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MAY 15 2019

AIR QUALITY DIVISION

May 14, 2019

Mr. Rex Lane, District Supervisor
Michigan Department of Environment, Great Lakes and Energy
Air Quality Division
Kalamazoo District Office
7953 Adobe Road
Kalamazoo, MI 49009-5026

Re: Annual Compliance Test Report - White Pigeon Compressor Station (SRN: N5573)

Dear Mr. Lane:

This report summarizes the results of testing conducted March 26-28, 2019 at Consumers Energy Company's (CEC) White Pigeon Compressor Station, located in White Pigeon, Michigan. CEC's Regulatory Compliance Testing Section (RCTS) conducted performance tests on four (4) 4-stroke lean burn (4SLB) natural gas-fired, reciprocating internal combustion engines (RICE), identified as EUENGINE1, EUENGINE2, EUENGINE3 and EUENGINE4. The purpose of the testing was to demonstrate compliance with (a) the required percent reduction in CO concentrations across the oxidation catalysts installed on EUENGINE1-4 [40 CFR Part 63, Subpart ZZZZ]; (b) the NOx, CO and VOC emission limits for EUENGINE1-4 [40 CFR Part 60, Subpart JJJJ]; and (c) the facility's current ROP (No. MI-ROP-N5573-2013) emissions limits, as cited in Table I of FGENGINES Flexible Group Conditions.

Summary of 40 CFR Part 63 Subpart ZZZZ CO Reduction Efficiency Results

Source	CO Reduction Efficiency (%) [ZZZZ Limit = ≥ 93%]	Catalyst Inlet Temperature (°F) [ZZZZ Limit = ≥ 450°F and ≤ 1350°F]	Catalyst Pressure Drop (Inches Water Gauge) [ZZZZ Limit = ±2" from Initial Test]	Initial Catalyst Pressure Drop (Inches Water Gauge)
EUENGINE1	99.4	725	4.1	3.5
EUENGINE2	98.7	753	3.1	3.2
EUENGINE3	98.7	737	2.7	2.9
EUENGINE4	99.4	747	3.3	3.0

Based on the dry CO concentrations measured at the oxidation catalyst inlet and outlet, corrected to 15% O_2, the above results indicate that each engine meets the 40 CFR Part 63, Subpart ZZZZ minimum CO reduction efficiency of 93 percent.

Summary of 40 CFR Part 60 Subpart JJJJ and ROP g/HP-hr Emission Results

Source	CO Emission Rate (g/hp-hr) [ROP Limit = 0.2; JJJJ Limit = 4.0]	NO_x Emission Rate (g/hp-hr) [ROP Limit = 0.5; JJJJ Limit = 2.0]	VOC Emission Rate, Expressed as NMOC (g/hp-hr) [JJJJ Limit = 1.0]
EUENGINE1	0.009	0.3	0.3
EUENGINE2	0.02	0.4	0.5
EUENGINE3	0.02	0.3	0.5
EUENGINE4	0.01	0.4	0.4

The NOx, CO and VOC engine emission rates shown above all fall within the permit requirements, as well as the applicable emission limits within 40 CFR Part 60, Subpart JJJJ.

Please contact me at (517) 788-2201 if there are any questions on this submittal.

Sincerely,

Amy D. Kapuga

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

Enc
cc: Karen Kajiya-Mills, EGLE-TPU Lansing
Director, Air and Radiation Division, US EPA – Region V
Tim Wolf, White Pigeon
Gregory Baustian, cover letter only
White Pigeon Emission Test File

DEQ

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
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 Environmental Quality, Air Quality Division upon request.

Source Name Consumers Energy Company - White Pigeon Compressor Station County St. Joseph

Source Address 68536 A Road City White Pigeon

AQD Source ID (SRN) N5573 ROP No. MI-ROP-N5573-2018 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:

Continuous Compliance Test Report for EUENGINE1, EUENGINE2, EUENGINE3 & EUENGINE4

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

Gregory Baustian	Ex. Director, Gas Compression & Generation	(616) 638-8037
Name of Responsible Official (print or type)	Title	Phone Number

[signature] 5/13/2019

Signature of Responsible Official Date

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

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-N5573-2018	SRN: N5573

Responsible Official's Name/Title
Gregory Baustian/Ex. Director, Gas Compression & Generation

Street Address
425 N. Fairview Road

City	State	ZIP Code
Zeeland	MI	49464

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

Facility Street Address (If different than Responsible Official's Street Address)
68536 A Road, Route 1

Facility Local Contact Name	Title	Phone (OPTIONAL)
Tim Wolf	Field Leader	269-483-2902

City	State	ZIP Code
White Pigeon	MI	49099

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

Basis for this notification (relevant standard or other requirement)	Compliance Date (mm/dd/yyyy)
40 CFR 63.6640	03/28/2019

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

Reason for noncompliance:

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

Name of Responsible Official (Print or Type)	Title	Date (mm/dd/yyyy)
Gregory Baustian	Ex. Manager, Gas Compression & Generation	5/13/2019

Signature of Responsible Official

Note: Responsible official is defined under §63.2 as one of the following: a president, vice-president, secretary, or treasurer of the company that owns the plant; the owner of the plant; the plant engineer or supervisor; a government official if the plant is owned by the Federal, State, city, or county government; or a ranking military officer if the plant is located on a military installation.

SECTION III: METHODS

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

Consumers Energy - White Pigeon (White Pigeon) installed oxidation catalyst systems to reduce carbon monoxide (CO) emissions, on each of their four (4) 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 March 26-28, 2019, 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 performance test. White Pigeon 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 follows the startup requirements in 63.6625(h). The startup time is limited to 30 minutes and this facility minimizes 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)
EUENGINE1	Plant 3	3/27/2019	99.4	725	4.1	3.5
EUENGINE2	Plant 3	3/26/2019	98.7	753	3.1	3.2
EUENGINE3	Plant 3	3/27/2019	98.7	737	2.7	2.9
EUENGINE4	Plant 3	3/28/2019	99.4	747	3.3	3.0

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)]

White Pigeon 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)
EUENGINE1	Plant 3	Caterpillar G3608; 2370 hp; 4SLB; non-emergency engine	CO	1.3
EUENGINE2	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	3.1
EUENGINE3	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	3.0
EUENGINE4	Plant 3	Caterpillar G3616; 4735 hp; 4SLB; non-emergency engine	CO	1.5

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)]

White Pigeon 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 is also equipped with oxidation catalysts. Specifically, Pollution Control Associates, Inc. (PCA) ADCAT™ CO Catalysts, Part No. 28283.5-300CO. The catalysts are designed in a modular manner, and each Caterpillar Model G3616 engine is equipped with four catalyst modules, while the Caterpillar Model G3608 engine is equipped with two catalyst modules. The ADCAT™ CO 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
EUENGINE1	Plant 3	Pollution Control Associates, Inc. (PCA) ADCAT™ CO Catalysts	Reduces CO by 93% or more
EUENGINE2	Plant 3	Pollution Control Associates, Inc. (PCA) ADCAT™ CO Catalysts	Reduces CO by 93% or more
EUENGINE3	Plant 3	Pollution Control Associates, Inc. (PCA) ADCAT™ CO Catalysts	Reduces CO by 93% or more
EUENGINE4	Plant 3	Pollution Control Associates, Inc. (PCA) ADCAT™ CO Catalysts	Reduces CO by 93% or more

The estimated formaldehyde and non-methane, non-ethane hydrocarbon (NMNEHC) destruction efficiencies are 85% and 75%, respectively.

