EXECUTIVE SUMMARY

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compound (VOC) testing at the exhaust of EUEMERGGEN installed at the Consumers Energy White Pigeon Compressor Station in White Pigeon, Michigan. The facility is classified as a major source of hazardous air pollutants (HAP) and the >500 horsepower engine is a natural gas-fired, four-stroke lean-burn (4SLB), spark ignited (SI), reciprocating internal combustion engine (RICE), powering an emergency generator to provide electricity for the site during power outages. EUEMERGGEN is the emissions unit identified within Michigan Department of Environment, Great Lakes and Energy (EGLE) Renewable Operating Permit (ROP) MI-ROP-N5573-2018 and is subject to federal air emissions regulations.

The test program was conducted March 3, 2020 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 60, Subpart JJJJ, *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines*, (aka NSPS SI ICE), and the ROP.

Three, 60-minute test runs were conducted at the engine following the procedures in United States Environmental Protection Agency (USEPA) Reference Methods (RM) 1, 3A, 4, 7E, 10, 19, and 25A in 40 CFR Part 60, Appendix A. There was one deviation from the approved stack test protocol or associated USEPA Reference Methods which was approved by the attending EGLE representative. During testing, EUEMERGGEN operated at horsepower and torque conditions within plus or minus (±) 10 percent of 100 percent peak (or the highest achievable) load, as specified in 40 CFR 60.4244(a).

The EUEMERGGEN test results indicate the NO_x, CO, and VOC emissions are compliant with applicable emissions limits, as summarized in Table E-1 below.

Table E-1
Summary of Test Results

Parameter	Units	Average Result of 3 Test Runs EUEMERGGEN	Emission Limit	
			40 CFR Part 60, Subpart JJJJ[1]	MI-ROP-N5573-2018
NO_x	g/HP-hr	0.41	2.0	0.5
	ppmvd at 15% O_2	29.9	160	
CO	g/HP-hr	2.23	4.0	
	ppmvd at 15% O_2	269.1	540	
VOC	g/HP-hr	0.51	1.0	
	ppmvd at 15% O_2	39.0	86	

NO_x nitrogen oxides
CO carbon monoxide
VOC volatile organic compounds (non-methane organic compounds), as propane
g/HP-hr grams per horsepower hour
ppmvd at 15% O_2 parts 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 O_2

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

1.0 INTRODUCTION

This report summarizes the results of compliance air emissions testing conducted March 3, 2020 at the Consumers Energy White Pigeon Compressor Station (WPCS) in White Pigeon, Michigan.

This document follows the Michigan Department of Environment, Great Lakes and Energy (EGLE) format described in the November 2019, Format for Submittal of Source Emission Test Plans and Reports. Reproducing only a portion of this report may omit critical substantiating documentation or cause information to be taken out of context. If any portion of this report is reproduced, please exercise due care in this regard.

1.1 Identification, Location, and Dates of Tests

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compound (VOC) testing of the stationary, spark-ignition (SI), reciprocating internal combustion engine (RICE), identified as EUEMERGGEN installed at WPCS in White Pigeon, Michigan on March 3, 2020.

A test protocol submitted to EGLE on December 18, 2019 was subsequently approved by Ms. Lindsey Wells, EGLE Environmental Quality Analyst, in a letter dated February 18, 2020. Ms. Wells and Mr. Chance Collins of EGLE were in attendance and observed portions of the compliance test. There was one process parameter deviation from the approved stack test protocol during the emissions test which was approved by the Mr. Collins. This deviation will be discussed in further detail in section 5.3 of this report.

1.2 Purpose of Testing

The test program was conducted March 3, 2020 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 60, Subpart JJJJ, "Standards of Performance for Stationary Spark Ignition Internal Combustion Engines," (aka NSPS SI ICE) and MI-ROP-N5573-2018. The applicable emission limits are presented in Table 1-1.

Table 1-1
Applicable Emission Limits

Parameter	Emission Limit	Units	Applicable Requirement
NO_x	0.5	g/HP-hr	MI-ROP-N5573-2018
	2.0	g/HP-hr	40 CFR Part 60, Subpart JJJJ
	160	ppmvd at 15% O_2	
CO	4.0	g/HP-hr	
	540	ppmvd at 15% O_2	
VOC†	1.0	g/HP-hr	
	86	ppmvd at 15% O_2	

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

† 40 CFR Part 60, Subpart JJJJ defines volatile organic compounds as found in 40 CFR, Part 51.100(s)(1)"*any compound of carbon…other than the following, which have been determined to have negligible photochemical reactivity: methane, ethane…* Therefore, Subpart JJJJ exhaust gas measurements of VOC will include only the total non-methane, non-ethane organic compounds.

