Turbine 1 NOx and O_2 Emissions Test Report

Prepared for:

CMS Generation Michigan Power L.L.C
Kalamazoo Generation Station

Comstock, Michigan

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Project No. 17-5060.00
August 10, 2017

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Executive Summary

BT Environmental Consulting, Inc. (BTEC) was retained by CMS Energy Kalamazoo River Generation Station (CMS Kalamazoo) to conduct a relative accuracy test audit (RATA) at the CMS Kalamazoo facility located in Comstock, Michigan. The RATA was performed on one Continuous Emissions Monitoring System (CEMS) serving the simple cycle turbine. The turbine is designated as EUCOMTURB01 (Turbine 01) and fires NG only. The RATA testing was conducted on June 13, 2017.

The testing performed also demonstrates compliance with Michigan Department of Environmental Quality (MDEQ) Permit No. MI-ROP-N6731-2011 and in accordance with Appendix E, 40 CFR, Part 75, and U.S. EPA Reference Methods 3A, 7E, and 19 found in 40 CFR, Part 60, Appendix A. The turbine was tested at 4 different loads between 55 MW and 74 MW. Testing during each load consisted of triplicate 21-minute test runs while combusting natural gas.

The source tested qualified for low emitter status as written in Appendix A, 40 CFR, Part 75 which states the source is considered a low NO_x emitter if emissions are less than 0.2 Lb/MMBtu and meets the RA criteria if the average difference between the RM and CEM measurements is less than 0.02 Lb/MMBtu. Additionally, if the average difference is less than 0.015 Lb/MMBtu, the system need not be retested for one year. Since this is the case, all NO_x lb/mmbtu results are presented to reflect this status.

The results of the RATA test program are summarized in the Executive Summary Table E-1

Table E-1
Summary of NOx lb/mmbtu CEMS RATA Results Turbine 01

Source	Compound	Low Emitter Emission Limit (Lb/MMBtu)	RM/CEM Difference (Lb/MMBtu)
Turbine 1100	NOx lb/mmbtu	+0.015	0.001

Table E-2
Executive Summary of Turbine 01 NOx Emission Results

Load	Emission Rates			Permit Limits	
	NOx (ppm dry @ 15% O_2)	NOx (Lb/MMBtu)	NOx lb/hr	NOX (ppm dry @ 15%O_2)	NOX (lb/hr)
74 MW	11.56	0.043	37.1	15 ppm	48.3 lb/hr
68 MW	9.57	0.035	28.6	15 ppm	48.3 lb/hr
61 MW	9.41	0.035	26.6	15 ppm	48.3 lb/hr
55 MW	9.26	0.034	24.5	15 ppm	48.3 lb/hr

1.0 Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by CMS Energy Kalamazoo River Generation Station (CMS Kalamazoo) to conduct a relative accuracy test audit (RATA) at the CMS Kalamazoo facility located in Comstock, Michigan. The RATA was performed on one Continuous Emissions Monitoring System (CEMS) serving the simple cycle turbine. The turbine is designated as EUCOMTURB01 (Turbine 01) and fires NG only.

The testing performed also demonstrates compliance with Michigan Department of Environmental Quality (MDEQ) Permit No. MI-ROP-N6731-2015a and in accordance with Appendix E, 40 CFR, Part 75, and U.S. EPA Reference Methods 3A, 7E, and 19 found in 40 CFR, Part 60, Appendix A. The turbine was tested at 4 different loads between 55 MW and 74 MW. Testing during each load consisted of triplicate 21-minute test runs while combusting natural gas.

The source tested qualified for low emitter status as written in Appendix A, 40 CFR, Part 75 which states the source is considered a low NO_x emitter if emissions are less than 0.2 Lb/MMBtu and meets the RA criteria if the average difference between the RM and CEM measurements is less than 0.02 Lb/MMBtu. Additionally, if the average difference is less than 0.015 Lb/MMBtu, the system need not be retested for one year. Since this is the case, all NO_x lb/mmbtu results are presented to reflect this status.

The testing was conducted on June 13, 2017. BTEC personnel Todd Wessel and Shane Rabideau performed the testing. Mr. Tim Morrison of CMS Kalamazoo and Mr. Ryan Dugan of CMC Solutions LLC assisted the study by coordinating process test times and gathering CEMS data.