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.

Notification of Compliance Status reports must be postmarked before the close of business on the 60th calendar day following the completion of the relevant compliance demonstration specified in the standard, unless a different reporting period is specified. In the second case, the letter shall be postmarked before the close of business on the day the report of the testing or monitoring results is required to be delivered or postmarked. Notifications may be combined as long as the due date requirements are met for each notification. [40 CFR §63.9(h)(2)(ii)].

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 %
EUENGINE1	Caterpillar G3608 Serial # BEN00515	2008	2370 hp	3/27/2019	99	48	29.2	40
EUENGINE2	Caterpillar G3616 Serial # BLB00456	2008	4735 hp	3/26/2019	98	45	29.4	26
EUENGINE3	Caterpillar G3616 Serial # BLB00485	2008	4735 hp	3/27/2019	97	30	29.4	58
EUENGINE4	Caterpillar G3616 Serial # BLB00487	2008	4735 hp	3/28/2019	99	45	29.1	66

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 60 Subpart JJJJ
40 CFR Part 63 Subpart ZZZZ
Continuous Compliance Test Report

EUENGINE3-1, EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4

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

May 9, 2019

Test Dates: March 26, 27, and 28, 2019

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order No. 34079973
Version No.: 0

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EXECUTIVE SUMMARY

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compound (VOC) testing upstream and/or downstream of oxidation catalysts installed in the exhaust of EUENGINE3-1, EUENGINE3-2, EUENGINE3-3, and EUENGINE3-4 in operation at the Consumers Energy White Pigeon Compressor Station in White Pigeon, Michigan. The facility is classified as a major source of hazardous air pollutants (HAP) and the engines are natural gas-fired, four-stroke lean-burn (4SLB), spark ignited (SI), reciprocating internal combustion engines (RICE), >500 horsepower that power compressors used to maintain pressure in the pipeline transporting natural gas from a main line to storage facilities located in Michigan or local distribution companies. The engines are collectively grouped as FGENGINES within Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) MI-ROP-N5573-2018 and subject to federal air emissions regulations.

The test program was conducted March 26, 27, and 28, 2019 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 60, Subpart JJJJ, "Standards of Performance for Stationary Spark Ignition Internal Combustion Engines," (aka NSPS SI ICE), 40 CFR Part 63, Subpart ZZZZ, "National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines," and the ROP.

Three, 60-minute test runs were conducted at each engine following the procedures in United States Environmental Protection Agency (USEPA) Reference Methods (RM) 1, 3A, 4, 7E, 10, 19, and 25A in 40 CFR Part 60, Appendix A. There were no deviations from the approved stack test protocol or associated USEPA Reference Methods. During testing, EUENGINE3-1, EUENGINE3-2, EUENGINE3-3, and EUENGINE3-4 operated at horsepower and torque conditions within plus or minus (±) 10 percent of 100 percent peak (or the highest achievable) load, as specified in 40 CFR 60.4244(a).

The results of the EUENGINE3-1, EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4 testing indicate the NO_x, CO, and VOC emissions are compliant with applicable emissions limits. The results of the emissions testing are summarized in Table E-1 on the following page.

Table E-1
Summary of Test Results

Parameter	Units	Average result of 3 Test Runs EUENGINE				Emission Limit		
		3-1	3-2	3-3	3-4	40 CFR Part 60, Subpart JJJJ[1, 2]	40 CFR Part 63, Subpart ZZZZ	MI-ROP-5573-2018
NO_x	g/HP-hr	0.31	0.39	0.29	0.35	2.0		0.5
	ppmvd at 15% O_2	26.8	33.3	25.2	29.4	160		
CO	g/HP-hr	0.009	0.022	0.021	0.011	4.0		0.2
	ppmvd at 15% O_2	1.3	3.1	3.0	1.5	540		
	% reduction	99.4	98.7	98.7	99.4		93	93
VOC	g/HP-hr	0.3	0.5	0.5	0.4	1.0		1.0
	ppmvd at 15% O_2	26.7	47.0	47.2	38.0	86		

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

[1] Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/HP-hr or ppmvd at 15 percent O_2
[2] Owners and operators of new lean burn SI stationary engines with a site rating ≥250 brake HP located at a major source that are meeting the requirements of 40 CFR Part 63, Subpart ZZZZ, Table 2a do not have to comply with the CO emission standards in 40 CFR Part 60, Subpart JJJJ, Table 1.

Detailed results are presented in Appendix Tables 1, 2, 3 and 4. Sample calculations, field data sheets, and laboratory data sheets are presented in Appendices A, B, and C. Engine operating data and supporting documentation are provided in Appendices D and E.

1.0 INTRODUCTION

This report summarizes the results of compliance air emissions testing conducted March 26, 27, and 28, 2019 at the Consumers Energy White Pigeon Compressor Station in White Pigeon, Michigan.

This document follows the Michigan Department of Environmental Quality (MDEQ) format described in the March 2018, Format for Submittal of Source Emission Test Plans and Reports. Reproducing only a portion of this report may omit critical substantiating documentation or cause information to be taken out of context. If any portion of this report is reproduced, please exercise due care in this regard.

1.1 IDENTIFICATION, LOCATION, AND DATES OF TESTS

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compound (VOC) testing of four, stationary, spark-ignition (SI), reciprocating internal combustion engines (RICE), identified as EUENGINE3-1, EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4 installed and operating at the White Pigeon Compressor Station in White Pigeon, Michigan on March 26, 27, and 28, 2019.

A test protocol submitted to the MDEQ on January 22, 2019 was subsequently approved by Mr. Tom Gasloli, MDEQ Environmental Quality Analyst, in a letter dated January 24, 2019. There were no deviations from the approved stack test protocol or associated USEPA Reference Methods.

1.2 PURPOSE OF TESTING

The test program was conducted March 26, 27, and 28, 2019 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 60, Subpart JJJJ, "Standards of Performance for Stationary Spark Ignition Internal Combustion Engines," (aka NSPS SI ICE), 40 CFR Part 63, Subpart ZZZZ, "National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines," and MI-ROP-N5573-2018. The applicable emission limits are presented in Table 1-1.

