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Report of Emissions Testing of the Fermentation Scrubber (CE016) and Vent Gas Scrubber (CE005)

Green Plains Holdings II, LLC
7025 Silberhorn Hwy
Blissfield, MI 49228

MDEQ Permit No: MI-ROP-N7383-2014

AET #14-01860

RECEIVED
JUN 20 2017
AIR QUALITY DIVISION

Report Date:

April 4, 2017

Field Testing Dates:

February 23-24, 2017

Prepared for:

Ms. Nicole Zielinski
Green Plains Holdings II, LLC
7025 Silberhorn Hwy
Blissfield, MI 49228

Prepared By:

American Engineering Testing, Inc.
550 Cleveland Avenue North
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ISO 17025 ACCREDITED

EXECUTIVE SUMMARY

Testing Certificate 1932.03

Green Plains Holdings II, LLC– Blissfield, MI
American Engineering Testing, Inc. Test Dates: February 23-24, 2017

Emissions testing were conducted on the Fermentation and Vent Gas Scrubbers February 23-24, 2017. The results are summarized below:

Emission Unit Tested	Pollutant	Emission Unit Limit	Test Result
Vent Gas Scrubber (CE005)	VOC	≤ 0.5 Lbs/Hr	0.026 Lbs/Hr (1)
	Acetaldehyde	≤ 0.31 Lbs/Hr	0.006 Lbs/Hr
	VOC Removal Efficiency	NA	99.8% Removal Efficiency
Fermentation Scrubber (CE016)	VOC	≤ 5.0 Lbs/Hr	2.18 Lbs/Hr (1)
	Acetaldehyde	≤ 1.55 Lbs/Hr	0.379 Lbs/Hr
	VOC Removal Efficiency	NA	99.7% Removal Efficiency

(1) Represents the sum of the detected VOC's

(2) Lactic acid concentration determined by modified NCASI Method 94.02 not included on A2LA Certificate 1932.03

Vent Gas Scrubber Emissions – February 23, 2017

	Run #1	Run #2	Run #3	Average
Acetaldehyde, Lbs/Hr	0.012	0.003	0.004	0.006
Acetic Acid, Lbs/Hr	0.016	0.005	0.003	0.008
Acrolein, Lbs/Hr	< 0.002	< 0.001	< 0.001	< 0.001
Butyl Acetate, Lbs/Hr	0.007	0.002	0.001	0.003
Ethanol, Lbs/Hr	< 0.014	< 0.005	< 0.005	< 0.008
Ethyl Acetate, Lbs/Hr	0.020	0.005	0.001	0.009
Formaldehyde, Lbs/Hr	< 0.001	< 0.0005	< 0.001	< 0.001
Formic Acid, Lbs/Hr	< 0.002	< 0.001	< 0.001	< 0.001
Methanol, Lbs/Hr	< 0.002	< 0.001	< 0.002	< 0.002
Lactic Acid, Lbs/Hr (2)	< 0.002	< 0.002	< 0.002	< 0.002
Total Detected VOCs, Lbs/hr	0.054	0.016	0.009	0.026
Total Detected and Non-Detected VOCs, Lbs/Hr	< 0.077	< 0.027	< 0.021	< 0.042
Total Detected and Non-Detected HAPs, Lbs/Hr	< 0.017	< 0.006	< 0.008	< 0.010

EXECUTIVE SUMMARY (continued)

Vent Gas Scrubber Emissions – February 23, 2017(cont'd)

	Run #1	Run #2	Run #3	Average
Vent Gas Scrubber Inlet VOCs as propane, Lbs/Hr	32.4	47.7	17.7	32.6
Vent Gas Scrubber Outlet VOCs as propane, Lbs/Hr	0.075	0.102	0.035	0.071
VOC Removal Efficiency, %	99.8	99.8	99.8	99.8
Operating Data				
Scrubber Water Flow Rate, gpm	18.24	18.10	18.38	18.24
ABS Injection Rate, mL/min	27.5	28.2	27.2	27.6
Beer Column Feed Rate, gpm	699.8	699.9	699.8	699.9
Ethanol Flow Rate, gpm	111.5	113.2	112.2	112.3

Fermentation Scrubber Emissions – February 24, 2017

	Run #1	Run #2	Run #3	Average
Acetaldehyde, Lbs/Hr	0.212	0.256	0.670	0.379
Acetic Acid, Lbs/Hr	0.199	0.163	0.183	0.182
Acrolein, Lbs/Hr	< 0.020	< 0.021	< 0.023	< 0.021
Butyl Acetate, Lbs/Hr	0.193	0.174	0.236	0.201
Ethanol, Lbs/Hr	0.395	0.349	0.416	0.387
Ethyl Acetate, Lbs/Hr	0.92	0.91	1.25	1.03
Formaldehyde, Lbs/Hr	< 0.010	< 0.011	< 0.012	< 0.011
Formic Acid, Lbs/Hr	< 0.060	< 0.065	< 0.070	< 0.065
Methanol, Lbs/Hr	< 0.067	< 0.072	< 0.078	< 0.072
Lactic Acid, Lbs/Hr (2)	< 0.011	< 0.011	< 0.012	< 0.011
Total Detected VOCs, Lbs/hr	1.92	1.85	2.75	2.18
Total Detected and Non-Detected VOCs, Lbs/Hr	< 2.09	< 2.03	< 2.95	< 2.36
Total Detected and Non-Detected HAPs, Lbs/Hr	< 0.309	< 0.360	< 0.783	< 0.484

