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40 CFR Part 63, Subpart ZZZZ Continuous Compliance Test Report

EUENGINE2

Consumers Energy Company
White Pigeon Compressor Station
68536 A Road
White Pigeon, Michigan 49099
SRN: N5573

August 5, 2022

Test Date: June 30, 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) reduction efficiency testing on a 4-stroke, lean burn (4SLB) natural gas-fired, spark-ignition, reciprocating internal combustion engine (RICE) identified as EUENGINE2 at the Consumers Energy White Pigeon Compressor Station in White Pigeon, Michigan.

The test program was conducted June 30, 2022 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 63, Subpart ZZZZ, "National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines," as incorporated within the facility's Renewable Operating Permit (ROP) MI-ROP-N5573-2018 issued by Michigan Department of Environment, Great Lakes and Energy (EGLE). A test protocol was submitted to EGLE on February 3, 2022 and subsequently approved by Mr. Trevor Drost, Environmental Quality Analyst, in his letter dated March 17, 2022.

Three, 60-minute test runs were conducted at the upstream and downstream exhaust ducts of the 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. There were no deviations from the approved stack test protocol or associated USEPA RM, except that the test date for EUENGINE2 was delayed until June 30, 2022, due to a major mechanical failure that occurred in April 2022. [EUENGINE1, EUENGINE3 and EUENGINE4 were previously tested and the test report was submitted on June 3, 2022.]

During testing, the engine was operated at horsepower and torque conditions within plus or minus (±) 10 percent of 100 percent load, as specified in 40 CFR 63.6620(b).

The Subpart ZZZZ test results summarized in Table E-1 indicate EUENGINE2 are operating in continuous compliance with the 40 CFR Part 63, Subpart ZZZZ RICE NESHAP, and as specified in the facility ROP.

Table E-1
Summary of Test Results

Source	CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature[1] (°F)	Oxidation Catalyst Pressure Drop Comparison (Inches Water Gauge)	
			Initial Test	2022 Results
	[Limit: ≥93%]	[Limit: ≥450°F & ≤1350°F]	[Limit: ±2" from Initial Test]	
EUENGINE2	98.5	742.5	3.5	3.2

[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, 2, and 3. Sample calculations and field data sheets are presented in Appendices A and B. Engine operating data and supporting documentation are provided in Appendices C and D.

1.0 INTRODUCTION

This report summarizes the results of compliance air emissions testing conducted June 30, 2022 at the Consumers Energy White Pigeon Compressor Station (WPCS) in White Pigeon, Michigan. This document follows the Michigan Department of Environment, Great Lakes and Energy (EGLE) format described in the November 2019, *Format for Submittal of Source Emission Test Plans and Reports*. Reproducing only a portion of this report may omit critical substantiating documentation or cause information to be taken out of context. If any portion of this report is reproduced, please exercise due care in this regard.

1.1 Identification, Location, and Dates of Tests

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted carbon monoxide (CO) reduction efficiency testing on a four-stroke, lean burn (4SLB), natural gas-fired, spark-ignition (SI), reciprocating internal combustion engine (RICE), identified as EUENGINE2 installed and operating at WPCS in White Pigeon, Michigan. The test program was conducted on June 30, 2022.

1.2 Purpose of Testing

The test program was conducted to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 63, Subpart ZZZZ, "National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines," as incorporated in the facility's Renewable Operating Permit MI-ROP-N5573-2018 issued by EGLE. The applicable operating requirements and emission limits evaluated during this test program are presented in Table 1-1.

Table 1-1
Summary of Engine Operating Requirements and Emission Limits

CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature (°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

WPCS operates a Caterpillar Model 3616 4SLB engine (EUENGINE2) installed at Plant 3 to maintain the pressure of the natural gas along the pipeline system. The engine is collectively grouped in the FGENGINES flexible group within MI-ROP-N5573-2018