Table 1-1
Applicable Emission Limits

Parameter	Emission Limit			Units
	40 CFR Part 60, Subpart JJJJ[1, 2]	40 CFR Part 63, Subpart ZZZZ	MI-ROP-5573-2018	
NO_x	2.0		0.5	g/HP-hr
	160			ppmvd at 15% O_2
CO[3]	4.0		0.2	g/HP-hr
	540			ppmvd at 15% O_2
		93	93	% reduction across oxidation catalyst
Formaldehyde[3]		14	14	ppmvd at 15% O_2
VOC	1.0		1.0	g/HP-hr
	86			ppmvd at 15% O_2

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

[1] Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/HP-hr or ppmvd at 15 percent O_2
[2] Owners and operators of new lean burn SI stationary engines with a site rating ≥250 brake HP located at a major source that are meeting the requirements of 40 CFR Part 63, Subpart ZZZZ, Table 2a do not have to comply with the CO emission standards in 40 CFR Part 60, Subpart JJJJ, Table 1.
[3] Table 2a to Subpart ZZZZ of Part 63 requires compliance by reducing CO emissions by 93 percent or more OR limit concentration of formaldehyde in the stationary RICE exhaust to 14 ppmvd or less at 15 percent O_2.

1.3 Brief Description of Source

EUENGINE3-1, EUENGINE3-2, EUENGINE3-3, and EUENGINE3-4 are natural gas-fired, four-stroke lean-burn (4SLB), spark ignited (SI), reciprocating internal combustion engines (RICE), >500 horsepower that power compressors used to maintain pressure in the pipeline transporting natural gas from a main line to storage facilities located in Michigan or local distribution companies. The engines are collectively grouped as FGENGINES within MDEQ MI-ROP-N5573-2018.

1.4 Contact Information

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

Table 1-2
Contact Information

Program Role	Contact	Address
State Regulatory Administrator	Ms. Karen Kajiya-Mills Technical Programs Unit Manager 517-335-4874 kajiya-millsk@michigan.gov	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Technical Programs Field Inspector	Mr. Tom Gasloli Technical Programs Unit Field Operations Section 517-284-6778 gaslolit@michigan.gov	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Regulatory Inspector	Mr. Chance Collins Environmental Quality Analyst 269-254-7119 collinsc21@michigan.gov/air	Michigan Department of Environmental Quality Kalamazoo District Office 7953 Adobe Road Kalamazoo, Michigan 49009-5025
Responsible Official	Mr. Gregory Baustian Executive Director-Natural Gas Compression and Storage 616-237-4009 gregory.baustian@cmsenergy.com	Consumers Energy Company Zeeland Generation 425 N. Fairview Road Zeeland, Michigan 49464
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	Ms. Janet Zondlak Senior Environmental Analyst 616-738-3702 Janet.zondlak@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460
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. Thomas Schmelter, QSTI Engineering Technical Analyst II 616-738-3234 thomas.schmelter@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460

2.0 SUMMARY OF RESULTS

2.1 Operating Data

During the performance test, the engines fired natural gas and pursuant to §60.4244(a), the engines were operated within 10% of 100 percent peak (or the highest achievable) load. The performance testing was conducted with the engines operating at an average load >98% torque and >98% horsepower, based on the maximum manufacturer's design capacity at engine and compressor site conditions. Refer to Appendix D for detailed operating data.

2.2 Applicable Permit Information

The White Pigeon Compressor Station operates in accordance with MI-ROP-N5573-2018. EUENGINE3-1, EUENGINE3-2, EUENGINE3-3, and EUENGINE3-4 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 60, Subpart JJJJ and 40 CFR Part 63, Subpart ZZZZ.

2.3 Results

The results of the EUENGINE3-1, EUENGINE3-2, EUENGINE3-3, and EUENGINE3-4 testing indicate the NO_x, CO, and VOC emissions are compliant with applicable emissions limits. Refer to Table 2-1 for the summary of test results.

Detailed results are presented in Appendix Tables 1, 2, 3 and 4. A discussion of the results is presented in Section 5.0. Sample calculations, field data sheets, and laboratory data sheets are presented in Appendices A, B, and C. Engine operating data and supporting documentation are provided in Appendices D and E.

Table 2-1
Summary of Test Results

Parameter	Units	Average result of 3 Test Runs EUENGINE				Emission Limit		
		3-1	3-2	3-3	3-4	40 CFR Part 60, Subpart JJJJ[1, 2]	40 CFR Part 63, Subpart ZZZZ	MI-ROP-5573-2018
NO_x	g/HP-hr	0.31	0.39	0.29	0.35	2.0		0.5
	ppmvd at 15% O_2	26.8	33.3	25.2	29.4	160		
CO	g/HP-hr	0.009	0.022	0.021	0.011	4.0		0.2
	ppmvd at 15% O_2	1.3	3.1	3.0	1.5	540		
	% reduction	99.4	98.7	98.7	99.4		93	93
VOC	g/HP-hr	0.3	0.5	0.5	0.4	1.0		1.0
	ppmvd at 15% O_2	26.7	47.0	47.2	38.0	86		

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

[1] Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/HP-hr or ppmvd at 15 percent O_2
[2] Owners and operators of new lean burn SI stationary engines with a site rating ≥250 brake HP located at a major source that are meeting the requirements of 40 CFR Part 63, Subpart ZZZZ, Table 2a do not have to comply with the CO emission standards in 40 CFR Part 60, Subpart JJJJ, Table 1.

3.0 SOURCE DESCRIPTION

EUENGINE3-1, EUENGINE3-2, EUENGINE3-2, and EUENGINE3-4 are 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]	EUENGINE3-1	EUENGINE3-2, EUENGINE3-3, and EUENGINE3-3
Purchase Year	2008	2008
Installation Date	June 15, 2010	June 15, 2010
Make	Caterpillar	Caterpillar
Model	G3608	G3616
Cylinders	8	16
Output (brake-horsepower)	2,370	4,735
Heat Input (mmBtu/hr)	16.1	32.0
Exhaust Flow Rate (acfm, wet)	16,144	32,100
Exhaust Gas Temp. (°F)	857	856
Engine Outlet O_2 (Vol-%, dry)	12.00	12.00
Engine Outlet CO_2 (Vol-%, dry)	5.81	5.81
CO, uncontrolled (ppmvd)	570.0	572.0
CO, controlled[2] (ppmvd)	39.9	40.0

