COMPLIANCE TEST REPORT
ANR PIPELINE
CENTRAL CHARLTON COMPRESSOR STATION
UNIT
EUCTCOMPENG0002

Prepared for:

TransCanada
In business to deliver

TransCanada's ANR Pipeline Company
Johannesburg, MI

Prepared by:

EQM

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

PN: 050614.0068

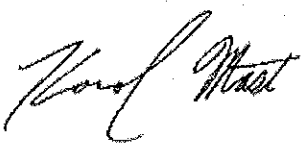
November 2017

PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at TransCanada in Johannesburg, 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 Johannesburg Compressor Station in Johannesburg, MI.



Karl Mast
Test Supervisor

SUMMARY

The compliance emissions testing was performed on Unit No. EUCTCOMPENG002 (Unit No. 2) in accordance with the requirements of Michigan Department of Environmental Quality, Air Quality Division, Permit No. MI-ROP-B7390-2012a. The testing was performed utilizing USEPA Methods 3A and 7E at the Exhaust Stack sampling location. The results of the testing are detailed in the following tables.

Unit No. 2 Emission Test Results		
Run No.	**NOx Emissions (g/bhp/hr)**	**NOx (lb/hr)**
1	0.54	4.16
2	0.58	4.50
3	0.58	4.45
Average	0.57	4.37
Emission Limit	6 at 100 % Speed and Torque	53

1. INTRODUCTION

This report presents the results of the source emissions testing conducted by Environmental Quality Management, Inc. (EQM) for Trans Canada's ANR Pipeline (ANR) Central Charlton Compressor Station near Johannesburg, MI. The Air Compliance Team of TransCanada's ANR Pipeline Company, contracted EQ which conducted the source emissions testing at the ANR Central Charlton Compressor Station in fulfillment of the Michigan Department of Environmental Quality, Air Quality Division (MDEQ), permit no. MI-ROPB7390-2012a.

The primary purpose of this testing program was to conduct emissions testing of the internal combustion reciprocating engine Unit No. EUCTCOMPENG002 (Unit 2), with an emission limit of 6 G/BHP-HR at 100 % Speed and Torque NO_x and 53 lb/hr of NO_x. EQM's responsibility was to conduct the compliance testing for the NOx, CO, and O2 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 No. 2 was performed on October 12, 2017 from 8:00 A.M. to 11:07 A.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, NOx, CO, and O2 test runs performed at the Unit 1 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, CO, and O2 emissions determinations.

The testing program was approved by and/or coordinated with Roy Cannon, TransCanada's ANR Pipeline Company. The emission testing program was performed by Karl Mast, Manager, Emission Measurement and Project Manager, EQM and Zach Hill, Test Technician,, EQM. The emission testing was observed by Jeremy Howe, Environmental Quality Analysts, Michigan Department of Environmental Management.

2. TEST RESULTS SUMMARY

The compliance testing was performed on Unit No. 2 in accordance with the requirements (MIROP-B7390-2012a) issued by MDEQ. A summary of the test results is given below:

Table 1. Test Results Summary -NO_x

Unit No. 2 Emission Test Results		
Run No.	**NOx Emissions (g/bhp/hr)**	**NOx (lb/hr)**
1	0.54	4.16
2	0.58	4.50
3	0.58	4.45
Average	0.57	4.37
Emission Limit	6 at 100 % Speed and Torque	53

Based on the information provided above, the Unit No. 2 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 1.

Additional testing information may be found in Appendix A.

