COMPLIANCE TEST REPORT
ANR STORAGE COMPANY
REED CITY COMPRESSOR STATION
ENGINES EURC011 & EURC012

Prepared for:

TC Energy

TC Energy ANR Pipeline Company
Reed City Compressor Station
7677 230th Avenue
Reed City, MI 49677
Osceola County
Permit MI-ROP-B3721-2014a

Prepared by:

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December 2019

PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at TC Energy in Reed City, 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 Compressor Station 8 in Reed City, MI.

Karl Mast
Test Supervisor

SUMMARY

The compliance emissions testing program was performed on Units EURC011 and EURC012 to comply with flexible groups FGRC001 and FGMACTZZZZ in the permit and are subject to 40 CFR Part 63, Subpart ZZZZ requirement specified in Permit MI-ROP-B3721-2014a. A summary of the test results is given below:

H_2CO% Destruction Effeciency					
Unit	**Run 1**	**Run 2**	**Run 3**	**Average**	**Limit**
EURC011	95.95	95.91	95.87	95.91	76%
EURC012	96.39	96.47	96.23	96.36	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) Reed City Compressor, near Reed City, MI, which is located in Osceola County. The primary purpose of this testing program was to conduct emissions testing to determine compliance with with flexible groups FGRC001 and FGMACTZZZZ in the permit and are subject to 40 CFR Part 63, Subpart ZZZZ requirement specified in Permit MI-ROP-B3721-2014a for the Units EURC011 (Unit 11) and EURC012 (Unit 12) Engines 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 Unit 11 and Unit 12. 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 11 was performed on October 16, 2019 from 4:18 P.M.-7:52 P.M. The Compliance testing conducted on Unit 12 was performed on October 16, 2019 from 11:15 A.M. to 2:47 P.M.

The following requirements were specific for the testing program:

1. Equipment calibrations performed and calibration data provided.

2. Three (3) 60 (60) –minute at H_2CO and O_2, test runs performed at the Unit 11 and Unit 12 pursuant to EPA, Title 40, Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A.

3. Process operations conditions maintained within 10% of 75% maximum rated load for Unit 11 and within 10% of 87% maximum rated load for Unit 12 during the emissions testing periods.

4. All testing and analyses performed in accordance with current EPA test methodologies and analytical procedures for H_2CO and O_2 emissions determinations via Extractive Fourier transform infarared (FTIR) spectrometry.

5. All testing and analyses performed in accordance with current EPA test methodologies and analytical procedures for O_2 to quantify the concentration levels from each source to correct formaldehyde concentrations fro oxygen content.

6. Stratification was found to be less than 3% in the turbine exhaust.

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, Trevor Tilmann and Phil Kauppi, Prism Analytical Technologies. The emission testing was observed by Jeremy Howe, Michigan EGLE.

2. TEST RESULTS SUMMARY

The compliance testing was performed on Units 11 and 12 systems in accordance with the requirements of the Code of Federal Regulations, Title 40, Part 60, Appendix A, and the Permit MI-ROP-B3721-2014a 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
EURC011	95.95	95.91	95.87	95.91	76%
EURC012	96.39	96.47	96.23	96.36	76%

Based on the information provided above, the Units 11 and 12 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 3-4.

Table 2 . Engine Operating, Ambient Conditions, Emissions Concentrations, Calculated Mass Emissions, Concentrations & Flows -Unit 11

