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AIR QUALITY DIVISION

EMISSIONS COMPLIANCE STUDY

Performed For
Fortistar Methane Group

At The
C & C Energy, LLC
EU-TURBINE (Solar Centaur Gas Turbine)
Marshall, Michigan

Test Date
July 11, 2017

Report No.
TRC Environmental Corporation Report 276839A

Report Submittal Date
August 11, 2017

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1.0 INTRODUCTION

TRC Environmental Corporation (TRC) performed an emission compliance test program on the EU-TURBINE (Solar Centaur Gas Turbine) of C & C Energy, LLC in Marshall, Michigan on July 11, 2017. The tests were authorized by and performed for Fortistar Methane Group.

The purpose of this test program was to determine nitrogen oxide (NO_x), carbon monoxide (CO), volatile organic compound (VOC) and hydrogen chloride (HCl) emission rates while the unit operated above 75% of the peak load. Sulfur dioxide (SO₂) was determined from the fuel analysis. This test program was performed to demonstrate compliance with Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MI-ROP-P0222-2012a and Title 40 of the Code of Federal Regulations, Part 60 (40CFR60) Subpart KKKK. The test program was conducted according to the TRC Test Protocol 276839-0000-0000 dated April 2017.

1.1 Project Contact Information

Participants		
Test Facility	C & C Energy, LLC 19401 15 Mile Road Marshall, Michigan 49068	Mr. Andrew Zalenski Environmental Manager 716-439-1004 ext. 118 (phone) 949-355-5260 (cell) 716-439-0135 (fax) azalenski@fortistar.com
Test Coordinator	Fortistar Methane Group 5087 Junction Road Lockport, New York 14094	
Air Emissions Testing Body (AETB)	TRC Environmental Corporation 7521 Brush Hill Road Burr Ridge, Illinois 60527	Mr. Anthony Sakellariou Senior Project Manager 312-533-2035 (phone) 312-533-2070 (fax) asakellariou@trcsolutions.com

The tests were conducted by David Wells and Anthony Sakellariou of TRC. Documentation of the on-site ASTM D7036-04 Qualified Individual(s) (QI) can be located in the appendix to this report.

Mr. Matt Deskins and Mr. Jeremy Howe of the Michigan Department of Environmental Quality (MDEQ) observed the testing.



1.2 Facility and Process Description

Fortistar owns and operates the C & C Energy facility in Marshall, Michigan. The facility operates under the terms and conditions of the Permit No. MI-ROP-PO222-2012A issued by the Michigan Department of Environmental Quality (MDEQ). The facility consists a Solar Centaur model T-4500 landfill gas fired turbine rated at 3500 kW, the gas fired turbine generator and gas skids containing moisture separators and blowers, step-up and station transformers mounted on concrete pads, and all necessary electrical switchgear.

Any excess landfill gas collected and not combusted in the turbines, as well generated during periods when the turbines may be off-line, is routed to an on-site flare to ensure continued combustion of the landfill gas.

2.0 SUMMARY OF RESULTS

The results of this test program are summarized in the table below. Detailed individual run results are presented in Section 6.0.

Parameter	Pollutant Tested	Measured Emissions	Permitted Emission Limit
NO _x	ppmvd @ 15% oxygen (O ₂)	29.5	96
	lb/hr	5.54	---
	ton/year	24.26	26
CO	lb/hr	2.25	---
	ton/year	9.84	89
SO ₂	lb/MMBtu	0.0005	0.15
VOC*	lb/hr	0.0	---
	ton/year	0.0	2.5
HCl	lb/hr	0.07	---
	ton/year	0.29	8.3

*Note: Negative value results presented as zero value for VOC emission value.

All ton per year limits are based on a 12-month rolling time period



The table below summarizes the test methods used, as well as the number and duration of each at each test location:

Unit ID	Parameter Measured	Test Method	No. of Runs	Run Duration
EU-TURBINE	Volumetric Flow Rate	USEPA 1, 2	4	≥5 min
	NO _x	USEPA 7E	3	≥60 min
	CO	USEPA 10	3	≥60 min
	O ₂ /CO ₂	USEPA 3A	3	≥60 min
	VOC	USEPA 25A	3	≥60 min
	HCl	USEPA 26	3	≥60 min
	SO ₂	ASTM D6228	1	---

3.0 DISCUSSION OF RESULTS

Volumetric Flow Rate

16 points per Method 1 were used for all four test runs. Pre and post flow tests were performed and used to calculate the applicable mass emission rates. The moisture results from the Method 26 train were used for the flow rate calculations. A cyclonic flow check was performed during the Post 1/Pre 2 flow traverse and entered into the Sample Location Information (Appendix).

