g/bph-hr)	455

Table 3-1
Summary of Engine Specifications

Parameter[1]	EUENGINE1
CO, Uncontrolled (b/bph-hr)	2.24
CO, Controlled [2] (ppmv, dry)	0.16

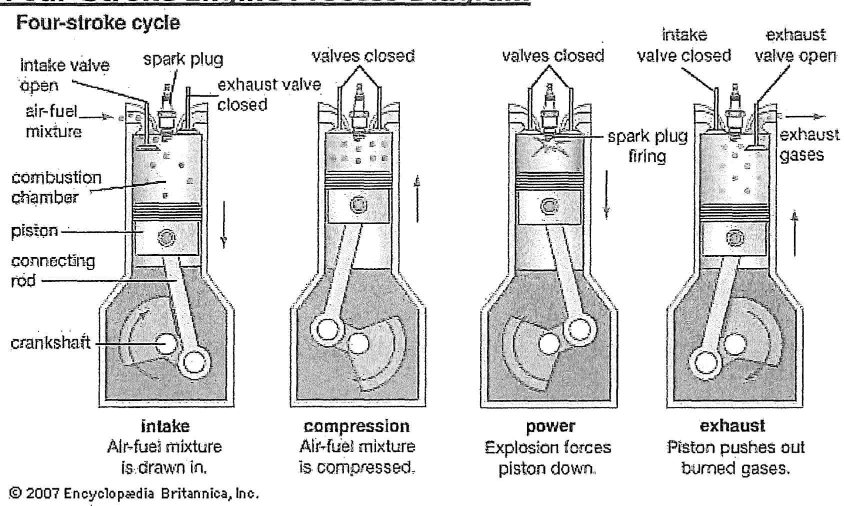
1 Engine parameters are based upon vendor data for operation at 100% of rated engine capacity
2 The controlled CO concentrations are based upon the vendor not to exceed CO concentrations at 100% load, and a reduction of 93% by volume for the associated oxidation catalysts.

3.1 Process

The engine utilizes a four-stroke cycle which starts with the downward air intake piston stroke which aspirates air through intake valves into the combustion chamber (cylinder). As the piston nears the bottom of the cylinder, fuel is injected and the intake valves close. As the piston travels upward, the air/fuel mixture is compressed and ignited, thus forcing the piston downward into the power stroke. At the bottom of the power stroke, exhaust valves open and the piston traveling upward expels the combustion by-products.

Refer to Figure 3-1 for a four-stroke engine process diagram.

Figure 3-1. Four-Stroke Engine Process Diagram



3.2 Process Flow

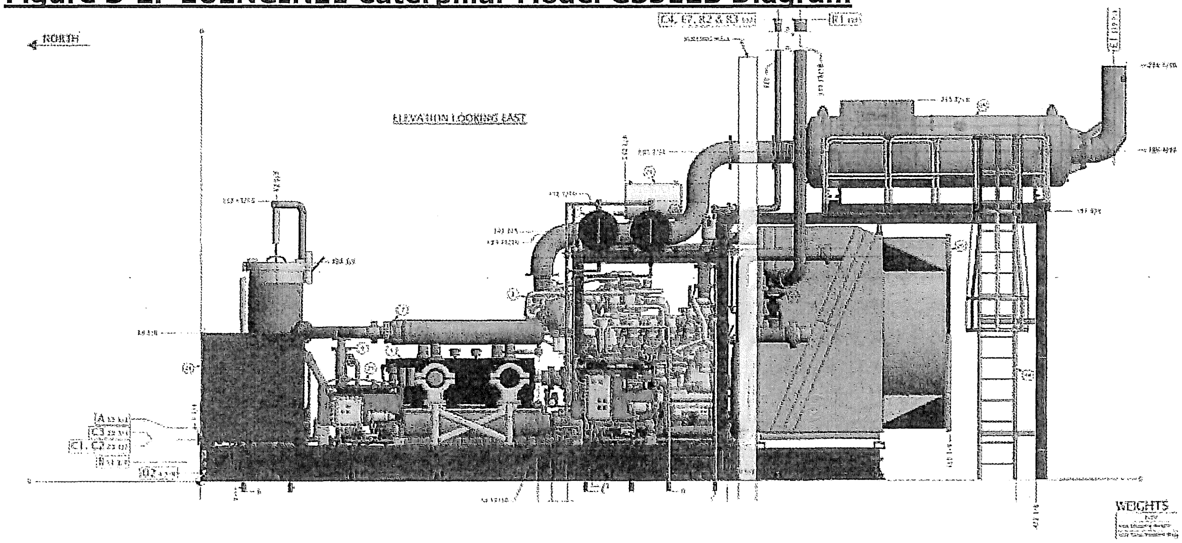
Engine NOx emissions are minimized using lean-burn combustion technology, achieved when a high level of excess air (generally 50% to 100% relative to the stoichiometric amount) is in the combustion chamber. The excess air absorbs combustion heat, thereby reducing combustion temperature and pressure, with lower NOx emissions the result.

