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

MONTROSE
AIR QUALITY SERVICES

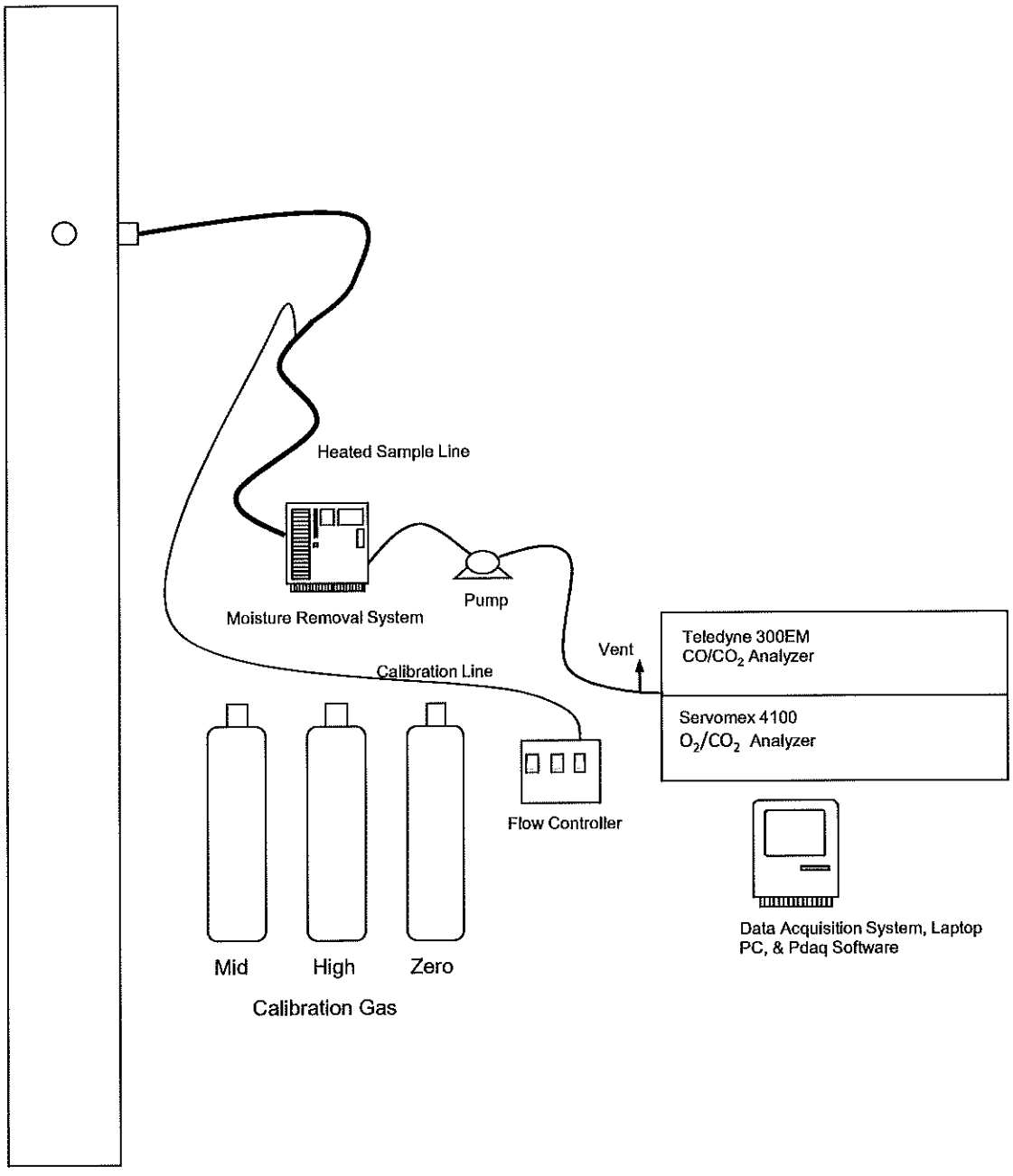
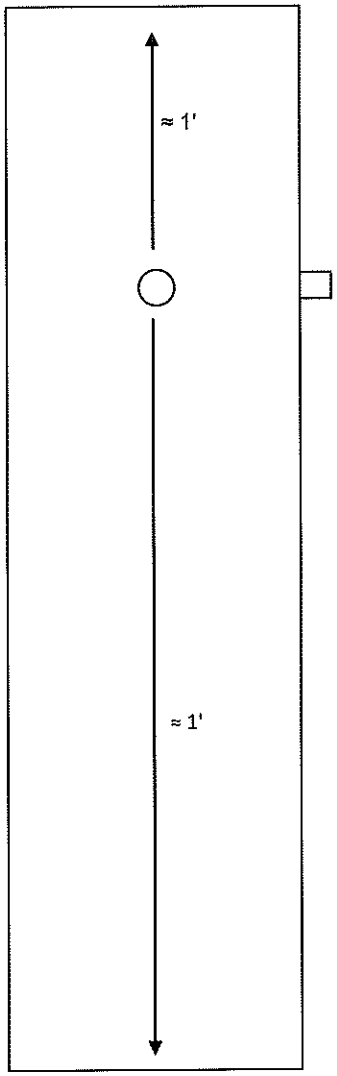


