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Final Report

Performance Source Testing Turbine #1
C&C Energy LLC
Marshall, MI Facility

September 2013

TRC Environmental Corporation
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Lombard, Illinois 60148

TRC Project No. 198348.0050.0000

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FINAL REPORT

Performance Source Testing Turbine #1
C&C Energy LLC
Marshall, Michigan Facility

Prepared for

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SECTION 1.0
INTRODUCTION

1.1 OVERVIEW

C&C Energy hired TRC Environmental Corporation (TRC) of Lombard, Illinois to conduct testing to determine the emissions from Gas Turbine #1 located at the C&C Energy Facility in Marshall, Michigan. The purpose of the testing was to verify that the emissions met the Michigan permit limits.

Emission testing of Turbine #1 was performed on September 4, 2013. The testing determined emissions of Oxides of Nitrogen (NOx) by USEPA Method 7E and Oxygen (O_2) by Method 3A. Sampling and analysis procedures described in this document were conducted using procedures deemed acceptable by the USEPA. TRC was responsible for the collection and analysis of all samples.

1.2 SCOPE OF WORK

The test program approach involved conducting a series of test runs at test ports located on the stack of the Solar Gas Turbine. Turbine #1 was tested at base load. Each test determined the concentration and emission rate for NOx and O_2. The Btu value and F-Factor (Fd) were also determined during this test series. The stochiometric gas composition was used to determine the exhaust flow rate using the Btu per cubic foot and F-Factor along with the fuel usage following method 19. The exhaust flow rate was then used in the Lbs/hr calculation.

The results of the test program are presented in a format acceptable to the USEPA. The required measurement parameters and test methods to accomplish these objectives were:

- 40 CFR Part 60, Appendix A, EPA Reference Methods (RM)
  - RM 3A Oxygen
  - RM 19 Btu values and F-Factor Emission Rates
  - RM 7E Emissions of Oxides of Nitrogen (NOx)
  - ASTM D3246 Determination of Sulfur Content in fuel gas

1.3 REPORT SUMMARY

This report presents the results of the test program completed at the C&C Energy facility in Marshall, Michigan. Included in the following pages are descriptions of the sampling locations, sampling and analytical procedures, calculations, and TRC's QA procedures, which ensure the integrity of the reported data. A summary of all test results is presented in Section 2. Additionally, appendices are included which contain all relevant field sampling data sheets, field recovery data sheets, field reduced data, flue gas analytical data reports, sampling equipment calibration documentation sheets and process data from the facility.

SECTION 2.0

SUMMARY OF RESULTS

This section presents a summary of the emissions testing conducted at the C&C Energy Facility in Marshall, MI. The reduced field data is located in Appendix A. The CEM data can be found in Appendix B. The plant process data can be found in Appendix C. Calibration Gas Certificates can be found in Appendix D. Calculation Formulas can be found in Appendix E. The QSTI Certificates can be found in Appendix F.

Table 2-1 Emissions for Gas Turbine #1

Test 1

Parameter	Units		NOx @ 15% O2
Concentration NOx	ppm	22.8	28.47
Concentration O2	%	16.18	
F-Factor	Fd	9527	
Emission Rate NOx	Lbs / MMBtu	0.115	
Emission Rate NOx	**Lbs / Hr**	**3.6**	
Tons Per Year		**15.768**	
Permit Limits			**96 ppm @15% O2**

Test 2

Parameter	Units		NOx @ 15% O2
Concentration NOx	ppm	23.2	29.02
Concentration O2	%	16.19	
F-Factor	Fd	9527	
Emission Rate NOx	Lbs / MMBtu	0.117	
Emission Rate NOx	**Lbs / Hr**	**3.7**	
Tons Per Year		**16.206**	
Permit Limits			**96 ppm @15% O2**

Test 3

Parameter	Units		NOx @ 15% O2
Concentration NOx	ppm	23.7	29.51
Concentration O2	%	16.17	
F-Factor	Fd	9527	
Emission Rate NOx	Lbs / MMBtu	0.119	
Emission Rate NOx	**Lbs / Hr**	**3.7**	
Tons Per Year		**16.206**	
Permit Limits			**96 ppm @15% O2**

Averages

Parameter	Units		NOx @ 15% O2
Average	**ppm**	**23.21**	**29.00**
Average	**Lbs / MMBtu**	**0.117**	
Average	**Lbs / hr**	**3.7**	
Average	**Tons Per Year**	**16.060**	
Permit Limits			**96 ppm @15% O2**