1.3 Brief Description of Source

EUEMERGGEN is a >500 horsepower, natural gas-fired, four-stroke lean-burn (4SLB), spark ignited (SI), reciprocating internal combustion engine (RICE) powering an emergency electric generator to provide electricity for the site during power outages. The engine is identified as the emissions unit EUEMERGGEN within MI-ROP-N5573-2018.

1.4 Contact Information

Table 1-2 presents the names, addresses, and telephone numbers of the contacts for information regarding the test and the test report, and names and affiliation of personnel involved in conducting the testing.

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 and Energy Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Technical Programs Field Inspector	Ms. Lindsey Wells Technical Programs Unit Field Operations Section 517-282-2345 wellsl8@michigan.gov	Michigan Department of Environment, Great Lakes and Energy Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Regulatory Inspector	Mr. Chance Collins Environmental Quality Analyst 269-254-7119 collinsc21@michigan.gov/air	Michigan Department of Environment, Great Lakes and Energy Kalamazoo District Office 7953 Adobe Road Kalamazoo, Michigan 49009-5025
Responsible Official	Mr. Gregory Baustian Executive Director-Natural Gas Compression and Storage 616-638-8037 gregory.baustian@cmsenergy.com	Consumers Energy Company Traverse City Service Center 821 Hastings Street Traverse City, Michigan 49686
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. Gerald (Frank) Rand Jr. Senior Environmental Analyst 734-850-4209 frank.randjr@cmsenergy.com	Consumers Energy Company 7216 Crabb Road Temperance, Michigan 48182
Test Facility	Mr. Timothy Wolf Gas Field Leader III 269-483-2902 timothy.wolf@cmsenergy.com	Consumers Energy Company White Pigeon Compressor Station 68536 A Road, Route 1 White Pigeon, Michigan 49099
Test Team Representative	Mr. Gregg Koteskey, QSTI Engineering Technical Analyst II 616-738-3172 gregg.koteskey@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), the engine was operated at the highest achievable load. The performance testing was conducted with the engine operating at an average load of 92%, based on the maximum manufacturer's design capacity. Refer to Appendix C for detailed operating data.

2.2 APPLICABLE PERMIT INFORMATION

WPCS operates in accordance with MI-ROP-N5573-2018. EUEMERGGEN is the emergency generator emission unit source identified in the permit. Incorporated within the permit are the applicable federal requirements of 40 CFR Part 60, Subpart JJJJ.

2.3 RESULTS

The EUEMERGGEN test results indicate the NO_x, CO, and VOC emissions are compliant with applicable emissions limits, as summarized in Table 2-1 below.

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

Table 2-1
Summary of Test Results

Parameter	Emission Limit	Average Result of 3 Test Runs EUEMERGGEN	Emission Limits	
			40 CFR Part 60, Subpart JJJJ[1]	MI-ROP-N5573-2018
NO_x	g/HP-hr	0.41	2.0	0.5
	ppmvd at 15% O_2	29.9	160	
CO	g/HP-hr	2.23	4.0	
	ppmvd at 15% O_2	269.1	540	
VOC	g/HP-hr	0.51	1.0	
	ppmvd at 15% O_2	39.0	86	

NO_x nitrogen oxides
CO carbon monoxide
VOC volatile organic compounds (non-methane organic compounds), as propane
g/HP-hr grams per horsepower hour
ppmvd at 15% O_2 parts 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 O_2

3.0 SOURCE DESCRIPTION

EUEMERGGEN is operated as an emergency SI ICE in the event of a site power outage. A summary of the engine specifications is presented in Table 3-1.

Table 3-1
Engine Specifications

Parameter[1]	EUEMERGGEN
Purchase Year	2008
Installation Date	June 15, 2010
Make	Caterpillar
Model	G3516B LE
Output (brake-horsepower)	1,818
Heat Input (mmBtu/hr)	12.8
Exhaust Flow Rate (acfm, wet)	11,923
Exhaust Gas Temp. (°F)	947

