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August 8, 2022

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AIR QUALITY DIVISION

Ms. Joyce Zhu, District Supervisor
Michigan Department of Environment, Great Lakes, and Energy
Warren District Office - Air Quality Division
27700 Donald Court
Warren, MI 48092-2793

Re: Test Report – Ray Compressor Station (SRN: B6636), Armada, MI

Dear Ms. Zhu:

The enclosed report summarizes the results of testing conducted on June 14-16, 2022 at Consumers Energy Company's Ray Compressor Station. Performance tests were conducted on five (5) 4-stroke lean burn (4SLB) natural gas-fired, reciprocating internal combustion engines (RICE), identified as EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34, and EUENGINE35 (i.e., FGENGINES3). The purpose of the testing was to evaluate continued compliance with 40 CFR Part 63, Subpart ZZZZ *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines* and MI-ROP-B6636-2020.

Summary of 40 CFR Part 63 Subpart ZZZZ Test Results

Source	Engine Load (%)	CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature (°F)	Catalyst Pressure Drop (Inches Water Gauge)	
				Initial Test	2022 Results
	[Requirement: 100% ± 10%]	[Requirement: ≥93%]	[Requirement: ≥450°F & ≤1350°F]	[Requirement: ±2" from Initial Test]	
EUENGINE31	98.7	96	848	2.2	2.5
EUENGINE32	101	98	863	2.3	2.4
EUENGINE33	96.7	98	841	2.0	2.1
EUENGINE34	97.6	96	852	2.7	2.3
EUENGINE35	97.9	96	872	2.1	1.8

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

The results of the testing indicate each engine is operating in compliance with applicable limits. Please contact me at 517-788-2201, or amy.kapuga@cmsenergy.com, if there are any questions on the report

Sincerely,

Amy D. Kapuga

Amy D. Kapuga, P.E.
Environmental Services Department

cc: Jeremy Howe, Supervisor, EGLE-TPU
William Harvey, Ray Compressor Station
Joe Mason, Consumers Energy-RCTS
Ray Emission Test File

EGLE

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
AIR QUALITY DIVISION

RENEWABLE OPERATING PERMIT REPORT CERTIFICATION

Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating Permit (ROP) program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as specified in Rule 213(3)(b)(ii), and be made available to the Department of Environment, Great Lakes, and Energy, Air Quality Division upon request.

Source Name: Consumers Energy – Ray Compressor Station   County: Macomb

Source Address: 69333 Omo Road   City: Armada

AQD Source ID (SRN): B6636   ROP No.: MI-ROP-B6636-2020   ROP Section No.: ______

Please check the appropriate box(es):

☐ **Annual Compliance Certification (Pursuant to Rule 213(4)(c))**

Reporting period (provide inclusive dates): From ______ To ______

☐ 1. During the entire reporting period, this source was in compliance with **ALL** terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the ROP.

☐ 2. During the entire reporting period this source was in compliance with all terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference, **EXCEPT** for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the ROP, unless otherwise indicated and described on the enclosed deviation report(s).

☐ **Semi-Annual (or More Frequent) Report Certification (Pursuant to Rule 213(3)(c))**

Reporting period (provide inclusive dates): From ______ To ______

☐ 1. During the entire reporting period, **ALL** monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred.

☐ 2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred, **EXCEPT** for the deviations identified on the enclosed deviation report(s).

☒ **Other Report Certification**

Reporting period (provide inclusive dates): From ______ To ______

Additional monitoring reports or other applicable documents required by the ROP are attached as described:

Test Report and NOCS for EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 & EUENGINE35

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete

Avelock Robinson	Director – Gas Compression Operations	(586) 716-3326
Name of Responsible Official (print or type)	Title	Phone Number

avelock Robinson   Digitally signed by avelock Robinson
Date: 2022.08.04 15:55:41 -04'00'

Signature of Responsible Official   Date

* Photocopy this form as needed.

EQP 5736 (Rev 04/30/2019)

Notification of Compliance Status Report

National Emission Standards for Hazardous Air Pollutants:
Stationary Reciprocating Internal Combustion Engines
40 CFR Part 63, subpart ZZZZ

SECTION I: GENERAL INFORMATION

Permit Number	Facility I.D. Number
MI-ROP-B6636-2020	SRN: B6636

Responsible Official's Name/Title
Avelock Robinson/Director, Gas Compression Operations

Street Address
10021 Marine City Highway

City	State	ZIP Code
Ira	MI	48023

Facility Name (if different from Responsible Official's Name)
Ray Compressor Station

Facility Street Address (If different than Responsible Official's Street Address)
69333 Omo Road

Facility Local Contact Name	Title	Phone (OPTIONAL)
William Harvey	Field Leader	

City	State	ZIP Code
Armada	MI	48062

Indicate the relevant standard or other requirement that is the basis for this notification and the source's compliance date: (§63.9(h)(2)(ii))

Basis for this notification (relevant standard or other requirement)	Compliance Date (mm/dd/yyyy)
40 CFR 63.6645(h)	06/16/2022

