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40 CFR Part 63 Subpart ZZZZ

Continuous Compliance Demonstration Test Report

EUENGINE1, EUENGINE2, EUENGINE3 & EUENGINE4

Consumers Energy Company
White Pigeon Compressor Station
68536 A Road, Route 1
White Pigeon, MI 49099
SRN: N5573

June 12, 2018

Test Dates: April 24 - 25, 2018

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order No. 31353774
Version No.: 0

EXECUTIVE SUMMARY

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted continuous compliance testing on four (4) 4-stroke lean burn (4SLB) natural gas-fired, spark-ignition, reciprocating internal combustion engines (RICE) identified as emission units (EU) EUENGINE1, EUENGINE2, EUENGINE3 and EUENGINE4 on April 24 – 25, 2018, at the White Pigeon Compressor Station (WPCS) Plant 3 in White Pigeon, Michigan.

The test program was conducted to verify compliance with the United States Environmental Protection Agency (U.S. EPA), Chapter 40 of the Code of Federal Regulations Part 63 (40 CFR Part 63), Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants* (NESHAP) for Stationary RICE, §63.6620 and Table 4. The RICE, installed in 2010, are operated by WPCS following requirements in the Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) MI-ROP-N5573-2013, in which RICE specific Subpart ZZZZ operating and test conditions are detailed.

During testing, each engine operated at load conditions within plus or minus (±) 10 percent of 100 percent load as specified in Subpart ZZZZ § 63.6620 (b).

Triplicate, 60-minute test runs for carbon monoxide (CO) and oxygen (O_2) were conducted simultaneously at each RICE oxidation catalyst inlet and outlet using U.S. EPA Reference Methods (RM) 1, 3A, 7E and 10 from 40 CFR 60 Appendix A. Percent CO reduction efficiency was calculated using 40 CFR 63, § 63.6620, Equation 1. RCTS conducted the test methods as described within the approved test protocol without deviation.

The Subpart ZZZZ test results summarized in Table E-1 indicate EUENGINE1, EUENGINE2, EUENGINE3 and EUENGINE4 are operating in continuous compliance with the 40 CFR 63 Subpart ZZZZ RICE NESHAP, and as specified in the facility ROP.

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

Source	CO Reduction Efficiency (%) [Limit: ≥93%]	Oxidation Catalyst Inlet Temperature (°F) [4-Hr RollingLimit: ≥450°F & ≤1350°F]	Oxidation Catalyst Pressure Drop Comparison (Inches Water Gauge) [Limit: ±2" from Baseline Test]	
			Baseline Test	2018 Results
EUENGINE1	99.5	741.6	3.5	3.3
EUENGINE2	99.4	768.0	3.2	2.9
EUENGINE3	98.9	774.4	2.9	2.9
EUENGINE4	99.5	784.2	3.0	3.4

Detailed test and engine operating results are presented in Appendix Tables 1 – 4. Sample Calculations, RICE operating data, Field Data Sheets and Test Support Documentation are presented in Appendices A – D.

1.0 INTRODUCTION

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted continuous compliance testing on four (4) 4-stroke lean burn (4SLB) natural gas-fired, spark-ignition, reciprocating internal combustion engines (RICE) identified as emission units (EU) EUENGINE1, EUENGINE2, EUENGINE3 and EUENGINE4 on April 24 – 25, 2018, at the White Pigeon Compressor Station (WPCS) Plant 3 in White Pigeon, Michigan. WPCS operates the RICE following requirements in the Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) MI-ROP-N5573-2018, in which the RICE are grouped collectively as FGENGINES.

This document follows the Michigan Department of Environmental Quality (MDEQ) format described in the December 2013, 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

A test protocol dated January 15, 2018 was submitted by CE to the MDEQ describing the FGENGINES CO reduction efficiency test scheduled for the week of March 19, 2018 at WPCS in White Pigeon, Michigan. The protocol was subsequently approved by Mr. David Patterson, MDEQ Environmental Quality Analyst, in a letter dated February 28, 2018; however facility process constraints required the test be rescheduled to the week of April 23, 2018.