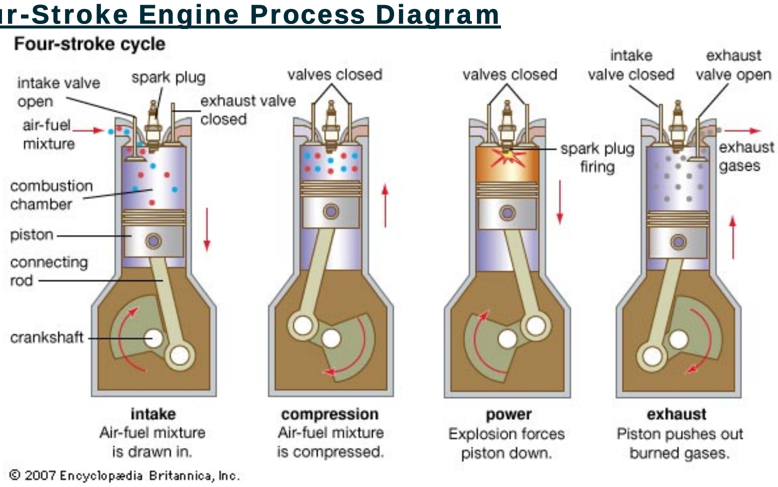
[1] All engine specifications are based upon vendor data for operation at 100% of rated engine capacity.

3.1 PROCESS

EUEMERGGEN is a natural gas-fired 4SLB SI RICE installed in 2010. In a four-stroke engine, air is aspirated into the cylinder during the downward travel of the piston on the intake stroke. The fuel charge is injected when the piston is near the bottom of the intake stroke; the intake ports close as the piston moves to the top of the cylinder, compressing the air/fuel mixture. The ignition and combustion of the air/fuel charge begins the downward movement of the piston called the power stroke. As the piston reaches the bottom of the power stroke, valves are opened and combustion products are expelled from the cylinder as the piston travels upward. A new air-to-fuel charge is injected as the piston moves downward with a new intake stroke.

The engine provides mechanical shaft power to an electricity producing generator. Refer to Figure 3-1 for a four-stroke engine process diagram.

Figure 3-1. Four-Stroke Engine Process Diagram



The natural gas-fired engine flue gas is controlled through parametric controls (i.e., timing and air-to-fuel ratio), and lean burn combustion technology. The Caterpillar engine includes an Advanced Digital Engine Management (ADEM) III electronic control system. The ADEM III electronic controls integrate governing (engine sensing and monitoring, air/fuel ratio control, ignition timing, and detonation control) into one comprehensive engine control system for optimum performance and reliability.

The NO_x emissions from the engine are minimized using lean-burn combustion technology. Lean-burn combustion refers to a high level of excess air (generally 50% to 100% relative to the stoichiometric amount) in the combustion chamber. The excess air absorbs heat during the combustion process, thereby reducing the combustion temperature and pressure and resulting in lower NO_x emissions.

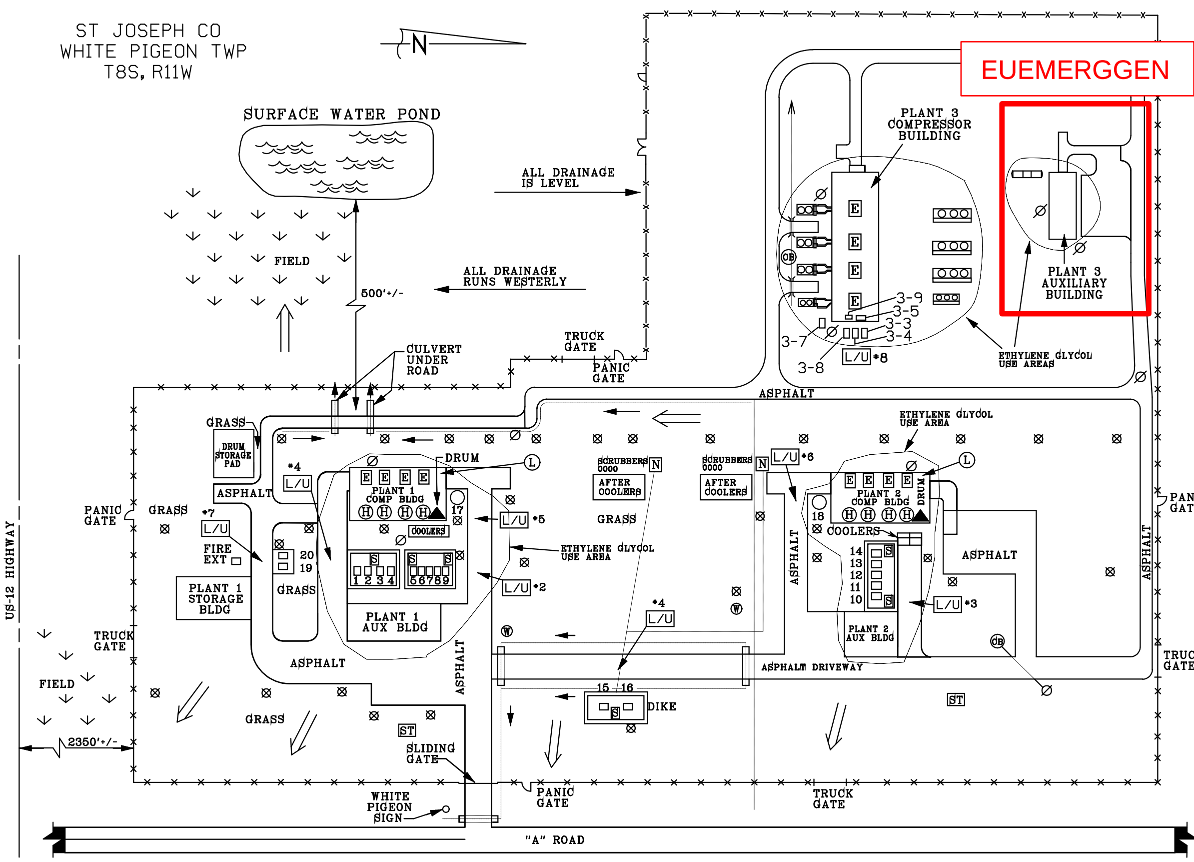
Detailed operating data recorded during testing are provided in Appendix C.

