Consumers Energy

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Compliance Test Report

RAY COMPRESSOR STATION
EUENGINE31, 32, 33 and 34

Ray Compressor Station
69333 Omo Road
Armada, Michigan 48005
State Registration Number (SRN) B6636

Test Dates: September 24 -26, & October 16, 2013

Report Submitted:
December 12, 2013

Work Order No. 16396703
Report Revision 0

Test Performed by the Consumers Energy Company
Equipment Performance Testing Section
Engineering Services Department

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1.0 INTRODUCTION

Identification, location and dates of tests

This report summarizes the results of testing conducted on September 24-26 and October 16, 2013 at Consumers Energy Company's (CEC) Ray Compressor Station. CEC's Equipment Performance Testing Section (EPTS) conducted initial performance tests for carbon monoxide (CO) reduction efficiency on four natural gas-fired reciprocating internal combustion engines (RICE) operating at Ray Compressor Station, in association with Flexible Group FGENGINES3 and individually identified as Emission Unit EUENGINE31, EUENGINE32, EUENGINE33 and EUENGINE34. (A fifth RICE unit associated with FGENGINES3, identified as EUENGINE35, was scheduled to be tested; however mechanical constraints prohibited it from operating.) Emission rate verification testing for nitrogen oxides (NO_x), CO and volatile organic compounds (VOC) was also performed at the exhaust locations of EUENGINE31 and EUENGINE32.

Purpose of Testing

The performance tests were performed to 1) verify initial compliance with U.S. EPA Title 40 of the Code of Federal Regulations (40 CFR) Part 63, Subpart ZZZZ, *National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines* and 2) verify NO_x, CO and VOC emission rates pursuant to MDEQ PTI No. 206-09, FGENGINES, Special Condition V.4. In addition to verifying that the oxidation catalysts are reducing CO concentrations by at least 93%, the testing was also designed to establish operating parameters for each engine. These operating parameters consisted of verifying that the catalyst inlet temperature remained between 450°F and 1350°F, and determining the average pressure drop across each oxidation catalyst.

Brief Description of Source

The Ray Compressor Station is a natural gas compressor station. The purpose of the facility is to maintain pressure of natural gas in order to move it in and out of storage reservoirs and along the pipeline system. Each of the RICE are 4-stroke lean burn (4SLB), Caterpillar Model G3616 engines, designed to exclusively fire natural gas, and equipped with oxidation catalysts to reduce CO and VOC emissions. Ray Compressor Station operates the engines pursuant to the Michigan Department of Environmental Quality (MDEQ) Permit to Install (PTI) No. 206-09, issued on October 14, 2010. Operation of the RICE commenced on or after April 22, 2013 and the Test Protocol was submitted and subsequently approved by the MDEQ in their letter dated August 28, 2013 (refer to Attachment 6). It should be noted that the test protocol was later revised (10/22/2013) to clarify that only a subset of the five G3616 engines would be tested for NO_x, CO and VOC.

Names, addresses, and telephone numbers of the contacts for information regarding the test and the test report, and names and affiliation of all personnel involved in conducting the testing

Performance tests were performed within 180 days of equipment startup by CEC EPTS Technical Analysts Brian Glendening, Brian Pape, Joe Mason and Brian Miska on September 24 – 26, and October 16, 2013. Mr. Mark Dziadosz and Mr. Robert Elmouchi from the MDEQ observed portions of the test. Ray Compressor Station facility manager Mr. Dominic Tomasino coordinated operation of the applicable RICE equipment and CEC Lead Project Engineer Edward Willoughby collected RICE operating data. The following table contains the contact information for the test program participants.