	Run #1	Run #2	Run #3	Average
Fermentation Scrubber Inlet VOCs as propane, Lbs/Hr	494	406	407	436
Fermentation Scrubber Outlet VOCs as propane, Lbs/Hr	1.3	1.3	1.9	1.5
VOC Removal Efficiency, %	99.7	99.7	99.5	99.7
Operating Data				
Scrubber Water Flow Rate, gpm	75.2	75.5	75.8	75.5
ABS Injection Rate, mL/min	38.2	38.2	38.5	38.3
Beer Column Feed Rate, gpm	700.9	699.8	699.8	700.2
Ethanol Flow Rate, gpm	113.5	112.2	112.5	112.7

1.0 INTRODUCTION

This document reports the results of the compliance test program conducted at:

Green Plains Holdings II, LLC
7025 Silberhorn Hwy
Blissfield, MI 49228

VOC/HAP emissions compliance testing was conducted February 23-24, 2017 on the Fermentation Scrubber (CE016) and Vent Gas Scrubber (CE005). The objective of this test program was to determine compliance with MDEQ Permit No. MI-ROP-N7383-2014. Testing was conducted in accordance with the following documents:

Test Protocol for Fermentation Scrubber (CE016) and Vent Gas Scrubber (CE005) Emissions Testing
Green Plains Holdings II, LLC
Date: January 18, 2017

A copy of this document is enclosed in Appendix I.

On-site American Engineering Testing personnel included Mr. James Dayton and Mr. Tanner Bakke. Testing was coordinated on-site by Ms. Nicole Zielinski of Green Plains Holdings II, LLC. Testing was witnessed by Tom Gasoli of the Michigan Department of Environmental Quality – Technical Programs Unit.

2.0 PROCESS AND CONTROL EQUIPMENT DESCRIPTIONS

Green Plains Holdings II, LLC is a 60 million gallon per year ethanol production facility. This facility produces ethanol utilizing the dry-mill process.

The Fermentation Scrubber controls the emissions from the fermentation operations and consists of a packed scrubber utilizing ammonium bisulfite injection for acetaldehyde control.

The Vent Gas Scrubber controls the emissions from the distillation operations and consists of a packed scrubber utilizing ammonium bisulfite for acetaldehyde control.

2.1 Testing Conditions

Testing was conducted at $\geq$ 90% of maximum production rates. The 200 proof ethanol production rate averaged 112.3 GPM and the beer column feed rate averaged 699.9 GPM during Vent Gas Scrubber testing. The 200 proof ethanol production rate averaged 112.7 GPM and the beer well feed rate averaged 700.2 GPM during Fermentation Scrubber testing. Production data recorded during the testing is included in Appendix F.

Fermenter fill levels were trended during each run during Fermentation Scrubber testing. Yeast counts were performed during each run during the Fermentation Scrubber testing. This data is included in Appendix F.

3.0 SUMMARY OF RESULTS

3.1 Vent Gas Scrubber Emissions Testing (CE005)

The speciated VOC/HAP emission rate from the Vent Gas Scrubber was determined on February 23, 2017

Speciated VOC/HAP emission and VOC removal efficiency testing were conducted during the time frames listed below:

Test 1 Run #1 – 08:00-08:59 hrs. – 02/23/17
Test 1 Run #2 – 10:21-11:20 hrs. – 02/23/17

Test 2 Run #1 – 13:09-14:08 hrs. – 02/23/17
Test 2 Run #2 – 15:07-16:06 hrs. – 02/23/17
Test 2 Run #3 – 17:31-18:30 hrs. – 02/23/17

A summary of the monitoring follows:

1. Test #1 was aborted at the end of Run #2 due to the scrubber failing to control emissions below the permitted rate. Scrubber fresh water rates during Test #1 averaged 12 gpm. Test #1 results and supporting data are provided in Appendix L.
2. An Extractive Fourier Transform Infrared Spectrometer (FTIR) was used at the Vent Gas Scrubber outlet for the determination of acetaldehyde, acetic acid, acrolein, butyl acetate, ethanol, ethyl acetate, formaldehyde, formic acid and methanol emissions following modified EPA Method 320. A methanol field spike was performed with a resulting 97.9% recovery. A summary of results are shown in Table 1. Detailed results are enclosed in Appendix A and FTIR raw data are enclosed in Appendix B.
3. Samples were collected and analyzed for lactic acid in accordance with Modified EPA Method 18/NCASI CI/SG/PULP 94.02. Speciated VOC/HAP field datasheets are located in Appendix C. A summary of the emission results is shown in Table 1. Lactic acid results used in this report were not adjusted for spike recoveries. The analytical laboratory results are located in Appendix K. Lactic acid samples for Test #1 were not analyzed per instructions from Mr. Tom Gasoli of MDEQ
4. Continuously recording flame ionization analyzers (FIA's) were deployed at the scrubber inlet and outlet for the determination of VOC removal efficiency. Average results were used for all removal efficiency calculations. The VOC removal efficiency averaged 99.8% for the three test runs. A summary of results is shown in Table 2. Results for individual test runs are enclosed in Appendix A. Field data sheets are enclosed in Appendix C. Raw FIA datalogger results and charts are enclosed in Appendix B.
5. Tedlar bag samples were collected at the scrubber outlet for stack gas oxygen and carbon dioxide content and were analyzed in accordance with EPA Method 3A. A summary of emission results is shown in Table 1. Detailed results and data sheets are enclosed in Appendix J.
6. Volumetric airflow measurements were conducted at the scrubber outlet in accordance with EPA Method 2. One measurement was conducted during each run for the determination of mass emission rates. Individual detailed air flow results and field data sheets are enclosed in Appendix E.

7. Based on the test results, the detected speciated VOC emission rate averaged 0.026 Lbs/Hr during the three test runs. The sum of the detected and non-detected VOCs averaged < 0.042 Lbs/Hr. Acetaldehyde was the only HAP detected and averaged 0.006 Lbs/Hr. The sum of the detected and non-detected HAP emission rate averaged < 0.010 Lbs/Hr during the three test runs. The scrubber water flow rate averaged 18.24 gpm and ammonium bisulfite injection averaged 27.6 mL/min for acetaldehyde control. A summary of the results is shown in Table 1.

3.2 Fermentation Scrubber Emissions Testing (CE016)

The speciated VOC/HAP emissions and VOC removal efficiency rates of the Fermentation Scrubber were determined on February 24, 2017. This test was conducted during peak emissions from the fermentation process.

Speciated VOC/HAP emission and VOC removal efficiency testing were conducted during the time frames listed below:

Run #1 – 10:55-11:54 hrs. – 02/24/17
Run #2 – 13:01-14:00 hrs. – 02/24/17
Run #3 – 14:49-15:48 hrs. – 02/24/17

A summary of the monitoring follows:

1. An Extractive Fourier Transform Infrared Spectrometer (FTIR) was used at the Fermentation Scrubber outlet for the determination of acetaldehyde, acetic acid, acrolein, butyl acetate, ethanol, ethyl acetate, formaldehyde, formic acid and methanol emissions following modified EPA Method 320. A methanol field spike was performed with a resulting 89.0% recovery. A summary of results are shown in Table 3. Detailed results are enclosed in Appendix A and FTIR raw data are enclosed in Appendix B.
2. Samples were collected and analyzed for lactic acid in accordance with Modified EPA Method 18/NCASI CI/SG/PULP 94.02. Speciated VOC/HAP field datasheets are located in Appendix C. A summary of the emission results is shown in Table 3. Analytical results used in this report were not adjusted for spike recoveries. The analytical laboratory results are located in Appendix K.
3. Continuously recording flame ionization analyzers (FIA's) were deployed at the scrubber inlet and outlet for the determination of VOC removal efficiency. Average results were used for all removal efficiency calculations. The VOC removal efficiency averaged 99.7% for the three test runs. A summary of results is shown in Table 4. Results for individual test runs are enclosed in Appendix A. Field data sheets are enclosed in Appendix C. Raw FIA datalogger results and charts are enclosed in Appendix B.
4. Tedlar bag samples were collected at the scrubber outlet for stack gas oxygen and carbon dioxide content and were analyzed in accordance with EPA Method 3A. A summary of emission results is shown in Table 1. Detailed results and data sheets are enclosed in Appendix J.
5. Volumetric airflow measurements were conducted at the scrubber outlet in accordance with EPA Method 2. Individual detailed air flow results and field data sheets are enclosed in Appendix E.

6. Based on the test results, the detected speciated VOC emission rate averaged 2.18 Lbs/Hr during the three test runs. The sum of the detected and non-detected VOCs averaged < 2.36 Lbs/Hr. Acetaldehyde was the only HAP detected and averaged 0.379 Lbs/Hr. The sum of the detected and non-detected HAP emission rate averaged < 0.484 Lbs/Hr during the three test runs. The scrubber water flow rate averaged 75.2 gpm and the ammonium bisulfite injection averaged 38.3 mL/min for acetaldehyde control. A summary of the results is shown in Table 3.

4.0 TEST PROCEDURES

Testing was conducted in accordance with the methods and procedures detailed in the following sections. American Engineering Testing, Inc. has been accredited by The American Association for Laboratory Accreditation (A2LA) and meets the requirements of ISO/IEC 17025 - 2005 "General Requirements for the Competence of Testing and Calibration Laboratories" for the tests included in this report with the exception of lactic acid testing.

