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MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

RENEWABLE OPERATING PERMIT REPORT CERTIFICATION

Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating Permit (ROP) program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as specified in Rule 213(3)(b)(ii), and be made available to the Department of Environmental Quality, Air Quality Division upon request.

Source Name: Western Michigan University — County: Kalamazoo

Source Address: 1903 W. Kalamazoo Avenue — City: Kalamazoo

AQD Source ID (SRN): K2131 — ROP No.: K2131-2015a — ROP Section No.:

Please check the appropriate box(es):

☐ **Annual Compliance Certification (Pursuant to Rule 213(4)(c))**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, this source was in compliance with **ALL** terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the ROP.

☐ 2. During the entire reporting period this source was in compliance with all terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference, **EXCEPT** for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the ROP, unless otherwise indicated and described on the enclosed deviation report(s).

☐ **Semi-Annual (or More Frequent) Report Certification (Pursuant to Rule 213(3)(c))**

Reporting period (provide inclusive dates): From _____ To _____

☐ 1. During the entire reporting period, **ALL** monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred.

☐ 2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred, **EXCEPT** for the deviations identified on the enclosed deviation report(s).

☒ **Other Report Certification**

Reporting period (provide inclusive dates): From N/A To N/A

Additional monitoring reports or other applicable documents required by the ROP are attached as described:

Test Report for EU-02-PEAKGEN in accordance with 40 CFR Part 63 Supart ZZZZ

Test Report for EU-138-EMERGEN-01 in accordance with 40 CFR Part 60 Subpart JJJJ

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete

Jan Van Der Kley	VP of Business & Finance	(269)387-2365
Name of Responsible Official (print or type)	Title	Phone Number

Jan Van Der Kley — 4-18-19

Signature of Responsible Official — Date

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

SOURCE TEST REPORT
2019 CARBON MONOXIDE TESTING
WESTERN MICHIGAN UNIVERSITY
ROBERT M. BEAM POWER PLANT – PEAKING ENGINE
KALAMAZOO, MICHIGAN

Prepared For:
Western Michigan University
Robert M. Beam Power Plant
Kalamazoo, MI

For Submittal To:
MDEQ – Air Quality Division
7953 Adobe Road
Kalamazoo, MI 49009

Prepared By:
Montrose Air Quality Services, LLC
4949 Fernlee Ave.
Royal Oak, MI 48073

Document Number:	**049AS-541989-RT-8**
Test Date:	**February 28, 2019**
Submittal Date:	**April 9, 2019**

STAC STACK TESTING ACCREDITATION COUNCIL
A2LA ACCREDITED TO ASTM D7036 ONLY CERT #3925.01

MONTROSE AIR QUALITY SERVICES

EXECUTIVE SUMMARY

Montrose Air Quality Services, LLC (MAQS) was retained by Western Michigan University (WMU) to measure carbon monoxide (CO) and oxygen (O2) concentrations from a single catalytic converter controlling emissions from a peaking engine at the Robert M. Beam Power Plant located in Kalamazoo, Michigan. The facility operates under Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MIROP-K2131-2015a.

The generator set is owned and operated by WMU and is included in ROP No. MI-ROP-K2131-2015a as EU-02-PEAKGEN. The emissions testing is required by the National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines codified at Title 40, Part 63, Subpart ZZZZ of the Code of Federal Regulations (40 CFR 63, Subpart ZZZZ). This standard requires either (1) a CO control efficiency across the catalyst bed of at least 93% or (2) a maximum CO emission rate of less than or equal to 47 ppmvd at 15% O2.

The emissions test program was conducted on February 28, 2019. The results of the emission test program are summarized by Table I.

Table I

Peaking Generator Overall Emission Summary

Test Date: February 28, 2019

Location	Pollutant	Concentration	Destruction Efficiency at 15% O2
Inlet to the catalytic converter	O2	8.52 %	
	CO	387 ppm	
	CO (at 15% O2)	184 ppm	
Outlet of the catalytic converter	O2	10.52 %	
	CO	5.87 ppm	98.19 %
	CO (at 15% O2)	3.34 ppm	

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

SUMMARY TABLES

FIGURES

APPENDIX

1. Introduction

Montrose Air Quality Services (MAQS) was retained by Western Michigan University (WMU) to measure carbon monoxide (CO) and oxygen (O2) concentrations from a single catalytic converter controlling emissions from a peaking engine at the Robert M. Beam Power Plant located in Kalamazoo, Michigan. The facility operates under Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MIROP-K2131-2015a.

The generator set is owned and operated by WMU and is included in ROP No. MI-ROP-K2131-2015a as EU-02-PEAKGEN. The emissions testing is required by the National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines codified at Title 40, Part 63, Subpart ZZZZ of the Code of Federal Regulations (40 CFR 63, Subpart ZZZZ). This standard requires either (1) a CO control efficiency across the catalyst bed of at least 93% or (2) a maximum CO emission rate of less than or equal to 47 ppmvd at 15% O2.

The emissions test program was conducted on February 28, 2019. The purpose of this report is to document the results of the test program.

AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (March 2018). The following is a summary of the emissions test program and results in the format suggested by the aforementioned document.

1.a Identification, Location, and Dates of Test

Western Michigan University – Robert M. Beam Power Plant is located at the WMU campus at 1903 West Michigan Avenue in Kalamazoo, Michigan.

Sampling and analysis for the emission test program was conducted on February 28, 2019.

1.b Purpose of Testing

National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines codified at Title 40, Part 63, Subpart ZZZZ of the Code of Federal Regulations (40 CFR 63, Subpart ZZZZ).

Table 1
Emission Limitations

Pollutant	Emission Limit
CO	93 % reduction; or
CO	47 ppm @ 15% O2

1.c Source Description

The emission unit is a four stroke lean-burn natural gas-fired peaking generator set manufactured by Caterpillar. The generator set (Model 3516) is rated for a maximum of 771 kW.

Emissions are controlled by a catalytic converter, which reduces the CO concentration by over 93%.

1.d Test Program Contacts

The contact for the source and test report is:

Mr. Todd Wessel
Client Project Manager
Montrose Air Quality Services, LLC
4949 Fernlee Avenue
Royal Oak, MI 48073
(616) 885-4013

Mr. George Jarvis
Power Plant Director
Western Michigan University
1903 West Michigan Avenue
Kalamazoo, Michigan 49008
(269) 387-8548

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

Table 2
Test Personnel

Name and Title	Affiliation	Telephone
Mr. George Jarvis Power Plant Director Western Michigan University	Western Michigan University 1903 West Michigan Avenue Kalamazoo, Michigan 49008	(269) 387-8548
Mr. Eric Marko Senior Staff Engineer	NTH Consultants, Ltd. 1010 Front Ave. NW Grand Rapids, Michigan 49504	(616) 265-5754
Mr. Todd Wessel Client Project Manager	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(616) 885-4013

Mr. Shane Rabideau Environmental Technician	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mark Weiss Director of Environmental	Western Michigazn University 1903 West Michigan Avenue Kalamazoo, Michigan 49008	(269) 387-5588

2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

2.a Operating Data

Process data monitored during the emissions test program includes inlet temperature and power produced. Process data is included in Appendix D.

2.b Applicable Permit

The applicable permit for this emissions test program is MDEQ ROP No. MI-ROP-K2131-2015a.

2.c Results

The overall results of the emission test program are summarized by Table 3 (see Section 5.a).

3. Source Description

Sections 3.a through 3.e provide a detailed description of the process.

3.a Process Description

WMU installed a catalytic converter to control CO from the peaking generator. The emission unit is a four stroke lean-burn natural gas-fired peaking generator set manufactured by Caterpillar. The generator set (Model 3516) is rated for a maximum of 771 kW.

3.b Process Flow Diagram

Due to the simplicity of the engine, a process flow diagram is not necessary.

3.c Raw and Finished Materials

The raw material used by the process is natural gas.

3.d Process Capacity

The generator set (Model 3516) is rated for a maximum of 771 kW.

3.e Process Instrumentation

Process data monitored during the emissions test program includes inlet temperature and power produced. Process data is included in Appendix D.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

4.a Sampling Train and Field Procedures

CO content was measured using a Teledyne Model 300EM CO gas analyzers, and the O_2 content was measured using a M&C Products PMA 100-L O_2 gas analyzers. A sample of the gas stream was drawn through a stainless-steel probe with an in-line glass fiber filter to remove any particulate, a heated Teflon® sample line, and through an electronic sample conditioner to remove the moisture from the sample before it enters the analyzers. Data was recorded at 10-second intervals on a PC equipped with data acquisition software.

The configuration of the sampling system allowed for the injection of calibration gases directly to the analyzers or through the sampling system. All monitors in use were calibrated with U.S. EPA Protocol No. 1 calibration gases and operated to insure that zero drift, calibration gas drift, and calibration error met the specified method requirements. Copies of the Protocol gas certificates can be found in Appendix D.

The sample gas was extracted at three points through a stainless steel probe positioned at, 17%, 50% and 83% of the stack diameter described by 40 CFR Part 60, Appendix B Performance Specification 2 Section 8.1.3.2 and illustrated in Figure2 2. A schematic of the sampling train is provided as Figure 1.

Sampling and analysis procedures utilized the following test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 3A, "*Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources*", was used to measure the O_2 and CO_2 concentration of the exhaust gas.

- Method 10, "*Determination of Carbon Monoxide Emissions from Stationary Sources*", was used to measure the CO concentration of the exhaust gas.

4.b Recovery and Analytical Procedures

This test program did not include laboratory samples, consequently, sample recovery and analysis is not applicable to this test program.

4.c Sampling Ports

Engine exhaust gas was extracted from the exhaust pipe with the probe tip located at three sample points in the duct.

4.d Traverse Points

Engine exhaust gas was extracted from the exhaust pipe with the probe tip located at three sample points in the duct.

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.

5.a Results Tabulation

The overall results of the emissions test program are summarized by Table 3. Detailed results for the emissions test program are summarized by Table 4.

Table 3

Peaking Generator Overall Emission Summary

Test Date: February 28, 2019

Location	Pollutant	Concentration	Destruction Efficiency at 15% O2
Inlet to the catalytic converter	O2	8.52 %	
	CO	387 ppm	
	CO (at 15% O2)	184 ppm	
Outlet of the catalytic converter	O2	10.52 %	
	CO	5.87 ppm	98.19 %
	CO (at 15% O2)	3.34 ppm	

5.b Discussion of Results

The emissions testing is required by the National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines codified at Title 40, Part 63, Subpart ZZZZ of the Code of Federal Regulations (40 CFR 63, Subpart ZZZZ). This standard requires either (1) a CO control efficiency across the catalyst bed of at least 93% or (2) a maximum CO emission rate of less than or equal to 47 ppmvd at 15% O2.

The WMU peaking engine meets both standards listed above.

5.c Sampling Procedure Variations

No sampling variations occurred during the testing.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

There was no control equipment maintenance performed during the emissions test program.

5.f Re-Test

The emissions test program was not a re-test.

5.g Audit Sample Analyses

No audit samples were collected as part of the test program.

5.h Calibration Sheets

Relevant equipment calibration documents are provided in Appendix B.

5.i Sample Calculations

Sample calculations are provided in Appendix C.

5.j Field Data Sheets

Field documents relevant to the emissions test program are presented in Appendix A

5.k Laboratory Data

Raw CEM data is provided electronically in Appendix D.

