Consumers Energy
Count on Us®

40 CFR Part 60 Subpart JJJJ Test Report

EUEMERGEN3-1

Consumers Energy Company
St. Clair Compressor Station
10021 Marine City Highway
Ira Township, Michigan 48023
SRN: N6637

August 28, 2023

Test Dates: July 13 and 17, 2023

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Orders 41145901
Version No.: 1.0

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

EXECUTIVE SUMMARY

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 of EUEMERGEN3-1, a 4-stroke, lean-burn (4SLB) natural gas-fired, reciprocating internal combustion engine (RICE) used to drive an emergency generator operated as needed at the St. Clair Compressor Station (SCCS) located in Ira, Michigan

The test program was conducted on July 13 and 17, 2023 to satisfy performance test requirements and evaluate compliance with *Standards of Performance for Stationary Spark Ignition* (SI) *Internal Combustion Engines* (ICE), 40 CFR Part 60, Subpart JJJJ, as specified in the SCCS Renewable Operating Permit (ROP) No. MI-ROP-B6637-2021. The engine is also subject to 40 CFR Part 63, Subpart ZZZZ, *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines*; however, pursuant to §63.6590(c)(1), compliance with this regulation is demonstrated by meeting the requirements of Subpart JJJJ.

Three, 60-minute tests measuring exhaust emissions of nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOC's), and oxygen (O_2) were conducted following the procedures in United States Environmental Protection Agency (USEPA) Reference Methods (RM) 1, 3A, 4 (ALT-008), 7E, 10, 19, and 25A in 40 CFR Part 60, Appendix A. There were no deviations from the approved stack test protocol submitted on June 6, 2023, or associated USEPA RM. The only deviation occurred during testing on July 13, 2023, where elevated VOC emissions were measured prompting an engine oil and filter replacement and re-test on July 17, 2023. Emissions data from July 13, 2023 are provided in Appendix D.

The test results, summarized in Table E-1, indicate EUEMERGEN3-1 is operating in compliance with 40 CFR Part 60, Subpart JJJJ. 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.

Table E-1
Summary of Test Results

Parameter	Units	Result	40 CFR Part 60, Subpart JJJJ Limit[1]
NO_x	g/HP-hr	**1.2**	2.0
	ppmvd at 15% O_2	**91**	160
CO	g/HP-hr	**2.6**	4.0
	ppmvd at 15% O_2	**313**	540
VOC (as NMOC)	g/HP-hr	**0.4**	1.0
	ppmvd at 15% O_2	**27**	86

NO_x nitrogen oxides
CO carbon monoxide
VOC (as NMOC) volatile organic compounds as non-methane organic compounds
g/HP-hr grams per horsepower hour
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.

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.

1.0 SUMMARY OF RESULTS

This report summarizes compliance air emission test results from EUEMERGEN3-1 conducted July 13 and 17, 2023, at the Consumers Energy St. Clair Compressor Station (SCCS) in Ira Township, Michigan.

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 a natural gas-fired 4-stroke lean-burn (4SLB), Caterpillar Model G3516B reciprocating internal combustion engine (RICE) designated as EUEMERGEN3-1 at the St. Clair Compressor Station in Ira Township, Michigan on July 13 and 17, 2023.

A test protocol outlining the proposed testing and data quality objectives was submitted to EGLE on June 6, 2023, and subsequently approved by Mr. Andrew Riley, Environmental Quality Analyst, in a letter dated July 7, 2023. There were no deviations from the approved stack test protocol or associated United States Environmental Protection Agency (USEPA) reference methods (RM). The only deviation occurred during testing on July 13, 2023, where elevated VOC emissions were measured prompting an engine oil and filter replacement and re-test on July 17, 2023. Emissions data from July 13, 2023 are provided in Appendix D.

1.2 Purpose of Testing

The test was conducted to satisfy performance test requirements and evaluate compliance with *Standards of Performance for Stationary Spark Ignition* (SI) *Internal Combustion Engines* (ICE), 40 CFR Part 60, Subpart JJJJ, as specified in the SCCS Renewable Operating Permit (ROP) No. MI-ROP-B6637-2021. The engine is also subject to 40 CFR Part 63, Subpart ZZZZ, *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines*; however, pursuant to §63.6590(c)(1), compliance with this regulation is demonstrated by meeting the requirements of Subpart JJJJ. The applicable emission limits are shown in Table 1-1.