SECTION II: CERTIFICATION OF COMPLIANCE STATUS

■ Yes, the facility referenced above **IS** operating in compliance with all of the relevant standards and other requirements of 40 CFR Part 63 subpart ZZZZ, National Emission Standards for Hazardous Air Pollutants: Stationary Reciprocating Internal Combustion Engines. [§63.9(h)(2)(i)(G)]

☐ No, the facility referenced above is **NOT** operating in compliance with all of the relevant standards and other requirements of 40 CFR Part 63 subpart ZZZZ, National Emission Standards for Hazardous Air Pollutants: Stationary Reciprocating Internal Combustion Engines

SECTION III: METHODS

Describe the methods you used to determine compliance. [§63.9(h)(2)(i)(A)]

Consumers Energy – Ray Compressor Station installed oxidation catalyst systems to reduce carbon monoxide (CO) emissions, on each of their five (5) new, stationary 4SLB engines in order to comply with the emission standards in Table 2a of 40 CFR Part 63, subpart ZZZZ. A performance test was conducted on the units on June 14-16, 2022, in accordance with the approved test protocol and requirements in Table 4 of 40 CFR Part 63, subpart ZZZZ. The catalyst inlet temperature and catalyst pressure drop were recorded during the initial performance test. Ray installed and operates continuous parametric monitoring systems (CPMS) to continuously measure the catalyst inlet temperature for each engine, according to the requirements in 40 CFR 63.6625(b) and (k). The catalyst inlet temperature and catalyst pressure drop that were recorded were within the allowed ranges as specified in Table 1b of 40 CFR Part 63, subpart ZZZZ. This facility followed the startup requirements in 63.6625(h). The startup time was limited to 30 minutes and this facility minimized the engine's time spent at idle during startup.

SECTION IV: RESULTS

Describe the results of any performance tests, opacity or visible emission observations, continuous monitoring system (CMS) performance evaluations, and/or other monitoring procedures or methods that were conducted. [§63.9(h)(2)(i)(B)]

Source ID	Source Location	Test Date	CO % Reduction	Catalyst Inlet Temperature (°F)	Catalyst Pressure Drop (inches)	Initial Catalyst Pressure Drop (inches)
EUENGINE31	Plant 3	6/14/2022	96	848	2.2	2.5
EUENGINE32	Plant 3	6/14-15/2022	98	863	2.3	2.4
EUENGINE33	Plant 3	6/15/2022	98	841	2.0	2.1
EUENGINE34	Plant 3	6/16/2022	96	852	2.7	2.3
EUENGINE35	Plant 3	6/16/2022	96	872	2.1	1.8

Please refer to attached Test Report for additional information.

SECTION V: CONTINUOUS COMPLIANCE

Describe the methods you will use to determine continuous compliance, including a description of monitoring and reporting requirements and test methods. [§63.9(h)(2)(i)(C)]

Ray will determine continuous compliance with applicable requirements by continuing to use monitoring methods as identified in Section III and Section IV of this notification. In addition, the facility plans to do the following: (1) continuously monitoring the catalyst inlet temperature to ensure it remains greater than or equal to 450°F and less than or equal to 1,350°F; (2) monitor the catalyst pressure drop monthly to ensure that the pressure drop across the catalyst does not change by more than 2 inches of water from the pressure drop across the catalyst measured during the initial performance test; (3) conduct a semi-annual (or annual) performance test on each engine to measure CO emissions to determine that CO is reduced by 93 percent or more; (4) record the necessary information as specified in §63.6655, and (5) submit the necessary notifications and reports, according to the requirements in §63.6645 and §63.6650.

SECTION VI: EMISSIONS

Describe the type and quantity of hazardous air pollutants (HAP) emitted by the source (**or surrogate pollutants if specified in the relevant standard**), reported in units and averaging times and in accordance with the test methods specified in the relevant standard. [§63.9(h)(2)(i)(D)]

Source ID	Source Location	Source Description	Air Pollutant	Concentration (ppm) @ 15% O_2
EUENGINE31	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	11.1
EUENGINE32	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	6.4
EUENGINE33	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	5.2
EUENGINE34	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	14.8
EUENGINE35	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	11.2

SECTION VII: FACILITY DESIGNATION

If the relevant standard applies to both major and area sources, present an analysis demonstrating whether the affected source is a major source, using the emissions data generated for this notification. [§63.9(h)(2)(i)(E)]

Ray is considered a major source of Hazardous Air Pollutant (HAP) emissions because the potential to emit of any single HAP regulated by the federal Clean Air Act, Section 112 is more than 10 tons per year and the potential to emit of all HAPs combined is more than 25 tons per year.

SECTION VIII: CONTROLS

Describe the air pollution control equipment or method for each emission point, including each control device (or method) for each hazardous air pollutant and the control efficiency (percent) for each control device or method. [§63.9(h)(2)(i)(F)]

The NO_x emissions from each of the engines are minimized through the use of 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.