Tables

Table 4
Carbon Monoxide (CO) Emissions Testing Results
Peaking Engine
Western Michigan University
Kalamazoo, Michigan

Parameter	Run 1
Sampling Date	2/28/2019
Sampling Start Time	11:45-12:00
Average Inlet O_2 Concentration (%, dry)	8.53
Average Inlet O_2 Concentration (%, dry, corrected)[1]	8.52
Average Inlet CO Concentration (ppmv, dry)	392.06
Average Inlet CO Concentration (ppmv, dry, corrected)[1]	387.02
Average Inlet CO Concentration (ppmv@15%O2)	184.44
Average Outlet O_2 Concentration (%, dry)	10.25
Average Outlet O_2 Concentration (%, dry, corrected)[1]	10.52
Average Outlet CO Concentration (ppmv, dry)	7.48
Average Outlet CO Concentration (ppmv, dry, corrected)[1]	5.87
Average Outlet CO Concentraton (ppmv@15%)	3.34
CO Destruction Efficiency	**98.19%**

[1]corrected for analyzer drift as per USEPA Method 7E

O_2 : oxygen

CO : carbon monoxide

$Conc_{@15\%O2} = Conc * (20.9 - 15)/(20.9 - \%O_2)$

$DE = (Conc_{in} - Conc_{out})/Conc_{in} * 100$

Drift Correction calculation

$$C_{gas} = (C - C_o)\frac{C_{ma}}{C_m - C_o}$$

Where:

Cgas =effluent gas concentration, dry basis, ppm

C = avg. gas concentration indicated by analyzer, dry basis, ppm

Co = avg. of initial and final system calibration bias check for the zero gas

Cm = avg. of initial and final system calibration bias check for the upscale calibration gas

Cma = actual concentration of the upscale calibration gas, ppm

Figures

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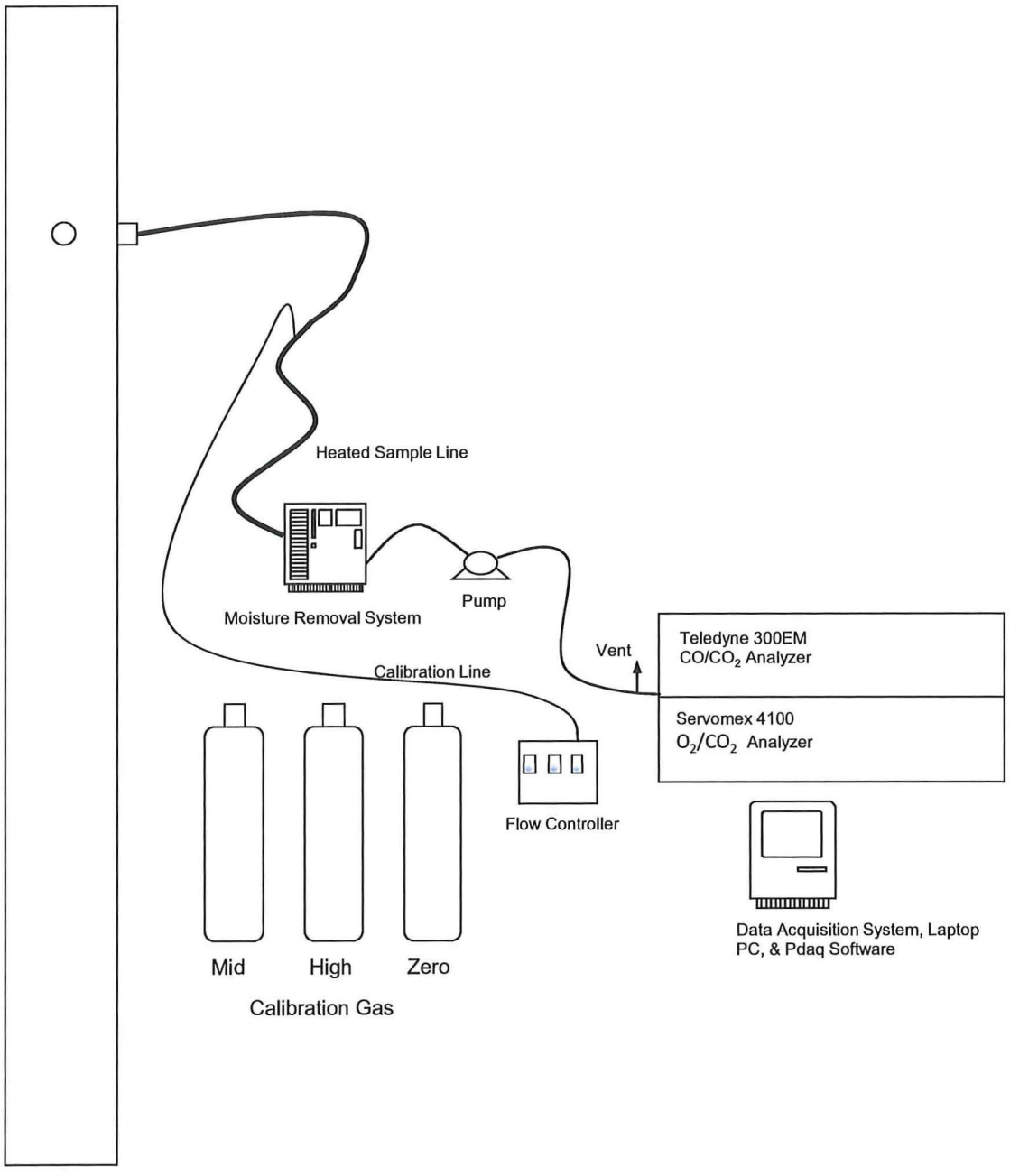

Figure No. 1

Site: **USEPA Method 3A and 10** **Western Michigan University** **Kalamazoo, Michigan**	**Sampling Date:** **February 28, 2019**	**Montrose Air Quality Services, LLC.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

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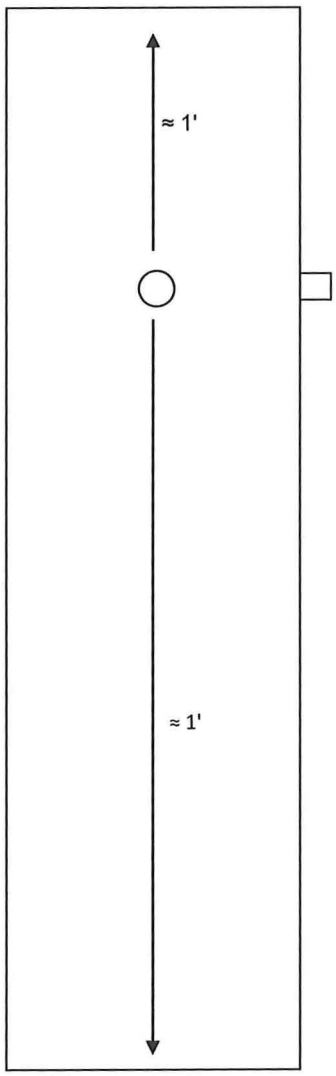
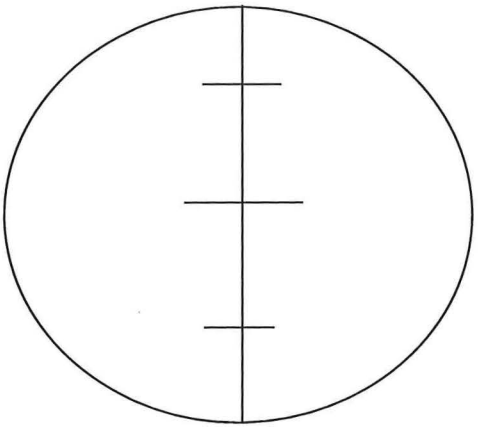
STACK DIAMETER = 9"





Not to Scale

Points	Distance "
1	1.50
2	4.50
3	7.50

Figure No. 2

Site: **Peaking Generator Inlet** **Western Michigan University** **Kalamazoo, Michigan**	**Sampling Dates:** **February 28, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Ave.** **Royal Oak, Michigan**

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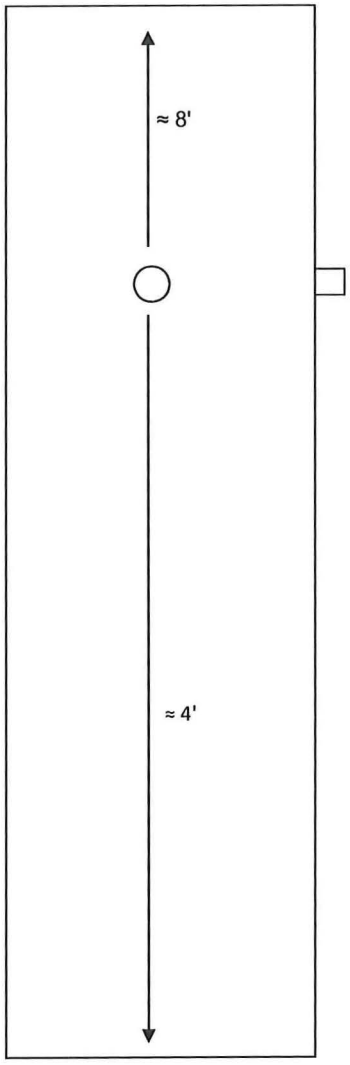
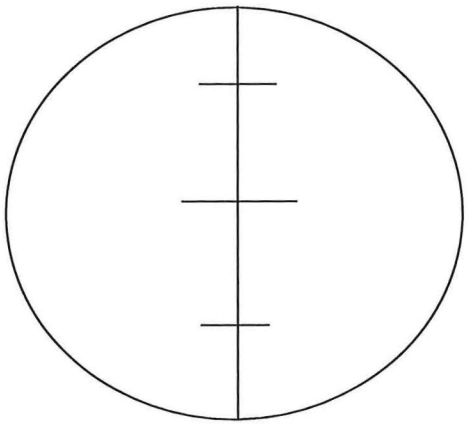
STACK DIAMETER = 9"





Not to Scale

Points	Distance "
1	1.50
2	4.50
3	7.50

Figure No. 3

Site: **Peaking Generator Exhaust** **Western Michigan University** **Kalamazoo, Michigan**	**Sampling Dates:** **February 28, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Ave.** **Royal Oak, Michigan**

Appendix A
Field and Computer Generated Raw Data and Field Notes

BTEC Inc. CEM Calibration Field Data Sheet

Page 1 of 1

Client Western NJ Univ
Date 2/28/19
Analyzer #'s 2, 11, 16, 5

Operator JW, SR
Sampling Location In & Out

Range						
Cylinder Values						Environics # (yes) no
Time	Pollutant O_2 In	Pollutant CO In	Pollutant O_2 out	Pollutant CO out	Pollutant	Notes: Run/Cal Info & File Name
10:42	20.5	2.3	20.1	0.4		Cal Error
10:47	20.4	1.7	0.11	1.6		"
10:52	20.4	2.5	0.00	90.4		"
10:54	20.4	2.0	0.00	49.9		"
11:05	0.7	2.1	10.2	0.9		"
11:09	20.1	0.95	8.7	2.3		"
11:11	10.09	0.96	8.7	2.2		"
11:15	0.00	1001	8.8	2.4		"
11:18	0.00	302	20.5	1.5		Cal Error
11:22	20.9	2.2	0.00	49.6		BIAS ✓ Out
11:29	0.04	1.1	9.8	0.81		BIAS ✓ Out
11:33	10.1	1.2	0.0	49.5		BIAS ✓ In
11:38	0.03	303	11	12.6		BIAS ✓ In
11:45	8.16	3029	10.44	8.5		START Run # 1
12:05	0.03	303				BIAS ✓
12:16	10.05	2.8				BIAS ✓
12:20			9.8	2.9		BIAS ✓
12:24			0.0	50.4		BIAS ✓