Performance Test Program Participants
Ray Compressor Station

Responsible Party	Address	Contact
Test Facility	Ray Compressor Station 69333 Omo Road Armada, Michigan 48005	Mr. Dominic Tomasino Compression Field Leader 586-784-2096 dominic.tomasino@cmsenergy.com
Corporate Air Quality Contact	Consumers Energy Company Environmental Services Department 1945 W Parnall Road Jackson, Michigan 49201	Ms. Amy Kapuga Senior Environmental Engineer 517-788-2201 amy.kapuga@cmsenergy.com
Test Representative	Consumers Energy Company Equipment Performance Testing Section 17000 Croswell Street West Olive, Michigan 49460	Mr. Joe Mason Technical Analyst 616-738-3385 joe.mason@cmsenergy.com
State Representative	Michigan Department of Environmental Quality Air Quality Division 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933-1502	Mr. Mark Dziadosz 586-753-3731 dziadoszm@michigan.gov Mr. Robert Elmouchi 586-753-3736 elmouchir@michigan.gov

2.0 SUMMARY OF RESULTS

Operating data (e.g., production rate, fuel type, or composition)

Operating data collected during each test run included catalyst inlet temperature, pressure drop across catalyst, engine load, ambient temperature, barometric pressure, humidity, fuel flow rate, suction pressure, discharge pressure, and horsepower. One notable process data exception occurred during the EUENGINE32 test, where engine horsepower was not logged during test run 1 and part of test run 2. While horsepower was being continuously monitored, the data was not being recorded by the data historian. The purpose of documenting engine horsepower is to verify engine load during the performance test, as Subpart ZZZZ § 63.6620 (b) states *the test must be conducted at any load condition within plus or minus 10 percent of 100 percent load.* Engine load is typically obtained by dividing the recorded horsepower value observed during each test run by the rated engine horse power. While the horsepower was not being recorded during the affected test runs, engine percent load was being recorded, and these recorded percent load values were used directly for the affected test runs in lieu of the calculated value based upon the actual and rated horsepower.

Also please note that during testing on EUENGINE32 and EUENGINE33, the recorded horsepower data implies that engine load was not within *plus or minus 10 percent of 100 percent load,* as specified by Subpart ZZZZ § 63.6620 (b). However, based upon engine suction and discharge pressures and actual field conditions, the units' available horsepower capacity was limited. Each unit was operating within plus or minus 10 percent of 100 percent of the highest attainable load the engine could acquire at that time.

Applicable permit number, SRN, and Emission Unit ID or designation for the source.

The Ray Compressor Station is currently operating pursuant to the terms and conditions of Renewable Operating Permit (ROP) No. MI-ROP-B6636-2010 and PTI No. 206-09, which was issued on October 14, 2010. Installation of the equipment authorized in PTI No. 206-09 was completed on or after April 22, 2013, and the terms and conditions of the installation permit will be incorporated into the ROP as required by Michigan Rule 216(1)(a)(v). Of the equipment listed in PTI No. 206-09, the five RICE, identified as EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 and EUENGINE35, must conduct initial performance testing under 40 CFR 63, Subpart ZZZZ. Furthermore, one or more of the five identical G3616 engines must be tested to verify NO_x, CO and VOC g/hp-hr emission rates.

Results expressed in units consistent with the emission limitation applicable to the source, and comparison with emission regulations.

Testing was conducted in order to assess the percent reduction in CO concentrations across oxidation catalysts installed on the natural gas-fired RICE and establish the pressure drop across the catalyst for use as a subsequent operating limitation. A summary of these test results are presented below.

Summary of Average Carbon Monoxide Reduction Results & Catalyst Pressure Drop

Source	CO Reduction Efficiency (Percent)	CO Reduction Requirement (Percent)	Catalyst Pressure Drop (Inches Water Gauge)	Catalyst Inlet Temperature (°F)
EUENGINE31	99.7	93	2.2	869
EUENGINE32	99.8	93	2.3	880
EUENGINE33	99.9	93	2.0	801
EUENGINE34	99.9	93	2.7	870

Based on the dry CO concentrations measured at the oxidation catalyst inlet and outlet corrected to 15% O_2, the above results indicate the oxidation catalyst is operating at a greater CO reduction efficiency than the 93 percentage requirement in Subpart ZZZZ.