Table 1-1
EUEMERGEN3-1 Emission Limits

Parameter	Emission Limit	Units	Applicable Requirement
NO_x	2.0	g/BHP-hr	40 CFR Part 60, Subpart JJJJ, Table 1[a]
	160	ppmvd at 15% O_2	
CO	4.0	g/BHP-hr	
	540	ppmvd at 15% O_2	
VOC	1.0	g/BHP-hr	
	86	ppmvd at 15% O_2	

NO_x nitrogen oxides
CO carbon monoxide
VOC volatile organic compounds (non-methane organic compounds (NMOC)
g/BHP-hr grams per brake horsepower hour
a Emission limit criteria must be met with the engine operating at or within ± 10 percent of 100 peak (or highest achievable) load. 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.

1.3 Brief Description of Source

EUEMERGEN3-1 is classified as a four-stroke lean-burn natural gas-fired, spark-ignition emergency reciprocating internal combustion engine, which is located and operating at the St. Clair Compressor Station in Ira Township, Michigan. The facility operates a Caterpillar Model G3516B 4SLB engine to turn an emergency generator to provide temporary electricity to the station during power outages. Table 1-2 presents contact information of personnel involved in the test program.

Table 1-2
Contact Information

Program Role	Contact	Address
Statewide Regulatory Oversite	Mr. Jeremy Howe Supervisor 517-335-4874 howej1@michigan.gov	EGLE Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933-1502
Regulatory Inspector	Ms. Noshin Khan Environmental Engineer 586-536-1197 khann5@michigan.gov	EGLE – Air Quality Division Warren District 27700 Donald Court Warren, Michigan 48092
Responsible Official	Mr. Avelock Robinson Director, Gas Compression Operations 586-716-3326 avelock.robinson@cmsenergy.com	Consumers Energy Company St. Clair Compressor Station 10021 Marine City Highway Ira, Michigan 48023
Corporate Air Quality Contact	Ms. Amy Kapuga Principal Environmental 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 Principal Environmental 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	Ms. Tara Guenther Manager of Compression 734-482-2042 tara.guenther@cmsenergy.com	Consumers Energy Company St. Clair Compressor Station 12201 Pleasant Lake Road Ira Township, Michigan 48158
Test Facility	Mr. Robert McLaren Supervisor Compression 586-716-3328 robert.mclaren@cmsenergy.com	Consumers Energy Company St. Clair Compressor Station 10021 Marine City Highway Ira, Michigan 48023
Test Team Representative	Mr. Thomas Schmelter Engineering Technical Analyst 616-738-3234 thomas.schmelter@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 operated within 10% of 100 percent peak (or the highest achievable) load. The performance testing was conducted with the engine operating at an average 94.8% of 1300 KW electrical load and 91.0% of 1818 maximum horsepower rating. Refer to Appendix C for detailed operating data.

2.2 Applicable Permit Information

The St. Clair Compressor Station is assigned State of Michigan Registration Number (SRN) B6637 and operates in accordance with air permit MI-ROP-B6637-2021. EUEMERGEN3-1 is the emission unit source identification. Incorporated within the permit are the applicable requirements of 40 CFR Part 60, Subpart JJJJ – *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines.*

2.3 Results

The test results in Tables 2-1 indicate the engine complies with the applicable emission limits and associated operating requirements. 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	Units	Result	40 CFR Part 60, Subpart JJJJ Limit[1]
NO_x	g/HP-hr	**1.2**	2.0
	ppmvd at 15% O_2	**91**	160
CO	g/HP-hr	**2.6**	4.0
	ppmvd at 15% O_2	**313**	540
VOC (as NMOC)	g/HP-hr	**0.4**	1.0
	ppmvd at 15% O_2	**27**	86

NO_x nitrogen oxides
CO carbon monoxide
VOC (as NMOC) volatile organic compounds as non-methane organic compounds
g/HP-hr grams per horsepower hour
[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

EUEMERGEN3-1 is a natural gas fired emergency RICE used to drive an emergency generator operated as needed at the St. Clair Compressor Station. A summary of the engine specifications from vendor data are provided in Table 3-1.