Run	1	2	3	
Date	10/16/19	10/16/19	10/16/19	
Time	16:18	17:35	18:52	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	578.0	577.0	574.0	576.3
Unit Speed (rpm)	845.0	846.0	854.0	848.3
Compressor Suction Pressure (PSIG)	303.0	303.0	303.0	303.0
Compressor Suction Temperature (^{o}F)	60.6	60.2	59.1	60.0
Compressor Discharge Pressure (PSIG)	635.0	635.0	641.0	637.0
Compressor Discharge Temperature (^{o}F)	167.7	167.1	167.3	167.4
Compressor Flow (MMSCF/D)	2.6	2.6	2.5	2.6
% Load	87.6	87.4	87.0	87.3
% Torque	88.1	87.8	86.6	87.5
Heat Rate (BTU/HP-hr)	0.0	0.0	0.0	0.0
Ambient Conditions				
Ambient Temperature (^{o}F)	45.37	45.19	43.59	44.72
Barometric Pressure (psi)	14.02	14.04	14.06	14.04
Ambient Relative Humidity (%)	85.00	89.00	85.00	86.33
Absolute Humidity (grains/LB)	82.14	85.36	76.44	81.32
Emissions Concentrations & Calculated Mass Emissions				
H_2CO Inlet ppmw	8.44	8.59	8.50	8.51
H_2CO Inlet (ppmw @ 15% 0_2	2.39	2.44	2.41	2.41
H_2CO Outlet ppmw	0.34	0.35	0.35	0.35
H_2CO Outlet (ppmw @ 15% 0_2	0.10	0.10	0.10	0.10
H_2CO % Removal Limit is 76%	95.95	95.91	95.87	95.91
% O_2 Inlet (raw measured wet)	0.10	0.10	0.10	0.10
% O_2 Outlet (raw measured wet)	0.21	0.20	0.18	0.20
Calculated Flows				
Fuel Flow - (SCFM)	52.50	53.17	50.83	52.17
Fuel Flow - (SCFH)	3,150	3,190	3,050	3,130
Exhaust Flow (WSCFM)	0.0	0.0	0.0	0
Air flow Beshouri (scfm)	0.00	0.00	0.00	0
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	3.15	3.19	3.05	3.13
** 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 3 . Engine Operating, Ambient Conditions, Emissions Concentrations, Calculated Mass Emissions, Concentrations & Flows -Unit 12

Run	1	2	3	
Date	10/16/19	10/16/19	10/16/19	
Time	11:15	12:31	13:47	
Engine Operating Conditions	HS-HT	HS-HT	HS-HT	Averages
Unit Horsepower from Control Panel	573.0	568.0	570.0	570.3
Unit Speed (rpm)	856.0	853.0	852.0	853.7
Compressor Suction Pressure (PSIG)	305.0	304.0	303.0	304.0
Compressor Suction Temperature (^{o}F)	62.2	62.4	70.1	64.9
Compressor Discharge Pressure (PSIG)	635.0	634.0	643.0	637.3
Compressor Discharge Temperature (^{o}F)	169.8	169.8	177.6	172.4
Compressor Flow (MMSCF/D)	2.6	2.6	2.5	2.6
% Load	86.8	86.1	86.4	86.4
% Torque	86.2	85.8	86.2	86.0
Heat Rate (BTU/HP-hr)	0.0	0.0	0.0	0.0
Ambient Conditions				
Ambient Temperature (^{o}F)	47.83	48.56	47.29	47.89
Barometric Pressure (psi)	13.97	13.98	14.00	13.98
Ambient Relative Humidity (%)	85.00	86.00	85.00	85.33
Absolute Humidity (grains/LB)	90.63	94.24	88.57	91.15
Emissions Concentrations & Calculated Mass Emissions				
H_2CO Inlet ppmw	15.24	15.02	15.10	15.12
H_2CO Inlet (ppmw @ 15% 0_2	4.32	4.26	4.28	4.29
H_2CO Outlet ppmw	0.55	0.53	0.57	0.55
H_2CO Outlet (ppmw @ 15% 0_2	0.16	0.15	0.16	0.16
H_2CO % Removal Limit is 76%	96.39	96.47	96.23	96.36
% O_2 Inlet (raw measured wet)	0.10	0.10	0.10	0.10
% O_2 Outlet (raw measured wet)	0.10	0.10	0.10	0.10
Calculated Emissions Concentrations				
Calculated Flows				
Fuel Flow - (SCFM)	43.67	43.50	43.50	43.56
Fuel Flow - (SCFH)	2,620	2,610	2,610	2,613
Exhaust Flow (WSCFM)	0.0	0.0	0.0	0
Air flow Beshouri (scfm)	0.00	0.00	0.00	0
Fuel Flow Measurements				
Fuel Flow From Screen(MSCFH)	2.62	2.61	2.61	2.61
** 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 Reed City Compressor Station is located in Reed City, MI. The facility operates two, four stroke, rich burn, natural gas-fired reciprocating internal combustion compressor enginesto compress natural gas for transport via natural gas pipeline. The engines fall under flexible groups FGRC001 and FGMACTZZZZ in the permit and are subject to 40 CFR Part 63, Subpart ZZZZ requirements.

