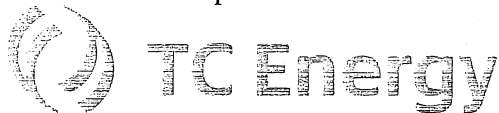

**COMPLIANCE TEST REPORT
ANR PIPELINE
SOUTH CHESTER COMPRESSOR STATION
JOHANNESBURG, MI
ENGINE EUSCENG003**

Prepared for:



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June 2019

SUMMARY

The compliance testing was performed on the Internal Combustion Reciprocating Engines\ EUSCENG003 (Unit 2) system in fulfillment of Michigan Department of Environmental Quality, Air Quality Division, permit no. MI-ROP-B7219-2012. 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 Limit	Measured Emissions	Pass/Fail
Unit 2	3600	72.9 lb/hr	15.62	Pass
Unit 2	3600	9.2g/bhp/hr	2.59	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 TC Energy'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 EUSCENG003 (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 TC Energy's process operations, and Compliance testing. The Compliance testing conducted on the Unit 2 was performed on Tuesday, May 2, 2019, from 8:00 A.M. to 11:09 A.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 O₂, CO, and NO_x test runs performed at the Engines 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 O₂, CO, and NO_x 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, TC Energy's ANR Pipeline Testing Coordinator. The emission testing was performed by Karl Mast, Manager, Emissions Measurement, and Kameron King, Test Technician, EQM. The emission testing was observed by Jeremy Howe and Sharon LeBlanc by MDEQ.

2. TEST RESULTS SUMMARY

The compliance testing was performed on the Units No. 1 and No. 2 systems 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 Emissions	Pass/Fail
Unit 2	3600	72.9 lb/hr	15.62	Pass
Unit 2	3600	9.2g/bhp/hr	2.59	Pass

Based on the information provided above, the 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 Parameters –Unit No. 2

Run	1	2	3	
Date	05/02/19	05/02/19	05/02/19	
Time	8:00-8:59	9:05-10:04	10:10-11:09	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	2,757.0	2,737.0	2,737.0	2,743.7
Unit Speed (rpm)	447.0	452.0	450.0	449.7
Turbo Speed (rpm)	8,514.0	8,671.0	8,734.0	8,639.7
P. Cyl. Exhaust Temperature Average (°F)	345.9	374.0	374.4	364.8
Air Manifold Pressure ("Hg)	12.7	13.3	13.2	13.1
Air Manifold Pressure (PSI)	6.2	6.5	6.5	6.4
Air Manifold Temperature (°F)	98.7	97.7	97.7	98.0
Jacket Water Inlet Temperature (°F)	165.0	164.8	164.5	164.8
Jacket Water Outlet Temperature (°F)	169.8	170.0	170.0	169.9
Lube Oil Inlet Temperature (°F)	154.2	153.5	153.7	153.8
Lube Oil Outlet Temperature (°F)	164.7	165.0	165.3	165.0
Compressor Suction Pressure (PSIG)	784.0	780.0	781.0	781.7
Compressor Suction Temperature (°F)	33.0	36.0	38.3	35.8
Compressor Discharge Pressure (PSIG)	1345.0	1353.0	1355.0	1,351.0
Compressor Discharge Temperature (°F)	125.6	127.5	127.8	127.0
Compressor Flow (MMSCF/D)	103.3	115.6	114.9	111.3
Fuel Torque (%) (from panel)	78.2	85.8	86.4	83.5
% Load	76.6	76.0	76.0	76.2
% Torque	77.1	75.7	76.0	76.3
Heat Rate (BTU/HP-hr)	6,689.9	7,417.1	7,478.1	7,195.0
Ambient Conditions				
Ambient Temperature (°F)	36.50	38.80	40.80	38.70
Barometric Pressure (psi)	14.13	14.13	14.14	14.13
Ambient Relative Humidity (%)	100.00	100.00	97.00	99.00
Absolute Humidity (grains/LB)	67.81	74.33	77.94	73.36

