BTEC Inc.

CO Destruction Efficiency Test Summary Report

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Prepared for:

Western Michigan University

Western Michigan University
Robert M Beam Power Plant
1903 West Michigan Ave
Kalamazoo, Michigan 49008

Project No. 14-4649.00
January 30, 2015

BT Environmental Consulting, Inc.
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Royal Oak, Michigan 48073
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EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained to perform stack testing at Western Michigan University (WMU) to measure carbon monoxide (CO) and oxygen (O_2) concentrations at the inlet and outlet of a single catalytic converter controlling emissions from a peaking engine at the Robert M. Beam Power Plant located in Kalamazoo, Michigan. On-site testing coordination was provided by NTH Consultants, Ltd. (NTH) on behalf of WMU. The facility operates under Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MI-ROP-K2131-2010a.

The generator set is owned and operated by WMU. 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 an initial compliance demonstration showing either (1) a CO control efficiency across the catalyst bed of at least 93% or (2) an average CO emission rate of less than 47 ppmvd at 15% O_2.

The emissions test program was conducted on January 15, 2015. The results of the emission test program are summarized by Table I.

Table I

Peaking Generator Overall Emission Summary

Test Date: January 15, 2015

Location	Pollutant	Concentration	Destruction Efficiency at 15% O2
Inlet to the catalytic converter	O_2	8.2 %	
	CO	178 ppm at 15% O_2	99.8 %
Outlet of the catalytic converter	O_2	8.5 %	
	CO	0.4 ppm at 15% O_2	99.8 %

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained to perform stack testing Western Michigan University (WMU) to measure carbon monoxide (CO) and oxygen (O_2) concentrations at the inlet and outlet of a single catalytic converter controlling emissions from a peaking engine at the Robert M. Beam Power Plant located in Kalamazoo, Michigan. On-site testing coordination was provided by NTH Consultants, Ltd. (NTH) on behalf of WMU. The facility operates under Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MI-ROP-K2131-2010a.

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The emissions test program was conducted on January 15, 2015. 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" (December 2013). 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 on Stadium Drive at WMU in Kalamazoo, Michigan.

Sampling and analysis for the emission test program was conducted on January 15, 2015.

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 for Initial Compliance

Pollutant	Emission Limit
CO	93 % reduction; or
CO	47 ppm @ 15% O_2

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. Generator set specifications are provided in Appendix D.

Emissions are controlled by a catalytic converter, which reduces the CO concentration by over 99%.

1.d Test Program Contacts

The contact for the source and test report is:

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
Ms. Rhiana Dornbos Sr. Staff Engineer	NTH Consultants, Ltd. 608 S. Washington Ave. Lansing, Michigan 48823	(517) 702-2953
Mr. Todd Wessel Senior Project Manager	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(616) 885-4013
Mr. Paul Diven Environmental Technician	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Tom Gasloli Environmental Quality Analyst	MDEQ Air Quality Division	(517) 284-6778

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 catalyst inlet temperature, pressure, fuel flow and power (kW) produced. Process data is included in Appendix D.

2.b Applicable Permit

The facility operates under MDEQ ROP No. MI-ROP-K2131-2010a; however, the ROP does not currently contain terms and conditions specific to the peaking generator as it was exempt from the requirement to obtain a permit to install pursuant to R 336.1285(g) of Michigan's Air Pollution Control Rules. The test program was conducted as required by 40 CFR 63, Subpart ZZZZ.

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. Generator set specifications are provided in Appendix D.

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. The engine was operated within 10% of 100% load during the entirety of the test event.

3.e Process Instrumentation

Process data monitored during the emissions test program includes catalyst inlet temperature, pressure, fuel flow and power (kW) 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 Teledyne Model 300EM CO gas analyzers, and the O_2 content was measured using 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 Figures 2-3. Three 60-minute test runs were conducted. 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 point in the duct in accordance with Table 4 of Subpart ZZZZ.

4.d Traverse Points

Engine exhaust gas was extracted from the exhaust pipe with the probe tip located at three sample point in the duct in accordance with Table 4 of Subpart ZZZZ.

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: January 15, 2015

Location	Pollutant	Concentration	Destruction Efficiency at 15% O_2
Inlet to the catalytic converter	O_2	8.2 %	
	CO	178 ppm at 15% O_2	99.8 %
Outlet of the catalytic converter	O_2	8.5 %	
	CO	0.4 ppm at 15% O_2	99.8 %

5.b Discussion of Results

BT Environmental Consulting, Inc. (BTEC) was retained by Western Michigan University (WMU) to measure carbon monoxide (CO) and oxygen (O_2) concentrations at the inlet and outlet of a single catalytic converter controlling emissions from a peaking engine at the Robert M. Beam Power Plant located in Kalamazoo, Michigan. The generator set is owned and operated by WMU. 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 an initial compliance demonstration showing either (1) a CO control efficiency across the catalyst bed of at least 93% or (2) an average CO emission rate of less than 47 ppmvd at 15% O_2.

