



Highland Compressor Station Turbines 1 & 2 Emissions Test Report

Prepared for:

Vector Pipeline L.P.

RECEIVED
AUG 18 2014
AIR QUALITY DIV.

Highland Compressor Station
2282 SOUTH DUCK LAKE ROAD
HIGHLAND, Michigan 48356

Project No. 14-4566.00
August 11, 2014

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



MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

RECEIVED

AUG 18 2014

RENEWABLE OPERATING PERMIT
REPORT CERTIFICATION

AIR QUALITY DIV.

Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating Permit (ROP) program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as specified in Rule 213(3)(b)(II), and be made available to the Department of Environmental Quality, Air Quality Division upon request.

Source Name Vector Pipeline L.P., Highland Compressor Station County Oakland

Source Address 2282 South Duck Lake Road City Highland Township

AQD Source ID (SRN) N6838 ROP No. MI-ROP-N6838- ROP Section No. _____
2014

Please check the appropriate box(es):

Annual Compliance Certification (Pursuant to Rule 213(4)(c))

Reporting period (provide inclusive dates): From _____ To _____

1. During the entire reporting period, this source was in compliance with ALL terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the ROP.

2. During the entire reporting period this source was in compliance with all terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference, EXCEPT for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the ROP, unless otherwise indicated and described on the enclosed deviation report(s).

Semi-Annual (or More Frequent) Report Certification (Pursuant to Rule 213(3)(c))

Reporting period (provide inclusive dates): From _____ To _____

1. During the entire reporting period, ALL monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred.

2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred, EXCEPT for the deviations identified on the enclosed deviation report(s).

Other Report Certification

Reporting period (provide inclusive dates): From _____ To _____

Additional monitoring reports or other applicable documents required by the ROP are attached as described:
Highland Compressor Station Stack Test Report for two natural gas turbines. Testing was
conducted on July 1 and 2, 2014 in accordance with the approved test plan.

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete

<u>Belinda Friis</u>	<u>Chief Compliance Officer</u>	<u>734-462-7621</u>
Name of Responsible Official (print or type)	Title	Phone Number
<u>Belinda Friis</u>		<u>8/15/14</u>
Signature of Responsible Official		Date

* Photocopy this form as needed.

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Vector Pipeline L.P. (Vector) to evaluate oxides of nitrogen (NOx) and carbon monoxide (CO) emission rates from two turbines operating at four load conditions at the Vector facility located in Highland, Michigan. The emissions test program was conducted on July 1 and 2, 2014.

Testing consisted of triplicate 21-minute test runs at four different loads (86%, 90%, 94%, and 100% NGP). The emissions test program is required by MDEQ Air Quality Division Renewable Operating Permit (ROP) No. MI-ROP-N6838-2014. The results of the emission test program are summarized by Tables 1 and 2.

Table 1
Turbine 1 Overall Emission Summary
Test Date: July 1, 2014

Load	Pollutant	Emission Rates		Emission Limits	
		lb/hr	ppmv ¹	lb/hr	ppmv ¹
86%	NOx	5.4	31	18.95	NA
	CO	250	NA	400	NA
90%	NOx	9.4	40	18.95	NA
	CO	156	NA	400	NA
94%	NOx	4.7	14	18.95	NA
	CO	0.12	NA	12.57	NA
100%	NOx	5.8	17	18.95	NA
	CO	0.01	NA	12.57	NA

1: Corrected to 15% O₂ at ISO standard day conditions

Table 2
Turbine 2 Overall Emission Summary
Test Date: July 2, 2014

Load	Pollutant	Emission Rates		Emission Limits	
		lb/hr	ppmv ¹	lb/hr	ppmv ¹
86%	NOx	4.8	26	18.95	NA
	CO	268	NA	400	NA
90%	NOx	7.8	33	18.95	NA
	CO	24	NA	400	NA
94%	NOx	2.3	7	18.95	NA
	CO	0.00	NA	12.57	NA
100%	NOx	3.3	9	18.95	NA
	CO	0.48	NA	12.57	NA

1: Corrected to 15% O₂ at ISO standard day conditions

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Vector Pipeline L.P. (Vector) to evaluate oxides of nitrogen (NOx) and carbon monoxide (CO) emission rates from two turbines operating at four load conditions at the Vector facility located in Highland, Michigan. The emissions test program was conducted on July 1 and 2, 2014. The purpose of this report is to document the results of the test program.

AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013). This document is provided as Appendix A. The following is a summary of the emissions test program and results in the format suggested by the aforementioned document.

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on July 1 and 2, 2014 at the Vector facility located in Highland, Michigan. The test program included evaluation of CO and NOx emissions from Turbines 1 and 2.

1.b Purpose of Testing

AQD issued renewable operating permit no. MI-ROP-N6838-2014 to Vector on February 26, 2014. Table 1 summarizes the limitations included in this permit.

