40 CFR Part 63, Subpart ZZZZ Test Report

EUENGINE3-1 and EUENGINE3-5

Consumers Energy Company
Freedom Compressor Station
12201 Pleasant Lake Road
Manchester, MI 48158
SRN: N3920

September 25, 2024

Test Date: August 20, 2024

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order No. 42373131, 42373135

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **IV**

1.0 INTRODUCTION **1**
1.1 IDENTIFICATION, LOCATION, AND DATES OF TESTS 1
1.2 PURPOSE OF TESTING 1
1.3 BRIEF DESCRIPTION OF SOURCE 1
1.4 CONTACT INFORMATION 1

2.0 SUMMARY OF RESULTS **2**
2.1 OPERATING DATA 2
2.2 APPLICABLE PERMIT INFORMATION 3
2.3 RESULTS 3

3.0 SOURCE DESCRIPTION **3**
3.1 PROCESS 4
3.2 PROCESS FLOW 5
3.3 MATERIALS PROCESSED 5
3.4 RATED CAPACITY 5
3.5 OPERATING PARAMETERS 5

4.0 SAMPLING AND ANALYTICAL PROCEDURES **6**
4.1 DESCRIPTION OF SAMPLING TRAIN AND FIELD PROCEDURES 6
4.2 SAMPLE LOCATION AND TRAVERSE POINTS (USEPA METHOD 1) 6
4.3 O_2 AND CO CONCENTRATIONS (USEPA METHODS 3A AND 10) 9

5.0 TEST RESULTS AND DISCUSSION **11**
5.1 TABULATION OF RESULTS 11
5.2 SIGNIFICANCE OF RESULTS 11
5.3 VARIATIONS FROM SAMPLING OR OPERATING CONDITIONS 11
5.4 PROCESS OR CONTROL EQUIPMENT UPSET CONDITIONS 11
5.5 AIR POLLUTION CONTROL DEVICE MAINTENANCE 11
5.6 RE-TEST DISCUSSION 11
5.7 RESULTS OF AUDIT SAMPLES 11
5.8 CALIBRATION SHEETS 12
5.9 SAMPLE CALCULATIONS 12
5.10 FIELD DATA SHEETS 12
5.11 LABORATORY QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES 12
5.12 QA/QC BLANKS 12

FIGURES

FIGURE 3-1. FOUR-STROKE ENGINE PROCESS DIAGRAM 4
FIGURE 3-2. ENGINE HP CALCULATION 5
FIGURE 4-1. PRE- AND POST-CATALYST SAMPLING PORT LOCATIONS 8
FIGURE 4-2. POST-CATALYST SAMPLING PORT LOCATION 9
FIGURE 4-3. METHODS 3A AND 10 SAMPLING SYSTEM 10

TABLES

TABLE E-1 SUMMARY OF ENGINE OPERATING RESULTS AND EMISSION LIMITS IV
TABLE 1-1 EUENGINE3-1 THROUGH 3-5 SUBPART ZZZZ REQUIREMENTS..... 1
TABLE 2-1 SUMMARY OF ENGINE OPERATING RESULTS AND EMISSION LIMITS 3
TABLE 4-1 TEST METHODS..... 6
TABLE 4-2 TEST MATRIX 6
TABLE 5-1 QA/QC PROCEDURES 12

APPENDICES

Appendix Table 1 EUENGINE3-1 Catalyst Inlet/Outlet Emission Rates and Process Data
Appendix Table 2 EUENGINE3-5 Catalyst Inlet/Outlet Emission Rates and Process Data

Appendix A Sample Calculations
Appendix B Field Data Sheets
Appendix C Operating Data
Appendix D Supporting Documentation

EXECUTIVE SUMMARY

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) performed carbon monoxide (CO) compliance testing on two four-stroke lean-burn (4SLB) natural gas-fired, spark-ignition, reciprocating internal combustion engines (RICE) identified as EUENGINE3-1 and EUENGINE3-5, operating at the Freedom Compressor Station (FCS) in Manchester, Michigan. The engines are grouped within flexible groups FGENGINES-P3, FGNSPSJJJJ and FGNESHAPZZZZ, as found in the Michigan Department of Environment, Great Lakes, and Energy (EGLE) renewable operating permit (ROP) No. MI-ROP-N3920-2022a and are subject to federal air emission regulations.

The testing was conducted on August 20, 2024 to evaluate compliance with the CO reduction efficiency emission limit in 40 CFR Part 63, Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants* (NESHAP) *for Stationary Reciprocating Internal Combustion Engines* as incorporated in EGLE ROP MI-ROP-N3920-2022a. A test protocol was submitted to EGLE on March 27, 2024, and subsequently approved by Jeremy Howe, Technical Programs Unit Supervisor, Air Quality Division, in a letter dated May 24, 2024.

