COMPLIANCE TEST REPORT
ANR PIPELINE
SOUTH CHESTER COMPRESSOR STATION
SOUTH CHESTER, MI
ENGINE EUSCENG002

Prepared for:

TransCanada
In business to deliver

TransCanada's ANR Pipeline Company
South Chester, MI

Prepared by:

EQM

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PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at Trans Canada in South Chester, 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 South Chester Compressor Station in South Chester, MI.

Karl Mast
Project Manager

SUMMARY

The compliance testing was performed on the Internal Combustion Reciprocating Engine EUSCENG002 (Unit 1) system in fulfillment of Michigan Department of Environmental Quality, Air Quality Division, permit no. MI-ROP-B7219-2012a. The compliance testing was performed on the Combustion Engines 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 Limt	Measured Limt	Pass/Fail
Unit 1	3600	72.9 lb/hr	12.66	Pass
Unit 1	3600	9.2g/bhp/hr	1.91	Pass

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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 South Chester compressor station, near Johannesburg, MI, which is located in Otsego County.

The primary purpose of this testing program was to conduct emissions testing to determine compliance with Michigan operating permit No. MI-ROP-B7219-2012a for the internal combustion reciprocating engine, unit EUSCENG002 (Unit 1) 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 1 was performed on Monday, November 19, 2018, from 11:10 A.M. to 2:17 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 the engine exhaust(s).

The testing program was approved by and/or coordinated with Shawn Flannigan, TransCanada's ANR Pipeline. The emission testing was performed by Karl Mast, Manager, Emission Measurement & Project Manager, EQM, and Zach Hill, Test Technician, EQM. The emission testing was observed by Jeremy Howe, Michigan DEQ.

2. TEST RESULTS SUMMARY

The compliance testing was performed on the Unit No. 1 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 Limit	Measured Limit	Pass/Fail
Unit 1	3600	72.9 lb/hr	12.66	Pass
Unit 1	3600	9.2g/bhp/hr	1.91	Pass

Based on the information provided above, Unit No. 1 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 Conditions –Unit No. 1

Run	1	2	3	
Date	11/19/18	11/19/18	11/19/18	
Time	11:10	12:15	13:20	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	3,009.0	3,021.0	3,014.0	3,014.7
Unit Speed (rpm)	455.0	450.0	449.0	451.3
Turbo Speed (rpm)	9,539.0	9,409.0	9,577.0	9,508.3
P. Cyl. Exhaust Temperature Average (^{O}F)	358.5	355.3	356.8	356.9
Air Manifold Pressure ("Hg)	34.2	33.4	33.4	33.7
Air Manifold Pressure (PSI)	16.8	16.4	16.4	16.5
Air Manifold Temperature (^{O}F)	98.6	98.1	98.2	98.3
Jacket Water Outlet Temperature (^{O}F)	167.2	165.6	166.3	166.4
Lube Oil Outlet Temperature (^{O}F)	161.0	161.0	162.0	161.3
Compressor Suction Pressure (PSIG)	753.0	756.0	761.0	756.7
Compressor Suction Temperature (^{o}F)	50.2	52.1	52.3	51.5
Compressor Discharge Pressure (PSIG)	2704.0	2705.0	2705.0	2,704.7
Compressor Discharge Temperature (^{o}F)	214.1	218.5	218.8	217.1
Compressor Flow (MMSCF/D)	40.4	40.5	40.5	40.5
Fuel Torque (%) (from panel)	87.6	87.3	87.8	87.6
% Load	83.6	83.9	83.7	83.7
% Torque	82.7	83.9	83.9	83.5
Heat Rate (BTU/HP-hr)	6,885.6	6,809.1	6,834.1	6,842.9
Ambient Conditions				
Ambient Temperature (^{o}F)	32.60	33.70	32.60	32.97
Barometric Pressure (psi)	14.08	14.02	14.07	14.05
Ambient Relative Humidity (%)	93.00	94.00	85.00	90.67
Absolute Humidity (grains/LB)	54.02	57.36	49.36	53.58