The WMU peaking engine meets both standards documented 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 2
Carbon Monoxide (CO) Emissions Testing Results
Peaking Engine
Western Michigan University
Kalamazoo, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	1/15/2015	1/15/2015	1/15/2015	
Sampling Start Time	9:12 - 10:12	10:30 - 11:30	11:48 - 12:48	
Average Inlet O_2 Concentration (%, dry)	8.12	8.13	8.11	8.12
Average Inlet O_2 Concentration (%, dry, corrected)[1]	8.14	8.20	8.22	8.19
Average Inlet CO Concentration (ppmv, dry)	390.20	391.38	391.15	390.91
Average Inlet CO Concentration (ppmv, dry, corrected)[1]	384.39	384.41	383.13	383.98
Average Inlet CO Concentration (ppmv@15%O2)	177.74	178.58	178.27	178.20
Average Outlet O_2 Concentration (%, dry)	8.70	8.16	8.50	8.45
Average Outlet O_2 Concentration (%, dry, corrected)[1]	8.71	8.17	8.51	8.46
Average Outlet CO Concentration (ppmv, dry)	0.41	0.36	0.50	0.42
Average Outlet CO Concentration (ppmv, dry, corrected)[1]	0.87	0.75	0.85	0.82
Average Outlet CO Concentraton (ppmv@15%)	0.42	0.35	0.40	0.39
CO Destruction Efficiency	**99.8%**	**99.8%**	**99.8%**	**99.8%**

[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

BTEC Inc.

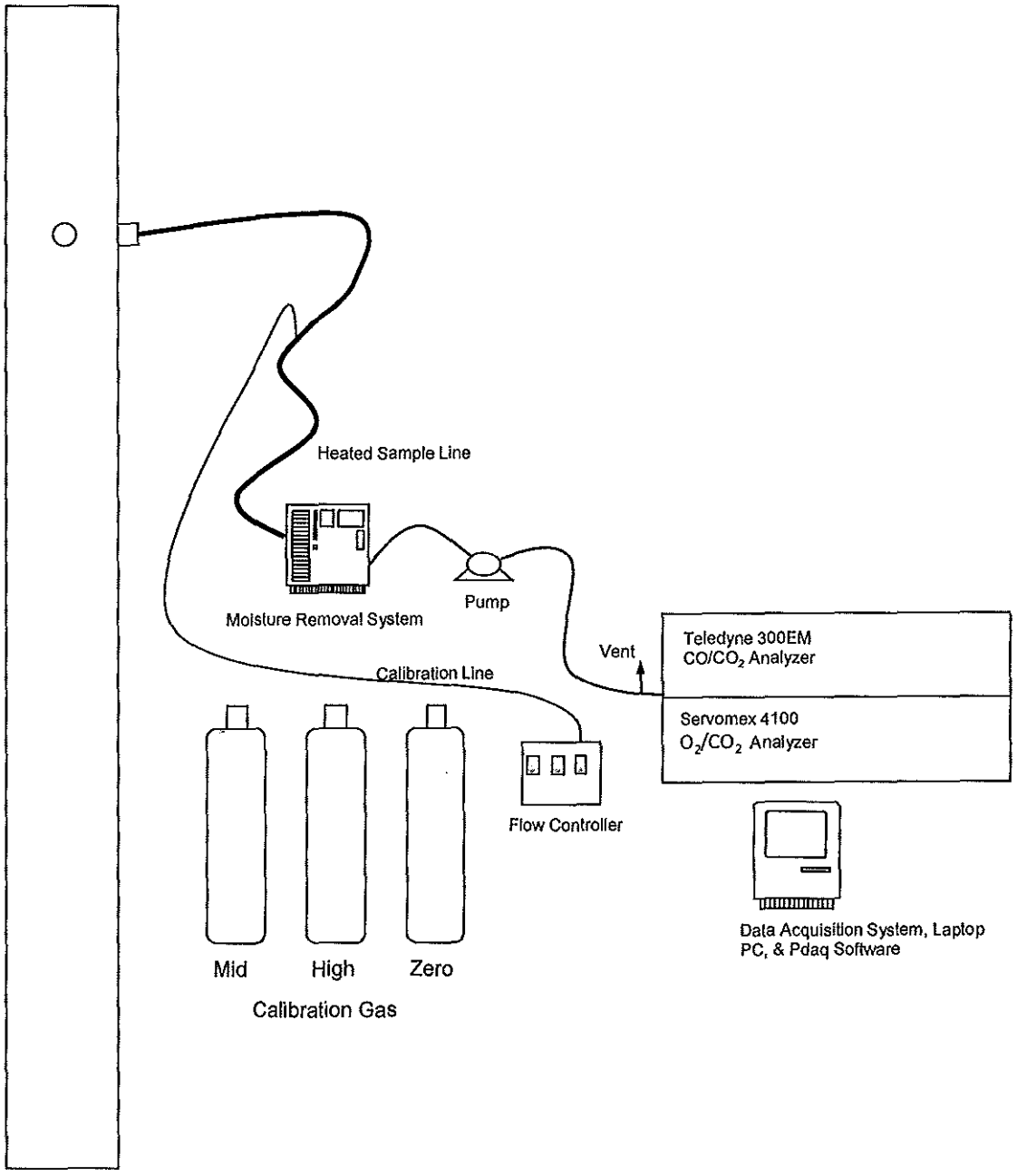

Figure No. 1

Site: **USEPA Method 3A and 10** **Western Michigan University** **Kalamazoo, Michigan**	**Sampling Date:** **January 15, 2015**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