There were no deviations from the approved stack test protocol or associated USEPA Reference Methods. Please note that the protocol includes test provisions for five (5) engines; EUENGINE3-2, EUENGINE3-3, and EUENGINE3-4 were previously tested in June 2024.

Triplicate 60-minute test runs were conducted at the upstream and downstream exhaust ducts of each engine's oxidation catalyst following the applicable procedures in United States Environmental Protection Agency (USEPA) Reference Methods (RM) 1, 3A, and 10 in 40 CFR Part 60, Appendix A.

During testing, the engines operated at load conditions within ±10 percent of 100 percent load, as specified in §63.6620(b). The test results are summarized in Table E-1.

Table E-1
Summary of Engine Operating Results and Emission Limits

Engine	Engine Load (%)	CO Reduction Efficiency (%)	Catalyst Inlet Temperature† (°F)	Catalyst Pressure Drop (inches)	Initial Catalyst Pressure Drop (inches)
	[Requirement: 100% ±10%]	[Requirement: ≥93%]	[Requirement: ≥450°F & ≤1350°F]	[Requirement: ±2" from Initial Test]	
EUENGINE3-1	92	96.5	810	2	1.3
EUENGINE3-5	92	98.0	768	2	2.0

†Compliance with the catalyst inlet temperature operating range is based on a 4-hour rolling average

The EUENGINE3-1 and EUENGINE3-5 results indicate compliance with the applicable CO reduction efficiency and operating limits in 40 CFR Part 63, Subpart ZZZZ as incorporated within renewable operating permit (ROP) MI-ROP-N3920-2022a.

Detailed results are presented in Appendix Tables 1 and 2. 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 emission tests on EUENGINE3-1 and EUENGINE3-5 operating at the Freedom Compressor Station (FCS) in Manchester, 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.

1.1 Identification, Location, and Dates of Tests

Consumers Energy (CE) Regulatory Compliance Testing Section (RCTS) conducted carbon monoxide (CO) reduction efficiency testing at two, four-stroke, lean burn (4SLB) 3,750 brake horsepower (BHP) natural gas-fired, spark-ignition reciprocating internal combustion engines (RICE), identified as EUENGINE3-1 and EUENGINE3-5 operating at FCS in Manchester, Michigan. The testing was conducted August 20, 2024.

1.2 Purpose of Testing

The purpose of the testing was to satisfy testing requirements and evaluate compliance with applicable emission limits in 40 CFR Part 63, Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants* (NESHAP) *for Stationary Reciprocating Internal Combustion Engines* as incorporated in the ROP. The applicable operating requirements and emission limits evaluated during this test program are presented in Table 1-1.

Table 1-1
EUENGINE3-1 through 3-5 Subpart ZZZZ Requirements

CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature (°F)	Oxidation Catalyst Pressure Drop Change (Inches Water Gauge)	Applicable Requirement
≥93†	≥450°F and ≤1350°F (based on 4-hr rolling average)	±2" from Initial Performance Test	MI-ROP-N3920-2022a, 40 CFR §63.6300(b) and Tables 2a and 2b

† 40 CFR Part 63, Subpart ZZZZ, Table 2a allows compliance to be demonstrated by limiting the concentration of formaldehyde in the stationary RICE exhaust to 14 ppmvd or less at 15% O_2 or by reducing CO emissions by ≥93%. Compliance using the CO reduction efficiency emission limit will be evaluated.

1.3 Brief Description of Source

EUENGINE3-1 and EUENGINE3-5 are classified as four-stroke lean-burn natural gas-fired, spark-ignition reciprocating internal combustion engines, located and operating at the Freedom Compressor Station in Manchester, Michigan. The engines are part of the flexible group FGENGINES-P3 as found in MI-ROP-N3920-2022a.

1.4 Contact Information

Table 1-2 presents the test program organization, major lines of communication, and names of responsible individuals.

