Derenzo Environmental Services
Consulting and Testing

RECEIVED
APR 11 2016
AIR QUALITY DIV.

AIR EMISSION TEST REPORT

Title	NATURAL GAS FIRED RECIPROCATING ENGINE CO EMISSIONS FOR THE RICE NESHAP
Report Date	March 18, 2016
Test Date	March 2, 2016

Facility Information	
Name	Jordan Development Company, LLC – Haymeadow
Street Address	NW, SE, NW, Section 11
City, County	Briley Township, Montmorency

Facility Permit Information			
State Registration No.:	N6101	Permit No.:	659-96A

Testing Contractor	
Company	Derenzo Environmental Services
Mailing Address	39395 Schoolcraft Road Livonia, Michigan 48150
Phone	(734) 464-3880
Project No.	1506003

AIR EMISSION TEST REPORT

NATURAL GAS FIRED RECIPROCATING ENGINE
CO EMISSIONS FOR THE
RICE NESHAP

1.0 INTRODUCTION

Jordan Development Company, LLC (Jordan Development) owns and operates one (1) Caterpillar (CAT®), Model No. G3516 LE, natural gas-fired, four-stroke lean burn (4SLB) spark ignition (SI) reciprocating internal combustion engine (RICE) at its Haymeadow facility, located in Briley Township, Montmorency County, Michigan. The SI RICE is subject to the emission standards and testing requirements in Title 40 of the Code of Federal Regulations (40 CFR) Part 63 Subpart ZZZZ *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines* (40 CFR Part 63 Subpart ZZZZ) as an existing 4SLB SI RICE with a power output greater than 500 horsepower (hp), located at an area source of hazardous air pollutant (HAP) emissions.

Pursuant to 40 CFR Part 63 Subpart ZZZZ, an owner/operator of an existing 4SLB SI RICE with a power output greater than 500 hp at an area source of HAP emissions (and is not classified as a remote source) must:

- Install an oxidation catalyst emission control system.
- Reduce carbon monoxide (CO) emissions by 93% or more, or reduce CO to an outlet concentration of 47 ppmvd at 15% oxygen.
- Perform initial compliance testing within one year of engine startup.

1.1 Purpose and Objectives of Testing

Derenzo Environmental Services (DES) was contracted to perform the SI RICE CO emissions testing specified in 40 CFR Part 63 Subpart ZZZZ. The CO compliance emission measurements consisted of three (3), one-hour test runs during which the catalyst exhaust gas was measured for O_2 and CO concentrations using instrumental analyzers.

The compliance testing was performed by DES representatives Tyler J. Wilson and Blake Beddow on March 2, 2016. The exhaust gas sampling and analysis was performed using procedures specified in the test protocol dated December 28, 2015.

1.2 Project Contacts and Report Certification

Questions regarding this emission test report should be directed to:

Mr. Tyler J. Wilson
Livonia Office Supervisor
Derenzo Environmental Services
39395 Schoolcraft Rd.
Livonia, MI 48150
(734) 464-3880

Mr. Troy E. Molby, P.E.
Jordan Development Company, LLC
Project Engineer
1503 Garfield Road North
Traverse City, Michigan 49686
(231) 935-4220

This test report was prepared by Derenzo Environmental Services based on the emission measurements and field sampling data collected by Derenzo Environmental Services. Facility process and operating data were collected and provided by representatives of Jordan Development Company and Gosling Czubak Engineering Services, Inc. (GCES).

The information presented in this report follows the Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) *Format for Submittal of Source Emission Test Plans and Reports, December 2013.*

A Notification of Compliance Status (NOCS) report, certified by the emission source owner/operator accompanies this test report.

Report Prepared By:

Tyler J. Wilson
Livonia Office Supervisor

Reviewed By:

Robert L. Harvey, P.E.
General Manager

2.0 SUMMARY OF TEST RESULTS

The exhaust gas from the natural gas-fueled 4SLB SI RICE is routed to an oxidation catalyst for the control of CO and hydrocarbons in the exhaust gas. The exhaust gas downstream of the emission control catalyst was sampled for three (3) one-hour test periods during the compliance testing performed March 2, 2016. Instrumental analyzers were used to measure concentrations of CO and O_2 in the catalyst exhaust gas. Table 1 below presents a summary of the compliance test results.

The testing was performed while the 4SLB SI RICE was operated at the highest achievable operating load. Table 2 below presents a summary of the emission unit operating conditions during the test periods.

The test results verify compliance with the 40 CFR Part 63 Subpart ZZZZ emission standard of 47 ppmvd at 15% O_2 for an existing 4SLB SI RICE >500 hp located at an area source of HAP emissions.

