COMPLIANCE TEST REPORT
ANR PIPELINE-GOODWELL COMPRESSOR STATION
COMBUSTION EUGDS TURBINE NO.6
COMBUSTION EUGDS TURBINE NO.7

Prepared for:

TransCanada
In business to deliver

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AIR QUALITY DIVISION

TransCanada's ANR Pipeline Company
White Cloud, MI

Prepared by:

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PREFACE

I, Karl Mast, do hereby certify that the source emissions testing conducted at TransCanada in White Cloud, 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 Pipeline's Goodwell Compressor Station in White Cloud, MI.

Karl Mast
Test Supervisor

SUMMARY

The compliance testing was performed on the Combustion Turbine No. 6 and Combustion Turbine No. 7 systems in accordance with the requirements of the Title 40, Code of Federal Regulations, Part 60 (40 CFR 60.4320(a). The results of the testing are detailed in the following tables.

NOx Test Results (NOx 25 ppmvd @ 15% O2)				
Turbine	Rated Power (BHP)	Permit Limit NOx 25 ppmvd @ 15% O2	Measured Limit NOx 25 ppmvd @ 15% O2	Pass/Fail
No. 6	7,865	25	12.14	Pass
No. 7	7,865	25	10.44	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 TransCanada's ANR Pipleline (ANR) at Goodwell compressor station, near White Cloud, MI, which is located in Newaygo County.

The primary purpose of this testing program was to conduct emissions testing to determine compliance with operating permit No. MI-ROP-N5576-2015 for Combustion EUGDS Turbine No. 6 and Combustion EUGDS Turbine No. 7 at ANR Pipeline's gas compressor facility.

EQM's responsibility was to conduct the compliance testing for the O2 and NOx emissions rates and perform data reduction for conformance evaluation. ANR Pipeline'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 TransCanada's process operations, and Compliance testing. The Compliance testing conducted on the Combustion Turbine No. 7 was performed on Tuesday, February 13, 2018, from 9:23 A.M. to 10:28 A.M. The Compliance testing conducted on the Combustion Turbine No. 6 was performed on Tuesday, February 13, 2018, from 10:40 A.M. To 11:46 A.M.

The following requirements were specific for the testing program:

1. Equipment calibrations performed and calibration data provided.
2. Three (3) twenty (20) -minute, minimum, O_2 and NOx test runs performed at the Combustion Turbine No. 6 and Combustion Turbine No. 7 at maximum achievable load and speed according to pipeline conditions pursuant to EPA, Title 40, Code of Federal Regulations, Part 60, Appendix A.
3. Process manufacturing operations maintained at 100% of capacities and production and fuel consumption rates recorded during the emissions testing periods.
4. All testing and analyses performed in accordance with current EPA test methodologies and analytical procedures for O_2 and NOx emissions determinations.
5. Stratification was found to be less than 0.15% in both turbine exhausts.
6. Diluent corrected stratification test was performed in accordance with Subpart KKKK.

The testing program was approved by and/or coordinated with Roy Cannon, TransCanada's ANR Pipeline Company. The emission testing was performed by Karl Mast, Manager, Emission Measurement and Project Manager, EQM, Jeff Cavanaugh, Test Technician, EQM. The emission testing was observed Jeremy Howe, MDEQ.

2. TEST RESULTS SUMMARY

The compliance testing was performed on the Combustion Turbine No. 6 and Combustion Turbine No. 7 system in accordance with the requirements of the Title 40, Code of Federal Regulations, Part 60 (40 CFR 60, Appendix A) A summary of the test results is given below:

Table 1. Test Results Summary-NO_x-Turbines No. 6 and No. 7

NOx Test Results (NOx 25 ppmvd @ 15% O2)				
Turbine	Rated Power (BHP)	Permit Limit NOx 25 ppmvd @ 15% O2	Measured Limit NOx 25 ppmvd @ 15% O2	Pass/Fail
No. 6	7,865	25	12.14	Pass
No. 7	7,865	25	10.44	Pass

Based on the information provided above, the Combustion Turbine No. 6 and Combustion Turbine No. 7 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 Table 2-10.

Additional testing information may be found in Appendix A.

