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Relative Accuracy Test Audit
Test Report

Carbon Green BioEnergy, LLC
Woodbury Facility
Thermal Oxidizer Stack (C10)
Lake Odessa, Michigan
September 4, 2019

Report Submittal Date
September 23, 2019

Project No. M193603

Corporate Headquarters
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Elmhurst, Illinois 60126
630-993-2100

Chicago, IL | Crown Point, IN | Concord, NC | Mendota Heights, MN | Denver, CO

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1.0 EXECUTIVE SUMMARY

MOSTARDI PLATT conducted a Continuous Emissions Monitoring System (CEMS) Relative Accuracy Test Audit (RATA) test program for Carbon Green BioEnergy, LLC at the Woodbury Facility in Lake Odessa, Michigan, on the Thermal Oxidizer Stack (C10) on September 4, 2019. This report summarizes the results of the test program and test methods.

The test location, test date, and test parameters are summarized below.

TEST INFORMATION		
Test Location	**Test Date**	**Test Parameters**
Thermal Oxidizer Stack (C10)	September 4, 2019	Oxygen (O_2) and Nitrogen Oxides (NO_X)

The purpose of the test program was to demonstrate the relative accuracies of the Thermal Oxidizer Stack (C10) O_2 and NO_x analyzers during the specified operating condition. The test results from this test program indicate that each CEMS meets the United States Environmental Protection Agency (USEPA) annual performance specification for relative accuracy as published in 40 Code of Federal Regulations Part 60 (40CFR60).

RATA RESULTS					
Test Location	**Date**	**Parameter**	**Units**	**Relative Accuracy Acceptance Criteria**	**Relative Accuracy (RA)**
Thermal Oxidizer Stack (C10)	9/4/19	NO_X	lb/mmBtu	≤ 20.0% of the mean reference value	4.97%
		NO_X	ppmvd	≤ 20.0% of the mean reference value	4.60%
		O_2	% dry	≤ 20.0% of the mean reference value	1.63%

The gas cylinders used to perform the RATA are summarized below.

GAS CYLINDER INFORMATION				
Parameter	**Gas Vendor**	**Cylinder Serial Number**	**Cylinder Value**	**Expiration Date**
NO_x	Airgas	CC273939	0.0 ppm	4/20/2026
NO_x	Airgas	CC417282	89.61 ppm	2/11/2027
NO_x	Airgas	CC492723	175.9 ppm	8/20/2026
O_2	Airgas	CC417282	0.0%	2/11/2027
O_2	Airgas	CC273939	4.917&	4/20/2026
O_2	Airgas	CC133918	8.928%	2/20/2025

The identification of individuals associated with the test program is summarized below.

TEST PERSONNEL INFORMATION		
Location	**Address**	**Contact**
Test Facility	Carbon Green BioEnergy, LLC 7795 Saddlebag Lake Road Lake Odessa, Michigan 48849	Mr. Edward Thomas (616) 374-3635 (phone) (517) 712-9034 (fax) ethomas@cgbioenergy.com
Testing Company Supervisor	Mostardi Platt 888 Industrial Drive Elmhurst, Illinois 60126	Mr. Paul F. Coleman Project Manager 630-993-2100 (phone) pcoleman@mp-mail.com
Testing Company Personnel		Mr. Chris Menet Test Technician

2.0 TEST METHODOLOGY

Emission testing was conducted following the United States Environmental Protection Agency (USEPA) methods specified in 40CFR60, Appendix A in addition the Mostardi Platt Quality Manual. Schematics of the test section diagram and sampling train used are included in Appendix A and B respectively. Calculation nomenclature are included in Appendix C. Copies of analyzer print-outs for each test run are included in Appendix D. CEM data and process data as provided by Carbon Green BioEnergy, LLC are also included in Appendix E.

The following methodologies were used during the test program:

Method 3A Oxygen (O_2) Determination

Stack gas O_2 concentrations and emission rates were determined in accordance with USEPA Method 3A. A Servomex analyzer was were used to determine the O_2 concentrations in the manner specified in the Method. The instrument has a paramagnetic detector and the O_2 operates in the nominal range of 0% to 25% with the specific range determined by the high-level calibration gas of 8.928%. High-range calibrations were performed using USEPA Protocol gas. Zero nitrogen (a low ppm pollutant in balance nitrogen calibration gases) was introduced during other instrument calibrations to check instrument zero. High- and a mid-range % O_2 levels in balance nitrogen were also introduced. Zero and mid-range calibrations were performed using USEPA Protocol gas after each test run. Copies of the gas cylinder certifications are found in Appendix G. This testing met the performance specifications as outlined in the Method.

Method 7E Nitrogen Oxide (NO_x) Determination

Stack gas NO_x concentrations and emission rates were determined in accordance with USEPA Method 7E, 40CFR60, Appendix A. A Thermo Scientific Model 42i Chemiluminescence Nitrogen Oxides Analyzer was used to determine nitrogen oxides concentrations, in the manner specified in the Method. The instrument operated in the nominal range of 0 ppm to 200 ppm with the specific range determined by the high-level span calibration gas of 175.9 ppm.

