



# Athens Compressor Station Turbine Emissions Test Report

*Prepared for:*

**Vector Pipeline L.P.**

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**AIR QUALITY DIV.**

Athens Compressor Station  
4981 Two Mile Road  
Athens, Michigan 49011

Project No. 16-4807.00  
March 30, 2016

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



MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY  
AIR QUALITY DIVISION

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RENEWABLE OPERATING PERMIT  
REPORT CERTIFICATION

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., Athens Compressor Station County Calhoun

Source Address 4981 Two Mile Road City Athens

AQD Source ID (SRN) N8151 ROP No. MI-N8151-2011 ROP Section No. A GP-15

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:

March 29, 2016 Test Report. The March 9, 2016 emissions test was conducted in accordance  
with the approved test plan, while facility operating conditions were in compliance with  
permit requirements. The facility was operating within Solonox (GNP%) operating  
parameters for the turbine.

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>3/31/16</u>
Signature of Responsible Official		Date

\* Photocopy this form as needed.

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EXECUTIVE SUMMARY

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BT Environmental Consulting, Inc. (BTEC) was retained by Vector Pipeline L.P. (Vector) to evaluate oxides of nitrogen (NO<sub>x</sub>) emission rates from a single turbine operating at 97% load condition at the Vector facility located in Athens Township, Michigan. The emissions test program was conducted on March 9, 2016.

Testing consisted of triplicate 20-minute test runs at a single load condition (97% NGP). The emissions test program is required by Title 40, Part 60, Subpart KKKK of the Code of Federal Regulations. The results of the emission test program are summarized by Table I.

**Table I**  
**Turbine Emission Summary**  
**Test Date: March 9, 2016**

Load	Pollutant	Emission Rate	Emission Limit
		ppmv <sup>1</sup>	ppmv <sup>1</sup>
97%	NO <sub>x</sub>	8.0	25

1: Corrected to 15% O<sub>2</sub>



## **1. Introduction**

BT Environmental Consulting, Inc. (BTEC) was retained by Vector Pipeline L.P. (Vector) to evaluate oxides of nitrogen (NO<sub>x</sub>) emission rates from a single turbine operating at 97% load condition at the Vector facility located in Athens Township, Michigan. The emissions test program was conducted on March 9, 2016. 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 March 9, 2016 at the Vector facility located in Athens Township, Michigan. The test program included evaluation of NO<sub>x</sub> emissions from Turbine 1.

### **1.b Purpose of Testing**

Annual or biannual verification of NO<sub>x</sub> emission rates is required by Title 40, Part 60, Subpart KKKK of the Code of Federal Regulations.

### **1.c Source Description**

Vector's Athens Township 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 1.



## **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 power turbine operating speed (%), percent natural gas producer speed (%), and natural gas higher heating value (Btu/scf). This data is summarized in Appendix B.

### **2.b Applicable Permit**

Michigan Permit No. MI-ROP-N8151-2011 limits the turbine to 25 ppm NO<sub>x</sub> corrected to 15% O<sub>2</sub>.

### **2.c Results**

The overall results of the emission test program are summarized by Table 2.

## **3. Source Description**

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

### **3.a Process Description**

A single natural gas compressor turbine was evaluated for NO<sub>x</sub> emission rates in terms of parts per million. The Solar Mars 100 turbine fires only natural gas and is rated at 15,000 horsepower at a heat input rate of 120 MMBtu/hr. The turbine exhausts to a single, independent exhaust stack and is equipped with dry low-NO<sub>x</sub> 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 in Appendix B.

### 3.d Process Capacity

The turbine is 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 power turbine operating speed (%), percent natural gas producer speed (%), and natural gas higher heating value (Btu/scf). This data is summarized in Appendix B.

## 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 NO<sub>x</sub> content of the gas stream was measured using a TECO Model 42i NO<sub>x</sub> gas analyzer, and the O<sub>2</sub> content was measured using a M&C Products PMA 100-L O<sub>2</sub> 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<sup>®</sup> 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 O<sub>2</sub> concentration of the exhaust gas.
- Method 7E, "*Determination of Nitrogen Oxide Emissions from Stationary Sources*", was used to measure the NO<sub>x</sub> 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 NO<sub>x</sub> emission rates.

The accuracy of the gas dilution system was verified using the procedures detailed by Method 205 and the NO<sub>x</sub> converter efficiency was verified as specified by Method 7E.

Exhaust gas flowrates were calculated using pollutant and diluent concentrations as well as turbine natural gas flowrate and average natural gas heating value data. A Method 7E exhaust gas stratification check was performed prior to the first test run and subsequent test runs were conducted using single point sampling for Turbine 1.

#### **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**

The sampling location met the minimum criteria specified by Method 1. During the first test run, the sample probe was moved to fifteen sampling locations to check for stratification. Since the individual traverse point diluent (O<sub>2</sub>) concentrations differed by no more than ±0.3 percent O<sub>2</sub> from the mean for all traverse points, the subsequent two test runs utilized single point sampling.

### **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 Table 2.

#### **5.b Discussion of Results**

Title 40, Part 60, Subpart KKKK of the Code of Federal Regulations limits NO<sub>x</sub> emissions from the gas turbine to 25 ppmv at 15% O<sub>2</sub>. The average NO<sub>x</sub> emission rate during the emissions test program was 8.0 ppmv at 15% O<sub>2</sub>.