Table 3-1
Summary of Engine Specifications

Parameter[1]	EUEMERGEN3-1
Manufactured Date	November 8, 2011
Make	Caterpillar
Model	G3516B
Serial No.	L6J00161
Output (brake-horsepower)	1,818
Heat Input, LHV (mmBtu/hr)	12.25
Exhaust Gas Temp. (°F)	974
Engine Outlet O_2 (Vol-%, dry)	9.3

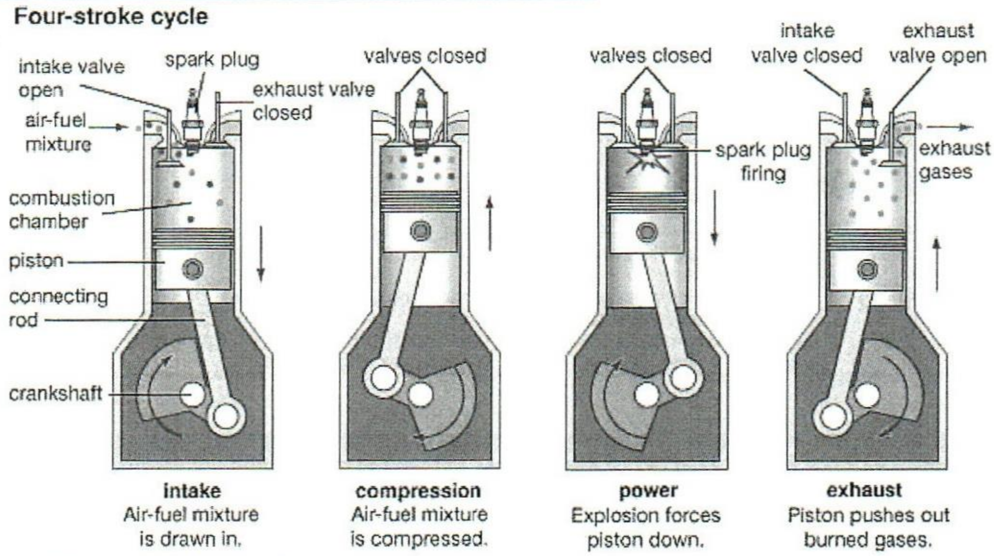
[1] Engine specifications are based upon vendor data for operation at 100% of rated engine capacity

3.1 Process

EUEMERGEN3-1 is a natural gas-fired 4SLB SI emergency RICE installed on February 10, 2016. 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 turn an emergency generator to provide temporary electricity to the station during power outages. Refer to Figure 3-1 for a four-stroke engine process diagram.