NO_x and CO

12 points per Method 1 were used for all three test runs. Test Run 2 data was used to populate the stratification check.

VOC

12 points per Method 1 were used for all three test runs. For all three test runs there were negative VOC average test results, subsequently those results were presented as zero. VOC concentrations are expressed in terms of propane.

HCl

Due to the port size and obstructions, only one port could be utilized for the HCl testing. Therefore, Method 26 (modified to use standard-size Method 4 impingers) was performed in lieu of Method 26A as stated in the test protocol. C&C Energy, LLC was granted verbal permission by Mr. Matt Deskins to use Method 26 in lieu of 26A as stated in the test protocol. An HCl audit sample was analyzed and appended to the report.



SO₂

Two fuel samples were taken at the end of the test program. One was analyzed for trace sulfur and major components and the other was held as a backup. A fuel factor of 9355 dry standard cubic feet per million Btu (dscf/MMBtu) was calculated from the fuel analysis and used to determine the SO₂ emission rate on a pounds per million Btu (lb/MMBtu) basis.

EU-TURBINE Operation

During the tests, the source operated at approximately 80% of peak load.

During test run 1 from 11:06 – 11:10 the process went off-line, therefore the gaseous data for this time period was omitted from the average, the Method 26 testing ran for five minutes longer and the flow in B port was repeated. Other than that incident, source operation appeared normal during the rest of the test program. Unit operating data was recorded by plant personnel and appended to the report.

The ports remained plugged during testing with hot gloves. No problems were encountered with the testing equipment during the test program. No other changes or problems were encountered that required modification of any procedures presented in the test plan. No adverse test or environmental conditions were encountered during the conduct of this test program.

4.0 SAMPLING AND ANALYSIS PROCEDURES

All testing, sampling, analytical, and calibration procedures used for this test program were performed in accordance with the methods presented in the following sections. Where applicable, the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods, USEPA 600/R-94/038c, September 1994 was used to supplement procedures.

4.1 Determination of Sample Point Locations by USEPA Method 1

This method is applicable to gas streams flowing in ducts, stacks, and flues and is designed to aid in the representative measurement of pollutant emissions and/or total volumetric flow rates from stationary sources. In order to qualify as an acceptable sample location, it must be located at a position at least two stack or duct equivalent diameters downstream and a half equivalent diameter upstream from any flow disturbance.

The cross-section of the measurement site was divided into a number of equal areas, and the traverse points were then located in the center of these areas. The minimum number of points were determined from Figure 1-2 (non-particulate) of USEPA Method 1.



4.2 Volumetric Flow Rate Determination by USEPA Method 2

This method is applicable for the determination of the average velocity and the volumetric flow rate of a gas stream.

The gas velocity head (ΔP) and temperature were measured at traverse points defined by USEPA Method 1. The velocity head was measured with a Type S (Stausscheibe or reverse type) pitot tube and oil-filled manometer; and the gas temperature was measured with a Type K thermocouple. The average gas velocity in the flue was calculated based on: the gas density (as determined by USEPA Methods 3 and 4); the flue gas pressure; the average of the square roots of the velocity heads at each traverse point, and the average flue gas temperature.

4.3 Determination of the Concentration of Gaseous Pollutants Using a Multi-Pollutant Sampling System

Concentrations of the pollutants in the following sub-sections were determined using one sampling system. The number of points at which sample was collected was determined in accordance with with 40CFR75 Appendix A, Section 6.5.6.

A straight-extractive sampling system was used. A data logger continuously recorded pollutant concentrations and generated one-minute averages of those concentrations. All calibrations and system checks were conducted using USEPA Protocol 1 gases. Three-point linearity checks were performed prior to sampling, and in the event of a failing system bias or drift test (and subsequent corrective action). System bias and drift checks were performed using the low-level gas and either the mid- or high-level gas prior to and following each test run.

The Low Concentration Analyzers (those that routinely operate with a calibration span of less than 20 ppm) used by TRC are ambient-level analyzers. Per Section 3.12 of Method 7E, a Manufacturer's Stability Test is not required for ambient-level analyzers. Analyzer interference tests were conducted in accordance with the regulations in effect at the time that TRC placed an analyzer model in service.

