BTEC Inc.

TecoChill Ch-200X Water Chiller Engine Emissions Test Report

Prepared for:

Wayne State University

Detroit, Michigan

Engine Location: WSU Computer Services
5925 Woodward Avenue
Detroit, Michigan

WSU Project No. 193-228857
BTEC Project No. 13-4453.00
December 4, 2013

BT Environmental Consulting, Inc.
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(248) 548-8070

BTEC Inc.

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Wayne State University (WSU) to evaluate emission rates from a new chiller engine located at the WSU Computer Services building at 5925 Woodward Avenue in Detroit, Michigan.

Testing consisted of triplicate 60-minute test runs. Because the engine qualifies for exemption from permitting pursuant to R 336.1285(g) and R 336.1212(4)(d), it is not included in a permit. 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 engine are summarized in Table E-I in addition to test program summary results.

Table E-I
Wayne State University
Computer Services Building Chiller Engine
Compliance Test Program Results Summary

Source	Pollutant	Test Result (ppmv @15%/O_2)	Emission Limitation (ppmv @15%/O_2)
Tecochill Ch-200X	NOx	1	82
	CO	23	270
	VOC	1	60

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1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Wayne State University (WSU) to evaluate emission rates from a new chiller engine located at the WSU Computer Services building at 5925 Woodward Avenue in Detroit, Michigan.

The Air Quality Division (AQD) of the Michigan Department of Environmental Quality (MDEQ) has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (February 2008, see Appendix A). 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 October 14, 2013 at 5925 Woodward Avenue in Detroit, Michigan. The purpose of this report is to document the results of the emissions determined during the compliance test program.

1.b Purpose of Testing

The engine driven chiller unit is owned and operated by WSU. Because the engine qualifies for exemption from permitting pursuant to R 336.1285(g) and R 336.1212(4)(d), it is not included in a permit. 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.

The purpose of the testing was to quantify emission levels of oxides of nitrogen (NOx), CO, and VOC (as propane). In addition, the concentrations of oxygen (O_2), methane (CH_4), formaldehyde (HCOH), carbon dioxide (CO_2) and moisture in the engine exhaust were measured during the emissions test program.

1.c Test Program Contact

The contact for the test program is:

Mr. Larry S. Fodor, CEM
Wayne State University
5454 Cass Avenue
Detroit, Michigan 48202
(313) 577-4352

1.d Test Personnel

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

2. Summary of Results

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

2.a Operating Data

Operating data monitored during the emissions test program included the following data monitored at 15-minute intervals throughout each emissions test run:

- Engine speed (rpm)
- Engine load (%)
- Fuel valve position (% open)
- Catalytic converter inlet oxygen monitor voltage (mV)
- Catalytic converter outlet oxygen monitor voltage (mV)
- Catalytic converter inlet temperature (^{o}F)
- Catalytic converter outlet temperature (^{o}F)

The monitored values are summarized in the field notes included in Appendix B.

2.b Applicable Permit

The engine qualifies for exemption from permitting pursuant to R 336.1285(g) and R 336.1212(4)(d), it is not included in a permit. 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 2.

2.d Emission Regulation Comparison

Emission limitations and emission test results for the WSU engine are summarized by Table 2. For all three pollutants, engine emission rates were far 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 Model 200X natural gas-fired water chiller unit manufactured by Tecogen Inc. of Waltham, Massachusetts. The chiller unit uses a General Motors 454 cubic inch displacement engine to drive a refrigeration compressor that chills water to set point temperature of 42°F. The chilled water then circulates through a piping system to cool the WSU Computer Services building. The engine is natural gas fired with the amount of cooling supplied by the refrigeration system modulated by automatically varying the engine speed (rpm) based on incoming water temperature. Engine information is provided in Appendix F.

3.b Raw and Finished Materials

The only raw material supplied to the chiller engine is natural gas.

3.c Process Capacity

The chiller is rated for a maximum of 200 tons of refrigeration and the engine is rated at 1.53 MMBtu/hr. Note that the engine/chiller is slightly oversized for the building demand and has had an average load during all operating hours of 31.8% since it was brought online in June 2013. The maximum documented load was approximately 55% on August 2, 2013.

3.d Process Instrumentation

The engine is equipped with process instrumentation necessary to provide each of the values listed in Section 2.a. The engine operating speed varies based on the chilling needs of the building and the engine fuel air ratio is controlled based on the catalyst inlet oxygen content voltage setting.