1.2 Purpose of Testing

The test program was conducted to verify continuous compliance with the United States Environmental Protection Agency (U.S. EPA), Chapter 40 of the Code of Federal Regulations Part 63 (40 CFR Part 63), Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants* (NESHAP) for Stationary RICE, §63.6620 and Table 4, as specified in the facility ROP. The RICE NESHAP CO requirement and equipment operating parameters are presented in Table 1-1.

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

CO Reduction Efficiency (%)	4-Hr Rolling Oxidation Catalyst Inlet Temperature (°F)	Oxidation Catalyst Pressure Drop Change (Inches Water Gauge)
≥93	≥450°F and ≤1350°F	±2" from Initial Performance Test (Baseline)

1.3 Brief Description of Source

WPCS operates one Caterpillar Model 3608 4SLB engine (EUENGINE1) and three Caterpillar Model 3616 4SLB engines (EUENGINE2 – 4) installed at Plant 3 to maintain natural gas pipeline pressure by compressing and moving along the pipeline system.

1.4 Contact Information

CE employees Mr. Timothy Wolf, WPCS Field Leader, coordinated the test in tandem with Ms. Amy Kapuga, Senior Engineer and Janet Zondlak, Gas Compression Environmental Coordinator. Mr. Craig Jaeger, Gas Compression Senior Technician, collected engine operating data. RCTS employees Joe Mason, Gregg Koteskey and Dillon King conducted the emission test program. MDEQ representatives Mr. David Patterson, Mr. Dennis Dunlap and

Mr. Cody Yazzie were onsite to witness portions of the test. Table 1-2 presents the contact names, addresses, and telephone numbers for each party affiliated with the test program.

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. David Patterson Technical Programs Unit Field Operations Section 517-284-6782 Pattersond2@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. Dennis Dunlap Environmental Quality Analyst 269-567-3553 dunlapd@michigan.gov Mr. Cody Yazzie Environmental Engineer 269-567-3554 yazziec@michigan.gov	Michigan Department of Environmental Quality Kalamazoo Michigan District 7953 Adobe Road Kalamazoo, Michigan 49009
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
Gas Compression Representative	Ms. Janet Zondlak Senior Environmental Analyst 616-738-3702 janet.zondlak@cmsenergy.com	Consumers Energy Company Gas Compression/Storage Operations 17010 Croswell Road West Olive, Michigan 49460
Test Facility	Mr. Timothy Wolf 269-483-2902 timothy.wolf@cmsenergy.com	Consumers Energy Company White Pigeon Compressor Station 68536 A Road White Pigeon, Michigan 49099
Test Team Representative	Mr. Joe Mason, QSTI Engineering Technical Analyst II 616-738-3385 Joe.mason@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

Pursuant to §63.6620(b), the engines operated within 10% of 100% load, with an average load >96% torque and horsepower >97%, based on the maximum manufacturer's design capacity at engine and compressor site conditions.

Refer to Attachment C for detailed RICE operating data.

2.2 Applicable Permit Information

WPCS is assigned State of Michigan Registration Number (SRN) N5573 and operates in accordance with MI-ROP-N5573-2018, which incorporates the applicable RICE NESHAP requirements and identifies EUENGINE1, EUENGINE2, EUENGINE3, and EUENGINE4 collectively as FGENGINES.

2.3 Results

Dry basis CO and O_2 concentrations were measured before and after each engine oxidation catalyst and the measured CO was corrected to 15% O_2. 40 CFR 63, § 63.6620, Equation 1 was then used to calculate CO reduction efficiency, which when combined with engine parameter data, indicate FGENGINES are operating in continuous compliance with the applicable RICE NESHAP and ROP limits. Refer to Table 2-1 for the summary of test results.

