COMPLIANCE TEST REPORT
COLD SPRINGS COMPRESSOR STATION
UNIT EU CS12CMPR-C

Prepared for:

TransCanada
In business to deliver

TransCanada's ANR Pipeline Company
Mancelona, MI

Prepared by:

EQM

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PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at TransCanada in Mancelona, Michigan 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 Cold Springs Compressor Station in Mancelona, Michigan.

Karl Mast
Test Supervisor

SUMMARY

The compliance emissions testing was performed on Engine Unit EU CS12CMPR-C (C) in fulfillment of Michigan Department of Environmental Quality, Air Quality Division, permit no. MI-ROP-B7198-2014a . The testing was performed utilizing USEPA Methods 1, 3A, and 7E at the Exhaust Stack sampling location. The results of the testing are detailed in the following tables.

Engine C NO_x Emission Test Results	
Run No.	**NOx Emissions (lb/hr)**
1	61.12
2	58.02
3	58.39
Average	59.18
Emission Limit	99.2

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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 (ANR) Cold Springs Compressor Station, near Mancelona, MI in fulfillment of Michigan Department of Environmental Quality, Air Quality Division, permit no. MI-ROP-B7198-2014a, the testing was performed utilizing USEPA Methods 1, 3A, and 7E at the Exhaust Stack sampling location.

To ensure that compliance with the emission limits is maintained, TransCanada's ANR Pipeline Company contracted Environmental Quality Management, Inc. (EQM) to perform source emissions testing on Engine C. The primary purpose of this testing program was to conduct emissions testing of the internal reciprocating Engine C with having an emission limit of 99.2 lbs/hr of NO_x.

EQM's responsibility was to conduct the compliance testing for the 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 Engine C was performed on November 20, 2018, from 7:51 A.M. to 10:59 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, and O_2 test runs performed at the Engine C 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.

The testing program was approved by and/or coordinated with Shawn Flannigan, TransCanada's ANR Pipeline Company. The emission testing was managed by Karl Mast, Manager Air Emissions Measurement, Zach Hill, Lead Field Test Supervisor, and Emily Woerpel, Test Technician, all EQM. The emission testing was not observed by Sharon LaBlanc, MDEQ.

2. TEST RESULTS SUMMARY

The compliance testing was performed on Engine C in fulfillment of Michigan Department of Environmental Quality, Air Quality Division, permit no. MI-ROP-B7198-2014a. A summary of the test results is given below:

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

Engine C NO_x Emission Test Results	
Run No.	**NOx Emissions (lb/hr)**
1	61.12
2	58.02
3	58.39
Average	59.18
Emission Limit	99.2

Based on the information provided above, the Engine C 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 Tables 2- 5.

Table 2. Engine Operating Conditions-Engine C

Run	1	2	3	
Date	11/20/18	11/20/18	11/20/18	
Time	7:51-8:50	8:55-9:54	10:00-10:59	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	3,712.0	3,693.0	3,722.0	3,709.0
Unit Speed (rpm)	351.0	352.0	352.0	351.7
Turbo Speed (rpm)	13,658.0	13,807.0	13,692.0	13,719.0
P. Cyl. Exhaust Temperature Average (°F)	835.0	836.0	836.0	835.7
Air Manifold Pressure ("Hg)	36.6	36.6	36.6	36.6
Air Manifold Pressure (PSI)	18.0	18.0	18.0	18.0
Air Manifold Temperature (°F)	110.0	110.0	110.0	110.0
Jacket Water Inlet Temperature (°F)	170.0	169.0	169.0	169.3
Lube Oil Inlet Temperature (°F)	160.0	172.0	173.0	168.3
Compressor Suction Pressure (PSIG)	960.5	956.5	958.0	958.3
Compressor Suction Temperature (°F)	38.0	38.0	39.0	38.3
Compressor Discharge Pressure (PSIG)	1880.5	1879.0	1874.5	1,878.0
Compressor Discharge Temperature (°F)	72.0	72.0	72.0	72.0
Compressor Flow (MMSCF/D)	519.0	545.0	N/A	532.0
Fuel Torque (%) (from panel)	100.0	100.0	99.0	99.7
% Load	99.0	98.5	99.3	98.9
% Torque	98.7	97.9	98.7	98.4
Heat Rate (BTU/HP-hr)	6,732.0	6,516.0	6,713.9	6,654.0