In addition, NO_x, CO and VOC emission rates were verified for the natural gas-fired RICE pursuant to MDEQ PTI No. 206-09, FGENGINES, Special Condition V.4.

Summary of NO_x, CO and VOC Emission Rates (g/bhp-hr)

Source	NO_x Emissions	NO_x Emission Limit	CO Emissions	CO Emission Limit	VOC Emissions	VOC Emission Limit
EUENGINE31	0.43	0.5	0.005	0.2	0.004	0.19
EUENGINE32	0.47	0.5	0.004	0.2	0.018	0.19

The NOx, CO and VOC engine emission rates shown above fall within the MDEQ PTI No. 206-09 requirements.

3.0 SOURCE DESCRIPTION

Description of process, including operation of emission control equipment

The Ray Compressor Station is a natural gas compressor station. The purpose of the facility is to maintain pressure of natural gas in order to move it in and out of storage reservoirs and along the pipeline system. Five (5) natural gas-fired reciprocating engine driven compressor units, designated at EUENGINE31, EUENGINE32, EUENGINE33, EUENGINE34 and EUENGINE35, were installed (PTI No. 206-09) to maintain reliability.

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

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

Process flow sheet or diagram (if applicable)

NA

Type and quantity of raw and finished materials processed during the tests

NA

Maximum and normal rated capacity of the process

Each of the RICE that were tested are 4SLB Caterpillar G3616 engines designed to exclusively fire natural gas, and are equipped with an oxidation catalyst to reduce CO and VOC emissions. The following table contains pertinent engine specifications.

Summary of Ray Compressor Station Plant 3 Engine Specifications

Parameter [1]	EUENGINE31 through 35
Make	Caterpillar
Model	G3616
Output (brake-horsepower)	4,735
Heat Input (mmBtu/hour)	32.0
Exhaust Gas Temp. (°F)	856

[1] All engine specifications are based upon vendor data for operation at 100% of rated engine capacity.

A description of process instrumentation monitored during the test

Engine process data collected included catalyst inlet temperature, pressure drop across the catalyst, engine load, horsepower, ambient temperature, barometric pressure, humidity, fuel flow rate, suction pressure and discharge pressure.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Description of sampling train(s) and field procedures

CO reduction efficiency was determined by concurrently measuring concentrations of carbon dioxide (CO_2) and CO at the catalytic oxidation inlet and outlet (engine exhaust), while the NO_x, CO and VOC emission rates were determined at the engine exhausts only. U.S. EPA Test Methods from 40 CFR Part 60, Appendix A were used exclusively, including Methods 3A, 7E, 10 and 25A, as described within the test protocol. Further, the test procedures employed for the CO reduction efficiency tests were consistent with those specified in 40 CFR Part 63, Subpart ZZZZ §63.6620 Equation 1 and Table 4.

Please note that EPTS measured CO_2 diluent concentrations in lieu of oxygen (O_2) to satisfy Subpart ZZZZ requirements for correcting CO concentrations to 15% O_2 prior to determining percent CO reduction. A CO_2 correction factor based on O_2 to CO_2 fuel factor ratios was developed as described in § 63.6620 (e)(2)(ii)(Eq.3), after which the CO concentrations were corrected to 15% O_2 based on dry basis CO_2 concentrations as described in Equation 4, § 63.6620 (e)(2)(iii).

All components of the CO_2, NO_x, CO and VOC extractive sample systems in contact with flue gas were constructed of Type 316 stainless steel and/or Teflon. Engine exhaust gas was drawn from the stack via a sample probe and heated sample line with the CO_2, NO_x and CO routed through an ice bath gas dryer for moisture removal prior to being distributed from a gas manifold into the respective analyzer. Conversely, the VOC sample system measures exhaust gas on a wet basis, therefore, the gas is diverted just prior to ice bath moisture removal and injected into the instrument directly. The output signal from each analyzer was connected to a computerized data acquisition system (DAS).

