COMPLIANCE TEST REPORT ANR PIPELINE
WOOLFOLK COMPRESSOR STATION
ENGINE EUWL017 and GENERATOR GEN004

November 13, 2024

Prepared for:

TC Energy

TC Energy's ANR Pipeline Company
Big Rapids, MI

Prepared by:

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PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at TC Energy in Big Rapids, 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 Woolfolk Compressor Station in Big Rapids, MI.

Karl Mast
Test Supervisor

SUMMARY

The compliance testing was performed on the Engine EUWL017 (Unit 17) system in fulfillment of the Renewable Operating Permit MI-ROP-B7220-2017A, Section D.V requirements and EUWLGEN004 (GEN 004) APU in fulfillment of section C, sub-section V, (R336.1213(3)) and 40 CFR 60, Subpart JJJJ issued by the Michigan Environment, Great Lakes & Energy (MEGLE), Air Quality Division. The results of the testing are summarized in the following table.

Unit 17-NO_x Test Summary Results						
Parameter	**Run 1**	**Run 2**	**Run 3**	**Average**	**Limit**	**Pass/Fail**
Lb/Hr	50.3246	49.2465	50.5396	50.0369	85.7	Pass
Gr/bhp-hr	6.7436	6.4824	6.5668	6.5976	9.7	Pass

GEN 004-NO_x, CO, VOC Test Summary Results				
Measured Unit	**Rated Power (HP)**	**Permit Limit**	**Results**	**Pass/Fail**
NOx ppmvd @ 15% O_2	≥500	160 ppmvd @ 15% O_2	71.48	Pass
CO ppmvd @ 15%O_2		540 ppmvd @ 15%O_2	151.59	Pass
VOC ppmvd @ 15%O_2		86 ppmvd @ 15%O_2	21.29	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 Storage Company's (ANR) Woolfolk Compressor Station, near Big Rapids, MI.

This report presents the results of the source emissions testing conducted by Environmental Quality Management, Inc. (EQM) for TC Energy's ANR (ANR) Woolfolk Compressor Station, near Big Rapids, MI, which is in Mecosta County. The primary purpose of this testing program was to conduct emissions testing to determine compliance with operating permit No. MI-ROP-B7220-2017a, section C, sub-section V, (R336.1213(3)) for the Generator labeled EUWLGEN004 (Generator 004) and on the internal combustion reciprocating engine, labeled EUWL017 (Unit 17) in fulfillment with the Renewable Operating Permit MI-ROP-B7220-2017A requirements issued by the Michigan Department of Environment, Great Lakes, and Energy (MEGLE).

To ensure that compliance with the emission limits is maintained, the Air Compliance Team of TC Energy's ANR Pipeline Company (ANR) contracted Environmental Quality Management, Inc. (EQM) to perform source emissions testing on Generator 004. The primary purpose of this testing program was to conduct emissions testing to determine compliance with permit No. MI-ROP-B7220-2017a at ANR Pipeline Co.'s Woolfolk gas compressor facility.

EQM's responsibility was to conduct the compliance testing for the NO_x, CO, O_2 and 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 Unit 17 was performed on November 13, 2024, from 12:55 P.M. to 4:11 P.M. The Compliance testing conducted on GEN 004 was performed on November 13, 2024, from 9:27 A.M. to 1:26 P.M.

The following requirements were specific for the testing rogram:

1. Equipment calibrations performed and calibration data provided.
2. Three (3) one (1) -hour, minimum, NOx and O2 test runs performed at the Unit 17 pursuant to EPA Reference methods as described in 40 CFR, Part 60, Appendix A.
3. Three (3) one (1) -hour, minimum, O2, CO, NOx, and VOC test runs performed at the Generator 004 pursuant to EPA Reference methods as described in 40 CFR, Part 60, Appendix A.

4. Process manufacturing operations maintained at 100% of capacities based on pipeline conditions. Production and fuel consumption rates recorded during the emissions testing periods.

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

6. Stratification was found to be less than 5% in the engine exhaust.

The testing program was approved by and/or coordinated with Pedro Amieva, TC Energy's ANR Pipeline Company. The emission testing was performed by Karl Mast, Manager, Emission Measurement, EQM, and Elijah Mergl, Test Technician I, EQM. The emission testing was observed by Clayton DeRonne, MEGLE.