Cylinder Serial Numbers

20.08% O_2 = CC150947 792.3 CO = CC469121
10.09% O_2 = CC469695

Revision 3.0
KL 1/6/14

BTEC Inc. CEM Calibration Field Data Sheet

Client WWU
Date 2/26/19
Analyzer #'s 61,18

Operator TW
Sampling Location

Range						
Cylinder Values						Environics # yes / no
Time	Pollutant NOx	Pollutant NO	Pollutant NO2	Pollutant CO	Pollutant	Notes: Run/Cal Info & File Name
15:47	90.6					
15:49:30	50.1					
15:52	0.7					
16:00	82.7	81	1.7			Bag on for converter check
16:16				403		
16:18:30				200		
16:22				403		
16:25:30				197		
16:29				404		
16:30	81.5	25.9	56			END NOx converter check
16:33				197		
16:38				2.2		
16:46:30	90.4			89.1		Audit bottle
16:50	0.7			2.3		
16:54				89.2		Audit bottle
16:57				2.3		
17:02				89.1		Audit bottle

Cylinder Serial Numbers

Audit cylinder = 89.66 ppm CO = XC016294B
91.37 NOx
499.7 NO_x = XC002707B

Revision 3.0
KL 1/6/14

2/22/19 Method 205 check

Envirotics Set point	Responce
400	404.64
200	197.44
400	404.6
200	196.65
400	405.12
200	196.79
0	2.18
Audit cylinder	89.24
0	2.21
Audit cylinder	89.33
0	2.3
Audit cylinder	89.18

2/28/19 Western MI Univ.

	O_2 In	CO In	O_2 Out	CO Out
Cal Error	20.48	2.07	20.12	0.40
	20.43	1.81	0.14	1.57
	20.43	2.53	0.00	90.51
	20.43	2.16	0.00	50.02
	0.09	2.08	10.17	0.96
	20.11	0.62	8.77	2.32
	10.09	0.99	8.78	2.24
	0.00	601.57	12.59	2.37
Cal Error	0.00	301.56	20.15	1.49
BIAS ✓	20.89	1.88	0.10	49.47
"	0.04	1.2	9.84	0.77
"	10.11	1.23	8.22	40.66
BIAS ✓ (1)	0.03	304.29	10.93	12.3
	8.53	392.06	10.25	7.48
	0.03	304.39	1.12	87.49
	10.06	2.63	0.00	5.23
	10.06	2.97	9.8	2.9
	10.08	3.16	0.00	50.42
Drift Corrected	8.52	387.02	10.12	5.87

CEMS DRIFT CALCULATION SPREAD SHEET

Client: Western Mi Univ
Source: Inlet
Date: 2/28/2019

Span:		20.08	600.00		20.08	600		
		O2	CO		O2	CO		CO
Calibration Gas Value =		10.08	300.00		10.08	300		lbs/mmbtu
Run #1 Initial Zero Bias Value =		0.03	1.23	analyzer	0.00	0.62		
Run #1 Initial System Bias Value =		10.11	304.29	system	0.03	2.63		
Run #1 Average =		8.53	392.06				**RUN 1**	0.41365
Run #1 Final Zero Bias Value =		0.03	2.63	analyzer	10.09	301.56		
Run #1 Final System Bias Value =		10.06	304.39	system	10.06	304.39		
Run #1 Total Drift Corrected =		8.52	387.02				8710	
zero calibration drift =	3%	0.00	0.23	zero bias	0.15	0.34	5% allowed	
calibration drift =		-0.25	0.02	span bias	-0.15	0.47		

Drift Correction calculation

$$C_{gas} = (C - C_o)\frac{C_{ma}}{C_m - C_o}$$

Where:
Cgas =effluent gas concentration, dry basis, ppm
C = avg. gas concentration indicated by analyzer, dry basis, ppm
Co = avg. of initial and final system calibration bias check for the zero gas
Cm = avg. of initial and final system calibration bias check for the upscale calibration gas
Cma = actual concentration of the upscale calibration gas, ppm

Revision 4.0
7-29-16 BC

CEMS DRIFT CALCULATION SPREAD SHEET

Client:	Western Mi Univ							
Source:	Outlet							
Date:	2/28/2019							
Span:		20.08	90.00		20.08	90		
		O2	CO		O2	CO		CO
Calibration Gas Value =		10.08	50.00		10.08	50		lbs/mmbtu
Run #1 Initial Zero Bias Value =		0	0.77	analyzer	0.00	0.40		
Run #1 Initial System Bias Value =		9.84	49.47	system	0.00	2.90		
Run #1 Average =		10.25	7.48				**RUN 1**	0.007479
Run #1 Final Zero Bias Value =		0	2.9	analyzer	10.17	50.02		
Run #1 Final System Bias Value =		9.8	50.42	system	9.8	50.42		
Run #1 Total Drift Corrected =		10.52	5.87				8710	
zero calibration drift =	3%	0.00	2.37	zero bias	0.00	2.78	5% allowed	
calibration drift =		-0.20	1.06	span bias	-1.84	0.44		

Drift Correction calculation

$$C_{gas} = (C - C_o)\frac{C_{ma}}{C_m - C_o}$$

Where:
Cgas =effluent gas concentration, dry basis, ppm
C = avg. gas concentration indicated by analyzer, dry basis, ppm
Co = avg. of initial and final system calibration bias check for the zero gas
Cm = avg. of initial and final system calibration bias check for the upscale calibration gas
Cma = actual concentration of the upscale calibration gas, ppm

Revision 4.0
7-29-16 BC

Appendix B
Equipment Calibration and Span Gas Documents

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/28/2019	Analyzer:	M&C	
Client:	Western Mi Univ	Serial #:	0502189	
Unit:	Inlet	Span:	20.08	
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS	
Calibration Gas:	O2	Concentration:	10.08	20.08
Cylinder #:	CC150947 CC469695	Units:	%	
Zero Gas:	Nitrogen			

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Span) *
Zero Gas	0.00	0.00	0.00	0.00
Mid Gas	10.08	10.09	0.01	0.05
High Gas	20.08	20.11	0.03	0.15

* Eq. 7E-1

$$ACE = \frac{(Cdir - Cv)}{CS} \times 100$$

Where:

ACE = Analyzer calibration error, % of span
Cdir = Measured concentration of a cal gas when introduced in direct cal mode
Cv = Manufacturer certified concentration of cal gas
CS = Calibration Span

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/28/2019	Analyzer:	Teledyne 300E	
Client:	Western Mi Univ	Serial #:	832	
Unit:	Inlet	Span:	600.00	
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS	
Calibration Gas:	CO	Concentration:	300.00	600.00
Cylinder #:	CC469121 CC469121	Units:	PPM	
Zero Gas:	Nitrogen			

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Span) *
Zero Gas	0.00	0.62	0.62	0.10
Mid Gas	300.00	301.56	1.56	0.26
High Gas	600.00	601.57	1.57	0.26

* Eq. 7E-1

$$ACE = \frac{(Cdir - Cv)}{CS} \times 100$$

Where:

ACE = Analyzer calibration error, % of span
Cdir = Measured concentration of a cal gas when introduced in direct cal mode
Cv = Manufacturer certified concentration of cal gas
CS = Calibration Span

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/28/2019	Analyzer:	Servomex 1400	
Client:	Western Mi Univ	Serial #:	1420B/894	
Unit:	Outlet	Span:	20.08	
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS	
Calibration Gas:	O2	Concentration:	10.08	20.08
Cylinder #:	CC150947 CC469695	Units:	%	
Zero Gas:	Nitrogen			

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Span) *
Zero Gas	0.00	0.00	0.00	0.00
Mid Gas	10.08	10.17	0.09	0.45
High Gas	20.08	20.12	0.04	0.20

* Eq. 7E-1

$$ACE = \frac{(Cdir - Cv)}{CS} \times 100$$

Where:

ACE = Analyzer calibration error, % of span
Cdir = Measured concentration of a cal gas when introduced in direct cal mode
Cv = Manufacturer certified concentration of cal gas
CS = Calibration Span

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/28/2019	Analyzer:	Teledyne 300EM	
Client:	Western Mi Univ	Serial #:	266	
Unit:	Outlet	Span:	90.00	
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS	
Calibration Gas:	CO	Concentration:	50.00	90.00
Cylinder #:	CC469121 CC469121	Units:	PPM	
Zero Gas:	Nitrogen			

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Span) *
Zero Gas	0.00	0.40	0.40	0.44
Mid Gas	50.00	50.02	0.02	0.02
High Gas	90.00	90.51	0.51	0.57

* Eq. 7E-1

$$ACE = \frac{(Cdir - Cv)}{CS} \times 100$$

Where:

ACE = Analyzer calibration error, % of span
Cdir = Measured concentration of a cal gas when introduced in direct cal mode
Cv = Manufacturer certified concentration of cal gas
CS = Calibration Span

Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
Troy, MI 48083
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E03NI60E15A0286	Reference Number:	32-401287021-1
Cylinder Number:	CC150947	Cylinder Volume:	159.6 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62018	Valve Outlet:	590
Gas Code:	CO2,O2,BALN	Certification Date:	Aug 27, 2018

Expiration Date: Aug 27, 2026

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON DIOXIDE	20.00 %	20.05 %	G1	+/- 1% NIST Traceable	08/27/2018
OXYGEN	20.00 %	20.08 %	G1	+/- 1% NIST Traceable	08/27/2018
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	12061526	CC354795	19.87 % CARBON DIOXIDE/NITROGEN	+/-0.6%	Jan 11, 2024
NTRM	10010924	K021247	20.89 % OXYGEN/NITROGEN	+/-0.5%	Jun 27, 2022

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
CO2 SIEMENS ULTRAMAT 6 E/N 173	Nondispersive Infrared(NDIR)	Aug 13, 2018
O2 FS, SIEMENS OXYMAT 6 E/N 182	Paramagnetic	Aug 20, 2018

Triad Data Available Upon Request

Approved for Release

Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
Troy, MI 48083
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E03NI80E15A0138	Reference Number:	32-401287020-1
Cylinder Number:	CC469695	Cylinder Volume:	150.9 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62018	Valve Outlet:	590
Gas Code:	CO2,O2,BALN	Certification Date:	Aug 28, 2018

Expiration Date: Aug 28, 2026

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON DIOXIDE	10.00 %	10.07 %	G1	+/- 1% NIST Traceable	08/28/2018
OXYGEN	10.00 %	10.08 %	G1	+/- 1% NIST Traceable	08/28/2018
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	08010629	K016293	13.94 % CARBON DIOXIDE/NITROGEN	+/-0.6%	Jan 30, 2024
NTRM	100106	K015462	9.967 % OXYGEN/NITROGEN	+/-0.3%	Apr 19, 2022

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
CO2 SIEMENS ULTRAMAT 6 E/N 173	Nondispersive Infrared(NDIR)	Aug 13, 2018
O2 FS, SIEMENS OXYMAT 6 E/N 182	Paramagnetic	Aug 20, 2018

Triad Data Available Upon Request

Approved for Release

Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
Troy, MI 48083
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E02NI99E15A0403	Reference Number:	32-400926418-1
Cylinder Number:	CC469121	Cylinder Volume:	144.3 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62017	Valve Outlet:	350
Gas Code:	CO,BALN	Certification Date:	Jun 20, 2017

Expiration Date: Jun 20, 2025

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON MONOXIDE	800.0 PPM	792.3 PPM	G1	+/- 1% NIST Traceable	06/20/2017
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	05-1620	KAL004479	970.00 PPM CARBON MONOXIDE/NITROGEN	+/-0.36%	May 14, 2021

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
E/N 54 Nicolet 6700 CO	FTIR	Jun 15, 2017

Triad Data Available Upon Request

Approved for Release

Appendix C
Example Calculations

EXAMPLE CALCULATIONS

Note: answers obtained by sample calculations may deviate from that presented within the report because of rounding differences.