Figure 3-1. Four-Stroke Engine Process Diagram

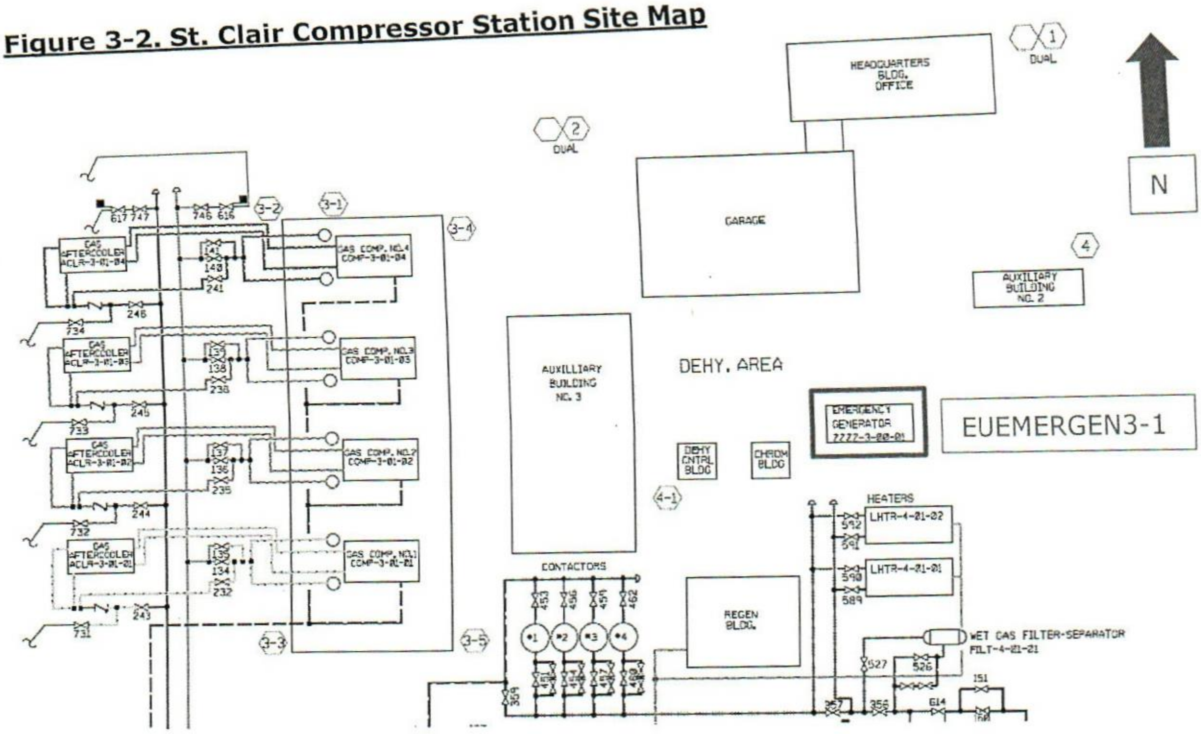


3.2 Process Flow

Located in southern St. Clair County, the St. Clair Compressor Station is a natural gas transmission and storage facility. The site pumps natural gas into and out of underground storage reservoirs and maintains the pressure along the pipeline system. During normal seasonal weather patterns, natural gas is purchased for storage injection in April through October and withdrawn from storage reservoirs in November through March.

EUEMERGEN3-1 maintains station electric power during a commercial power outage. The natural gas engine generator set is designed to start and supply power before equipment shutdowns to maintain station flow rate. The emergency generator engine was the focus of this test program. Refer to Figure 3-2 for the St. Clair Compressor Station Site Map depicting the EUEMERGEN3-1 location.

Figure 3-2. St. Clair Compressor Station Site Map



Natural gas combustion by-products are controlled through parametric controls (i.e., timing and operating at a lean 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 an elevated level of excess air (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 are provided in Appendix C.

3.3 Materials Processed

The fuel utilized in EUEMERGEN3-1 is exclusively natural gas, as defined in 40 CFR 72.2. During testing on July 17, 2023, the natural gas combusted within the engine was comprised of approximately 93% methane, 6.4% ethane, 0.3% nitrogen, and 0.2% 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 United States Environmental Protection Agency (USEPA) Method 19 and used in emission rate calculations.

3.4 Rated Capacity

EUEMERGEN3-1 has a maximum output of approximately 1,818 horsepower, and as equipped with the electrical generator, a maximum electrical output of 1,318 kilowatts. The engine has a rated heat input of 12.25 million British thermal units per hour (mmBtu/hour).

However, the maximum achievable operating condition of the engine is constrained by site and pipeline specific conditions.

3.5 Process Instrumentation

During testing, the following engine operating parameters were monitored and collected:

- Date and Time
- Engine power (HP)
- Electrical output (kW)
- Engine speed (RPM)
- Engine Load as Max kW (% max)
- Total three phase current (ampere)
- Fuel gas flow (scfm)
- Total engine operating time (hr)

The horsepower of the engine was calculated based on the following:

1 kilowatt (kW) = 1.34102 Horsepower (HP)