Table 2. Operating Parameters and Ambient Conditions-Turbine No. 6

Run	1	2	3	
Date	02/13/18	02/13/18	02/13/18	
Time	10:40	11:05	11:26	
Engine Operating Conditions	High	High	High	Averages
Unit Horsepower from Control Panel	6,209.0	6,288.0	6,299.0	6,265.3
% Load	78.9	79.9	80.1	79.7
Unit Speed (rpm) CT/GG/GP/Jet	14,332.0	14,332.0	14,332.0	14,332.0
% CT Speed	95.5	95.5	95.5	95.5
Gas Compressor Speed (rpm) PT/Booster	14,130.0	14,044.0	14,034.0	14,069.3
% CT Speed	98.8	98.2	98.1	98.4
Compressor Suction Pressure (PSIG)	144.0	150.0	150.0	148.0
Compressor Suction Temperature (°F)	40.0	43.0	42.0	41.7
Compressor Discharge Pressure (PSIG)	447.0	448.0	448.0	447.7
Compressor Discharge Temperature (°F)	222.0	223.0	223.0	222.7
Compressor Flow	149.0	149.0	149.0	149.0
% Torque	82.6	83.7	83.8	83.4
Heat Rate (BTU/HP-hr)	9,426.2	9,157.7	9,141.7	9,241.9
Ambient Conditions				
Ambient Temperature (°F)	23.00	23.00	23.00	23.00
Barometric Pressure (psi)	14.35	14.35	14.35	14.35
Ambient Relative Humidity (%)	58.00	58.00	58.00	58.00
Absolute Humidity (grains/LB)	22.12	22.12	22.12	22.12

Table 3. Emissions Concentrations & Calculated Mass Emissions/Calculated Emissions Concentrations/Calculated Flows-Turbine No. 6

Run	1	2	3	
Date	02/13/18	02/13/18	02/13/18	
Time	10:40	11:05	11:26	
Emissions Concentrations & Calculated Mass Emissions				Averages
NO_x ppm (BIAS Corrected)	11.21	11.21	11.19	11.20
NO_X g/BHP-HR	0.21	0.21	0.21	0.21
NO_X LB/HR	2.86	2.87	2.87	2.87
NO_X (ppm @ 15% O_2)	11.98	12.23	12.20	12.14
NO_X (ppm @ 15% O_2, ISO)	18.17	18.54	18.51	18.40
NOx LB/MMBTU	0.04	0.05	0.04	0.04
CO ppm (raw measured dry)	4.39	4.28	4.21	4.29
CO g/BHP-HR	0.05	0.05	0.05	0.05
CO LB/HR	0.68	0.67	0.66	0.67
CO LB/MMBTU **	0.01	0.01	0.01	0.01
CO (ppm @ 15% O_2)	4.69	4.67	4.59	4.65
CO (ppm @ 15% O_2, ISO)	7.12	7.08	6.96	7.05
% O_2 (BIAS Corrected)	15.38	15.49	15.49	15.45
Calculated Emissions Concentrations				
% CO_2 (Wet) *	2.96	2.91	2.91	2.93
%CO_2 (Dry) *	3.16	3.10	3.10	3.12
% H_2O *	6.22	6.12	6.12	6.16
% O_2 (Wet) *	14.42	14.54	14.54	14.50
% N_2 + CO (Wet) *	76.40	76.42	76.42	76.41
Calculated Flows				
Fuel Flow - (SCFM)	1033.33	1016.67	1016.67	1022.22
Fuel Flow - (SCFH)	62,000	61,000	61,000	61,333
Fuel Flow (LB/HR)	7,598.2	7,521.4	7,542.5	7,554
Exhaust Flow (LB/HR)	139,689.7	140,050.2	140,050.2	139,930
Exhaust Flow (WSCFM)	36,411.9	36,428.7	36,428.7	36,423
Air Flow (WSCFM)	34,205	34,331	34,331	34,289
Exhaust Flow Method 19 (wscfm)	35,535	35,673	35,673	35,627
Exhaust Flow Method 19 (lbm/min)	1,633	1,639	1,639	1,637
Exhaust Flow Carbon Balance (lbm/min)	2,728.58	2,737.05	2,737.05	2,734
Air flow Beshouri (scfm)	35,497.37	35,607.52	35,607.52	35,571
BSAC, #/BHP-hr	25.11	24.88	24.84	25
Fuel Flow Measurements				
Fuel Flow From Screen(MSCF)	62.00	61.00	61.00	61.33
Fuel Flow (SCFH) From Fuel Orifice	165,656	163,982	164,440	164,693
Fuel Gas Differential Pressure ("H_2O)	303.00	297	298	299
Fuel Gas Static Pressure (PSIG)	219.00	219	219	219
Fuel Gas Temperature (°F)	66.00	66	65	66
** 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. Operating Parameters and Ambient Conditions-Turbine No. 7