Table 3. Ambient Conditions & Emissions Concentrations/Calculated Mass Emissions-Engine C

Run	1	2	3	
Date	11/20/18	11/20/18	11/20/18	
Time	7:51-8:50	8:55-9:54	10:00-10:59	
Ambient Conditions				Averages
Ambient Temperature (°F)	18.00	20.00	20.00	19.33
Barometric Pressure (psi)	14.13	14.13	14.13	14.13
Ambient Relative Humidity (%)	92.00	91.00	89.00	90.67
Absolute Humidity (grains/LB)	28.87	31.12	30.44	30.14
Emissions Concentrations & Calculated Mass Emissions				
NO_x ppm (BIAS Corrected)	986.90	980.83	949.66	972.46
NO_X g/BHP-HR	7.47	7.13	7.12	7.24
NO_X LB/HR	61.12	58.02	58.39	59.18
NO_X (ppm @ 15% O_2)	600.28	591.71	573.49	588.49
NO_X (ppm @ 15% O_2, ISO)	949.49	935.59	905.17	930.08
NOx LB/MMBTU	2.21	2.18	2.11	2.17
CO ppm (raw measured dry)	351.90	357.12	363.61	357.54
CO g/BHP-HR	1.62	1.58	1.66	1.62
CO LB/HR	13.27	12.86	13.61	13.25
CO LB/MMBTU **	0.48	0.48	0.49	0.48
CO (ppm @ 15% O_2)	214.04	215.44	219.58	216.35
CO (ppm @ 15% O_2, ISO)	338.56	340.65	346.58	341.93
% O_2 (BIAS Corrected)	11.20	11.12	11.13	11.15
Calculated Emissions Concentrations				
% CO_2 (Wet) *	4.92	4.95	4.95	4.94
%CO_2 (Dry) *	5.49	5.53	5.52	5.51
% H_2O *	10.30	10.41	10.39	10.37
% O_2 (Wet) *	10.05	9.96	9.97	9.99
% N_2 + CO (Wet) *	74.73	74.67	74.68	74.69

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

Run	1	2	3	
Date	11/20/18	11/20/18	11/20/18	
Time	7:51-8:50	8:55-9:54	10:00-10:59	
Calculated Flows				**Averages**
Fuel Flow - (SCFM)	450.00	433.33	450.00	**444.44**
Fuel Flow - (SCFH)	27,000	26,000	27,000	**26,667**
Exhaust Flow (LB/HR)	35,556.1	33,962.2	35,285.1	**34,934**
Exhaust Flow (WSCFM)	9,275.3	8,870.0	9,219.1	**9,121**
Exhaust Gas Volume (ACFM)	23,958.0	22,925.5	23,831.2	**23,572**
Air Flow (WSCFM)	8,340	7,966	8,280	**8,195**
Exhaust Flow Method 19 (wscfm)	8,628	8,240	8,566	**8,478**
Exhaust Flow Method 19 (lbm/min)	384	366	381	**377**
Exhaust Flow Carbon Balance (lbm/min)	680.51	650.25	675.91	**669**
Air flow Beshouri (scfm)	8,853.90	8,460.14	8,794.01	**8,703**
BSAC, #/BHP-hr	10.24	9.83	10.14	**10**
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	27.00	26.00	27.00	**26.67**
Fuel Gas Differential Pressure ("H_2O)	27.00	27	27	**27**
Fuel Gas Static Pressure (PSIG)	112.00	111	112	**112**
**** 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 Cold Springs Compressor Station is located in Mancelona, MI and operates a natural gas fired compressor station. The plant is located at 10000 Pflum Road, Mancelona, MI, which is located in Antrim County.