#### **5.c Sampling Procedure Variations**

There were no sampling procedure variations used during the emission compliance test program.

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#### **5.d Process or Control Device Upsets**

No upset conditions occurred during testing.

#### **5.e Control Device Maintenance**

The turbine is 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.

#### **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 E.

#### **5.k Laboratory Data**

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



**Table 1**  
**Test Personnel**

<b>Name</b>	<b>Affiliation</b>
Matthew DiPaola	Vector Pipeline
Rex Lane	MDEQ-AQD
Tom Gasloli	MDEQ-AQD
Matthew Young	BTEC
Mason Sakshaug	BTEC

**Table 2**  
**Turbine 1 Detailed Emission Test Results Summary**  
**Vector Pipeline**  
**BTEC Project No. 16-4807.00**  
**Sampling Date: March 9, 2016**

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	3/9/2016	3/9/2016	3/9/2016	
Oxides of Nitrogen Concentration (ppmv)	6.4	6.8	6.7	6.7
Oxygen concentration (%)	16.0	15.6	15.6	15.7
Oxygen concentration (%) (corrected as per USEPA 7E)	16.1	15.7	15.7	15.8
Natural Gas Heating Value (Btu/scf)	1043.0	1043.0	1043.0	1043
NOx Concentration (ppmv, corrected as per USEPA 7E)	6.6	7.0	6.9	6.9
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	7.9E-07	8.3E-07	8.3E-07	8.2E-07
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.030	0.029	0.029	0.029
<b>Nox Concentration (ppmv@15% O2)</b>	<b>8.2</b>	<b>7.9</b>	<b>7.9</b>	<b>8.0</b>

NOx Correction			
Co	0.28	0.38	0.35
Cma	49.57	49.57	49.57
Cm	46.24	46.07	45.89

O2 Correction			
Co	0.14	0.14	0.14
Cma	10.02	10.02	10.02
Cm	9.99	9.99	9.99

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)

24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)

35.31 = ft<sup>3</sup> per m<sup>3</sup>

453600 = mg per lb

10<sup>6</sup> = Btu per MMBtu

3785.4 = mL per gallon

Co= Average of initial and final zero gases

Cma=Actual concentration of the calibration gas

Cm= Average of initial and final calibration gases

**Equations**

$$\text{lb/dscf} = \text{ppmv} * \text{MW}/24.14 * 1/35.31 * 1/453,600$$

$$\text{eq 19-1: } E = C_d F_d * 20.9 / (20.9 - \%O_{2d})$$

$$\text{NOx @ 15\% O2} = \text{NOx measured (ppm)} * (5.9/(20.9 - \text{O2\% measured}))$$

$$\text{Nox corrected to ISO standard day conditions} = (\text{Nox @15\%}) * (P_{std}/P_{amb})^{0.5} * 2.718^{(19 * (1 - 0.00633))} * (T_{std}/T_{amb})^{1.53}$$

Ambient pressure and relative humidity obtained from [www.wunderground.com](http://www.wunderground.com)

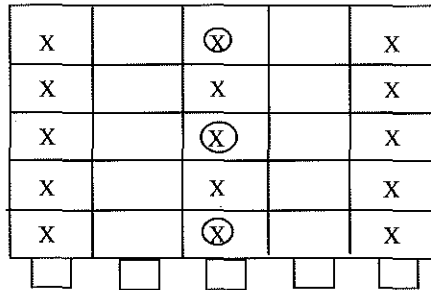
Ambient humidity in g H2O/g air obtained from psychrometric chart



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)

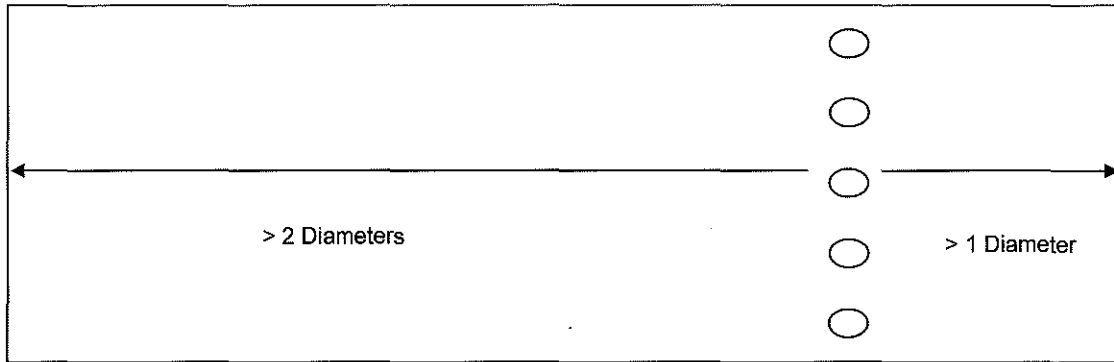


Figure 2

Site:  
 Turbine 1  
 Vector Pipeline  
 Athens Twp, Michigan

Sampling Dates:  
 March 9, 2016

**BT Environmental Consulting,  
 Inc.**  
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