Derenzo Environmental Services
Consulting and Testing

AIR EMISSION TEST REPORT

Title	AIR EMISSION TEST REPORT FOR THE VERIFICATION OF AIR POLLUTANT EMISSIONS FROM NATURAL GAS FIRED INTERNAL COMBUSTION ENGINES
Report Date	July 25, 2017
Test Dates	June 20 – 21, 2017

Facility Information	
Name	Core Energy, LLC Chester 10 CPF
Site Location	SW ¼ SW ¼ SEC 10 T29N R2W
City, County	Chester Twp, Otsego, Michigan

Facility Permit Information			
PTI No.:	579-95D	Facility SRN :	N5798

Testing Contractor	
Company	Derenzo Environmental Services
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1705002

AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
NATURAL GAS FUELED INTERNAL COMBUSTION ENGINES

CORE ENERGY, LLC
CHESTER 10 CPF

1.0 INTRODUCTION

Core Energy, LLC (Core Energy, SRN 5798) operates natural gas-fired reciprocating internal combustion engines (RICE) at the Chester 10 CPF facility in Chester Twp, Otsego County, Michigan. The RICE are fueled by natural gas and used to provide mechanical power to operate gas compressors. The facility compresses carbon dioxide gas prior to injecting it into oil wells.

The Michigan Department of Environmental Quality-Air Quality Division (MDEQ-AQD) has issued Permit to Install (PTI) No. 579-95D to Core Energy for the operation of three (3) RICE. The units covered by PTI No. 579-95D consists of:

- Two (2) Caterpillar (CAT®) Model No. G3608 RICE identified as emission units EUENGINE1 (controlled) and EUENGINE2 (uncontrolled).
- One (1) Caterpillar (CAT®) Model No. G3612 RICE identified as emission unit EUENGINE3 (controlled).

Air emission compliance testing was performed pursuant to PTI No. 579-95D and the federal Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ). The MDEQ-AQD also requested that the formaldehyde emission rate for EUENGINE1 and 2 be determined.

The compliance testing was performed by Derenzo Environmental Services, a Michigan-based environmental consulting and testing company. Derenzo Environmental Services representatives Tyler Wilson and Andy Rusnak performed the field sampling June 20 – 21, 2017.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated May 9, 2017 that was reviewed and approved by the Michigan Department of Environmental Quality (MDEQ). MDEQ representatives Ms. Becky Radulski and Mr. Tom Gasloli observed portions of the testing project.

Questions regarding this emission test report should be directed to:

Andy Rusnak, QSTI
Technical Manager
Derenzo Environmental Services
4180 Keller Rd., Ste. B
Holt, MI 48842
Ph: (517) 268-0043

Mr. Bob Tipsword
Operations Manager
Core Energy, LLC
1011 Noteware Drive
Traverse City, Michigan 49686
(231) 946-2419

Report Certification

This test report was prepared by Derenzo Environmental Services based on field sampling data collected by Derenzo Environmental Services. Facility process data were collected and provided by Core Energy employees or representatives. This test report has been reviewed by Core Energy representatives and approved for submittal to the MDEQ.

I certify that the testing was conducted in accordance with the specified test methods and submitted test plan unless otherwise specified in this report. I believe the information provided in this report and its attachments are true, accurate, and complete.

Report Prepared By:

Andy Rusnak, QSTI
Technical Manager
Derenzo Environmental Services

I certify that the facility and emission units were operated at maximum routine operating conditions for the test event. Based on information and belief formed after reasonable inquiry, the statements and information in this report are true, accurate and complete.

Responsible Official Certification:

Bob Tipsword
Operations Manager
Core Energy, L.L.C.

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Core Energy operates a gas compressor station at the Chester Twp. facility. Natural gas, which has been recovered from nearby wells, has the carbon dioxide removed at an adjacent facility. The removed carbon dioxide gas is routed to the Core Energy Chester 10 CPF facility. Core Energy operates three (3) natural gas fired RICE at the facility. The RICE provide mechanical power to attached gas compressors. The compressed carbon dioxide is injected back into oil wells.

2.2 Rated Capacities and Air Emission Controls

Core Energy operates two (2) CAT® Model No. G3608 RICE (EUENGINE1 and EUENGINE2). The CAT® Model No. G3608 RICE has a rated output of 1,947 brake-horsepower (bhp) at 860 rpm (2,225 bhp at 1,000 rpm).