**Table 1
NOx and CO Emission Limitations**

Facility	NOx Emission Limit	CO Emission Limits
Highland	18.95 lbs/hr	400 lbs/hr*
		12.57 lbs/hr**

**Limit applicable when turbine is operating between 86% and 92% of gas producer speed*

***Limit applicable when turbine is operating at or above 92% of gas producer speed*

1.c Source Description

Vector's Highland Compressor Station is used to compress natural gas for transmission through the Vector pipeline.



1.d Test Program Contacts

The contact for the source and test report is:

Mr. Terry McMillin
Senior EHS Coordinator
Vector Pipeline
1100 Louisiana, Suite 3300
Houston, Texas 77002
(753) 353-5620

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

**Table 2
Test Personnel**

Name	Affiliation
Matthew DiPaola	Vector Pipeline
John Wojcik	Vector Pipeline
Corrie Towns	Vector Pipeline
Tom Maza	MDEQ-AQD
Sebastian Kallumkal	MDEQ-AQD
Todd Wessel	BTEC
Randal Tysar	BTEC

2. Summary of Results

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

2.a Operating Data

Process data monitored during the emissions test program included percent natural gas producer speed (%), turbine natural gas firing rate (kscfd), natural gas higher heating value (Btu/scf), natural gas specific gravity, power turbine rotational speed (rpm), power turbine load (hp), and whether or not the turbine was operating in “So-Lo-NOx” mode.

2.b Applicable Permit

The applicable permit for this emissions test program is Renewable Operating Permit (ROP) No. MI-ROP-N6838-2014.

2.c Results

The overall results of the emission test program are summarized by Tables 3 and 4 (see Section 5.a). Detailed results for each turbine can be found in Tables 5 and 6. The results



summarized by Tables 3 and 4 (section 5.a) show that the NO_x and CO emissions are well below the limits summarized by Table 1 (Section 1.b).

3. Source Description

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

3.a Process Description

Two identical natural gas compressor turbines were evaluated for CO and NO_x emission rates in terms of pounds per hour. Both Solar Mars 100 turbines fire only natural gas and are rated at 15,000 horsepower at a heat input rate of 120 MMBtu/hr. Each turbine exhausts to a single, independent exhaust stack and each is equipped with dry low-NO_x emission controls.

3.b Process Flow Diagram

Due to the simplicity of the natural gas compressor turbines, a process flow diagram is not necessary.

3.c Raw and Finished Materials

The raw material used by the process is natural gas and turbine natural gas firing rates during the emissions test program are summarized by the process field data sheets included in Appendix B.

3.d Process Capacity

Both turbines are rated at 15,000 horsepower and 120 MMBtu/hr. However, maximum turbine power output and heat input capacity at any given time are variable depending on ambient air temperature and pressure as well as pipeline gas pressure.

3.e Process Instrumentation

Process data monitored during the emissions test program included percent natural gas producer speed (%), turbine natural gas firing rate (kscfd), natural gas higher heating value (Btu/scf), natural gas specific gravity, power turbine rotational speed (rpm), power turbine load (hp), and whether or not the turbine was operating in "So-Lo-NO_x" mode.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

4.a Sampling Train and Field Procedures

Turbine exhaust CO content was measured using a TECO 48i CO gas analyzer (or equivalent), the NO_x content of the gas stream was measured using a TECO Model 42i NO_x gas analyzer (or equivalent), and the O₂ content was measured using a M&C Products PMA 100-L O₂ 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 enters the analyzer. Data was recorded at 4-second intervals on a PC equipped with data acquisition software.

For analyzer calibrations, calibration gases were mixed to desired concentrations using an Environics Series 4040 Computerized Gas Dilution System. The Series 4040 consists of a single chassis with four mass flow controllers. The mass flow controllers are factory-calibrated using a primary flow standard traceable to the United State's National Institute of Standards and Technology (NIST). Each flow controller utilizes an 11-point calibration table with linear interpolation, to increase accuracy and reduce flow controller nonlinearity. A schematic of the sampling train is provided as Figure 1.

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 Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources*", was used to measure the O₂ concentration of the exhaust gas.
- Method 7E, "*Determination of Nitrogen Oxide Emissions from Stationary Sources*", was used to measure the NO_x concentration of the exhaust gas.
- Method 10, "*Determination of Carbon Monoxide Emissions from Stationary Sources*", was used to measure the NO_x concentration of the exhaust gas.
- Method 19, "*Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*", was used to determine the exhaust gas CO and NO_x emission rates.

The accuracy of the gas dilution system was verified using the procedures detailed by Method 205 and the NO_x converter efficiency was verified as specified by Method 7E.

Exhaust gas flowrates were calculated using diluent concentrations as well as turbine natural gas flowrate and average natural gas heating value data. For both turbines, exhaust gas stratification checks were performed during the first test run and subsequent test runs were conducted using single-point sampling as approved by AQD.

4.b Recovery and Analytical Procedures

This test program did not include laboratory samples and, consequently, sample recovery and analysis is not applicable to this test program.

4.c Sampling Ports

Figure 2 shows relevant sampling port and traverse point locations.