USEPA METHOD 3A, 7E, AND 10

Analyzer Drift Correction

$$C = \left(\overline{C} - C_o\right)\left(\frac{C_{ma}}{C_m - C_o}\right)$$

Where: C = Effluent gas concentration, dry basis (ppm or %).
$\overline{C}$ = Average gas concentration indicated by gas analyzer, dry basis (ppm or %).
C_o = Average of initial and final system calibration bias check responses for the zero gas (ppm or %).
C_{ma} = Actual concentration of the upscale calibration gas (ppm or %).
C_m = Average of initial and final system calibration bias check responses for the upscale calibration gas (ppm or %).

For example, for Test Run 1 inlet, the initial and final CO zero gas calibration checks, respectively, were 1.23 ppm and 2.63 ppm so $C_0 = (1.23 + 2.63)/2 = 1.93$ ppm. The initial and final CO upscale gas calibration checks, respectively, were 304.29 ppm and 304.39 ppm so $C_m = (304.29 + 304.39)/2 = 304.34$ ppm. The actual concentration of the upscale calibration gas, C_{ma} was 300.0 ppm. The average CO concentration indicated by the gas analyzer was 392.06 ppm. The actual stack gas CO concentration, corrected for analyzer drift, is then:

$$C = \left(392.06 - 1.93\right)\left(\frac{300.0}{304.34 - 1.93}\right) = 387.02\, ppmvd$$

Correction to 15% Oxygen

$Conc_{@15\%O2}$ = Conc * (20.9 -15)/(20.9 - %O2)

Where: Conc= Effluent gas concentration, dry basis (ppmv).
$\%O_2$= Drift corrected oxygen concentration, dry basis (%).

For example, for Test Run 1 at the inlet the drift corrected CO value is 387.02 ppmv and the drift correction O_2 value is 8.52%. The actual CO concentration corrected to 15% O_2 is then:

$Conc_{@15\%O2}$ = 387.02 * (20.9 -15)/(20.9 -8.52) = 184.44

Destruction Efficiency

VOC Destruction Efficiency (%)

$$DE = \left(\frac{C_{in} - C_{out}}{C_{in}} \right) \cdot 100$$

Where: DE = VOC Destruction Efficiency (%)
C_{in} = VOC Inlet Concentration (ppmv @ 15% O_2)
C_{out} = VOC Outlet Concentration (ppmv @ 15% O_2)

The VOC DE for Run 1 at the catalytic converter Exhaust is:

$$DE = \left(\frac{184.44\,ppmv - 3.34\,ppmv}{184.44\,ppmv} \right) \cdot 100 = 98.19\%$$

Western Michigan University
Robert M. Beam Power Plant
EU-02-PEAKGEN

Western Michigan University Peaking Engine Data

Date:	February 28, 2019
Location:	Robert M. Beam Power Plant

Time	Engine kW	Catalyst inlet Temperature (°F)
11:45:00 AM	740	775
11:49:00 AM	740	780
11:53:00 AM	740	780
11:56:00 AM	745	780
12:00:00 PM	750	780

MONTROSE
AIR QUALITY SERVICES

SOURCE TEST REPORT
2019 OXIDES OF NITROGEN, CARBON MONOXIDE, AND VOLATILE ORGANIC COMPOUND TESTING
WESTERN MICHIGAN UNIVERSITY
SANGREN HALL EMERGENCY GENERATOR
KALAMAZOO, MICHIGAN

Prepared For:
Western Michigan University
1903 West Michigan Avenue
Kalamazoo, MI

For Submittal To:
MDEQ – Air Quality Division
7953 Adobe Road
Kalamazoo, MI 49009

Prepared By:
Montrose Air Quality Services, LLC
4949 Fernlee Ave.
Royal Oak, MI 48073

Document Number:	**049AS-541981-RT-9**
Test Date:	**February 27, 2019**
Submittal Date:	**April 9, 2019**

STAC STACK TESTING ACCREDITATION COUNCIL
A2LA ACCREDITED TO ASTM D7036 ONLY CERT #3925.01

MONTROSE
AIR QUALITY SERVICES

EXECUTIVE SUMMARY

Montrose Air Quality Services, LLC. (MAQS) was retained by Western Michigan University (WMU) to evaluate emission rates from an emergency generator set located outside Sangren Hall (Sangren). Sangren is located on WMU's campus at 1903 West Michigan Avenue in Kalamazoo, Michigan. The generator set is a Gaseous Fuel Generator Set Model GTA50 CC Engine Series rated for a maximum of 600 kW at a gross engine power output of 1,035 hp and manufactured by Cummins.

Testing consisted of triplicate 60-minute test runs. The generator set is owned and operated by WMU and is included in Renewable Operating Permit No. MI-ROP-K2131-2015a as EU-138-EMERGEN-01. The emissions testing is required by the Standards of Performance for Stationary Spark Ignition Internal Combustion Engines codified at Title 40, Part 60, Subpart JJJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJJ). Emission limitations included in Subpart JJJJ that are applicable to this generator set are summarized in Table I in addition to test program summary results.

Table I
Western Michigan University
Sangren Hall Emergency Generator
Compliance Test Program Results Summary
Test Date February 27, 2019

Source	Pollutant	Test Result (ppmvd @15% O_2)	Emission Limitation (ppmvd @15% O_2)
Sangren Hall GTA50 CC Generator Set EU-138-EMERGEN-01	NOx	47	160
	CO	111	540
	VOC	0	86

Note: The measured total hydrocarbon concentration, minus methane, was negative and, therefore, is reported as zero.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

SUMMARY TABLES

FIGURES

APPENDIX

1. Introduction

Montrose Air Quality Services, LLC. (MAQS) was retained by Western Michigan University (WMU) to evaluate emission rates from an emergency generator set located outside Sangren Hall (Sangren). Sangren is located on WMU's campus at 1903 West Michigan Avenue in Kalamazoo, Michigan. The generator set is a Gaseous Fuel Generator Set Model GTA50 CC Engine Series rated for a maximum of 600 kW at a gross engine power output of 1,035 hp and manufactured by Cummins.

The Air Quality Division (AQD) of Michigan's Department of Environmental Quality has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (March 2018). The following is a summary of the emissions test program and results in the format outlined by the AQD document.

1.a Identification, Location, and Dates of Test

Field-sampling for this emission test program was conducted on February 27, 2019 at Sangren Hall on WMU's campus at 1903 West Michigan Avenue in Kalamazoo, Michigan. The purpose of this report is to document the results of the emissions test program.

1.b Purpose of Testing

The generator set is owned and operated by WMU and is included in Renewable Operating Permit No. MI-ROP-K2131-2015a as EU-138-EMERGEN-01. The emissions testing is required by the Standards of Performance for Stationary Spark Ignition Internal Combustion Engines codified at Title 40, Part 60, Subpart JJJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJJ). Emission limitations included in Subpart JJJJ that are applicable to this generator set are summarized by Table 2 (see Section 2.d).

The purpose of the testing was to quantify emission levels of oxides of nitrogen (NOx), carbon monoxide (CO), and volatile organic compounds (VOC) (as propane). In addition, the concentrations of oxygen (O_2) and methane (CH_4) in the engine exhaust were measured during the emissions test program.

1.c Test Program Contact

The contacts for the test program are:

Mr. Todd Wessel
Client Project Manager
Montrose Air Quality Services, LLC
4949 Fernlee Ave.
Royal Oak, MI 48073
(616) 885-4013

Mr. Mark Weiss
Director of Environmental Health and Safety
Western Michigan University
1903 W. Michigan Ave
Kalamazoo MI 49008-5485
(269) 387-5588

Ms. Rhiana Dornbos
Project Manager
NTH Consultants, Ltd.
1010 Front Ave. NW
Grand Rapids, Michigan 49504
(616) 265-5755

1.d Test Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 1.

Table 1
Test Personnel

Name and Title	Affiliation	Telephone
Ms. Rhiana Dornbos Project Engineer	NTH Consultants, Ltd. 1010 Front Ave. NW Grand Rapids, Michigan 49504	(517) 702-2953
Ms. Chloe Palajac Staff Engineer	NTH Consultants, Ltd. 1010 Front Ave. NW Grand Rapids, Michigan 49504	(616) 265-5757
Mark Weiss Director of Environmental Health and Safety	Western Michigan University 1903 W. Michigan Ave Kalamazoo MI 49008-5485	(269) 387-5588
Mr. Todd Wessel Client Project Manager	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(616) 885-4013
Mr. Shane Rabideau Field Technician	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Tom Gasloli Environmental Quality Analyst	MDEQ Air Quality Division Lansing District Office	(517) 248-6778

Ms. Monica Brothers Environmental Quality Analyst	MDEQ Air Quality Division Kalamazoo District Office	(269) 567-3552

2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

2.a Operating Data

The generator set was run prior to testing to ensure proper internal temperature could be reached for the onboard non-selective catalytic reduction (NSCR) system and to adjust the fuel/air mix ratio for optimal emissions control system performance. As specified by 40 CFR 60.4244(a), emissions testing was conducted with the engine operating within 10 percent of 100 percent peak load. The power generation rate during the emissions test program was approximately 546 kW. Operating data is provided in Appendix E.

2.b Applicable Permit

The generator set is owned and operated by WMU and is included in Renewable Operating Permit No. MI-ROP-K2131-2015a as EU-138-EMERGEN-01. The emissions testing is required by the Standards of Performance for Stationary Spark Ignition Internal Combustion Engines codified at Title 40, Part 60, Subpart JJJJ of the Code of Federal Regulations (40 CFR 60, Subpart JJJJ).

2.c Results

The overall results of the emissions compliance test program are summarized by Table 3 (see Section 5.a).

2.d Emission Regulation Comparison

Emission limitations for the Sangren Hall emergency generator set are summarized by Table 2.

Table 2
Emission Limitations for Emergency Generators Greater Than 130 hp

Pollutant	Emission Limitation (ppmv@15% O_2)	Emission Limitation (g/bhp-hr)
NOx	160	2.0
CO	540	4.0
VOC	86	1.0

Note: Emission Limitations are expressed in two separate units. Either set of emission limitations can be used to demonstrate compliance with 40 CFR 60, Subpart JJJJ. Emissions were determined in terms of concentration (ppmvd@15% O_2).