3.2 Process Flow

Located in southwestern St. Joseph County, WPCS helps maintain natural gas pressures in the natural gas pipeline transmission system. The station receives natural gas from the ANR and Trunk line interstate pipeline sources and provides adequate system pressure to support customer load and injection operations at other compressor stations. The Plant 3 compressor engines have the capacity to pump 800 million cubic feet of natural gas a day.

The facility is divided into three plants comprising natural gas reciprocating compressor engines, emergency generators, and associated equipment to maintain pressure in natural gas transmission system. The Plant 3 emergency generator was the focus of this test program. Refer to Figure 3-2 for the White Pigeon Compressor Station Plant 3 Site Map.

Figure 3-2. White Pigeon Compressor Station Plant 3 Site Map



3.3 Materials Processed

The fuel utilized in EUEMERGGEN is exclusively natural gas, as defined in 40 CFR 72.2. During testing, the natural gas combusted within the engines was comprised of approximately 92% methane, 6% ethane, 2% nitrogen, and 0.3% carbon dioxide. The daily natural gas chromatograph analysis results are provided in Appendix C. The gas composition and Btu content were used to calculate site-specific F factors in accordance with USEPA Method 19 and used in emissions rate calculations.

3.4 Rated Capacity

EUEMERGGEN has a maximum power output of approximately 1,818 horsepower, and as equipped with the electric generator, a maximum electrical output of 1,300 kilowatts. The engine has a rated heat input of 12.8 million British thermal units per hour (mmBtu/hour). The engine operating parameters were recorded and averaged for each test run. Refer to Appendix C for operating data recorded during testing.

3.5 Process Instrumentation

The engine operating parameters were continuously monitored during testing by a distributed control system for the Caterpillar engine, data acquisition system, and by Consumers Energy operations personnel. Data were collected at 1-minute intervals during each test for the following parameters:

- Power (BHP)
- Engine speed (rpm)
- Engine Torque / Power Rate (% max)
- Generator Total Current (amps)
- Generator Load (% max)

Engine fuel flow rates during the test were monitored manually from the engine control system, since the facility fuel meter typically used for this purpose was found faulty during test run 1. The minimum and maximum fuel flow rate observed for each test run and the maximum flow rate was manually recorded for each sixty-minute test run.

- Fuel use (scf/min)

Refer to Appendix D for operating data.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy RCTS tested for NO_x, CO, VOC, and oxygen (O_2) concentrations using the United States Environmental Protection Agency (USEPA) test methods presented in Table 4-1. The sampling and analytical procedures associated with each parameter are described 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	4 / ALT-008	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)
Emission rates	19	Sulfur Dioxide Removal and Particulate, Sulfur Dioxide and Nitrogen Oxides from Electric Utility Steam Generators
Volatile organic compounds	25A	Measurement of Gaseous Organic Compound Emissions by Gas Chromatography

4.1 Description of Sampling Train and Field Procedures

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

Table 4-2
Test Matrix

Date (2020)	Run	Sample Type	Start Time (EDT)	Stop Time (EDT)	Test Duration (min)	EPA Test Method	Comment
March 3	1	O_2 NO_x CO VOC	12:38	13:38	60	1 3A 4 7E 10 19 25A	Three-point sample at exhaust stack
	2		14:25	15:25	60		Three-point sample at exhaust stack
	3		15:55	16:55	60		Three-point sample at exhaust stack