Natural gas combustion by-products are controlled by parametric controls (i.e., timing and lean air-to-fuel operating ratios) and by a post-combustion oxidizing catalyst. The catalyst module installed on the engine exhaust stack uses proprietary materials to align oxidation temperatures of CO and other organic compounds to engine exhaust gas temperatures, thus maximizing catalyst efficiency. Exhaust gas CO and VOC is oxidized to CO_2 and water, and NO to NO_2 conversion is suppressed.

The catalyst vendor guarantees 93% CO destruction efficiency, while control of formaldehyde and non-methane, non-ethane hydrocarbons (NMNEHC) are estimated to be 85% and 75%, respectively.

Refer to Figure 3-2 for the Huron Compressor Station EUENGINE1 Caterpillar Model G3512B diagram.

Figure 3-2. EUENGINE1 Caterpillar Model G3512B Diagram



3.3 Materials Processed

The engine fires natural gas containing sulfur content less than 20 grains/100 scf with a total heating value per cubic foot between 950 and 1,100 Btu, as documented in pipeline natural gas tariff sheets supplied to Consumers Energy Compressor Stations.

3.4 Rated Capacity

The engine has a rated heat input of 8.47 mmBtu/hr with a maximum output of 1,035 horsepower.

3.5 Process Instrumentation

During testing, the following engine operating parameters were continuously monitored and collected in one-minute increments:

- Date and time
- Engine speed (RPM)
- Engine torque (%)
- Engine horsepower (BHP)
- Fuel gas flow (scfh)
- Suction pressure (psi)
- Discharge pressure (psi)

Refer to Appendix D for this operating data.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Triplicate one-hour test runs for NO_x, CO, VOC, and oxygen (O_2) concentrations were conducted using the USEPA test methods in Table 4-1. The sampling and analytical procedures associated with each parameter are described further in the following sections.

Table 4-1
Test Methods

Parameter	Method	USEPA Title
Sample traverses	1	Sample and Velocity Traverses for Stationary Sources
Oxygen	3A	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Moisture content	ALT-008/4	Alternative Moisture Measurement Method Midget Impingers/Determination of Moisture Content in Stack Gases
Nitrogen oxides (NO_x)	7E	Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Carbon monoxide (CO)	10	Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Methane (CH_4) & Ethane (C_2H_6)	18	Measurement of Gaseous Organic Compound Emissions by Gas Chromatography
Emission rates	19	Sulfur Dioxide Removal and Particulate, Sulfur Dioxide and Nitrogen Oxides from Electric Utility Steam Generators
Volatile organic compounds	25A	Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer

4.1 Description of Sampling Train and Field Procedures

The test matrix in Table 4-2 summarizes the sampling and analytical methods performed during this test program.