The CO_2, NO_x, and CO analyzers were calibrated with U.S. EPA Protocol calibration gases at a minimum of three points: zero (0-20% of calibration span), mid-level (40-60% of calibration span) and high-level gas (equal to the calibration span). The VOC instrument was calibrated based on direction from the MDEQ, using the bias and drift correction conditions described in U.S. EPA Method 7E and calibrated following the calibration gas specifications of U.S. EPA Method 25A with four gases consisting of zero, low (25 to 35 percent of calibration span), mid (45 to 55 percent of calibration span) and high (equivalent to instrument span), using methane. All instruments were operated thereafter to insure that zero drift, calibration gas drift, bias and calibration error met the specified method requirements.

The data measured from the pollutant and diluent analyzers was averaged for each run and corrected for drift and bias. CO concentrations in part per million by volume (ppmv) used for determining CO reduction efficiency were also corrected to 15 percent O_2 using the CO_2 correction factor ratio equation in 40 CFR Part 63, Subpart ZZZZ, § 63.6620 (e)(2)(ii) and then adjusted to 15 percent O_2 as specified in § 63.6620 (e)(2)(iii). CO_2 concentrations were measured as percent by volume, dry basis. The extractive sample system apparatus diagram is shown in Figure 1.

CO_2 diluent concentrations were monitored using a non-dispersive infrared (NDIR) analyzer following the guidelines of U.S. EPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from a Stationary Source (Instrumental Analyzer Procedure).*

NO_x concentrations were monitored using a chemiluminescence analyzer following the guidelines of U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure).*

The CO concentrations were measured using an NDIR analyzer following the guidelines of U.S. EPA Reference Method 10, *Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure).*

VOC concentrations were monitored using a flame ionization analyzer following the guidelines of U.S. EPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame ionization Analyzer (FIA)* using the drift and bias corrections specified in U.S. EPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure).* The gas sample enters the FIA via a sample capillary into two detectors, one of which evaluates the sample as total volatile organic compounds (VOC) concentration including methane, while the second detector oxidizes and removes all hydrocarbons except methane using a non-methane hydrocarbon cutter. The individual detector signal outputs are coupled to corresponding electrometer amplifiers allowing for continuous data acquisition and evaluation of real-time total VOC, Methane and total gaseous non-methane organics.

Each U.S. EPA reference method performed during this test contains specific language stating that to obtain reliable results, persons using these methods should have a thorough knowledge of the techniques associated with each method. To that end, CEC EPTS attempts to minimize any factors which could cause sampling errors by implementing a quality assurance (QA) program into every component of field testing, including the following information.

U.S. EPA Protocol gas standards certified according to the U.S. EPA Traceability Protocol for Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997 and certified to have a total relative uncertainty of ±1 percent were used to calibrate the analyzers during the test program. Although not required in the context of this test program, the vendors providing the calibration gases also participate in the Protocol Gas Verification Program (PGVP), an EPA audited program recently developed for 40 CFR Part 75.

The extractive sample system instruments were calibrated and operated following the appropriate method guidelines, based on specifications contained in Method 7E (as referenced in Methods 3A and 10). Before daily testing began, an analyzer calibration error (ACE) test is conducted by introducing the calibration gases directly into each analyzer. If the measured response doesn't meet the ±2 percent of instrument span specification, or within 0.5 ppmv absolute difference to pass the ACE check, appropriate action is taken and the ACE is re-done. Prior to beginning the first run, an initial system bias is conducted by introducing the low and upscale calibration gases into the sampling system at the probe outlet and drawing it through the sample conditioning system in the same manner as the exhaust gas sample, while measuring the instrument response. Each instrument response must meet a specification of ≤ 5.0 percent of instrument span.

Low and upscale bias calibrations were performed after each run thereafter to quantify system calibration drift and bias. During the initial system bias tests, system response time is measured and the sample flow rate throughout the remainder of the test was monitored to maintain the sample rate within 10 percent of the average flow rate observed during the response time test. Sampling for each run was started after twice the system response time had elapsed.