The EURC011 and EURC012 are 660 horsepower White Superior engines model number 8G825. The engines were installed in 1963. Process data is specified in table 4. General engine information is located in Tables 5-6.

Table 4. Process Data

Unit	Run 1	Run 2	Run 3	Average	Rated
Unit 11	578	577	574	576	660
Unit 12	573	568	570	570	660

Table 5. Unit 11 General Information

General Information

Date:	16-Oct-19
Company:	TC Energy
Station:	Reed City
Unit:	11
Engine Type:	White Superior 660
Rated RPM:	850 RPM
Rated BHP:	660 BHP

Permit Limits

	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:				
CO:				
VOC:				
H2CO:	>76 DE			

Limits are actuallly listed as average values

Table 6. Unit 12 General Information

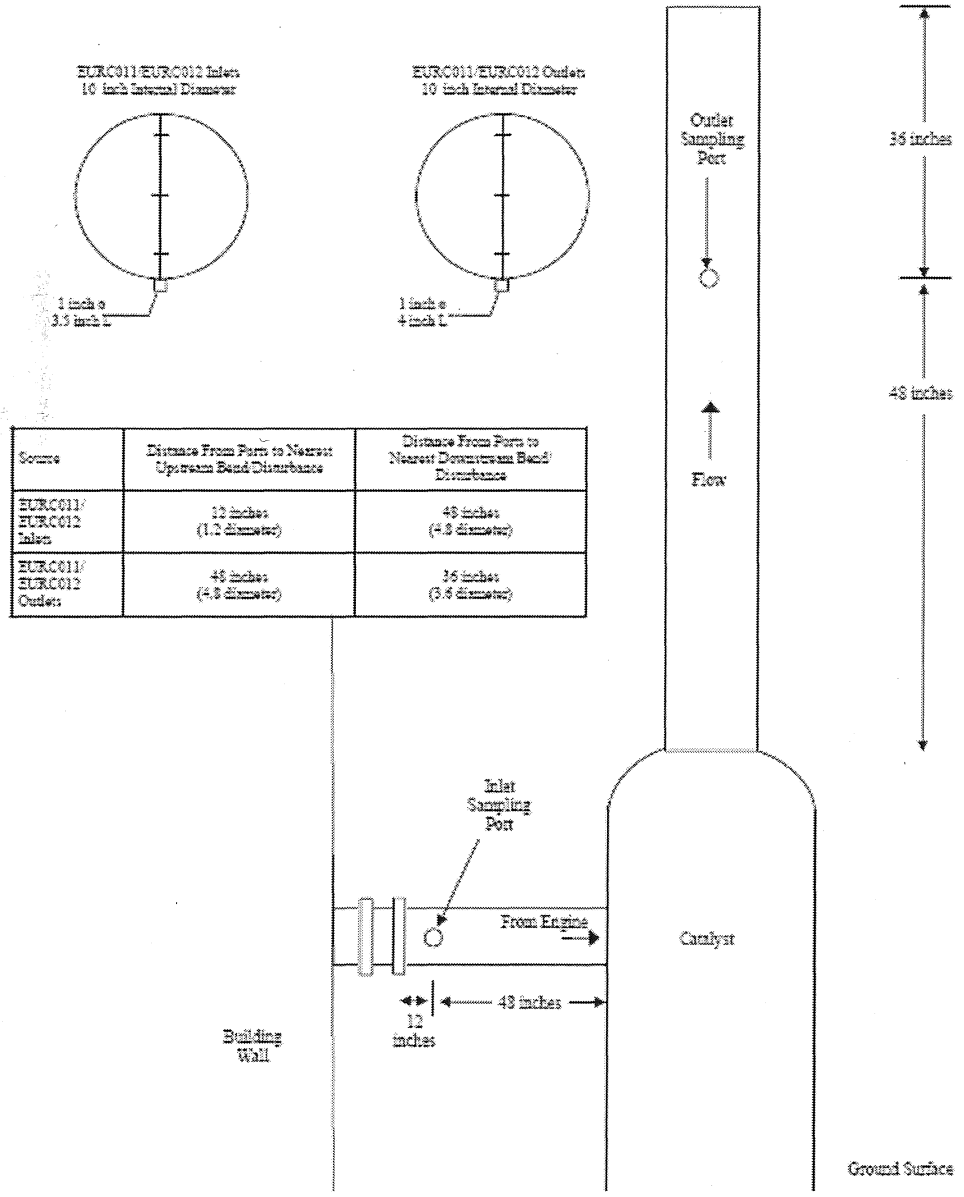
General Information

Date:	16-Oct-19
Company:	TC Energy
Station:	Reed City
Unit:	12
Engine Type:	White Superior 660
Rated RPM:	850 RPM
Rated BHP:	660 BHP

Permit Limits

	ppm@15%	g/Bhp-Hr	lb/hr	TPY
NOx:				
CO:				
VOC:				
H2CO:	>76 DE			

Limits are actuallly listed as average values



Source	Distance From Ports to Nearest Upstream Bend Disturbance	Distance From Ports to Nearest Downstream Bend/ Disturbance
EURC011/ EURC012 Inlets	12 inches (1.2 diameter)	48 inches (4.8 diameter)
EURC011/ EURC012 Outlets	48 inches (4.8 diameter)	36 inches (3.6 diameter)

Figure 1. Unit 11 and Unit 12 Sampling Ports & Traverse Point Locations

