

Turbines 1, 2, 3, and 4 NOx, O₂, and CO Emissions Test Report

Prepared for:

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

Gaylord, Michigan

CMS Generation Michigan Power LLC Livingston Generation Station North Townline Road Gaylord, MI 49735

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Project No. 17-5063.00 August 22, 2017

BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan 48073 (248) 548-8070



EXECUTIVE SUMMARY

BT Environmental Consulting Inc. (BTEC) was retained by CMS Generation, Michigan Power L.L.C, Livingston Generating Station (CMS-Gaylord) to conduct compliance emissions testing on four simple cycle combustion turbines installed at the CMS-Gaylord facility located in Gaylord, Michigan. The natural gas fired turbines (identified as Turbine Units 1, 2, 3, and 4) each have a rated load capacity of 39 Megawatts (MW). The testing was conducted to determine compliance with the emission limits stated in the Michigan Department of Environmental Quality (MDEQ) Permit No. MI-ROP-N6526-2014a. Nitrogen oxides (NOx), oxygen (O2), and carbon monoxide (CO) concentrations were monitored to establish the concentration and mass emission rate of NOx and CO from the turbines.

The test consisted of triplicate twenty four-minute test runs, conducted at each of four operational loads between 85 and 100 percent of the achievable megawatt capacity for each turbine. The test program was conducted on June 27 - 30, 2017. A summary of the NOx and CO concentrations and emissions are presented in Tables E-1, E-2, E-3, and E-4. Detailed NOx and CO concentration and emission results can be found in Tables 7-10 at the end of this report.

| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr |
|-------|------------------------------|---------------|-------------------------|
| 100% | 75 | 0.33 | 125.8 |
| 95% | 77 | 0.31 | 126.9 |
| 95% * | 71 | 0.36 | 116.0 |
| 90% | 75 | 0.31 | 117.9 |
| 85% | 75 | 0.30 | 103.1 |
| Limit | 75 ppm | 0.48 lb/mmbtu | 624.0lb/hr ¹ |

Executive Summary Table E-1 Turbine 1 Summary of NOx and CO Emissions

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen

Lb/mmBtu: Pound per million British thermal unit

Lb/hour: Pound per hour

1: Limit is for all four turbines combined (Turbines 1-4)

*The water injection ratio was changed and the 95% load was retested



| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr |
|-------|------------------------------|---------------|-------------------------|
| 100% | 75 | 0.37 | 137.3 |
| 95% | 75 | 0.35 | 133.0 |
| 90% | 71 | 0.39 | 104.7 |
| 85% | 66 | 0.44 | 109.1 |
| Limit | 75 ppm | 0.48 lb/mmbtu | 624.0lb/hr ¹ |

Executive Summary Table E-2 Turbine 2 Summary of NOx and CO Emissions

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen

Lb/mmBtu: Pound per million British thermal unit

Lb/hour: Pound per hour

1: Limit is for all four turbines combined (Turbines 1-4)

| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr | | |
|-------|------------------------------|---------------|-------------------------|--|--|
| .00% | 61 | 0.34 | 118.9 | | |
| 95% | 61 | 0.32 | 113.3 | | |
| 90% | 62 | 0.33 | 110.3 | | |
| 85% | 60 | 0.37 | 104.6 | | |
| Limit | 75 ppm | 0.48 lb/mmbtu | 624.0lb/hr ¹ | | |

Executive Summary Table E-3 Turbine 3 Summary of NOx and CO Emissions

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen

Lb/mmBtu: Pound per million British thermal unit

Lb/hour: Pound per hour

1: Limit is for all four turbines combined (Turbines 1-4)



| Turbine 4 Summary of NOx and CO Emissions | | | | | | | |
|---|------------------------------|---------------|-------------------------|--|--|--|--|
| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr | | | | |
| 100% | 69 | 0.33 | 122.0 | | | | |
| 95% | 67 | 0.32 | 114.8 | | | | |
| 90% | 67 | 0.32 | 108.2 | | | | |
| 85% | 65 | 0.35 | 101.4 | | | | |
| Limit | 75 ppm | 0.48 lb/mmbtu | 624.0lb/hr ¹ | | | | |