Table 1-2
Contact Information

Program Role	Contact	Address
Regulatory Agency Representative	Jeremy Howe Technical Programs Unit Supervisor 231-878-6687 howej1@michigan.gov	EGLE Technical Programs Unit Constitution Hall, 2nd Floor South 525 West Allegan Street Lansing, Michigan 48933
State Regulatory Inspector	Mike Kovalchick Environmental Quality Analyst 517-416-5025 kovalchickm@michigan.gov	EGLE Jackson District Office 301 East Louis Glick Highway Jackson, Michigan 49201
Responsible Official	Avelock Robinson Director of Gas Compression Ops 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	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
Corporate Air Quality Contact	Joy Hwang Environmental Engineer 517-768-3761 joy.hwang@cmsenergy.com	Consumers Energy Company Environmental Services Department 1945 West Parnall Road Jackson, Michigan 49201
Test Facility Operations Manager	Tara Guenther Manager Gas Compression 734-428-2042 tara.guenther@cmsenergy.com	Consumers Energy Company Freedom Compressor Station 12201 Pleasant Lake Road Manchester, Michigan 48158
Test Facility Operations Supervisor	Zeke Duke Supervisor Gas Compression 734-318-4803 zeke.duke@cmsenergy.com	Consumers Energy Company Freedom Compressor Station 12201 Pleasant Lake Road Manchester, Michigan 48158
Field Environmental Coordinator	Gerald (Frank) Rand, Jr. Principal Environmental Analyst 734-850-4209 frank.randjr@cmsenergy.com	Consumers Energy Company South Monroe Service Center 7116 Crabb Road Temperance, Michigan 48182
Test Team Representative	Thomas Schmelter, QSTI Principal Lab 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 testing, EUENGINE3-1 and EUENGINE3-5 operated at load conditions within ±10 percent of 100 percent load, as specified in §63.6620(b). Refer to Attachment C for detailed operating data.

2.2 Applicable Permit Information

FCS is assigned State of Michigan Registration Number (SRN) N3920 and operates in accordance with MI-ROP-N3920-2022a. EUENGINE3-1 and 3-5 are emission units identified as part of flexible groups FGENGINES-P3, FGNSPSJJJJ, and FGNESHAPZZZZ. The applicable 40 CFR Part 60, Subpart JJJJ and Part 63, Subpart ZZZZ NESHAP requirements are incorporated within the ROP.

2.3 Results

The EUENGINE3-1 and EUENGINE3-5 CO reduction efficiency results indicate compliance with 40 CFR Part 63, Subpart ZZZZ as incorporated within the ROP. Refer to Table 2-1 for the average test result summary.

Table 2-1
Summary of Engine Operating Results and Emission Limits

Engine	Engine Load (%)	CO Reduction Efficiency (%)	Catalyst Inlet Temperature† (°F)	Catalyst Pressure Drop (inches)	Initial Catalyst Pressure Drop (inches)
	[Requirement: 100% ±10%]	[Requirement: ≥93%]	[Requirement: ≥450°F & ≤1350°F]	[Requirement: ±2" from Initial Test]	
EUENGINE3-1	92	96.5	810	2	1.3
EUENGINE3-5	92	98.0	768	2	2.0

†Compliance with the catalyst inlet temperature operating range is based on a 4-hour rolling average

Detailed results are discussed in Section 5.0 and shown in Appendix Tables 1 and 2. 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.

3.0 SOURCE DESCRIPTION

EUENGINE3-1 and EUENGINE3-5 provide compressor mechanical shaft power to maintain natural gas pipeline pressure for movement along the natural gas pipeline system. Significant maintenance has not been performed on the engines within the past three months. Vendor-supplied engine specifications is summarized in Table 3-1.

Table 3-1
Summary of Engine Specifications

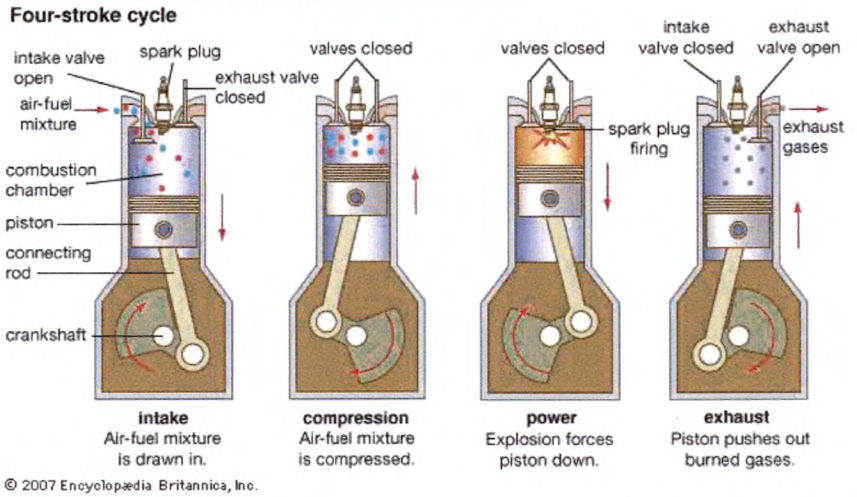
Parameter[1]	FGENGINES-P3
Make	Waukesha
Model	12V275GL
Output (brake-horsepower)	3,750
Heat Input, LHV (MMBtu/hr)	28.96
Exhaust Flow Rate (ACFM, wet)	23,373
Exhaust Gas Temperature (°F)	828