Each of the engines are also equipped with oxidation catalysts. The catalysts are designed in a modular manner, and each Caterpillar Model G3616 engine is equipped with four catalyst modules. The catalysts use proprietary materials in order to lower the temperature at which the oxidation process occurs for CO and other organic compounds. As a result, the oxidation process will occur at the exhaust gas temperatures generated by the engines. The catalyst vendor has guaranteed a CO destruction efficiency of 93%. The estimated formaldehyde and non-methane, non-ethane hydrocarbon (NMNEHC) destruction efficiencies are 85% and 75%, respectively.

Source ID	Source Location	Control Device	Control Efficiency
EUENGINE31	Plant 3	CO Catalysts	Reduces CO by 93% or more
EUENGINE32			
EUENGINE33			
EUENGINE34			
EUENGINE35			

SECTION IX: CONSTRUCTION/RECONSTRUCTION

A. Did you submit an application for construction or reconstruction under §63.5(d) that contained preliminary or estimated data? [§63.9(h)(5)]

Yes ☐ **No** ☐

Not applicable ☒ (did not submit an application for construction or reconstruction).

B. If you answered yes, provide actual emission data or other corrected information below.

SECTION X: AVERAGE PERCENT LOAD DETERMINATION

In accordance with 40 CFR § 63.6620(i), the notification of compliance status must contain the following information: engine manufacturer and model number, year of purchase, manufacturer's site-rated brake horsepower and ambient conditions (i.e., temperature, pressure and humidity) during the performance tests. The notification must also include a detailed description of how the average engine percent load during performance testing was determined.

Source ID	Engine Mfg/ Model #	Purchase Year	Site-Rated Horsepower	Test Date	Average Engine Load %	Ambient Temperature °F	Ambient Pressure in Hg	Ambient Humidity %
EUENGINE31	Caterpillar G3616	2009	4735 hp	6/14/2022	98.7	73	28.93	60
EUENGINE32	Caterpillar G3616	2009	4735 hp	6/14-15/2022	101	77	28.92	66
EUENGINE33	Caterpillar G3616	2009	4735 hp	6/15/2022	96.7	87	28.92	57
EUENGINE34	Caterpillar G3616	2009	4735 hp	6/16/2022	97.6	77	28.86	78
EUENGINE35	Caterpillar G3616	2009	4735 hp	6/16/2022	97.9	85	28.87	47

Each of the Caterpillar engines is equipped with the Advanced Digital Engine Management III (ADEM III) electronic control system. The ADEM III electronic controls integrate governing (engine sensing & monitoring, air/fuel ratio control, ignition timing, and detonation control) into one comprehensive engine control system for optimum performance and reliability.

The ADEM III system monitors the engine parameters, including engine speed and fuel consumption, and the data is used to calculate the actual amount of work, or horsepower, the engine is doing to compress the gas. This procedure is an industry standard. The percent load was then determined as the actual horsepower divided by the site-rated horsepower, multiplied by 100 (to convert to percent load).

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40 CFR Part 63 Subpart ZZZZ Continuous Compliance Test Report

EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34, and EUENGINE35

Consumers Energy Company
Ray Compressor Station
69333 Omo Road
Armada, Michigan 48005
SRN: B6636

July 21, 2022

Test Dates: June 14 – 16, 2022

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order No. 39525898
Version No.: 0

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EXECUTIVE SUMMARY

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted carbon monoxide (CO), and oxygen (O_2) testing at five natural gas-fired, reciprocating internal combustion engines (RICE) designated as EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34, and EUENGINE35, operating at the Ray Compressor Station in Armada, Michigan. Each engine is a four-stroke lean burn (4SLB); spark ignited 4,735 brake horsepower (BHP) engine operating at a major source of hazardous air pollutant (HAP) emissions. The engines provide mechanical shaft power to compressors maintaining natural gas pipeline pressure for movement in and out of storage reservoirs and along the pipeline system.

The test program was performed was performed on June 14 - 16, 2022 to satisfy performance test requirements and verify compliance with United States Environmental Protection Agency (USEPA) 40 CFR Part 63, Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants* (NESHAP) *for Stationary Reciprocating Internal Combustion Engines* as incorporated in Michigan Department of Environment, Great Lakes and Energy (EGLE), Renewable Operating Permit (ROP) MI-ROP-B6636-2020.

A test protocol was submitted to EGLE on April 6, 2022, and subsequently approved by Ms. Regina Angellotti, Environmental Quality Analyst, in a letter dated May 5, 2022. No deviations from the approved test protocol or associated Reference Methods therein occurred. EGLE representative Mr. Andrew Riley was onsite On June 14, 2022, to witness testing on Engine 3-1.

During testing, the engines operated within ± 10 percent of 100 percent peak (or highest achievable) load, as specified in 40 CFR §60.4244(a). Triplicate 60-minute test runs were conducted at each engine following procedures in USEPA Reference Methods (RM) 1, 3A, 7E and 10 in 40 CFR Part 60, Appendix A. Percent CO reduction efficiency was calculated using 40 CFR 63, § 63.6620, Equation 1. The summary of results in Table E-1 indicate each engine and oxidation catalyst complies with applicable percent CO reduction limits.

