



Athens Compressor Station Turbine Emissions Test Report

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Prepared for:

Vector Pipeline L.P.

Athens Compressor Station
4981 Two Mile Road
Athens, Michigan 49011

Project No. 049AS-333230
May 31, 2018

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



EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Vector Pipeline L.P. (Vector) to evaluate oxides of nitrogen (NOx) 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 April 10, 2018.

Testing consisted of triplicate stack traverses 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: April 10, 2018

Load	Pollutant	Emission Rate	Emission Limit
		ppmv¹	ppmv¹
97%	NOx	19.5	25

1: Corrected to 15% O₂

JUN 05 2018

1. Introduction

AIR QUALITY DIVISION

BT Environmental Consulting, Inc. (BTEC) was retained by Vector Pipeline L.P. (Vector) to evaluate oxides of nitrogen (NO_x) 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 April 10, 2018. 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). 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 April 10, 2018 at the Vector facility located in Athens Township, Michigan. The test program included evaluation of NO_x emissions from Turbine 1.

1.b Purpose of Testing

Annual or biannual verification of NO_x 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:

Julia Knezek
EHS Supervisor
5400 Westheimer Ct.
PO Box 1642
Houston, TX 77251-1642
(903) 323-4384

Names and affiliations for personnel who were present during the testing program are summarized by Table 1.

**Table 1
Test Personnel**

Name	Address	Phone Number
Jeremy Howe MDEQ AQD	120 West Chapin Street Cadillac, MI 49601	(231)878-6687
Michael Betzold Vector	4981 Two Mile Road Athens, Michigan 49011	(269)729 4419
Joe Richardson Vector	4981 Two Mile Road Athens, Michigan 49011	(269)729 4419
Mason Sakshaug BTEC	4949 Fernlee Avenue Royal Oak, MI 48073	(989)323-0355
Shane Rabideau BTEC	4949 Fernlee Avenue Royal Oak, MI 48073	(248)548-8070

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 D.

2.b Applicable Permit

Michigan Permit No. MI-ROP-N8151-2016 limits the turbine to 25 ppm NO_x corrected to 15% O₂.

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_x 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_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 in Appendix D.

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 D.

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_x content of the gas stream was measured using a TECO Model 42i NO_x gas analyzer, and the O₂ content was measured using a M&C Products PMA 100-L O₂ gas analyzer. 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. 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 NOx 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 NOx emission rates.

The NOx 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 for all three runs.

4.b Recovery and Analytical Procedures

This test program did not include laboratory samples and, consequently, sample recovery and analysis are 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. The sampling probe was moved to twelve sampling locations during each test run..

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 NOx emissions from the gas turbine to 25 ppmv at 15% O₂. The average NOx emission rate during the emissions test program was 19.5 ppmv at 15% O₂.

5.c Sampling Procedure Variations

The NOx system bias test conducted after Test Run No. 1 of testing did not meet the quality assurance criteria of Method 7E. Consequently, the system was recalibrated and Test Run 1 was results were not reported (i.e., overall test result was the average of Test Runs 2, 3, and 4.



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 B.

5.i Sample Calculations

Sample calculations are provided in Appendix C.

5.j Field Data Sheets

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

5.k Laboratory Data

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

Table 2
Turbine 1 Detailed Emission Test Results Summary
Vector Pipeline
BTEC Project No. 049AS-333230
Sampling Date: April 10, 2018

Parameter	Run 2	Run 3	Run 4	Average
Test Run Date	4/10/2018	4/10/2018	4/10/2018	
Oxides of Nitrogen Concentration (ppmv)	16.9	17.6	17.5	17.3
Oxygen concentration (%)	15.8	15.8	15.8	15.8
Oxygen concentration (%) (corrected as per USEPA 7E)	15.8	15.8	15.8	15.8
Natural Gas Heating Value (Btu/scf)	1046.9	1047.6	1046.2	1047
NOx Concentration (ppmv, corrected as per USEPA 7E)	16.9	17.0	16.7	16.9
NOx Concentration (lb/dscf, corrected as per USEPA 7E)	2.0E-06	2.0E-06	2.0E-06	2.0E-06
NOx Emission Factor (lb/MMBtu, corrected as per USEPA 7E)	0.072	0.073	0.071	0.072
Nox Concentration (ppmv@15% O2)	19.5	19.7	19.4	19.5

97% Lead

NOx Correction			
Co	0.09	0.23	0.28
Cma	24.79	24.79	24.79
Cm	24.80	25.56	25.81

O2 Correction			
Co	0.06	0.07	0.07
Cma	10.06	10.06	10.06
Cm	10.09	10.09	10.08

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 = ft³ per m³
 453600 = µg per lb
 10⁶ = 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

lb/dscf = ppmv * MW/24.14 * 1/35.31 * 1/453,600

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

NOx @ 15% O2 = NOx measured (ppm) X (5.9/(20.9-O2% measured))

Nox corrected to ISO standard day conditions = (Nox @15%) x (P_{std}/P_{amb})^{0.5} x 2.718^{(1.9*(1-0.00633))} x (T_{std}/T_{amb})^{1.53}

Ambient pressure and relative humidity obtained from www.wunderground.com
 Ambient humidity in g H2O/g air obtained from psychrometric chart