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

Source	CO Reduction Efficiency (%)	Oxidation Catalyst Inlet Temperature (°F)	Oxidation Catalyst Pressure Drop Comparison (Inches Water Gauge)	
			Baseline Test	2018 Results
	[Limit: ≥93%]	[4-Hr Rolling Limit: ≥450°F & ≤1350°F]	[Limit: ±2" from Baseline Test]	
EUENGINE1	99.5	741.6	3.5	3.3
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EUENGINE3	98.9	774.4	2.9	2.9
EUENGINE4	99.5	784.2	3.0	3.4

Detailed results are presented in Appendix Tables 1 - 4. Sample Calculations, RICE operating data, Field Data Sheets and Test Support Documentation are presented in Appendices A – D.

3.0 SOURCE DESCRIPTION

WPCS operates one Caterpillar Model 3608 4SLB engine (EUENGINE1) and three Caterpillar Model 3616 4SLB engines (EUENGINE2 – 4) at Plant 3 to maintain natural gas pipeline pressure by compressing and moving along the pipeline system. A summary of the engine specifications are provided in Table 3-1.

Table 3-1
Engine Specifications

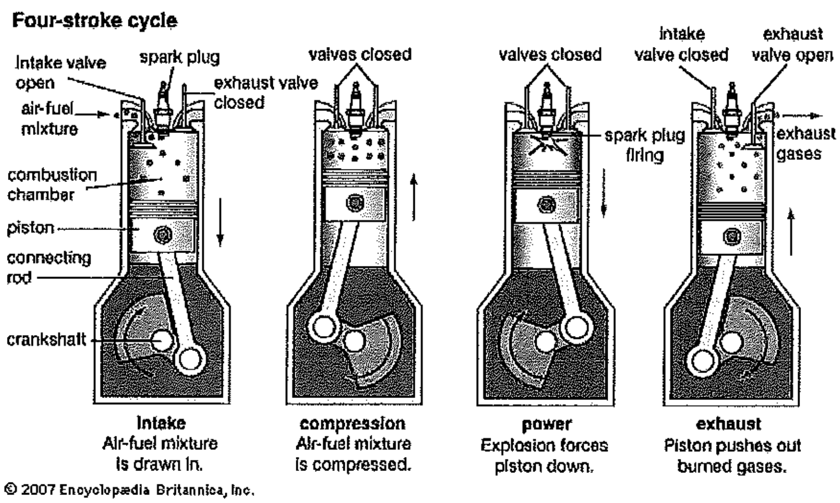
Engine ID	Engine Description		Site-Rated HP	Emission Control
	Manufacturer	Model		
EUENGINE1	Caterpillar	G3608	2,370	Oxidation catalyst
EUENGINE2 EUENGINE3 EUENGINE4	Caterpillar	G3616	4,735	Oxidation catalyst

3.1 Process

EUENGINE1, EUENGINE2, EUENGINE3 and EUENGINE4 are natural gas-fired 4SLB RICE 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 are then closed 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 gas compressors and/or pumps. The compressors and/or pumps are used to withdraw or inject natural gas into high pressure natural gas storage fields or to help move natural gas and 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 engine includes a control module that monitors and adjusts engine parameters for optimal performance. While this test program was not inclusive of nitrogen oxides (NO_x), it should be noted 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.

Four oxidation catalyst modules, manufactured by Pollution Control Associates, Inc. (PCA) are installed on each engine. The catalysts use propriety 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 also provides control of formaldehyde, as well as non-methane and non-ethane hydrocarbons.

3.2 Process Flow

Located in St. Joseph County, the White Pigeon Compressor Station receives and processes approximately 65 percent of the natural gas delivered to Consumers Energy gas customers. Natural gas interstate pipelines originating in the southern and western United States join together near WPCS. At the facility, gas flow is monitored and managed by Consumers Energy system controllers in Jackson and White Pigeon. The Plant 3 high-speed compressor engines have a combined capacity of approximately 16,500 horsepower and the capacity to pump approximately 800 million cubic feet of natural gas per day.