4.d Traverse Points

For both turbines, exhaust gas stratification checks were performed during the first test run and subsequent test runs were conducted using single-point sampling as approved by AQD.

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 and 4.

Table 3
Turbine 1 Overall Emission Summary
Test Date: July 1, 2014

Load	Pollutant	Emission Rates		Emission Limits	
		lb/hr	ppmv ¹	lb/hr	ppmv ¹
86%	NOx	5.4	31	18.95	NA
	CO	250	NA	400	NA
90%	NOx	9.4	40	18.95	NA
	CO	156	NA	400	NA
94%	NOx	4.7	14	18.95	NA
	CO	0.12	NA	12.57	NA
100%	NOx	5.8	17	18.95	NA
	CO	0.01	NA	12.57	NA

1: Corrected to 15% O₂ at ISO standard day conditions

Table 4
Turbine 2 Overall Emission Summary
Test Date: July 2, 2014

Load	Pollutant	Emission Rates		Emission Limits	
		lb/hr	ppmv ¹	lb/hr	ppmv ¹
86%	NOx	4.8	26	18.95	NA
	CO	268	NA	400	NA
90%	NOx	7.8	33	18.95	NA
	CO	24	NA	400	NA
94%	NOx	2.3	7	18.95	NA
	CO	0.00	NA	12.57	NA
100%	NOx	3.3	9	18.95	NA
	CO	0.48	NA	12.57	NA

1: Corrected to 15% O₂ at ISO standard day conditions

Detailed data for each test run can be found in Tables 5 and 6.

5.b Discussion of Results

Emission limitations for Renewable Operating Permit (ROP) No. MI-ROP-N6838-2014 are summarized by Table 1 (see section 1.b). The overall results of the emissions test program are summarized by Tables 3 and 4 (see section 5.a). Detailed results for each run of the emissions test program are summarized by Tables 5 and 6.

5.c Sampling Procedure Variations

Natural gas combustion rate and natural gas heating value were not recorded for Test Run 1 on Turbine 1 at the 94% load condition. With the approval of AQD, the average natural gas combustion rate and natural gas heating value from Runs 2 and 3 was used to calculate exhaust gas flowrates for Run 1.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

The turbines are not equipped with emissions control equipment.

5.f Re-Test

The emissions test program was not a re-test.

5.g Audit Sample Analyses

No audit samples were collected as part of the test program.

RECEIVED
AUG 18 2014
AIR QUALITY DIV.

5.h Calibration Sheets

Relevant equipment calibration documents are provided in Appendix C.

5.i Sample Calculations

Sample calculations are provided in Appendix D.

5.j Field Data Sheets

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

5.k Laboratory Data

There are no laboratory results for this test program. Raw CEM data is provided electronically in Appendix E.

TABLES

Table 5
Turbine 1 Detailed Emission Test Results Summary
Vector Pipeline
BTEC Project No. 14-4566.00
Sampling Date: July 1, 2014