2.0 Process Description

The CMS-Kalamazoo facility located in Comstock, Michigan operates one simple-cycle Turbine that fires natural gas (NG).

The turbine has a maximum output capacity of approximately 74 Megawatts (MW) and is exclusively fired with natural gas. The turbine generator consists of a compressor, combustion turbine, and generator. Energy is generated at the combustion turbine by drawing in and compressing ambient air, burning fuel with the compressed air and expanding the hot combustion gases in a three stage turbine. The mechanical energy recovered in the turbine is used for both compression of the ambient air and electrical generation.

The CMS-Kalamazoo facility located in Comstock has recently installed a Continuous Emissions Monitoring System (CEMS). The primary function of the CEMS is to gather emission and process data to build a Predictive Emission Monitoring System (PEMS) model. The SmartCEM-75™ Predictive Emission Monitoring System (PEMS) will provide continuous data recording and report generation for compliance with 40 CFR Part 75 and 40 CFR Part 60 regulations. The data acquisition system will provide a secure and reliable means of collecting and retrieving compliance data. This application will be customized to meet the requirements of gas turbines under the applicable regulations including 40 CFR Part 60, Appendix GG and as a predictive emissions monitoring system (PEMS), an alternative to continuous emissions monitoring under Subpart E of 40 CFR Part 75, for gas-fired turbines.

2.1 Continuous Emissions Monitoring System (CEMS) Description

The Continuous Emission Monitoring System (CEMS) provides continuous data recording and report generation for potential compliance with 40 CFR Part 75 and 40 CFR Part 60 regulations. The data acquisition system provides a secure and reliable means of collecting and retrieving compliance data. This application has been customized to meet the requirements of gas turbines under the applicable regulations including 40 CFR Part 60, Appendix GG.

Turbine process data includes NOx ppm, O_2%, megawatt load, heat input and NG fuel flow. The Turbine process data can be found in Appendix B.

3.0 Sampling and Analytical Methodologies

Sampling and analytical methodologies are summarized in Sections 3.1 through 3.4. A Schematic drawing of BTEC's continuous emissions monitoring system is presented as Figure 1. Traverse point locations for the Turbine are illustrated in Figure 2.

3.1 Continuous Emissions Monitoring

Measurement of exhaust gas concentrations was conducted utilizing the following reference test methods codified at 40 CFR 60, Appendix A:

- Method 3A- Determinations of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary Sources;
- Method 7E - Determination of Nitrogen Oxides Emissions From Stationary Sources;
- Performance Specification 2 – Specifications and Test Procedures for SO_2 and NO_x Continuous Emission Monitoring Systems in Stationary Sources;
- Performance Specification 3 – Specifications and Test Procedures for O_2 and CO_2 Continuous Emission Monitoring Systems in Stationary Sources;

BTEC's extractive monitors require that the effluent gas sample be conditioned to eliminate any possible interference (i.e., water vapor and/or particulate matter) before being transported and injected into each analyzer. All components of the sampling system that contact the sample were constructed of Type 316 stainless steel, Pyrex glass or Teflon®. The output signal from each monitor was recorded at 10-second intervals on a PC equipped with Labview® II data acquisition software (DAS). The samples were extracted from the stack using a heated sample probe/filter assembly, heated sample line, stack gas conditioner with a Teflon diaphragm pump and routed through a distribution manifold for delivery to the analyzers. 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.

A detailed stratification traverse was conducted on the turbine during the first test run. The results of the traverse document that the turbine is not stratified. Therefore the sample gas was extracted at a single point through a heated stainless steel probe positioned approximately 6 feet from the stack wall as described by 40 CFR Part 60, Appendix B Performance Specification 2 Section 8.1.3.2 and illustrated in Figures 2. Twelve 21-minute test runs were conducted, three test runs at each load (4) on the CEMS, with the best nine used to calculate the relative accuracy (RA). A diagram of the reference monitoring system is illustrated in Figure 1.

The turbine NOx concentrations were measured in parts per million (ppm). The NOx concentration was converted to an emission rate and reported as Lb/MMBtu, using equation 19-1 of U.S. EPA Method 19 of Appendix A, 40 CFR 60. NOx concentrations were corrected to 15 percent oxygen using the equation below. Oxygen concentrations are reported in percent (%). The fuel factor for each test run is presented in CMS Kalamazoo's process and RATA data found in Appendix B.