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 10– Determination of Carbon Monoxide 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)

USEPA Methods 3A, 7E, 10, 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-1 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 A.

Calculations that were used in this testing event for the Unit 11 and Unit 12 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

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

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 (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)

$$Conc.i_{(Std.O_2)} = Conc.i_{(Measured O_2)}\left(\frac{20.9\% - Std.O_2\%}{20.9\% - Measured\ O_2\%}\right)$$

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

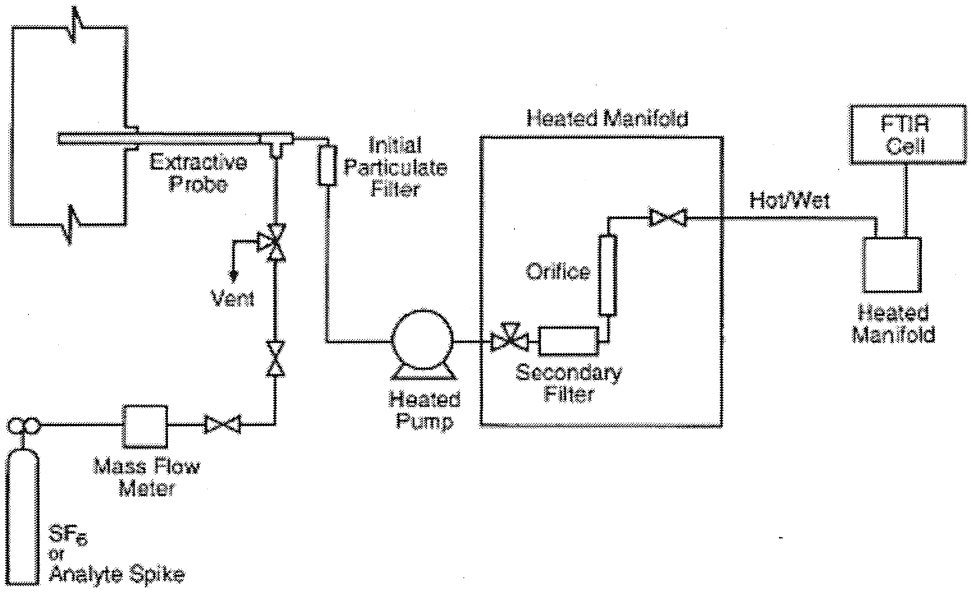


Figure 2. USEPA Method 320 Sampling Train

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 EURC011 and Unit EURC012 at TC Energy's ANR Pipeline Company's Reed City Compressor Station located in Reed City, Michigan. The testing was conducted on October 16, 2019.

During the course of the testing, the Unit EURC011 and Unit EURC012 conformed to the requirements of flexible groups FGRC001 and FGMACTZZZZ 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 Unit EURC011 and Unit EURC012 emissions shall be determined by others.

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