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ANR Pipeline Company

Emission Performance Test Report
Annual Ozone Season Monitoring
ANR Pipeline – Woolfolk Compressor Station
December 11, 2018

Emissions Test Report

Units E01 to E04, E06 to E08: **Natural Gas Fired Internal Combustion** **Reciprocating Engines**

Permit No.: MI-ROP-B7220-2017a

ANR Pipeline Company
Woolfolk Compressor Station
Mecosta County, Michigan

Date: **December 11, 2018**

Prepared for: **Michigan Department of Environmental
Quality (MDEQ)**

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1. Introduction

1.1. The Air Compliance Team of TransCanada's US Pipelines Central conducted monitoring at ANR Woolfolk Compressor Station (SRN: B7220) pursuant to the Compliance Plan ANR submitted to comply with R336.1818(3)(a). The Compliance Plan has been approved by the MDEQ.

1.2. The purpose of the monitoring was to comply with the ozone season monitoring requirement in the ANR Compliance Plan and is in accordance with R336.1818(4)(a)(ii)(A)(2). The monitoring demonstrates compliance with the projected NOx emission rate in the ANR Compliance Plan. As such, the following parameter was determined:

1.2.1. Woolfolk Units #2001 to #2009:
20.5 g/bhp-hr of NOx

1.3. Facilities Information:

ANR Woolfolk Compressor Station
11750 150th Avenue
Big Rapids, MI 49307

Environmental Contact:
Chris Waltman
700 Louisiana Street
Houston, TX 77002
(715) 758-3341

2. Process Description

2.1. Woolfolk compressor station operates nine NOx SIP affected engines; 2001 through 2005 are Ingersoll-Rand KVG-103, 1,000 HP each and 2006 through 2009 are Ingersoll-Rand KVG-123, 1,320 HP each. All engines are natural gas fired, reciprocating internal combustion engine used in Natural Gas Transmission. More specifically, the engine is used in the compression of natural gas from an initial "suction" pressure to a final "discharge" pressure, which creates the pressure gradient necessary to transport natural gas through ANR Pipeline's interstate pipeline system

3. Methodology

3.1. American Society of Testing and Materials test method D6522-00: Standard Test Method for Determination of Nitrogen Oxides, Carbon Monoxide, and Oxygen Concentrations in Emissions from Natural Gas-Fired Reciprocating Engines, Combustion Turbines, Boilers, and Process Heaters Using Portable Analyzers was employed for determination of compliance with Section 1.2.1.

4. Sample System

4.1. Sample system components, as outlined in Method D6522-00, were utilized for monitoring. These components include, but are not limited to, sample probe, heated sample line, sample transport lines, calibration assembly, moisture removal system, particulate filter, sample pump, sample flow rate control, gas analyzer, data recorder, and external interference gas scrubber.

5. Sample Location

5.1. Sampling location was selected as specified in sections 10.1.1 and 10.1.2 of Method D6522-00 at a location of five duct diameters downstream of any flow disturbance and three duct diameters upstream of the discharge to atmosphere.

5.2. All the stratification sampling for all the units showed a variance in concentration of less than 5%, therefore, as per section 10.1.4 of Method D6522-00, sampling was taken from a single point located in the center of the stack.

6. Sample Time

6.1. Monitoring was conducted during normal engine operation, i.e. not during periods of startup, shutdown, or malfunction. Each engine was monitored at the maximum load achievable based upon pipeline and ambient conditions.

6.2. Each engine was sampled at three 30-minute test runs. Samples were taken at a frequency of once per minute.

7. Results

7.1. Results of the monitoring demonstrated that all units tested below the permitted levels of 20.5 g/BHP-hr. Detailed emissions summaries and calibration records can be found in the following pages.