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 2 of 40 CFR Part 60, Subpart JJJJ, and USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources*. The sampling location for EUEMERGGEN is presented in Figure 4-1 and discussed in the following section:

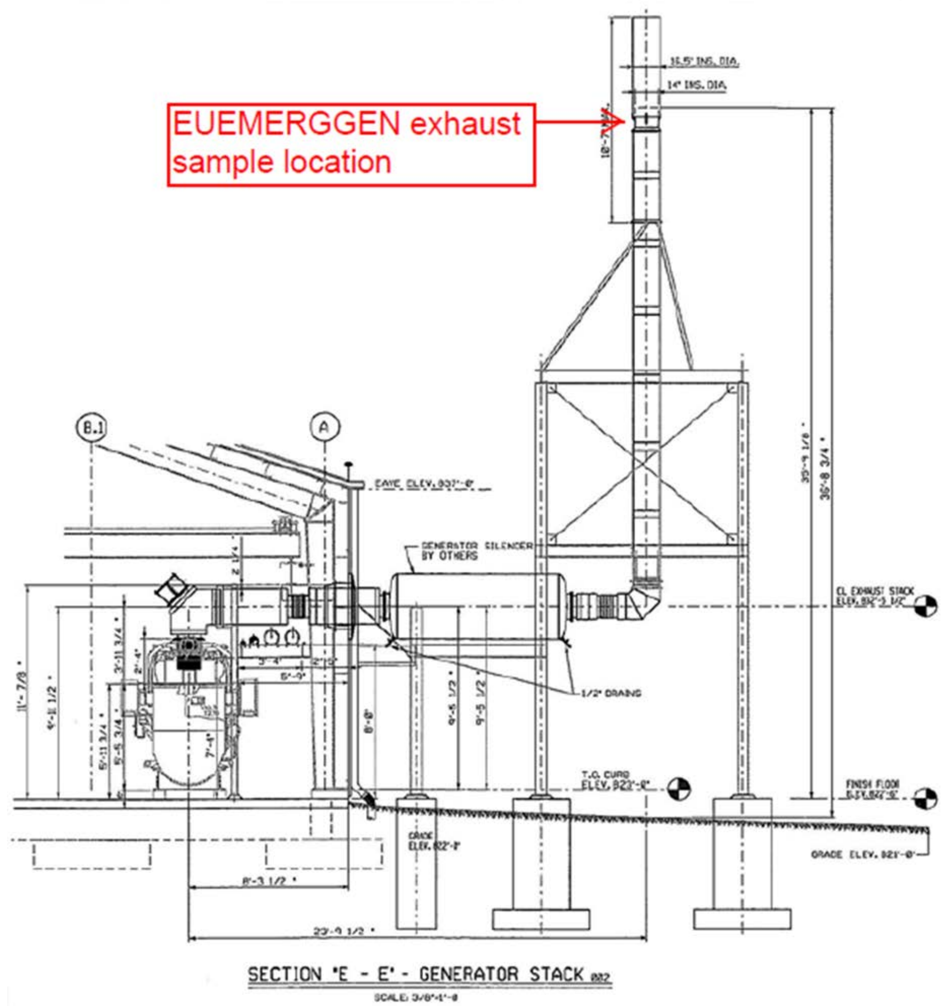
EUEMERGGEN Exhaust

Sample Port located in a 14-inch diameter stack/duct:

- Approximately 309-inches or 22.1 duct diameters downstream of a flow disturbance where the engine exhaust makes a 90 degree turn, and
- Approximately 63.5-inches or 4.5 duct diameters upstream of the stack exit.

The sample ports are 1-inch in diameter and extend 3 inches beyond the stack wall. Because the duct is >12 inches in diameter and the sampling port locations meet the two and one-half diameter criterion of Section 11.1.1 of Method 1 of 40 CFR Part 60, Appendix A-1, the exhaust was sampled at 3 traverse points located at 16.7, 50.0, and 83.3% of the measurement line ('3-point long line'). The exhaust flue gas was sampled from the three traverse points at approximately equal intervals during the tests.