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

Run	1	2	3	
Date	05/02/19	05/02/19	05/02/19	
Time	8:00-8:59	9:05-10:04	10:10-11:09	
Emissions Concentrations & Calculated Mass Emissions				
NO _x ppm (BIAS Corrected)	143.01	256.21	251.78	217.00
NO _x g/BHP-HR	1.60	3.12	3.04	2.59
NO _x LB/HR	9.71	18.83	18.33	15.62
NO _x (ppm @ 15% O ₂)	129.21	227.66	219.75	192.21
NO _x (ppm @ 15% O ₂ , ISO)	214.29	381.59	369.56	321.81
NO _x LB/MMBTU	0.48	0.84	0.81	0.71
CO ppm (BIAS Corrected)	190.92	152.41	154.93	166.09
CO g/BHP-HR	1.30	1.13	1.14	1.19
CO LB/HR	7.89	6.82	6.86	7.19
CO LB/MMBTU **	0.39	0.30	0.30	0.33
CO (ppm @ 15% O ₂)	172.50	135.42	135.22	147.71
CO (ppm @ 15% O ₂ , ISO)	286.09	226.99	227.40	246.83
% O ₂ (BIAS Corrected)	14.37	14.26	14.14	14.26
Calculated Emissions Concentrations				
% CO ₂ (Wet) *	3.40	3.45	3.50	3.45
% CO ₂ (Dry) *	3.71	3.76	3.83	3.77
% H ₂ O *	8.16	8.38	8.55	8.37
% O ₂ (Wet) *	13.20	13.06	12.93	13.06
% N ₂ + CO (Wet) *	75.24	75.10	75.02	75.12
Calculated Flows				
Fuel Flow - (SCFM)	331.17	364.50	367.50	354.39
Fuel Flow - (SCFH)	19,870	21,870	22,050	21,263
Fuel Flow (LB/HR)	1,868.0	1,880.9	1,879.3	1,876
Exhaust Flow (LB/HR)	37,559.1	40,627.2	40,203.8	39,463
Exhaust Flow (WSCFM)	9,821.6	10,655.1	10,578.1	10,352
Exhaust Gas Volume (ACFM)	15,779.5	17,715.8	17,583.7	17,026
Air Flow (WSCFM)	9,122	9,875	9,781	9,592
Exhaust Flow Method 19 (wscfm)	9,459	10,238	10,139	9,945
Exhaust Flow Method 19 (lbm/min)	423	458	454	445
Exhaust Flow Carbon Balance (lbm/min)	731.92	792.81	785.75	770
Air flow Beshouri (scfm)	9,522.82	10,315.05	10,223.23	10,020
BSAC, #/BHP-hr	15.08	16.44	16.29	16
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	19.87	21.87	22.05	21.26
Fuel Flow (SCFH) From Fuel Orifice	42,018	42,307	42,271	42,199
Fuel Gas Differential Pressure ("H ₂ O)	40.30	40.9	40.9	41
Fuel Gas Static Pressure (PSIG)	97.30	97.2	97	97
Fuel Gas Temperature (°F)	59.90	60	60	60
** BASED ON FUEL SPECIFIC DRY F-FACTOR CALCULATION	Run 1	Run 2	Run 3	
* BASED ON CARBON BALANCE (STOICH. + O ₂)				
- A/F IS TOTAL MASS RATIO				

3. PROCESS DESCRIPTION

TC Energy’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 and Unit No. 2 during the test:

Table 4. Unit No. 2 General Information

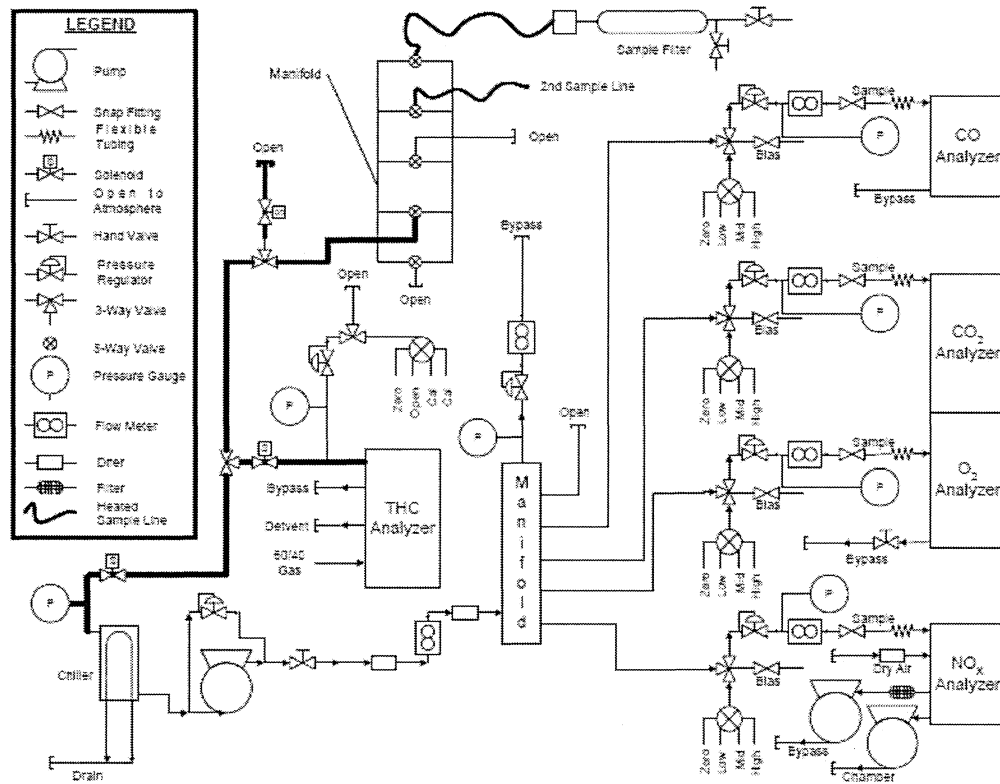
General Information		Permit Limits				
Date:	2-May-19	NOx:	ppm@15%	g/Bhp-Hr	lb/hr	TPY
Company:	ANR	CO:		9.2	72.9	
Station:	South Chester	VOC:				
Unit:	2	H2CO:				
Engine Type:	Cooper 12Q145LM	<i>Limits are actually listed as average values</i>				
Rated RPM:	450 RPM					
Rated BHP:	3600 BHP					
Fuel Gas Analysis		Fuel Meter Type				
Constituent	Mole Percent	Enter Type from List Below				
Nitrogen	0.621	2				
Carbon Dioxide	0.681	Orifice Meter (upstream pressure tap):	1			
Methane	95.087	Orifice Meter (downstream pressure tap):	2			
Ethane	3.489	Electronic Flow Meter (EFM):	3			
Propane	0.113	Venturi (Nozzle) Meter:	4			
I-Butane	0.004	Roots Meter w/ Accumulator:	5			
N-Butane	0.004	Pipe I.D.:	3.068			
I-Pentane	0.000	Orifice I.D.:	1.5			
N-Pentane	0.000					
Hexane +	0.001					
Total	100.000					

Table 5. Unit No. 2-Production Data-Horse Power (HP)

Unit No. 2 Horse Power (HP)	
Run No.	Unit No. 2
1	2,757
2	2,737
3	2,737
Average	2,744
Rated HP	3,600

Based on pipeline conditions the above was the maximum achievable load.

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)

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. 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

$$F_d = \frac{[(3.64 \cdot H_{Wt\%} \cdot 100) + (1.53 \cdot C_{Wt\%} \cdot 100)]}{GCV} \cdot 10^6$$

$$+ \frac{[(0.14 \cdot N_{2Wt\%} \cdot 100) - (0.46 \cdot O_{2Wt\%} \cdot 100)]}{GCV} \cdot 10^6$$

$$\frac{\rho_{FuelGas}}$$

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

$$NOx_{\frac{g}{bhp-hr}} = C_d \times F_d \times \frac{209}{209 - \%O_2} \times Q_n \times \frac{GCV}{10^6} \times \frac{4536}{Bhp}$$

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

$$NO_{x\frac{lb}{hr}} = C_d \times F_d \times \frac{209}{209 - \%O_2} \times Q_h \times \frac{GCV}{10^6}$$

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 South Chester Compressor Station near Johannesburg, MI. The Compliance testing was conducted on May 2, 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