4.3.1 CO₂ Determination by USEPA Method 3A

This method is applicable for the determination of CO₂ concentrations in controlled and uncontrolled emissions from stationary sources only when specified within the regulations. The CO₂ analyzer was equipped with a non-dispersive infrared (IR) detector.

4.3.2 O₂ Determination by USEPA Method 3A

This method is applicable for the determination of O₂ concentrations in controlled and uncontrolled emissions from stationary sources only when specified within the regulations. The O₂ analyzer was equipped with a paramagnetic-based detector.



4.3.3 NO_x Determination by USEPA Method 7E

This method is applicable for the determination of NO_x concentrations in controlled and uncontrolled emissions from stationary sources only when specified within the regulations. The NO_x analyzer utilized a photomultiplier tube to measure the linear and proportional luminescence caused by the reaction of nitric oxide and ozone.

4.3.4 CO Determination by USEPA Method 10

This method is applicable for the determination of CO concentrations in controlled and uncontrolled emissions from stationary sources only when specified within the regulations. The non-dispersive infrared analyzer (NDIR) CO analyzer was equipped with an internal gas correlation filter wheel, which eliminates potential detector interference. As such, use of an interference removal trap was not required.

4.4 Total Organic Concentration Determination by USEPA Method 25A

This method is applicable for the determination of total gaseous organic concentration of vapors consisting primarily of alkanes, alkenes, and/or arenes (aromatic hydrocarbons). The concentration is expressed in terms of propane (or other appropriate organic calibration gas) or in terms of carbon.

A gas sample was extracted from the source through a heated sample line and glass fiber filter to a flame ionization analyzer (FIA). If necessary, a source-specific response factor was developed for the FIA.

4.5 Hydrogen Halide and Halogen Determination by USEPA Method 26

This method is applicable for determining emissions of hydrogen halides (HCl, HBr, and HF) and halogens (Cl₂ and Br₂) from stationary sources when specified by the applicable subpart.

An integrated sample was extracted at a constant rate from the source. The sample flowed through a heated probe and filter, and solutions of dilute sulfuric acid. The filter collected particulate matter including halide salts but was not recovered or analyzed. The liquid solutions were analyzed via ion chromatography (IC).

4.6 Determination of F-Factors by USEPA Method 19

This method is applicable for the determination of the pollutant emission rate using oxygen (O₂) or carbon dioxide (CO₂) concentrations and the appropriate F factor (the ratio of combustion gas volumes to heat inputs) and the pollutant concentration. The appropriate F-Factor was calculated from fuel analysis using the equations in Section 12.3.3.1 of Method 19.



5.0 QUALITY ASSURANCE PROCEDURES

TRC integrates our Quality Management System (QMS) into every aspect of our testing service. We follow the procedures specified in current published versions of the test Method(s) referenced in this report. Any modifications or deviations are specifically identified in the body of the report. We routinely participate in independent, third party audits of our activities, and maintain:

- Accreditation from the Louisiana Environmental Laboratory Accreditation Program (LELAP);
- Accreditation from the Stack Testing Accreditation Council (STAC) and the American Association for Laboratory Accreditation (A2LA) that our operations conform with the requirements of ASTM D 7036 as an Air Emission Testing Body (AETB).

These accreditations demonstrate that our systems for training, equipment maintenance and calibration, document control and project management will fully ensure that project objectives are achieved in a timely and efficient manner with a strict commitment to quality.

All calibrations are performed in accordance with the test Method(s) identified in this report. If a Method allows for more than one calibration approach, or if approved alternatives are available, the calibration documentation in the appendices specifies which approach was used. All measurement devices are calibrated or verified at set intervals against standards traceable to the National Institute of Standards and Technology (NIST). NIST traceability information is available upon request.

ASTM D7036-04 specifies that: *“AETBs shall have and shall apply procedures for estimating the uncertainty of measurement. Conformance with this section may be demonstrated by the use of approved test protocols for all tests. When such protocols are used, reference shall be made to published literature, when available, where estimates of uncertainty for test methods may be found.”* TRC conforms with this section by using approved test protocols for all tests.