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	7/1/2014	7/1/2014	7/1/2014	
80% Load				
Oxides of Nitrogen Concentration (ppmv)	20.4	20.4	20.4	20.4
Oxygen concentration (%)	17.2	17.2	17.2	17.2
Oxygen concentration (%) (corrected as per USEPA 7E)	17.2	17.2	17.2	17.2
Natural Gas Flowrate (ksccf/hr)	42.5	42.3	43.0	42.6
Natural Gas Heating Value (Btu/scf)	1038	1038	1038	1038
NOx Concentration (ppmv, corrected as per USEPA 7E)	20.8	21.0	21.0	20.9
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	2.5E-06	2.5E-06	2.5E-06	2.5E-06
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.123	0.122	0.122	0.122
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	5.4	5.4	5.4	5.4
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	31	31	31	31
90% Load				
Oxides of Nitrogen Concentration (ppmv)	30.6	30.6	30.9	30.7
Oxygen concentration (%)	16.6	16.6	16.6	16.6
Oxygen concentration (%) (corrected as per USEPA 7E)	16.6	16.6	16.6	16.6
Natural Gas Flowrate (ksccf/hr)	56.4	57.8	56.5	56.9
Natural Gas Heating Value (Btu/scf)	1038	1038	1038	1038
NOx Concentration (ppmv, corrected as per USEPA 7E)	30.9	31.3	31.7	31.3
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	3.7E-06	3.7E-06	3.8E-06	3.7E-06
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.157	0.160	0.161	0.159
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	9.2	9.6	9.4	9.4
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	39	40	40	40
94% Load				
Oxides of Nitrogen Concentration (ppmv)	12.6	12.7	13.3	12.9
Oxygen concentration (%)	15.7	15.7	15.7	15.7
Oxygen concentration (%) (corrected as per USEPA 7E)	15.7	15.7	15.6	15.7
Natural Gas Flowrate (ksccf/hr)	83.6	83.7	83.5	83.6
Natural Gas Heating Value (Btu/scf)	1038	1038	1038	1038
NOx Concentration (ppmv, corrected as per USEPA 7E)	12.7	12.8	13.4	13.0
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	1.5E-06	1.5E-06	1.6E-06	1.5E-06
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.053	0.053	0.056	0.054
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	4.6	4.6	4.9	4.7
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	13	13	14	14
100% Load				
Oxides of Nitrogen Concentration (ppmv)	13.7	14.4	14.5	14.2
Oxygen concentration (%)	15.5	15.5	15.5	15.5
Oxygen concentration (%) (corrected as per USEPA 7E)	15.4	15.5	15.5	15.5
Natural Gas Flowrate (ksccf/hr)	98.0	97.2	96.5	97.2
Natural Gas Heating Value (Btu/scf)	1038	1038	1038	1038
NOx Concentration (ppmv, corrected as per USEPA 7E)	13.8	14.5	14.7	14.3
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	1.7E-06	1.7E-06	1.8E-06	1.7E-06
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.055	0.058	0.059	0.057
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	5.6	5.8	5.9	5.8
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	16	17	17	17
80% Load				
Carbon Monoxide Concentration (ppmv)	1583.2	1560.9	1555.7	1566.6
Oxygen concentration (%)	17.2	17.2	17.2	17.2
Oxygen concentration (%) (corrected as per USEPA 7E)	17.2	17.2	17.2	17.2
Natural Gas Flowrate (ksccf/hr)	42.5	42.3	43.0	42.6
Natural Gas Heating Value (Btu/scf)	1038.0	1038.0	1038.0	1038
CO Concentration (ppmv, corrected as per USEPA 7E)	1604.4	1581.8	1575.5	1587.2
CO Concentration (lb/dscf, corrected as per USEPA 7E)	1.2E-04	1.1E-04	1.1E-04	1.2E-04
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	5.760	5.608	5.562	5.644
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	254	246	248	250
90% Load				
Carbon Monoxide Concentration (ppmv)	841.1	842.7	838.6	840.8
Oxygen concentration (%)	16.6	16.6	16.6	16.6
Oxygen concentration (%) (corrected as per USEPA 7E)	16.6	16.6	16.6	16.6
Natural Gas Flowrate (ksccf/hr)	56.4	57.8	56.5	56.9
Natural Gas Heating Value (Btu/scf)	1038.0	1038.0	1038.0	1038
CO Concentration (ppmv, corrected as per USEPA 7E)	852.0	854.9	850.4	852.4
CO Concentration (lb/dscf, corrected as per USEPA 7E)	6.2E-05	6.2E-05	6.2E-05	6.2E-05
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	2.633	2.655	2.629	2.639
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	154	159	154	156
94% Load				
Carbon Monoxide Concentration (ppmv)	0.5	0.6	0.5	0.5
Oxygen concentration (%)	15.7	15.7	15.7	15.7
Oxygen concentration (%) (corrected as per USEPA 7E)	15.7	15.7	15.6	15.7
Natural Gas Flowrate (ksccf/hr)	83.6	83.7	83.5	83.6
Natural Gas Heating Value (Btu/scf)	1038.0	1038.0	1038.0	1038
CO Concentration (ppmv, corrected as per USEPA 7E)	0.4	0.7	0.6	0.6
CO Concentration (lb/dscf, corrected as per USEPA 7E)	3.2E-08	4.8E-08	4.2E-08	4.0E-08
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.001	0.002	0.001	0.001
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	0.09	0.14	0.13	0.12
100% Load				
Carbon Monoxide Concentration (ppmv)	0.2	-0.8	-1.0	-0.5
Oxygen concentration (%)	15.5	15.5	15.5	15.5
Oxygen concentration (%) (corrected as per USEPA 7E)	15.4	15.5	15.5	15.5
Natural Gas Flowrate (ksccf/hr)	98.0	97.2	96.5	97.2
Natural Gas Heating Value (Btu/scf)	1038.0	1038.0	1038.0	1038
CO Concentration (ppmv, corrected as per USEPA 7E)	0.1	0.0	0.0	0.0
CO Concentration (lb/dscf, corrected as per USEPA 7E)	9.0E-09	0.0E+00	0.0E+00	3.0E-09
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.000	0.000	0.000	0.000
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	0.03	0.00	0.00	0.01

NOx Correction			
Co	0.48	0.23	0.22
Cma	49.70	49.70	49.70
Cm	48.13	48.08	48.00

O2 Correction			
Co	0.21	0.21	0.20
Cma	9.90	9.90	9.90
Cm	9.99	10.01	10.01

NOx Correction			
Co	0.52	0.60	0.60
Cma	49.70	49.70	49.70
Cm	48.76	48.25	48.16

O2 Correction			
Co	0.20	0.19	0.20
Cma	9.90	9.90	9.90
Cm	9.99	9.98	9.99

NOx Correction			
Co	0.44	0.48	0.35
Cma	49.70	49.70	49.70
Cm	48.26	48.15	48.11

O2 Correction			
Co	0.25	0.24	0.24
Cma	9.90	9.90	9.90
Cm	10.03	10.03	10.04

NOx Correction			
Co	0.39	0.51	0.44
Cma	49.70	49.70	49.70
Cm	48.18	48.15	48.18

O2 Correction			
Co	0.23	0.22	0.21
Cma	9.90	9.90	9.90
Cm	10.04	10.01	10.00

CO Correction			
Co	-1.38	-1.02	-0.99
Cma	997.00	997.00	997.00
Cm	983.33	983.48	984.13