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 Chromatograph Gas Analysis
 Certificate of Accuracy: EPA Protocol Gas

Section 1: Unit E01

Ingersoll Rand KVG-103 (1000 hp)

Emission Data Sheet Summary

Sample Calculations

General Information

Linearity Check

NO Stability Check

NO₂ Stability Check

Calibration Error

Engine Operating Data

Run 1 – 3

Data Summary

General Information

Start Date: 9/12/2018
 Company: ANR
 Station: Woolfolk

Unit Information

Unit No.: 2001
 Manufacturer: I/R
 Model: KVG 103
 Rated BHP: 1000
 Rated RPM: 330

Gas Analysis

Nitrogen: 0.9948 I - Butane: 0.0194
 Carbon Dioxide: 0.4705 N - Butane: 0.0224
 Methane: 90.8057 I - Pentane: 0.0037
 Ethane: 7.2987 N - Pentane: 0.0014
 Propane: 0.3803 Hexane +: 0.0032
Total: 100.000

Test Data

General Data

Run	1	2	3	Averages
Date	9/12/18	9/12/18	9/12/18	
Time	9:41:49 AM	10:24:17 AM	11:13:32 AM	

Operating Data

Horsepower	923	930	935	929
Speed	329	331	331	330
% Load	92.3%	93.0%	93.5%	92.9%
% Torque	92.6%	92.9%	93.2%	92.9%
Fuel Use (scfh)	8,818	8,948	8,890	8,885
UDHV (BTU/dscf)	1,062.2	1,062.2	1,062.2	1,062.2
Curve				
AMP (psig)				
AMT (°F)				
Suct. Press. (psig)	542	537	534	537
Suct. Temp. (°F)	62.0	62.5	63.0	62.5
Disc. Press. (psig)	791	791	789	790
Disc. Temp. (°F)	93.0	93.0	93.0	93.0

Emissions Data

NO (ppm)	1419.29	1486.16	1549.61	1485.02
NO <small>Bias corrected</small> (ppm)	1418.89	1500.30	1564.80	1494.66
NO ₂ (ppm)	85.13	88.52	91.61	88.42
NO ₂ <small>Bias corrected</small> (ppm)	86.17	89.71	92.85	89.58
NO _x (ppm)	1505.07	1590.01	1657.64	1584.24
NO _x (ppm@ 15% O ₂)	545.90	576.02	601.12	574.34
NO _x (lb/hr)	18.84	20.17	20.91	19.97
NO _x (g/bhp-hr)	9.3	9.8	10.1	9.7
NO _x (TPY)	82.5	88.3	91.6	87.5
O ₂ (%)	4.63	4.61	4.63	4.63

Data Summary

General Information

Start Date: 9/12/2018
 Company: ANR
 Station: Woolfolk

Unit Information

Unit No.: 2002
 Manufacturer: I/R
 Model: KVG 103
 Rated BHP: 1000
 Rated RPM: 330

Gas Analysis

Nitrogen: 1.0121 I - Butane: 0.0194
 Carbon Dioxide: 0.4787 N - Butane: 0.023
 Methane: 90.7477 I - Pentane: 0.004
 Ethane: 7.3137 N - Pentane: 0.0021
 Propane: 0.396 Hexane +: 0.0033
Total: 100.000

Test Data

General Data				
Run	1	2	3	Averages
Date	9/12/18	9/12/18	9/12/18	
Time	09:23:41	10:13:18	11:00:21	
Operating Data				
Horsepower	937	939	934	937
Speed	330	330	329	330
% Load	93.7%	93.9%	93.4%	93.7%
% Torque	93.6%	93.8%	93.8%	93.7%
Fuel Use (scfh)	8,680	8,655	8,633	8,656
UDHV (BTU/dscf)	1,062.4	1,062.4	1,062.4	1,062.4
Curve				
AMP (psig)				
AMT (°F)				
Suct. Press. (psig)	537	534	530	534
Suct. Temp. (°F)	62.6	63.1	63.4	63.0
Disc. Press. (psig)	792	791	787	790
Disc. Temp. (°F)	93.0	93.0	93.0	93.0
Emissions Data				
NO (ppm)	1431.71	1474.19	1478.35	1461.42
NO <small>Bias corrected</small> (ppm)	1417.23	1459.66	1463.81	1446.90
NO ₂ (ppm)	78.52	86.94	89.94	85.13
NO ₂ <small>Bias corrected</small> (ppm)	78.53	86.96	89.96	85.15
NO _x (ppm)	1495.77	1546.61	1553.77	1532.05
NO _x (ppm@ 15% O ₂)	558.46	575.35	579.53	571.11
NO _x (lb/hr)	18.97	19.49	19.58	19.35
NO _x (g/bhp-hr)	9.2	9.4	9.5	9.4
NO _x (TPY)	83.1	85.4	85.8	84.7
O ₂ (%)	5.10	5.04	5.08	5.07

