



### SUMMARY

The compliance emissions testing program was performed on Unit EUWL004 due to a catalyst switch to comply with flexible groups FG-RICE-818-WLENGINES and RICE MACT in the permit and are subject to 40 CFR Part 63, Subpart ZZZZ requirement specified in Permit MI-ROP-B7220-2017a. A summary of the test results is given below:

<b>H<sub>2</sub>CO % Destruction Efficiency</b>					
<b>Unit</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>	<b>Limit</b>
EUWL004	87.30	86.85	86.57	86.90	76%



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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) Woolfolk Compressor, near Big Rapids, MI, which is located in Mecosta County. The primary purpose of this testing program was to conduct emissions testing to determine compliance with flexible groups FG-RICE-818-WLENGINES and RICE MACT in the permit and are subject to 40 CFR Part 63, Subpart ZZZZ requirement specified in Permit MI-ROP-B7220-2017a for the Unit EUWL004 (Unit 4), Engine at ANR's gas compressor facility.

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 eight units. 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 the Formaldehyde (H<sub>2</sub>CO) 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. EQM contracted the services of Prism Analytical Technologies out of Mount Pleasant, MI for the Method 320.

The following report provides information pertaining to TC Energy's process operations, and Compliance testing. The Compliance testing conducted on Unit 4 was performed on February 17, 2022 from 11:45 A.M. to 3:14 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 H<sub>2</sub>CO test runs performed at the Unit 4 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 H<sub>2</sub>CO emissions determinations via Extractive Fourier transform infrared (FTIR) spectrometry.

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 Activities Lead, EQM, Garrett Cox, Test Technician, EQM and Amanda Niles, Prism Analytical Technologies. The emission testing was not observed by Michigan EGLE.



## 2. TEST RESULTS SUMMARY

The compliance testing was performed on Unit 4 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:

<b>Table 1. H<sub>2</sub>CO % Destruction Efficiency</b>					
<b>Unit</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>	<b>Limit</b>
EUWL004	87.30	86.85	86.57	86.90	76%

Based on the information provided above, all eight units 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 EUWL004**

Run	1	2	3	
Date	02/17/22	02/17/22	02/17/22	
Time	11:45	13:16	14:54	
<b>Engine Operating Conditions</b>	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	929.0	972.0	955.0	952.0
Unit Speed (rpm)	319.0	331.0	333.0	327.7
Compressor Suction Pressure (PSIG)	311.0	304.0	298.0	304.3
Compressor Suction Temperature (°F)	24.8	23.9	23.2	24.0
Compressor Discharge Pressure (PSIG)	651.0	645.0	633.0	643.0
Compressor Flow (MMSCF/D)	26.2	26.6	26.4	26.4
% Load	92.9	97.2	95.5	95.2
% Torque	96.1	96.9	94.6	95.9
Heat Rate (BTU/HP-hr)	10,083.1	9,964.9	10,162.5	10,070.2
<b>Ambient Conditions</b>				
Ambient Temperature (°F)	25.00	28.67	26.00	26.56
Barometric Pressure (psi)	14.17	14.08	14.06	14.10
Ambient Relative Humidity (%)	72.00	72.00	72.00	72.00
Absolute Humidity (grains/LB)	30.29	35.51	31.84	32.55

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**Table 3. Emissions Concentrations, Calculated  
Mass Emissions, Concentrations & Flows -Unit EUWL004**

Run	1	2	3	
Date	02/17/22	02/17/22	02/17/22	
Time	11:45	13:16	14:54	
<b>Emissions Concentrations &amp; Calculated Mass Emissions</b>				
H <sub>2</sub> CO Inlet ppmw	17.32	17.22	17.45	17.33
H <sub>2</sub> CO Inlet (ppmw @ 15% O <sub>2</sub> )	6.44	6.41	6.53	6.46
H <sub>2</sub> CO Outlet ppmw	1.77	2.01	2.10	1.96
H <sub>2</sub> CO Outlet (ppmw @ 15% O <sub>2</sub> )	0.82	0.84	0.88	0.85
H <sub>2</sub> CO % Removal Limit is 76%	87.30	86.85	86.57	86.90
H <sub>2</sub> O ppm (% FTIR)	12.03	13.07	13.19	12.76
% O <sub>2</sub> Inlet (raw measured wet)	5.02	5.06	5.13	5.07
% O <sub>2</sub> Outlet (raw measured wet)	8.12	6.85	6.77	7.25
% O <sub>2</sub> (BIAS Corrected Dry)	8.84	8.72	8.71	8.76
<b>Calculated Flows</b>				
Fuel Flow - (SCFM)	161.67	167.17	167.50	165.44
Fuel Flow - (SCFH)	9,700	10,030	10,050	9,927
Exhaust Flow (LB/HR)	10,853.3	11,072.8	11,090.1	11,005
Exhaust Flow (WVSCFM)	2,719.2	2,619.4	2,614.6	2,651
Air Flow (WVSCFM)	2,517	2,577	2,581	2,558
Exhaust Flow Method 19 (scfm)	2,600	2,661	2,665	2,642
Exhaust Flow Method 19 (lbm/min)	120	123	123	122
Exhaust Flow Carbon Balance (lbm/min)	207.35	212.40	212.71	211
Air flow Beshouri (scfm)	2,697.67	2,763.48	2,767.52	2,743
<b>Fuel Flow Measurements</b>				
Fuel Flow From Screen(MSCFH)	9.70	10.03	10.05	9.93
<b>** BASED ON FUEL SPECIFIC DRY F-FACTOR CALCULATION</b>	Run 1	Run 2	Run 3	
<b>* BASED ON CARBON BALANCE (STOICH. + O<sub>2</sub>)</b>				
<b>- A/F IS TOTAL MASS RATIO</b>				