Table 1. Summary of compliance test results, catalyst outlet

Emission Unit ID	CO Concentration (ppmvd)	Oxygen Content (% vol)	CO Concentration (ppmvd @15% O_2)
EUENGINE1	24.6	6.80	10.3
Emission Standard	--	--	47

Table 2. Summary of emission unit operating conditions

Emission Unit ID	Operating Hours[†]	Engine Horsepower	Catalyst Inlet (°F)
EUENGINE1	98,208	521	776

[†] Engine run hour meter reading at the beginning of Test 1.

3.0 SOURCE DESCRIPTION

3.1 Emission Unit Location and Description

The Jordan Development facility is located in the SE ¼ of the NW ¼ of Section 11 in Briley Township, Montmorency County, Michigan.

Jordan Development uses natural gas as fuel to power one (1) CAT® G3516 LE lean-burn engine that is connected to a compressor that is used to compress natural gas for pipeline transmission. The engine that was tested replaced an identical existing engine at the source. Based on the date of manufacture, the replacement engine is classified as an existing 4SLB SI RICE with a power output greater than 500 hp, located at an area source of HAP emissions. Jordan Development provided the following identification information for the tested engine:

- Model No. G3516 LE
- Serial No. 4EK01953
- Date of manufacture: April 15, 1998

3.2 Rated Capacities, Type and Quantity of Raw Materials Used

The CAT® G3516 LE 4SLB SI RICE is fueled exclusively with natural gas. The engine has a maximum rated output of 1,265 hp and a rated fuel heat input rate of 9.55 million British thermal units per hour (MMBtu/hr).

The emissions testing was performed while the 4SLB SI RICE operated at 'full operating load', which is the maximum achievable operating rate for the engine/compressor considering the restrictions associated with the connected gas transmission service (i.e., allowable gas flow and pressures). Engine output or percent load percent was determined by Archrock personnel using the Caterpillar Gas Engine Ratings Pro (GERP) software.

Appendix A provides gas engine and compressor operating records provided by Jordan Development and GCES.

3.3 Emission Control System Description

Exhaust gases from the 4SLB SI RICE are directed through a selective catalytic reduction (SCR) emission control system, which reduces CO and other hydrocarbon emissions prior to their release to ambient air. The catalyst is designed to reduce CO emissions by greater than 93%.

CO and other hydrocarbons in the SI RICE exhaust gas stream are oxidized by the catalyst using excess oxygen that is present in the SI RICE exhaust gas stream. The SI RICE exhaust gas provides the heat necessary to initiate the catalytic reaction (an additional heat source is not used to preheat the SCR inlet gas).

The temperature at the catalyst inlet is monitored continuously to verify that SI RICE exhaust gas temperature / catalyst inlet temperature is within the proper range for the catalytic reaction. Table 6 of 40 CFR Part 63 Subpart ZZZZ specifies that the catalyst inlet temperature must be maintained between 450 and 1350°F for a 4SLB SI RICE.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

This section provides a summary of the exhaust gas sampling and analytical procedures that were used during the test event.

4.1 Testing Location and Sampling System

A continuous sample of the RICE exhaust gas was obtained from the sampling ports installed just downstream of the emission control catalyst. During each one-hour pollutant sampling period, a continuous sample of the RICE exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the instrumental analyzers.

Appendix B provides a diagram of the sampling location.

4.2 Exhaust Gas Oxygen and CO Concentration (USEPA Methods 3A and 10)

The O_2 content and CO concentration in the RICE exhaust gas stream was measured continuously throughout each one-hour test period in accordance with USEPA Methods 3A and 10. A Servomex 1440D oxygen analyzer with a paramagnetic sensor was used to measure the O_2 content; CO concentration was measured using a Thermo Environmental Instruments, Inc. Model 48c non-dispersive infrared (NDIR) analyzer. Sampling times were recorded on field data sheets.

Instrument response for each analyzer was recorded on an ESC Model 8816 data logging system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages. Prior to, and at the conclusion of each test, instrument calibration was verified using appropriate calibration gases to determine accuracy and system bias (described in Section 4.3 of this document).

Appendix C provides field data sheets and calculations.

Appendix D provides raw (one-minute average) instrumental analyzer response data for each test period.

4.3 Quality Assurance Procedures

4.3.1 Instrument Calibration and System Bias Checks

At the beginning of the day, initial three-point instrument calibrations were performed by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the appropriate upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and verifying the instrument response against the initial instrument calibration readings.