Core Energy operates one (1) CAT® Model No. G3612 RICE (EUENGINE3). The CAT® Model No. G3612 RICE has a rated output of 3,071 bhp at 865 rpm (3,550 bhp at 1,000 rpm).

Engine Nos. 1 and 3 (EUENGINE1 and EUENGINE3) are equipped with oxidation catalyst to control emissions of carbon monoxide. Engine No. 2 (EUENGINE2) is not equipped with add on pollution control equipment. Air pollutant emissions are minimized through the proper operation and efficient fuel combustion in the engines.

2.3 Sampling Locations

The RICE exhaust gas is directed through mufflers (and pollution control devices for EUENGINE1 and 3) prior to being released to the atmosphere through dedicated vertical exhaust stacks with vertical release points.

The engine exhaust sampling ports for EUENGINE1 are located in the exhaust stack prior to release to the ambient air. The exhaust stack has an inner diameter of 25.5 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 68.0 inches (2.7 duct diameters) upstream and 36.0 inches (1.4 duct diameters) downstream from any flow disturbance. The sampling location does not satisfy the USEPA Method 1 criteria for a representative sample location (B dimension is less than 2.0 diameters).

The engine exhaust sampling ports for EUENGINE2 are located in the exhaust stack prior to release to the ambient air. The exhaust stack has an inner diameter of 17.0 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location greater than 120 inches (>7.1 duct diameters) upstream and 36.5 inches (2.1 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

The engine exhaust sampling ports for EUENGINE3 are located in the exhaust stack prior to release to the ambient air. The exhaust stack has an inner diameter of 26.0 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 180 inches (6.9 duct diameters) upstream and 63.0 inches (2.4 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

Individual traverse points were determined in accordance with USEPA Method 1.

Appendix 1 provides diagrams of the emission test sampling locations.

3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

3.1 Purpose and Objective of the Tests

The conditions for FGENGINES in PTI No. 579-95D state:

> *Upon request by the AQD District Supervisor, the permittee shall verify NOx and CO emission factors used to calculate emissions from EUENGINE1 and EUENGINE2, by testing at owner's expense, in accordance with Department requirements. If a test has been conducted, any resulting increase in an emission factor shall be implemented to calculate NOx and CO;* and
>
> *The permittee shall conduct an initial performance test for EUENGINE3 to verify compliance with the emission limits in SC I.4* (NOx), *SC I.8* (CO), *and SC I.9* (VOC) *within one year of engine startup and subsequent testing every 8,760 hours or three years, whichever comes first, thereafter.*

Additionally, the MDEQ requested that Core Energy test one (1) controlled (EUENGINE1) and one (1) uncontrolled (EUENGINE2) RICE to determine the emissions of formaldehyde.

Testing was performed to demonstrate compliance with the air pollutant emission limits specified in PTI No. 579-95D for the RICE in FGENGINES. The formaldehyde testing for EUENGINE 1 and 2 satisfied the MDEQ additional testing request.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while the Core Energy RICE were operated at maximum routine operating conditions. Core Energy representatives provided the horsepower output in 15-minute increments for each test period.

Fuel flowrate, engine shaft rotation (rpm) and catalyst inlet temperature were also recorded by Core Energy representatives in 15-minute increments for each test period.

Appendix 2 provides operating records provided by Core Energy representatives for the test periods.

Engine output (bhp) cannot be measured directly and was calculated based on the recorded engine shaft rotation (rpm). Core Energy provided engine spec sheets that listed the horsepower produced and engine shaft rotation (rpm) at maximum load. To determine the horsepower output at a lower load the following equation was used:

Engine Output (bhp-hr) = Max Output (bhp-hr) * Measured rotation (rpm) / Max rotation (rpm)

Table 3.1 presents a summary of the average engine operating conditions during the test periods.

3.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled RICE (EUENGINE1, 2 and 3) were each sampled for three (3) one-hour test periods during the compliance testing performed June 20 – 21, 2017.

Table 3.2 presents the average measured emission rates for the engines (average of the three test periods for each engine).

Test results for each one hour sampling period and comparison to the permitted emission rates is presented in Section 6.0 of this report.