During testing of EUEMERGEN3-1 the process data was recorded in 15-minute increments using manual readings of field instrumentation and data acquisition systems. Refer to Appendix C for operating data.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Triplicate one-hour test runs for NO_x, CO, VOC, and 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	4/Alt-008	Determination of Moisture Content in Stack Gases
Nitrogen oxides	7E	Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Carbon monoxide	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	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 (2023)	Run	Sample Type	Start Time (EST)	Stop Time (EST)	Test Duration (min)	EPA Test Method	Comment
				EUEMERGEN3-1			
July 13*	1	O_2 NO_x CO VOC	08:45	09:44	60	1 3A 4(alt-008) 7E 10 19 25A	Engine testing terminated after Run 1 to allow Michigan CAT to investigate cause of upward trend in VOC concentrations
July 17	1	O_2 NO_x CO VOC	09:15	10:14	60	1 3A 4(alt-008) 7E 10 19 25A	3-points located in each duct at 16.7, 50.0 & 83.3 % of the measurement line were traversed
	2		11:00	12:31	60		Test paused between 11:12-11:43 due to O2 analyzer data acquisition signal loss
	3		13:30	14:29	60		

4.2 Sample Location and Traverse Points (USEPA Method 1)

The number and location of traverse points for each engine 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 EUEMERGEN3-1 is described as:

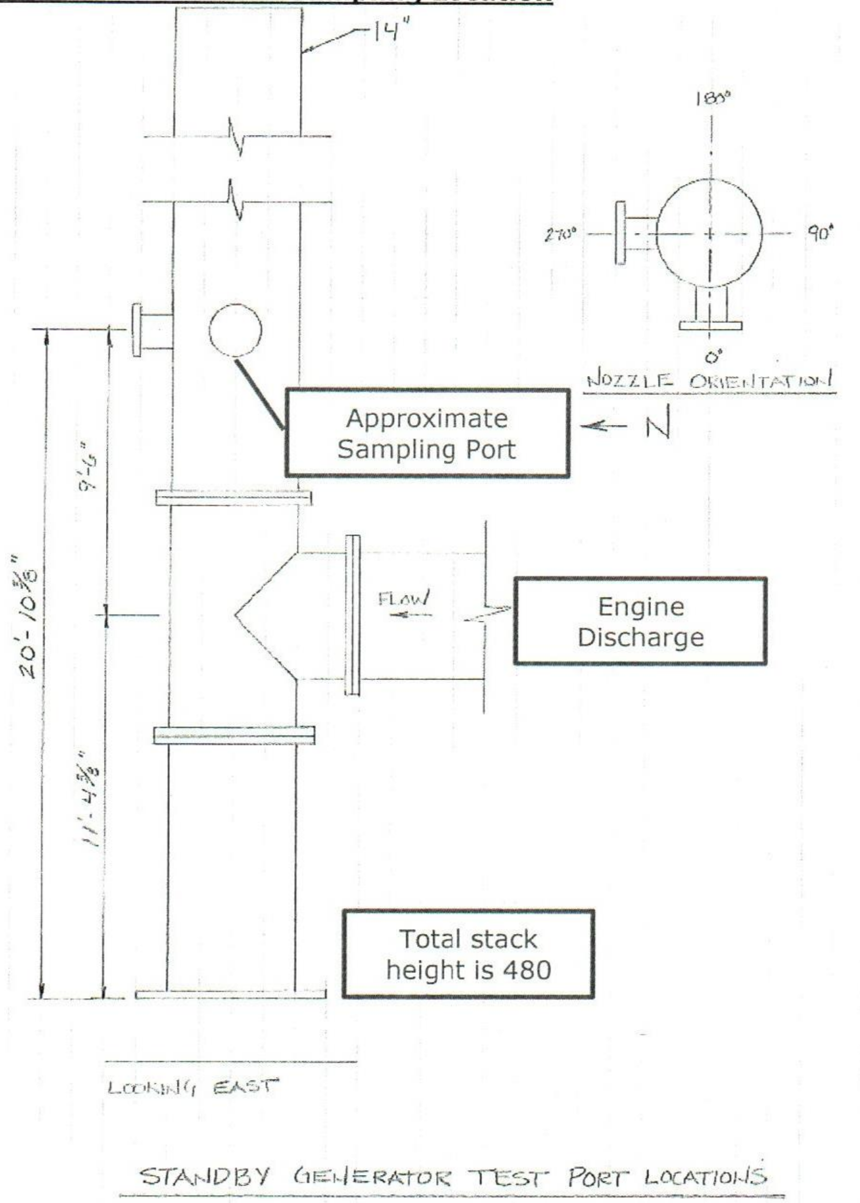
Sample Port in 14-inch diameter duct:

- Approximately 24-feet or 20 duct diameters downstream of a flow disturbance where the engine exhaust makes a 90-degree turn, and
- Approximately 60-inches or 4 duct diameters upstream of the exit to atmosphere.