The instrument analyzers were calibrated with USEPA Protocol 1 certified O_2 and CO concentrations in nitrogen and zeroed using nitrogen. A STEC ten-step gas divider was used (as needed) to obtain intermediate calibration gas concentrations.

4.3.2 Sampling System Response Time Determination

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

The Thermo Environmental Instruments, Inc. Model 48c analyzer exhibited the longest system response time at 59 seconds. Results of the response time determinations were recorded on field data sheets. For each test period, test data were collected once the sample probe was in position for at least twice the maximum system response time.

4.3.3 Gas Divider Certification (USEPA Method 205)

The STEC 10-step gas divider was used in the field to obtain appropriate calibration span gases. The 10-step gas divider was NIST-certified within the last 12 months with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step gas divider delivers calibration gas values at 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% of the USEPA Protocol 1 calibration gas that is introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of the 10-step gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

4.3.4 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure CO and O_2 concentrations have had an interference response test performed prior to their use in the field (June 21, 2007 and June 12, 2014, respectively), pursuant to the interference response test procedures specified in USEPA Method

7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 3.0% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

Appendix E presents test equipment quality assurance data (instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results).

5.0 DISCUSSION OF TEST RESULTS

5.1 Results Summary and Comparison to Emission Standard

Emissions testing was performed for the natural-gas fueled CAT® G3516 LE engine to measure exhaust gas O_2 content and CO concentration downstream of the installed SCR oxidation catalyst. Pursuant to 40 CFR Part 63 Subpart ZZZZ, an owner/operator of an existing 4SLB SI RICE with a power output greater than 500 hp at an area source of HAP emissions (and is not classified as a remote source) must install an oxidation catalyst emission control system and reduce CO emissions by 93% or more, or reduce CO to an outlet concentration of no more than 47 ppmvd at 15% oxygen.

The emission test results are presented in Table 3. The measured exhaust gas CO concentration at the outlet of the SCR oxidation catalyst (one-hour average) ranged between 10.27 and 10.33 ppmvd at 15% oxygen, which is less than the emission standard specified for a 4SLB SI RICE (i.e., less than 47 ppmvd at 15% oxygen).

5.2 Operating Conditions During the Compliance Test

The emissions testing was performed while the 4SLB SI RICE operated at 'full operating load', which is the maximum achievable operating rate for the engine/compressor considering the restrictions associated with the connected gas transmission service (i.e., allowable gas flow and pressures). Engine output ranged between 506 and 533 hp (approximately 41% of rated engine capacity) as determined by Archrock personnel using the Caterpillar Gas Engine Ratings Pro (GERP) software. Operating data are provided in Appendix A.

The catalyst inlet temperature was recorded at 15-minute intervals. Catalyst inlet temperature during the three tests ranged between 771 and 780°F. Table 6 of 40 CFR Part 63 Subpart ZZZZ specifies that the catalyst inlet temperature must be maintained between 450 and 1350°F for a 4SLB SI RICE.

The engine operating hours (run hour meter) recorded at the beginning of Test No. 1 was 98,208 hours. According to 40 CFR Part 63 Subpart ZZZZ the testing must be repeated every 8,760

operating hours or no less frequent than every three years. Therefore, testing must be repeated prior to exceeding 106,968 engine run hours.

5.3 Variations from Normal Sampling Procedures or Operating Conditions

The testing was performed according to the procedures specified in the test protocol dated December 28, 2015, with the following minor exceptions noted below.

The gas engine was operated normally during the test periods as full operating load, not at 100% of rated capacity as indicated in the test protocol. Engine operation is restricted based on the gas compressor and the connected gas transmission service (i.e., allowable gas flow and pressures).

Table 3. Measured exhaust gas carbon monoxide and oxygen concentrations for the Jordan Development CAT® G3516 LE natural gas-fueled internal combustion engine

Test Number Test Date Test Period (24-hr)	1 03/02/16 742-842	2 03/02/16 855-955	3 03/02/16 1008-1108	Three Test Average
Engine Operating Parameters				
Engine horsepower (hp)	519	515	529	521
Engine load at RPM (%)	41.1	40.7	41.8	41.2
Catalyst Data				
Inlet temperature (°F)	776	776	777	776
Exhaust Gas Measurements[1]				
Oxygen content (%vol)	6.81	6.79	6.79	6.80
CO concentration (ppmvd)	24.7	24.7	24.6	24.7
CO concentration (ppmvd 15% O_2)[2]	10.3	10.3	10.3	10.3

Notes
1. Measured at the catalyst outlet.
2. 40 CFR Part 63 Subpart ZZZZ emission standard is 47 ppmvd at 15% O_2.