Table 3.1 Average engine operating conditions during the test periods

Engine Parameter	EUENGINE1	EUENGINE2	EUENGINE3
Engine shaft rotation (rpm)	860	866	850
Engine output (bhp)	1,914	1,927	3,019
Fuel Use (scfm)	188	192	316
Catalyst inlet temperature (°F)	762	-	771

Table 3.2 Average measured emission rates for each engine (three-test average)

	CO Emission Rates		NO_x Emission Rates		Formaldehyde Emission Rates	VOC Emission Rates
Emission Unit	(TpY)	(g/bhp-hr)	(TpY)	(g/bhp-hr)	(TpY)	(g/bhp-hr)
EUENGINE1	0.00	0.00	12.58	0.68	0.08	0.34
Permit Limit	*11.42*	-	*11.42*	-	-	-
EUENGINE2	30.90	1.66	14.73	0.79	3.85	0.44
Permit Limit	*60.75*	-	*10.96*	-	-	-
EUENGINE3	1.71	0.06	9.49	0.33	-	0.37
Permit Limit	*17.13*	*2.0*	*17.13*	*1.0*	-	*0.7*

Notes for Table No. 3.2:

1. Annual mass emission rates are based off of the tested emission rate (lb/hr) and a maximum of 8,760 annual operating hours.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the air emission testing was reviewed and approved by the MDEQ. This section provides a summary of the sampling and analytical procedures that were used during the testing periods.

4.1 Summary of Sampling Methods

USEPA Method 1	Exhaust gas velocity measurement locations were determined based on the physical stack arrangement and requirements in USEPA Method 1
USEPA Method 2	Exhaust gas velocity pressure was determined using a Type-S Pitot tube connected to a red oil incline manometer; temperature was measured using a K-type thermocouple connected to the Pitot tube.
USEPA Method 3A	Exhaust gas O_2 and CO_2 content was determined using paramagnetic and infrared instrumental analyzer.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 7E	Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using an infrared instrumental analyzer
USEPA Method 25A / ALT-096	Exhaust gas VOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column
ASTM D6348	Determination of gaseous compounds by extractive direct interface Fourier Transform infrared (FTIR) spectroscopy

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The RICE exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 during each test. An S-type or standard Pitot tube connected to a red-oil manometer was used to determine velocity pressure at each traverse point across the stack cross section. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked to verify the integrity of the measurement system.

The absence of significant cyclonic flow for each exhaust configuration was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each velocity traverse point with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

Appendix 3 provides exhaust gas flowrate calculations and field data sheets.

4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the RICE exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a Servomex 1440D single beam single wavelength (SBSW) infrared gas analyzer. The O_2 content of the exhaust was monitored using a Servomex 1440D gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the IC engine 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 analyzers; therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition 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, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document). Sampling times were recorded on field data sheets.

Appendix 4 provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of the EUENGINE3 exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. The moisture sampling was performed concurrently with the instrumental analyzer sampling. During each sampling period a gas sample was extracted at a constant rate from the source where moisture was removed from the sampled gas stream using impingers that were submersed in an ice bath. At the conclusion of each sampling period, the moisture gain in the impingers was determined gravimetrically by weighing each impinger to determine net weight gain.

4.5 NO_x and CO Concentration Measurements (USEPA Methods 7E and 10)

NO_X and CO pollutant concentrations in the RICE exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NO_X analyzer and a TEI Model 48i infrared CO analyzer.

Throughout each test period, a continuous sample of the engine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on an ESC Model 8816 data acquisition system that logged data as one-minute averages. Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias.

Appendix 4 provides CO and NO_X calculation sheets. Raw instrument response data are provided in Appendix 5.

4.6 Measurement of Volatile Organic Compounds (USEPA Method 25A/ALT-096)

The VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in the engine exhaust gas. NMHC pollutant concentration was determined using a TEI Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains an internal gas chromatograph column that separates methane from non-methane components. The concentration of NMHC in the sampled gas stream, after separation from methane, is determined relative to a propane standard using a flame ionization detector in accordance with USEPA Method 25A.

The USEPA Office of Air Quality Planning and Standards (OAQPS) has issued an alternate test method approving the use of the TEI 55i-series analyzer as an effective instrument for measuring NMOC from gas-fueled reciprocating internal combustion engines (RICE) in that it uses USEPA Method 25A and 18 (ALT-096).