Run	1	2	3	
Date	02/13/18	02/13/18	02/13/18	
Time	9:23	9:47	10:08	
Condition				
Engine Operating Conditions	High	High	High	Averages
Unit Horsepower from Control Panel	6,365.0	6,341.0	6,347.0	6,351.0
% Load	80.9	80.6	80.7	80.8
Unit Speed (rpm) CT/GG/GP/Jet	14,287.0	14,287.0	14,277.0	14,283.7
% CT Speed	95.2	95.2	95.2	95.2
Gas Compressor Speed (rpm) PT/Booster	14,180.0	14,120.0	14,100.0	14,133.3
% CT Speed	99.2	98.7	98.6	98.8
Compressor Suction Temperature (°F)	37.0	39.0	38.0	38.0
Compressor Discharge Pressure (PSIG)	445.0	447.0	447.0	446.3
Compressor Discharge Temperature (°F)	223.0	223.0	222.0	222.7
Compressor Flow	150.0	150.0	149.0	149.7
% Torque	85.0	84.6	84.8	84.8
Ambient Conditions				
Ambient Temperature (°F)	23.00	23.00	23.00	23.00
Barometric Pressure (psi)	14.35	14.35	14.35	14.35
Ambient Relative Humidity (%)	58.00	58.00	58.00	58.00
Absolute Humidity (grains/LB)	22.12	22.12	22.12	22.12

Table 5. Emissions Concentrations & Calculated Mass Emissions/Calculated Emissions Concentrations/Calculated Flows-Turbine No. 7

Run	1	2	3	
Date	02/13/18	02/13/18	02/13/18	
Time	9:23	9:47	10:08	
Emissions Concentrations & Calculated Mass Emissions				Averages
NO_x ppm (BIAS Corrected)	10.56	9.66	9.65	9.96
NO_X g/BHP-HR	0.22	0.20	0.20	0.21
NO_X LB/HR	3.13	2.77	2.77	2.89
NO_X (ppm @ 15% O_2)	11.31	10.00	10.01	10.44
NO_X (ppm @ 15% O_2, ISO)	17.15	15.16	15.17	15.83
NOx LB/MMBTU	0.04	0.04	0.04	0.04
CO ppm (raw measured dry)	4.82	4.55	4.49	4.62
CO g/BHP-HR	0.06	0.06	0.06	0.06
CO LB/HR	0.87	0.79	0.79	0.82
CO LB/MMBTU **	0.01	0.01	0.01	0.01
CO (ppm @ 15% O_2)	5.16	4.71	4.66	4.84
CO (ppm @ 15% O_2, ISO)	7.83	7.14	7.06	7.34
% O_2 (BIAS Corrected)	15.39	15.20	15.21	15.27
Calculated Emissions Concentrations				
% CO_2 (Wet) *	2.96	3.04	3.04	3.01
%CO_2 (Dry) *	3.15	3.25	3.24	3.21
% H_2O *	6.21	6.37	6.36	6.31
% O_2 (Wet) *	14.43	14.23	14.24	14.30
% N_2 + CO (Wet) *	76.40	76.36	76.36	76.37
Calculated Flows				
Fuel Flow - (SCFM)	1200.00	1200.00	1200.00	1200.00
Fuel Flow - (SCFH)	72,000	72,000	72,000	72,000
Fuel Flow (LB/HR)	7,569.4	7,564.8	7,548.3	7,561
Exhaust Flow (LB/HR)	162,499.5	157,432.5	157,690.8	159,208
Exhaust Flow (WSCFM)	42,356.5	41,184.9	41,244.6	41,595
Air Flow (WSCFM)	39,794	38,480	38,547	38,940
Exhaust Flow Method 19 (wscfm)	41,342	39,964	40,034	40,446
Exhaust Flow Method 19 (lbm/min)	1,900	1,837	1,840	1,859
Exhaust Flow Carbon Balance (lbm/min)	3,174.20	3,072.43	3,077.62	3,108
Air flow Beshouri (scfm)	41,294.69	39,970.65	40,038.15	40,434
BSAC, #/BHP-hr	28.49	27.66	27.68	28
Fuel Flow Measurements				
Fuel Flow From Screen(MSCF)	72.00	72.00	72.00	72.00
Fuel Flow (SCFH) From Fuel Orifice	165,027	164,926	164,567	164,840
Fuel Gas Differential Pressure ("H_2O)	302.00	301	301	301
Fuel Gas Static Pressure (PSIG)	220.00	220	219	220
Fuel Gas Temperature (°F)	70.00	69	69	69
** 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. PROCESS DESCRIPTION