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

3.1 Process

The engines utilize the four-stroke engine cycle which starts with the downward air intake piston stroke which aspirates air through intake valves into the combustion chamber (cylinder). When 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



The flue gas generated by natural gas combustion is controlled through parametric controls (i.e., timing and air-to-fuel ratio), lean burn combustion technology, and oxidation catalysts. The Waukesha engines include control modules that monitor and adjust engine parameters for optimal performance. The NO_x emissions are minimized using lean-burn combustion technology which is defined as an elevated 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.

The four catalyst modules installed in the engine's exhaust use propriety materials to lower the oxidation temperature of CO and other organic compounds within the range of exhaust gas temperatures generated by the engines. The catalyst also provides control of formaldehyde, non-methane, and non-ethane hydrocarbons. Detailed operating data recorded during testing are provided in Appendix C.

3.2 Process Flow

Located in southwest Washtenaw County, the Freedom Compressor Station helps maintain natural gas pressures in the natural gas pipeline system. The main function of the station is to transport natural gas from the Panhandle Eastern Pipeline Company's supply lines to Consumers Energy's pipeline system. The Panhandle Eastern Pipeline is an approximate 6,000-mile system that extends from natural gas producing areas in the Anadarko Basin of Texas, Oklahoma and Kansas through Missouri, Illinois, Indiana, Ohio and into Michigan.

The engines are used to drive two-stage compressors to maintain pressure and move natural gas through the pipeline system. The bottom portion of the exhaust stacks incorporate an annulus where an outer stack surrounds an inner circular stack. The engine exhaust gases enter the annulus via two horizontal ducts into the outer stack, flowing downward through oxidation catalysts placed at the bottom of the annulus. After passing through the catalysts, the gases enter the inner stack through an opening located near the base of the freestanding stack. The gases then travel vertically through the freestanding stack, (via the inner stack) until they discharge unobstructed to atmosphere through the 65-foot-high stack.

3.3 Materials Processed

The fuel utilized is exclusively natural gas, as defined in 40 CFR Part 72.2. During testing, the natural gas combusted within the engines was comprised of approximately 92% methane, 7% ethane, 0.4% 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 for emission rate calculations in accordance with USEPA Method 19.

3.4 Rated Capacity

Each identical engine has a rated heat input of 28.96 MMBtu/hr and is limited to a maximum output of 3,750 horsepower. The engine control systems monitor engine parameters, including speed and fuel consumption, to calculate the amount of work, or horsepower, the engine is using. This engine monitoring procedure is an industry standard. Engine horsepower will be calculated as the actual horsepower from Figure 3-2 below, divided by the site-rated horsepower, multiplied by 100%.

Figure 3-2. Engine HP Calculation

$$\mathrm{ccTOTAL_{HP}} = \frac{\mathrm{CATData_INT[42]} \times \mathrm{aiST_ENGINE}}{100{,}000 \times 3{,}750}$$

Where:

$\mathrm{ccTOTAL_{HP}}$	=	Engine horsepower (HP)
CATData_INT[42]	=	Torque of engine (%)
aiST_ENGINE	=	Engine RPM
100,000	=	100% torque x 1,000 RPM (top speed of engine)
3,750	=	Rated HP of engine.

3.5 Operating Parameters

The engines were operated within ±10% of 100% peak (or the highest achievable) load during the performance tests. The following operating parameters were recorded at 15-minute intervals during the test program:

- Engine load as compressor torque (% max)
- Engine speed (RPM)
- Engine brake horsepower (BHP)

- Fuel gas flow (scfm)
- Pressure drop across oxidation catalyst (in. H_2O)
- Catalyst inlet temperature (°F)
- Suction pressure (psi)
- Discharge pressure (psi)

4.0 SAMPLING AND ANALYTICAL PROCEDURES

CO and oxygen (O_2) concentrations were measured using the test methods shown 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	USEPA	
	Method	Title
Sample traverse	1	Sample and Velocity Traverses for Stationary Sources
Oxygen (O_2)	3A	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Carbon monoxide (CO)	10	Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)

4.1 Description of Sampling Train and Field Procedures

The Table 4-2 test matrix below summarizes the sample parameters and analytical methods employed.