Parameter	Units	Values
Concentration SO2	ppm	<1.0
Emission Rate SO2	**Lbs / MMBtu**	**<0.007**
Emission Rate SO2	Lbs / Hr	<0.220
Permit Limit		**0.15 Lb/MMBtu**

Fuel Usage Data	Run 1	Run 2	Run 3	Average
SCFM	**1022.3**	**1035.0**	**1028.5**	**1028.6**
Scf/hr	**61,338**	**62,100**	**61,700**	**61,716**

SECTION 3.0
FIELD SAMPLING PROGRAM

3.1 OVERVIEW

This section describes the procedures that TRC followed during the field-sampling program. Throughout the program TRC followed EPA Reference Methods 40 CFR Part 60 Appendix A. Deviations from the specified test methods are fully documented in this final report.

The remainder of this section is divided into several subsections: Field Program Description, Pre-sampling Activities and Onsite Sampling Activities.

3.2 FIELD PROGRAM DESCRIPTION

The field sampling was conducted by TRC over the course of one day. The C&C Energy facility operated the Gas Turbine #1 at base load for the emissions testing. Three one hour runs were performed on Turbine #1 stack.

3.3 PRE-SAMPLING ACTIVITIES

Pre-sampling activities included equipment calibration and other miscellaneous tasks. Each of these activities are described or referenced in the following subsections. Other pre-sampling activities included team meetings, equipment packing, and finalization of all details leading up to the coordinated initiation of the sampling program.

3.3.1 Equipment Calibration

TRC follows an orderly program of positive actions to prevent the failure of equipment or instruments during use. This preventative maintenance and careful calibration help to ensure accurate measurements from field and laboratory instruments.

Once the equipment has gone through the cleaning and repair process it is then calibrated. All equipment that is scheduled for field use is cleaned and checked prior to calibration. Once the equipment has been calibrated, it is packed and stored to ensure the integrity of the equipment. An adequate supply of spare parts is taken in the field to minimize downtime from equipment failure.

Inspection and calibration of the equipment is a crucial step in ensuring the successful completion of the field effort. All equipment is inspected for proper operation and durability prior to calibration. Calibration of the following equipment is conducted in accordance with the procedures outlined in EPA documents entitled "*Quality Assurance Handbook for Air Pollution Measurement Systems; Volume III - Stationary Source Specific Methods*" (EPA-600/4-77-027b) and 40 CFR Part 60 Appendix A. All calibrations were performed prior to test program.

- Thermocouples (QA Handbook, Vol III, Section 3.4.2, pp. 12-18) - verified against a mercury-in-glass thermometer at three points including the anticipated measurement range. Acceptance limits – impinger ± 2°F; DGM ± 5.4°F; stack 1.5 percent of stack temperature.

- Field barometer is (QA Handbook, Vol III, Section 3.4.2, pp. 18-19) - compared against a mercury-in-glass barometer or use Airport Station BP and corrected for elevation. Acceptance criteria: - +/- 0.02 in. Hg: post-test check - same.

3.4 ONSITE SAMPLING ACTIVITIES

3.4.1 EPA Method 19

Velocity traverses were calculated using the fuel usage and methane content in accordance with EPA Reference Method 19. One gas sample was taken by TRC and sent to Texas Oil tech laboratories. Texas Oil tech determined the gas composition which was then used to calculate the f-factor and Btu's per cubic foot values. The calculation formulas can be found in Appendix E with the plant process data in Appendix C. The average gas velocity was calculated for the test series.

3.4.2 EPA Method 3A for O_2

TRC sampled for O_2 concentrations using a California Analytical 650 NOXYGEN analyzer. Samples were extracted at the outlet stack for oxygen using USEPA Method 3A.

Response times were performed using the zero and high range calibration gas. A known concentration gas was introduced through the sampling system from the time it is introduced and until the time it reaches 90 percent of the span gas value. This was the upscale response time. The same procedure was performed from the high to the zero and this was the downscale response. This procedure was performed three times for both upscale and downscale. The longest recorded time was doubled and this was known as the response time.