The calculation illustrated below utilizes dry bias corrected pollutant concentrations and the associated dry bias corrected O_2 concentrations.

$$C_{adj} = C_d \frac{5.9}{20.9 - \%O_2}$$

where:

C_{adj}	=	Pollutant concentration corrected to 15 percent O_2 ppm.
C_d	=	Pollutant concentration measured, dry basis, ppm.
$\%O_2$	=	Measured O_2 concentration dry basis, percent.

3.2 Oxygen (USEPA Method 3A)

A M&C PMA 100L non-dispersive infra-red (NDIR) analyzer was used to measure O_2 concentrations following the guidelines of U.S. EPA Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from a Stationary Source (Instrumental Analyzer Procedure)", in conjunction with Performance Specification No. 3 of Appendix B, 40 CFR 60. The analyzer was set at 25% instrument span and calibrated before the RATA with zero nitrogen and high range USEPA Protocol 1 span gas (80 to 100% of span). Following calibration, a mid range USEPA Protocol 1 gas (40 to 60% of span) was introduced. The response error did not exceed 2% of the instrument span, as required by the method. Calibration error results are presented in Appendix A. Calibration drift checks were performed at the completion of each run.

3.3 Nitrogen Oxides (USEPA Method 7E)

A Thermo Environmental Model 42i-HL Chemiluminescence analyzer was used to measure parts per million of nitrogen oxides in the dry sample gas following the guidelines of U.S. EPA Method 7E, "Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure)", in conjunction with Performance Specification No. 2 of Appendix B, 40 CFR 60. The analyzer measures the concentration of NO_x by converting NO_x to NO and then measuring the light emitted by the reaction of NO with ozone. The NO_x analyzer was set at 0-100 ppm instrument span during the RATAs. The NO_X sampling system was calibrated at three points: zero, mid range (40-60% of span), and high range (80-100% of span) with USEPA Protocol 1 calibration gases. BTEC conducted several NO_2 to NO conversion efficiency tests, as specified in U.S. EPA Method 7E. The results of the NO_2 to NO conversion efficiency test can be found on the enclosed compact disk.

4.0 Test Results

The CEMS associated with the turbine tested at CMS Kalamazoo passed the Relative Accuracy Test Audit. The best runs were used to calculate the relative accuracy. You may choose to perform more than nine total RM tests. If you perform more than nine tests, you may reject a maximum of three tests as long as the total number of test results used to determine the RA is nine or greater.

The CEMS results for the turbine is expressed in Lb/MMBtu consistent with 40 CFR 75.

40 CFR 75, Appendix A requires that relative accuracy for the NO_x system be less than or equal to 10% when expressed as a percentage of the average reference method result in Lb/MMBtu. The system also qualifies for annual versus semiannual RATA testing if the relative accuracy is less than or equal to 7.5%. Alternatively, the system may meet the relative accuracy criteria of 40 CFR 75, Appendix A under the low-NO_x emitter provisions. A unit is considered to be a low NO_x emitter if NO_x emissions are less than 0.2 Lb/MMBtu and meets the relative accuracy criteria if the average difference between RM and CEM measurements is less than 0.02 Lb/MMBtu. Additionally, if the average difference is less than 0.015 Lb/MMBtu, the system need not be retested for one year. The turbine at the CMS Kalamazoo facility qualifies for the low-NO_x emitter status and achieved results with in the 0.015 Lb/MMBtu criteria.

The measurement uncertainty associated with this emissions test program includes the measurement uncertainty associated with the use of U.S. EPA Test Methods 3A, 7E, and 19 including:

- Inaccuracy in Method 19 “F-factors” in terms of dscf/MMBtu, and
- Representative sampling locations for the reference method probe in relation to the CEMS probe.

It should be noted that the primary purpose of the emissions test program is to evaluate the relative accuracy of the CEMS rather than to evaluate emission rates. Consequently, any inaccuracy in the Method 19 F-factor would be equivalent for both the reference method testing and the CEMS and would not affect the results of the test program.

It would be virtually impossible to quantify the measurement uncertainty associated with the sampling location; however, this measurement uncertainty is mitigated for the reference method testing by documenting the lack of stratification in the exhaust gas stream.