Table 4-2 Test Matrix

Date (2019)	Run	Sample Type	Start Time (EST)	Stop Time (EST)	Test Duration (min)	EPA Test Method	Comment
EUENGINE1							
November 5	1	O_2, NO_x, CO, CH_4, C_2H_6, VOC	10:45	11:45	60	1, 3A, 4, 7E, 10, 18, 19, 25A	1-point located in the exhaust duct at approximately 50.0 % of the sample location diameter
	2		12:45	13:45	60		
	3		14:00	15:00	60		

4.2 Sample Location and Traverse Points (USEPA Method 1)

The number and location of traverse points was evaluated according to the requirements in Table 4 of 40 CFR Part 63, Subpart ZZZZ, Table 2 of 40 CFR Part 60, Subpart JJJJ, and USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources*.

EUENGINE1 is equipped with sample ports located upstream and downstream (Pre and Post) of the oxidation catalyst. Note that the existing post catalyst sample ports could not be accessed, therefore a ¾" hole was drilled in the stack wall on the same plane as the existing ports for use as a sample port during the test.

The downstream ports are located:

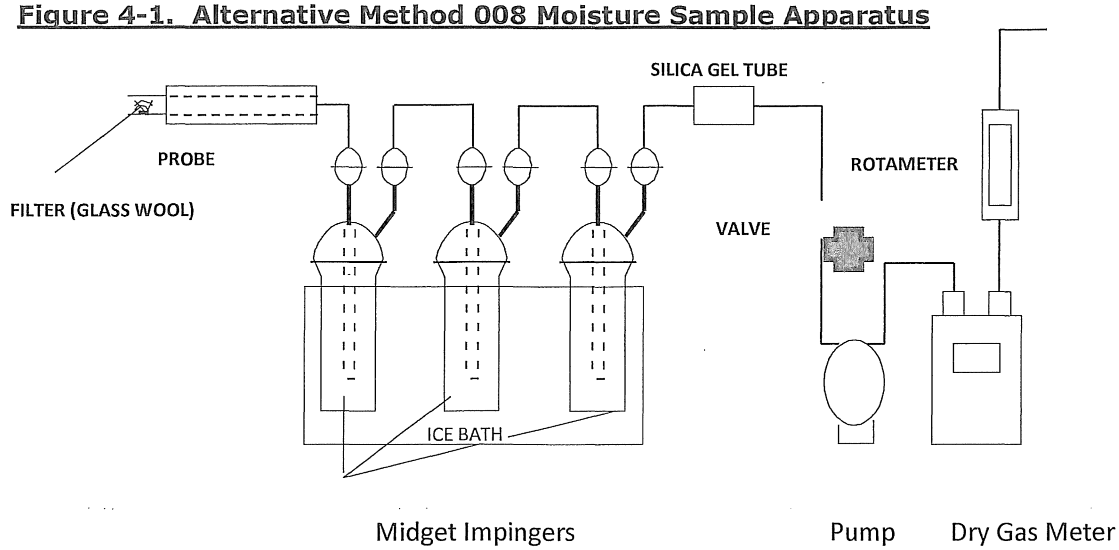
- At least 28 inches (2.0 duct diameters) downstream of a duct bend (disturbance) at the engine exhaust, and
- At least 7 inches (0.5 duct diameters) upstream the stack exit.

With the exhaust duct outer diameter measuring 14 inches, the sample port locations met the two and one-half diameter upstream-downstream criterion in Section 11.1.1 of Method 1 and RCTS planned to sample exhaust gas at equal intervals from each of three traverse points located at 16.7, 50.0, and 83.3% of the measurement line (the 3-point long line) during each run. However, EGLE representative Mr. Thomas Gasloli indicated a single sample point located within the centroid section of the duct would be sufficient, as gas stratification was unlikely.

4.3 Moisture Content (USEPA ALT-008)

Exhaust gas moisture content was determined in accordance with USEPA ALT-008, *Alternative Moisture Measurement Method Midget Impingers*, an alternative method for correcting pollutant concentration data to appropriate moisture conditions (e.g. pollutant and/or air flow data on a dry or wet basis) validated May 19, 1993 by the USEPA Emission Measurement Branch. The procedure is incorporated into Method 6A of 40 CFR Part 60 and is based on field validation tests described in *An Alternative Method for Stack Gas Moisture Determination* (Jon Stanley, Peter Westlin, 1978, USEPA Emissions Measurement Branch). The sample apparatus configuration follows the general guidelines contained in Figure 4-2 and § 8.2 of USEPA Method 4, *Determination of Moisture Content in Stack Gases,* and ALT-008 Figure 1 or 2. The flue gas is withdrawn from the stack at a constant rate through a heated sample probe, umbilical, four midget impingers, and a metering console with pump. The moisture is removed from the gas stream in the ice-bath chilled impingers and determined gravimetrically. Refer to Figure 4-1 for a figure of the Alternative Method 008 Moisture Sample Apparatus.