1.4 Contact Information

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

Table 1-2
Contact Information

Program Role	Contact	Address
State Regulatory Administrator	Mr. Jeremy Howe Technical Programs Unit Supervisor 231-878-6687 Howej1@michigan.gov	EGLE Technical Programs Unit Cadillac District Office 120 West Chapin Street Cadillac, MI 49601-2158
State Regulatory Inspector	Mr. Chance Collins Environmental Quality Analyst 269-254-7119 collinsc21@michigan.gov/air	EGLE Kalamazoo District Office 7953 Adobe Road Kalamazoo, Michigan 49009-5025
State Field Operations Section	Mr. Trevor Drost Environmental Quality Analyst 517-245-5781 drostt@michigan.gov/air	EGLE Kalamazoo District Office 7953 Adobe Road Kalamazoo, Michigan 49009-5025
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 Senior Engineer 517-788-2201 amy.kapuga@cmsenergy.com	Consumers Energy Company Environmental Services Department 1945 West Parnall Road Jackson, Michigan 49201
Field Environmental Coordinator	Mr. Gerald (Frank) Rand Jr. Senior Environmental Analyst 734-807-0935 frank.randjr@cmsenergy.com	Consumers Energy Company So. Monroe Service Center 7116 Crabb Road Temperance, Michigan 48182
Test Facility	Mr. Timothy Wolf Gas Field Leader III 269-483-2902 timothy.wolf@cmsenergy.com	Consumers Energy Company White Pigeon Compressor Station 68536 A Road, Route 1 White Pigeon, Michigan 49099
Test Team Representative	Mr. Joe Gallagher, Engineering Technical Analyst 989-450-9420 joseph.gallagher@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2742 N. Weadock Hwy, ESD Trailer #4 Essexville, Michigan 48732

2.0 SUMMARY OF RESULTS

2.1 OPERATING DATA

During the performance test, the engine fired natural gas and pursuant to §63.6620(b), was operated within (±) 10% of 100 percent load. The performance test was conducted with the engine operating at a 3-run average load of 91% engine torque or greater, 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

The White Pigeon Compressor Station operates in accordance with MI-ROP-N5573-2018. EUENGINE1, EUENGINE2, EUENGINE3, and EUENGINE4 are the emission unit sources identified in the permit. Collectively they are included within the FGENGINES flexible group. Incorporated within the permit are the applicable federal requirements of 40 CFR Part 63, Subpart ZZZZ. EUENGINE2 was evaluated during this test program.

2.3 Results

The CO reduction efficiency results indicate compliance with 40 CFR Part 63, Supbart ZZZZ as incorporated within MI-ROP-N5573-2018. Refer to Table 2-1 for the summary of test results.

Table 2-1
Summary of Test Results

Source	CO Reduction Efficiency (%) [Limit: ≥93%]	Oxidation Catalyst Inlet Temperature[1] (°F) [Limit: ≥450°F & ≤1350°F]	Oxidation Catalyst Pressure Drop Comparison (Inches Water Gauge) Initial Test	2022 Results
			[Limit: ±2" from Initial Test]	
EUENGINE2	98.5	742.5	3.5	3.2

[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 - 3. 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.

3.0 SOURCE DESCRIPTION

EUENGINE2 is operated as needed to maintain natural gas pressure along the natural gas pipeline system. A summary of the engine specifications is presented in Table 3-1.