Samples of the exhaust gas were delivered directly to the instrumental analyzer using the Teflon® heated sample line to prevent condensation. The sample to the NHMC analyzer was not conditioned to remove moisture. Therefore, VOC measurements correspond to standard conditions with no moisture correction (wet basis).

Prior to, and at the conclusion of each test, the instrument was calibrated using mid-range calibration (propane) and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document).

Appendix 4 provides VOC calculation sheets. Raw instrument response data for the NMHC analyzer is provided in Appendix 5.

4.7 Determination of Moisture and Formaldehyde Emissions (ASTM D6348)

Formaldehyde and moisture concentration in the RICE exhaust gas streams was determined using a MKS Multi-Gas 2030 Fourier transform infrared (FTIR) spectrometer.

Samples of the exhaust gas were delivered directly to the instrumental analyzer using a Teflon® heated sample line to prevent condensation. The sample to the FTIR analyzer was not conditioned to remove moisture. Therefore, formaldehyde measurements correspond to standard conditions with no moisture correction (wet basis).

A calibration transfer standard (CTS), ethylene standard, and nitrogen zero gas were analyzed before and after each test run. Analyte spiking, of each engine, with acetaldehyde was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR. Data was collected at 0.5 cm^{-1} resolution. Instrument response was recorded using MKS data acquisition software.

Appendix 4 provides formaldehyde calculation sheets. Instrument response data for the FTIR is provided in Appendix 6.

5.0 QA/QC ACTIVITIES

5.1 NO_x Converter Efficiency Test

The NO_2 – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_2 concentration is within 90% of the expected value.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_2 concentration was 96.0% of the expected value, i.e., within 10% of the expected value as required by Method 7E).

5.2 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC 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 STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of 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.

5.3 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_X, CO, O_2 and CO_2 have had an interference response test preformed prior to their use in the field (July 26, 2006, June 12, 2014 and April 19, 2016), 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 2.5% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

5.4 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the NO_x, CO, CO_2 and O_2 analyzers 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 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 determining the instrument response against the initial instrument calibration readings.

At the beginning of each test day, appropriate high-range, mid-range, and low-range span gases followed by a zero gas were introduced to the NMHC analyzer, in series at a tee connection, which is installed between the sample probe and the particulate filter, through a poppet check valve. After each one hour test period, mid-range and zero gases were re-introduced in series at the tee connection in the sampling system to check against the method's performance specifications for calibration drift and zero drift error.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NO_x, and CO in nitrogen and zeroed using hydrocarbon free nitrogen. The NMHC (VOC) instrument was calibrated with USEPA Protocol 1 certified concentrations of propane in air and zeroed using hydrocarbon-free air. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

5.5 Determination of Exhaust Gas Stratification

A stratification test was performed for each RICE exhaust stack. The stainless steel sample probe was positioned at sample points correlating to 16.7, 50.0 (centroid) and 83.3% of each stack diameter. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded concentration data for each RICE exhaust stack indicated that the measured NO_x, CO, O_2 and CO_2 concentrations did not vary by more than 5% of the mean across each stack diameter. Therefore, the RICE exhaust gas was considered to be unstratified and the compliance test sampling was performed at a single sampling location within the RICE exhaust stack.

5.6 FTIR QA/QC Activities

At the beginning of each day a calibration transfer standard (CTS, ethylene gas), analyte of interest (acetaldehyde) and nitrogen calibration gas were directly injected into the FTIR to evaluate the unit response.

Prior to and after each test run the CTS was analyzed. The ethylene was passed through the entire system (system purge) to verify the sampling system response and to ensure that the sampling system remained leak-free at the stack location. Nitrogen was also passed through the sampling system to ensure the system is free of contaminants.

Analyte spiking, of each emission unit, with acetaldehyde was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR and assured the ability of the FTIR to quantify that compound in the presence of effluent gas. The spike target dilution ratio was 1:10 (1 part cal gas; 9 parts stack gas).

As part of the data validation procedure, reference spectra were manually fit to that of the sample spectra (two spectra from each test period) and a concentration was determined. The reference spectra were scaled to match the peak amplitude of the sample, thus providing a scale factor. The scale factor multiplied by the reference spectra concentration was used to determine the concentration value for the sample spectra. The manually-calculated results were then compared with the software-generated results to ensure the quality of the data. EUENGINE1 data was manually validated using the MKS method analyzer software due to the low measured concentrations. The software used multi-point calibration curves to quantify each spectrum.