As summarized by Table 3 (Section 5.a), the emissions test result for each pollutant was less than the corresponding emission limitation.

3. Source Description

Sections 3.a through 3.e provide a detailed description of the process.

3.a Process Description

The emission unit is a natural gas-fired emergency generator set manufactured by Cummins. The generator set (Model GTA50 CC) is rated for a maximum of 600 kW at a gross engine power output of 1,035 bhp.

3.b Raw and Finished Materials

The only raw material supplied to the generator set is natural gas.

3.c Process Capacity

The only raw material supplied to the generator set is natural gas. The generator is rated for 600 kW.

3.d Process Instrumentation

The engine is equipped with controls to adjust the fuel-air ratio of the engine intake manifold.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify emissions from the emergency generator.

4.a Sampling Train and Field Procedures

Sampling and analysis procedures followed the methodologies of the following emissions test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 3A - *"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources"* was used to evaluate the O_2 content of the engine exhaust
- Method 7E - *"Determination of Nitrogen Oxides Emissions from Stationary Sources"* was used to measure NOx concentrations in the exhaust gas
- Method 10 - *"Determination of Carbon Monoxide Emissions from Stationary Sources"* was used to measure CO concentrations in the exhaust gas
- Method 25A - *"Determination of Total Gaseous Organic Concentration Using Flame Ionization Analyzer"* was used to measure VOC concentrations in the exhaust gas

The O_2 content and the CO content were measured using a Teledyne 300E CO/O_2 gas analyzer. The NOx content of the gas stream was measured using a TECO Model 42C NOx gas analyzer. A sample of the gas stream was drawn through an insulated stainless-steel probe with an in-line glass fiber filter to remove any particulate, a heated Teflon® sample line, and through an electronic sample conditioner to remove the moisture from the sample before it enters the analyzers. Data was recorded at 10-second intervals on a PC equipped with data acquisition software. A schematic drawing of the Methods 3A, 7E, and 10 sampling train is provided as Figure 1.

Volatile Organic compound (VOC) concentrations were measured according to 40 CFR 60, Appendix A, Method 25A. A sample of the gas stream was drawn through a stainless steel probe with an in-line glass fiber filter to remove any particulate, and a heated Teflon® sample line to prevent the condensation of any moisture from the sample before it enters the analyzer. Data was recorded at 10-second intervals on a PC equipped with data acquisition software. MAQS will use a JUM Model 109A Methane/Non-Methane THC hydrocarbon analyzer to determine the VOC concentration.

The JUM Model 109A analyzer utilizes two flame ionization detectors (FIDs) in order to report the average ppmv for total hydrocarbons (THC), as propane, as well as the average

ppmv for methane (as methane). Upon entry, the analyzer splits the gas stream. One FID ionizes all of the hydrocarbons in the gas stream sample into carbon, which is then detected as a concentration of total hydrocarbons. Using an analog signal, specifically voltage, the concentration of THC is then sent to the data acquisition system (DAS), where recordings are taken at 4-second intervals to produce an average based on the overall duration of the test. This average is then used to determine the average ppmv for THC reported as the calibration gas, propane, in equivalent units.

The second FID reports methane only. The sample enters a chamber containing a catalyst that destroys all of the hydrocarbons present in the gas stream other than methane. As with the THC sample, the methane gas concentration is sent to the DAS and recorded. The methane concentration, reported as methane, can then be converted to methane, reported as propane, by dividing the measured methane concentration by the analyzer's response factor.

The analyzer's response factor is obtained by introducing a methane calibration gas to the calibrated J.U.M. 109A. The response of the analyzer's THC FID to the methane calibration gas, in ppmv as propane, is divided by the Methane analyzer's response to the methane calibration gas, in ppmv as methane. A schematic drawing of the Method 25A sampling train is provided as Figure 2.

For analyzer calibrations, calibration gases were mixed to desired concentrations using an Environics Series 4040 Computerized Gas Dilution System. The Series 4040 consists of a single chassis with four mass flow controllers. The mass flow controllers are factory-calibrated using a primary flow standard traceable to the United State's National Institute of Standards and Technology (NIST). Each flow controller utilizes an 11 point calibration table with linear interpolation, to increase accuracy and reduce flow controller nonlinearity.

All analyzers were calibrated in accordance with the procedures of Methods 3A, 7E, 10, and 25A.

4.b Recovery and Analytical Procedures

Recovery and analytical procedures were described in Section 4.a.

4.c Sampling Ports

All sampling took place at the engine exhaust ducts. The entire run time was spent in one of two exhaust ducts, with the sampling probe being switched between ducts at the halfway point of the test run (based on time, not sample volume). Readings from approximately three minutes of time required for switchover were removed from the MAQS analysis averages.

4.d Traverse Points

The exhaust ducts are 8.25 inches in diameter. The north exhaust duct was traversed at three points across the duct for a total of 10 minutes each during each emissions test run. The south exhaust duct was sampled at a single point for thirty minutes during each emissions test run.

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.

5.a Results Tabulation

The results of the emissions test program are summarized by Table 3.

Table 3
Western Michigan University
Sangren Hall Emergency Generator
Compliance Test Program Results Summary

Source	Pollutant	Test Result (ppmvd @15%/O_2)	Emission Limitation (ppmvd @15%/O_2)
GTA50 CC Generator Set	NOx	47	160
	CO	111	540
	VOC	0	86

Note: The measured total hydrocarbon concentration, minus methane, was negative and, therefore, is reported as zero.

5.b Discussion of Results

Emission limitations are summarized by Table 2 (see Section 1.b). The results of the emissions test program are summarized by Table 3 (see Section 5.a). Detailed emissions test results are summarized by Table 4.

5.c Sampling Procedure Variations

No sampling procedure variations occurred during testing.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

Preventative and corrective maintenance is performed per manufacturer recommendations.

5.f Audit Sample Analyses

No audit samples were collected as part of the test program.

5.g Calibration Sheets

All relevant equipment calibration documents are provided as Appendix A.

5.h Sample Calculations

Sample calculations are provided in Appendix B.

5.i Field Data Sheets

Field documents relevant to the emissions test program are presented in Appendix C.

5.j Laboratory Data

All analysis was done live through the use of online Analyzers and as such there is no laboratory data. Raw analyzer data is provided in Appendix D.

Tables

Table 4
North/South Exhaust Average
NOx, CO, and VOC Emission Rates
Western Michigan University
Kalamazoo, MI

MAQS Project No. **049AS-541981**
Sampling Date: **2/27/2019**

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	2/27/2019	2/27/2019	2/27/2019	
Test Run Time	13:08-13:38, 13:43-14:13	14:44-15:14, 15:18-15:48	16:12-16:42, 16:47-17:17	
Oxygen Concentration (%)	0	0	0	**0.0**
Oxygen Concentration (%, drift corrected as per USEPA 7E)	0.0	0.0	0.0	**0.0**
Outlet Oxides of Nitrogen Concentration (ppmv)	202.9	171.9	131.4	**168.7**
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	200.1	170.0	127.1	**165.8**
Outlet NOx Concentration (ppmv, corrected to 15% O_2)	**56.4**	**47.9**	**35.9**	**46.7**
Outlet Carbon Monoxide Concentration (ppmv)	373.8	439.0	368.5	**393.8**
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	372.9	436.5	366.4	**391.9**
Outlet CO Concentration (ppmv, corrected to 15% O_2)	**105.1**	**123.1**	**103.4**	**110.5**
Outlet VOC Concentration (ppmv as propane)	74.5	76.9	74.9	**75.4**
Outlet Methane Concentration (ppmv as methane)	186.9	200.6	175.9	**187.8**
Outlet VOC Concentration (ppmv, corrected as per USEPA 7E)	72.6	73.5	71.9	**72.7**
Outlet Methane Concentration (ppmv, corrected as per USEPA 7E)	186.5	203.0	177.4	**189.0**
Outlet VOC Concentration (ppmv propane, -Methane)	-6.8	-10.3	-1.6	**-6.2**
Outlet VOC Concentration (ppmv propane, -Methane, corrected to 15%O2)	**-1.9**	**-2.9**	**-0.4**	**-1.8**
Outlet VOC Concentration (ppmv propane, -Methane, corrected as per USEPA 7E)	-8.5	-14.7	-5.2	**-9.5**
Outlet VOC Concentration (ppmv propane, -Methane, corrected as per USEPA 7E, corrected to 15%O2)	**-2.4**	**-4.2**	**-1.5**	**-2.7**

ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CO = 28.01, NOx = 46.01, SO_2 = 64.05, C_3H_8 = 44.10, carbon = 12.01)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
Response factor obtained from introducing propane into methane analyzer: **2.3**

Co= Average of initial and final zero gases
Cma=Actual concentration of the calibration gas
Cm= Average of initial and final calibration gases
$C_c=KC_{meas}$
where Cc = Concentration as Carbon (ppmv), K= Carbon equivalent correction factor (3 for Propane)
and C_{meas} = concentration as measured (as propane)

Equations
lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * ***scfm*** * 60 *for* VOC
lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * ***dcfm*** * 60
$Conc_{@15\%O2}$ = Conc * (20.9 -15)/(20.9 - $\%O_2$)

Figures

MONTROSE
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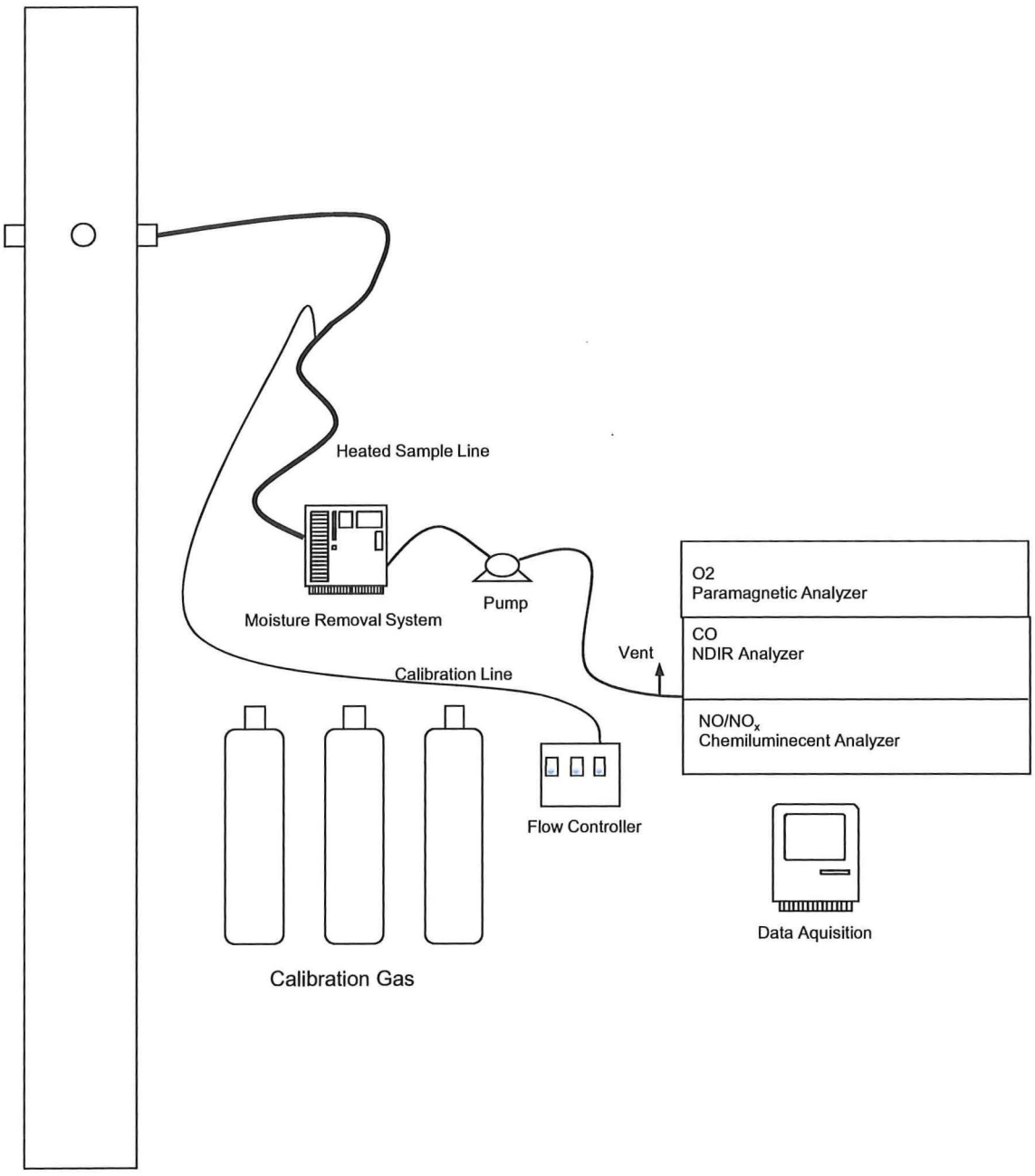