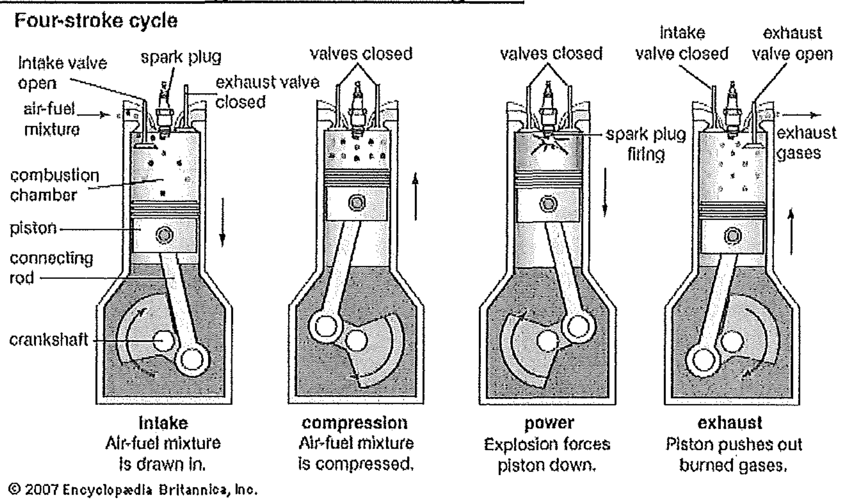
Table 3-1 Engine Specifications

Parameter[1]	EUENGINE2
Purchase Year	2008
Installation Date	June 15, 2010
Make	Caterpillar
Model	G3616
Cylinders	16
Output (brake-horsepower)	4,735
Heat Input (mmBtu/hr)	32.0
Exhaust Flow Rate (acfm, wet)	32,100
Exhaust Gas Temp. (°F)	856
Engine Outlet O_2 (Vol-%, dry)	12.00
Engine Outlet CO_2 (Vol-%, dry)	5.81
CO, uncontrolled (ppmvd)	572.0
CO, controlled[2] (ppmvd)	40.0

3.1 Process

The engine utilizes 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 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 engine is equipped with an oxidation catalyst. Pollution Control Associates, Inc. (PCA) manufacturers the model ADCAT CO catalysts (part number 28283.5-300CO) that is installed on the engine exhaust stack. The catalyst is designed in a modular manner where the Caterpillar Model G3616 engine is equipped with four catalyst modules. The catalyst uses proprietary materials to lower the oxidation temperature of CO and other organic compounds, thus maximizing the catalyst efficiency specific to the exhaust gas temperatures generated by the engine. The catalyst vendor has guaranteed a CO removal efficiency of 93%.

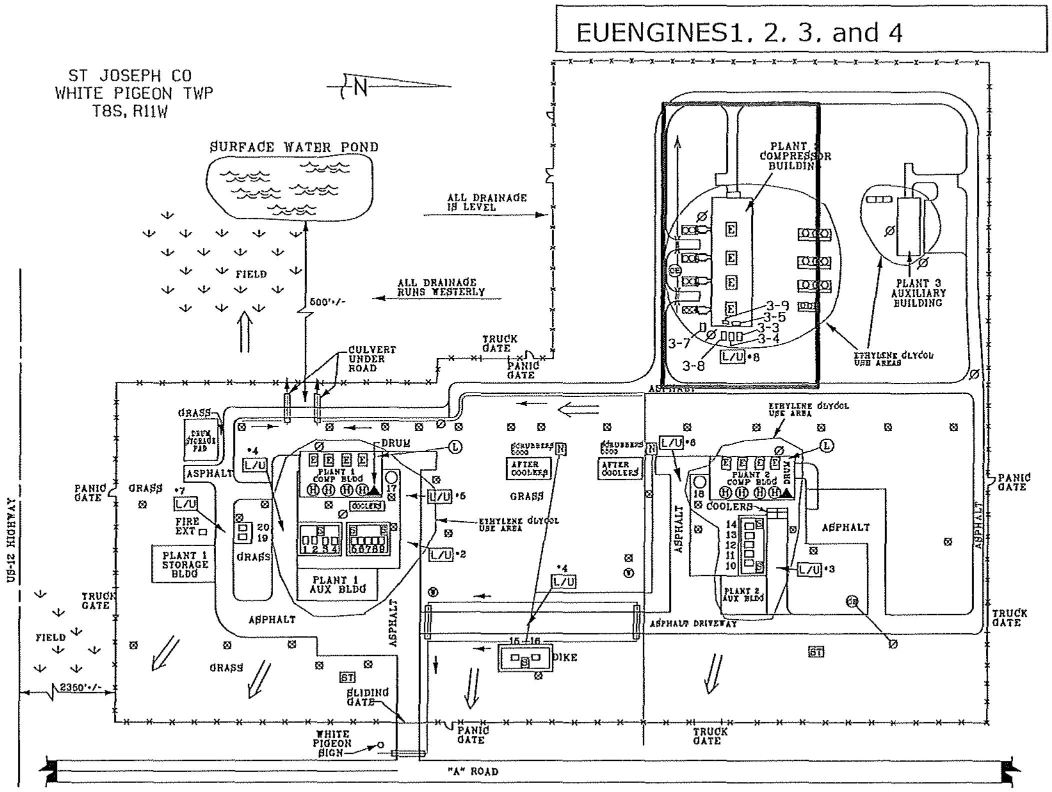
Detailed operating data recorded during testing are provided in Appendix C.