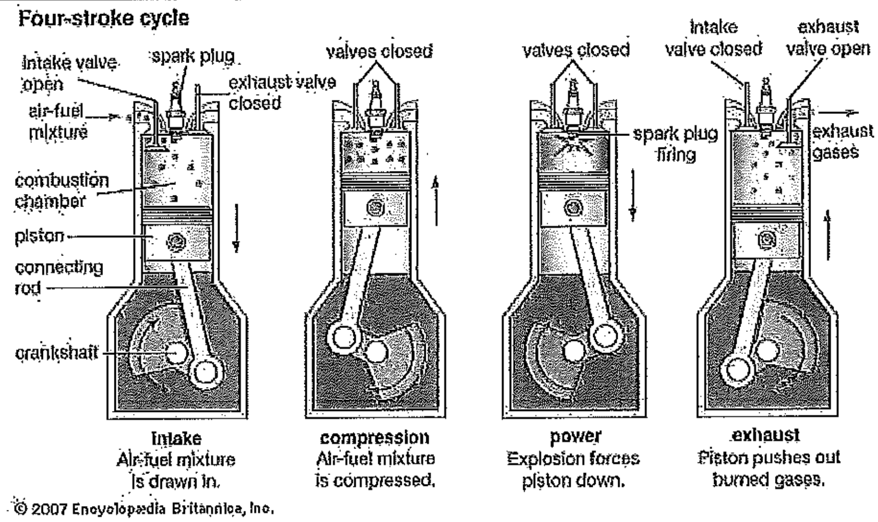
1 All engine specifications are based upon vendor data for operation at 100% of rated engine capacity.
2 The controlled CO concentrations are based upon the vendor not to exceed CO concentrations at 100% load, and a reduction of 93% by volume for the associated oxidation catalysts.

3.1 Process

EUENGINE3-1, EUENGINE3-1, EUENGINE3-3, and EUENGINE3-4 are natural gas-fired 4SLB SI RICEs constructed in 2010. In a four-stroke engine, air is aspirated into the cylinder during the downward travel of the piston on the intake stroke. The fuel charge is injected when the piston is near the bottom of the intake stroke; the intake ports close as the piston moves to the top of the cylinder, compressing the air/fuel mixture. The ignition and combustion of the air/fuel charge begins the downward movement of the piston called the power stroke. As the piston reaches the bottom of the power stroke, valves are opened and combustion products are expelled from the cylinder as the piston travels upward. A new air-to-fuel charge is injected as the piston moves downward with a new intake stroke.

The engines provide mechanical shaft power to a gas compressor. The compressors are used to maintain pressure within the natural gas pipeline transmission and distribution system. Refer to Figure 3-1 for a four-stroke engine process diagram.

Figure 3-1. Four-Stroke Engine Process Diagram



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

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

The engines are also equipped with oxidation catalysts. Pollution Control Associates, Inc. (PCA) manufacturers the model ADCAT CO catalysts (part number 28283.5-300CO) that are installed on each engine exhaust stack. The catalysts are designed in a modular manner where each Caterpillar Model G3616 engine is equipped with four catalyst modules, while the Caterpillar Model 3608 engine is equipped with two 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 engines. The catalyst vendor has guaranteed a CO removal efficiency of 93%. The catalysts also provide control of formaldehyde, as well as non-methane and non-ethane hydrocarbons with the estimated destruction efficiency of 85% and 75%, respectively.

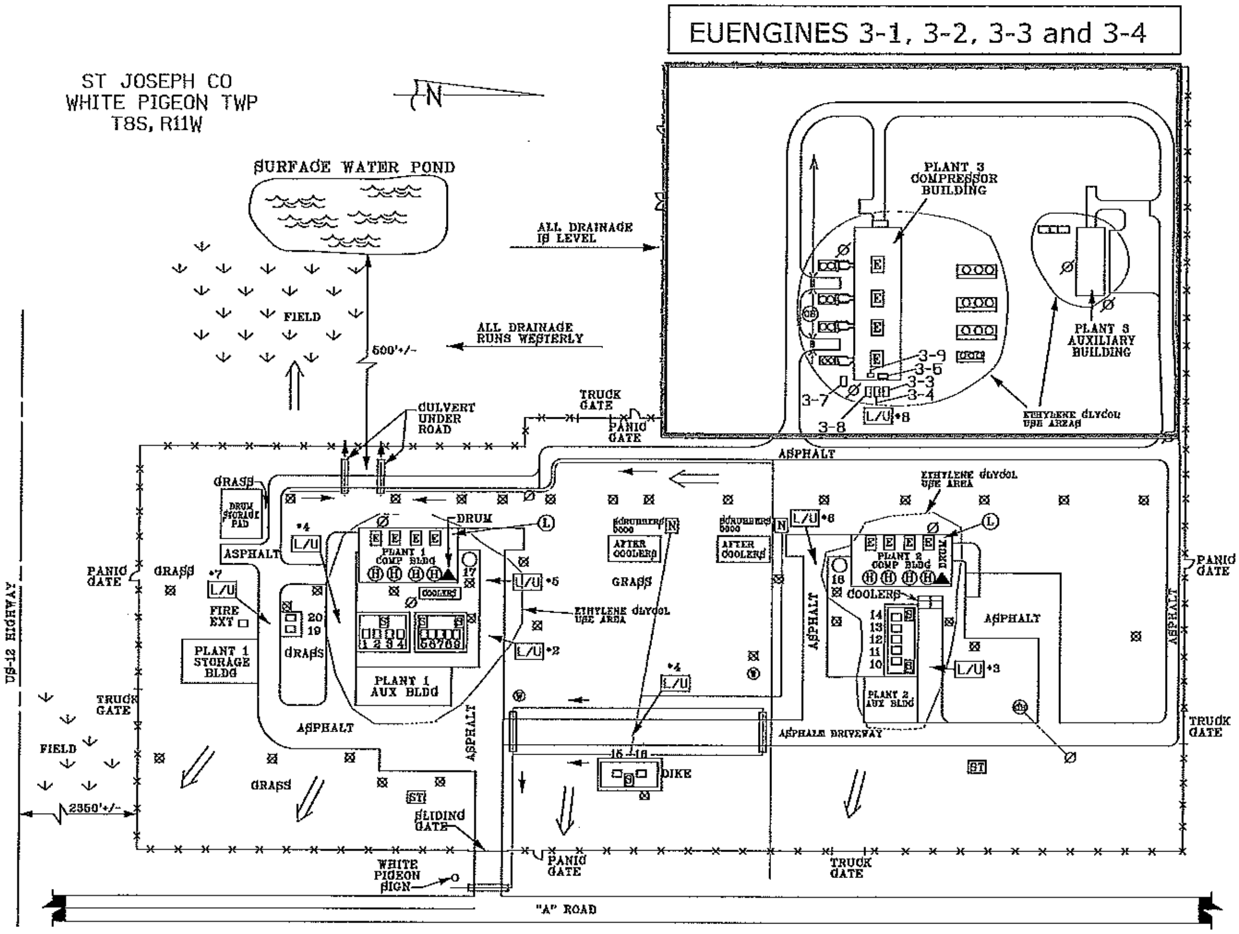
Detailed operating data recorded during testing are provided in Appendix D.

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 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 engines were 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 EUENGINE3-1, EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4 is exclusively natural gas, as defined in 40 CFR 72.2. During testing, the natural gas combusted within the engines was comprised of approximately 93% methane, 4% ethane, 2% nitrogen, and 0.5% carbon dioxide.