TransCanada's ANR Goodwell Compressor Station is located in White Cloud, Michigan and operates two Solar Centaur 60, 7,865 hp natural gas fired turbines with low NO_x burner for NO_x control labeled EUGDS Turbine 6 and EUGDS Turbine 7. The plant is located at 6759 East Five Mile Road, White Cloud, MI

The Solar Centaur 60 gas turbine is a simple cycle, natural gas fired, split-shaft turbine. In a simple cycle turbine, filtered atmosphere air is first compressed by the axial flow compressor. The hot compressed air is then fired with natural gas in the combustor. The hot exhaust gases expand through two turbine stages. The gas producer (G.P.) turbine drives the axial flow air while the power turbine (P.T.) drives the centrifugal pipeline compressor. The pipeline gas compressor moves natural gas through the pipeline by compressing it from an initial "suction" state to a more compressed "discharge" state.

The following tables provide a summary of the production rates for the Turbines No. 6 and No. 7 during the test:

Table 6. Production Data-Brake Horse Power (BHP)

Turbine No. 6 and No. 7 Brake Horse Power (BHP)		
Run No.	**Turbine No. 6**	**Turbine No. 7**
1	6,209	6,365
2	6,288	6,341
3	6,299	6,347
Average	6,265	6,351
Rated BHP	7,865	7,865

