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Report of...

NO_x Emission Sampling

Performed for the...

Michigan Public Power Agency
Lansing, Michigan

On the...

Combustion Turbine Peaking Plant
Kalkaska, Michigan

April 11-12, 2017

Project #: 311.01

By...

Network Environmental, Inc.
Grand Rapids, MI

I. INTRODUCTION

Network Environmental, Inc. was retained by the Michigan Public Power Agency of Lansing, Michigan, to perform emission testing at their combustion turbine peaking plant Kalkaska CT #1 located in Kalkaska, MI. The purpose of the testing was to verify or update the NO_x baseline correlation curve and monitored operating parameters, pursuant to Renewable Operating Permit (ROP) PTI No. MI-ROP-N7113-2016. The ROP has established the following emission limits for this facility:

Compound	Emission Limit
NO_x	25 PPM(v) Dry @ 15% O_2 (Avg. Hours/Day)
	103 PPM(v) Dry @ 15% O_2 (Avg. Per Three Test Periods)
	34.6 Tons/Year (12 Month Rolling Avg.)

There are two (2) natural gas fired turbines (EU-TURBINE1A and EU-TURBINE1B in the ROP) that operate in simple cycle mode at the facility. The following testing is reported herein:

- EU-TURBINE1A: Three (3) test runs at each of four (4) different operating loads (approximately 90%, 80%, 65% and 50% of the theoretical maximum load for the unit in ideal conditions).
- EU-TURBINE1B: Three (3) test runs at 96% load and one (1) test run at 90% load (of the theoretical maximum load for the unit in ideal conditions).

Testing was stopped after Run 1 of the 90% load test on EU-TURBINE1B due to operating performance issues with the unit.

The following reference test methods were employed to conduct the sampling:

- Oxides of Nitrogen (NO_x) – U.S. EPA Method 7E
- Oxygen (O_2) – U.S. EPA Method 3A

The sampling was performed over the period of April 11-12, 2017 by Stephan K. Byrd and David D. Engelhardt of Network Environmental, Inc.. Assisting with the sampling were Mr. Keith Parrott of the Michigan Public Power Agency, Mr. Christopher Occhipinti of NTH Consultants, Ltd. and the operating staff of the facility. Mr. Jeremy Howe and Ms. Caryn Owens of the MDEQ – Air Quality Division were present to observe the sampling and source operation on April 12.

II. PRESENTATION OF RESULTS

II.1 TABLE 1
TOTAL OXIDES OF NITROGEN (NO_x) EMISSION RESULTS
EU-TURBINE1A
MICHIGAN PUBLIC POWER AGENCY
KALKASKA, MICHIGAN
APRIL 11, 2017

Load	Sample	Time	MW [1] Load	$\%O_2$ [2]	NO_x Emissions			
					PPM [3]	PPM @ 15% O_2 [4]	Lbs/MMBTU [5]	Lbs/Hr [6]
90% Load	10	16:55-17:35	27.0	15.2	20.4	20.9	0.077	21.47
	11	17:44-18:24	27.1	15.2	20.1	20.7	0.076	21.26
	12	18:32-19:13	27.2	15.2	20.2	20.8	0.077	21.56
	Average		**27.1**	**15.2**	**20.2**	**20.8**	**0.077**	**21.43**
80% Load	4	11:24-12:04	24.0	15.3	19.7	20.7	0.076	20.28
	5	12:14-12:54	24.0	15.3	19.8	20.8	0.077	20.53
	6	13:04-13:45	24.0	15.2	20.0	20.7	0.076	20.27
	Average		**24.0**	**15.3**	**19.8**	**20.7**	**0.076**	**20.36**
65% Load	7	14:01-14:42	19.5	15.7	19.4	21.8	0.080	18.18
	8	14:52-15:33	19.5	15.7	19.5	21.9	0.081	18.41
	9	15:42-16:23	19.5	15.7	19.5	22.0	0.081	18.40
	Average		**19.5**	**15.7**	**19.5**	**21.9**	**0.081**	**18.33**
50% Load	1	07:52-08:33	15.0	16.2	17.9	22.5	0.083	15.65
	2	08:50-09:29	15.0	16.2	17.8	22.4	0.082	15.43
	3	09:40-11:05[7]	15.0	16.3	17.8	22.9	0.084	15.82
	Average		**15.0**	**16.2**	**17.8**	**22.6**	**0.083**	**15.63**