Table E-1 Summary of 40 CFR Part 63 Subpart ZZZZ Test Results

Source	Engine Load (%)	CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature[1] (°F)	Oxidation Catalyst Pressure Drop Comparison (Inches Water Gauge) Initial Test	2022 Results
	[Requirement: 100% ± 10%]	[Requirement: ≥93%]	[Requirement: ≥450°F & ≤1350°F]	[Requirement: ±2" from Initial Test]	
EUENGINE31	98.7	96	848	2.2	2.5
EUENGINE32	101	98	863	2.3	2.4
EUENGINE33	96.7	98	841	2.0	2.1
EUENGINE34	97.6	96	852	2.7	2.3
EUENGINE35	97.9	96	872	2.1	1.8

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

Detailed results are presented in Appendix Tables 1 – 5. Sample calculations, field data sheets, engine data and supporting documentation are provided in Appendices A - D.

1.0 INTRODUCTION

This report summarizes compliance air emission results from tests conducted on June 14 - 16, 2022 at the Consumers Energy Ray Compressor Station (RCS) in Armada, Michigan.

This document follows the November 2019, Michigan Department of Environment, Great Lakes and Energy (EGLE) *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 carbon monoxide (CO), and oxygen (O_2) testing on emission units (EU) EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 and EUENGINE35, operating at the RCS facility in Armada, MI.

A test protocol was submitted to EGLE on April 6, 2022, and subsequently approved by Ms. Regina Angellotti, Environmental Quality Analyst, in a letter dated May 5, 2022. There were no deviations from the approved test protocol or associated Reference Methods therein. EGLE representative Mr. Andrew Riley was onsite On June 14, 2022, to witness testing at Engine 3-1.

1.2 Purpose of Testing

The purpose of the test program was to satisfy performance test requirements and verify compliance with USEPA 40 CFR Part 63, Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants* (NESHAP) *for Stationary Reciprocating Internal Combustion Engines*, (aka RICE MACT), as incorporated in State of Michigan, ROP MI-ROP-B6636-2020. During testing, the engines operated within ± 10 percent of 100 percent peak (or highest achievable) load, as specified in 40 CFR §60.4244(a).

The RICE MACT CO efficiency and process operating requirements are shown in Table 1-1.

Table 1-1
Summary of 40 CFR 63, Subpart ZZZZ Requirements

CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature (°F) ≥450° F and ≤1350° F	Oxidation Catalyst Pressure Drop Change (Inches Water Gauge)
≥93	≥450°F and ≤1350°F (based on a 4-hour rolling average)	±2" from Initial Performance Test

1.3 Brief Description of Source

EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 and EUENGINE35 are natural gas-fired, 4SLB spark ignition (SI) RICE coupled to compressors, which are used to transport natural gas into/out of the storage fields or along the pipeline system. The engines are collectively grouped as FGENGINES3 within the ROP.

1.4 Contact Information

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

Table 1-2
Contact Information

Program Role	Contact	Address
State Regulatory Administrator	Mr. Jeremy Howe Technical Programs Unit Supervisor 231-878-6687 howej@michigan.gov	Michigan Department of Environment, Great Lakes and Energy 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State District Manager	Ms. Joyce Zhu Environmental Manager 586-606-2572 zhuj@michigan.gov	EGLE – Air Quality Division Warren District SE Michigan Office 27700 Donald Court Warren, Michigan 48092
State Technical Programs Field Inspector	Mr. Andrew Riley Technical Programs Unit Field Operations Section 586-565-7379 rileya8@michigan.gov	
State Regulatory Inspector	Mr. Robert Elmouchi Environmental Quality Analyst 586-753-3736 elmouchir@michigan.gov	
Responsible Official	Mr. Avelock Robinson Director of Gas Compression 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 Senior Engineer 517-788-2201 amy.kapuga@cmsenergy.com	Consumers Energy Company Environmental Services Department 1945 West Parnall Road Jackson, Michigan 49201
Field Environmental Coordinator	Mr. Thomas Fox Senior Engineer II 989-667-5153 thomas.fox@cmsenergy.com	Consumers Energy Company Bay City Customer Service Center 4141 E. Wilder Road Bay City, MI 48706
Test Facility	Mr. William F. Harvey Gas Field Lead 586-784-2096 william.f.harvey@cmsenergy.com	Consumers Energy Company Ray Compressor Station 69333 Omo Road Armada, Michigan 48005
Test Team Representative	Mr. Joe Mason, QSTI Sr. Engineering Technical Analyst 231-720-4856 joe.mason@cmsenergy.com	Consumers Energy Company D.E. Karn Power Plant 2742 N. Weadock Hwy., ESD Trailer #4 Essexville, Michigan 48732

2.0 SUMMARY OF RESULTS

2.1 OPERATING DATA

During the compliance test, the engines fired natural gas, and pursuant to §60.4244(a), operated within 10% of 100 percent peak (or the highest achievable) load based on the maximum manufacturer's design capacity at engine and compressor site conditions. Refer to Appendix C for detailed operating data.