Data Summary

General Information

Start Date: 9/13/2018

Company: ANR

Station: Woolfolk

Unit Information

Unit No.: 2003

Manufacturer: I/R

Model: KVG 103

Rated BHP: 1000

Rated RPM: 330

Gas Analysis

Nitrogen: 1.0638 I - Butane: 0.0193

Carbon Dioxide: 0.5019 N - Butane: 0.0248

Methane: 90.5552 I - Pentane: 0.0031

Ethane: 7.4046 N - Pentane: 0

Propane: 0.4248 Hexane +: 0.0027

Total: 100.000

Test Data

General Data				
Run	1	2	3	Averages
Date	9/13/18	9/13/18	9/13/18	
Time	1:07:31 PM	1:50:09 PM	2:33:35 PM	
Operating Data				
Horsepower	951	946	942	946
Speed	331	330	330	330
% Load	95.1%	94.6%	94.2%	94.6%
% Torque	94.8%	94.6%	94.2%	94.5%
Fuel Use (scfh)	8,615	8,643	8,600	8,619
UDHV (BTU/dscf)	1,062.7	1,062.7	1,062.7	1,062.7
Curve				
AMP (psig)				
AMT (°F)				
Suct. Press. (psig)	495	496	497	496
Suct. Temp. (°F)	55.0	55.3	55.5	55.2
Disc. Press. (psig)	785	785	785	785
Disc. Temp. (°F)	93.0	93.0	93.0	93.0
Emissions Data				
NO (ppm)	2078.00	2080.84	2110.77	2089.87
NO <small>Bias corrected</small> (ppm)	2094.02	2096.91	2127.38	2106.10
NO ₂ (ppm)	117.52	107.52	99.74	108.26
NO ₂ <small>Bias corrected</small> (ppm)	122.03	111.65	103.57	112.42
NO _x (ppm)	2216.05	2208.55	2230.96	2218.52
NO _x (ppm@ 15% O ₂)	810.22	806.67	813.55	810.14
NO _x (lb/hr)	27.33	27.29	27.39	27.34
NO _x (g/bhp-hr)	13.0	13.1	13.2	13.1
NO _x (TPY)	119.7	119.5	120.0	119.7
O ₂ (%)	4.76	4.75	4.72	4.74

Data Summary

General Information

Start Date: 9/13/2018
 Company: ANR
 Station: Woolfolk

Unit Information

Unit No.: 2004
 Manufacturer: I/R
 Model: KVG 103
 Rated BHP: 1000
 Rated RPM: 330

Gas Analysis

Nitrogen: 1.0638 I - Butane: 0.0193
 Carbon Dioxide: 0.5019 N - Butane: 0.0248
 Methane: 90.5552 I - Pentane: 0.0031
 Ethane: 7.4046 N - Pentane: 0
 Propane: 0.4248 Hexane +: 0.0027
Total: 100.000

