SOURCE TEST REPORT
2019 SUBPART KKKK ANNUAL NOX TESTING
CMS ENERGY
KALAMAZOO RIVER GENERATING STATION
EUCOMBTURB01
COMSTOCK, MI

Prepared For:

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For Submittal To:

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Technical Programs Unit
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STAC

ACCREDITED
TO ASTM D7036 ONLY
CERT #3925.01

MONTROSE
AIR QUALITY SERVICES

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Executive Summary

Montrose Air Quality Services, LLC (MAQS) was retained by CMS Michigan Power LLC – Kalamazoo River Generation Station (CMS-Kalamazoo) to evaluate oxides of nitrogen (NOx) emission rates from one combustion turbine (EUCOMBTURB01) at the CMS-Kalamazoo facility located in Comstock, Michigan. To determine NO_x lb/mmBtu and lb/hr emission rates and NO_x ppm concentrations corrected to 15% O_2, simultaneous NO_x and O_2 concentration measurements were obtained. The emission testing was conducted on November 6, 2019.

The emissions test program was conducted consistent with the MAQS Emissions Test Plan dated October 3, 2019 and submitted to Air Quality Division (AQD) of Michigan's Department of Environment, Great Lakes & Energy (EGLE) and EGLE's approval letter dated October 25, 2019. The testing was performed to demonstrate compliance with Title 40, Part 60, Subpart KKKK of the Code of Federal Regulations (40 CFR 60, Subpart KKKK) and Michigan Department of Environment, Great Lakes, and Energy Permit No. MI-ROP-N6731-2015b. The turbine was tested at 86% of peak load approximately 74 MW. The testing event consisted of triplicate 24-minute test runs while combusting natural gas.

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

Table E-1
Executive Summary of EUCOMBTURB01 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	9.15	0.0337	30.2	15	72.9

As shown in the above table, EUCOMBTURB01 was found to be in compliance with the emission limits established in Subpart KKKK.

1.0 Introduction

Montrose Air Quality Services, LLC (MAQS) was retained by CMS Michigan Power LLC – Kalamazoo River Generation Station (CMS-Kalamazoo) to evaluate oxides of nitrogen (NOx) emission rates from one combustion turbine (EUCOMBTURB01) at the CMS-Kalamazoo facility located in Comstock, Michigan. To determine NO_x lb/mmBtu and lb/hr emission rates and NO_x ppm concentrations corrected to 15% O_2, simultaneous NO_x and O_2 concentration measurements were obtained. The emission testing was conducted on November 6, 2019.

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Triplicate test runs were completed at a single operating load of 86% of peak power on November 6, 2019. MAQS personnel Todd Wessel and Shane Rabideau performed the testing. Mr. Paul Snoes and Mr. Timothy Morrison of CMS assisted the study by coordinating process test times and gathering process data. Mr. David Patterson and Ms. Monica Brothers of EGLE were present to witness the testing.

2.0 Process Description

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

The turbine was previously rated at an output of approximately 74 Megawatts (MW). After recent modifications authorized under PTI 8-18, the turbine is now rated at an output capacity of approximately 86 MW. EUCOMBTURB01 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.

3.0 Sampling and Analytical Methodologies

Sampling and analytical methodologies are summarized in Sections 3.1 through 3.3. A Schematic drawing of MAQS'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 - "*Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources*;"
- Method 7E - "*Determination of Nitrogen Oxides Emissions from Stationary Sources;*"
- Method 19 - "*Determination of Sulfur Dioxide Removal and Particulate, Sulfur Dioxide and Nitrogen Oxides Rates*"

MAQS'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 4-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 C, and all calibration gases were obtained from vendors participating in the EPA's Protocol Gas Verification Program as of the date that the calibration gases were certified.

MAQS conducted a stratification travers during run number 1 of the testing event. The samples were extracted at three points in each of four ports for a total of twelve sample points per run as described by 40 CFR Part 75, Appendix E. The middle port was inaccessible and was not sampled and, consequently, the traverse points were a small deviation from the locations specified by Method 1; please see Figure 2. A diagram of the reference monitoring system is illustrated in Figure 1. The maximum and minimum oxygen concentration was 15.1 and 14.97 % respectively, therefore the turbine was deemed un-stratified and the samples were extracted at a single point in the stack.