2.2 Applicable Permit Information

RCS operates EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 and EUENGINE35 in accordance with the facility ROP, which incorporates 40 CFR Part 63, Subpart ZZZZ requirements.

2.3 Results

The test results in Table 2-1 indicate each engine and oxidation catalyst complies with the applicable percent CO reduction limits.

Table 2-1
Summary of 40 CFR Part 63 Subpart ZZZZ Test Results

Source	Engine Load (%)	CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature (°F)	Oxidation Catalyst Pressure Drop Comparison (Inches Water Gauge)	
				Initial Test	2022 Results
	[Requirement: 100% ± 10%]	[Requirement: ≥93%]	[Requirement: ≥450°F & ≤1350°F]	[Requirement: ±2" from Initial Test]	
EUENGINE31	98.7	96	848	2.2	2.5
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EUENGINE35	97.9	96	872	2.1	1.8
[1]Compliance with the catalyst inlet temperature operating range is based on a 4-hour rolling average					

Detailed results are presented in Appendix Tables 1 – 5. Section 5.0 contains a discussion of results. 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

EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 and EUENGINE35 were constructed in 2013. A summary of the engine specifications is presented in Table 3-1.

Table 3-1
Summary of Engine Specifications

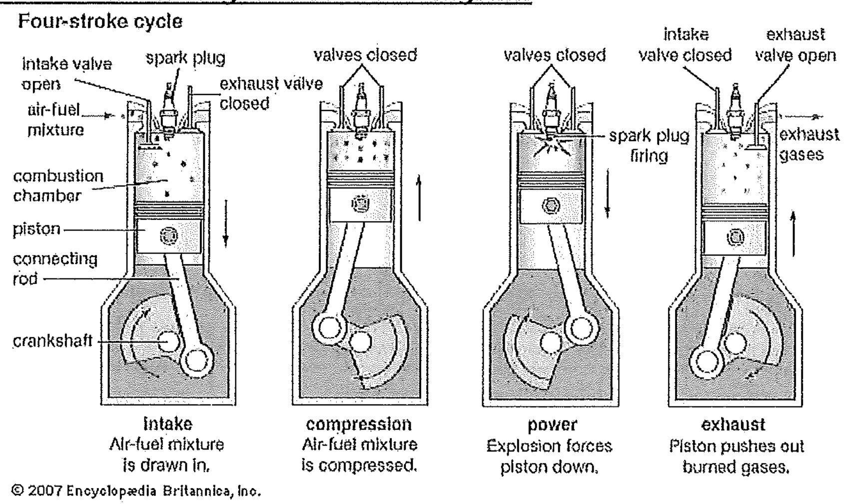
Parameter[1]	EUENGINE31 through EUENGINE35
Make	Caterpillar
Model	G3616
Output (brake-horsepower)	4,735
Heat Input (mmBtu/hr)	32.0
Exhaust Flow Rate (ACFM, wet)	32,100
Exhaust Gas Temp.	856
Engine Outlet O_2 (Vol-%, dry)	12.00
Engine Outlet CO_2 (Vol-%, dry)	5.81
CO, Uncontrolled (ppmv, dry)	572.0
CO, Controlled (ppmv, dry)[2]	40.0

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

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. Significant maintenance has not been performed on the engines or oxidation catalysts within the past three months. 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 operating at a lean air-to-fuel ratio) and by post-combustion oxidizing catalysts manufactured by EmeraChem, LLC (Part No. 28283.5-300CO). Four catalyst modules installed on each engine exhaust stack use proprietary materials to lower the oxidation temperature of CO and other organic compounds, thus maximizing the catalyst efficiency specific to the exhaust gas temperatures of the engines. As CO passes through the catalytic oxidation system, CO and VOC are oxidized to CO_2 and water, while suppressing the conversion of NO to NO_2.

Nitrogen oxides (NO_x) emissions from the engines are minimized through the use of 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 resulting in lower NO_x emissions.

While the catalyst vendor guarantees 93% CO destruction efficiency, the catalyst also controls formaldehyde and non-methane, non-ethane hydrocarbons (NMNEHC). Estimated formaldehyde and NMNEHC destruction efficiencies are 85% and 75%, respectively.

A continuous parameter monitoring system (CPMS) monitors catalyst inlet temperature in accordance with the requirements specified in Table 5 (1) of 40 CFR Part 63, Subpart ZZZZ. This parameter is monitored in accordance with the site-specific preventative maintenance / malfunction and abatement plan as a means to evaluate an efficient catalytic reaction and the performance of the pollution control equipment. Detailed operating data are provided in Appendix C.

3.2 Process Flow

Located in northern Macomb County, the Ray Compressor Station helps maintain natural gas pressure along pipeline systems and for gas injection and withdrawal. An aerial photograph of the Ray Compressor Station is provided in Figure 3-2.