Executive Summary Table E-4

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen

Lb/mmBtu: Pound per million British thermal unit

Lb/hour: Pound per hour

1: Limit is for all four turbines combined (Turbines 1-4)



1. Introduction

BT Environmental Consulting Inc. (BTEC) was retained by CMS Generation, Michigan Power L.L.C, Livingston Generating Station (CMS-Gaylord) to conduct compliance emissions testing on four simple cycle combustion turbines installed at the CMS-Gaylord facility located in Gaylord, Michigan. The natural gas fired turbines (identified as Turbine Units 1, 2, 3, and 4) each have a rated load capacity of 39 Megawatts (MW). The testing was conducted to determine compliance with the emission limits stated in the Michigan Department of Environmental Quality (MDEQ) Permit No. MI-ROP-N6526-2014a. Nitrogen oxides (NOx), oxygen (O₂), and carbon monoxide (CO) concentrations were monitored to establish the concentration and mass emission rate of NOx and CO from the turbines.

The test consisted of triplicate twenty four-minute test runs, conducted at each of four operational loads of 85, 90, 95 and 100 percent of the achievable megawatt capacity. The test program was conducted on June 27 - 30, 2017. A summary of the NOx and CO concentrations and emissions are presented in Tables 3-6. Detailed NOx and CO concentration and emission results can be found in Tables 7-10 at the end of this report.

The Air Quality Division (AQD) of Michigan's Department of Natural Resources and Environment 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 June 27 - 30, 2017 at the CMS-Gaylord facility located in Gaylord, Michigan The purpose of this report is to document the results of the emissions determined during compliance test program.

The emission test program included the evaluation of oxides of nitrogen (NOx), Oxygen (O₂), and carbon monoxide (CO) concentrations from three 39MW combustion turbines (Turbine 1, Turbine 2, Turbine 3, and Turbine 4).

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1.b Purpose of Testing

Turbine 1 is included in Michigan Renewable Operating Permit MI-ROP-N6526-2014a. The emission limits relevant to this emissions test program are summarized by Table 1.

| Table 1 |
|--|
| Operating Permit MI-ROP-N6526-2014a Emission Limits |
| Turbines 2-4 |

| Pollutant | Limit | | |
|------------------------------------|----------------------------|--|--|
| Nitrogen Oridor (NO.) | 624.0 lb/hr ¹ | | |
| Nitrogen Oxides (NO _x) | 75 ppm @ 15%O ₂ | | |
| Carbon Monoxide (CO) | 0.48 lb/mmbtu | | |

¹: Limit is for all four turbines combined (Turbines 1-4)

1.c Source Description

The CMS-Gaylord facility located in Gaylord, Michigan operates four simple-cycle Turbines that fire natural gas (NG).

Each turbine is nominally rated at an output capacity of 39 Megawatts (MW). The turbines use natural gas as a primary fuel. The turbine generator consists of a compressor, combustion turbine, and generator. Energy is generated at the combustion turbine by drawing in ambient air by means of burning fuel and expanding the hot combustion gases in a three-stage turbine. A water injection system minimizes the emissions of nitrogen oxides from the turbines, while the emissions of CO and SO₂ are minimized by the efficient combustion of low sulfur bearing clean-burning fuels.