Table 2. Operating & Ambient Conditions, Unit No. 2

Run	1	2	3	
Date	10/12/17	10/12/17	10/12/17	
Time	8:00	9:05	10:08	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	3,513.0	3,508.0	3,481.0	3,500.7
Unit Speed (rpm)	451.0	450.0	450.0	450.3
Turbo Speed (rpm)	9,474.0	9,522.0	9,517.0	9,504.3
P. Cyl. Exhaust Temperature Average (^{O}F)	331.9	332.3	332.1	332.1
Air Manifold Pressure ("Hg)	25.1	25.1	25.0	25.1
Air Manifold Pressure (PSI)	12.3	12.3	12.3	12.3
Air Manifold Temperature (^{O}F)	99.9	99.8	99.7	99.8
Jacket Water Inlet Temperature (^{O}F)	157.6	159.3	159.3	158.7
Jacket Water Outlet Temperature (^{O}F)	163.7	165.1	165.3	164.7
Lube Oil Inlet Temperature (^{O}F)	139.5	139.3	139.3	139.4
Lube Oil Outlet Temperature (^{O}F)	159.8	159.9	160.0	159.9
Compressor Suction Pressure (PSIG)	1277.0	1278.0	1274.0	1,276.3
Compressor Suction Temperature (^{o}F)	88.1	90.9	92.8	90.6
Compressor Discharge Pressure (PSIG)	3201.0	3202.0	3203.0	3,202.0
Compressor Discharge Temperature (^{o}F)	237.9	241.2	242.4	240.5
Compressor Flow (MMSCF/D)	48.6	48.2	47.3	48.0
Fuel Torque (%) (from panel)	87.9	87.9	87.7	87.8
% Load	87.8	87.7	87.0	87.5
% Torque	92.5	92.6	91.9	92.3
Heat Rate (BTU/HP-hr)	6,545.2	6,559.8	6,597.4	6,567.4
Ambient Conditions				
Ambient Temperature (^{o}F)	56.20	62.40	65.20	61.27
Barometric Pressure (psi)	28.76	28.72	28.74	28.74
Ambient Relative Humidity (%)	61.40	54.10	46.80	54.10
Absolute Humidity (grains/LB)	42.82	47.18	44.96	44.99

Table 3. Emissions Concentrations/Calculated Mass Emmissions & Concentrations

Run	1	2	3	
Date	10/12/17	10/12/17	10/12/17	
Time	8:00	9:05	10:08	
Emissions Concentrations & Calculated Mass Emissions				
NO_x ppm (BIAS Corrected)	48.37	52.66	52.51	51.18
NO_X g/BHP-HR	0.54	0.58	0.58	0.57
NO_X LB/HR	4.16	4.50	4.45	4.37
NO_X (ppm @ 15% O_2)	44.38	47.95	47.59	46.64
NO_X (ppm @ 15% O_2, ISO)	45.42	48.79	47.73	47.31
NOx LB/MMBTU	0.16	0.18	0.18	0.17
CO ppm (raw measured dry)	247.66	251.27	256.10	251.68
CO ppm (BIAS Corrected)	247.66	251.27	256.10	251.68
CO g/BHP-HR	1.67	1.69	1.72	1.69
CO LB/HR	12.96	13.06	13.22	13.08
CO LB/MMBTU **	0.51	0.51	0.52	0.51
CO (ppm @ 15% O_2)	227.25	228.78	232.10	229.38
CO (ppm @ 15% O_2, ISO)	232.57	232.80	232.77	232.71
% O_2 (BIAS Corrected)	14.47	14.42	14.39	14.43
Calculated Emissions Concentrations				
% CO_2 (Wet) *	3.37	3.39	3.41	3.39
%CO_2 (Dry) *	3.65	3.67	3.69	3.67
% H_2O *	7.57	7.70	7.68	7.65
% O_2 (Wet) *	13.37	13.31	13.28	13.32
% N_2 + CO (Wet) *	75.68	75.60	75.63	75.64

Table 4. Calculated Flows & Fuel Flow Measurements

Run	1	2	3
Date	10/12/17	10/12/17	10/12/17
Time	8:00	9:05	10:08
Calculated Flows			
Fuel Flow - (SCFM)	414.17	414.50	413.67
Fuel Flow - (SCFH)	24,850	24,870	24,820
Fuel Flow (LB/HR)	1,195.1	1,196.8	1,193.6
Exhaust Flow (LB/HR)	47,157.6	46,654.8	46,260.7
Exhaust Flow (WSCFM)	12,421.0	12,347.4	12,273.2
Air Flow (WSCFM)	11,542	11,463	11,388
Exhaust Flow Method 19 (wscfm)	11,976	11,893	11,815
Exhaust Flow Method 19 (lbm/min)	533	530	526
Exhaust Flow Carbon Balance (lbm/min)	925.77	919.67	913.77
Air flow Beshouri (scfm)	12,045.07	11,965.66	11,888.90
BSAC, #/BHP-hr	14.97	14.89	14.91
Fuel Flow Measurements			
Fuel Flow From Screen(MSCFH)	24.85	24.87	24.82
Fuel Flow (SCFH) From Fuel Orifice	26,954	26,992	26,920
Fuel Gas Differential Pressure ("H_2O)	66.20	66.4	66.2
Fuel Gas Static Pressure (PSIG)	94.30	94.3	94.3
Fuel Gas Temperature (°F)	66.00	66	67.2
** 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 Company Central Charlton Compressor Station (ANR) is located in Johannesburg, MI and operates a natural gas fired compressor station. The plant is located at 14490 Beckett Road, Johannesburg, MI. The facility has two Cooper Bessemer model 12Q145-HM natural gas fired internal combustion reciprocating engines labeled EUCTCOMPENG001 (Unit 1) and EUCTCOMPENG002 (Unit 2). Unit 2 was the source for this testing event.