Test Data

General Data				
Run	1	2	3	Averages
Date	9/13/18	9/13/18	9/13/18	
Time	9:51:56 AM	10:47:24 AM	11:27:03 AM	
Operating Data				
Horsepower	920	937	936	931
Speed	328	329	330	329
% Load	92.0%	93.7%	93.6%	93.1%
% Torque	92.5%	93.9%	93.7%	93.4%
Fuel Use (scfh)	9,385	9,568	9,543	9,498
UDHV (BTU/dscf)	1,062.7	1,062.7	1,062.7	1,062.7
Curve				
AMP (psig)				
AMT (°F)				
Suct. Press. (psig)	529	505	502	512
Suct. Temp. (°F)	55.8	54.8	55.1	55.2
Disc. Press. (psig)	787	801	801	796
Disc. Temp. (°F)	93.0	93.0	93.0	93.0
Emissions Data				
NO (ppm)	1217.35	1382.35	1509.61	1369.77
NO _{Bias corrected} (ppm)	1216.75	1383.63	1512.35	1370.91
NO ₂ (ppm)	73.84	73.39	78.03	75.09
NO _{2 Bias corrected} (ppm)	76.39	75.93	80.73	77.68
NO _x (ppm)	1293.14	1459.56	1593.08	1448.59
NO _x (ppm@ 15% O ₂)	459.07	514.24	560.20	511.17
NO _x (lb/hr)	16.87	19.26	20.93	19.02
NO _x (g/bhp-hr)	8.3	9.3	10.1	9.3
NO _x (TPY)	73.9	84.4	91.7	83.3
O ₂ (%)	4.28	4.15	4.12	4.19

Data Summary

General Information

Start Date: 9/12/2018
 Company: ANR
 Station: Woolfolk

Unit Information

Unit No.: 2006
 Manufacturer: I/R
 Model: KVG 123
 Rated BHP: 1320
 Rated RPM: 330

Gas Analysis

Nitrogen: 0.9948 I - Butane: 0.0194
 Carbon Dioxide: 0.4705 N - Butane: 0.0224
 Methane: 90.8057 I - Pentane: 0.0037
 Ethane: 7.2987 N - Pentane: 0.0014
 Propane: 0.3803 Hexane +: 0.0032
Total: 100.000

Test Data

General Data				
Run	1	2	3	Averages
Date	9/12/18	9/12/18	9/12/18	
Time	1:59:41 PM	2:43:41 PM	3:48:26 PM	
Operating Data				
Horsepower	1,229	1,226	1,244	1,233
Speed	330	328	328	329
% Load	93.1%	92.9%	94.2%	93.4%
% Torque	93.0%	93.4%	94.9%	93.7%
Fuel Use (scfh)	11,558	11,493	11,725	11,592
UDHV (BTU/dscf)	1,062.2	1,062.2	1,062.2	1,062.2
Curve				
AMP (psig)				
AMT (°F)				
Suct. Press. (psig)	524	514	509	516
Suct. Temp. (°F)	66.8	72.1	65.2	68.0
Disc. Press. (psig)	791	791	789	790
Disc. Temp. (°F)	93.0	93.0	93.0	93.0
Emissions Data				
NO (ppm)	1021.77	1096.39	1013.29	1043.82
NO <small>Bias corrected</small> (ppm)	1019.31	1095.34	1010.67	1041.77
NO ₂ (ppm)	69.32	69.55	66.84	68.57
NO ₂ <small>Bias corrected</small> (ppm)	70.34	70.57	67.82	69.58
NO _x (ppm)	1089.65	1165.91	1078.49	1111.35
NO _x (ppm@ 15% O ₂)	401.61	427.99	402.86	410.82
NO _x (lb/hr)	18.16	19.25	18.48	18.63
NO _x (g/bhp-hr)	6.7	7.1	6.7	6.9
NO _x (TPY)	79.6	84.3	81.0	81.6
O ₂ (%)	4.89	4.83	5.11	4.94

Data Summary

General Information

Start Date: 9/13/2018
 Company: ANR
 Station: Woolfolk

Unit Information

Unit No.: 2007
 Manufacturer: I/R
 Model: KVG 123
 Rated BHP: 1000
 Rated RPM: 330

Gas Analysis

Nitrogen: 1.0638 I - Butane: 0.0193
 Carbon Dioxide: 0.5019 N - Butane: 0.0248
 Methane: 90.5552 I - Pentane: 0.0031
 Ethane: 7.4046 N - Pentane: 0
 Propane: 0.4248 Hexane +: 0.0027
Total: 100.000

