PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at TC Energy in Blue Lake, 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 Blue Lake Compressor Station located in Blue Lake, MI.

Karl Mast
Test Supervisor

SUMMARY

The compliance emissions testing program was performed on Unit EU BLCMPR-A in fulfillment of Michigan Department of Environmental Quality, Air Quality Division, permit no. MI-ROP-B7198-2014a, to 40 CFR Part 60, Subpart JJJJ requirement. The testing was performed utilizing USEPA Methods 1, 3A, 7E, 10, 18, 19 and 25A at the Exhaust Stack sampling locations. The results of the testing are detailed in the following tables. A summary of the test results is given below:

Table 1. EU BLCMPR-A Test Summary Results

Parameter	Run 1	Run 2	Run 3	Average	Limit	Pass/Fail
NO_x lb/hr	21.2893	21.1144	22.7763	21.7266	26.4	PASS
NO_x g/hpr-hr	1.9179	1.8608	1.9758	1.9182	2	PASS
CO lb/hr	24.5342	24.6724	23.8030	24.3365	37.0	PASS
CO g/hpr-hr	2.2103	2.1744	2.0648	2.1498	2.8	PASS
VOC lb/hr	0.3022	0.9056	0.4363	0.5480	9.7	PASS
VOC g/hpr-hr	0.0272	0.0798	0.0378	0.0483	0.73	PASS

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TABLES

APPENDICES

1. INTRODUCTION

This report presents the results of the source emissions testing conducted by Environmental Quality Management, Inc. (EQM) for TC Energy's ANR (ANR) Blue Lake 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, 7E 18, 19 and 25A at the Exhaust Stack sampling location to demonstrate compliance under 40 CFR 60, Subpart JJJJ.

To ensure that compliance with the emission limits is maintained, the Air Compliance Team of TC Energy's ANR contracted Environmental Quality Management, Inc. (EQM) to perform source emissions testing on the Engine EU BLCMPR-A. The primary purpose of this testing program was to conduct emissions testing to determine compliance with the permit at ANR's gas compressor facility.

EQM's responsibility was to conduct and oversee the compliance testing for Nitrogen Oxide (NOx), Carbon Monoxide (CO), and Volitle Organic Compounds (VOC) emission 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 EU BLCMPR-A (Unit A) was performed on May 18, 2022 from 9:30 A.M. to 12:51 P.M.

The following requirements were specific for the testing program:

1. Equipment calibrations performed and calibration data provided.

2. Three (3) sixty (60) –minute NOx, CO, O2, and VOC test runs performed at the Unit A pursuant to EPA, Title 40, Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A.

3. Process operations conditions maintained within 10% rated load during the emissions testing periods.

4. All testing and analyses performed in accordance with current EPA test methodologies and analytical procedures for CO, NOx, O2 and VOC, emissions determinations.

The testing program was approved by and/or coordinated with Tyrah Lydia, TC Energy's ANR Pipeline. The emission testing was performed by Karl Mast, Project Manager, EQM, Zach Hill, Field Activitivies Lead, EQM, and Garrett Cox, Test Technician, EQM. The emission testing was observed by Jeremy Howe, BeckyRadulski, Daniel Droste and David Bowman, Michigan EGLE.

2. TEST RESULTS SUMMARY

The compliance testing was performed on Unit A system in accordance with the requirements of the Code of Federal Regulations, Title 40, Part 60, Appendix A, and the Permit MI-ROP-B7220-2017a requirements. A summary of the test results is given below:

Table 1. EU BLCMPR-A Test Summary Results

Parameter	Run 1	Run 2	Run 3	Average	Limit	Pass/Fail
NO_x lb/hr	21.2893	21.1144	22.7763	21.7266	26.4	PASS
NO_x g/hpr-hr	1.9179	1.8608	1.9758	1.9182	2	PASS
CO lb/hr	24.5342	24.6724	23.8030	24.3365	37.0	PASS
CO g/hpr-hr	2.2103	2.1744	2.0648	2.1498	2.8	PASS
VOC lb/hr	0.3022	0.9056	0.4363	0.5480	9.7	PASS
VOC g/hpr-hr	0.0272	0.0798	0.0378	0.0483	0.73	PASS

Based on the information provided above, unit A 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 and Ambient Conditions -Unit EU BLCMPR-A