The Model 42i operates on the principle that nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. Specifically,

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

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a stainless steel NO_2-to-NO converter heated to about 645°C. The flue gas sample is drawn into the Model 42*i* through the sample bulkhead. The sample flows through a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO_2-to-NO converter and then to the reaction chamber (NO_x mode). A flow sensor prior to the reaction chamber measures the sample flow. Dry air enters the Model 42*i* through the dry air bulkhead, passes through a flow switch, and then through a silent discharge ozonator. The ozonator generates the ozone needed for the chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO_2 molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence generated during this reaction. From the reaction chamber, the exhaust travels through the ozone (O_3) converter to the pump, and is released through the vent.

The NO and NO_x concentrations calculated in the NO and NO_x modes are stored in memory. The difference between the concentrations is used to calculate the NO_2 concentration. The Model 42i outputs NO, NO_2, and NO_x concentrations to the front panel display, the analog outputs, and also makes the data available over the serial or ethernet connection.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 250°F. Excess moisture in the stack gas was removed using a refrigerated condenser. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run. This testing met the performance specifications as outlined in the Method.

A list of calibration gases used and the results of all calibration and other required quality assurance checks are found in Appendix F. Copies of the gas cylinder certifications are found in Appendix G. The NO_2 to NO converter test can be found in Appendix H. This testing met the performance specifications as outlined in the Method.

3.0 TEST RESULT SUMMARIES

Client: Carbon Green BioEnergy, LLC
Facility: Woodbury Facility
Project #: M193603
Fuel Type: Natural Gas

Location: Thermal Oxidizer Stack (C10)
Date: 9/4/19
Test Method: 7E, 3A
Fuel Factor: 8710

O2 based NOx lb/mmBtu RATA

CEM Monitor Information

NO_x Monitor/Model:	CAI 650 NOXYGEN	**NO_x Serial # :**	TT1012
O2 Monitor/Model:	CAI 650 NOXYGEN	**O2 Serial # :**	TT1012

1=accept 0=reject	Test Run	Test Date	Start Time	End Time	RM NO_x lb/MMBtu	CEM NO_x lb/MMBtu	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	09/04/19	8:03	8:23	0.062	0.065	-0.003	0.000
1	2	09/04/19	8:36	8:56	0.065	0.066	-0.001	0.000
1	3	09/04/19	9:09	9:29	0.068	0.066	0.002	0.000
1	4	09/04/19	9:42	10:02	0.069	0.068	0.001	0.000
1	5	09/04/19	10:15	10:35	0.071	0.068	0.003	0.000
1	6	09/04/19	10:48	11:08	0.070	0.068	0.002	0.000
1	7	09/04/19	11:21	11:41	0.073	0.069	0.004	0.000
0	8	09/04/19	11:54	12:14	0.074	0.069	0.005	0.000
1	9	09/04/19	12:27	12:47	0.075	0.071	0.004	0.000
1	10	09/04/19	13:00	13:20	0.075	0.072	0.003	0.000

n	**9**	
t(0.975)	**2.306**	
Mean Reference Method Value	**0.070**	**RM avg**
Mean CEM Value	**0.068**	**CEM avg**
Sum of Differences	**0.015**	**di**
Mean Difference	**0.002**	**d**
Sum of Differences Squared	**0.000**	**di^2**
Standard Deviation	**0.002**	**sd**
Confidence Coefficient 2.5% Error (1-tail)	**0.002**	**cc**
Relative Accuracy	**4.97**	**RA**

Client: Carbon Green BioEnergy, LLC **Location:** Thermal Oxidizer Stack (C10)
Facility: Woodbury Facility **Date:** 9/4/19
Project #: M193603 **Test Method:** 7E

NO_x ppmvd RATA

CEM Monitor Information

NO_x Monitor/Model:			CAI 650 NOXYGEN		NO_x Serial # :		TT1012	
1=accept 0=reject	Test Run	Test Date	Start Time	End Time	RM NO_x ppmvd	CEM NO_x ppmvd	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	09/04/19	8:03	8:23	53.3	56.7	-3.4	11.56
1	2	09/04/19	8:36	8:56	55.6	57.0	-1.4	1.96
1	3	09/04/19	9:09	9:29	58.5	57.7	0.8	0.64
1	4	09/04/19	9:42	10:02	59.4	58.5	0.9	0.81
1	5	09/04/19	10:15	10:35	61.5	58.7	2.8	7.84
1	6	09/04/19	10:48	11:08	60.8	58.6	2.2	4.84
1	7	09/04/19	11:21	11:41	62.3	59.2	3.1	9.61
0	8	09/04/19	11:54	12:14	62.9	59.4	3.5	12.25
1	9	09/04/19	12:27	12:47	63.2	60.6	2.6	6.76
1	10	09/04/19	13:00	13:20	63.5	61.4	2.1	4.41

n	9	
t(0.975)	2.306	
Mean Reference Method Value	59.789	RM avg
Mean CEM Value	58.711	CEM avg
Sum of Differences	9.700	di
Mean Difference	1.078	d
Sum of Differences Squared	48.430	di^2
Standard Deviation	2.179	sd
Confidence Coefficient 2.5% Error (1-tail)	1.675	cc
Relative Accuracy	4.60	RA