1.d Test Program Contact

Facility Contact: Mr. Steve Ellison CMS Generation Michigan Power LLC Livingston Generation Station North Townline Road Gaylord, MI 49735 (989) 705-2552

Testing Team Contact: Mr. Todd Wessel Senior Project Manager BT Environmental Consulting, Inc. 4949 Fernlee Ave Royal Oak, Michigan 48073 Phone (616) 885-4013 CMS Generation Michigan Power L.L.C 2 Turbines 1 - 4 NOx, O2, and CO Emissions Test Report



1.e Testing Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

| Test Personnel | | | | | | |
|---|--|----------------|--|--|--|--|
| Name and Title | Affiliation | Telephone | | | | |
| Mr. Steve Ellison | CMS Generation Michigan Power LLC Livingston Generation Station North Townline Road Gaylord, MI 49735 | (989) 705-2552 | | | | |
| Mr. Todd Wessel Senior Project Manager | BTEC 4949 Fernlee Avenue Royal Oak, MI 48073 | (616) 885-4013 | | | | |
| Mr. Dave Trahan Environmental Technician | BTEC 4949 Fernlee Avenue Royal Oak, MI 48073 | (248) 548-8070 | | | | |
| Mr. Dave Patterson | | | | | | |

Table 2 Test Personnel

2. Summary of Results

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

2.a Operating Data

The following information was collected during the performance test:

- 1. Date, time, MW load
- 2. Natural gas flow
- 3. Water injection rate
- 4. Compressor temperature and pressure

2.b Applicable Permit

The applicable permit for this emissions test program is Michigan Renewable Operating Permit No. MI-ROP-N6526-2014a.

2.c Results



The overall results of the emissions compliance test program are summarized by Tables 3-6 (see Section 5.a). Detailed results for each engine can be found in Tables 7-10.

2.d Emission Regulation Comparison

Emission limitations are summarized by Table 1.

3. Source Description

Sections 3.a through 3.d provide a detailed description of the process.

3.a Process Description

The CMS-Gaylord Generating Plant, located in Gaylord, Michigan, is owned and operated by CMS Generation Michigan Power LLC, Livingston Generation Station. The plant contains four dresser-Rand combustion turbines that are utilized to generate electrical power. Each of the turbines (4) are rated at 39 Megawatts (MW) however, this rating is not achievable during the summer months. For this testing project the maximum achievable MW is approximately 33.0.

3.b Raw and Finished Materials

The raw material supplied to the turbine includes natural gas. The finished material is electricity.

3.c Process Capacity

Each turbine is nominally rated at an output capacity of approximately 39 Megawatts (MW).

3.d Process Instrumentation

Process data monitored during the emissions test program is provided in Appendix E.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify emission rates from the turbines.

4.a Sampling Train and Field Procedures

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 Molecular Weight of Dry Stack Gas"

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 Method 7E - "Determination of Nitrogen Oxide Emissions from Stationary Sources"
 Method 10 - "Determination of Carbon Monoxide Emissions from 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 four sampling points in each sampling port. Each test run sampled a different sampling port as illustrated in Figure 2. Twelve 24-minute test runs were conducted, three test runs at each load (4) on the turbine. 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 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 O₂ ppm.
 $C_d =$ Pollutant concentration measured, dry basis, ppm.
%O₂ = Measured O₂ concentration dry basis, percent.

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In accordance with Method 7E, a 3-point (zero, mid, and high) bias check and calibration check was performed on the each analyzer prior to initiating the test program. Following each test run, a 2-point (zero and high) calibration drift check was performed. The NOx analyzer was operated at the 0-100 ppm range, the CO analyzer was operated in the 0-1000 ppm range and was calibrated in the 0-1000 range and in the 0-100 range, and the oxygen analyzer was operated in the 0-25% range. A USEPA Method 7E NO₂ to NO conversion efficiency test was performed and the results are included in Appendix E.

4.b Recovery and Analytical Procedures

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

4.c Sampling Ports

Figure 1 documents the exhaust stack dimensions and approximate sampling point locations.

4.d Traverse Points

Sixteen sampling points were tested for stratification in accordance with US EPA Method 7E, section 8.1.2. The mean concentration of the oxygen in the stack was approximately 16.77% with a maximum deviation of 0.08%. Therefore the turbine was deemed unstratified. The turbine exhaust stack is approximately 60 feet in height. The turbine exhaust gas flows through a rectangular exhaust duct with dimensions of 137.75 inches by 173.75 inches. Figure 1 documents the exhaust stack dimensions and approximate sampling point locations.