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 emission test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A) and 40 CFR 63, Appendix A:

- Method 3A - *"Determination of Oxygen and Carbon Dioxide Concentrations in missions from Stationary Sources"*

- Method 320 - *"Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infared Spectroscopy"*

The O_2 content was measured using a M&C Products PMA 100-L O_2 gas analyzer (or equivalent). 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 entered the analyzers. Data was recorded at 4-second intervals on a PC equipped with data acquisition software.

Exhaust gas CO, NO, NO_2, CH_2O, CH_4, C_2H_6 (ethane), C_2H_4(ethylene), and total aliphatic hydrocarbons (as hexane) concentrations were measured by Fourier Transform Infrared (FTIR) spectroscopy. Emissions from the engine were continually purged through the sampling system and FTIR. The sample gas was extracted from the engine exhaust using a heated stainless steel probe, maintained at 191°C. A heated filter box (191°C) connected the probe to the filter assembly to a heated transfer line. A 0.1μ glass filter was used for particulate matter removal. A heated diaphragm pump was used to pull the sample from the engine. The sampling rate was 8 to 10 liters per minute.

The heated transfer line, held at 191°C, connected the probe/filter assembly to the FTIR. The FTIR was equipped with a temperature-controlled, 5.11 meter multipass gas cell maintained at 191°C.

FTIR data was collected using an MKS MultiGas 2030 FTIR spectrometer. All data was collected at 0.5cm^{-1} resolution. Each sample spectrum was derived from the co-addition of 60 scans, with a new data point generated every one minute.

FTIR sampling and analysis was conducted by Prism Analytical Technologies, Inc. (PATI) of Mount Pleasant, Michigan. A copy of PATI's test summary report is included as Appendix C. Figure 1 presents a diagram of the O_2 monitoring system and Figure 2 presents a diagram of the FTIR monitoring system.

4.b Recovery and Analytical Procedures

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

4.c Sampling Ports

Sampling ports were installed at 90° from one another in the single, 4" engine exhaust pipe at a location approximately 11 feet downstream and 4 feet upstream from the nearest disturbance in flow. The FTIR and Method 3A sampling probes were inserted into the 4" pipe at a single sampling location.

4.d Traverse Points

Sampling ports were installed at 90° from one another in the single, 4" engine exhaust pipe at a location approximately 11 feet downstream and 4 feet upstream from the nearest disturbance in flow. The FTIR and Method 3A sampling probes were inserted into the 4" pipe at a single sampling location.

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 2. Detailed emission test results are summarized by Table 3.

5.b Discussion of Results

Emission limitations and emission test results for the WSU engine are summarized by Table 2. For all three pollutants, engine emission rates were far less than the corresponding emission limitation.

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

No control device maintenance was performed during the testing.

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 in Appendix D.

5.h Sample Calculations

Sample calculations are provided in Appendix E.

5.i Field Data Sheets

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

5.j Laboratory Data

All analysis was conducted using online analyzers and, consequently, there is no laboratory data. Raw analyzer data is provided in Appendix B.

TABLES

Table 1
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Robert Buday	Tecogen 13763 Brougham Drive Sterling Heights, MI 48313	(586) 838-4626
Mr. Larry Fodor, CEM	Wayne State University 5454 Cass Avenue Detroit, Michigan 48202	(313) 577-4352
Mr. Edward Bishop	Bishop Environmental Consulting/Wayne State University	(248) 321-8554
Mr. Thomas Edwards Project Manager	Wayne State University 5454 Cass Avenue Detroit, Michigan 48202	(313) 577-0002
Mr. Steve Weis	MDEQ Air Quality Division Detroit Office	(313) 456-4688
Mr. Tom Maza Technical Programs Unit	MDEQ Air Quality Division Technical Programs Unit	(313) 456-4709
Ms. Lindsey Wells Chemist/FTIR Specialist	Prism Analytical Technologies 2625 Denison Drive Mount Pleasant, MI 48858	(989) 772-5088
Mr. Randal J. Tysar Senior Environmental Engineer	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Barry Boulianne Sr. Project Manager	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8072

Table 2
Wayne State University
Computer Services Building Chiller Engine
Compliance Test Program Results Summary

Source	Pollutant	Test Result (ppmv @15%/O_2)	Emission Limitation (ppmv @15%/O_2)
Tecochill Ch-200X	NOx	1	82
	CO	23	270
	VOC	1	60

Table 3
Wayne State University
Computer Services Building Tecochill Ch-200X
Detailed Average Emission Test Results Summary

FTIR Reported Results

Run	Duct	CO (ppmv dry)	NOx (ppmv dry)	VOCs (ppmv dry)
Run 1	Engine Exhaust	91.8	6.9	4.5
Run 2	Engine Exhaust	115.0	3.2	3.0
Run 3	Engine Exhaust	42.7	1.9	2.7