Figure 3-2. Ray Compressor Station Aerial Photograph

The engine exhaust stacks are of non-typical design. Specifically, the bottom portion of the stack contains an outer and an inner circular stack (similar to a doughnut if viewed from the top of the stack). Engine exhaust gas enters the free-standing outer stack via two horizontal ducts exiting the engine and flows downward through oxidation catalysts in the bottom of the outer stack. The gases are then directed into the inner stack through an opening near the stack base, traveling upwards approximately 95-feet to an unobstructed vertical discharge to atmosphere.

3.3 Materials Processed

The engine fuel fired is exclusively natural gas, as defined in 40 CFR §72.2. Recent natural gas sample analysis indicates this composition to be approximately 93% methane, 5% ethane, 1% nitrogen, and 0.5% carbon dioxide.

3.4 Rated Capacity

Each engine has a rated heat input of 32 mmBtu/hr and a maximum output of 4,735 horsepower. These input/output capacities are a function of facility and gas transmission extraction and/or storage demand. During testing, engine operating parameters were recorded and averaged for each test run. Refer to Appendix C for this operating data.

3.5 Process Instrumentation

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

- Discharge pressure (psi)
- Engine Load as Compressor Torque (% max)
- Engine speed (rpm)
- Power (BHP)
- Suction pressure (psi)
- Fuel use (scf/hr)
- Catalyst exhaust pressure (in. H_2O)
- Catalyst inlet / engine exhaust temperature (°F)

Refer to Appendix C for operating data.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy RCTS tested for CO and oxygen (O_2) concentrations using the 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)
Nitrogen oxides (NO_x)	7E [1]	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)

[1] The Method 7E NO_x parameter was not measured, however Method 3A and 10 analyzers followed Method 7E quality assurance and sample traverse point guidance.

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)	USEPA Test Method	Comment
EUENGINE31							
June 14	1	O_2 CO	09:15	10:14	60	1 3A 10	A 3-point traverse (16.7, 50.0 & 83.3% of the measurement line) conducted at each location during Run 1. Single point sampling thereafter.
	2		10:32	11:31	60		
	3		11:48	12:47	60		
EUENGINE32							
June 14	1	O_2 CO	13:30	14:29	60	1 3A 10	A 3-point traverse (16.7, 50.0 & 83.3% of the measurement line) conducted at each location during Run 1. Single point sampling thereafter.
	2		14:46	15:45	60		
June 15	3		07:53	08:52	60		
EUENGINE33							
June 15	1	O_2 CO	10:11	11:10	60	1 3A 10	A 3-point traverse (16.7, 50.0 & 83.3% of the measurement line) conducted at each location during Run 1. Single point sampling thereafter.
	2		11:28	12:27	60		
	3		12:46	13:45	60		
EUENGINE34							
June 16	1	O_2 CO	07:37	08:36	60	1 3A 10	A 3-point traverse (16.7, 50.0 & 83.3% of the measurement line) conducted at each location during Run 1. Single point sampling thereafter.
	2		08:53	09:52	60		
	3		10:06	11:05	60		
EUENGINE35							
June 16	1	O_2 CO	11:53	12:52	60	1 3A 10	A 3-point traverse (16.7, 50.0 & 83.3% of the measurement line) conducted at each location during Run 1. Single point sampling thereafter.
	2		13:06	14:05	60		
	3		14:20	15:19	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 4 of 40 CFR Part 63 and USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources*.

Each engine is equipped with sample ports located upstream of the oxidation catalyst in (two) horizontal 24-inch diameter ducts exiting the engine and building. The ports are:

- At least 208 inches (8.7 duct diameters) downstream of a duct bend disturbance at the engine exhaust, and
- At least 57 inches (2.4 duct diameters) upstream of flow disturbance caused by a change in duct diameter and flow direction as it enters the oxidation catalyst.

Each engine is also equipped with sample ports located downstream of the oxidation catalyst in (one) vertical 36-inch diameter stack at:

- Approximately 72-inches (2 stack diameters) downstream of a flow disturbance, and
- Approximately 43-inches (1.2 stack diameters) upstream of the stack exit.

The pre and post-catalyst sample ports presented as Figures 4-1 and 4-2 are 4-inch in diameter and extend approximately 4-inches beyond the stack wall.

Since each exhaust duct or stack is > 12 inches in diameter and the sample port locations meet the two and one-half diameter criterion in Section 11.1.1 of Method 1, exhaust gas was sampled at equal time intervals from each of three traverse points located at 16.7, 50.0, and 83.3% of the measurement line ('3-point long line') during Run 1. Stratification data obtained during Run 1 revealed each location was unstratified, therefore sampling was conducted at a single sample point which most closely matched the mean concentration.