Figure 1

Site: **USEPA Method 3A/7E/10** **Western Michigan University** **Sangren Hall Emergency Generator Test**	**Sampling Date:** **February 27, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

MONTROSE
AIR QUALITY SERVICES

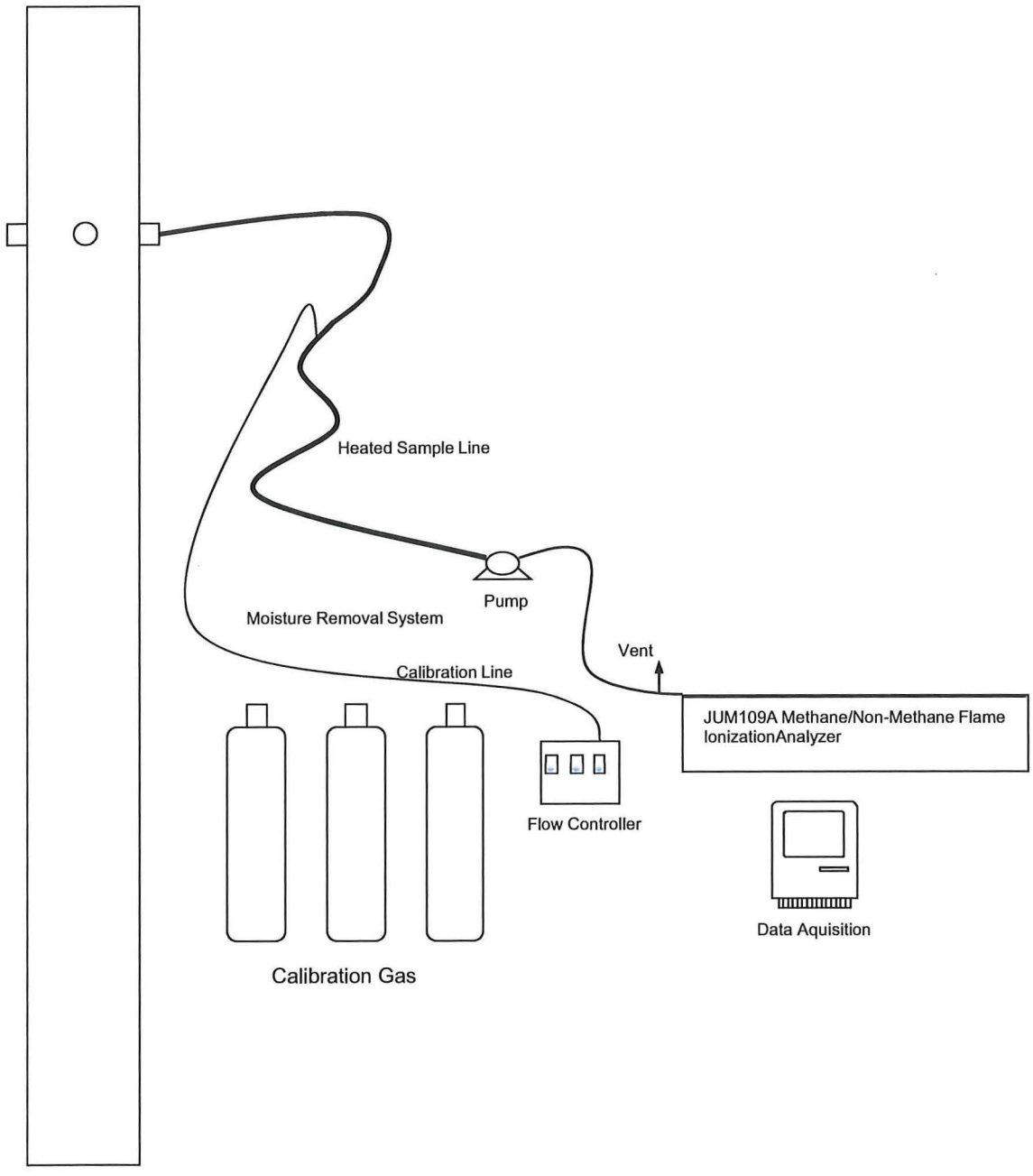

Figure 2

Site: **USEPA Method 25A** **Western Michigan University** **Sangren Hall Emergency Generator Test**	**Sampling Date:** **February 27, 2019**

Montrose Air Quality Services, LLC
4949 Fernlee Avenue
Royal Oak, MI 48073

Appendix A
Equipment Calibration and Span Gas Documents

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/27/2019	Analyzer:	Thermo Electron
Client:	Western Mi Univ	Serial #:	42CHL-62301-334
Unit:	Sangren Hall Generator	Span:	450.00
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS
Calibration Gas:	NOx	Concentration:	225.00 450.00
Cylinder #:	XCOO2707 XCOO2707B	Units:	ppm
Zero Gas:	Nitrogen		

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Span) *
Zero Gas	0.00	1.02	1.02	0.23
Mid Gas	225.00	231.64	6.64	1.48
High Gas	450.00	449.53	0.47	0.10

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/27/2019	Analyzer:	M&C
Client:	Western Mi Univ	Serial #:	0502189
Unit:	Sangren Hall Generator	Span:	20.08
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS
Calibration Gas:	O2	Concentration:	10.08 20.08
Cylinder #:	CC150947 CC469695	Units:	%
Zero Gas:	Nitrogen		

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Span) *
Zero Gas	0.00	0.00	0.00	0.00
Mid Gas	10.08	9.97	0.11	0.55
High Gas	20.08	19.85	0.23	1.15

* Eq. 7E-1

$$ACE = \frac{(Cdir - Cv)}{CS} \times 100$$

Where:

ACE = Analyzer calibration error, % of span
Cdir = Measured concentration of a cal gas when introduced in direct cal mode
Cv = Manufacturer certified concentration of cal gas
CS = Calibration Span

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/27/2019	Analyzer:	Teledyne 300EM
Client:	Western Mi Univ	Serial #:	266
Unit:	Sangren Hall Generator	Span:	750.00
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS
Calibration Gas:	CO	Concentration:	375.00 750.00
Cylinder #:	CC469121 CC469121	Units:	PPM
Zero Gas:	Nitrogen		

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Span) *
Zero Gas	0.00	2.12	2.12	0.28
Mid Gas	375.00	385.27	10.27	1.37
High Gas	750.00	756.10	6.10	0.81

* Eq. 7E-1

$$ACE = \frac{(Cdir - Cv)}{CS} \times 100$$

Where:

ACE = Analyzer calibration error, % of span
Cdir = Measured concentration of a cal gas when introduced in direct cal mode
Cv = Manufacturer certified concentration of cal gas
CS = Calibration Span

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/27/2019	Analyzer:	J.U.M. Engineering 109L-2
Client:	Western Mi Univ	Serial #:	06111923-99
Unit:	Sangren Hall Generator	Span:	300.00
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS
Calibration Gas:	Propane	Concentration:	300.00
Cylinder #:	CC216760 CC216760 CC216760	Units:	PPM
Zero Gas:	Air		

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Cylinder) *
Zero Gas	0.00	0.76	0.76	0.25
Low Gas	90.00	89.88	0.12	0.13
Mid Gas	150.00	149.75	0.25	0.17
High Gas	300.00	297.92	2.08	0.69

ANALYZER CALIBRATION ERROR CHECK DATA

Test Date:	2/27/2019	Analyzer:	J.U.M. Engineering 109L-2
Client:	Western Mi Univ	Serial #:	06111923-99
Unit:	Sangren Hall Generator	Span:	500.00
Sample Location:	Exhaust	Recorder Range:	-5 to 95% FS
Calibration Gas:	Methane	Concentration:	500.00
Cylinder #:	EB0013277 EB001327 EB001327	Units:	PPM
Zero Gas:	Air		

	Cylinder Value ppm	Analyzer Response ppm	Absolute Difference ppm	Difference (% of Cylinder) *
Zero Gas	0.00	0.27	0.27	0.05
Low Gas	150.00	145.90	4.10	2.73
Mid Gas	250.00	251.94	1.94	0.78
High Gas	500.00	501.66	1.66	0.33

* Eq. 7E-1

$$ACE = \frac{(Cdir - Cv)}{CS} \times 100$$

Where:

ACE = Analyzer calibration error, % of span
Cdir = Measured concentration of a cal gas when introduced in direct cal mode
Cv = Manufacturer certified concentration of cal gas
CS = Calibration Span