O2 Correction			
Co	0.21	0.21	0.20
Cma	9.90	9.90	9.90
Cm	9.99	10.01	10.01

CO Correction			
Co	0.65	-1.58	-1.71
Cma	997.00	997.00	997.00
Cm	984.13	983.11	983.51

O2 Correction			
Co	0.20	0.19	0.20
Cma	9.90	9.90	9.90
Cm	9.99	9.98	9.99

CO Correction			
Co	0.10	-0.03	-0.08
Cma	49.70	49.70	49.70
Cm	49.37	48.25	48.33

O2 Correction			
Co	0.25	0.24	0.24
Cma	9.90	9.90	9.90
Cm	10.03	10.03	10.04

CO Correction			
Co	0.04	-0.43	0.10
Cma	49.70	49.70	49.70
Cm	48.27	47.83	47.97

O2 Correction			
Co	0.23	0.22	0.21
Cma	9.90	9.90	9.90
Cm	10.04	10.01	10.00

Notes: (1) Natural Gas Flowrate for Run 1 at 94% load was not recorded and, as approved on-site by MDEQ, was assumed to be equal to the average of the values recorded for Runs 2 and 3.
(2) Natural Gas Heating Value did vary slightly during the testing and, therefore, the maximum value of 1038 was used for all test runs.
(3) CO concentration results for Runs 2 and 3 at 100% load were negative and have been changed to zero.

Calculated using USEPA Method 19 equation 19-1

dscf = dry standard cubic feet
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (NOx = 46.01, CO = 28.01)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft³ per m³
453.60 = mg per lb
10⁵ = Btu per MMBtu
3785.4 = mL per gallon
Ambient Temperature = 39°F
Ambient Pressure = 29.78 in. Hg
Ambient Humidity = 0.005 g H2O/g air

Co= Average of initial and final zero gases
Cma= Actual concentration of the calibration gas
Cm = Average of initial and final calibration gases

Equations

lb/dscf = ppmv * MW/24.14 * 1/35.31 * 1/453,600
eq 19-1: $E = C_i F_i * 20.9 / (20.9 - \%O_2)$
NOx @ 15% O2 = NOx measured (ppm) X (5.9/(20.9-O2% measured))
Nox corrected to ISO standard day conditions = (Nox @ 15%) x (P/P_{std})^{0.5} x 2.718^{(15-(T_{std}/T_{amb}))}

Table 6
Turbine 2 Detailed Emission Test Results Summary
Vector Pipeline
BTEC Project No. 14-4566.00
Sampling Date: July 2, 2014

