COMPLIANCE TEST REPORT
Excelsior Compressor Station
Engine Euexcomp-B

Prepared for:

TransCanada
In business to deliver

TransCanada's ANR Pipeline Company
Excelsior Compressor Station
4963 State Road Northeast
Kalkaska, MI
Kalkaska County
Permit MI-ROP-B7196-2017

April 23, 2019

Prepared by:

EQM

Environmental Quality Management, Inc.
1280 Arrowhead Court
Suite 2
Crown Point, IN 46307
(219) 661-9900
www.eqm.com

PN: 050614.0086.008

May 2019

PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at Trans Canada in Kalkaska, 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
Project Manager

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 Trans Canada's Excelsior Compressor Station in Kalkaska, MI.

Karl Mast
Project Manager

SUMMARY

The compliance testing was performed on the Internal Combustion Reciprocating Engine EUEXCOMP-B (Unit 2) system in fulfillment of Michigan Department of Environmental Quality, Air Quality Division, permit no. MI-ROP-B7196-2017. The compliance testing was performed on the Combustion Engine in accordance with the requirements of the Code of Federal Regulations, Title 40, Part 60, Appendix A. The results of the testing are detailed in the following tables.

NO_x Test Results				
Reciprocating Engine	Rate Power (BHP)	Permit Limit	Measured Limit	Pass/Fail
Unit 2	3750	99.2 lb/hr	73.87	Pass

CONTENTS

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

This report presents the results of the source emissions testing conducted by Environmental Quality Management, Inc. (EQM) for TransCanada's ANR Pipeline (ANR) at Excelsior Compressor Station, near Kalkaska, MI, which is located in Kalkaska County.

The primary purpose of this testing program was to conduct emissions testing to determine compliance with Michigan operating permit No.MI-ROP-B7196-2017 for the internal combustion reciprocating engine, unit EUEXCOMP-B (Unit 2) at ANR's gas compressor facility.

EQM's responsibility was to conduct the compliance testing for NOx 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 the Unit 2 was performed on Tuesday, April 23, 2019, from 8:00 A.M. to 12:30 P.M.

The following requirements were specific for the testing program:

1. Equipment calibrations performed and calibration data provided.
2. Three (3) one hour (1) hour O_2, CO, and NOx test runs performed at the Engine at one (1) load condition, pursuant to EPA, Title 40, Code of Federal Regulations, Part 60, Appendix A.
3. Process manufacturing operations maintained at 100%- (+/-15%) 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 O_2, CO, and NOx emissions determinations.
5. Stratification was found to be less than 5% in both engine exhausts.

The testing program was approved by and/or coordinated with Tyrah Lydia, TransCanada's ANR Pipeline. The emission testing was performed by Karl Mast, Project Manager, EQM and Zach Hill, Lead Field Testing Activities, EQM. The emission testing was observed by Jeremy Howe, Michigan DEQ.

2. TEST RESULTS SUMMARY

The compliance testing was performed on the Unit No. 2 system in accordance with the requirements of the Title 40, Code of Federal Regulations, Part 60, Appendix A. A summary of the test results is given below:

Table 1. Test Results Summary-NO_x Results

NO_x Test Results				
Reciprocating Engine	Rate Power (BHP)	Permit Limt	Measured Limt	Pass/Fail
Unit 2	3750	99.2 lb/hr	73.87	Pass

Based on the information provided above, the Unit No. 2 system 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 2-5.

Additional testing information may be found in Appendix A.

Table 2. Operating and Ambient Parameters –Unit No. 2

Run	1	2	3	
Date	04/23/19	04/23/19	04/23/19	
Time	8:00-8:59	9:04-10:03	10:08-12:30	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	3,358.0	3,352.0	3,291.0	3,333.7
Unit Speed (rpm)	342.0	344.0	343.0	343.0
P. Cyl. Exhaust Temperature Average (^{O}F)	830.6	829.2	816.2	825.3
Air Manifold Temperature (^{O}F)	110.0	109.9	107.8	109.2
Jacket Water Inlet Temperature (^{O}F)	169.3	169.9	171.5	170.2
Lube Oil Inlet Temperature (^{O}F)	159.7	159.9	161.7	160.4
Compressor Suction Pressure (PSIG)	698.0	691.0	683.0	690.7
Compressor Suction Temperature (^{o}F)	98.8	98.1	93.1	96.7
Compressor Discharge Pressure (PSIG)	1244.0	1250.0	1229.0	1,241.0
Compressor Discharge Temperature (^{o}F)	97.8	97.2	95.1	96.7
Compressor Flow (MMSCF/D)	120.9	118.0	117.1	118.7
Fuel Torque (%) (from panel)	96.2	96.2	95.2	95.9
% Load	89.5	89.4	87.8	88.9
% Torque	91.6	90.9	89.6	90.7
Heat Rate (BTU/HP-hr)	6,996.7	7,003.8	6,997.3	6,999.3
Ambient Conditions				
Ambient Temperature (^{o}F)	42.00	39.00	37.00	39.33
Barometric Pressure (psi)	14.01	14.03	14.06	14.03
Ambient Relative Humidity (%)	97.00	96.00	95.00	96.00
Absolute Humidity (grains/LB)	82.46	72.41	66.01	73.62