<u>Description of recovery and analytical procedures</u>
NA

<u>Dimensioned sketch showing all sampling ports in relation to breeching and to upstream and downstream disturbances or obstructions of gas flow and A sketch of cross-sectional view of stack indicating traverse point locations and exact stack dimensions</u>
Figure 3 shows the Caterpillar Model G3616 Stack Schematic.

5.0 TEST RESULTS and DISCUSSION

Detailed tabulation of results, including process operating conditions and flue gas conditions

RICE operating data, catalyst inlet and outlet data, field data, calibration information and sample calculations are contained in Attachments 1 - 4. Attachment 5 contains the MDEQ acceptance letter for this test event.

Discussion of significance of results relative to operating parameters and emission regulations

The average percent reduction of CO, for each of the four units, was greater than the minimum required destruction efficiency. Thus, Units EUENGINE31, EUENGINE32, EUENGINE33, and EUENGINE34 are in compliance with the CO percent reduction across the catalyst. In addition, the catalyst inlet temperatures were monitored continuously throughout testing and were shown to be within the required range of 450°F and 1350°F. The pressure drop across the catalyst was also monitored throughout the testing, and these pressure drops will be used to establish appropriate operating ranges for each engine. In addition, the NOx, CO and VOC engine emission rates are within the MDEQ PTI No. 206-09 requirements.

Discussion of any variations from normal sampling procedures or operating conditions, which could have affected the results.

As noted previously, during testing on EUENGINE32 and EUENGINE33, the recorded horsepower data implies that engine load was not within *plus or minus 10 percent of 100 percent load,* as specified by Subpart ZZZZ §63.6620 (b). While the intent was to operate all of the engines within the preceding range, actual field conditions on the dates of testing were such that the maximum gas compressor mechanical energy requirements limited the available horsepower capacity.

After closely examining the test results, Consumers Energy does not believe that operating at slightly less than 90% load, or at a lower available horsepower, had a material impact upon the Subpart ZZZZ compliance test results. Specifically, the average inlet and outlet CO concentrations corrected to 15% O_2 were similar for all four engines (Inlet = 217.2 to 221.1 ppm; Outlet = 0.1 to 0.8 ppm), which also resulted in very similar CO destruction efficiencies (99.7 to 99.9%). Furthermore, the engine exhaust gas temperatures observed at approximately 90% load were comparable to or lower than those observed close to 100% load. As the oxidation catalyst destruction efficiency is influenced by exhaust gas temperature, the similarity in exhaust gas temperatures indicates that operating at slightly less than 90% load did not result in a higher than expected CO destruction efficiency had these same engines been operated closer to 100% load.

Documentation of any process or control equipment upset condition which occurred during the testing.

NA

Description of any major maintenance performed on the air pollution control device(s) during the three month period prior to testing
NA

In the event of a re-test, a description of any changes made to the process or air pollution control device(s)
NA

Results of any quality assurance audit sample analyses required by the reference method
NA

Calibration sheets for the dry gas meter, orifice meter, pitot tube, and any other equipment or analytical procedures which require calibration
Attachment 3 contains the analyzer calibration data, calibration gas Certificates of Analysis, and the results of stratification testing which was to be used to determine the appropriate number of traverse points.

Sample calculations of all the formulas used to calculate the results
Sample calculations for all formulas used in the test report are contained in Attachment 4.

Copies of all field data sheets, including any pre-testing, aborted tests, and/or repeat attempts
Please refer to Attachment 1 for process data collected during the test runs; Attachment 2 for calculation spreadsheets for each of the test runs; and Attachment 3 for data sheets with the measured CO and CO_2 concentrations for each test run.