3.4 Rated Capacity

EUENGINE3-1 has a maximum power output of approximately 2,370 horsepower while EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4 are rated at 4,735 horsepower. The engines have a rated heat input of 16.1 and 32.0 million British thermal units per hour (mmBtu/hour), respectively. The normal rated capacities of the engines are a function of facility and gas transmission demand. The engine operating parameters were recorded and averaged for each test run. Refer to Appendix D 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)
- Catalyst inlet temperature (°F)
- Catalyst exhaust temperature (°F)
- Power (BHP)
- Engine speed (rpm)
- Compressor Torque (% max)
- Compressor Load Step (unit less)
- Fuel use (1,000 scf/hr)

Refer to Appendix D for operating data.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

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

Table 4-1
Test Methods

Parameter	Method	USEPA Title
Sample traverses	1	Sample and Velocity Traverses for Stationary Sources
Oxygen	3A	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Moisture content	4	Determination of Moisture Content in Stack Gases
Nitrogen oxides (NO_x)	7E	Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Carbon monoxide (CO)	10	Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Emission rates	19	Sulfur Dioxide Removal and Particulate, Sulfur Dioxide and Nitrogen Oxides from Electric Utility Steam Generators
Volatile organic compounds	25A	Measurement of Gaseous Organic Compound Emissions by Gas Chromatography

4.1 Description of Sampling Train and Field Procedures

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

Table 4-2
Test Matrix

Date (2019)	Run	Sample Type	Start Time (EDT)	Stop Time (EDT)	Test Duration (min)	EPA Test Method	Comment
EUENGINE3-2							
March 26	1	O_2 NO_x CO VOC	9:35	10:34	60	1 3A 4 7E 10 19 25A	Run Void due to analyzer drift
	2		13:15	14:14	60		VOC analyzer failed drift criterion; results drift corrected per USEPA Method 7E, as approved by MDEQ. Stratification test performed
	3		15:00	15:59	60		Single point sample at exhaust stack
	4		16:25	17:24	60		Single point sample at exhaust stack Natural gas sample collected at 17:16
EUENGINE3-1							
March 27	1	O_2 NO_x CO VOC	15:07 15:55	15:41 16:20	60	1 3A 4 7E 10 19 25A	Natural gas sample collected at 8:20 Test paused from 15:42-15:54 to change combustion air cylinder to VOC analyzer Stratification test performed
	2		16:54	17:53	60		Single point sample at exhaust stack
	3		18:25	19:24	60		Single point sample at exhaust stack
EUENGINE3-3							
March 27	1	O_2 NO_x CO VOC	9:30	10:29	60	1 3A 4 7E 10 19 25A	Natural gas sample collected at 08:20 Stratification test performed
	2		11:00	11:59	60		Single point sample at exhaust stack
	3		12:30	13:29	60		Single point sample at exhaust stack
EUENGINE3-4							
March 28	1	O_2 NO_x CO VOC	9:10	10:09	60	1 3A 4 7E 10 19 25A	Natural gas sample collected at 8:01 Stratification test performed
	2		10:40	11:39	60		Single point sample at exhaust stack
	3		12:16	13:15	60		Single point sample at exhaust stack

4.2 Sample Location and Traverse Points (USEPA Method 1)

The number and location of traverse points was evaluated according to the requirements in Table 4 of 40 CFR Part 63, Subpart ZZZZ, Table 2 of 40 CFR Part 60, Subpart JJJJ, and

USEPA Method 1, Sample and Velocity Traverses for Stationary Sources. The sampling locations for EUENGINE3-1 and EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4 are presented in the following section:

EUENGINE3-1

Sample Port Location Upstream of Oxidation Catalyst in 26-inch diameter duct:

- Approximately 60-inches or 2.3 duct diameters downstream of a flow disturbance where the engine exhaust enters the exhaust stack, and
- Approximately 85-inches or 3.3 duct diameters upstream of the catalysts.

Sample Port Location Downstream of Oxidation Catalyst in 26-inch diameter duct:

- Approximately 52-inches or 2 duct diameters downstream of a flow disturbance, and
- Approximately 573-inches or 22 duct diameters upstream of the stack exit.

EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4

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.

Pre-catalyst and post-catalyst sampling port location drawings are presented as Figures 4-1 (EUENGINE3-1) and 4-2 (EUENGINES 3-2, 3-3 and 3-4).

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 sampling port locations meet the two and one-half diameter criterion of Section 11.1.1 of Method 1 of 40 CFR Part 60, Appendix A-1, the exhaust ducts were sampled at 3 traverse points located at 16.7, 50.0, and 83.3% of the measurement line ('3-point long line'). The exhaust flue gas was sampled from the three traverse points at approximately equal intervals during the tests. The sampling port upstream of the oxidation catalyst was not traversed and flue gas concentrations were measured at a single sample location due to duct configuration.

After the conclusion of the first valid run at each source, the pollutant concentrations were averaged for the sample period at each traverse point and compared to the average concentration measured during the 60-minute test following the procedures in USEPA Method 7E to evaluate pollutant stratification. The results of the stratification tests indicated that sampling was acceptable from a single sampling point near the centroid of the duct or stack and are presented in Appendix B.

