## 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 located in Big Rapids, MI.

Karl Mast
Test Supervisor

## 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-B7220-2022. A summary of the test results is given below:

| $H_2CO$ % Destruction Effeciency | | | | | |
|---|---|---|---|---|---|
| **Unit** | **Run 1** | **Run 2** | **Run 3** | **Average** | **Limit** |
| EUWL004 | 94.94 | 88.58 | 87.78 | 90.43 | 76% |

## CONTENTS



## 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 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 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-B7220-2022 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 ($H_2CO$) 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 July 6, 2023 from 10:01 A.M.-1:31 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 $H_2CO$ 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 $H_2CO$ emissions determinations via Extractive Fourier transform infarared (FTIR)

spectrometry.

The testing program was approved by and/or coordinated with Pedro Amieva, TC Energy's ANR Pipeline. The emission testing program was managed by Karl Mast, Project Manager, EQM. Ben Fern, EQM, assisted with the testing program. The testing data collection was performed by Phillip Kauppi and Melissa Bennett, Prism Analytical Technologies. The emission testing was observed byChris Robinson, 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-B7220-2022 requirements. A summary of the test results is given below:

**Table 1. $H_2CO$ % Destruction Effeciency**

| Unit | Run 1 | Run 2 | Run 3 | Average | Limit |
|---|---|---|---|---|---|
| EUWL004 | 94.94 | 88.58 | 87.78 | 90.43 | 76% |

Based on the information provided above, Engine EUWL0004 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 | 07/06/23 | 07/06/23 | 07/06/23 | |
| Time | 10:01 | 11:16 | 12:31 | |
| **Engine Operating Conditions** | HS-HT | HS-HT | HS-HT | Averages |
| Unit Horsepower from Control Panel | 917.0 | 908.0 | 929.0 | 918.0 |
| Unit Speed (rpm) | 329.0 | 330.0 | 324.0 | 327.7 |
| Compressor Suction Pressure (PSIG) | 365.0 | 361.0 | 319.0 | 348.3 |
| Compressor Suction Temperature (°F) | 55.7 | 54.1 | 55.9 | 55.2 |
| Compressor Discharge Pressure (PSIG) | 656.0 | 652.0 | 643.0 | 650.3 |
| Compressor Flow (MMSCF/D) | 30.3 | 29.9 | 25.6 | 28.6 |
| % Load | 91.7 | 90.8 | 92.9 | 91.8 |
| % Torque | 92.0 | 90.8 | 94.6 | 92.5 |
| Heat Rate (BTU/HP-hr) | 10,014.1 | 10,006.6 | 9,968.3 | 9,996.3 |
| **Ambient Conditions** | | | | |
| Ambient Temperature (°F) | 30.00 | 30.00 | 30.00 | 30.00 |
| Barometric Pressure (psi) | 14.18 | 14.18 | 14.18 | 14.18 |
| Ambient Relative Humidity (%) | 94.00 | 91.00 | 75.00 | 86.67 |
| Absolute Humidity (grains/LB) | 48.74 | 47.17 | 38.81 | 44.91 |

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

| Run | 1 | 2 | 3 | |
|---|---|---|---|---|
| Date | 07/06/23 | 07/06/23 | 07/06/23 | |
| Time | 10:01 | 11:16 | 12:31 | |
| **Emissions Concentrations & Calculated Mass Emissions** | | | | Averages |
| $H_2CO$ Inlet ppmw | 8.67 | 8.50 | 8.61 | **8.59** |
| $H_2CO$ Inlet (ppmw @ 15% $0_2$) | 3.08 | 3.02 | 3.06 | **3.05** |
| **$H_2CO$ Outlet ppmw** | **0.43** | **0.95** | **1.03** | **0.80** |
| $H_2CO$ Outlet (ppmw @ 15% $0_2$) | 0.16 | 0.34 | 0.37 | **0.29** |
| $H_2CO$ % Removal Limit is 76% | 94.94 | 88.58 | 87.78 | **90.43** |
| $H_2O$ ppm (% FTIR) | 16.15 | 16.28 | 16.10 | **16.18** |
| % $O_2$ Inlet (raw measured wet) | 4.29 | 4.29 | 4.29 | **4.29** |
| % $O_2$ Outlet (raw measured wet) | 4.63 | 4.64 | 4.64 | **4.64** |
| % $O_2$ (BIAS Corrected Dry) | 4.85 | 4.86 | 4.86 | **4.86** |
| **Calculated Flows** | | | | |
| Fuel Flow - (SCFM) | 157.83 | 156.17 | 159.17 | **157.72** |
| Fuel Flow - (SCFH) | 9,470 | 9,370 | 9,550 | **9,463** |
| Exhaust Flow (LB/HR) | 8,327.0 | 8,235.4 | 8,371.5 | **8,311** |
| Exhaust Flow (WSCFM) | 2,163.7 | 2,141.8 | 2,182.9 | **2,163** |
| Air Flow (WSCFM) | 1,860 | 1,840 | 1,875 | **1,858** |
| **Exhaust Flow Method 19 (scfm)** | 1,917 | 1,897 | 1,933 | **1,915** |
| **Exhaust Flow Method 19 (lbm/min)** | 90 | 89 | 91 | **90** |
| Exhaust Flow Carbon Balance (lbm/min) | 156.11 | 154.46 | 157.43 | **156** |
| Air flow Beshouri (scfm) | 2,031.11 | 2,009.72 | 2,048.33 | **2,030** |
| **Fuel Flow Measurements** | | | | |
| Fuel Flow From Screen(MSCFH) | 9.47 | 9.37 | 9.55 | 9.46 |
| ** 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 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.