4.1 Volumetric Airflow Measurement

The location of the sampling sites and sampling points were determined in accordance with EPA Method 1. Upstream and downstream distances to flow disturbances were measured and used to determine the minimum number of traverse points. Test locations are enclosed in Figures 1 and 2.

The stack gas velocity and volumetric flow rate were determined in accordance with EPA Method 2. An electronic digital manometer in conjunction with an S-type pitot tube was used to measure the pressure differential at each traverse point. The stack temperature was measured using a digital thermometer and a type-k thermocouple. Ambient pressure was determined using a calibrated altimeter.

EPA Method 4 was used to determine the stack gas moisture content. Stack gas moisture content was determined using wet-bulb/dry-bulb temperatures. Temperatures were measured using a digital thermometer and two fast-responding, low-mass thermocouples.

Calculations and nomenclatures used are enclosed in Appendix G. Calibration data for equipment used during testing is enclosed in Appendix H.

4.2 Speciated VOC/HAP Concentration Measurements

4.2.1 Speciated VOC/HAP by EPA Method 320

Acetaldehyde, acetic acid, acrolein, butyl acetate, ethanol, ethyl acetate, formaldehyde, formic acid and methanol were quantified utilizing extractive Fourier Transform Infrared Spectroscopy (FTIR) following modified EPA Method 320.

Samples were transported to the FTIR using a Teflon™ transfer line. The transfer line was operated at approximately 250° F. The FTIR gas cell was operated at approximately 300° F. Samples were analyzed using an MKS series 2030 FTIR system configured with a ZnSe beam splitter, 5.11 meter multi-pass gas cell and mercury cadmium telluride (MCT) detector. The gas cell was composed of nickel-coated aluminum with ZnSe cell windows.

Potential Interferants

CO_2 is the primary interferant at the scrubber exhaust. Quantitative CO_2 spectra were included in the analytical method which improved the method performance in spectral areas that were not saturated.

Relatively low water concentrations were present and caused minimal interference. Quantitative water spectra were included in the analytical method.

FTIR Instrument Calibration

Certified (+/- 1.0%) ethylene gas standard was used as calibration transfer standard (CTS) to determine instrument cell pathlength. The pathlength was verified for the instrument using the CTS spectrum while ethylene flowed directly to the cell. A second ethylene spectrum was collected to verify system stability.

Pathlength stability was verified by analyzing ethylene spectra collected throughout testing. Pathlength stability was within +/- 5% of the initial value.

In addition, a cylinder of acetaldehyde in nitrogen was used to perform calibration checks during testing.

FTIR System Leak Checks

A daily sampling system leak check was performed on the instrument prior to testing to verify system integrity. The leak check was performed by capping the sample probe and applying a vacuum to the system using the sample pump. A rotameter was attached to the pump outlet and the flow rate was measured. All leak rates met the EPA Method requirement of less than 200 mL/min. In addition, the cell was sealed, pressurized and an initial cell pressure reading was recorded. After a minimum of two minutes the final cell pressure reading was recorded and a leak rate was calculated based on the pressure readings, the cell volume, and the elapsed time. This leak rate was converted to a percentage of the cell volume and corrected for sample integration time in accordance with EPA Method 320. All values were less than 4% of the system volume over the sample integration time.

Matrix Spiking

In accordance with EPA Method 320 Sections 8.6.2 and 9.2, matrix spiking was conducted using methanol in nitrogen with SF_6 as a tracer gas. The cylinder was analyzed with the FTIR prior to spiking. Matrix spiking was conducted by introducing the spike gas into the back of the sample probe. No background methanol concentrations were detected in the stack exhaust prior to or immediately after the QA spiking procedure.

The spike gas flow rate averaged 8.0% and 8.8% of the total flow delivered to the instrument for the Vent Gas Scrubber and Fermentation Scrubber spikes respectively. The spike data was evaluated in accordance with EPA Method 320 Section 8.6.2 and met the criteria of 70-130% recovery.

Detection Limit Verification

EPA Method 320 Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared Spectroscopy section 3.21 requires that the quantitation limit be determined by analyzing the residual sample spectrum after the target analytes and interferences have been subtracted. It states that the noise in the subtracted sample spectra may be much greater than the noise in a zero absorbance spectra (such as nitrogen) and that the quantitation limit is generally much higher than the instrument sensitivity. The detection limits stated in this report were generated from the analyses of residual sample spectrum not zero absorbance spectrum.

The addendum to EPA Method 320 section 4.1.3 states the detection limit is the lowest concentration of an analyte for which its overall fraction uncertainty (OFU) is required to be less that its analytical uncertainty (AU). For this project a 30% analytical uncertainty was assigned and the fractional model uncertainty (FMU) was the largest overall fractional uncertainty. The FMU is calculated using the error generated from the least squares fit (LSF) analytical method. This error is generated from the analysis of the residual sample spectrum. The average FMUs for both detected and non-detected concentrations met the method requirements of being less than the 30% analytical uncertainty.