### 3. FACILITY AND PROCESS DESCRIPTION

TC Energy’s ANR Woolfolk Compressor Station is located in Big Rapids, MI. The facility operates five Ingersoll-Rand Compressor Engine labeled EUWL001, EUWL002, EUWL003, EUWL004, and EUWL005. The engines are a four stroke, rich burn, natural gas fired reciprocating compressor engine, Model KVG-103, 1000 horsepower, and used to compress natural gas for transport via natural gas pipeline. The units is subject to the RICE MACT and Rule 818 and are subject to 40 CFR Part 63, Subpart ZZZZ requirements. Engine EUWL004 was the subject of this testing.

Process data is specified in Table 4. General engine information is located in Table 5.

<b>Table 4. Process Data (Horsepower)</b>					
<b>Unit</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>	<b>Rated</b>
EUWL004	929.0	972.0	955.0	952.0	1,000



**Table 5. Unit EUWL004 General Information**

General Information				
Date:	17-Feb-22			
Company:	TC Energy			
Station:	Woolfolk			
Unit:	4			
Engine Type:	IR KVG 103			
Rated RPM:	330	RPM		
Rated BHP:	1000	BHP		
Permit Limits				
	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:				
CO:				
VOC:				
H2CO:	>76 DE			
<i>Limits are actually listed as average values</i>				
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 ID:	3.068			
Orifice ID:	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 19– Determination of Volumetric Flow Rate From Stationary Sources
- U.S. EPA Method 320– Determination of Formaldehyde From Stationary Sources (Extractive Fourier Transform infrared (FTIR) Spectrometry)

USEPA Methods 3A and 19 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.

USEPA Method 320 was performed at the Exhaust Stack sampling locations by using MKS MultiGas 2030 FTIR spectrometers. The FTIRs were equipped with temperature-controlled, 5.11 meter multipass gas cells maintained at 191 °C. Gas flows and sampling system pressures were monitored using rotameters and pressure transducers. All data were collected at 0.5 cm<sup>-1</sup>



resolution. Each spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every one minute. Additional information may be found in Appendix B.

USEPA Method 3A was performed to quantify the concentrations levels of Oxygen (O<sub>2</sub>) from the Engine 4 Inlet to correct formaldehyde concentration for Oxygen. Post catalyst oxygen determination were made by EQM. Pre catalyst engine Oxygen determinations were made by Prism. Additional information may be found in Appendix A and Appendix B.

Calculations that were used in this testing event for the Unit 4 are as follows:

Calibration Correction

$$C_{GAS} = (C_R - C_O) \frac{C_{MA}}{C_M - C_O}$$

Where:

- C<sub>GAS</sub>: Corrected flue gas concentration (ppmvd)
- C<sub>R</sub>: Flue gas concentration (ppmvd)
- C<sub>O</sub>: Average of initial and final zero checks (ppmvd)
- C<sub>M</sub>: Average of initial and final span checks (ppmvd)
- C<sub>MA</sub>: Actual concentration of span gas (ppmvd)

EPA F-Factor

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

Where:

- F<sub>d</sub>: Fuel specific F-factor, dscf/MMBtu
- H<sub>Wt%</sub>: Hydrogen weight percent
- C<sub>Wt%</sub>: Carbon weight percent
- N<sub>2Wt%</sub>: 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