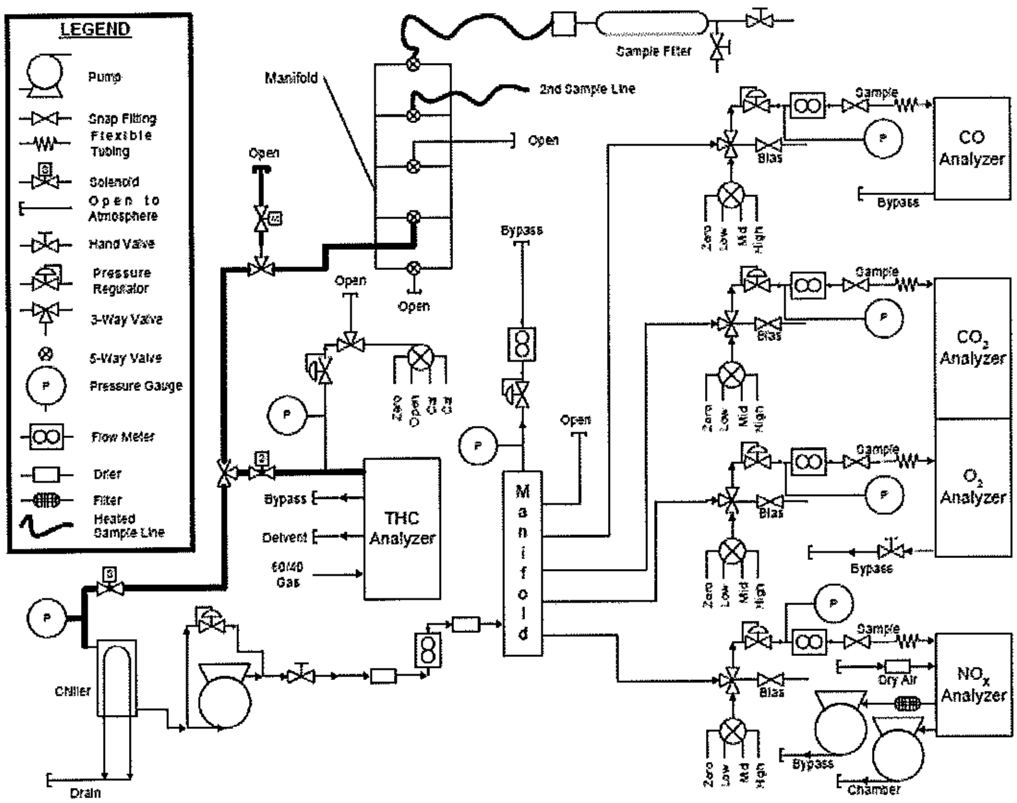
The Engine C is an Ingersoll Rand KVR-410 natural gas fired internal combustion reciprocating engines. The Ingersoll Rand KVR-410 is a four stroke lean burn natural gas fired internal combustion reciprocating engine driving gas compressors. The energy released during the combustion process drives integral 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 for the Engine C during the test:

Table 5. Engine C Production Data (Horse Power)

Engine C Production Data (HP)	
Run No.	**Horse Power**
1	3712
2	3693
3	3722
Average	3709

Figure 1. Engine C -Flow Schematic



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 1 – Sample and Velocity Traverses for Stationary Sources
- 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)

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 Engines E06 and E07 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

NOx 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

To convert ppm to lb/scf	Multiply by
NOx	1.194×10^{-7}

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 internal combustion reciprocating Engine C located at TransCanada's ANR Pipeline Company's Cold Springs Compressor Station in Mancelona, Michigan. The testing was conducted on November 20, 2018.

During the course of the testing, the Engine C 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 C emissions shall be determined by others.

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