6.0 TEST RESULTS SUMMARY

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TURBINE EMISSIONS TEST SUMMARY

Project Name	C & C Energy				
Unit Identification	EU-TURBINE				
Fuel Type	Landfill Gas				
Turbine Model	Solar Centaur model T-4500				
Test Run Number		1	2	3	Average
Date	mm/dd/yy	07/11/17	07/11/17	07/11/17	-
Start Time of Test	hh:mm	10:50	12:45	14:30	-
End Time of Test	hh:mm	11:59	13:54	15:34	-
Fuel Analysis					
Fuel Heating Value	btu/lb	7554			7554
Fd factor	dscf/MMBtu	9355			9355
Relative Density	lb-mole gas/lb-mole air	0.9536			0.9536
Specific Density	lb/ft3	0.07281			0.07281
Gross HV (Dry)	Btu/ft3	549.6			549.6
Emission Data					
O₂ Concentration	% Dry	16.10	16.12	16.12	16.11
NOx	ppmvd	24.3	24.2	23.1	23.9
	ppmvd at 15% Oxygen	29.9	29.9	28.5	29.5
	lb/hr	5.84	5.57	5.20	5.54
	ton/hr	25.60	24.39	22.79	24.26
CO	ppmvd	15.69	15.59	16.54	15.94
	lb/hr	2.29	2.18	2.27	2.25
	ton/hr	10.04	9.55	9.93	9.84
SO₂ (by fuel analysis)	Molar ppm (fuel gas)	1.76			1.76
	grains/100 SCF @STP (fuel gas)	0.104			0.104
	lb/MMBtu	0.0005			0.0005



VOLATILE ORGANIC COMPOUNDS TEST RESULTS SUMMARY

Project Number: <u>276839</u>	Test Date(s): <u>07/11/17</u>
Customer: <u>C & C Energy</u>	Facility: <u>Marshall, MI</u>
Unit Identification: <u>EU-TURBINE</u>	Recorded by: <u>Anthony Sakellariou</u>

Location	Source 1			
Test Run No.	1	2	3	Average
Test Date	7/11/2017	7/11/2017	7/11/2017	
Test Time - Start	10:50	12:45	14:30	
Test Time - End	11:59	13:54	15:34	
VOC (ppmw as Propane)	-0.08	-0.16	-0.12	-0.12
Volumetric Flow Rate (scfm)	36,248	34,706	34,081	35,012
VOC (lb/hr as Propane)	-0.02	-0.04	-0.03	-0.03
VOC (ton/yr as Propane)	-0.09	-0.17	-0.12	-0.13



HYDROGEN HALIDE AND HALOGEN TEST RESULTS SUMMARY (METHOD 26)

Company: C & C Energy
 Plant: Marshall, MI
 Unit: EU-TURBINE
 Location: Stack

Test Run Number	1	2	3	Average
Source Condition	>75% Peak	>75% Peak	>75% Peak	
Date	7/11/17	7/11/17	7/11/17	
Start Time	10:50	12:45	14:30	
End Time	11:55	13:45	15:30	
Sample Duration (min):	65.0	60.0	60.0	61.7
Gas CO ₂ Content (%v/v dry):	4.2	4.4	4.3	4.3
Gas O ₂ Content (%v/v dry):	16.1	16.1	16.1	16.1
Gas Dry MW, M _d (lb/lb-mole):	29.32	29.35	29.33	29.33
Barometric Pressure, P _{bar} ("Hg)	28.81	28.78	28.84	28.81
Flue Pressure, P _s ("Hg)	28.67	28.64	28.70	28.67
Meter Volume, V _{m(std)} (dscf):	45.567	42.063	42.077	43.236
Fractional Moisture Content, B _{ws} :	0.076	0.075	0.078	0.076
Volumetric Flow Rate, Q _{std(dry)} (dscfm):	33,510	32,052	31,422	32,328
Hydrogen Chloride (HCl)				
Net Mass Collected (mg):	0.81	0.74	0.43	0.66 ADL
Concentration (lb/dscf):	3.92E-08	3.88E-08	2.24E-08	3.35E-08 ADL
Concentration (ppmvd):	0.41	0.41	0.24	0.35 ADL
Concentration (ppmww):	0.38	0.38	0.22	0.33 ADL
Emission Rate (lb/hr):	0.08	0.07	0.04	0.07 ADL
Emission Rate (ton/yr):	0.35	0.33	0.19	0.29

ADL - all analytical values used to calculate and report an in-stack emissions value are greater than the laboratory's reported detection level(s)