(1) MW Load = Megawatts Load as supplied by the Michigan Public Power Agency.
(2) $\%O_2$ = Percent Oxygen On A Dry Basis
(3) NO_x PPM = Parts Per Million (v/v) On A Dry Basis
(4) NO_x PPM @ 15% O_2 = Parts Per Million (v/v) On A Dry Basis Corrected To 15% Oxygen
(5) Lbs/MMBTU = Pounds Per Million BTU of Heat Input (calculated on a dry basis using U.S. EPA Method 19 with an F-Factor of 8710 for Natural Gas)
(6) Lbs/Hr = Pounds of NOx Per Hour. Calculated using the Lbs/MMBTU data and MMBTU/Hr heat input data supplied by the Michigan Public Power Agency.
(7) Sample 3 (50% Load) was suspended at the halfway mark (port change) because of a problem with a fitting on the sampling probe. The probe was repaired and the sample was completed. The actual sampling times during this sample were 09:40-09:58 and 10:47-11:05.

II.2 TABLE 2
TOTAL OXIDES OF NITROGEN (NO_x) EMISSION RESULTS
EU-TURBINE1B
MICHIGAN PUBLIC POWER AGENCY
KALKASKA, MICHIGAN
APRIL 12, 2017

Load	Sample	Time	MW (1) Load	$\%O_2$ (2)	NO_x Emissions			
					PPM (3)	PPM @ 15% O_2 (4)	Lbs/MMBTU (5)	Lbs/Hr (6)
96% Load	1	07:02-07:44	28.7	15.0	23.8	23.8	0.088	26.02
	2	07:52-08:34	28.7	14.9	24.1	23.9	0.088	26.05
	3	08:42-09:24	28.8	14.9	24.4	24.2	0.089	26.39
	Average		**28.7**	**14.9**	**24.1**	**24.0**	**0.088**	**26.15**
90% Load	4	09:59-10:42	27.0	14.9	25.6	25.4	0.094	27.69

(1) MW Load = Megawatts Load as supplied by the Michigan Public Power Agency.
(2) $\%O_2$ = Percent Oxygen On A Dry Basis
(3) NO_x PPM = Parts Per Million (v/v) On A Dry Basis
(4) NO_x PPM @ 15% O_2 = Parts Per Million (v/v) On A Dry Basis Corrected To 15% Oxygen
(5) Lbs/MMBTU = Pounds Per Million BTU of Heat Input (calculated on a dry basis using U.S. EPA Method 19 with an F-Factor of 8710 for Natural Gas)
(6) Lbs/Hr = Pounds of NOx Per Hour. Calculated using the Lbs/MMBTU data and MMBTU/Hr heat input data supplied by the Michigan Public Power Agency.

III. DISCUSSION OF RESULTS

The results of the emission sampling are summarized in Tables 1 through 2 (Sections II.1 through II.2). The results are presented as follows:

III.1 EU-TURBINE1A NO_x

Table 1 – Oxides of Nitrogen (NO_x) Emission Results Summary

- % Load
- Sample
- Time
- MW Load – Megawatts Load as supplied by the Michigan Public Power Agency
- Oxygen Concentration (%) – Percent O_2 On a Dry Basis
- NO_x Concentration (PPM Actual) – Parts Per Million (v/v) on a Dry Basis at Actual Exhaust Oxygen
- NO_x Concentration (PPM @ 15% O_2) – Parts Per Million (v/v) On a Dry Basis Corrected to 15% O_2
- NO_x Mass Emission Rate (Lbs/MMBTU) – Pounds Per Million BTU of Heat Input (calculated on a dry basis using U.S. EPA Method 19 with an F-Factor of 8710 for Natural Gas)
- NO_x Lbs/Hr – Pounds Per Hour (calculated using the Lbs/MMBTU data and MMBTU/Hr heat input data supplied by the Michigan Public Power Agency).