The sample port is 1-inch in diameter and extends approximately 3 inches beyond the stack wall. Because the duct is >12 inches in diameter and the sampling port location meets 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 duct 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 equal intervals during the test for Run 1.

A three traverse point stratification test was performed using parameter concentrations from Run 1 in accordance with USEPA Method 7E, §8.1.2. The individual point and mean parameter concentrations were calculated, and the gas stream was considered unstratified; therefore, parameter concentrations were measured from a single point near the centroid of the stack for Runs 2 and 3.

Figure 4-1. EUEMERGEN3-1 Sampling Location

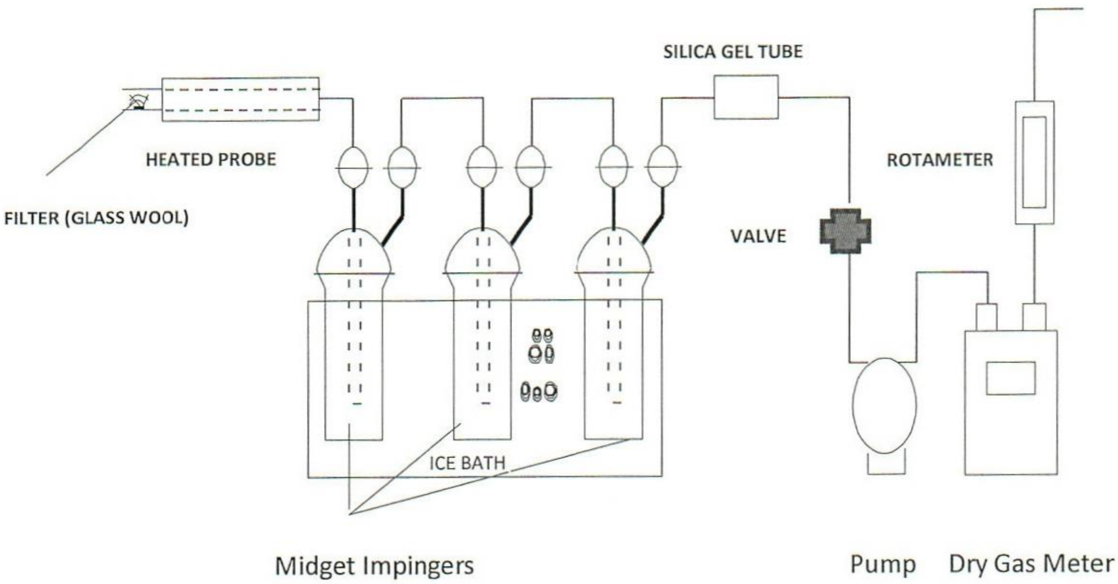


Sketch Number	Title	Rev	Date	DRW BY	CHK BY	APR BY
SK-126M-025	Standby Generator Test Port Locations	0	5/24/2017	PL	JC	CS

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 was 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 figure of the Alternative Method 008 Moisture Sample Apparatus.