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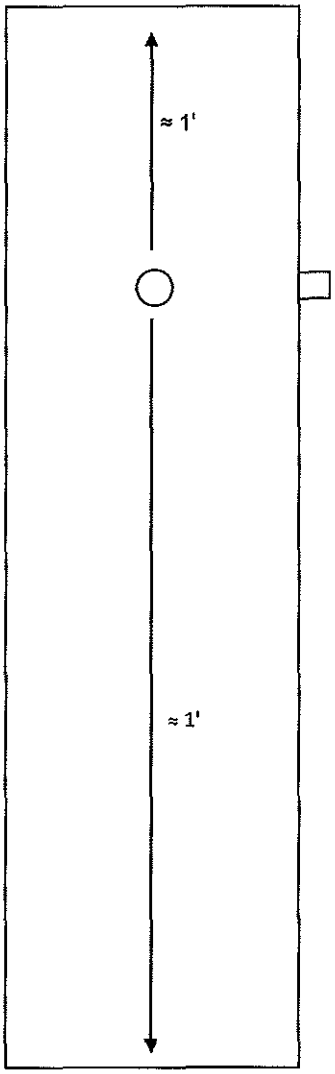
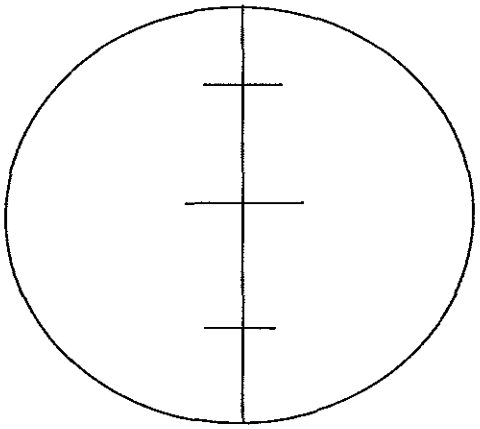
STACK DIAMETER = 9"





Not to Scale

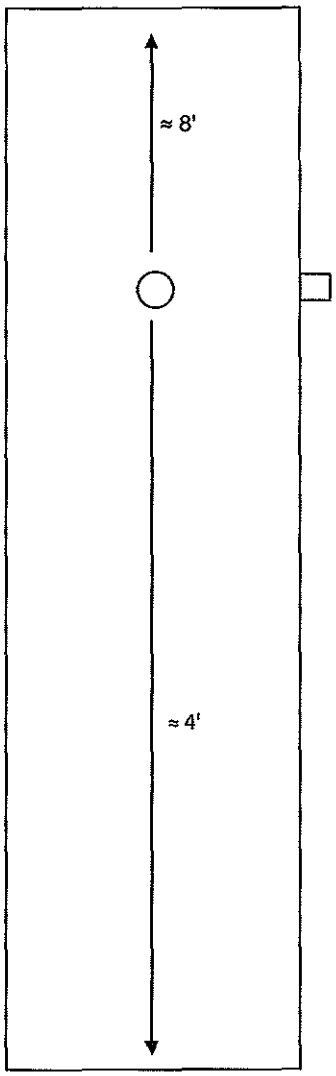
Points	Distance "
1	1.50
2	4.50
3	7.50

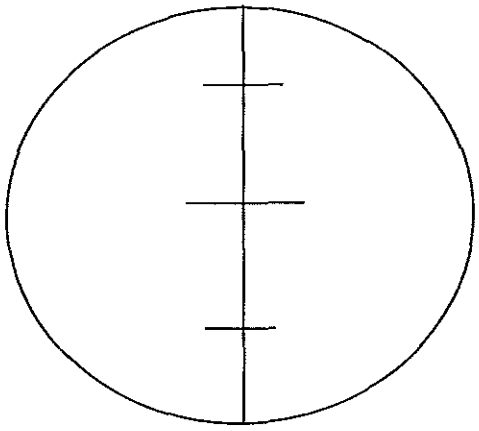
Figure No. 2

Site: **Peaking Generator Inlet** **Western Michigan University** **Kalamazoo, Michigan**	**Sampling Dates:** **January 15, 2015**	**BT Environmental Consulting, Inc.** **4949 Fernlee Ave.** **Royal Oak, Michigan**

BTEC Inc.

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:** **January 15, 2015**	**BT Environmental Consulting, Inc.** **4949 Fernlee Ave.** **Royal Oak, Michigan**