**Table 4. Process Data (Horsepower)**

| Unit | Run 1 | Run 2 | Run 3 | Average | Rated |
|---|---|---|---|---|---|
| EUWL004 | 917.0 | 908.0 | 929.0 | 918.0 | 1,000 |

**Table 5. Unit EUWL004 General Information**

**General Information**

| | |
|---|---|
| Date: | 6-Jul-23 |
| 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 | | | |

*Limits are actuallly listed as average values*

**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 19– Determination of Volumetric Flow Rate From Stationary Sources
- U.S. EPA Method 320– Determination of Formaldehyde From Stationary Sources (Extractive Fourier Transform infareed (FTIR) Spectrometry)

Extractive Fourier transform infrared (FTIR) spectrometry following USEPA Method 320 was performed to quantify the concentration levels of formaldehyde from the engine. Moisture concentrations were determined from the FTIR data to correct to a dry value.

USEPA Method 3A was performed to quantify the concentration levels of oxygen (O2) from the Engine.

FTIR data were collected 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-1 resolution. Each spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every one minute.

QA/QC procedures followed US EPA Methods 320. All calibration gases were introduced to the analyzer and the sampling system using an instrument grade stainless steel rotameter. All QA/QC procedures were within the acceptance criteria allowance of the applicable EPA methodology.

Formaldehyde spiking was performed on the pre-catalyst and post-catalyst FTIR systems prior to and following testing to verify the ability of the sampling system to quantitatively deliver a sample containing formaldehyde from the base of the probe to the FTIR. Analyte spiking assures the ability of the FTIR to quantify formaldehyde in the presences of effluent gas.

As part of the spiking procedure, samples from each source were measured to determine nativeformaldehyde concentrations to be used in the spike recovery calculations. Inlet analyte spiking was performed in ambient air. The analyte spiking gases contained a low concentration of sulfur hexafluoride (SF6). The determined SF6 concentration in the spiked sample was used to calculate the dilution factor of the spike and thus used to calculate the concentration of the spiked formaldehyde. The spike target dilution ratio was 1:10 or less.

The following equation illustrates the percent recovery calculation.

Sec. 9.2.3 (3) USEPA Method 320

$$DF = \frac{SF6(spk)}{SF6(dir)}$$

Sec. 9.2.3 (4) USEPA Method 320

DF x Spike (dir) + Unspike(1-DF)

| | |
|---|---|
| DF | = Dilution factor of the spike gas |
| SF6(dir) | = SF6 concentration measured directly in undiluted spike gas |
| SF6(spk) | = Diluted SF6 concentration measured in a spiked sample |
| Spikedir | = Concentration of the analyte in the spike standard measure by the FTIR directly |
| CS | = Expected concentration of the spiked samples |
| Unspike | = Native concentration of analytes in unspiked samples |

As part of the post collection data validation, data validation procedure, reference spectra are manually fit to that of the sample spectra and a concentration is determined. The reference spectra are scaled to match the peak amplitude of the sample, thus providing a scale factor. The scale factor multiplied by the reference spectra concentration is used to determine the concentration value for the sample spectra. Sample pressure and temperature corrections are then applied to compute the final sample concentration. The manually calculated results are then compared with the softwaregenerated results. The data is then validated if the two concentrations are within ± 20% agreement. If there is a difference greater than ± 20% the spectra are reviewed for possible spectra interferences or any other possible causes leading to misquantified data.