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.



5.a Results Tabulation

The results of the emissions test program are summarized by Tables 3-5.

| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr | | |
|-------|------------------------------|---------------|-------------------------|--|--|
| 100% | 75 | 0.33 | 125.8 | | |
| 95% | 77 | 0.31 | 126.9 | | |
| 95% * | 71 | 0.36 | 116.0 | | |
| 90% | 75 | 0.31 | 117.9 | | |
| 85% | 75 | 0.30 | 103.1 | | |
| Limit | 75 pmm | 0.48 lb/mmbtu | 624.0lb/hr ¹ | | |

Table 3Turbine 1 NOx and CO Summary

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen

Lb/mmBtu: Pound per million British thermal unit

Lb/hour: Pound per hour

1: Limit is for all four turbines combined (Turbines 1-4)

*The water injection ratio was changed and the 95% load was retested

| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr |
|-------|------------------------------|---------------|-------------------------|
| 100% | 75 | 0.37 | 137.3 |
| 95% | 75 | 0.35 | 133.0 |
| 90% | 71 | 0.39 | 104.7 |
| 85% | 66 | 0.44 | 109.1 |
| Limit | 75 pmm | 0.48 lb/mmbtu | 624.0lb/hr ¹ |

Table 4Turbine 2 NOx and CO Summary

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen Lb/mmBtu: Pound per million British thermal unit

Lb/hour: Pound per hour



1: Limit is for all four turbines combined (Turbines 1-4)

| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr |
|-------|------------------------------|---------------|-------------------------|
| 100% | 61 | 0.34 | 118.9 |
| 95% | 61 | 0.32 | 113.3 |
| 90% | 62 | 0.33 | 110.3 |
| 85% | 60 | 0.37 | 104.6 |
| Limit | 75 pmm | 0.48 lb/mmbtu | 624.0lb/hr ¹ |

Table 5Turbine 3 NOx and CO Summary

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen

Lb/mmBtu: Pound per million British thermal unit

Lb/hour: Pound per hour

1: Limit is for all four turbines combined (Turbines 1-4)

| Load | NOx pmm @ 15% O ₂ | CO lb/mmbtu | NOx lb/hr |
|-------|------------------------------|---------------|-------------------------|
| 100% | 69 | 0.33 | 122.0 |
| 95% | 67 | 0.32 | 114.8 |
| 90% | 67 | 0.32 | 108.2 |
| 85% | 65 | 0.35 | 101.4 |
| Limit | 75 pmm | 0.48 lb/mmbtu | 624.0lb/hr ¹ |

Table 6Turbine 4 NOx and CO Summary

ppm: Part per million

15% O₂: Concentration corrected to 15% Oxygen Lb/mmBtu: Pound per million British thermal unit Lb/hour: Pound per hour

1: Limit is for all four turbines combined (Turbines 1-4)

Detailed data for each test run can be found in Tables 7-10.



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5.b Discussion of Results

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Emission limitations for Michigan Renewable Operating Permit MI-ROP-N6526-2014a are summarized by Table 1 (see section 1.b) and Tables 3-5 (see section 5.c). The results of the emissions test program are summarized by Tables 3-5 (see section 5.a). Detailed data for each test run can be found in Tables 6-8.

5.c Sampling Procedure Variations

As discussed in section 4a, the the CO analyzer was operated in the 0-1000 ppm range and was calibrated in the 0-1000 range and in the 0-100 range. Linearity checks (calibration error) were conducted in each range to demonstrate the instruments accuracy across the ranges. Since the CO concentration in the stack was closer to the 88.65 calibration gas rather than the 480.1 calibration gas this gas was utilized throughout the testing study.