Copies of all laboratory data including QA/QC.
NA

TABLE 1

Summary of RICE Efficiency and Emissions
EUENGINE31

TABLE 1
SUMMARY OF RICE EFFICIENCY AND EMISSIONS
RAY COMPRESSOR STATION
EUENGINE31
September 26, 2013

Time Period	Run 1	Run 2	Run 3	Averages
	0926-1026	**1044-1144**	**1202-1302**	
Process Conditions				
Engine Speed, Revolutions Per Minute:	999	999	1,000	**999**
Brake Horsepower:	4,251	4,258	4,259	**4,256**
Load, Percent:	90	90	90	**90**
Catalyst Delta P, Inches of Water:	2.18	2.18	2.18	**2.2**
Catalyst Inlet Temperature, degrees F:	873	868	866	**869**
Inlet Gas Conditions				
Carbon Dioxide Concentration, percent:	4.87	4.89	4.91	**4.89**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	321.26	314.29	309.89	**315.15**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	222.44	216.77	212.74	**217.32**
Outlet Gas Conditions				
Carbon Dioxide Concentration, percent:	5.19	5.19	5.18	**5.19**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	0.71	0.84	1.92	**1.15**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	0.47	0.54	1.25	**0.75**
Percent Reduction Efficiency	99.8	99.7	99.4	**99.7**
Emission Rate, Grams Per Brake Horsepower:	0.003	0.004	0.007	**0.005**
Emission Limit, Grams Per Brake Horsepower:	0.2	0.2	0.2	**0.2**
Drift Corrected Nitrogen Oxides Concentration (ppmdv):	51.1	58.1	51.1	**53.5**
Emission Rate, Grams Per Brake Horsepower:	0.41	0.47	0.41	**0.43**
Emission Limit, Grams Per Brake Horsepower:	0.5	0.5	0.5	**0.5**
Drift Corrected Volatile Organic Compounds Concentration (ppmwv):	0.6	0.1	1.0	**0.6**
Emission Rate, Grams Per Brake Horsepower:	0.005	0.001	0.008	**0.004**
Emission Limit, Grams Per Brake Horsepower:	0.19	0.19	0.19	**0.19**

TABLE 2

Summary of RICE Efficiency and Emissions
EUENGINE32

TABLE 2

SUMMARY OF RICE EFFICIENCY AND EMISSIONS

RAY COMPRESSOR STATION

EUENGINE32

September 24 and 25, 2013

September 24, 2013 Time Period	Run 1	Run 2	Run 3	Averages
	1224-1324	1345-1445	1505-1605	
Process Conditions				
Engine Speed, Revolutions Per Minute:	1,000	1,000	1,000	**1,000**
Brake Horsepower [1]:	4,182	4,192	4,209	**4,194**
Load, Percent:	88	89	89	**89**
Catalyst Delta P, Inches of Water:	2.37	2.36	2.30	**2.3**
Catalyst Inlet Temperature, degrees F:	882	879	879	**880**
Inlet Gas Conditions				
Carbon Dioxide Concentration, percent:	4.89	4.93	4.94	**4.92**
Carbon Monoxide				
Drift Corrected Carbon Monoxide Concentration (ppmdv):	309.36	320.17	322.29	**317.27**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	213.03	218.81	219.71	**217.18**
Outlet Gas Conditions				
Carbon Dioxide Concentration, percent:	5.35	5.31	5.29	**5.32**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	0.68	0.05	0.97	**0.57**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	0.43	0.03	0.62	**0.36**
Percent Reduction Efficiency	99.80	99.99	99.72	**99.8**
September 25, 2013 Time Period	**Run 1**	**Run 2**	**Run 3**	**Averages**
	1220-1320	**1337-1437**	**1454-1554**	
Process Conditions				
Engine Speed, Revolutions Per Minute:	1,000	1,000	1,000	**1,000**
Brake Horsepower:	4,203	4,234	4,243	**4,226**
Load, Percent:	88.8	89.4	89.6	**89.3**
Catalyst Delta P, Inches of Water:	2.44	2.44	2.44	**2.4**
Catalyst Inlet Temperature, degrees F:	879.0	875	873.92	**876.1**
Outlet Gas Conditions				
Carbon Dioxide Concentration, percent:	5.20	5.21	5.21	**5.207**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	1.95	0.45	0.18	**0.857**
Carbon Monoxide Emission Rate, Grams Per Brake Horsepower:	0.01	0.002	0.001	**0.004**
Carbon Monoxide Emission Limit, Grams Per Brake Horsepower:	0.2	0.2	0.2	**0.2**
Drift Corrected Nitrogen Oxides Concentration (ppmdv):	58.5	57.2	58.5	**58.1**
Nitrogen Oxides Emission Rate, Grams Per Brake Horsepower:	0.47	0.46	0.47	**0.47**
Nitrogen Oxides Emission Limit, Grams Per Brake Horsepower:	0.5	0.5	0.5	**0.5**
Drift Corrected Volatile Organic Compounds Concentration (ppmwv):	1.5	2.1	3.3	**2.3**
VOC Emission Rate, Grams Per Brake Horsepower:	0.011	0.016	0.026	**0.018**
VOC Emission Limit, Grams Per Brake Horsepower:	0.19	0.19	0.19	**0.19**