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2. TEST RESULTS SUMMARY

The compliance testing was performed on Unit 17 in accordance with the requirements in permit MI-ROP-B7220-2017A, Section D.V and on GEN 004 in accordance with requirements 40 CFR 60, Subpart JJJJ issued by the Michigan EGLE, Air Quality Division. A summary of the test results is given below:

Table 1. Unit 17-NO_x Test Summary Results

Parameter	Run 1	Run 2	Run 3	Average	Limit	Pass/Fail
Lb/Hr	50.3246	49.2465	50.5396	50.0369	85.7	Pass
Gr/bhp-hr	6.7436	6.4824	6.5668	6.5976	9.7	Pass

Table 2. GEN 004-NO_x, CO, VOC Test Summary Results

Measured Unit	Rated Power (HP)	Permit Limit	Results	Pass/Fail
NOx ppmvd @ 15% O_2	≥500	160 ppmvd @ 15% O_2	71.48	Pass
CO ppmvd @ 15%O_2		540 ppmvd @ 15%O_2	151.59	Pass
VOC ppmvd @ 15%O_2		86 ppmvd @ 15%O_2	21.29	Pass

Based on the information provided above, Unit 17 and GEN 004 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 3-7.

Additional testing information may be found in Appendix A.

Table 3. Operating Parameters and Ambient Conditions, Emissions Concentrations/Calculated Mass Emissions & Emissions Concentrations & Flows - Unit 17

Run	1	2	3	
Date	11/13/24	11/13/24	11/13/24	
Time	12:55	13:05	15:12	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	3,385.0	3,446.0	3,491.0	3,440.7
Unit Speed (rpm)	436.0	438.0	441.0	438.3
Compressor Suction Pressure (PSIG)	582.0	517.0	520.0	539.7
Compressor Suction Temperature (°F)	77.0	73.0	74.3	74.8
Compressor Discharge Pressure (PSIG)	829.0	813.0	814.0	818.7
Compressor Discharge Temperature (°F)	130.6	142.5	143.1	138.7
Compressor Flow (MMSCF/D)	165.3	136.2	138.5	146.7
% Load HP	84.6	86.2	87.3	86.0
% Load RPM	102.6	103.1	103.8	103.1
% Torque	82.5	83.6	84.1	83.4
Heat Rate (BTU(LHV)/HP-hr)	7,405.4	7,291.0	7,158.4	7,284.9
Ambient Conditions				
Ambient Temperature (°F)	42.50	42.50	44.70	43.23
Barometric Pressure (psi)	14.32	14.32	14.31	14.31
Ambient Relative Humidity (%)	69.00	66.00	73.00	69.33
Absolute Humidity (grains/LB)	58.21	55.65	67.15	60.33
Emissions Concentrations & Calculated Mass Emissions				
NO_x ppm (BIAS Corrected)	558.92	534.27	532.74	541.98
NO_X g/BHP-HR	6.7436	6.4824	6.5668	6.5976
NO_X LB/HR	50.3246	49.2465	50.5396	50.0369
NO_X (ppm @ 15% O_2)	492.9190	481.2508	496.5507	490.2402
NOx LB/MMBTU	1.8158	1.7728	1.8292	1.8059
NO_X Tons/Year	220.4216	215.6998	221.3635	219.1616
NO_X LB/SCF Fuel	1.937E-03	1.891E-03	1.951E-03	1.93E-03
NO_X LB/MMSCF Fuel	1936.5032	1890.6632	1950.7710	1925.9791
% O_2 (BIAS Corrected)	14.21	14.35	14.57	14.38
Calculated Flows				
Fuel Flow - (SCFM)	434.0000	435.0000	432.6667	433.8889
Fuel Flow - (SCFH)	26040.00	26100.00	25960.00	26033.3333
Fuel Flow (LB/HR)	1197.3030	1200.0618	1193.6247	1196.9965
Fuel Flow (MMcf/hr)	2.60E-02	2.61E-02	2.60E-02	2.60E-02
Air Flow (SCFM)	12,092.6298	12,377.2703	12,734.8636	12,401.5879
Exhaust Flow Method 19 (scfm)	12,542.8389	12,840.4484	13,215.4501	12,866.2458
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	26.04	26.10	25.96	26.03
** 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				