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 four sampling points in each sampling port. Each test run sampled a different sampling port as illustrated in Figure 2. This was done due to the fact that the turbine operates in excess of 1000 degrees F and each port change takes a significant amount of time as well as the safety factors associated with testing hot sources.

All of the sampling variations were discussed and approved on site with the MDEQ representatives.

5.d Process or Control Device Upsets

While testing Turbine No. 1 it was noted that at the 95% load the turbine exceeded the permissible permit limit of 75 ppm NOx at 15% Oxygen. The water injection ratio was changed and that load level was retested with passing results.

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 as Appendix C.

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5.h Sample Calculations

Sample calculations are provided in Appendix D.

5.i Field Data Sheets

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

5.j Laboratory Data

No laboratory analysis was included in this test program.

Table 7 Turbine 1 NOx and CO Emission Rates CMS Generation Michigan Power LLC Gaylord, Michigan BTEC Project No. 17-5063 Sampling Date: June 27, 2017

| NOx PPM <u>Dry</u> | 02% <u>Dry</u> | <u>NOx at 15% O2</u> | EQ-19-1 NOx lbs/mmbtu | NOx lbs/hr | Fuel Flow <u>SCFH</u> | | CO ppm | CO lbs/mmbtu | Start <u>Time</u> | <u>Load</u> | NOx@15% O2 <u>Average</u> | Permit Limit NOx@15% O2 | CO lbs/mmbtu <u>Average</u> | Permit Limit CO Ibs/mmbtu |
|-------------------------|-------------------------|----------------------------|------------------------------------|--|----------------------------|----------------------|----------------------------|-------------------------|-------------------------|----------------------|------------------------------|----------------------------|--------------------------------|------------------------------|
| 50.92 50.56 50.79 | 16.89 16.9 16.91 | 74.920 74.576 75.103 | 0.276 0.275 0.277 Average | 128.121 124.576 124.565 125.754 | 446350 436000 432900 | 1040 1040 1040 | 97.64 107.04 99.27 | 0.322 0.354 0.329 | 9:56 | 100% 100% 100% | 75 | 75 | 0.33 | 0.48 |
| 49.89 51.67 53.88 | 16.96 16.95 16.95 | 74.708 77.178 80.479 | 0.275 0.284 0.296 Average | 122.336 126.557 131.940 126.944 | 427400 428000 427900 | 1040 1040 1040 | 99.66 97.45 82.91 | 0.334 0.326 0.277 | 11:18 11:57 12:37 | 95% | 77 | 75 | 0.31 | 0.48 |
| 44.59 44.33 45.56 | 17.16 17.18 17.15 | 70.343 70.308 71.681 | 0.259 0.259 0.264 Average | 115.321 115.373 117.241 115.979 | 427900 428300 426900 | 1040 1040 1040 | 104.51 103.68 100.23 | 0.369 0.368 0.353 | 14:05 14:45 15:22 | 95% | 71 | 75 | 0.36 | 0.48 |
| 48.95 48.69 48.54 | 17.06 17.05 17.07 | 75.210 74.616 74.774 | 0.277 0.275 0.275 Average | 118.633 117.696 117.431 117.920 | 411700 411700 409900 | 1040 1040 1040 | 90.64 91.01 92.54 | 0.312 0.312 0.319 | 15:59 16:36 17:13 | 90% | 75 | 75 | 0.31 | 0.48 |
| 49.69 49.88 50.64 | 16.96 16.98 16.98 | 74.409 75.074 76.218 | 0.274 0.277 0.281 Average | 111.696 112.638 84.948 103.094 | 391800 391600 290900 | 1040 1040 1040 | 88.44 87.12 88.44 | 0.297 0.294 0.298 | 17:51 18:28 19:10 | | 75 | 75 | 0.30 | 0.48 |