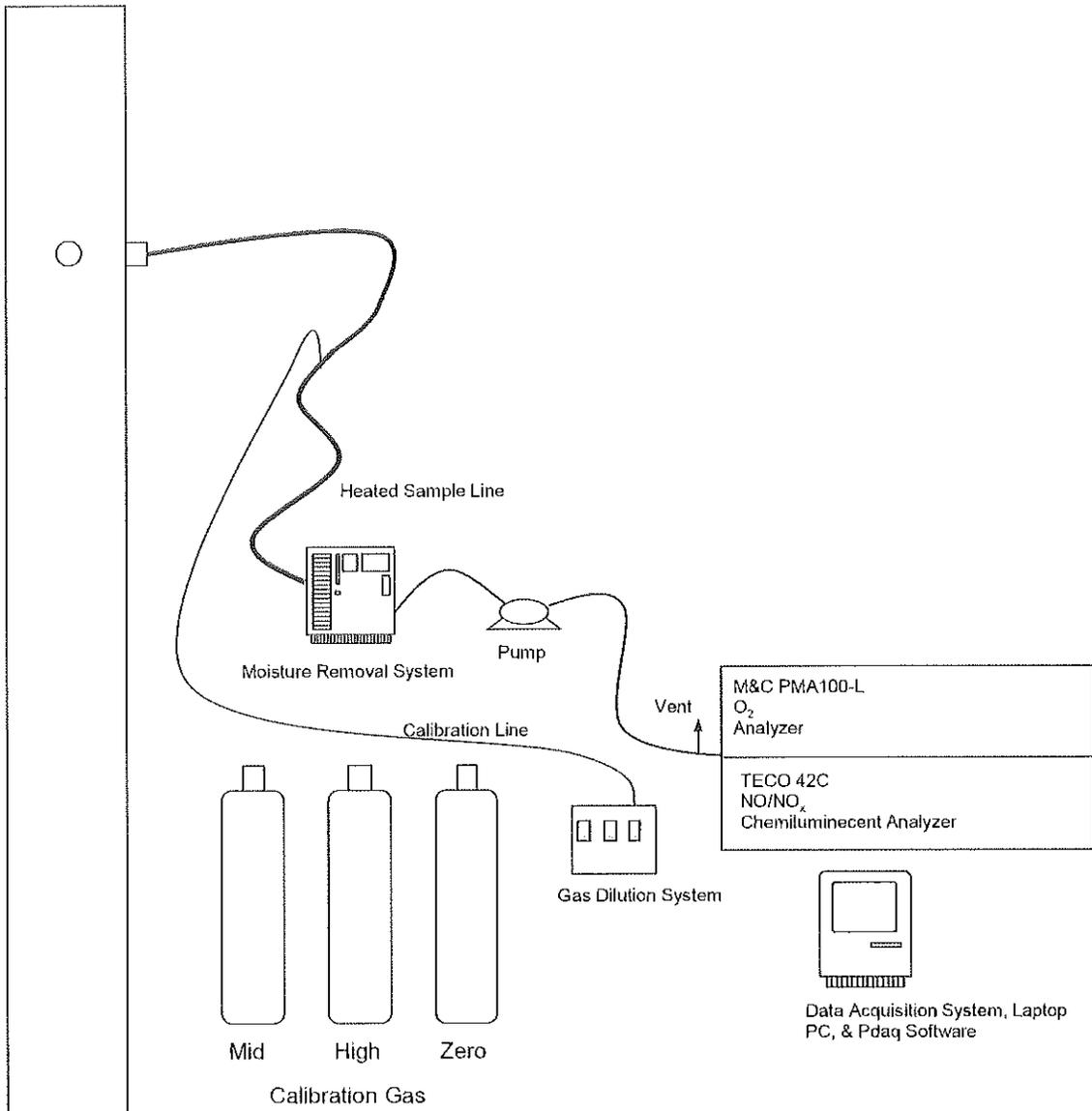


Figure 1

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

Sampling Date:
April 10, 2018

BT Environmental Consulting Inc.
4949 Fernlee Avenue
Royal Oak, MI 48073



Stack Dimensions: 91" X 91"

Not to Scale

Points	Distance "
1	15.2
2	45.5
3	75.8

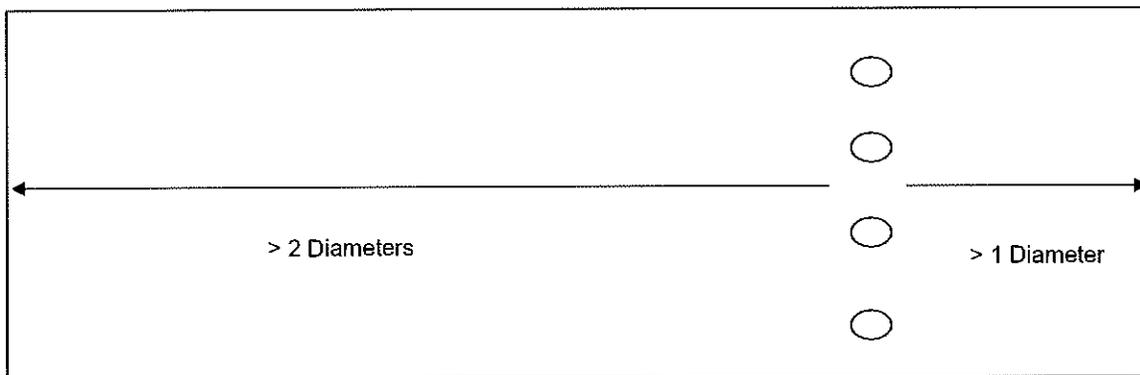
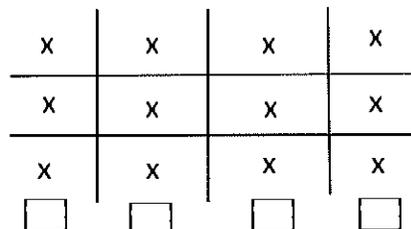


Figure 2

Site:
Turbine 1
Vector Pipeline
Athens Twp, Michigan

Sampling Dates:
April 10, 2018

**BT Environmental Consulting,
Inc.**
4949 Fernlee Avenue
Royal Oak, Michigan 48073