Additional detection limit verification was performed in accordance with ASTM Method 6348 Standard Test Method for Determination of Gaseous Compounds by Extractive Direct Interface Fourier Transform Infrared (FTIR) Spectroscopy section A2.3. This section requires that the target detection limit be less than three-times the LSF analytical method error for the test data.

As stated in the Test Protocol the following deviations apply to this testing:

- EPA Method 2 temperature measurements were performed at a single, center of stack sampling point.
- EPA Method 4 moisture determinations were performed from a single, center of stack sampling point.
-
- EPA Method 320: The Fractional Model Uncertainty (FMU) was used for the Overall Fractional Uncertainty (FMU).
- QC spiking was performed for methanol only

Additional FTIR analytical and quality control procedures are enclosed in Appendix D. Calculations and nomenclatures used are enclosed in Appendix G. Calibration data for equipment used during testing is enclosed in Appendix H.

4.2.2 Lactic Acid by NCASI CI/SG/PULP-94.02

Lactic acid concentrations were quantified using Modified EPA Method 18/NCASI CI/SG/PULP-94.02. Samples were collected using a sampling console set to a desired sample rate, then passed through two cold water impingers and one silica tube. Subsequent analyses were performed using high performance liquid chromatography (HPLC). Analytical results used in this report were not adjusted for spike recoveries.

Calculations and nomenclatures used are enclosed in Appendix G. Calibration data for equipment used during testing is enclosed in Appendix H. Calibration data for lactic acid analyses is included in Appendix K.

4.3 VOC Concentration Measurements

The VOC concentration measurements were conducted in accordance with EPA Method 25A. Results for Method 25A were not bias-adjusted. The gas sample stream was transported to the analyzer using heated (250° F) Teflon™ transfer lines. The analyzers were calibrated prior to the start of testing and drift checks were conducted at the conclusion of each test to verify system performance. Analyzer calibration gas cylinder certificates are enclosed in Appendix H. Calculations and nomenclatures used are enclosed in Appendix G.

5.0 SIGNATURES

The services performed by American Engineering Testing, Inc. for this project have been conducted in a manner consistent with that level of skill and care ordinarily exercised by other members of the profession currently practicing in this area. The results included in this report relate only to the items being tested and at the time and conditions present during this test.

We verify that the test procedures were performed in accordance with the approved test plan and that the data presented in this test report are, to the best of our knowledge and belief, true, accurate, and complete.

Report Prepared By:
American Engineering Testing, Inc.

James Dayton
Environmental Chemist
Environmental Field

Report Reviewed By:
American Engineering Testing, Inc.

Robert R. Elliott
Vice President
Environmental Technical Services

Table 1

Summary of Vent Gas Scrubber Exhaust VOC/HAP Results
Green Plains Holdings II, LLC - Blissfield, MI
February 23, 2017 - AET #14-01860

Parameter		Test 2 Run #1	Test 2 Run #2	Test 2 Run #3	Average
Date		2/23/17	2/23/17	2/23/17	
Time		13:09-14:08	15:07-16:06	17:31-18:30	
Avg Volumetric Flow (SCFM)		450	260	300	340
Stack Gas Oxygen (%)		10.4	16.2	16.9	14.5
Stack gas Carbon Dioxide (%)		49.5	22.1	18.6	30.1
Stack Gas Moistue (%)		1.3%	1.3%	1.2%	1.3%
EPA Method 320 Speciated VOC/HAP Results					
Acetaldehyde (PPMV)		3.8	1.8	1.9	2.5
Acetaldehyde (LB/HR)		0.012	0.003	0.004	0.006
Acetic Acid (PPMV)		3.7	2.2	1.3	2.4
Acetic Acid (LB/HR)		0.016	0.005	0.003	0.008
Acrolein (PPMV)		< 0.50	< 0.50	< 0.50	< 0.50
Acrolein (LB/HR)		< 0.002	< 0.001	< 0.001	< 0.001
Butyl Acetate (PPMV)		0.82	0.48	0.29	0.53
Butyl Acetate (LB/HR)		0.007	0.002	0.001	0.003
Ethanol (PPMV)		< 4.3	< 2.5	< 2.5	< 3.1
Ethanol (LB/HR)		< 0.014	< 0.005	< 0.005	< 0.008
Ethyl Acetate (PPMV)		3.3	1.4	0.68	1.8
Ethyl Acetate (LB/HR)		0.020	0.005	0.001	0.009
Formaldehyde (PPMV)		< 0.40	< 0.40	< 0.40	< 0.40
Formaldehyde (LB/HR)		< 0.001	< 0.0005	< 0.001	< 0.001
Formic Acid (PPMV)		< 0.60	< 0.60	< 0.60	< 0.60
Formic Acid (LB/HR)		< 0.002	< 0.001	< 0.001	< 0.001
Methanol (PPMV)		< 1.0	< 1.0	< 1.0	< 1.0
Methanol (LB/HR)		< 0.002	< 0.001	< 0.002	< 0.002
EPA Method 94.02 Speciated VOC Results					
Lactic Acid (µg)		< 29.2	< 11.9	< 10.9	< 17.3
Lactic Acid (LB/HR)		< 0.002	< 0.002	< 0.002	< 0.002
Total Detected VOC (LB/HR)		0.054	0.016	0.009	0.026
Total Detected and Non-Detected VOC (LB/HR)		< 0.077	< 0.027	< 0.021	< 0.042
Total Detected HAPs (LB/HR)		0.012	0.003	0.004	0.006
Total Detected and Non-Detected HAPs (LB/HR)		< 0.017	< 0.006	< 0.008	< 0.010
Operating Data					
Scrubber Fresh Water Flow Rate (GPM)		18.24	18.10	18.38	18.24
ABS Injection Rate (mL/min)		27.5	28.2	27.2	27.6
Beer Feed Rate (GPM)		699.8	699.9	699.8	699.9
200 Proof Ethanol Flow Rate (GPM)		111.5	113.2	112.2	112.3