Table 7. Unit 6 General Information

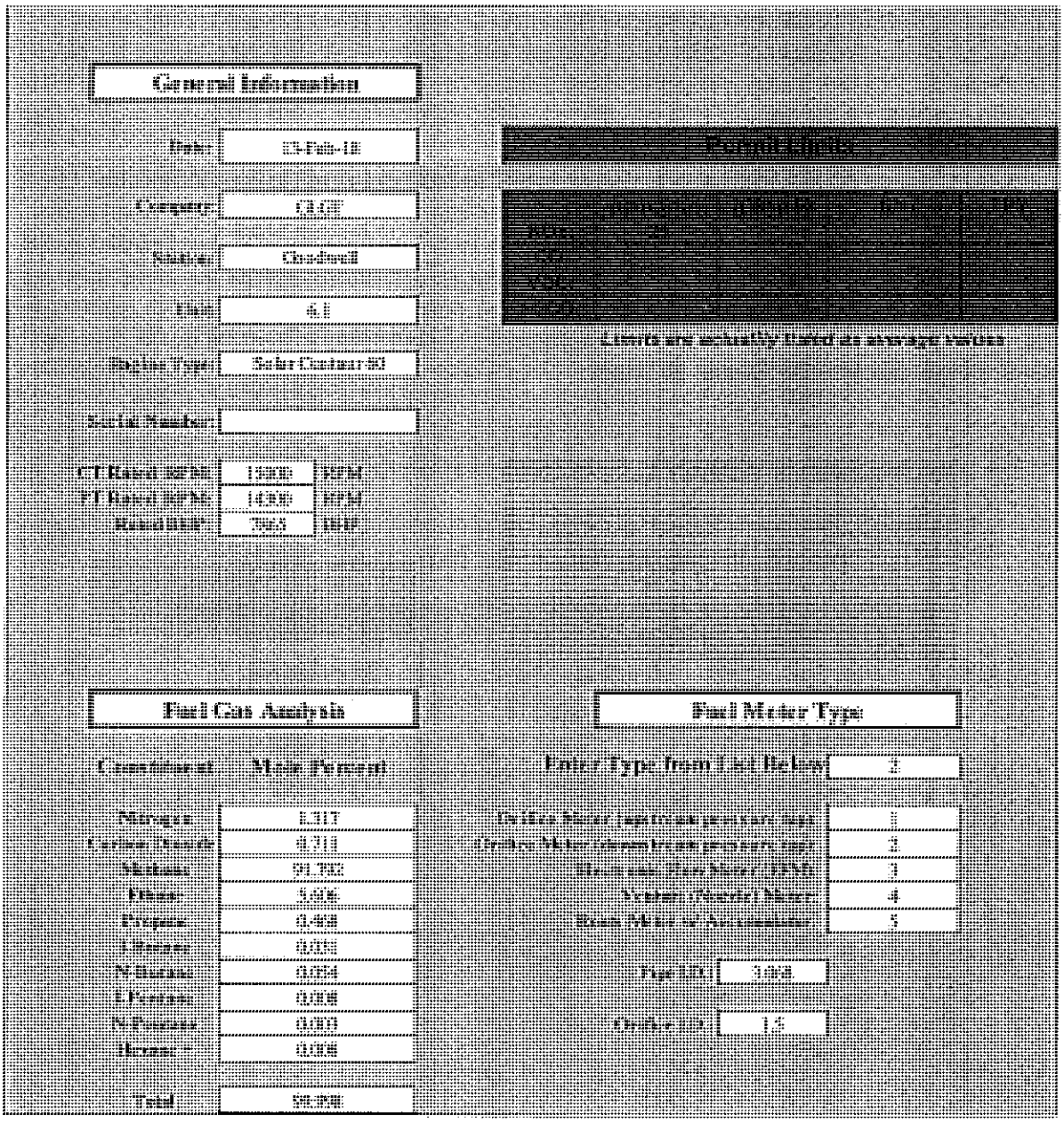


Table 8. Unit 7 General Information

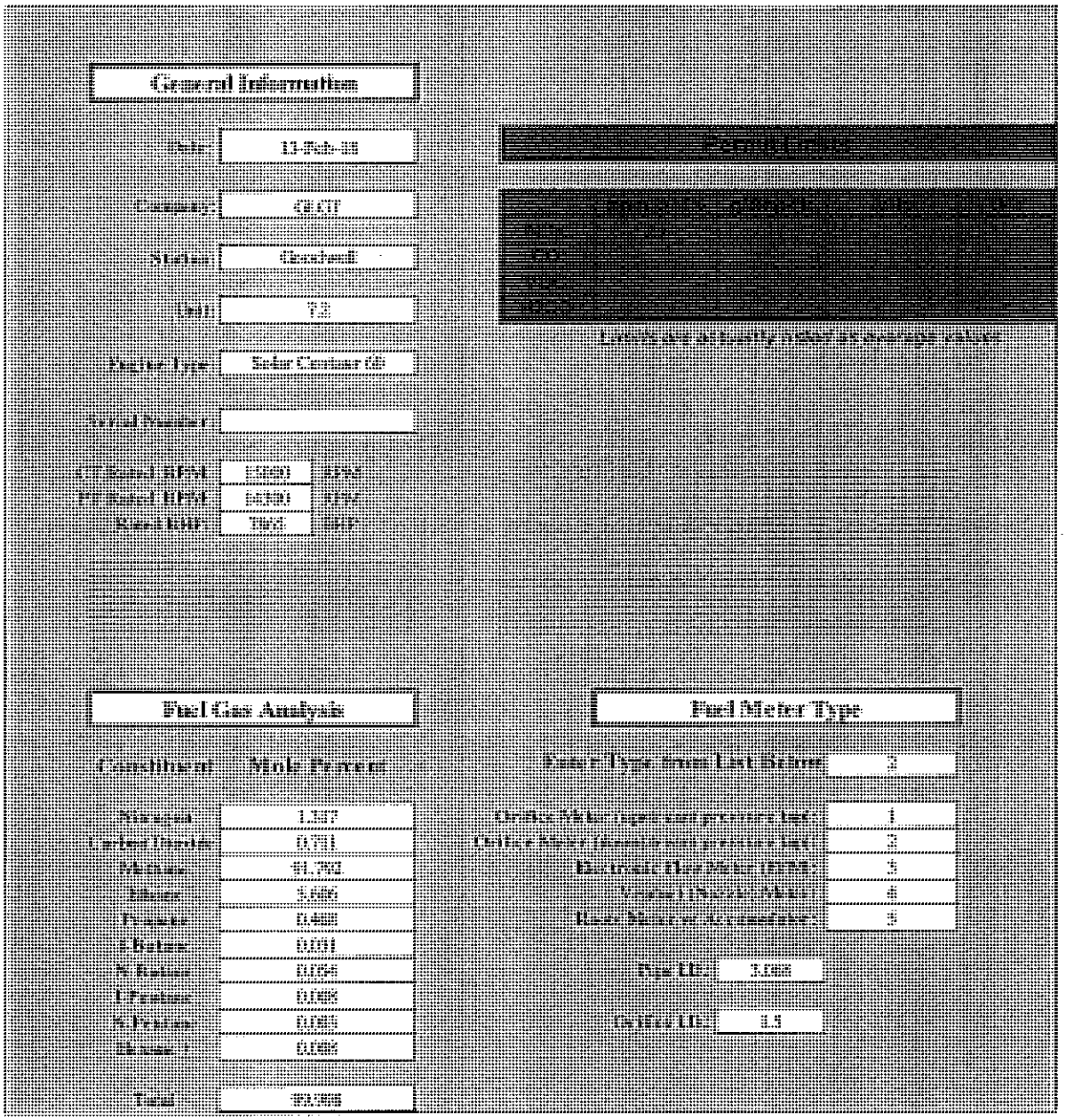
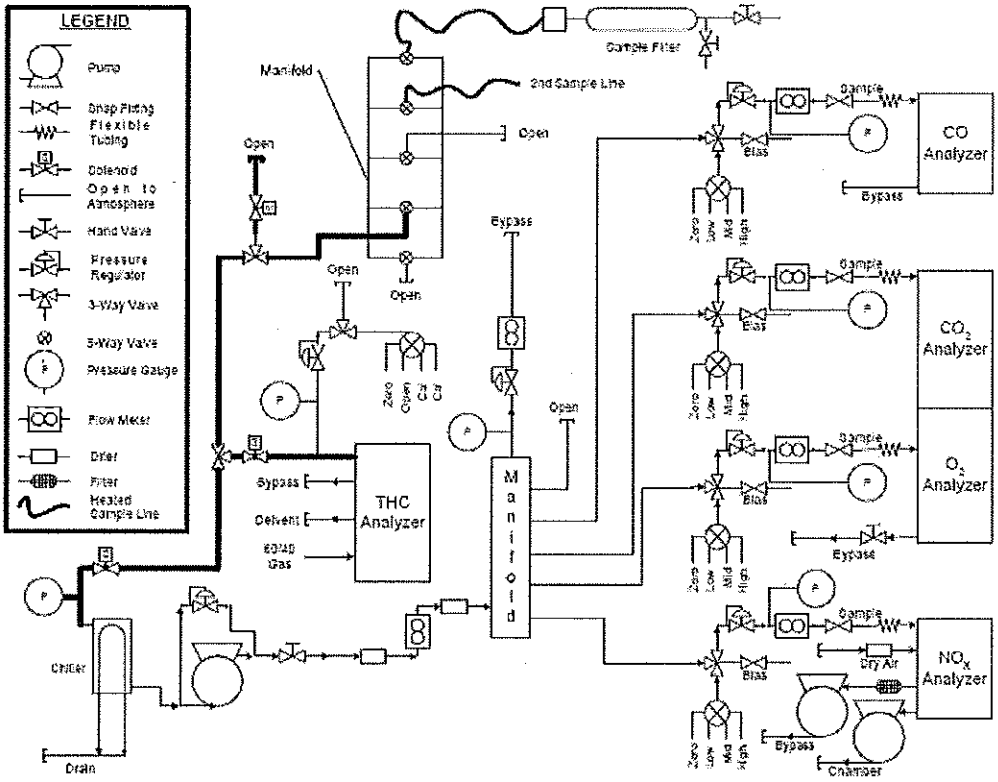


Figure 1. Flow Schematic



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 7E – Determination of Nitrogen Oxides Emissions From Stationary Sources (Instrumental Analyzer Procedure)

USEPA Methods 3A and 7E 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 Units No. 6 and No. 7 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

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

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 Turbine 6 and Turbine 7 at TransCanada's ANR Pipeline Company's Goodwell Compressor Station located in White Cloud, MI. The testing was conducted on February 13, 2018.

During the course of the testing, the Turbine 6 and Turbine 7 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 Turbine 6 and Turbine 7 emissions shall be determined by others.

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