Figure 4-1. Alternative Method 008 Moisture Sample Apparatus



The silica gel tube depicted in the figure above was replaced with a midget impinger (bubbler) with a straight tube insert, as allowed in ALT-008, §1

4.4 O_2, NO_X, and CO (USEPA Methods 3A, 7E, and 10)

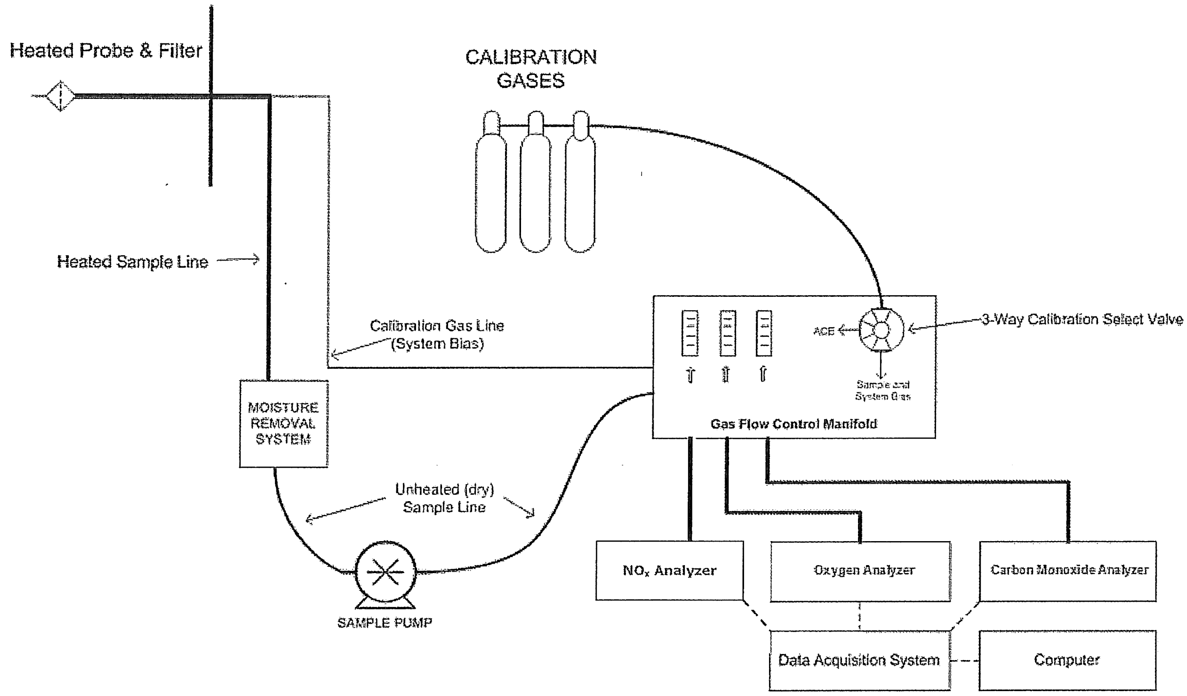
Oxygen, nitrogen oxides, and/or carbon monoxide concentrations were measured using the following sampling and analytical procedures:

- USEPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure),*
- USEPA Method 7E, *Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)*, and
- USEPA Method 10, *Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure).*

Each cited method sampling is procedurally similar with the exception of the analyzer and analytical technique used. Engine exhaust gas was extracted from the stacks or ducts through a stainless-steel probe, heated Teflon® sample line, and through a gas conditioning system to remove water and dry the sample before entering a sample pump, flow control manifold, and gas analyzers.