Figure 4-1. EUENGINE3-1 Sampling Locations

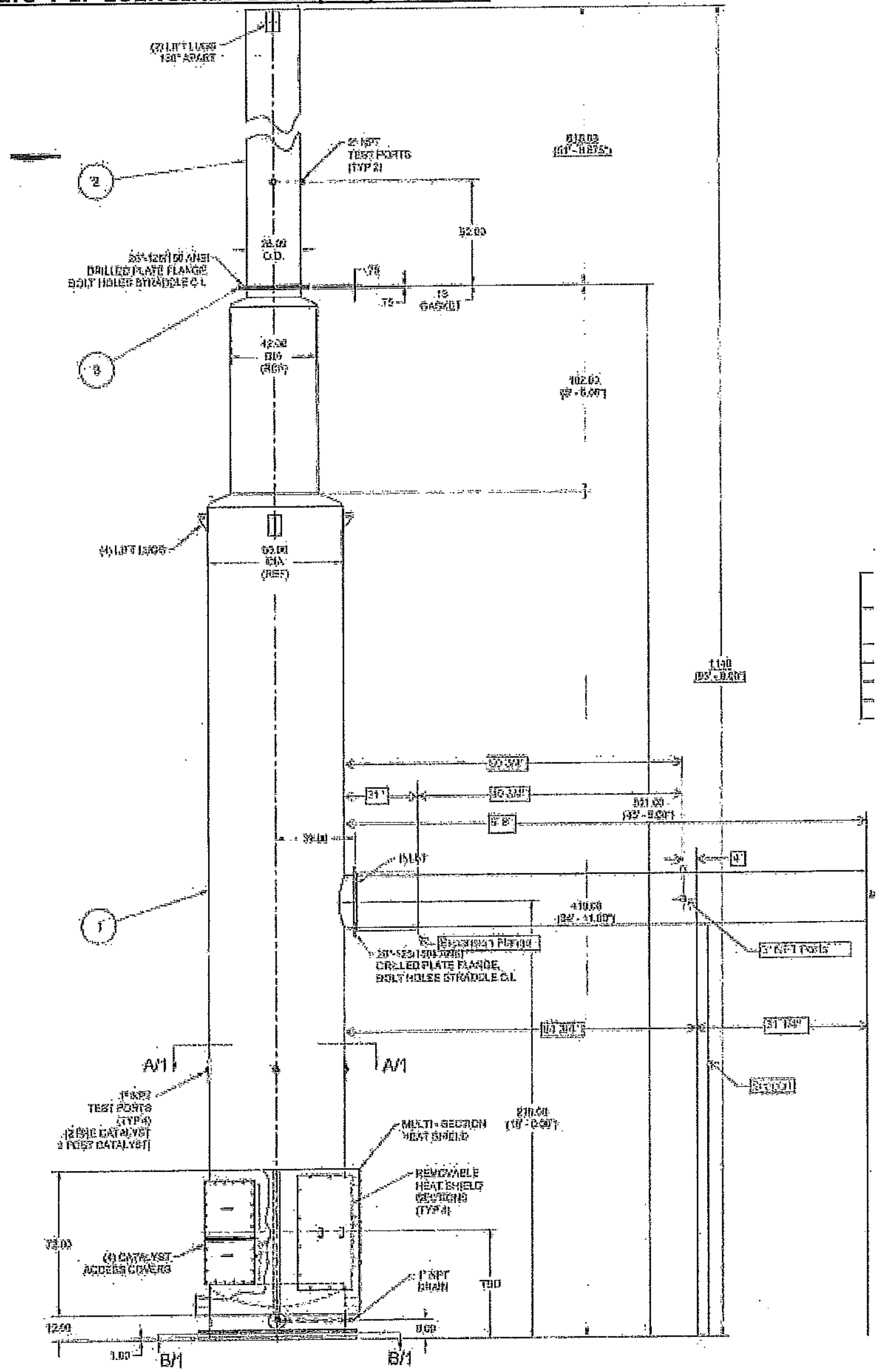
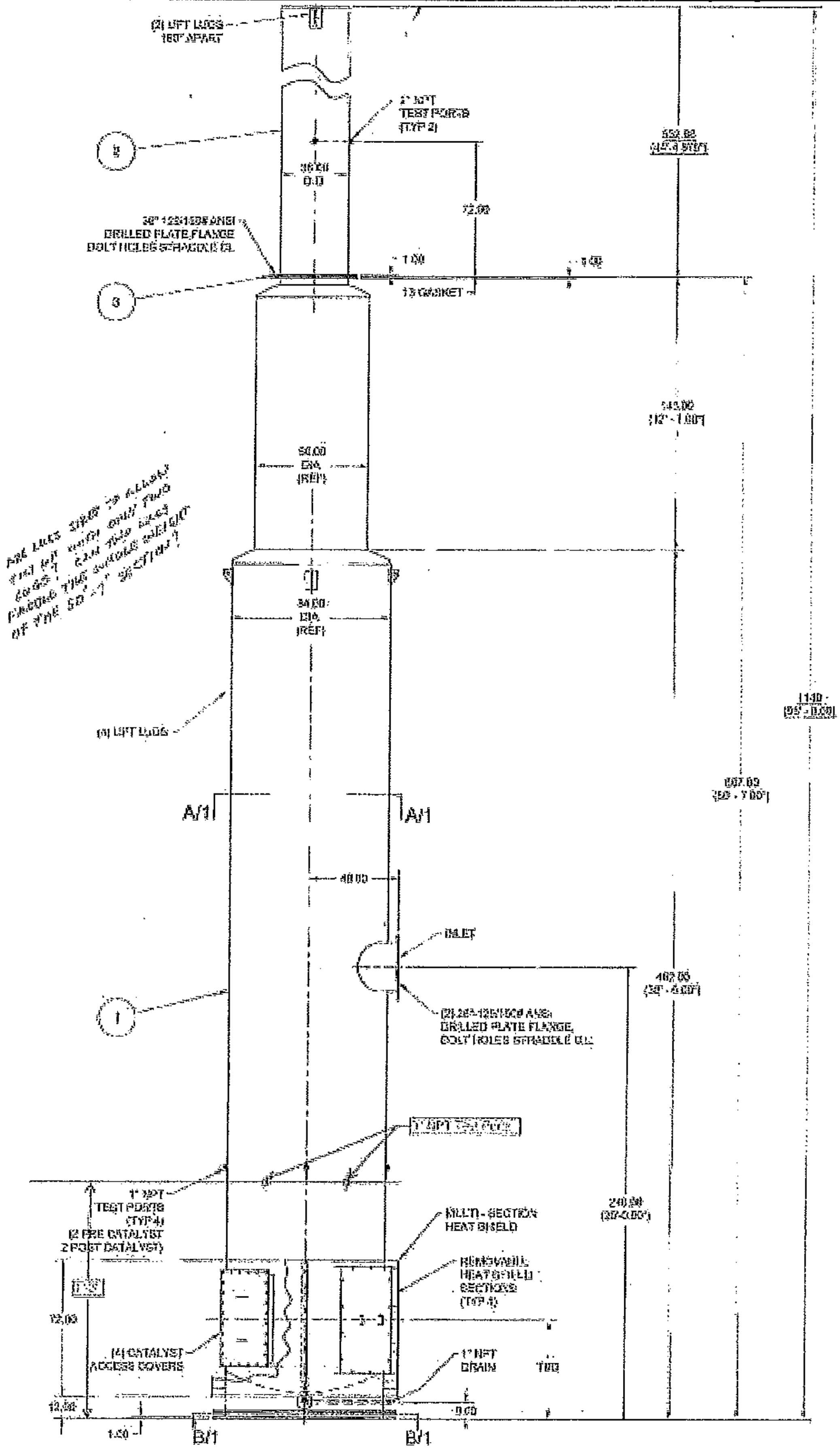


Figure 4-2. EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4 Sampling Locations



4.3 Moisture Content (USEPA Method 4)

The alternative procedure in 40 CFR Part 60, Appendix A Method 4, *Determination of Moisture Content in Stack Gases*, §16.4 was used to calculate flue gas moisture content by summing the moisture mole fraction of the ambient air, the free water in the fuel fired, and the hydrogen in the fuel. This data was used to convert measured pollutant concentration from a wet basis to dry basis. The natural gas fuel sample laboratory analyses result and the water content from the market main are contained in Appendix C of this report.