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	7/2/2014	7/2/2014	7/2/2014	
80% Load				
Oxides of Nitrogen Concentration (ppmv)	17.7	17.7	17.5	17.7
Oxygen concentration (%)	17.1	17.1	17.1	17.1
Oxygen concentration (%) (corrected as per USEPA 7E)	17.1	17.1	17.1	17.1
Natural Gas Flowrate (kscf/hr)	46.8	46.1	47.7	46.9
Natural Gas Heating Value (Btu/scf)	1033	1033	1033	1033
NOx Concentration (ppmv, corrected as per USEPA 7E)	17.4	17.3	17.0	17.2
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	2.1E-06	2.1E-06	2.0E-06	2.1E-06
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.100	0.098	0.097	0.098
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	4.8	4.7	4.8	4.8
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	27	26	26	26
50% Load				
Oxides of Nitrogen Concentration (ppmv)	24.5	26.2	25.5	25.4
Oxygen concentration (%)	16.5	16.5	16.7	16.6
Oxygen concentration (%) (corrected as per USEPA 7E)	16.5	16.5	16.6	16.5
Natural Gas Flowrate (kscf/hr)	60.8	60.4	60.6	60.6
Natural Gas Heating Value (Btu/scf)	1033	1033	1033	1033
NOx Concentration (ppmv, corrected as per USEPA 7E)	23.8	25.9	25.5	25.1
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	2.8E-06	3.1E-06	3.0E-06	3.0E-06
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.117	0.128	0.129	0.125
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	7.4	8.0	8.0	7.8
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	31	34	34	33
94% Load				
Oxides of Nitrogen Concentration (ppmv)	6.8	6.8	6.7	6.7
Oxygen concentration (%)	15.8	15.9	15.9	15.9
Oxygen concentration (%) (corrected as per USEPA 7E)	15.7	15.7	15.7	15.7
Natural Gas Flowrate (kscf/hr)	82.9	82.8	83.0	82.9
Natural Gas Heating Value (Btu/scf)	1033	1033	1033	1033
NOx Concentration (ppmv, corrected as per USEPA 7E)	6.7	6.6	6.5	6.6
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	7.9E-07	7.8E-07	7.8E-07	7.9E-07
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.028	0.027	0.027	0.027
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	2.4	2.3	2.3	2.3
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	7	7	7	7
100% Load				
Oxides of Nitrogen Concentration (ppmv)	8.3	8.3	8.5	8.4
Oxygen concentration (%)	15.7	15.6	15.6	15.6
Oxygen concentration (%) (corrected as per USEPA 7E)	15.5	15.4	15.4	15.4
Natural Gas Flowrate (kscf/hr)	96.8	97.0	97.3	97.0
Natural Gas Heating Value (Btu/scf)	1033	1033	1033	1033
NOx Concentration (ppmv, corrected as per USEPA 7E)	8.1	8.1	8.3	8.2
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	9.7E-07	9.7E-07	9.9E-07	9.8E-07
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.032	0.032	0.033	0.033
NOx Emission Rate (lb/hr) (corrected as per USEPA 7E)	3.2	3.2	3.3	3.3
NOx Concentration (ppmv @ 15% O2 and ISO Standard Day Conditions)	9	9	9	9
80% Load				
Carbon Monoxide Concentration (ppmv)	1570.6	1524.6	1557.4	1550.9
Oxygen concentration (%)	17.1	17.1	17.1	17.1
Oxygen concentration (%) (corrected as per USEPA 7E)	17.1	17.1	17.1	17.1
Natural Gas Flowrate (kscf/hr)	46.8	46.1	47.7	46.9
Natural Gas Heating Value (Btu/scf)	1033.0	1033.0	1033.0	1033
CO Concentration (ppmv, corrected as per USEPA 7E)	1612.6	1566.1	1606.1	1594.9
CO Concentration (lb/dscf, corrected as per USEPA 7E)	1.2E-04	1.1E-04	1.2E-04	1.2E-04
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	5.629	5.408	5.549	5.529
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	272	258	274	268
90% Load				
Carbon Monoxide Concentration (ppmv)	120.0	120.9	124.7	121.9
Oxygen concentration (%)	16.5	16.5	16.7	16.6
Oxygen concentration (%) (corrected as per USEPA 7E)	16.5	16.5	16.6	16.5
Natural Gas Flowrate (kscf/hr)	60.8	60.4	60.6	60.6
Natural Gas Heating Value (Btu/scf)	1033.0	1033.0	1033.0	1033
CO Concentration (ppmv, corrected as per USEPA 7E)	123.6	124.3	128.2	125.4
CO Concentration (lb/dscf, corrected as per USEPA 7E)	9.0E-06	9.0E-06	9.3E-06	9.1E-06
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.370	0.375	0.394	0.380
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	23	23	25	24
94% Load				
Carbon Monoxide Concentration (ppmv)	-0.8	-0.6	-0.2	-0.5
Oxygen concentration (%)	15.8	15.9	15.9	15.9
Oxygen concentration (%) (corrected as per USEPA 7E)	15.7	15.7	15.7	15.7
Natural Gas Flowrate (kscf/hr)	82.9	82.8	83.0	82.9
Natural Gas Heating Value (Btu/scf)	1033.0	1033.0	1033.0	1033
CO Concentration (ppmv, corrected as per USEPA 7E)	0.0	0.0	0.0	0.0
CO Concentration (lb/dscf, corrected as per USEPA 7E)	0.0E+00	0.0E+00	0.0E+00	0.0E+00
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.000	0.000	0.000	0.000
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	0.00	0.00	0.00	0.00
100% Load				
Carbon Monoxide Concentration (ppmv)	0.0	2.9	3.6	2.2
Oxygen concentration (%)	15.7	15.6	15.6	15.6
Oxygen concentration (%) (corrected as per USEPA 7E)	15.5	15.4	15.4	15.4
Natural Gas Flowrate (kscf/hr)	96.8	97.0	97.3	97.0
Natural Gas Heating Value (Btu/scf)	1033.0	1033.0	1033.0	1033
CO Concentration (ppmv, corrected as per USEPA 7E)	-0.4	2.6	3.7	2.0
CO Concentration (lb/dscf, corrected as per USEPA 7E)	-3.0E-08	1.9E-07	2.7E-07	1.4E-07
CO Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	-0.001	0.006	0.009	0.005
CO Emission Rate (lb/hr) (corrected as per USEPA 7E)	-0.10	0.64	0.90	0.48