3.3 Materials Processed

Fuel fired in EUENGINE1 EUENGINE2, EUENGINE3 and EUENGINE4 is exclusively natural gas, as defined in 40 CFR 72.2, which is comprised of approximately 94% methane, 4% ethane, 1% nitrogen, and 0.75% carbon dioxide.

3.4 Rated Capacity

EUENGINE1 has a maximum horsepower output rating of approximately 2,370 and a heat input of 16.1 million British thermal units per hour (mmBtu/hour). EUENGINES2 – 4 each have a maximum horsepower output of approximately 4,735 and a heat input of 32.0 mmBtu/hour. These rated capacities are a function of facility and gas transmission demand.

3.5 Process Instrumentation

The engine processes were continuously monitored by Consumers Energy operations personnel during testing. At a minimum, data were collected at 1-minute intervals during each test for the following parameters:

- Fuel use (mmcf/hr)
- Engine speed (rpm)
- Power (BHP)
- Torque (% max)
- Catalyst inlet temperature (°F)
- Catalyst differential pressure (in. H_2O)
- Suction pressure (PSI)

4.0 SAMPLING AND ANALYTICAL PROCEDURES

RCTS conducted the test program using the U.S. EPA test methods proposed in the approved test protocol and as presented in Table 4-1. The RM analyzers were calibrated with U.S. EPA Protocol calibration gases at a minimum of three points: low (0-20% of calibration span), mid-level (40-60% of calibration span) and high-level gas (equal to the calibration span) following specifications in U.S. EPA Method 7E. The output signal from each analyzer was connected to a computerized data acquisition system (DAS) and each instrument was operated to insure zero drift, calibration gas drift, bias and calibration error met Method 7E requirements. All sample system components in contact with flue gas were constructed of Type 316 stainless steel and/or Teflon.

Table 4-1
Test Methods

Parameter	Method	USEPA Title
Sample Port and Traverse Point Selection	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	7E [1]	*Determination of Nitrogen Oxides Emissions From Stationary Sources (Instrumental Analyzer Procedure)*
Carbon Monoxide	10	*Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)*

[1] While NO_x emissions were not part of this test program, Method 7E traverse point stratification and analyzer quality assurance guidance was followed.

4.1 Description of Sampling Train and Field Procedures

A Test Matrix summarizing test program sampling dates, run times and durations, and analytical methods performed is presented in Table 4-2.

Table 4-2
Test Matrix

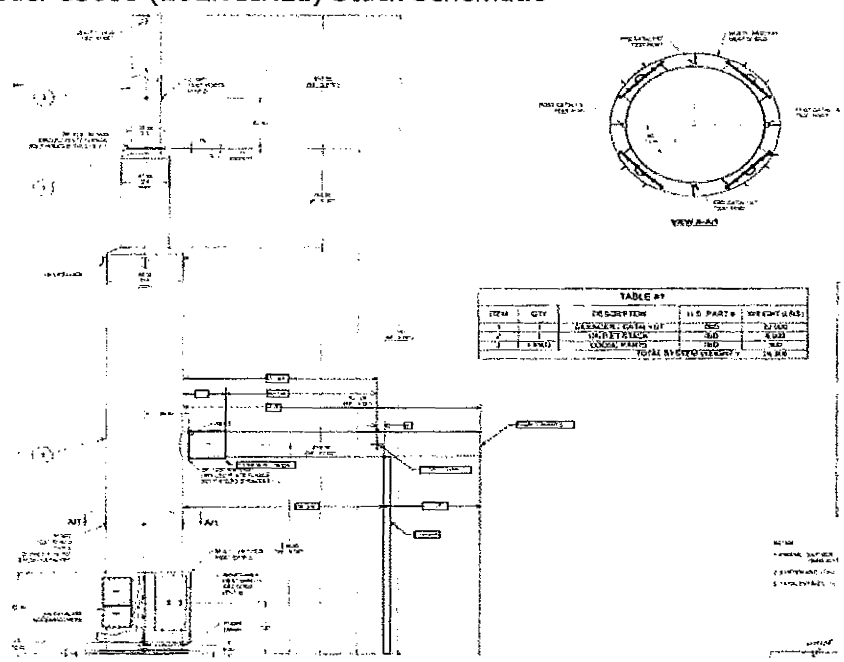
Date (2018)	Run	Sample Type	Start Time (EDT)	Stop Time (EDT)	Test Duration (min)	EPA Test Method	Comment
EUENGINE1							
April 25	1	O_2 CO	12:19	13:19	60	3A 10	RM1 and 7E specifications were maintained during each test run.
	2		13:33	14:33	60		
	3		14:58	15:58	60		
EUENGINE2							
April 25	1	O_2 CO	08:20	09:20	60	3A 10	RM1 and 7E specifications were maintained during each test run.
	2		09:35	10:35	60		
	3		10:52	11:52	60		
EUENGINE3							
April 24	1	O_2 CO	13:00	14:00	60	3A 10	RM1 and 7E specifications were maintained during each test run.
	2		14:15	15:15	60		
	3		15:30	16:30	60		
EUENGINE4							
April 24	1	O_2 CO	09:00	10:00	60	3A 10	RM1 and 7E specifications were maintained during each test run.
	2		10:15	11:15	60		
	3		11:30	12:30	60		