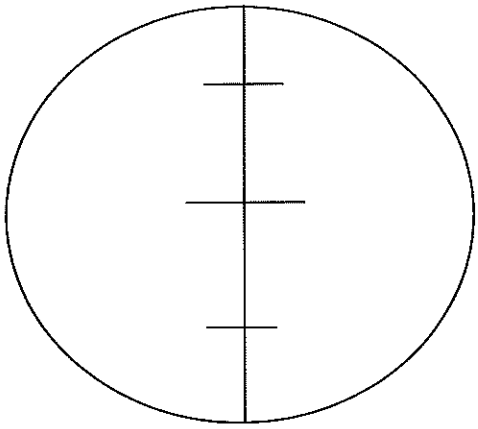
Figure No. 1

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**

MONTROSE
AIR QUALITY SERVICES

STACK DIAMETER = 9"





Not to Scale

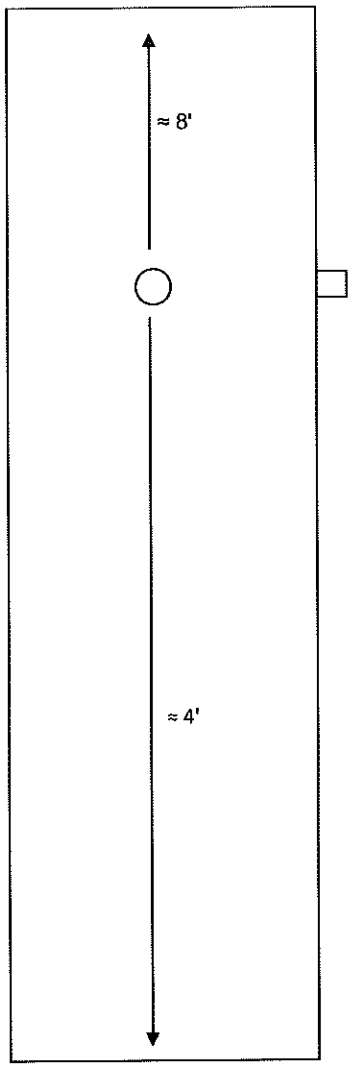
Points	Distance "
1	1.50
2	4.50
3	7.50

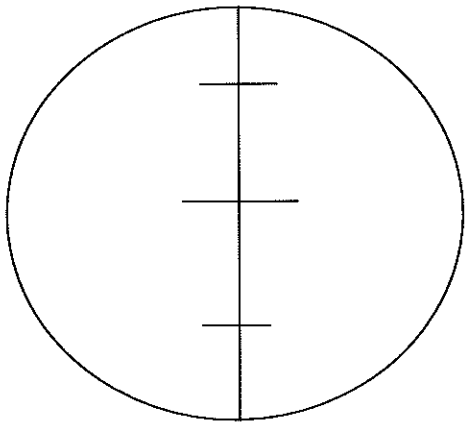
Figure No. 2

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**

MONTROSE
AIR QUALITY SERVICES

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**