3.2 Process Flow

Located in southwestern St. Joseph County, the White Pigeon Compressor Station helps maintain natural gas pressures in the natural gas pipeline transmission system. The station receives natural gas from the ANR, 1800, and Trunkline interstate pipeline sources and provides adequate system pressure to support customer load and injection operations at other compressor stations. The Plant 3 compressor engines have the capacity to pump 800 million cubic feet of natural gas a day.

The facility is divided into three plants comprising natural gas reciprocating compressor engines, emergency generators, and associated equipment to maintain pressure in natural gas transmission system. The Plant 3 natural gas compressor engine EUENGINE2 was the focus of this test program. Refer to Figure 3-2 for the White Pigeon Compressor Station Plant 3 Site Map.

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



3.3 Materials Processed

The fuel utilized in EUENGINE2 is exclusively natural gas, as defined in 40 CFR 72.2. During testing, the natural gas from the ANR and Truckline pipelines was combusted within the engines and comprised of approximately 93% methane, 6% ethane, 1% nitrogen, and 0.2% carbon dioxide.

3.4 Rated Capacity

EUENGINE2 has a maximum power output of approximately 4,735 horsepower. The engine has a rated heat input of 16.1 and 32.0 million British thermal units per hour (mmBtu/hour), respectively. The normal rated capacity of the engine is a function of facility and gas transmission demand. The engine operating parameters were recorded and averaged for each test run. Refer to Appendix C for operating data recorded during testing.

3.5 PROCESS INSTRUMENTATION

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

- Discharge pressure (psi)
- Suction pressure (psi)
- Catalyst differential pressure (in. H_2O)
- Pre Catalyst inlet temperature (°F)
- Power (BHP)
- Engine speed (rpm)
- Compressor Torque (% max)
- Compressor Load Step (unit less)
- Fuel use (1,000 scf/hr)

Refer to Appendix C for operating data.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy RCTS tested for CO and O_2 concentrations using the United States Environmental Protection Agency (USEPA) test methods presented in Table 4-1. The sampling and analytical procedures associated with each parameter are described in the following sections.

Table 4-1
Test Methods

Parameter	USEPA	
	Method	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)
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 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 (2022)	Run	Sample Type	Start Time (EDT)	Stop Time (EDT)	Test Duration (min)	EPA Test Method	Comment
EUENGINE2							
June 30	1	O_2 CO	8:20	9:19	60	1 3A 10	Three-point traverse during Run 1; Single-point sample during Runs 2 and 3.
	2		9:35	10:34	60		
	3		10:50	11:49	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*. The engine sampling locations are presented in the following section. Pre-catalyst and post-catalyst sampling port location drawings are presented as 4-1.

EUENGINE2

Sample Port Location Upstream of Oxidation Catalyst in 34.5-inch equivalent diameter duct (note sample port is within the duct annulus):