Run	1	2	3	
Date	05/18/22	05/18/22	05/18/22	
Time	9:30	10:40	11:52	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	5,035.0	5,147.0	5,229.0	5,137.0
Unit Speed (rpm)	324.0	322.0	324.0	323.3
Compressor Suction Pressure (PSIG)	681.0	681.0	681.0	681.0
Compressor Suction Temperature (°F)	46.0	47.0	48.0	47.0
Compressor Discharge Pressure (PSIG)	1460.0	1435.0	1400.0	1,431.7
Compressor Discharge Temperature (°F)	170.0	168.0	164.0	167.3
Compressor Flow (MMSCF/D)	65.3	67.3	70.5	67.7
% Load	83.9	85.8	87.2	85.6
% Torque	85.5	87.9	88.8	87.4
Heat Rate (BTU(LHV)/HP-hr)	7,619.8	7,595.4	7,579.3	7,598.1
Ambient Conditions				
Ambient Temperature (°F)	53.00	57.00	57.00	55.67
Barometric Pressure (psi)	14.02	14.00	13.99	14.00
Ambient Relative Humidity (%)	50.00	43.00	45.00	46.00
Absolute Humidity (grains/LB)	63.97	63.69	66.75	64.80

Table 3. Emissions Concentrations, Calculated Mass Emissions, Concentrations & Flows -Unit EU BLCMPR-A

Run	1	2	3	
Date	05/18/22	05/18/22	05/18/22	
Time	9:30	10:40	11:52	
Emissions Concentrations & Calculated Mass Emissions				
NO_x ppm (BIAS Corrected)	127.64	124.46	135.31	129.14
NO_X g/BHP-HR	1.9179	1.8608	1.9758	1.9182
NO_X LB/HR	21.2893	21.1144	22.7763	21.7266
NO_X (ppm @ 15% O_2)	136.6744	133.0279	141.5477	137.0833
NOx LB/MMBTU	5.0313E-01	4.8970E-01	5.2106E-01	5.0463E-01
NO_X Tons/Year	93.2471	92.4809	99.7600	95.1627
NO_X LB/SCF Fuel	5.256E-04	5.115E-04	5.443E-04	5.27E-04
NO_X LB/MMSCF Fuel	5.2555E+02	5.1153E+02	5.4429E+02	5.2712E+02
CO ppm (BIAS Corrected)	241.65	238.92	232.31	237.63
CO g/BHP-HR	2.2103	2.1744	2.0648	2.1498
CO LB/HR	24.5342	24.6724	23.8030	24.3365
CO LB/MMBTU **	5.7981E-01	5.7222E-01	5.4455E-01	5.6553E-01
CO (ppm @ 15% O_2)	258.7541	255.3674	243.0193	252.3803
CO Tons/Year	107.4597	108.0651	104.2570	106.5939
CO LB/MMSCF Fuel	6.0565E+02	5.9773E+02	5.6883E+02	5.9074E+02
THC ppm	661.42	667.97	669.06	6.662E+02
Non-Methane/Non-Ethane VOC's ppmvd (As Propane)	3.0194	8.8784	4.2196	5.3725
VOC (ppm @ 15% O_2)	3.2331	9.4896	4.4141	5.7123
Method 18 CH4 PPM Bag Samples	653.60	644.80	658.00	652.13
VOC Moisture, % volume	13.67	13.01	12.63	13.10
VOC LB/HR (As Propane)**-Using Method 25A Measured THC	0.3022	0.9056	0.4363	0.5480
VOC g/BHP-hr (As Propane)**-Using Method 25A Measured THC	0.0272	0.0798	0.0378	0.0483
VOC LB/MMBTU	7.1426E-03	2.1002E-02	9.9817E-03	1.2709E-02
VOC LB/MMSCF Fuel	7.4609E+00	2.1938E+01	1.0427E+01	1.3275E+01
% O_2 (BIAS Corrected)	15.39	15.38	15.26	15.34
Calculated Flows				
Fuel Flow - (SCFM)	676.5000	689.3333	698.8333	688.2222
Fuel Flow - (SCFH)	40590.00	41360.00	41930.00	41293.3333
Fuel Flow (LB/HR)	1826.6671	1861.3193	1886.9710	1858.3192
Fuel Flow (MMcf/hr)	4.0590E-02	4.1360E-02	4.1930E-02	4.1293E-02
Exhaust Flow (LB/HR)	89,274.2895	90,532.1431	89,991.8277	89,932.7534
Exhaust Flow (SCFM)	23,838.5817	24,253.5176	24,144.5228	24,078.8740
Air Flow (WSCFM)	22,379.6576	22,763.2913	22,590.6538	22,577.8676
Exhaust Flow Method 19 (scfm)	23,235.1847	23,633.0693	23,449.0058	23,439.0866
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	40.59	41.36	41.93	41.29
** 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

TC Energy's ANR Blue Lake Compressor Station is located in Maneclona, MI and operates a natural gas fired compressor station. The plant is located at 10000 Pflum Road, Mancelona, MI, which is located in Kalkaska County.