Table 4. Emissions Test Results-GEN 004

Summary of Stack Gas Parameters and Test Results GEN 004 APU TC Energy Woolfolk Compressor Station US EPA Test Method 3A, 7, 10, 18, & 25A Page 1 of 1					
	RUN NUMBER	***O-1***	***O-2***	***O-3***	
	RUN DATE	***11/13/2024***	***11/13/2024***	***11/13/2024***	***Average***
	RUN START	***9:26***	***10:52***	***12:27***	
	MEASURED DATA				
P_{bar}	Barometric Pressure, inches Hg	29.100	29.030	29.000	29.04
B_{ws}	Moisture, % by volume	20.2	14.40	14.66	16.4
	Kilowatts	**748.3**	**748.3**	**747.5**	**748.0**
	Oxygen				
O_2	**Concentration PPM Dry**	**7.92**	**7.76**	**7.79**	**7.82**
	Nitrogen Oxides				
NO_x	**Concentration PPM Dry**	**200.58**	**137.67**	**136.54**	**158.26**
NO_x	**Concentration PPM Dry @ 15% O_2**	**91.17**	**61.82**	**61.45**	**71.48**
	Carbon Monoxide				
CO	**Concentration PPM Dry**	**341.67**	**335.29**	**330.92**	**335.96**
CO	**Concentration PPM Dry @ 15% O_2**	**155.30**	**150.55**	**148.93**	**151.59**
	Total Hydrocarbons				
THC	**Concentration PPM Wet C1**	**617.2**	**522.97**	**523.93**	**554.70**
THC	**Concentration PPM Dry C1**	**742.06**	**598.28**	**600.74**	**647.03**
CH_4	**Concentration PPM Bag Sample**	**505.26**	**505.84**	**506.42**	**505.84**
VOC	**Concentration PPM Dry C1**	**236.80**	**92.44**	**94.32**	**141.19**
VOC	**Concentration PPM Dry C3**	**78.93**	**30.81**	**31.44**	**47.06**
VOC	**Concentration PPM Dry @ 15% O_2**	**35.88**	**13.84**	**14.15**	**21.29**

3. PROCESS DESCRIPTION

TC Energy's ANR Woolfolk Compressor Station (ANR) is in Big Rapids, MI and operates a natural gas fired compressor station. The plant is located at 11039 150th Avenue, Big Rapids, MI. The Generator (GEN 004) replaced the emergency generators (EUWLGEN001 and EUWLGEN002). The Generator is a natural gas-fired spark ignition 1, 172 horsepower internal combustion engine emergency generator. The generator is regulated under 40 CFR Part 60 Subpart JJJJ.

Unit EUWL017 is a Cooper Bessemer 12Q145HM natural gas fired internal combustion reciprocating engine rated at 4,000 hp and 425 rpm. The engine 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 move the gas to its destination or to another compressor station.

The following tables provide a summary of the production rates for GEN 004 and Unit 17 during the test:

Table 5. Unit 17-Process Data

Parameter	Run 1	Run 2	Run 3	Average	% Load	Rated
Horsepower	3,385.0	3,446.0	3,491.0	3,440.7	86.0	4,000
RPM	582.0	517.0	520.0	539.7	103.1	425

Table 6. GEN 004-Process Data

Parameter	Run 1	Run 2	Run 3	Average	% Load	Rated
Kilowatts	748.3	748.3	747.5	748.0	N/A	N/A
Horsepower[1]	1003.49	1003.45	1002.45	1003.13	85.59	1,172

Table 7. Unit 17 General Information

General Information	
Date:	13-Nov-24
Company:	TC Energy
Station:	Woolfolk
Unit:	17
Engine Type:	Cooper Bessmer
Serial Number:	12Q145HM