4.2 Sample Location and Traverse Points (U.S. EPA Method 1 & 7E)

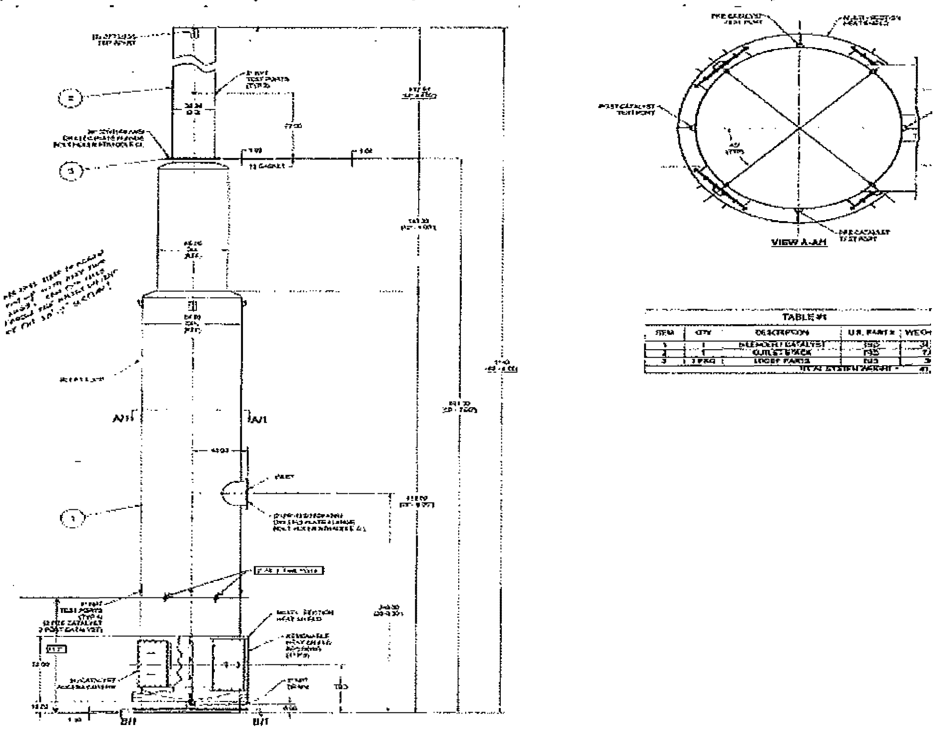
Traverse points for each RICE exhaust stack and the EUENGINE1 oxidizer *inlet* were determined using U.S. EPA Method 1, *Sample and Velocity Traverses for Stationary Sources* and U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure)*. Three traverse points were located across each duct at 16.7, 50.0, and 83.3% of the diameter following Method 7E § 8.1.2 criteria. In comparison, the modular oxidizer catalyst sample inlet area at EUENGINE2, 3 and 4 is atypical from U.S. EPA Method 1 perspective, limiting the sampling to one traverse point located at approximately 50% of the duct area. Representative engine drawings are presented in Figure 4-1.