3.4.3 EPA Method 7E for Oxides of Nitrogen

EPA Reference Method 7E "Determination of Oxides of Nitrogen Emissions from Stationary Sources (Instrumental Analyzer Procedure)," was utilized for the measurement of NO_x. The analyzer used was the California Analytical 650 NOXYGEN chemiluminescent NO/NO_x Monitor. The instrument operation is based on the principal of the chemiluminescent reaction of nitric oxide (NO) and ozone. Light emission results when electronically excited nitrogen dioxide (NO_2) molecules revert to their ground state. To measure NO concentrations, the gas sample to be analyzed, is blended with ozone (O_3) in the instrument's reaction chamber. The resulting chemiluminescence is monitored through an optical

filter by a highly sensitive photo multiplier (PMT) positioned at one end of the reaction chamber. The filter/photo multiplier combination responds to light in a narrow wavelength band unique to this chemiluminescent reaction (detailed below) the filter assists in eliminates interferences in this wavelength:

$$NO + O_3 \rightarrow NO_2 + O_2 + hv$$

To measure NO_x concentrations (NO plus NO_2), the sample gas flow is diverted through an NO_2-to-NO converter. The chemiluminescent response in the reaction chamber to the converter effluent is linearly proportional to the NO_x concentration entering the converter (sample gas). The system was operated in the NO_x mode during all phases of the program.

SECTION 4.0
QUALITY ASSURANCE

4.1 OVERVIEW

TRC Environmental Corporation management is fully committed to an effective Quality Assurance/Quality Control Program whose objective is the delivery of a quality product. For much of TRC's work, that product is data resulting from field measurements, sampling and analysis activities, engineering assessments, and the analysis of gathered data for planning purposes. The Quality Assurance Program works to provide complete, precise, accurate, representative data in a timely manner for each project, considering both the project's needs and budget constraints.

This section highlights the specific QA/QC procedures to be followed on this Test Program.

4.2 FIELD QUALITY CONTROL SUMMARY

4.2.1 Instrument Calibrations

All instrument calibrations meet the performance criteria defined in 40 CFR 60 Appendix A, Methods 3A and 7E.

Calibration error tests were also performed on the analyzer to meet the specifications set forth in 40 CFR 60 Method 7E. A total of three gases were sent through the analyzer to insure that linearity was achieved throughout the span range. Ultra pure N_2 was used for the zero, EPA Protocol 1 gases were used for the high and mid level ranges.

Preceding the calibration error checks, system bias checks were performed. Bias checks consist of sending zero calibration gas and calibration span gas through the entire system and recording the values once the analyzer has stabilized. These stabilized values must be within +/- 2.0% of the previous test run.

4.2.2 Calibration Procedures

Calibration of the field sampling equipment was performed prior to the field sampling effort. Calibrations were performed as described in the EPA publications "*Quality Assurance Handbook for Air Pollution Measurement Systems; Volume III - Stationary Source Specific Methods*" (EPA-600/4-77-027b) and EPA 40 CFR Part 60 Appendix A. Equipment calibrated includes the sample CEM system, and barometer. Copies of the equipment calibration forms can be found in Appendix D.

4.2.3 Equipment Leak Checks

Prior to sampling, the sampling system was leak checked.

4.3 DATA REDUCTION, VALIDATION, AND REPORTING

Specific QC measures were used to ensure the generation of reliable data from sampling and analysis activities. Proper collection and organization of accurate information followed by clear and concise reporting of the data is a primary goal in all projects.

4.3.1 Field Data Reduction

The Field Team Leader reviewed the data collected in the field. Appendix E provides the calculation worksheets used in the field and a listing of formulas to be used to reduce the field data.

4.3.2 Laboratory Analysis Data Reduction

Analytical data was obtained from Texas Oil Tech Laboratories. The data was used to calculate BTU/cf, and the Fd F-Factor. The fuel usage combined with the BTU/cf and F-Factor's are used to calculate the flow rate and Lbs/MMBtu concentrations.

4.3.3 Data Validation

TRC supervisory and QC personnel used validation methods and criteria appropriate to the type of data and the purpose of the measurement.

Field sampling data was validated by the Field Team Leader and/or the QC Coordinator based on their review of the adherence to an approved sampling protocol and written sample collection procedure.

The following criteria were used to evaluate the field sampling data:

- Use of approved test procedures;
- Proper operation of the process being tested;
- Use of properly operating and calibrated equipment;
- Leak checks conducted;
- Use of reagents conforming to QC specified criteria;
- Proper chain-of-custody maintained.

The criteria listed below were used to evaluate the analytical data:

- Use of approved analytical procedures;
- Use of properly operating and calibrated instrumentation;
- Acceptable results from analyses of QC samples (i.e., the reported values should fall within the 95 percent confidence interval for these samples).