All the NO_x raw sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

Sample 3 (50% Load) was suspended at the halfway mark (port change) because of a problem with a fitting on the sampling probe. The probe was repaired and the sample was completed. The actual sampling times during this sample were 09:40-09:58 and 10:47-11:05.

III.2 EU-TURBINE1B NO_x

Table 2 – Oxides of Nitrogen (NO_x) Emission Results Summary

- % Load
- Sample
- Time
- MW Load – Megawatts Load as supplied by the Michigan Public Power Agency
- Oxygen Concentration (%) – Percent O_2 On a Dry Basis
- NO_x Concentration (PPM Actual) – Parts Per Million (v/v) on a Dry Basis at Actual Exhaust Oxygen
- NO_x Concentration (PPM @ 15% O_2) – Parts Per Million (v/v) On a Dry Basis Corrected to 15% O_2

- NO_x Mass Emission Rate (Lbs/MMBTU) – Pounds Per Million BTU of Heat Input (calculated on a dry basis using U.S. EPA Method 19 with an F-Factor of 8710 for Natural Gas)
- NO_x Lbs/Hr – Pounds Per Hour (calculated using the Lbs/MMBTU data and MMBTU/Hr heat input data supplied by the Michigan Public Power Agency).

All the NO_x raw sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

After sampling during the first load (96%) on EU-TURBINE1B, problems with turbine performance were encountered. Sampling was stopped after the first run of the second load (90%) and testing was stopped.

IV. SOURCE DESCRIPTION

The MPPA Kalkaska Power Plant is located at 1750 Prough Road, Kalkaska County, Kalkaska, Michigan. The plant is operated by Traverse City Light and Power (TCL&P) under contract to MPPA. The facility came on-line in 2002 and has been designated as a "peaking unit" which means it is operated primarily at peak load for short periods of time. The units have a capacity factor of not more than 20% on an annual basis and 10% on a three year average basis. The facility operates one Pratt & Whitney FT8 TWINPAC turbine set consisting of two simple-cycle natural gas-fired turbines, each with nominal heat input rating of 273.15 MMBtu/hr (EU-TURBINE1A and EU-TURBINE1B). The turbines are rated nominally at 55 MW (546.3 MMBtu/hr). The turbine set combusts pipeline grade natural gas (PNG) with a sulfur content less than 1.5 grains per 100 standard cubic feet (scf). The facility is limited to a 12-month rolling average gas usage of 595.6 MM cubic feet.

The turbine set is equipped with a water injection system for NO_x emissions control. Exhaust gases from each turbine are exhausted directly to the atmosphere through identical 114-inch estimated inside diameter (ID) steel stacks at approximately 60 feet above grade. NO_x emissions data are obtained using a PEMS that uses modeling software and data from sensors (fuel flow, water injection rate, combustion and stack temperatures, and stack exhaust flow rates) to predict NO_x emission rates in units of Lbs/MMBTU, pursuant to calculation methodology specified in 40 CFR Part 75, Appendix E.

Source operating data during the testing can be found in Appendix E of this document.

V. SAMPLING AND ANALYTICAL PROTOCOL

The sampling was conducted on the 114 inch I.D. exhaust stacks at a location approximately 2 duct diameters downstream and 0.5 duct diameter upstream from the nearest disturbances. There are 2 sample ports on each stack. A schematic diagram of the exhaust stacks and the sampling locations can be found in Figure 1.