4.4 O_2, NO_X, and CO (USEPA Methods 3A, 7E, and 10)

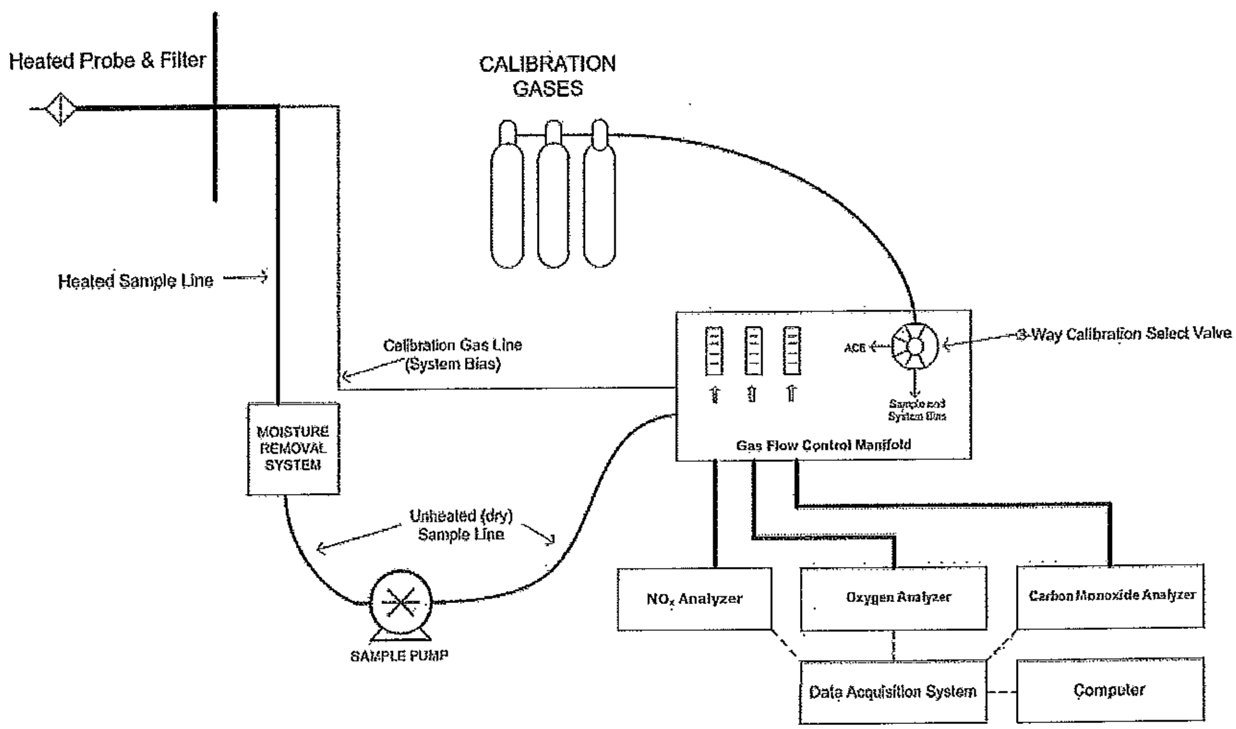
Oxygen, nitrogen oxides, and/or carbon monoxide concentrations were measured using the following sampling and analytical procedures:

- USEPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)*,
- USEPA Method 7E, Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure), and
- USEPA Method 10, *Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure).*

The sampling procedures of the methods are similar with the exception of 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, 7E, and 10 sampling system.

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



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

A NO_2 to NO conversion efficiency test was performed on the NO_x analyzer prior to beginning the test program to evaluate the ability of the instrument to convert NO_2 to NO before analyzing for NO_x.

Upon successful completion of the calibration error and initial system bias tests, sample flow rate and component temperatures were verified and the probes were inserted into the ducts at the appropriate traverse point. After confirming the engine was operating at established conditions, the test run was initiated. Gas concentrations were recorded at 1-minute intervals throughout each 60-minute test run.

After the conclusion of each test run, a post-test 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.

4.5 Emission Rates (USEPA Method 19)

USEPA Method 19, *Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*, was used to calculate a fuel specific F factor and exhaust gas flowrate.

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

Figure 4-4. USEPA Method 19 Emission Flow Rate Equation

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

Where:

Q_s = stack flow rate (dscf/min)
F_d = fuel-specific oxygen-based F factor, dry basis, from Method 19 (scf/mmBtu)
H = fuel heat input rate, (mmBtu/min), at the higher heating value (HHV) measured at engine fuel feed line, calculated as (fuel feed rate in ft^3/min) x (fuel heat content in mmBtu/ft^3)
O_2 = stack oxygen concentration, dry basis (%)

4.6 Volatile Organic Compounds (USEPA Method 25A)

VOC concentrations were measured from each engine using a Thermo Model 55i Direct Methane and Non-methane Analyzer following the guidelines of USEPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer (FIA)*. The instrument uses a flame ionization detector (FID) to measure the exhaust gas total hydrocarbon concentration in conjunction with a gas chromatography column that separates methane from other organic compounds.

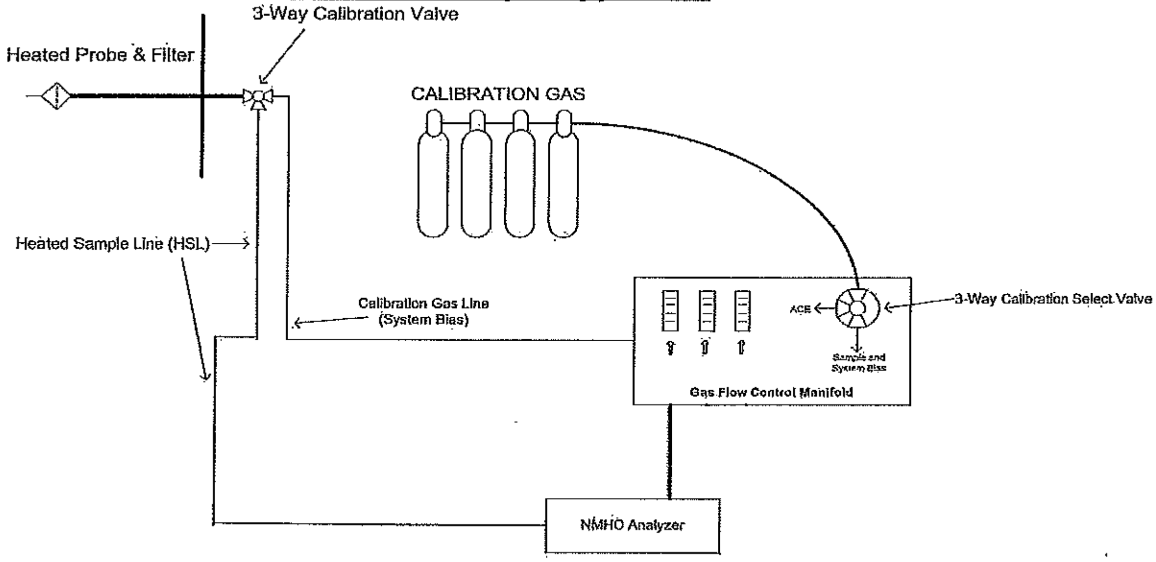
The components of the extractive sample interface apparatus are constructed of Type 316 stainless steel and Teflon. Flue gas was sampled from the stack via a sample probe and heated sample line and into the analyzer, which communicates with data acquisition handling systems (DAHS) via output signal cables. The analyzer uses a rotary valve and gas chromatograph column to separate methane from hydrocarbons in the sample and quantifies these components using a flame ionization detector.