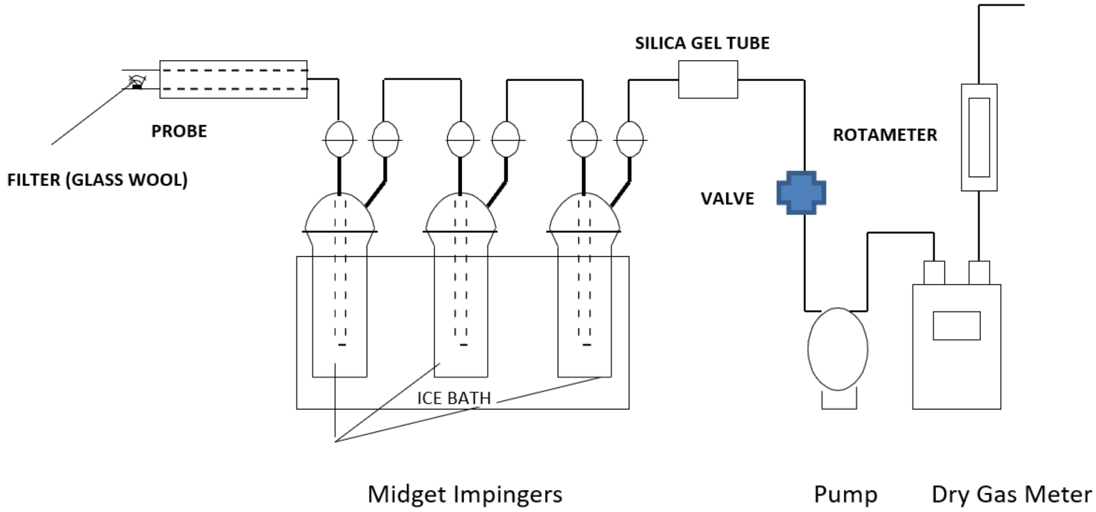
Figure 4-1. EUEMERGGEN Sampling Location



4.3 MOISTURE CONTENT (USEPA METHOD 4 / 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 4-2 for a depiction of the Alternative Method 008 Moisture Sample Apparatus.

Figure 4-2. 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)

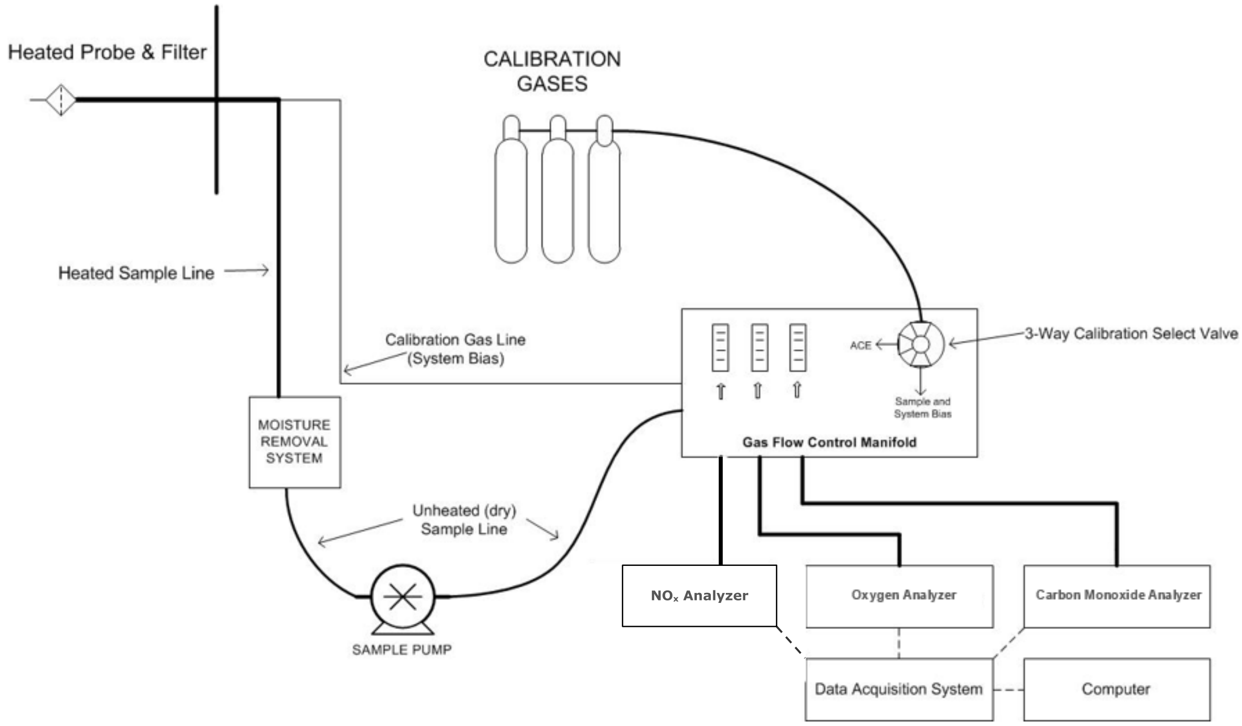
Oxygen, nitrogen oxides, and carbon monoxide concentrations were measured using the following sampling and analytical procedures:

- 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).*

Apart from the analyzers and analytical technique used, the sampling procedures of each method are similar. The measured oxygen concentrations were used to adjust the pollutant concentrations to 15% O_2 and calculate pollutant emission rates.

