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COMPLIANCE TEST REPORT
WOOLFOLK COMPRESSOR STATION
COMBUSTION ENGINE EUWL017

Prepared for:

TransCanada
In business to deliver

TransCanada's ANR Pipeline Company
Big Rapids, MI

Prepared by:

EQM

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June 2017

PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at TransCanada in Big Rapids, MI was performed in accordance with the procedures set forth by the United States Environmental Protection Agency, and that the data and results submitted within this report are an exact representation of the testing.

Karl Mast
Test Supervisor

I, Karl Mast, do hereby attest that all work on this project was performed under my direct supervision, and that this report accurately and authentically presents the source emissions testing conducted at ANR's Woolfolk Compressor Station in Big Rapids, MI

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Karl Mast
Test Supervisor

SUMMARY

The compliance emissions testing was performed on Engine EUWL017 to comply with the established NOx standards pursuant to testing requirements specified in Permit MI-ROP-B7220-2017, section C, sub-section V, (R336.1213(3)). The testing was performed in accordance with the requirements of the Code of Federal Regulations, Title 40, Part 60, Appendix A. A summary of the test results is given below:

Engine EUWL017 NO_x Emission Test Results		
Run No.	**NO_x Emissions (lbs/hr)**	**NO_x Emissions (g/bhp/hr)**
1	17.02	2.04
2	16.33	1.95
3	17.51	2.06
Average	16.96	2.02
Emission Limit	85.7	9.7

1. INTRODUCTION

This report presents the results of the source emissions testing conducted by Environmental Quality Management, Inc. (EQM) for TransCanada's ANR (ANR) Woolfolk Compressor Station, near Big Rapids, MI, which is located in Mecosta County. The primary purpose of this testing program was to conduct emissions testing to determine compliance with operating permit No. MI-ROP-B7220-2017, section C, sub-section V, (R336.1213(3) for the Combustion Engine Unit EUWL017 at ANR Pipeline's gas compressor facility.

To ensure that compliance with the emission limits is maintained, the Air Compliance Team of TransCanada's ANR Pipeline Company (ANR) contracted Environmental Quality Management, Inc. (EQM) to perform source emissions testing on Engine EUWL017. The primary purpose of this testing program was to conduct emissions testing of the internal combustion engine EUWL017, with an emission limit of 85.7 lbs/hr of NO_x and/or 9.7 g/bhp/hr.

EQM's responsibility was to conduct the compliance testing for the NO_x emissions rates and perform data reduction for conformance evaluation. ANR's responsibility was to maintain process operating parameters and to assist in providing process operating data per compliance test requirements.

The following report provides information pertaining to TransCanada's process operations, and Compliance testing. The Compliance testing conducted on Engine EUWL017 was performed on May 11, 2017 from 9:01 A.M. to 1:41 P.M.

The following requirements were specific for the testing program:

1. Equipment calibrations performed and calibration data provided.
2. Three (3) one (1) -hour, minimum, NO_x, and O_2 test runs performed at the Engine EUWL017 pursuant to EPA Reference methods as described in 40 CFR, Part 60, Appendix A.
3. Process manufacturing operations maintained at 100% of capacities and production and fuel consumption rates recorded during the emissions testing periods.
4. All testing and analyses performed in accordance with current EPA test methodologies and analytical procedures for NOx, and O_2, emissions determinations.
5. Strata Checks were not possible at the EUWL017 Exhaust due to ports were not installed. There was a permanently mounted CEMS probe that had a line from inside the building to hook up to.

The testing program was approved by and/or coordinated with Roy Cannon, TransCanada's ANR Pipeline Company. The emission testing was managed by Karl Mast, Manager Air Emissions, EQM, Zach Hill, Team Leader, EQM and Jeff Cavanaugh, Test Technician, EQM. The emission testing was not observed by any regulatory personnel.