Figure 4-2. Alternative Method 008 Moisture Sample Apparatus



The silica gel tube depicted in this figure 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)

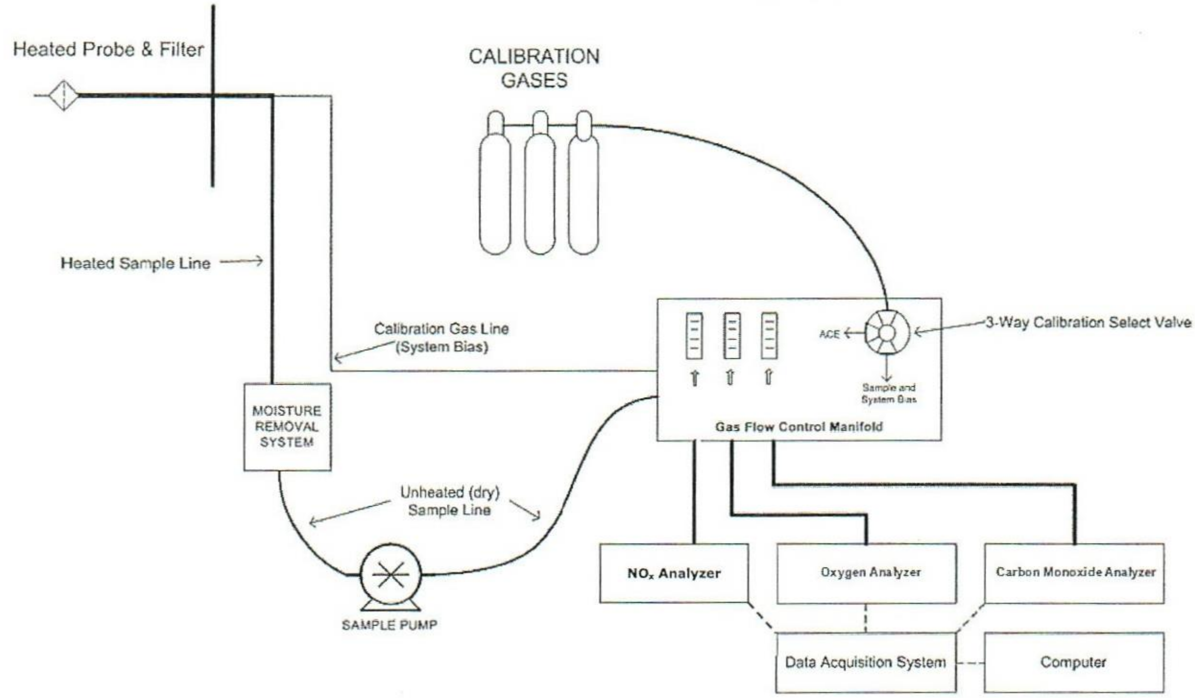
Oxygen, nitrogen oxides, and carbon monoxide concentrations were measured using the following sampling and analytical procedures:

- 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).*

Each cited method sampling is procedurally similar except for the analyzer and analytical technique used. Engine exhaust gas was extracted from the stack 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 4-3 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 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.

For the analyzer calibration error tests, bias tests and drift checks, these evaluations are also passed if the standard criteria are not achieved, but the absolute difference between the analyzer responses and calibration gas is less than or equal to 0.5 ppmv for NO_x and CO or 0.5% for O_2.

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 factor and exhaust gas flowrate.

A fuel sample was collected during testing and analyzed by gas chromatography, ultraviolet fluorescence, and/or electronic sensing cells to obtain hydrocarbons, non-hydrocarbons, heating value, and other parameters of the natural gas samples. The results were used to calculate F_w and F_d factors (ratios of combustion gas volumes to heat inputs) using USEPA Method 19 Equations 19-13, 19-14, and 19-15. This F_d factor was then used to calculate the emission flow rate with the corresponding equation presented in Figure 4-4. The flow rate was used in calculations to present emissions in units of g/HP-hr, which is presented in Figure 4-5.

Figure 4-4. 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 = 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
Cd = 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}
KCO = 1.164×10^{-3}
KVOC = 1.833×10^{-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)