Engine exhaust gas was extracted from the stack 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 4-3 depicts a drawing of the Methods 3A, 7E, and 10 sampling system.

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



Prior to sampling engine exhaust gas, the analyzers were calibrated by performing a calibration error test where zero-, mid-, and high-level calibration gases were introduced directly to the back of the analyzers. The calibration error check was 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 was performed where the zero- and mid- or high- calibration gases were 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 was 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 were verified, and the probes were inserted into the ducts at the appropriate traverse point. After confirming the engine was operating at established conditions, the test run was initiated. Gas concentrations were recorded at 1-minute intervals throughout each 60-minute test run.

After the conclusion of each test run, a post-test, or final, system bias check was performed to evaluate analyzer bias and drift from the pre- and post-test system bias checks. The system-bias checks verify the analyzer bias was within ±5.0% of span, and drift was within ±3.0%. The analyzers responses were used to correct the 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 a fuel specific F_c factor and exhaust gas flowrate pursuant to guidance by USEPA to not use default published F factors for such Subpart JJJJ test events.

The natural gas processed by WPCS is the same gas used for firing EUEMERGGEN. The facility collects a daily sample of this gas and analyzes it via gas chromatography (GC) for hydrocarbons, non-hydrocarbons, heating value, and other parameters. The test day GC results were obtained to calculate F_w, F_d, and F_c factors (ratios of combustion gas volumes to heat inputs) using USEPA Method 19 Equations 19-13 (F_d), 19-14 (F_w), and 19-15 (F_c). The F_d factor was used to calculate the exhaust gas flow rate using *Equation 19-1* presented in Figure 4-4, which was incorporated into 40 CFR Part 60 Subpart JJJJ *Equations 1, 2, and 3* to calculate g/HP-hr emission rates.

Figure 4-4. USEPA Method 19 Exhaust Flow Rate Equation 19-1

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

Where:

Q_s = stack flow rate (dscf/min)
F_d = fuel-specific oxygen-based F factor, dry basis, from Method 19 (dscf/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 (%)

Figure 4-5. 40 CFR Part 60 Subpart JJJJ Equation 1, 2, 3

$$ER = \frac{Cd \ x \ K \ x \ Q \ x \ T}{HP - hr}$$

Where:

ER = Emission rate of pollutant in g/HP-hr
C_d = Measured pollutant concentration in parts per million by volume, dry basis (ppmvd)
K = Conversion constant for ppm pollutant to grams per standard cubic meter at 20°C:
KNOx = 1.912×10^{-3} (Equation 1)
KCO = 1.164×10^{-3} (Equation 2)
KVOC = 1.833×10^{-3} (Equation 3)
Q = Stack gas volumetric flow rate, in cubic meter per hour, dry basis
T = Time of test run, in hours

4.6 VOLATILE ORGANIC COMPOUNDS (USEPA METHOD 25A)

VOC concentrations were measured from the engine 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.