1 Subpart ZZZZ RICE brake horsepower is a variable used to calculate percent engine load or torque. Unfortunately, during Run 1 and part of Run 2 on September 24, the historian did not log horsepower. However since the engine % load was already a pre-programmed historian parameter, the % load value was used to calculate the horsepower.

TABLE 3

Summary of RICE Efficiency and Emissions
EUENGINE33

TABLE 3

SUMMARY OF RICE CARBON MONOXIDE REDUCTION EFFICIENCY

RAY COMPRESSOR STATION

EUENGINE33

October 16, 2013

Time Period	Run 1 1015-1115	Run 2 1151-1251	Run 3 1311-1411	Averages
Process Conditions				
Engine Speed, Revolutions Per Minute:	862	845	846	**851**
Brake Horsepower:	4,200	4,093	4,095	**4,129**
Load, Percent*:	103	102	102	**102**
Catalyst Delta P, Inches of Water:	1.98	1.98	1.98	**2.0**
Catalyst Inlet Temperature, degrees F:	801	800	801	**801**
Inlet Gas Conditions				
Carbon Dioxide Concentration, percent:	4.69	4.66	4.82	**4.72**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	311.05	310.59	313.43	**311.69**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	223.62	224.53	219.38	**222.51**
Outlet Gas Conditions				
Carbon Dioxide Concentration, percent:	4.83	4.83	4.94	**4.87**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	0.17	0.01	0.38	**0.18**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	0.12	0.00	0.26	**0.13**
Percent Reduction Efficiency	99.9	100.0	99.9	**99.9**

* Load, Percent is based upon available horsepower during testing (=4105 hp)

TABLE 4

Summary of RICE Efficiency and Emissions
EUENGINE34

TABLE 4
SUMMARY OF CARBON MONOXIDE REDUCTION EFFICIENCY
RAY COMPRESSOR STATION
EUENGINE34
October 16, 2013

Time Period	Run 1 1540-1640	Run 2 1655-1755	Run 3 1814-1914	Averages
Process Conditions				
Engine Speed, Revolutions Per Minute:	999	999	999	**999**
Brake Horsepower:	4,603	4,615	4,616	**4,612**
Load, Percent:	97	97	97	**97**
Catalyst Delta P, Inches of Water:	2.70	2.70	2.70	**2.7**
Catalyst Inlet Temperature, degrees F:	871	870	870	**870**
Inlet Gas Conditions				
Carbon Dioxide Concentration, percent:	5.52	5.30	5.65	**5.49**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	362.32	360.07	357.05	**359.81**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	221.08	229.12	213.13	**221.11**
Outlet Gas Conditions				
Carbon Dioxide Concentration, percent:	5.27	5.37	5.38	**5.34**
Drift Corrected Carbon Monoxide Concentration (ppmdv):	0.04	0.44	0.76	**0.41**
Corrected Carbon Monoxide Concentration (ppmdv @ 15% O2):	0.03	0.28	0.48	**0.26**
Percent Reduction Efficiency	100.0	99.9	99.8	**99.9**