Table 4-2
Test Matrix

Date (2024)	Run	Sample Type	Start Time (EST)	Stop Time (EST)	Test Duration (min)	EPA Test Method	Comment
EUENGINE3-1							
Aug 20	1	O_2 CO	07:50	08:49	60	1, 3A, 10	Three-point traverse during Run 1; Single-point sample during Runs 2 and 3.
	2		09:03	10:02	60		
	3		10:17	11:16	60		
EUENGINE3-5							
Aug 20	1	O_2 CO	12:21	13:20	60	1, 3A, 10	Three-point traverse during Run 1; Single-point sample during Runs 2 and 3.
	2		13:30	14:29	60		
	3		14:43	15:42	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, and USEPA Method 1, *Sample and Velocity*

Traverses for Stationary Sources. Sample ports are installed upstream and downstream (Pre and Post) of the oxidation catalyst.

Pre-catalyst Sampling Ports:

Two test ports, 4-inches in diameter and sealed by 2-inch gate valves approximately 4-inches outside the duct wall, are installed in each of two 16-inch diameter horizontal exhaust ducts exiting the engine. The pre-catalyst sampling ports are located:

- Approximately 347-inches or 21.7 duct diameters downstream of a duct bend disturbance in the engine exhaust duct, and
- Approximately 63-inches or 3.9 duct diameters upstream of the flow disturbance caused by a change in duct diameter and flow direction as it enters exhaust stack and oxidation catalyst.

Post-catalyst Sampling Ports:

Two test ports, 4-inches in diameter and sealed by 2-inch gate valves approximately 4-inches outside the duct wall, are installed in a 30-inch vertical exhaust stack exiting the oxidation catalyst. The post-catalyst sampling ports are located:

- Approximately 240-inches or 8.0 duct diameters downstream of a duct diameter change flow disturbance, and
- Approximately 118-inches or 3.9 duct diameters upstream of the stack exit to atmosphere.

Because the ducts are >12 inches in diameter and the sampling port locations meet the two and half-diameter criterion of Section 11.1.1 of Method 1 of 40 CFR Part 60, Appendix A-1, the 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 three-point traverse concentrations, sampled in accordance with USEPA Method 7E §8.1.2, were calculated and the gas streams were found unstratified; therefore, subsequent measurements during runs 2 and 3 were obtained from a single point near the centroid of the stack.

Pre-catalyst and post-catalyst sampling port location drawings are presented as Figures 4-1 and 4-2.