2. TEST RESULTS SUMMARY

The compliance testing was performed on Engine EUWL017 system in accordance with the requirements of the Code of Federal Regulations, Title 40, Part 60, Appendix A. A summary of the test results is given below:

Table 1. Test Results Summary-Test Results-Engine EUWL017

Engine EUWL017 NO_x Emission Test Results		
Run No.	**NO_x Emissions (lbs/hr)**	**NO_x Emissions (g/bhp/hr)**
1	17.02	2.04
2	16.33	1.95
3	17.51	2.06
Average	16.96	2.02
Emission Limit	85.7	9.7

Based on the information provided above, the Engine EUWL017 met the acceptance criteria during the course of the testing. A complete list of performance parameters for each test run that was performed at the stack sampling locations can be found in Table 2-6.

Table 2. Engine Operating and Ambient Conditions-Engine EUWL017

Run	1	2	3	
Date	05/11/17	05/11/17	05/11/17	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	3,779.0	3,803.0	3,857.0	3,813.0
Unit Speed	475.0	475.0	476.0	475.3
Turbo RPM	8,648.0	8,697.0	8,906.0	8,750.3
P. Cyl. Exhaust Temperature Average (^{O}F)	380.0	380.1	397.9	386.0
Air Manifold Pressure (PSI)	19.4	19.5	20.3	19.7
Air Manifold Temperature (^{O}F)	96.6	98.1	101.2	98.6
Jacket Water Inlet Temperature (^{O}F)	161.4	162.5	163.0	162.3
Jacket Water Outlet Temperature (^{O}F)	165.6	167.7	167.3	166.9
Lube Oil Inlet Temperature (^{O}F)	143.4	143.6	142.0	143.0
Lube Oil Outlet Temperature (^{O}F)	159.8	160.0	159.8	159.9
Compressor Suction Pressure (PSIG)	289.0	290.0	367.0	315.3
Compressor Suction Temperature (^{o}F)	57.2	59.7	45.1	54.0
Compressor Discharge Pressure (PSIG)	759.0	757.0	766.0	760.7
Compressor Discharge Temperature (^{o}F)	195.3	198.6	162.0	185.3
Compressor Flow (MMSCF/D)	69.7	69.7	92.9	77.4
Fuel Torque (%) (from panel)	83.4	83.8	87.8	85.0
% Load	94.5	95.1	96.4	95.3
% Torque	94.5	95.1	96.2	95.3
Heat Rate (BTU/HP-hr)	6,234.6	6,172.9	6,445.4	6,284.3
Ambient Conditions				
Ambient Temperature (^{o}F)	56.30	63.80	68.00	62.70
Barometric Pressure (psi)	14.69	14.69	14.68	14.69
Ambient Relative Humidity (%)	64.00	52.00	42.00	52.67
Absolute Humidity (grains/LB)	88.61	94.12	87.87	90.20

Table 3. Emissions Concentrations/Calculated Mass Emissions & Calculated Emissions Concentrations-Engine EUWL017

Run	1	2	3	Averages
Date	05/11/17	05/11/17	05/11/17	
Emissions Concentrations & Calculated Mass Emissions				
NO_x ppm (BIAS Corrected)	183.84	181.62	190.99	185.48
NO_X g/BHP-HR	2.04	1.95	2.06	2.02
NO_X LB/HR	17.02	16.33	17.51	16.96
NO_X (ppm @ 15% O_2)	177.23	170.63	172.83	173.56
NO_X (ppm @ 15% O_2, ISO)	287.29	274.63	270.26	277.39
NOx LB/MMBTU	0.65	0.63	0.64	0.64
CO ppm (BIAS Corrected)	160.06	161.09	127.89	149.68
CO g/BHP-HR	1.08	1.05	0.84	0.99
CO LB/HR	9.02	8.82	7.14	8.33
CO LB/MMBTU **	0.35	0.34	0.26	0.32
CO (ppm @ 15% O_2)	154.31	151.34	115.73	140.46
CO (ppm @ 15% O_2, ISO)	250.13	243.58	180.97	224.89
% O_2 (BIAS Corrected)	14.78	14.62	14.38	14.59
Calculated Emissions Concentrations				
% CO_2 (Wet) *	3.21	3.27	3.38	3.29
%CO_2 (Dry) *	3.49	3.57	3.69	3.59
% H_2O *	8.16	8.39	8.48	8.34
% O_2 (Wet) *	13.57	13.39	13.16	13.38
% N_2 + CO (Wet) *	75.06	74.94	74.98	75.00