Formaldehyde Removal Efficiency, RE (%)

$$RE = \left( \frac{\text{Inlet Formaldehyde} - \text{Outlet Formaldehyde}}{\text{Inlet Formaldehyde}} \right) \times 100$$

**Where:**

Inlet Formaldehyde = Inlet formaldehyde concentration at 15% O<sub>2</sub>

Outlet Formaldehyde = Inlet formaldehyde concentration at 15% O<sub>2</sub>

Inlet Analyzer Drift Correction

$$C_{gas} = (C_{Ave} - CO) \left( \frac{C_{ma}}{C_m - CO} \right)$$

**Where:**

- $C_{GAS}$ : Average effluent gas concentration adjusted for bias
- $C_{Ave}$ : Average unadjusted gas concentration indicated by data recorder for the test run
- $CO$ : Average of initial and final zero checks
- $C_M$ : Actual concentration of the upscale calibration gas
- $C_{MA}$ : Average of initial and final system calibration bias check responses for the upscale calibration gas

Outlet Analyzer Drift Correction

$$C_{gas} = (C_{Ave} - CO) \left( \frac{C_{ma}}{C_m - CO} \right)$$

**Where:**

- $C_{GAS}$ : Average effluent gas concentration adjusted for bias
- $C_{Ave}$ : Average unadjusted gas concentration indicated by data recorder for the test run
- $CO$ : Average of initial and final zero checks (ppmvd)
- $C_M$ : Actual concentration of the upscale calibration gas



CMA: Average of initial and final system calibration bias check responses for the upscale calibration gas

Inlet Concentration, C<sub>1</sub> (corrected to 15%O<sub>2</sub>)

$$\text{Conc. } i_{(\text{Std. O}_2)} = \text{Conc. } i_{(\text{Measured O}_2)} \left( \frac{20.9\% - \text{Std. O}_2\%}{20.9\% - \text{Measured O}_2\%} \right)$$

**Where:**

Conc.  $i_{(\text{Std. O}_2)}$  = Concentration at standard O<sub>2</sub> level

Conc.  $i_{(\text{Measured O}_2)}$  = Concentration measured at O<sub>2</sub> level

Std. O<sub>2</sub>% = Oxygen concentration at standard level

Measured O<sub>2</sub>% = Oxygen concentration at measured level

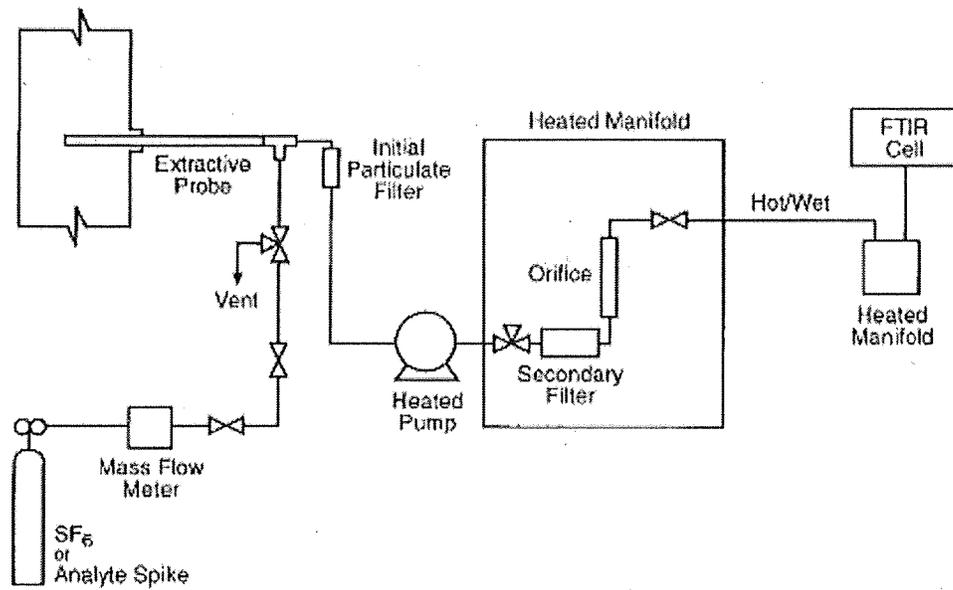


Figure 1. USEPA Method 320 Sampling Train



## 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 EUWL004 at TC Energy's ANR Pipeline Company's Woolfolk Compressor Station located in Big Rapids, Michigan. The testing was conducted on February 17, 2022..

During the course of the testing, the eight engines conformed to the requirements of flexible groups FG-RICE-818-WLENGINES and RICE MACT in the permit and are subject to 40 CFR Part 63, Subpart ZZZZ 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



## **A. FIELD DATA**