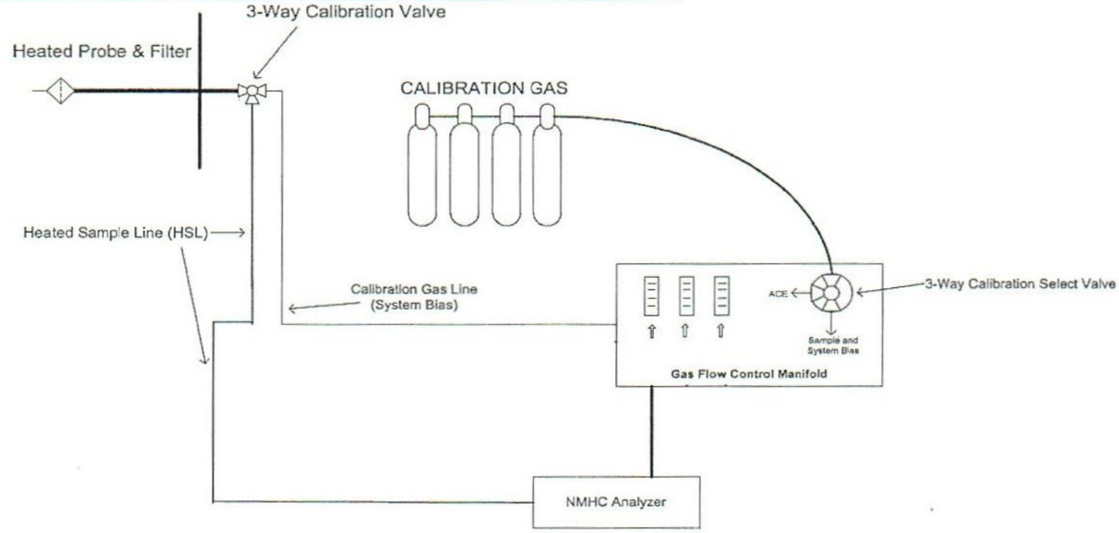
VOC concentrations were measured from each engine using a Thermo Model 55i Direct Methane and Non-methane Analyzer following the guidelines of USEPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer (FIA)*. The instrument uses a flame ionization detector (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 4-6 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.

Figure 4-6. USEPA Method 25A Sample Apparatus



5.0 TEST RESULTS AND DISCUSSION

The test program conducted July 13 and 17, 2023, 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 testing indicate EUEMERGEN3-1 is compliant with the applicable NO_x, CO, and VOC emissions limits and associated operating requirements as summarized in Table 2-1. Appendix Table 1 contains detailed tabulation of results, process operating conditions, and exhaust gas conditions.

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

No sampling or operating condition variations occurred during the test event. However, during Run 1 (08:45-09:44) on July 13, 2023, the VOC concentration began trending upward and exceeded the range of the VOC analyzer; therefore, Michigan CAT was enlisted to investigate the cause of the upward trend of the VOC concentration.

It was determined that the engine oil needed replacement. It should be noted, the annual maintenance, including an engine oil and filter change, was already scheduled for EUENGINE3-1 to be performed in July 2023. The engine oil and filter were changed in the evening on July 13, 2023, with air emissions testing resumed on July 17, 2023. Refer to Appendix D for the data from July 13, 2023.

5.4 Air Pollution Control Device Maintenance

Other than routine 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.

5.5 Re-Test Discussion

Based on the results of this test program, a re-test is not required. Subsequent air emissions testing is required every 8,760 engine operating hours, or 3 years, whichever comes first.

- The engine hours at the conclusion of testing were 159 hours. Therefore, subsequent testing is required when the engine reaches 8,919 operating hours, or by July 17, 2026, whichever comes first.

5.6 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 sampling 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
M4 (ALT-008): Field balance calibration	Verify moisture measurement accuracy	Use Class 6 weight to check balance accuracy	Daily before use	The field balance must measure the weight within ±0.5 gram of the certified mass
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 span or ≤0.5 ppmv or ≤0.5 % abs. difference
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 span Drift: ±3.0% of span or ≤ 0.5 ppmv or 0.5% abs. difference
M7E: NO_2-NO converter efficiency	Evaluates NO_2-NO converter operation	NO_2 gas introduced directly into analyzer	Pre-test or Post-test	NO_x response ≤2% drop from peak value observed
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

5.7 Calibration Sheets

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

5.8 Sample Calculations

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

5.9 Field Data Sheets

Field data sheets are presented in Appendix B.

5.10 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 D for the laboratory data sheets associated with the natural gas fuel samples collected during the test program.

5.11 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.

Appendix Table