Unit No. 2 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 inject or withdraw natural gas from a natural gas storage field.

The following tables provide a summary of the production rates and general information for the Unit No. 2 during the test:

Table 5. Production Data

Unit 2 Horse Power (HP)	
Run No.	**HP**
1	3,513
2	3,508
3	3,481
Average	3500.7
Rated	4,800

Table 6. Engine Rating and General Information

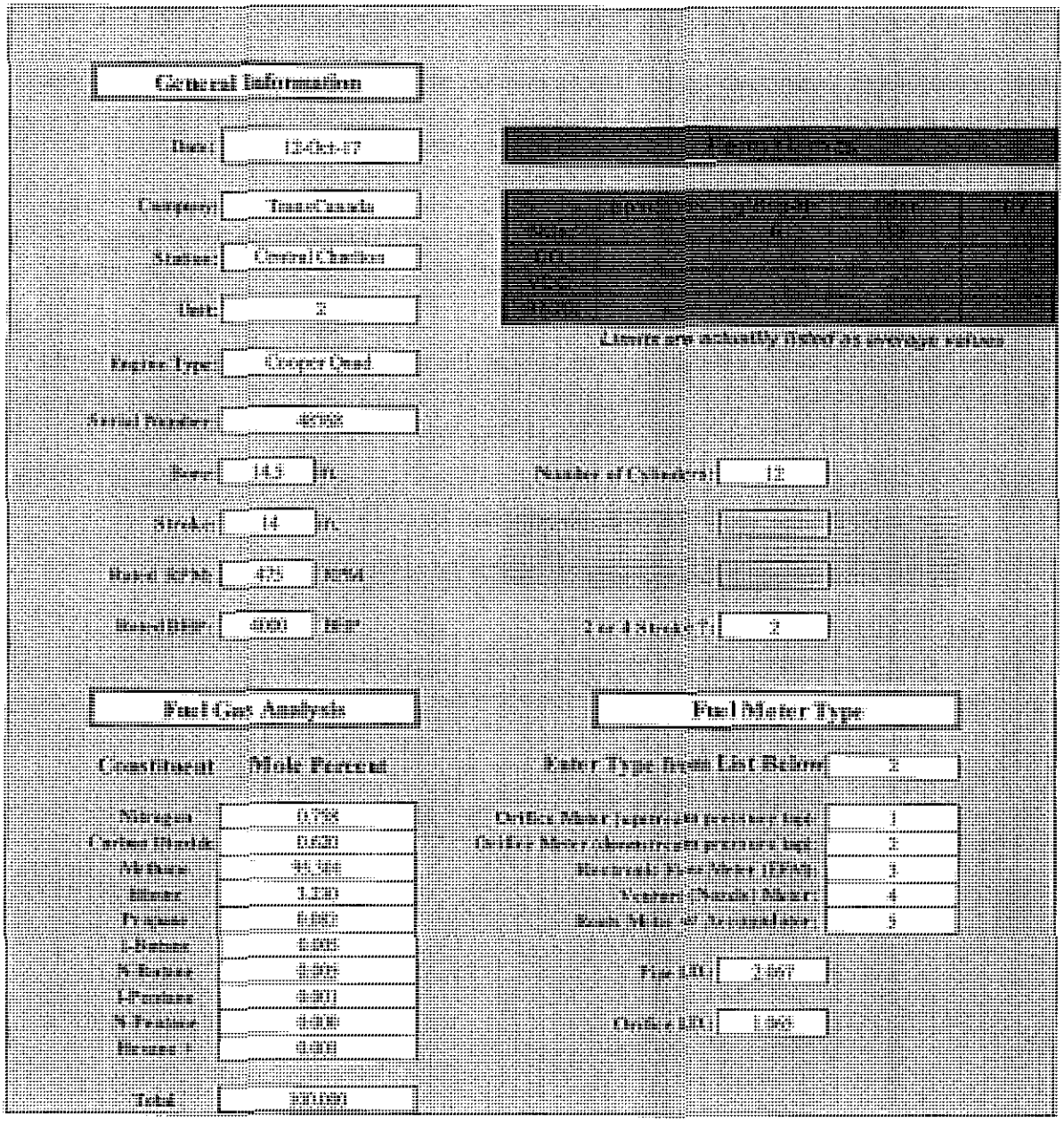
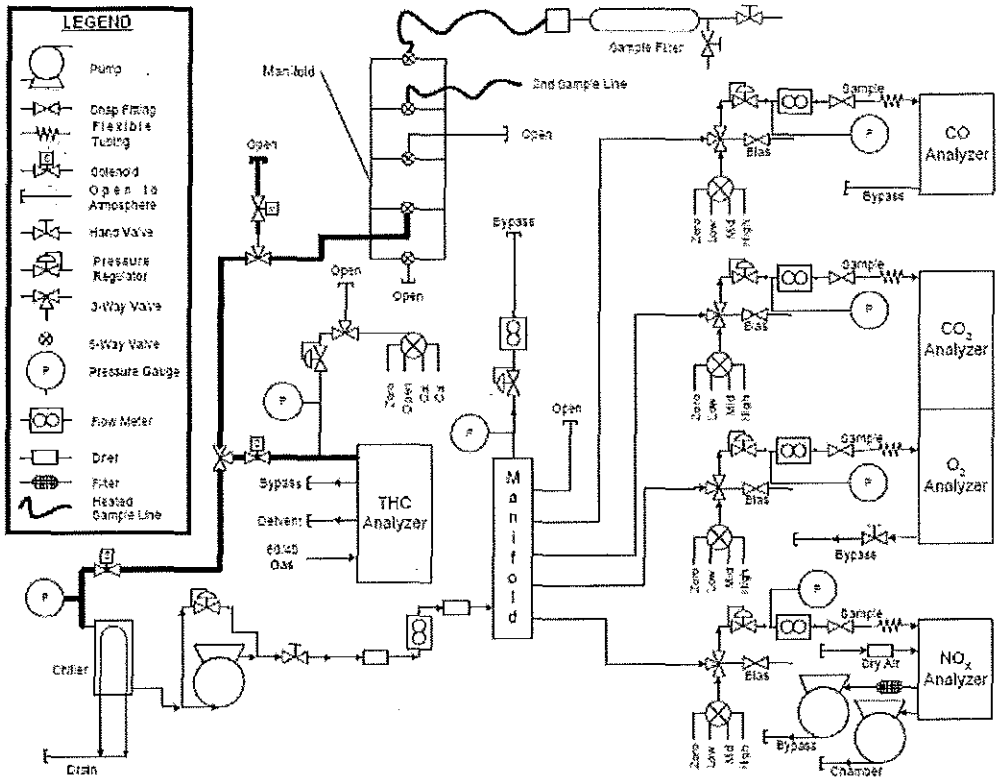


Figure 1. Flow Schematic



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 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

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

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 g/bhp-hr)

$$Em = Cd \times Fd \times \frac{20.9}{(20.9 - \%O_2)} \times Qh \times \frac{GCV}{10^6} \times \frac{453.6}{BHP}$$

Where:

Cd:	Pollutant concentration, NOx lb/scf
$\%O_2$:	Oxygen concentration in percent, measured on a dry basis
Fd:	Fuel specific F-factor, dscf/MMBtu
Qh:	Fuel rate, scf/hr
GCV:	Heating value fuel, Btu/scf

Mass Emission Calculations lb/hr

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

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

An Emissions Test was conducted on the Unit No. 2 at TransCanada's ANR Pipeline Company's Johannesburg Compressor Station located in Johannesburg, MI. The testing was conducted on October 12, 2017.

During the course of the testing, the Engine Unit No. 2 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 Unit No. 2 emissions shall be determined by others. For additional information pertaining to the testing program see Appendix E of this report.