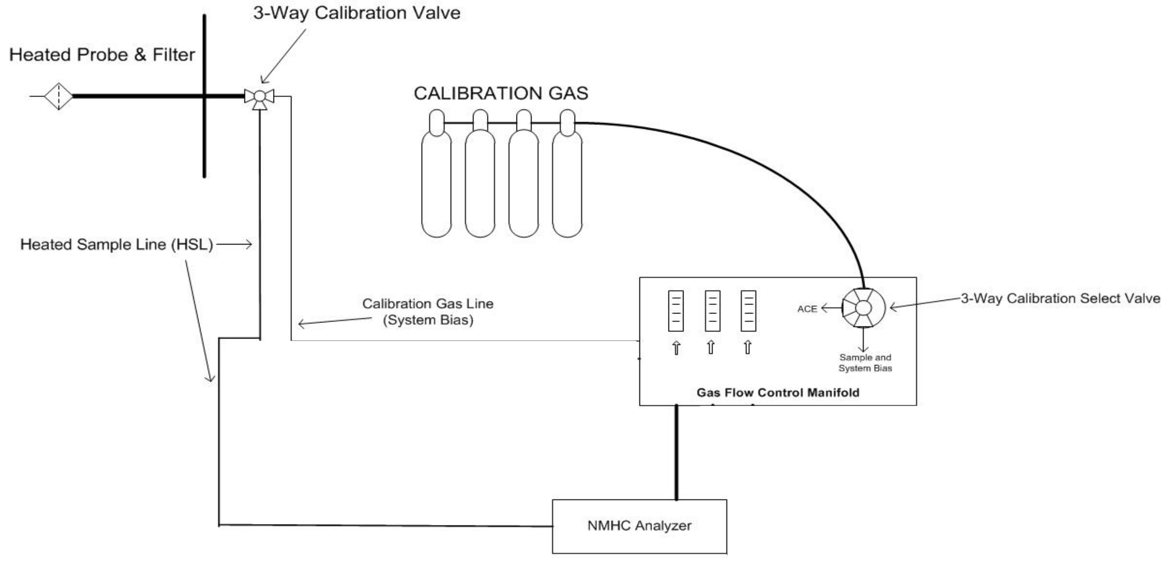
The components of the extractive sample interface apparatus are constructed of Type 316 stainless steel and Teflon. Flue gas was sampled from the stack via a sample probe and heated sample line and into the analyzer, which communicates with data acquisition handling systems (DAHS) via output signal cables. 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 4-5 for a drawing of the USEPA Method 5 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). Please note that since the field VOC instrument measures on a wet basis, exhaust gas moisture content was determined during each test run to convert the wet VOC concentrations to a dry basis and calculate VOC mass emission rates.

Please note that 40 CFR Part 63, 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 analyzer used measures exhaust gas ethane as part of the NMOC measurement. Therefore, if the natural gas fired contained elevated ethane concentrations, such as that obtained from shale sources, the NMOC concentrations measured may reflect a positive NMOC bias or in some instances, non-compliance.

Figure 4-6. USEPA Method 25A Sample Apparatus



5.0 TEST RESULTS AND DISCUSSION

The test program was conducted March 3, 2020 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 60, Subpart JJJJ, *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines*, (aka NSPS SI ICE), and MI-ROP-N5573-2018.

5.1 Tabulation of Results

The EUEMERGGEN test results indicate the NO_x, CO, and VOC emissions are compliant 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 engine.

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

During the first test run on EUEMERGGEN, it was noted that the facility fuel flow meter recording the amount of natural gas fired by the engine, was operating erratically and recording inaccurate fuel flows. The EUEMERGGEN engine control system is equipped with a fuel flow meter as well, which displays fuel flow in standard cubic feet per minute, however this data could not be recorded on a data acquisition system. RCTS and facility staff discussed this issue with Mr. Chance Collins of EGLE and received approval to manually record and use the fuel flow data from the engine control system for the compliance test emission calculations. The EUEMERGGEN fuel flow rate observed during the test runs remained stable between 219-222 scfm for each test run. Conservatively, the maximum observed fuel flow rate was used for calculating emissions rates.

5.4 Process or Control Equipment Upset Conditions

The engine was operating at the highest achievable load (92% of peak) 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.

5.6 Re-Test Discussion

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

- every 8,760 engine operating hours or 3 years (2023), whichever is first, thereafter to evaluate compliance with NO_x, CO, and VOC emission limits in 40 CFR Part 63, Subpart JJJJ and the ROP. The service meter indicated 210 hours of operation after the conclusion of the compliance test.

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 suitability of sample location	Measure distance from ports to downstream and upstream flow disturbances	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.
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 operation of analyzers	Calibration gases introduced directly into analyzers	Pre-test	±2.0% of calibration span
M3A, M7E, M10: System Bias and Analyzer Drift	Evaluates analyzer and sample system integrity and accuracy over test duration	Calibration gases introduced at sample probe tip, heated sample line, and into analyzers	Pre- and Post-test	±5.0% of calibration span for bias and ±3.0% of calibration span for drift
M7E: NO_2-NO converter efficiency	Evaluates operation of NO_2-NO converter	NO_2 calibration gas introduced directly into analyzer	Pre- or Post-test	NO_x response ≥90% of certified NO_2 calibration gas introduced
M25A: Calibration Error	Evaluates operation of analyzer and sample system	Calibration gases introduced through sample system	Pre-test	±5.0% of the calibration gas value
M25A: Zero and Calibration Drift	Evaluates analyzer and sample system integrity and accuracy over test duration	Calibration gases introduced through sample system	Pre- 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 D.

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.

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 D.