Figure 4-2 depicts a drawing of the Methods 3A, 7E, and 10 sampling system.

Figure 4-2. USEPA Methods 3A, 7E, and 10 Sampling System



Prior to sampling engine exhaust gas, the analyzers are calibrated by performing a calibration error test where zero-, mid-, and high-level calibration gases are introduced directly to the back of the analyzers. The calibration error check is performed to evaluate if the analyzers response was within ±2.0% of the calibration gas span or high calibration gas concentration. An initial system-bias test is then performed where the zero- and mid- or high- calibration gases are introduced at the sample probe to measure the ability of the system to respond accurately to within ±5.0% of span.

A NO_2 to NO conversion efficiency test is performed on the NO_X analyzer prior to beginning the test program to evaluate the ability of the instrument to convert NO_2 to NO before analyzing for NO_X.

Upon successful completion of the calibration error and initial system bias tests, sample flow rate and component temperatures are verified, and the probes inserted into the ducts at the appropriate traverse point. After confirming the engine is operating at established conditions, the test run is initiated. Gas concentrations are recorded at 1-minute intervals throughout each 60-minute test run. Oxygen concentrations are measured to adjust the pollutant concentrations to 15% O_2 and calculate pollutant emission rates.

At the conclusion of each test run, a post-test system bias check is performed to compare analyzer bias and drift relative to pre-test system bias checks, ensuring analyzer bias is within ±5.0% of span and drift is within ±3.0%. The analyzer response is also used to correct measured gas concentrations for analyzer drift.

4.5 Emission Rates (USEPA Method 19)

USEPA Method 19, *Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*, was used to calculate exhaust gas flowrate.

The default natural gas fuel factor in Method 19 is then used to calculate the emission flow rate with the corresponding equation presented in Figure 4-3. The flow rate was used in calculations to present emissions in units of g/HP-hr.

Figure 4-3. USEPA Method 19 Emission Flow Rate Equation

$$Q_s = F_d H \frac{20.9}{20.9 - O_2}$$

Where:

Q_s = stack flow rate (dscf/min)
F_d = Volumes of combustion components per unit of heat content (scf/mmBtu)
H = fuel heat input rate, (mmBtu/min), at the higher heating value (HHV) measured at engine fuel feed line, calculated as (fuel feed rate in ft^3/min) x (fuel heat content in mmBtu/ft^3)
O_2 = stack oxygen concentration, dry basis (%)

4.6 Volatile Organic Compounds (USEPA Methods 18 and 25A)

VOC concentrations were measured using a Thermo Model 55i Direct Methane and Non-methane Analyzer following the guidelines of USEPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer (FIA)*. The instrument uses a flame ionization detector (FID) to measure the exhaust gas total hydrocarbon concentration in conjunction with a gas chromatography column that separates methane from other organic compounds.

The components of the extractive sample interface apparatus are constructed of Type 316 stainless steel and Teflon. Flue gas was sampled from the stack via a sample probe and heated sample line and into the analyzer, which communicates with data acquisition handling systems (DAHS) via output signal cables. The analyzer uses a rotary valve and gas chromatograph column to separate methane from hydrocarbons in the sample and quantifies these components using a flame ionization detector.

Sample gas is injected into the column and due to methane's low molecular weight and high volatility, the compound moves through the column more quickly than other organic compounds that may be present and is quantified by the FID. The column is then flushed with inert carrier gas and the remaining non-methane organic compounds are analyzed in the FID. This analytical technique allows separate measurements for methane and non-methane organic compounds via the use of a single FID. Refer to Figure 4-3 for a drawing of the USEPA Method 25A sampling apparatus.

The field VOC instrument was calibrated with zero air and three propane and methane in air calibration gases following USEPA Method 25A procedures at the zero level, low (25 to 35 percent of calibration span), mid (45 to 55 percent of calibration span) and high (equivalent to 80 to 90 percent of instrument span). Note that the field VOC instrument measures on a wet basis, therefore measured exhaust gas moisture content was used to convert wet basis VOC concentrations to dry and calculate VOC mass emission rates.