Table 2

Summary of Vent Gas Scrubber (CE005) VOC Removal Efficiency Results
Green Plains Riga - Blissfield, MI
AET #14-01860
February 23, 2017

Run #1 13:09-14:08

Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Vent Gas Scrubber Inlet	450	10,486	32.4	31,459	26.5
L2	Vent Gas Scrubber Outlet	450	24.4	0.075	73.1	0.062
		Removal Efficiency ((L1 - L2) ÷ L1) • 100		**99.8%**		

Run #2 15:07-16:06

Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Vent Gas Scrubber Inlet	260	11,389	20.3	34,166	16.6
L2	Vent Gas Scrubber Outlet	260	24.3	0.043	73.0	0.036
		Removal Efficiency ((L1 - L2) ÷ L1) • 100		**99.8%**		

Run #3 17:31-18:30

Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Vent Gas Scrubber Inlet	300	8,596	17.7	25,789	14.5
L2	Vent Gas Scrubber Outlet	300	17.0	0.035	51.0	0.029
		Removal Efficiency ((L1 - L2) ÷ L1) • 100		**99.8%**		

AVERAGES RUNS # 1-3

Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Vent Gas Scrubber Inlet	337	10,157	23.5	30,472	19.2
L2	Vent Gas Scrubber Outlet	337	21.9	0.051	65.7	0.042
		Average Removal Efficiency		**99.8%**		

Table 3

Summary of Fermentation Scrubber Exhaust VOC/HAP Results
Green Plains Holdings II, LLC - Blissfield, MI
February 24, 2017 - AET #14-01860

Parameter		Test 3 Run #1	Test 3 Run #2	Test 3 Run #3	Average
Date		2/24/17	2/24/17	2/24/17	
Time		10:55-11:54	13:01-14:00	14:49-15:48	
Avg Volumetric Flow (SCFM)		5,600	6,000	6,500	6,000
Stack Gas Oxygen (%)		0.0	0.0	0.0	0.0
Stack gas Carbon Dioxide (%)		98.1	97.4	99.0	98.2
Stack Gas Moistue (%)		1.1%	1.1%	1.1%	1.1%
EPA Method 320 Speciated VOC/HAP Results					
Acetaldehyde (PPMV)		5.5	6.2	15	8.9
Acetaldehyde (LB/HR)		0.212	0.256	0.670	0.379
Acetic Acid (PPMV)		3.8	2.9	3.0	3.2
Acetic Acid (LB/HR)		0.199	0.163	0.183	0.182
Acrolein (PPMV)		< 0.40	< 0.40	< 0.40	< 0.40
Acrolein (LB/HR)		< 0.020	< 0.021	< 0.023	< 0.021
Butyl Acetate (PPMV)		1.9	1.6	2.0	1.8
Butyl Acetate (LB/HR)		0.193	0.174	0.236	0.201
Ethanol (PPMV)		9.8	8.1	8.9	8.9
Ethanol (LB/HR)		0.395	0.349	0.416	0.387
Ethyl Acetate (PPMV)		12	11	14	12
Ethyl Acetate (LB/HR)		0.92	0.91	1.25	1.03
Formaldehyde (PPMV)		< 0.40	< 0.40	< 0.40	< 0.4
Formaldehyde (LB/HR)		< 0.010	< 0.011	< 0.012	< 0.011
Formic Acid (PPMV)		< 1.5	< 1.5	< 1.5	< 1.5
Formic Acid (LB/HR)		< 0.060	< 0.065	< 0.070	< 0.065
Methanol (PPMV)		< 2.4	< 2.4	< 2.4	< 2.4
Methanol (LB/HR)		< 0.067	< 0.072	< 0.078	< 0.072
EPA Method 94.02 Speciated VOC Results					
Lactic Acid (µg)		< 11.9	< 11.4	< 11.4	< 11.6
Lactic Acid (LB/HR)		< 0.011	< 0.011	< 0.012	< 0.011
Total Detected VOC (LB/HR)		1.92	1.85	2.75	2.18
Total Detected and Non-Detected VOC (LB/HR)		< 2.09	< 2.03	< 2.95	< 2.36
Total Detected HAPs (LB/HR)		0.212	0.256	0.670	0.379
Total Detected and Non-Detected HAPs (LB/HR)		< 0.309	< 0.360	< 0.783	< 0.484
Operating Data					
Scrubber Fresh Water Flow Rate (GPM)		75.2	75.5	75.8	75.5
ABS Injection Rate (mL/min)		38.2	38.2	38.5	38.3
Beer Feed Rate (GPM)		700.9	699.8	699.8	700.2
200 Proof Ethanol Flow Rate (GPM)		113.5	112.2	112.5	112.7