The turbine NO_x concentrations were measured in parts per million by volume, dry basis (ppmvd). The run average NO_x concentration was then corrected to 15 percent oxygen using the equation presented below. The lb/MMBtu emission rate was calculated using equation 19-1 of U.S. EPA Method 19 of Appendix A, 40 CFR 60. Oxygen concentrations are reported in percent by volume, dry basis (%). The gross heating value of the fuel (Btu/scf) was provided by CMS-Kalamazoo and was used to calculate the NO_x emissions on a lb/hr basis.

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 and Carbon Dioxide (USEPA Method 3A)

An M&C Products PMA 100-L 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)". The analyzer calibration span was set equal to the concentration of the high level calibration gas and the analyzer was calibrated before the testing with a gas mixture not containing any O_2 (the high level NOx calibration gas) and high level USEPA Protocol 1 calibration gas. Following calibration, a mid range USEPA Protocol 1 gas (40 to 60% of calibration 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 Teledyne Model T200H 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)". 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 calibration span was set equal to the high level calibration gas NO_x concentration. The NO_X sampling system was calibrated at three points: zero, mid-level (40-60% of the calibration span), and high level (equal to the calibration span) with USEPA Protocol 1 calibration gases. MAQS 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 results of the emissions test program for NO_x ppm at 15% O_2 and lbs/hr rates are summarized by Table 1. The table also includes the NO_x emission rates expressed as lb/mmBtu; these emission rates were used in calculating the lbs/hr emission rates.

Table 1
Summary of EUCOMBTURB01 NOx Emission Results for Permit Compliance

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	9.15	0.0337	30.2	15	72.9

Table 2
Summary of EUCOMBTURB01 Appendix E Emissions and Parametric Data

Heat Input (MMBtu/hr)	Nitrogen Oxides (lb/MMBtu)	Inlet Guide Vane [IGV] (Deg)	Compressor Discharge Temperature [CDT] (°F)	Compressor Discharge Pressure [CDP] (psi)	Exhaust Temperature [ET] (°F)
846	0.0493	67.2	595	147	1,009
Vendor Ranges		42 - 86	520 - 725	90 - 220	950 – 1,125

The emissions test program was conducted following an approved emissions test protocol. 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:

- Uncertainty in Method 19 "F-factors" in terms of dscf/MMBtu, and
- Representative sampling locations for the reference method probe.

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 moving the probe to three points across the stack in each of four ports during each emissions test run.

Because the emissions test program was conducted according to an approved emissions test plan, the measurement uncertainty for this emissions test program is considered adequate for the objectives of the emissions test program.

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

Appendix A – MAQS Calibration Error and Drift Correction Data
Appendix B – Field and Computer Generated Raw Data and Field Notes
Appendix C – Span Gas Certification Documentation
Appendix D – Example Calculations
Appendix E – Process Data
Appendix F – Test Program Correspondence
Appendix G – Compact Disk with all MAQS's CEMS data files

All testing performed was done in conformance to the ASTM D7036-04 standard. As required by 40 CFR 75, Appendix A, Section 6.1.2 (see certificate of accreditation in Appendix F), MAQS operated in conformance with the requirements of ASTM D7036-04 during this emissions test project and this emissions test report. The on-site emissions test program was supervised by Mr. Todd Wessel. Mr. Wessel's qualified individual certificate and information are also provided in Appendix F.

MEASUREMENT UNCERTAINTY STATEMENT

Both qualitative and quantitative factors contribute to field measurement uncertainty and should be taken into consideration when interpreting the results contained within this report. Whenever possible, Montrose Air Quality Services, LLC, (MAQS) personnel reduce the impact of these uncertainty factors through the use of approved and validated test methods. In addition, MAQS personnel perform routine instrument and equipment calibrations and ensure that the calibration standards, instruments, and equipment used during test events meet, at a minimum, test method specifications as well as the specifications of our Quality Manual and ASTM D 7036-04. The limitations of the various methods, instruments, equipment, and materials utilized during this test have been reasonably considered, but the ultimate impact of the cumulative uncertainty of this project is not fully identified within the results of this report.