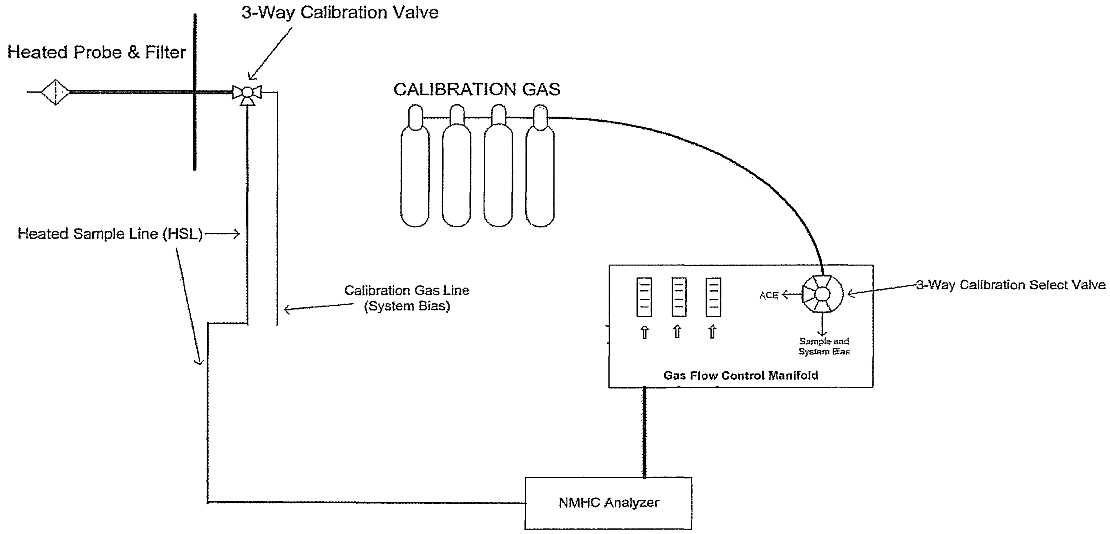
Also note that 40 CFR Part 60, Subpart JJJJ refers to the definition of VOC found in 40 CFR, Part 51 and does not include methane or ethane. Specifically, §51.100(s)(1) defines VOC as *"any compound of carbon…other than the following, which have been determined to have negligible photochemical reactivity: methane, ethane…"* The Thermo 55i field analyzer used includes exhaust gas ethane as part of the NMOC measurement. Therefore, one tedlar bag sample per test run was collected in bags manufactured from polyvinyl fluoride (PVF) film, also known as Tedlar film, to quantify the ethane fraction of the NMOC concentration using

USEPA Method 18, *Measurement of Gaseous Organic Compound Emissions by Gas Chromatography*.

The methane and ethane bag concentrations were measured by separating the major organic components using a gas chromatograph (GC) column equipped with a suitable detector. To identify and quantify the major components, the retention times of each separated component were compared with those of known compounds under identical conditions. The approximate concentrations were estimated before analysis and standard mixtures prepared so the GC/detector was calibrated under physical conditions identical to those used for the samples.

Method 18 requires the sample results to be corrected based on results obtained from a spike recovery study. For the bag sampling technique to be considered valid for a compound, the recovery must be between 70% <R < 130%. The recovery study performed on the Huron Compressor engine Tedlar bag samples successfully achieved the R value requirement and that value was applied to correct the reported methane and ethane concentrations as propane. The USEPA Method 18 laboratory report is presented in Appendix E.

Figure 4-4. USEPA Method 25A Sample Apparatus



5.0 TEST RESULTS AND DISCUSSION

The November 5, 2019 test program satisfies the performance testing and compliance evaluation requirements in 40 CFR Part 60, Subpart JJJJ, *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines*.

5.1 Tabulation of Results

The results of the NO_x, CO, and VOC engine emissions test indicate compliance with the applicable emissions limits summarized in Table 2-1. Appendix Table 1 contains detailed tabulation of results, process operating conditions, and exhaust gas conditions for the RICE.