CEMS DRIFT CALCULATION SPREAD SHEET

Client: Western Mi Univ
Source: Sangren Hall Generator
Date: 2/27/2019

Span:		450.00 NOx	20.08 O2	750.00 CO	300.00 VOC	500.00 Methane		450.00 NOx	20.08 O2	750 CO	300 VOC	500 Methane		NOx	CO
Calibration Gas Value =		225.00	10.08	375.00	150.00	250.00		225	10.08	375	150	250		lbs/mmbtu	lbs/mmbtu
Run #1 Initial Zero Bias Value =		4.6	0.03	2.16	0.63	2.12	analyzer	1.02	0.00	2.12	0.76	0.27			
Run #1 Initial System Bias Value =		229.38	9.67	373.67	152.1	253.7	system	1.53	0.03	2.11	0.71	-0.09			
Run #1 Average =		202.90	0.00	373.80	74.45	186.93							**RUN 1**	0.2078	0.235736
Run #1 Final Zero Bias Value =		1.53	0.03	2.11	0.71	-0.09	analyzer	231.64	9.97	385.27	149.75	251.94			
Run #1 Final System Bias Value =		226.13	9.87	378.04	154.03	246.75	system	226.13	9.87	378.04	154.03	246.75			
Run #1 Total Drift Corrected =		200.11	-0.03	372.94	72.62	186.50		F Factor =					8710		
zero calibration drift =	3%	-0.68	0.00	-0.01	0.03	-0.44	zero bias	0.11	0.15	0.00	-0.02	-0.07	5% allowed		
calibration drift =		-0.72	1.00	0.58	0.64	-1.39	span bias	-1.22	-0.50	-0.96	1.43	-1.04			
Run #2 Initial Zero Bias Value =		1.53	0.03	2.11	0.71	-0.09	analyzer	1.02	0	2.12	0.76	0.27			
Run #2 Initial System Bias Value =		226.13	9.87	378.04	154.03	246.75	system	1.27	0.02	2.40	0.70	1.46			
Run #2 Average =		171.87	0.00	439.00	76.94	200.57							**RUN 2**	0.1766	0.275967
Run #2 Final Zero Bias Value =		1.27	0.02	2.4	0.7	1.46	analyzer	231.64	9.97	385.27	149.75	251.94			
Run #2 Final System Bias Value =		227.81	9.86	376.94	158.35	246.86	system	227.81	9.86	376.94	158.35	246.86			
Run #2 Total Drift Corrected =		170.04	-0.03	436.47	73.55	203.04		F Factor =					8710		
zero calibration drift =		-0.06	-0.05	0.04	0.00	0.31	zero bias	0.06	0.10	0.04	-0.02	0.24			
calibration drift =		0.37	-0.05	-0.15	1.44	0.02	span bias	-0.85	-0.55	-1.11	2.87	-1.02			
Run #3 Initial Zero Bias Value =		1.27	0.02	2.4	0.7	1.46	analyzer	1.02	0	2.12	0.76	0.27			
Run #3 Initial System Bias Value =		227.81	9.86	376.94	158.35	246.86	system	11.53	0.01	2.14	0.71	1.80			
Run #3 Average =		131.43	0.00	368.52	74.88	175.86							**RUN 3**	0.1321	0.231778
Run #3 Final Zero Bias Value =		11.53	0.01	2.14	0.71	1.8	analyzer	231.64	9.97	385.27	149.75	251.94			
Run #3 Final System Bias Value =		227.58	9.87	377.29	152.48	247.47	system	227.58	9.87	377.29	152.48	247.47			
Run #3 Total Drift Corrected =		127.12	-0.02	366.40	71.92	177.40		F Factor =					8710		
zero calibration drift =		2.28	-0.05	-0.03	0.00	0.07	zero bias	2.34	0.05	0.00	-0.02	0.31			
calibration drift =		-0.05	0.05	0.05	-1.96	0.12	span bias	-0.90	-0.50	-1.06	0.91	-0.89			

Drift Correction calculation $$C_{gas} = (C - C_o)\frac{C_{ma}}{C_m - C_o}$$

Where:
Cgas =effluent gas concentration, dry basis, ppm
C = avg. gas concentration indicated by analyzer, dry basis, ppm
Co = avg. of initial and final system calibration bias check for the zero gas
Cm = avg. of initial and final system calibration bias check for the upscale calibration gas
Cma = actual concentration of the upscale calibration gas, ppm

Revision 4.0
7-29-16 BC

Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
Troy, MI 48083
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E02NI99E15A0403	Reference Number:	32-400926418-1
Cylinder Number:	CC469121	Cylinder Volume:	144.3 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62017	Valve Outlet:	350
Gas Code:	CO,BALN	Certification Date:	Jun 20, 2017

Expiration Date: Jun 20, 2025

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON MONOXIDE	800.0 PPM	792.3 PPM	G1	+/- 1% NIST Traceable	06/20/2017
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	05-1620	KAL004479	970.00 PPM CARBON MONOXIDE/NITROGEN	+/-0.36%	May 14, 2021

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
E/N 54 Nicolet 6700 CO	FTIR	Jun 15, 2017

Triad Data Available Upon Request

Approved for Release

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E02NI99E15A0919	Reference Number:	32-400584495-1
Cylinder Number:	XC002707B	Cylinder Volume:	144.4 CF
Laboratory:	MIC - Royal Oak-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62015	Valve Outlet:	660
Gas Code:	NO,NOX,BALN	Certification Date:	Aug 27, 2015

Expiration Date: Aug 27, 2023

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
NOX	500.0 PPM	499.7 PPM	G1	+/- 0.7% NIST Traceable	08/20/2015, 08/27/2015
NITRIC OXIDE	500.0 PPM	499.7 PPM	G1	+/- 0.7% NIST Traceable	08/20/2015, 08/27/2015
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	15060327	CC448287	241.0 PPM NITRIC OXIDE/NITROGEN	+/-0.4%	Mar 30, 2021
PRM	12329	726612	25.02 PPM NITROGEN DIOXIDE/NITROGEN	+/- 1.5%	Oct 15, 2014
GMIS	812201409	CC500636	15.04 PPM NITROGEN DIOXIDE/NITROGEN	+/-2.0%	Aug 12, 2017

The SRM, PRM or RGM noted above is only in reference to the GMIS used in the assay and not part of the analysis.

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
E/N 54 Nicolet 6700 NO	FTIR	Aug 11, 2015
E/N 54 Nicolet 6700 NO2	FTIR	Aug 14, 2015

Triad Data Available Upon Request

Signature on file

Approved for Release

Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
Troy, MI 48083
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E04NI99E15A0443	Reference Number:	32-401211740-1
Cylinder Number:	XC016294B	Cylinder Volume:	144.4 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62018	Valve Outlet:	660
Gas Code:	CO,NO,NOX,SO2,BALN	Certification Date:	Jun 01, 2018

Expiration Date: Jun 01, 2026

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
NOX	90.00 PPM	91.37 PPM	G1	+/- 1.4% NIST Traceable	05/25/2018, 06/01/2018
CARBON MONOXIDE	90.00 PPM	89.66 PPM	G1	+/- 0.6% NIST Traceable	05/25/2018
NITRIC OXIDE	90.00 PPM	91.36 PPM	G1	+/- 1.4% NIST Traceable	05/25/2018, 06/01/2018
SULFUR DIOXIDE	90.00 PPM	90.10 PPM	G1	+/- 1.1% NIST Traceable	05/25/2018, 06/01/2018
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	090102-42	KAL004895	98.48 PPM CARBON MONOXIDE/NITROGEN	+/- 0.5%	Jan 14, 2019
PRM	12376	D562879	10.01 PPM NITROGEN DIOXIDE/AIR	+/-2.0%	Aug 17, 2018
NTRM	130104	KAL004168	97.60 PPM NITRIC OXIDE/NITROGEN	+/- 0.8%	May 09, 2019
GMIS	124206889142	CC322843	4.613 PPM NITROGEN DIOXIDE/NITROGEN	+/-2.0%	Oct 20, 2020
NTRM	11010409	KAL004782	99.6 PPM SULFUR DIOXIDE/NITROGEN	+/- 0.8%	Jul 28, 2023

The SRM, PRM or RGM noted above is only in reference to the GMIS used in the assay and not part of the analysis.

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
E/N 54 Nicolet 6700 CO	FTIR	May 07, 2018
E/N 54 Nicolet 6700 NO	FTIR	May 11, 2018
E/N 54 Nicolet 6700 NO2	FTIR	May 11, 2018
E/N 54 Nicolet 6700 SO2	FTIR	May 11, 2018

Triad Data Available Upon Request

Approved for Release

Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
Troy, MI 48083
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E03NI80E15A0138	Reference Number:	32-401287020-1
Cylinder Number:	CC469695	Cylinder Volume:	150.9 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62018	Valve Outlet:	590
Gas Code:	CO2,O2,BALN	Certification Date:	Aug 28, 2018

Expiration Date: Aug 28, 2026

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON DIOXIDE	10.00 %	10.07 %	G1	+/- 1% NIST Traceable	08/28/2018
OXYGEN	10.00 %	10.08 %	G1	+/- 1% NIST Traceable	08/28/2018
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	08010629	K016293	13.94 % CARBON DIOXIDE/NITROGEN	+/-0.6%	Jan 30, 2024
NTRM	100106	K015462	9.967 % OXYGEN/NITROGEN	+/-0.3%	Apr 19, 2022

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
CO2 SIEMENS ULTRAMAT 6 E/N 173	Nondispersive Infrared(NDIR)	Aug 13, 2018
O2 FS, SIEMENS OXYMAT 6 E/N 182	Paramagnetic	Aug 20, 2018

Triad Data Available Upon Request

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Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
Troy, MI 48083
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E03NI60E15A0286	Reference Number:	32-401287021-1
Cylinder Number:	CC150947	Cylinder Volume:	159.6 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62018	Valve Outlet:	590
Gas Code:	CO2,O2,BALN	Certification Date:	Aug 27, 2018

Expiration Date: Aug 27, 2026

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON DIOXIDE	20.00 %	20.05 %	G1	+/- 1% NIST Traceable	08/27/2018
OXYGEN	20.00 %	20.08 %	G1	+/- 1% NIST Traceable	08/27/2018
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	12061526	CC354795	19.87 % CARBON DIOXIDE/NITROGEN	+/-0.6%	Jan 11, 2024
NTRM	10010924	K021247	20.89 % OXYGEN/NITROGEN	+/-0.5%	Jun 27, 2022

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
CO2 SIEMENS ULTRAMAT 6 E/N 173	Nondispersive Infrared(NDIR)	Aug 13, 2018
O2 FS, SIEMENS OXYMAT 6 E/N 182	Paramagnetic	Aug 20, 2018

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Airgas
an Air Liquide company

Airgas Great Lakes region
Airgas USA, LLC
1290 Combermere Dr.
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CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E02AI99E15A0563	Reference Number:	32-401352171-1
Cylinder Number:	CC216760	Cylinder Volume:	146.3 CF
Laboratory:	112 - Troy-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62018	Valve Outlet:	590
Gas Code:	PPN,BALA	Certification Date:	Nov 30, 2018

Expiration Date: Nov 30, 2026

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
PROPANE	900.0 PPM	895.5 PPM	G1	+/- 1.0% NIST Traceable	11/30/2018
AIR	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	05-1386	ALM008872	1193 PPM PROPANE/AIR	+/-1.0%	Jul 01, 2019

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
E/N 54 Nicolet 6700 C3 2500 PPM	FTIR	Nov 27, 2018

Triad Data Available Upon Request

Approved for Release

Airgas

Airgas USA, LLC
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ROYAL OAK, MI 48067
248-399-8020
www.airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Customer:	BT ENVIRONMENTAL CONSULTING		
Part Number:	E02AI99E15A1928	Reference Number:	32-400445518-1
Cylinder Number:	EB0013277	Cylinder Volume:	146.2 CF
Laboratory:	MIC - Royal Oak-32 (SAP) - MI	Cylinder Pressure:	2015 PSIG
PGVP Number:	B62014	Valve Outlet:	590
Gas Code:	CH4,BALA	Certification Date:	Oct 29, 2014

Expiration Date: Oct 29, 2022

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
METHANE	920.0 PPM	933.9 PPM	G1	+/- 1.0% NIST Traceable	10/29/2014
AIR	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	11061204	CC2197	985.2 PPM METHANE/AIR	+/- 0.6%	May 25, 2017

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
E/N 54 Nicolet 6700 CH4	FTIR	Oct 03, 2014