Table 3. Emissions Concentrations, Calculated Mass Emissions & Fuel Flows
Unit No. 1

Run	1	2	3	
Date	11/19/18	11/19/18	11/19/18	
Time	11:10	12:15	13:20	
Emissions Concentrations & Calculated Mass Emissions				Averages
NO_X ppm (raw measured dry)	152.00	151.54	149.08	150.87
NO_X ppm (BIAS Corrected)	152.00	151.54	149.08	150.87
NO_X g/BHP-HR	1.95	1.90	1.87	1.91
NO_X LB/HR	12.92	12.64	12.43	12.66
NO_X (ppm @ 15% O_2)	153.04	150.77	148.08	150.63
NO_X (ppm @ 15% O_2, ISO)	247.91	246.16	236.95	243.67
NOx LB/MMBTU	0.56	0.56	0.55	0.55
CO ppm (raw measured dry)	279.64	280.25	280.64	280.18
CO ppm (BIAS Corrected)	279.64	280.25	280.64	280.18
CO g/BHP-HR	2.18	2.14	2.14	2.15
CO LB/HR	14.47	14.23	14.24	14.31
CO LB/MMBTU **	0.63	0.62	0.62	0.63
CO (ppm @ 15% O_2)	281.55	278.83	278.75	279.71
CO (ppm @ 15% O_2, ISO)	456.09	455.23	446.06	452.46
% O_2 (raw measured dry)	15.04	14.97	14.96	14.99
% O_2 (BIAS Corrected)	15.04	14.97	14.96	14.99
Calculated Emissions Concentrations				
% CO_2 (Wet) *	3.09	3.12	3.13	3.11
%CO_2 (Dry) *	3.33	3.37	3.37	3.36
% H_2O *	7.25	7.37	7.23	7.28
% O_2 (Wet) *	13.95	13.87	13.88	13.90
% N_2 + CO (Wet) *	75.71	75.64	75.76	75.71
Calculated Flows				
Fuel Flow - (SCFM)	371.83	369.17	369.67	370.22
Fuel Flow - (SCFH)	22,310	22,150	22,180	22,213
Fuel Flow (LB/HR)	2,088.0	2,073.6	2,076.0	2,079
Exhaust Flow (LB/HR)	46,784.3	45,901.7	45,843.2	46,176
Exhaust Flow (WSCFM)	12,198.2	11,986.5	11,985.2	12,057
Exhaust Gas Volume (ACFM)	19,977.9	19,639.5	19,603.5	19,740
Air Flow (WSCFM)	11,407	11,193	11,190	11,263
Exhaust Flow Method 19 (wscfm)	11,841	11,618	11,614	11,691
Exhaust Flow Method 19 (lbm/min)	530	520	520	523
Exhaust Flow Carbon Balance (lbm/min)	912.10	895.29	895.06	901
Air flow Beshouri (scfm)	11,866.83	11,648.19	11,645.12	11,720
BSAC, #/BHP-hr	17.28	16.89	16.92	17
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	22.31	22.15	22.18	22.21
Fuel Flow (SCFH) From Fuel Orifice	46,883	46,559	46,613	46,685
Fuel Gas Differential Pressure ("H_2O)	51.50	48.5	48.9	50
Fuel Gas Static Pressure (PSIG)	98.40	99.1	99.1	99
Fuel Gas Temperature (°F)	77.30	57.1	60.2	65
** 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 South Chester Compressor Station is located in Johannesburg, Michigan and run two Cooper Bessemer model 12Q145LM natural gas fired internal combustion reciprocating engines labeled EUSCENG002 (Unit 1) and EUSCENG003 (Unit 2).

More specifically, these engines are 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 inject or withdraw natural gas from a natural gas storage field.