Figure 4-1. Pre- and Post-Catalyst Sampling Port Locations

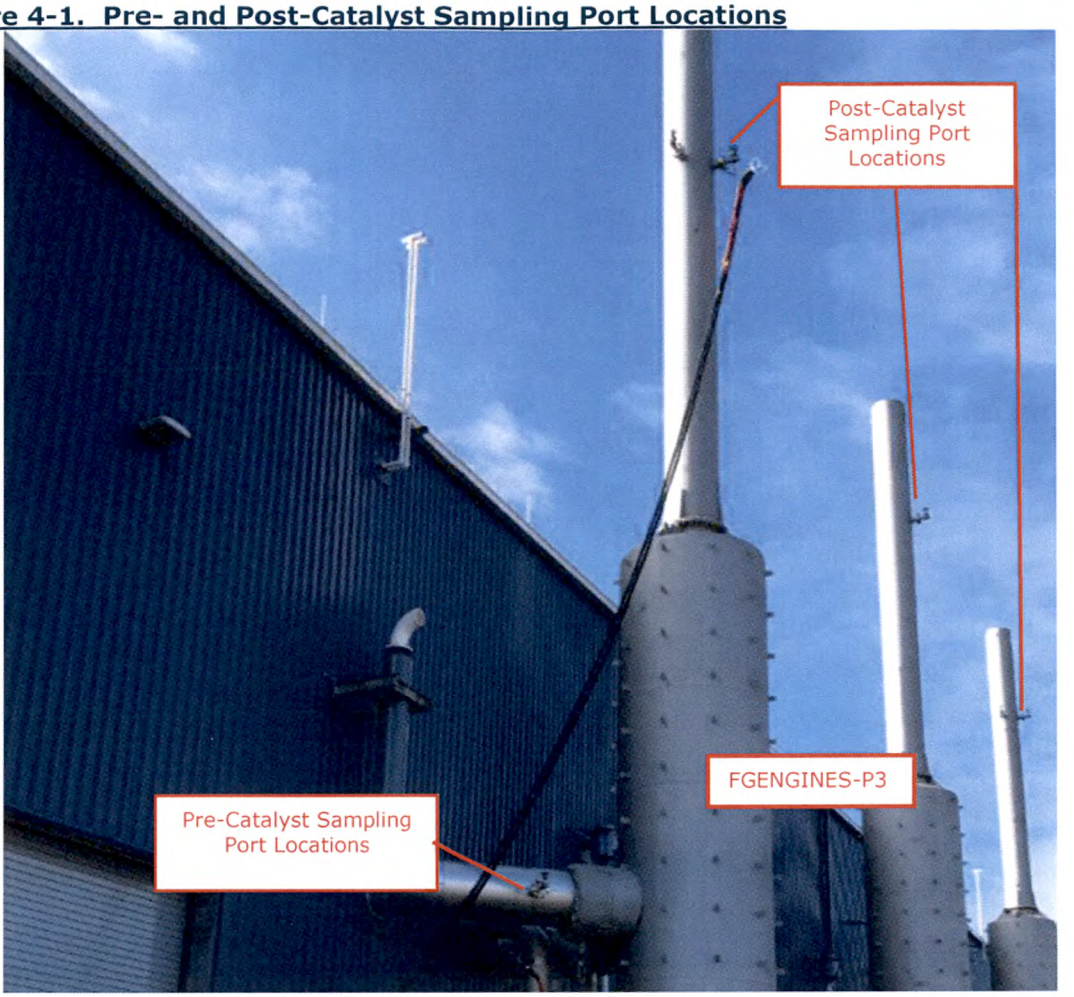
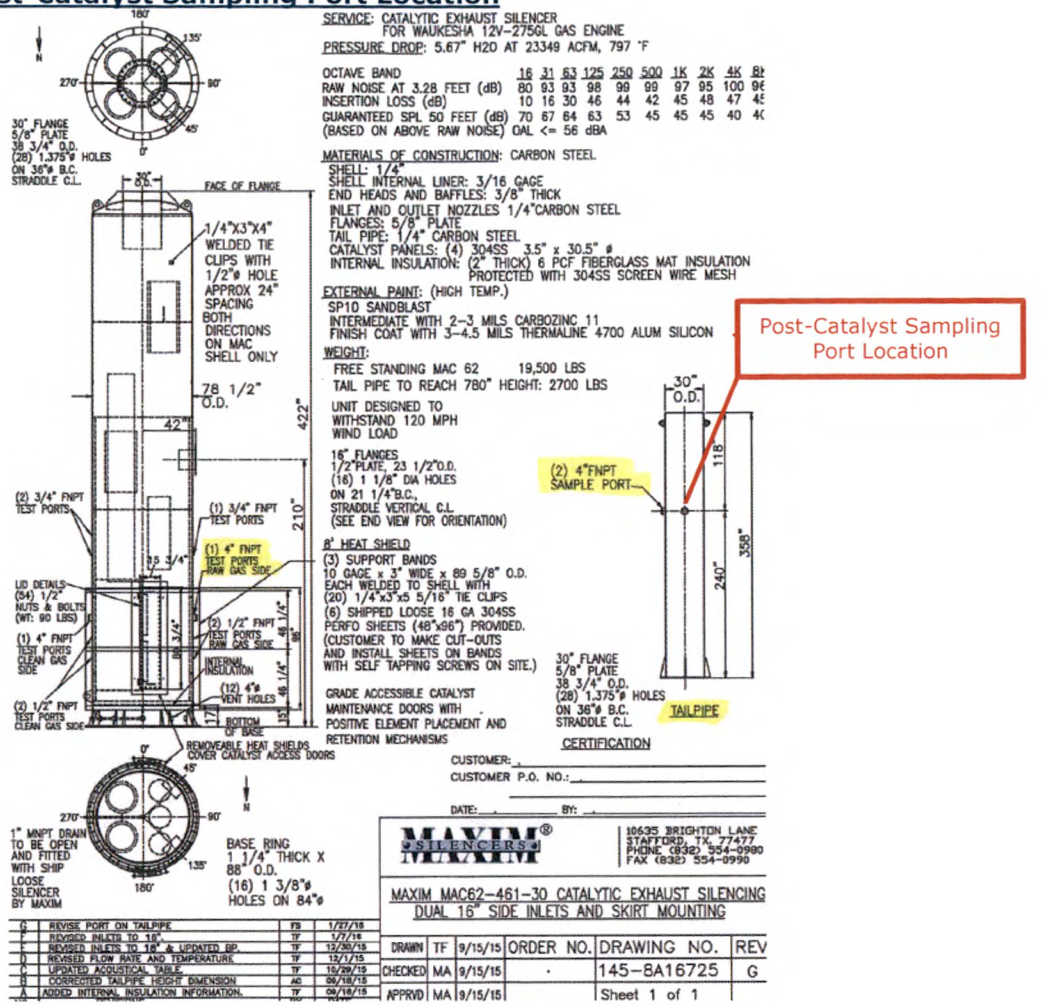