NOx Correction			
Co	0.22	0.37	0.42
Cma	49.60	49.60	49.60
Cm	50.18	50.19	50.16

O2 Correction			
Co	0.09	0.10	0.10
Cma	9.90	9.90	9.90
Cm	9.93	9.96	9.97

NOx Correction			
Co	0.52	0.32	0.02
Cma	49.60	49.60	49.60
Cm	50.43	49.81	49.67

O2 Correction			
Co	0.09	0.09	0.15
Cma	9.90	9.90	9.90
Cm	9.96	9.95	10.01

NOx Correction			
Co	0.07	0.12	0.12
Cma	49.60	49.60	49.60
Cm	49.86	50.18	50.22

O2 Correction			
Co	0.20	0.20	0.15
Cma	9.90	9.90	9.90
Cm	10.07	10.03	10.09

NOx Correction			
Co	0.12	0.12	0.12
Cma	49.60	49.60	49.60
Cm	49.92	49.95	49.91

O2 Correction			
Co	0.14	0.19	0.22
Cma	9.90	9.90	9.90
Cm	10.03	10.07	10.09

CO Correction			
Co	0.52	0.94	0.92
Cma	997.00	997.00	997.00
Cm	971.27	970.93	967.11

O2 Correction			
Co	0.09	0.10	0.10
Cma	9.90	9.90	9.90
Cm	9.93	9.96	9.97

CO Correction			
Co	0.31	-0.27	-0.36
Cma	997.00	997.00	997.00
Cm	965.62	971.82	972.41

O2 Correction			
Co	0.09	0.09	0.15
Cma	9.90	9.90	9.90
Cm	9.96	9.95	10.01

CO Correction			
Co	-0.11	1.26	0.86
Cma	49.70	49.70	49.70
Cm	49.67	49.03	49.05

O2 Correction			
Co	0.20	0.20	0.15
Cma	9.90	9.90	9.90
Cm	10.07	10.03	10.09

CO Correction			
Co	0.43	0.25	-0.20
Cma	49.70	49.70	49.70
Cm	49.49	50.26	50.03

O2 Correction			
Co	0.14	0.19	0.22
Cma	9.90	9.90	9.90
Cm	10.03	10.07	10.09

Note: (1) Natural Gas Heating Value did vary slightly during the testing and, therefore, the maximum value of 1033 was used for all test runs.
(2) CO concentration results for Run 1 at 100% load and for all three runs at 94% load were negative and have been changed to zero.

Calculated using USEPA Method 19 equation 19-1

dscf = dry standard cubic feet
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (NOx = 46.01, CO = 28.01)
24.14 = molar volume of air at standard conditions (760, 29.92" Hg)
35.31 = ft³ per m³
453600 = mg per lb
10⁶ = Btu per MMBtu
3785.4 = mL per gallon
Ambient Temperature = 39°F
Ambient Pressure = 29.78 in. Hg
Ambient Humidity = 0.005 g H2O/g air

Co = Average of initial and final zero gases
Cma = Actual concentration of the calibration gas
Cm = Average of initial and final calibration gases

Equations
lb/dscf = ppmv * MW/24.14 * 1/35.31 * 1/453600
eq 19-1: $E = C_i F_a * 20.9 / (20.9 - \%O_2)$
NOx @ 15% O2 = NOx measured (ppm) X (5.9/(20.9-O2% measured))
NOx corrected to ISO standard dry conditions = (NOx @ 15%) x (P_{amb}/P_{std})^{0.5} x 2.718^(15-O2% measured) x (T_{amb}/T_{std})^{1.5}

RECEIVED

AUG 18 2014

AIR QUALITY DIV.