The results of all testing is presented in Tables 1 and 2. The following information is appended:

A	Turbine 01 Reference Monitor (BTEC) RATA Data
B	Turbine 01 CEM System (CMS Kalamazoo) RATA Data
C	BTEC Field Data
D	Span Gas Certification Documentation
E	Example Calculations
F	Compact Disk with all BTEC's CEMS Data Files

Limitations

The information and opinions rendered in this report are exclusively for use by CMS Energy Kalamazoo River Generation Station (CMS Kalamazoo). BTEC will not distribute or publish this report without CMS Kalamazoo's consent except as required by law or court order. BTEC accepts responsibility for the competent performance of its duties in executing the assignment and preparing reports in accordance with the normal standards of the profession, but disclaims any responsibility for consequential damages.

REPORT SIGNATURES

BTEC operated in conformance with the requirements of ASTM D7036-04 during this emissions test project and this emissions test report:

This report was prepared by: Brandon Chase

Brandon V. Chase
Quality Manager

This report was reviewed by: P.P.

Randal J. Tysar
Technical Manager

Table 1
Summary of NOx lb/mmbtu CEMS RATA Results Turbine 01

Source	Compound	Low Emitter Emission Limit (Lb/MMBtu)	RM/CEM Difference (Lb/MMBtu)
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Table 2
Executive Summary of Turbine 01 NOx Emission Results

Load	Emission Rates			Permit Limits	
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BTEC Inc.

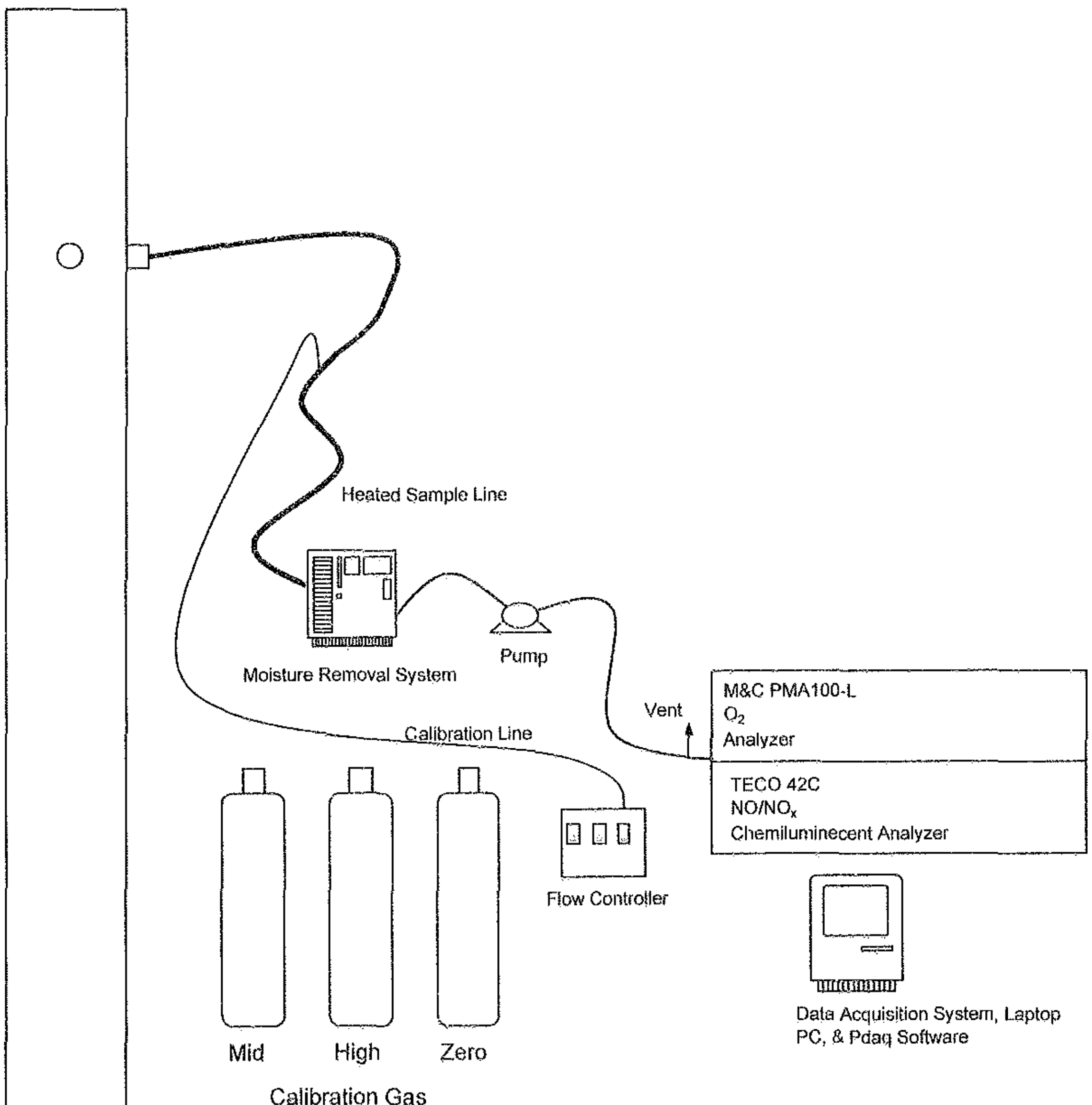
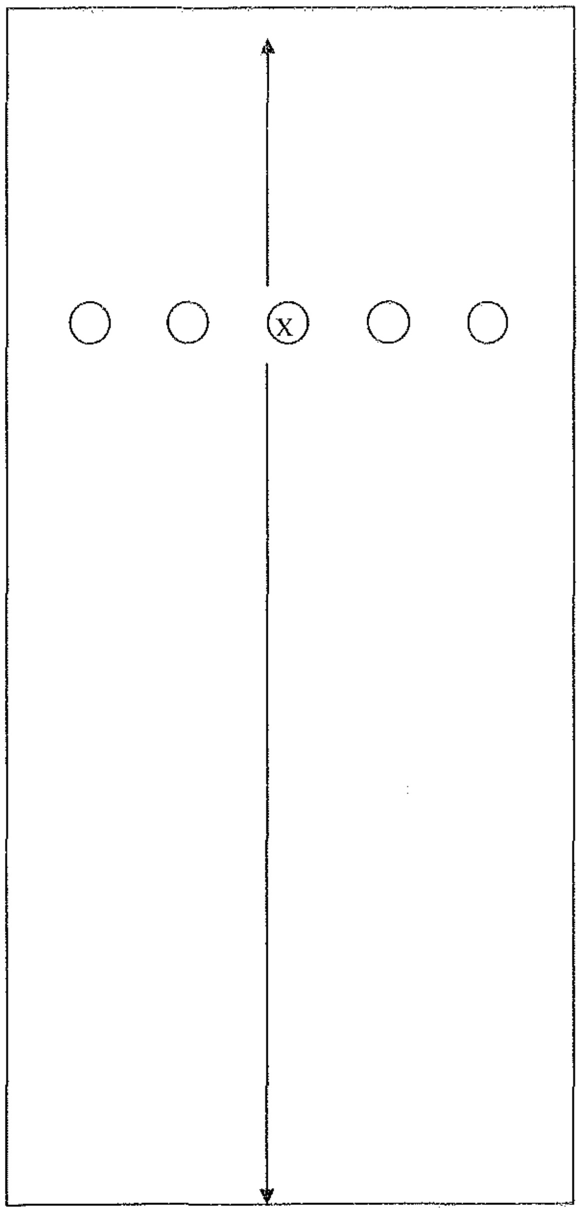


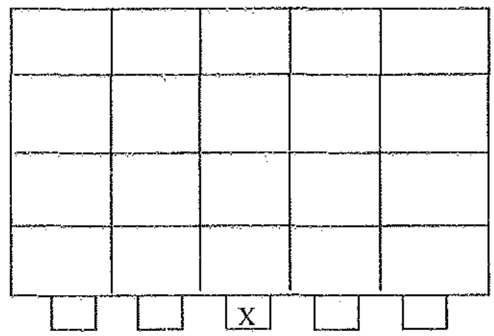
Figure No. 1

Site: USEPA Method 3A and 7E CMS Energy Comstock TWP, Michigan	Sampling Date: June 13, 2017	BT Environmental Consulting Inc. 4949 Fernlee Avenue Royal Oak, Michigan 48073

BTEC Inc.

Stack Dimensions: 137.75" X 173.75"





Not to Scale

Note: The middle port was inaccessible and was not sampled

Figure No. 2

Site:	Sampling Date:	BT Environmental Consulting Inc.
EUCOMTURB01 (Turbine 1)	June 13, 2017	4949 Fernlee Avenue
CMS Energy		Royal Oak, Michigan 48073
Comstock TWP, Michigan		