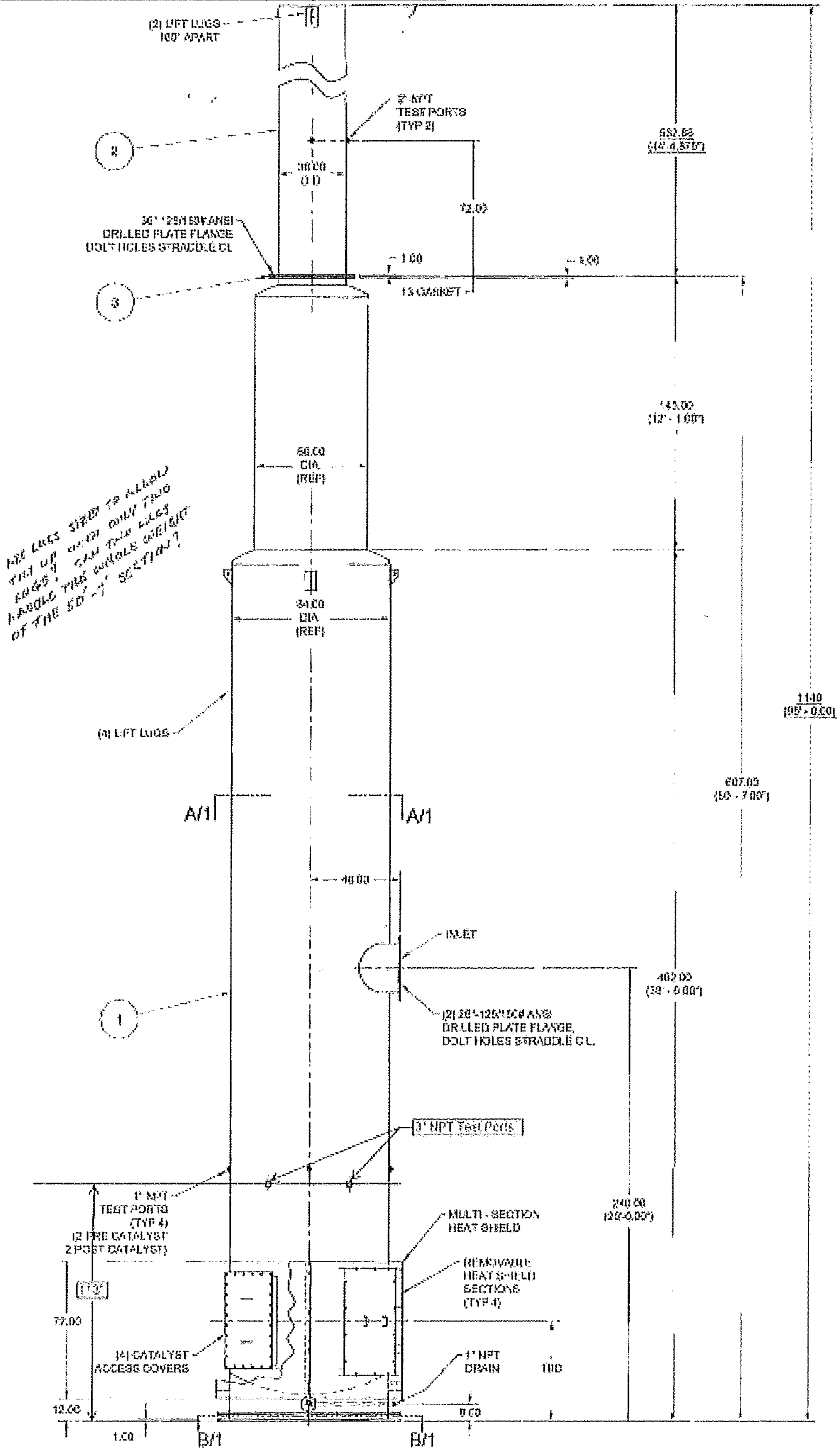
- Approximately 127-inches or 3.7 duct diameters downstream of a flow disturbance where the engine exhaust enters the exhaust stack, and
- Approximately 41-inches or 1.2 duct diameters upstream of the catalysts.

Sample Port Location Downstream of Oxidation Catalyst in 36-inch diameter duct:

- Approximately 72-inches or 2 duct diameters downstream of a flow disturbance, and
- Approximately 679-inches or 18.9 duct diameters upstream of the stack exit.

The sample ports are 0.5 to 1-inch in diameter and extend 3 inches beyond the stack wall. Because the ducts are >12 inches in diameter and the port locations meet the two and one-half diameter criterion of Section 11.1.1 of Method 1 of 40 CFR Part 60, Appendix A-1, the exhaust ducts were sampled at approximately equal intervals at 3 traverse points located at 16.7, 50.0, and 83.3% of the measurement line.