Figure 4-1. Pre-Catalyst Sampling Port Location

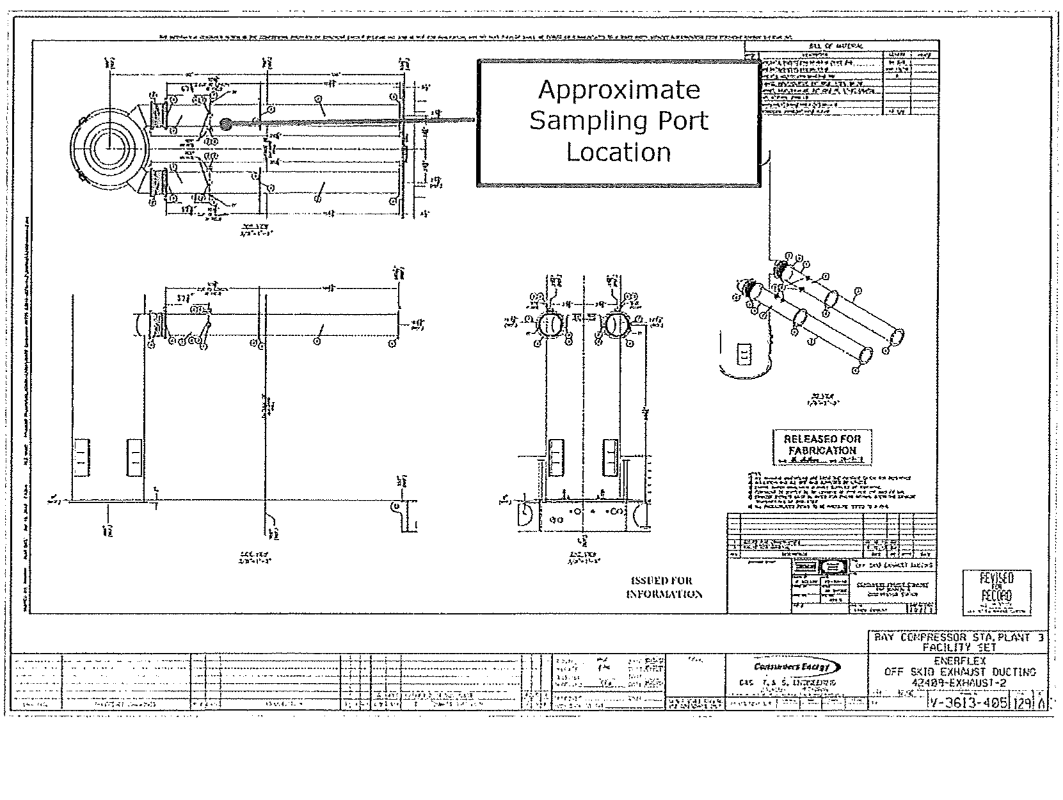
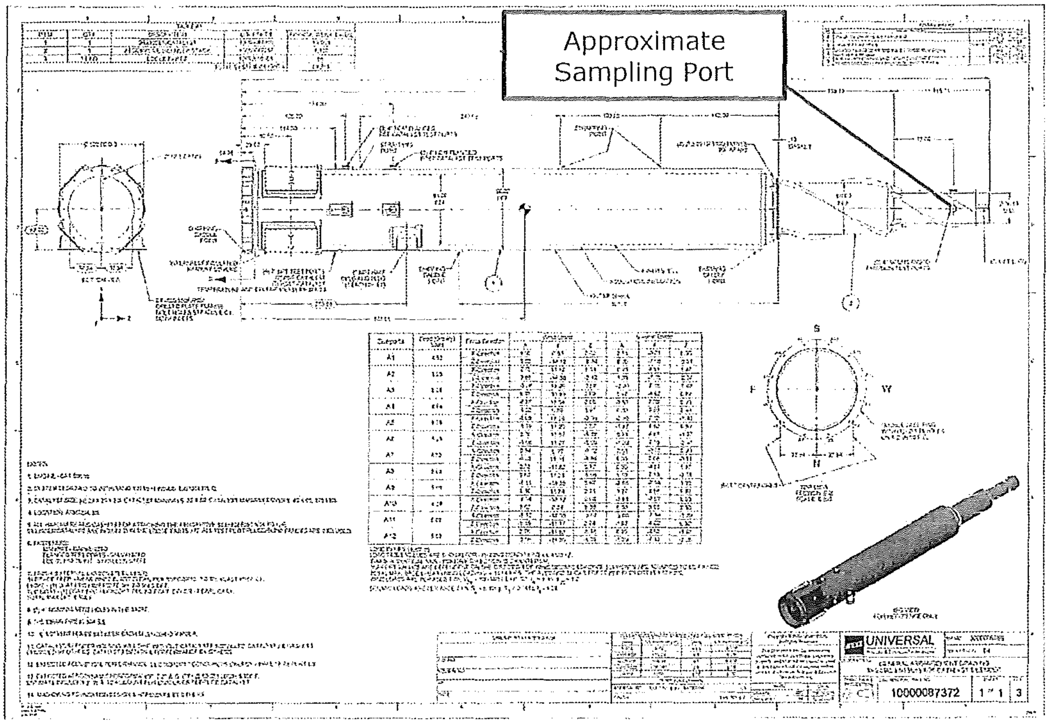