Table 3. Emissions Concentrations, Calculated Mass Emissions & Fuel Flows Unit No. 2

Run	1	2	3	
Date	04/23/19	04/23/19	04/23/19	
Time	8:00-8:59	9:04-10:03	10:08-12:30	
Emissions Concentrations & Calculated Mass Emissions				
NO_X ppm (raw measured dry)	1389.68	1402.98	1275.53	1356.06
NO_x ppm (BIAS Corrected)	1389.68	1402.98	1275.53	1356.06
NO_X g/BHP-HR	10.28	10.41	9.45	10.05
NO_X LB/HR	76.12	76.94	68.55	73.87
NO_X (ppm @ 15% O_2)	795.26	804.43	730.64	776.78
NO_X (ppm @ 15% O_2, ISO)	1355.07	1345.45	1207.01	1302.51
NOx LB/MMBTU	2.93	2.96	2.69	2.86
CO ppm (raw measured dry)	228.14	227.89	225.74	227.26
CO ppm (BIAS Corrected)	228.14	227.89	225.74	227.26
CO g/BHP-HR	1.03	1.03	1.02	1.02
CO LB/HR	7.61	7.61	7.38	7.53
CO LB/MMBTU **	0.29	0.29	0.29	0.29
CO (ppm @ 15% O_2)	130.56	130.67	129.31	130.18
CO (ppm @ 15% O_2, ISO)	222.46	218.55	213.61	218.21
% O_2 (raw measured dry)	10.59	10.61	10.60	10.60
% O_2 (BIAS Corrected)	10.59	10.61	10.60	10.60
Calculated Emissions Concentrations				
% CO_2 (Wet) *	5.11	5.12	5.13	5.12
%CO_2 (Dry) *	5.81	5.79	5.80	5.80
% H_2O *	11.92	11.71	11.60	11.74
% O_2 (Wet) *	9.33	9.37	9.37	9.36
% N_2 + CO (Wet) *	73.64	73.80	73.90	73.78
Calculated Flows				
Fuel Flow - (SCFM)	427.83	427.50	419.33	424.89
Fuel Flow - (SCFH)	25,670	25,650	25,160	25,493
Fuel Flow (LB/HR)	1,558.9	1,554.9	1,528.9	1,548
Exhaust Flow (LB/HR)	31,397.0	31,463.3	30,855.2	31,238
Exhaust Flow (WSCFM)	8,263.1	8,270.8	8,105.8	8,213
Exhaust Gas Volume (ACFM)	21,441.0	21,416.1	20,730.1	21,196
Air Flow (WSCFM)	7,377	7,385	7,237	7,333
Exhaust Flow Method 19 (wscfm)	7,631	7,640	7,487	7,586
Exhaust Flow Method 19 (lbm/min)	334	334	327	332
Exhaust Flow Carbon Balance (lbm/min)	604.34	604.97	592.87	601
Air flow Beshouri (scfm)	7,861.83	7,870.07	7,712.67	7,815
BSAC, #/BHP-hr	10.01	10.04	10.02	10
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	25.67	25.65	25.16	25.49
Fuel Flow (SCFH) From Fuel Orifice	35,866	35,773	35,176	35,605
Fuel Gas Differential Pressure ("H_2O)	28.30	28.2	26.7	28
Fuel Gas Static Pressure (PSIG)	101.50	101.3	103.7	102
Fuel Gas Temperature (^oF)	70.00	70	70	70
** 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. PROCESS DESCRIPTION

TransCanada's ANR Pipeline's Excelsior Compressor Station is located in Kalkaska, Michigan and runs an Ingersoll Rand KVR-410 natural gas fired internal combustion reciprocating engine labeled EUEXCOMP-B (Unit 2).

More specifically, The Ingersoll Rand KVR-412 is a four stroke lean burn, 3,750 HP rated, 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 inject or withdraw natural gas from a natural gas storage field.