Figure 4-1. WPCS Engine Duct Schematics

Caterpillar Model G3608 (EUENGINE1) Stack Schematic



Caterpillar Model G3616 (EUENGINE2, EUENGINE3 & EUENGINE4) Stack Schematic

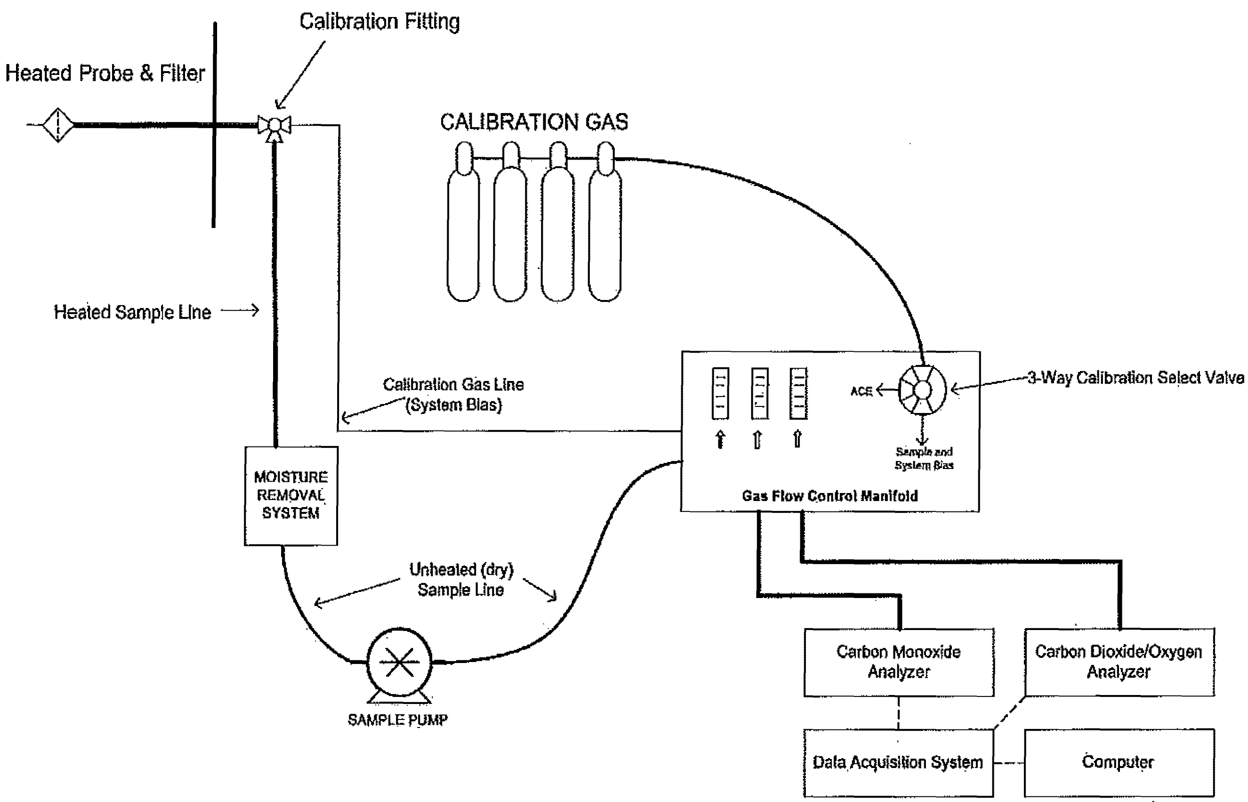


4.3 O_2 AND CO CONCENTRATIONS (U.S. EPA METHODS 3A AND 10)

Oxygen and carbon monoxide concentrations were measured concurrently at each engine catalyst inlet and outlet following guidelines U.S. EPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)* and Method 10, *Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure).*