The Umit EU BLCMPR-A is a natural gas-fired, 6,000, HP 2-stroke lean burn Dresser Rand TCVD-12 compressor engine. More specifically, the engines are used to compress natural gas into the storage reservoir during injection, and into the pipeline during withdrawal.The following tables provide a summary of the production rates for the Unit A during the tests:

Table 4. EU BLCMPR-A Process Data

Parameter	Run 1	Run 2	Run 3	Average	Rated	% Load
Horsepower	5,035.0	5,147.0	5,229.0	5,137.0	6,000	85.6
RPM	324.0	322.0	324.0	323.3	330	98.0

Table 5. EU BLCMPR-A General Information

General Information

Date:	18-May-22
Company:	TC Energy
Station:	Blue Lakes
Unit:	A
Engine Type:	DRESSER RAND

Permit Limits

	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:		2	26.4	
CO:		2.8	37	
VOC:		0.73	9.7	
H2CO:				

Limits are actuallly listed as average values

Bore:	18 in.	Number of Cylinders:	10
Stroke:	20 in.		
Rated RPM:	330 RPM	Rod Length:	45 in.
Rated BHP:	6000 BHP	2 or 4 Stroke ?:	2

Fuel Gas Analysis

Constituent	Mole Percent
Nitrogen	0.497
Carbon Dioxide	0.616
Methane	93.598
Ethane	5.148
Propane	0.125
I-Butane	0.007
N-Butane	0.006
I-Pentane	0.002
N-Pentane	0.001
Hexane +	0.001
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

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 Oxide Concentrations in Emissions From Stationary Sources (Instrumental Analyzer Procedure)
- U.S. EPA Method 10 – Determination of Carbon Monoxide Concentrations in Emissions From Stationary Sources (Instrumental Analyzer Procedure)
- U.S. EPA Method 19– Determination of Volumetric Flow Rate From Stationary Sources
- U.S. EPA Method 18– Determination of VOC Emissions From Stationary Sources (Instrumental Analyzer Procedure)
- U.S. EPA Method 25A - Determination of VOC Emissions From Stationary Sources (Instrumental Analyzer Procedure)

USEPA Methods 3A, 4, 7E, 10, 18 and 25A 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 A 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

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

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 g/bhr/hr

$$NOx_{\frac{g}{bhp-hr}} = C_d \times F_d \times \frac{20.9}{20.9 - \%O_2} \times Q_h \times \frac{GCV}{10^6} \times \frac{453.6}{Bhp}$$

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

NOx Mass Emission 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

NO_X Corrected to 15% O_2

$$Em = NO_X \left(\frac{5.9}{20.9 - \%O_2} \right)$$

Where:

E_m: Pollutant concentration corrected to 15% O_2, ppm
NO_x: Pollutant concentration, ppm
$\%O_2$: Oxygen concentration in percent, measured on a dry basis

NO Interference Response

$$INO = \left[\left(\frac{R_{NO-NO2}}{C_{NO2G}} \times \frac{C_{NO2S}}{C_{NOxS}}\right)\right] \times 100$$

Where:

I_{NO}: NO interference response (%)
R_{NO-NO2}: NO response to NO2 span gas (ppm NO)
C_{NO2G}: Concentration of NO_2 span gas (ppm NO2)
C_{NO2S}: Concentration of NO_2 in stack gas (ppm NO_2)
C_{NOxS}: Concentration of NO_x in stack gas (ppm NO_x)

CO Mass Emissions Calculations lb/hr

$$CO_{\frac{g}{bhp-hr}} = C_d \times F_d \times \frac{20.9}{20.9 - \%O_2} \times Q_h \times \frac{GCV}{10^6}$$

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

CO Mass Emissions Calculations g/bhp/hr

$$CO_{\frac{g}{bhp-hr}} = C_d \times F_d \times \frac{20.9}{20.9 - \%O_2} \times Q_h \times \frac{GCV}{10^6} \times \frac{453.6}{BHP}$$

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

VOC ppm

$$VOC_{ppmvd} = \frac{THC_{ppmvw} - \frac{1}{3}CH_{4\,ppmvd} - \frac{2}{3}C_2H_{6\,ppmvd}}{1 - \left(\frac{\%H_2O}{100}\right)}$$

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

VOC Mass Emissions Calculations lb/hr

$$VOC_{\frac{g}{bhp-hr}} = C_d \times F_d \times \frac{20.9}{20.9 - \%O_2} \times Q_h \times \frac{GCV}{10^6}$$

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

Where VOC measurement registered as a negative emission, it was reported as a zero. This was the case for Units A and B during the testing event.

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 compressor engines labeled Unit EU BLCMPR-A at TC Energy's ANR Pipeline Company's Blue Lake Compressor Station located in Blue Lake, Michigan. The testing was conducted on May 18, 2022..

During the course of the testing, the Engine A 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 and 40 CFR Part 60, Subpart JJJJ requirement..

The usefulness and/or significance of the emissions values presented in this document as they relate to the compliance status of the emissions shall be determined by others.

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