Figure 4-2. Post-Catalyst Sampling Port Location



4.3 O_2 and CO Concentrations (USEPA Methods 3A and 10)

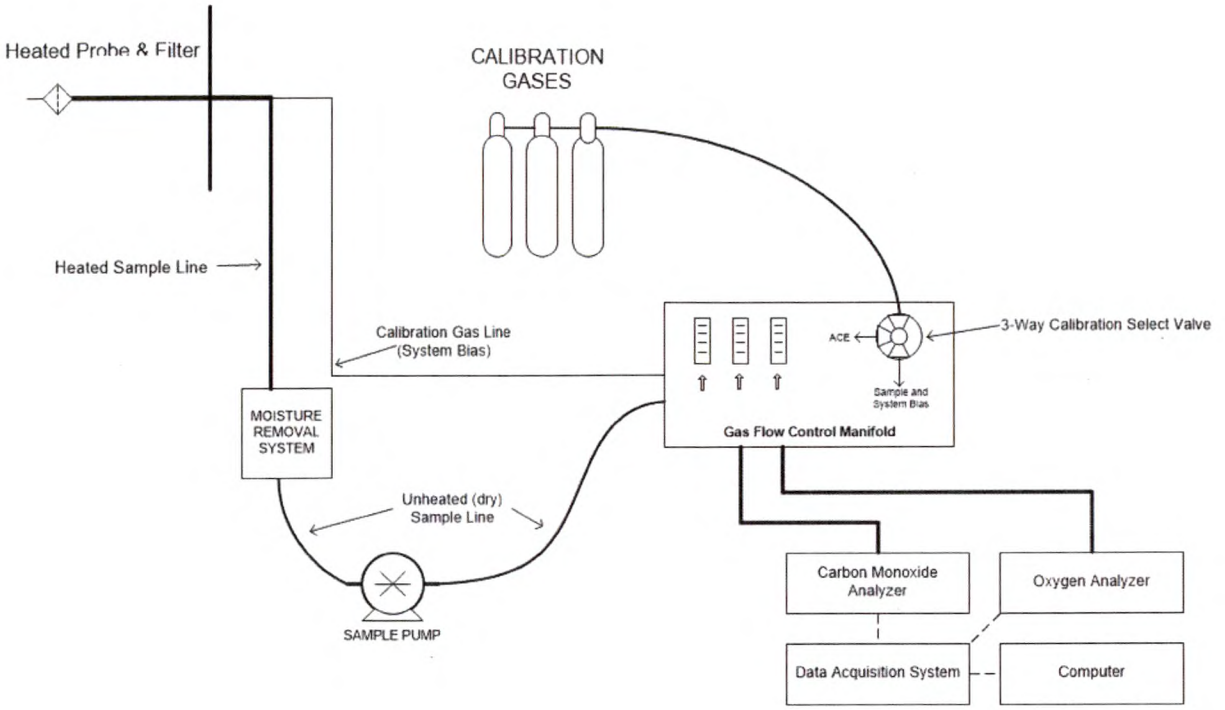
Oxygen and carbon monoxide concentrations were measured using the following sampling and analytical procedures:

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

The sampling procedures of each method is similar, except for the analyzers and analytical technique used to quantify the parameters of interest. The measured oxygen concentrations were used to adjust the pollutant concentrations to 15% O_2.

Engine exhaust gas was extracted from the stacks through a stainless-steel probe, heated Teflon® sample line, and 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 and 10 sampling system.

Figure 4-3. Methods 3A 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 analyzer response was within ±2.0% of the calibration gas span (i.e., high calibration gas concentration). An initial system-bias test was performed where the zero- and mid-calibration gases were introduced at the sample probe to measure the ability of the system to respond accurately to within ±5.0% of span.

Upon successful completion of the calibration error and initial system bias tests, sample flow rate and component temperatures were verified, and the probe was inserted into the duct 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 system bias check was performed to evaluate analyzer bias and drift from the pre- and post-test system bias checks. The system bias checks evaluated if the analyzer bias was within ±5.0% of span and drift was within ±3.0% of span. The analyzer responses were used to correct the 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 response and calibration gas concentration is less than or equal to 0.5 ppmv for CO or 0.5% for O_2.