Table 4

Summary of Fermentation Scrubber (CE016) VOC Removal Efficiency Results
Green Plains Riga - Blissfield, MI
AET #14-01860
February 24, 2017

Run #1 10:55-11:54

Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Fermentation Scrubber Inlet	5,600	12,856	494	38,567	404
L2	Fermentation Scrubber Outlet	5,600	32.7	1.3	98.2	1.03
		Destruction Efficiency ((L1 - L2) ÷ L1) • 100		**99.7%**		

Run #2 13:01-14:00

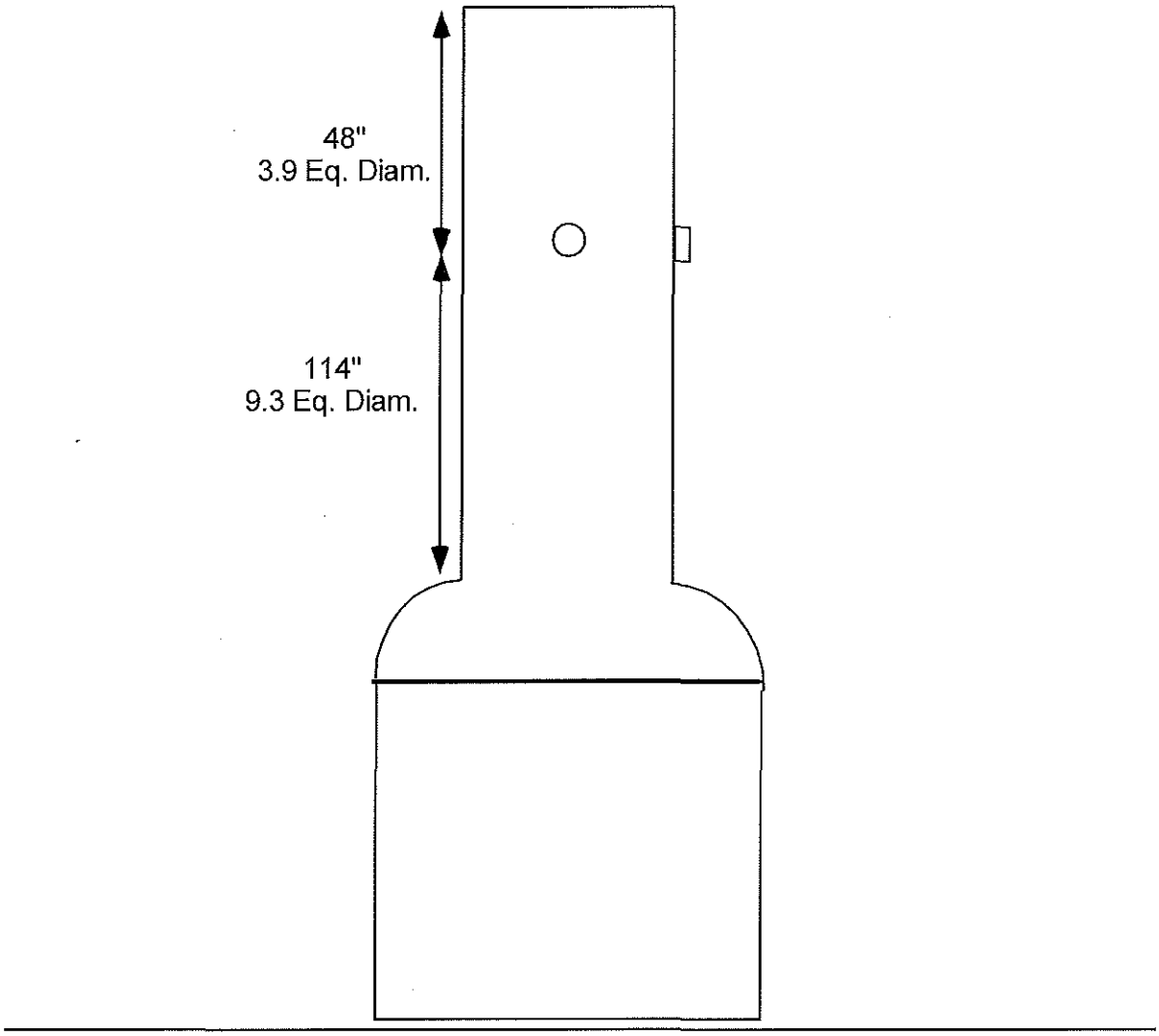
Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Fermentation Scrubber Inlet	6,000	9,846	406	29,539	332
L2	Fermentation Scrubber Outlet	6,000	31.0	1.3	93.0	1.04
		Destruction Efficiency ((L1 - L2) ÷ L1) • 100		**99.7%**		