Twelve (12) sampling points (6 per port) were used to collect the samples. The sampling point dimensions were as follows:

Sampling Point	Dimension (Inches)
1	5.02
2	16.64
3	33.74
4	80.26
5	97.36
6	108.98

V.1 Oxides of Nitrogen – The NO_x sampling was conducted in accordance with U.S. EPA Reference Method 7E. A Thermo Environmental Model 42H gas analyzer was used to monitor the exhausts. A heated teflon sample line was used to transport the exhaust gases to a gas conditioner to remove moisture and reduce the temperature. From the gas conditioner stack gases were passed to the analyzer. The analyzer produces instantaneous readouts of the NO_x concentrations (PPM).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 54.0 PPM was used to establish the initial instrument calibration. A calibration gas of 25.66 PPM was used to determine the calibration error of the analyzer. A direct injection of 49.6 PPM nitrogen dioxide (NO_2) was performed to show the conversion efficiency of the monitor. The conversion efficiency was 94.35% and can be found in Appendix A. The sampling system (from the back of the stack probe to the analyzer) was injected using the 25.66 PPM gas to determine the system bias. After each sample, a system zero and system injection of 25.66 PPM were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified. Each sample was thirty-six (36) minutes in duration (3 minutes per sampling point). Each sample was suspended after eighteen (18) minutes during the sampling port change.

The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhausts. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. A diagram of the sampling train is shown in Figure 2.

V.2 Oxygen – The O_2 sampling was conducted in accordance with U.S. EPA Reference Method 3A. A Servomex Model 1400M portable stack gas analyzer was used to monitor the exhausts. A heated teflon sample line was used to transport the exhaust gases to a gas conditioner to remove moisture and reduce the temperature. From the gas conditioner stack gases were passed to the analyzers. The analyzers produce instantaneous readouts of the O_2 concentrations (%).

The analyzer was calibrated by direct injection prior to the testing. A Span gas of 20.96% O_2 was used to establish the initial instrument calibrations. Calibration gases of 12.1% O_2 and 5.96% O_2 were used to determine the calibration error of the analyzer. The sampling system (from the back of the stack probe to the analyzer) was injected using the 12.1% O_2 gas to determine the system bias. After each sample, a system zero and system injection of 12.1% O_2 were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified.

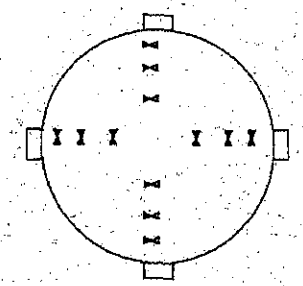
The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhausts. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. A diagram of the sampling train is shown in Figure 2.

This report was prepared by:

David D. Engelhardt
Vice President

This report was reviewed by:

Stephan K. Byrd
President



Crossectional Area Showing
Traverse Point Locations

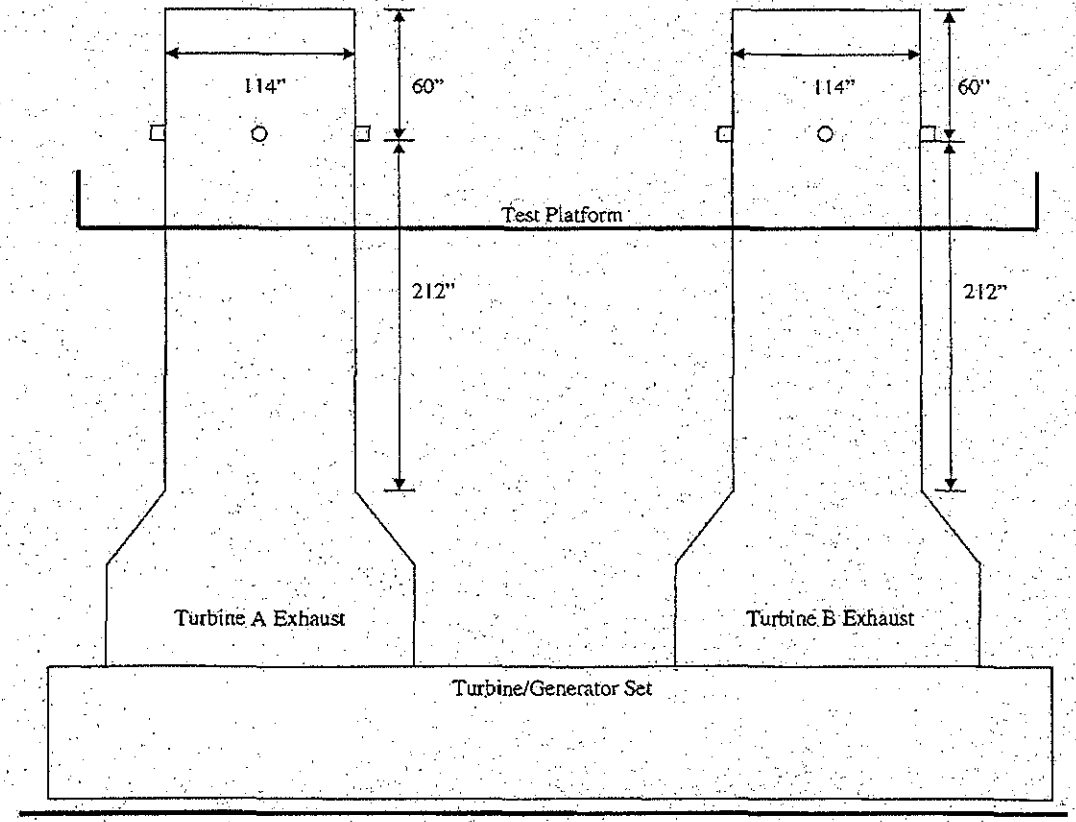


Figure 1

Source & Sampling Location

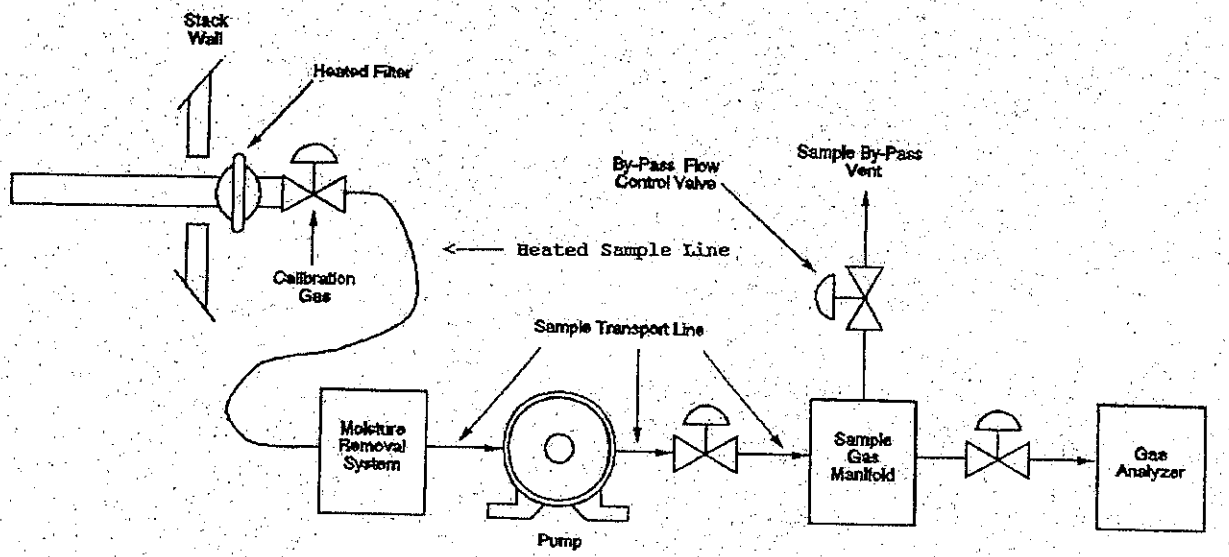


Figure 2

NO_x & O_2 Sampling Train