5.7 Meter Box Calibrations

The Nutech Model 2010 sampling console, which was used for exhaust gas moisture content sampling, was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

The digital pyrometer in the Nutech metering consoles were calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix 7 presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, meter box calibration records, Pitot tube calibration records, stratification checks, CTS results, spike results and manual FTIR data validation results).

6.0 RESULTS

6.1 Test Results and Allowable Emission Limits

Engine operating data and air pollutant emission measurement results for each one hour test period are presented in Tables 6.1 through 6.3.

Except for the NO_x test results for EUEGINE1 and 2, the measured air pollutant concentrations and emission rates for all one-hour test periods are less than or equal to the allowable limits specified in MDEQ-AQD PTI No. 579-95D:

Engine No. 1
- 11.42 TpY for NO_x; and
- 11.42 TpY for CO.

Engine No. 2
- 10.96 TpY for NO_x; and
- 60.75 TpY for CO.

Engine No. 3
- 17.13 TpY and 1.0 g/bhp-hr for NO_x;
- 17.13 TpY and 2.0 g/bhp-hr for CO; and
- 0.7 g/bhp-hr for VOC.

The measured NO_x emission rate for EUENGINE1 would exceed the permit limit by 1.16 TpY (12.58 TpY versus the allowable emission limit of 11.42 TpY) assuming 8,760 annual operating hours. The measured NO_x emission rate for EUENGINE2 would exceed the permit limit by 3.77 TpY (14.73 TpY versus the allowable emission limit of 10.96 TpY) assuming 8,760 annual operating hours.

6.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing for all pollutants was performed in accordance with USEPA and ASTM methods and the approved test protocol. The engine-generator sets were operated at maximum routine operating conditions and no variations from normal operating conditions occurred during the engine test periods with the following exception:

The first formaldehyde test run on EUENGINE1 was discarded because the post test system nitrogen purge failed to eliminate all of the formaldehyde from the system. The sample line was brand new and it is believed that when it obtained an operating temperature of 375 °F the Teflon line off gassed low levels of various hydrocarbons. An alternate sampling line was used for Test Period Nos. 2 and 3 the system nitrogen purge effectively zeroed out the FTIR. The results were discussed with Mr. Tom Gasloli and it was agreed that the first test run should be discarded and the results for EUENGINE1 be based upon the results from Test Run Nos. 2 and 3 (this data was not being used to demonstrate compliance with an emission limit). Data for the discarded run is presented in the appendices.

Table 6.1 Measured exhaust gas conditions and NO_x, CO, VOC and formaldehyde air pollutant emission rates for EUENGINE1

Test No.	1	2	3	
Test date	6/20/2017	6/20/2017	6/20/2017	Three Test
Test period (24-hr clock)	825-925	1123-1223	1254-1354	Average
Fuel flowrate (scfm)	188	188	188	188
Engine output (rpm)	860	860	860	860
Engine output (bhp)	1,914	1,914	1,914	1,914
Catalyst Inlet temperature (°F)	763	762	761	762
Exhaust Gas Composition				
CO_2 content (% vol)	5.45	5.41	5.41	5.42
O_2 content (% vol)	12.0	12.1	12.1	12.1
Moisture (% vol)	9.52	9.42	10.3	9.74
Exhaust gas temperature (°F)	621	610	606	612
Exhaust gas flowrate (dscfm)	4,481	4,533	4,512	4,508
Exhaust gas flowrate (scfm)	4,952	5,004	5,029	4,995
Nitrogen Oxides				
NO_X conc. (ppmvd)	89.3	88.3	89.0	88.9
NO_X emissions (lb/hr)	2.87	2.87	2.88	2.87
NO_X emissions (TpY)	12.57	12.57	12.61	12.58
Permitted emissions (TpY)	-	-	-	*11.42*
Carbon Monoxide				
CO conc. (ppmvd)	0.0	0.0	0.0	0.0
CO emissions (lb/hr)	0.0	0.0	0.0	0.0
CO emissions (TpY)	0.00	0.00	0.00	0.00
Permitted emissions (TpY)	-	-	-	*11.42*
Formaldehyde				
Formaldehyde conc. (ppmv)	-	0.90	0.70	0.80
Formaldehyde emissions (lb/hr)	-	0.02	0.02	0.02
Formaldehyde emissions (TpY)	-	-	-	0.08