Client: Carbon Green BioEnergy, LLC **Location:** Thermal Oxidizer Stack (C10)
Facility: Woodbury Facility **Date:** 9/4/19
Project #: M193603 **Test Method:** 3A

O_2 % (dry) RATA

CEM Monitor Information

O_2 Monitor/Model:			CAI 650 NOXYGEN		O_2 Serial # :		TT1012	
1=accept 0=reject	Test Run	Test Date	Start Time	End Time	RM O_2 % (dry)	CEM O_2 % (dry)	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	09/04/19	8:03	8:23	2.1	2.1	0.0	0.00
1	2	09/04/19	8:36	8:56	2.2	2.1	0.1	0.01
1	3	09/04/19	9:09	9:29	2.1	2.1	0.0	0.00
1	4	09/04/19	9:42	10:02	2.2	2.2	0.0	0.00
0	5	09/04/19	10:15	10:35	2.2	2.1	0.1	0.01
1	6	09/04/19	10:48	11:08	2.1	2.1	0.0	0.00
1	7	09/04/19	11:21	11:41	2.3	2.3	0.0	0.00
1	8	09/04/19	11:54	12:14	2.3	2.3	0.0	0.00
1	9	09/04/19	12:27	12:47	2.5	2.5	0.0	0.00
1	10	09/04/19	13:00	13:20	2.5	2.5	0.0	0.00

n	9	
t(0.975)	2.306	
Mean Reference Method Value	2.256	RM avg
Mean CEM Value	2.244	CEM avg
Sum of Differences	0.100	di
Mean Difference	0.011	d
Sum of Differences Squared	0.010	di^2
Standard Deviation	0.033	sd
Confidence Coefficient 2.5% Error (1-tail)	0.026	cc
Relative Accuracy	1.63	RA

4.0 CERTIFICATION

MOSTARDI PLATT is pleased to have been of service to Carbon Green BioEnergy, LLC. If you have any questions regarding this test report, please do not hesitate to contact us at 630-993-2100.

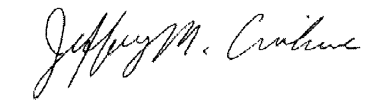
CERTIFICATION

As the program manager, I hereby certify that this test report represents a true and accurate summary of emissions test results and the methodologies employed to obtain those results. The test program was performed in accordance with the test methods and the Mostardi Platt Quality Manual, as applicable.

MOSTARDI PLATT

Program Manager

Paul F. Coleman



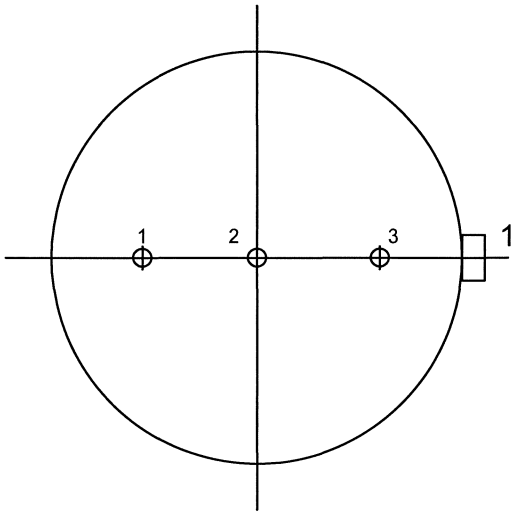
Quality Assurance

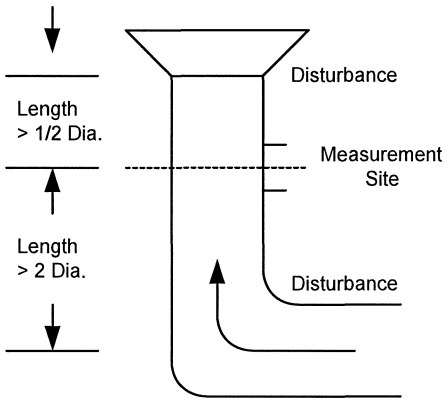
Jeffrey M. Crivlare

APPENDICES

Appendix A - Test Section Diagram

GASEOUS TRAVERSE FOR ROUND DUCTS





Job:	Carbon Green BioEnergy, LLC Woodbury, Illinois
Date:	September 4, 2019
Test Location:	Thermal Oxidizer Stack (C10)
Stack Diameter (Feet):	6.0
Stack Area (Square Feet):	28.27
No. Sample Points:	3
No of Ports:	1
Port Length (Inches):	8.0

Distance from inside wall
at port to traverse point:

1. 5.0 Feet (83.3 % of diameter)
2. 3.0 Feet (50.0 % of diameter)
3. 1.0 Feet (16.7 % of diameter)

Appendix B - Sample Train Diagram

USEPA Methods 3A and 7E Extractive Gaseous Sampling Diagram