O_2 Analyzer Drift Correction

Run	Duct	Uncorrected O_2	Cma	Init Zero	Final Zero	Init Span	Final Span	Cm	Co	*Cgas
Run 1	Engine Exhaust	0.00	10.1	0.01	0.03	10.10	10.13	10.11	0.02	-0.02
Run 2	Engine Exhaust	0.01	10.1	0.03	0.02	10.13	10.10	10.11	0.03	-0.02
Run 3	Engine Exhaust	0.01	10.1	0.02	0.02	10.10	10.14	10.12	0.02	-0.01

*Drift-corrected O_2 values are negative; for 15% O_2 correction calculations a value of zero is used for the O_2 value.

O_2 Analyzer Drift Correction

Cgas =effluent gas concentration,
C = avg. gas concentration indicated by analyzer
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
Cma = actual concentration of the upscale calibration gas,

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

Results Corrected to 15% O_2 | Mass Flow Results

Run	Duct	CO (ppmv dry)	Nox (ppmv dry)	VOCs (non methane) (ppmv dry)	Exhaust Gas Flowrate (dscfm)	CO (lbs/hr)	Nox (lbs/hr)	VOCs (non methane) (lbs/hr)
Run 1	Engine Exhaust	25.9	1.9	1.3	91.67	0.04	0.005	0.003
Run 2	Engine Exhaust	32.5	0.9	0.8	88.34	0.04	0.002	0.002
Run 3	Engine Exhaust	12.1	0.5	0.8	95.54	0.02	0.001	0.002
	Averages:	**23**	**1**	**1**	**91.85**	**0.03**	**0.003**	**0.002**

FIGURES

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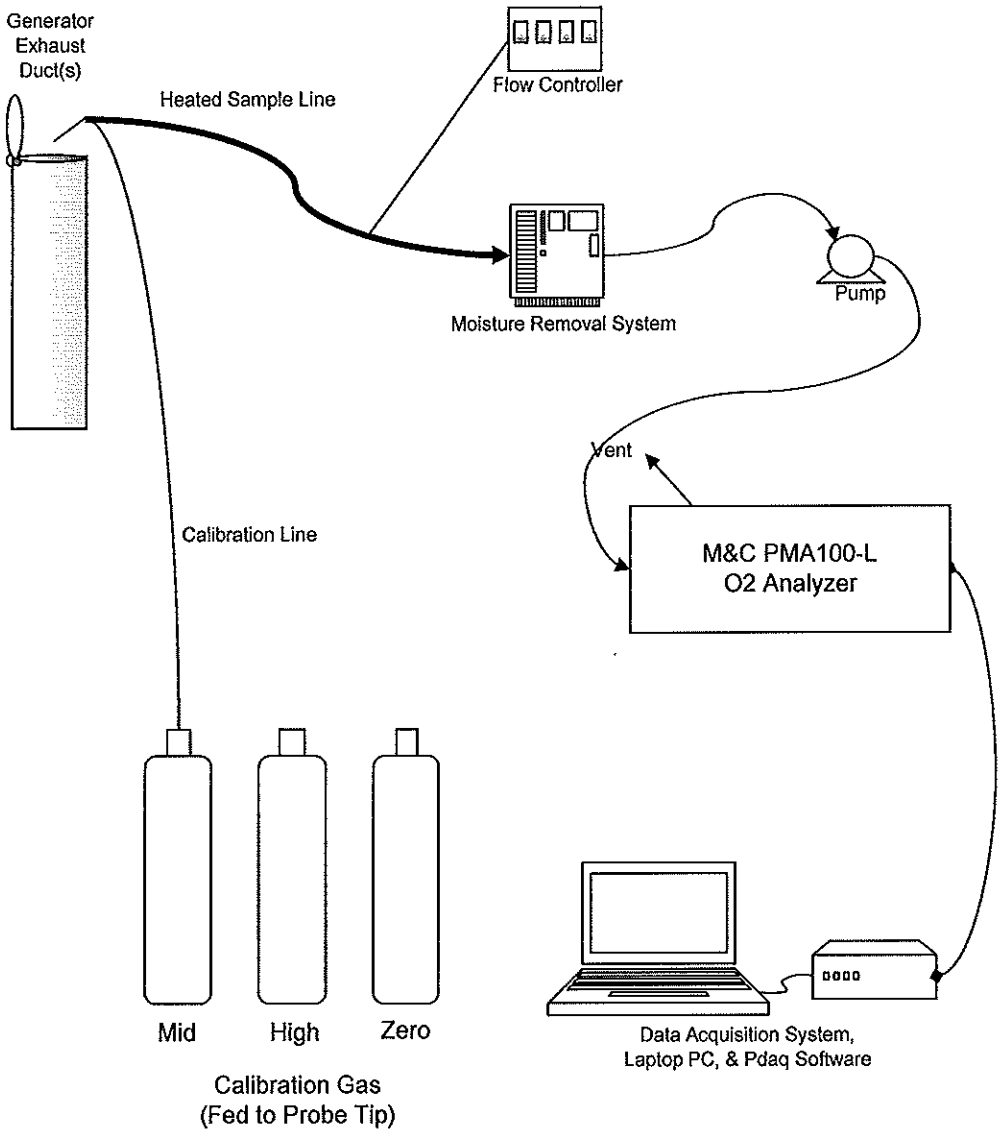