Table 4. Calculated Flows/Fuel Flow Measurements-Engine EUWL017

Run	1	2	3	Averages
Date	05/11/17	05/11/17	05/11/17	
Calculated Flows				
Fuel Flow - (SCFM)	417.00	415.50	440.00	424.17
Fuel Flow - (SCFH)	25,020	24,930	26,400	25,450
Fuel Flow (LB/HR)	1,162.8	1,167.6	1,226.2	1,186
Exhaust Flow (LB/HR)	49,859.9	48,224.5	49,289.0	49,124
Exhaust Flow (WSCFM)	13,316.1	12,987.1	13,333.4	13,212
Air Flow (WSCFM)	12,421	12,064	12,309	12,265
Exhaust Flow Method 19 (wscfm)	12,898	12,525	12,775	12,733
Exhaust Flow Method 19 (lbm/min)	592	575	586	584
Exhaust Flow Carbon Balance (lbm/min)	994.01	966.22	987.08	982
Air flow Beshouri (scfm)	12,932.38	12,570.85	12,842.18	12,782
BSAC, #/BHP-hr	14.98	14.46	14.54	15
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	25.02	24.93	26.40	25.45
Fuel Flow (SCFH) From Fuel Orifice	25,550	25,655	26,942	26,049
Fuel Gas Differential Pressure ("H_2O)	81.20	82.1	91.1	85
Fuel Gas Static Pressure (PSIG)	88.70	88.7	88	88
Fuel Gas Temperature (°F)	55.30	56.7	56.8	56
** BASED ON FUEL SPECIFIC DRY F-FACTOR CALCULATION	Run 1	Run 2	Run 3	
* BASED ON CARBON BALANCE (STOICH. + O2) - A/F IS TOTAL MASS RATIO				

3. FACILITY AND PROCESS DESCRIPTION

TransCanada's ANR Woolfolk Compressor Station (ANR) is located in Big Rapids, MI and operates a natural gas fired compressor station. The plant is located at 11039 150th Avenue, Big Rapids, MI. The Engine EUWL017 is a Cooper Bessemer model 12Q145HM natural gas fired internal combustion reciprocating engine.

The Cooper Bessemer 12Q145HM is a two stroke lean burn natural gas fired internal combustion reciprocating engine driving gas compressors. The energy released during the combustion process drives integral reciprocating gas compressors, thus raising the pressure of the incoming natural gas to move the gas to its final destination or to another compressor station.

The following table provide a summary of the production rates for the Engine EUWL017 during the test:

Table 5. Engine EUWL017 Rated Information

General Information

Date:	11-May-17	
Company:	ANR	
Station:	Woolfolk Compressor	
Unit:	207	
Engine Type:	Cooper Bessemer	
Serial Number:	EUWL017	
Bore:	15	in.
Stroke:	14	in.
Rated RPM:	475	RPM
Rated BHP:	4000	BHP

Permit Limits

	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:		9.7	85.7	
CO:				
VOC:				
H2CO:				