Notes for Table 6.1:

1. Presented TpY values are based on a maximum of 8,760 annual operating hours.

Table 6.2 Measured exhaust gas conditions and NO_x, CO, VOC and formaldehyde air pollutant emission rates for EUENGINE2

Test No.	1	2	3	
Test date	6/21/2017	6/21/2017	6/21/2017	Three Test
Test period (24-hr clock)	803-903	927-1027	1051-1151	Average
Fuel flowrate (scfm)	192	193	192	192
Engine output (rpm)	866	866	866	866
Engine output (bhp)	1,927	1,927	1,927	1,927
Engine load (%)	90	91	91	91
Exhaust Gas Composition				
CO_2 content (% vol)	5.59	5.56	5.56	5.57
O_2 content (% vol)	11.7	11.8	11.8	11.7
Moisture (% vol)	10.7	10.6	10.6	10.6
Exhaust gas temperature (°F)	637	641	632	637
Exhaust gas flowrate (dscfm)	4,531	4,587	4,601	4,573
Exhaust gas flowrate (scfm)	5,073	5,131	5,144	5,116
Nitrogen Oxides				
NO_X conc. (ppmvd)	103	103	102	103
NO_X emissions (lb/hr)	3.35	3.38	3.36	3.36
NO_X emissions (TpY)	14.65	14.81	14.72	14.73
Permitted emissions (TpY)	-	-	-	*10.96*
Carbon Monoxide				
CO conc. (ppmvd)	356	352	352	353
CO emissions (lb/hr)	7.04	7.06	7.06	7.05
CO emissions (TpY)	30.84	30.91	30.94	30.90
Permitted emissions (TpY)	-	-	-	*60.75*
Formaldehyde				
Formaldehyde conc. (ppmv)	36.8	36.7	36.6	36.7
Formaldehyde emissions (lb/hr)	0.87	0.88	0.88	0.88
Formaldehyde emissions (TpY)	-	-	-	3.85

Notes for Table 6.2:

1. Presented TpY values are based on a maximum of 8,760 annual operating hours.

Table 6.3 Measured exhaust gas conditions and NOx, CO and VOC air pollutant emission rates for EUENGINE3

Test No. Test date Test period (24-hr clock)	1 6/21/2017 1445-1545	2 6/21/2017 1610-1710	3 6/21/2017 1732-1832	Three Test Average
Fuel flowrate (scfm)	316	316	316	316
Engine output (rpm)	851	851	849	850
Engine output (bhp)	3,021	3,020	3,016	3,019
Catalyst Inlet temperature (°F)	771	771	772	771
<u>Exhaust Gas Composition</u>				
CO_2 content (% vol)	5.50	5.49	5.51	5.50
O_2 content (% vol)	11.9	11.9	11.9	11.9
Moisture (% vol)	10.3	10.2	10.4	10.3
Exhaust gas temperature (°F)	632	641	635	636
Exhaust gas flowrate (dscfm)	6,867	6.786	6,918	6,857
Exhaust gas flowrate (scfm)	7,656	7,554	7,721	7,644
<u>Nitrogen Oxides</u>				
NOx conc. (ppmvd)	45.1	43.6	43.5	44.1
NOx emissions (lb/hr)	2.22	2.12	2.16	2.17
NOx emissions (TpY)	9.73	9.29	9.44	9.49
Permitted emissions (TpY)	-	-	-	*17.13*
NOx emissions (g/bhp*hr)	0.33	0.32	0.32	0.32
*Permitted emissions (g/bhp*hr)*	-	-	-	*1.0*
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	13.0	13.2	13.2	13.1
CO emissions (lb/hr)	0.39	0.39	0.40	0.39
CO emissions (TpY)	1.71	1.71	1.74	1.72
Permitted emissions (TpY)	-	-	-	*17.13*
CO emissions (g/bhp*hr)	0.06	0.06	0.06	0.06
*Permitted emissions (g/bhp*hr)*	-	-	-	*2.0*
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	46.2	46.7	46.5	46.5
VOC emissions (g/bhp*hr)[1]	0.36	0.36	0.37	0.37
*Permitted emissions (g/bhp*hr)*	-	-	-	*0.7*

<u>Notes for Table 6.3:</u>

1. Presented TpY values are based on a maximum of 8,760 annual operating hours.