Table 8 Turbine 2 NOx and CO Emission Rates CMS Generation Michigan Power LLC Gaylord, Michigan BTEC Project No. 17-5063 Sampling Date: June 28, 2017

| NOx PPM <u>Drv</u> | 02% <u>Drv</u> | NOx at 15% O2 | EQ-19-1 <u>NOx lbs/mmbtu</u> | NOx lbs/hr | Fuel Flow <u>SCFH</u> | <u>BTU's</u> | <u>CO ppm</u> | CO lbs/mmbtu | Start <u>Time</u> | Load | NOx@15% O2 <u>Average</u> | Permit Limit <u>NOx@15% O2</u> | CO lbs/mmbtu <u>Average</u> | Permit Limit CO lbs/mmbtu |
|-------------------------|-------------------------|----------------------------|------------------------------------|--|----------------------------|----------------------|----------------------------|-------------------------|-------------------------|----------------------|------------------------------|-----------------------------------|--------------------------------|------------------------------|
| 51.49 49.94 50.02 | 16.91 16.93 16.91 | 76.138 74.218 73.964 | 0.280 0.273 0.272 Average | 139.700 136.035 136.024 137.253 | 478900 478400 480000 | 1040 1040 1040 | 111.9 111.81 110.05 | 0.371 0.372 0.364 | 8:29 9:30 10:07 | 100% 100% 100% | 75 | 75 | 0.37 | 0.48 |
| 50.12 49.89 50.62 | 16.97 16.97 16.97 | 75.244 74.898 75.994 | 0.277 0.276 0.280 Average | 132.668 131.945 134.429 133.014 | 460200 459800 461700 | 1040 1040 1040 | 106.79 103.46 102.75 | 0.359 0.348 0.345 | 10:50 11:28 12:04 | 95% | 75 | 75 | 0.35 | 0.48 |
| 46.24 47.23 46.55 | 17.02 17.03 17.02 | 70.313 72.004 70.785 | 0.259 0.265 0.261 Average | 119.988 123.922 122.691 122.200 | 445400 449200 452400 | 1040 1040 1040 | 114.07 113.03 114.73 | 0.388 0.386 0.391 | 12:42 13:20 13:59 | 90% | 71 | 75 | 0.39 | 0.48 |
| 43.43 42.78 40.58 | 17.14 17.13 17.16 | 68.148 66.950 64.017 | 0.251 0.247 0.236 Average | 112.142 109.939 105.098 109.060 | 429500 428600 428500 | 1040 1040 1040 | 120.26 124.48 130.98 | 0.423 0.436 0.463 | 14:37 15:15 15:50 | 85% | 66 | 75 | 0.44 | 0.48 |

Table 9 Turbine 3 NOx and CO Emission Rates CMS Generation Michigan Power LLC Gaylord, Michigan BTEC Project No. 17-5063 Sampling Date: June 29, 2017

| NOx PPM <u>Dry</u> | 02% <u>Dry</u> | <u>NOx at 15% O2</u> | EQ-19-1 NOx lbs/mmbtu | <u>NOx lbs/hr</u> | Fuel Flow <u>SCFH</u> | <u>BTU's</u> | <u>CO ppm</u> | CO lbs/mmbtu | Start <u>Time</u> | Load | NOx@15% O2 <u>Average</u> | Permit Limit <u>NOx@15% O2</u> | CO lbs/mmbtu <u>Average</u> | Permit Limit <u>CO lbs/mmbtu</u> |
|-------------------------|-------------------------|----------------------------|------------------------------------|--|----------------------------|----------------------|----------------------------|-------------------------|-------------------------|----------------------|------------------------------|-----------------------------------|--------------------------------|-------------------------------------|
| 42.84 41.22 41.59 | 16.84 16.85 16.85 | 62.255 60.049 60.588 | 0.229 0.221 0.223 Average | 122.194 116.851 117.552 118.866 | 512300 507900 506400 | 1040 1040 1040 | 111.56 101.92 101.36 | 0.363 0.332 0.331 | 8:27 9:27 10:05 | 100% 100% 100% | 61 | 75 | 0.34 | 0.48 |
| 40.92 41.16 41.43 | 16.92 16.88 16.9 | 60.660 60.409 61.109 | 0.223 0.223 0.225 Average | 113.974 112.067 113.857 113.299 | 490400 484200 486300 | 1040 1040 1040 | 98.85 96.41 95.74 | 0.328 0.317 0.316 | 10:42 11:19 11:54 | 95% | 61 | 75 | 0.32 | 0.48 |
| 40.11 40.42 42.49 | 16.98 16.97 16.96 | 60.370 60.681 63.627 | 0.222 0.224 0.234 Average | 107.761 108.457 114.819 110.346 | 465900 466500 471000 | 1040 1040 1040 | 99.62 98.21 92.39 | 0.336 0.330 0.310 | 12:30 13:06 13:46 | 90% | 62 | 75 | 0.33 | 0.48 |
| 40.17 38.1 38.63 | 17.08 17.09 17.08 | 62.043 59.000 59.664 | 0.229 0.217 0.220 Average | 109.131 102.423 102.250 104.601 | 459100 453100 447300 | 1040 1040 1040 | 101.44 111.68 103.26 | 0.351 0.387 0.357 | 14:22 15:00 15:35 | 85% | 60 | 75 | 0.37 | 0.48 |