Triad Data Available Upon Request

Approved for Release

Appendix B
Example Calculations

Example Calculations

Correction of Test Run Average Concentrations:

$$C_{gas} = (C_{avg} - C_o)\frac{C_{ma}}{C_m - C_o}$$

Where:

C_{gas} = Effluent gas concentration, dry basis
C_{avg} = Average gas concentration indicated by gas analyzer, dry basis
C_o = Average of initial and final system calibration bias check responses for the zero gas
C_m = Average of initial and final system calibration bias check responses for the upscale calibration gas
C_{ma} = Actual concentration of the upscale calibration gas

For example, for the NOx concentration on Cummins Emergency Generator Set, Test Run No. 3, the parameters were as follows:

Average NOx concentration, uncorrected = 131.43 ppm
Initial NOx Zero calibration Response = 1.27 ppm
Final NOx Zero calibration Response = 11.53 ppm
Actual concentration of the upscale calibration gas = 225.0 ppm
Initial system calibration response for the upscale calibration gas = 227.81 ppm
Final system calibration response for the upscale calibration gas = 227.58 ppm

Consequently, the NOx concentration for Cummins Emergency Generator Set, Test Run No. 3, is as follows:

$$\left[131.43 - \left(\frac{1.27 + 11.53}{2}\right)\right]\left[\frac{225.0}{\left(\frac{227.81 + 227.58}{2}\right) - \left(\frac{1.27 + 11.53}{2}\right)}\right] = 127.12\,ppmv$$

Example Calculations

Correction of Emissions Averages to 15% O_2

$$C_{corrected} = (C_{avg}) \frac{(20.9 - 15.0)}{(20.9 - O_2)}$$

Where:

$C_{corrected}$ = Gas concentration, corrected to 15% O_2
C_{avg} = Average gas concentration, dry basis
O_2 = Measured Oxygen concentration (percentage basis)

For example, for NOx concentration for Cummins Emergency Generator Set, Test Run No. 3, the Oxygen measured was 0.0% post drift correction. The NOx concentration was measured at 127.12 ppmv dry. NOx corrected to 15% O_2 was then calculated as follows:

$$127.12\,ppmv \frac{(20.9 - 15)}{(20.9 - 0)} = 35.89\,ppmv$$

Appendix C
Field Data Sheets and Field Notes

BTEC Inc. CEM Calibration Field Data Sheet

Client WMI
Date 2/26/19
Analyzer #'s 6118

Operator TW
Sampling Location

Range						
Cyinder Values						Environics # yes / no
Time	Pollutant NOx	Pollutant NO	Pollutant NO2	Pollutant CO	Pollutant	Notes: Run/Cal Info & File Name
15:47	90.6					
15:49:30	50.1					
15:52	0.7					
16:00	82.7	81	1.7			Bag on for converter check
16:16				403		
16:18:30				200		
16:22				403		
16:25:30				197		
16:29				404		
16:30	81.5	25.9	56			END NOx converter check
16:33				197		
16:38				2.2		
16:46:30	90.4			89.1		Audit bottle
16:50	0.7			2.3		
16:54				89.2		Audit bottle
16:57				2.3		
17:02				89.1		Audit bottle

Cylinder Serial Numbers

Audit cylinder = 89.46 ppm CO = XC016294B
91.37 NOx
499.7 NOx = XC002707B

Revision 3.0
KL 1/6/14

BTEC Inc. CEM Calibration Field Data Sheet

Client WM4
Date 2/27/19
Analyzer #'s 2, 6, 14, 18

Operator JW, SR
Sampling Location Sangren Hall Generator

Range						
Cylinder Values						Environics # yes / no
Time	Pollutant NO_x	Pollutant O_2	Pollutant CO	Pollutant CO_2	Pollutant THC CH_4	Notes: Run/Cal Info & File Name
7:12	90.1	0.02	1.5	0.05	1.7 - 1.4	90 NOx
7:15	49.9	0.02	1.5	0.04	1.5 0.1	50 NOx
7:20	0.3	0.01	402	2.3	1.4 0	400 CO
7:23	0.3	0.00	195			200 CO
7:29	0.1	0.00	196	1.8	1.4 0.03	200 CO
7:33	0.00	19.84	1.5	-4	1.4 -0.09	20% O2
7:37	0.00	9.96	1.5	-3	1.5 -0.23	10% O2
7:48	0	19.9	2	0	299.5 0.25	300 propane
7:51	0	20.4	2	0	150 0.6	150
7:53	0	20.5	1.8	0.01	89.9 0.5	90 propane
7:57	0	20.5	1.6	0.03	211.7 501	500 Methane
8:00	0	20.5	1.6	0.03	108 251	250 Methane
8:03	0	20.5	1.6	0.01	102.8 146	150 Methane
8:08	0.00	0.06	202	1.8	0.86 -1.8	200 CO BIAS ✓
8:13	49.4	0.04	1.8	0.03	0.74 - 1.5	50 NOX BIAS ✓
8:20	0.6	9.91	1.4	-3	2.5 0.77	10% O2 BIAS ✓
12:26	449.4	0.01	1.08			450 NOx
12:30	232	0	2.13			225 NOx
12:34	2.0	0.00	755	THC	CH_4	750 CO
12:37	1.0	0.00	385			375 CO
12:45	2.4	0	373			375 CO BIAS ✓
12:52	12.5	9.66	2.18	0.6	3.3	10% O2 BIAS

Cylinder Serial Numbers

B95.5 propane = CC216760 792.3 CO = CC469191
91.37, 89.66 = XC0162948 933.9 CH_4 = EB0013277
20.08% O_2 = CC150947 499.7 NOx = XC002707B
10.08% O_2 = CC469695

Revision 3.0
KL 1/6/14

BTEC Inc. CEM Calibration Field Data Sheet

Client WMU
Date 2/27/19
Analyzer #'s 2, 6, 14, 18

Operator TW SR
Sampling Location Sangren Hall Generator

Range						
Cyinder Values						Environics # yes / no
Time	Pollutant NO_x	Pollutant O_2	Pollutant CO	Pollutant THC	Pollutant CH_4	Notes: Run/Cal Info & File Name
12:56	229	0.03	2.7	0.85	2.6	225 NOx BIAS
13:00	160	20.07	2.7	152	2.0	150 THC
13:03	4.5	20.2	3.1	1068	254	250 Methane
13:08	135	0	432	81.9	240	START Run #1 S[redacted] Port / Stack
13:43	190	0	2846	97.8	195	North port / stack
14:19	1.5	20.3	2.36	104	215	250 Methane
14:22	1.5	20.3	2.1	106	226	250 Methane
14:24	1.5	20.1	3.4	1539	29	150 Propane
14:28	1.5	20.3	2.3	107	243.4	250 Methane
14:33	225.9	0.04	2.1	0.95	-0.02	225 NOx
14:37	3.5	0.03	378	0.84	-0.19	375 CO
14:40	3.5	9.87	2.65	0.69	2.6	10% O2
14:44	144	0.00	381	79	288	START Run 2 North Port / Stack
15:18	144.9	0.00	931	82.7	209	Stack South Stack
15:52	1.62	9.89	2.67	0.83	2.31	10% O2
15:56	1.5	0.02	376	0.67	1.5	375 CO
16:00	227	0.02	2.66	0.75	1.16	225 NOx
16:05	2.0	20.2	2.4	1083.9	246	250 Methane
16:08	2.5	20.05	348	1584	5.7	150 Propane
16:12	1167	0	977	108	217	START Run 3 South Stack
16:47	329	0.00	1546	92.7	149	START North Stack
17:22	13.5	20.1	~~2.1~~ 2.1	152	3.9	150 Propane

Cylinder Serial Numbers

17:27	18	20.3	2.1	108	247	250 Methane
17:33	228	0.04	2.1	0.89	2.0	225 NOx
17:37	12	0.01	377	0.7	1.9	375 CO
17:41	11	9.87	3.1	0.7	2.6	10% O2

Revision 3.0
KL 1/6/14

2/22/19 Method 205 check

Envirotis Set point	Responce
400	404.64
200	197.44
400	404.6
200	196.65
400	405.12
200	196.79
0	2.18
Audit cylinder	89.24
0	2.21
Audit cylinder	89.33
0	2.3
Audit cylinder	89.18

2/27/19 Western MI University, Sangren Hall
Generator Pre Cals

NOx	O2	CO	THC	CH4
0.00	19.85	1.25	1.48	-0.05
0.00	9.97	1.55	1.51	-0.21
0.00	20.1	2.03	297.92	0.27
0.00	20.47	1.95	149.75	0.96
0.00	20.48	1.83	89.88	0.48
0.00	20.52	1.72	211.67	501.66
0.00	20.49	1.69	108.21	251.94
0.00	20.48	1.65	62.88	145.90
0.48	9.91	1.44	0.76	2.4

2/27/19 WWU Sangren Hall Generator

	NO_x	O_2	CO	THC	CH_4	
LE	449.53	0.01	2.12	63.63	141.77	
"	231.64	0.00	2.14	67.27	164.65	1.53, 0.00, 756.1, 49.4, 1379
CE	1.02	0.00	385.27	60.83	136.05	
BIAS	22.94	0.08	373.67	0.82	2.14	
"	12.28	9.67	2.16	0.63	3.33	
"	229.38	0.03	2.93	0.83	2.66	
"	5.82	20.08	2.73	152.10	2.12	
BIAS	4.6	20.25	3.16	106.91	253.7	
(1)	202.9	0.00	373.8	74.45	186.93	
	1.53	20.09	2.94	154.03	2.92	
	2.03	20.31	2.11	107.47	246.75	
	226.13	0.06	2.11	0.94	-0.09	
	3.53	0.03	378.04	0.86	-0.27	
	3.53	9.87	2.76	0.71	2.6	
(2)	171.87	0.00	439	76.94	200.57	
	1.53	9.86	2.53	0.8	2.35	
	1.27	0.02	376.94	0.70	1.46	
	227.31	0.02	2.53	0.76	1.62	
	2.03	20.26	2.4	109.05	246.86	
	2.03	20.07	2.9	158.35	5.69	
(3)	131.43	0.00	368.52	74.88	175.86	
	14.03	20.14	2.28	152.48	3.97	
	16.19	20.27	2.33	108.68	247.47	
	227.58	0.03	2.14	0.85	1.8	
	12.03	0.01	377.29	0.73	1.92	
	11.58	9.87	2.76	0.71	2.6	

Appendix E
Engine Operating Data

Western Michigan University
EU-138-EMERGEN-01

Test Date:	February 27, 2019
Location	Sangren Hall
Engine ID:	EU-138-EMERGEN-01
Engine Serial Number:	CM12A041038

Test Run	Run Times	Average Genset Load (kW)[1]	Engine Hours Meter Reading at Start of Test (hours)	Engine Hours Meter Reading at End of Test (hours)	Engine Run Time during Test (hours)
Test Run #1	13:08-14:13	546	185.1	186.3	1.2
Test Run #2	14:44-15:48	545	186.7	187.85	1.15
Test Run #3	16:12-17:17	546	188.2	189.35	1.15

[1] Load (kW) set by Cummins load bank to operate within 10% of 100% load (within 10% of 600 kW).

Note: Cummins technician set the air-to-fuel ratio by manually adjusting a knob on the engine. Cummins was unable to record the setting of air-to-fuel flow ratio from testing, as discussed with MDEQ while on-site.