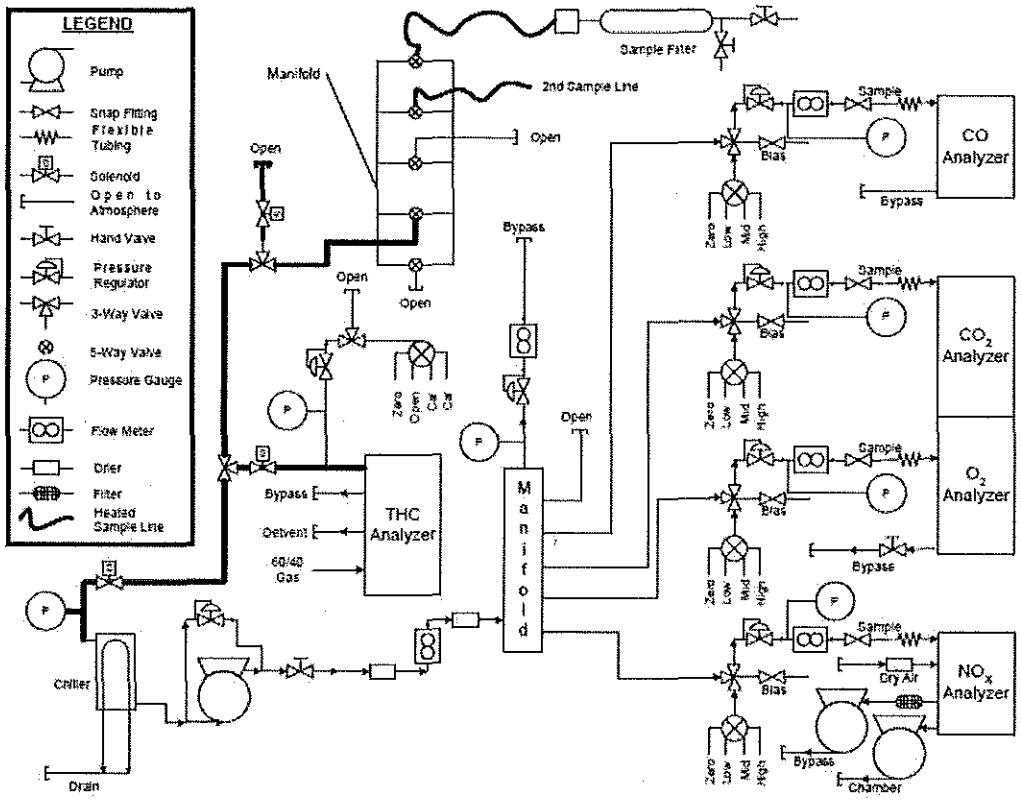
Limits are actuallly listed as average values

Number of Cylinders:	12
2 or 4 Stroke ?:	2

Table 6. Engine EUWL017 Production Data (Horse Power)

Engine EUWL017 Production Data (HP)	
Run No.	Horse Power
1	3779.0
2	3803.0
3	3857.0
Average	3813.0

Figure 1. Engine EUWL017-Flow Schematic



4. TEST PROCEDURES

EQ and EQ's affiliates and subcontractors use current U.S. EPA accepted testing methodologies in their Air Quality Programs as listed in the U.S. Code of Federal Regulations, Title 40, Part 60, Appendix A. For this testing program, the following specific methodologies were utilized:

- U.S EPA Method 2 – Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
- U.S. EPA Method 3A – Determination of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary Sources (Instrumental Analyzer Procedure)
- U.S EPA Method 4 – Determination of Moisture Content in Stack Gases
- U.S. EPA Method 7E – Determination of Nitrogen Oxides Emissions From Stationary Sources (Instrumental Analyzer Procedure)

USEPA Methods 3A and 7E were performed at the Exhaust Stack sampling location by continuously extracting a gas sample from the stack through a single point stainless steel sample probe. The extracted sample was pulled through a series of filters to remove any particulate matter. Directly after the probe, the sample was conditioned by a series of refrigeration dryers to remove moisture from the gas stream. After the refrigeration dryers, the sample was transported through a Teflon® line to the analyzers. The flow of the stack gas sample was regulated at a constant rate to minimize drift.

At the start of the day, each monitor was checked for calibration error by introducing zero, mid-range and high-range EPA Protocol 1 gases to the measurement system at a point upstream of the analyzers. In this report, the calibration error test is referred to as instrument calibration. The gas was injected into the sampling valve located at the outlet of the sampling probe. The bias test was conducted before and after each consecutive test run by introducing zero and upscale calibration gases for each monitor. The upscale calibration gases used for each monitor were the high calibration gases.

Measurement System Performance Specifications were as follows:

- Analyzer Calibration Error - Less than +/- 2% of the span of the zero, mid-range and high-range calibration gases.
- Sampling System Bias - Less than +/-5% of the span for the zero, mid-range and high-range calibration gases.
- Zero Drift - Less than +/-3% of the span over the period of each test run.
- Calibration Drift - Less than +/-3% of the span over the period of each set of runs.