Two FTIR spectra per test run were manually validated to confirm formaldehyde concentration results. See the FTIR Validations appendix for results.

Oxygen concentrations were determined using Brand Gaus, Model 4710 Oxygen Analyzers, which utilize Linear Output Zirconium Oxide ($ZrO_2$) Technology. An $O_2$ analyzer was installed at the exhaust of each FTIR, with all flow passing through the $O_2$ analyzer. The $O_2$ analyzer continually measures oxygen as it flows through the system.

QA/QC procedures followed US EPA Methods 3A. All calibration gases were introduced to the analyzer and the sampling system using an instrument grade stainless steel rotameter. All QA/QC procedures were within the acceptance criteria allowance of the applicable EPA methodology.

EPA 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-1 resolution. Each spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every one minute. Additional and more detailed information may be found in Appendix A.

Other 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:**

$C_{GAS}$: 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 |

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% O2

Outlet Formaldehyde = Inlet formaldehyde concentration at 15% O2

Inlet Analyzer Drift Correction

$$Cgas = (CAve - CO)\left(\frac{Cma}{Cm - Co}\right)$$

**Where:**

| | |
|---|---|
| $C_{GAS}$: | Average effluent gas concentration adjusted for bias |
| $C_{Ave}$: | Average unadjusted gas concentration indicated by data recorder for the test run |

$C_O$: 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

$$Cgas = (CAve - CO)(\frac{Cma}{Cm - Co})$$

**Where:**

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

Inlet Concentration, $C_1$ (corrected to 15%$O_2$)

$$\text{Conc.i}_{(\text{Std.}O_2)} = \text{Conc.i}_{(\text{Measured}O_2)}\left(\frac{20.9\% - \text{Std.}O_2\%}{20.9\% - \text{Measured}\,O_2\%}\right)$$

**Where:**

Conc.$i_{(Std.O2)}$=Concentration at standard $O_2$ level
Conc.$i_{(MeasuredO2)}$=Concentration measured at $O_2$ level
Std.$O_2$%=Oxygen concentration at standard level
Measured $O_2$%=Oxygen concentration at measured level

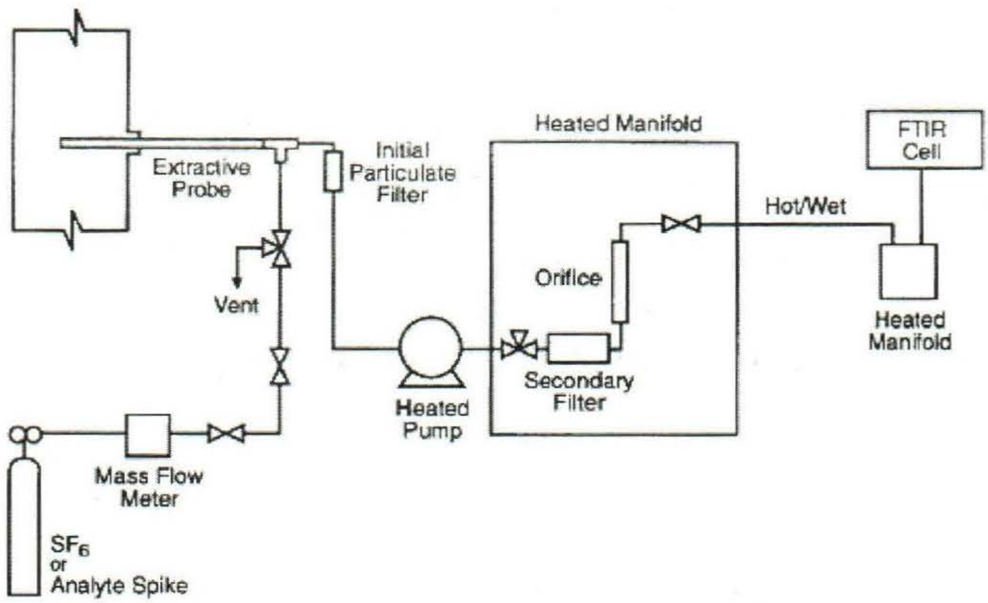


**Figure 1. USEPA Method 320 Sampling Train**

## 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 July 6, 2023.

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.