Limitations

The information and opinions rendered in this report are exclusively for use by CMS-Kalamazoo. MAQS will not distribute or publish this report without CMS-Kalamazoo's consent except as required by law or court order. MAQS 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.

This report was prepared by:_____
Jacob Young
Staff Engineer

This report was reviewed by:_____ P.E.
Todd Wessel
Client Project Manager

Tables

Table 3
Detailed Summary of EUCOMBTURB01 NOx Emission Results
CMS Generation - Kalamazoo River Generation Station
6-Nov-19

Run	Date	Time	Power (MW)	NOx PPM DRY	O2 PPM	NOx PPM @ 15% O2	NOx lbs/mmBTU	NOx lbs/hr	Fuel Flow SCFH	BTU's BTU/scf
1	11/6/2019	1140-1215	74.3	9.09	14.98	9.06	0.0334	29.85	832631	1074
2	11/6/2019	1227-1250	74.3	9.30	14.94	9.21	0.0339	30.41	834436	1074
3	11/6/2019	1301-1324	74.4	9.27	14.95	9.19	0.0338	30.29	833195	1074
Average						9.15	0.0337	30.18		

Figures

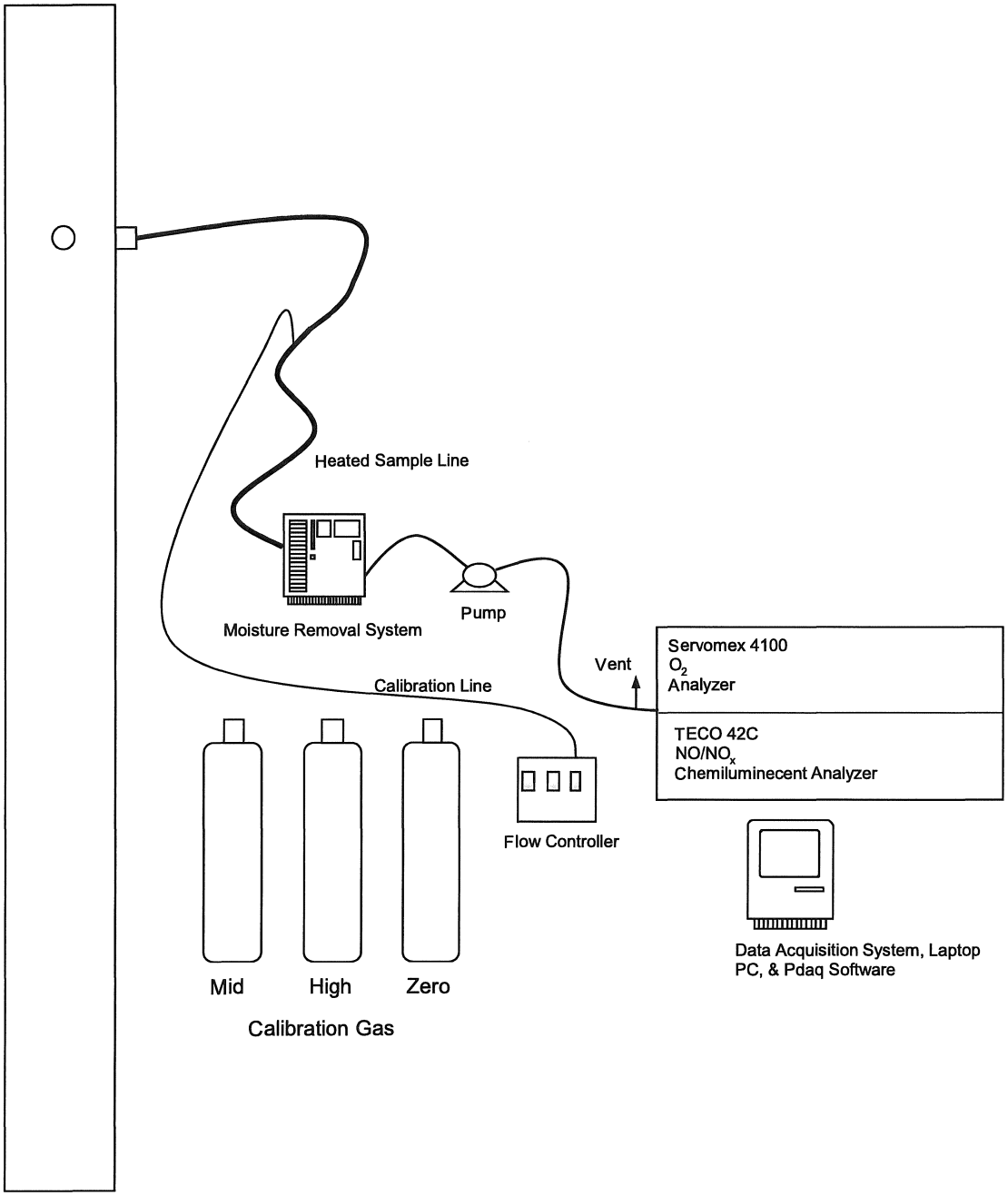

Figure No. 1

Site:	Sampling Date:	
USEPA Method 3A and 7E **CMS Michigan Power LLC** **Comstock, Michigan**	**November 6, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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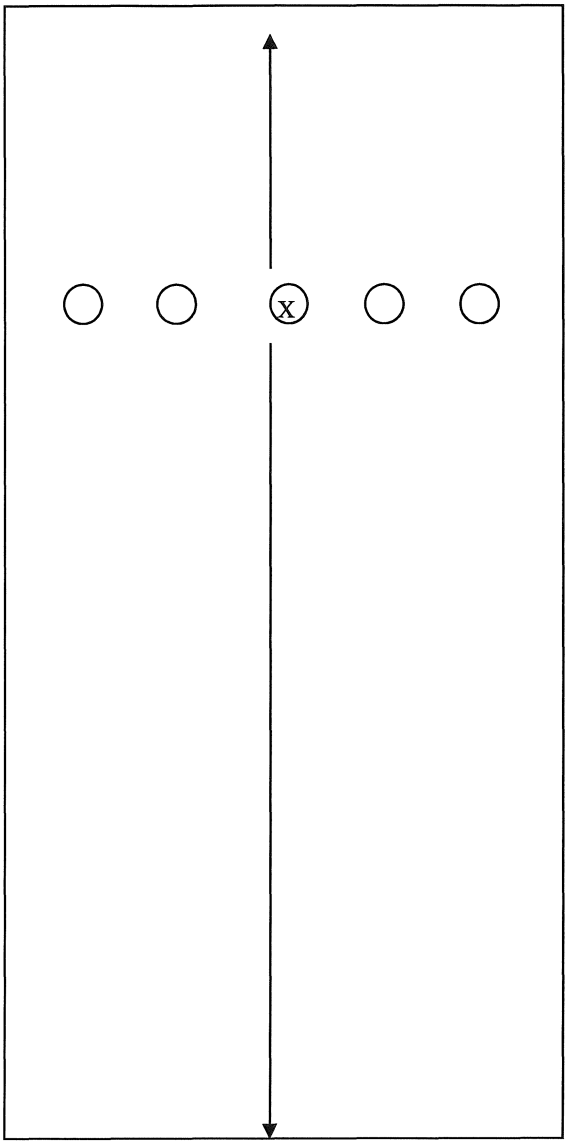
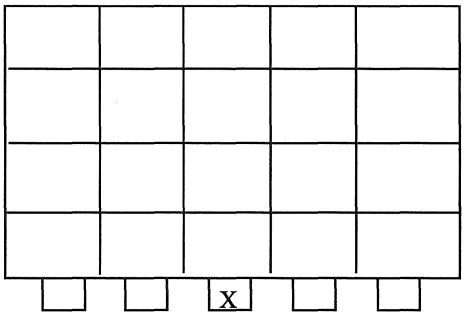
Stack Dimensions: 137.75" X 173.75"





Not to Scale

Note: The middle port was inaccessible and was not sampled

Figure No. 2

Site: **EUCOMTURB01 (Turbine 1)** **CMS Michigan Power LLC** **Comstock, Michigan**	**Sampling Date:** **November 6, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**