Calculations that were used in this testing event for the Engine EUWL017 are as follows:

Calibration Correction

$$C_{GAS} = (C_R - C_O)\frac{C_{MA}}{C_M - C_O}$$

Where:

C_{GAS}:	Corrected flue gas concentration (ppmvd)
C_R:	Flue gas concentration (ppmvd)
C_O:	Average of initial and final zero checks (ppmvd)
C_M:	Average of initial and final span checks (ppmvd)
C_{MA}:	Actual concentration of span gas (ppmvd)

EPA F-Factor

$$F_d = \frac{\left[(3.64 \cdot H_{Wt\%} \cdot 100) + (1.53 \cdot C_{Wt\%} \cdot 100)\right]}{\frac{GCV}{\rho_{FuelGas}}} \cdot 10^6 + \frac{\left[(0.14 \cdot N_{2Wt\%} \cdot 100) - (0.46 \cdot O_{2Wt\%} \cdot 100)\right]}{\frac{GCV}{\rho_{FuelGas}}} \cdot 10^6$$

Where:

F_d:	Fuel specific F-factor, dscf/MMBtu
$H_{Wt\%}$:	Hydrogen weight percent
$C_{Wt\%}$:	Carbon weight percent
$N_{2Wt\%}$:	Nitrogen weight percent
$O_{2Wt\%}$:	Oxygen weight percent
GCV:	Heating value of the fuel, BTU/dscf
$\rho_{Fuel\ Gas}$:	Density of the fuel gas, lb/scf

NO_x Gr/bhp/hr

$$NOx_{\frac{g}{bhp\text{-}hr}} = C_d \times F_d \times \frac{20.9}{20.9 - \%O_2} \times Q_h \times \frac{GCV}{10^6} \times \frac{4536}{Bhp}$$

Where:

Cd: Pollutant concentration, lb/scf
Fd: Fuel specific F-factor, dscf/MMBtu
Qh: Fuel flow, scf/hr
%O2: Oxygen concentration in percent, measured on a dry basis
GCV: Upper dry heating value of fuel, Btu/dscf

Mass Emissions Calculations, lb/hr

$$NOx_{\frac{lb}{hr}} = C_d \times F_d \times \frac{20.9}{20.9 - \%O_2} \times Q_h \times \frac{GCV}{10^6}$$

Where:

Cd: Pollutant concentration, lb/scf
Fd: Fuel specific F-factor, dscf/MMBtu
Qh: Fuel flow, scf/hr
%O2: Oxygen concentration in percent, measured on a dry basis
GCV: Upper dry heating value of fuel, Btu/dscf

5. QUALITY ASSURANCE PROCEDURES

Each reference method presented in the U.S. Code of Federal Regulations details the instrument calibration requirements, sample recovery and analysis, data reduction and verification, types of equipment required, and the appropriate sampling and analytical procedures to ensure maximum performance and accuracy. EQ and EQ's affiliates and subcontractors adhere to the guidelines for quality control set forth by the United States Environmental Protection Agency. These procedures are outlined in the following documents:

- Code of Federal Regulations, Title 40, Part 51
- Code of Federal Regulations, Title 40, Part 60
- Quality Assurance Handbook, Volume 1, EPA 600/9-76-005
- Quality Assurance Handbook, Volume 2, EPA 600/4-77-027a
- Quality Assurance Handbook, Volume 3, EPA 600/4-77-027b

6. CONCLUSIONS

An Emissions Test was conducted on the internal combustion reciprocating engine EUWL017 at TransCanada's ANR Pipeline Company's Woolfolk Compressor Station located in Big Rapids, Michigan. The testing was conducted on May 11, 2017.

During the course of the testing, the Engine EUWL017 conformed to the requirements of Code of Federal Regulations, Title 40, Part 60, Appendix A, National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines.

The usefulness and/or significance of the emissions values presented in this document as they relate to the compliance status of the Engine EUWL017 emissions shall be determined by others.

For additional information pertaining to the testing program see Appendix E of this report.