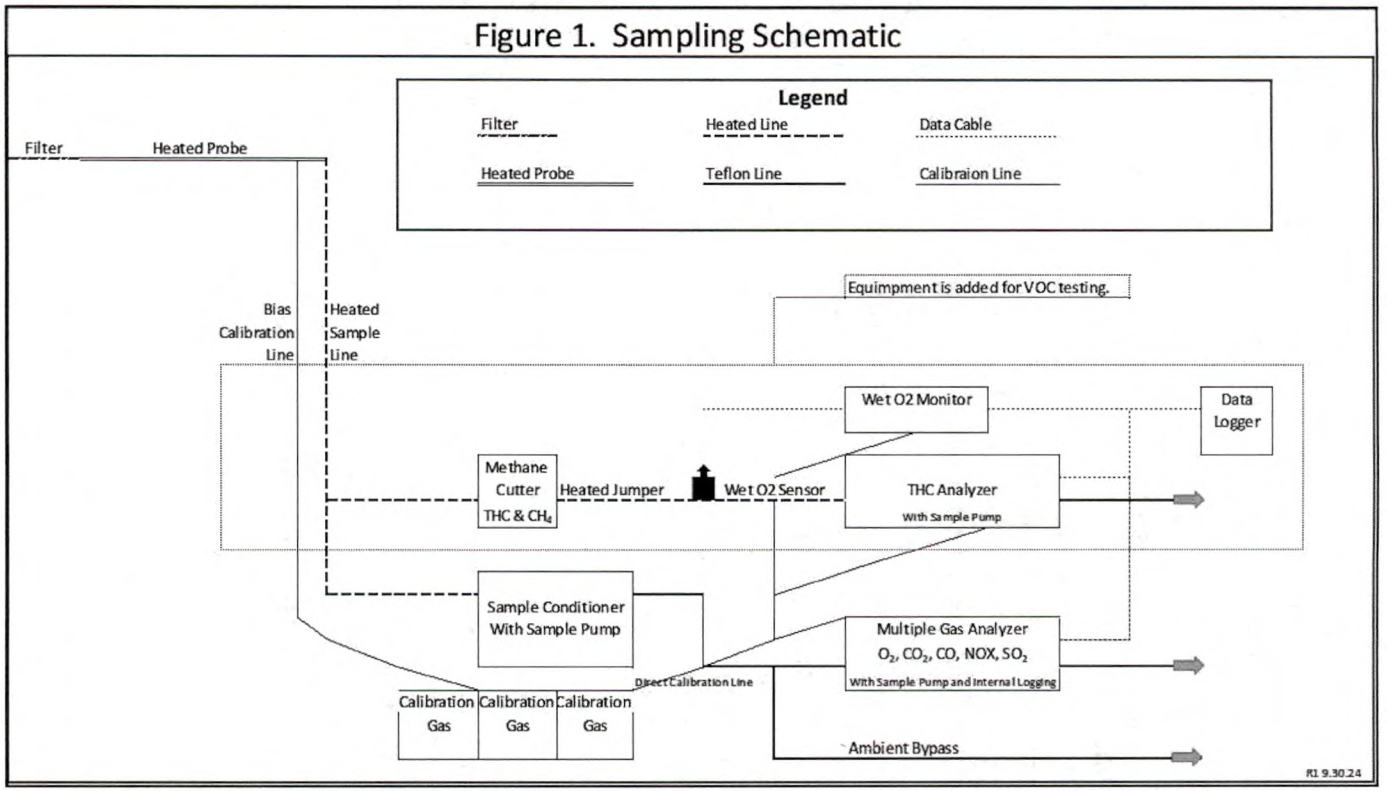
Permit Limits				
	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:		9.75	85.7	
CO:				
VOC:				
H2CO:				

Limits are actuallly listed as average values

Rated RPM:	425	RPM
Rated BHP:	4000	BHP

Fuel Gas Analysis	
Constituent	Mole Percent
Nitrogen	0.758
Carbon Dioxide	0.375
Methane	91.069
Ethane	7.343
Propane	0.388
I-Butane	0.024
N-Butane	0.031
I-Pentane	0.006
N-Pentane	0.003
Hexane +	0.004
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



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 4 – Determination of Moistures From Stationary Sources (hot and wet oxygen monitor 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)
- U.S. EPA Method 18 – Determination of VOC Emissions From Stationary Sources (Instrumental Analyzer Procedure)
- U.S. EPA Method 19 – Determintation of Stack Gas volumetric flow Rate by Fuel "F" Factor and heat Input
- 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 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 Calculations Lb/Hr

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

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 from:	To	Multiply by:
ppm NO_x	lb/scf	1.194×10^{-7}

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

Mass Emissions Calculations g/bhr/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:

Cd:	Pollutant concentration, lb/scf
Fd:	Fuel specific F-factor, dscf/MMBtu
Qh:	Fuel flow, scf/hr
%O2:	Oxygen concentration in percent, measured on a dry basis
GCV:	Upper dry heating value of fuel, Btu/dscf

No testing or sample recovery procedure deviations or errors occurred during the onsite sampling phase of the testing program. No significant process deviations or upsets occurred during the emissions testing periods.

The emissions test data and supporting data collected during the field sampling can be found in Appendix A of this report.

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 Engine Unit 17 and Generator GEN 004 at TC Energy's ANR Pipeline Company's Woolfolk Compressor Station located in Big Rapids, MI. The testing was conducted on November 13, 2024.

During the course of the testing, Engine Unit 17 and GEN 004 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 Engine Unit 17 and the Generator GEN 004 emissions shall be determined by others.

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