Figure 1
USEPA Method 3A

Site: **TecoChill Ch-200X** **Wayne State University** **Computer Services Building** **Detroit, MI**	**Sampling Date:** **October 14, 2013**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

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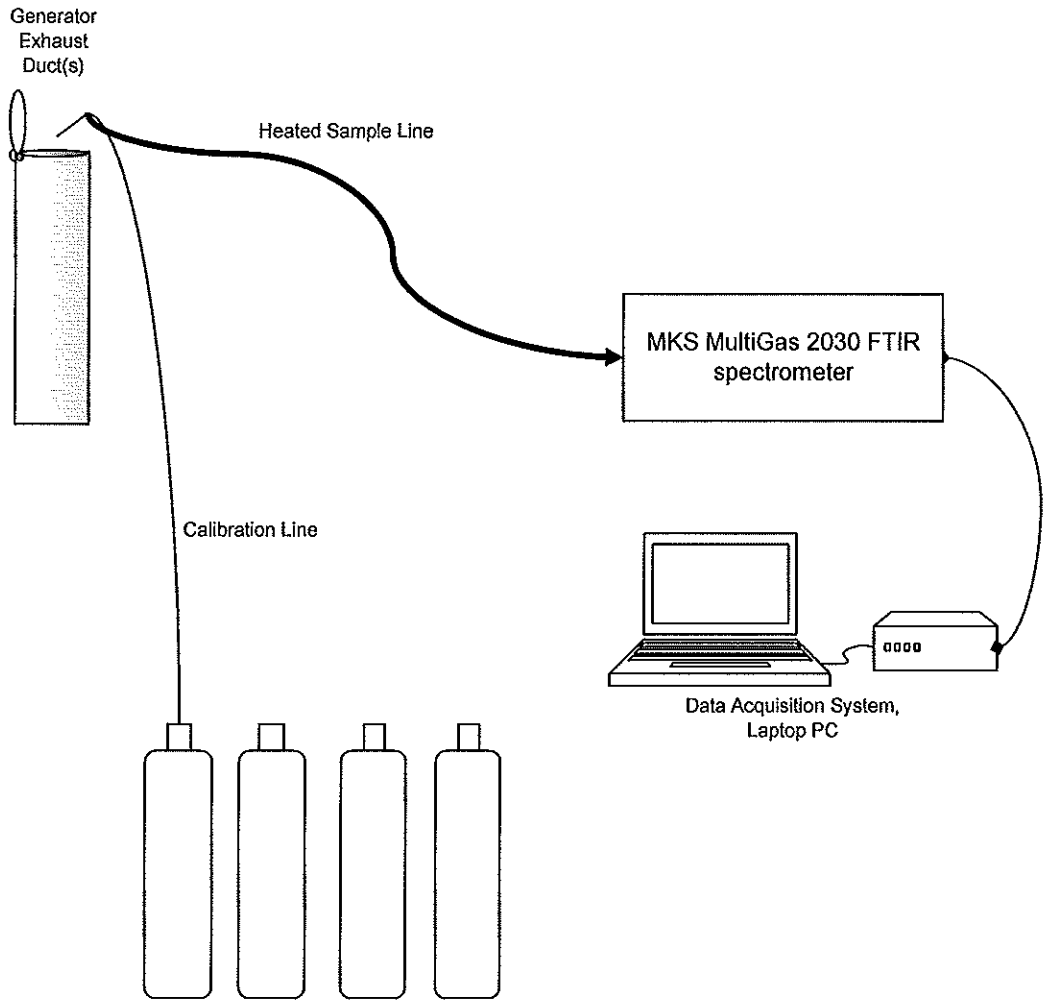

Figure 2
USEPA Method 320

Site: **TecoChill Ch-200X** **Wayne State University** **Computer Services Building** **Detroit, MI**	**Sampling Date:** **October 14, 2013**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**