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Table 10 Turbine 4 NOx and CO Emission Rates CMS Generation Michigan Power LLC Gaylord, Michigan BTEC Project No. 17-5063 Sampling Date: June 30, 2017

| NOx PPM <u>Dry</u> | 02% <u>Dry</u> | <u>NOx at 15% O2</u> | EQ-19-1 <u>NOx Ibs/mmbtu</u> | NOx lbs/hr | Fuel Flow <u>SCFH</u> | <u>BTU's</u> | <u>CO ppm</u> | <u>CO lbs/mmbtu</u> | Start <u>Time</u> | <u>Load</u> | NOx@15% O2 <u>Average</u> | Permit Limit NOx@15% O2 | CO lbs/mmbtu <u>Average</u> | Permit Limit <u>CO Ibs/mmbtu</u> |
|-------------------------|-------------------------|----------------------------|------------------------------------|--|----------------------------|----------------------|----------------------------|-------------------------|-------------------------|----------------------|------------------------------|----------------------------|--------------------------------|-------------------------------------|
| 49.01 47.67 48.1 | 16.8 16.72 16.71 | 70.527 67.285 67.730 | 0.260 0.248 0.250 Average | 126.040 119.667 120.407 122.038 | 466450 464200 464000 | 1040 1040 1040 | 102.4 103.72 102.35 | 0.330 0.328 0.323 | 8:34 9:34 10:12 | 100% 100% 100% | 69 | 75 | 0.33 | 0.48 |
| 45.64 48.1 48.4 | 16.77 16.74 16.75 | 65.200 68.219 68.810 | 0.240 0.251 0.253 Average | 111.737 115.996 116.816 114.849 | 447300 443800 443100 | 1040 1040 1040 | 108.94 95.91 94.32 | 0.349 0.305 0.300 | 10:47 11:24 12:01 | 95% | 67 | 75 | 0.32 | 0.48 |
| 45.12 46.14 46.54 | 16.83 16.83 16.82 | 65.407 66.886 67.300 | 0.241 0.246 0.248 Average | 105.877 108.835 109.973 108.229 | 422500 424700 426500 | 1040 1040 1040 | 100.22 97.37 98.46 | 0.325 0.316 0.319 | 12:40 13:18 13:56 | 90% | 67 | 75 | 0.32 | 0.48 |
| 44.05 43.85 44.09 | 16.92 16.91 16.93 | 65.300 64.841 65.524 | 0.241 0.239 0.241 Average | 101.326 100.439 102.301 101.355 | 405000 404300 407500 | 1040 1040 1040 | 106.12 105.78 104.93 | 0.352 0.350 0.349 | 14:32 15:10 15:46 | 85% | 65 | 75 | 0.35 | 0.48 |