Run #3 14:49-15:48

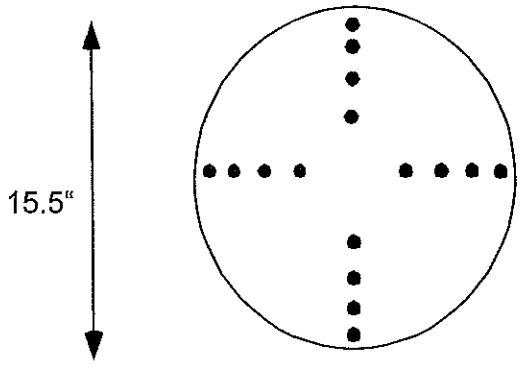
Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Fermentation Scrubber Inlet	6,500	9,129	407	27,388	333
L2	Fermentation Scrubber Outlet	6,500	42.2	1.9	127	1.54
		Destruction Efficiency ((L1 - L2) ÷ L1) • 100		**99.5%**		

AVERAGES RUNS # 1-3

Line #	Exhaust Location	Airflow Rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
L1	Fermentation Scrubber Inlet	6,033	10,610	436	31,831	356
L2	Fermentation Scrubber Outlet	6,033	35.3	1.5	106	1.2
		Average Destruction Efficiency		**99.7%**		



Vent Scrubber Outlet



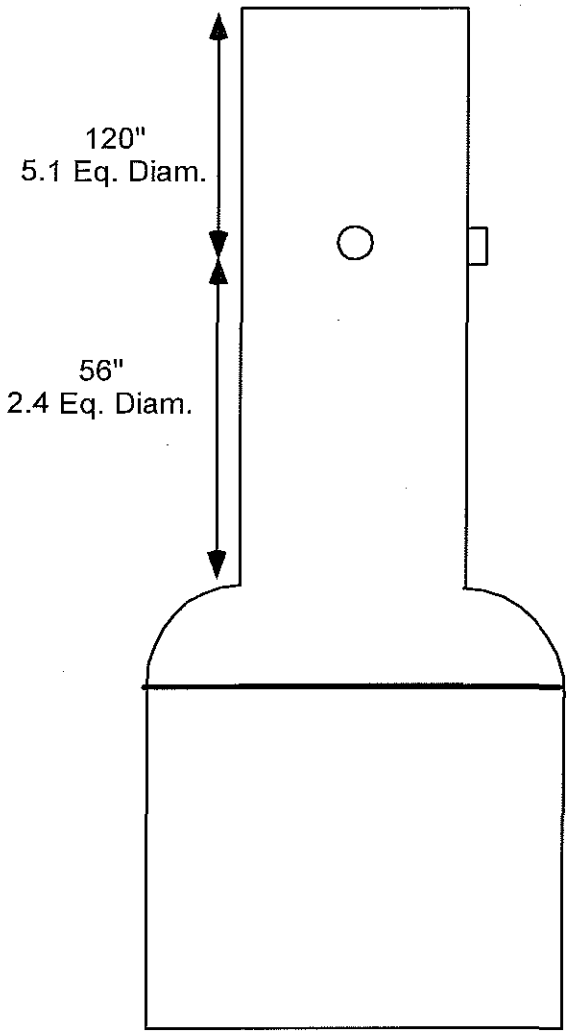
AMERICAN ENGINEERING TESTING, INC.

Vent Gas Scrubber Exhaust – Test Locations

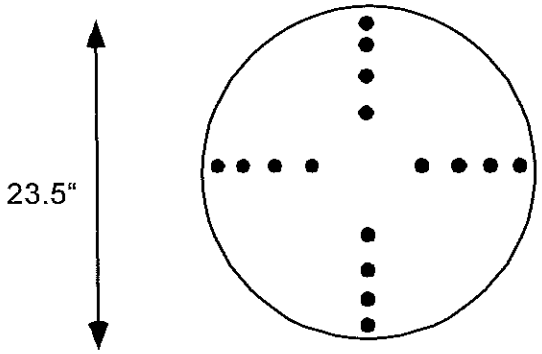
Green Plains Holdings II LLC – Riga, MI

Date: 01-18-17

AET Project No. 14-01860



Fermentation Scrubber Outlet



AMERICAN ENGINEERING TESTING, INC.

Fermentation Scrubber Exhaust – Test Locations

Green Plains Holdings II LLC – Riga, MI

Date: 01-18-17

AET Project No. 14-01860