Sample gas is injected into the column and due to methane's low molecular weight and high volatility, the compound moves through the column more quickly than other organic compounds that may be present and is quantified by the FID. The column is then flushed with inert carrier gas and the remaining non-methane organic compounds are analyzed in the FID. This analytical technique allows separate measurements for methane and non-methane organic compounds via the use of a single FID. Refer to Figure 4-5 for a drawing of the USEPA Method 5 sampling apparatus.

The field VOC instrument was calibrated with zero air and three propane and methane in air calibration gases following USEPA Method 25A procedures at the zero level, low (25 to 35 percent of calibration span), mid (45 to 55 percent of calibration span) and high (equivalent to 80 to 90 percent of instrument span). Please note that since the field VOC instrument measures on a wet basis, exhaust gas moisture content was used to convert the wet VOC concentrations to a dry basis and calculate VOC mass emission rates. The moisture content results from natural gas fuel samples collected during the test program were used to calculate the final VOC concentrations and emission rates.

Please note that 40 CFR Part 63, Part 60, Subpart JJJJ refers to the definition of VOC found in 40 CFR, Part 51 and does not include methane or ethane. Specifically, §51.100(s)(1) defines VOC as *any compound of carbon...other than the following, which have been determined to have negligible photochemical reactivity: methane, ethane...* The Thermo 55i analyzers used measure exhaust gas ethane as part of the NMOC measurement. Therefore, if the RICE are firing natural gas containing elevated ethane concentrations, such as that obtained from shale sources, the NMOC concentrations measured may reflect a positive NMOC bias or non-compliance.

Figure 4-5. USEPA Method 25A Sample Apparatus



5.0 TEST RESULTS AND DISCUSSION

The test program was conducted March 26, 27, and 28, 2019 to satisfy performance testing requirements and evaluate compliance with 40 CFR Part 60, Subpart JJJJ, "Standards of Performance for Stationary Spark Ignition Internal Combustion Engines," (aka NSPS SI ICE), 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 results of the EUENGINE3-1, EUENGINE3-2, EUENGINE3-3 and EUENGINE3-4 testing indicate the NO_x, CO, and VOC emissions are compliant with applicable emissions limits as summarized in Table 2-1. Appendix Tables 1, 2, 3 and 4 contain detailed tabulation of results, process operating conditions, and exhaust gas conditions for each 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. During testing of EUENGINE3-2 on March 26, 2019, VOC analyzer drift exceeding USEPA Method 25A acceptance criteria was observed. The analyzer's Run 1 post-test response to the mid calibration gas exceeded the calibration drift criteria of 3 percent of span and Run 1 was void. Measured pollutant and diluent concentrations for Run 1 are included in Appendix B; however, the data was not used to calculate results.

After the conclusion of EUENGINE3-2 Run 1, RCTS attempted to identify the cause of the VOC analyzer drift by introducing additional calibration gases and adjusting sampling parameters. Based on observations of analyzer behavior to a series of evaluations, it was concluded that sample flow was a cause of analyzer drift. The VOC sampling system was reconfigured to stabilize sample flow and the instrument was recalibrated in preparation for

Run 2. As the reconfiguration affected the CO, NO_x, and O_2 sampling system at the catalyst exhaust, system bias tests were performed on these instruments that verified acceptable analyzer operation with no sample system leaks.

After the conclusion of EUENGINE3-2 Run 2, the post-test drift check of the VOC analyzer for the mid calibration gas exceeded the acceptable criteria of 3 percent of span. Based on the review of sampling parameters it was observed that analyzer fuel flow rate was fluctuating and causing the analyzer to drift. After discussing with MDEQ representatives, applying USEPA Method 7E equations to correct the measured concentrations for analyzer drift, and reviewing the calculated result of 0.3 g VOC/HP-hr to the limit of 1.0, Run 2 was accepted. During subsequent tests the analyzer fuel flow was continuously monitored to ensure stability and no other drift issues were encountered.

Telephone conversations with the vendor of the VOC analyzer suggest the fuel flow frit within the analyzer may be a cause of the issue. The vendor indicated the instrument will respond accurately so long as the analyzers setup/calibration parameters, such a fuel flow, combustion air flow, etc., are maintained throughout the measurement period.

EUENGINE3-1 Run 1 was paused for approximately 15-minutes in order to replace a cylinder of combustion air that was nearing empty.

5.4 Process or Control Equipment Upset Conditions

The 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 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 60 Subpart JJJJ and the ROP
- every 8,760 engine operating hours or 3 years (2022), whichever is first, thereafter to evaluate compliance with NO_x, CO, and VOC emission limits in 40 CFR Part 63, Subpart ZZZZ and the ROP. The engine hours after the conclusion of testing were:
    - EUENGINE3-1: 29,286 hours
    - EUENGINE3-2: 26,448 hours
    - EUENGINE3-3: 26,997 hours
    - EUENGINE3-4: 30,749 hours

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 if the sampling location is suitable 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, M25A: Calibration gas standards	Ensures accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A, M7E, M10: Calibration Error	Evaluates operation of analyzers	Calibration gases introduced directly into analyzers	Pre-test	±2.0% of the calibration span
M3A, M7E, M10: System Bias and Analyzer Drift	Evaluates analyzer and sample system integrity and accuracy over test duration	Calibration gases introduced at sample probe tip, heated sample line, and into analyzers	Pre-test and Post-test	±5.0% of the analyzer calibration span for bias and ±3.0% of analyzer calibration span for drift
M7E: NO_2-NO converter efficiency	Evaluates operation of NO_2-NO converter	NO_2 calibration gas introduced directly into analyzer	Pre-test or Post-test	NO_x response ≥90% of certified NO_2 calibration gas introduced
M25A: Calibration Error	Evaluates operation of analyzer and sample system	Calibration gases introduced through sample system	Pre-test	±5.0% of the calibration gas value
M25A: Zero and Calibration Drift	Evaluates analyzer and sample system integrity and accuracy over test duration	Calibration gases introduced through sample system	Pre-test and Post-test	±3.0% of the analyzer calibration span

5.8 Calibration Sheets

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

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. Refer to Appendix C for the laboratory data sheets associated with the natural gas fuel samples collected during the test program.

5.12 QA/QC Blanks

Other than Method 3A. 7E, 10, and 25A QA/QC and calibration gases used for zero calibrations, no other reagent or media blanks were used. QA/QC data are presented in Appendix E.

Appendix Tables