5.2 Significance of Results

The results of the testing indicate compliance with the applicable emission limits.

5.3 Variations from Sampling or Operating Conditions

Please note the approved test protocol contains a statement that in the event of elevated VOC concentrations, one Tedlar bag sample may be collected to verify the methane and ethane using Method 18 analysis. Based on discussions with onsite EGLE representatives, this approach was expanded to include collecting one Tedlar bag sample per test run.

Also note the Thermo 55i field VOC analyzer used was initially not functioning properly due to back pressure caused by condensed moisture in the instrument exhaust, diagnosed after a phone call with Thermo Scientific. Once the condensation was cleared, the instrument operated properly, meeting all required QAQC criteria.

5.4 Process or Control Equipment Upset Conditions

The engine and gas compressor were operating under maximum routine conditions and no upsets were encountered during testing.

5.5 Air Pollution Control Device Maintenance

No major air pollution control device maintenance was performed during the three-month period prior to the test event. Engine optimization is continuously performed to ensure lean-burn combustion and ongoing compliance with regulatory emission limits.

5.6 Re-Test Discussion

Based on the results of this test program, a re-test is not required. Subsequent air emissions testing on the engines will be performed:

- Every 8,760 engine operating hours or 3 years (2022), whichever is first, thereafter to evaluate compliance with NO_x, CO, and VOC emission limits in 40 CFR Part 63, Subpart JJJJ.

5.7 Results of Audit Samples

Audit samples for the reference methods utilized during this test program are not available from USEPA Stationary Source Audit Sample Program providers.

The USEPA reference methods performed state reliable results are obtained by persons equipped with a thorough knowledge of the techniques associated with each method. Factors with the potential to cause measurement errors are minimized by implementing quality control (QC) and assurance (QA) programs into the applicable components of field testing. QA/QC components were included in this test program. Table 5-1 summarizes the primary field quality assurance and quality control activities that were performed. Refer to Appendix E for supporting documentation.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluates sampling location suitability for sampling	Measure distance from ports to downstream and upstream flow disturbances	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Duct diameter/ dimensions	Verifies area of stack is accurately measured	Review as-built drawings and field measurement	Pre-test	Field measurement agreement with as-built drawings
M3A, M7E, M10, M25A: Calibration gas standards	Ensures accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A, M7E, M10: Calibration Error	Evaluates analyzer operation	Calibration gases introduced directly into analyzers	Pre-test	±2.0% of calibration span
M3A, M7E, M10: System Bias and Analyzer Drift	Evaluates analyzer/sample system integrity and accuracy over test duration	Calibration gas introduced at sample probe tip, HSL, and into analyzers	Pre-test and Post-test	Bias: ±5.0% of calibration span Drift: ±3.0% of calibration span
M7E: NO_2-NO converter efficiency	Evaluates NO_2-NO converter operation	NO_2 calibration gas introduced directly into analyzer	Pre-test or Post-test	NO_x response ≥90% of certified NO_2 calibration gas
M25A: Calibration Error	Evaluates analyzer and sample system operation	Calibration gases introduced through sample system	Pre-test	±5.0% of the calibration gas value
M25A: Zero and Calibration Drift	Evaluates analyzer/sample system integrity and accuracy over test duration	Calibration gases introduced through sample system	Pre-test and Post-test	±3.0% of the analyzer calibration span

5.8 Calibration Sheets

Calibration sheets, including gas protocol sheets and analyzer quality control and assurance checks are presented in Appendix E.

5.9 Sample Calculations

Sample calculations and formulas used to compute emissions data are presented in Appendix A.

5.10 Field Data Sheets

Field data sheets are presented in Appendix B.

5.11 Laboratory Quality Assurance / Quality Control Procedures

The method specific quality assurance and quality control procedures in each method employed during this test program were followed, without deviation. Refer to Appendix C for the laboratory data sheets associated with the natural gas fuel samples collected during the test program.

5.12 QA/QC Blanks

The Method 3A, 7E, 10, and 25A calibration gases described in Table 5-1 above were the only QA/QC media employed during the test event. QA/QC data are shown in Appendix E.