The O_2 analyzer measurement principle is paramagnetic and CO measurements utilize infrared gas filter correlation. Prior to testing, an analyzer calibration error (ACE) is performed by injecting zero, mid, and high-level calibration gases directly to the analyzers to verify responses are within ±2.0% of the high-level span gas concentration. An initial system bias test is then performed by injecting a zero gas followed by an upscale gas to the measurement system to verify system responses are within ±5.0 percent of span. When complete, the analyzers are quality assured and ready for testing. Hot engine exhaust gas is extracted from each duct into stainless steel probes, heated sample lines and electronic gas conditioners for particulate and moisture removal prior to analyzer injection. After completing each run, a final system bias is performed to correct the data for analyzer drift and bias. The CO concentrations are then corrected to 15 percent O_2 and the percent CO reduction efficiency is calculated. Refer to Appendix C for comprehensive run by run results. Figure 4-2 depicts the Methods 3A and 10 sampling system.

Figure 4-2. Methods 3A and 10 Sampling System



5.0 TEST RESULTS AND DISCUSSION

The test program was conducted to verify continuous compliance with the U.S. EPA, 40 CFR Part 63, Subpart ZZZZ, Stationary RICE NESHAP, §63.6620 and Table 4, as specified in the facility ROP.

5.1 Tabulation of Results

The CO and O2 concentrations measured before and after each engine oxidation catalyst indicate EUENGINE1, EUENGINE2, EUENGINE3 and EUENGINE4 are operating in continuous compliance with the Stationary RICE NESHAP and the WPCS ROP. The Field Data Sheets in Appendix C contain detailed results and process operating conditions.

5.2 Significance of Results

By demonstrating continuous compliance with 40 CFR Part 63, Subpart ZZZZ, the WPCS engines may be operated as designed and permitted.

5.3 Variations from Sampling or Operating Conditions

The test program was largely unremarkable with no significant operating condition variations or upsets observed.

5.4 Process or Control Equipment Upset Conditions

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

5.5 Air Pollution Control Device Maintenance

No maintenance was performed beyond vendor recommended (scheduled) maintenance.

5.6 Re-Test Discussion

Based on results from this test program, no further testing or re-testing is required in 2018.

5.7 Results of Audit Samples

While audit samples for the reference methods in this test program are not available from U.S. EPA Stationary Source Audit Sample Program providers, the methods are written with multiple quality control (QC) and quality assurance (QA) specifications and requirements to ensure the results obtained are proven and documented. RCTS conducted this test using experienced staff, qualified and equipped with a thorough knowledge of the method QA/QC techniques, which when properly applied, minimizes field test error potential. Table 5-1 summarizes the primary field QA/QC procedures for the methods performed during this test program. Refer to Appendix D for further supporting documentation.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluate suitability of sample location for sampling	Measure upstream/ downstream flow disturbance distance from sample ports	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.
M1, M7E: Duct diameter/ dimensions	Verify accurate duct area measurement	Review as-built drawings and field measurement	Pre-test	Field measurement agreement with as-built drawings
M3A, M7E, M10: Calibration gas standards	Ensure accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A, M7E, M10: Analyzer Calibration Error	Verify analyzer operation	Introduce Calibration gas directly into analyzers	Pre-test	±2.0% of the calibration span
M3A, M7E, M10: System Bias and Analyzer Drift	Verify measurement system integrity and analyzer accuracy over test duration	Calibration gases introduced into entire measurement system	Pre-test and Post-test	Bias: ±5.0% of analyzer calibration span Drift: ±3.0% of analyzer 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 contained in Appendix C.

5.11 Laboratory Quality Assurance / Quality Control Procedures

There were no laboratory analyses performed for this test program, however all applicable method specific QA/QC procedures were followed, without deviation.

5.12 QA/QC Blanks

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