5.0 TEST RESULTS AND DISCUSSION

The testing was performed to satisfy testing requirements and evaluate compliance with applicable emission limits in 40 CFR Part 63, Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants* (NESHAP) *for Stationary Reciprocating Internal Combustion Engines* as incorporated in the ROP.

5.1 Tabulation of Results

As summarized in Table 2-1, the emission test results indicate EUENGINE3-1 and EUENGINE3-5 comply with the applicable regulatory requirements. Appendix Tables 1 and 2 contain detailed results.

5.2 Significance of Results

Compliance with the applicable regulatory requirements allows EUENGINE3-1 and EUENGINE3-5 to be operated for their intended purpose until the next scheduled test event.

5.3 Variations from Sampling or Operating Conditions

No variations from sampling or operating conditions occurred during this test program.

5.4 Process or Control Equipment Upset Conditions

The engines, gas compressors, and pump equipment operated under maximum routine conditions with no upsets during the test.

5.5 Air Pollution Control Device Maintenance

Ongoing engine optimization is performed to ensure lean-burn combustion and continuous regulatory emission limit compliance.

5.6 Re-Test Discussion

An engine re-test is not required based on these test program results. Subsequent air emissions testing on the engines will be performed annually (since two passing events have occurred) to evaluate the reduction of CO emissions across the oxidation catalyst in accordance with 40 CFR Part 63 Subpart ZZZZ and MI-ROP-N3920-2022a.

5.7 Results of Audit Samples

Audit samples for 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 field test components. QA/QC components included in this test program are summarized in Table 5-1. Refer to Appendix D for supporting documentation.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluates sample location suitability	Measure downstream and upstream flow disturbances	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream
M1: Duct diameter/ dimensions	Verifies accurate stack area measurement	Review as-built drawings and field measurement	Pre-test	Field measurement agreement with as-built drawings
M3A and 10: Calibration gas standards	Ensures accurate calibration standards	Calibration gas traceability protocol	Pre-test	Calibration gas uncertainty ≤2.0%
M3A and 10: Calibration Error	Evaluates analyzer operation	Calibration gases introduced directly into analyzers	Pre-test	±2.0% of span, 0.5 ppmv or 0.5% O_2 abs. difference
M3A and 10: System Bias and Analyzer Drift	Evaluates analyzer and sample system integrity/accuracy over test duration	Cal gas introduced at sample probe tip, heated sample line, and into analyzers	Pre- and Post-test	Bias: ±5.0% of span; Drift: ±3.0% of span or ≤ 0.5 ppmv/0.5% O_2 abs. difference

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. QA/QC procedures. External laboratory analysis was not applicable to this test program.

5.12 QA/QC Blanks

Other than calibration gases used for instrument calibrations, no other reagent or media blanks were used.

Appendix Tables

Table 1
Freedom Compressor Station
EUENGINE3-1 Emission Rates and Process Data
August 20, 2024

Parameter	Average Result	
Diluent Concentrations and Emissions	**Inlet**	**Outlet**
O_2 Concentration, %, dry	11.7	11.7
Carbon Monoxide (CO) Concentrations and Emissions	**Inlet**	**Outlet**
CO Concentration, ppmvd	383.1	13.6
CO Concentration, ppmvd @15% O_2	247.0	8.7
CO Percent Reduction Efficiency, Percent:	96.48	
Engine and Process Data		
Natural Gas Fuel Factor, F_c, scf/mmBtu:	1,019.5	
Natural Gas Fuel Factor, F_d, dscf/mmBtu:	8,589.2	
Engine Fuel Flow Rate, scfm	396	
Stack gas flow rate, dscfm:	7,556	
Engine Speed, RPM:	999	
Engine Torque, %:	92	
Engine Power, BHP:	3,437	

Table 2
Freedom Compressor Station
EUENGINE3-5 Emission Rates and Process Data
August 20, 2024

Parameter	Average Result	
Diluent Concentrations and Emissions	**Inlet**	**Outlet**
O_2 Concentration, %, dry	11.9	11.8
Carbon Monoxide (CO) Concentrations and Emissions	**Inlet**	**Outlet**
CO Concentration, ppmvd	404.0	8.0
CO Concentration, ppmvd @15% O_2	264.7	5.2
CO Percent Reduction Efficiency, Percent:	98.04	
Engine and Process Data		
Natural Gas Fuel Factor, F_c, scf/mmBtu:	1,019.5	
Natural Gas Fuel Factor, F_d, dscf/mmBtu:	8,589.2	
Engine Fuel Flow Rate, scfm	408	
Stack gas flow rate, dscfm:	7,927	
Engine Speed, RPM:	1,000	
Engine Torque, %:	92	
Engine Power, BHP:	3,447	