The following table provides a summary of rated information for each engine and the production rates for the Unit No. 2 during the test:

Table 4. Unit No. 2-Production Data-Horse Power (HP)

Unit No. 2 Horse Power (HP)	
Run No.	**Unit No. 2**
1	3,358
2	3,352
3	3,291
Average	3,334
Rated HP	3,750

Table 5. Unit No. 2 General Information

General Information

Date:	23-Apr-19
Company:	ANR
Station:	Excelsior
Unit:	B
Engine Type:	KVR-412
Rated RPM:	350 RPM
Rated BHP:	3750 BHP
Number of Cylinders:	10
2 or 4 Stroke ?:	2

Permit Limits

	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:			99.2	
CO:				
VOC:				
H2CO:				

Limits are actuallly listed as average values

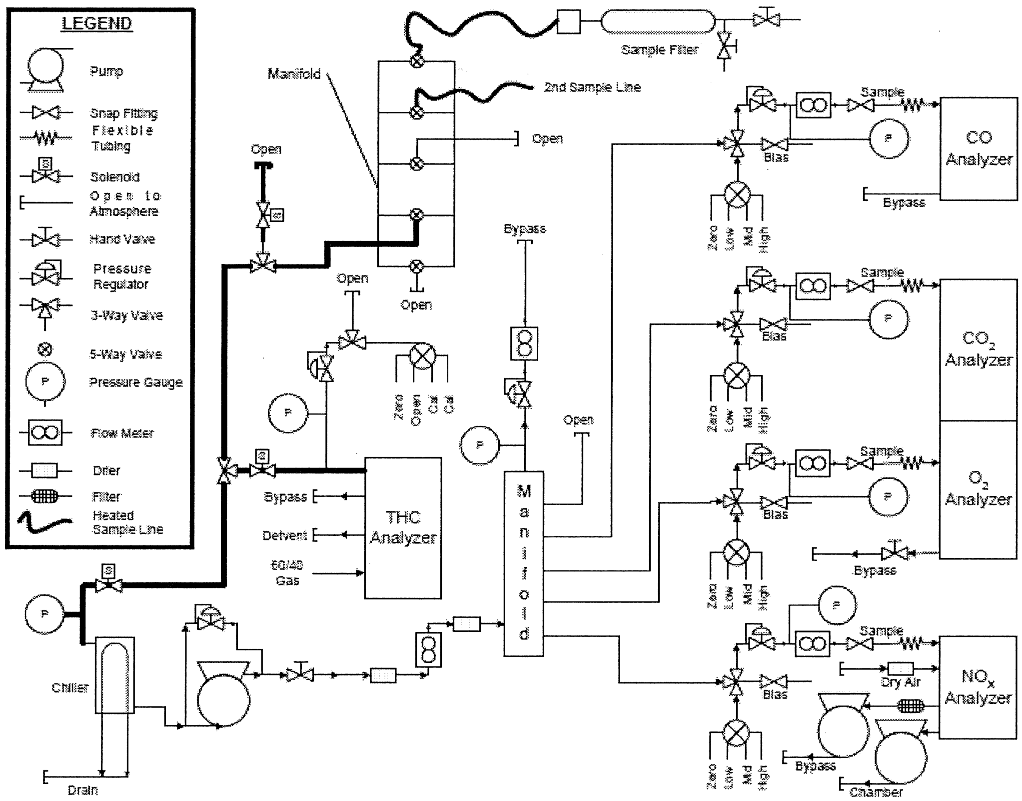
Fuel Gas Analysis

	Constituent	Mole Percent
☑	Nitrogen	0.304
☑	Carbon Dioxide	0.613
☑	Methane	98.446
☑	Ethane	0.000
☑	Propane	0.504
☑	I-Butane	0.045
☑	N-Butane	0.057
☑	I-Pentane	0.016
☑	N-Pentane	0.006
	Hexane +	0.010
	Total	100.000

Fuel Meter Type

Enter Type from List Below	2
Orifice Meter (upstream pressure tap):	1
Orifice Meter (downstream pressure tap):	2
Electronic Flow Meter (EFM):	3
Venturi (Nozzle) Meter:	4
Roots Meter w/ Accumulator:	5
Pipe I.D.:	3.068
Orifice I.D.:	1.5

Figure 1. Flow Schematic



Additional Information pertaining to the Fuel Flows may be found in Appendix B.

4. TEST PROCEDURES

EQM and EQM'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 3A – Determination of Oxygen and Carbon Dioxide Concentrations in Emissions From Stationary Sources (Instrumental Analyzer Procedure)
- U.S. EPA Method 7E – Determination of Nitrogen Oxides Emissions From Stationary Sources (Instrumental Analyzer Procedure)
- U.S. EPA Method 10 – Determination of Carbon Monoxide Emissions From Stationary Sources (Instrumental Analyzer Procedure)

USEPA Methods 3A, 7E, and 10 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 Unit No. 2 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

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:

C_d:	Pollutant concentration, lb/scf
F_d:	Fuel specific F-factor, dscf/MMBtu
Q_h:	Fuel flow, scf/hr
$\%O_2$:	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. EQM and EQM'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

A Compliance Test was conducted on Combustion Engine Unit No. 2 at ANR Excelsior Compressor Station near Kalkaska, MI. The Compliance testing was conducted on April 23, 2019.

During the course of the testing, the Combustion Engine Unit No. 2 conformed to the requirements of Code of Federal Regulations, Title 40, Part 60, Appendix A.

The usefulness and/or significance of the emissions values presented in this document as they relate to the compliance status of the Combustion Engine Unit No. 2 emissions shall be determined by others.

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

A. FIELD TEST DATA