Test Data

General Data				
Run	1	2	3	Averages
Date	9/13/18	9/13/18	9/13/18	
Time	08:48:11	09:47:29	10:27:15	
Operating Data				
Horsepower	1,244	1,214	1,209	1,222
Speed	328	328	329	328
% Load	124.4%	121.4%	120.9%	122.2%
% Torque	125.1%	122.3%	121.5%	122.9%
Fuel Use (scfh)	11,990	9,102	11,575	10,889
UDHV (BTU/dscf)	1,062.7	1,062.7	1,062.7	1,062.7
Curve	1	1	1	1
AMP (psig)				
AMT (°F)				
Suct. Press. (psig)	530	505	503	513
Suct. Temp. (°F)	55.8	54.8	55.1	55.2
Disc. Press. (psig)	787	802	802	797
Disc. Temp. (°F)	93.0	93.0	93.0	93.0
Emissions Data				
NO (ppm)	701.45	733.94	842.29	759.23
NO Bias corrected (ppm)	702.17	735.04	844.68	760.63
NO ₂ (ppm)	60.03	55.97	55.58	57.19
NO ₂ Bias corrected (ppm)	60.19	56.11	55.73	57.34
NO _x (ppm)	762.36	791.16	900.41	817.98
NO _x (ppm@ 15% O ₂)	285.39	293.96	332.21	303.85
NO _x (lb/hr)	13.40	10.47	15.05	12.97
NO _x (g/bhp-hr)	4.9	3.9	5.6	4.8
NO _x (TPY)	58.7	45.9	65.9	56.8
O ₂ (%)	5.14	5.02	4.91	5.02

Data Summary

General Information

Start Date: 9/12/2018
 Company: ANR
 Station: Woolfolk

Unit Information

Unit No.: 2008
 Manufacturer: I/R
 Model: KVG 123
 Rated BHP: 1000
 Rated RPM: 330

Gas Analysis

Nitrogen: 1.0121 I - Butane: 0.0194
 Carbon Dioxide: 0.4787 N - Butane: 0.023
 Methane: 90.7477 I - Pentane: 0.004
 Ethane: 7.3137 N - Pentane: 0.0021
 Propane: 0.396 Hexane +: 0.0033
Total: 100.000

Test Data

General Data				
Run	1	2	3	Averages
Date	9/12/18	9/12/18	9/12/18	
Time	13:00:00	13:43:52	14:42:41	
Operating Data				
Horsepower	1,206	1,230	1,256	1,231
Speed	330	331	329	330
% Load	120.6%	123.0%	125.6%	123.1%
% Torque	120.8%	122.5%	125.9%	123.1%
Fuel Use (scfh)	10,878	10,993	11,150	11,007
UDHV (BTU/dscf)	1,062.4	1,062.4	1,062.4	1,062.4
Curve	1	1	1	1
AMP (psig)				
AMT (°F)				
Suct. Press. (psig)	537	534	530	534
Suct. Temp. (°F)	62.6	63.1	63.4	63.0
Disc. Press. (psig)	792	791	787	790
Disc. Temp. (°F)	93.0	93.0	93.0	93.0
Emissions Data				
NO (ppm)	1767.06	1761.81	1708.32	1745.73
NO Bias corrected (ppm)	1760.24	1754.92	1700.82	1738.66
NO ₂ (ppm)	97.61	96.03	94.81	96.15
NO ₂ Bias corrected (ppm)	99.05	97.44	96.20	97.56
NO _x (ppm)	1859.29	1852.36	1797.02	1836.22
NO _x (ppm@ 15% O ₂)	680.43	680.46	662.10	674.33
NO _x (lb/hr)	28.97	29.27	28.89	29.04
NO _x (g/bhp-hr)	10.9	10.8	10.4	10.7
NO _x (TPY)	126.9	128.2	126.5	127.2
O ₂ (%)	4.78	4.84	4.89	4.83