The following tables provide a summary of rated information for each engine and the production rates for the Unit No. 1, that was the focus of this project during the test:

Table 4. Unit No. 1 General Information

General Information

Date:	19-Nov-18
Company:	GLGT
Station:	South Chester
Unit:	1
Engine Type:	Cooper Bessemer
Rated RPM:	450 RPM
Rated BHP:	3600 BHP

Permit Limits

	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:		9.2	72.9	
CO:				
VOC:				
H2CO:				

Limits are actualily listed as average values

Fuel Gas Analysis

Constituent	Mole Percent
Nitrogen	0.6995
Carbon Dioxide	0.6738
Methane	94.9595
Ethane	3.3731
Propane	0.2658
I-Butane	0.0140
N-Butane	0.0011
I-Pentane	0.0009
N-Pentane	0.0000
Hexane +	0.0025
Total	99.990

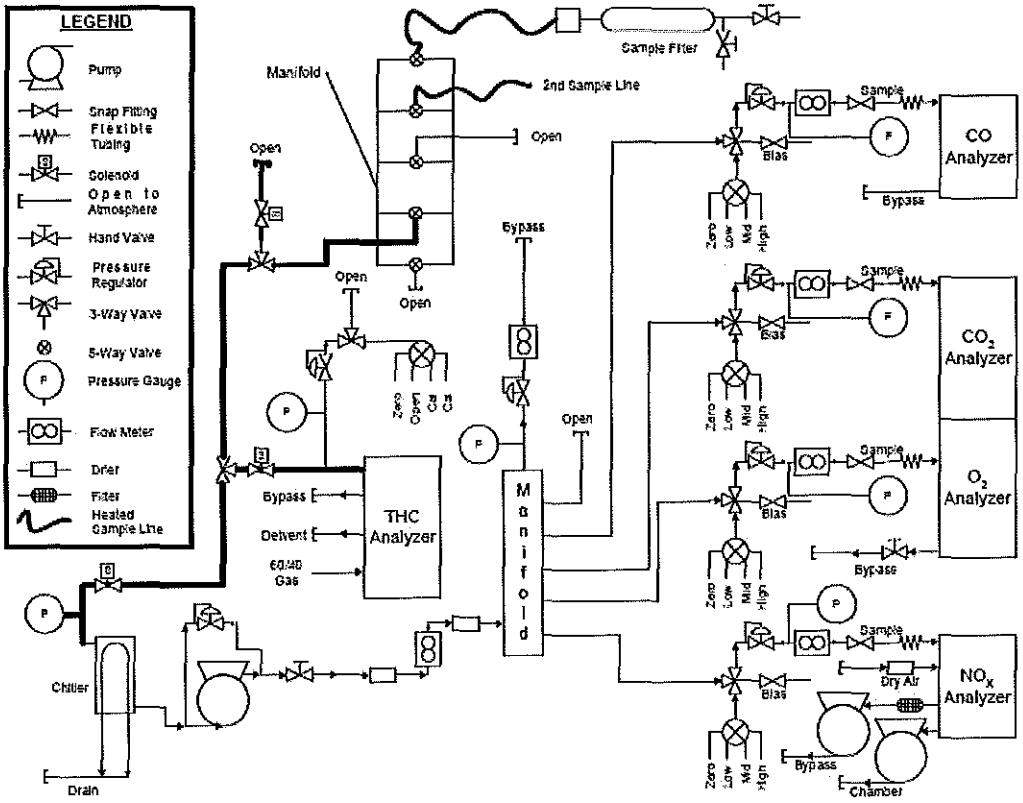
Fuel Meter Type

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

Table 5. Unit No. 1-Production Data-Horse Power (HP)

Unit No. 1 Horse Power (HP)	
Run No.	**Unit No. 1**
1	3,009
2	3,021
3	3,014.
Average	3,014.7
Rated HP	3,600

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 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 Unit No. 1 and 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 g/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:

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

Mass Emissions Calculations lb/hr

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

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. 1 at ANR South Chester Compressor Station near Johannesburg, MI. The Compliance testing was conducted on November 19, 2018.

During the course of the testing, the Combustion Engine Unit No. 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. 1 emissions shall be determined by others.

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