Figure 4-2. Post-Catalyst Sampling Port Location



4.3 O_2 AND CO (USEPA METHODS 3A AND 10)

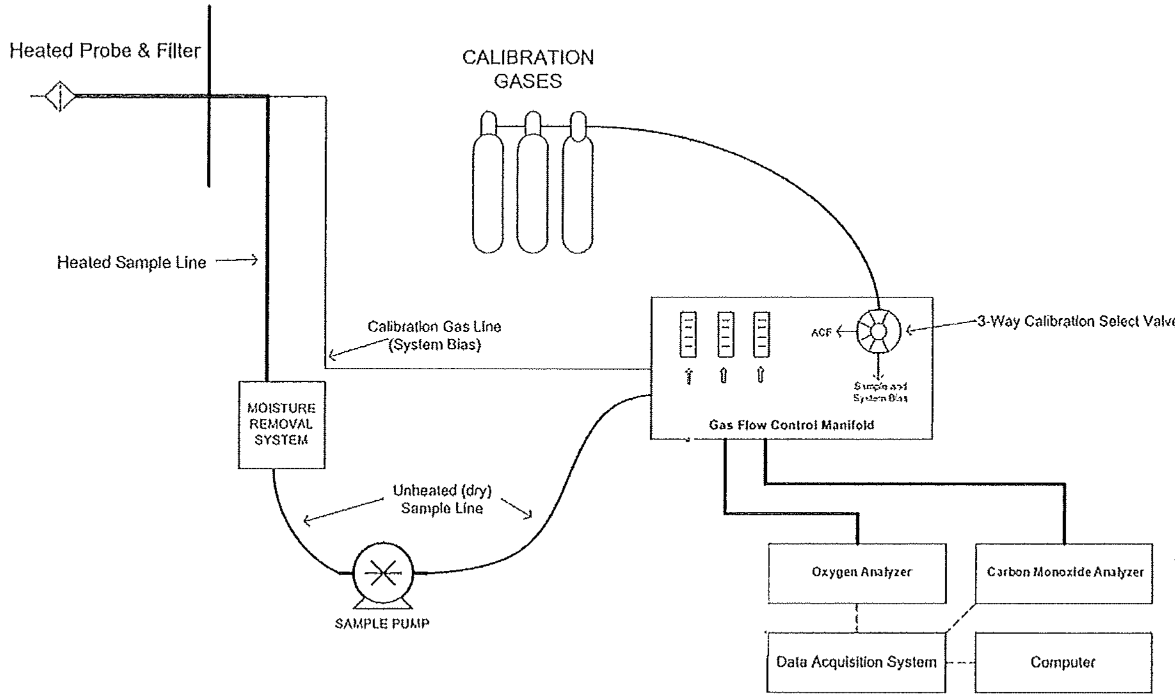
Oxygen and carbon monoxide concentrations were measured using the following sampling and analytical procedures:

- 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).*

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

Engine exhaust gas was extracted from the stacks or ducts through a stainless-steel probe, heated Teflon® sample line, and through a gas conditioning system to remove water and dry the sample before entering a sample pump, flow control manifold, and gas analyzers. Figure 4-3 depicts a drawing of the Methods 3A and 10 sampling system.

Figure 4-3. USEPA Methods 3A 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.

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.

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.

5.0 TEST RESULTS AND DISCUSSION

The test program conducted June 14 – 16, 2022, satisfies the performance testing and compliance evaluation requirements in 40 CFR Part 63, Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines* and MI-ROP-B6636-2020.

5.1 Tabulation of Results

The EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34, and EUENGINE35 oxidation catalysts comply with the CO destruction efficiency limits summarized in Table 2-1. Tabulated results, process operating conditions, and exhaust gas conditions for each respective RICE is shown in Appendix Tables 1 through 5.

5.2 Significance of Results

The test results indicate compliance with applicable CO destruction efficiency requirements.

5.3 Variations from Sampling or Operating Conditions

No sampling or operating condition variations occurred during the test event.

5.4 Process or Control Equipment Upset Conditions

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

5.5 Air Pollution Control Device Maintenance

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

5.6 Re-Test Discussion

Based on the results of this test program, a re-test is not required. Subsequent 40 CFR Part 63 Subpart ZZZZ oxidation catalyst CO reduction efficiency testing will be performed annually at each engine.

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 D for supporting documentation.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluates sampling location suitability for sampling	Measure distance from ports to downstream and upstream flow disturbances	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.
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: Calibration gas standards	Ensures accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A, M7E, M10: Calibration Error	Evaluates analyzer operation	Calibration gases introduced directly into analyzers	Pre-test	±2.0% of calibration span
M3A, M7E, M10: System Bias and Analyzer Drift	Evaluates analyzer/sample system integrity and accuracy over test duration	Calibration gas introduced at sample probe tip, HSL, and into analyzers	Pre-test and Post-test	Bias: ±5.0% of calibration span Drift: ±3.0% of calibration span

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

Laboratory analysis was not required for this compliance demonstration.

5.12 QA/QC Blanks

The 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.