Figure 4-1. EUENGINE2 Sampling Locations



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

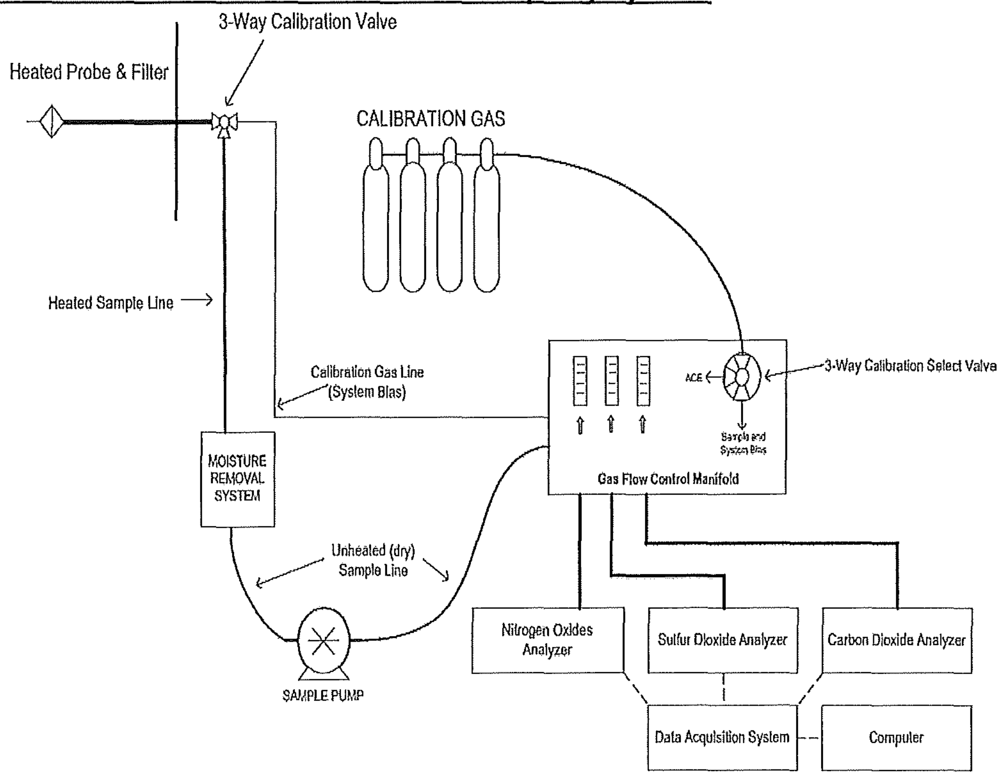
Oxygen and carbon monoxide concentrations were measured using the following sampling and analytical procedures:

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

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

Upon successful completion of the calibration error and initial system bias tests, sample flow rate and component temperatures were verified, and the probes were inserted into the ducts

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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 analyzers bias was within ±5.0% of span and drift was within ±3.0%. The analyzers responses were used to correct the measured gas concentrations for analyzer drift.

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 CO or 0.5% for O_2.

5.0 TEST RESULTS AND DISCUSSION

The test program was conducted June 30, 2022 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 63, Subpart ZZZZ, "National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines," and MI-ROP-N5573-2018.

5.1 Tabulation of Results

The EUENGINE2 test results indicate the CO emissions are compliant with applicable emissions limits as summarized in Table 2-1. Appendix Table 1 contains detailed tabulation of results, process operating conditions, and exhaust gas conditions for the respective RICE.

5.2 Significance of Results

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

5.3 Variations from Sampling or Operating Conditions

No operating condition variations were observed during the test program.

5.4 Process or Control Equipment Upset Conditions

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

5.5 Air Pollution Control Device Maintenance

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

5.6 Re-Test Discussion

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

- annually to evaluate the reduction of CO emissions across the oxidation catalyst in accordance with 40 CFR Part 63, Subpart ZZZZ and the ROP

5.7 Results of Audit Samples

Audit samples for the reference methods utilized during this test program are not available from USEPA Stationary Source Audit Sample Program providers. The USEPA reference methods performed state reliable results are obtained by persons equipped with a thorough knowledge of the techniques associated with each method. Factors with the potential to cause measurement errors are minimized by implementing quality control (QC) and assurance (QA) programs into the applicable components of field testing. QA/QC components were included in this test program. Table 5-1 summarizes the primary field quality assurance and quality control activities that were performed. Refer to Appendix E for supporting documentation.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluates suitability of sample location	Measure distance from ports to downstream and upstream flow disturbances	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.
M1: Duct diameter/ dimensions	Verifies area of stack is accurately measured	Review as-built drawings and field measurement	Pre-test	Field measurement agreement with as-built drawings
M3A, M10: Calibration gas standards	Ensures accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A, M10: Calibration Error	Evaluates operation of analyzers	Calibration gases introduced directly into analyzers	Pre-test	±2.0% of the calibration span
M3A, M10: System Bias and Analyzer Drift	Evaluates analyzer and sample system integrity and accuracy over test duration	Calibration gases introduced at sample probe tip, heated sample line, and into analyzers	Pre and Post-test	±5.0% of the analyzer calibration span for bias and ±3.0% of analyzer calibration span for drift

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

Other than Method 3A and 10 QA/QC and calibration gases used for zero calibrations, no other reagent or media blanks were used. QA/QC data are presented in Appendix D.

Appendix Tables