FIGURES

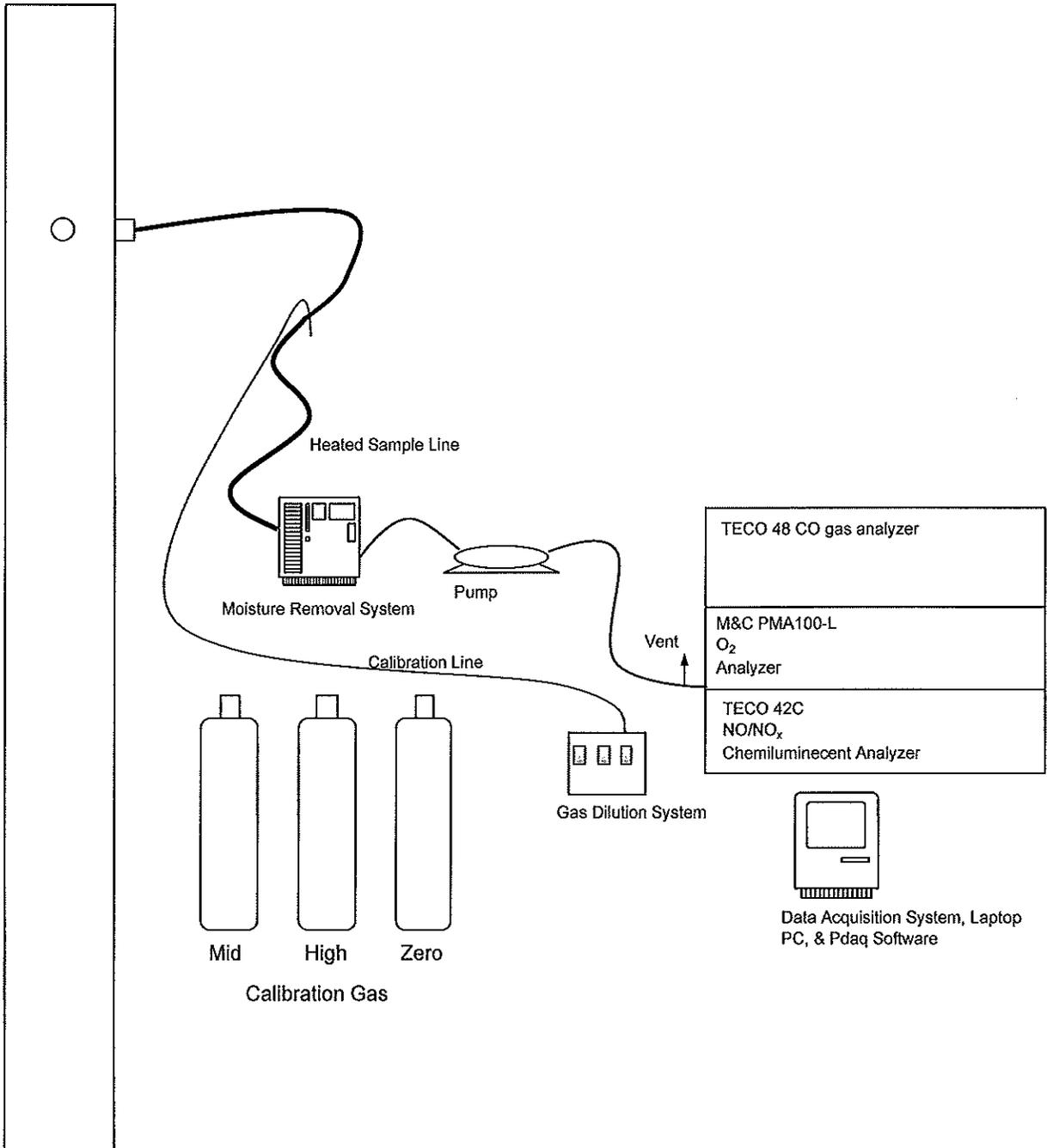


Figure 1

Site:
USEPA Method 3A, 7E, and 10
Vector Pipeline
Highland, Michigan

Sampling Dates:
July 1 and 2, 2014

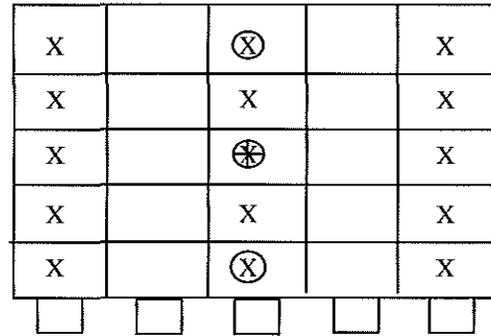
BT Environmental Consulting Inc.
4949 Fernlee Avenue
Royal Oak, MI



Stack Dimensions: 91" X 91"

Not to Scale

Points	Distance "
1	9.1
2	27.3
3	45.5
4	63.7
5	81.9



- X = Initial Stratification Traverse Points (15)
- = Turbine 1 Sample Points (3)
- ⊗ = Turbine 2 Sample Point (1)

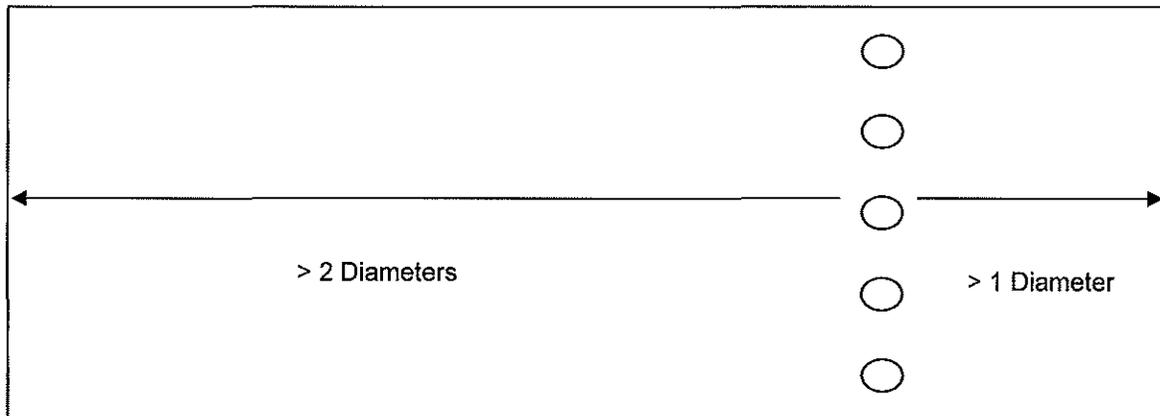


Figure 2

Site:
Turbines 1 & 2
Vector Pipeline
Highland Twp, Michigan

Sampling Dates:
July 1 and 2, 2014

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, MI